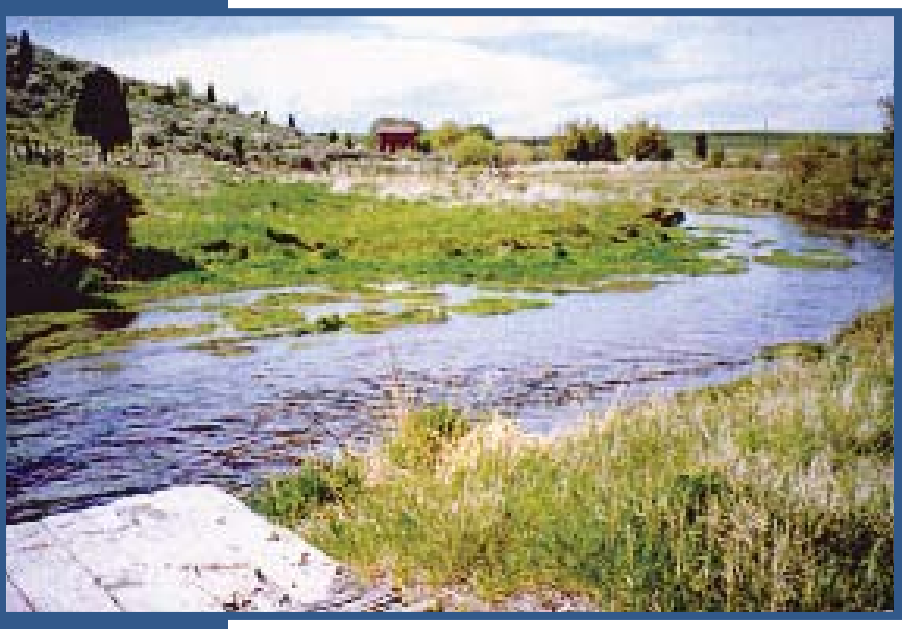
Submitted to:
Monsanto Soda Springs Plant
Highway 34
Soda Springs, ID 839276



SECOND FIVE-YEAR REVIEW REPORT FOR GROUNDWATER CONDITIONS AT THE MONSANTO SODA SPRINGS PLANT SODA SPRINGS, ID

July 2008
913-1101.605

9131101605cv01.indd DATE 04/04/08

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Submitted to:

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Soda Springs Plant
Highway 34
Soda Springs, Idaho 83276

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July 3, 2008

913-1101.605

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Summary of First Five-Year Review of Groundwater Conditions 2
1.1.1 U.S. Environmental Protection Agency Five-Year Review 3

2.0 SITE CHRONOLOGY 4

3.0 SITE BACKGROUND 6
3.1 Site and Vicinity Description 6
3.1.1 History of Groundwater Effects 7
3.1.2 Geology 7
3.1.3 Hydrogeology 7
3.1.4 Sources of Affected Groundwater 9
3.1.5 Summary of Previous Investigations 10

4.0 REMEDIAL ACTIONS 12
4.1 Remedial Measures before Record of Decision 12
4.2 Remedy Selection 12
4.3 Operation and Maintenance 14

5.0 FIVE-YEAR REVIEW PROCESS 15
5.1 Document Review 15
5.2 Data Review 15
5.3 Evaluation of Groundwater and Outfall Monitoring Data 16
5.3.1 Status of Attaining Remedial Goals 16
5.3.2 Constituent Concentration Trend Analysis 16
5.3.2.1 Methods of Trend Analysis 17
5.3.3 Results of Statistical Analyses – 1991 to 2007 18
5.3.3.1 Summary of Statistical Analyses 1991 to 2007 31
5.3.4 Results of Statistical Analyses – 2000 to 2007 32
5.3.4.1 Summary of Statistical Analyses 2000 to 2007 42
5.4 Evaluation of Extent of Constituent Plumes 43
5.4.1 Cadmium in Upper Basalt Zone 43
5.4.2 Fluoride in Upper Basalt Zone 44
5.4.3 Manganese in Upper Basalt Zone 44
5.4.4 Nitrate as N in Upper Basalt Zone 45
5.4.5 Selenium in Upper Basalt Zone 45
5.4.6 Chloride in Upper Basalt Zone 46
5.4.7 Molybdenum in Upper Basalt Zone 46
5.4.8 Sulfate in Upper Basalt Zone 47
5.5 Evaluation of Groundwater Modeling Projections 48
5.5.1 Original Solute Transport Model 48
5.5.2 Revised Solute Transport Model 48
5.5.3 Comparisons between GoldSim Model Results and Observed Concentrations . 49

5.5.3.1 Chloride ... 49
5.5.3.2 Fluoride ... 50
5.5.3.3 Nitrate ... 51
5.5.3.4 Selenium ... 52
5.5.3.5 Manganese ... 53
5.5.3.6 Cadmium ... 54
5.5.3.7 Discussion ... 55

6.0 ISSUES RAISED IN FIRST FIVE-YEAR REVIEW ... 57
6.1 Lewis Well ... 57
6.2 Monitored Natural Attenuation (MNA) ... 58
6.2.1 Observations since First Five-Year Review ... 58
6.2.1.1 UBZ-4 ... 58
6.2.1.2 UBZ-2 ... 59
6.3 Technical Issues ... 67
6.3.1 Molybdenum Concentrations ... 68
6.3.2 Use of Total Nitrogen as Nitrate for Demonstrating Compliance with MCL 68
6.3.3 Soda Creek ... 69

7.0 TECHNICAL ASSESSMENT ... 70
7.1 Attainment of Question A ... 70
7.1.1 Institutional Controls ... 70
7.1.2 UBZ-2 Monitored Natural Attenuation ... 70
7.1.3 UBZ-4 Region ... 72
7.1.4 Attainment of Question A ... 72
7.2 Attainment of Question B ... 72
7.2.1 Changes in Standards and To Be Considereds (TBCs) ... 73
7.2.2 Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics ... 73
7.2.2.1 Exposure Pathways ... 73
7.2.2.2 Toxicity ... 74
7.2.2.3 To Be Considereds ... 74
7.3 Attainment of Question C ... 74
7.4 Technical Assessment Summary ... 74
7.5 Issues ... 75
7.6 Recommendations and Follow-Up Actions ... 75
7.7 Protectiveness Statement ... 75

8.0 REFERENCES ... 76

LIST OF TABLES

Table 1	Summary of Site Chronology
Table 2	Groundwater Remedial Goals for the Monsanto Site
Table 3	2007 Results Compared to Remedial Goals
Table 4a	Summary of Cadmium Statistical Analyses 1991 to 2007
Table 4b	Summary of Fluoride Statistical Analyses 1991 to 2007
Table 4c	Summary of Manganese Statistical Analyses 1991 to 2007
Table 4d	Summary of Nitrate as N Statistical Analyses 1991 to 2007
Table 4e	Summary of Selenium Statistical Analyses 1991 to 2007
Table 4f	Summary of Chloride Statistical Analyses 1991 to 2007
Table 4g	Summary of Molybdenum Statistical Analyses 1991 to 2007
Table 4h	Summary of Sulfate Statistical Analyses 1991 to 2007
Table 5	Summary of Constituent Trends 1991 to 2007
Table 6a	Summary of Cadmium Statistical Analyses 2000 to 2007
Table 6b	Summary of Fluoride Statistical Analyses 2000 to 2007
Table 6c	Summary of Manganese Statistical Analyses 2000 to 2007
Table 6d	Summary of Nitrate as N Statistical Analyses 2000 to 2007
Table 6e	Summary of Selenium Statistical Analyses 2000 to 2007
Table 6f	Summary of Chloride Statistical Analyses 2000 to 2007
Table 6g	Summary of Molybdenum Statistical Analyses 2000 to 2007
Table 6h	Summary of Sulfate Statistical Analyses 2000 to 2007
Table 7	Summary of Constituent Trends 2000 to 2007
Table 8	Predicted and Observed 2002 and 2007 Concentrations-Original - RI Model
Table 9	Summary of Predicted and Observed Concentrations in 2002 and 2007
Table 10	Precipitation Summary for Soda Springs
Table 11	Estimated Groundwater Velocity and Hydraulic Conductivity - UBZ-2
Table 12	Summary of Constituent Response in UBZ-2 Source Areas

LIST OF FIGURES

Figure 1	Monsanto Plant Vicinity Map
Figure 2	Location of Wells and Springs in the Upper Basalt Zone
Figure 3	Location of Wells in the Lower Basalt Zone
Figure 4	Monsanto Facility Map
Figure 5	Groundwater Elevation of the Upper Basalt Zone July 2007
Figure 6	Groundwater Elevation of the Lower Basalt Zone July 2007
Figure 7a	Cadmium (June 2002), Upper Basalt Zone
Figure 7b	Cadmium (June/July 2007), Upper Basalt Zone
Figure 8a	Fluoride (June 2002), Upper Basalt Zone
Figure 8b	Fluoride (June/July 2007), Upper Basalt Zone
Figure 9a	Manganese (June 2002), Upper Basalt Zone
Figure 9b	Manganese (June/July 2007), Upper Basalt Zone
Figure 10a	Nitrate as N (June 2002), Upper Basalt Zone
Figure 10b	Nitrate as N (June/July 2007), Upper Basalt Zone
Figure 11a	Selenium (June 2002), Upper Basalt Zone
Figure 11b	Selenium (June/July 2007), Upper Basalt Zone
Figure 12a	Chloride (June 2002), Upper Basalt Zone

Figure 12b Chloride (June/July 2007), Upper Basalt Zone
Figure 13a Molybdenum (June 2002), Upper Basalt Zone
Figure 13b Molybdenum (June/July 2007), Upper Basalt Zone
Figure 14a Sulfate (June 2002), Upper Basalt Zone
Figure 14b Sulfate (June/July 2007), Upper Basalt Zone
Figure 15 Lewis Well Chemical Hydrographs

LIST OF ATTACHMENTS

Attachment A Theoretical Background of Statistical Methods
Attachment B Output of Statistical Analyses—MAKESENS Graphs 1991 to 2007
Attachment C Output of Statistical Analyses—MAKESENS Graphs 2000 to 2007
Attachment D GoldSim Solute Transport Model Output
Attachment E UBZ-2 Chemical Hydrographs
Attachment F Molybdenum Hydrographs
Attachment G Institutional Controls Information

LIST OF ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AOC	Administrative Order on Consent
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	constituent of concern
EPA	U.S. Environmental Protection Agency
FS	feasibility study
Golder	Golder Associates Inc.
gpm	gallons per minute
GPS	Global Positioning System
IDEQ	Idaho Department of Environmental Quality
LBZ	Lower Basalt Zone
MCL	maximum contaminant level
mg/L	milligrams per liter
MNA	monitored natural attenuation
Monsanto	Monsanto Chemical Company
N	nitrogen
NCP	National Contingency Plan
NO_3	nitrate
NPL	National Priorities List
RAO	remedial action objective
RG	remedial goal
RI	remedial investigation
ROD	Record of Decision
SO_2	sulfur dioxide
UBZ	Upper Basalt Zone
UFS	Underflow Solids (Ponds)

1.0 INTRODUCTION

The purpose of the five-year review is to determine whether the remedy at the Monsanto Chemical Company (Monsanto) Soda Springs site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify issues found during the review, if any, and identify recommendations to address those issues (EPA, 2001).

This five-year review report is prepared pursuant to Comprehensive Environmental Response and Liability Act (CERCLA) § 121 and the National Contingency Plan (NCP). CERCLA § 121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

This requirement is further interpreted by the U.S. Environmental Protection Agency (EPA) in the NCP 40 CFR § 300.430(f)(ii), which states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

Golder Associates Inc. (Golder) conducted this five-year review of the groundwater remedy employed at the Monsanto Soda Springs Plant located in Caribou County, Idaho. This is the second five-year review of the groundwater remedy at the Monsanto Soda Springs Plant. The first was completed in 2003 (Golder, 2003a) based on data collected up to June 2002. This review was conducted for groundwater conditions based on data collected up to June 2007. The portion of the five-year review pertaining to the soils remedy implemented at the plant was conducted by MWH.

This review is required because the selected groundwater remedy resulted in constituents remaining onsite above remedial goals. This and future reviews will be used to evaluate whether the remedy remains protective, to confirm that constituent concentration trends in groundwater are declining as predicted, and to eventually confirm the achievement of the remedial goals (RGs). The triggering action for this statutory review is the initiation of the remedial action on April 30, 1997.

The goals of this five-year review report include the following:

- Review and assessment of groundwater, surface water, and outfall monitoring data (collected and evaluated at least annually).
- Comparison of groundwater, surface water, and outfall quality and the extent of constituent plumes to regulatory levels, remedial goals, and groundwater modeling projections. This comparison will be used to determine if and when RGs have been achieved, and if RGs have not been achieved, that institutional controls are still in place that effectively prevent human exposure.

- Evaluation of need to reevaluate the groundwater model and or groundwater remedial actions, or both, if groundwater recovery appears to significantly differ from model projections.

1.1 Summary of First Five-Year Review of Groundwater Conditions

The first five-year review included evaluation of groundwater data collected through June 2002 (Golder, 2003a). The following summarizes the technical assessment of the first five-year review of groundwater conditions:

- The institutional controls on groundwater in the area south of the plant are in place and functioning as intended. No groundwater in this area is being used for domestic use, and controls are in place to prevent future use. Additional information on the institutional controls that are in place in the area around the plant is included in Attachment G.
- Monitored natural attenuation was the chosen remedy in the Upper Basalt Zone (UBZ) -2 zone. Concentrations of constituents of concern that are not retarded were either at the remedial goal or were anticipated to meet the remedial goals within 20 years, based on the results of contaminant transport modeling and the annual groundwater sampling. Concentrations of highly retarded constituents might not exceed the remedial goals at the point of compliance wells.
- Monitored natural attenuation plus containment with the plant production wells was the chosen remedy in the UBZ-4 zone. Constituents that are not retarded (fluoride, nitrate, and selenium) and manganese meet the remedial goals, based on the results of groundwater sampling. The concentrations of cadmium, a highly retarded constituent, may take years to meet remedial goals. However, the continuous pumping of the plant production wells contains affected groundwater and prevents off-site migration.
- Monitored natural attenuation (UBZ-2 and UBZ-4) in conjunction with containment by the plant production wells (in UBZ-4) and institutional controls are appropriate remedies for groundwater. Monsanto has committed to continue the annual monitoring of the point of compliance wells and other wells and springs.
- The chosen remedies for groundwater in the UBZ-2 and UBZ-4 regions are functioning as intended and are therefore appropriate remedies, based on the results of the annual water quality monitoring and transport modeling.
- The drinking water maximum contaminant levels (MCLs) for constituents of concern fluoride, nitrate, cadmium, and selenium have not changed since the remedial investigation (RI) was completed in 1995. Therefore, the remedial goals for these constituents (drinking water MCLs) remain valid and protective for groundwater at the Monsanto Soda Springs plant site. The remedial goal for manganese is 0.18 milligrams per liter (mg/L). The remedial goal for manganese is a risk-based concentration. There have been no changes in the exposure pathways or toxicity values for manganese. Therefore, the remedial goal for manganese remains valid and protective for the Monsanto site.
- There have been no changes in the physical conditions at the Monsanto site, the methods used to develop the risk assessment, or the toxicity factors for the constituents of concern. The remedies contained in the Record of Decision (ROD) for groundwater at the Monsanto site are functioning as intended and are protective of human health and the environment, based on the information review conducted as part of the five-year review process.

1.1.1 U.S. Environmental Protection Agency Five-Year Review

The EPA prepared a five-year review report for the Monsanto Soda Springs Plant (EPA, 2003). The EPA's review identified the following issues with regard to groundwater:

- Groundwater from the Lewis Well contained elevated concentrations of cadmium and other constituents. The property where this well is located does not have institutional controls.
- Monitored natural attenuation for groundwater may take longer than anticipated in the remedial investigation/feasibility study (RI/FS).
- The following three technical matters regarding groundwater were identified:
  - Increasing molybdenum concentrations south of the operating area
  - The use of total nitrogen as nitrate for demonstrating compliance with the remedial goal (groundwater MCL for nitrate)
  - Annual sampling, analyses, and trend evaluation reporting for Soda Creek discharge concentrations

The EPA first five-year review report included the following recommendations and follow-up actions with regard to groundwater:

- Submit a plan pertaining to institutional controls for the Lewis Well and nearby properties.
- Collect and analyze surface water discharges to Soda Creek and report the findings annually, and as part of the next five-year review, and provide trend analyses of the data.
- Engage in a technical dialog with EPA and the Idaho Department of Environmental Quality (IDEQ) to resolve three groundwater technical issues: 1) institutional controls at the Lewis Well; 2) reevaluation of monitored natural attenuation; and 3) the use of total nitrogen as nitrate for demonstrating compliance.

The issues identified in the EPA five-year review are addressed in Section 6.

2.0 SITE CHRONOLOGY

A history of plant operations and groundwater investigations at the Monsanto Soda Springs plant is summarized on Table 1.

TABLE 1

Summary of Site Chronology

Event	Date
Monsanto purchased site and initiated elemental phosphorus production on the property from locally mined phosphorus ore. The site was previously used for agricultural and domestic purposes.	1952
Landowner immediately south of the former plant boundary identified local groundwater impacts, notably excess-fluoride-related health problems in livestock drinking groundwater from nearby springs.	Early 1980s
Monsanto purchased land immediately south (Harris and Ponderosa) and southwest (Kackley) of the former plant boundary	Early to Mid 1980s
Golder was employed to assess the impacts of past and current operations on groundwater and surface water quality. The results of this investigation indicated that groundwater beneath the plant contained elevated concentrations of several metals and anions, including cadmium, selenium, fluoride, and sulfate.	1984
CERCLA site inspection was conducted by Ecology and Environment (an EPA contractor) that included additional groundwater sampling and analysis. The findings were consistent with Monsanto's earlier findings (Golder, 1985) and found elevated levels of fluoride, cadmium, selenium, and sulfate in monitoring and production wells.	April 1988
EPA placed the Monsanto Company (Monsanto) elemental phosphorus plant in Soda Springs, Idaho on the National Priorities List (NPL)	August 30, 1990
Administrative Order on Consent (AOC) issued by EPA and agreed to by Monsanto for the preparation and performance of a remedial investigation and feasibility study (RI/FS) for the Soda Springs plant	March 19, 1991
A RI/FS was conducted for the Soda Springs plant.	March 1991 to November 1995
Monsanto sampled between 50 and 60 monitoring wells, off-site wells, and springs every six months as part of the RI/FS work plan.	1991 to 1998
EPA submitted a Record of Decision (ROD) for the Monsanto site that documents the selected remedy for environmental media affected by operations at the Soda Springs plant.	April 30, 1997
Wells and springs have been sampled annually as part of remediation monitoring.	1998 to Date
Environmental Protection Easement and Declaration of Restrictive Covenants recorded as official records at Caribou County Courthouse	December 22, 1999
Geophysical survey and installation of four new monitoring wells south of the plant site	June 2007

3.0 SITE BACKGROUND

3.1 Site and Vicinity Description

The Monsanto Soda Springs Plant is located in southeastern Idaho approximately one mile north of the city of Soda Springs, Caribou County, Idaho (Figure 1). CERCLA regulations define the term "site" as the areal extent of affected areas and all suitable areas in very close proximity to the affected areas necessary for implementation of the response action. The term "plant" is used in this document to refer to those portions of the site that are owned by Monsanto and used for their elemental phosphorus manufacturing operations. The plant covers an area of approximately 540 acres, with the entire site covering an area of approximately 800 acres.

With elevations ranging from 5,880 feet to 5,990 feet above mean sea level (amsl), the plant lies in a tributary valley to the Bear River that is drained by Soda Creek. The valley is broad and rural, with mixed agriculture, residential, and industrial uses, and is bordered on the east by the Aspen Range and on the west by the Soda Springs Hills and Chesterfield Range. The largest population center in the area is the city of Soda Springs, with a population of approximately 3,000 people. A number of other industrial sites are located in the valley. These include:

- Tronox Inc. (formerly Kerr-McGee Chemical Corporation; former production of vanadium compounds), located east of Highway 34 from the plant
- Evergreen Resources (fertilizer products), located about 1,000 to 2,000 feet southeast of the plant
- Soda Springs Phosphate Industries (fertilizer products), located adjacent to Evergreen Resources
- Nu-West Industries (phosphoric acid production and fertilizer products), located approximately four miles north of the plant
- N.A. Degerstrom (gallium and silver extraction), located approximately two miles north of the plant

The city of Soda Springs obtains its municipal water from two springs located in the eastern portion of the valley: Formation Spring to the northeast of the Monsanto plant and Ledger Springs to the southeast of the Monsanto plant. Both springs are in different hydrogeologic systems from those at the site and, thus, are unaffected by site conditions. Twenty-two domestic water supply wells are registered within three miles of the site (most of them upgradient of the site), as well as seven irrigation wells. Hooper Springs, located downgradient of the site but showing no evidence of elevated levels of constituents of concern, is occasionally used by tourists and residents for drinking. The only domestic wells known to have been affected by groundwater from the site are at a home located 0.2 mile south of the plant (Lewis Well) and a well located about 600 feet south of the Fenceline (Harris Well). The Lewis home was connected to municipal water by Monsanto after elevated levels of selenium were found in the well. The Harris property was purchased by Monsanto and the well is no longer used for drinking water supply purposes. Both wells are part of the site groundwater monitoring network.

The Monsanto plant is located outside the limits of the City of Soda Springs and employs approximately 400 people. Potable water at the site is provided from the supply well PW-04, which is located at the northern (upgradient) edge of the plant.

3.1.1 History of Groundwater Effects

Monsanto purchased agricultural land in 1952 to construct the elemental phosphorus production plant using locally mined phosphorus ore. The site was previously used for agricultural and domestic purposes. In the early 1980s, a landowner immediately south of the former plant boundary identified local groundwater effects after livestock drinking water from several nearby springs experienced problems related to excess fluoride exposure. In 1984, Golder was employed to assess the effects of past and current operations on groundwater and surface water quality. The results of this investigation indicated that groundwater beneath the plant contained elevated concentrations of several metals and anions, including cadmium, selenium, fluoride, and sulfate. The sources of these constituents were determined to be the Old Underflow Solids (UFS) Ponds, the Northwest Pond, and the Old Hydroclarifier. The investigation also concluded that groundwater under the southeastern portion of the plant contained elevated concentrations of vanadium, chloride, and sulfate (Golder, 1985).

Based on groundwater flow directions and geochemical data, the elevated concentrations beneath the southeast corner of the plant were attributed to the Kerr-McGee Chemical Corporation, located to the east across Highway 34 from the plant. In April 1988, a CERCLA site inspection was conducted by Ecology and Environment (an EPA contractor) that included additional groundwater sampling and analysis. The findings were consistent with Monsanto's earlier findings (Golder, 1985) and found elevated levels of fluoride, cadmium, selenium, and sulfate in monitoring and production wells.

3.1.2 Geology

The geology (and resultant hydrogeology) near the site is complex. Regionally, the plant is located near the southern end of the Blackfoot Lava Field that has infilled a generally north-northwest trending valley bordered by the Chesterfield Range and the Soda Hills on the west and by the Aspen Range on the east. The plant is located within the Bear River graben.

Locally, the site is underlain by a thin veneer of soils that overlie the basalt flows of the Blackfoot Lava Field. There are five basalt flows separated by interbeds or weathered basalt zones beneath the plant. The basalt flows vary in thickness from less than 10 feet to 80 feet. The sedimentary units and weathered basalt zones range in thickness from 1 to 23 feet. The basalt flows overlie the Salt Lake Formation.

Northwest-trending, en-echelon normal faults (both west- and east-side-down relative displacement) are present in the site area and commonly form narrow grabens that are typically 1,000 to 1,500 feet wide and up to 2.5 to 3 miles long (Figures 2 and 3). These faults extend from the southeast of the plant north to the Blackfoot Reservoir. A prominent fault (Monsanto fault) enters the plant near the northwest corner and appears to die out just west of the southeast corner of the plant. A subsidiary fault parallels this fault approximately 1,500 feet to the southwest. Fault displacement has interrupted lateral groundwater flow and created springs near the plant.

There are several normal faults east of the plant that appear to act as a hydraulic barrier so that groundwater west of the Finch Spring fault apparently does not flow into the Ledger Creek Springs area.

3.1.3 Hydrogeology

This section presents a summary of the hydrogeological conditions at the site. Details are presented in the Phase I RI Preliminary Site Characterization Summary report (Golder, 1992) and the Phase II

RI report (Golder, 1995). The wells and springs at and near the Monsanto plant are shown on Figures 2 and 3. Figure 4 shows the locations of various operational facilities. As described in the Phase II RI report (Golder, 1995), the two primary hydrostratigraphic zones underlying the Monsanto plant are the Upper Basalt Zone (UBZ) and the Lower Basalt Zone (LBZ). The UBZ is the principal aquifer and is found in most places beneath the plant at depths of about 100 feet below ground surface (bgs). The depth to the water table varies across the plant from about 20 feet bgs in the northeast corner of the plant to about 100 feet bgs in the center of the plant. The LBZ is less permeable than the UBZ (with a hydraulic conductivity of at least three orders of magnitude less) and underlies the UBZ to a depth of at least 250 feet bgs.

Groundwater flow in the UBZ and the LBZ is influenced by faulting, regional hydrogeological conditions, and pumping of the plant production wells (Figures 5 and 6). The groundwater flow direction beneath the plant is generally from north to south paralleling the geological structures. Both the major fault and the subsidiary fault running beneath the plant appear to act as barriers to groundwater flow in the plant area.

The ambient (control) groundwater quality beneath the plant correlates to one of the three regional systems: the Shallow Groundwater System, the Mead Thrust Aquifer System, and the Chesterfield Range Aquifer System. The Shallow Groundwater System consists of fresh water that comes into contact with surface soil and basaltic units. The Mead Thrust Aquifer System also consists of fresh water, and receives recharge from the mountains to the east of the Monsanto plant. The Chesterfield Range Aquifer System consists of sodic water and receives recharge from the Chesterfield Range to the west of the plant.

The UBZ and LBZ have been divided into smaller regions, based primarily on hydrogeological controls and groundwater quality. The breakdown of the UBZ and LBZ regions is shown on Figures 2 and 3, respectively, and is described in the subsections below.

UBZ-1 & LBZ-1

These zones are located in the immediate southwestern corner of the plant and are bounded by the subsidiary fault to the northeast. Control groundwater quality in UBZ-1 consists of sodic water and mixed sodic and fresh water. Control groundwater quality in LBZ-1 is sodic.

The springs near Soda Creek and the Harris Well are included in UBZ-1 (Figure 2). However, as shown in the cross-section in Figure 3-11 of the Phase II RI Report (Golder, 1995), the Harris Well may be completed within both the UBZ-1 and the LBZ-1 zones. Thus, some of the constituents observed in control sodic groundwater in LBZ-1 occur in this well.

UBZ-2 & LBZ-2

These zones are located in the southwestern central portion of the plant and are bounded by the major and subsidiary faults running beneath the plant. The Old UFS Ponds are located above these zones. Control groundwater quality in UBZ-2 is assumed to be fresh (Shallow Groundwater System). Control groundwater quality in LBZ-2 is sodic.

As shown in the cross-section in Figure 3-8 of the Phase II RI Report (Golder, 1995), TW-34 and TW-35 are completed in the transition zone between UBZ-2 and LBZ-2. Some sodic groundwater occurs in these wells due to the upward hydraulic gradient from LBZ-2. Thus, these wells contain groundwater with elevated constituents that occur naturally in the deeper sodic groundwater, such as manganese.

UBZ-3 & LBZ-3

These zones are included within the eastern and southeastern portions of the plant and are influenced by former Kerr-McGee operations. Control groundwater quality in UBZ-3 is fresh, and is assumed to be that of the Mead Thrust Aquifer System, with minor mixing with the Shallow Groundwater System. Water quality in these zones is also influenced by operations at the former Kerr-McGee plant. Constituents such as vanadium, ammonium, and molybdenum are in elevated concentrations in this system. These constituents are associated with the former Kerr-McGee operations.

UBZ-4 & LBZ-4

The zones primarily underlie the northern and central portions of the plant. Plant facilities located above these zones include the northwest pond and the Old Hydroclarifier. Control groundwater quality in UBZ-4 is primarily fresh (mostly Shallow Groundwater System); however, the groundwater quality in the immediate northwestern corner of the plant is sodic. Control groundwater quality in LBZ-4 is primarily sodic.

The four production wells (PW-1, PW-2, PW-3, and PW-4) are open to up to four interflow zones, including both the UBZ and the LBZ. Two monitoring wells (TW-18 and TW-44) are completed in LBZ-4.

3.1.4 Sources of Affected Groundwater

Groundwater affected by Monsanto activities is predominantly confined to the UBZ within the plant site area. Groundwater flow in the UBZ is toward the south Plant Fenceline. The wells located at the South Fenceline, at the Southern Boundary, and the 2007 monitoring wells (and within Monsanto boundaries) monitor the migration of the plumes originating within plant boundaries.

There are two constituent plumes on the site originating from Monsanto operations. Affected groundwater originates from three principal source areas within the Monsanto plant (Figure 4):

- Old UFS Ponds (UBZ-2)
- Northwest Pond (UBZ-4)
- Old Hydroclarifier (UBZ-4)

The plume from the Old UFS Ponds occurs in the UBZ-2 groundwater zone and flows within the groundwater system toward the south. The plumes from the Northwest Pond and the Old Hydroclarifier occur in the UBZ-4 zone and flow southward toward the plant production wells used for non-contact cooling water supply. Pumping from the production wells PW-01, PW-02, and PW-03 from UBZ-4 contains the plumes originating from the Northwest Pond and the Old Hydroclarifier areas to prevent off-site migration. There are other minor source areas on the site such as the former sewage lagoon, the unlined non-contact cooling water ponds, and the old coke and quartzite slurry ponds. A fourth plume originates on the former Kerr McGee's plant site, and has spread onto the southeastern portion of the Monsanto plant site.

3.1.5 Summary of Previous Investigations

In 1978, Monsanto installed five groundwater monitoring wells (TW-2, TW-3, TW-4, TW-5, and TW-6) and initiated a quarterly groundwater sampling program that continued until 1984. Two additional wells (TW-7 and TW-8) were installed downgradient of the first five wells in 1982. Some off-site spring sampling was conducted by Monsanto in 1983.

In 1984, Golder was employed to assess the impacts of past and current operations on groundwater and surface water quality (Golder, 1985). Thirty-one monitoring wells were installed to supplement seven existing monitoring wells and quarterly sampling was continued. The results of this investigation indicated that groundwater beneath the plant contained elevated concentrations of several metals and anions, including cadmium, selenium, vanadium, fluoride, sulfate, and other inorganic constituents of less concern. The sources of these elevated concentrations were hypothesized to be the Old UFS Ponds, the Northwest Pond, and the Old Hydroclarifier. A separate plume containing elevated levels of chloride, sulfate, and vanadium was found in the southeast portion of the site that later, based on groundwater flow directions and geochemical data, was attributed to the former Kerr-McGee Chemical Corporation located to the east across Highway 34 from the plant.

In April 1988, a CERCLA site inspection was conducted by Ecology and Environment (an EPA contractor) that included additional groundwater sampling and analysis. The findings were consistent with Monsanto's earlier findings (Golder, 1985) and found elevated levels of fluoride, cadmium, selenium, and sulfate in monitoring and production wells.

Monsanto collected groundwater samples from approximately 40 wells and springs regularly before 1991. From 1991 to 1998, Monsanto sampled between 50 and 60 monitoring wells, off-site wells, and springs every six months as part of the RI/FS work plan. From 1998 to date, wells and springs have been sampled annually.

As part of the Phase II RI for the Monsanto plant, Golder developed a solute transport model to predict the fate and transport of constituents in groundwater near the plant (Golder, 1993; Golder 1995). First, a groundwater flow model was developed for the Blackfoot Lava Field, which included both the Upper Basalt Zone and the Lower Basalt Zone aquifers. Second, a solute transport model was developed for the UBZ-2 zone to predict the travel time for constituents to three selected endpoints to the south of the plant (the southern plant boundary, the estimated discharge point of the plume into Soda Creek, and the estimated discharge point of the plume into Bear River). The model predicted that all constituents within the UBZ-2 plume migrating to the southern plant boundary should achieve background levels within 5 to 30 years, depending on the constituent and its rate of retardation in groundwater.

In 2003, the first five-year review was conducted for the Monsanto plant (Golder, 2003a). As part of the five-year review, the solute transport model for the UBZ-2 was reevaluated and updated based on data collected since the completion of the Phase II RI. The solute transport model was used to predict concentrations of the constituents of concern at the Plant Fenceline, Southern Boundary wells, Soda Creek, and the source area (Old UFS Ponds).

The model predicted concentrations of fluoride and nitrate below the remedial goals at the Plant Fenceline and Southern Boundary wells. Selenium concentrations were predicted to continue to decline and meet the remedial goal in about 20 years. Concentrations of manganese and cadmium at the Fenceline and Southern Boundary wells were predicted to be below the remedial goal, and were expected to remain so for the next 100 years. Based on the modeling, concentrations of cadmium and

manganese at these locations may never exceed the remedial goal because of the high retardation of these metals.

In 2006, in response to the southward migration of the plume from UBZ-2, a geophysical survey (electrical resistivity imaging) was completed to attempt to delineate the extent of the plume beyond the Southern Boundary wells and provide potential locations for new monitoring wells (Golder, 2006a). In June and July 2007, four new monitoring wells were installed south of the plant site to delineate the southern extent of the UBZ-2 plume (Golder, 2007a). These wells were added to the annual groundwater sampling locations. Groundwater quality data from the 2007 monitoring wells are reported in the 2007 annual report (Golder, 2007b)

4.0 REMEDIAL ACTIONS

4.1 Remedial Measures before Record of Decision

Before implementation of the remedial action designated in the ROD, significant environmental improvements were conducted at the plant, some made independently by Monsanto and others were done to comply with state or federal requirements, or both. Improvements related to groundwater include the following:

- August 1985: Removal of the Old Hydroclarifier, which was suspected as potentially affecting groundwater, and replacement with a new unit that includes a synthetic liner, a leachate collection system, and a monitoring well network.
- 1986: Four underground fuel storage tanks were replaced with aboveground tanks with concrete sumps. The underground tanks were removed to comply with new regulations and there was no indication that the tanks had leaked.
- 1987: Four wells (TW-3, TW-4, TW-5, and TW-6) that were discovered to be creating hydraulic connection between the upper and lower aquifers due to poor construction (and thus, possible constituent migration) were abandoned in accordance with regulatory guidelines.
- 1983 to 1988: The Old UFS Ponds, suspected as sources of groundwater contamination, were taken out of service. In 1988, the upper layer of contaminated soil was removed and the depression was backfilled with material excavated from the Northwest Pond and clean material. The ponds were then filled with molten slag and sealed with a bentonite cap to isolate the remaining underflow solids from infiltration and prevent further migration of constituents. Solids that remained in the pond are below the cap, but above the water table.
- 1988: The Northwest Pond, suspected as a source of groundwater contamination, was closed and excavated. Discolored soils were removed and deposited in the Old UFS Ponds. The base of the pond was sealed with bentonite. The area is currently permitted by the Idaho Department of Environmental Quality to receive plant sanitary solid waste and is being operated as a lined general waste landfill.
- 1985 to 1989: Several wells were installed around the Old Hydroclarifier and used as recovery wells to intercept contaminated groundwater. The groundwater was pumped into the new hydroclarifier. Three wells were pumped intermittently at a rate of approximately 12 gallons per minute (gpm) per well until 1989. In the spring of 1989, the plant stopped pumping these wells because of potential NPL listing of the plant, and pumping has not resumed.
- 1993: Plant sewage evaporation ponds were taken out of service and the plant connected to the municipal wastewater collection system. The ponds were closed in 1995.

4.2 Remedy Selection

On April 30, 1997, the EPA submitted the Record of Decision for the site that documented the selected remedy for environmental media affected by operations at the Soda Springs plant (EPA, 1997). The ROD identified the constituents of potential concern for soil, sediments, and groundwater based on exceedances of EPA risk screening criteria. The selected remedy for groundwater is monitored natural attenuation with institutional controls (such as legally enforceable prohibitions on

drinking water wells in the affected area) to prevent human exposure to groundwater until groundwater quality recovers to background conditions. Except for the annual monitoring of groundwater, relevant springs, and the plant discharge outfall, no further action was deemed necessary because there are no current drinking water users of the affected groundwater and because the combination of past remedial actions and natural attenuation is projected to restore groundwater to levels that allow for unrestricted use and exposure within 30 years.

The ROD established groundwater remedial goals for the constituents of concern: cadmium, fluoride, nitrate, selenium, and manganese. The remedial goals are the MCLs under the Safe Drinking Water Act for cadmium, fluoride, nitrate, and selenium, and a risk-based concentration for manganese, as shown below in Table 2.

TABLE 2

Groundwater Remedial Goals for the Monsanto Site

Parameter	Remediation Goal (mg/L)	Regulatory Source
Cadmium	0.005	Maximum Contaminant Level
Fluoride	4	Maximum Contaminant Level
Nitrate as NO_3/ Nitrate as N	44 / 10	Maximum Contaminant Level
Selenium	0.05	Maximum Contaminant Level
Manganese	0.18	Risk-Based Concentration

The ROD established the points of compliance for remedial goal monitoring. Well TW-19 (in UBZ) is listed in the ROD as a point of compliance; however, well TW-19 does not produce sufficient water. Well TW-20 (also in UBZ) is located in the same well pair as TW-19, and therefore replaces that well as a point of compliance. The ROD also lists TW-29 as a point of compliance. This well is located at the north end of the plant where groundwater is unaffected by plant operations. It was assumed that the listing of TW-29 in the ROD was a typographical error, and that TW-39 was the intended point of compliance. Well TW-39 is located at the south Plant Fenceline and is completed in the UBZ. Based on these modifications, the point of compliance wells are listed below.

- Production wells - Wells PW-01, PW-02, and PW-03
- South Fenceline wells - Wells TW-20, TW-34, TW-35, and TW-39
- Southern Plant Boundary wells - Wells TW-53, TW-54, TW-55, and Harris Well
- Soda Creek

The well locations are shown on Figure 2. Well TW-34 is affected by naturally occurring manganese concentrations because it is completed in the transition zone between the UBZ (fresh water) and LBZ (sodic water containing naturally elevated manganese concentrations). TW-34 is therefore not appropriate for monitoring the UBZ. The South Fenceline wells are located inside the southern Plant Fenceline near Hooper Springs Road. The Southern Plant Boundary wells are located within the

Monsanto property boundary near its southern margin (about 1,200 feet south of the Plant Fenceline). The locations of the point of compliance wells are shown on Figure 2.

Several sample locations have been established to monitor and evaluate discharges to surface water, and effects of discharges on surface water quality. These sample locations are not point of compliance locations, but are used to evaluate water quality in Soda Creek. The sample locations for surface water quality are listed below and shown on Figure 2.

- Mormon Creek – Mormon Creek at its confluence with Soda Creek (sampled since 2002)
- Pond Inlet – Effluent inlet to the non-contact cooling water pond upgradient of the effluent discharge into Soda Creek (sampling initiated in 2004)
- Soda Upstream – Soda Creek upstream of the effluent discharge pipe (sampled since 2001)
- Soda Downstream – Soda Creek downstream of the effluent discharge pipe (sampled since 2001)
- Effluent Discharge – Effluent released into Soda Creek at the effluent discharge pipe (sampled in triplicate since 2000)
- Soda Creek downstream of the effluent discharge, immediately upstream of the weir diverting flow to the irrigation canal (sampling initiated in 2005)

4.3 Operation and Maintenance

Long-term operations and maintenance for groundwater at the site consist of annual long-term groundwater sampling. This sampling has been ongoing at the site since the ROD was signed and is continuing with annual reports sent to the EPA. This activity is adequately funded and a budget for the future is in place by Monsanto.

5.0 FIVE-YEAR REVIEW PROCESS

5.1 Document Review

This five-year review included a review of the following relevant documents:

- *Phase I Remedial Investigation/Feasibility Study, Preliminary Site Characterization Summary Report for the Soda Springs Elemental Phosphorus Plant* (Golder ,1992);
- *Phase II Remedial Investigation Report for the Soda Springs Elemental Phosphorus Plant* (Golder, 1995);
- *Record of Decision, Monsanto Chemical Company Superfund Site, Caribou County, Idaho* (EPA, 1997);
- *First Five-Year Review for Groundwater Conditions at the Monsanto Soda Springs Plant* (Golder, 2003a);
- 1998 through 2007 Annual Groundwater Sampling Summary Reports (Golder, 1998; Golder, 1999; Golder, 2000; Golder, 2001; Golder, 2002; Golder, 2003b; Golder, 2004; Golder 2005; Golder, 2006b; Golder, 2007b);
- *Monsanto Soda Springs Plant Site – Geophysical Survey South of Plant to Locate New Wells*, (Golder, 2006a)
- *Well Completion Report, Monitoring Wells TW-59, TW-60, TW-61, and TW-62, Monsanto Soda Springs Plant*; (Golder, 2007a).

5.2 Data Review

As stated in the ROD, the following elements are required for this data review portion of the five-year review:

- Review and assess groundwater and outfall monitoring data (collected and evaluated at least annually)
- Compare groundwater and outfall quality and extent of constituent plumes to regulatory levels, remedial goals, and groundwater modeling projections. Determine if and when remedial goals have been achieved, and if the goals have not been achieved, that institutional controls are still in place and effectively preventing human exposure.

The first element of data review for the five-year review (Evaluation of Groundwater and Outfall Monitoring Data) is presented in Section 5.3. The second element of the five-year review is presented in two sections: Evaluation of Extent of Constituent Plumes (Section 5.4) and Evaluation of Groundwater Modeling Projections (Section 5.5).

5.3 Evaluation of Groundwater and Outfall Monitoring Data

5.3.1 Status of Attaining Remedial Goals

Based on the June and July 2007 sampling results, most points of compliance are below remedial goals for the constituents of concern. The 2007 concentrations are compared to remedial goals in Table 3. For fluoride, all compliance points are below remedial goals. Cadmium exceeds the remedial goal at three point of compliance wells (PW-01, TW-20, and TW-39), manganese exceeds the remedial goal at one point of compliance well (TW-34), nitrate exceeds the remedial goal at one point of compliance well (TW-20), and selenium exceeds the remedial goal at five compliance points (TW-20, TW-39, TW-53, TW-54, and Harris Well). However, all exceedances of the remedial goals are located at points within Monsanto boundaries and constituents have not migrated off site, thus the institutional controls are still effective. The point of compliance locations are shown on Figure 2.

5.3.2 Constituent Concentration Trend Analysis

To quantitatively assess if the constituents of concern are declining as projected in the RI, statistical analyses were performed on the groundwater quality data from 1991 (start of RI process) through the most recent sampling round conducted in June and July 2007. The analyses were performed for the following two time periods:

- The complete data set, from 1991 through 2007, to evaluate the overall constituent trends since the start of the RI process
- From 2000 through 2007, to evaluate recent constituent trends

For many compliance points, water quality data are available for earlier than 1991. Earlier data are not used because they are not as temporally consistent and samples were not collected according to the strict quality assurance/quality control guidelines that were adhered to for samples collected since 1991.

As with the annual summary reports on groundwater conditions at the Soda Springs plant, constituents included in the statistical analyses include the constituents of concern listed in the ROD (cadmium, fluoride, nitrate as N, selenium, and manganese), as well as several other indicator constituents (chloride, molybdenum, and sulfate). Analyses were conducted at the points of compliance identified in the ROD, in addition to analyses for several different areas not specified in the ROD. These additional points are mainly in areas of the original contamination sources. The points of compliance and additional points include the following, shown on Figure 2:

Points of Compliance

- Production wells – PW-01, PW-02, and PW-03 (as well as PW-04, though not defined as a point of compliance)
- South Fenceline wells – TW-20, TW-34, TW-35, and TW-39
- Southern Plant Boundary wells – TW-53, TW-54, TW-55, and Harris Well
- Soda Creek

Additional Points:

- Northwest Pond area wells – TW-16, TW-17, and TW-18
- Old Underflow Solid Ponds area wells – TW-22, TW-24, TW-37, and TW-45
- Hydroclarifier area wells – TW-40 and TW-44
- Springs and well south of plant – Homestead, Calf Spring, Mormon A Spring, and Lewis Well
- Effluent Discharge and Mormon Creek

5.3.2.1 Methods of Trend Analysis

The statistical methods employed for this analysis are summarized in Sections 5.3.2.1.1 through 5.3.2.1.3 below. Theoretical details of each method and the Excel template application are provided in Attachment A.

5.3.2.1.1 Mann-Kendall Test

To assess whether constituent concentrations were increasing or decreasing after source removal, the Mann-Kendall nonparametric estimator of trends (Mann, 1945; Kendall, 1975; Gilbert, 1987) was used. This procedure is useful for evaluating environmental data because missing values are allowed, a small data set ($n \geq 5$) is sufficient, the data do not need to conform to a particular distribution, the test is not affected by gross outliers or data errors, and data reported as less than the detection limit are allowed (Gilbert, 1987). The Mann-Kendall test is a nonparametric test of sequential signs (positive or negative) that indicates monotonic increases or decreases in successive data that persist over several sampling intervals. Depending on the size of the data set, the output of the Mann-Kendall test is the S statistic ($5 < n < 10$) or the Z statistic ($n \geq 10$, unless there are many tied data values). Positive and negative S or Z statistics indicate increasing (positive) or decreasing (negative) concentration trends. In order for a trend to be positively identified, the degree of confidence (significance level) that a trend exists should be very high. Golder suggests a significance level of $\alpha \leq 0.05$. In other words, there is only a 5 percent or less probability that a statistically significant trend does not exist. Details of the equations used for calculating the S and Z statistics are included in Attachment A and Gilbert (1987).

With the Mann-Kendall test, the null hypothesis, H_0, of no trend in the data (i.e., the observed concentrations are randomly ordered in time) is tested against the alternative hypothesis, H_A, of an increasing or decreasing monotonic trend. If S or Z is positive with a significance level (α) less than 0.05, the H_0 is rejected in favor of H_A for an increasing concentration trend; likewise, if S or Z is negative with a significance level (α) less than 0.05, the H_0 is rejected in favor of H_A for a decreasing concentration trend. In other words, if α was calculated as greater than 0.05, no significant trend was defined. If α was calculated as equal to or less than 0.05, a significant increasing or decreasing trend was defined, depending on the sign of the Z/S statistic.

5.3.2.1.2 Sen's Method

If a linear trend is present in the time series of concentration data, the true slope of data (change in concentration per unit time) can be estimated using the nonparametric Sen's Method for Estimation of Slope (Sen, 1968; Gilbert, 1987). Unlike calculation of true slope by computing the least-squares estimate of the slope by linear regression models, Sen's method is not greatly affected by gross data

errors or outliers, and the calculation allows missing data values. Sen's method is closely related to the Mann-Kendall method and, similar to the S and Z-statistics, positive and negative slopes indicate increasing and decreasing concentration trends, respectively. The magnitude of the slope indicates the rate at which the constituent concentrations are changing; the sign of the slope indicates if it is increasing (+) or decreasing (-). Details of the equations used to compute Sen's estimate of slope are in Gilbert (1987).

5.3.2.1.3 MAKESENS Excel Template

An Excel template MAKESENS (Mann-Kendall test for trend and Sen's slope estimates) was used for detecting and estimating constituent concentration trends in data from the Monsanto site by computing the Mann-Kendall and Sen's methods (Salmi et al., 2002). MAKESENS analyzes for the presence of increasing or decreasing trends by first testing with the Mann-Kendall test and secondly the slope of a linear trend is estimated with Sen's method. When $n<10$, MAKESENS automatically computes the S statistic, but Sen's method is not computed because the normal approximation is not valid. When $n \geq 10$, MAKESENS automatically computes the Z statistic followed by the linear slope with Sen's method.

5.3.3 Results of Statistical Analyses – 1991 to 2007

This section describes the results of the statistical analyses conducted on the water quality data collected since the start of the RI process in 1991. This analysis provides an update of the analyses completed for the first five year review, which provided an evaluation of the data collected from 1991 to 2002 (Golder 2003a). Graphical portrayal of the input and output files to MAKESENS for each constituent and sampling point are provided in Attachment B. Summary tables of the statistical results for the evaluation of the 1991 to 2007 data for each constituent are provided in Tables 4a through 4h. Tables 4a through 4h also provide the results of the statistical analyses completed from 1991 to 2002 (Golder 2003a) for comparison. Table 5 provides a summary of constituent concentration trends. Often during the earlier years of the statistical analysis (1992, 1993, and 1994), water quality samples were collected biannually in late spring and late fall. Because the statistical methods employed required a single annual average, if two results were available for the year, the average of the values was calculated and used for the annual value. In most sampling years, however, all samples were collected in late spring.

A number of wells exhibit increasing then decreasing concentrations, suggesting the passage of a slug of the constituent past the well. The statistical methods employed for these analyses assume linear, monotonic distributions (significant trend) or random distributions (no trend). If a dual trend is present, no trend will be detected or it will be skewed to the stronger of the two and not give a representative analysis.

Production Wells

In the production wells, cadmium, chloride, fluoride, manganese, nitrate, selenium, and sulfate concentrations were decreasing or stable. Molybdenum was stable in PW-01, PW-03, and PW-04, but increased in PW-02. Details of the statistical analyses results are presented below, including comparisons with the results of the statistical analyses completed during the first five-year review on the data collected between 1991 and 2002.

Cadmium

In production wells PW-01, PW-02, and PW-03, cadmium exhibited a significant decreasing concentration trend since 1991 ($Z = -3.17$, -3.59, and -3.69, respectively, with $\alpha = 0.01$, 0.001, and 0.001, respectively). The slopes of the respective decreasing concentrations were -0.0004, -0.001, and -0.0003 mg/L per year calculated from Sen's Q. Cadmium in PW-04 has been, for the most part, not detected; thus, no significant increasing or decreasing trend was computed.

Cadmium concentrations in the production wells were either stable or decreasing between 1991 and 2002.

Fluoride

In all four production wells (PW-01, PW-02, PW-03, and PW-04), fluoride concentrations showed no significant concentration trend between 1991 and 2007 ($\alpha \geq 0.1$ for all wells).

Fluoride concentrations were stable in PW-01, but were increasing in PW-02, PW-03, and PW-04 between 1991 and 2002.

Manganese

In all four production wells (PW-01, PW-02, PW-03, and PW-04), manganese concentrations were mostly not detected and thus, showed no significant concentration trend ($\alpha > 0.1$ for all wells) since 1991. Similarly, no concentration trend was observed for manganese between 1991 and 2002.

Nitrate as N

Nitrate as N concentrations in production wells PW-01, PW-02, PW-03, and PW-04) showed no significant concentration trend since 1991 ($\alpha \geq 0.1$ for all wells). No concentration trend was observed for nitrate as N between 1991 and 2002.

Selenium

In all four production wells (PW-01, PW-02, PW-03, and PW-04), there was no significant selenium concentration trend since 1991 ($\alpha > 0.1$ for all wells). No concentration trend was observed for selenium between 1991 and 2002.

Chloride

No significant concentration trends were exhibited by PW-01, PW-02, PW-03, or PW-04 ($\alpha \geq 0.1$ for all wells), with all wells showing statistically stable concentrations since 1991. Chloride concentrations were either decreasing or stable between 1991 and 2002.

Molybdenum

Since 1991, molybdenum concentrations in production wells PW-01 and PW-03 exhibited no significant concentration trends ($\alpha \geq 0.1$). PW-02 showed a significant increasing trend ($Z = 2.70$, $\alpha = 0.01$, and a slope of 0.001 mg/L per year). PW-04 showed a significant increasing concentration trend ($Z – 2.04$, $\alpha = 0.05$, with a slope of 0.0003 mg/yr) but molybdenum concentrations were non-detect between 1991 and 2003 and the trend is the result of varying detection limits for molybdenum.

Between 1991 and 2002, molybdenum concentrations in the production wells were stable (no concentration trend).

Sulfate

Since 1991, sulfate concentrations in all four production wells (PW-01, PW-02, PW-03, and PW-04) showed no significant concentration trend ($\alpha > 0.1$) and appeared to be statistically stable. This is similar to the analyses completed for the first five-year review.

South Fenceline Wells

In the South Fenceline wells, cadmium, fluoride, manganese, nitrate, selenium, molybdenum, and chloride, were stable or decreasing in all wells between 1991 and 2007. Sulfate was increasing in TW-35, but stable or decreasing in the other wells.

Cadmium

TW-20 did not exhibit a significant concentration trend since 1991. Cadmium in TW-34 and TW-35 were mostly not detected and, thus, showed no significant trend ($\alpha > 0.1$). TW-39 showed a significant decreasing trend since 1991 ($Z = -2.06$, $\alpha = 0.05$, and a slope of -0.0004 mg/L per year). Analysis of cadmium data between 1991 and 2002 indicated concentrations were either decreasing (TW-20) or stable (TW-34, TW-35, and TW-39).

Fluoride

Fluoride concentrations in TW-20 and TW-39 exhibited significant decreasing concentration trends since 1991 ($Z = -2.84$ and -3.84, respectively, with $\alpha = 0.01$ and 0.001, respectively) with a decreasing concentration slope of approximately -0.303 mg/L per year for TW-20 and approximately -0.205 mg/L per year for TW-39. TW-34 and TW-35 showed no significant concentration trends ($\alpha > 0.1$).

Fluoride concentrations were either stable or decreasing in the South Fenceline wells between 1991 and 2002, with the exception of TW-35, where a significant increasing trend was observed.

Manganese

All wells in the South Fenceline area (TW-20, TW-34, TW-35, and TW-39) showed no significant concentration trend ($\alpha > 0.1$ for all wells) since 1991. This is similar to the results of the analyses conducted during the first five-year review.

Nitrate as N

TW-20, TW-34, TW-35, and TW-39 showed no significant concentration trend since 1991 ($\alpha > 0.1$). In TW-20 and TW-39, the lack of a significant trend appeared to be caused by a slug of nitrate moving through the wells from 1994 to 2001, followed by a second slug starting to pass through the wells starting in 2002. Between 2000 and 2007, nitrate as N concentrations exhibited a significant increasing concentration trend in TW-20. Trends between 2000 and 2007 are discussed in Section 5.3.2.1.6. Analyses of nitrate data from 1991 to 2002 indicated either stable or decreasing concentrations in all South Fenceline wells.

Selenium

Selenium in TW-39 had a significant decreasing trend since 1991 ($Z = -2.23$, $\alpha = 0.05$, with a slope of -0.017 mg/L per year). All remaining wells in the South Fenceline area (TW-20, TW-34, and TW-35) showed no significant selenium concentration trend ($\alpha \geq 0.1$ for all wells) since 1991. In TW-20, the statistical analyses were recalculated without the anomalously high value from 2002; but the trend was insignificant ($\alpha > 0.1$).

Between 1991 and 2002, selenium concentrations were either stable or decreasing in the South Fenceline wells.

Chloride

Chloride concentrations in TW-39 exhibited a significant decreasing concentration trend since 1991 ($Z = -4.29$, with $\alpha = 0.001$), with a slope of -6.6 mg/L per year. Chloride concentrations in TW-20, TW-34, and TW-35 showed no significant concentration trend between 1991 and 2007 ($\alpha > 0.1$).

Between 1991 and 2002, chloride concentrations were either stable or decreasing in the South Fenceline wells.

Molybdenum

In the South Fenceline wells, TW-39 exhibited a significant decreasing concentration trend since 1991 ($Z = -3.11$ with $\alpha = 0.01$) with a slope of -0.003 mg/L per year. TW-20, TW-34, and TW-35 showed no significant concentration trend ($\alpha \geq 0.1$) between 1991 and 2007; molybdenum in TW-34 and TW-35 has remained not detected since 1991. In TW-20, an increasing concentration trend was observed between 2001 and 2007 (see Section 5.3.2.1.6).

Between 1991 and 2002, molybdenum concentrations were stable in the South Fenceline wells.

Sulfate

TW-35 showed a significant increasing trend since 1991 ($Z = 2.07$, $\alpha = 0.05$, with a slope of 0.981 mg/L per year). TW-20, TW-34, and TW-35 showed no significant concentration trends since 1991 ($\alpha > 0.1$). Sulfate appeared to increase from 2001 to 2007 in TW-20, but the statistical analyses over this time period indicated no statistically significant trend ($\alpha = 0.1$).

Between 1991 and 2002, sulfate concentrations were stable in the South Fenceline wells.

Southern Boundary Wells

In the Southern Boundary wells (TW-53, TW-54, TW-55, and TW-56, all in the UBZ), cadmium, fluoride, manganese, nitrate, selenium, and chloride were stable or decreasing in all four wells. Molybdenum increased in TW-53, but decreased in TW-54 and was stable in TW-55 and TW-56. Sulfate increased in TW-53, but was stable or decreasing in the other wells

Cadmium

Cadmium was not detected in TW-53, TW-55, and TW-56 for all years since 1991 and no trend was computed. In TW-54, although there were some detected concentrations, no trend was computed. The results of the analyses conducted on data collected between 1991 and 2002 were similar.

Fluoride

Fluoride concentration trends at Southern Boundary wells TW-53, TW-55, and TW-56 showed no significant trend since 1991 ($\alpha > 0.1$). TW-54 exhibited a decreasing concentration trend since 1991 ($Z = -3.02$ with $\alpha = 0.01$) with a decreasing slope of -0.253 mg/L per year.

The data collected between 1991 and 2002 indicated a decreasing concentration trend in TW-54, but an increasing trend in TW-53, TW-55, and TW-56.

Manganese

Manganese concentrations in the Southern Boundary area wells (TW-53, TW-54, and TW-55) showed no significant concentration trend ($\alpha > 0.1$ for all wells) since 1991. TW-56 exhibited a decreasing concentration trend since 1991 ($Z = -2.08$ with $\alpha = 0.05$) with a decreasing slope of -0.001 mg/L per year.

The results of the analyses conducted on data collected between 1991 and 2002 indicated no concentration trend.

Nitrate as N

Southern Boundary Area wells TW-53, TW-54, TW-55, and TW-56 showed no significant concentration trend since 1991 ($\alpha > 0.1$ for all wells). The results of the analyses conducted on data collected between 1991 and 2002 indicated either stable or decreasing concentration trends.

Selenium

Selenium concentrations in the Southern Boundary wells showed no significant trends since 1991 ($\alpha \geq 0.1$ for all wells).

The results of the analyses conducted on data collected between 1991 and 2002 indicated either stable or decreasing concentration trends.

Chloride

Chloride concentrations in Southern Boundary wells TW-53, TW-54, and TW-55 showed no significant trends since 1991 ($\alpha \geq 0.1$). A significant decreasing trend was observed in TW-56 ($Z = -3.65$, $\alpha = 0.001$, and a slope of -2.4 mg/L per year).

The results of the analyses conducted on data collected between 1991 and 2002 indicated either stable or decreasing concentration trends.

Molybdenum

Well TW-53 exhibited a significant increasing concentration trend since 1992 ($Z = 2.21$ with $\alpha = 0.05$) with a concentration slope of 0.0021 mg/L per year. TW-54, however, exhibited a significant decreasing concentration trend ($Z = -3.38$ with $\alpha = 0.001$) with a slope of -0.0048 mg/L per year. TW-55 showed no significant concentration trend since 1991 because molybdenum was not detected in most samples. TW-56 also showed no significant concentration trend, but all concentrations were detected ($\alpha > 0.1$) and have remained statistically stable since 1991.

The results of the analyses conducted on data collected between 1991 and 2002 indicated either stable or decreasing concentration trends.

Sulfate

Sulfate concentrations in Southern Boundary wells TW-54, and TW-55 showed no significant concentration trends since 1991 ($\alpha > 0.1$). TW-53 showed a statistically significant increasing trend ($Z = 2.21$, $\alpha = 0.05$, with a slope of 10.88 mg/L per year). TW-56, however, exhibited a significant decreasing concentration trend ($Z = -3.49$ with $\alpha = 0.001$) with a slope of approximately -3.89 mg/L per year.

The results of the analyses conducted on data collected between 1991 and 2002 indicated stable or decreasing concentration trends.

Harris Well and Mormon A Spring

In the Harris Well and Mormon A Spring, cadmium, fluoride, manganese, chloride and molybdenum were stable. Nitrate and selenium were increasing in Mormon A Spring and were stable in the Harris Well. Sulfate was increasing in both Mormon A Spring and the Harris Well.

Cadmium

Cadmium in the Harris Well and Mormon A Spring showed no concentration trend since 1991. Mormon A Spring showed stable cadmium concentrations, while cadmium in the Harris Well was mostly non-detect since 1991. This is similar to the results of the analyses of the data collected between 1991 and 2002.

Fluoride

Fluoride concentrations in Mormon A Spring and the Harris Well exhibited no significant trend since 1991 ($\alpha > 0.1$ for both locations). The data collected between 1991 and 2002 indicated stable concentrations in Mormon A Spring, but increasing concentrations in the Harris Well.

Manganese

Manganese concentrations in Mormon A Spring and the Harris Well showed no significant concentration trend ($\alpha > 0.1$ for both locations) since 1991. This is similar to the results of the analyses of the data collected between 1991 and 2002.

Nitrate as N

Nitrate as N concentrations in the Harris Well showed no significant concentration trend ($\alpha = 0.1$) since 1991. Mormon A Spring showed a significant increasing nitrate concentration ($Z = 3.17$ and $\alpha = 0.01$), with a slope of 0.28 mg/L per year.

The results of the analyses conducted on data collected between 1991 and 2002 indicated stable or decreasing concentration trends.

Selenium

Since 1991, selenium concentrations in Mormon A Spring have exhibited a significant increasing concentration trend ($Z = 2.72$ with $\alpha = 0.01$) with a slope of 0.008 mg/L per year. The Harris Well, however, showed no significant concentration trend since 1991 ($\alpha > 0.1$). However, concentration distributions since 1991 suggest passage of a slug of selenium in the Harris Well, with concentrations increasing from 1991 to 1994, and then decreasing from 1994 to 2000. Between 2000 and 2006, selenium concentrations increased again, suggesting passage of a second slug of selenium.

The data collected between 1991 and 2002 indicated that selenium concentrations were increasing in Mormon A Spring and stable in the Harris Well.

Chloride

Chloride concentrations in Mormon A Spring and the Harris Well have not exhibited a significant concentration trend since 1991 ($\alpha = 0.1$).

The data collected between 1991 and 2002 indicated that chloride concentrations were decreasing or stable.

Molybdenum

Molybdenum concentrations in Mormon A Spring and the Harris Well have not exhibited a significant concentration trend since 1991 ($\alpha > 0.1$).

The data collected between 1991 and 2002 indicated that molybdenum concentrations were increasing in Mormon A Spring and stable in the Harris Well.

Sulfate

Sulfate concentrations in Mormon A Spring have exhibited a significant increasing concentration trend since 1991 ($Z = 2.64$ with $\alpha = 0.01$) with a slope of approximately 15.7 mg/L per year. The Harris Well also exhibited a significant increasing concentration trend ($Z = 2.89$ with $\alpha = 0.01$) with a slope of approximately 15.3 mg/L per year.

The data collected between 1991 and 2002 indicated that sulfate concentrations were increasing in Mormon A Spring and were stable in the Harris Well.

Northwest Pond Wells

In the wells near the Northwest Pond (TW-16 and TW-17 in the UBZ, and TW-18 in the LBZ), cadmium, fluoride, nitrate, selenium, chloride, molybdenum, and sulfate were stable or decreasing in all wells. Manganese was decreasing in TW-16, but increasing in TW-17 and TW-18.

Cadmium

Cadmium concentrations in TW-16 showed a statistically significant decreasing concentration trend ($Z = -3.64$ and $\alpha = 0.001$) since 1991, with a slope of -0.01 mg/L per year. TW-17 and TW-18 showed no significant concentration trend and, thus, have remained stable since 1991. TW-18 has remained stable at non-detected concentrations through this period.

The data collected between 1991 and 2002 indicated that cadmium concentrations were decreasing or stable in the wells near the Northwest Pond.

Fluoride

Fluoride concentrations in TW-16 and 17 exhibited significant decreasing trends ($Z = -3.88$ and –2.52, respectively, with $\alpha = 0.001$ and 0.05) with a slope of -0.12 and -0.05 mg/L per year since 1991. TW-18 showed no significant concentration trend ($\alpha > 0.1$) since 1991.

The data collected between 1991 and 2002 indicated that fluoride concentrations were decreasing in TW-16 and TW-17, but increasing in TW-18.

Manganese

Manganese concentrations in TW-16 exhibited a significant decreasing trend ($Z = -2.36$ with $\alpha = 0.05$) since 1991, with a slope of approximately -0.002 mg/L per year. Manganese concentrations in TW-16 have been below the detection limit since 1998. TW-17, however, showed a significant increasing concentration trend since 1991 ($Z = 4.87$ with $\alpha = 0.001$) with a slope of 0.08 mg/L per year. Manganese concentrations in TW-18 also have a significant increasing concentration trend ($Z = 2.57$ with $\alpha = 0.05$) and a slope of 0.004 mg/L per year.

The data collected between 1991 and 2002 indicated that manganese concentrations were decreasing in TW-16 and TW-18, but increasing in TW-17.

Nitrate as N

In two of the wells near the Northwest Pond (TW-16 and TW-17), no significant concentration trends were exhibited since 1991 ($\alpha > 0.1$ for both wells), with TW-17 containing mostly non-detected concentrations of nitrate as N. TW-18 showed a significant decreasing concentration trend for nitrate, with $Z = -2.78$ and $a = 0.01$, and a slope of -0.002 mg/L per year. TW-18 contained mostly non-detected concentrations of nitrate as N.

The data collected between 1991 and 2002 indicate that nitrate as N concentrations were stable in the wells near the Northwest Pond.

Selenium

All three wells near the Northwest Pond (TW-16, TW-17, and TW-18) exhibited no significant concentration trends ($\alpha > 0.1$ for all wells) since 1991. The data collected between 1991 and 2002 indicated that selenium concentrations were stable in the wells near the Northwest Pond.

Chloride

Since 1991, TW-16 and TW-18 have not exhibited a significant concentration trend ($\alpha > 0.1$ for both wells). TW-17, however, exhibited a significant decreasing concentration trend ($Z = -4.20$ with $\alpha = 0.001$) with a slope of -6.36 mg/L per year.

The data collected between 1991 and 2002 indicated that chloride concentrations were decreasing or stable in the Northwest Pond wells.

Molybdenum

Since 1992, TW-16 showed no significant concentration trend ($\alpha > 0.1$). TW-17 showed a significant decreasing concentration trend ($Z = -3.11$ with $\alpha = 0.01$), and a slope of -0.001 mg/L per year. TW-18 had a significant increasing concentration trend. However, molybdenum concentrations were mainly not detected between 1992 and 2003. After 2003, molybdenum was detected at or near the detection limit. Thus, the apparent significant concentration trend is likely an artifact of the varying detection limits.

The data collected between 1991 and 2002 indicated that molybdenum concentrations were decreasing or stable in the wells near the Northwest Pond.

Sulfate

Sulfate concentrations in TW-16 and TW-18 showed no significant concentration trend ($\alpha > 0.1$) and appeared to be statistically stable since 1991. TW-17, however, exhibited a significant decreasing concentration trend ($Z = -4.48$ with $\alpha = 0.001$) with a slope of approximately -6.3 mg/L per year.

The data collected between 1991 and 2002 indicated that sulfate concentrations were decreasing or stable in the Northwest Pond wells.

Old Underflow Solids Ponds Area Wells

In the Old Underflow Solids Ponds area wells (TW-37 in the UBZ and TW-45 in the LBZ located at the source area), cadmium, fluoride, manganese, selenium, chloride, and molybdenum were stable or decreasing in all wells. Nitrate and sulfate were decreasing in TW-45 but increasing in TW-37.

Cadmium

Cadmium concentrations in TW-22, TW-24, and TW-37 showed no significant concentration trend, thus they have remained stable since 1991. TW-45 exhibited a significant decreasing concentration trend ($Z = -3.67$ with $\alpha = 0.001$) since 1991, with a slope of -0.001 mg/L per year.

The data collected between 1991 and 2002 indicated that cadmium concentrations were decreasing or stable in the wells near the Old UFS Ponds.

Fluoride

Wells TW-24 and TW-45 showed no significant concentration trends ($\alpha \geq 0.05$) and, thus, have been statistically stable since 1991. TW-22 and TW-37 exhibited significant decreasing concentration trends ($Z = -2.52$ and -3.84, respectively, with $\alpha = 0.05$ and 0.001, respectively) with a slope of approximately -0.17 mg/L per year (TW-22) and -0.38 mg/L per year (TW-37).

The data collected between 1991 and 2002 indicated that fluoride concentrations were decreasing or stable in the wells near the Old UFS Ponds.

Manganese

Wells TW-22 and TW-24 in the Old UFS Ponds area showed no significant concentration trends since 1991 ($\alpha \geq 0.1$). TW-37 and TW-45, however, exhibited significant decreasing concentration trends ($Z = -2.60$ and -4.16, respectively, with $\alpha = 0.01$ and 0.001, respectively) with a slope of -0.03 mg/L per year (TW-37) and -0.01 mg/L per year (TW-45) since 1991.

The data collected between 1991 and 2002 indicated that manganese concentrations were decreasing or stable in the wells near the Old UFS Ponds.

Nitrate as N

Nitrate as N concentrations in TW-22 and TW-24 did not exhibit any significant concentration trends since 1991 ($\alpha > 0.1$ for both wells). TW-45 showed a significant decreasing concentration trend ($Z = -3.76$ with $\alpha = 0.001$) with a slope of approximately -0.005 mg/L per year. TW-37 showed a significant increasing nitrate concentration trend ($Z = 3.01$ and $\alpha = 0.01$), with a slope of 0.26 mg/L per year.

The data collected between 1991 and 2002 indicated that nitrate as N concentrations were decreasing or stable in the wells near the Old UFS Ponds.

Selenium

Selenium concentration trends in all wells at the Old UFS Ponds (TW-22, TW-24, TW-37 and TW-45) did not exhibit any significant trends ($\alpha > 0.1$ for all wells) since 1991.

The data collected between 1991 and 2002 indicated that selenium concentrations were stable in the wells near the Old UFS Ponds.

Chloride

Since 1991, TW-45 exhibited a significant decreasing concentration trend ($Z = -4.45$, with $\alpha = 0.001$) with a slope of approximately -2.1 mg/L per year. TW-22, TW-24, and TW-37 did not exhibit any significant concentration trends ($\alpha \geq 0.1$ for all wells).

The data collected between 1991 and 2002 indicated that chloride concentrations were decreasing or stable in the wells near the Old UFS Ponds.

Molybdenum

TW-22 and TW-37 both exhibited significant decreasing concentration trends since 1991 (Z = -3.15 and –3.92. respectively, with α = 0.01 and 0.001, respectively) with slopes of approximately -0.02 mg/L per year for both wells. TW-24 and TW-45 did not exhibit any significant concentration trends ($\alpha \geq 0.1$ for both wells).

The data collected between 1991 and 2002 indicated that molybdenum concentrations were stable in the wells near the Old UFS Ponds.

Sulfate

Since 1991, TW-22 and TW-24 did not show a significant concentration trend ($\alpha \geq 0.1$). TW-45 showed a significant decreasing trend (Z = -2.53 with α = 0.05), and a slope of -3.6 mg/L per year. TW-37 showed a significant increasing trend for sulfate (Z = 2.02 with α = 0.05) and a slope of 9.33 mg/L per year.

The data collected between 1991 and 2002 indicated that sulfate concentrations were stable in the wells near the Old UFS Ponds.

Old Hydroclarifier Wells

In the wells near the Old Hydroclarifier wells (TW-40 in the UBZ and TW-44 in the LBZ), cadmium, fluoride, manganese, nitrate, selenium, chloride and molybdenum were stable in both wells. Sulfate was stable in TW-40, but increasing in TW-44.

Cadmium

No significant concentration trends were computed for either TW-40 or TW-44 since 1991 ($\alpha > 0.1$). Similarly, the data collected between 1991 and 2002 indicated no significant concentration trends.

Fluoride

No significant concentration trends were computed for either TW-40 or TW-44 since 1991 ($\alpha \geq 0.01$) The data collected between 1991 and 2002 indicated no significant concentration trends in TW-40, but a significant increasing trend in TW-44.

Manganese

Manganese concentrations in TW-40 showed a significant decreasing trend (Z = -3.86 with α = 0.001) with a slope of approximately -0.02 mg/L per year since 1991. TW-44 did not exhibit a significant decreasing trend ($\alpha > 0.1$).

Similarly, the data collected between 1991 and 2002 indicated similar concentration trends.

Nitrate as N

TW-40 showed no significant trends in nitrate as N concentrations since 1991 (α >0.1). There was a significant decreasing trend for nitrate in TW-44 (Z = -2.17 and α = 0.05), with a slope of -0.004

mg/L per year. Since 1997, nitrate concentrations in TW-44 were mostly below the detection limit. The data collected between 1991 and 2002 indicated stable concentration trends.

Selenium

TW-40 and TW-44 exhibited no significant concentration trend for selenium ($\alpha \geq 0.1$) since 1991. The data collected between 1991 and 2002 indicated increasing concentration trends in TW-40, and stable concentrations in TW-44.

Chloride

Chloride concentrations in TW-40 did not exhibit a significant concentration trend ($\alpha > 0.1$) since 1991. However, chloride concentrations in TW-44 exhibited a significant increasing concentration trend ($Z = 2.31$ with $\alpha = 0.01$) with a slope of 0.47 mg/L per year. The data collected between 1991 and 2002 indicated increasing concentration trends in TW-44, and stable concentrations in TW-40.

Molybdenum

Molybdenum concentrations in TW-40 and TW-44 did not exhibit a significant concentration trend ($\alpha > 0.1$) since 1991. The data collected between 1991 and 2002 indicated no significant concentration trends in TW-40 or TW-44.

Sulfate

TW-40 showed no significant concentration trend for sulfate ($\alpha > 0.1$) since 1991. TW-44 showed a significant increasing trend for sulfate ($Z = 2.23$ and $\alpha = 0.05$) with a slope of 1.9 mg/L per year. The data collected between 1991 and 2002 indicated no significant concentration trends in TW-40 or TW-44.

Springs and Well South of Plant

In the springs and wells south of the plant (Calf Spring, Homestead Spring, and the Lewis Well), cadmium, fluoride, manganese, selenium, and molybdenum were stable in both springs and the Lewis Well. Nitrate and chloride were stable in Calf Spring and the Lewis Well, but increasing in Homestead Spring. Sulfate was increasing in both springs, but stable in the Lewis Well.

Cadmium

Calf Spring, Homestead Spring, and the Lewis Well showed stable, non-detected concentrations of cadmium. No significant trend ($\alpha > 0.1$) was computed for either spring or the well since 1991. Cadmium was stable (no significant trend) between 1991 and 2002 in both springs.

Fluoride

Since 1991, the Lewis Well, Calf Spring, and Homestead Spring showed no significant concentration trend for fluoride ($\alpha > 0.1$). Calf Spring had stable (no significant trend) fluoride concentrations between 1991 and 2002, while fluoride concentrations were increasing in Homestead Spring.

Manganese

Manganese concentrations in both Calf Spring and Homestead Spring and the Lewis Well showed no significant concentration trends since 1991 ($\alpha > 0.1$). Manganese was stable (no significant trend) between 1991 and 2002 in both springs.

Nitrate as N

Since 1991, nitrate as N concentrations showed no significant concentration trends in Calf Spring or the Lewis Well ($\alpha = 0.1$). In Homestead Spring, there was a significant increasing trend ($Z = 3.34$ and $\alpha = 0.001$) with a slope of 0.28 mg/L per year. Calf Spring had stable (no significant trend) nitrate concentrations between 1991 and 2002, while nitrate concentrations were increasing in Homestead Spring.

Selenium

Selenium concentrations in Calf Spring and Homestead Spring showed no significant concentration trend ($\alpha > 0.1$) since 1991. In the Lewis Well, there was a significant decrease in selenium concentration ($Z = -2.19$ with $\alpha = 0.05$) and a slope of -0.0019 mg/L/yr. Calf Spring had stable (no significant trend) selenium concentrations between 1991 and 2002, while selenium concentrations were increasing in Homestead Spring.

Chloride

Chloride concentrations in Calf Spring showed no significant concentration trend ($\alpha > 0.1$) since 1991. However, chloride in Homestead Spring exhibited a significant increasing concentration trend ($Z = 3.30$ with $\alpha = 0.001$) with a slope of approximately 0.67 mg/L per year since 1991. In the Lewis Well, there was a significant decrease in chloride concentration ($Z = -2.14$ and $\alpha = 0.05$), and a slope of 2.49 mg/L/yr.

Calf Spring had stable (no significant trend) chloride concentrations between 1991 and 2002, while chloride concentrations were increasing in Homestead Spring.

Molybdenum

Molybdenum concentrations in the Lewis Well, Calf Spring, and Homestead Spring showed no significant concentration trend ($\alpha > 0.1$) since 1991, with all data points in Homestead Spring being non-detected. Molybdenum was stable (no significant trend) between 1991 and 2002 in both springs.

Sulfate

Both Calf Spring and Homestead Spring exhibited significant increasing concentration trends since 1991 ($Z = 3.23$ and 2.72, respectively, and $\alpha = 0.01$ for both) with slopes of 22.1 and 2.1 mg/L per year, respectively. An increasing trend was also observed between 1991 and 2002 in both springs. In the Lewis Well, sulfate showed no significant concentration trend ($\alpha > 0.1$).

Soda Creek and Mormon Creek

Data collection at these stations started in 2000. The results of the statistical analyses completed on the data collected between 2000 and 207 at these stations are described in Section 5.3.4.

5.3.3.1 Summary of Statistical Analyses 1991 to 2007

Wells and surface water sampling locations listed in Table 5 showed stable (no significant trend) or decreasing concentration trends since 1991/1992 with the following exceptions:

Cadmium

- None of the Table 5 locations

Fluoride

- None of the Table 5 locations

Manganese

- Northwest Pond wells: TW-17, TW-18

Nitrate as N

- Mormon A Spring
- Old UFS Ponds well: TW-37
- Springs south of plant: Homestead Spring

Selenium

- Mormon A Spring

Chloride

- Old Hydroclarifier well: TW-44
- Spring south of plant: Homestead Spring

Molybdenum

- Production wells: PW-02, PW-04
- Southern Boundary well: TW-53
- Northwest Pond well: TW-18

Sulfate

- South Fenceline well: TW-35
- Southern Boundary well: TW-53
- Mormon A Spring and Harris Well

- Old UFS Ponds well: TW-37
- Old Hydroclarifier well: TW-44
- Springs south of plant: Calf Spring, Homestead Spring

5.3.4 Results of Statistical Analyses – 2000 to 2007

Graphical portrayal of the input and output files to MAKESENS for each constituent and sampling point are provided in Attachment C. Summary tables of the statistical results are provided in Tables 6a through 6h. Table 7 provides a summary of constituent trends. Between 2000 and 2007, annual samples were collected in late spring. The Mann-Kendall Z statistic could not be calculated for the analyses completed from 2000 to 2007 because the number of samples (n) at each sampling location was less than 10. For $5<n<10$, the Man Kendall test calculates the S statistic. Slopes could not be calculated for any of the well locations because the number of samples for each sampling location was less than 10.

Production Wells

In the production wells, cadmium, fluoride, manganese, nitrate, selenium, chloride, and sulfate concentrations were decreasing or stable. Molybdenum was increasing in PW-01, PW-02, and PW-03, but was stable in PW-04. Details of the statistical analyses results are presented below.

Cadmium

In production wells PW-01, PW-02, PW-03, and PW-04, cadmium exhibited no significant concentration trend since 2000 ($\alpha > 0.1$). Cadmium in PW-04 was, for the most part, not detected, thus no significant increasing or decreasing trend was computed.

Fluoride

Fluoride showed a significant decreasing concentration trend ($S = -18$ with $\alpha = 0.05$) in PW-03. In the remaining production wells (PW-01, PW-02, and PW-04), fluoride concentrations showed no significant concentration trend ($\alpha \geq 0.1$ for all wells).

Manganese

In all four production wells (PW-01, PW-02, PW-03, and PW-04), manganese concentrations were mostly not detected and, thus, showed no significant concentration trend ($\alpha > 0.1$ for all wells).

Nitrate as N

Nitrate as N concentrations in production wells PW-01, PW-02, and PW-03, and PW-04) showed no significant concentration trend ($\alpha \geq 0.1$ for all wells).

Selenium

In all four production wells (PW-01, PW-02, PW-03, and PW-04), there was no significant concentration trend for selenium ($\alpha > 0.1$ for all wells).

Chloride

No significant concentration trends were exhibited by PW-01, PW-02, PW-03, or PW-04 ($\alpha \geq 0.1$ for all wells).

Molybdenum

Since 2000, molybdenum concentrations in production wells PW-01, PW-02, and PW-03 exhibited a significant increasing concentration trend (S = 20 and α = 0. 05 for all wells). PW-04 showed no significant concentration trend ($\alpha > 0.1$).

Sulfate

Since 2000, sulfate concentrations in all four production wells (PW-01, PW-02, PW-03, and PW-04) showed no significant concentration trend ($\alpha > 0.1$) and appeared to be statistically stable.

South Fenceline Wells

In the South Fenceline wells, manganese and selenium were stable or decreasing in all wells between 2000 and 2007. Cadmium, fluoride, nitrate, molybdenum, and sulfate were increasing in TW-20, but stable or decreasing in the other wells. Chloride was increasing in TW-35, but stable or decreasing in the other wells.

Cadmium

Cadmium concentrations increased in TW-20 between 2000 and 2005, and then decreased in 2006 and 2007. TW-20 exhibited a significant increasing concentration trend for cadmium (S = 18 and α = 0.05) between 2000 and 2007. TW-34 and TW-35 were mostly not detected and, thus, showed no significant trend ($\alpha > 0.1$ for all wells). Cadmium was stable in TW-39, with no significant concentration trend ($\alpha > 0.1$).

Fluoride

Fluoride concentrations increased in TW-20 between 2000 and 2006, and then decreased in 2007. Fluoride concentrations in TW-20 exhibited a significant increasing concentration trend (S = 22 with α = 0.01) between 2000 and 2007. TW-34, TW-35, and TW-39 showed no significant concentration trends ($\alpha > 0.1$).

Manganese

All wells in the South Fenceline area (TW-20, TW-34, TW-35, and TW-39) showed no significant concentration trend for manganese ($\alpha > 0.1$ for all wells).

Nitrate as N

Nitrate as N concentrations increased in TW-20 between 2001 and 2006, and then decreased in 2007. Between 2000 and 2007, nitrate as N concentrations exhibited a significant increasing concentration trend in TW-20 (S = 22 with α = 0.01). Nitrate as N concentrations appeared to be decreasing in

TW-34, confirmed with a significant decreasing trend (S = -18 with $\alpha = 0.05$). No significant trend was observed in TW-35 or TW-39 between 2002 and 2007.

Selenium

Selenium in TW-35 had a significant decreasing trend (S = 18 and $\alpha = 0.05$). In TW-20 and TW-35, there was an apparent increase in the selenium concentration between 2001 and 2005, however, all remaining wells in the South Fenceline area (TW-20, TW-34, and TW-39) showed no significant selenium concentration trend ($\alpha \geq 0.1$ for all wells) between 2000 and 2007. Selenium in TW-35 was mostly not detected over this period.

Chloride

Chloride concentrations in TW-35 exhibited significant increasing concentration trends (S = 18 with $\alpha = 0.05$). In TW-20, there was an apparent increase in the chloride concentration between 2000 and 2005, but the analysis indicated there was no significant chloride concentration trend ($\alpha > 0.1$) in TW-20. Chloride concentrations in TW-34 and TW-39 also showed no significant concentration trend ($\alpha > 0.1$).

Molybdenum

In the South Fenceline wells, the apparent increase in molybdenum concentrations in TW-20 was confirmed by the statistical analysis indicating a significant increasing concentration trend (S = 22 with $\alpha = 0.01$). TW-34, TW-35, and TW-39 showed no significant concentration trend ($\alpha \geq 0.1$) between 2000 and 2007; molybdenum in TW-34 and TW-35 has remained not detected since 1991.

Sulfate

Sulfate concentrations in TW-20 increased between 2000 and 2006. The increase in sulfate concentrations was significant (S = 20 with $\alpha = 0.05$). TW-34, TW-35, and TW-39 did not show significant sulfate concentration trends since 2000 ($\alpha > 0.1$).

Southern Boundary Wells

In the Southern Boundary wells (TW-53, TW-54, TW-55, and TW-56, all in the UBZ), cadmium, fluoride, manganese, and molybdenum were stable or decreasing in all four wells. Nitrate was increasing in TW-54, but was stable or decreasing in the other wells. Selenium, chloride, and sulfate were increasing in TW-55, but were stable or decreasing in the other wells.

Cadmium

Cadmium was not detected in TW-53, TW-55, and TW-56 between 2000 and 2007 and no trend was computed. In TW-54, though there were some detected concentrations, no trend was computed ($\alpha > 0.1$).

Fluoride

Fluoride concentration trends at all of the Southern Boundary wells (TW-53, TW-54, TW-55, and TW-56) showed no significant trend ($\alpha > 0.1$).

Manganese

Manganese concentrations in the Southern Boundary area wells (TW-53, TW-54, TW-55, and TW-56) showed no significant concentration trend ($\alpha > 0.1$ for all wells).

Nitrate as N

Nitrate concentrations increased in TW-54 between 2002 and 2006. The increase in nitrate concentrations in TW-54 was statistically significant (S = 20 with $\alpha > 0.05$). Southern Boundary area wells TW-53, TW-55, and TW-56 showed no significant concentration trend since 1991 ($\alpha > 0.1$ for all wells).

Selenium

In TW-55, selenium concentrations increased between 2000 and 2004. The increase in selenium concentrations was statistically significant (S = 20 with $\alpha = 0.05$). Selenium concentrations in the other Southern Boundary wells (TW-53, TW-54, and TW-56) showed no significant trends ($\alpha \geq 0.1$ for all wells). Selenium in TW-56 was mostly not detected over this period.

Chloride

In TW-55, chloride concentrations were increasing between 2000 and 2007 (S = 20 with $\alpha = 0.05$). Chloride concentrations in Southern Boundary wells TW-53 and TW-54 appeared to be increasing; however, the concentrations did not show significant trends ($\alpha \geq 0.1$). Similarly, chloride concentrations in TW-56 appeared to be decreasing but the decrease did not show a significant trend ($\alpha \geq 0.1$).

Molybdenum

There was no significant concentration trend in any of the Southern Boundary wells ($\alpha > 0.1$). Molybdenum in TW-55 was mostly not detected over this period.

Sulfate

Sulfate concentrations in Southern Boundary wells TW-53 and TW-54 appeared to be increasing but showed no significant concentration trends ($\alpha > 0.1$). TW-55 showed a statistically significant increasing trend (S = 21 with $\alpha = 0.01$). TW-56, however, exhibited a significant decreasing concentration trend (S = -24 with $\alpha = 0.01$).

Harris Well and Mormon A Spring

In the Harris Well and Mormon A Spring, cadmium, fluoride, manganese, selenium, and molybdenum were stable. Fluoride, nitrate, and sulfate were stable in Mormon A Spring, but increasing in the Harris Well.

Cadmium

Cadmium in the Harris Well and Mormon A Spring showed no concentration trend ($\alpha > 0.1$) for either location). Mormon A Spring showed stable cadmium concentrations, while cadmium in Harris Well was mostly not detected.

Fluoride

Fluoride concentrations in Mormon A Spring and the Harris Well exhibited no significant trend (α > 0.1 for either location).

Manganese

Manganese concentrations in Mormon A Spring and the Harris Well showed no significant concentration trend (α > 0.1 for both locations). Manganese concentrations were mostly not detected in both locations over this time.

Nitrate as N

Nitrate as N concentrations in Mormon A Spring showed no significant concentration trend (α = 0.1). In the Harris Well, nitrate concentrations appeared to be increasing between 2000 and 2007. The statistical analyses completed over this time indicated a significant increasing slope (S = 24, and α = 0.01).

Selenium

Selenium concentrations in Mormon A Spring and the Harris Well appeared to be increasing between 2000 and 2007 but the statistical analysis showed no significant concentration trend (α > 0.1).

Chloride

Chloride concentrations in Mormon A Spring did not exhibit a significant concentration trend (α = 0.1). In the Harris Well, chloride concentrations appeared to be increasing between 2000 and 2007. The statistical analyses completed over this time indicated a significant increasing slope (S = 24, and α = 0.01).

Molybdenum

Molybdenum concentrations in Mormon A Spring and the Harris Well did not exhibit a significant concentration trend (α > 0.1).

Sulfate

Sulfate concentrations in Mormon A Spring appeared to be increasing but did not exhibit a significant concentration trend (α > 0.1). Sulfate concentrations in the Harris Well also appeared to be increasing, confirmed by a significant increasing concentration trend (S = 22 with α = 0.01)

Northwest Pond Wells

In the wells near the Northwest Pond wells (TW-16 and TW-17 in the UBZ, and TW-18 in the LBZ), cadmium, fluoride, nitrate, selenium, chloride, and sulfate were stable or decreasing in all wells. Manganese was decreasing in TW-16 and stable in TW-18, but increasing in TW-17. Molybdenum was increasing in TW-18 but stable in TW-16 and TW-17.

Cadmium

TW-16, TW-17, and TW-18 showed no significant concentration trend ($\alpha > 0.1$) and, thus, have remained stable between 2000 and 2007. TW-18 has remained stable at non-detected concentrations through this period.

Fluoride

Fluoride concentrations in TW-16, TW-17, and TW-18 showed no significant trend ($\alpha > 0.1$) and, thus, have remained stable between 2000 and 2007.

Manganese

Manganese concentrations in TW-17 exhibited a significant increasing trend ($S = 22$ with $\alpha = 0.01$). Manganese concentrations in TW-18 showed no significant trend ($\alpha > 0.1$) between 2000 and 2007. Manganese concentrations in TW-16 have been stable and below the detection limit through this period.

Nitrate as N

The wells near the Northwest Pond (TW-16, TW-17, and TW-18), exhibited no significant concentration trends ($\alpha > 0.1$ for all wells), with TW-17 and TW-18 containing mostly non-detected concentrations of nitrate as N between 2000 and 2007.

Selenium

Two of the wells near the Northwest Pond (TW-16 and TW-17) did not exhibit significant concentration trends ($\alpha > 0.1$ for both wells). TW-18 exhibited a significant decreasing trend ($S = -18$ with $\alpha = 0.05$). Selenium concentrations in TW-17 and TW-18 were at or near the detection limit between 2000 and 2007.

Chloride

None of the wells near the Northwest Pond (TW-16, TW-17 and TW-18) exhibited a significant concentration trend between 2000 and 2007 ($\alpha > 0.1$ for all wells).

Molybdenum

TW-16 and TW-17 showed no significant concentration trend ($\alpha > 0.1$). TW-18 showed a significant increasing concentration trend ($S = 19$ with $\alpha = 0.05$). However, molybdenum concentrations were mainly not detected between 2000 and 2003. After 2003, molybdenum was detected at or near the detection limit. Thus, the apparent significant concentration trend is likely an artifact of the varying detection limits.

Sulfate

Sulfate concentrations in TW-16 and TW-18 showed no significant concentration trend ($\alpha > 0.1$) and appeared to be statistically stable. TW-17, however, exhibited a significant decreasing concentration trend ($S = -23$ with $\alpha = 0.01$).

Old Underflow Solids Ponds Area Wells

In the wells in the Old UFS Ponds area (TW-37 in the UBZ and TW-45 in the LBZ), cadmium, fluoride, manganese, nitrate, selenium, chloride, and molybdenum were stable or decreasing in all wells. Sulfate was increasing in TW-37, and stable or decreasing in the other wells (TW-22, TW-24, and TW-45).

Cadmium

Cadmium concentrations in TW-22, TW-24, and TW-37 showed no significant concentration trend, thus they have remained stable. In 2000, concentrations of cadmium in TW-37 appeared to increase. Statistical analysis of the data collected between 2000 and 2007 did not indicate a significant concentration trend ($\alpha = 0.1$). TW-45 exhibited a significant decreasing cadmium concentration trend (S = -20 with $\alpha = 0.05$.

Fluoride

All wells in the Old UFS Ponds area showed no significant concentration trends between 2000 and 2007 ($\alpha \geq 0.1$).

Manganese

The wells near the Old UFS Ponds area showed no significant concentration trends between 2000 and 2007 ($\alpha \geq 0.1$).

Nitrate as N

The wells near the Old UFS Ponds area showed no significant concentration trends between 2000 and 2007 ($\alpha \geq 0.1$), including TW-37, where nitrate concentrations appeared to be increasing. Nitrate concentrations in TW-45 were generally below the detection limit between 2000 and 2007.

Selenium

The wells near the in the Old UFS Ponds area showed no significant concentration trends between 2000 and 2007 ($\alpha \geq 0.1$). Selenium concentrations in TW-45 were generally below the detection limit between 2000 and 2007.

Chloride

The wells near the in the Old UFS Ponds area showed no significant concentration trends between 2000 and 2007 ($\alpha \geq 0.1$). TW-37 chloride concentrations increased between 2002 and 2006, but the increase was not statistically significant.

Molybdenum

TW-22 and TW-37 both exhibited significant decreasing concentration trends (S = -23 and –20, respectively, with $\alpha = 0.01$ and 0.05, respectively). TW-24 and TW-45 did not exhibit any significant concentration trends ($\alpha \geq 0.1$ for both wells).

Sulfate

TW-22, TW-24, and TW-45 did not show a significant concentration trend ($\alpha \geq 0.1$). Sulfate concentrations in TW-37 increased between 2002 and 2007. The increasing sulfate concentration trend in TW-37 was statistically significant (S = 20 with $\alpha = 0.05$).

Old Hydroclarifier Wells

In the wells near the Old Hydroclarifier (TW-40 in the UBZ and TW-44 in the LBZ), cadmium, fluoride, manganese, selenium, chloride, molybdenum, and sulfate were stable or decreasing in both wells. Nitrate was increasing in TW-40 and stable in TW-44.

Cadmium

No significant concentration trends were computed for either TW-40 or TW-44 between 2000 and 2007 ($\alpha > 0.1$). Cadmium concentrations were at or below the detection limit in TW-44 over this time.

Fluoride

No significant concentration trends were computed for either TW-40 or TW-44 between 2000 and 2007 ($\alpha \geq 0.01$).

Manganese

No significant concentration trends were computed for either TW-40 or TW-44 between 2000 and 2007 ($\alpha \geq 0.01$).

Nitrate as N

A significant increasing trend was computed for nitrate as N in TW-40 (S = 15 and $\alpha \geq 0.05$) between 2000 and 2007. No significant concentration trend was computed for TW-44 ($\alpha \geq 0.01$). Nitrate as N concentrations was at or below the detection limit in TW-44 over this time.

Selenium

TW-40 and TW-44 exhibited no significant concentration trend for selenium ($\alpha \geq 0.1$).

Chloride

Chloride concentrations in TW-40 did not exhibit a significant concentration trend ($\alpha > 0.1$). However, chloride concentrations in TW-44 exhibited a significant decreasing concentration trend (S = -18 with $\alpha = 0.05$) between 2000 and 2007.

Molybdenum

Molybdenum concentrations in TW-40 and TW-44 did not exhibit a significant concentration trend ($\alpha > 0.1$) between 2000 and 2007.

Sulfate

Sulfate concentrations in TW-40 and TW-44 did not exhibit a significant concentration trend (α > 0.1).

Springs and Well South of Plant

In the springs and well south of the plant (Calf Spring, Homestead Spring, and Lewis Well), cadmium, fluoride, manganese, nitrate, selenium, chloride, sulfate and molybdenum were stable or decreasing in both springs and the Lewis Well.

Cadmium

The Lewis Well, Calf Spring, and Homestead Spring showed stable, non-detected concentrations of cadmium. No significant trend (α >0.1) was computed for the springs or well between 2000 and 2007. Cadmium concentration in the Lewis Well and Homestead Spring were generally below the detection limit.

Fluoride

The Lewis Well, Calf Spring, and Homestead Spring showed no significant concentration trend for fluoride (α >0.1) between 2000 and 2007.

Manganese

Manganese concentrations in the Lewis Well and in both Calf Spring and Homestead Spring showed no significant concentration trends since 1991 (α > 0.1) between 2000 and 2007. Manganese concentration in the Lewis Well and Homestead Spring were generally below the detection limit.

Nitrate as N

Nitrate concentrations in the Lewis Well, Homestead Spring, and Calf Spring showed no significant concentration trends (α > 0.1) between 2000 and 2007.

Selenium

Selenium concentrations in Calf Spring and the Lewis Well showed no significant concentration trend (α > 0.1) between 2000 and 2007. Selenium concentrations in Homestead Spring showed a significant decrease (S= -19 with α = 0.05)

Chloride

Chloride concentrations in Calf Spring, Homestead Spring, and the Lewis Well showed no significant concentration trends between 2000 and 2007 (α > 0.1).

Molybdenum

Molybdenum concentrations in both Calf Spring and Homestead Spring showed no significant concentration trend (α > 0.1) between 2000 and 2007, with all data points in Homestead Spring being non-detected. The Lewis Well showed a statistically significant decrease in selenium concentration (S = -20 and α = 0.05).

Sulfate

Sulfate concentrations in Calf Spring, Homestead Spring, and the Lewis Well showed no significant concentration trends ($\alpha > 0.1$) between 2000 and 2007.

Soda Creek and Mormon Creek

The effluent discharge to Soda Creek has been sampled since 2000. Three samples were collected from the effluent discharge. Sampling was initiated at two locations in Soda Creek in 2001. One station is located upstream of the effluent discharge, and the second is located downstream of the effluent discharge and downstream of Mormon Creek. Sampling was initiated in 2002 at the mouth of Mormon Creek, immediately upstream of the confluence with Soda Creek. The sample collected at Mormon Creek represented a composite sample of spring discharge from Mormon A, B, and C springs and Calf Spring. The sample locations are shown on Figure 2.

A sampling station was also established on Soda Creek immediately upstream of the irrigation diversion weir in 2005. There are insufficient data from this station to complete a statistical analysis at this time.

Concentrations of all constituents (cadmium, fluoride, manganese, nitrate, selenium, chloride, molybdenum, and sulfate) were stable or decreasing in the effluent discharge, Soda Creek upstream and downstream of the effluent discharge pipe, and in Mormon Creek.

Cadmium

The effluent discharge, both sampling locations in Soda Creek and Mormon Creek, showed stable non-detected concentrations of cadmium. No significant trend ($\alpha > 0.1$) was computed for the effluent discharge, Soda Creek, or Mormon Creek.

Fluoride

The effluent discharge, Soda Creek, and Mormon Creek showed no significant concentration trend for fluoride ($\alpha > 0.1$).

Manganese

Manganese concentrations in the effluent discharge, Soda Creek, and Mormon Creek showed no significant concentration trends ($\alpha > 0.1$). Manganese concentrations in the effluent discharge were below the detection limit between 2000 and 2007.

Nitrate as N

Nitrate as N concentrations showed no significant concentration trends in the effluent discharge, Soda Creek, or Mormon Creek ($\alpha = 0.1$).

Selenium

Selenium concentrations in the effluent discharge, Soda Creek, and Mormon Creek showed no significant concentration trend ($\alpha > 0.1$). Selenium concentrations at the Soda Creek upstream station were generally below the detection limit between 2000 and 2007.

Chloride

Chloride concentrations in the effluent discharge and Soda Creek showed no significant concentration trend ($\alpha > 0.1$). However, chloride in Mormon Creek exhibited a significant decreasing concentration trend ($S = -11$ with $\alpha = 0.05$). The slope could not be calculated because $n < 10$.

Molybdenum

Molybdenum concentrations in the effluent discharge, Soda Creek, and Mormon Creek showed no significant concentration trend ($\alpha > 0.1$). Molybdenum concentrations at the Soda Creek upstream station were generally below the detection limit between 2000 and 2007.

Sulfate

The effluent discharge, Soda Creek, and Mormon Creek showed no significant concentration trend ($\alpha > 0.1$) for sulfate.

5.3.4.1 Summary of Statistical Analyses 2000 to 2007

Wells and surface water sampling locations listed on Table 7 showed stable (no significant trend) or decreasing concentration between 2000 and 2007 (Table 7) with the following exceptions:

Cadmium

- South Fenceline well: TW-20

Fluoride

- South Fenceline well: TW-20

Manganese

- Northwest Pond well: TW-17

Nitrate as N

- South Fenceline well: TW-20
- Southern Boundary well: TW-54
- Harris Well
- Old Hydroclarifier well: TW-40

Selenium

- Southern Boundary well: TW-55

Chloride

- South Fenceline well: TW-35

- Southern Boundary well: TW-55
- Harris Well

Molybdenum

- Production wells: PW-01, PW-02, PW-03
- South Fenceline well: TW-20
- Northwest Pond well: TW-18

Sulfate

- South Fenceline well: TW-20
- Southern Boundary well: TW-55
- Harris Well
- Old UFS Ponds well: TW-37

5.4 Evaluation of Extent of Constituent Plumes

Isopleth maps for the constituents of concern and additional constituents were created from the June /July 2007 data to evaluate changes, if any, in the extent of the constituent plumes. The 2007 plumes were compared to 2002 plume maps presented in the first five-year review (Golder, 2003a). The plumes based on the 2002 data are shown on Figures 7a through 14a. The plumes based on the 2007 water quality data are presented on Figures 7b through 14b. For constituents with remedial goals based on the MCL or a risk-based concentration (cadmium, fluoride, manganese, nitrate, and selenium), the remedial goal is shown on each figure. Several other constituents (chloride, sulfate, and molybdenum) do not have remedial goals but have been plotted to illustrate the extent of affected groundwater.

The location of the Lewis Well was confirmed in 2007 and surveyed using a Global Positioning System (GPS) unit. The location of the Lewis Well was about 600 feet west of where it was originally shown on previous maps prepared before this report. Because of the confirmation of the location of the well, there was an adjustment in the plume extents at the Lewis Well in 2007 compared to the plumes determined in 2002.

5.4.1 Cadmium in Upper Basalt Zone

The remedial goal for cadmium is the MCL of 0.005 mg/L. Visual comparison of the cadmium plume in UBZ-4 from 2002 to 2007 shows that the plume appears to be decreasing in concentration and to have decreased slightly in areal extent (Figures 7a and 7b). Results of statistical analyses support visual observations. TW-40 in the Old Hydroclarifier area shows a possibly decreasing, but statistically insignificant, concentration trend. TW-16 and TW-17 near the Northwest Pond area shows a decreasing trend.

The production wells exhibit decreasing concentration trends, with present concentrations less than the remedial goals (RGs) in PW-02 and PW-03. Concentrations are above the remedial goal but decreasing in PW-01.

The cadmium plume in UBZ-2 extended beyond the Plant Fenceline to the Southern Boundary wells based on a detection in TW-54 in 2002 (Figure 7a). In 2007, the cadmium plume extended to the Fenceline wells, but cadmium was not detected in the Southern Boundary wells or in the new monitoring wells TW-61 or TW-62 south of the Southern Boundary wells (Figure 7b).

Concentrations of cadmium in the Old UFS Ponds source area well (TW-37) appear to be relatively stable. This is supported by statistical analyses that show wells near the Old UFS Ponds having stable or insignificant concentration trends. Similarly, in the South Fenceline area, cadmium concentrations appear to be stable with the exception of TW-20. This is supported by the statistical analyses that show an increasing concentration trend in TW-20 between 2000 and 2007, but stable concentrations in the other wells (TW-34, TW-35, and TW-39).

5.4.2 Fluoride in Upper Basalt Zone

The remedial goal for fluoride is the MCL of 4 mg/L. The 2002 fluoride plume in UBZ-4 appears to be relatively similar to the 2007 plume (Figures 8a and 8b, respectively). Concentrations in the old source area at the Old Hydroclarifier appear to be stable, supported by statistical analysis at TW-40. Similarly, concentrations at the Northwest Pond are stable or decreasing, supported by statistical analyses at TW-16 and TW-17.

Concentrations downgradient of the source areas appear to be stable due to capture by the plant production wells. This observation is supported by statistical analyses at the production wells (stable trends at PW-01, PW-02, and PW-03). These observations suggest that natural attenuation and containment by pumping are performing as expected in UBZ-4.

In UBZ-2, the areal extent of the fluoride plume in 2007 is relatively similar to the 2002 plume. The southern extent of the UBZ-2 fluoride plume has been delineated by monitoring wells TW-61 and TW-62. The fluoride plume does not extend to these wells (Figure 8b).

Concentrations in the source area at the Old UFS Ponds are decreasing, consistent with natural attenuation and supported by statistical analysis at TW-37 showing a decreasing concentration trend since 1991.

Downgradient concentrations suggest migration of the plume with groundwater flow. Fluoride concentrations are generally stable or show insignificant concentration trends at the South Fenceline wells. Trends at the Southern Boundary wells and Harris Well are stable or the concentrations have decreased since 1991, consistent with natural attenuation. Based on these observations, natural attenuation of fluoride in UBZ-2 appears to be performing as expected.

5.4.3 Manganese in Upper Basalt Zone

The remedial goal for manganese is a risk-based concentration of 0.18 mg/L. The 2002 UBZ-4 manganese plume in the Old Hydroclarifier area is similar to the 2007 plume in areal extent and concentration profile (Figures 9a and 9b). Concentrations in the wells in the Old Hydroclarifier area have decreased to non-detected levels. Statistical analysis at TW-40 shows a decreasing concentration trend. However, the source at the Northwest Pond area appears to continue to provide manganese to groundwater, as concentrations in this part of the plume appear to be increasing

(supported by statistical analysis at TW-17 showing an increasing concentration trend). Concentrations of manganese in the plant production wells have been at or near non-detected levels since 1991 and do not show a significant concentration trend.

The manganese plume in UBZ-2 appears to be stable, with little change in areal extent or concentration from 2002 to 2007. Manganese concentrations in the source area wells (Old UFS Ponds area) showed decreasing trends between 2000 and 2007 (well TW-37).

The downgradient wells showed stable concentration trends (based on statistical analyses at TW-22 and TW-24, as well as at the South Fenceline and Southern Boundary wells). These observations are consistent with the expectations of retardation of manganese in the UBZ. Manganese was not detected at the Southern Boundary wells or monitoring wells TW-59 or TW-62.

Elevated manganese concentrations in monitoring wells TW-60 and TW-61 are the result of the effects of sodic groundwater in these wells (Golder 2007b). Sodic groundwater typically has higher manganese concentrations than fresh groundwater, and has been observed in other UBZ wells in the southeast corner of the plant such as TW-34 and TW-35 (Golder, 1995).

5.4.4 Nitrate as N in Upper Basalt Zone

The remedial goal for nitrate is the MCL of 10 mg/L (as N). The nitrate plume in the UBZ-4 zone associated with the Northwest Pond and Old Hydroclarifier has increased slightly in areal extent and in concentration between 2002 and 2007 (Figures 10a and 10b; respectively). Nitrate concentrations have increased between 2000 and 2007 in TW-40 in the Old Hydroclarifier source area. Nitrate concentrations were stable in the Northwest Pond area wells (TW-16 and 17).

The nitrate plume in UBZ-4 continues to be contained by the plant production wells. Nitrate concentrations in the plant production wells (PW-1, PW-2, and PW-3) showed stable concentrations between 2000 and 2007.

The nitrate plume on the east side of the plant in the UBZ-3 and UBZ-4 zones has decreased in areal extent and concentration as the plume from the former Kerr-McGee plant passes through the area.

The nitrate plume in the UBZ-2 has increased in areal extent and decreased in concentration, consistent with a conservative constituent migrating through the UBZ-2 zone. This is supported by statistical analyses showing stable or decreasing nitrate concentrations in well TW-37 near the Old UFS Ponds.

Nitrate concentrations in the Fenceline wells are also stable (except TW-20 between 2000 and 2007). Similarly, nitrate concentrations in the Southern Boundary wells are stable (except TW-54 between 2000 and 2007). Nitrate concentrations are increasing at the Harris Well (2000 to 2007) and Mormon A Spring (1991 to 2007).

Nitrate concentrations onsite and south of the Southern Boundary wells may be affected by off-site agricultural practices. The southern extent of the UBZ-2 nitrate plume has been delineated by monitoring well TW-62. The nitrate plume does not appear to extend to TW-62 (Figure 10b).

5.4.5 Selenium in Upper Basalt Zone

The remedial goal for selenium is the MCL 0.05 mg/L. In UBZ-4, the 2007 selenium plume was similar in areal extent to the 2002 plume downgradient of the Old Hydroclarifier (Figures 11a and

11b). Selenium concentrations at the Old Hydroclarifier area wells appear to be stable, supported by statistical analysis at TW-40 showing no concentration trend. Similarly, the statistical analyses showed no significant concentration trend for the Northwest Pond area wells (TW-16 and TW-17).

The selenium plume from the Old Hydroclarifier and Northwest Pond is contained by the plant production wells. Selenium concentrations in the plant production wells appear to be stable, supported by statistical analysis at PW-1, PW-2, and PW-3 showing no concentration trend.

In UBZ-2, the selenium plume is increasing in areal extent towards Mormon Creek as the selenium plume migrates. Selenium concentrations in the Old UFS Ponds source area are stable, supported by statistical analysis at TW-37 showing a stable or statistically insignificant concentration trend.

Downgradient selenium concentrations are stable or decreasing (supported by statistical analyses at the South Fenceline and Southern Boundary wells), with the exception of Mormon A Spring, which exhibited increasing concentration trends between 1991 and 2007, and TW-55 (2000 to 2007), suggesting migration of the plume into these areas. Evaluation of the selenium data collected at Mormon A Spring between 2000 and 2007 suggests stable or statistically insignificant concentration trends.

The southern extent of the selenium plume has been delineated by monitoring wells TW-62 and TW-59, where concentrations were less than the remedial goal. Selenium was detected at very low concentrations (less than 0.003 mg/L) in monitoring wells TW-60 and 61 (Figure 11b). These observations are consistent with natural attenuation.

5.4.6 Chloride in Upper Basalt Zone

There is no remedial goal for chloride at the Monsanto site. The extent of the chloride plumes in UBZ-4 increased between 2002 and 2007 (Figures 12a and 12b), with concentrations staying stable or decreasing in the Old Hydroclarifier and Northwest Pond area wells. The chloride plume is captured by the plant production wells.

The extent of the chloride plume in the UBZ-2 appears to be increasing in the source area. However statistical analyses of chloride data at well TW-37 near the Old UFS Ponds indicates statistically stable concentrations for data collected between 2000 and 2007 (and between 1991 and 2007).

The chloride plume extent at the Fenceline wells (TW-20 and TW-39) appears to be stable, with the chloride concentrations generally stable or decreasing in these wells, consistent with natural attenuation.

The data collected between 2000 and 2007 indicated chloride concentrations are increasing at the Southern Boundary wells (TW-55), Harris Well, and Homestead Spring, consistent with passage of the chloride plume in this area and natural attenuation.

Chloride concentrations in monitoring wells TW-59 and TW-62 suggest the chloride plume has migrated south of the Southern Boundary wells.

5.4.7 Molybdenum in Upper Basalt Zone

There is no remedial goal for molybdenum at the Monsanto site. The areal extent of the molybdenum plume in UBZ-4 was relatively stable between 2002 and 2007 (Figures 13a and 13b), consistent with capture of the molybdenum plume by the plant production wells. In well TW-40 at the Old

Hydroclarifier area, molybdenum concentrations appear to be stable, supported by statistical analyses. In the Northwest Pond area wells, molybdenum concentrations are either stable or decreasing (TW-16 and TW-17).

Molybdenum concentrations in the UBZ-4 plume are increasing in the plant production wells (PW-1, PW-2, and PW-3), but are decreasing downgradient of the production wells (TW-38).

The molybdenum plume inside the plant boundary adjacent to the former Kerr-McGee plant in UBZ-4 (TW-33) and in UBZ-3 downgradient of TW-12 and TW-56 is decreasing in concentration. This is consistent with the migration of the molybdenum plume from the former Kerr-McGee operations onto the Monsanto site, and is supported by statistical analyses in TW-12 and TW-56, which indicate decreasing molybdenum concentrations.

The areal extent of the molybdenum plume in UBZ-2 was relatively stable between 2002 and 2007 (Figures 13a and 13b). Molybdenum concentrations in well TW-37 at the Old UFS Ponds area are decreasing.

Molybdenum concentrations in the Fenceline well (TW-20 from 2000 to 2007) and Southern Boundary well (TW-53 from 1991 to 2007) are increasing based on statistical analyses. Molybdenum concentrations are stable in other areas of UBZ-2 such as Mormon A Spring and the Harris Well.

The molybdenum plume does not extend to the new monitoring wells (TW-62 and TW-59; Figure 13b), located south of the Southern Boundary wells. Molybdenum concentrations in these wells are similar to the background well (TW-57) in the UBZ-2.

5.4.8 Sulfate in Upper Basalt Zone

There is no remedial goal for sulfate at the Monsanto site. Visual comparison of the sulfate plumes in 2002 and 2007 suggests that the areal extent of the plume in UBZ-4 has remained relatively stable (Figures 14a and 14b). Statistical analyses of concentrations in wells the Old Hydroclarifier area (TW-40) and Northwest Pond area-(TW-16 and TW-17) support this observation, with stable or decreasing trends. These observations are consistent with natural attenuation in UBZ-4 and capture by the plant production wells in UBZ-4. Sulfate concentrations in the plant production wells are stable.

The plume on the east side of the plant originating from former Kerr-McGee plant has decreased in areal extent and concentration as a result of migration of the plume with groundwater flow. This is supported by decreasing concentration trends in TW-12 and TW-56.

The sulfate plume in UBZ-2 has increased in area and concentration. Sulfate concentrations in TW-37 in the Old UFS Ponds area appears to be increasing, supported by statistical analyses of the data.

The statistical analyses of sulfate concentrations in downgradient areas indicate increasing sulfate concentrations in TW-20 at the Plant Fenceline, in TW-55 at the southern boundary, and in the Harris Well. Homestead Spring and Calf Spring also exhibit an increasing concentration trend, suggesting movement of the sulfate plume downgradient, consistent with natural attenuation.

The southern extent of the sulfate plume extends to monitoring well TW-62, but does not extend to wells TW-60 or TW-61 (Figure 14b)

5.5 Evaluation of Groundwater Modeling Projections

The selected remedy for groundwater at the Monsanto plant, per the ROD, is natural attenuation until constituent concentrations are at or below remedial goals. One of the elements of the five-year review process, per the ROD, is to compare modeled concentrations against measured groundwater concentrations to determine whether there is a significant difference. If there is a significant difference, the ROD states that the model and the need for additional groundwater remedial actions should be reevaluated.

The solute transport model (RI Model) used as the basis for the ROD was developed using groundwater monitoring data for five years (1991 to 1995). Comparison of the RI Model output and additional groundwater quality data collected between 1995 and 2002 completed as part of the first five-year review report (Golder, 2003a) indicated that the RI Model should be updated to more accurately predict groundwater concentrations at the Fenceline, Southern Boundary, and Soda Creek. A revised contaminant transport model (the GoldSim Model) was developed as part of the first five-year review that was calibrated to the additional groundwater quality data collected between 1995 and 2002.

5.5.1 Original Solute Transport Model

A groundwater solute transport model was developed as part of the Phase II RI for the Monsanto plant to predict the fate and transport of constituents in groundwater near the plant. The RI Model was developed for the Old UFS Ponds area, the portion of the plant west of the Monsanto Fault where there is potential for off-site transport of constituents in groundwater (UBZ-2), because this plume is not contained by the plant pumping wells (Golder, 1993; Golder, 1995). This RI Model is described in detail in Section 2.3 and Attachment L-2 of the Phase II RI (Golder 1995).

The RI Model projected concentrations over time at three endpoints south of the plant (the southern plant boundary, the estimated discharge point of the plume into Soda Creek, and the estimated discharge point of the plume into Bear River). Projections were calculated for constituent transport for a period of over 100 years. Although plumes are present in UBZ-4, originating from the Old Hydroclarifier and the Northwest Pond, modeling was not conducted for this area because pumping in the production wells contains the plumes in UBZ-4 and prevents off-site migration of the constituents.

Comparisons of the observed 2002 and 2007 concentrations and the concentrations predicted by the RI model are summarized on Table 8. The RI Model generally underpredicts concentrations of chloride and nitrate, and overpredicts concentrations of fluoride, cadmium, and manganese. The RI Model reasonably predicts selenium concentrations at the Fenceline and Southern Boundary.

5.5.2 Revised Solute Transport Model

A revised solute transport model ("GoldSim Model") was developed for the first five-year review to provide a more accurate projection of groundwater concentrations in the UBZ-2 zone south of the Monsanto plant (Golder, 2003a). The RI Model was revised to account for the observed changes in groundwater quality since the model was developed in 1993 and reinterpretation of the source area history and groundwater quality data from the monitoring wells. The groundwater quality changes resulted from decreases in constituent concentrations since 1993 and stabilization of concentrations for selected constituents such as fluoride, cadmium, and manganese. The additional monitoring data and reinterpretation of the source areas also provided information to refine the groundwater velocities near the Old UFS Ponds. The source concentrations were also revised based on the additional groundwater quality data collected since 1993.

The GoldSim Model was used to evaluate the concentrations of the constituents of concern at the Plant Fenceline (Wells TW-20 and TW-39), at the Southern Boundary wells (TW-54 and TW-55), at Mormon A Spring and the Harris Well, and at the downgradient property line, about 10,000 feet from the Old UFS Ponds. The GoldSim Model was first constructed to verify the results of the analytical modeling conducted in 1993. Details of the GoldSim Model setup, comparisons to the RI Model, and model results are described in Section 5.5.2 of the first five-year review report (Golder, 1993a).

5.5.3 Comparisons between GoldSim Model Results and Observed Concentrations

A comparison of the GoldSim Model-predicted concentrations and the observed constituent concentrations between 1991 and 2007 is presented in Attachment D. The model predicted concentrations and the actual concentrations from the 2002 and 2007 sampling events for the constituents of concern are tabulated in Table 9. The model-predicted chloride and nitrate concentrations include background concentrations of 16 mg/L (chloride) and 4 mg/L (nitrate). The 2007 chloride and nitrate concentrations in UBZ-2 background well TW-57 were 14.5 mg/L and 1.47 mg/L, respectively. The results are discussed in Sections 5.5.3.1 to 5.5.3.6 below.

5.5.3.1 Chloride

Chloride has not been identified as a constituent of concern at the Monsanto site. Chloride is conservative in the site groundwater, meaning it travels at the average linear groundwater velocity.

It is estimated that the revised chloride source concentration while the Old UFS Ponds were in operation was 400 mg/L (Figure D-1 in Attachment D). The model predicts decaying chloride concentrations following closure of the Old UFS Pond, with background concentrations reached in about 2000. The model does not predict an increase in chloride concentrations at the Old UFS Ponds that was observed in TW-22 and TW-24 between about 1996 and 2001, and in TW-37 between about 2004 and 2007. Given that wells TW-22 and TW-24 are located downgradient of well TW-37, there is evidence of two additional releases from the source area, one from the area near TW-22/24 in the mid-1990s and the other near TW-37 between 2004 and 2007. The increase in chloride concentrations during these periods is discussed in Section 6.2.1.2.1.

The GoldSim Model predicts the chloride plume peak reached the Plant Fenceline at some time between about 1988 and 1992 (Figure D-2 in Attachment D). The maximum chloride concentrations in these wells occurred between about 1989 and 1991. The 2002 chloride concentration is predicted to be about 60 mg/L, slightly lower than the observed concentrations of about 100 mg/L. The model predicts the chloride concentration to be about 33 mg/L in 2007. This is lower than the observed 2007 chloride concentration of about 100 to 115 mg/L in wells TW-20 and TW-39. The 2007 chloride concentrations at the Fenceline wells reflect the passage of a secondary release from the source area(s).

At the Southern Boundary wells, the GoldSim Model predicts that the chloride plume peak reaches wells TW-54 and TW-55 between about 1990 and 1994 (Figure D-3 in Attachment D). Sampling started in these wells in 1992. Chloride concentrations were highest in these wells between 1992 and 1994. The 2002 chloride concentration at these wells was about 40 to 100 mg/L. The model predicts a 2002 concentration of about 60 mg/L. The present chloride concentrations are about 60 to 100 mg/L, and the model predicts a 2007 chloride concentration of about 36 mg/L. Similar to the Fenceline wells, the observed chloride concentrations in 2007 reflect the passage of a secondary release from the source area(s).

The GoldSim Model predicts the chloride plume peak to arrive at the Harris Well and Mormon A Spring between about 1993 and 1995 (Figure D-4 in Attachment D). The chloride peak was observed in Mormon A Spring between about 1992 and 1995. An earlier peak was observed between about 1980 and 1984 that is likely not related to the Old UFS Ponds, but possibly to the old sewage effluent ponds. The maximum chloride concentration occurred between about 1994 and 1996 in the Harris Well. The present chloride concentration at these locations is about 120 mg/L; the GoldSim Model predicts a concentration of about 20 mg/L. Chloride concentrations at the Harris Well have been increasing since 2000, reflecting the passage of a secondary release from the source area(s).

The GoldSim Model predicts the chloride plume peak to reach a point 10,000 feet downstream from the Old UFS Ponds between about 1997 and 1999 (Figure D-5 in Attachment D). This point represents the southern boundary of Monsanto property. The 2007 monitoring wells in UBZ-2 are located about 6,500 feet (TW-62) to 8,000 feet (TW-59) from the Old UFS Ponds (Figure 2).

The 2007 chloride concentrations at monitoring wells TW-59 and TW-62 are 60 mg/L and 74 mg/L, respectively. The predicted concentration at these locations is 39 mg/L. In 2007, the chloride concentration at Homestead Spring was 28 mg/L, slightly less than the predicted concentration of 39 mg/L

In summary, the GoldSim Model predicts the chloride concentrations and time history at the point of compliance wells downgradient of the Old UFS Ponds reasonably well through about 2002, taking into account the background concentrations. The model predicts that the chloride concentrations at the downgradient wells will continue to decline, reaching background concentrations of 16 mg/L in the Fenceline wells in about 2020 and in the Southern Boundary wells in 2023. The GoldSim Model does not account for the observed increases in chloride concentration since 2000 in the Fenceline wells, Southern Boundary wells, and Harris Well because the model assumes a single source with decaying concentrations. The GoldSim Model does not predict the second chloride peak observed at the Fenceline, Southern Boundary, and Harris wells between 2000 and 2007 because the model simulates one decaying source term following pond closure rather than the observed two or three releases from the source area.

5.5.3.2 Fluoride

Fluoride is a constituent of concern at the Monsanto site with a remedial goal of 4 mg/L. Fluoride is transported conservatively in groundwater at the Monsanto site. The source concentration used for fluoride is shown on Figure D-6 of Attachment D. It is estimated that the fluoride concentration while the Old UFS Ponds were in operation was 31 mg/L. The model predicts fluoride concentrations decayed after the ponds were closed, and reached a steady state concentration of about 6 mg/L in about 1988. The steady state concentration reflects dissolution of fluoride minerals in the aquifer mass that were deposited when the pond were in operation. A short-term fluoride increase was observed in wells TW-22 and TW-24 between about 1995 and 2000, indicating a secondary release from the source area. The secondary peak was not observed in TW-37. The model does not predict the transport of a secondary release from the source area.

The GoldSim Model predicts that the fluoride plume peak reached the Fenceline wells between 1988 and 1992, with maximum concentrations of about 11 to 12 mg/L (Figure D-7 in Attachment D). The maximum fluoride concentrations observed at this time were about 6 to 8 mg/L; however, the Fenceline wells were not sampled for fluoride between the end of 1988 and the end of 1991. The GoldSim Model predicts fluoride concentrations will be less than the remedial goal of 4 mg/L by 2006 at the Fenceline wells. Fluoride concentrations are presently lower than the remedial goal at about 2.05 mg/L and 3.34 mg/L in wells TW-20 and TW-39, respectively, less than the predicted

concentration of 3.8 mg/L. Similar to chloride, a second fluoride peak was observed in wells TW-20 and TW-39 between 2004 and 2007.

The GoldSim Model predicts a fluoride plume peak concentration of about 8 mg/L at the Southern Boundary wells (Figure D-8 in Attachment D) between about 1990 and 1994. The Southern Boundary wells were installed and sampled in 1992. The 1992 fluoride concentration in these wells ranged from about 0.1 to 5 mg/L. Fluoride concentrations at these wells are predicted to be less than the remedial goal in 2002. At the Southern Boundary wells, the 2007 fluoride concentration is about 0.26 to 3.66 mg/L, while the model predicts a fluoride concentration of 3.2 mg/L. Similar to chloride, a second fluoride peak was observed starting in 2006 in the Southern Boundary wells.

The GoldSim Model predicts a fluoride plume peak concentration of about 8 mg/L at the Harris Well and Mormon Spring (Figure D-9 in Attachment D) between about 1990 and 1994. Observed concentrations at that time were about 2 to 4 mg/L in Mormon A Spring and about 1 mg/L in the Harris Well. Fluoride concentrations at these locations are predicted to be less than the remedial goal in 2002. The present fluoride concentration at Mormon A Spring and the Harris Well is about 2.5 to 3 mg/L, similar to the predicted concentration of 2.7 mg/L. Similar to chloride, fluoride concentrations in the Harris Well and Mormon A Spring started to increase in 2004, suggesting transport of a secondary release from the source area. The GoldSim Model predicts fluoride concentrations to reach a maximum of about 3 mg/L (less than the remedial goal) between 1997 and 1999 at the property boundary (Figure D-10). The 2007 fluoride concentrations at monitoring wells TW-59 and TW-62 are less than 0.1 mg/L and 0.22 mg/L, respectively. The predicted concentration at these locations is 1.9 mg/L. The present concentration at Homestead Spring is less than 1 mg/L, lower than the predicted concentration of 1.9 mg/L.

In summary, the GoldSim Model predicts the fluoride concentrations and time history at the point of compliance wells downgradient of the Old UFS Ponds reasonably well. The model predicts that the fluoride concentrations at the downgradient wells will continue to decline, reaching steady-state concentrations in the Fenceline wells in about 2020 and in the Southern Boundary wells in 2023. The steady state concentrations are below the remedial goals and reflect the constant source concentration from the dissolution of fluoride minerals that likely precipitated in the aquifer mass while the ponds were in operation. The GoldSim Model does not match the arrival of a fluoride plume at Mormon A Spring and the Harris Well that occurred in the mid 1980s. This plume probably represents seepage from the former sewage evaporation ponds and not the plume from the Old UFS Ponds. The GoldSim Model does not predict the second peak observed at the Fenceline, Southern Boundary, and Harris wells between 2004 and 2007 because the model simulates one decaying source term following pond closure followed by steady state concentrations from the dissolution of fluoride minerals.

5.5.3.3 Nitrate

The remedial goal for nitrate is 10 mg/L (as nitrogen). Nitrate is transported conservatively at the Monsanto site. Nitrate is also present at background levels of about 2 to 4 mg/L in the groundwater (2007 sampling results -TW-29 and TW-57). A higher nitrate concentration of 16 mg/L was observed in the sulfur dioxide (SO_2) North Landfill well, north of the northern plant boundary, in 2007 (Figure 10b). The model-predicted that nitrate concentrations include a background concentration of 4 mg/L.

It is estimated that the Old UFS Ponds source concentration for nitrate while the ponds were in operation was 13.4 mg/L (including a background concentration of 4 mg/L). The source concentration history used for nitrate is shown on Figure D-11 of Attachment D. The model predicts

nitrate concentrations decayed after the ponds were closed, and reached a steady state concentration of about 4 mg/L in about 1988. A nitrate peak was observed in TW-37 between about 2002 and 2007, indicating an additional release from the source area at this time. In addition, nitrate concentrations increased in TW-22 and TW-24 between about 1995 and 2000. These wells are downgradient of TW-37. The nitrate increase in these wells indicates an additional release possibly from a source area near TW-22 and TW-24. The model does not predict this secondary release from the source area.

The GoldSim Model predicts the nitrate plume peak to arrive at the Fenceline wells between about 1988 and 1992. The GoldSim Model predicts nitrate to reach concentrations of about 8 mg/L at that time (Figure D-1, Attachment D). The predicted maximum concentration at the Fenceline wells is less than the remedial goal at all times. It appears that a second nitrate peak arrived at the Fenceline wells between about 2002 and 2007, with a maximum concentration of about 20 mg/L in TW-20 and 12 mg/L in TW-12. This is similar to observations of chloride and fluoride at the Fenceline wells. The present nitrate concentration at the Fenceline wells is about 10 mg/L, greater than the predicted value of 5.4 mg/L, reflecting the passage of a second nitrate peak from a secondary release in the source area(s) (Figure D-12, Attachment D).

At the Southern Boundary wells (Figure D-13, Attachment D) and the Harris Well and Mormon A Spring (Figure D-14, Attachment D), the GoldSim Model predicts nitrate concentrations reach a maximum between 1990 and 1994. Maximum concentrations at these locations during that time were about 3 to 7 mg/L, less than the remedial goal of 10 mg/L (as N). The present nitrate concentrations at TW-54 and TW-55 are about 4 to 10 mg/L, in comparison to the predicted value of about 5.3 mg/L. The 2007 nitrate concentrations at Mormon A Spring and the Harris Well are about 9 mg/L. The 2007 concentrations reflect the passage of a second nitrate peak, similar to the observations of a second chloride and fluoride peaks. The GoldSim Model predicts a concentration of about 5 mg/L in Mormon Creek in 2007. The observed nitrate concentration was also about 4.5 mg/L in 2007.

The GoldSim Model predicts nitrate concentrations to peak at about 5 mg/L between 1997 and 1999 at the property boundary (Figure D-15, Attachment D). The 2007 nitrate concentrations at the 2007 monitoring wells in UBZ-2 (TW-59 and TW-62) are 5.8 mg/L and 5.1 mg/L, respectively (Figure D-15, Attachment D). The nitrate concentrations in these wells may be influenced by upgradient agricultural activities. The present concentration at Homestead Spring is about 14 mg/L. Nitrate concentrations in Homestead Spring may be affected by upgradient agricultural activities.

In summary, the GoldSim Model predicts the nitrate concentrations and time history at the point of compliance wells downgradient of the Old UFS Ponds reasonably well. Similar to the chloride model, the nitrate model predicts the concentrations well downgradient compliance wells through about 2002, but does not match the concentrations after 2002 because of the passage of a second nitrate peak, similar to chloride and fluoride. The model assumes a single source with decaying concentrations rather than several sources over time. The model predicts that the nitrate concentrations at the downgradient wells will continue to decline, reaching background concentrations of 4 mg/L in the Fenceline wells in about 2020 and in the Southern Boundary wells in 2023. The GoldSim Model does not match the arrival of a nitrate plume at Mormon A Spring and the Harris Well in the mid 1980s. This plume probably represents seepage from the former sewage evaporation ponds and not the plume from the Old UFS Ponds.

5.5.3.4 Selenium

The remedial goal for selenium is 0.05 mg/L. The assumed Old UFS Ponds source concentration of 1.4 mg/L is shown on Figure D-16 in Attachment D. Selenium data before 1991 did not meet quality

assurance requirements. Selenium concentrations at the source declined from an assumed maximum of 1.4 mg/L following closure of the Old UFS Ponds. Based on the observed concentration of selenium in TW-37 in 2002 and the observed concentrations in the downgradient wells at the Fenceline and Southern Boundary in 2002, the selenium concentration at the source area was projected to reach a quasi-steady state concentration of about 0.05 mg/L by about 2010 (Golder, 2003a). At TW-37, the selenium concentration was about 0.16 mg/L in 2007, and a second selenium peak was observed between about 2004 and 2007. This is indicative of a release from the source at this time. In addition, selenium concentrations increased in TW-22 and TW-24 between about 1996 and 2001. Similar to nitrate, this pattern suggests several releases from the source area over time which are not captured in the GoldSim Model.

The GoldSim Model predicts the selenium concentration at the Plant Fenceline wells reached a maximum of about 0.6 mg/L between about 1988 and 1992 (Figure D-17). The concentrations decrease after 1992 and are predicted to decrease below the remedial goal of 0.05 mg/L by 2020. The present selenium concentration at the Fenceline wells is about 0.08 to 0.13 mg/L, while the GoldSim Model predicts a concentration of about 0.16 mg/L. Similar to the other conservative constituents (chloride, fluoride, and nitrate), a second peak was observed at the Fenceline wells (TW-20) between 2001 and 2005).

The GoldSim Model predicts selenium concentrations reached a maximum concentration of about 0.45 mg/L at the Southern Boundary wells (Figure D-18, Attachment D) between 1990 and 1994. Selenium concentrations between 1992 and 1994 were about 0.1 to 0.6 mg/L. The selenium concentration decreases after 1994, and is predicted to fall below the remedial goal by 2020. The present selenium concentration at the Southern Boundary wells is about 0.04 to 0.085 mg/L. In comparison, the GoldSim Model predicts a 2007 concentration of about 0.16 mg/L. The GoldSim Model does not predict the passage of a second selenium peak that was observed between about 2001 and 2006 in the Southern Boundary wells (TW-54 and TW-55).

The GoldSim Model predicts the peak of the selenium plume at the Harris Well and Mormon Springs (Figure D-19, Attachment D) between about 1991 and 1994. The predicted concentration at that time is about 0.35 mg/L. The 2007 selenium concentration at these locations ranges from 0.12 mg/L to 0.14 mg/L, while the GoldSim Model predicts a concentration of about 0.15 mg/L. The GoldSim Model does not predict the passage of a second selenium peak that was observed between about 2002 and 2006 in the Harris Well and Mormon A Spring.

At the property boundary, the GoldSim Model predicts the peak of the selenium plume to arrive between about 1997 and 1999, with a maximum concentration of about 0.17 mg/L. The 2007 selenium concentrations at monitoring wells TW-59 and TW-62 are 0.032 mg/L and 0.045 mg/L, respectively (Figure D-20, Attachment D). The predicted 2007 concentration at these locations is 0.12 mg/L. The present selenium concentration at Homestead Spring is about 0.007 mg/L. The GoldSim Model predicts a present concentration of about 0.12 mg/L (Figure D-19, Attachment D).

In summary, the GoldSim Model predicts the selenium concentrations and time history at the point of compliance wells downgradient of the Old UFS Ponds fairly well. The model does not account for the additional releases from the source area and currently overpredicts the downgradient concentrations

5.5.3.5 Manganese

The remedial goal for manganese is 0.18 mg/L. The Old UFS Ponds source concentration history for manganese is shown on Figure D-25 in Attachment D. It was assumed that the manganese source

concentration declined from a maximum of 4.95 mg/L to a quasi-steady state concentration of about 0.7 mg/L. Manganese concentrations in TW-37 have been about 0.6 mg/L since 1997 (Figure D-21, Attachment D).

The GoldSim Model predicts that the peak of the manganese plume will not arrive at the Fenceline by the end of the model simulation in 2164. The predicted concentration at that time is about 0.003 mg/L, well below the remedial goal of 0.18 mg/L. The GoldSim Model predicts the present manganese concentration at the Plant Fenceline to be less than 0.001 mg/L. Manganese is presently below detection at the Plant Fenceline (Figure D-22), with the exception of TW-34 and TW-35, where the 2007 manganese concentrations were 0.222 mg/L and 0.158 mg/L, respectively. Manganese concentrations in TW-34 and TW-35 are affected by sodic groundwater.

The GoldSim Model predicts the peak of the manganese plume will not arrive at the other downgradient locations (Southern Boundary wells, Mormon A Spring, Harris Well, new monitoring wells, or property line) by the end of the model simulation in 2164. The GoldSim Model predicts current manganese concentrations at these locations to be less than 0.001 mg/L (Figures D-23 through D-25, Attachment D). The present concentrations at these locations are less than the detection limit, with the exception of TW-62, where manganese was detected at 0.004 mg/L, and TW-60 and TW-61, where manganese concentrations were 6.04 mg/L and 0.493 mg/L, respectively, in 2007. Manganese concentrations in TW-60 and TW-61 are affected by sodic groundwater.

In summary, the GoldSim Model predicts manganese concentrations at the source area (TW-37) reasonably well. The GoldSim Model predicts manganese concentrations to be at very low levels (less than 0.0001 mg/L) at the downgradient wells. Manganese concentrations at these locations are generally less than the laboratory detection limit. Therefore, the model could not be calibrated to downgradient data and it is difficult to determine whether the model will accurately predict the behavior of manganese in the future.

5.5.3.6 Cadmium

The remedial goal for cadmium is 0.005 mg/L. The assumed source concentration history for cadmium is shown on Figure D-26 of Attachment D. The cadmium source concentration is projected to have declined from a maximum of 1.4 mg/L to a quasi-steady state concentration of about 0.4 mg/L. Cadmium concentrations in TW-37 were about 0.4 mg/L between 1991 and 2004. In 2004, cadmium concentrations started to increase and are currently about 0.58 mg/L. Geochemical modeling completed as part of the first five-year review indicated cadmium was likely transported as complexes with chloride and sulfate (Golder, 2003a), rather than as free cadmium ions [Cd^{2+}], which are subject to the adsorption process and would be highly retarded. The observed increase in cadmium concentrations in TW-37 in 2004 is coincidental with an increase in chloride and sulfate, suggesting cadmium is being transported as a chloride or sulfate complex, rather than free cadmium ions.

The GoldSim Model predicts very low (less than 0.00001 mg/L) present cadmium concentrations at the Fenceline wells, Southern Boundary wells, Harris Well, Mormon A Spring, and the new monitoring wells (Figures D-27 through D-30, Attachment D). However, the present cadmium concentrations at these locations are variable (Table 9) ranging from less than 0.0006 mg/L to 0.0174 mg/L at Mormon A Spring. The elevated cadmium concentrations are probably due to the presence of cadmium chloride and cadmium sulfate complexes while the Old UFS Ponds were active (Golder, 2003a), allowing cadmium to be transported conservatively in groundwater.

A second cadmium peak was observed in TW-20 and TW-39 between about 2001 and 2007, with a maximum concentration of about 0.01 mg/L (TW-20) to 0.016 mg/L (TW-39). The second peak is coincidental with concurrent increases in chloride and sulfate in the Fenceline wells. The second cadmium peak was not observed at the Southern Boundary wells or the Harris Well, but was observed in Mormon A Spring between about 2003 and 2007, again coincidental with a second chloride and sulfate peak. The GoldSim Model predicts that the peak of the cadmium plume will not arrive at the fenceline before at least 2164 (the model was run for 200 years from 1964 to 2164). The predicted concentration in 2064 at the Fenceline wells is less than 0.0001 mg/L (Figures D-27, Attachment D). The predicted cadmium concentrations at the downgradient locations (Southern Boundary wells, Mormon A Spring, Harris Well, 2007 monitoring wells, and Soda Creek discharge) are also all less than 0.0001 mg/L

In summary, the GoldSim Model predicts that the cadmium plume originating from the Old UFS Ponds is highly retarded and cadmium concentrations are predicted to remain below the remedial goals at very low levels (less than 0.0001 mg/L) at the compliance points, downgradient wells, and springs. Cadmium concentrations at these locations are generally less than the laboratory detection limit (Southern Boundary wells) or elevated due to cadmium complexes (Fenceline wells and Mormon A Spring). Therefore, the model could not be calibrated to downgradient data and it is difficult to determine whether the model will accurately predict the behavior of cadmium in the future as long as cadmium is transported as a complex, rather than cadmium ions. Over the long term, cadmium present in groundwater from the dissolution of otavite (cadmium carbonate) in the aquifer below the Old UFS Ponds will occur as free cadmium ions [Cd^{2+}], which will be subject to the adsorption process and will be highly retarded, and downgradient concentrations are predicted to be similar to the GoldSim Model predictions.

5.5.3.7 Discussion

The GoldSim Model predicts the following:

- Concentrations of fluoride are predicted to be less than the remedial goals at the Plant Fenceline wells by 2006 and in Southern Boundary wells by 2002. The fluoride concentration at Mormon A Spring (discharge to Soda Creek) is predicted to be below the remedial goal by 2001. The GoldSim Model is consistent with measured fluoride concentrations being less than the remedial goal in 2007 at the Fenceline wells (TW-20 and TW-39), Southern Boundary wells (TW-54 and TW-55), and Mormon A Spring (Table 9).
- Concentrations of nitrate are predicted to be below the remedial goal at all times at the Fenceline wells and Southern Boundary wells and in Mormon A Spring. The GoldSim Model is generally consistent with measured nitrate concentrations being less than the remedial goal in 2007 at the Fenceline wells (except TW-20), Southern Boundary wells, and Mormon A Spring (Table) (Table 9).
- Concentrations of selenium are predicted to be less than the remedial goal at the Fenceline wells and Southern Boundary wells and Mormon A Spring by about 2017. The GoldSim Model is consistent with measurements of selenium concentrations that are slightly above the remedial goal in 2007 at the Fenceline wells, Southern Boundary wells, and Mormon A Spring (Table 9).
- Concentrations of manganese at the Fenceline wells and Southern Boundary wells are predicted to be less than the remedial goal for the next 100 years because of the high retardation for manganese. The GoldSim Model is consistent with measurements of

manganese concentrations being less than the remedial goal in 2007 at the Fenceline and Southern Boundary wells and Mormon A Spring.

- Concentrations of cadmium at the Fenceline wells and Southern Boundary wells are predicted to be less than the remedial goal for the next 100 years. Based on the modeling, concentrations of cadmium at these locations will remain less than the remedial goal because of the high retardation factor. The GoldSim Model is generally consistent with measurements of cadmium concentrations being less than the remedial goal in 2007 at the Southern Boundary wells. The GoldSim Model does not predict cadmium concentrations well at the Fenceline wells or Mormon A Spring because the model does not consider cadmium transport as a chloride or sulfate complex.

The GoldSim Model has the following limitations with regard to predicting future concentrations at the source area (Old UFS Ponds) and downgradient wells:

- The GoldSim Model was developed using a single source (Old UFS Ponds) with decaying source concentrations once the ponds were closed. Based on the data, possibly two additional releases have occurred from the source area during the mid-1990s and most recently between 2004 to present. . These additional releases appear to be related to periods of above average precipitation (Section 6.2.1.2.1). The GoldSim Model does not account for subsequent release or mobilization of constituents following closure of the Old UFS Ponds.
- The GoldSim Model assumes cadmium is transported as cadmium ions, which are highly retarded. Geochemical modeling and observations of coincident increases in cadmium, sulfate and chloride concentrations in the source area wells (TW-37, TW-22, and TW-24), the Fenceline wells (TW-20 and TW-37), and Mormon A Spring suggest cadmium is transported conservatively as a complex with chloride or sulfate, rather than cadmium ions (Golder, 2003a).

6.0 ISSUES RAISED IN FIRST FIVE-YEAR REVIEW

This section describes the groundwater-related issues raised by EPA (EPA, 2003) in the first five-year review and how these issues have been addressed in the second five-year review.

6.1 Lewis Well

Issue:

Groundwater samples from the Lewis Well have revealed elevated cadmium and other hazardous constituent concentrations during the past five years, and the property where this well is located does not have institutional controls.

Response:

Groundwater in the Lewis Well appears to be affected by both the plume from the Tronox (former Kerr McGee) site and UBZ-2. Review of groundwater quality data collected in the Lewis Well since 1991 indicates the following with respect to the constituents of concern:

- Cadmium was detected at a concentration of 0.0155 mg/L in 2002. Cadmium was not detected in the preceding or following years (1991 through 2001 or 2003 through 2007), suggesting the 2002 result was the result of laboratory error. Cadmium was also detected once in 1987 at a concentration of 0.014 mg/L. Cadmium was not detected between 1979 and 1986, or between 1988 and 2002, suggesting the 1987 result was also laboratory error (Figure 15). Therefore, there is no evidence of elevated cadmium in the Lewis Well.

- Fluoride was not detected at a concentration of greater than 1 mg/L in the Lewis Well between 1991 and 2002, except once in 1991 at a concentration of about 5.5 mg/L. All other fluoride concentrations are less than 1 mg/L, less than the remedial goal of 4 mg/L, suggesting the 1991 result was a laboratory error (Figure 15).

- Manganese has been periodically detected in the Lewis Well since 1991 at concentrations of up to 0.015 mg/L, well below the remedial goal of 0.18 mg/L (Figure 15).

- Nitrate concentrations generally ranged between about 6 and 9 mg/L, less than the remedial goal of 10 mg/L. Nitrate was detected in 1993 and 1996 at a concentration of about 12 mg/L (Figure 15). Nitrate concentrations in the Lewis Well are affected by nearby agricultural activities as well as the nitrate plume from the Tronox (Kerr-McGee) plant and the Monsanto plant.

- Selenium concentrations in the Lewis Well were generally below the remedial goal of 0.05 mg/L. Selenium concentrations exceeded the remedial goal between about 1991 and 1995, but have been less than the remedial goal since 1995, with the exception of one sample in collected in 2005 (Figure 15).

- Concentrations of molybdenum have decreased from a peak concentration of 0.27 mg/L in 1997 to about 0.08 in 2007 (Figure 15). The peak observed in 1997 is consistent with the migration of the molybdenum plume from the former Kerr-McGee plant. The peak of the molybdenum plume was observed in upgradient well TW-12 in 1993.

- Statistical analyses of the groundwater quality data from the Lewis Well indicated the concentrations of all constituents of concern are either declining or have stable or no significant concentration trends (Table 5 and Table 7).

The Lewis Well is only used for irrigation; the residence has been supplied with water from the Soda Springs municipal supply for domestic purposes. The concentrations of the constituents of concern are either below detection (cadmium and manganese), stable and below the remedial goal (fluoride and nitrate), or decreasing and below the remedial goal (selenium). The Lewis Well will continue to be sampled annually.

6.2 Monitored Natural Attenuation (MNA)

Issue:

MNA for groundwater underneath the operating area may take longer than anticipated during the RI/FS, though this observation needs to be reevaluated during the next five-year review.

Response:

The contaminant transport modeling completed as part of the remedial investigation/feasibility study (RI/FS) indicted conservative constituents (fluoride, nitrate, selenium, chloride, sulfate) would reach background concentrations at the Plant Fenceline 20 to 30 years after closure of the source areas, which occurred in 1988. Concentrations of manganese and cadmium were predicted to reach background concentration in about 2020 to 2030. The modeling completed as part of the RI/FS used about five years of groundwater quality data.

An updated model, the GoldSim Model, was prepared as part of the first five-year review to include the water quality data collected between 1991 and 2002. The GoldSim Model indicated that concentrations of fluoride should reach the remedial goals at the Fenceline wells by 2006, and reach the remedial goals at the Southern Boundary wells should be reached in 2002. For nitrate, the model predicted concentrations at the Fenceline wells and Southern Boundary wells should never exceed the remedial goals. Selenium concentrations were predicted to reach the remedial goal at the Fenceline wells by about 2020, and reach the remedial goal at the Southern Boundary wells in about 2017. The model predicted that because of retardation, future concentrations of manganese and cadmium would remain below the remedial goal at the Fenceline wells and Southern Boundary wells.

6.2.1 Observations since First Five-Year Review

6.2.1.1 UBZ-4

Elevated constituents in the UBZ-4 originate from the Northwest Pond and Old Hydroclarifier (Figure 4). The plume in UBZ-4 is contained by pumping from plant production wells PW-01, PW-02, and PW-03. Thus, the extent of the plume has remained relatively stable or has decreased slightly. The constituent plume has not migrated outside of the UBZ-4 region.

The concentrations of the constituents of concern in the UBZ-4 are generally decreasing, with the exception of manganese in the Northwest Pond area and nitrate at the Old Hydroclarifier. Cadmium is the only constituent that exceeded the remedial goal in a UBZ-4 compliance well in 2007 (PW-01). Cadmium also exceeded the remedial goal in PW-01 in 2002.

Thus, there have been few changes in the extent of the constituent plume since 2002, and the concentrations of the constituents of concern have been decreasing, consistent with monitored natural attenuation.

6.2.1.2 UBZ-2

Elevated constituents in the UBZ-2 originate primarily from the Old UFS Ponds (Figure 4). The ponds were capped in 1988 by filling the ponds with molten slag and then capping the ponds with a bentonite cover. The bentonite cover was then covered with crushed slag. The plume is not contained by pumping. The plume extent has either increased slightly as the plume migrates towards Soda Creek (for mobile constituents such as nitrate, selenium, fluoride, sulfate, and chloride) or remained stable (for cadmium and manganese). The area of groundwater that exceeds the remedial goals in the UBZ-2 remains on Monsanto property.

The concentrations of the constituents of concern in the UBZ-2 are generally decreasing based on the statistical analyses, with the following exceptions:

- Nitrate at Mormon A Spring, Homestead Spring, TW-37, TW-20, TW-53, and the Harris Well
- Cadmium at TW-20
- Fluoride at TW-20
- Selenium at TW-55 and Mormon A Spring

The following constituents of concern exceed the remedial goals at point of compliance wells in the UBZ-2 in 2007 (Table 3):

- Cadmium exceeds the remedial goal at TW-20 and TW-39.
- Nitrate exceeds the remedial goal at TW-20.
- Selenium exceeds the remedial goal at the Harris Well, TW-20, TW-39, TW-53, and TW-54.

The remedial goals for fluoride and manganese were met for all UBZ-2 compliance wells in 2007.

Concentrations of constituents of concern in the new monitoring wells (TW-59 through TW-62, inclusive) were all below the remedial goals, with the exception manganese in two wells (TW-60 and TW-61). Elevated manganese in new wells TW-60 and TW-61 is the result of naturally-occurring sodic groundwater that contains high manganese concentrations (Golder 2007b).

6.2.1.2.1 Short-Term Constituent Concentrations

Attachment E presents chemical hydrographs of constituent concentrations in the wells near the Old UFS Ponds (TW-22, TW-24, and TW-37), the Fenceline wells (TW-20 and TW-39), the Southern Boundary wells (TW-54 and TW-55), the Harris Well, and Calf and Mormon A Springs.

There were several periods of short-term increases in concentrations in wells near the Old UFS Ponds (TW-37, TW-22, and TW-24). The short-term concentration increases are summarized on the following table:

Constituent	TW-37	TW-22/TW-24
Sulfate	1993 to 2000 2002 to 2007	1993 to 2001 2003 to 2007
Chloride	2002 to 2007	1993 to 2001 2004 to 2006
Nitrate	2002 to 2007	1993 to 2001 2004 to 2007
Fluoride	Not Observed	1993 to 2001 2004 to 2007
Cadmium	2002 to 2007	1993 to 1998 2002 to 2005
Manganese	Not Observed	1993 to 2000 (TW-22) 1999-2004 (TW-24)
Selenium	1993 to 1995 2003 to 2006	1993 to 2001 2003 to 2006
Molybdenum	Not Observed	1993 to 2001 2005 to 2007

In summary, there have been two periods of short-term increases in concentrations in wells near the Old UFS Ponds. The first period was in the middle to late 1990s; the second period started in about 2002 and has continued to 2007.

Concentrations of cadmium, nitrate, fluoride, selenium, sulfate, and chloride increased in the Fenceline wells between about 2000 and 2005 and then decreased in 2006 and 2007 (Golder, 2007b). The increases were generally not statistically significant between 2000 and 2007 (Table 7), but suggest passage of a "slug" of groundwater within the UBZ-2 with elevated concentrations. The source for this "slug" of groundwater was likely the Old UFS Ponds and/or the vadose zone below the ponds (a capped former source area) or a source north of the old coke and quartzite dust slurry pond (an area that is predominately covered with slag). These source areas are discussed in Sections 6.2.1.2.1.1 and 6.2.1.2.1.2.

6.2.1.2.1.1 Old Underflow Solids Ponds

The Old UFS Ponds were used to dewater underflow solids obtained from the Hydroclarifier. The slurry materials from the Hydroclarifier were directed to the ponds and allowed to dewater, with the fluid portion infiltrating through the base of the ponds. The remaining dewatered solids were excavated and returned to the process circuit. Chemical analyses of the underflow solids were performed during the Phase II RI. The analyses indicated the underflow solids contained elevated concentrations of cadmium, selenium, manganese, fluoride, and nitrate (Golder, 1995).

In 1983, use of the ponds for dewatering halted when it was discovered the ponds were a source of groundwater contamination. The remaining solids in the ponds were subsequently excavated. In 1988, the ponds were sealed to limit infiltration of precipitation and snowmelt. Approximately 35,000 tons of materials were left in place in the ponds when they were capped. The ponds were sealed by first filling the ponds with molten slag, which hardened in place. The slag was then capped with a 1-foot-thick layer of bentonite. The bentonite was covered with about a foot of crushed slag in order to protect the cap. The area of the bentonite cap and crushed slag included the area surrounding the ponds to provide an infiltration barrier to the surrounding soils along with the pond area.

Infiltration modeling of the cap at the Old UFS Ponds predicted the infiltration rate through the cap was about 0.3 inch per year (Golder 1995).

6.2.1.2.1.2 Coke and Quartzite Dust Slurry Pond

The coke and quartzite dust slurry pond was used to dewater coke and quartzite dust collected by a wet scrubber system. Chemical analyses of the coke and quartz slurry and raw coke and quartzite were performed during the Phase II RI. The analyses indicated both the slurry and the raw materials contained only trace amounts of selenium, cadmium, and manganese. The coke and quartzite pond was not identified as a source of groundwater contamination in the Phase II RI (Golder, 1995).

The pond was taken out of service in 1987 when a new dewatering filter press was installed. Some solids were excavated from the pond when it was taken out of service. The pond was filled with slag after it was taken out of service.

6.2.1.2.1.3 Precipitation

Precipitation at the Soda Springs Airport (National Climatic Data Center 2008) for the Water Years 1983 to 2007 is summarized on Table 10. The average Water Year precipitation (October 1 to September 30) over the period of record (1980 to 2007) is 15.34 inches. Table 10 also includes the deviation from the average Water Year precipitation.

Evaluation of precipitation records and groundwater quality data from wells near the Old UFS Ponds area (TW-37, TW-22, and TW-24) suggests that increases in constituent concentrations in the source area wells are related to periods of above average precipitation that occurred in the early to mid 1990's and in 2005 (Table 10).

Time history plots of concentrations in the wells near the source area (TW-37, TW-22, and TW-24) were compared with deviation from average Water Year precipitation to qualitatively evaluate the response to precipitation. The Water Year precipitation was used to include the effects of snow accumulation over the winter, snowmelt, and spring precipitation. Groundwater samples are typically collected in late spring or early summer after 1994. Before 1994, samples were collected in late fall

and late spring. The observed relationships between chemical concentrations and the deviation from average Water Year precipitation are discussed in Sections 6.2.1.2.1.4 to 6.2.1.2.1.11.

6.2.1.2.1.4 Sulfate

A time-history plot for sulfate in wells near the source area and in downgradient wells is shown on Figure E-1 in Attachment E. As shown on Figure E-1, there is an increase in sulfate concentration in three wells near the source areas (TW-37, TW-22, and TW-24) in the late 1990s, followed by a decrease in concentrations. There is a second increase in concentration starting in about 2002, with sulfate concentrations in TW-37 continuing to increase through 2007, while concentrations in TW-22 and 24 started to decrease in 2007.

Figure E-2 (Attachment E) shows the relationship between sulfate concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation (15.34 inches). In general, there are two periods of above average precipitation. The first is between about 1995 and 1999, and the second in 2005 and 2006.

Sulfate concentrations in the background well (TW-57) do not respond to precipitation. Sulfate concentrations in TW-37 respond to precipitation during both periods of above average precipitation (mid to late 1990s and 2005 to 2006). Sulfate concentrations in TW-22 and TW-24 respond to precipitation during both periods of above average precipitation (mid to late 1990s and 2005 to 2006).

Sulfate concentrations in TW-37 peak about one year after peak precipitation, while sulfate concentrations in TW-22 and TW-24 peak in the same year as peak precipitation. This suggests a source near TW-37 and a separate source near TW-22 and TW-24. There is a greater increase in sulfate concentration in TW-22 and TW-24 than TW-37, most likely because the bentonite and slag cap limits infiltration through the Old UFS Ponds.

An increase in sulfate concentration is observed in Fenceline well TW-20 in about 2001. This suggests passage of a “slug” of groundwater within the UBZ-2 plume. Comparing the peak concentration in the source area wells and Fenceline well indicates a groundwater velocity of about 1.0 foot per year (ft/yr; Table 11), consistent with earlier estimates (Golder, 2003a). An increase in sulfate concentration was observed in the wells near the source area in 2005 and 2006. Based on the estimated groundwater velocity, this sulfate slug is expected to arrive at the Fenceline wells in about 7 to 9 years.

6.2.1.2.1.5 Chloride

A time-history plot for chloride in the wells near the source area and downgradient wells is shown on Figure E-3 (Attachment E). As shown on Figure E-3, there is an increase in chloride concentration in some wells near the source areas in the late 1990s, followed by a decrease in concentrations. In well TW-37 chloride concentrations decreased thorough about 1993, and were generally stable between 1993 and 2002. Chloride concentrations increase in TW-37 starting in about 2002, with chloride concentrations reaching a peak in 2006. In wells TW-22 and 24 there is an increase in chloride in 1993 to 2001, and again between 2005 and 2006. Chloride concentrations in TW-22 and TW-24 started to decrease in 2006.

Figure E-4 (Attachment E) shows the relationship between chloride concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the

deviation from the average Water Year precipitation. Chloride concentrations in TW-57 do not respond to precipitation.

Chloride concentrations in TW-37 increased significantly only during 2005 to 2006. Chloride concentrations in TW-22 and TW-24 increased during both periods of above average precipitation (mid to late 1990s and 2005 to 2006). In the late 1990s, chloride concentrations in both TW-22 and TW-24 increased in response to increased precipitation, but there was a greater increase in TW-22. In 2005 and 2006, chloride concentrations in both TW-22 and TW-24 increased.

Chloride concentrations in TW-37 peaked about one year after peak precipitation in 2005, while chloride concentrations in TW-22 and TW-24 peaked in the same year as peak precipitation (2005). This suggests a source near TW-37 and a separate source near TW-22 and TW-24.

An increase in chloride concentration was observed in Fenceline well TW-20 in about 2001. Comparing the peak chloride concentrations in the source area wells and Fenceline well TW-20 indicates a groundwater velocity of about 1.4 ft/yr (Table 11), consistent with earlier estimates (Golder, 2003a). An increase in chloride concentration was observed in the wells near the source area in 2005 and 2006. Based on the estimated groundwater velocity, this chloride slug is expected to arrive at the Fenceline wells in about 6 to 7 years.

6.2.1.2.1.6 Nitrate

A time-history plot for nitrate in the wells near source area and downgradient wells is shown on Figure E-5 (Attachment E). As shown on Figure E-5, there was an increase in nitrate concentration in wells TW-22 and TW-24 near the source area in the late 1990s, followed by a decrease in concentrations. There was an additional increase in concentration starting between about 2002 and 2004 for wells TW-37, TW-22, and TW-24, with nitrate concentrations in TW-37 reaching a peak in 2006, while concentrations in TW-22 and 24 peaked in 2006 and were relatively stable in 2007.

Figure E-6 (Attachment E) shows the relationship between nitrate concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation. As shown on Figure E-6, nitrate concentrations in TW-57 showed a slight response to precipitation. Thus, some of the observed increase in nitrate concentrations in the source area wells is attributable to an increase in background concentrations.

Nitrate concentrations in TW-37 increased slightly during the period of above-average precipitation (mid to late 1990s), but increased significantly during 2005 and 2006). Nitrate concentrations in TW-22 and TW-24 increased during both periods of above average precipitation (mid to late 1990s and 2005 to 2006). In 2005 and 2006, the increase in nitrate concentration in TW-37 was greater than in TW-24.

Similar to sulfate and chloride, nitrate concentrations in TW-37 peaked about one year after peak precipitation in 2005, while nitrate concentrations in TW-22 and TW-24 peaked in the same year as peak precipitation (2005). The data indicate a source near TW-37 and a separate source near TW-22 and TW-24.

An increase in nitrate concentration is observed in Fenceline well TW-20 in about 2001. Comparing the peak nitrate concentrations in the source area wells and Fenceline well TW-20 indicates a groundwater velocity of about 1.2 ft/yr (Table 10), consistent with earlier estimates (Golder, 2003a). An increase in nitrate concentration was observed in the wells near the source area in 2005 and 2006.

Based on the estimated groundwater velocity, this nitrate slug is expected to arrive at the Fenceline wells in about 7 to 9 years.

6.2.1.2.1.7 Fluoride

A time-history plot for fluoride in the wells near the source area and downgradient wells is shown on Figure E-7 (Attachment E). Fluoride concentrations have decreased in TW-37 continuously since the Old UFS Ponds were closed and capped. As shown on Figure E-7, there is an increase in fluoride concentration in TW-22 and TW-24 between about 1993 and 2001, followed by a decrease in concentrations. Fluoride concentrations also increased in TW-22 and TW-24 in about 2004, with concentrations in TW-22 slowly increasing through 2007, while concentrations decreased in TW-24 in 2007.

Figure E-8 (Attachment E) shows the relationship between fluoride concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation. As shown on Figure E-8, fluoride concentrations in TW-57 do not show a response to precipitation. Fluoride concentrations in TW-37 do not increase during wet periods.

Fluoride concentrations in TW-22 and TW-24 increased during both periods of above-average precipitation (mid to late 1990s and 2005 to 2006). There is a greater increase in fluoride concentrations in TW-24 during both periods.

The increase in fluoride concentrations in TW-22 and TW-24 indicates a source for fluoride is present between the location of TW-37 and the location of TW-22 and TW-24. The Fenceline well TW-20 shows an increase in fluoride concentrations between about 2004 and 2006. Based on the estimated groundwater velocity, this likely represents the peak that was observed in TW-22 and TW-24 in the mid to late 1990s. A similar peak is expected in TW-20 in 5 to 7 years.

6.2.1.2.1.8 Cadmium

A time-history plot for cadmium in the wells near the source area and downgradient wells is shown on Figure E-9 (Attachment E). As shown on Figure E-9, cadmium concentrations in TW-37 were generally stable in the 1990s and started to increase in about 2002, and have increased through 2007. In TW-24, the cadmium concentration increased slightly between about 1993 and 1998, and then again between about 2002 and 2005.

Figure E-10 (Attachment E) shows the relationship between cadmium concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the Water Year precipitation. As shown on Figure E-10, cadmium concentrations in TW-57 do not respond to precipitation. Cadmium concentrations in TW-37 did not materially increase during the first period of above average precipitation (mid to late 1990s). Cadmium concentrations in TW-37 were generally decreasing during this time. There was an increase in cadmium concentrations in TW-37 starting in about 2003 and continuing until the present.

Cadmium concentrations in TW-24 increased during both periods of above average precipitation (mid to late 1990s and 2005 to 2006). There was no observable increase in TW-22.

6.2.1.2.1.9 Manganese

A time-history plot for manganese in wells near the source area and downgradient wells is shown on Figure E-11 (Attachment E). As shown on Figure E-11, manganese concentrations in TW-37 were generally decreasing until about 1997, and then relatively stable. In TW-22, manganese concentrations increased between 1995 and 1997, and have gradually decreased since 1998. Manganese concentrations in TW-24 increased starting in about 1999, and decreased in 2005 and 2006.

Figure E-12 (Attachment E) shows the relationship between manganese concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation. As shown on Figure E-12, manganese concentrations in TW-57 do not respond to precipitation. Manganese concentrations in TW-37 do not increase during either period of above-average precipitation. Manganese concentrations in TW-22 and TW-24 increased during the mid to late 1990s, but do not appear to respond to the above-average precipitation in 2005 and 2006.

The increase in manganese concentrations in TW-22 and TW-24, while no increases are observed at TW-37, suggests a source of manganese is present between the location of TW-37 and the location of TW-22 and TW-24.

6.2.1.2.1.10 Selenium

A time-history plot for selenium in wells near the source area and downgradient wells is shown on Figure E-13 (Attachment E). As shown on Figure E-13, there was an increase in selenium concentration in TW-37 between about 1993 and 1995. In TW-22 and TW-24, an increase in selenium concentrations was observed between about 1993 and 2001. A further increase in selenium concentrations was observed in the wells near the source area (TW-37, TW-22, and TW-24) starting in about 2003. Concentrations in these wells declined in 2007.

Figure E-14 (Attachment E) shows the relationship between selenium concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation. As shown on Figure E-14, selenium concentrations in TW-57 do not show a response to precipitation. Selenium concentrations in TW-37 increased during both periods of above average precipitation (mid 1990s and 2005 to 2006).

Selenium concentrations in TW-22 and TW-24 also increased during both periods of above average precipitation (mid to late 1990s and 2005 to 2006).

An increase in selenium concentration is observed in Fenceline wells in about 2001. This confirms the passage of a “slug” of groundwater within the UBZ-2 plume. Comparing the peak selenium concentrations in the source area wells and Fenceline well TW-20 indicates a groundwater velocity of about 2.3 ft/yr (Table 10), slightly higher than earlier estimates (Golder, 2003a) and estimates made from nitrate, chloride, and sulfate data. An increase in selenium concentration was observed in the wells near the source area in 2002 to 2006. Based on the estimated groundwater velocity, this selenium slug is expected to arrive at the Fenceline wells in about 5 to 7 years.

6.2.1.2.1.11 Molybdenum

A time-history plot for molybdenum in wells near the source area and downgradient wells is shown on Figure E-15. As shown on Figure E-15, molybdenum concentration in TW-37 generally decreased

continuously. There was an increase in molybdenum concentration in wells TW-22 and TW-24 in the mid to late 1990s, followed by a decrease in concentrations. Molybdenum concentrations increased in TW-22 in 2005, but a similar increase was not observed in TW-24.

Figure E-16 (Attachment E) shows the relationship between molybdenum concentrations in wells near the Old UFS Ponds (TW-22, TW-24, and TW-37) and the UBZ-2 background well (TW-57) and the deviation from the average Water Year precipitation. As shown on Figure E-16, molybdenum concentrations in TW-57 do not show a response to precipitation. Molybdenum concentrations in TW-37 did not increase during the two periods of above-average precipitation (mid to late 1990s and 2005 to 2006).

Molybdenum concentrations in TW-22 and TW-24 increased during the periods of above-average precipitation in mid to late 1990s, with a greater increase observed in TW-24. During the period of above-average precipitation in 2005 and 2006, molybdenum concentrations in TW-24 increased significantly, while there is little, if any, increase in TW-22.

The observations suggest a source of molybdenum is present between the location of TW-37 and the location of TW-22 and TW-24.

An increase in molybdenum concentration is observed in the Fenceline wells in about 2001. This suggests passage of a "slug" of groundwater within the UBZ-2 plume. Comparing the peak molybdenum concentrations in the source area wells and Fenceline well TW-20 indicates a groundwater velocity of about 1.1 ft/yr (Table 11), similar to earlier estimates (Golder, 2003a), suggesting little or no retardation of molybdenum is occurring. An increase in molybdenum concentration was observed in the wells near the source area in 2005 to 2006. Based on the estimated groundwater velocity, this molybdenum slug is expected to arrive at the Fenceline wells in about 5 to 9 years.

6.2.1.2.1.12 Summary

The relationship between precipitation and constituent concentrations in wells near the UBZ-2 source area is summarized in Table 12. The relationships are summarized as follows:

- There are two periods of above average precipitation. The first is between about 1995 and 1999, and the second in 2005 and 2006.
- Sulfate in TW-37, TW-22, and TW-24 increases during both periods of above-average precipitation.
- Chloride in TW-37 is decreasing or stable, while chloride in TW-22, and TW-24 increases during the period of above-average precipitation in the mid to late 1990s. During the period of above average precipitation in 2005 and 2006, chloride in TW-37 and TW-24 increases, while there is less of an increase in TW-22.
- Nitrate in TW-37 is stable, while nitrate in, TW-22 and TW-24 increases during the period of above average precipitation in the 1990s. During the period of above-average precipitation in 2005 and 2006, nitrate in TW-37 increases, while there is less of an increase in TW-22 and TW-24. Nitrate is the only constituent that shows an increase in response to precipitation in the background well (TW-57).
- Fluoride in TW-37 does not increase during wetter periods. Fluoride in TW-22 and TW-24 increases during both periods of above-average precipitation.

- Cadmium in TW-37 does not increase during the period of above average precipitation in the 1990s, but does increase during the wet period in 2005 and 2006. Cadmium in TW-22 and TW-24 increases during the period of above-average precipitation in the 1990s. During the period of above-average precipitation in 2005 and 2006, cadmium TW-24 increases, while there is less of an increase in TW-22.
- Manganese in TW-37 did not increase during in the late 1990s, near the end of the first period of above average precipitation, and was stable during the wet period in 2005 and 2006. Manganese in TW-22 and TW-24 increases during the period of above-average precipitation in the mid to late 1990s. During the wet period in 2005 and 2006, there is little manganese increase in both TW-22 and TW-24.
- Selenium in TW-37, TW-22, and TW-24 increases during both periods of above-average precipitation (mid to late 1990s and 2005 to 2006).
- Molybdenum in TW-37 does not increase in wet periods. Molybdenum in TW-22 and TW-24 increases during both periods of above-average precipitation.
- Groundwater velocities calculated by determining the arrival of peak concentrations at the downgradient wells suggest the groundwater velocity is in the range of 1 to 2 ft/d.
- The increases in concentration during wet periods suggest that the Old UFS Ponds and/or underlying vadose zone are an intermittent source for sulfate, chloride, nitrate, selenium, and cadmium, but not a source of fluoride, manganese, or molybdenum.
- There appears to be another source area near wells TW-22 and TW-24 that intermittently releases sulfate, chloride, nitrate, fluoride, selenium, cadmium, manganese, and molybdenum.
- The increases in concentrations in the source areas associated with wet periods generally dissipate within 1 to 2 years after the wet period ends. This is confirmed by statistical analyses that indicate generally stable or decreasing concentration trends in the UBZ-2 (Table 7).

6.2.1.2.2 Groundwater Velocities

The groundwater velocity used in the GoldSim Model was 1 foot per day, and the hydraulic conductivity was estimated to be about 40 feet per day (Golder, 2003a). The groundwater quality data were reevaluated using the data collected between 2002 and 2007 to estimate the groundwater velocity and hydraulic conductivity. The results are summarized in Table 11. The analyses indicate the groundwater velocity ranges from about 0.8 to 2 ft/d, and the hydraulic conductivity ranges from about 33 to 220 ft/d. Given the close approximation of the groundwater velocity estimated from observations and that used in the GoldSim Model, the model is considered representative of the site conditions.

6.3 Technical Issues

EPA (2003) also raised the following three technical issues that did not lead to concerns over the protectiveness of the groundwater remedy but were details that required resolution:

> *Three related technical matters that don't lead to EPA concerns about the protectiveness of the MNA remedy for groundwater, but are necessary details to be resolved with Monsanto based on this five year review are 1) increasing molybdenum concentrations south of the operating area; 2) use of total nitrogen as nitrate for demonstrating compliance with the MCL; and 3) annual*

sampling, analyses, and trend evaluation reporting of Soda Creek discharge concentrations at a level of detail similar to annual and five-year review groundwater reporting.

The responses to these technical issues are discussed in Sections 6.3.1 to 6.3.3 below.

6.3.1 Molybdenum Concentrations

The first five-year review indicated statistically significant increases in molybdenum concentrations in TW-53 and the Harris Well, both located south of the Plant Fenceline (Golder, 2003a). Molybdenum hydrographs for wells and springs at the Monsanto site are included in Attachment F. The observed increases likely represent passage of a molybdenum plume that was observed in the Fenceline wells between about 1990 and 1994 and the Southern Boundary wells between about 1995 and 1999. The observed increases of molybdenum concentration at the Fenceline and Southern Boundary are consistent with estimates of the groundwater velocity at the site (Table 11). TW-22 and TW-37 have statistically significant decreasing molybdenum concentrations between 1991 and 2007 (Table 5) and 2000 to 2007 (Table 7). However, there is a short-term increase in molybdenum concentrations in TW-22 and TW-24 during the mid to late 1990s and in TW-24 during 2005 to 2006. These short-term increases in concentration were not observed in TW-37 (Figure F-7, Attachment F).

The additional source release observed in TW-22 and TW-24 in the mid to late 1990s appears to have migrated to the downgradient Fenceline well TW-20 (Figure F-2 in Attachment F). Molybdenum concentrations started to increase in TW-20 in about 2001, and reached a peak concentration in about 2005. The observed increase in TW-20 is consistent with the estimated groundwater velocities in UBZ-2 (Table 11). Molybdenum concentrations started to increase in about 2005 in Southern Boundary well TW-54.

The statistical analyses completed as part of the second five-year review for 2000 to 2007 indicates either stable concentrations or no significant concentration trend for molybdenum at either TW-53 or the Harris Well.

The statistical analyses competed as part of the second five-year review indicate increasing molybdenum concentrations in the plant area (PW-01, PW-02, PW-03), and in the Fenceline wells (TW-20) between 2000 and 2007 (Table 7).

In the plant area (UBZ-4), there is a statistically significant increase in molybdenum concentrations in PW-01, PW-02, and PW-03 (Figure F-1 in Attachment F). Molybdenum concentrations are decreasing in well TW-17 near the Northwest Pond, and are stable in other wells near source areas (TW-16 near the Northwest Pond and TW-40 near the Old Hydroclarifier; Attachment F Figures F-6 and F-9, respectively). Molybdenum concentrations are also decreasing in well TW-38, downgradient of the production wells (Figure F-13 in Attachment F). The decreasing or stable concentrations in the wells near the source area and in the downgradient wells suggest the production wells are containing the molybdenum plume. This is confirmed by comparison of the molybdenum isopleth maps in 2002 and 2007 (Figures 13a and 13b, respectively), which indicate the areal extent of the molybdenum plume has been stable between 2002 and 2007.

6.3.2 Use of Total Nitrogen as Nitrate for Demonstrating Compliance with MCL

In the Record of Decision for the Monsanto site (EPA, 1997), the remedial goal for nitrate is specified as 44 mg/L (expressed as nitrate). The analytical data presented for nitrate at the Monsanto Soda Springs site are reported as nitrate expressed as nitrogen. The equivalent remedial goal for nitrate expressed as nitrogen is 10 mg/L.

6.3.3 Soda Creek

The effluent discharge to Soda Creek has been sampled at the discharge location since 2000. Three samples were collected at the discharge location during each sampling period. Surface water sampling stations were established on Soda Creek upstream and downstream of the effluent discharge in 2001 (Figure 2). In 2005, sampling at the irrigation diversion weir downstream of the effluent discharge location was initiated. Mormon Creek, which discharges to Soda Creek downstream of the effluent discharge location and upstream of the downstream sampling location (Figure 2), was added to the annual sampling starting in 2002.

Statistical analyses of the water quality data were not included in the first five-year review because there was insufficient data at that time to complete the analyses. The water quality data from these locations were visually evaluated for trends in the annual reports. Statistical analyses of water quality trends at these locations (the effluent discharge, Soda Creek upstream and downstream of the effluent discharge, and Mormon Creek) have been completed as part of the second five-year review and are included in Section 5.3 of this report, and summarized on Table 7. The statistical analyses indicate the concentrations of the constituents of concern in the effluent discharge, surface water upstream and downstream of the effluent discharge, and in Mormon Creek are stable, with no statistically significant concentration trends for any of the constituents of concern, with the exception of a significant decreasing concentration trend for chloride in Mormon Creek.

Mormon Creek is a tributary to Soda Creek. Mormon Creek is not a point of compliance location, but is included as one of the annual sampling locations. Selenium is above the remedial goal of 0.05 mg/L in Mormon Creek, which is a spring-fed creek formed by the discharge of Mormon A, B, and C Springs and Calf Spring. Mormon A Spring is the largest tributary to Mormon Creek. Selenium concentrations remain above the remedial goal in Mormon A Spring consistent with the passage of the UBZ-2 selenium plume. The revised solute transport model predicts selenium concentrations to decrease below the remedial goal in about 2017 in Mormon A Spring (Section 5.5.3.4). Thus, selenium concentrations in Mormon Creek should also decline below the remedial goal. Selenium concentrations in Soda Creek downstream of Mormon Creek remain below the remedial goal.

7.0 TECHNICAL ASSESSMENT

The EPA document *Comprehensive Five-Year Review Guidance* (EPA, 2001) provides guidance for conducting five-rear reviews. EPA (2001) recommends that the following three questions be answered in the technical assessment:

- Question A: Is the remedy functioning as intended by the decision documents?
- Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy still valid?
- Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

7.1 Attainment of Question A

This section describes the effectiveness of the chosen remedies for groundwater in the UBZ-2 and UBZ-4 zones. The chosen remedy in the UBZ-2 zone is monitored natural attenuation. The chosen remedy in the UBZ-4 zone is also monitored natural attenuation. In the UBZ-4 region, pumping of the plant production wells controls the off-site migration of affected groundwater. Institutional controls are also in place for groundwater in the UBZ-2 and UBZ-4 zones.

7.1.1 Institutional Controls

Institutional controls are in place in the UBZ-2 and UBZ-4 zones (Figure 2) to restrict the use of groundwater that may not meet the remedial goals. The institutional controls in place include the following:

- Monsanto has purchased property downgradient of the plant site, including properties with wells that were impacted by the site releases in UBZ-2. Access to these properties is controlled and the properties will not be developed. No wells will be developed on these properties and access to the springs on these properties is restricted.
- Monsanto supplied drinking water from the Soda Springs municipal system to the one downgradient residence with a domestic well that was impacted by the site (Lewis Well). The domestic well is no longer used for water supply.

The institutional controls in place south of the plant are an appropriate remedy and are functioning as intended. Affected groundwater from this area is not being used for domestic purposes, and controls are in place to prevent future development of groundwater in this area.

7.1.2 UBZ-2 Monitored Natural Attenuation

Monitored natural attenuation is the chosen remedy in the UBZ-2 zone (Figure 2). Monsanto monitors groundwater quality annually in the point of compliance wells and springs in this region, and also monitors water quality in several other wells and springs in the UBZ-2 zone. The groundwater quality for the constituents of concern in the UBZ-2 zone is summarized in Tables 3 and 7, and below.

- Nitrate and fluoride currently meet the remedial goals in all point of compliance wells with the exception of nitrate in one well (TW-20) at the Plant Fenceline, where the nitrate concentration is slightly above the remedial goal. Nitrate concentrations are generally

stable or decreasing at the point of compliance wells, except for TW-20, TW-54, and the Harris Well. Fluoride concentrations in the downgradient wells are generally stable or decreasing, with the exception of TW-20, and fluoride remains below the remedial goal in all downgradient wells.

- Manganese meets the remedial goals at all point of compliance wells and has generally stable or decreasing concentrations in the wells in the UBZ-2 zone. Manganese in TW-34 is the result of the upwelling of sodic water from the LBZ that contains naturally occurring elevated manganese (Golder, 1995). Manganese is highly retarded and the manganese plume may not arrive at the point of compliance wells in concentrations that exceed the remedial goal.
- Selenium concentrations exceed the remedial goal in several of the Fenceline wells and Southern Boundary wells (TW-20, TW-39, TW-53, and TW-54) and in the Harris Well and Mormon A Spring. Selenium is also above the remedial goal in Mormon Creek (not a point of compliance location), but remains below the remedial goal in Soda Creek downstream of Mormon Creek. The selenium concentrations in these wells and in Mormon Creek are generally stable or declining and modeling indicates the concentrations of selenium should fall below the remedial goal within 20 years or less at these locations.
- Cadmium meets the remedial goals at all point of compliance wells except for TW-20 and TW-39. Exceedances at these wells are believed to be temporary as a result of cadmium-chloride or cadmium sulfate complexes related to elevated chloride and sulfate concentrations from the Old UFS Ponds. Cadmium is generally stable or decreasing in the remaining wells in the UBZ-2 zone. Cadmium is highly retarded and once the chloride and sulfate plumes have dissipated, the cadmium plume is not expected to reach the point of compliance wells in the UBZ-2 zone in concentrations that exceed the remedial goal.

Based on the results of the annual groundwater sampling and modeling, concentrations of the constituents of concern that are not retarded either currently meet the remedial goals or are anticipated to meet them within the next 20 years, with the exception of cadmium in TW-20 and TW-39. Future cadmium concentrations in these wells are difficult to predict because of transport of cadmium as a complex with chloride and sulfate. The concentrations of highly retarded constituents (manganese and cadmium) may never reach the point of compliance wells at concentrations that exceed the remedial goals.

Concentrations of constituents of concern increased from about 2000 and 2005 in the Fenceline wells because of the passage of a "slug" of groundwater within the UBZ-2 plume with elevated concentrations. This slug was related to a release from a source area(s) in the mid 1990s during a period of above-average precipitation. The potential source is either infiltration of precipitation through the cap at the Old UFS Ponds, which were closed and capped in the late 1980's (Golder 1995) and/or release from the vadose zone below the cap as a result of the fluctuating groundwater level. Concentrations in the Fenceline wells began to decrease in 2006 and 2007. Similar increases related to above-average precipitation could occur in the future.

Between 2002 and 2007, the extent of the plume of mobile constituents increased slightly, while the plume extent for retarded constituents remained stable. The southern extent of the UBZ-2 plume was delineated by four monitoring wells installed in 2007. The extent of groundwater in UBZ-2 with concentrations above the remedial goals does not extend to the monitoring wells installed in 2007 (Golder, 2007b), and thus remains on Monsanto property.

Monitored natural attenuation is an appropriate remedy for the UBZ-2 zone. Monsanto has expanded the monitoring network downgradient of the Southern Boundary wells and has committed to continue the annual monitoring of the point of compliance wells and other wells and springs in the UBZ-2 region. The area of groundwater that exceeds the remedial goals in the UBZ-2 remains on Monsanto property.

7.1.3 UBZ-4 Region

Monitored natural attenuation plus containment using the plant production wells is the chosen remedy in the UBZ-4 zone (Figure 2). Monsanto monitors groundwater quality annually in the point of compliance wells (plant production wells) in this region, and also monitors water quality in several other wells in the UBZ-4 zone. The groundwater quality of the constituents of concern in the UBZ-4 zone is summarized as follows:

- Fluoride and nitrate, the most mobile (conservative) constituents, meet remedial goals in the point of compliance wells. Nitrate and fluoride are stable in all of the production wells.
- Selenium concentrations meet the remedial goal in all production wells, and selenium concentrations in the production wells are generally stable.
- Manganese concentrations meet the remedial goals in all of the plant production wells, and are stable.
- Cadmium concentrations meet the remedial goals in PW-02 and PW-03. Cadmium concentrations exceed the remedial goal in PW-01; however, cadmium concentrations have a significant decreasing concentration trend. Cadmium is highly retarded and may take tens of years to meet the remedial goal.

Based on the results of the annual groundwater sampling, concentrations of the fluoride, nitrate, and selenium that are not retarded and manganese currently meet the remedial goals. The concentrations of cadmium, a highly retarded constituent, may take years to meet remedial goals. The continuous pumping of the plant production wells contains affected groundwater and prevents off-site migration.

Monitored natural attenuation in conjunction with containment by the plant production wells and institutional controls are appropriate remedies for the UBZ-4 zone. Monsanto has committed to continue the annual monitoring of the point of compliance wells and other wells and springs in the UBZ-4 region.

7.1.4 Attainment of Question A

Based on the results of the annual water quality monitoring and transport modeling, the chosen remedies for groundwater in the UBZ-2 and UBZ-4 regions are functioning as intended and are therefore appropriate remedies.

7.2 Attainment of Question B

This section describes any changes in the factors that were considered in the ROD for the constituents of concern for groundwater. The constituents of concern identified in the ROD are cadmium, selenium, fluoride, nitrate, and manganese. The remedial goals for the constituents of concern are the MCLs under the Safe Drinking Water Act for cadmium, fluoride, nitrate, and selenium, and a risk-based concentration for manganese.

7.2.1 Changes in Standards and To Be Considereds (TBCs)

The remedial goals for cadmium, selenium, nitrate, and fluoride are the MCLs under the Safe Drinking Water Act as follows:

- Cadmium: 0.005 mg/L
- Selenium: 0.05 mg/L
- Nitrate: 10 mg/L (as nitrogen)
- Fluoride: 4 mg/L

The MCLs for these constituents have not changed since the RI was completed in 1995. Therefore, the remedial goals for these constituents remain valid and protective for groundwater at the Monsanto site.

The remedial goal for manganese is 0.18 mg/L. The remedial goal for manganese is a risk-based concentration. There have been no changes in the exposure pathways or toxicity values for manganese. Therefore, the remedial goal for manganese remains valid and protective for the Monsanto site.

7.2.2 Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

This section describes the changes, if any, in exposure pathways, toxicity, and other contaminant characteristics that could affect the choice of remedy of the remedial goals of the remedy.

7.2.2.1 Exposure Pathways

The following listed items show that there have been no changes in potential exposure pathways near the site since the completion of RI activity:

- The land use and the proposed land use in the vicinity of the site, including downgradient of the plant site, has not changed.
- Institutional controls are in place and functioning as intended.
- There are no newly identified or changed human health or ecological routes of exposure or receptors.
- There are no newly-identified contaminants or sources of contamination at the site. All previously identified sources of contamination have been closed. In the UBZ-2, constituents are being transported from source areas during periods of above-average precipitation, resulting in the migration of “slugs” of groundwater with elevated concentrations. During periods of average or below average precipitation, source area concentrations are generally decreasing. Overall, constituent concentrations in Old UFS Ponds area wells are declining.
- There have been no unanticipated deleterious byproducts of the remedy since it was instituted, and none are anticipated.
- There have been no changes in the physical conditions of the site that would affect the transport of the contaminants or the protectiveness of the remedy. The GoldSim Model is

predicting the long-term water quality reasonably well. These changes do not affect the protectiveness of the remedy.

7.2.2.2 Toxicity

There have been no changes in the toxicity of the constituents of concern since the ROD was issued.

7.2.2.3 To Be Considereds

There were no To Be Considereds identified in the ROD.

7.3 Attainment of Question C

The protectiveness of the chosen remedy for groundwater at the site is appropriate because of the following reasons:

- Concentrations of the constituents of concern in groundwater are either generally stable or decreasing and projected to meet RGs within about 20 years for most constituents.
- There are no known groundwater users downgradient of the site.
- Institutional controls for groundwater are in place and functioning as intended.
- There are no changes in the land use or planned land use for property purchased by Monsanto for institutional controls, and access to groundwater resources (wells and springs) on these properties is controlled.
- Transport modeling indicates that highly retarded constituents (cadmium and manganese) may not reach the point of compliance wells at concentrations that exceed the remedial goals.
- Monsanto has committed to long-term monitoring of groundwater quality and operation of the production wells to control the off-site migration of affected groundwater.

7.4 Technical Assessment Summary

According to the data reviewed and the transport modeling, the remedy is functioning as intended by the ROD. The concentrations of the constituents of concern are either generally stable or declining. The remedial goals for fluoride are being met at the points of compliance, and nitrate is slightly above the remedial goal in one Fenceline well. Cadmium occurs above the RGs in two Fenceline wells and one plant production well. The exceedences in the Fenceline wells are likely related to greater cadmium solubility due to the formation of cadmium chloride or cadmium sulfate complexes from elevated chloride and sulfate concentrations from the Old UFS Ponds source area. Chloride and sulfate concentrations are declining and once these plumes have dissipated; cadmium transport will be dominated by the distribution coefficient (highly retarded). Manganese only exceeds the RG in TW-34 (a well completed in a transition zone between the UBZ and LBZ that contains naturally elevated manganese). The use of this well as a point of compliance should be discontinued. Well TW-35 is completed in a similar zone and should also be discontinued. Selenium concentrations exceed the RG at the Fenceline (two wells), Harris Well, and Southern Boundary wells (2 wells). Concentrations at these locations are generally declining or stable. The GoldSim modeling indicates selenium should meet the RGs in 20 years.

There have been some short-term increases in concentration of several conservative constituents at the fenceline (chloride, fluoride, nitrate, selenium, molybdenum, and sulfate) in the UBZ-2. The increases in concentration are related to periods of above-average precipitation that result in the transport of constituents to groundwater from the source area (Old UFS Ponds). The transport of constituents from the source area resulted in the passage of a "slug" of groundwater with elevated concentrations. It is likely that similar increases will occur in the future during periods of above-average precipitation. Concentrations are expected to decrease during periods of average or below average precipitation. Long-term concentration trends in the UBZ-2 source area wells are generally stable or declining. It is possible an extended period of above-average precipitation could result in additional releases to groundwater that could result in increased concentrations at the point of compliance wells and extend the time required to meet the remedial goals.

There have been no changes in the physical conditions at the site, the methods used to develop the risk assessment or the toxicity factors for the constituents of concern.

7.5 Issues

No issues requiring further investigation of the groundwater at the Monsanto site or action were discovered during the course of the five-year review.

The EPA first five-year review (EPA, 2003) commented on several issues related to groundwater. These issues were discussed in Section 6.

7.6 Recommendations and Follow-Up Actions

The following are recommendations for the continued performance of the implemented remedies for groundwater at the Monsanto site:

- The annual groundwater monitoring program should be continued with the addition of the monitoring wells drilled in 2007.
- The annual groundwater quality reports should be continued.
- The effectiveness of the chosen remedies should be reevaluated in the next five-year review in 2013.

7.7 Protectiveness Statement

Based on the information review conducted as part of the five-year review process, the remedies contained in the ROD for groundwater at the Monsanto Soda Springs site are functioning as intended and are protective of human health and the environment.

8.0 REFERENCES

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TABLES

2007 Results Compared to Remedial Goals

Location	UBZ Zone	Cadmium (mg/L)	Q	Fluoride (mg/L)	Q	Manganese (mg/L)	Q	Nitrite as N (mg/L)	Q	Selenium (mg/L)	Q
REMEDIAL GOAL		**0.005**		**4**		**0.18**		**10**		**0.05**	
Groundwater											
Harris Well	UBZ-2	0.00032	B	2.54		0.0026	B	8.96		0.123	
TW-20	UBZ-2	0.0068		2.05	J	<0.0009	U	10.5		0.0847	
TW-20 (duplicate)	UBZ-2	0.0052		3.09	J	<0.0007	U	11.4		0.0798	
TW-34	UBZ-2	<0.0003	U	0.6	J	0.222*		0.034		0.0011	
TW-35	UBZ-2	<0.0003	U	<0.1	UJ	0.158		0.021		0.003	U
TW-35 (split)	UBZ-2	<0.0002	U	<1	U	0.151		<0.01	U	<0.002	U
TW-39	UBZ-2	0.0093		3.34	UJ	<0.0007	UJ	9.56		0.125	
TW-53	UBZ-2	<0.0006	U	2.92	UJ	<0.0007	UJ	7.15		0.115	
TW-54	UBZ-2	<0.0006	U	3.66	UJ	<0.0007	UJ	9.7		0.0849	
TW-54 (duplicate)	UBZ-2	<0.0006	U	3.68	UJ	<0.0007	UJ	9.69		0.085	
TW-55	UBZ-2	<0.0006	U	0.26	UJ	<0.0007	UJ	4.15		0.0413	
TW-55 (split)	UBZ-2	<0.0002	U	<1	U	<0.001	UJ	3.88		0.12	
PW-01	UBZ-4	0.0314		0.89		<0.0007	U	4.56		0.0167	
PW-02	UBZ-4	0.0016	B	0.46		<0.0007	U	3.74		0.0064	
PW-03	UBZ-4	0.0014	B	0.21		<0.0007	U	3.64		0.0043	
PW-04	UBZ-4	<0.0003	U	0.41		<0.0008	U	4.23		<0.003	U
Surface Water											
Soda Down	na	<0.0006	U	0.71		0.114		0.993		0.0112	
Soda Up	na	<0.0006	U	0.51		0.125		0.304		0.00042	B

Note: Shaded cells indicate remediation goal is exceeded.

* natural background

Summary of Cadmium Statistical Analyses 1991 to 2007

Cadmium (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-3.17	-0.0037	Significant	⇩	⇩
	PW-02	17	-3.59	-0.0007	Significant	⇩	⇩
	PW-03	17	-3.63	-0.0003	Significant	⇩	⇩
	PW-04	17	-0.21	0.0000	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	12	-3.30	-0.0011	Not Significant	⇔	⇩
	TW-34	17	-0.47	0.0000	Not Significant	⇔	⇔
	TW-35	17	-0.86	0.0000	Not Significant	⇔	⇔
	TW-39	17	-2.06	-0.0004	Significant	⇩	⇔
Southern Boundary Wells	TW-53	16	-0.24	0.0000	Not Significant	⇔	⇔
	TW-54	16 (15)	-0.50 (-0.81)	0.000 (0.000)	Not Significant	⇔	⇔
	TW-55	16	-0.52	0.0000	Not Significant	⇔	⇔
	TW-56	16	-0.43	0.0000	Not Significant	⇔	⇔
Springs	MORMON A SPRING	17	0.41	0.0000	Not Significant	⇔	⇔
	HARRIS WELL	17	-0.97	0.0000	Not Significant	⇔	⇔
NW Pond Wells	TW-16	17	-3.64	-0.0127	Significant	⇩	⇩
	TW-17	16	-0.27	0.0000	Not Significant	⇔	⇔
	TW-18	16	-0.47	0.0000	Not Significant	⇔	⇔
Underflow Solids Pond Area Wells	TW-22	17	-0.25	-0.0001	Not Significant	⇔	⇔
	TW-24	16	1.89	0.0042	Not Significant	⇔	⇔
	TW-37	17	0.99	0.0045	Not Significant	⇔	⇔
	TW-45	17	-3.67	-0.0006	Significant	⇩	⇩
Old Hydroclarifier Wells	TW-40	15	-0.49	-0.0729	Not Significant	⇔	⇔
	TW-44	17	-0.58	-0.0001	Not Significant	⇔	⇔
Wells and Springs South of Plant	CALF SPRING	13	0.43	0.0001	Not Significant	⇔	⇔
	Lewis Well	17	-0.80	0.0000	Not Significant	⇔	na
	HOMESTEAD SPRING	17	-0.30	0.0000	Not Significant	⇔	⇔

Note: Results in parenthesis indicate results from calculation with anomalous values removed.

Summary of Fluoride Statistical Analyses 1991 to 2007

Fluoride (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-1.48	-0.024	Not Significant	⇔	⇔
	PW-02	17	0.04	0.002	Not Significant	⇔	⇧
	PW-03	17	-1.36	-0.011	Not Significant	⇔	⇧
	PW-04	17	1.77	0.010	Not Significant	⇔	⇧
South Fenceline Wells	TW-20	12	-3.50	-0.533	Significant	⇩	⇩
	TW-34	17	-0.37	-0.005	Not Significant	⇔	⇔
	TW-35	17	-0.58	-0.005	Not Significant	⇔	⇧
	TW-39	17	-3.84	-0.205	Significant	⇩	⇔
Southern Boundary Wells	TW-53	16	1.40	0.071	Not Significant	⇔	⇧
	TW-54	16	-3.02	-0.253	Significant	⇩	⇩
	TW-55	16	0.90	0.009	Not Significant	⇔	⇧
	TW-56	16	0.36	0.004	Not Significant	⇔	⇧
Springs	MORMON A SPRING	17	-1.20	-0.081	Not Significant	⇔	⇔
	HARRIS WELL	17	0.58	0.028	Not Significant	⇔	⇧
NW Pond Wells	TW-16	17	-3.88	-0.122	Significant	⇩	⇩
	TW-17	16	-2.52	-0.046	Significant	⇩	⇩
	TW-18	16	-0.63	-0.004	Not Significant	⇔	⇧
Underflow Solids Pond Area Wells	TW-22	17	-2.52	-0.168	Significant	⇩	⇔
	TW-24	16	-1.31	-0.136	Not Significant	⇔	⇔
	TW-37	17	-3.84	-0.378	Significant	⇩	⇩
	TW-45	17	-1.69	-0.017	Not Significant	⇔	⇔
Old Hydroclarifier Wells	TW-40	15	-0.69	-0.074	Not Significant	⇔	⇔
	TW-44	17	1.81	0.017	Not Significant	⇔	⇧
Wells and Springs South of Plant	CALF SPRING	13	-0.24	-0.017	Not Significant	⇔	⇔
	Lewis Well	17	0.00	0.0005	Not Significant	⇔	na
	HOMESTEAD SPRING	17	0.99	0.006	Not Significant	⇔	⇧

Note: Shaded cells indicate a significant increasing concentration trend

Summary of Manganese Statistical Analyses 1991 to 2007

Manganese (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	0.30	0.0000	Not Significant	⇔	⇔
	PW-02	17	0.00	0.0000	Not Significant	⇔	⇔
	PW-03	17	0.08	0.0000	Not Significant	⇔	⇔
	PW-04	17	0.08	0.0000	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	12	-0.14	0.0000	Not Significant	⇔	⇔
	TW-34	17	-0.37	-0.0012	Not Significant	⇔	⇔
	TW-35	17	1.40	0.0008	Not Significant	⇔	⇔
	TW-39	17	0.30	0.0000	Not Significant	⇔	⇔
Southern Boundary Wells	TW-53	16	-0.27	0.0000	Not Significant	⇔	⇔
	TW-54	16	-1.54	-0.0001	Not Significant	⇔	⇔
	TW-55	16	0.23	0.0000	Not Significant	⇔	⇔
	TW-56	16	-2.08	-0.0009	Significant	⇩	⇔
Springs	MORMON A SPRING	17	0.47	0.0000	Not Significant	⇔	⇔
	HARRIS WELL	17	0.08	0.0000	Not Significant	⇔	⇔
NW Pond Wells	TW-16	17	-2.36	-0.0022	Significant	⇩	⇩
	TW-17	16	4.87	0.0818	Significant	⇧	⇧
	TW-18	16	2.57	0.0041	Significant	⇧	⇔
Underflow Solids Pond Area Wells	TW-22	17	-1.85	-0.0137	Not Significant	⇔	⇔
	TW-24	16	0.00	-0.0001	Not Significant	⇔	⇔
	TW-37	17	-2.60	-0.0257	Significant	⇩	⇔
	TW-45	17	-4.16	-0.0124	Significant	⇩	⇩
Old Hydroclarifier Wells	TW-40	15	-3.86	-0.0241	Significant	⇩	⇩
	TW-44	17	1.36	0.0013	Not Significant	⇔	⇔
Wells and Springs South of Plant	CALF SPRING	13	0.13	0.0000	Not Significant	⇔	⇔
	Lewis Well	17	-0.58	0.0000	Not Significant	⇔	na
	HOMESTEAD SPRING	17	0.74	0.0003	Not Significant	⇔	⇔

Note: Shaded cells indicate a significant increasing concentration trend

Summary of Nitrate as N Statistical Analyses 1991 to 2007

Nitrate (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-1.73	-0.0444	Not Significant	⇔	⇔
	PW-02	17	-1.77	-0.0783	Not Significant	⇔	⇔
	PW-03	17	-1.65	-0.0664	Not Significant	⇔	⇔
	PW-04	17	0.37	0.0044	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	12	-2.26	-0.3275	Not Significant	⇔	⇩
	TW-34	17	0.12	0.0006	Not Significant	⇔	⇔
	TW-35	17	-0.46	-0.0009	Not Significant	⇔	⇔
	TW-39	17	0.50	0.0442	Not Significant	⇔	⇔
Southern Boundary Wells	TW-53	16	-0.50	-0.0497	Not Significant	⇔	⇔
	TW-54	16	0.63	0.0988	Not Significant	⇔	⇩
	TW-55	16	0.14	0.0011	Not Significant	⇔	⇔
	TW-56	16	1.49	0.0700	Not Significant	⇔	⇔
Springs	MORMON A SPRING	17	3.17	0.2784	Significant	⇧	⇔
	HARRIS WELL	17	1.85	0.2333	Not Significant	⇔	⇔
NW Pond Wells	TW-16	17	-0.87	-0.0559	Not Significant	⇔	⇔
	TW-17	16	-0.41	-0.0007	Not Significant	⇔	⇔
	TW-18	16	-2.78	-0.0023	Significant	⇩	⇔
Underflow Solids Pond Area Wells	TW-22	17	-0.54	-0.0631	Not Significant	⇔	⇔
	TW-24	16	-0.27	-0.0085	Not Significant	⇔	⇔
	TW-37	17	3.01	0.2595	Significant	⇧	⇔
	TW-45	17	-3.76	-0.0054	Significant	⇩	⇩
Old Hydroclarifier Wells	TW-40	15	0.55	0.2857	Not Significant	⇔	⇔
	TW-44	17	-2.17	-0.0039	Significant	⇩	⇔
Wells and Springs South of Plant	CALF SPRING	13	1.65	0.1853	Not Significant	⇔	⇔
	Lewis Well	17	-0.37	-0.04	Not Significant	⇔	na
	HOMESTEAD SPRING	17	3.34	0.2837	Significant	⇧	⇔

Note: Shaded cells indicate a significant increasing concentration trend

Summary of Selenium Statistical Analyses 1991 to 2007

Selenium (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-0.10	-0.0004	Not Significant	⇔	⇔
	PW-02	17	-0.74	-0.0003	Not Significant	⇔	⇔
	PW-03	17	-1.15	-0.0004	Not Significant	⇔	⇔
	PW-04	17	1.32	0.00008	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	17 (16)	0.37 (0.14)	0.002 (0.002)	Not Significant	⇔	⇔
	TW-34	17	0.95	0.0003	Not Significant	⇔	⇔
	TW-35	17	-0.21	0.0000	Not Significant	⇔	⇔
	TW-39	17	-2.23	-0.0172	Significant	⇩	⇔
Southern Boundary Wells	TW-53	16	-0.32	-0.0025	Not Significant	⇔	⇔
	TW-54	16 (15)	-0.50 (-0.79)	-0.004 (-0.008)	Not Significant	⇔	⇔
	TW-55	16	-1.76	-0.0079	Not Significant	⇔	⇩
	TW-56	16	1.15	0.0000	Not Significant	⇔	⇔
Springs	MORMON A SPRING	17	2.72	0.0084	Significant	⇧	⇧
	HARRIS WELL	17	0.29	0.0022	Not Significant	⇔	⇔
NW Pond Wells	TW-16	17	-1.15	-0.0037	Not Significant	⇔	⇔
	TW-17	16	-1.17	-0.0002	Not Significant	⇔	⇔
	TW-18	16	-0.91	0.0000	Not Significant	⇔	⇔
Underflow Solids Pond Area Wells	TW-22	17	-0.16	-0.0003	Not Significant	⇔	⇔
	TW-24	16	-1.22	-0.0090	Not Significant	⇔	⇔
	TW-37	17	-0.37	-0.0040	Not Significant	⇔	⇔
	TW-45	17	-0.70	-0.0001	Not Significant	⇔	⇔
Old Hydroclarifier Wells	TW-40	15	1.88	0.0436	Not Significant	⇔	⇧
	TW-44	17	-1.14	-0.0001	Not Significant	⇔	⇔
Wells and Springs South of Plant	CALF SPRING	13	-0.55	-0.0067	Not Significant	⇔	⇔
	Lewis Well	17	-2.19	-0.0019	Significant	⇩	na
	HOMESTEAD SPRING	17	0.00	0.0000	Not Significant	⇔	⇧

Note: Shaded cells indicate a significant increasing concentration trend

Results in parenthesis indicate results from calculation with anomalous values removed.

Summary of Chloride Statistical Analyses 1991 to 2007

Chloride (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-1.29	-2.29	Not Significant	⇔	⇩
	PW-02	17	1.94	1.27	Not Significant	⇔	⇔
	PW-03	17	1.15	0.43	Not Significant	⇔	⇔
	PW-04	17	-0.04	0.00	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	12	-2.47	-7.38	Not Significant	⇔	⇩
	TW-34	17	-0.04	-0.08	Not Significant	⇔	⇔
	TW-35	17	-0.82	-0.22	Not Significant	⇔	⇩
	TW-39	17	-4.29	-6.60	Significant	⇩	⇩
Southern Boundary Wells	TW-53	16	0.77	0.90	Not Significant	⇔	⇔
	TW-54	16	-1.26	-2.84	Not Significant	⇔	⇩
	TW-55	16	-1.22	-1.25	Not Significant	⇔	⇩
	TW-56	16	-3.65	-2.38	Significant	⇩	⇔
Springs	MORMON A SPRING	17	-1.65	-1.73	Not Significant	⇔	⇩
	HARRIS WELL	17	1.81	3.49	Not Significant	⇔	⇔
NW Pond Wells	TW-16	17	1.07	0.61	Not Significant	⇔	⇔
	TW-17	16	-4.20	-6.37	Significant	⇩	⇩
	TW-18	16	0.36	0.03	Not Significant	⇔	⇔
Underflow Solids Pond Area Wells	TW-22	17	-1.69	-2.59	Not Significant	⇔	⇔
	TW-24	16	-0.27	-0.28	Not Significant	⇔	⇔
	TW-37	17	-0.12	-0.03	Not Significant	⇔	⇩
	TW-45	17	-4.45	-2.07	Significant	⇩	⇩
Old Hydroclarifier Wells	TW-40	15	-0.10	-4.10	Not Significant	⇔	⇔
	TW-44	17	2.31	0.47	Significant	⇧	⇧
Wells and Springs South of Plant	CALF SPRING	13	-0.67	-0.85	Not Significant	⇔	⇔
	Lewis Well	17	-2.14	-2.49	Significant	⇩	na
	HOMESTEAD SPRING	17	3.30	0.67	Significant	⇧	⇧

Note: Shaded cells indicate a significant increasing concentration trend

Summary of Molybdenum Statistical Analyses 1991 to 2007

Molybdenum (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	14	-0.22	-0.0001	Not Significant	⇔	⇔
	PW-02	16	2.70	0.0014	Significant	⇧	⇔
	PW-03	16	-0.18	-0.0004	Not Significant	⇔	⇔
	PW-04	16	2.04	0.0003	Significant	⇧	⇔
South Fenceline Wells	TW-20	11	-3.58	-0.0067	Not Significant	⇔	⇔
	TW-34	16	1.44	0.0004	Not Significant	⇔	⇔
	TW-35	16	1.84	0.0003	Not Significant	⇔	⇔
	TW-39	16	-3.11	-0.0034	Significant	⇩	⇔
Southern Boundary Wells	TW-53	16	2.21	0.0021	Significant	⇧	⇧
	TW-54	16	-3.38	-0.0048	Significant	⇩	⇔
	TW-55	16	1.62	0.0003	Not Significant	⇔	⇩
	TW-56	16	1.08	0.0007	Not Significant	⇔	⇔
Springs	MORMON A SPRING	16	-1.44	-0.0016	Not Significant	⇔	⇔
	HARRIS WELL	16	0.59	0.0007	Not Significant	⇔	⇧
NW Pond Wells	TW-16	16	-0.23	-0.0002	Not Significant	⇔	⇔
	TW-17	16	-3.11	-0.0014	Significant	⇩	⇩
	TW-18	15	2.05	0.0006	Significant	⇧	⇔
Underflow Solids Pond Area Wells	TW-22	16	-3.15	-0.0219	Significant	⇩	⇔
	TW-24	16	-0.23	-0.0050	Not Significant	⇔	⇔
	TW-37	16	-3.92	-0.0233	Significant	⇩	⇔
	TW-45	16	-1.80	-0.0008	Not Significant	⇔	⇔
Old Hydroclarifier Wells	TW-40	14	-0.55	-0.0007	Not Significant	⇔	⇔
	TW-44	16	-0.59	-0.0002	Not Significant	⇔	⇔
Wells and Springs South of Plant	CALF SPRING	12	-1.30	-0.0012	Not Significant	⇔	⇔
	Lewis Well	17	-0.37	-0.0016	Not Significant	⇔	na
	HOMESTEAD SPRING	16	0.74	0.0000	Not Significant	⇔	⇔

Note: Shaded cells indicate a significant increasing concentration trend
Results in parenthesis indicate results from calculation with anomalous values removed.

Summary of Sulfate Statistical Analyses 1991 to 2007

Sulfate (1991-2007)	Location	Total # Values (n)	Z-Test Result	Median Slope (mg/L per year)	Conclusion 1991-2007	General Trend 1991-2007	General Trend 1991 - 2002
Production Wells	PW-01	15	-0.50	-0.57	Not Significant	⇔	⇔
	PW-02	17	1.48	1.15	Not Significant	⇔	⇔
	PW-03	17	0.37	0.46	Not Significant	⇔	⇔
	PW-04	17	-1.11	-0.40	Not Significant	⇔	⇔
South Fenceline Wells	TW-20	17	1.40	9.22	Not Significant	⇔	⇔
	TW-34	17	0.78	1.32	Not Significant	⇔	⇔
	TW-35	17	2.07	0.98	Significant	⇧	⇔
	TW-39	17	0.66	5.09	Not Significant	⇔	⇔
Southern Boundary Wells	TW-53	16	2.21	10.88	Significant	⇧	⇔
	TW-54	16	0.95	4.93	Not Significant	⇔	⇔
	TW-55	16	-0.68	-3.17	Not Significant	⇔	⇔
	TW-56	16	-3.49	-3.89	Significant	⇩	⇔
Springs	MORMON A SPRING	17	2.64	15.68	Significant	⇧	⇧
	HARRIS WELL	17	2.89	15.29	Significant	⇧	⇔
NW Pond Wells	TW-16	17	0.12	0.10	Not Significant	⇔	⇔
	TW-17	16	-4.48	-6.25	Significant	⇩	⇩
	TW-18	16	0.09	0.05	Not Significant	⇔	⇔
Underflow Solids Pond Area Wells	TW-22	17	-1.65	-11.08	Not Significant	⇔	⇔
	TW-24	16	-1.49	-12.85	Not Significant	⇔	⇔
	TW-37	17	2.02	9.33	Significant	⇧	⇔
	TW-45	17	-2.53	-3.60	Significant	⇩	⇔
Old Hydroclarifier Wells	TW-40	15	0.94	10.00	Not Significant	⇔	⇔
	TW-44	17	2.23	1.91	Significant	⇧	⇔
Wells and Springs South of Plant	CALF SPRING	13	3.23	22.14	Significant	⇧	⇧
	Lewis Well	17	-1.81	-5.06	Not Significant	⇔	na
	HOMESTEAD SPRING	17	2.72	2.13	Significant	⇧	⇧

Note: Shaded cells indicate a significant increasing concentration trend
Results in parenthesis indicate results from calculation with anomalous values removed.

Summary of Constituent Trends 1991 to 2007

	Location	Cadmium	Fluoride	Manganese	Nitrate	Selenium	Chloride	Molybdenum	Sulfate
Production Wells (UBZ-4)	PW-01	⇩	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	PW-02	⇩	⇔	⇔	⇔	⇔	⇔	⇧	⇔
	PW-03	⇩	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	PW-04	⇔	⇔	⇔	⇔	⇔	⇔	⇧	⇔
South Fenceline Wells (UBZ-2)	TW-20	⇔	⇩	⇔	⇔	⇔	⇔	⇔	⇔
	TW-34	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-35	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇧
	TW-39	⇩	⇩	⇔	⇔	⇩	⇩	⇩	⇔
Southern Boundary Wells (UBZ-2)	TW-53	⇔	⇔	⇔	⇔	⇔	⇔	⇧	⇧
	TW-54	⇔	⇩	⇔	⇔	⇔	⇔	⇩	⇔
	TW-55	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-56	⇔	⇔	⇩	⇔	⇔	⇩	⇔	⇩
Springs (UBZ-2)	MORMON A SPRING	⇔	⇔	⇔	⇧	⇧	⇔	⇔	⇧
	HARRIS WELL	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇧
NW Pond Wells (UBZ-4)	TW-16	⇩	⇩	⇩	⇔	⇔	⇔	⇔	⇔
	TW-17	⇔	⇩	⇧	⇔	⇔	⇩	⇩	⇩
	TW-18	⇔	⇔	⇧	⇩	⇔	⇔	⇧	⇔
Underflow Solids Pond Area Wells (UBZ-2)	TW-22	⇔	⇩	⇔	⇔	⇔	⇔	⇩	⇔
	TW-24	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-37	⇔	⇩	⇩	⇧	⇔	⇔	⇩	⇧
	TW-45	⇩	⇔	⇩	⇩	⇔	⇩	⇔	⇩
Old Hydroclarifier Wells (UBZ-4)	TW-40	⇔	⇔	⇩	⇔	⇔	⇔	⇔	⇔
	TW-44	⇔	⇔	⇔	⇩	⇔	⇧	⇔	⇧
Wells and Springs South of Plant (UBZ-2)	CALF SPRING	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇧
	Lewis Well	⇔	⇔	⇔	⇔	⇩	⇩	⇔	⇔
	HOMESTEAD SPRING	⇔	⇔	⇔	⇧	⇔	⇧	⇔	⇧

Note: Shaded cells indicate a significant increasing concentration trend

Summary of Cadmium Statistical Analyses 2000 to 2007

Cadmium (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	-6.00	na	Not Significant	⇔
	PW-02	8	0.00	na	Not Significant	⇔
	PW-03	8	-7.00	na	Not Significant	⇔
	PW-04	8	-2.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	18.00	na	Significant	⇧
	TW-34	8	-7.00	na	Not Significant	⇔
	TW-35	8	-10.00	na	Not Significant	⇔
	TW-39	8	-12.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	-3.00	na	Not Significant	⇔
	TW-54	8	-2	na	Not Significant	⇔
	TW-55	8	-5.00	na	Not Significant	⇔
	TW-56	8	-3.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	-6.00	na	Not Significant	⇔
	HARRIS WELL	8	-12.00	na	Not Significant	⇔
NW Pond Wells	TW-16	8	-4.00	na	Not Significant	⇔
	TW-17	8	-2.00	na	Not Significant	⇔
	TW-18	8	-3.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-6.00	na	Not Significant	⇔
	TW-24	8	3.00	na	Not Significant	⇔
	TW-37	8	16.00	na	Not Significant	⇔
	TW-45	8	-20.00	na	Significant	⇩
Old Hydroclarifier Wells	TW-40	7	11.00	na	Not Significant	⇔
	TW-44	8	-17.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	4.00	na	Not Significant	⇔
	Lewis Well	8	-8.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	-3.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	0.000	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-11.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	-9.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	1.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

TABLE 6b

Summary of Fluoride Statistical Analyses 2000 to 2007

Fluoride (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	0.00	na	Not Significant	⇔
	PW-02	8	-6.00	na	Not Significant	⇔
	PW-03	8	-18.00	na	Significant	⇩
	PW-04	8	-2.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	22.00	na	Significant	⇧
	TW-34	8	-6.00	na	Not Significant	⇔
	TW-35	8	-15.00	na	Not Significant	⇔
	TW-39	8	-12.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	-14.00	na	Not Significant	⇔
	TW-54	8	-4.00	na	Not Significant	⇔
	TW-55	8	-12.00	na	Not Significant	⇔
	TW-56	8	-12.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	-12.00	na	Not Significant	⇔
	HARRIS WELL	8	-16.00	na	Not Significant	⇔
NW Pond Wells	TW-16	8	-10.00	na	Not Significant	⇔
	TW-17	8	8.00	na	Not Significant	⇔
	TW-18	8	-10.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-14.00	na	Not Significant	⇔
	TW-24	8	-2.00	na	Not Significant	⇔
	TW-37	8	-17.00	na	Not Significant	⇔
	TW-45	8	1.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	-7.00	na	Not Significant	⇔
	TW-44	8	-4.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	-3.00	na	Not Significant	⇔
	Lewis Well	8	-14.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	-2.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	2.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-5.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	-7.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	5.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

Summary of Manganese Statistical Analyses 2000 to 2007

Manganese (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	4.00	na	Not Significant	⇔
	PW-02	8	4.00	na	Not Significant	⇔
	PW-03	8	4.00	na	Not Significant	⇔
	PW-04	8	5.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	3.00	na	Not Significant	⇔
	TW-34	8	8.00	na	Not Significant	⇔
	TW-35	8	10.00	na	Not Significant	⇔
	TW-39	8	3.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	-12.00	na	Not Significant	⇔
	TW-54	8	-14.00	na	Not Significant	⇔
	TW-55	8	4.00	na	Not Significant	⇔
	TW-56	8	-10.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	3.00	na	Not Significant	⇔
	HARRIS WELL	8	-9.00	na	Not Significant	⇔
NW Pond Wells	TW-16	8	3.00	na	Not Significant	⇔
	TW-17	8	22.00	na	Significant	⇧
	TW-18	8	4.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-16.00	na	Not Significant	⇔
	TW-24	8	-4.00	na	Not Significant	⇔
	TW-37	8	-12.00	na	Not Significant	⇔
	TW-45	8	-16.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	-11.00	na	Not Significant	⇔
	TW-44	8	-10.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	6.00	na	Not Significant	⇔
	Lewis Well	8	-6.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	-12.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	-6.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	9.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	5.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	-3.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

Summary of Nitrate as N Statistical Analyses 2000 to 2007

Nitrate (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	10.00	na	Not Significant	⇔
	PW-02	8	-2.00	na	Not Significant	⇔
	PW-03	8	8.00	na	Not Significant	⇔
	PW-04	8	2.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	22.00	na	Significant	⇧
	TW-34	8	-18.00	na	Significant	⇩
	TW-35	8	-8.00	na	Not Significant	⇔
	TW-39	8	4.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	14.00	na	Not Significant	⇔
	TW-54	8	20.00	na	Significant	⇧
	TW-55	8	14.00	na	Not Significant	⇔
	TW-56	8	10.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	16.00	na	Not Significant	⇔
	HARRIS WELL	8	24.00	na	Significant	⇧
NW Pond Wells	TW-16	8	10.00	na	Not Significant	⇔
	TW-17	8	-6.00	na	Not Significant	⇔
	TW-18	8	-9.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-6.00	na	Not Significant	⇔
	TW-24	8	-2.00	na	Not Significant	⇔
	TW-37	8	16.00	na	Not Significant	⇔
	TW-45	8	-13.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	15.00	na	Significant	⇧
	TW-44	8	-16.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	6.00	na	Not Significant	⇔
	Lewis Well	8	6.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	14.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	2.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-7.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	-1.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	5.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

Summary of Selenium Statistical Analyses 2000 to 2007

Selenium (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	-6.00	na	Not Significant	⇔
	PW-02	8	-1.00	na	Not Significant	⇔
	PW-03	8	4.00	na	Not Significant	⇔
	PW-04	8	-6.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	12	na	Not Significant	⇔
	TW-34	8	-11.00	na	Not Significant	⇔
	TW-35	8	-18.00	na	Significant	⇩
	TW-39	8	-10.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	10.00	na	Not Significant	⇔
	TW-54	8	8.00	na	Not Significant	⇔
	TW-55	8	20.00	na	Significant	⇧
	TW-56	8	-4.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	6.00	na	Not Significant	⇔
	HARRIS WELL	8	16.00	na	Not Significant	⇔
NW Pond Wells	TW-16	8	-16.00	na	Not Significant	⇔
	TW-17	8	-8.00	na	Not Significant	⇔
	TW-18	8	-18.00	na	Significant	⇩
Underflow Solids Pond Area Wells	TW-22	8	-6.00	na	Not Significant	⇔
	TW-24	8	-8.00	na	Not Significant	⇔
	TW-37	8	4.00	na	Not Significant	⇔
	TW-45	8	-9.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	-13.00	na	Not Significant	⇔
	TW-44	8	-14.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	0.00	na	Not Significant	⇔
	Lewis Well	8	5.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	-19.00	na	Significant	⇩
Soda Creek	Effluent Discharge (2000 to 2007)	8	-2.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-9.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	-5.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	5.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

Summary of Chloride Statistical Analyses 2000 to 2007

Chloride (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	14.00	na	Not Significant	⇔
	PW-02	8	14.00	na	Not Significant	⇔
	PW-03	8	16.00	na	Not Significant	⇔
	PW-04	8	-6.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	12.00	na	Not Significant	⇔
	TW-34	8	2.00	na	Not Significant	⇔
	TW-35	8	18.00	na	Significant	⇧
	TW-39	8	-14.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	16.00	na	Not Significant	⇔
	TW-54	8	11.00	na	Not Significant	⇔
	TW-55	8	20.00	na	Significant	⇧
	TW-56	8	-20.00	na	Significant	⇩
Springs	MORMON A SPRING	8	13.00	na	Not Significant	⇔
	HARRIS WELL	8	24.00	na	Significant	⇧
NW Pond Wells	TW-16	8	14.00	na	Not Significant	⇔
	TW-17	8	-16.00	na	Not Significant	⇔
	TW-18	8	-3.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-4.00	na	Not Significant	⇔
	TW-24	8	0.00	na	Not Significant	⇔
	TW-37	8	16.00	na	Not Significant	⇔
	TW-45	8	-14.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	5.00	na	Not Significant	⇔
	TW-44	8	-18.00	na	Significant	⇩
Springs South of Plant	CALF SPRING	4	6.00	na	Not Significant	⇔
	Lewis Well	8	14.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	10.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	-12.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-13.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	-9.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	-11.00	na	Significant	⇩

Note: Shaded cells indicated significant increasing trend.

Slope could not be calculated because n is less than 10.

Summary of Molybdenum Statistical Analyses 2000 to 2007

Molybdenum (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion (2000-2007)	General Trend (2000-2007)
Production Wells	PW-01	8	20.00	na	Significant	⇧
	PW-02	8	20.00	na	Significant	⇧
	PW-03	8	20.00	na	Significant	⇧
	PW-04	8	10.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	22.00	na	Significant	⇧
	TW-34	8	13.00	na	Not Significant	⇔
	TW-35	8	13.00	na	Not Significant	⇔
	TW-39	8	-16.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	-12.00	na	Not Significant	⇔
	TW-54	8	-8.00	na	Not Significant	⇔
	TW-55	8	13.00	na	Not Significant	⇔
	TW-56	8	11.00	na	Not Significant	⇔
Springs	MORMON A SPRING	8	-6.00	na	Not Significant	⇔
	HARRIS WELL	8	-8.00	na	Not Significant	⇔
NW Pond Wells	TW-16	8	14.00	na	Not Significant	⇔
	TW-17	8	0.00	na	Not Significant	⇔
	TW-18	8	19.00	na	Significant	⇧
Underflow Solids Pond Area Wells	TW-22	8	-23.00	na	Significant	⇩
	TW-24	8	-4.00	na	Not Significant	⇔
	TW-37	8	-20.00	na	Significant	⇩
	TW-45	8	8.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	-1.00	na	Not Significant	⇔
	TW-44	8	-5.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	-2.00	na	Not Significant	⇔
	Lewis Well	8	-20.00	na	Significant	⇩
	HOMESTEAD SPRING	8	6.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	14.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	2.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	5.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	1.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

Summary of Sulfate Statistical Analyses 2000 to 2007

Sulfate (2000-2007)	Location	Total # Values (n)	S-Test Result	Median Slope (mg/L per year)	Conclusion 2000-2007	General Trend 2000-2007
Production Wells	PW-01	8	6.00	na	Not Significant	⇔
	PW-02	8	2.00	na	Not Significant	⇔
	PW-03	8	10.00	na	Not Significant	⇔
	PW-04	8	-16.00	na	Not Significant	⇔
South Fenceline Wells	TW-20	8	20.00	na	Significant	⇧
	TW-34	8	0.00	na	Not Significant	⇔
	TW-35	8	10.00	na	Not Significant	⇔
	TW-39	8	2.00	na	Not Significant	⇔
Southern Boundary Wells	TW-53	8	14.00	na	Not Significant	⇔
	TW-54	8	8.00	na	Not Significant	⇔
	TW-55	8	21.00	na	Significant	⇧
	TW-56	8	-24.00	na	Significant	⇩
Springs	MORMON A SPRING	8	6.00	na	Not Significant	⇔
	HARRIS WELL	8	22.00	na	Significant	⇧
NW Pond Wells	TW-16	8	8.00	na	Not Significant	⇔
	TW-17	8	-23.00	na	Significant	⇩
	TW-18	8	0.00	na	Not Significant	⇔
Underflow Solids Pond Area Wells	TW-22	8	-12.00	na	Not Significant	⇔
	TW-24	8	-8.00	na	Not Significant	⇔
	TW-37	8	20.00	na	Significant	⇧
	TW-45	8	-12.00	na	Not Significant	⇔
Old Hydroclarifier Wells	TW-40	7	-3.00	na	Not Significant	⇔
	TW-44	8	10.00	na	Not Significant	⇔
Springs South of Plant	CALF SPRING	4	4.00	na	Not Significant	⇔
	Lewis Well	8	16.00	na	Not Significant	⇔
	HOMESTEAD SPRING	8	-4.00	na	Not Significant	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	8	9.00	na	Not Significant	⇔
	Soda Up (2001 to 2007)	7	-11.00	na	Not Significant	⇔
	Soda Down (2001 to 2007)	7	1.00	na	Not Significant	⇔
	Mormon Creek (2002 to 2007)	6	9.00	na	Not Significant	⇔

Note: Shaded cells indicated significant increasing trend.
Slope could not be calculated because n is less than 10.

TABLE 7

Summary of Constituent Trend 2000 to 2007

	Location	Cadmium	Fluoride	Manganese	Nitrate	Selenium	Chloride	Molybdenum	Sulfate
Production Wells	PW-01	⇔	⇔	⇔	⇔	⇔	⇔	⇧	⇔
	PW-02	⇔	⇔	⇔	⇔	⇔	⇔	⇧	⇔
	PW-03	⇔	⇩	⇔	⇔	⇔	⇔	⇧	⇔
	PW-04	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
South Fenceline Wells	TW-20	⇧	⇧	⇔	⇧	⇔	⇔	⇧	⇧
	TW-34	⇔	⇔	⇔	⇩	⇔	⇔	⇔	⇔
	TW-35	⇔	⇔	⇔	⇔	⇩	⇧	⇔	⇔
	TW-39	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
Southern Boundary Wells	TW-53	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-54	⇔	⇔	⇔	⇧	⇔	⇔	⇔	⇔
	TW-55	⇔	⇔	⇔	⇔	⇧	⇧	⇔	⇧
	TW-56	⇔	⇔	⇔	⇔	⇔	⇩	⇔	⇩
Springs	MORMON A SPRING	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	HARRIS WELL	⇔	⇔	⇔	⇧	⇔	⇧	⇔	⇧
NW Pond Wells	TW-16	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-17	⇔	⇔	⇧	⇔	⇔	⇔	⇔	⇩
	TW-18	⇔	⇔	⇔	⇔	⇩	⇔	⇧	⇔
Underflow Solids Pond Area Wells	TW-22	⇔	⇔	⇔	⇔	⇔	⇔	⇩	⇔
	TW-24	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	TW-37	⇔	⇔	⇔	⇔	⇔	⇔	⇩	⇧
	TW-45	⇩	⇔	⇔	⇔	⇔	⇔	⇔	⇔
Old Hydroclarifier Wells	TW-40	⇔	⇔	⇔	⇧	⇔	⇔	⇔	⇔
	TW-44	⇔	⇔	⇔	⇔	⇔	⇩	⇔	⇔
Well and Springs South of Plant	CALF SPRING	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	Lewis Well	⇔	⇔	⇔	⇔	⇔	⇔	⇩	⇔
	HOMESTEAD SPRING	⇔	⇔	⇔	⇔	⇩	⇔	⇔	⇔
Soda Creek	Effluent Discharge (2000 to 2007)	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	Soda Up (2001 to 2007)	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	Soda Down (2001 to 2007)	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔
	Mormon Creek (2002 to 2007)	⇔	⇔	⇔	⇔	⇔	⇩	⇔	⇔

Note: Shaded cells indicate a significant increasing concentration trend

TABLE 8

Predicted and Observed 2002 and 2007 Concentrations - RI Model

Constituent	Remedial Goal (mg/L)	Location	Predicted 2002 Concentration (mg/L)	Observed 2002 Concentration[a] (mg/L)	Predicted 2007 Concentration (mg/L)	Observed 2007 Concentration[c] (mg/L)
Chloride	na	Source (TW-37)	20	25	17	130
		Fence Line (TW-20, TW-39)	26	102 to 110	19	101 to 115
		Southern Boundary (TW-54, TW-55)	26	37 to 109	19	59 to 99
Fluoride	4	Source (TW-37)	17	12.96	17	9.77
		Fence Line (TW-20, TW-39)	17	1.803 to 3.38	16.1	2.05 to 3.34
		Southern Boundary (TW-54, TW-55)	17	0.69 to 2.64	15.58	0.26 to 3.66
Nitrate as N	10	Source (TW-37)	0.83	3.79	0.39	10.8
		Fence Line (TW-20, TW-39)	1.97	6.08 to 6.95	1.55	9.56 to 10.5
		Southern Boundary (TW-54, TW-55)	1.99	1.04 to 2.91	1.54	4.15 to 9.7
Manganese	0.18	Source (TW-37)	0.19	0.01	0.072	0.589
		Fence Line (TW-20, TW-39)	0.43	0.01 to 0.80	0.18	<0.0007
		Southern Boundary (TW-54, TW-55)	0.45	0.01	0.19	<0.0007
Cadmium	0.005	Source (TW-37)	0.08/0.004[b]	0.397	0.035/0.002[b]	0.577
		Fence Line (TW-20, TW-39)	0.67/0.03	0.0059 to 0.016	0.35/0.018	0.0068 to 0.0093
		Southern Boundary (TW-54, TW-55)	0.86/0.04	0.002	0.50/0.026	<0.0006
Selenium	0.05	Source (TW-37)	0.13	0.389	0.063	0.162
		Fence Line (TW-20, TW-39)	0.15	0.055 to 0.217	0.09	0.0847 to 0.125
		Southern Boundary (TW-54, TW-55)	0.16	0.013 to 0.092	0.09	0.085 to 0.12

a. Concentration observed in 2002.
b. No solubility control/solubility control
c. Concentration observed in 2007
d. Shaded cells exceed remedial goal.

Summary of Predicted and Observed Concentrations in 2002 and 2007

PREDICTED AND OBSERVED CONCENTRATIONS IN 2002													
		Fence Line Wells			**Southern Boundary Wells**			**Mormon-Harris**			**Property Boundary**		
Constituent	Remedial Goal (mg/L)	GoldSim Prediction (mg/L)	TW-20 (mg/L)	TW-39 (mg/L)	GoldSim Prediction (mg/L)	TW-54 (mg/L)	TW-55 (mg/L)	GoldSim Prediction (mg/L)	Harris Well (mg/L)	Mormon A Spring (mg/L)	GoldSim Prediction (mg/L)	TW-59 (mg/L)	TW-62 (mg/L)
Chloride	na	59.3	101.9	110.4	62.7	109.1	36.7	60.9	89.3	101.8	51.2	Not Drilled	
Fluoride	4	4.3	1.8	3.4	3.8	2.6	0.7	3.3	3.1	3.1	2.4	Not Drilled	
Nitrate	10	5.9	6.9	3.8	5.8	1.0	2.9	5.6	5.8	6.0	5.1	Not Drilled	
Selenium	0.05	0.32	0.30	0.09	0.30	0.34	0.02	0.26	0.11	0.27	0.17	Not Drilled	
Manganese	0.18	<0.00001	<0.06	<0.06	<0.00001	<0.06	<0.06	<0.00001	<0.06	<0.06	<0.00001	Not Drilled	
Cadmium	0.005	<0.00001	0.0059	0.0120	<0.00001	0.0176	<0.002	<0.00001	<0.002	0.0149	<0.00001	Not Drilled	

PREDICTED AND OBSERVED CONCENTRATIONS IN 2007													
		Fence Line Wells			**Southern Boundary Wells**			**Mormon-Harris**			**Property Boundary**		
Constituent	Remedial Goal (mg/L)	GoldSim Prediction (mg/L)	TW-20 (mg/L)	TW-39 (mg/L)	GoldSim Prediction (mg/L)	TW-54 (mg/L)	TW-55 (mg/L)	GoldSim Prediction (mg/L)	Harris Well (mg/L)	Mormon A Spring (mg/L)	GoldSim Prediction (mg/L)	TW-59 (mg/L)	TW-62 (mg/L)
Chloride	na	32.9	99.3	115	36.4	98.9	59.4	21.2	121.0	120.0	38.7	60.3	74.4
Fluoride	4	3.8	2.05	3.34	3.2	3.66	0.26	2.7	2.54	2.94	1.9	<0.1	0.22
Nitrate as N	10	5.4	10.5	9.6	5.3	9.70	4.15	5.1	8.96	9.22	4.8	5.76	5.00
Selenium	0.05	0.159	0.0847	0.125	0.159	0.0849	0.0413	0.149	0.123	0.136	0.121	0.0321	0.0456
Manganese	0.18	<0.00001	<0.0009	<0.0007	<0.00001	<0.0007	<0.0007	<0.00001	0.0026	<0.0009	<0.00001	<0.0007	0.0039
Cadmium	0.005	<0.00001	0.0068	0.0093	<0.00001	<0.0006	<0.0006	<0.00001	0.0032	0.0174	<0.00001	<0.0006	<0.0006

Notes:

Nitrate and chloride predicted concentrations include background of 4 mg/L and 16 mg/L, respctively.

na: Not Applicable

Exceedances of remedial goals shaded (model output and actual concentrations).

Nitrate in Homestead Spring, TW-59, and TW-62 may be affected by upgradient agricultural activity.

Precipitation Summary for Soda Springs

Water Year	Monthly Precipitation (inches)												Water Year Total (inches)	Deviation from Average Water Year (inches)
	October	November	December	January	February	March	April	May	June	July	August	September		
1983	0.76	1.53	0.79	0.93	0.72	0.62	0.99	1.34	1.68	2.70	4.00	2.23	18.29	2.95
1984	1.93	3.91	2.37	0.25	1.56	0.92	1.64	0.84	2.45	2.33	1.48	2.35	22.03	6.69
1985	1.05	1.09	0.50	0.44	1.71	2.13	0.34	2.03	1.15	4.07	nm	nm	14.51	-0.83
1986	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	2.08	3.03	-	-
1987	1.54	0.34	0.02	0.80	0.22	0.18	0.50	3.26	0.59	2.55	2.63	0.10	12.73	-2.61
1988	1.01	0.73	0.97	0.84	0.09	0.40	1.19	0.86	0.94	0.57	0.38	0.87	8.85	-6.49
1989	0.03	2.51	0.76	1.38	1.29	2.82	0.87	1.12	1.59	0.27	1.09	0.44	14.17	-1.17
1990	1.80	0.51	0.31	1.04	0.45	1.69	2.41	1.54	0.83	0.24	0.94	1.69	13.45	-1.89
1991	1.02	1.46	1.75	0.72	0.22	2.09	2.02	3.65	0.98	0.35	1.81	0.94	17.01	1.67
1992	0.98	1.61	0.48	0.53	0.93	1.01	0.78	0.25	1.09	1.00	0.14	0.68	9.48	-5.86
1993	1.52	0.97	1.24	1.95	2.10	2.18	2.43	3.55	1.84	1.87	1.26	0.84	21.75	6.41
1994	1.21	0.47	0.72	0.45	2.97	0.49	1.38	2.06	0.27	0.53	2.61	0.14	13.30	-2.04
1995	2.35	1.70	0.67	1.08	0.52	2.43	1.30	2.54	1.93	1.75	0.63	0.43	17.33	1.99
1996	0.42	1.02	1.32	1.54	1.46	1.66	0.74	5.24	0.35	1.30	0.04	nm	15.09	-0.25
1997	0.69	0.00	3.31	2.50	0.31	0.93	1.45	2.08	2.18	3.21	2.65	2.60	21.91	6.57
1998	0.72	0.10	0.48	1.67	1.21	1.78	nm	2.84	1.59	0.82	1.12	1.24	13.57	-1.77
1999	1.37	1.12	0.59	1.42	2.63	0.95	1.71	3.88	1.71	0.48	1.87	0.94	18.67	3.33
2000	0.65	0.40	0.52	1.45	1.84	0.83	0.46	2.11	0.42	0.18	1.43	0.61	10.90	-4.44
2001	1.58	0.51	0.58	0.48	0.41	0.93	1.83	0.77	0.82	0.46	0.30	0.67	9.34	-6.00
2002	0.67	1.58	1.88	1.12	0.14	1.12	1.66	1.56	0.98	0.92	0.03	3.34	15.00	-0.34
2003	1.32	0.93	1.09	0.55	1.10	1.32	0.82	1.91	0.26	0.48	0.46	1.03	11.27	-4.07
2004	0.11	0.94	1.74	0.88	1.00	0.99	0.98	2.46	2.18	0.82	1.83	0.87	14.80	-0.54
2005	3.60	0.41	0.87	2.08	0.63	1.28	2.27	nm	2.64	0.82	1.10	1.22	16.92	1.58
2006	0.86	0.91	1.61	3.13	0.47	1.73	2.34	0.46	0.90	0.39	1.06	1.96	15.82	0.48
2007	1.54	1.27	1.09	0.37	1.08	0.60	1.21	0.55	0.67	0.68	0.95	0.97	10.98	-4.36
Monthly Average	1.20	1.08	1.07	1.15	1.04	1.30	1.36	2.04	1.25	1.20	1.33	1.27	-	-

Note:
Data from Soda Springs Airport (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?id8535)
Period of record 1980-2007
Average WY precipitation over period of record: 15.34 inches
nm: not measured

TABLE 11

Estimated Groundwater Velocity and Hydraulic Conductivity - UBZ-2

Well Pair	Distance (feet)	Upgradient Peak	Downgradient Peak	Estimated Groundwater Velocity (ft/d)	Estimated Hydraulic Conductivity (ft/d)
Nitrate					
TW-37/TW-22	4,059	1985	1994	1.2	59
TW-37/Calf Spring	4,786	1985	1995	1.3	62
TW-22/TW-20	2,733	1998	2006	0.9	45
TW-22/TW-54	3,501	1998	2006	1.2	57
			Geometric Mean	1.2	55
Chloride					
TW-37/TW-20	4,059	1985	1992	1.6	76
TW-22/TW-20	2,733	1999	2005	1.2	59
			Geometric Mean	1.4	67
Selenium					
TW-37/TW-22	4,059	1994	1999	2.0	96
TW-22/TW-20	2,733	1999	2005	1.2	59
TW-20/Mormon A	1,694	2005	2006	4.6	220
			Geometric Mean	2.3	108
Sulfate					
TW-22/Calf Spring	3,371	1985	1994	1.0	49
TW-22/TW-20	2,733	1998	2006	0.9	44
TW-22/TW-54	3,501	1998	2006	1.2	56
TW-22/TW-54	3,501	1985	1995	0.9	44
			Geometric Mean	1.0	48
Molybdenum					
TW-12/Lewis *(UBZ-3)*	3,075	1993	1997	2.1	100
TW-20/TW-54	1,000	1994	1996	1.4	65
TW-20/Harris	1,076	1994	1997	1.0	47
TW-20/Mormon A Spring	1,694	1994	1997	1.5	73
TW-24/TW-20	2,733	1997	2006	0.8	39
			Geometric Mean (excludes UBZ-3)	1.1	54
			Geometric Mean (all constituents in UBZ-2)	1.3	61

Notes:

Assumes overall hydraulic gradient = 0.0063 (based on 2007 groundwater elevation date - TW-37 to TW-54

Assumed effective porosity = 30%

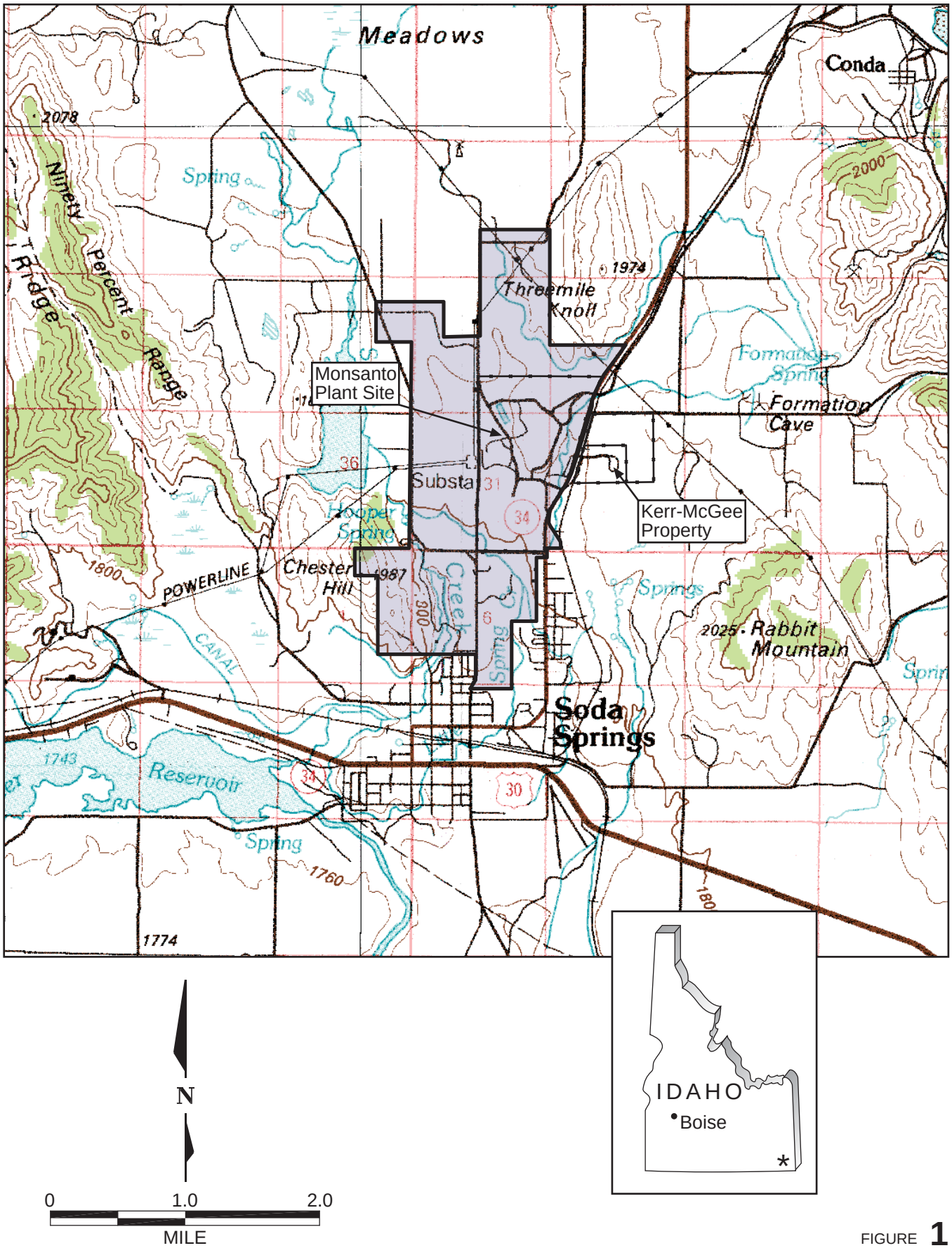
All wells in UBZ-2 except as noted

Summary of Constituent Response in UBZ-2 Source Areas to Precipitation

Constituent	TW-57 Background		TW-37 Source Area		TW-22/TW24 Source Area	
	1990's	2005-2006	1990's	2005-2006	1990's	2005-2006
Sulfate	□	□	●	●	●	●
Chloride	□	□	□	●	●	● (TW-24) ❍ (TW-22)
Nitrate	❍	❍	□	●	●	● (TW-24) ❍ (TW-22)
Fluoride	□	□	□	□	●	●
Cadmium	□	□	□	●	●	● (TW-24) ❍ (TW-22)
Manganese	□	□	❍	□	●	□?
Selenium	□	□	●	●	●	●
Molybdenum	□	□	□	□	●	● (TW-24) ❍ (TW-22)

Note:
Strong apparent relationship to precipitation: ●
Some apparent relationship to precipitation: ❍
No apparent relationship to precipitation: □

FIGURES



SOURCE: Topographic map of the USGS Soda Springs Quadrangle (1:100,000) 1982.

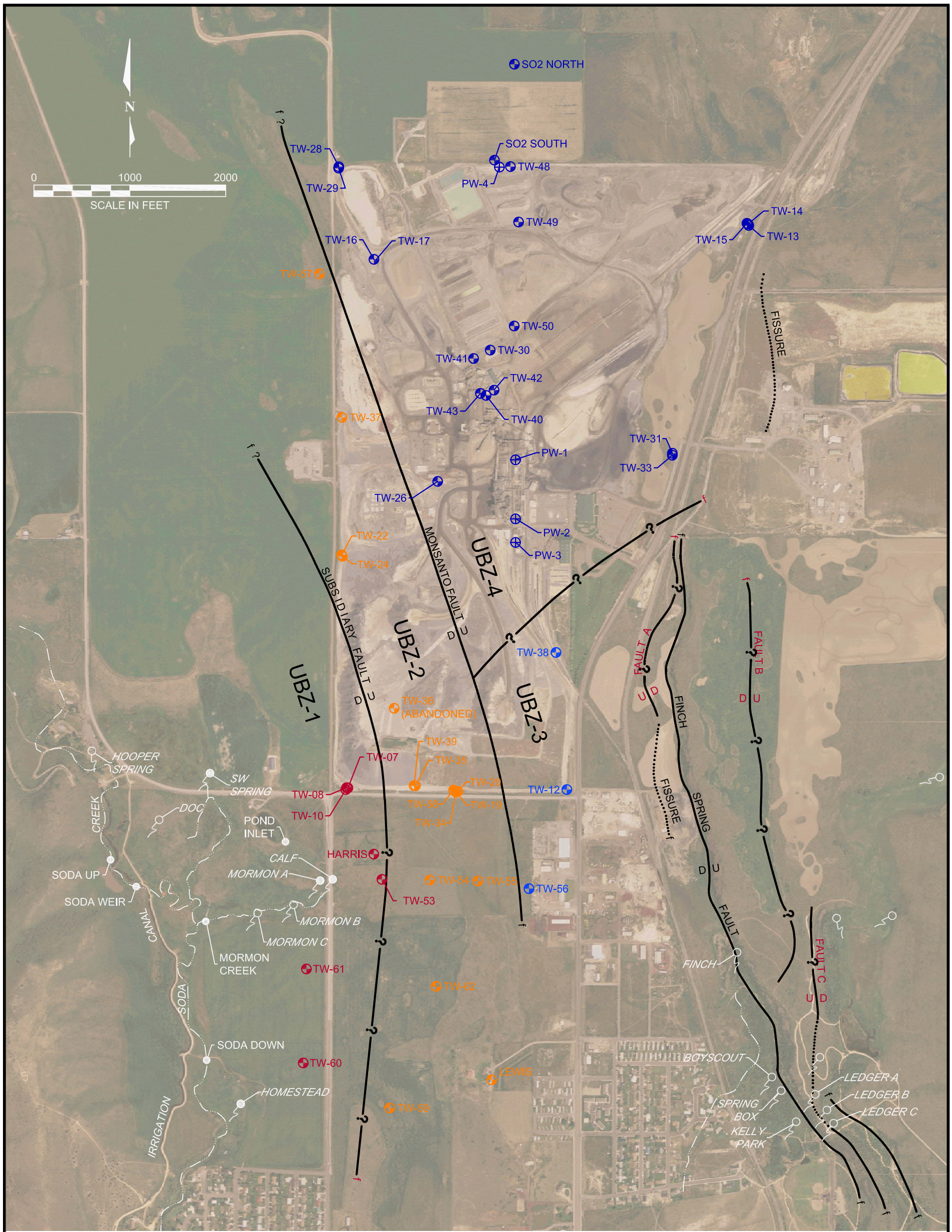
FIGURE **1**

MONSANTO PLANT VICINITY MAP

MONSANTO/2ND 5 REVIEW REPORT/ID

9131101001605fg04_R2.ai DATE 03/07/08 | AMP

Golder Associates



LEGEND:

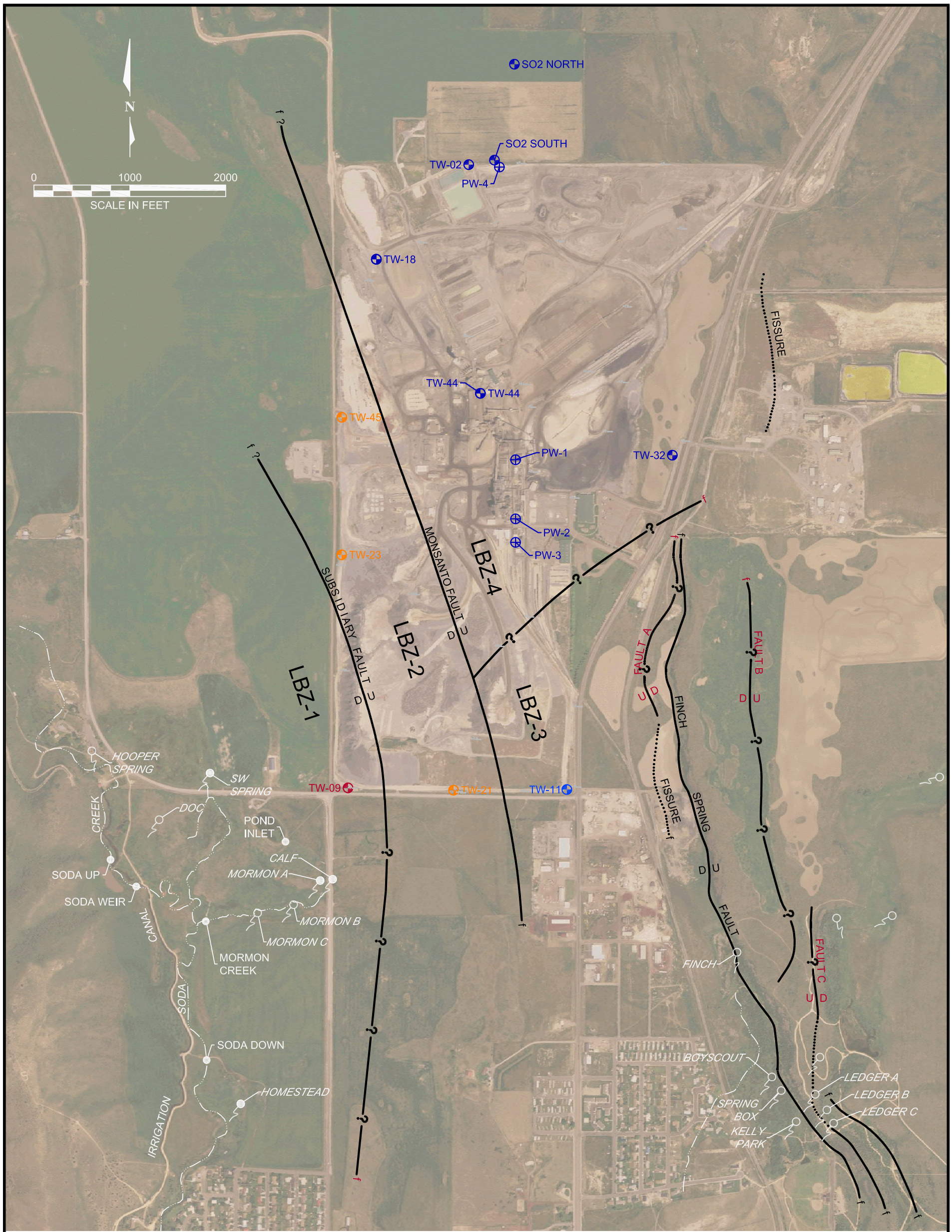
f U D f	FAULT
f U D ? f	FAULT (INFERRED)
f f	FISSURE
UBZ-1	GROUNDWATER ZONE
TW-60	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1
LEWIS	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2
TW-56	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3
TW-33	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
PW-1	PRODUCTION WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
MORMON A	SPRING LOCATION WITH NAME (WHERE KNOWN)
MORMON B	SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
MORMON CREEK	SURFACE WATER LOCATION WITH NAME

FIGURE **2**

LOCATION OF SPRINGS AND WELLS IN THE UPPER BASALT ZONE

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).



LEGEND:

f U D f	FAULT
f U D ? f	FAULT (INFERRED)
f f	FISSURE
LBZ-1	GROUNDWATER ZONE
TW-09	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-1
TW-21	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-2
TW-11	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-3
TW-44	MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-4
PW-1	PRODUCTION WELL LOCATION WITH NAME
MORMON A	SPRING LOCATION WITH NAME (WHERE KNOWN)
MORMON B	SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
MORMON CREEK	SURFACE WATER LOCATION WITH NAME

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

FIGURE **3**

LOCATION OF WELLS IN THE LOWER BASALT ZONE

MONSANTO/SECOND 5-YEAR REVIEW/ID

LEGEND:

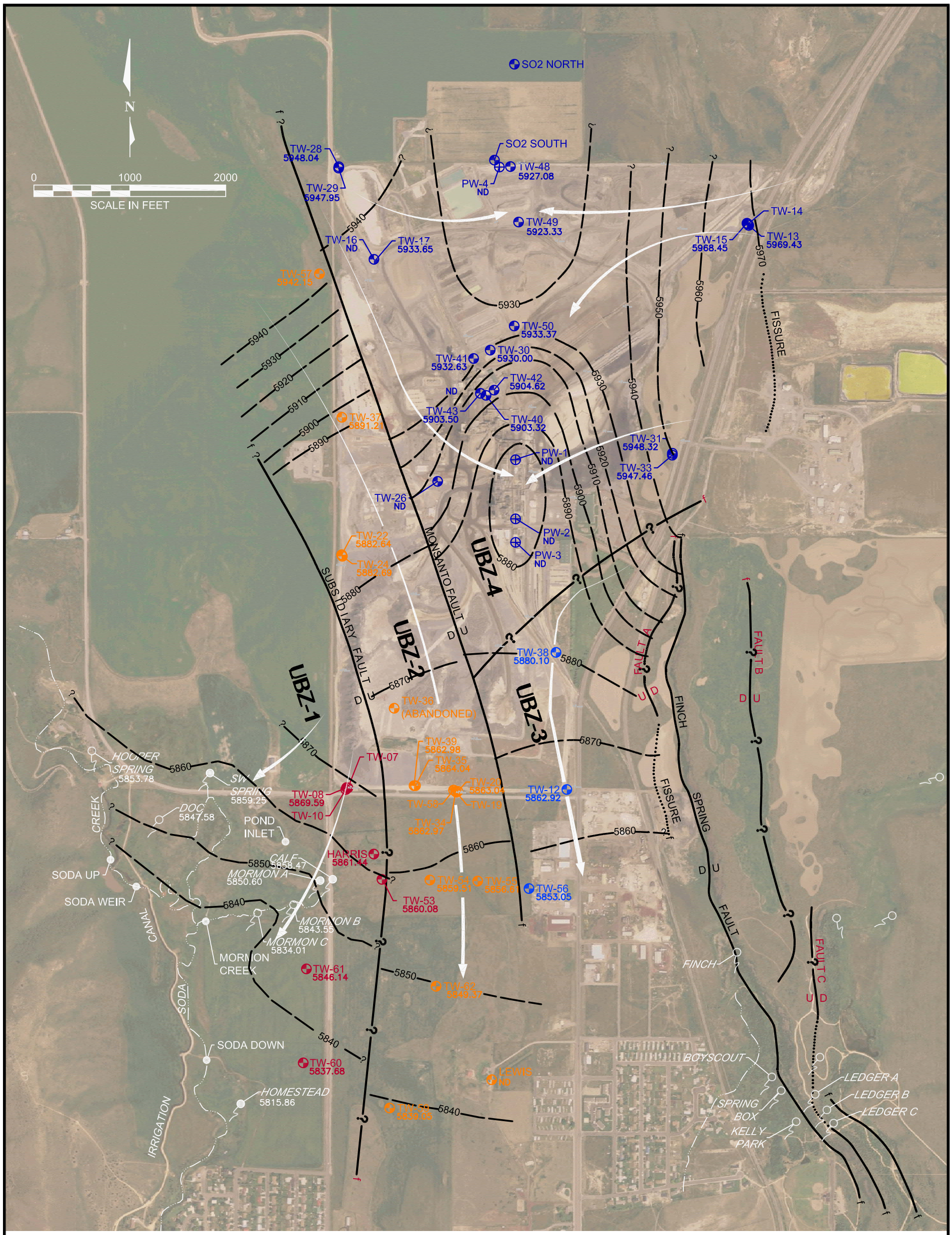
- MONSANTO PROPERTY BOUNDARY (APPROXIMATE)
- PLANT PERIMETER FENCE
- CREEK / IRRIGATION DITCH
- FACILITY AREA
- ORIGINAL SOURCE AREA

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE **4**

MONSANTO FACILITY MAP

MONSANTO/SECOND 5-YEAR REVIEW/ID



LEGEND:

- FAULT
- FAULT (INFERRED)
- FISSURE
- UBZ-1 — GROUNDWATER ZONE
- GROUNDWATER FLOW DIRECTION
- 5840 — GROUNDWATER CONTOUR (10 FOOT INTERVAL)
- MORMON A — SPRING LOCATION WITH NAME (WHERE KNOWN)
- MORMON B — SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
- MORMON CREEK — SURFACE WATER LOCATION WITH NAME
- GROUNDWATER ELEVATION (FEET) WITH QUALIFIER (IF ANY)
  ND = NO DATA
- TW-60 5837.68 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1
- TW-59 5839.05 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2
- TW-56 5853.05 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3
- TW-28 5948.04 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
- PW-1 ND — PRODUCTION WELL LOCATION WITH NAME

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE **5**

GROUNDWATER ELEVATION OF THE UPPER BASALT ZONE (JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

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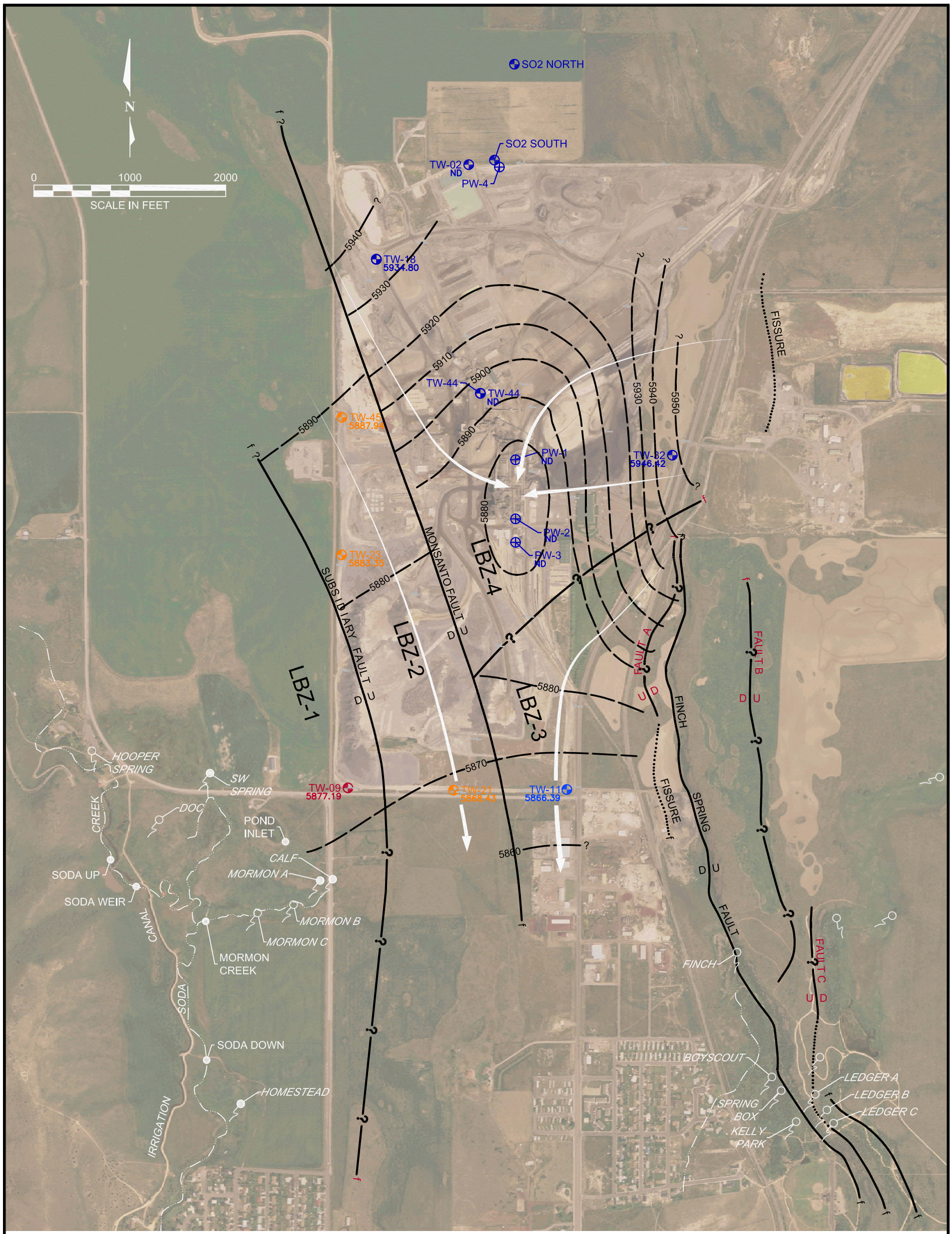
Golder Associates



LEGEND:

- FAULT
- FAULT (INFERRED)
- FISSURE
- LBZ-1 — GROUNDWATER ZONE
- GROUNDWATER FLOW DIRECTION
- 5900 — GROUNDWATER CONTOUR (10 FOOT INTERVAL)
- MORMON A — SPRING LOCATION WITH NAME (WHERE KNOWN)
- MORMON B — SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN)
- MORMON CREEK — SURFACE WATER LOCATION WITH NAME
- TW-60 5837.68 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-1
- TW-59 5839.05 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-2
- TW-11 5866.39 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-3
- TW-18 5934.80 — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE LBZ-4
- PW-4 ND — PRODUCTION WELL LOCATION WITH NAME

GROUNDWATER ELEVATION (FEET) WITH QUALIFIER (IF ANY)
ND = NO DATA

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE 6

GROUNDWATER ELEVATION OF THE LOWER BASALT ZONE (JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

Golder Associates

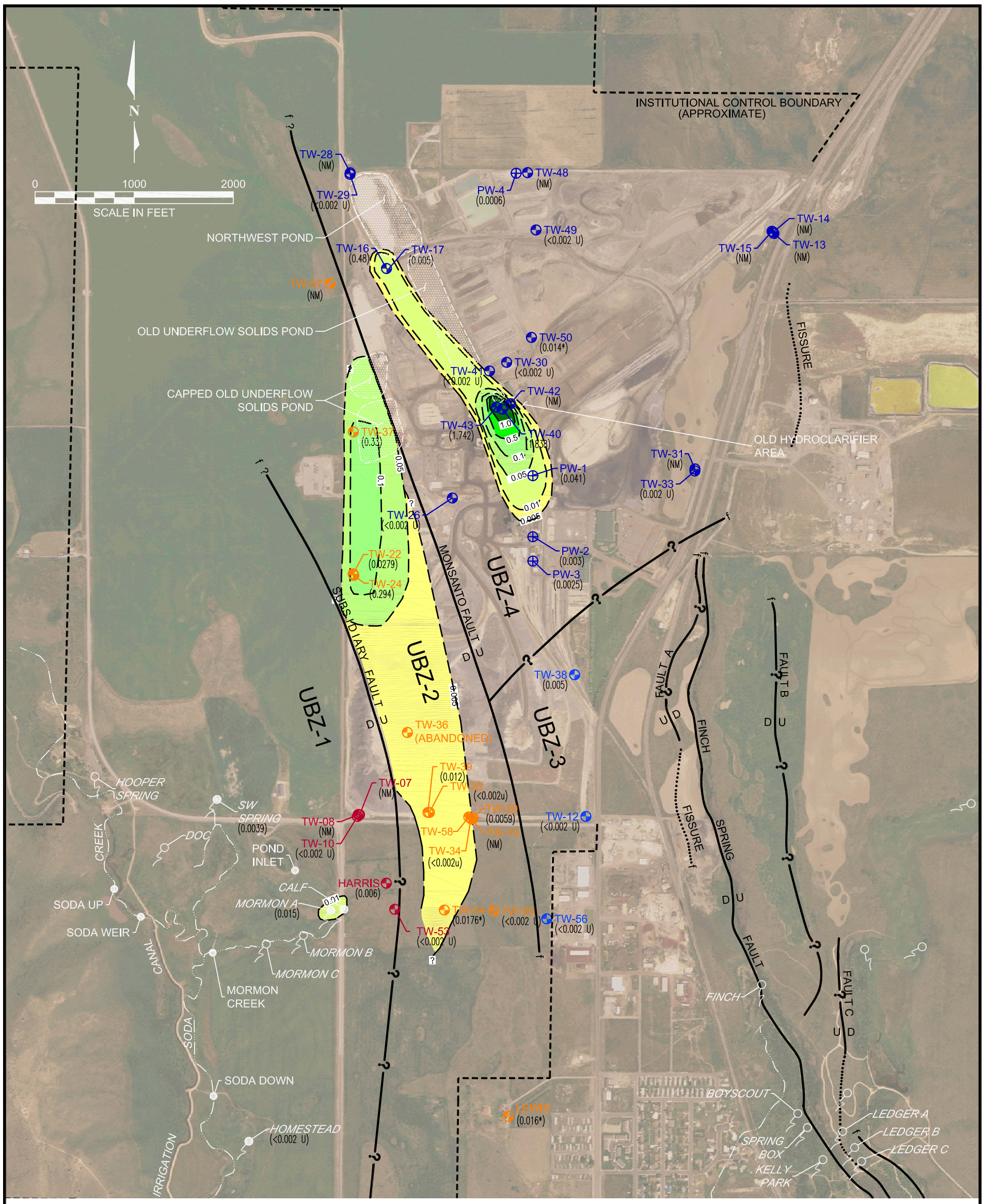


FIGURE **7a**

CADMIUM OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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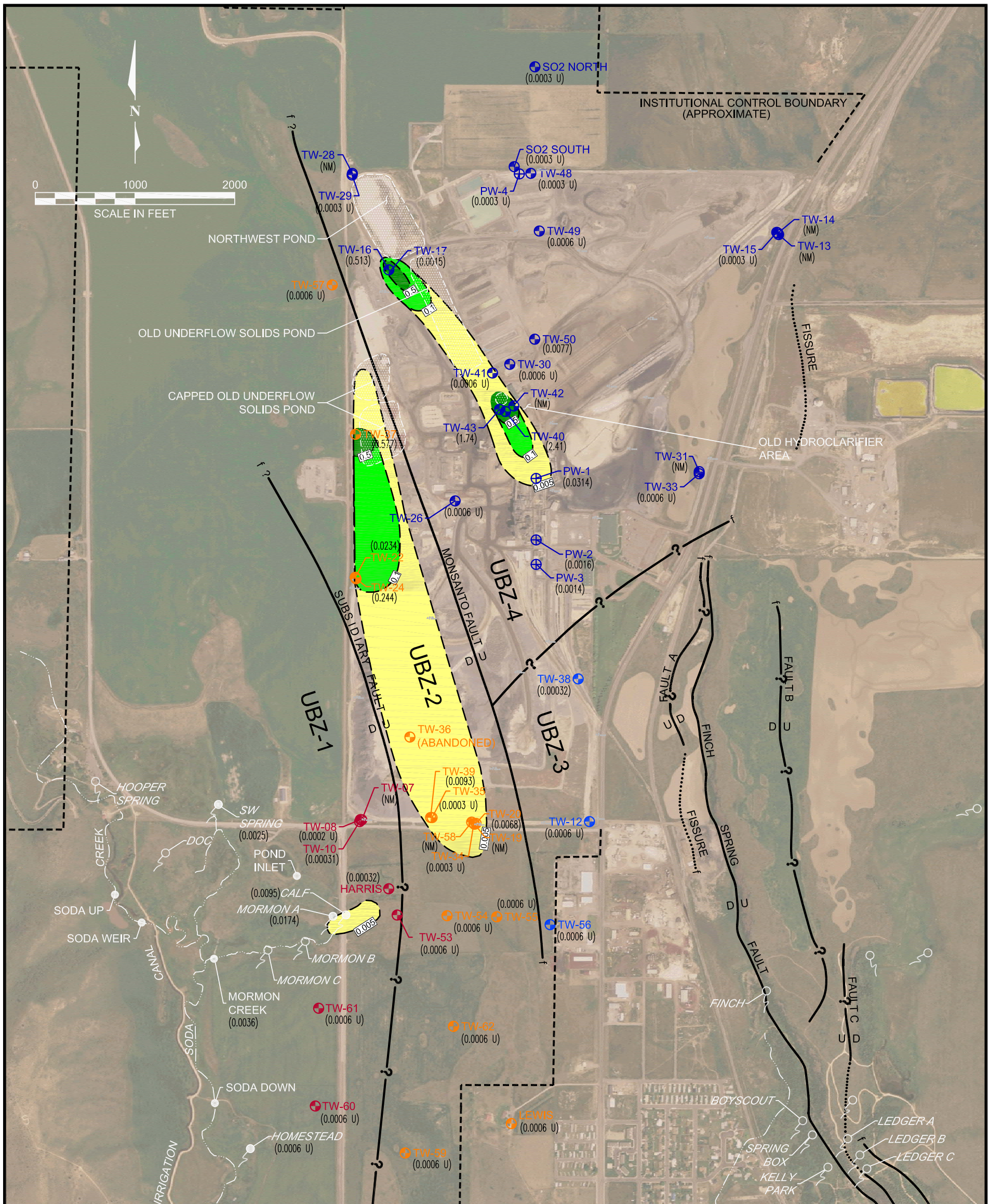
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

0.005 0.05 0.5 1.0 0.10 0.01

CHEMICAL ISOPLETH (mg/L)
DASHED WHERE APPROXIMATE
? WHERE UNKNOWN

REMEDIAL GOAL = 0.005 mg/L (MCL)

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)
(NM) = NOT MEASURED
(...U) = NOT DETECTED

FIGURE **7b**

CADMIUM OF THE UPPER BASALT ZONE (JUNE 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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Golder Associates

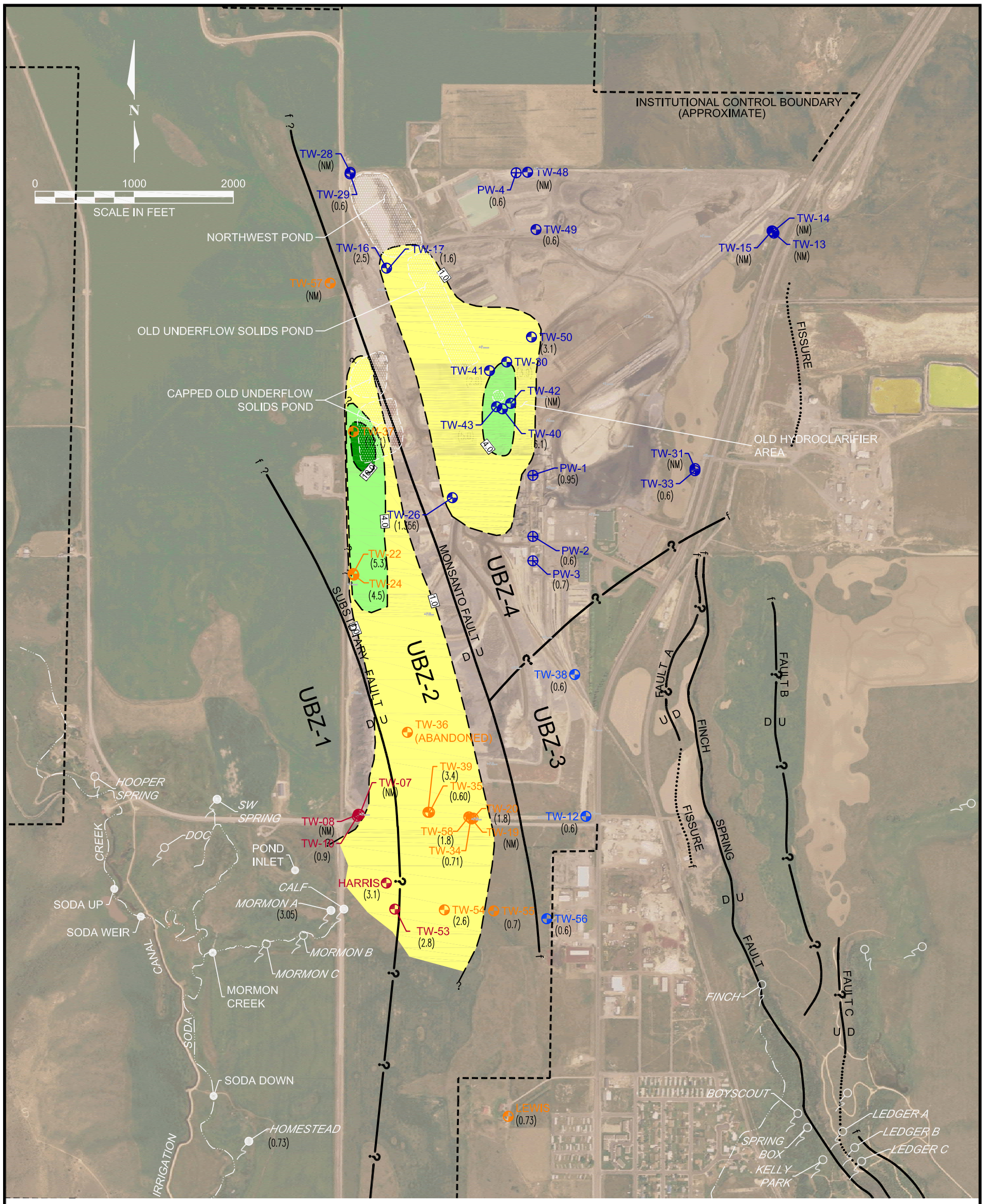

FIGURE **8a**

FLOURIDE OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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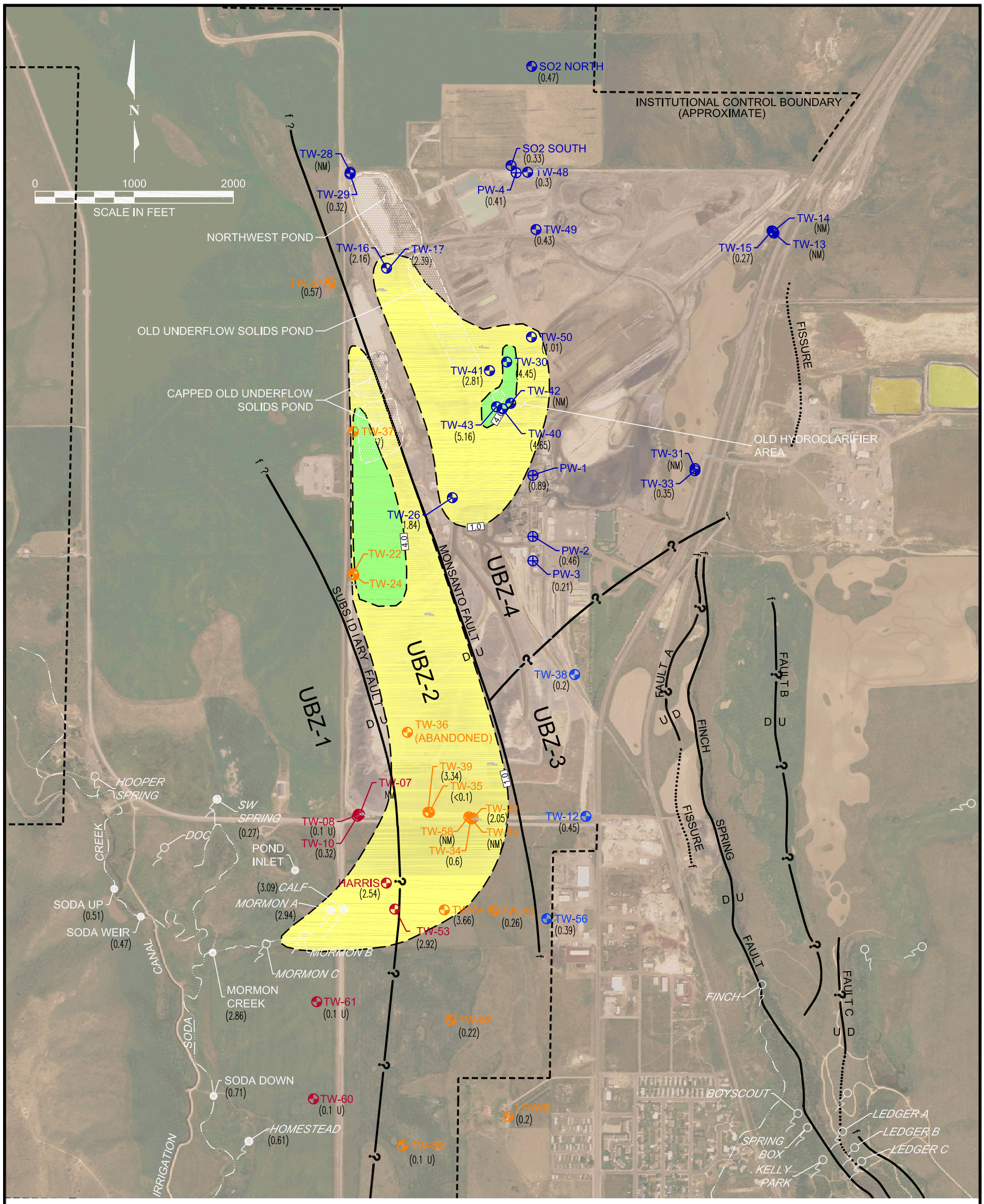
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

4 10 1 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

REMEDIAL GOAL = 4 mg/L (MCL)

FIGURE **8b**

FLOURIDE OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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Golder Associates

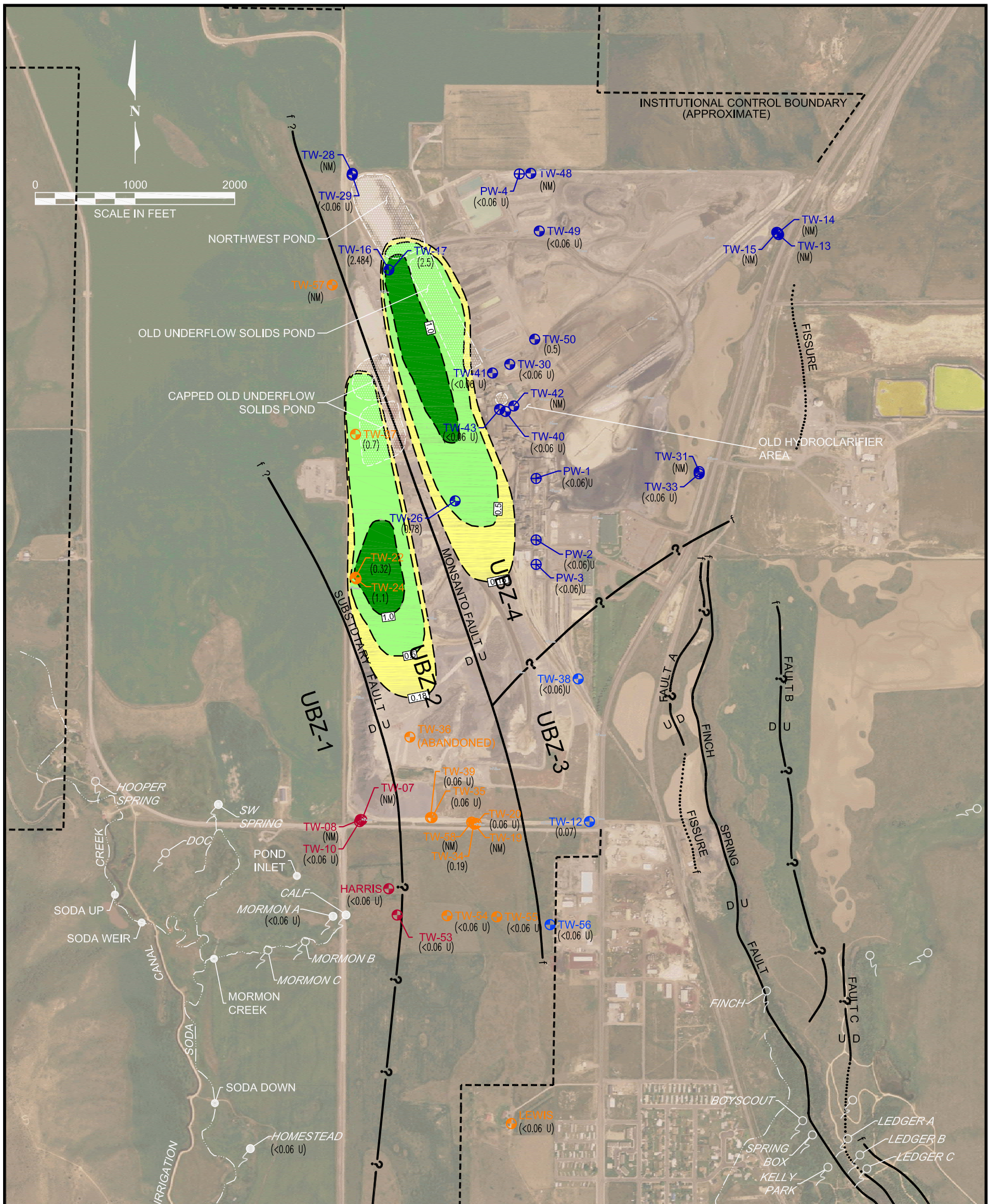

FIGURE **9a**

MANGANESE OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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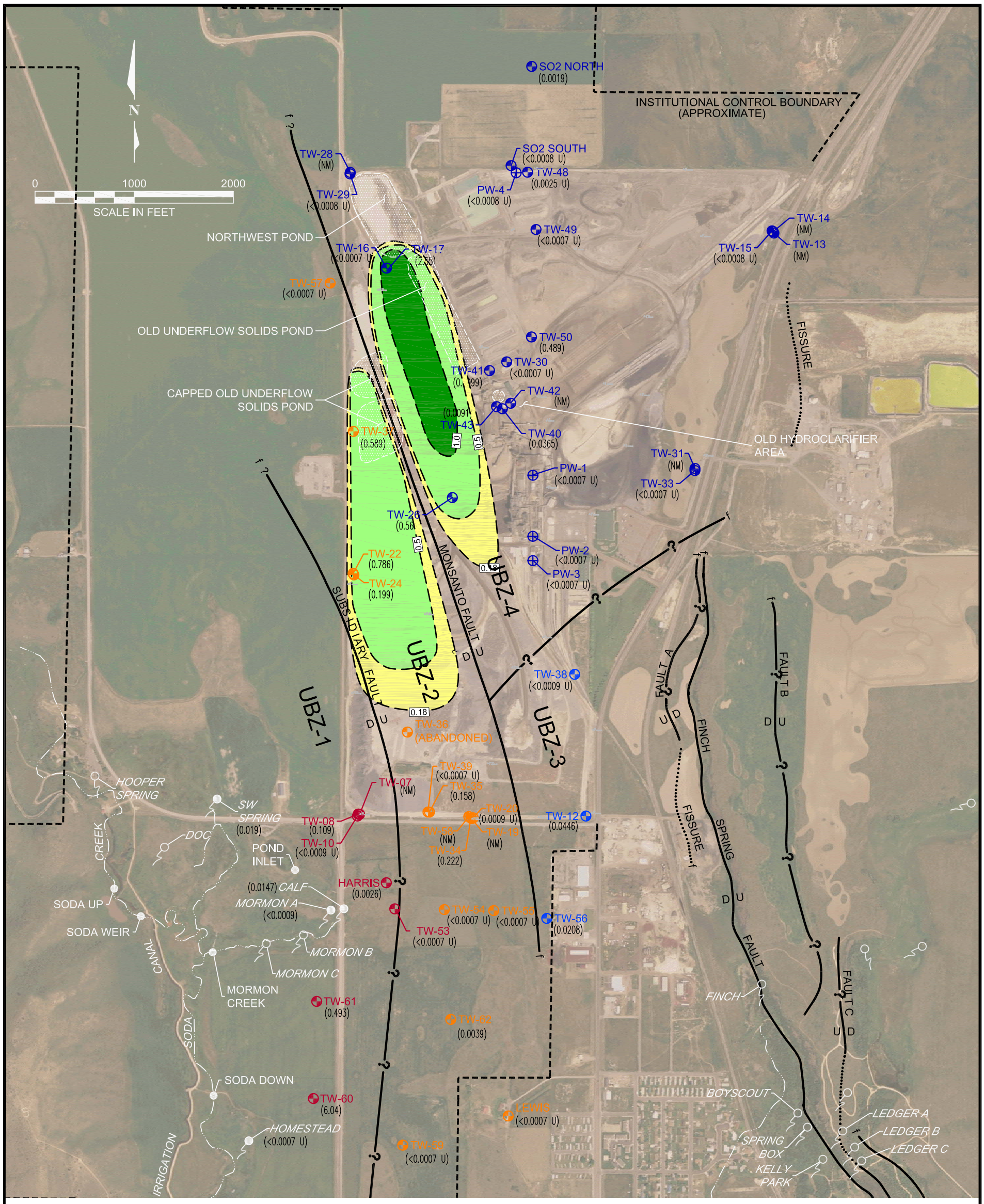
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED
(ND) = NO DATA
(...U) = NOT DETECTED

0.5 1.0 0.18 — CHEMICAL ISOPLETH (mg/L)
DASHED WHERE APPROXIMATE
? WHERE UNKNOWN

REMEDIAL GOAL = 0.18 mg/L (RBC)

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).
WELL LOCATIONS BY GOLDER ASSOCIATES, (12/12/2001).

FIGURE **9b**

MANGANESE OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIWW/ID

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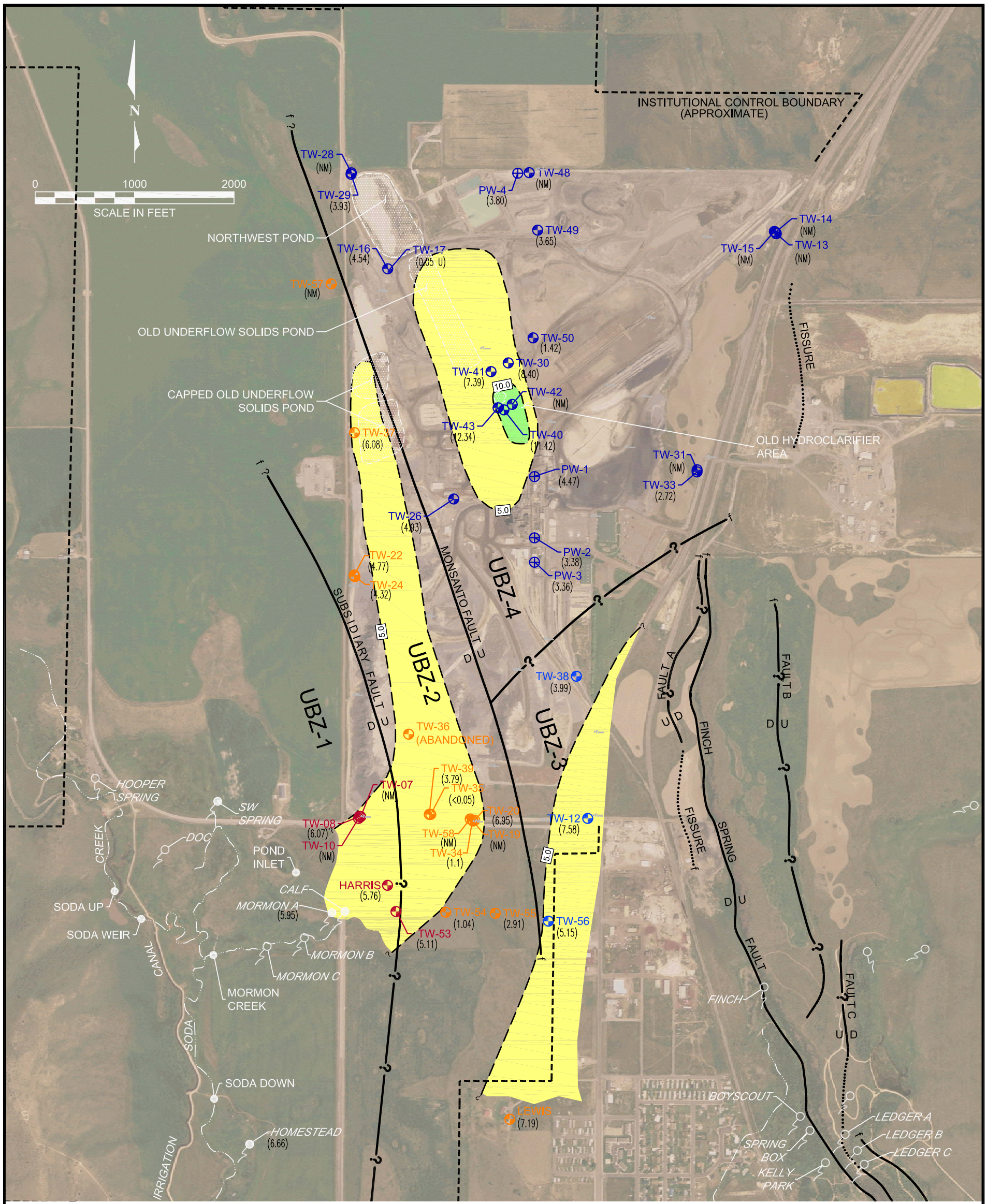
Golder Associates



LEGEND:

FAULT

FAULT (INFERRED)

FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

REMEDIAL GOAL = 10 mg/L (MCL)

FIGURE **10a**

NITRATE (AS N) OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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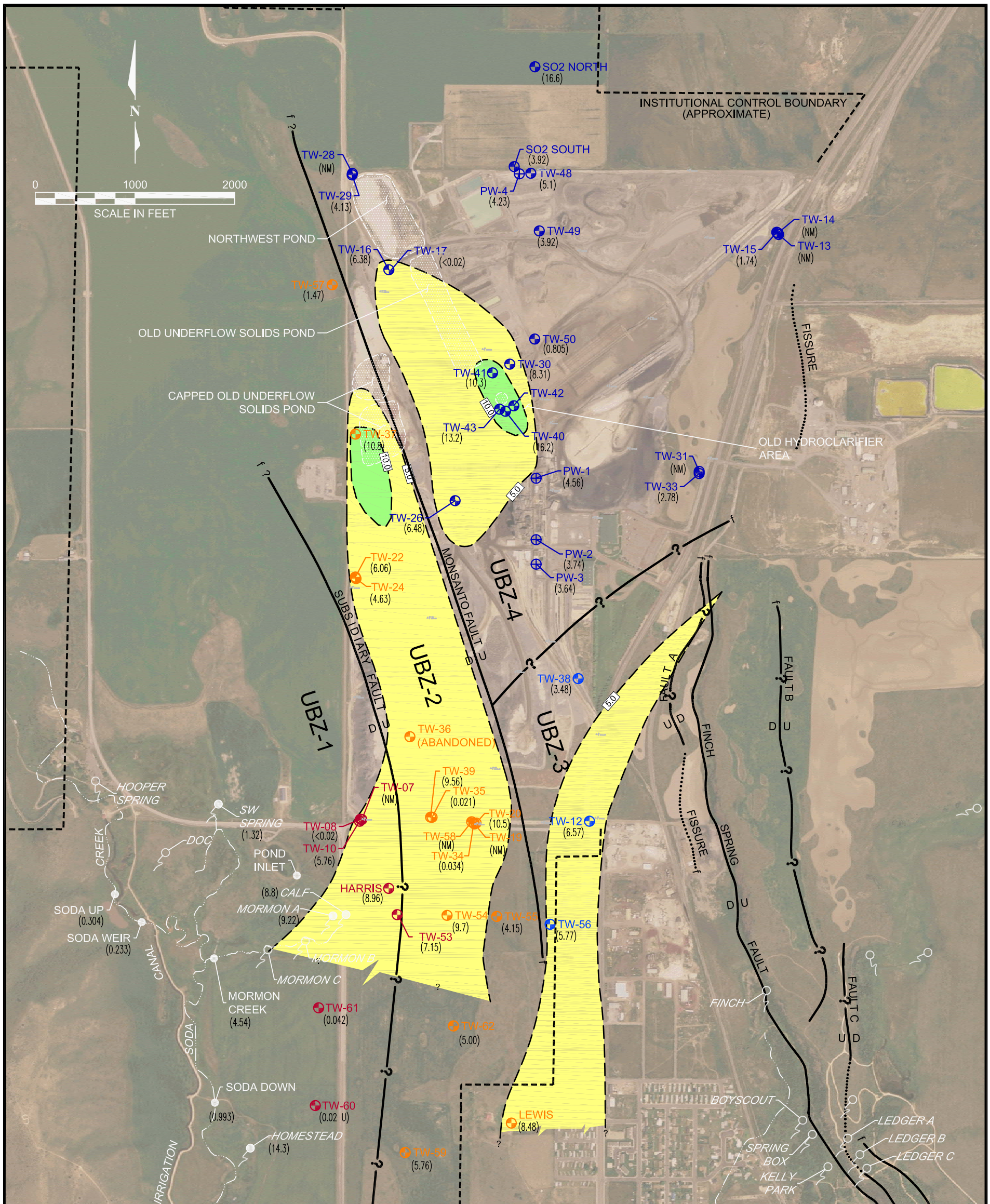
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

5 10 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

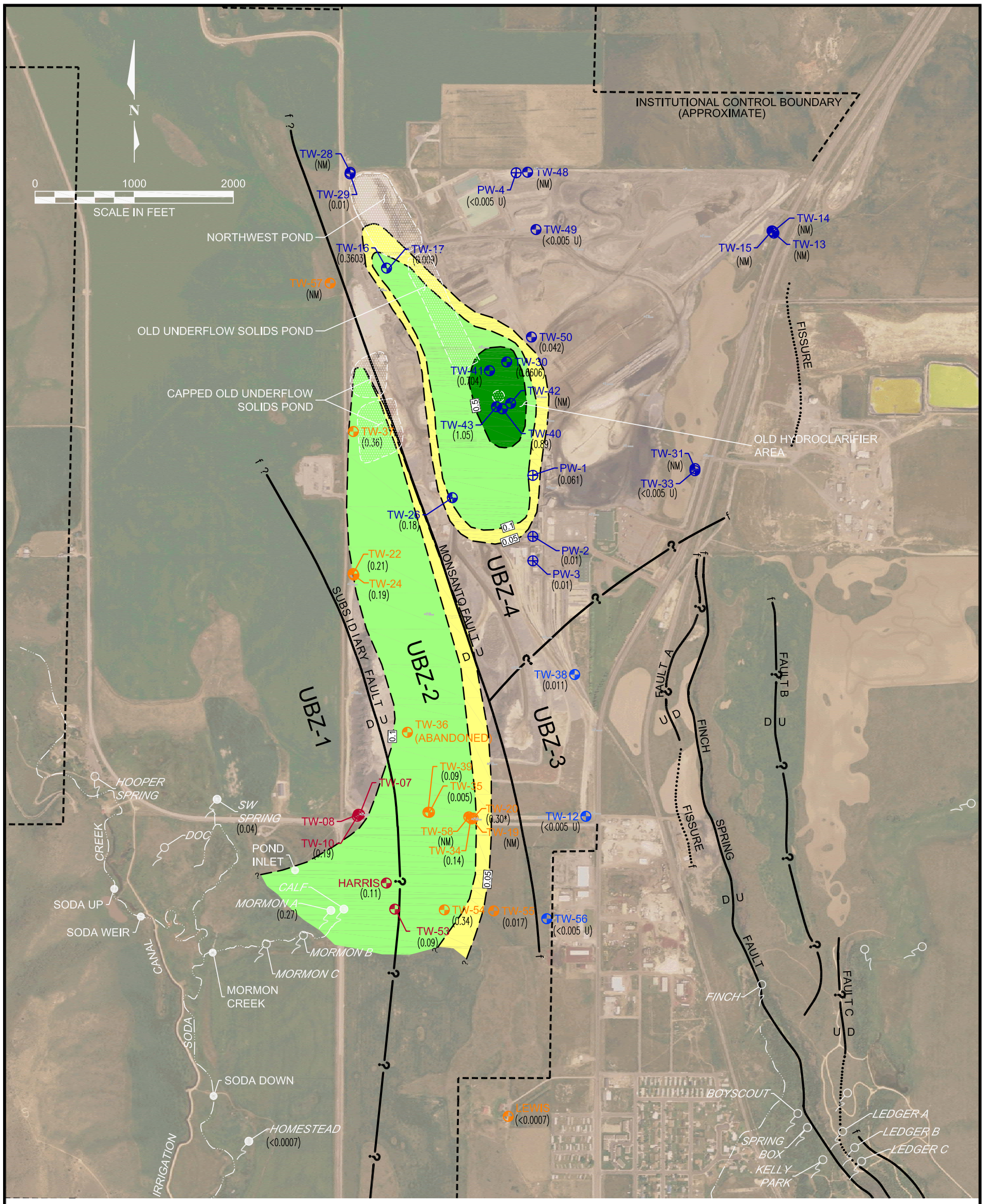
REMEDIAL GOAL = 10 mg/L (MCL)

FIGURE **10b**

NITRATE (AS N) OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).



LEGEND:

- FAULT
- FAULT (INFERRED)
- FISSURE
- UBZ-1 — GROUNDWATER ZONE
- SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)
- SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B
- SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)
- TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1
- TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2
- TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3
- TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4
- PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME
- SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)
  - (NM) = NOT MEASURED
  - (...U) = NOT DETECTED
- CHEMICAL ISOPLETH (mg/L)
  - DASHED WHERE APPROXIMATE
  - ? WHERE UNKNOWN

REMEDIAL GOAL = 0.05 mg/L (MCL)

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

FIGURE **11a**

SELENIUM OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

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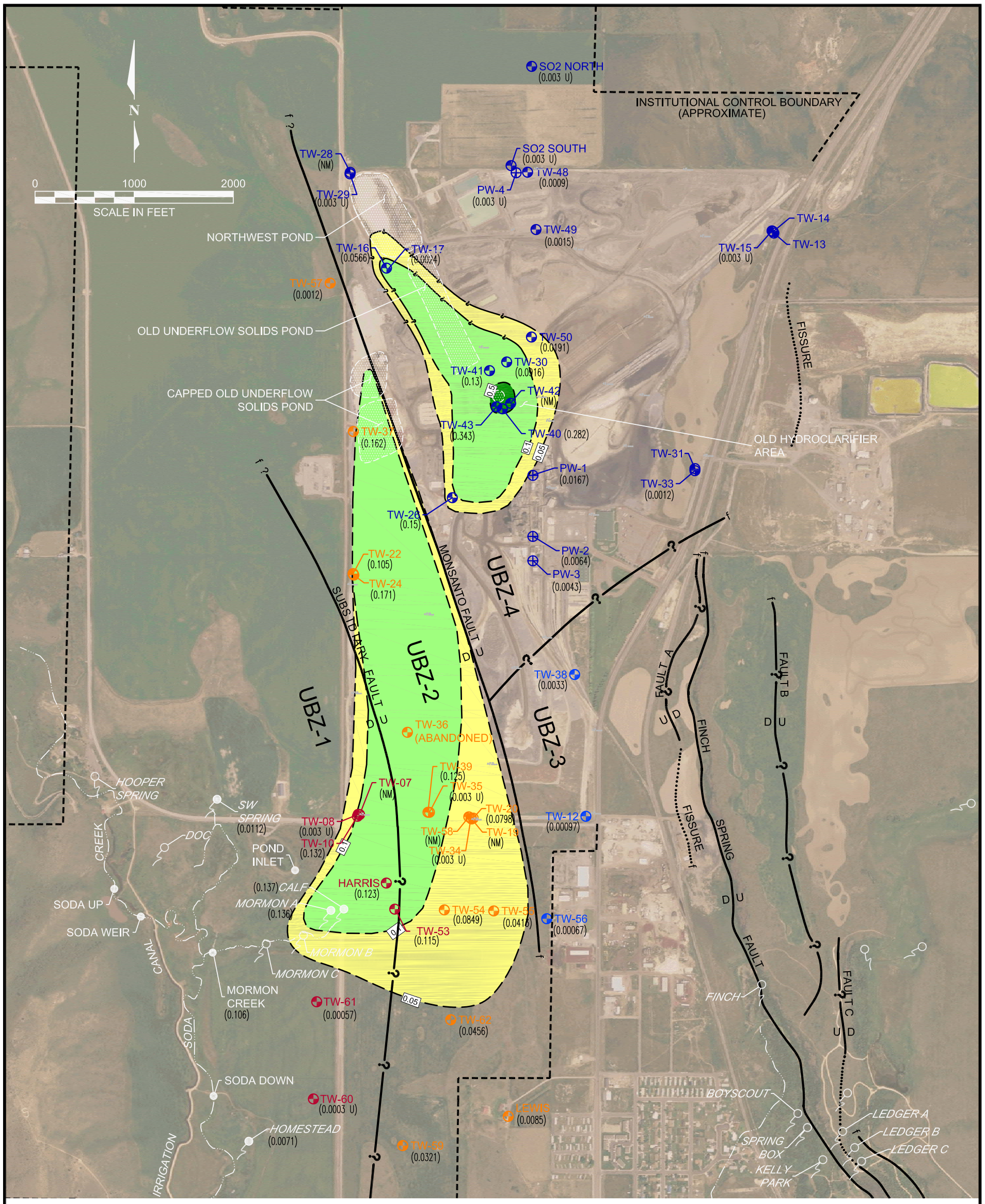
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

0.1 0.5 0.05 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

REMEDIAL GOAL = 0.05 mg/L (MCL)

FIGURE **11b**

SELENIUM OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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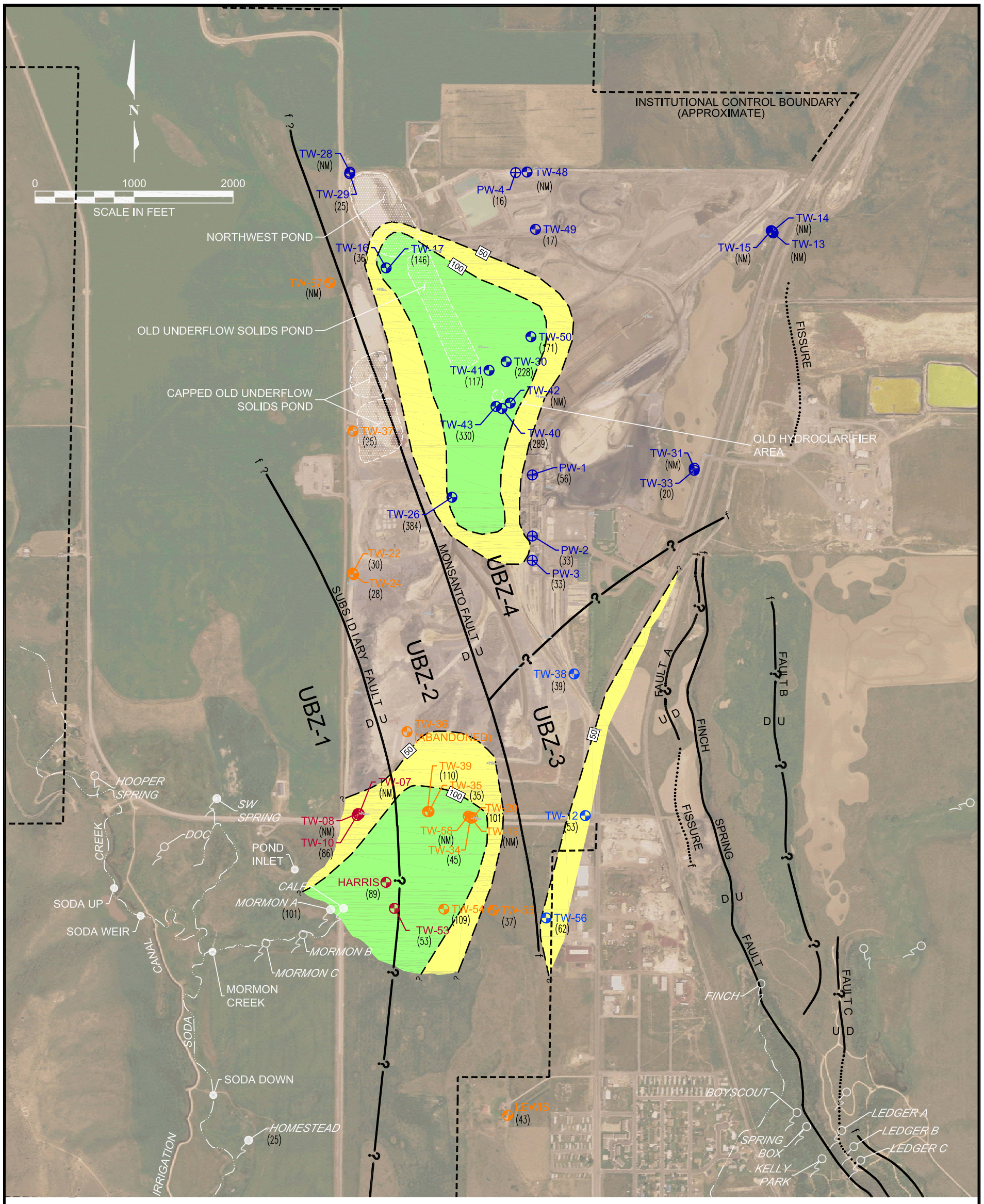

LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

50 100 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

FIGURE **12a**

CHLORIDE OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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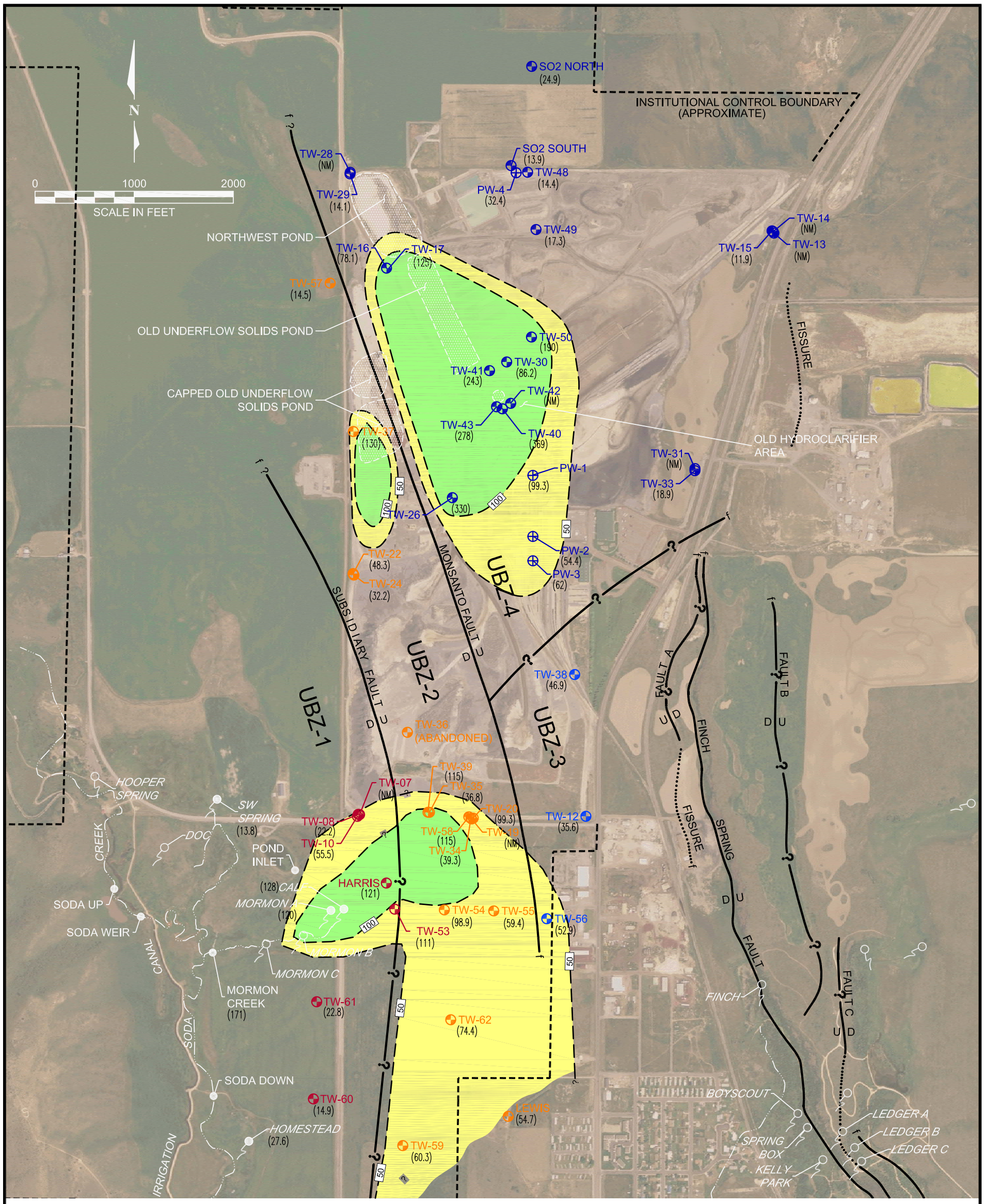

LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

50 100 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

FIGURE **12b**

CHLORIDE OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

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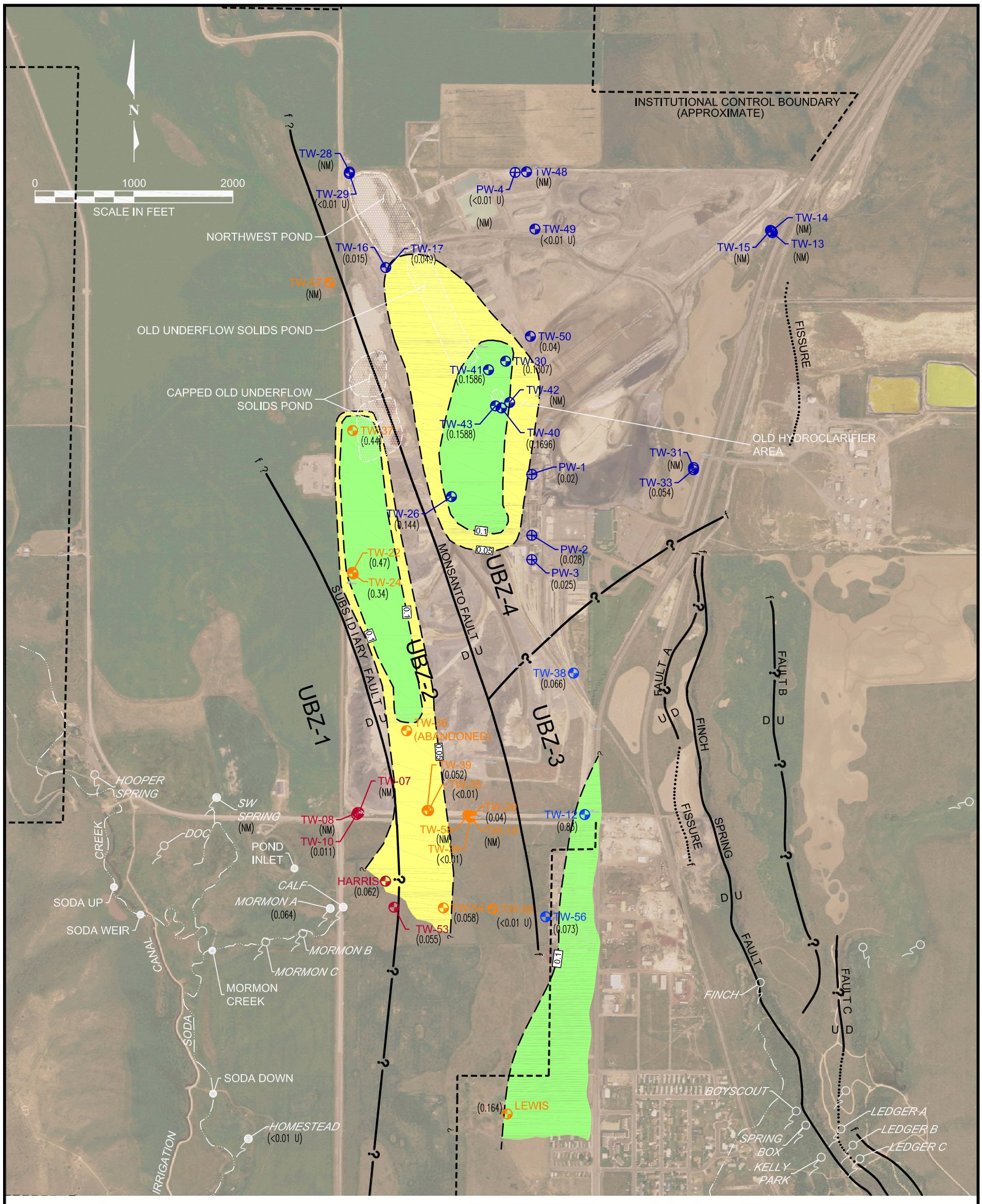
Golder Associates



LEGEND:

f U f FAULT

f U D ? D f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

? 0.05 ? 0.1 ? — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

FIGURE **13a**

MOLYBDENUM OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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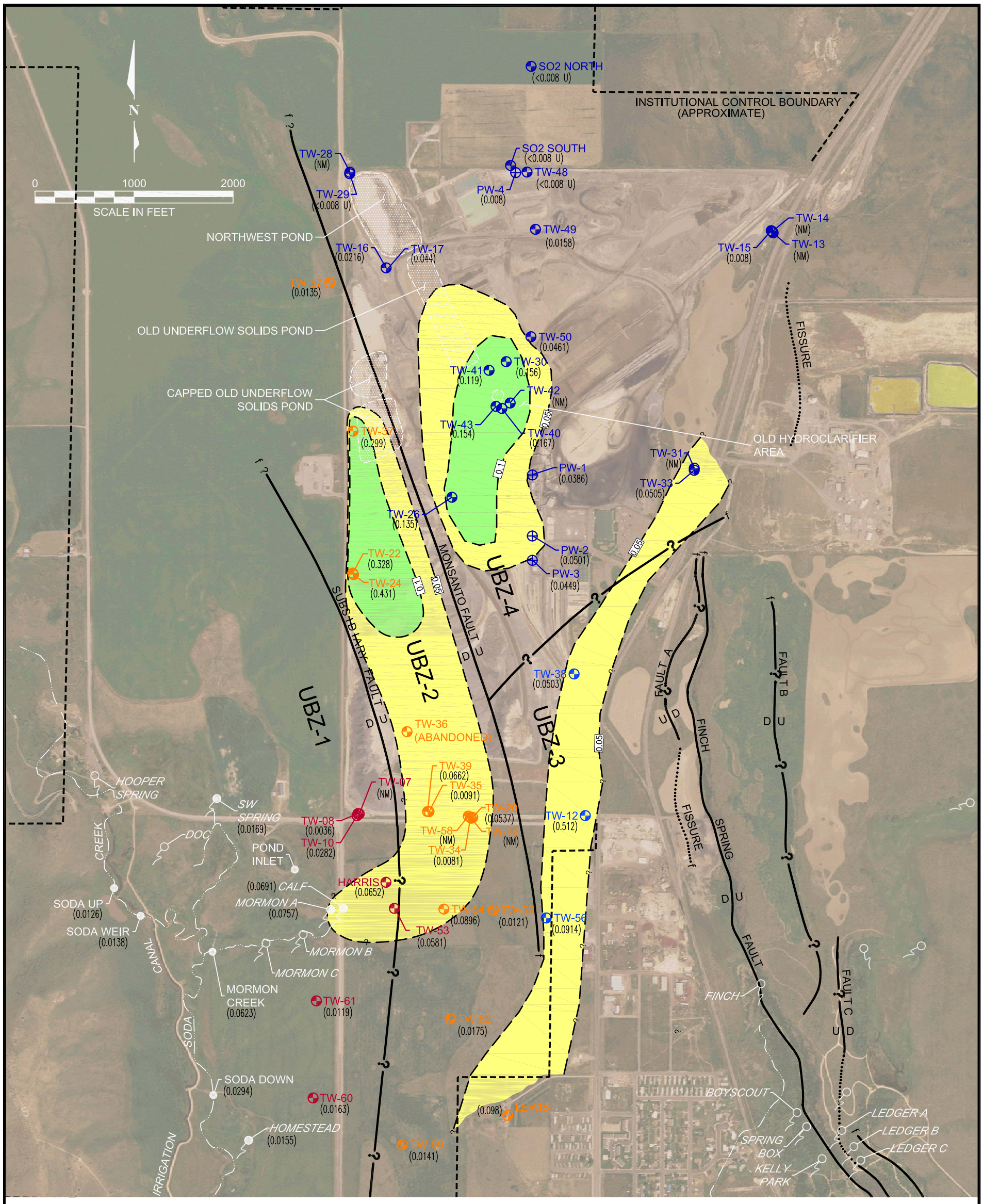
Golder Associates



LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)
(NM) = NOT MEASURED
(...U) = NOT DETECTED
(SAMPLES COLLECTED [DATE])

? 0.05 ? ? 0.1 ? — CHEMICAL ISOPLETH (mg/L)
DASHED WHERE APPROXIMATE
? WHERE UNKNOWN

FIGURE **13b**

MOLYBDENUM OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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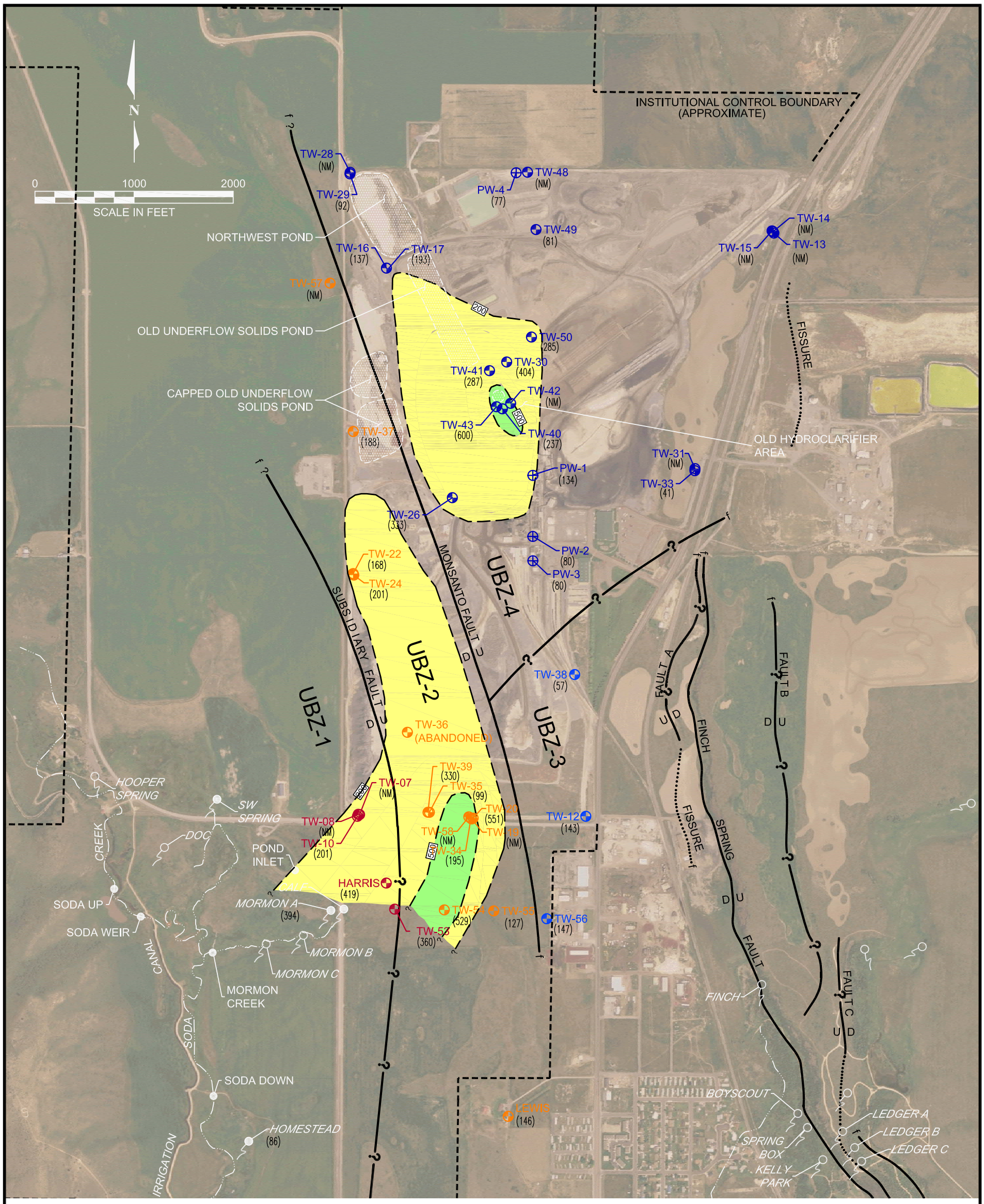

LEGEND:

f U D f FAULT

f U D ? f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

200 500 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

FIGURE **14a**

SULFATE OF THE UPPER BASALT ZONE (JUNE 2002)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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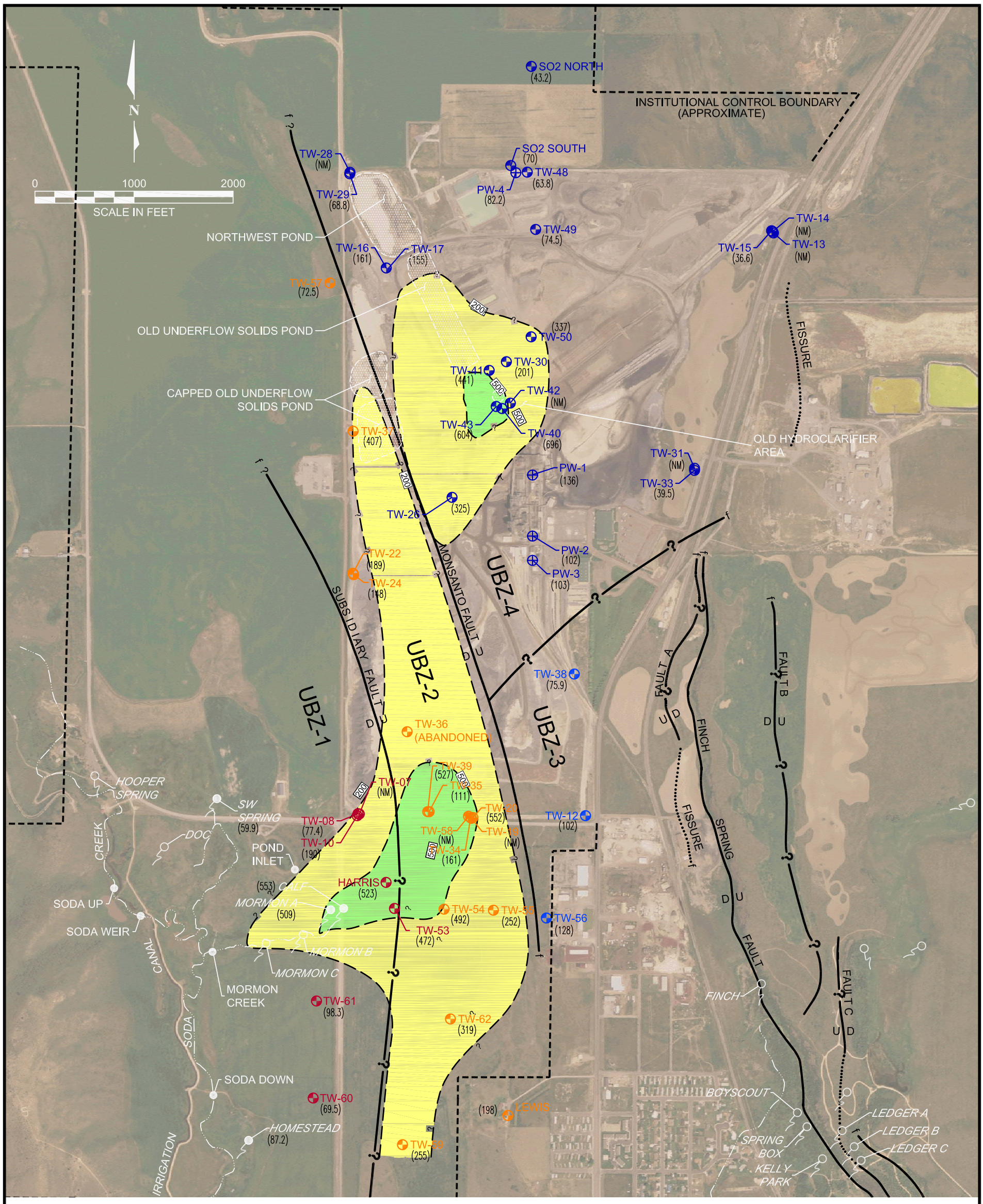

LEGEND:

f U f FAULT

f U D ? D f FAULT (INFERRED)

f f FISSURE

UBZ-1 GROUNDWATER ZONE

SPRING LOCATION WITH NAME (WHERE KNOWN) — MORMON A (0.015)

SPRING LOCATION (NOT SAMPLED) WITH NAME (WHERE KNOWN) — MORMON B

SURFACE WATER LOCATION WITH NAME — MORMON CREEK (NM)

TW-60 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-1

TW-59 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-2

TW-56 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-3

TW-28 (<0.002 U) — MONITORING WELL LOCATION WITH NAME IN GROUNDWATER ZONE UBZ-4

PW-1 (0.041) — PRODUCTION WELL LOCATION WITH NAME

SAMPLE: CHEMICAL CONCENTRATION (mg/L) WITH QUALIFIER (IF ANY)

(NM) = NOT MEASURED

(...U) = NOT DETECTED

200 500 — CHEMICAL ISOPLETH (mg/L)

DASHED WHERE APPROXIMATE

? WHERE UNKNOWN

FIGURE **14b**

SULFATE OF THE UPPER BASALT ZONE (JUNE/JULY 2007)

MONSANTO/SECOND 5-YEAR REVIEW/ID

SOURCE:
AERIAL PHOTO FROM MONSANTO (5/2/2003).
SITE TOPOGRAPHY FROM AERIAL MAPPING, INC., IDAHO (5/11/1996).

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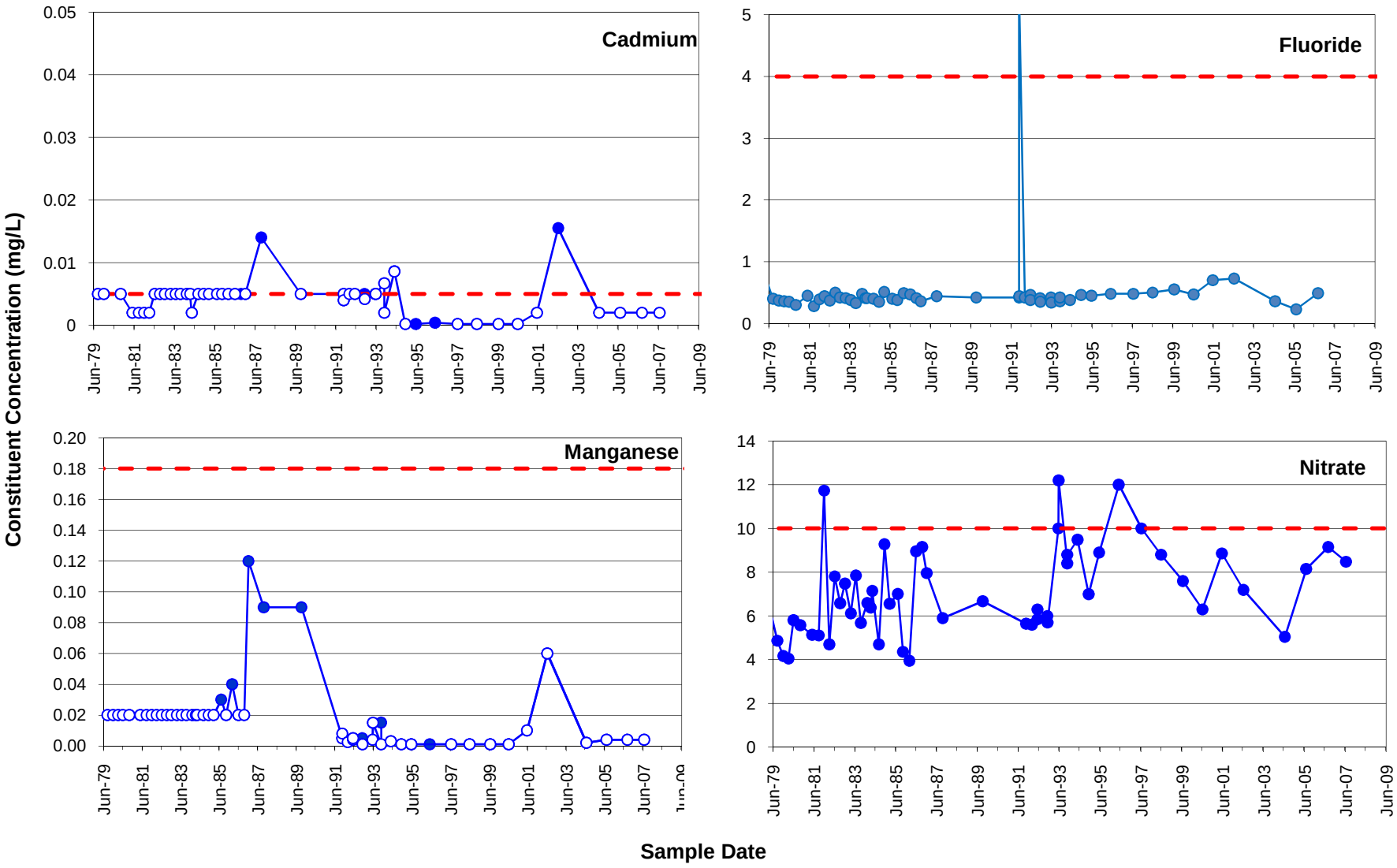


FILE NAME lewis well

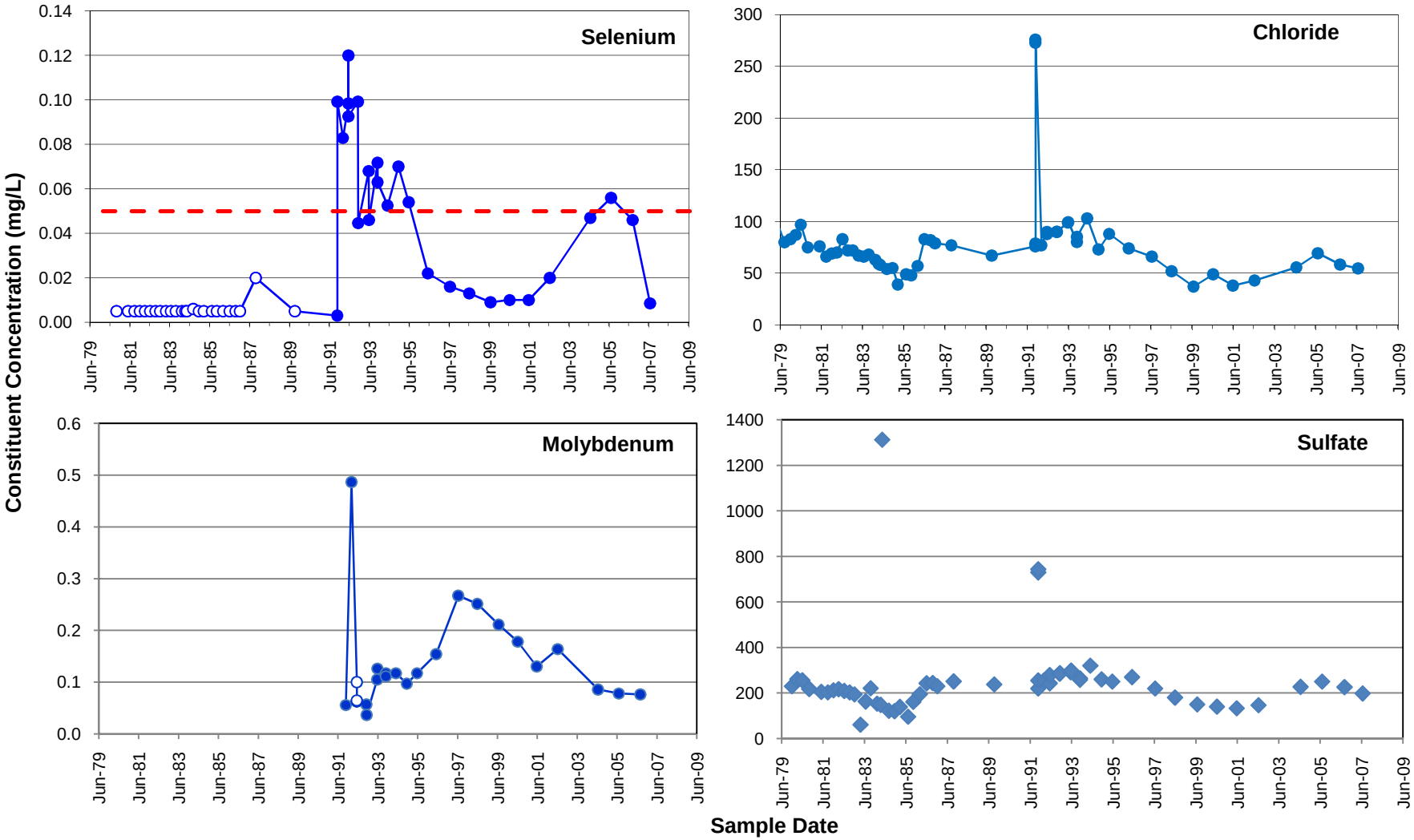
Golder Associates

TITLE **Lewis Well Chemical Hydrographs (Page 1 of 2)**

FIGURE 15a

Constituent Concentration (mg/L)
Non-Detects
Remediation Goal

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME lewis well

Golder Associates

TITLE **Lewis Well Chemical Hydrographs (Page 2 of 2)**

FIGURE 15b

Constituent Concentration (mg/L)

Non-Detects

Remedial Goal

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB

ATTACHMENT A

THEORETICAL BACKGROUND OF STATISTICAL METHODS

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series.

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

FI17 Virolahti 1987- 2000

CALCULATE TREND STATISTICS

Number of time series in the calculation:	9									
Number of annual values in the calculation:	14	14	14	14	12	11	14	12	12	0
Select the FIRST YEAR of the calculation:	1987	1987	1987	1987	1989	1990	1987	1989	1989	
Select the LAST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	2000	

Year	SO4 mg S/	NH4 mg N/	NO3 mg N/	Ca mg/l	K mg/l	SO2 ug S/m	SO4 ug S/m	HNO3+NO3	NH3+NH4 ug N/m3	
1987	1.46	0.73	0.48	0.69			1.68			
1988	1.22	0.49	0.49	0.75			1.59			
1989	1.19	0.66	0.47	0.56	0.23		1.22	0.42	1.07	
1990	1	0.45	0.44	0.54	0.19	2.01	1.27	0.38	0.95	
1991	1.11	0.52	0.43	0.64	0.3	2.17	1.5	0.41	0.95	
1992	1.16	0.72	0.5	0.66	0.31	1.31	1.2	0.35	0.93	
1993	0.78	0.38	0.34	0.44	0.15	1.84	1.18	0.33	0.82	
1994	0.84	0.41	0.36	0.43	0.22	1.61	1.04	0.34	0.75	
1995	0.79	0.45	0.38	0.42	0.14	1.05	0.89	0.28	0.69	
1996	0.85	0.43	0.43	0.41	0.12	1.51	1.09	0.35	0.8	
1997	0.54	0.33	0.33	0.26	0.13	0.79	0.75	0.26	0.96	
1998	0.49	0.34	0.3	0.27	0.2	1.02	0.81	0.29	0.85	
1999	0.61	0.41	0.41	0.28	0.12	0.96	0.85	0.32	1.16	
2000	0.66	0.43	0.39	0.27	0.13	0.66	0.67	0.28	0.95	

TREND STATISTICS

FI17 Virolahti 1987- 2000

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Significf.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
SO4 mg S/l	*1987*	*2000*	*14*		-3.50	***	-0.063	-0.089	-0.034	-0.085	-0.044	1.30	1.46	1.10	1.44	1.19
NH4 mg N/l	*1987*	*2000*	*14*		-2.47	*	-0.018	-0.040	0.000	-0.035	-0.004	0.59	0.73	0.44	0.73	0.47
NO3 mg N/l	*1987*	*2000*	*14*		-2.47	*	-0.013	-0.020	0.002	-0.019	-0.004	0.48	0.52	0.40	0.51	0.45
Ca mg/l	*1987*	*2000*	*14*		-3.78	***	-0.034	-0.053	-0.021	-0.046	-0.025	0.69	0.82	0.60	0.79	0.61
K mg/l	*1989*	*2000*	*12*		-2.27	*	-0.010	-0.029	0.002	-0.023	-0.002	0.25	0.42	0.16	0.37	0.18
SO2 ug S/m3	*1990*	*2000*	*11*		-3.11	**	-0.135	-0.231	-0.048	-0.187	-0.060	2.51	3.22	1.55	2.92	1.68
SO4 ug S/m3	*1987*	*2000*	*14*		-4.05	***	-0.070	-0.098	-0.036	-0.092	-0.046	1.58	1.72	1.33	1.68	1.41
HNO3+NO3 ug N/m3	*1989*	*2000*	*12*		-2.82	**	-0.011	-0.023	-0.002	-0.020	-0.005	0.42	0.50	0.35	0.47	0.38
NH3+NH4 ug N/m3	*1989*	*2000*	*12*		-0.28		-0.005	-0.062	0.037	-0.047	0.025	0.96	1.22	0.60	1.17	0.69
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

FI17 Virolahti 1987- 2000

TsNumber	9
Name	NH3+NH4 ug N/m3
Years	1989 - 2000
n	12
Test S	
Test Z	-0.28
Signific.	
Q	-5.00E-03
Qmin99	-6.16E-02
Qmax99	3.66E-02
Qmin95	-4.72E-02
Qmax95	2.52E-02
B	9.60E-01
Bmin99	1.22E+00
Bmax99	5.98E-01
Bmin95	1.17E+00
Bmax95	6.88E-01

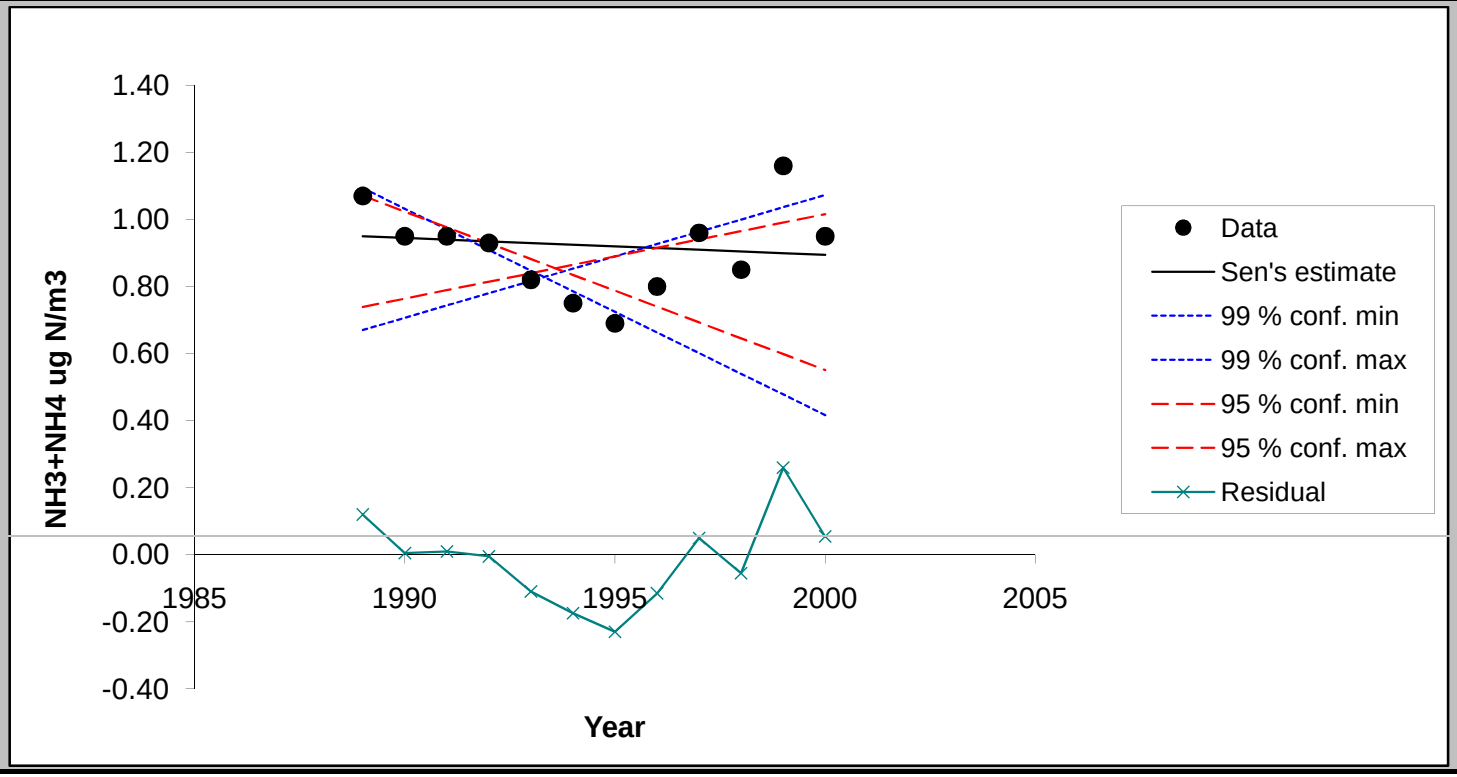


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1987

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1989	1.07	0.95	1.09	0.67	1.07	0.74	0.12
1990	0.95	0.95	1.03	0.71	1.02	0.76	0.01
1991	0.95	0.94	0.97	0.74	0.98	0.79	0.01
1992	0.93	0.94	0.91	0.78	0.93	0.81	-0.01
1993	0.82	0.93	0.85	0.82	0.88	0.84	-0.11
1994	0.75	0.93	0.79	0.85	0.83	0.86	-0.18
1995	0.69	0.92	0.72	0.89	0.79	0.89	-0.23
1996	0.80	0.92	0.66	0.93	0.74	0.92	-0.12
1997	0.96	0.91	0.60	0.96	0.69	0.94	0.05
1998	0.85	0.91	0.54	1.00	0.65	0.97	-0.06
1999	1.16	0.90	0.48	1.04	0.60	0.99	0.26
2000	0.95	0.90	0.42	1.07	0.55	1.02	0.05

Ilmanlaadun julkaisuja
Publikationer om luftkvalitet
Publications on air quality

No. 31

DETECTING TRENDS OF ANNUAL VALUES OF ATMOSPHERIC POLLUTANTS BY THE MANN-KENDALL TEST AND SEN'S SLOPE ESTIMATES -THE EXCEL TEMPLATE APPLICATION MAKESENS

Timo Salmi
Anu Määttä
Pia Anttila
Tuija Ruoho-Airola
Toni Amnell

Ilmatieteen laitos
Meteorologiska Institutet
Finnish Meteorological Institute

Helsinki 2002

ISBN 951-697-563-1
ISSN 1456-789X
Painopaikka:Edita Oyj

Helsinki 2002

FINNISH METEOROLOGICAL INSTITUTE

Published by Finnish Meteorological Institute
Vuorikatu 24, P.O. Box 503
FIN-00101 Helsinki, Finland

Series title, number and report code of publication
Publications on Air Quality No. 31
Report code FMI-AQ-31
Date August 2002

Authors
Timo Salmi, Anu Määttä, Pia Anttila, Tuija Ruoho-Airola and Toni Amnell

Name of project Air Quality Assessment in the Baltic countries as a consequence of local pollution and long range transport - a co-operation between Nordic and Baltic countries within the framework of the EMEP's 20 years Assessment

Commissioned by Nordic Council of Ministers

Title
Detecting trends of annual values of atmospheric pollutants by the Mann-Kendall test and Sen's slope estimates –the Excel template application MAKESENS

Abstract

An Excel template – MAKESENS – is developed for detecting and estimating trends in the time series of annual values of atmospheric and precipitation concentrations. The procedure is based on the nonparametric Mann-Kendall test for the trend and the nonparametric Sen's method for the magnitude of the trend. The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series with no seasonal or other cycle. The Sen's method uses a linear model for the trend. The theory of the calculation, the user's manual and the macro code are presented. As an example the long term trends of precipitation and atmospheric concentrations of some compounds at the Virolahti air quality monitoring station of the Finnish Meteorological Institute are calculated and briefly discussed.

Publishing unit
Finnish Meteorological Institute, Air Quality Research

Classification (UDK)
504.064
519.234

Keywords
trend, Mann-Kendall test, Sen's method, annual time series, trend significance

ISSN and series title
1456-789X Publications on Air Quality

ISBN
951-697-563-1

Language
English

Sold by
Finnish Meteorological Institute / Library
P.O.Box 503, FIN-00101 Helsinki
Finland

Pages 35

Price

Note

Table of Contents

1 Introduction 7

2 Calculation of the Mann-Kendall test and the magnitude of the trend with the Sen's method in MAKESENS 7

2.1 Mann-Kendall test 8

2.1.1 Number of data values less than 10 8

2.1.2 Number of data values 10 or more 10

2.2 Sen's method 11

3 User's manual for MAKESENS 12

3.1 Entering the time series and other input values 13

3.2 Summary table of results 16

3.3 Visual viewing of data and results 19

4 Examples 21

5 Summary 24

6 References 25

7 Appendix 1. The macro code of MAKESENS 26

1 Introduction

An Excel template MAKESENS (Mann-Kendall test for trend and Sen's slope estimates) is developed for detecting and estimating trends in the time series of the annual values of atmospheric and precipitation concentrations. The need for this kind of simple and easy- to-use tool came up in the research project "Air quality Assessment in the Baltic countries as a consequence of local pollution and long range transport - a co-operation between Nordic and Baltic countries within the framework of EMEP's 20-years Assessment" financed by the Nordic Council of Ministers. This subproject is a contribution to the EMEP's (Evaluation of the Long-Range Transmission of Air Pollutants in Europe) twenty years of assessment work initiated by the EMEP's Task Force on Measurements and Modelling in Vienna October 2000 (TFMM 2000). This European-wide effort will assess the outcome of the emission control measures in Europe between 1980-2000, focusing on the significance of changes in concentrations and deposition in relation to emission changes.

The calculation of the Mann-Kendall test and the nonparametric Sen's method are briefly described here. We also present a detailed user's manual of MAKESENS, its macro code and some examples. In addition to the statistical calculations, MAKESENS also provides a simple graphical interface to assist the visual inspection of the time series and the statistical results. The details of the theories can be found in Gilbert (1987). Also Sirois (1998) gives an educative summary of the application of these methods in atmospheric chemistry studies.

2 Calculation of the Mann-Kendall test and the magnitude of the trend with the Sen's method in MAKESENS

MAKESENS performs two types of statistical analyses. First the presence of a monotonic increasing or decreasing trend is tested with the nonparametric Mann-Kendall test and

secondly the slope of a linear trend is estimated with the nonparametric Sen's method (Gilbert 1987). These methods are here used in their basic forms; the Mann-Kendall test is suitable for cases where the trend may be assumed to be monotonic and thus no seasonal or other cycle is present in the data. The Sen's method uses a linear model to estimate the slope of the trend and the variance of the residuals should be constant in time. These methods offer many advantages that have made them useful in analysing atmospheric chemistry data. Missing values are allowed and the data need not conform to any particular distribution. Besides, the Sen's method is not greatly affected by single data errors or outliers.

2.1 Mann-Kendall test

The Mann-Kendall test is applicable in cases when the data values x_i of a time series can be assumed to obey the model

$$x_i = f(t_i) + \varepsilon_i \ , \tag{1}$$

where $f(t)$ is a continuous monotonic increasing or decreasing function of time and the residuals ε_i can be assumed to be from the same distribution with zero mean. It is therefore assumed that the variance of the distribution is constant in time.

We want to test the null hypothesis of no trend, H_o, i.e. the observations x_i are randomly ordered in time, against the alternative hypothesis, H_1, where there is an increasing or decreasing monotonic trend. In the computation of this statistical test MAKESENS exploits both the so called S statistics given in Gilbert (1987) and the normal approximation (Z statistics). For time series with less than 10 data points the S test is used, and for time series with 10 or more data points the normal approximation is used.

2.1.1 Number of data values less than 10

The number of annual values in the studied data series is denoted by n. Missing values are allowed and n can thus be smaller than the number of years in the studied time series.

The Mann-Kendall test statistic S is calculated using the formula

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k), \tag{2}$$

where x_j and x_k are the annual values in years j and k, $j > k$, respectively, and

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} 1 & if\ x_j - x_k > 0 \\ 0 & if\ x_j - x_k = 0 \\ -1 & if\ x_j - x_k < 0 \end{cases}. \tag{3}$$

If n is 9 or less, the absolute value of S is compared directly to the theoretical distribution of S derived by Mann and Kendall (Gilbert, 1987). In MAKESENS the two-tailed test is used for four different significance levels α : 0.1, 0.05, 0.01 and 0.001. At certain probability level H_0 is rejected in favour of H_1 if the absolute value of S equals or exceeds a specified value $S_{\alpha/2}$, where $S_{\alpha/2}$ is the smallest S which has the probability less than $\alpha/2$ to appear in case of no trend. A positive (negative) value of S indicates an upward (downward) trend.

The minimum values of n with which these four significance levels can be reached are derived from the probability table for S as follows.

Significance level $\boldsymbol{\alpha}$	**required** $\boldsymbol{n}$
0.1	≥ 4
0.05	≥ 5
0.01	≥ 6
0.001	≥ 7

The significance level 0.001 means that there is a 0.1% probability that the values x_i are from a random distribution and with that probability we make a mistake when rejecting H_0 of no trend. Thus the significance level 0.001 means that the existence of a monotonic trend is very probable. Respectively the significance level 0.1 means that there is a 10% probability that we make a mistake when rejecting H_0.

2.1.2 Number of data values 10 or more

If n is at least 10 the normal approximation test is used. However, if there are several tied values (i.e. equal values) in the time series, it may reduce the validity of the normal approximation when the number of data values is close to 10.

First the variance of S is computed by the following equation which takes into account that ties may be present:

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p(t_p - 1)(2t_p + 5) \right]. \qquad (4)$$

Here q is the number of tied groups and t_p is the number of data values in the pth group.

The values of S and $VAR(S)$ are used to compute the test statistic Z as follows

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{VAR(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \dfrac{S+1}{\sqrt{VAR(S)}} & if\ S < 0 \end{cases} \qquad (5)$$

The presence of a statistically significant trend is evaluated using the Z value. A positive (negative) value of Z indicates an upward (downward) trend. The statistic Z has a normal distribution. To test for either an upward or downward monotone trend (a two-tailed test) at α level of significance, H_0 is rejected if the absolute value of Z is greater than $Z_{1-\alpha/2}$, where

$Z_{1-\alpha/2}$ is obtained from the standard normal cumulative distribution tables. In MAKESENS the tested significance levels α are 0.001, 0.01, 0.05 and 0.1.

2.2 Sen's method

To estimate the true slope of an existing trend (as change per year) the Sen's nonparametric method is used. The Sen's method can be used in cases where the trend can be assumed to be linear. This means that *f(t)* in equation (1) is equal to

$$f(t) = Qt + B \tag{6}$$

where Q is the slope and B is a constant.

To get the slope estimate *Q* in equation (6) we first calculate the slopes of all data value pairs

$$Q_i = \frac{x_j - x_k}{j - k}\ , \tag{7}$$

where $j>k$.

If there are *n* values x_j in the time series we get as many as $N = n(n-1)/2$ slope estimates Q_i. The Sen's estimator of slope is the median of these *N* values of Q_i. The *N* values of Q_i are ranked from the smallest to the largest and the Sen's estimator is

$$Q = Q_{[(N+1)/2]}, \text{ if } N \text{ is odd}$$

or (8)

$$Q = \frac{1}{2}\left(Q_{[N/2]} + Q_{[(N+2)/2]}\right), \text{ if } N \text{ is even.}$$

A 100(1-α)% two-sided confidence interval about the slope estimate is obtained by the nonparametric technique based on the normal distribution. The method is valid for *n* as small as 10 unless there are many ties.

The procedure in MAKESENS computes the confidence interval at two different confidence levels; α = 0.01 and α = 0.05, resulting in two different confidence intervals.

At first we compute

$$C_{\alpha} = Z_{1-\alpha/2}\sqrt{VAR(S)}\ , \qquad (9)$$

where *VAR(S)* has been defined in equation (4), and $Z_{1-\alpha/2}$ is obtained from the standard normal distribution.

Next $M_1 = (N - C_{\alpha})/2$ and $M_2 = (N + C_{\alpha})/2$ are computed. The lower and upper limits of the confidence interval, Q_{min} and Q_{max}, are the M_1^{th} largest and the $(M_2 + 1)^{th}$ largest of the N ordered slope estimates Q_i. If M_1 is not a whole number the lower limit is interpolated. Correspondingly, if M_2 is not a whole number the upper limit is interpolated.

To obtain an estimate of B in equation (6) the *n* values of differences $x_i - Qt_i$ are calculated. The median of these values gives an estimate of B (Sirois 1998). The estimates for the constant B of lines of the 99% and 95% confidence intervals are calculated by a similar procedure.

3 User's manual for MAKESENS

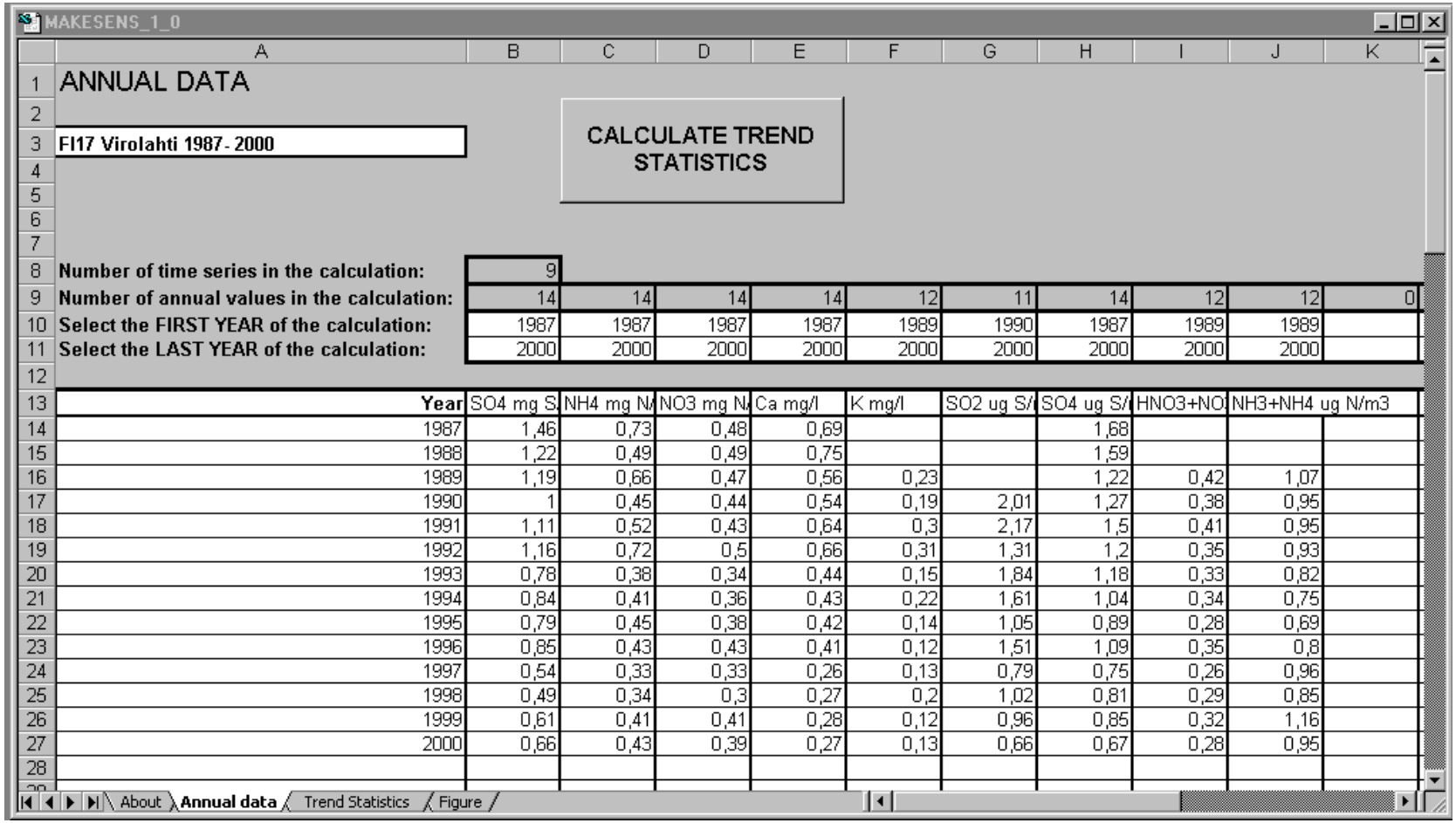
The MAKESENS template was created using Microsoft Excel 97 and the macros were coded with Microsoft Visual Basic. The template consists of four worksheets: **About**, **Annual data, Trend Statistics** and **Figure**. The **About** worksheet gives general information about the template. The data of time series are entered into the **Annual data**

worksheet. The calculation macro can be activated by using the button **Calculate Trend Statistics** and the **Trend Statistics** worksheet contains the results. Finally, the original data and the statistics can be viewed numerically and visually in the **Figure** worksheet one time series at a time.

3.1 Entering the time series and other input values

All the input values are entered in the **Annual data** worksheet (see Figure 1). The years, the annual values and the names of the time series have to be typed or copied (**Paste Special/Values**) to the fixed places of the worksheet. The cells in the worksheet, in which the user may enter data have no shading. The other cells are protected and have grey shading.

- **A title to the whole data set** can be typed in cell **A3** . This title is also shown in cells **'Trend Statistics'!A3** and **'Figure'!B4.**
- **The names of the time series** are entered in cells **B13:Z13** starting from the column **B.** The maximum number of time series that can be entered is 25. The names are transposed into the cells **'Trend Statistics'!A6:A30.** The name of the time series is also shown in cell ´**Figure'!C10** and as the title of Y-axis in the figure.
- Cell **A13** is reserved for the column title "Year".
- From cell **A14** downwards the user must enter an **increasing and continuous series of years**. The range of the years shall cover all the time series but excess years in the beginning or at the end are allowed. The number of years is limited to 100 but can be extended by changing the value of the constant **MaxData** in the macro code (Appendix 1).
- The **annual values** of each time series must be entered below the name of the time series according to the years in the column **A**. An empty cell indicates a missing value. The values of a time series or the entire table of annual data can also be copied from another table.



MAKESENS_1_0

ANNUAL DATA

FI17 Virolahti 1987- 2000

CALCULATE TREND STATISTICS

Number of time series in the calculation:	9										
Number of annual values in the calculation:	14	14	14	14	12	11	14	12	12	0	
Select the FIRST YEAR of the calculation:	1987	1987	1987	1987	1989	1990	1987	1989	1989		
Select the LAST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	2000		
Year	SO4 mg S/	NH4 mg N/	NO3 mg N/	Ca mg/l	K mg/l	SO2 ug S/	SO4 ug S/	HNO3+NO	NH3+NH4 ug N/m3		
1987	1,46	0,73	0,48	0,69			1,68				
1988	1,22	0,49	0,49	0,75			1,59				
1989	1,19	0,66	0,47	0,56	0,23		1,22	0,42	1,07		
1990	1	0,45	0,44	0,54	0,19	2,01	1,27	0,38	0,95		
1991	1,11	0,52	0,43	0,64	0,3	2,17	1,5	0,41	0,95		
1992	1,16	0,72	0,5	0,66	0,31	1,31	1,2	0,35	0,93		
1993	0,78	0,38	0,34	0,44	0,15	1,84	1,18	0,33	0,82		
1994	0,84	0,41	0,36	0,43	0,22	1,61	1,04	0,34	0,75		
1995	0,79	0,45	0,38	0,42	0,14	1,05	0,89	0,28	0,69		
1996	0,85	0,43	0,43	0,41	0,12	1,51	1,09	0,35	0,8		
1997	0,54	0,33	0,33	0,26	0,13	0,79	0,75	0,26	0,96		
1998	0,49	0,34	0,3	0,27	0,2	1,02	0,81	0,29	0,85		
1999	0,61	0,41	0,41	0,28	0,12	0,96	0,85	0,32	1,16		
2000	0,66	0,43	0,39	0,27	0,13	0,66	0,67	0,28	0,95		

About | Annual data | Trend Statistics | Figure

Figure 1. The input data is entered to the **Annual data** worksheet of MAKESENS.

- **The first and the last year** to be handled in trend calculation must be entered in **rows 10 and 11**, above the names of the time series. Every time series must have its own starting and ending year. With these rows you can easily define different time spans for the trend statistics calculation of each time series. The starting and ending years are also shown in the cells **'Trend Statistics'!B6:C30**, and in **'Figure'!C11**.
- **The number of values** of each time series which are selected to trend calculation are shown in **row 9**. These values are also shown in the cells '**Trend Statistics'!D6:D30** and in **'Figure'!C12**. If the number of values for a time series is equal to or less than 9, the Mann-Kendall test is performed using the S statistics and the confidence interval for the Sen's slope estimate is not determined. If this number is at least 10, the Mann-Kendall test is performed using the Z statistic (normal approximation) and the 95% and 99% confidence intervals for the Sen's slope estimates are calculated.
- Cell **B8** shows **the number of the time series** from which the statistics will be calculated.

There is no input data checking in the trend-macro. If you get strange results or even errors, please check the input data you have entered. It is important that the values are entered in the appropriate cells. Some of the cells that are not allowed to be changed are protected.

The calculation of the trend statistics is started by clicking the '**Calculate Trend Statistics**' button in the **Annual data** worksheet. The Status bar near the bottom of the screen shows when the calculation process is ready. The summary table of the results will appear to the **Trend Statistics** worksheet (Figure 2) and the **Figure** worksheet (Figure 3) will be activated with the first time series.

3.2 Summary table of results

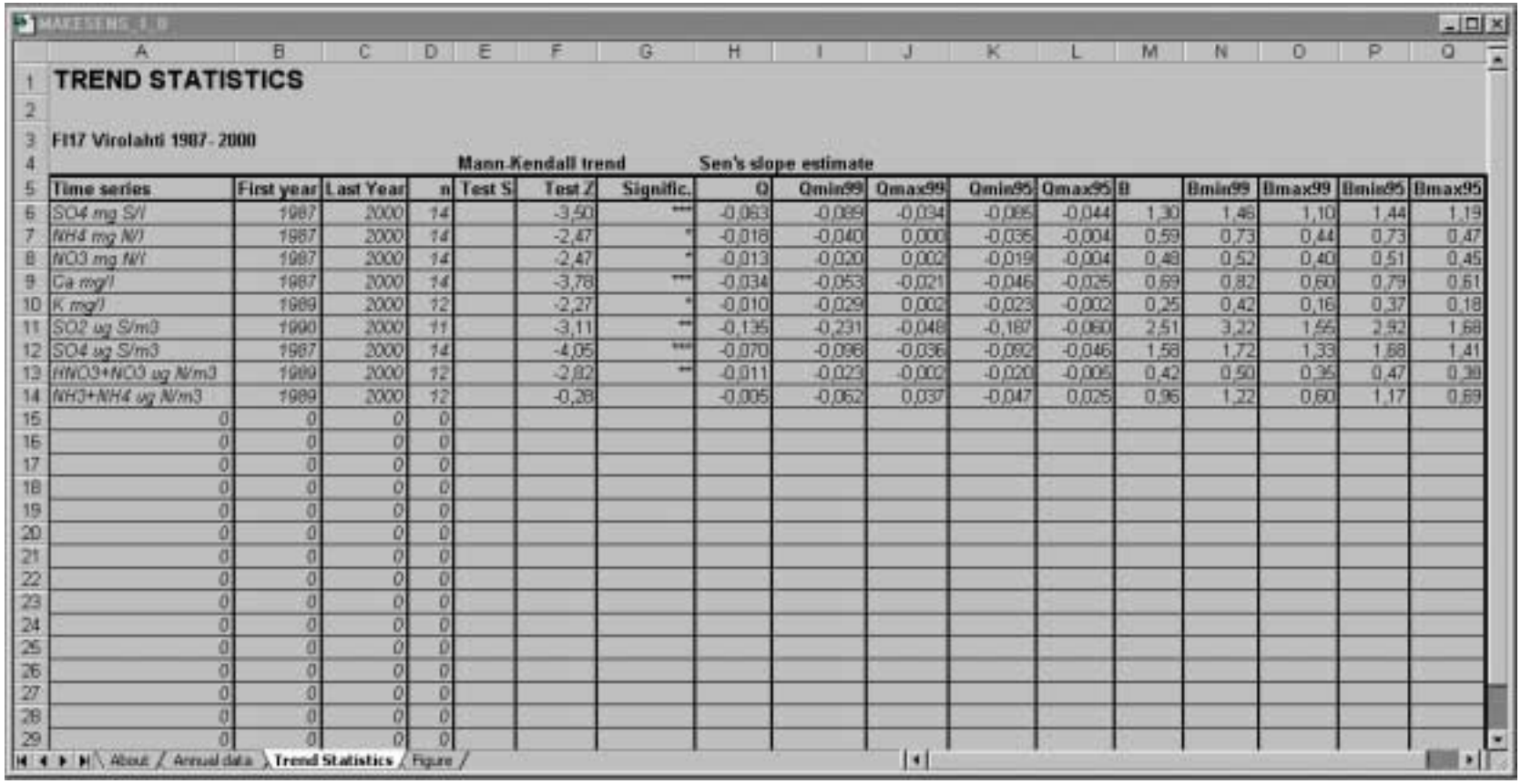
During the statistical calculations the summary table of the results in the **Trend Statistics** worksheet is updated. Results are given for each time series in rows starting from **row 6** (see Figure 2).

The values of the cell **A3** and of the area **A6:D30** are derived directly from the **Annual data** worksheet. The trend calculation procedure writes the results of the calculation to the area **E6:Q30** when you press the "**Calculate Trend Statistics"** button.

The columns in this worksheet have the following meanings:

- **Time series** (column **A**): the names of the time series are derived from the **Annual data** worksheet (from row **13**)
- **First year** (column **B**): starting year of each time series (from the **Annual data** worksheet)
- **Last year** (column **C**): ending year of each time series (from the **Annual data** worksheet)
- **n (**column **D**): the number of annual values in the calculation excluding missing values (from the **Annual data** worksheet**)**.
- **Test S** (column **E**): If n is 9 or less, the test statistic *S* is displayed. The absolute value of *S* is compared to the probabilities of the Mann-Kendall nonparametric test for trend (Table A18 given in Gilbert 1987) to define if there is a monotonic trend or not at the level α of significance. A positive (negative) value of *S* indicates an upward (downward) trend. In n is larger than 9, this cell is empty.
- **Test Z** (column **F**): If n is at least 10, the test statistic Z is displayed. The absolute value of Z is compared to the standard normal cumulative distribution to define if there is a trend or not at the selected level α of significance. A positive (negative) value of Z indicates an upward (downward) trend. If n is 9 or less, this cell is empty.

Signific. (column **G**): the smallest significance level α with which the test shows that the null hypothesis of no trend should be rejected. If n is 9 or less, the test is based to



TREND STATISTICS

FI17 Virolahti 1987- 2000

					Mann-Kendall trend			Sen's slope estimate									
Time series	First year	Last Year	n	Test S	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
SO4 mg S/l	1987	2000	14		-3,50	***	-0,063	-0,089	-0,034	-0,085	-0,044	1,30	1,46	1,10	1,44	1,19
NH4 mg N/l	1987	2000	14		-2,47	*	-0,016	-0,040	0,000	-0,035	-0,004	0,59	0,73	0,44	0,73	0,47
NO3 mg N/l	1987	2000	14		-2,47	*	-0,013	-0,020	0,002	-0,019	-0,004	0,48	0,52	0,40	0,51	0,45
Ca mg/l	1987	2000	14		-3,78	***	-0,034	-0,053	-0,021	-0,046	-0,025	0,69	0,82	0,60	0,79	0,61
K mg/l	1989	2000	12		-2,27	*	-0,010	-0,029	0,002	-0,023	-0,002	0,25	0,42	0,16	0,37	0,18
SO2 ug S/m3	1990	2000	11		-3,11	**	-0,135	-0,231	-0,048	-0,187	-0,080	2,51	3,22	1,55	2,92	1,68
SO4 ug S/m3	1987	2000	14		-4,05	***	-0,070	-0,096	-0,036	-0,092	-0,046	1,58	1,72	1,33	1,68	1,41
HNO3+NO3 ug N/m3	1989	2000	12		-2,82	**	-0,011	-0,023	-0,002	-0,020	-0,005	0,42	0,50	0,35	0,47	0,39
NH3+NH4 ug N/m3	1989	2000	12		-0,28		-0,005	-0,062	0,037	-0,047	0,025	0,96	1,22	0,60	1,17	0,69
0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													
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0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													
0	0	0	0													

Figure 2. The **Trend Statistics** worksheet of MAKESENS shows the results of the calculation.

the S statistic and if n is at least 10, the test is based to the Z statistic (normal approximation). For the four tested significance levels the following symbols are used in the template:

***	if trend at α = 0.001 level of significance
**	if trend at α = 0.01 level of significance
*	if trend at α = 0.05 level of significance
+	if trend at α = 0.1 level of significance

If the cell is blank, the significance level is greater than 0.1.

- **Sen's slope estimate Q** (column **H**): the Sen's estimator for the true slope of linear trend i.e. change per unit time period (in this case a year)
- **Qmin99** (column **I**): the lower limit of the 99 % confidence interval of Q (α= 0.1)
- **Qmax99** (column **J**): the upper limit of the 99 % confidence interval of Q (α= 0.1)
- **Qmin95** (column **K**): the lower limit of the 95 % confidence interval of Q (α= 0.05)
- **Qmax95** (column **L**): the upper limit of the 95 % confidence interval of Q (α= 0.05)
- **B** (column **M**): estimate of the constant B in equation (6) f(year)=Q*(year-firstYear)+B for a linear trend
- **Bmin99** (column **N**): estimate of the constant Bmin99 in equation (6) f(year)=Qmin99*(year-firstYear)+Bmin99 for 99% confidence level of linear trend
- **Bmax99** (column **O**): estimate of the constant Bmax99 in equation (6) f(year)=Qmax99*(year-firstYear)+Bmax99 for 99% confidence level of linear trend:
- **Bmin95** (column **P**): estimate of the constant Bmin95 in equation (6) f(year)=Qmin95*(year-firstYear)+Bmin95 for 95% confidence level of a linear trend:
- **Bmax95** (column **Q**): estimate of the constant Bmax95 in equation (6) f(year)=Qmax95*(year-firstYear)+Bmax95 for 95% confidence level of a linear trend

When calculating the constants B in MAKESENS the time is used in the form

$t = year - firstYear$, where *firstYear* is the first year of all data in the **Annual data** worksheet.

The confidence intervals are valid only if n is at least 10 and there are not many ties (equal values). If n is less that 10, the constants Q and B for the confidence intervals are not shown in MAKESENS.

3.3 Visual viewing of data and results

After the statistics calculation the results can be viewed both numerically and visually on the **Figure** worksheet (see Figure 3). The results are shown one time series at a time. You can switch from one time series to another by pressing the button **Next Time Series** and **Previous Time Series**. The title in cell **A4** is derived from the cell **'Annual data'!A3**.

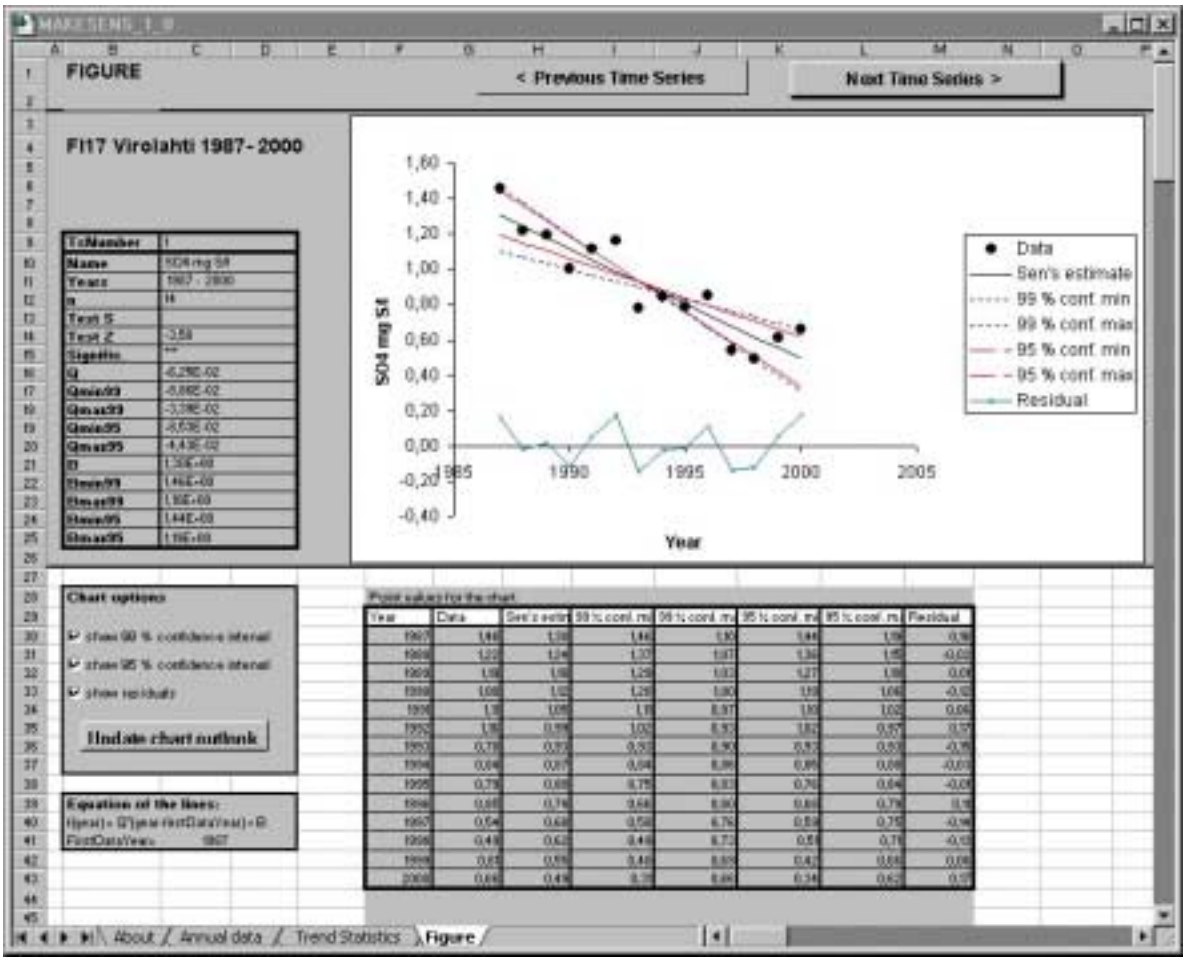

Figure 3. The **Figure** worksheet of MAKESENS.

The numerical results of the statistical calculation of one time series are shown in the area **B9:C25**. **'TsNumber'** is the ordinal number of the time series in the tables of the **Annual data** and **Trend Statistics** worksheets. The other values are derived from table **'Trend Statistics'**!**A5:Q30.** The first and the last year are combined to the same cell **C11**. All these values are updated when the button **Next Time Series** or **Previous Time Series** is pressed.

The table of point values for the chart is shown in columns **F:M,** from row 29 downwards. The years in column **F** and the data values in column **G** are derived from the **Annual data** worksheet. Column **H** contains the point values of the line for the Sen's estimator for a linear trend calculated with the equation f(year) = Q*(year-firstYear) + B. In columns **I:L** are the corresponding point values of the lines of 99% and 95% confidence intervals for the Sen's estimator. The calculated residuals (data minus trend) are shown in column **M.** All these values are updated when the **Next Time Series** or **Previous Time Series** button is pressed. The titles of the columns may be changed. The titles in the legend box of this chart are derived from these values.

In the chart the original data points of the time series, the Sen's estimator for a linear trend, the lines for 99% and 95% confidence intervals and the residuals (data minus trend) are shown.

In the **Chart options B28:D37** box you can quickly select whether the confidence intervals or residuals will be shown in the chart. The outlook of the chart can then be updated by pressing the **Update chart outlook** button. The macro recreates the chart and all the earlier chart settings are lost. The properties of the chart can also be modified directly with standard Excel tools but these modifications will be lost when the **Update chart outlook** button is pressed. The buttons **Next Time Series** or **Previous Time Series**, on the other hand, preserve all chart settings except the title of the value axis which will always be the name of the time series.

4 Examples

The graphs produced with MAKESENS serve as a visual help for the interpretation of the results given on the **Trend Statistics** worksheet. As an example the trend statistics of some time series from the Finnish EMEP station Virolahti (FI17) are shown in Figures 4 – 6 and briefly discussed here.

In Figure 4 there are two examples of annual time series: atmospheric SO_4^{2-} concentration and SO_4^{2-} concentration in precipitation which nicely fulfill the premises of the statistical methods used; The time series consist of annual averages with monotonously decreasing trends. The residuals seem to be from a random distribution indicating that a linear model may be applied. The statistical calculations give a high level of significance with narrow angles between the confidence lines.

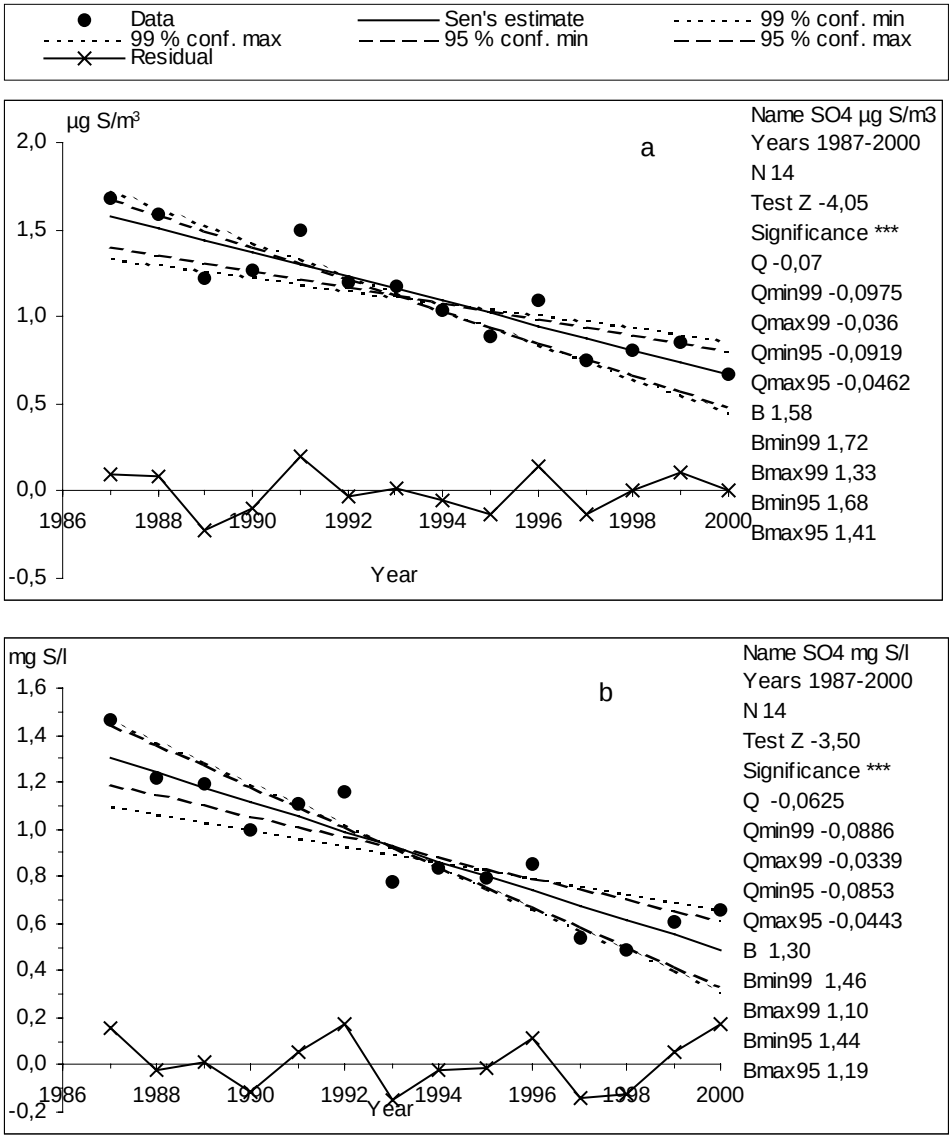

Figure 4. Annual time series and trend statistics of atmospheric SO_4^{2-} concentrations (a) and SO_4^{2-} concentrations in precipitation (b) at Virolahti FI17.

The case of NH_4^+ concentration in precipitation is a bit more problematic (Figure 5). The Mann-Kendall test indicates a decreasing trend at the 0.05 significance level but the Sen's slope gives non-positive slope even at the 1% confidence interval. Thus the decreasing trend seems to be more probable with the Sen's method than with the Mann-Kendall. The reason to this difference may be that the presumptions of the Sen's method are not totally

fulfilled. The Sen's method uses a linear model for the trend but here the slope seems to diminish at the end which also can be seen from the residuals which are not random. However the trend seems to be monotonic and thus the Mann-Kendall test is suitable. This time series contains also two tied groups which may reduce the accuracy of these methods with few data values as in this case.

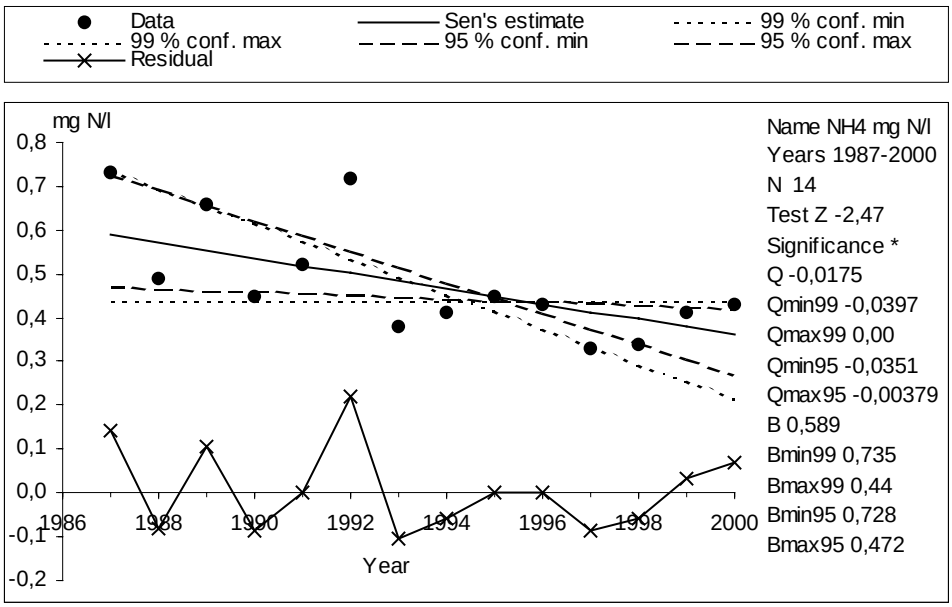

Figure 5. Annual time series and trend statistics of NH_4^+ in precipitation at Virolahti FI17.

The case of atmospheric NH_3+NH_4^+ concentration (Figure 6) is an example of time series to which neither of the used methods are statistically suitable. The trend is clearly first decreasing and then increasing and thus the trend is neither linear nor monotonic. This conclusion can also be made on the grounds of the residuals. However the statistical methods could be used separately to the decreasing and increasing parts of the time series but then the small number of data reduces the statistical significance of the results.

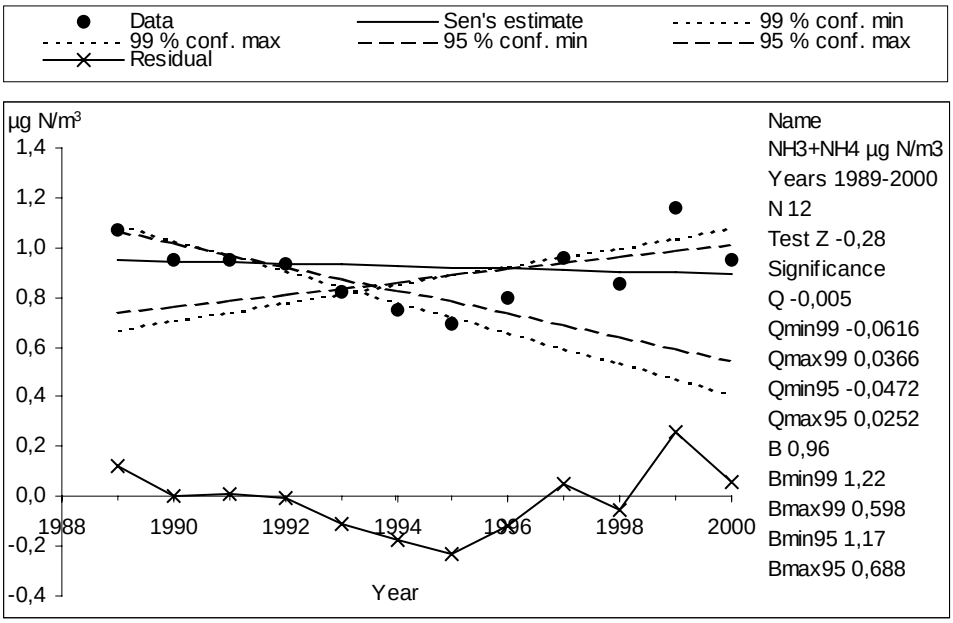

Figure 6. Annual time series and trend statistics of atmospheric NH_3 + NH_4^+ concentrations at Virolahti FI17.

5 Summary

An Excel template – MAKESENS – is developed for the calculation of the annual trend statistics. The procedure is based on the nonparametric Mann-Kendall test for the trend and the nonparametric Sen's method for the magnitude of the trend. The theory of calculation, the user's manual and the macro code are presented. As an example the annual trends of precipitation concentrations and atmospheric concentrations of some compounds measured at the Finnish air quality monitoring station Virolahti are calculated and briefly discussed.

Examination of the time series is very important before performing and interpreting the statistical calculations with MAKESENS. The Mann-Kendall method may be used in cases where the possible trend can be assumed to be monotonic. In the Sen's method it is assumed that the trend is linear and the residuals are from the same distribution with zero mean. The time series should fulfill these presumptions in order to produce correct statistical results with MAKESENS.

In the Mann-Kendall test missing values are allowed and the data need not conform to any particular distribution. The Sen's method is not greatly affected by gross data errors or outliers, and also it can be computed when data are missing.

Acknowledgements

The authors thank the Nordic Council of Ministers for the financial support to this work.

6 References

Gilbert, R.O., 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold , New York.

Sirois, Allan, 1998. A Brief and Biased Overview of Time Series Analysis or How to Find that Evasive Trend. In WMO report No. 133: WMO/EMEP workshop on Advanced Statistical methods and their Application to Air Quality Data sets (Helsinki, 14-18 September 1998).

TFMM 2000. Minutes of the First Meeting of the Task Force (23 - 25 October 2000, Vienna, Austria). http://www.ubavie.gv.at/tfmm/pages/meet.htm

7 Appendix 1. The macro code of MAKESENS

```
'   Copyright 2002 Finnish Meteorological Institute
'   Timo Salmi & Anu Määttä & Toni Amnell
'   MAKESENS Version 1.0

'COMMON SETTINGS
Option Base 1   'Default indexing of arrays starts from 1
'Code for missing data in arrays:
Const MissingValue As Double = -999999#
'Maximum number of data in one time series:
Const MaxData As Integer = 100
'Codes for different significance levels:

'Minimum count of data to use normal approximation
' in Mann-Kendall test. Below this value the S statistics
' is used:
Const MinMannKendNorm As Integer = 10
'Minimum count of data to calculate confidence interval
'in Sen's method
Const MinSenConf As Integer = 10

Const S001 As String = "***"    'alpha = 0.001
Const S01 As String = "**"      'alpha = 0.01
Const S05 As String = "*"       'alpha = 0.05
Const S1 As String = "+"        'alpha = 0.1

'Arrays of critical values of Mann-Kendall statistic S
' for significance levels 0.001, 0.01, 0.05 and 0.1
' of two-sided test when n is between 4 and 10.
' The arrays will be filled by the subroutine fillS
Dim S_001(4 To 10) As Integer
Dim S_01(4 To 10) As Integer
Dim S_05(4 To 10) As Integer
Dim S_1(4 To 10) As Integer

Private Sub CB_CalculateStatistics_Click()
' The main program of calculation
' - Retrieves the data values from the sheet "Annual data" with
'   the subroutine GetData
' - Calculates the statistics with the subroutines MannKendall
'   and Sen and with the function calcB and saves the results into
'   the sheet "Trend statistics"
' - Finally calls the workbook level routines makeCollection and
'   drawFigure preparing the sheet Figure

Dim nofCol As Integer 'Number of columns i.e. time series
Dim colno As Integer  'Column number of a time series
Dim firstYear As Integer 'first year of a time series
Dim baseYear As Integer  'first year of all time series
Dim nYears As Integer    'number of years in a time series
```

```
Dim n As Integer         'true data values in a time series
                         'i.e. missing values are not considered
Dim x(MaxData) As Double 'Array for data values of a time series
Dim s As Integer         'Mann-Kendall test statistic for n=4..10
Dim Z As Double          'Mann-Kendall test statistic for n>10
Dim signif As String     'significance of trend
'Sen's slope estimator Q and its 99% and 95% confidence levels:
Dim Q As Double, Qmin99 As Double, Qmax99 As Double
Dim Qmin95 As Double, Qmax95 As Double
'Constants B for equation of lines of Sen's slope and conf. intervals:
Dim B As Double, Bmin99 As Double, Bmax99 As Double
Dim Bmin95 As Double, Bmax95 As Double


' The result cells are emptied before the calculation starts
Worksheets("Trend Statistics").Range("E6:Q30") = ""

nofCol = Worksheets("Annual data").Cells(8, 2).value
baseYear = Worksheets("Annual data").Cells(14, 1).value
Call fillS    'initializes arrays of  Mann-Kendall probabilities

'Calculation of trend statistics for each time series at a time
For colno = 2 To nofCol + 1
    If Not GetData(colno, baseYear, firstYear, nYears, n, x) Then
        Exit Sub
    End If
    If n >= 2 Then   'nothing can be computed, if n<2
    'First the existence of trend is tested using Mann-Kendall method.
        Call MannKendall(nYears, x, s, Z, signif)
        If n < MinMannKendNorm Then
            Worksheets("Trend Statistics").Cells(4 + colno, 5) = s
        Else
            Worksheets("Trend Statistics").Cells(4 + colno, 6) = Z
        End If
         Worksheets("Trend Statistics").Cells(4 + colno, 7) = signif
        'Evaluation of Sen's slope estimator and confidence intervals
        Call Sen(nYears, x, Q, Qmin99, Qmax99, Qmin95, Qmax95)
         Worksheets("Trend Statistics").Cells(4 + colno, 8) = Q
         B = calcB(nYears, x, firstYear, baseYear, Q)
         Worksheets("Trend Statistics").Cells(4 + colno, 13) = B

        If n >= MinSenConf Then
            Worksheets("Trend Statistics").Cells(4 + colno, 9) = Qmin99
            Worksheets("Trend Statistics").Cells(4 + colno, 10) = Qmax99
            Worksheets("Trend Statistics").Cells(4 + colno, 11) = Qmin95
            Worksheets("Trend Statistics").Cells(4 + colno, 12) = Qmax95
        'Coefficients B for equation of linear trend f(t)=Qt+B
            Bmin99 = calcB(nYears, x, firstYear, baseYear, Qmin99)
            Bmax99 = calcB(nYears, x, firstYear, baseYear, Qmax99)
            Bmin95 = calcB(nYears, x, firstYear, baseYear, Qmin95)
            Bmax95 = calcB(nYears, x, firstYear, baseYear, Qmax95)
            Worksheets("Trend Statistics").Cells(4 + colno, 14) = Bmin99
            Worksheets("Trend Statistics").Cells(4 + colno, 15) = Bmax99
            Worksheets("Trend Statistics").Cells(4 + colno, 16) = Bmin95
```

```
            Worksheets("Trend Statistics").Cells(4 + colno, 17) = Bmax95
        End If
    End If
Next colno

' Draw the figure of the first component
Sheets("Figure").Cells(9, 3).value = 1
Sheets("Figure").Cells(10, 3).value = Sheets("Annual data").Cells(13,
2).value
Application.Run "makeCollection"
Application.Run "DrawFigure"
End Sub 'CB_CalculateStatistics_Click

Private Function GetData(ByVal colno As Integer, ByVal baseYear As
Integer, firstYear As Integer, nYears As Integer, n As Integer, x() As
Double) As Boolean
' Retrieving of data of one time series into the array x()
' colno is the column of the worksheet "Annual data" where the
' values of the time series exist.
' The real number of annual values n in time series is calculated
' If the cell is empty it is understood as a missing value.

Dim rowno As Integer     'row of the data cell
Dim lastYear As Integer  'last year of the time series
Dim nVal As Integer      'counter for number of true data
Dim i As Integer         'counter for data loop
Dim Error As Integer
firstYear = Worksheets("Annual data").Cells(10, colno).value
lastYear = Worksheets("Annual data").Cells(11, colno).value
nYears = lastYear - firstYear + 1

nVal = 0
For i = 1 To nYears
    If firstYear < baseYear Then
        Error = MsgBox("For the time series """ + _
        Worksheets("Annual data").Cells(13, colno).value + _
        """ first year is too early!")
        GetData = False
        Exit Function
    End If
    rowno = 13 + i + firstYear - baseYear
    If IsEmpty(Worksheets("Annual data").Cells(rowno, colno)) Then
        x(i) = MissingValue
    Else
        nVal = nVal + 1
        x(i) = Worksheets("Annual data").Cells(rowno, colno)
    End If
Next i
n = nVal
GetData = True
End Function ' GetData

Private Sub MannKendall(ByVal nYears As Integer, x() As Double, s As
Integer, Z As Double, signif As String)
```

```
'Calculates the MannKendall test
'Calls the function tiedSum
'Uses the string constants S001, S01, S05 and S1

Dim absS As Integer      'value of absS
Dim varS As Double       'the variance of S
Dim absZ As Double         'value of abs(Z)
Dim k As Integer, j As Integer  'counters for slopes
Dim n As Long         'number of true values in x()

Z = MissingValue         ' returns MissingValue for Z
                        ' if they are not calculated
'Computing of the Mann-Kendall statistic S.
signif = ""
n = IIf(x(nYears) <> MissingValue, 1, 0)
s = 0
For k = 1 To nYears - 1
    If x(k) <> MissingValue Then
        n = n + 1
        For j = k + 1 To nYears
            If x(j) <> MissingValue Then
                s = s + Sgn(x(j) - x(k))
            End If
        Next j
    End If
Next k

If n < 4 Then
'If n is less than 4, the method can not be used at all
    Exit Sub
ElseIf n < MinMannKendNorm Then
'If n is between 4 and 10, S is compared directly to Mann-Kendall
statistics for S
    absS = Abs(s)
    signif = Switch(absS >= S_001(n), S001, absS >= S_01(n), S01, absS >=
S_05(n), S05, absS >= S_1(n), S1, True, "")
Else 'n>=MinMannKendNorm
'If n is at least 10, the normal distribution is used
'Firstly the variance VAR(S) is calculated
'The correction term for ties is calculated by the function tiedSum
    varS = (n * (n - 1) * (2 * n + 5) - tiedSum(nYears, x)) / 18#
'Calculation  of test statistic Z using S and its variance VAR(S)
    Z = Switch(s > 0, (s - 1) / Sqr(varS), s < 0, (s + 1) / Sqr(varS), s
= 0, 0#)
'The absolute value of Z is compared to critical value Z[1-alpha/2]
'which is obtained from the standard normal table. The presence and
'significance of the trend is evaluated by testing four different
'levels of significance: '0.001, 0.01, 0.05 and 0.1
    absZ = Abs(Z)
    signif = Switch(absZ > 3.292, S001, absZ > 2.576, S01, absZ > 1.96,
S05, absZ > 1.645, S1, True, "")
End If

End Sub 'MannKendall
```

```
Private Sub Sen(ByVal nYears As Integer, x() As Double, Q As Double,
Qmin99 As Double, Qmax99 As Double, Qmin95 As Double, Qmax95 As Double)
'Calculates Sen's slope estimator Q and its 99% (Qmax99,Qmin99)
' and 95 % (Qmax95, Qmin95)confidence levels
' Calls the function tiedSum and the subroutine
CalulateConfidenceInterval

Dim nofQ As Integer      'number of value pairs
Dim Qarray(MaxData * (MaxData - 1) / 2) As Double 'Array for the slopes
of value pairs
Dim k As Integer, j As Integer 'counters for loops
Dim n As Long         'number of true values in x()
Dim Calpha As Double     'C-alpha for calculation of conf.intervals of Q

'Computing of slopes of individual value pairs into Qarray
nofQ = 0   'used as counter for Qarray
n = IIf(x(nYears) = MissingValue, 0, 1)
For k = 1 To nYears - 1
    If x(k) <> MissingValue Then
        n = n + 1
        For j = k + 1 To nYears
            If x(j) <> MissingValue Then
                nofQ = nofQ + 1
                Qarray(nofQ) = (x(j) - x(k)) / (j - k)
            End If
        Next j
    End If
Next k

'The median of individual slopes in Qarray  is the Sen's
'slope estimator. The median is calculated by the function "median".
Q = median(nofQ, Qarray)

If n >= MinSenConf Then
'The confidence intervals are calculated only if n is at least 10.
'Computing of variance VAR(S) of Mann-Kendall statistics S.
'The correction term for ties is calculated by the function tiedSum
    varS = (n * (n - 1) * (2 * n + 5) - tiedSum(nYears, x)) / 18#

'The 100(1-alpha)% two-sided confidence intervals for the
'Sen's slope are computed with two values of alpha: 0.01 and 0.05
'which means 99% and 95% confidence intervals. The values of
'Z[1-alpha/2] are obtained from the standard normal table.
'Case alpha=0.01: Z[1-alpha/2]=Z[0.995]=2.576
    Calpha = 2.576 * Sqr(varS)
    Call CalculateConfidenceInterval(Calpha, nofQ, Qarray, Qmin99,
Qmax99)

'Case alpha=0.05: Z[1-alpha/2]=1.96
    Calpha = 1.96 * Sqr(varS)
    Call CalculateConfidenceInterval(Calpha, nofQ, Qarray, Qmin95,
Qmax95)
Else
```

```
    Qmin99 = MissingValue
    Qmax99 = MissingValue
    Qmin95 = MissingValue
    Qmax95 = MissingValue
End If
End Sub 'Sen

Private Function tiedSum(n As Integer, x() As Double) As Integer
'Calculates sum related to tied groups(= two or more equal values)
'   for the variance of Mann-Kendall statistics S
'n = number of values in the array x including missing values
'Function tiedSum is called by subroutines Sen and MannKendallNorm

Dim m As Integer         ' number of tied groups
Dim tval() As Double     ' data values of tied groups
ReDim tval(n)
Dim t() As Integer, nt As Integer ' number of data in tied groups
ReDim t(n)
Dim p, i As Integer     'indexes for the loops
Dim newValue As Boolean
Dim tSum As Integer

'Calculation of the number of tied groups m and the number of data
' in tied groups t()
m = 0
For i = 1 To n - 1
    If x(i) <> MissingValue Then
        newValue = True
        If m > 0 Then
            For p = 1 To m
               If x(i) = tval(p) Then
                    newValue = False 'this value is alredy managed
                    Exit For
               End If
            Next p
        End If

        If newValue Then
            nt = 1  'number of equal values x(i)
            For p = i + 1 To n
                If x(p) = x(i) Then
                    nt = nt + 1
                End If
            Next p

            If nt > 1 Then ' new group only if nt>1
                m = m + 1
                t(m) = nt
                tval(m) = x(i)
            End If
        End If
    End If
Next i
```

```
'Calculating the sum related to tied groups for variance
tSum = 0
If m > 0 Then
    For p = 1 To m
        tSum = tSum + t(p) * (t(p) - 1) * (2 * t(p) + 5)
    Next p
End If
tiedSum = tSum
End Function 'tiedSum

Sub CalculateConfidenceInterval(ByVal Calpha As Double, ByVal nofQ As
Integer, Qarray() As Double, lowerLimit As Double, upperLimit As Double)
'Computes confidence interval for Sen's slope estimate.
'Input parameters:  Calpha = Z[1-alpha/2],
'                   nofQ - number of slopes of all data pairs
'                   Qarray - array of slopes of all data pairs
'Subroutine returns the lowerLimit and upperLimit.
'Calls the subroutine SortArray
'Is called by the subroutine Sen
    Dim M1 As Double        'M1:th largest ordered slope
    Dim M2 As Double        'M2:th largest ordered slope
    Dim M1int As Integer    'integer part of M1 (>0)
    Dim M2int As Integer    'integer part of M2+1 (>0)
    Dim QarraySort() As Double
    ReDim QarraySort(nofQ)

    'The array Qarray is sorted to the array QarraySort
    Call SortArray(nofQ, Qarray, QarraySort)
    M1 = (nofQ - Calpha) / 2
    M2 = (nofQ + Calpha) / 2

    If M1 > 1 Then
    'to be sure that index does not point outside QarraySort
        M1int = Int(M1) 'find the integer part of M1
        'Interpolation of the lower limit
        lowerLimit = QarraySort(M1int) + (M1 - M1int) * (QarraySort(M1int
+ 1) - QarraySort(M1int))
    Else
        lowerLimit = QarraySort(1)
    End If

    If M2 < nofQ - 1 Then
    'to be sure that index does not point outside QarraySort
        M2int = Int(M2 + 1) 'because the indexing of QarraySort begins
from zero
        'Interpolation of the upper limit
        upperLimit = QarraySort(M2int) + (M2 + 1 - M2int) *
(QarraySort(M2int + 1) - QarraySort(M2int))
    Else
        upperLimit = QarraySort(nofQ)
    End If
End Sub 'CalculateConfidenceInterval
```

```
Public Function calcB(nYears As Integer, x() As Double, firstYear As
Integer, baseYear As Integer, Q As Double) As Double
' calculates the constant B for the equation of linear trend f(t)=Q*t+b.
' The zero point of time axis is the "baseYear"
' Calls the function median
Dim n As Integer    'the number of true values in time series
Dim year As Integer 'the true year of the data value
Dim i As Integer    'index for loop
Dim val() As Double 'array of differences
ReDim val(nYears)

n = 0
For i = 1 To nYears
    year = firstYear + i - 1
    If x(i) <> MissingValue Then
        n = n + 1
        val(n) = x(i) - Q * (year - baseYear)
    End If
Next i

' the estimate for B is median of the calculated differences
calcB = median(n, val)
End Function ' calcB

Private Function median(nofV As Integer, values() As Double) As Double
' calculates median of values in the array values(), indexed from 1 to
nofV
' calls the subroutine sortArray
' is called by the fuction calcB and by the subroutine Sen
    Dim i As Integer
    Dim sortedValues() As Double
    ReDim sortedValues(nofV)

    Call SortArray(nofV, values, sortedValues)
    If nofV Mod 2 = 0 Then     'nofv is even
        i = Int(nofV / 2)
        median = (sortedValues(i + 1) + sortedValues(i)) / 2
    Else                            'nOfvalues is odd
        median = sortedValues((nofV + 1) / 2)
    End If
End Function 'median

Sub SortArray(ByVal nofV As Integer, values() As Double, sortedValues()
As Double)
'This subroutine ranks the values of an array from smallest to largest.
'The sorting method is SELECTION SORT
'The ranked values are stored into the other array called sortedValues.
'Input parameters:  nofV - number of values in the array values
'                   values - values to be ranked, indexed from 1 to nofV
'Subroutine returns the sorted array at sortedValues.
'Is called by the function median and by the subroutine
'CalculateConfidence interval

Dim ind As Integer, i As Integer, j As Integer
```

```
Dim minV As Double, maxV As Double
Dim carray() As Double   'the data is first copied to this array
ReDim carray(nofV)
Dim ignoreV As Double    'value that is ignored in carray when sorting

For i = 1 To nofV       'Copy the original array to carray
    carray(i) = values(i)
Next i

'Find the smallest and largest value
ind = 1
minV = carray(1)  'initialize the smallest value
maxV = carray(1)  'initialize the largest value
For i = 2 To nofV
    If carray(i) < minV Then
        minV = carray(i)
        ind = i
    End If
    If carray(i) > maxV Then
        maxV = carray(i)
    End If
Next i

sortedValues(1) = minV 'the smallest data value
ignoreV = minV - 10    'smaller value than the smallest data value
carray(ind) = ignoreV  'this value is later ignored in sorting

'now sort the values
For j = 2 To nofV
    minV = maxV
    For i = 1 To nofV
        'find the minimum from the rest of the array
        If carray(i) <= minV And carray(i) > ignoreV Then
            minV = carray(i)
            ind = i
        End If
    Next i
    sortedValues(j) = minV
    carray(ind) = ignoreV  'from now on this element is ignored
Next j
End Sub 'SortArray

Private Sub fillS()
'Fills the arrays S_nnn of probabilities for two-tailed
' Mann-Kendall test
'The index of tables is the number of data if n=4...10
'Each array entry is an absolute value of the Mann-Kendall
' statistic S, with which the probability that there is no trend
' is less than the probability level p related to the array:
' S_001: p=0.001, S_01: p=0.01, S_05: p=0.05 and S_1: p=0.1.
' Source of values: Gilbert, 1987, Table A18
'Value 9999 indicates that the probability level can not be
' reached with given number of data
```

```
Dim n As Integer
For n = 4 To 10
    S_001(n) = 9999
    S_01(n) = 9999
    S_05(n) = 9999
    S_1(n) = 9999
Next n
S_001(7) = 21
S_001(8) = 26
S_001(9) = 30
S_001(10) = 35
S_01(6) = 15
S_01(7) = 19
S_01(8) = 22
S_01(9) = 26
S_01(10) = 29
S_05(5) = 10
S_05(6) = 11
S_05(7) = 15
S_05(8) = 18
S_05(9) = 20
S_05(10) = 23
S_1(4) = 6
S_1(5) = 8
S_1(6) = 11
S_1(7) = 13
S_1(8) = 16
S_1(9) = 18
S_1(10) = 21

End Sub
```

ATTACHMENT B

OUTPUT OF STATISTICAL ANALYSES—MAKESENS GRAPHS 1991 TO 2007

(PLEASE SEE ATTACHED CD)

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

TREND STATISTICS

TW-20 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-1.07		-0.0003	-0.0011	0.0004	-0.0008	0.0002	0.0099	0.0146	0.0048	0.0122	0.0064
F (mg/L)	*1991*	*2007*	*17*		-2.84	**	-0.303	-0.503	-0.044	-0.456	-0.123	5.61	6.97	3.27	6.82	4.51
Mn (mg/L)	*1991*	*2007*	*17*		-0.21		0.0000	-0.0005	0.0002	-0.0003	0.0001	0.0020	0.0070	-0.0007	0.0042	-0.0001
Nitrate (mg/L)	*1991*	*2007*	*17*		0.54		0.157	-0.320	0.749	-0.228	0.613	7.55	9.98	2.41	9.49	3.22
Se (mg/L)	*1991*	*2007*	*17*		0.37		0.002	-0.033	0.029	-0.025	0.015	0.13	0.41	-0.01	0.39	0.07
Cl (mg/L)	*1991*	*2007*	*17*		-0.66		-1.444	-7.529	5.305	-6.245	3.004	121.83	176.00	64.24	170.60	78.98
Mo (mg/L)	*1991*	*2007*	*16*		-1.49		-0.002	-0.006	0.002	-0.005	0.000	0.075	0.106	0.038	0.100	0.049
SO4 (mg/L)	*1991*	*2007*	*17*		1.40		9.222	-28.615	39.526	-13.246	28.000	483.11	634.46	159.69	572.98	298.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

ANNUAL DATA

TW-20 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1991	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.019	6.97	0.0025	7.55	0.011	176		500
1992	0.0168	6.37	0.0023	8.13	0.702	174.5	0.106	528
1993	0.0092	4.88	0.0151	9.03	0.229	100	0.090	524
1994	0.0071	5.18	0.0241	9.65	0.315	117.5	0.066	552
1995	0.009	5.3	0.0005	8.7	0.33	91	0.087	520
1996	0.008	3.9	0.001	8.9	0.14	91	0.06	520
1997	0.006	4.6	0.0005	6.9	0.058	140	0.051	380
1998	0.004	2.6	0.0005	6.6	0.066	76	0.049	320
1999	0.0032	2	0.001	5	0.04	58	0.039	240
2000	0.0028	1.5	0.0005	4.9	0.03	55	0.032	220
2001	0.004	1.6	0.005	4.57	0.055	63	0.03	262
2002	0.0059	1.80	0.03	6.95	0.304	101.9	0.04	552
2003	0.0063	1.81	0.001	7.965	0.34	105	0.0509	634
2004	0.0096	1.67	0.001	8.16	0.392	139.5	0.0547	640
2005	0.0111	2.37	0.002	12.95	0.429	138.5	0.0626	744
2006	0.0106	3.605	0.002	20.25	0.079	129.5	0.063	920
2007	0.0060	2.57	0.002	10.95	0.08225	100.15	0.05795	555

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.07
Signific.	
Q	-3.47E-04
Qmin99	-1.06E-03
Qmax99	3.72E-04
Qmin95	-8.10E-04
Qmax95	2.46E-04
B	9.89E-03
Bmin99	1.46E-02
Bmax99	4.79E-03
Bmin95	1.22E-02
Bmax95	6.36E-03

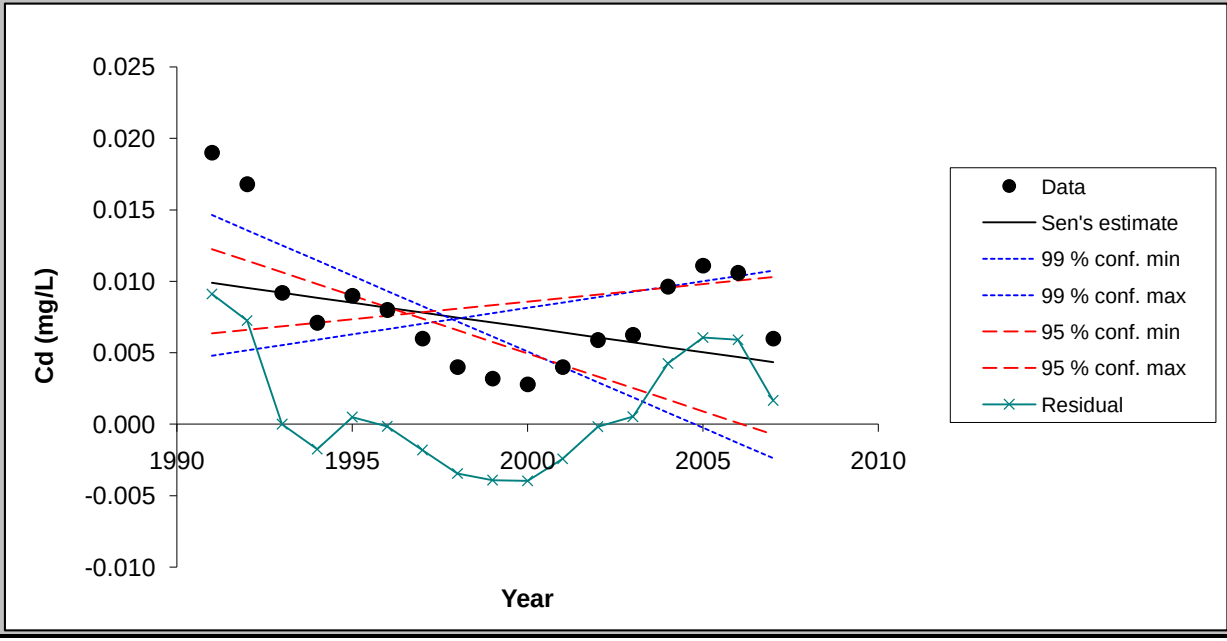

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.01	0.01	0.00	0.01	0.01	0.01
1992	0.02	0.01	0.01	0.01	0.01	0.01	0.01
1993	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1994	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1995	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1996	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1997	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1998	0.00	0.01	0.01	0.01	0.01	0.01	0.00
1999	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.00	0.01	0.01	0.01	0.00	0.01	0.00
2001	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2002	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2006	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2007	0.01	0.00	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.84
Signific.	**
Q	-3.03E-01
Qmin99	-5.03E-01
Qmax99	-4.36E-02
Qmin95	-4.56E-01
Qmax95	-1.23E-01
B	5.61E+00
Bmin99	6.97E+00
Bmax99	3.27E+00
Bmin95	6.82E+00
Bmax95	4.51E+00

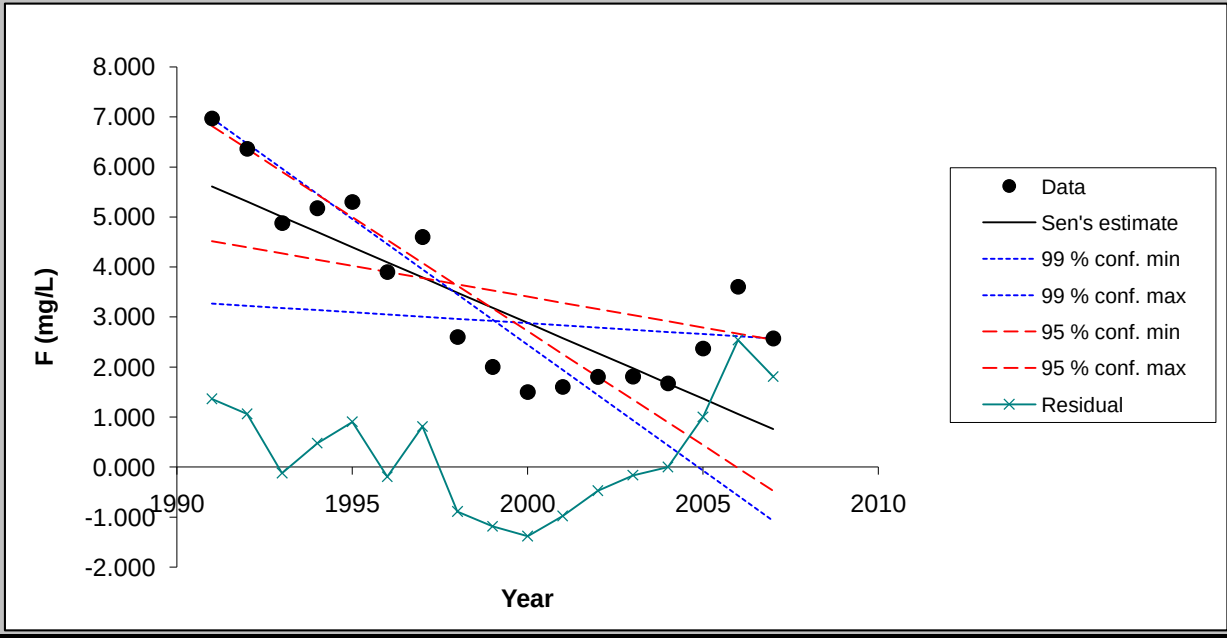

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	6.97	5.61	6.97	3.27	6.82	4.51	1.36
1992	6.37	5.30	6.47	3.22	6.37	4.39	1.06
1993	4.88	5.00	5.96	3.18	5.91	4.27	-0.12
1994	5.18	4.70	5.46	3.14	5.45	4.15	0.48
1995	5.30	4.40	4.96	3.09	5.00	4.02	0.90
1996	3.90	4.09	4.46	3.05	4.54	3.90	-0.19
1997	4.60	3.79	3.95	3.01	4.08	3.78	0.81
1998	2.60	3.49	3.45	2.96	3.63	3.65	-0.89
1999	2.00	3.18	2.95	2.92	3.17	3.53	-1.18
2000	1.50	2.88	2.44	2.88	2.72	3.41	-1.38
2001	1.60	2.58	1.94	2.83	2.26	3.29	-0.98
2002	1.80	2.28	1.44	2.79	1.80	3.16	-0.47
2003	1.81	1.97	0.94	2.74	1.35	3.04	-0.16
2004	1.67	1.67	0.43	2.70	0.89	2.92	0.00
2005	2.37	1.37	-0.07	2.66	0.43	2.79	1.00
2006	3.61	1.06	-0.57	2.61	-0.02	2.67	2.54
2007	2.57	0.76	-1.08	2.57	-0.48	2.55	1.81

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.21
Signific.	
Q	0.00E+00
Qmin99	-5.00E-04
Qmax99	2.12E-04
Qmin95	-2.69E-04
Qmax95	1.50E-04
B	2.00E-03
Bmin99	7.00E-03
Bmax99	-6.95E-04
Bmin95	4.22E-03
Bmax95	-1.00E-04

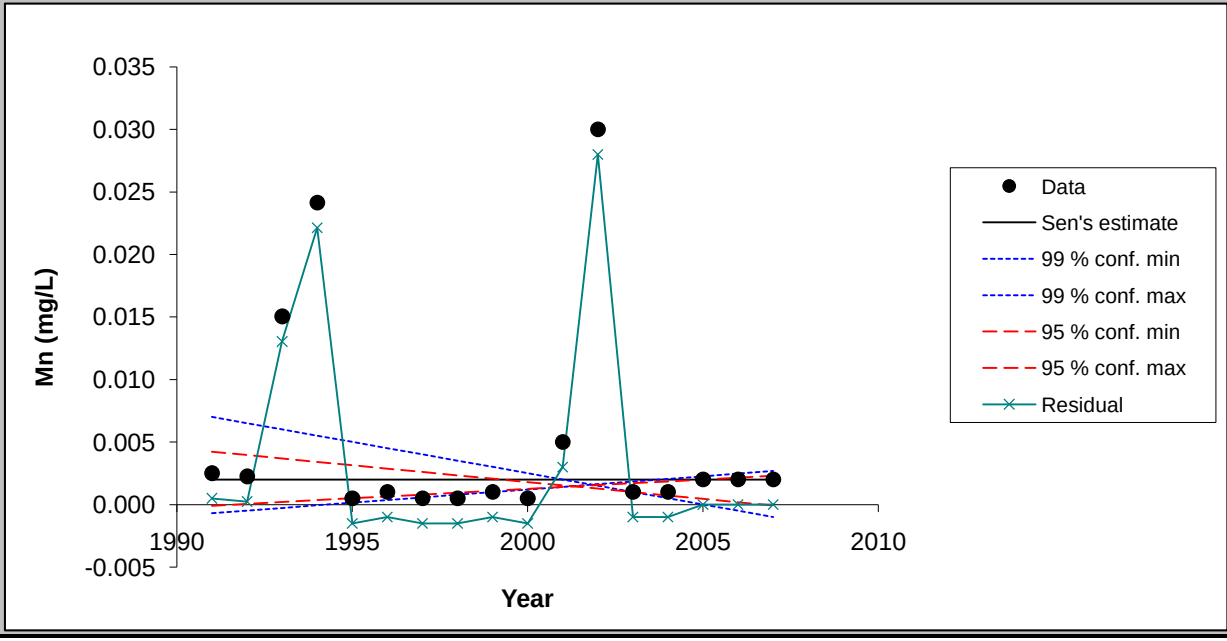

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.02	0.00	0.01	0.00	0.00	0.00	0.01
1994	0.02	0.00	0.01	0.00	0.00	0.00	0.02
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.54
Signific.	
Q	1.57E-01
Qmin99	-3.20E-01
Qmax99	7.49E-01
Qmin95	-2.28E-01
Qmax95	6.13E-01
B	7.55E+00
Bmin99	9.98E+00
Bmax99	2.41E+00
Bmin95	9.49E+00
Bmax95	3.22E+00

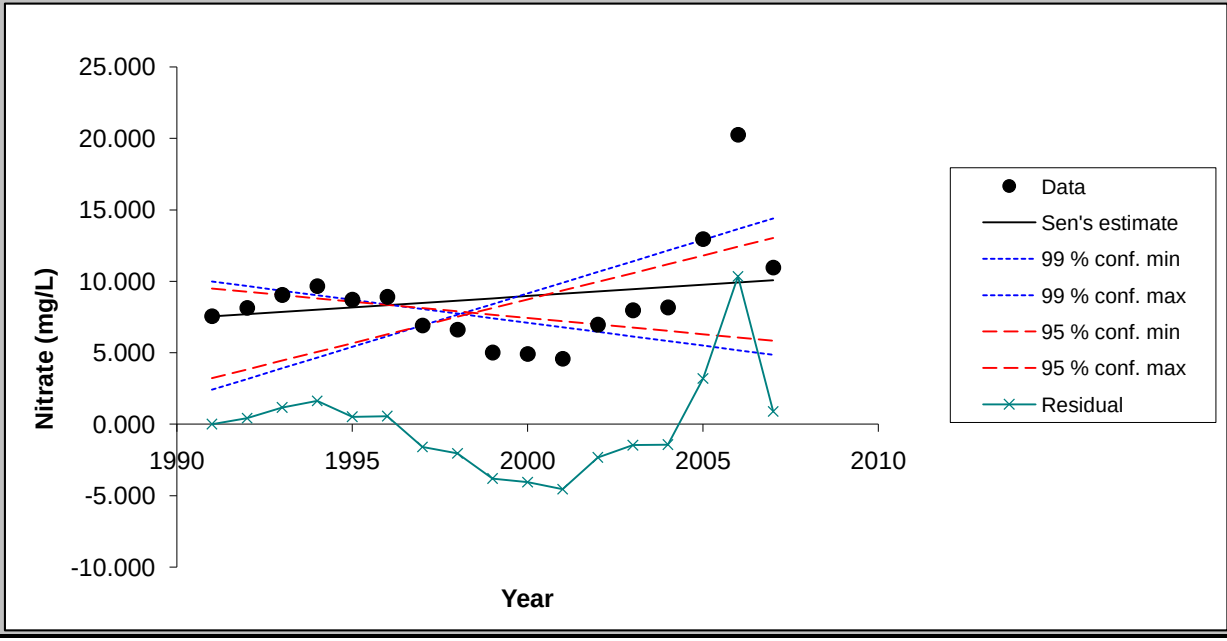

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	7.55	7.55	9.98	2.41	9.49	3.22	0.00
1992	8.13	7.71	9.66	3.16	9.26	3.84	0.42
1993	9.03	7.86	9.34	3.90	9.03	4.45	1.17
1994	9.65	8.02	9.02	4.65	8.81	5.06	1.63
1995	8.70	8.18	8.70	5.40	8.58	5.67	0.52
1996	8.90	8.34	8.38	6.15	8.35	6.29	0.56
1997	6.90	8.49	8.06	6.90	8.12	6.90	-1.59
1998	6.60	8.65	7.74	7.65	7.89	7.51	-2.05
1999	5.00	8.81	7.42	8.40	7.67	8.13	-3.81
2000	4.90	8.96	7.10	9.15	7.44	8.74	-4.06
2001	4.57	9.12	6.78	9.90	7.21	9.35	-4.55
2002	6.95	9.28	6.46	10.64	6.98	9.96	-2.33
2003	7.96	9.44	6.14	11.39	6.75	10.58	-1.47
2004	8.16	9.59	5.82	12.14	6.53	11.19	-1.43
2005	12.95	9.75	5.50	12.89	6.30	11.80	3.20
2006	20.25	9.91	5.18	13.64	6.07	12.42	10.34
2007	10.95	10.06	4.85	14.39	5.84	13.03	0.89

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.37
Signific.	
Q	2.38E-03
Qmin99	-3.30E-02
Qmax99	2.88E-02
Qmin95	-2.52E-02
Qmax95	1.50E-02
B	1.28E-01
Bmin99	4.14E-01
Bmax99	-5.22E-03
Bmin95	3.91E-01
Bmax95	6.52E-02

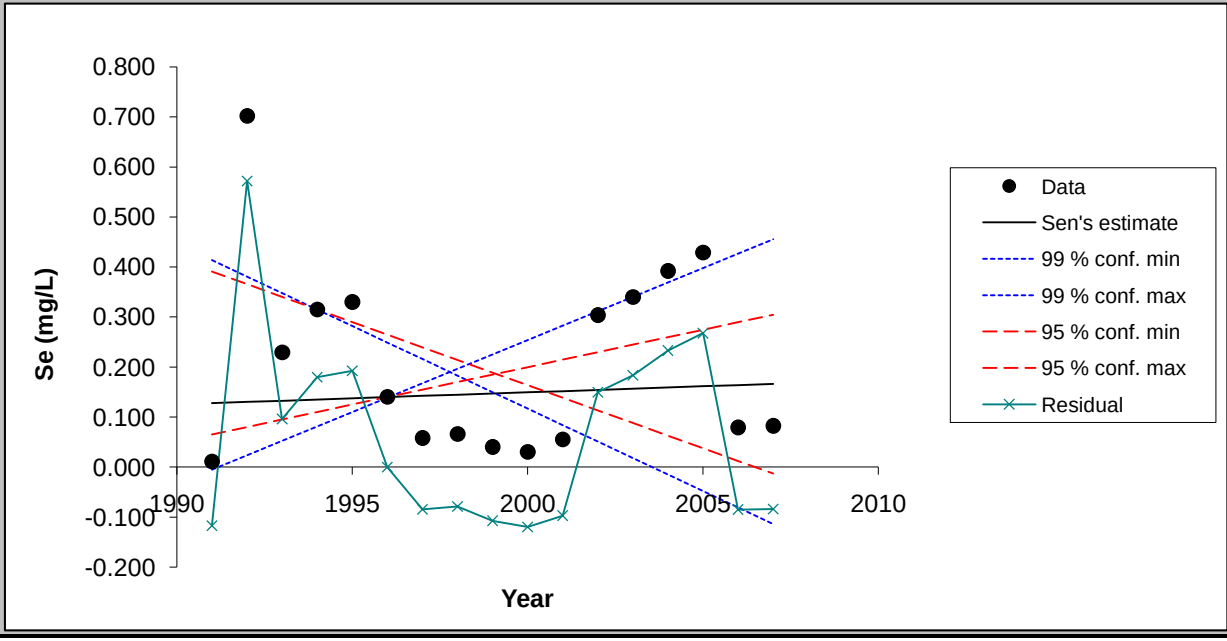

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.13	0.41	-0.01	0.39	0.07	-0.12
1992	0.70	0.13	0.38	0.02	0.37	0.08	0.57
1993	0.23	0.13	0.35	0.05	0.34	0.10	0.10
1994	0.32	0.14	0.32	0.08	0.32	0.11	0.18
1995	0.33	0.14	0.28	0.11	0.29	0.13	0.19
1996	0.14	0.14	0.25	0.14	0.26	0.14	0.00
1997	0.06	0.14	0.22	0.17	0.24	0.15	-0.08
1998	0.07	0.14	0.18	0.20	0.21	0.17	-0.08
1999	0.04	0.15	0.15	0.22	0.19	0.18	-0.11
2000	0.03	0.15	0.12	0.25	0.16	0.20	-0.12
2001	0.05	0.15	0.08	0.28	0.14	0.21	-0.10
2002	0.30	0.15	0.05	0.31	0.11	0.23	0.15
2003	0.34	0.16	0.02	0.34	0.09	0.24	0.18
2004	0.39	0.16	-0.02	0.37	0.06	0.26	0.23
2005	0.43	0.16	-0.05	0.40	0.04	0.27	0.27
2006	0.08	0.16	-0.08	0.43	0.01	0.29	-0.08
2007	0.08	0.17	-0.11	0.46	-0.01	0.30	-0.08

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.66
Signific.	
Q	-1.44E+00
Qmin99	-7.53E+00
Qmax99	5.30E+00
Qmin95	-6.25E+00
Qmax95	3.00E+00
B	1.22E+02
Bmin99	1.76E+02
Bmax99	6.42E+01
Bmin95	1.71E+02
Bmax95	7.90E+01

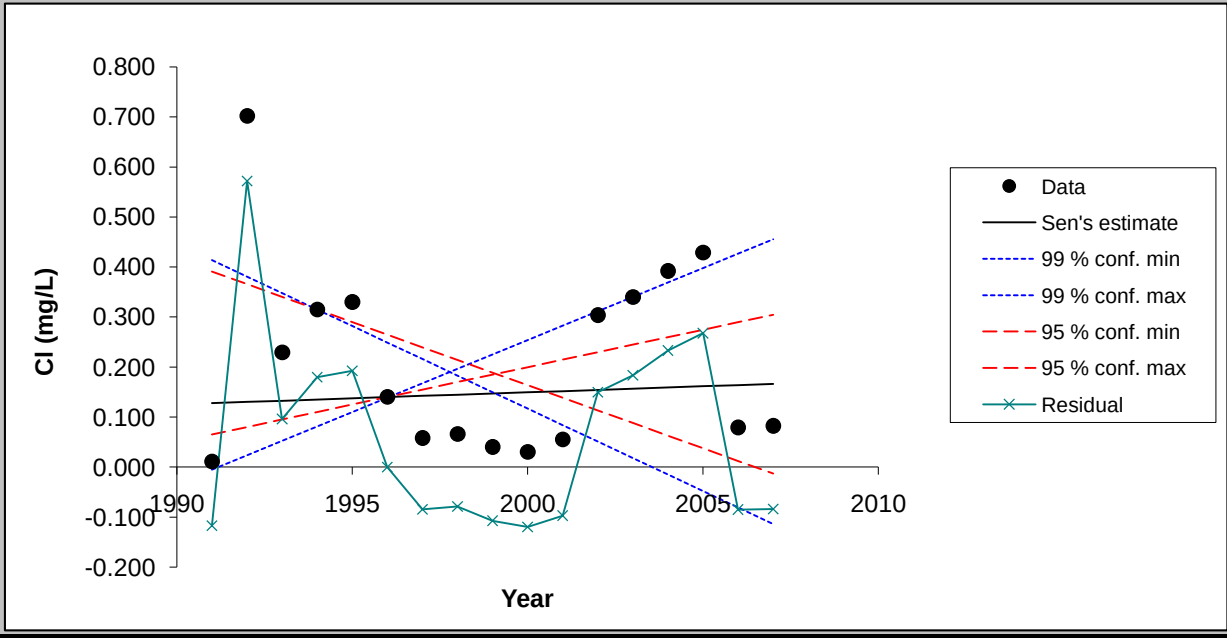

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	176.00	121.83	176.00	64.24	170.60	78.98	54.17
1992	174.50	120.39	168.47	69.54	164.35	81.99	54.11
1993	100.05	118.94	160.94	74.85	158.11	84.99	-18.89
1994	117.50	117.50	153.41	80.15	151.86	88.00	0.00
1995	91.00	116.06	145.88	85.45	145.62	91.00	-25.06
1996	91.00	114.61	138.36	90.76	139.37	94.00	-23.61
1997	140.00	113.17	130.83	96.06	133.13	97.01	26.83
1998	76.00	111.72	123.30	101.37	126.88	100.01	-35.72
1999	58.00	110.28	115.77	106.67	120.64	103.02	-52.28
2000	55.00	108.83	108.24	111.98	114.39	106.02	-53.83
2001	63.00	107.39	100.71	117.28	108.15	109.03	-44.39
2002	101.90	105.94	93.18	122.59	101.90	112.03	-4.04
2003	105.00	104.50	85.65	127.89	95.65	115.03	0.50
2004	139.50	103.06	78.12	133.20	89.41	118.04	36.44
2005	138.50	101.61	70.59	138.50	83.16	121.04	36.89
2006	129.50	100.17	63.07	143.80	76.92	124.05	29.33
2007	100.15	98.72	55.54	149.11	70.67	127.05	1.43

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-1.49
Signific.	
Q	-2.25E-03
Qmin99	-6.33E-03
Qmax99	1.63E-03
Qmin95	-5.37E-03
Qmax95	4.99E-04
B	7.54E-02
Bmin99	1.06E-01
Bmax99	3.80E-02
Bmin95	9.96E-02
Bmax95	4.91E-02

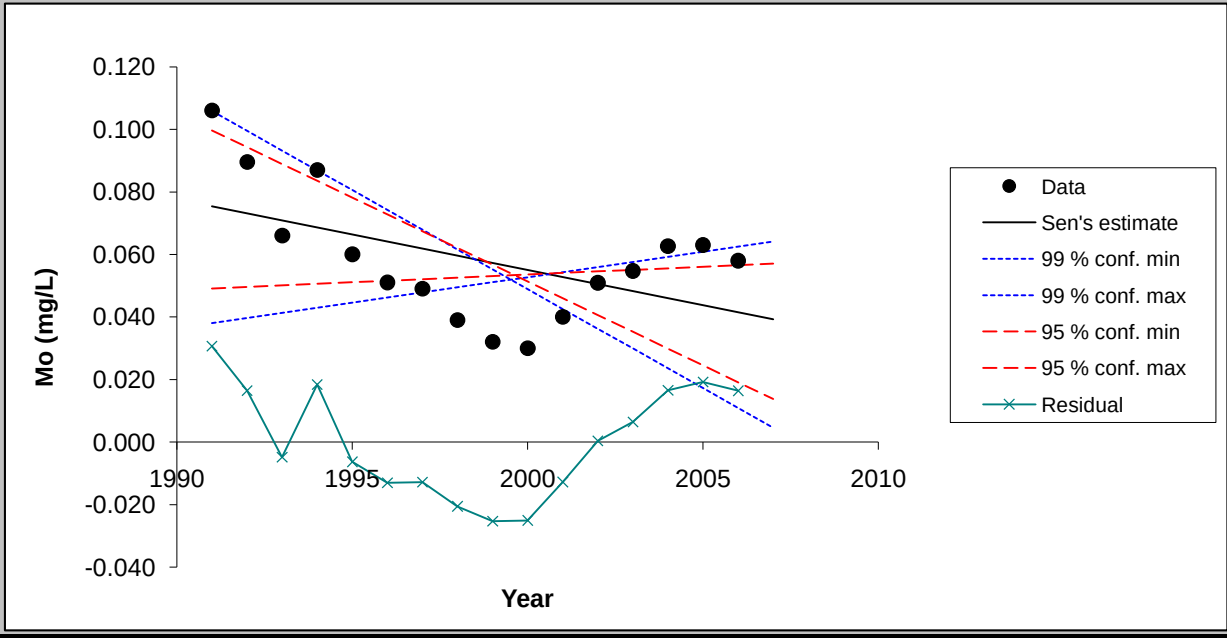

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.11	0.08	0.11	0.04	0.10	0.05	0.03
1992	0.09	0.07	0.10	0.04	0.09	0.05	0.02
1993	0.07	0.07	0.09	0.04	0.09	0.05	0.00
1994	0.09	0.07	0.09	0.04	0.08	0.05	0.02
1995	0.06	0.07	0.08	0.04	0.08	0.05	-0.01
1996	0.05	0.06	0.07	0.05	0.07	0.05	-0.01
1997	0.05	0.06	0.07	0.05	0.07	0.05	-0.01
1998	0.04	0.06	0.06	0.05	0.06	0.05	-0.02
1999	0.03	0.06	0.06	0.05	0.06	0.05	-0.03
2000	0.03	0.06	0.05	0.05	0.05	0.05	-0.03
2001	0.04	0.05	0.04	0.05	0.05	0.05	-0.01
2002	0.05	0.05	0.04	0.06	0.04	0.05	0.00
2003	0.05	0.05	0.03	0.06	0.04	0.06	0.01
2004	0.06	0.05	0.02	0.06	0.03	0.06	0.02
2005	0.06	0.04	0.02	0.06	0.02	0.06	0.02
2006	0.06	0.04	0.01	0.06	0.02	0.06	0.02
2007		0.04	0.00	0.06	0.01	0.06	

FIGURE

< Previous Time Series | Next Time Series >

TW-20 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.40
Signific.	
Q	9.22E+00
Qmin99	-2.86E+01
Qmax99	3.95E+01
Qmin95	-1.32E+01
Qmax95	2.80E+01
B	4.83E+02
Bmin99	6.34E+02
Bmax99	1.60E+02
Bmin95	5.73E+02
Bmax95	2.98E+02

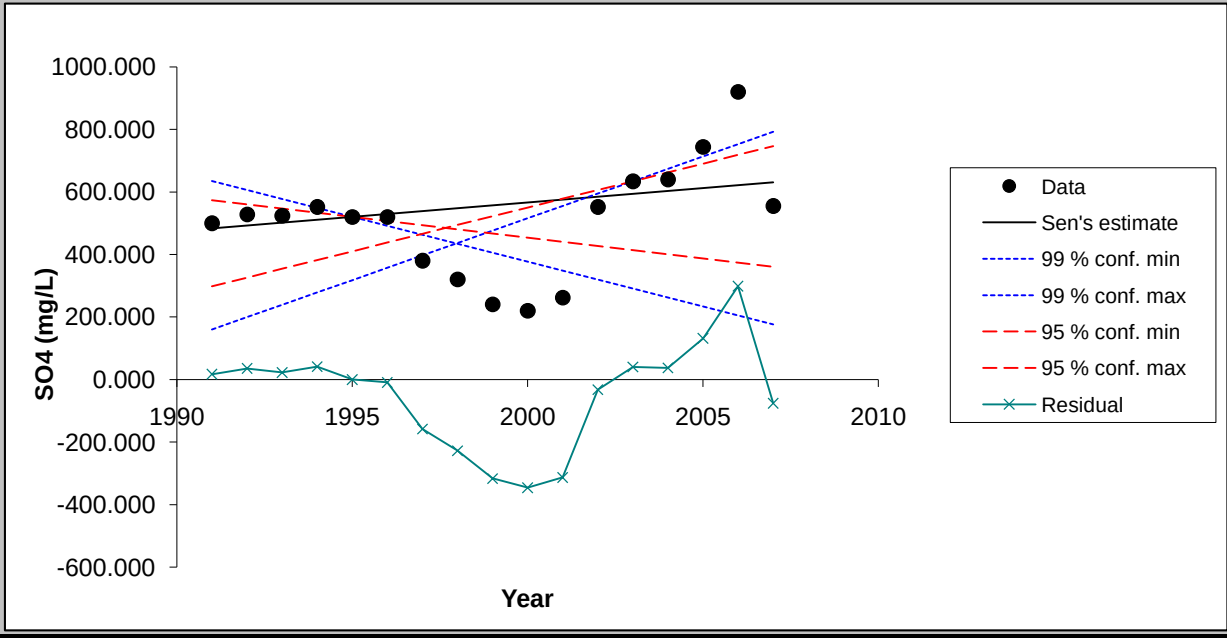

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	500.00	483.11	634.46	159.69	572.98	298.00	16.89
1992	528.00	492.33	605.84	199.22	559.74	326.00	35.67
1993	524.00	501.56	577.23	238.74	546.49	354.00	22.44
1994	552.00	510.78	548.61	278.27	533.25	382.00	41.22
1995	520.00	520.00	520.00	317.79	520.00	410.00	0.00
1996	520.00	529.22	491.39	357.32	506.75	438.00	-9.22
1997	380.00	538.44	462.77	396.85	493.51	466.00	-158.44
1998	320.00	547.67	434.16	436.37	480.26	494.00	-227.67
1999	240.00	556.89	405.54	475.90	467.02	522.00	-316.89
2000	220.00	566.11	376.93	515.42	453.77	550.00	-346.11
2001	262.00	575.33	348.31	554.95	440.53	578.00	-313.33
2002	551.95	584.56	319.70	594.47	427.28	606.00	-32.61
2003	634.00	593.78	291.08	634.00	414.03	634.00	40.22
2004	640.00	603.00	262.47	673.53	400.79	662.00	37.00
2005	744.00	612.22	233.85	713.05	387.54	690.00	131.78
2006	920.00	621.44	205.24	752.58	374.30	718.00	298.56
2007	555.00	630.67	176.62	792.10	361.05	746.00	-75.67

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-20 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	15	16
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.019	6.97	0.0025	7.55	0.011	176		500
1992	0.0168	6.37	0.0023	8.13	0.702	174.5	0.106	528
1993	0.0092	4.88	0.0151	9.03	0.229	100	0.090	524
1994	0.0071	5.18	0.0241	9.65	0.315	117.5	0.066	552
1995	0.009	5.3	0.0005	8.7	0.33	91	0.087	520
1996	0.008	3.9	0.001	8.9	0.14	91	0.06	520
1997	0.006	4.6	0.0005	6.9	0.058	140	0.051	380
1998	0.004	2.6	0.0005	6.6	0.066	76	0.049	320
1999	0.0032	2	0.001	5	0.04	58	0.039	240
2000	0.0028	1.5	0.0005	4.9	0.03	55	0.032	220
2001	0.004	1.6	0.005	4.57	0.055	63	0.03	262
2003	0.0063	1.81	0.001	7.965	0.34	105	0.0509	634
2004	0.0096	1.67	0.001	8.16	0.392	139.5	0.0547	640
2005	0.0111	2.37	0.002	12.95	0.429	138.5	0.0626	744
2006	0.0106	3.605	0.002	20.25	0.079	129.5	0.063	920
2007	0.0060	2.57	0.002	10.95	0.08225	100.15	0.05795	555

TREND STATISTICS

TW-20 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*16*		-1.26		-0.0004	-0.0013	0.0004	-0.0010	0.0002	0.0104	0.0156	0.0049	0.0135	0.0066
F (mg/L)	*1991*	*2007*	*16*		-2.93	**	-0.333	-0.580	-0.066	-0.496	-0.149	5.92	7.19	3.89	6.92	4.72
Mn (mg/L)	*1991*	*2007*	*16*		-0.50		0.0000	-0.0005	0.0002	-0.0003	0.0001	0.0015	0.0058	-0.0005	0.0037	0.0000
Nitrate (mg/L)	*1991*	*2007*	*16*		0.41		0.169	-0.400	0.826	-0.285	0.568	7.75	10.07	2.07	9.72	4.53
Se (mg/L)	*1991*	*2007*	*16*		0.14		0.002	-0.037	0.025	-0.028	0.011	0.09	0.43	0.01	0.37	0.05
Cl (mg/L)	*1991*	*2007*	*16*		-0.99		-3.008	-9.796	5.660	-7.006	2.488	132.31	168.48	63.81	157.26	87.86
Mo (mg/L)	*1992*	*2007*	*15*		-1.68	+	-0.003	-0.007	0.001	-0.006	0.000	0.080	0.104	0.043	0.101	0.052
SO4 (mg/L)	*1991*	*2007*	*16*		0.90		9.980	-32.289	37.244	-25.226	28.000	490.04	618.72	242.08	597.68	353.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-1.26
Signific.	
Q	-4.21E-04
Qmin99	-1.27E-03
Qmax99	4.00E-04
Qmin95	-1.00E-03
Qmax95	2.33E-04
B	1.04E-02
Bmin99	1.56E-02
Bmax99	4.92E-03
Bmin95	1.35E-02
Bmax95	6.62E-03

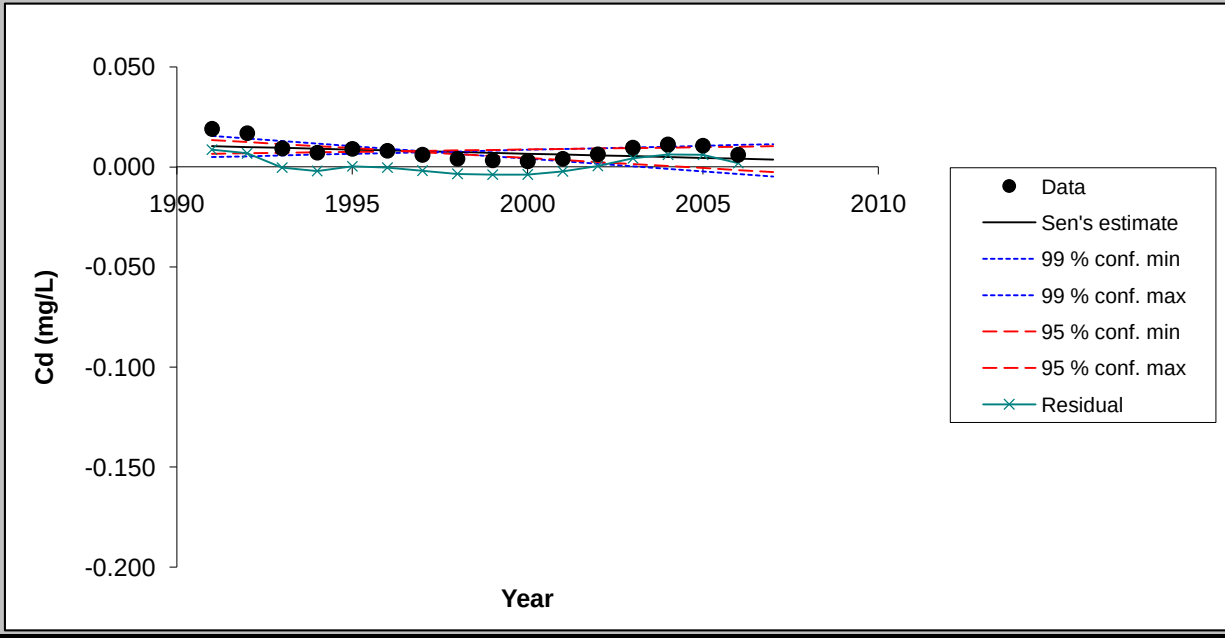

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.01	0.02	0.00	0.01	0.01	0.01
1992	0.02	0.01	0.01	0.01	0.01	0.01	0.01
1993	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1994	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1995	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1996	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1997	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1998	0.00	0.01	0.01	0.01	0.01	0.01	0.00
1999	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2001	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2002	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2006	0.01	0.00	0.00	0.01	0.00	0.01	0.00
2007		0.00	0.00	0.01	0.00	0.01	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-2.93
Signific.	**
Q	-3.33E-01
Qmin99	-5.80E-01
Qmax99	-6.59E-02
Qmin95	-4.96E-01
Qmax95	-1.49E-01
B	5.92E+00
Bmin99	7.19E+00
Bmax99	3.89E+00
Bmin95	6.92E+00
Bmax95	4.72E+00

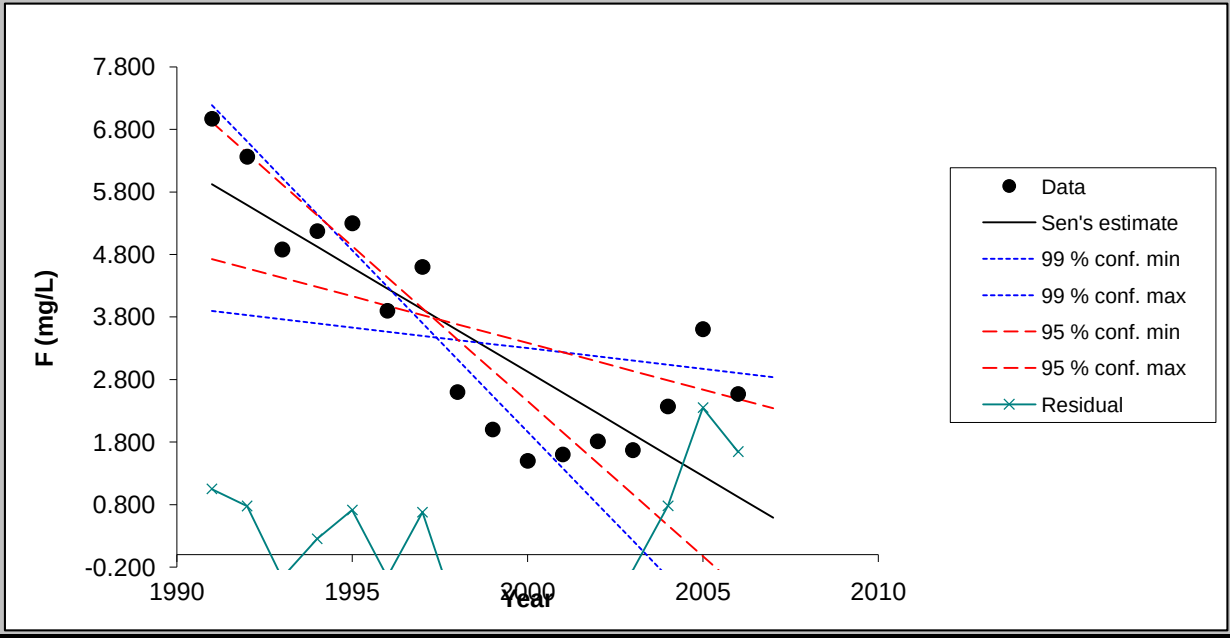

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	6.97	5.92	7.19	3.89	6.92	4.72	1.05
1992	6.37	5.59	6.61	3.83	6.42	4.58	0.78
1993	4.88	5.25	6.03	3.76	5.92	4.43	-0.37
1994	5.18	4.92	5.45	3.70	5.43	4.28	0.25
1995	5.30	4.59	4.87	3.63	4.93	4.13	0.71
1996	3.90	4.26	4.28	3.56	4.43	3.98	-0.36
1997	4.60	3.92	3.70	3.50	3.94	3.83	0.68
1998	2.60	3.59	3.12	3.43	3.44	3.68	-0.99
1999	2.00	3.26	2.54	3.37	2.95	3.53	-1.26
2000	1.50	2.92	1.96	3.30	2.45	3.38	-1.42
2001	1.60	2.59	1.38	3.24	1.95	3.24	-0.99
2002	1.81	2.26	0.80	3.17	1.46	3.09	-0.45
2003	1.67	1.92	0.22	3.10	0.96	2.94	-0.25
2004	2.37	1.59	-0.36	3.04	0.47	2.79	0.78
2005	3.61	1.26	-0.94	2.97	-0.03	2.64	2.35
2006	2.57	0.92	-1.52	2.91	-0.53	2.49	1.65
2007		0.59	-2.10	2.84	-1.02	2.34	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.50
Signific.	
Q	-3.25E-19
Qmin99	-5.00E-04
Qmax99	1.87E-04
Qmin95	-2.89E-04
Qmax95	1.39E-04
B	1.50E-03
Bmin99	5.75E-03
Bmax99	-4.69E-04
Bmin95	3.74E-03
Bmax95	-4.78E-06

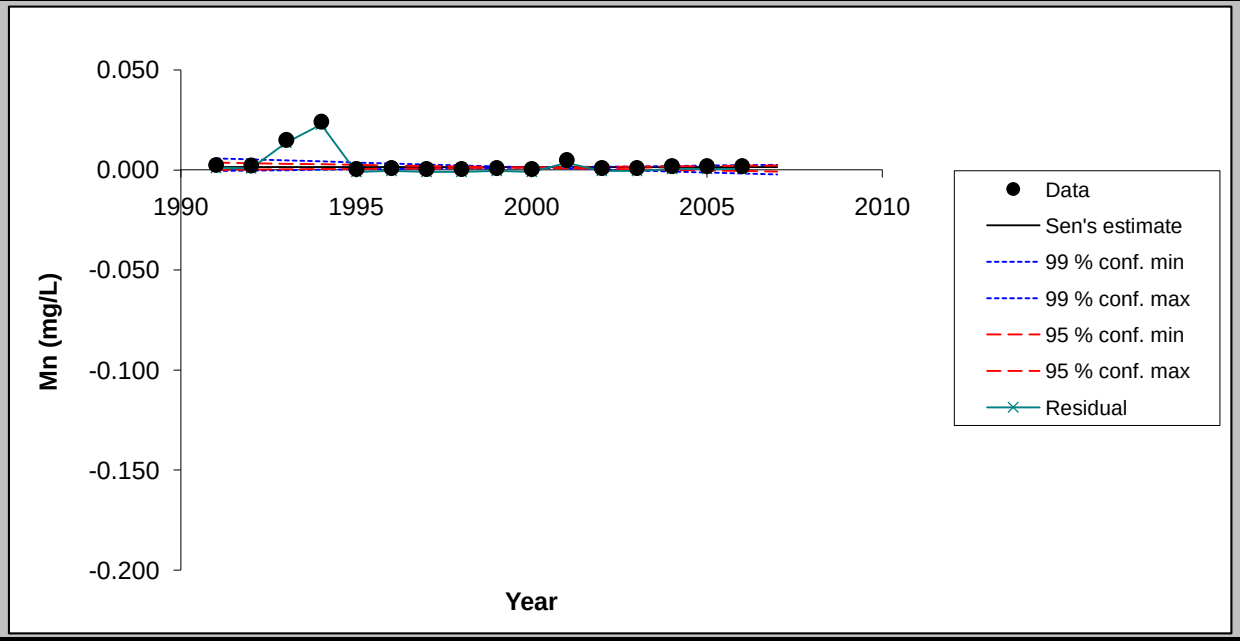

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.02	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.02	0.00	0.00	0.00	0.00	0.00	0.02
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007		0.00	0.00	0.00	0.00	0.00	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	0.41
Signific.	
Q	1.69E-01
Qmin99	-4.00E-01
Qmax99	8.26E-01
Qmin95	-2.85E-01
Qmax95	5.68E-01
B	7.75E+00
Bmin99	1.01E+01
Bmax99	2.07E+00
Bmin95	9.72E+00
Bmax95	4.53E+00

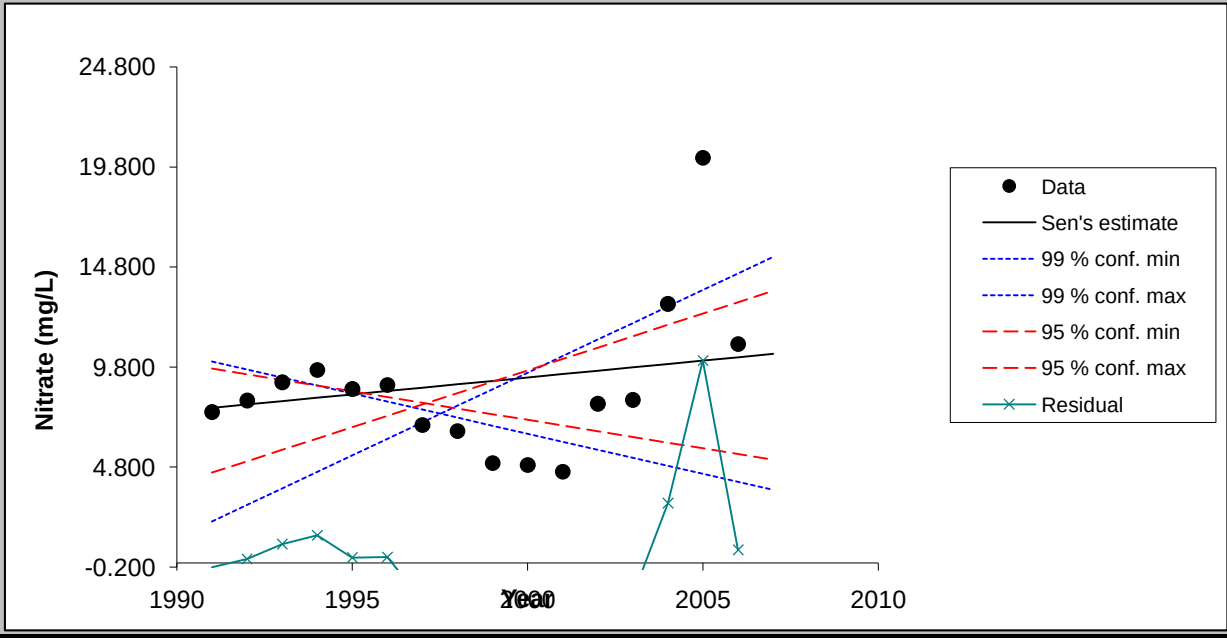

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	7.55	7.75	10.07	2.07	9.72	4.53	-0.20
1992	8.13	7.92	9.67	2.90	9.44	5.10	0.20
1993	9.03	8.09	9.27	3.73	9.15	5.67	0.94
1994	9.65	8.26	8.87	4.55	8.87	6.23	1.39
1995	8.70	8.43	8.47	5.38	8.58	6.80	0.27
1996	8.90	8.60	8.07	6.21	8.30	7.37	0.30
1997	6.90	8.77	7.67	7.03	8.01	7.94	-1.87
1998	6.60	8.94	7.27	7.86	7.73	8.51	-2.34
1999	5.00	9.11	6.87	8.69	7.44	9.07	-4.11
2000	4.90	9.28	6.47	9.51	7.16	9.64	-4.38
2001	4.57	9.45	6.07	10.34	6.87	10.21	-4.88
2002	7.96	9.62	5.67	11.16	6.59	10.78	-1.65
2003	8.16	9.79	5.27	11.99	6.30	11.34	-1.63
2004	12.95	9.96	4.87	12.82	6.02	11.91	2.99
2005	20.25	10.13	4.47	13.64	5.73	12.48	10.12
2006	10.95	10.30	4.07	14.47	5.45	13.05	0.65
2007		10.46	3.67	15.30	5.16	13.62	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	0.14
Signific.	
Q	1.94E-03
Qmin99	-3.71E-02
Qmax99	2.55E-02
Qmin95	-2.84E-02
Qmax95	1.07E-02
B	9.17E-02
Bmin99	4.26E-01
Bmax99	1.18E-02
Bmin95	3.69E-01
Bmax95	4.87E-02

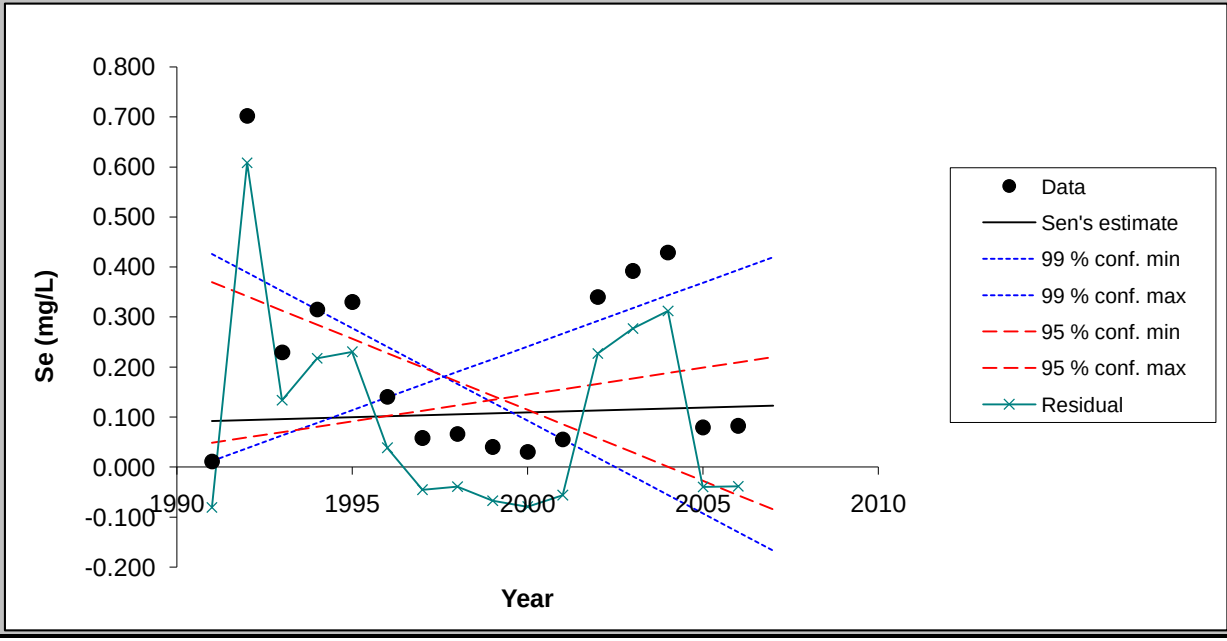

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.09	0.43	0.01	0.37	0.05	-0.08
1992	0.70	0.09	0.39	0.04	0.34	0.06	0.61
1993	0.23	0.10	0.35	0.06	0.31	0.07	0.13
1994	0.32	0.10	0.31	0.09	0.28	0.08	0.22
1995	0.33	0.10	0.28	0.11	0.26	0.09	0.23
1996	0.14	0.10	0.24	0.14	0.23	0.10	0.04
1997	0.06	0.10	0.20	0.16	0.20	0.11	-0.05
1998	0.07	0.11	0.17	0.19	0.17	0.12	-0.04
1999	0.04	0.11	0.13	0.22	0.14	0.13	-0.07
2000	0.03	0.11	0.09	0.24	0.11	0.15	-0.08
2001	0.05	0.11	0.06	0.27	0.09	0.16	-0.06
2002	0.34	0.11	0.02	0.29	0.06	0.17	0.23
2003	0.39	0.12	-0.02	0.32	0.03	0.18	0.28
2004	0.43	0.12	-0.06	0.34	0.00	0.19	0.31
2005	0.08	0.12	-0.09	0.37	-0.03	0.20	-0.04
2006	0.08	0.12	-0.13	0.39	-0.06	0.21	-0.04
2007		0.12	-0.17	0.42	-0.08	0.22	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.99
Signific.	
Q	-3.01E+00
Qmin99	-9.80E+00
Qmax99	5.66E+00
Qmin95	-7.01E+00
Qmax95	2.49E+00
B	1.32E+02
Bmin99	1.68E+02
Bmax99	6.38E+01
Bmin95	1.57E+02
Bmax95	8.79E+01

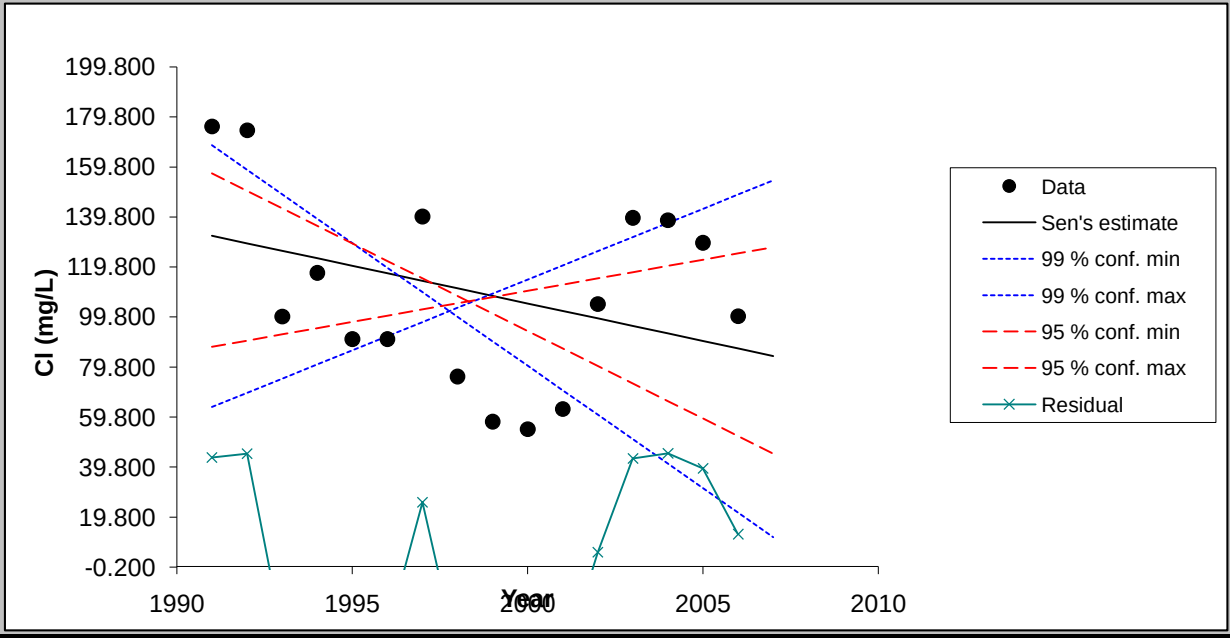

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	176.00	132.31	168.48	63.81	157.26	87.86	43.69
1992	174.50	129.30	158.68	69.47	150.25	90.34	45.20
1993	100.05	126.29	148.89	75.13	143.25	92.83	-26.24
1994	117.50	123.28	139.09	80.79	136.24	95.32	-5.78
1995	91.00	120.27	129.30	86.45	129.23	97.81	-29.27
1996	91.00	117.27	119.50	92.11	122.23	100.30	-26.27
1997	140.00	114.26	109.70	97.77	115.22	102.79	25.74
1998	76.00	111.25	99.91	103.43	108.22	105.27	-35.25
1999	58.00	108.24	90.11	109.09	101.21	107.76	-50.24
2000	55.00	105.23	80.32	114.75	94.20	110.25	-50.23
2001	63.00	102.23	70.52	120.41	87.20	112.74	-39.23
2002	105.00	99.22	60.72	126.07	80.19	115.23	5.78
2003	139.50	96.21	50.93	131.73	73.18	117.71	43.29
2004	138.50	93.20	41.13	137.39	66.18	120.20	45.30
2005	129.50	90.19	31.34	143.05	59.17	122.69	39.31
2006	100.15	87.18	21.54	148.71	52.17	125.18	12.97
2007		84.18	11.74	154.37	45.16	127.67	

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	15
Test S	
Test Z	-1.68
Signific.	+
Q	-2.64E-03
Qmin99	-7.00E-03
Qmax99	1.33E-03
Qmin95	-5.77E-03
Qmax95	4.23E-04
B	7.99E-02
Bmin99	1.04E-01
Bmax99	4.30E-02
Bmin95	1.01E-01
Bmax95	5.16E-02

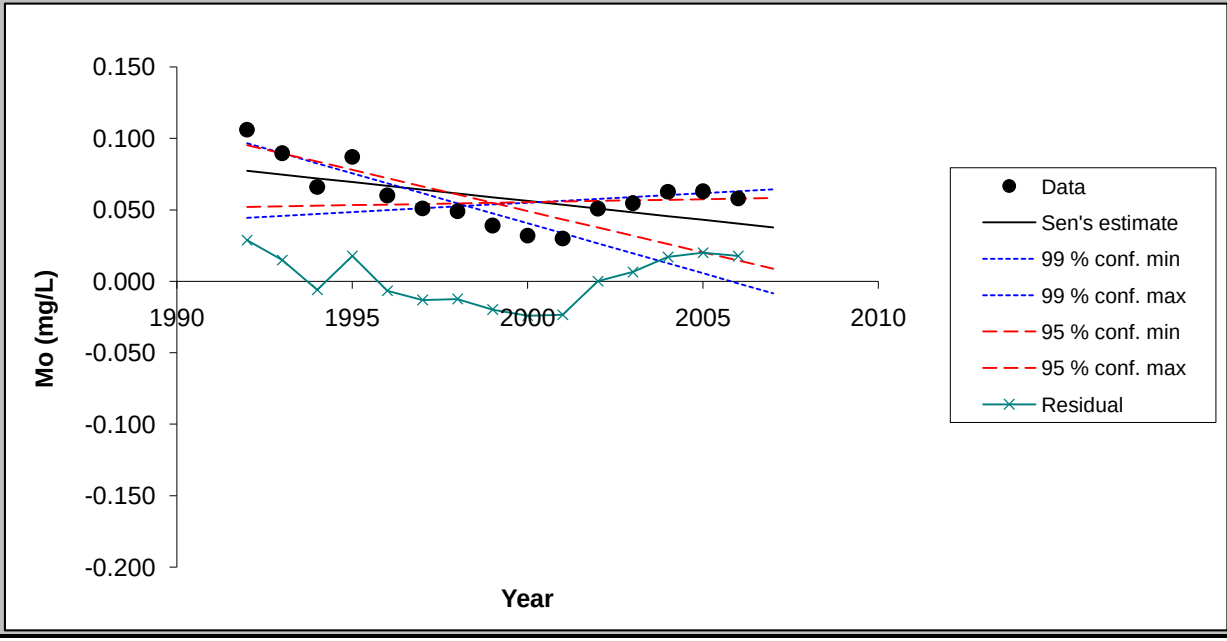

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.11	0.08	0.10	0.04	0.10	0.05	0.03
1993	0.09	0.07	0.09	0.05	0.09	0.05	0.01
1994	0.07	0.07	0.08	0.05	0.08	0.05	-0.01
1995	0.09	0.07	0.08	0.05	0.08	0.05	0.02
1996	0.06	0.07	0.07	0.05	0.07	0.05	-0.01
1997	0.05	0.06	0.06	0.05	0.07	0.05	-0.01
1998	0.05	0.06	0.05	0.05	0.06	0.05	-0.01
1999	0.04	0.06	0.05	0.05	0.05	0.05	-0.02
2000	0.03	0.06	0.04	0.05	0.05	0.06	-0.02
2001	0.03	0.05	0.03	0.06	0.04	0.06	-0.02
2002	0.05	0.05	0.03	0.06	0.04	0.06	0.00
2003	0.05	0.05	0.02	0.06	0.03	0.06	0.01
2004	0.06	0.05	0.01	0.06	0.03	0.06	0.02
2005	0.06	0.04	0.01	0.06	0.02	0.06	0.02
2006	0.06	0.04	0.00	0.06	0.01	0.06	0.02
2007		0.04	-0.01	0.06	0.01	0.06	

FIGURE

< Previous Time Series | Next Time Series >

TW-20 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	0.90
Signific.	
Q	9.98E+00
Qmin99	-3.23E+01
Qmax99	3.72E+01
Qmin95	-2.52E+01
Qmax95	2.80E+01
B	4.90E+02
Bmin99	6.19E+02
Bmax99	2.42E+02
Bmin95	5.98E+02
Bmax95	3.53E+02

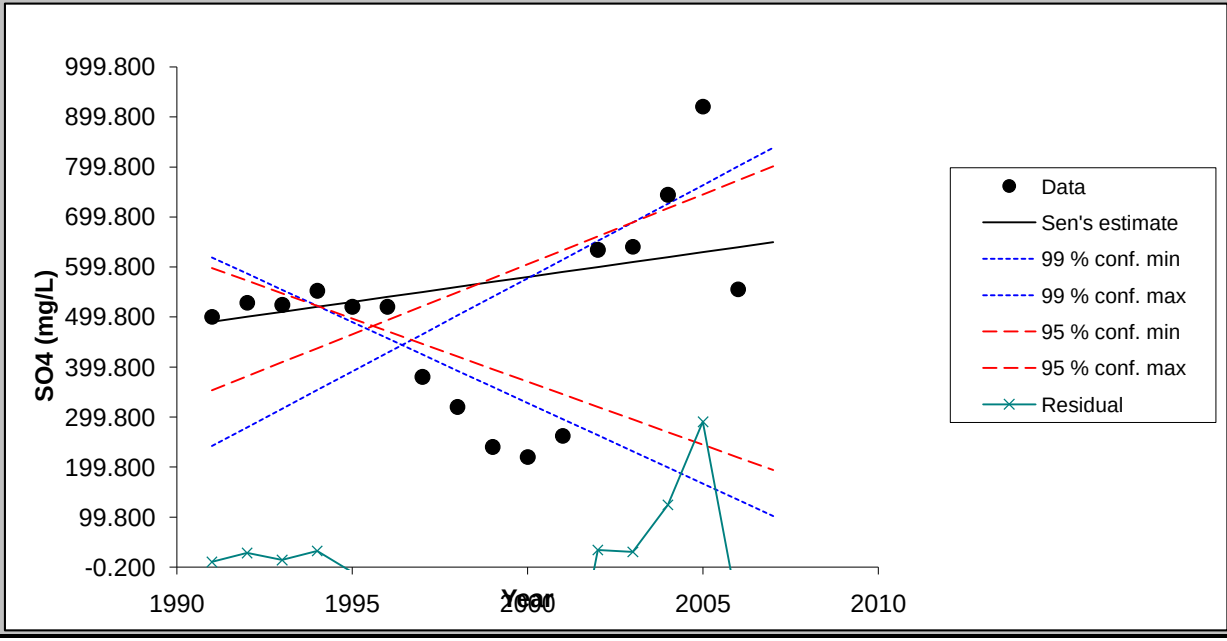

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	500.00	490.04	618.72	242.08	597.68	353.00	9.96
1992	528.00	500.02	586.43	279.32	572.45	381.00	27.98
1993	524.00	510.00	554.14	316.56	547.23	409.00	14.00
1994	552.00	519.98	521.86	353.81	522.00	437.00	32.02
1995	520.00	529.96	489.57	391.05	496.77	465.00	-9.96
1996	520.00	539.94	457.28	428.29	471.55	493.00	-19.94
1997	380.00	549.92	424.99	465.54	446.32	521.00	-169.92
1998	320.00	559.90	392.70	502.78	421.10	549.00	-239.90
1999	240.00	569.88	360.41	540.03	395.87	577.00	-329.88
2000	220.00	579.86	328.12	577.27	370.65	605.00	-359.86
2001	262.00	589.84	295.83	614.51	345.42	633.00	-327.84
2002	634.00	599.82	263.54	651.76	320.19	661.00	34.18
2003	640.00	609.80	231.25	689.00	294.97	689.00	30.20
2004	744.00	619.78	198.96	726.24	269.74	717.00	124.22
2005	920.00	629.76	166.67	763.49	244.52	745.00	290.24
2006	555.00	639.74	134.38	800.73	219.29	773.00	-84.74
2007		649.72	102.09	837.97	194.06	801.00	

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-34 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.94	0.25	0.25	0.002	21		138
1992	0.0015	0.41	0.207	0.125	0.007	51.0	0.0276	207.5
1993	0.0029	0.43	0.344	0.03	0.001	46	0.0048	185.5
1994	0.0006	0.42	0.178	0.10	0.003	43.6	0.0065	184.5
1995	0.0001	0.63	0.516	0.024	0.001	42	0.0025	72
1996	0.0001	0.67	0.189	0.09	0.002	43	0.0025	170
1997	0.0001	0.60	0.228	0.072	0.001	39	0.0025	140
1998	0.0001	0.05	0.154	0.17	0.011	44	0.0025	180
1999	0.0001	0.57	0.268	0.11	0.004	33	0.0025	150
2000	0.0001	0.47	0.204	0.23	0.009	40	0.0025	180
2001	0.001	0.7	0.22	0.95	0.009	38	0.005	150
2002	0.001	0.71	0.191	1.12	0.013	45	0.005	195.1
2003	0.00100	0.41	0.18	0.29	0.012	43.7	0.011	192
2004	0.00100	0.33	0.236	0.1	0.015	44.6	0.016	206
2005	0.00100	0.244	0.238	0.11	0.0046	47.7	0.01	199
2006	0.00100	0.63	0.206	0.05	0.0011	40.5	0.011	175
2007	0.00100	0.6	0.222	0.034	0.00055	39.3	0.0081	161

TREND STATISTICS

TW-34 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.47		0.0000	-0.0001	0.0001	0.0000	0.0001	0.0010	0.0021	-0.0003	0.0015	0.0001
F (mg/L)	*1991*	*2007*	*17*		-0.37		-0.01	-0.04	0.03	-0.03	0.02	0.61	0.88	0.35	0.80	0.39
Mn (mg/L)	*1991*	*2007*	*17*		-0.37		-0.001	-0.011	0.005	-0.008	0.004	0.23	0.32	0.16	0.28	0.18
Nitrate (mg/L)	*1991*	*2007*	*17*		0.12		0.001	-0.015	0.028	-0.010	0.020	0.102	0.274	-0.048	0.206	-0.010
Se (mg/L)	*1991*	*2007*	*17*		0.95		0.0003	-0.0005	0.0013	-0.0001	0.0010	0.0017	0.0080	-0.0033	0.0050	-0.0009
Cl (mg/L)	*1991*	*2007*	*17*		-0.04		-0.080	-1.000	1.019	-0.668	0.561	43.40	49.00	32.89	47.34	37.30
Mo (mg/L)	*1992*	*2007*	*16*		1.44		0.0004	-0.0004	0.0010	0.0000	0.0008	0.0014	0.0086	-0.0039	0.0050	-0.0017
SO4 (mg/L)	*1991*	*2007*	*17*		0.784		1.319	-3.172	5.282	-1.368	4.464	168.13	202.21	132.46	188.60	138.43
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.47
Signific.	
Q	0.00E+00
Qmin99	-1.08E-04
Qmax99	1.00E-04
Qmin95	-4.55E-05
Qmax95	6.44E-05
B	1.00E-03
Bmin99	2.08E-03
Bmax99	-3.00E-04
Bmin95	1.50E-03
Bmax95	9.84E-05

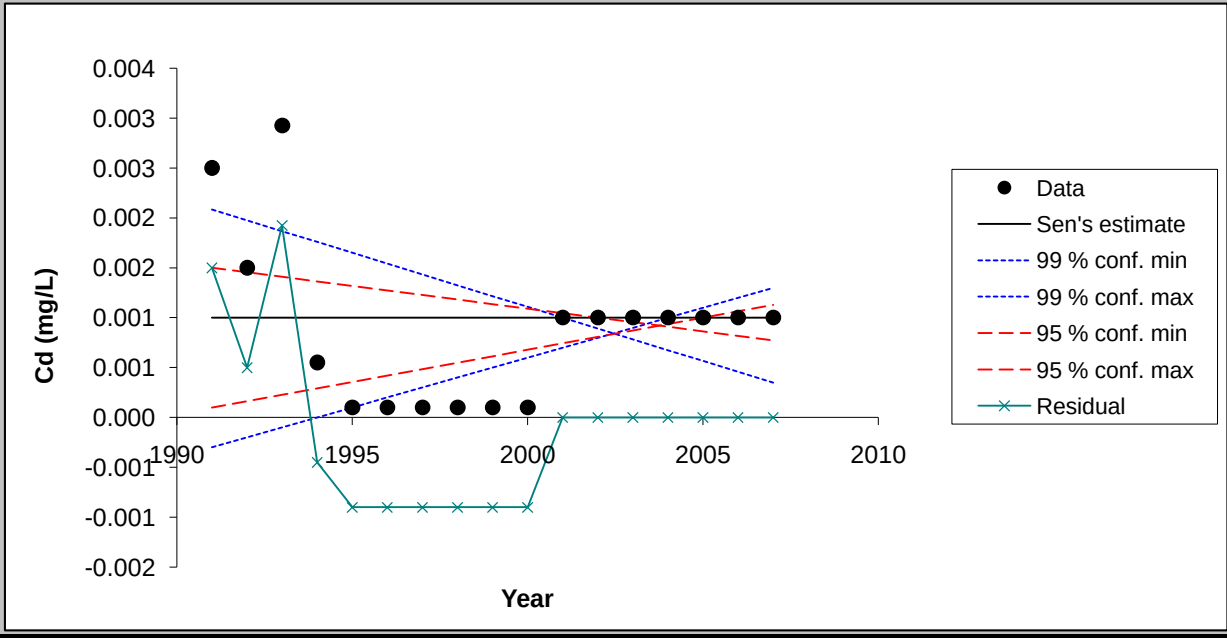

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.37
Signific.	
Q	-5.13E-03
Qmin99	-4.27E-02
Qmax99	2.69E-02
Qmin95	-3.31E-02
Qmax95	1.72E-02
B	6.11E-01
Bmin99	8.84E-01
Bmax99	3.54E-01
Bmin95	7.98E-01
Bmax95	3.88E-01

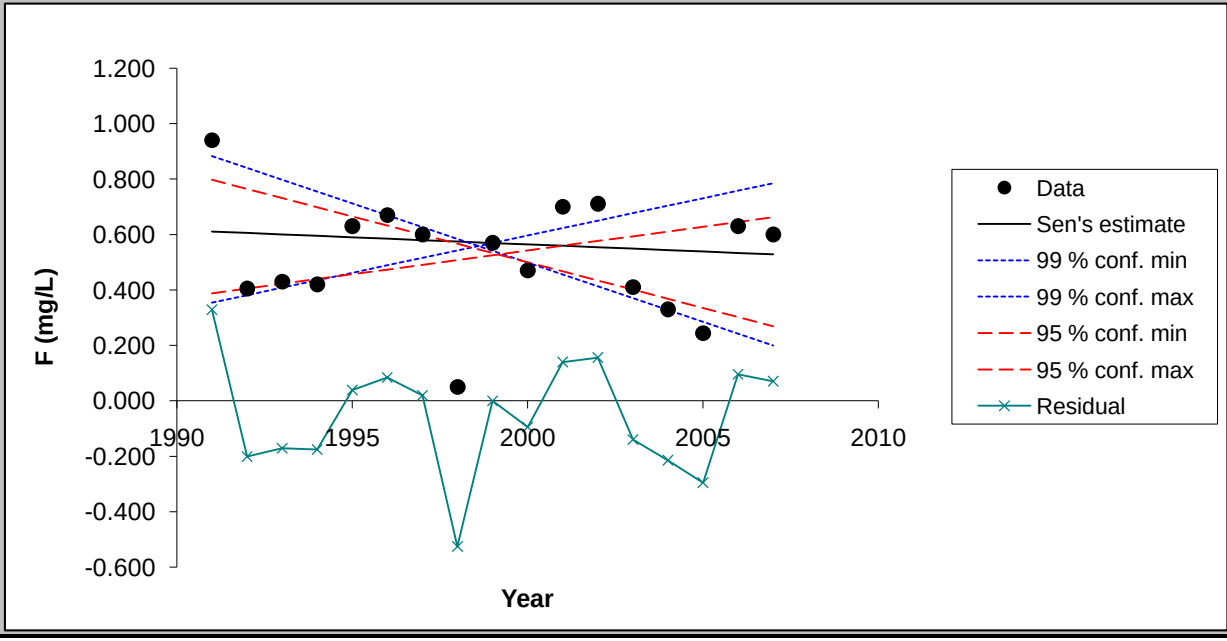

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.94	0.61	0.88	0.35	0.80	0.39	0.33
1992	0.41	0.61	0.84	0.38	0.77	0.41	-0.20
1993	0.43	0.60	0.80	0.41	0.73	0.42	-0.17
1994	0.42	0.60	0.76	0.44	0.70	0.44	-0.18
1995	0.63	0.59	0.71	0.46	0.67	0.46	0.04
1996	0.67	0.59	0.67	0.49	0.63	0.47	0.08
1997	0.60	0.58	0.63	0.52	0.60	0.49	0.02
1998	0.05	0.58	0.58	0.54	0.57	0.51	-0.53
1999	0.57	0.57	0.54	0.57	0.53	0.53	0.00
2000	0.47	0.56	0.50	0.60	0.50	0.54	-0.09
2001	0.70	0.56	0.46	0.62	0.47	0.56	0.14
2002	0.71	0.55	0.41	0.65	0.43	0.58	0.16
2003	0.41	0.55	0.37	0.68	0.40	0.59	-0.14
2004	0.33	0.54	0.33	0.70	0.37	0.61	-0.21
2005	0.24	0.54	0.29	0.73	0.34	0.63	-0.30
2006	0.63	0.53	0.24	0.76	0.30	0.65	0.10
2007	0.60	0.53	0.20	0.79	0.27	0.66	0.07

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.37
Signific.	
Q	-1.18E-03
Qmin99	-1.13E-02
Qmax99	5.42E-03
Qmin95	-8.00E-03
Qmax95	3.75E-03
B	2.32E-01
Bmin99	3.16E-01
Bmax99	1.62E-01
Bmin95	2.79E-01
Bmax95	1.82E-01

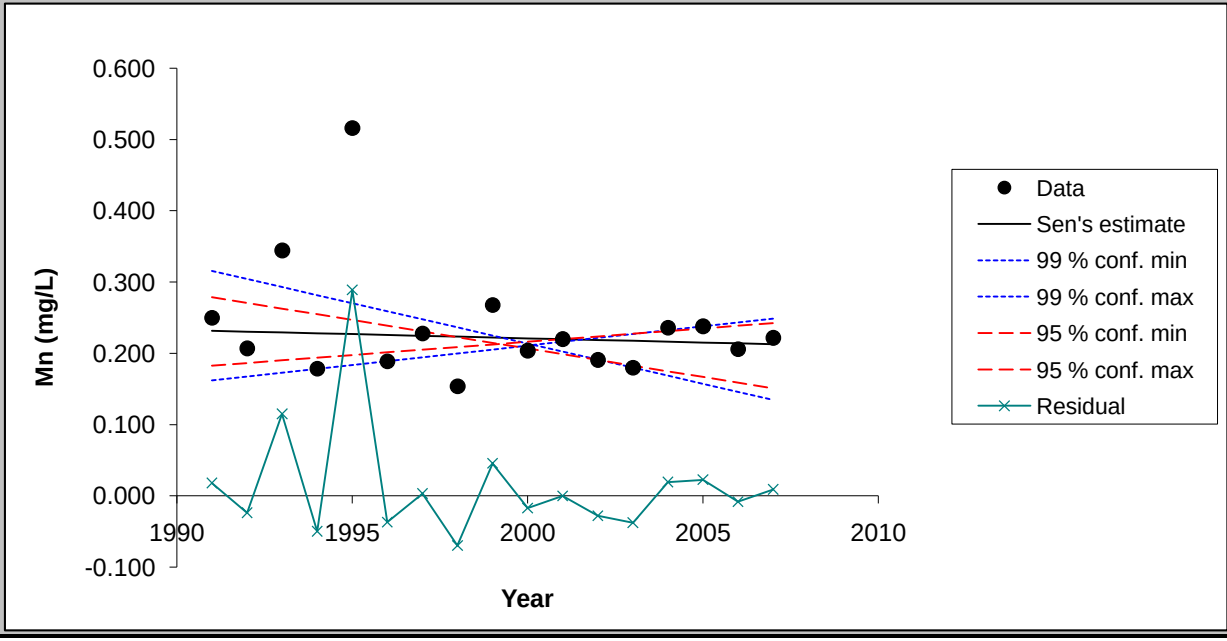

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	0.23	0.32	0.16	0.28	0.18	0.02
1992	0.21	0.23	0.30	0.17	0.27	0.19	-0.02
1993	0.34	0.23	0.29	0.17	0.26	0.19	0.12
1994	0.18	0.23	0.28	0.18	0.26	0.19	-0.05
1995	0.52	0.23	0.27	0.18	0.25	0.20	0.29
1996	0.19	0.23	0.26	0.19	0.24	0.20	-0.04
1997	0.23	0.22	0.25	0.19	0.23	0.20	0.00
1998	0.15	0.22	0.24	0.20	0.22	0.21	-0.07
1999	0.27	0.22	0.23	0.21	0.22	0.21	0.05
2000	0.20	0.22	0.21	0.21	0.21	0.22	-0.02
2001	0.22	0.22	0.20	0.22	0.20	0.22	0.00
2002	0.19	0.22	0.19	0.22	0.19	0.22	-0.03
2003	0.18	0.22	0.18	0.23	0.18	0.23	-0.04
2004	0.24	0.22	0.17	0.23	0.17	0.23	0.02
2005	0.24	0.22	0.16	0.24	0.17	0.23	0.02
2006	0.21	0.21	0.15	0.24	0.16	0.24	-0.01
2007	0.22	0.21	0.13	0.25	0.15	0.24	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.12
Signific.	
Q	5.60E-04
Qmin99	-1.50E-02
Qmax99	2.82E-02
Qmin95	-1.04E-02
Qmax95	2.00E-02
B	1.02E-01
Bmin99	2.74E-01
Bmax99	-4.78E-02
Bmin95	2.06E-01
Bmax95	-1.00E-02

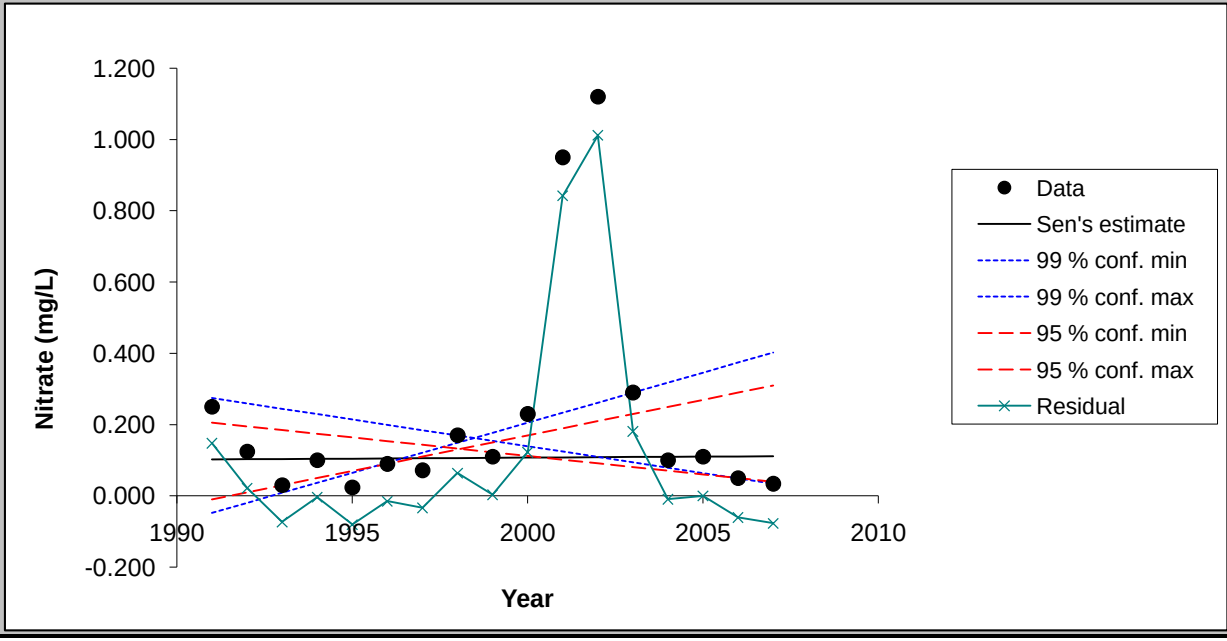

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	0.10	0.27	-0.05	0.21	-0.01	0.15
1992	0.12	0.10	0.26	-0.02	0.20	0.01	0.02
1993	0.03	0.10	0.24	0.01	0.19	0.03	-0.07
1994	0.10	0.10	0.23	0.04	0.17	0.05	0.00
1995	0.02	0.10	0.21	0.06	0.16	0.07	-0.08
1996	0.09	0.10	0.20	0.09	0.15	0.09	-0.01
1997	0.07	0.11	0.18	0.12	0.14	0.11	-0.03
1998	0.17	0.11	0.17	0.15	0.13	0.13	0.06
1999	0.11	0.11	0.15	0.18	0.12	0.15	0.00
2000	0.23	0.11	0.14	0.21	0.11	0.17	0.12
2001	0.95	0.11	0.12	0.23	0.10	0.19	0.84
2002	1.12	0.11	0.11	0.26	0.09	0.21	1.01
2003	0.29	0.11	0.09	0.29	0.08	0.23	0.18
2004	0.10	0.11	0.08	0.32	0.07	0.25	-0.01
2005	0.11	0.11	0.06	0.35	0.06	0.27	0.00
2006	0.05	0.11	0.05	0.37	0.05	0.29	-0.06
2007	0.03	0.11	0.03	0.40	0.04	0.31	-0.08

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.95
Signific.	
Q	2.90E-04
Qmin99	-4.58E-04
Qmax99	1.28E-03
Qmin95	-1.30E-04
Qmax95	1.00E-03
B	1.68E-03
Bmin99	7.96E-03
Bmax99	-3.31E-03
Bmin95	5.04E-03
Bmax95	-9.00E-04

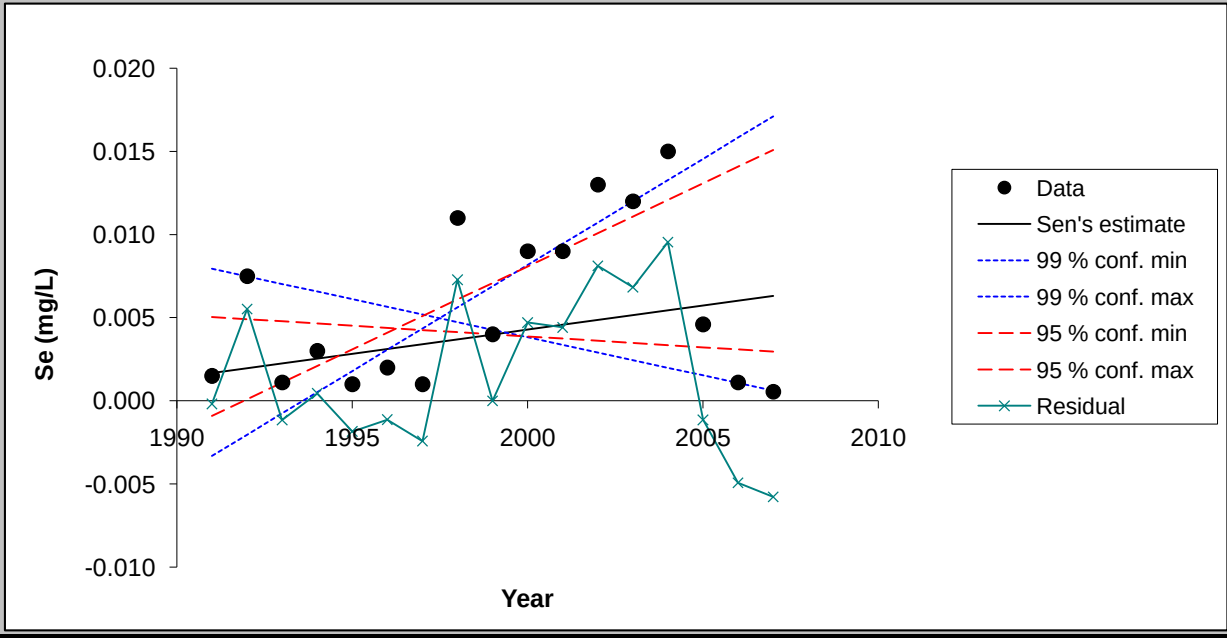

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.00	0.00	0.01
1993	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.00	0.01	0.00
1998	0.01	0.00	0.00	0.01	0.00	0.01	0.01
1999	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2000	0.01	0.00	0.00	0.01	0.00	0.01	0.00
2001	0.01	0.00	0.00	0.01	0.00	0.01	0.00
2002	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2004	0.02	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.00	0.01	0.00	0.02	0.00	0.01	0.00
2007	0.00	0.01	0.00	0.02	0.00	0.02	-0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.04
Signific.	
Q	-8.00E-02
Qmin99	-1.00E+00
Qmax99	1.02E+00
Qmin95	-6.68E-01
Qmax95	5.61E-01
B	4.34E+01
Bmin99	4.90E+01
Bmax99	3.29E+01
Bmin95	4.73E+01
Bmax95	3.73E+01

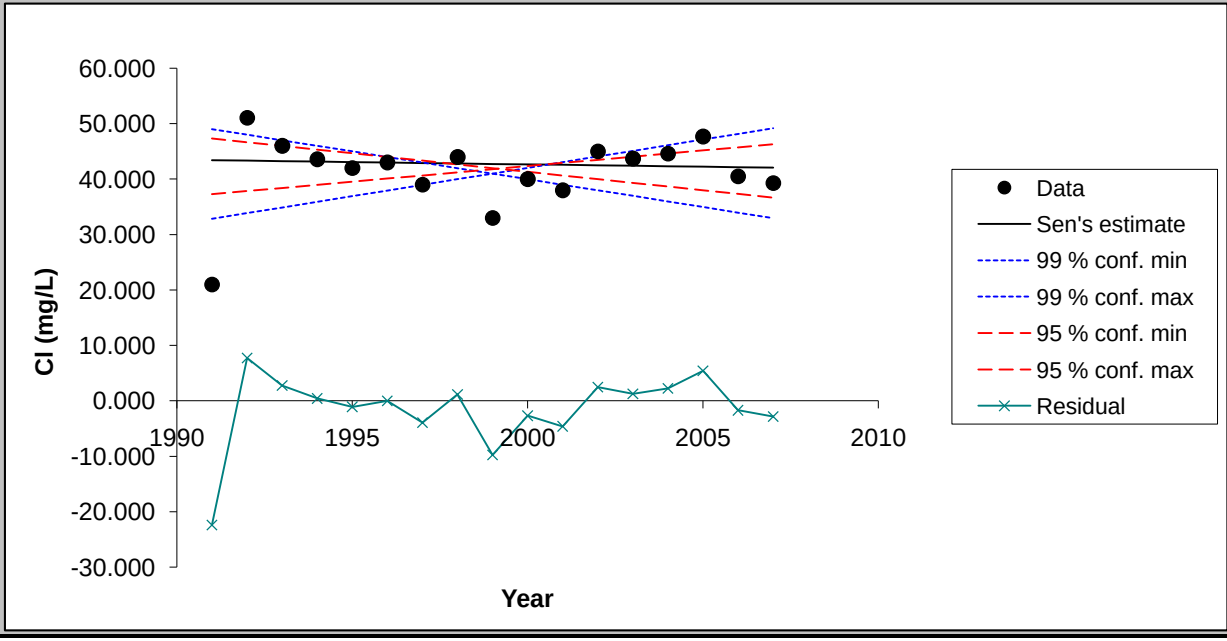

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	21.00	43.40	49.00	32.89	47.34	37.30	-22.40
1992	51.05	43.32	48.00	33.90	46.67	37.86	7.73
1993	46.00	43.24	47.00	34.92	46.00	38.43	2.76
1994	43.60	43.16	46.00	35.94	45.33	38.99	0.44
1995	42.00	43.08	45.00	36.96	44.66	39.55	-1.08
1996	43.00	43.00	44.00	37.98	44.00	40.11	0.00
1997	39.00	42.92	43.00	39.00	43.33	40.67	-3.92
1998	44.00	42.84	42.00	40.02	42.66	41.23	1.16
1999	33.00	42.76	41.00	41.04	41.99	41.79	-9.76
2000	40.00	42.68	40.00	42.06	41.32	42.35	-2.68
2001	38.00	42.60	39.00	43.08	40.66	42.92	-4.60
2002	45.01	42.52	38.00	44.10	39.99	43.48	2.49
2003	43.70	42.44	37.00	45.11	39.32	44.04	1.26
2004	44.60	42.36	36.00	46.13	38.65	44.60	2.24
2005	47.70	42.28	35.00	47.15	37.99	45.16	5.42
2006	40.50	42.20	34.00	48.17	37.32	45.72	-1.70
2007	39.30	42.12	33.00	49.19	36.65	46.28	-2.82

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.44
Signific.	
Q	3.96E-04
Qmin99	-4.45E-04
Qmax99	1.01E-03
Qmin95	0.00E+00
Qmax95	8.33E-04
B	1.40E-03
Bmin99	8.64E-03
Bmax99	-3.87E-03
Bmin95	5.00E-03
Bmax95	-1.67E-03

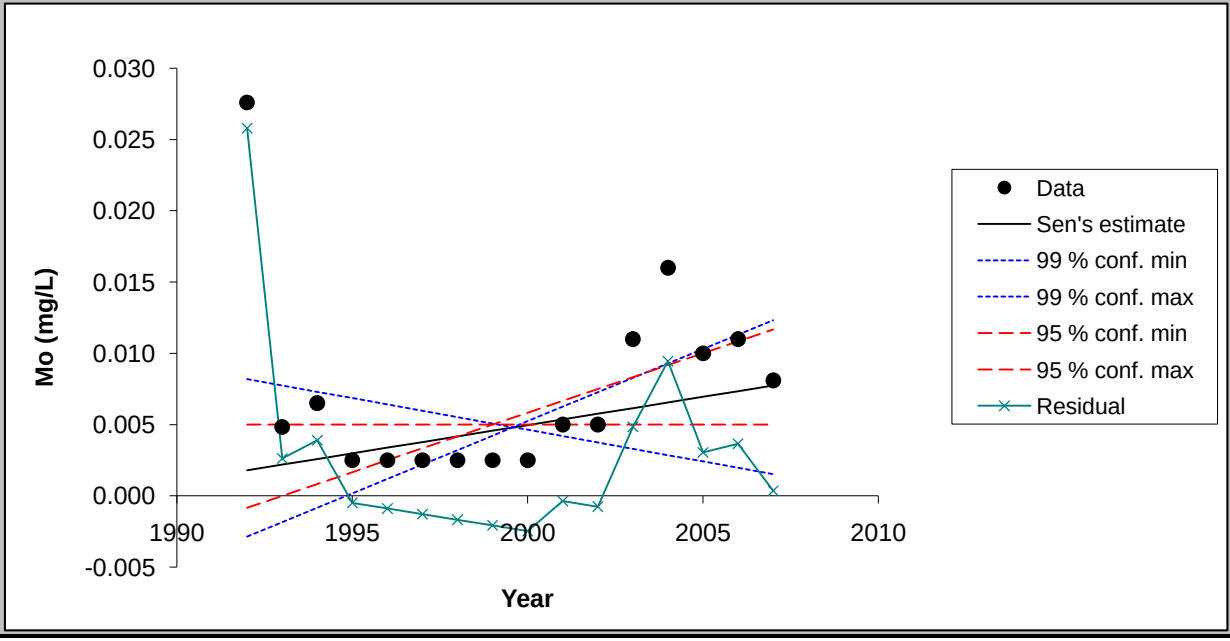

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.00	0.01	0.00	0.00	0.00	0.03
1993	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1994	0.01	0.00	0.01	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2001	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.02	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2007	0.01	0.01	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-34 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.78
Signific.	
Q	1.32E+00
Qmin99	-3.17E+00
Qmax99	5.28E+00
Qmin95	-1.37E+00
Qmax95	4.46E+00
B	1.68E+02
Bmin99	2.02E+02
Bmax99	1.32E+02
Bmin95	1.89E+02
Bmax95	1.38E+02

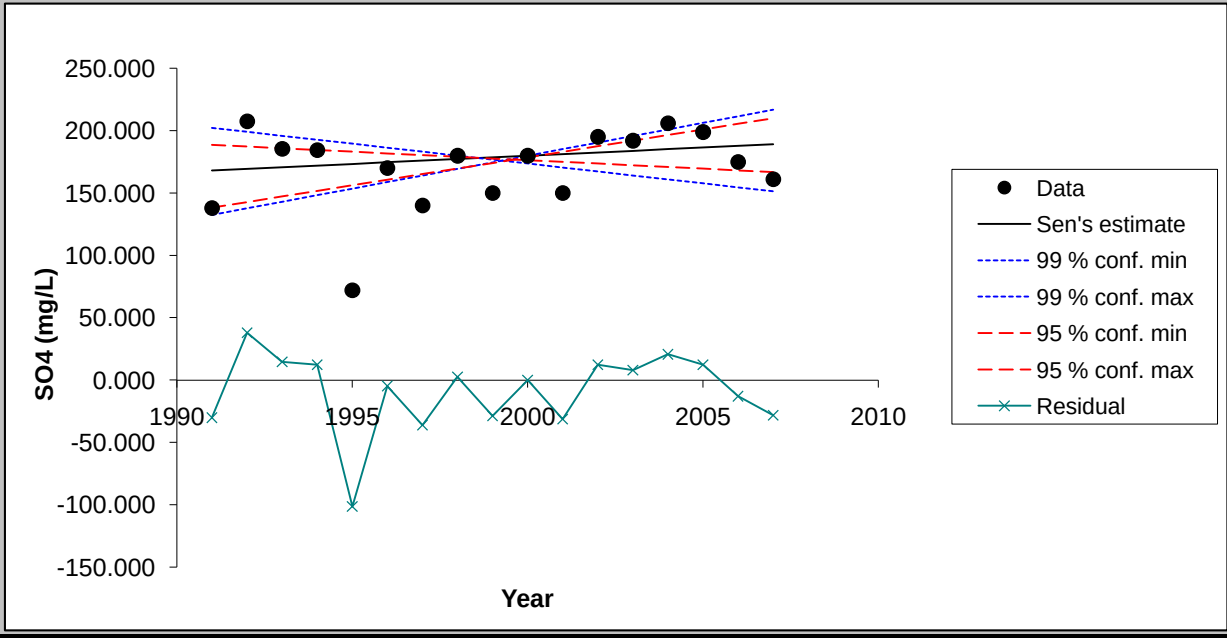

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	138.00	168.13	202.21	132.46	188.60	138.43	-30.13
1992	207.50	169.45	199.03	137.74	187.24	142.89	38.05
1993	185.50	170.77	195.86	143.03	185.87	147.36	14.73
1994	184.50	172.09	192.69	148.31	184.50	151.82	12.41
1995	72.00	173.40	189.52	153.59	183.13	156.29	-101.40
1996	170.00	174.72	186.34	158.87	181.76	160.75	-4.72
1997	140.00	176.04	183.17	164.15	180.40	165.21	-36.04
1998	180.00	177.36	180.00	169.44	179.03	169.68	2.64
1999	150.00	178.68	176.83	174.72	177.66	174.14	-28.68
2000	180.00	180.00	173.66	180.00	176.29	178.61	0.00
2001	150.00	181.32	170.48	185.28	174.92	183.07	-31.32
2002	195.06	182.64	167.31	190.56	173.56	187.54	12.42
2003	192.00	183.96	164.14	195.85	172.19	192.00	8.04
2004	206.00	185.28	160.97	201.13	170.82	196.46	20.72
2005	199.00	186.60	157.79	206.41	169.45	200.93	12.40
2006	175.00	187.91	154.62	211.69	168.09	205.39	-12.91
2007	161.00	189.23	151.45	216.97	166.72	209.86	-28.23

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-35 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.24	0.12	0.25	0.0015	39		96
1992	0.0015	0.27	0.0683	0.08	0.012	42.9	0.0259	100
1993	0.0029	0.205	0.1605	0.08	0.0006	36.9	0.0048	94.0
1994	0.0001	0.26	0.145	0.005	0.001	50	0.0025	110
1995	0.0001	0.28	0.153	0.005	0.002	41	0.0025	100
1996	0.0001	0.3	0.153	0.005	0.0005	37	0.0025	96
1997	0.0001	0.34	0.155	0.005	0.0025	32	0.0025	100
1998	0.0001	0.3	0.162	0.03	0.001	31	0.0025	110
1999	0.0001	0.26	0.139	0.17	0.005	23	0.0025	130
2000	0.0001	0.23	0.138	0.19	0.005	27	0.0025	140
2001	0.001	0.5	0.14	0.025	0.0025	32	0.005	94
2002	0.001	0.601	0.1682	0.025	0.005	34.7	0.005	99.4
2003	0.001	0.37	0.157	0.01	0.005	35.6	0.0101	103
2004	0.001	0.05	0.1415	0.01	0.00125	38.83333	0.0139	107
2005	0.001	0.185	0.141	0.055	0.00125	38.95	0.0054	112.5
2006	2.12E-05	0.05	0.161	0.01	0.0015	38.5	0.01	114
2007	0.001	0.05	0.158	0.021	0.000145	36.8	0.0091	111

TREND STATISTICS

TW-35 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.86		0.0000	-0.0001	0.0001	0.0000	0.0001	0.0010	0.0019	-0.0003	0.0014	0.0001
F (mg/L)	*1991*	*2007*	*17*		-0.58		-0.005	-0.026	0.017	-0.018	0.011	0.27	0.46	0.18	0.39	0.23
Mn (mg/L)	*1991*	*2007*	*17*		1.40		0.001	-0.001	0.004	0.000	0.003	0.15	0.16	0.11	0.15	0.12
Nitrate (mg/L)	*1991*	*2007*	*17*		-0.46		-0.001	-0.015	0.003	-0.007	0.001	0.03	0.19	0.00	0.10	0.02
Se (mg/L)	*1991*	*2007*	*17*		-0.21		0.0000	-0.001	0.000	0.000	0.000	0.00	0.01	0.00	0.00	0.00
Cl (mg/L)	*1991*	*2007*	*17*		-0.82		-0.216	-1.188	0.921	-1.004	0.527	38.19	44.09	26.06	43.90	30.59
Mo (mg/L)	*1992*	*2007*	*16*		1.84	+	0.0003	0.0000	0.0008	0.0000	0.0007	0.0015	0.0049	-0.0025	0.0049	-0.0013
SO4 (mg/L)	*1991*	*2007*	*17*		2.07	*	0.981	-0.130	3.609	0.000	2.000	96.00	104.56	78.35	103.00	88.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.86
Signific.	
Q	0.00E+00
Qmin99	-1.24E-04
Qmax99	9.94E-05
Qmin95	-4.46E-05
Qmax95	5.40E-05
B	1.00E-03
Bmin99	1.89E-03
Bmax99	-2.98E-04
Bmin95	1.45E-03
Bmax95	1.36E-04

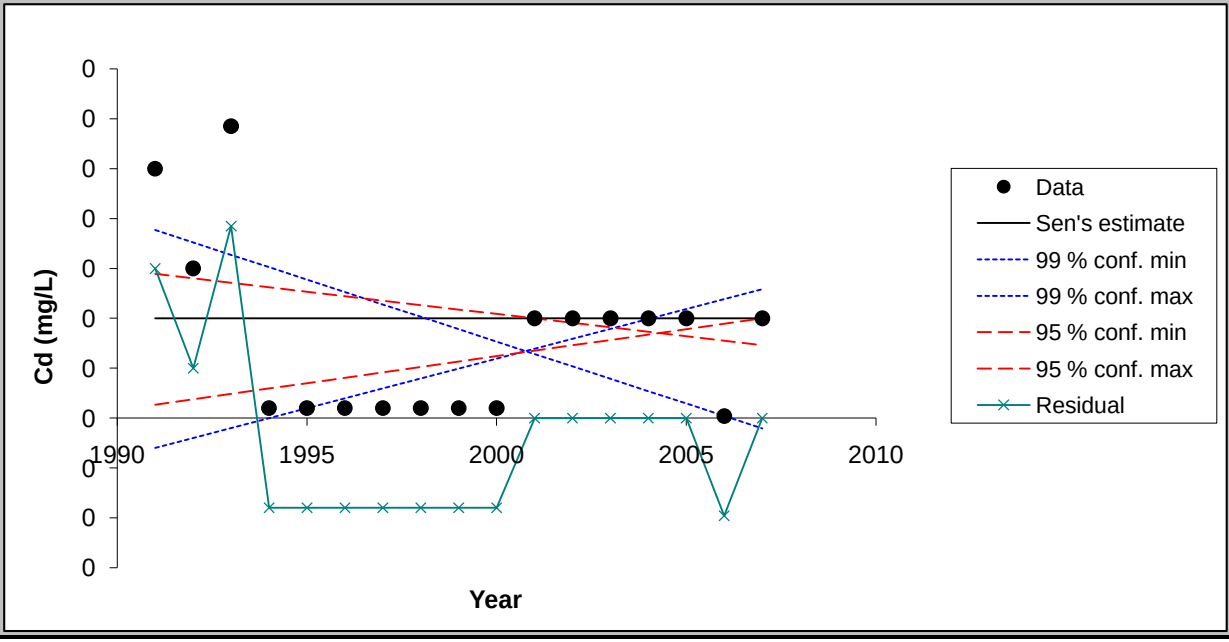

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.58
Signific.	
Q	-5.00E-03
Qmin99	-2.56E-02
Qmax99	1.69E-02
Qmin95	-1.81E-02
Qmax95	1.06E-02
B	2.75E-01
Bmin99	4.59E-01
Bmax99	1.81E-01
Bmin95	3.90E-01
Bmax95	2.28E-01

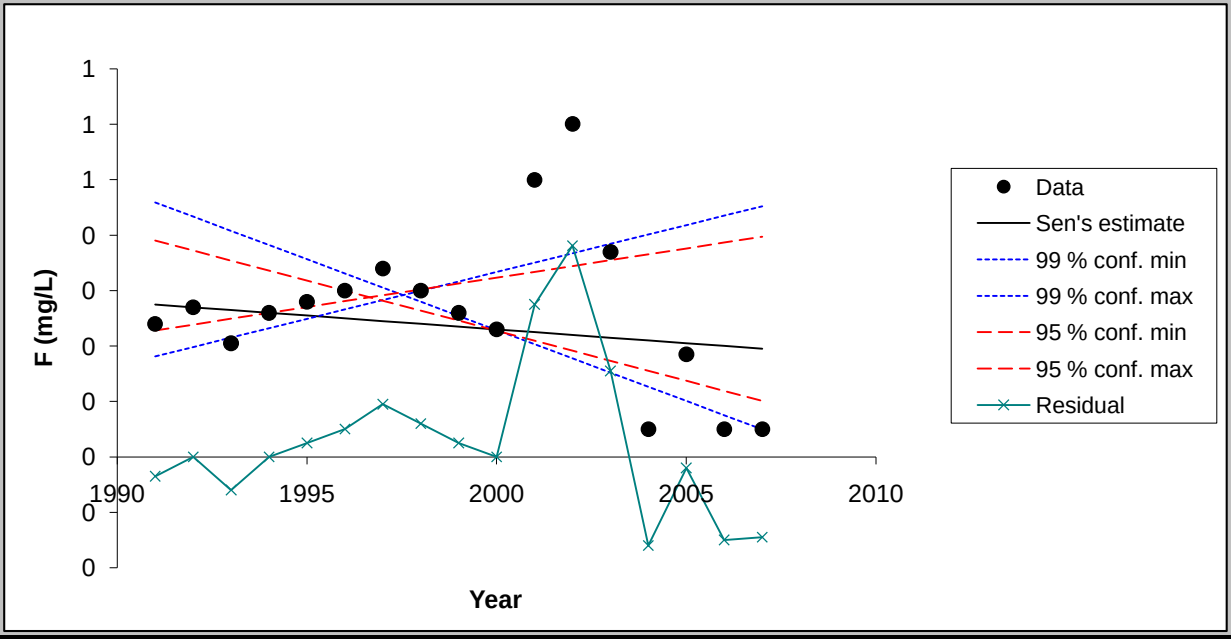

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.24	0.27	0.46	0.18	0.39	0.23	-0.03
1992	0.27	0.27	0.43	0.20	0.37	0.24	0.00
1993	0.20	0.26	0.41	0.22	0.35	0.25	-0.06
1994	0.26	0.26	0.38	0.23	0.34	0.26	0.00
1995	0.28	0.26	0.36	0.25	0.32	0.27	0.03
1996	0.30	0.25	0.33	0.27	0.30	0.28	0.05
1997	0.34	0.25	0.31	0.28	0.28	0.29	0.09
1998	0.30	0.24	0.28	0.30	0.26	0.30	0.06
1999	0.26	0.24	0.25	0.32	0.25	0.31	0.02
2000	0.23	0.23	0.23	0.33	0.23	0.32	0.00
2001	0.50	0.23	0.20	0.35	0.21	0.33	0.27
2002	0.60	0.22	0.18	0.37	0.19	0.34	0.38
2003	0.37	0.22	0.15	0.38	0.17	0.36	0.15
2004	0.05	0.21	0.13	0.40	0.16	0.37	-0.16
2005	0.19	0.21	0.10	0.42	0.14	0.38	-0.02
2006	0.05	0.20	0.08	0.44	0.12	0.39	-0.15
2007	0.05	0.20	0.05	0.45	0.10	0.40	-0.15

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.40
Signific.	
Q	7.64E-04
Qmin99	-1.29E-03
Qmax99	4.21E-03
Qmin95	-4.87E-04
Qmax95	2.98E-03
B	1.46E-01
Bmin99	1.59E-01
Bmax99	1.06E-01
Bmin95	1.55E-01
Bmax95	1.20E-01

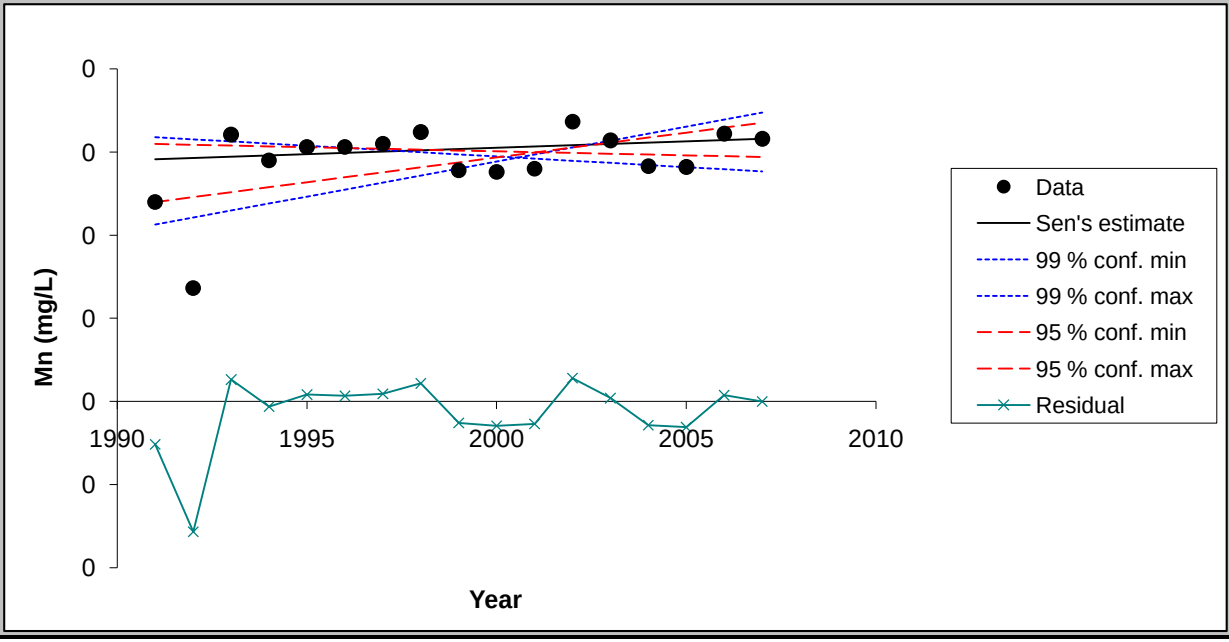

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.12	0.15	0.16	0.11	0.15	0.12	-0.03
1992	0.07	0.15	0.16	0.11	0.15	0.12	-0.08
1993	0.16	0.15	0.16	0.11	0.15	0.13	0.01
1994	0.14	0.15	0.16	0.12	0.15	0.13	0.00
1995	0.15	0.15	0.15	0.12	0.15	0.13	0.00
1996	0.15	0.15	0.15	0.13	0.15	0.13	0.00
1997	0.16	0.15	0.15	0.13	0.15	0.14	0.00
1998	0.16	0.15	0.15	0.14	0.15	0.14	0.01
1999	0.14	0.15	0.15	0.14	0.15	0.14	-0.01
2000	0.14	0.15	0.15	0.14	0.15	0.15	-0.01
2001	0.14	0.15	0.15	0.15	0.15	0.15	-0.01
2002	0.17	0.15	0.14	0.15	0.15	0.15	0.01
2003	0.16	0.15	0.14	0.16	0.15	0.16	0.00
2004	0.14	0.16	0.14	0.16	0.15	0.16	-0.01
2005	0.14	0.16	0.14	0.17	0.15	0.16	-0.02
2006	0.16	0.16	0.14	0.17	0.15	0.16	0.00
2007	0.16	0.16	0.14	0.17	0.15	0.17	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.46
Signific.	
Q	-9.00E-04
Qmin99	-1.50E-02
Qmax99	2.86E-03
Qmin95	-7.29E-03
Qmax95	7.83E-04
B	3.49E-02
Bmin99	1.90E-01
Bmax99	-3.57E-03
Bmin95	9.79E-02
Bmax95	1.64E-02

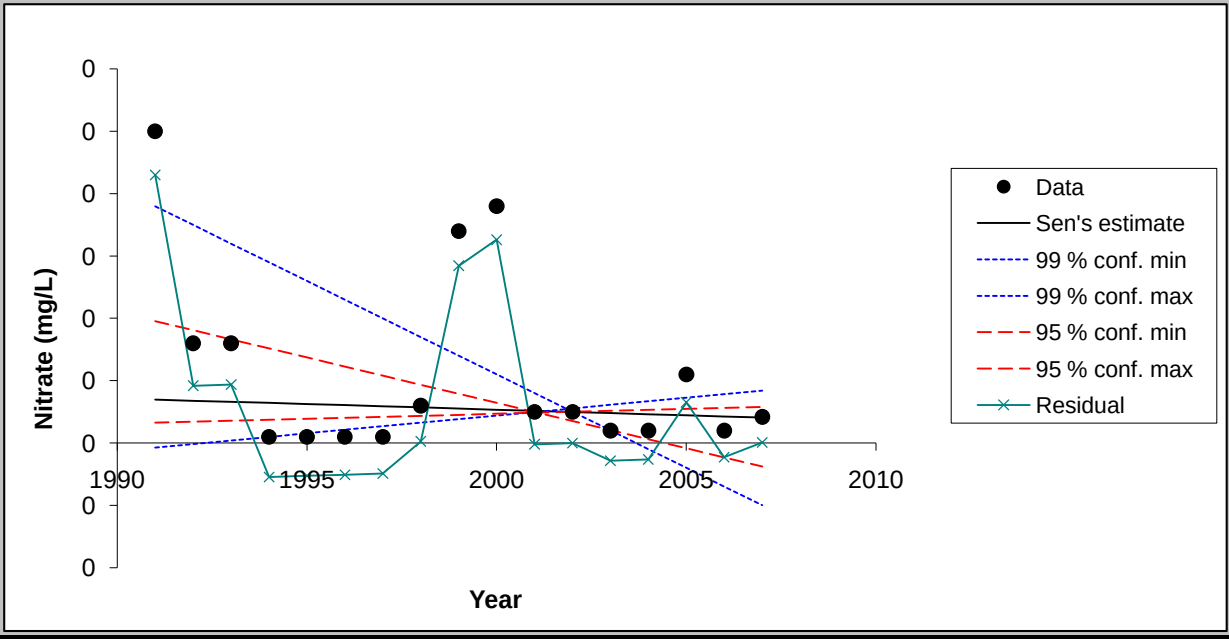

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	0.03	0.19	0.00	0.10	0.02	0.22
1992	0.08	0.03	0.17	0.00	0.09	0.02	0.05
1993	0.08	0.03	0.16	0.00	0.08	0.02	0.05
1994	0.00	0.03	0.14	0.00	0.08	0.02	-0.03
1995	0.00	0.03	0.13	0.01	0.07	0.02	-0.03
1996	0.00	0.03	0.11	0.01	0.06	0.02	-0.03
1997	0.00	0.03	0.10	0.01	0.05	0.02	-0.02
1998	0.03	0.03	0.08	0.02	0.05	0.02	0.00
1999	0.17	0.03	0.07	0.02	0.04	0.02	0.14
2000	0.19	0.03	0.05	0.02	0.03	0.02	0.16
2001	0.03	0.03	0.04	0.02	0.03	0.02	0.00
2002	0.03	0.03	0.02	0.03	0.02	0.03	0.00
2003	0.01	0.02	0.01	0.03	0.01	0.03	-0.01
2004	0.01	0.02	0.00	0.03	0.00	0.03	-0.01
2005	0.06	0.02	-0.02	0.04	0.00	0.03	0.03
2006	0.01	0.02	-0.03	0.04	-0.01	0.03	-0.01
2007	0.02	0.02	-0.05	0.04	-0.02	0.03	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.21
Signific.	
Q	-1.08E-19
Qmin99	-5.05E-04
Qmax99	3.76E-04
Qmin95	-2.45E-04
Qmax95	1.98E-04
B	1.50E-03
Bmin99	7.81E-03
Bmax99	-1.29E-04
Bmin95	4.44E-03
Bmax95	5.21E-04

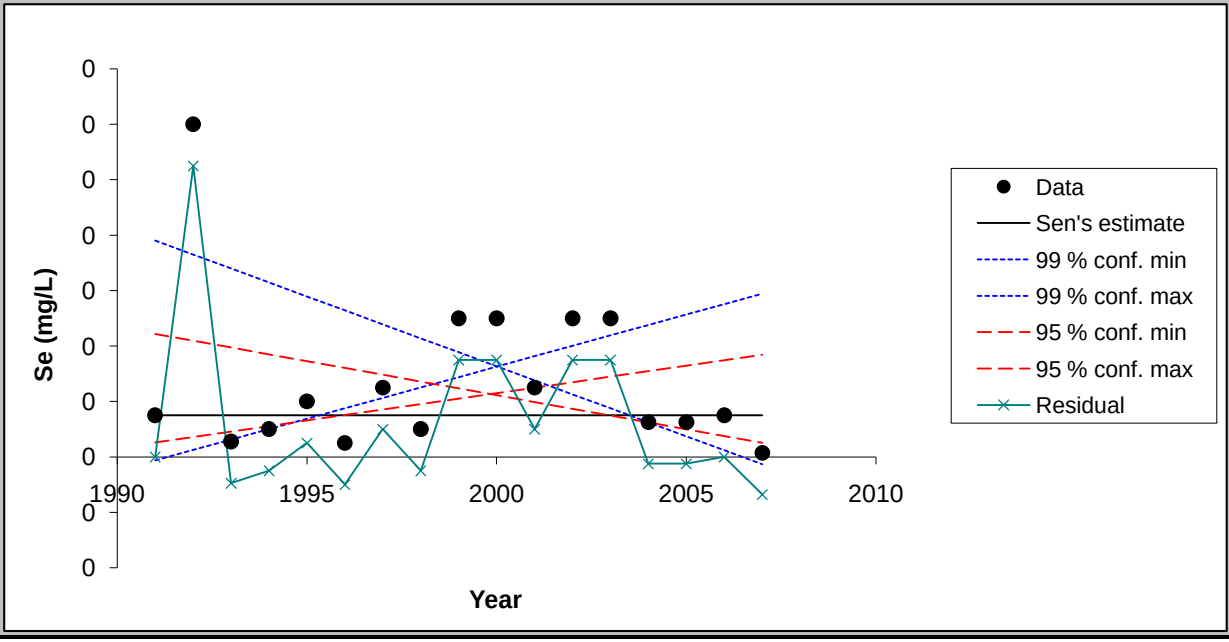

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.00	0.00	0.01
1993	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.01	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.82
Signific.	
Q	-2.16E-01
Qmin99	-1.19E+00
Qmax99	9.21E-01
Qmin95	-1.00E+00
Qmax95	5.27E-01
B	3.82E+01
Bmin99	4.41E+01
Bmax99	2.61E+01
Bmin95	4.39E+01
Bmax95	3.06E+01

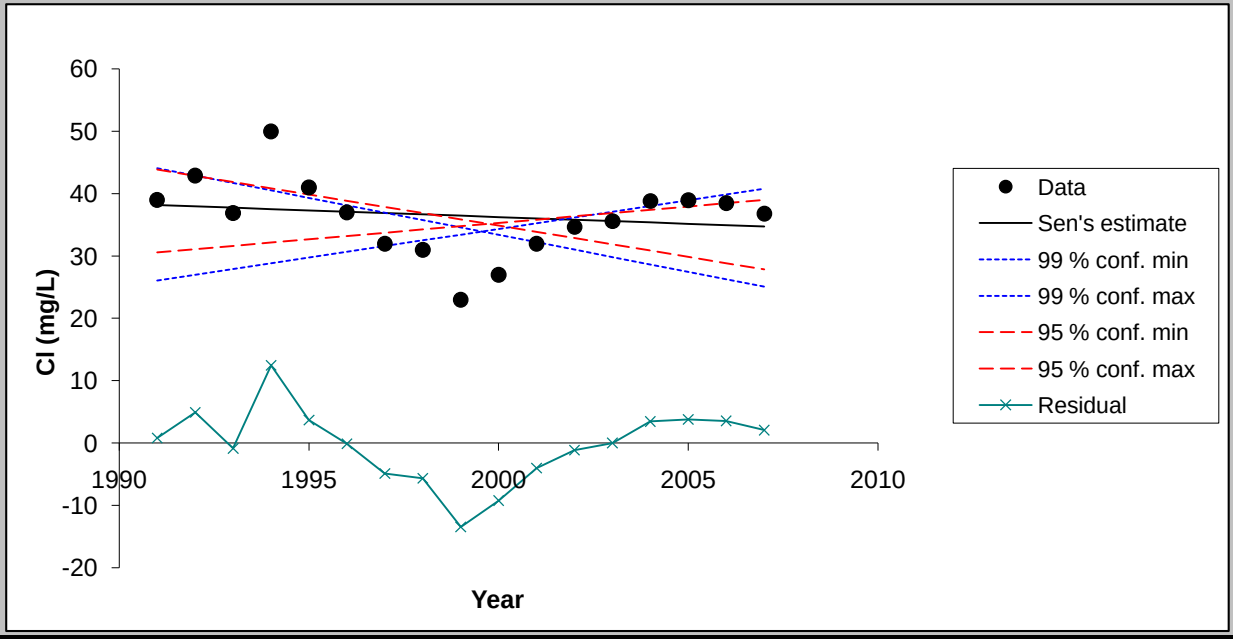

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	39.00	38.19	44.09	26.06	43.90	30.59	0.81
1992	42.90	37.98	42.90	26.98	42.90	31.12	4.92
1993	36.90	37.76	41.71	27.90	41.90	31.65	-0.86
1994	50.00	37.55	40.52	28.82	40.89	32.17	12.45
1995	41.00	37.33	39.34	29.74	39.89	32.70	3.67
1996	37.00	37.11	38.15	30.66	38.89	33.23	-0.11
1997	32.00	36.90	36.96	31.58	37.88	33.76	-4.90
1998	31.00	36.68	35.77	32.50	36.88	34.28	-5.68
1999	23.00	36.46	34.59	33.42	35.88	34.81	-13.46
2000	27.00	36.25	33.40	34.35	34.87	35.34	-9.25
2001	32.00	36.03	32.21	35.27	33.87	35.86	-4.03
2002	34.68	35.82	31.02	36.19	32.86	36.39	-1.14
2003	35.60	35.60	29.84	37.11	31.86	36.92	0.00
2004	38.83	35.38	28.65	38.03	30.86	37.45	3.45
2005	38.95	35.17	27.46	38.95	29.85	37.97	3.78
2006	38.50	34.95	26.27	39.87	28.85	38.50	3.55
2007	36.80	34.74	25.09	40.79	27.85	39.03	2.06

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.84
Signific.	+
Q	3.17E-04
Qmin99	0.00E+00
Qmax99	8.33E-04
Qmin95	0.00E+00
Qmax95	6.83E-04
B	1.53E-03
Bmin99	4.91E-03
Bmax99	-2.50E-03
Bmin95	4.91E-03
Bmax95	-1.26E-03

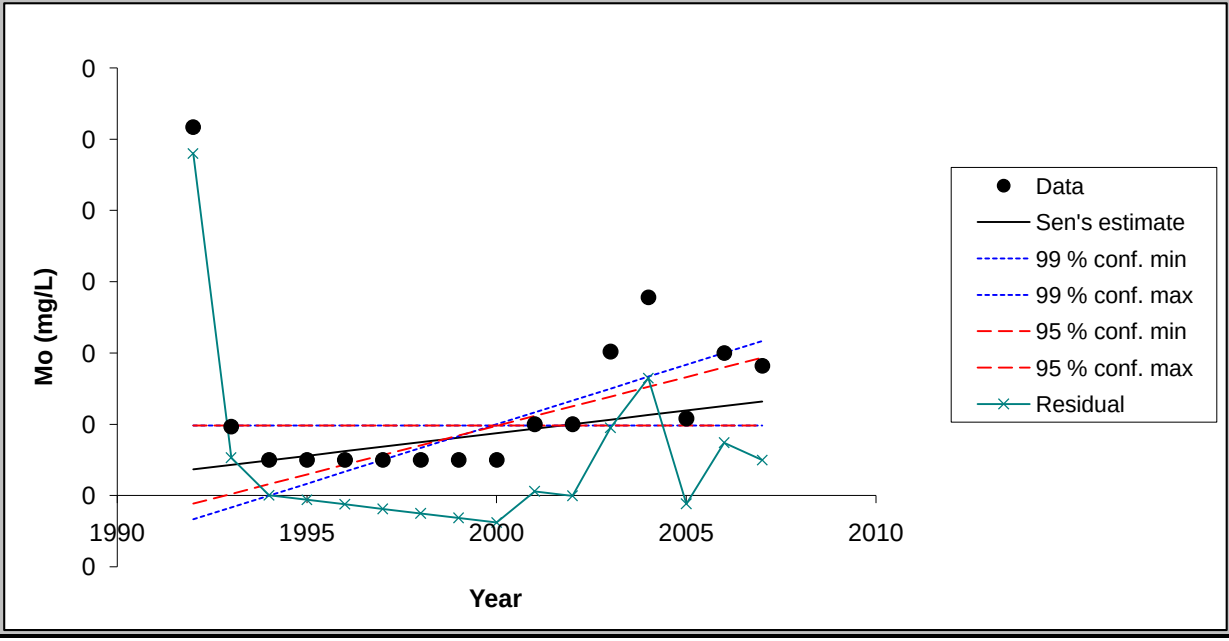

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.00	0.00	0.00	0.00	0.00	0.02
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2007	0.01	0.01	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-35 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.07
Signific.	*
Q	9.81E-01
Qmin99	-1.30E-01
Qmax99	3.61E+00
Qmin95	0.00E+00
Qmax95	2.00E+00
B	9.60E+01
Bmin99	1.05E+02
Bmax99	7.83E+01
Bmin95	1.03E+02
Bmax95	8.80E+01

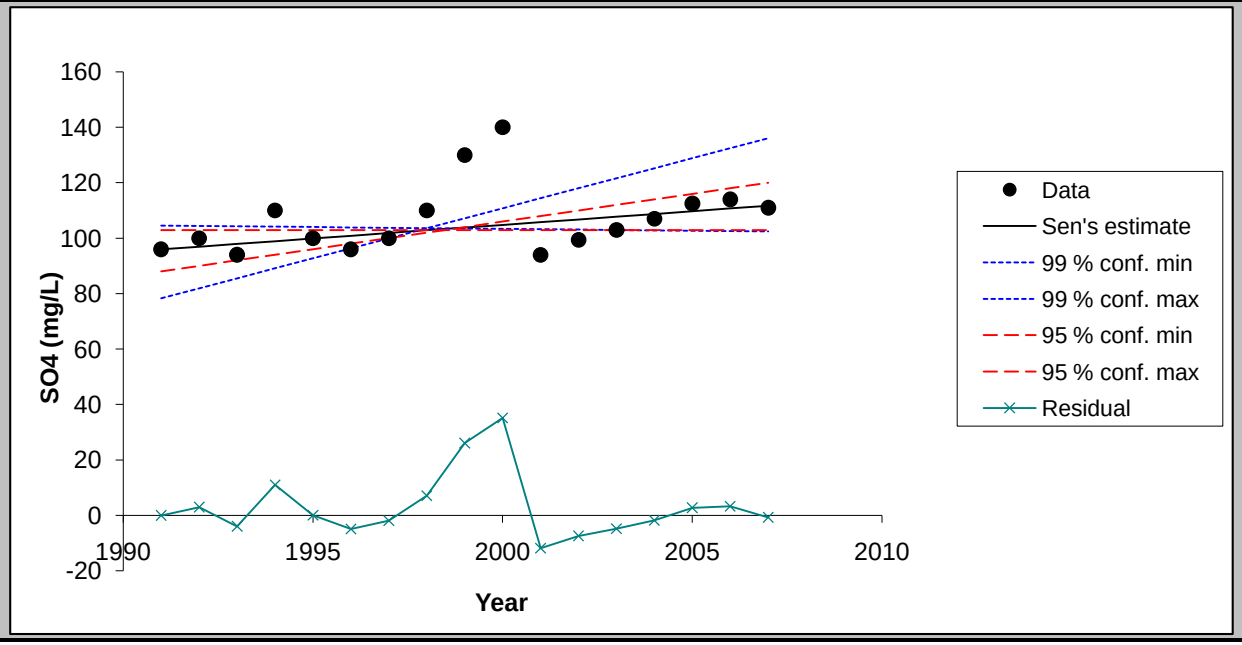

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	96.00	96.00	104.56	78.35	103.00	88.00	0.00
1992	100.00	96.98	104.43	81.96	103.00	90.00	3.02
1993	94.05	97.96	104.30	85.57	103.00	92.00	-3.91
1994	110.00	98.94	104.17	89.17	103.00	94.00	11.06
1995	100.00	99.92	104.04	92.78	103.00	96.00	0.08
1996	96.00	100.90	103.91	96.39	103.00	98.00	-4.90
1997	100.00	101.88	103.78	100.00	103.00	100.00	-1.88
1998	110.00	102.87	103.65	103.61	103.00	102.00	7.13
1999	130.00	103.85	103.52	107.22	103.00	104.00	26.15
2000	140.00	104.83	103.39	110.83	103.00	106.00	35.17
2001	94.00	105.81	103.26	114.43	103.00	108.00	-11.81
2002	99.40	106.79	103.13	118.04	103.00	110.00	-7.39
2003	103.00	107.77	103.00	121.65	103.00	112.00	-4.77
2004	107.00	108.75	102.87	125.26	103.00	114.00	-1.75
2005	112.50	109.73	102.74	128.87	103.00	116.00	2.77
2006	114.00	110.71	102.61	132.48	103.00	118.00	3.29
2007	111.00	111.69	102.48	136.09	103.00	120.00	-0.69

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-39 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.02	6.34	0.0025	5.9	0.007	183		420
1992	0.0041	5.42	0.0045	6.0	0.463	174	0.0575	407.5
1993	0.0156	4.69	0.0151	7.2	0.249	172	0.0892	372.5
1994	0.0219	4.92	0.001	7.2	0.32	177.5	0.088	407.5
1995	0.0145	5.3	0.0005	9.4	0.35	170	0.08	440
1996	0.014	4.6	0.0005	12	0.21	150	0.076	470
1997	0.013	2.7	0.0005	15	0.28	140	0.078	570
1998	0.011	4.5	0.0005	12	0.23	160	0.075	550
1999	0.013	4.6	0.0005	11	0.28	100	0.087	630
2000	0.015	4.5	0.0005	12	0.3	120	0.083	640
2001	0.016	3.9	0.005	7.1	0.217	124	0.06	481
2002	0.012	3.38	0.03	3.8	0.087	110.4	0.052	330.4
2003	0.011	2.71	0.001	4.565	0.123	100	0.0491	332
2004	0.0119	1.96	0.001	4.22	0.105	95.1	0.0459	321
2005	0.013	2.05	0.002	11.2	0.139	87.7	0.0437	439
2006	0.0122	2.76	0.002	12.2	0.03	91	0.039	505
2007	0.0093	3.34	0.002	9.56	0.125	115	0.0662	527

TREND STATISTICS

TW-39 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-2.06	*	-0.0004	-0.0008	0.0002	-0.0007	0.0000	0.0161	0.0206	0.0118	0.0193	0.0130
F (mg/L)	*1991*	*2007*	*17*		-3.84	***	-0.205	-0.330	-0.100	-0.287	-0.131	5.63	6.67	4.94	6.34	5.26
Mn (mg/L)	*1991*	*2007*	*17*		0.30		0.0000	-0.0003	0.0002	-0.0002	0.0001	0.0010	0.0045	-0.0005	0.0030	-0.0001
Nitrate (mg/L)	*1991*	*2007*	*17*		0.50		0.044	-0.380	0.767	-0.271	0.628	8.85	10.92	4.87	10.48	5.33
Se (mg/L)	*1991*	*2007*	*17*		-2.23	*	-0.017	-0.029	0.006	-0.026	-0.004	0.37	0.47	0.18	0.44	0.26
Cl (mg/L)	*1991*	*2007*	*17*		-4.29	***	-6.600	-8.039	-4.054	-7.422	-4.861	183.00	198.83	164.54	191.59	172.61
Mo (mg/L)	*1992*	*2007*	*16*		-3.11	**	-0.003	-0.004	-0.001	-0.004	-0.001	0.09	0.10	0.08	0.10	0.08
SO4 (mg/L)	*1991*	*2007*	*17*		0.66		5.091	-12.590	30.301	-7.691	23.027	420.00	532.95	316.60	508.46	338.42
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.06
Signific.	*
Q	-3.72E-04
Qmin99	-8.03E-04
Qmax99	1.50E-04
Qmin95	-6.62E-04
Qmax95	-3.61E-11
B	1.61E-02
Bmin99	2.06E-02
Bmax99	1.18E-02
Bmin95	1.93E-02
Bmax95	1.30E-02

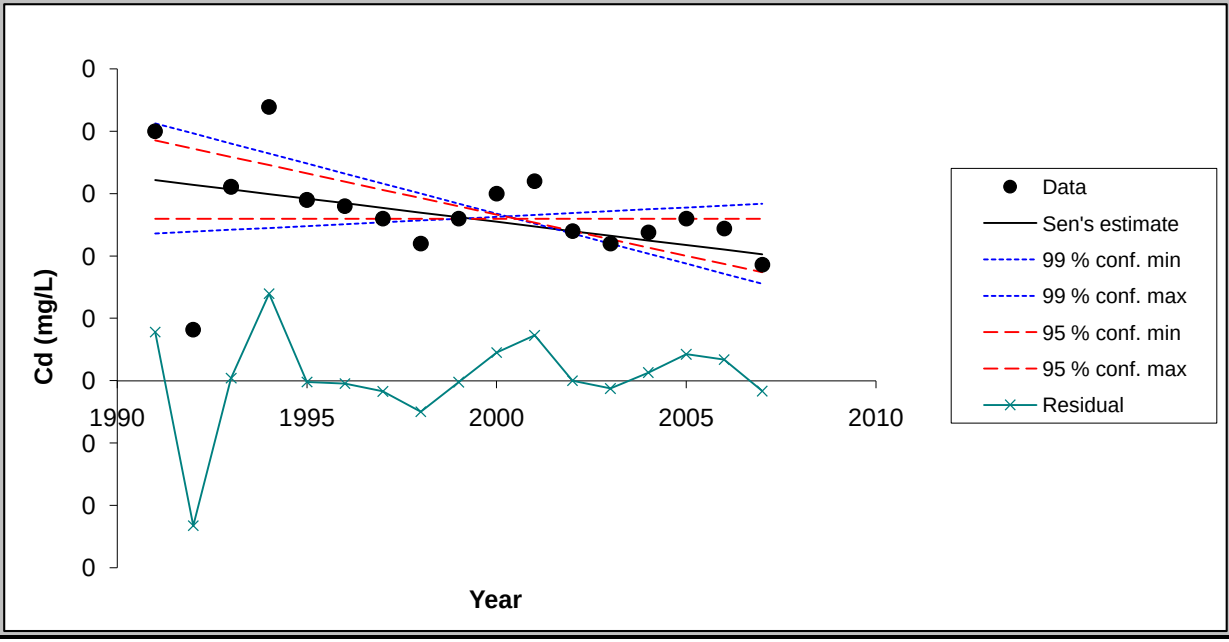

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.02	0.02	0.01	0.02	0.01	0.00
1992	0.00	0.02	0.02	0.01	0.02	0.01	-0.01
1993	0.02	0.02	0.02	0.01	0.02	0.01	0.00
1994	0.02	0.01	0.02	0.01	0.02	0.01	0.01
1995	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1996	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1997	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1998	0.01	0.01	0.02	0.01	0.01	0.01	0.00
1999	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.02	0.01	0.01	0.01	0.01	0.01	0.00
2002	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2003	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2004	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2005	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2006	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2007	0.01	0.01	0.01	0.01	0.01	0.01	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.84
Signific.	***
Q	-2.05E-01
Qmin99	-3.30E-01
Qmax99	-9.97E-02
Qmin95	-2.87E-01
Qmax95	-1.31E-01
B	5.63E+00
Bmin99	6.67E+00
Bmax99	4.94E+00
Bmin95	6.34E+00
Bmax95	5.26E+00

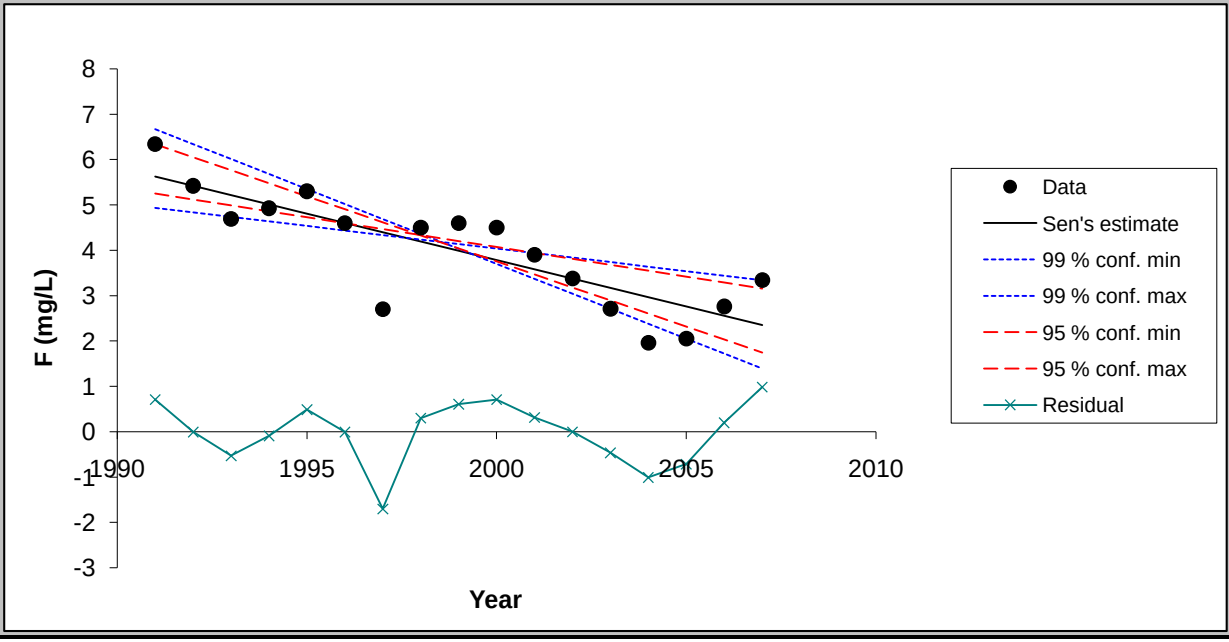

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	6.34	5.63	6.67	4.94	6.34	5.26	0.71
1992	5.42	5.43	6.34	4.84	6.05	5.13	-0.01
1993	4.69	5.22	6.01	4.74	5.77	4.99	-0.53
1994	4.92	5.02	5.68	4.64	5.48	4.86	-0.09
1995	5.30	4.81	5.35	4.54	5.19	4.73	0.49
1996	4.60	4.61	5.02	4.44	4.90	4.60	-0.01
1997	2.70	4.40	4.69	4.34	4.62	4.47	-1.70
1998	4.50	4.20	4.36	4.24	4.33	4.34	0.30
1999	4.60	3.99	4.03	4.14	4.04	4.21	0.61
2000	4.50	3.79	3.70	4.04	3.76	4.07	0.71
2001	3.90	3.58	3.37	3.94	3.47	3.94	0.32
2002	3.38	3.38	3.04	3.84	3.18	3.81	0.00
2003	2.71	3.17	2.71	3.74	2.89	3.68	-0.46
2004	1.96	2.97	2.38	3.64	2.61	3.55	-1.01
2005	2.05	2.76	2.05	3.54	2.32	3.42	-0.71
2006	2.76	2.56	1.72	3.44	2.03	3.29	0.20
2007	3.34	2.35	1.39	3.34	1.75	3.16	0.99

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.30
Signific.	
Q	0.00E+00
Qmin99	-2.88E-04
Qmax99	1.75E-04
Qmin95	-1.67E-04
Qmax95	1.38E-04
B	1.00E-03
Bmin99	4.46E-03
Bmax99	-4.52E-04
Bmin95	3.00E-03
Bmax95	-7.32E-05

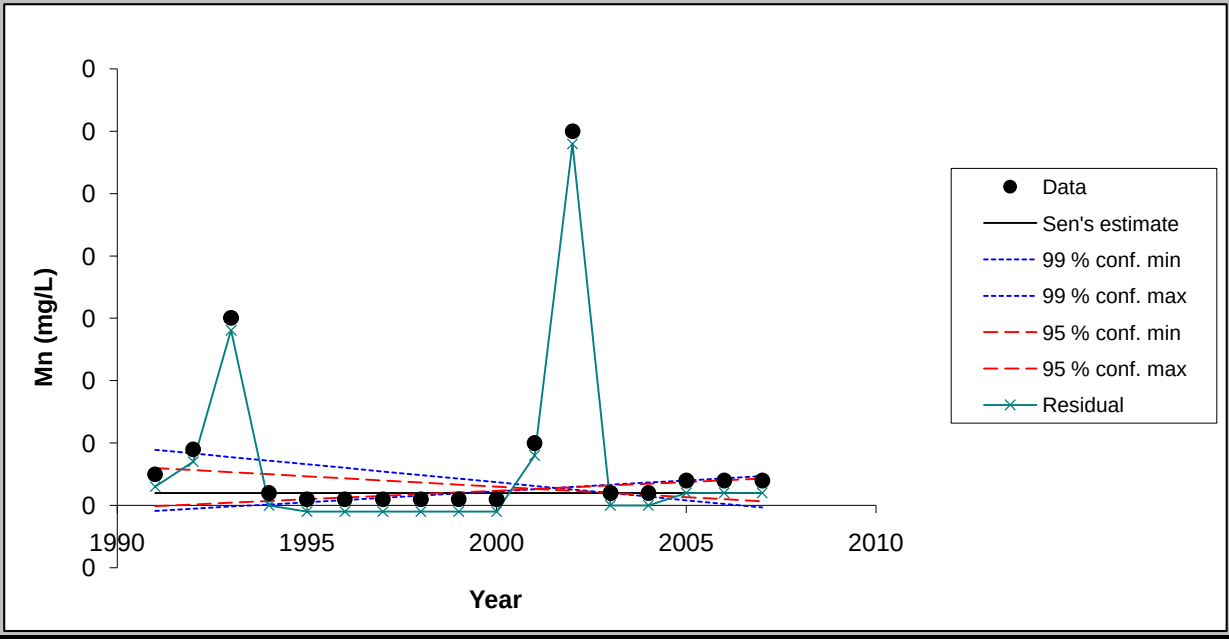

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.02	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.50
Signific.	
Q	4.42E-02
Qmin99	-3.80E-01
Qmax99	7.67E-01
Qmin95	-2.71E-01
Qmax95	6.28E-01
B	8.85E+00
Bmin99	1.09E+01
Bmax99	4.87E+00
Bmin95	1.05E+01
Bmax95	5.33E+00

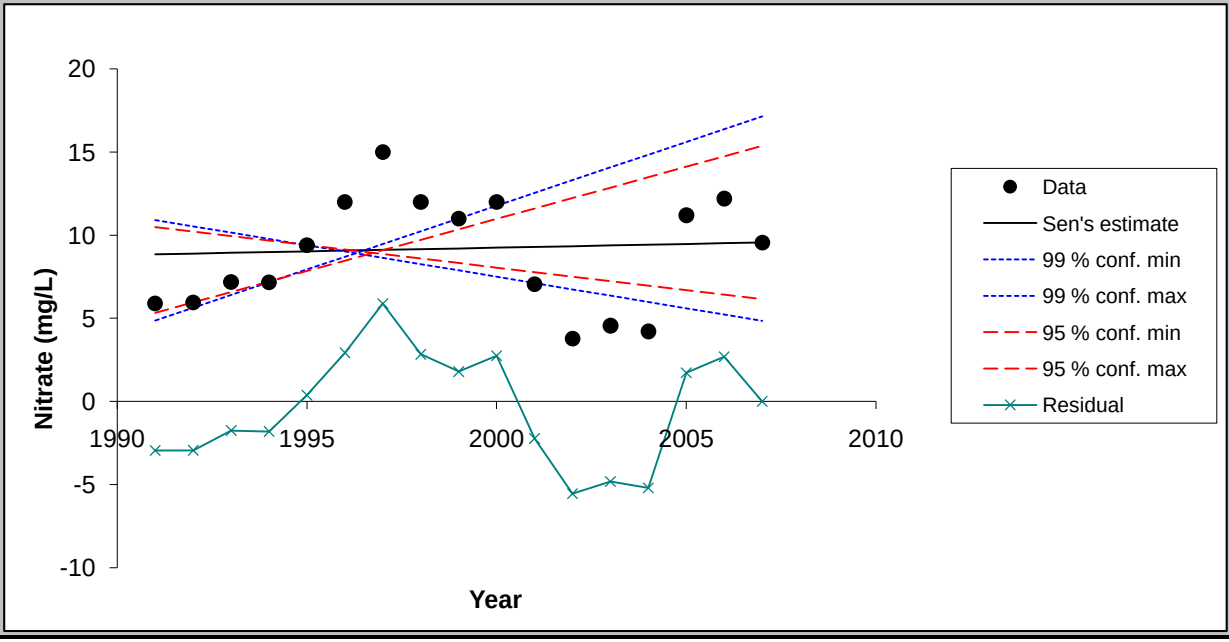

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.90	8.85	10.92	4.87	10.48	5.33	-2.95
1992	5.95	8.90	10.54	5.64	10.21	5.95	-2.94
1993	7.19	8.94	10.16	6.41	9.94	6.58	-1.75
1994	7.17	8.99	9.78	7.17	9.67	7.21	-1.81
1995	9.40	9.03	9.40	7.94	9.40	7.84	0.37
1996	12.00	9.07	9.02	8.71	9.13	8.47	2.93
1997	15.00	9.12	8.64	9.48	8.86	9.09	5.88
1998	12.00	9.16	8.26	10.24	8.59	9.72	2.84
1999	11.00	9.21	7.88	11.01	8.32	10.35	1.79
2000	12.00	9.25	7.50	11.78	8.05	10.98	2.75
2001	7.06	9.30	7.12	12.54	7.78	11.61	-2.24
2002	3.79	9.34	6.74	13.31	7.50	12.23	-5.55
2003	4.57	9.38	6.36	14.08	7.23	12.86	-4.82
2004	4.22	9.43	5.98	14.84	6.96	13.49	-5.21
2005	11.20	9.47	5.60	15.61	6.69	14.12	1.73
2006	12.20	9.52	5.22	16.38	6.42	14.75	2.68
2007	9.56	9.56	4.84	17.14	6.15	15.37	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.23
Signific.	*
Q	-1.72E-02
Qmin99	-2.93E-02
Qmax99	5.53E-03
Qmin95	-2.59E-02
Qmax95	-4.08E-03
B	3.72E-01
Bmin99	4.70E-01
Bmax99	1.82E-01
Bmin95	4.35E-01
Bmax95	2.57E-01

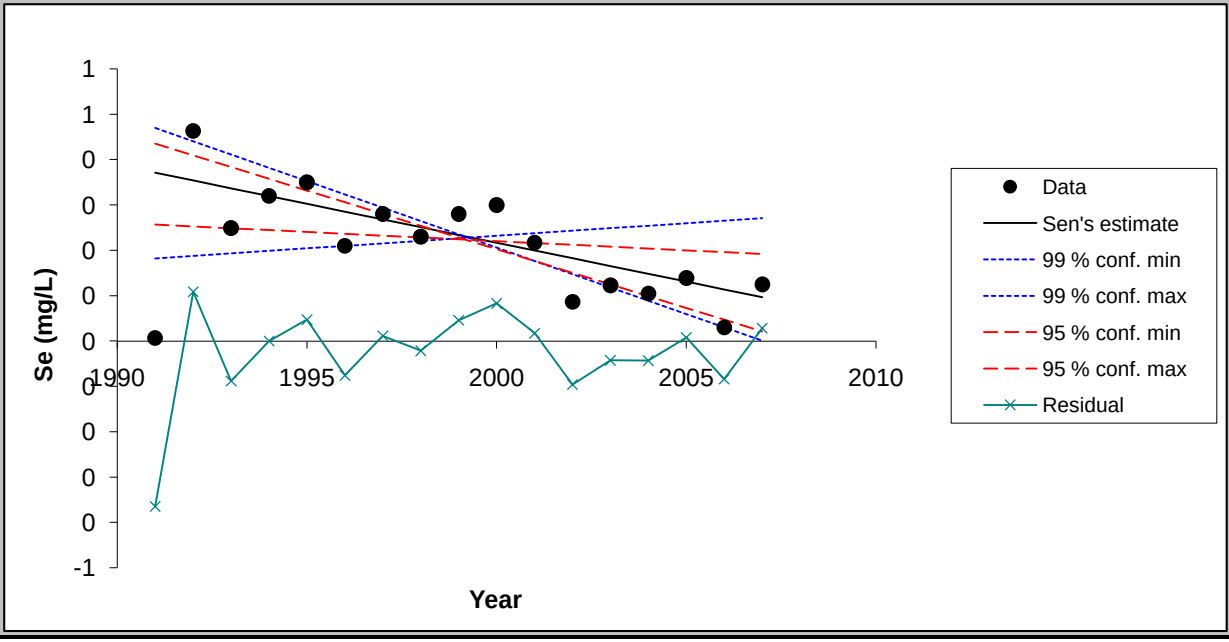

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.37	0.47	0.18	0.44	0.26	-0.36
1992	0.46	0.35	0.44	0.19	0.41	0.25	0.11
1993	0.25	0.34	0.41	0.19	0.38	0.25	-0.09
1994	0.32	0.32	0.38	0.20	0.36	0.24	0.00
1995	0.35	0.30	0.35	0.20	0.33	0.24	0.05
1996	0.21	0.29	0.32	0.21	0.31	0.24	-0.08
1997	0.28	0.27	0.29	0.22	0.28	0.23	0.01
1998	0.23	0.25	0.26	0.22	0.25	0.23	-0.02
1999	0.28	0.23	0.24	0.23	0.23	0.22	0.05
2000	0.30	0.22	0.21	0.23	0.20	0.22	0.08
2001	0.22	0.20	0.18	0.24	0.18	0.22	0.02
2002	0.09	0.18	0.15	0.24	0.15	0.21	-0.10
2003	0.12	0.17	0.12	0.25	0.12	0.21	-0.04
2004	0.11	0.15	0.09	0.25	0.10	0.20	-0.04
2005	0.14	0.13	0.06	0.26	0.07	0.20	0.01
2006	0.03	0.11	0.03	0.27	0.05	0.20	-0.08
2007	0.13	0.10	0.00	0.27	0.02	0.19	0.03

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-4.29
Signific.	***
Q	-6.60E+00
Qmin99	-8.04E+00
Qmax99	-4.05E+00
Qmin95	-7.42E+00
Qmax95	-4.86E+00
B	1.83E+02
Bmin99	1.99E+02
Bmax99	1.65E+02
Bmin95	1.92E+02
Bmax95	1.73E+02

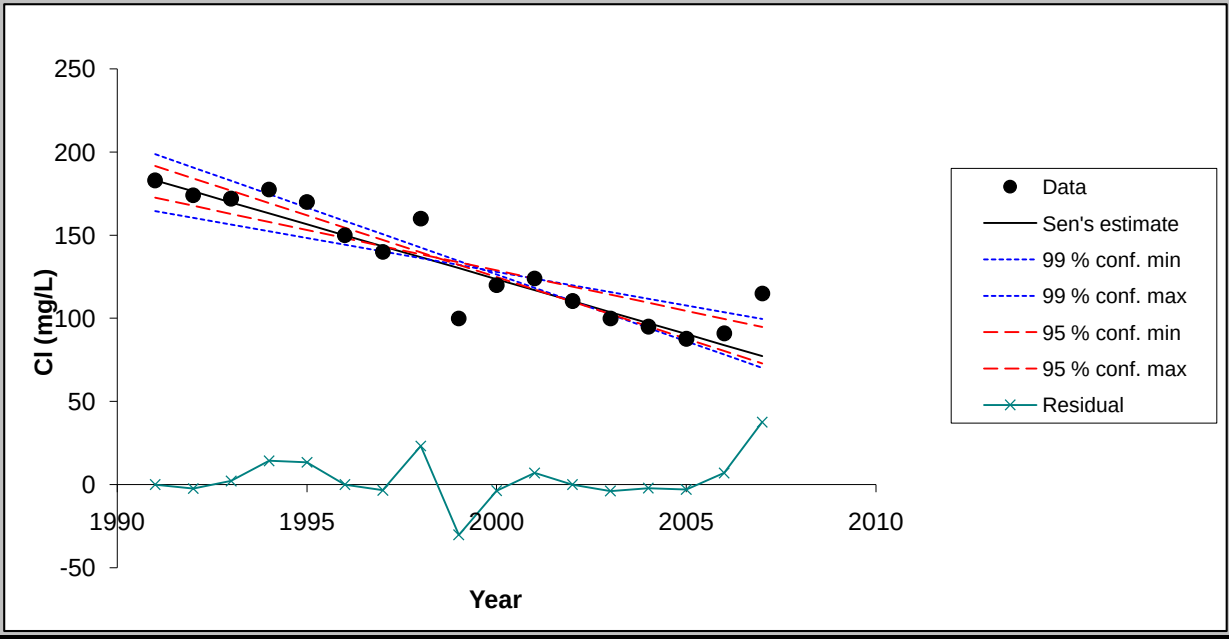

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	183.00	183.00	198.83	164.54	191.59	172.61	0.00
1992	174.00	176.40	190.79	160.49	184.16	167.75	-2.40
1993	172.00	169.80	182.76	156.43	176.74	162.89	2.20
1994	177.50	163.20	174.72	152.38	169.32	158.03	14.30
1995	170.00	156.60	166.68	148.33	161.90	153.17	13.40
1996	150.00	150.00	158.64	144.27	154.48	148.31	0.00
1997	140.00	143.40	150.60	140.22	147.05	143.45	-3.40
1998	160.00	136.80	142.56	136.16	139.63	138.58	23.20
1999	100.00	130.20	134.52	132.11	132.21	133.72	-30.20
2000	120.00	123.60	126.48	128.05	124.79	128.86	-3.60
2001	124.00	117.00	118.44	124.00	117.37	124.00	7.00
2002	110.40	110.40	110.40	119.95	109.94	119.14	0.00
2003	100.00	103.80	102.36	115.89	102.52	114.28	-3.80
2004	95.10	97.20	94.32	111.84	95.10	109.42	-2.10
2005	87.70	90.60	86.28	107.78	87.68	104.55	-2.90
2006	91.00	84.00	78.24	103.73	80.26	99.69	7.00
2007	115.00	77.40	70.20	99.67	72.83	94.83	37.60

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.11
Signific.	**
Q	-3.35E-03
Qmin99	-4.37E-03
Qmax99	-8.54E-04
Qmin95	-4.08E-03
Qmax95	-1.16E-03
B	9.34E-02
Bmin99	1.03E-01
Bmax99	8.01E-02
Bmin95	1.00E-01
Bmax95	8.24E-02

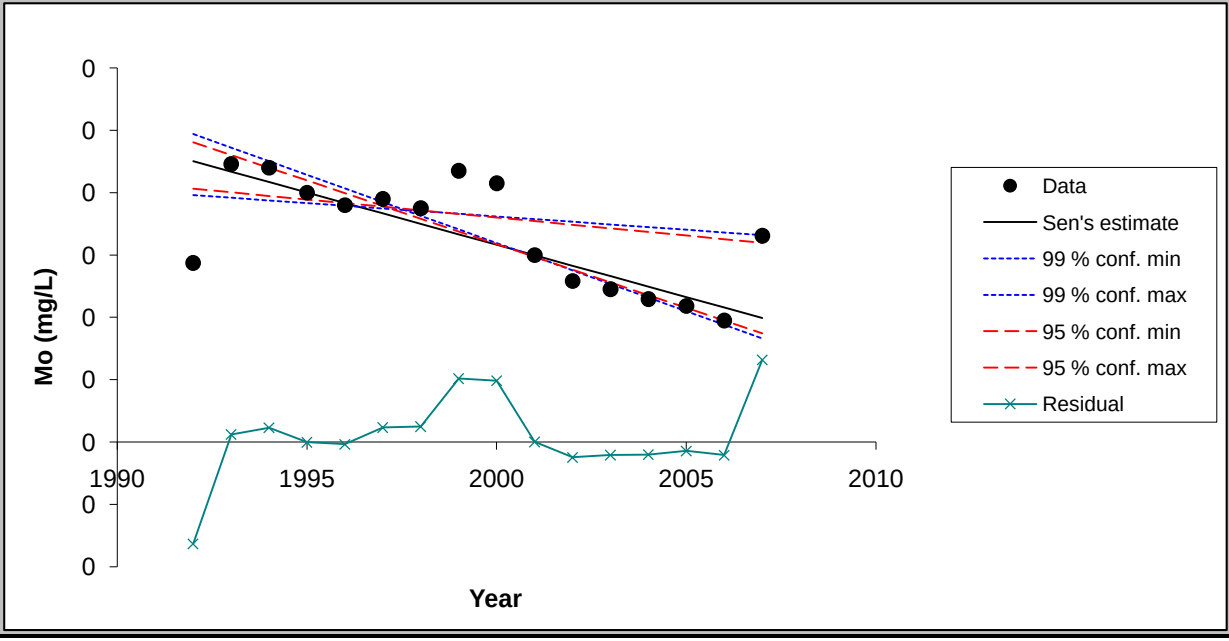

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.06	0.09	0.10	0.08	0.10	0.08	-0.03
1993	0.09	0.09	0.09	0.08	0.09	0.08	0.00
1994	0.09	0.08	0.09	0.08	0.09	0.08	0.00
1995	0.08	0.08	0.09	0.08	0.08	0.08	0.00
1996	0.08	0.08	0.08	0.08	0.08	0.08	0.00
1997	0.08	0.07	0.08	0.07	0.08	0.08	0.00
1998	0.08	0.07	0.07	0.07	0.07	0.07	0.01
1999	0.09	0.07	0.07	0.07	0.07	0.07	0.02
2000	0.08	0.06	0.06	0.07	0.06	0.07	0.02
2001	0.06	0.06	0.06	0.07	0.06	0.07	0.00
2002	0.05	0.06	0.06	0.07	0.06	0.07	0.00
2003	0.05	0.05	0.05	0.07	0.05	0.07	0.00
2004	0.05	0.05	0.05	0.07	0.05	0.07	0.00
2005	0.04	0.05	0.04	0.07	0.04	0.07	0.00
2006	0.04	0.04	0.04	0.07	0.04	0.07	0.00
2007	0.07	0.04	0.03	0.07	0.03	0.06	0.03

FIGURE

< Previous Time Series | Next Time Series >

TW-39 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.66
Signific.	
Q	5.09E+00
Qmin99	-1.26E+01
Qmax99	3.03E+01
Qmin95	-7.69E+00
Qmax95	2.30E+01
B	4.20E+02
Bmin99	5.33E+02
Bmax99	3.17E+02
Bmin95	5.08E+02
Bmax95	3.38E+02

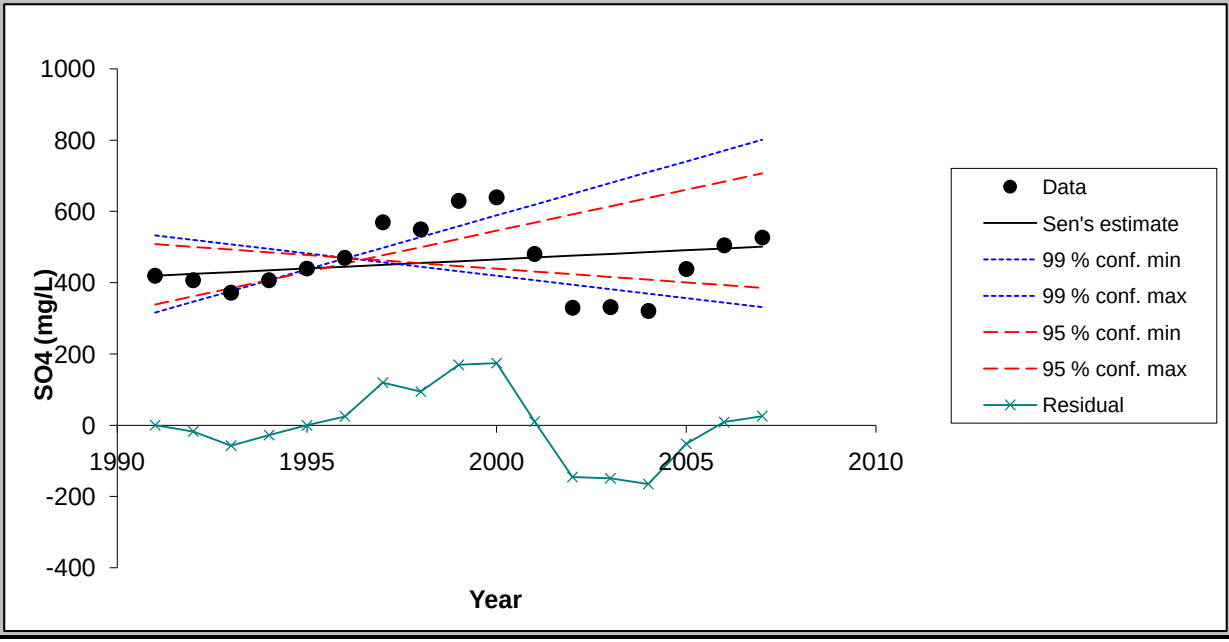

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	420.00	420.00	532.95	316.60	508.46	338.42	0.00
1992	407.50	425.09	520.36	346.90	500.77	361.45	-17.59
1993	372.50	430.18	507.77	377.20	493.07	384.47	-57.68
1994	407.50	435.27	495.18	407.50	485.38	407.50	-27.77
1995	440.00	440.36	482.59	437.80	477.69	430.53	-0.36
1996	470.00	445.45	470.00	468.10	470.00	453.55	24.55
1997	570.00	450.55	457.41	498.40	462.31	476.58	119.45
1998	550.00	455.64	444.82	528.71	454.62	499.61	94.36
1999	630.00	460.73	432.23	559.01	446.93	522.64	169.27
2000	640.00	465.82	419.64	589.31	439.23	545.66	174.18
2001	481.00	470.91	407.05	619.61	431.54	568.69	10.09
2002	330.36	476.00	394.46	649.91	423.85	591.72	-145.64
2003	332.00	481.09	381.87	680.21	416.16	614.75	-149.09
2004	321.00	486.18	369.28	710.51	408.47	637.77	-165.18
2005	439.00	491.27	356.69	740.82	400.78	660.80	-52.27
2006	505.00	496.36	344.10	771.12	393.09	683.83	8.64
2007	527.00	501.45	331.51	801.42	385.39	706.85	25.55

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Harris Well (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.66	0.001	0.25	0.0015	7		30
1992	0.0023	0.6625	0.00315	0.72	0.01705	19	0.0308	65.5
1993	0.00292	1.195	0.01505	5.25	0.262	83.1	0.034	298
1994	0.00235	2.31	0.00275	6.465	0.379	134	0.054	399.5
1995	0.0001	2.9	0.0005	8.1	0.34	120	0.074	460
1996	0.0001	4.1	0.0005	7.4	0.26	120	0.074	460
1997	0.0001	4.4	0.002	7.2	0.2	81	0.078	400
1998	0.0001	4.3	0.0005	6.5	0.13	89	0.086	350
1999	0.0001	4.4	0.0005	4.9	0.12	56	0.086	300
2000	0.0003	4.2	0.0005	4.8	0.08	64	0.092	260
2001	0.001	3.6	0.005	5.5	0.102	74	0.06	348
2002	0.001	3.111	0.03	5.76	0.1068	89.312	0.0622	419.387
2003	0.001	2.5	0.0033	6.89	0.255	98.3	0.0763	478
2004	0.001	2	0.0039	6.09	0.273	98.2	0.0554	437
2005	0.001	2.58	0.002	6.32	0.24	106	0.06	439
2006	0.001	2.49	0.002	7.47	0.286	103	0.047	463
2007	0.00016	2.54	0.0013	8.96	0.123	121	0.0652	523

TREND STATISTICS

Harris Well (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.97		0.00000	-0.00017	0.00010	-0.00015	0.00001	######	0.00269	-0.00029	0.00248	0.00081
F (mg/L)	*1991*	*2007*	*17*		0.58		0.028	-0.200	0.295	-0.160	0.183	2.23	5.31	0.65	4.87	1.09
Mn (mg/L)	*1991*	*2007*	*17*		0.08		0.0000	-0.0004	0.0003	-0.0003	0.0002	0.0020	0.0047	-0.0002	0.0037	0.0007
Nitrate (mg/L)	*1991*	*2007*	*17*		1.85	+	0.233	-0.077	0.520	-0.023	0.486	3.97	7.04	0.65	6.53	1.01
Se (mg/L)	*1991*	*2007*	*17*		0.29		0.002	-0.020	0.020	-0.012	0.017	0.19	0.32	0.00	0.29	0.01
Cl (mg/L)	*1991*	*2007*	*17*		1.81	+	3.489	-1.912	7.874	-0.427	7.113	56.43	110.35	3.82	94.01	11.07
Mo (mg/L)	*1992*	*2007*	*16*		0.59		0.001	-0.003	0.004	-0.002	0.003	0.054	0.091	0.027	0.086	0.032
SO4 (mg/L)	*1991*	*2007*	*17*		2.89	**	15.286	0.325	33.560	4.106	30.116	243.00	398.52	31.94	375.36	59.07
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.97
Signific.	
Q	-1.39E-11
Qmin99	-1.69E-04
Qmax99	9.70E-05
Qmin95	-1.45E-04
Qmax95	1.37E-05
B	1.00E-03
Bmin99	2.69E-03
Bmax99	-2.88E-04
Bmin95	2.48E-03
Bmax95	8.08E-04

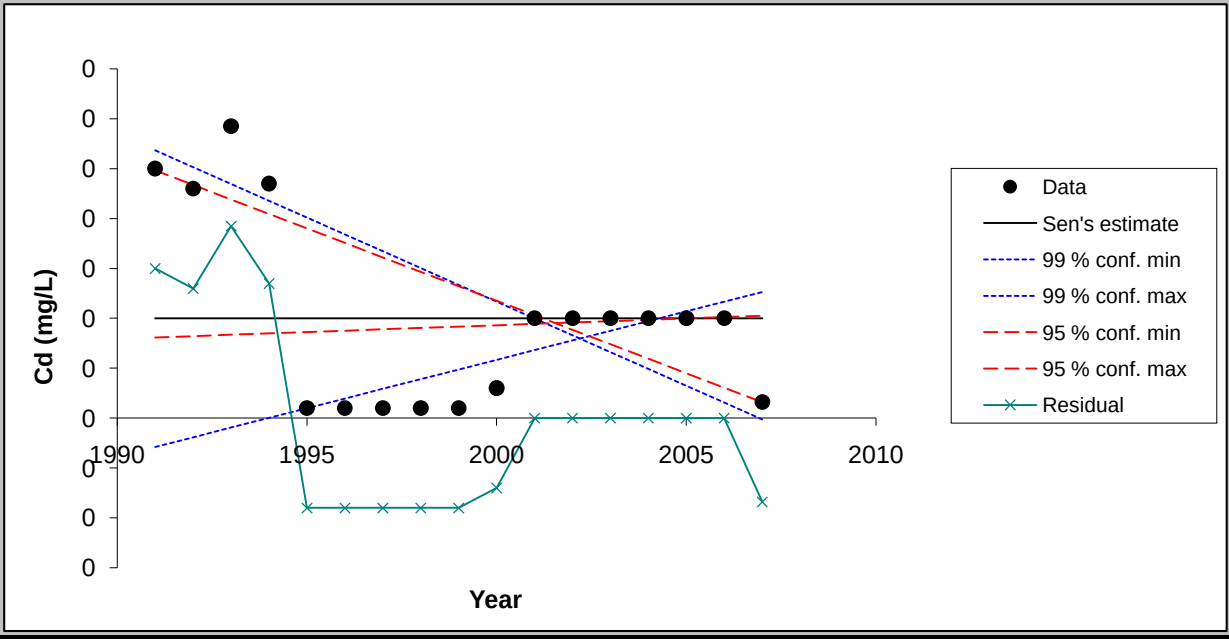

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.58
Signific.	
Q	2.76E-02
Qmin99	-2.00E-01
Qmax99	2.95E-01
Qmin95	-1.60E-01
Qmax95	1.83E-01
B	2.23E+00
Bmin99	5.31E+00
Bmax99	6.46E-01
Bmin95	4.87E+00
Bmax95	1.09E+00

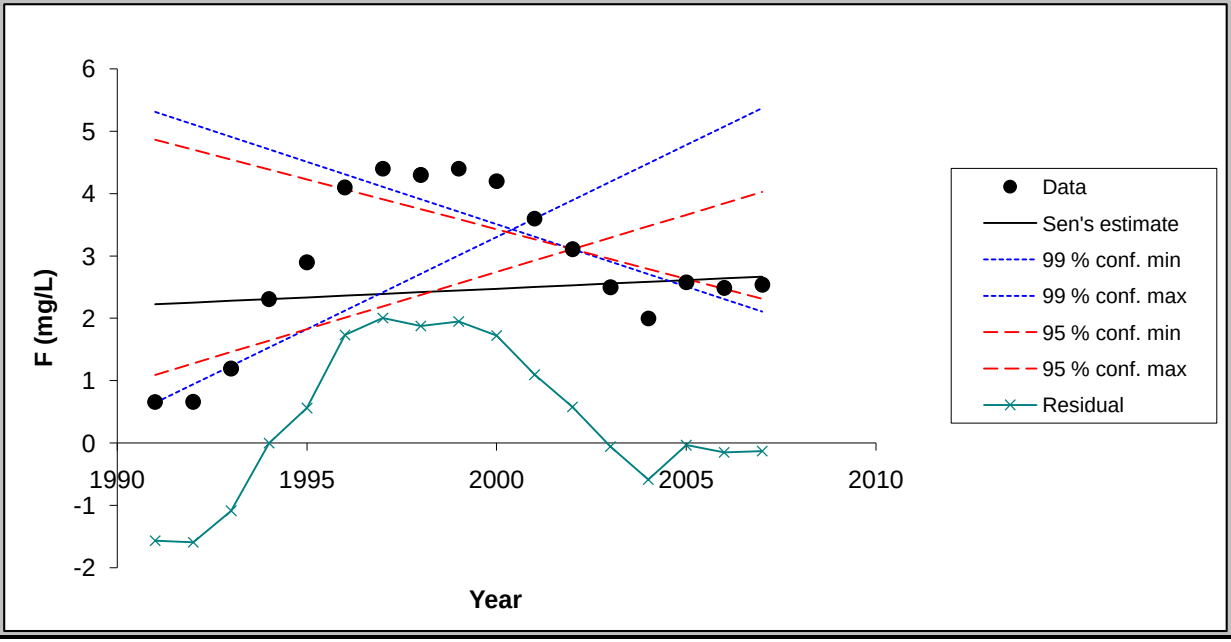

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.66	2.23	5.31	0.65	4.87	1.09	-1.57
1992	0.66	2.25	5.11	0.94	4.71	1.28	-1.59
1993	1.19	2.28	4.91	1.24	4.55	1.46	-1.09
1994	2.31	2.31	4.71	1.53	4.39	1.64	0.00
1995	2.90	2.34	4.51	1.83	4.23	1.83	0.56
1996	4.10	2.37	4.31	2.12	4.07	2.01	1.73
1997	4.40	2.39	4.11	2.42	3.91	2.19	2.01
1998	4.30	2.42	3.91	2.71	3.75	2.38	1.88
1999	4.40	2.45	3.71	3.01	3.59	2.56	1.95
2000	4.20	2.48	3.51	3.30	3.43	2.74	1.72
2001	3.60	2.50	3.31	3.60	3.27	2.93	1.10
2002	3.11	2.53	3.11	3.90	3.11	3.11	0.58
2003	2.50	2.56	2.91	4.19	2.95	3.29	-0.06
2004	2.00	2.59	2.71	4.49	2.79	3.48	-0.59
2005	2.58	2.61	2.51	4.78	2.63	3.66	-0.03
2006	2.49	2.64	2.31	5.08	2.47	3.84	-0.15
2007	2.54	2.67	2.11	5.37	2.31	4.03	-0.13

FIGURE

< Previous Time Series | Next Time Series >

Harris Well (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.08
Signific.	
Q	0.00E+00
Qmin99	-4.48E-04
Qmax99	2.94E-04
Qmin95	-2.85E-04
Qmax95	2.09E-04
B	2.00E-03
Bmin99	4.69E-03
Bmax99	-2.30E-04
Bmin95	3.71E-03
Bmax95	7.44E-04

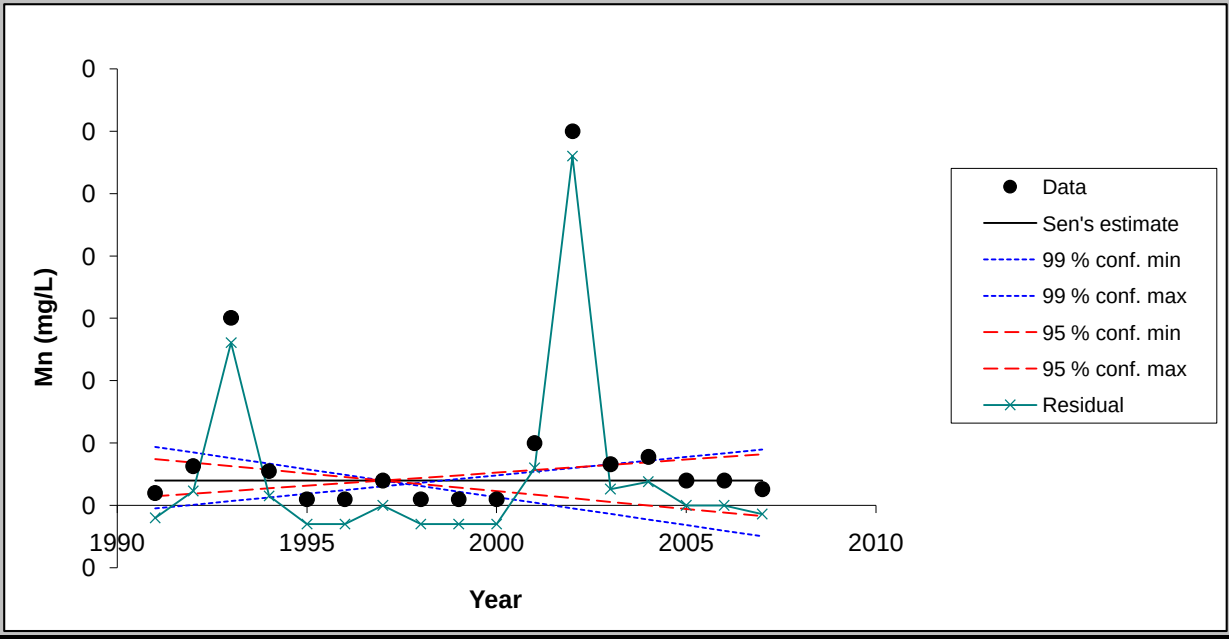

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.02	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.85
Signific.	+
Q	2.33E-01
Qmin99	-7.69E-02
Qmax99	5.20E-01
Qmin95	-2.31E-02
Qmax95	4.86E-01
B	3.97E+00
Bmin99	7.04E+00
Bmax99	6.48E-01
Bmin95	6.53E+00
Bmax95	1.01E+00

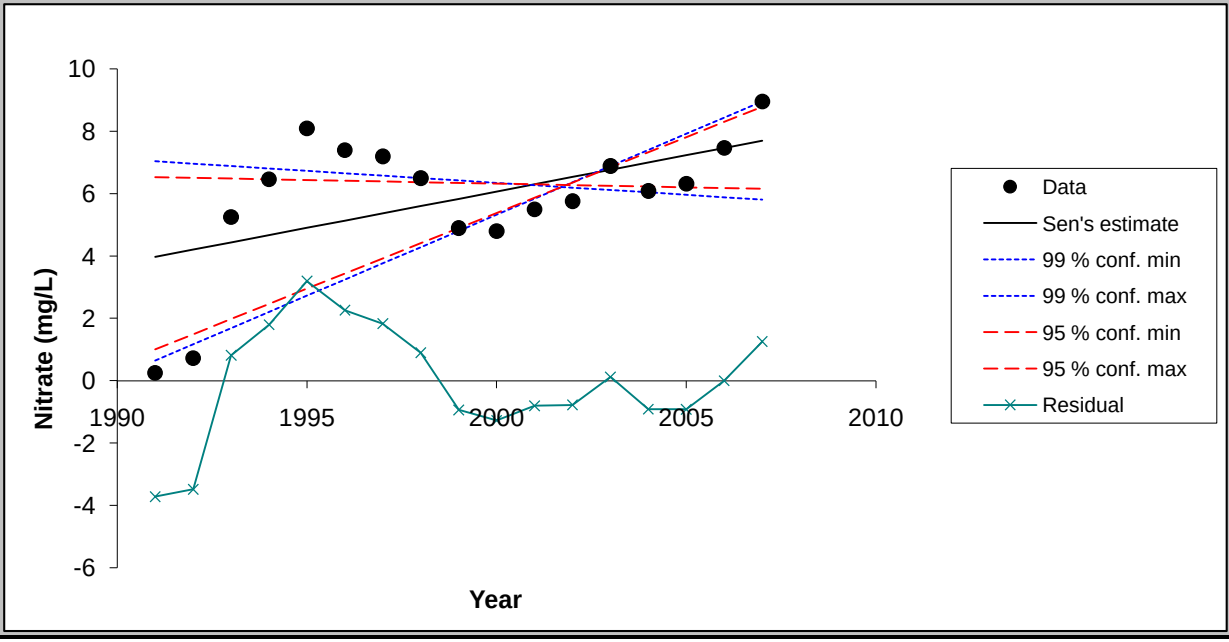

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	3.97	7.04	0.65	6.53	1.01	-3.72
1992	0.72	4.20	6.96	1.17	6.51	1.50	-3.48
1993	5.25	4.44	6.88	1.69	6.49	1.98	0.81
1994	6.47	4.67	6.81	2.21	6.47	2.47	1.80
1995	8.10	4.90	6.73	2.73	6.44	2.95	3.20
1996	7.40	5.14	6.65	3.25	6.42	3.44	2.26
1997	7.20	5.37	6.58	3.76	6.40	3.93	1.83
1998	6.50	5.60	6.50	4.28	6.37	4.41	0.90
1999	4.90	5.84	6.42	4.80	6.35	4.90	-0.94
2000	4.80	6.07	6.35	5.32	6.33	5.39	-1.27
2001	5.50	6.30	6.27	5.84	6.30	5.87	-0.80
2002	5.76	6.54	6.19	6.36	6.28	6.36	-0.78
2003	6.89	6.77	6.12	6.88	6.26	6.85	0.12
2004	6.09	7.00	6.04	7.40	6.23	7.33	-0.91
2005	6.32	7.24	5.96	7.92	6.21	7.82	-0.92
2006	7.47	7.47	5.88	8.44	6.19	8.30	0.00
2007	8.96	7.70	5.81	8.96	6.16	8.79	1.26

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.29
Signific.	
Q	2.22E-03
Qmin99	-1.98E-02
Qmax99	1.96E-02
Qmin95	-1.21E-02
Qmax95	1.68E-02
B	1.87E-01
Bmin99	3.24E-01
Bmax99	-2.58E-03
Bmin95	2.86E-01
Bmax95	1.27E-02

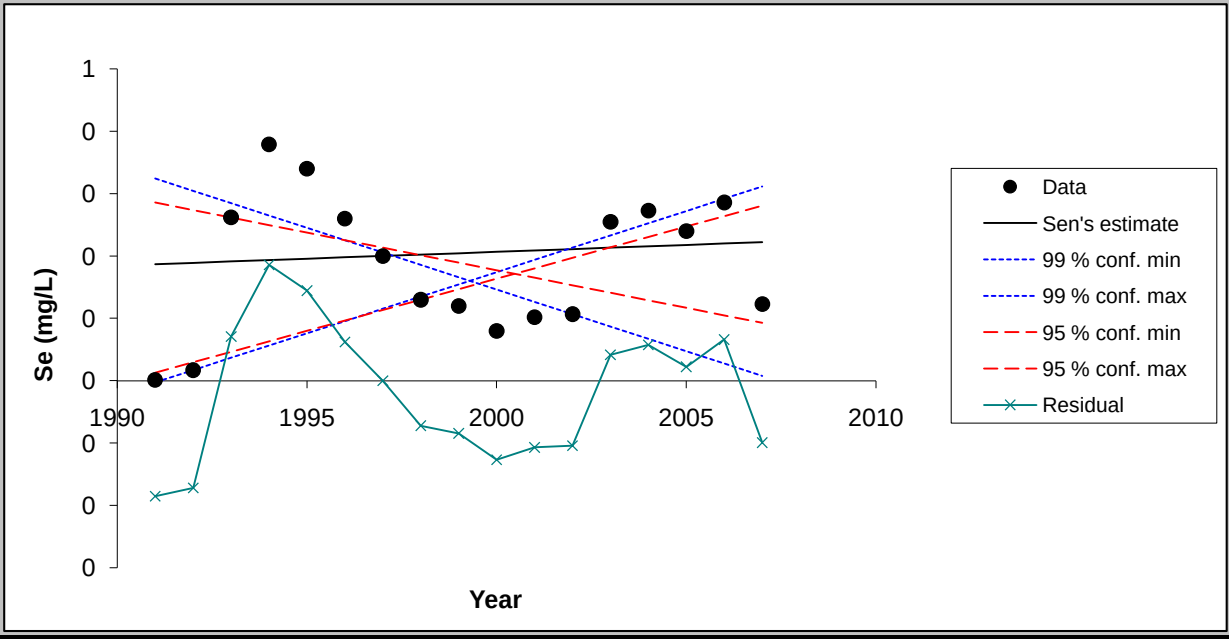

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.19	0.32	0.00	0.29	0.01	-0.19
1992	0.02	0.19	0.30	0.02	0.27	0.03	-0.17
1993	0.26	0.19	0.28	0.04	0.26	0.05	0.07
1994	0.38	0.19	0.26	0.06	0.25	0.06	0.19
1995	0.34	0.20	0.25	0.08	0.24	0.08	0.14
1996	0.26	0.20	0.23	0.10	0.23	0.10	0.06
1997	0.20	0.20	0.21	0.12	0.21	0.11	0.00
1998	0.13	0.20	0.19	0.13	0.20	0.13	-0.07
1999	0.12	0.20	0.17	0.15	0.19	0.15	-0.08
2000	0.08	0.21	0.15	0.17	0.18	0.16	-0.13
2001	0.10	0.21	0.13	0.19	0.17	0.18	-0.11
2002	0.11	0.21	0.11	0.21	0.15	0.20	-0.10
2003	0.25	0.21	0.09	0.23	0.14	0.21	0.04
2004	0.27	0.22	0.07	0.25	0.13	0.23	0.06
2005	0.24	0.22	0.05	0.27	0.12	0.25	0.02
2006	0.29	0.22	0.03	0.29	0.11	0.26	0.07
2007	0.12	0.22	0.01	0.31	0.09	0.28	-0.10

FIGURE

< Previous Time Series | Next Time Series >

Harris Well (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.81
Signific.	+
Q	3.49E+00
Qmin99	-1.91E+00
Qmax99	7.87E+00
Qmin95	-4.27E-01
Qmax95	7.11E+00
B	5.64E+01
Bmin99	1.10E+02
Bmax99	3.82E+00
Bmin95	9.40E+01
Bmax95	1.11E+01

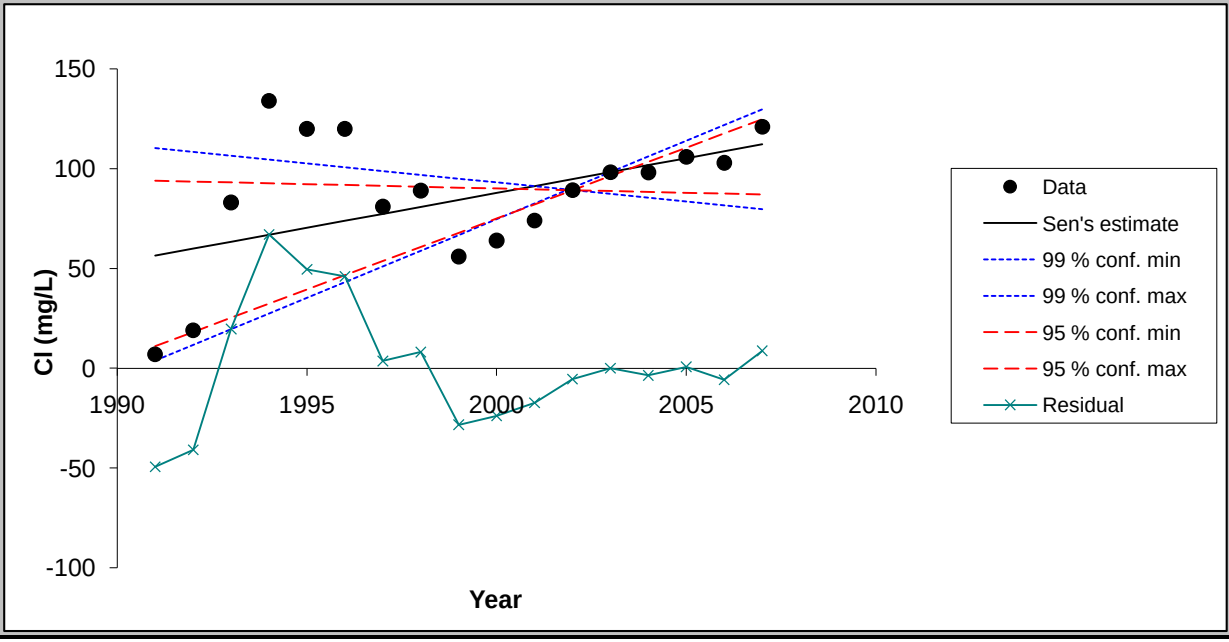

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	7.00	56.43	110.35	3.82	94.01	11.07	-49.43
1992	19.00	59.92	108.43	11.69	93.59	18.18	-40.92
1993	83.10	63.41	106.52	19.56	93.16	25.30	19.69
1994	134.00	66.90	104.61	27.44	92.73	32.41	67.10
1995	120.00	70.39	102.70	35.31	92.30	39.52	49.61
1996	120.00	73.88	100.78	43.19	91.88	46.64	46.12
1997	81.00	77.37	98.87	51.06	91.45	53.75	3.63
1998	89.00	80.86	96.96	58.93	91.02	60.86	8.14
1999	56.00	84.34	95.05	66.81	90.59	67.97	-28.34
2000	64.00	87.83	93.14	74.68	90.17	75.09	-23.83
2001	74.00	91.32	91.22	82.55	89.74	82.20	-17.32
2002	89.31	94.81	89.31	90.43	89.31	89.31	-5.50
2003	98.30	98.30	87.40	98.30	88.88	96.42	0.00
2004	98.20	101.79	85.49	106.17	88.46	103.54	-3.59
2005	106.00	105.28	83.58	114.05	88.03	110.65	0.72
2006	103.00	108.77	81.66	121.92	87.60	117.76	-5.77
2007	121.00	112.26	79.75	129.79	87.17	124.88	8.74

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.59
Signific.	
Q	7.29E-04
Qmin99	-2.65E-03
Qmax99	4.07E-03
Qmin95	-2.29E-03
Qmax95	3.25E-03
B	5.39E-02
Bmin99	9.07E-02
Bmax99	2.71E-02
Bmin95	8.65E-02
Bmax95	3.24E-02

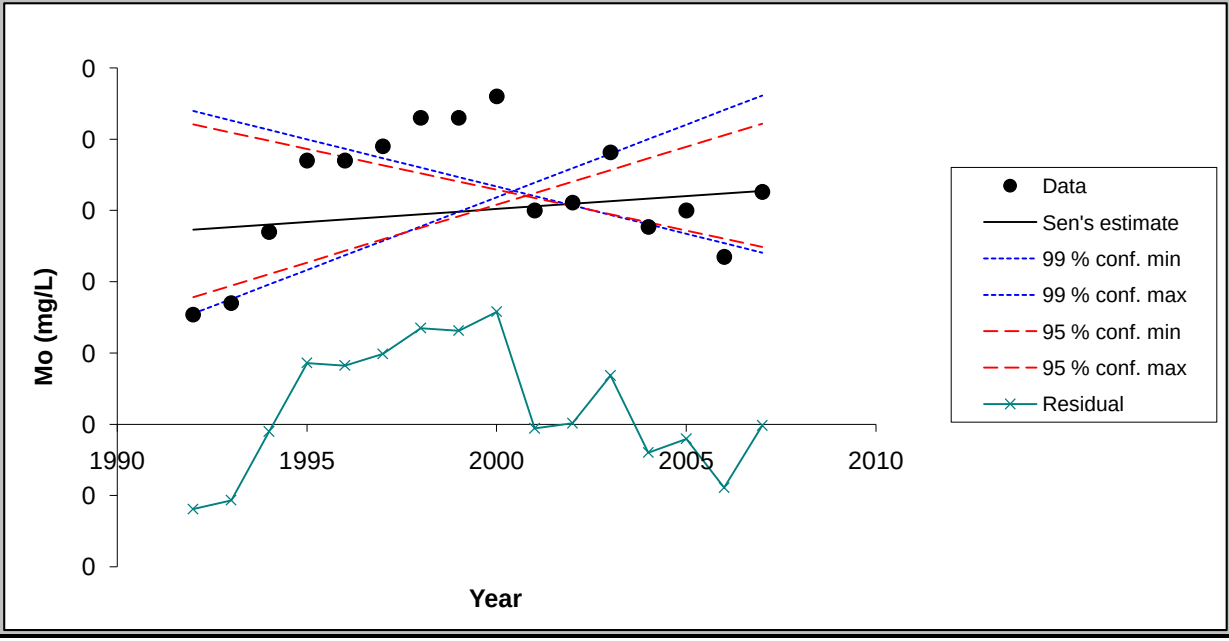

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.05	0.09	0.03	0.08	0.04	-0.02
1993	0.03	0.06	0.09	0.04	0.08	0.04	-0.02
1994	0.05	0.06	0.08	0.04	0.08	0.04	0.00
1995	0.07	0.06	0.08	0.04	0.08	0.05	0.02
1996	0.07	0.06	0.08	0.05	0.07	0.05	0.02
1997	0.08	0.06	0.07	0.05	0.07	0.05	0.02
1998	0.09	0.06	0.07	0.06	0.07	0.06	0.03
1999	0.09	0.06	0.07	0.06	0.07	0.06	0.03
2000	0.09	0.06	0.07	0.06	0.07	0.06	0.03
2001	0.06	0.06	0.06	0.07	0.06	0.06	0.00
2002	0.06	0.06	0.06	0.07	0.06	0.07	0.00
2003	0.08	0.06	0.06	0.08	0.06	0.07	0.01
2004	0.06	0.06	0.06	0.08	0.06	0.07	-0.01
2005	0.06	0.06	0.05	0.08	0.05	0.08	0.00
2006	0.05	0.06	0.05	0.09	0.05	0.08	-0.02
2007	0.07	0.07	0.05	0.09	0.05	0.08	0.00

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.89
Signific.	**
Q	1.53E+01
Qmin99	3.25E-01
Qmax99	3.36E+01
Qmin95	4.11E+00
Qmax95	3.01E+01
B	2.43E+02
Bmin99	3.99E+02
Bmax99	3.19E+01
Bmin95	3.75E+02
Bmax95	5.91E+01

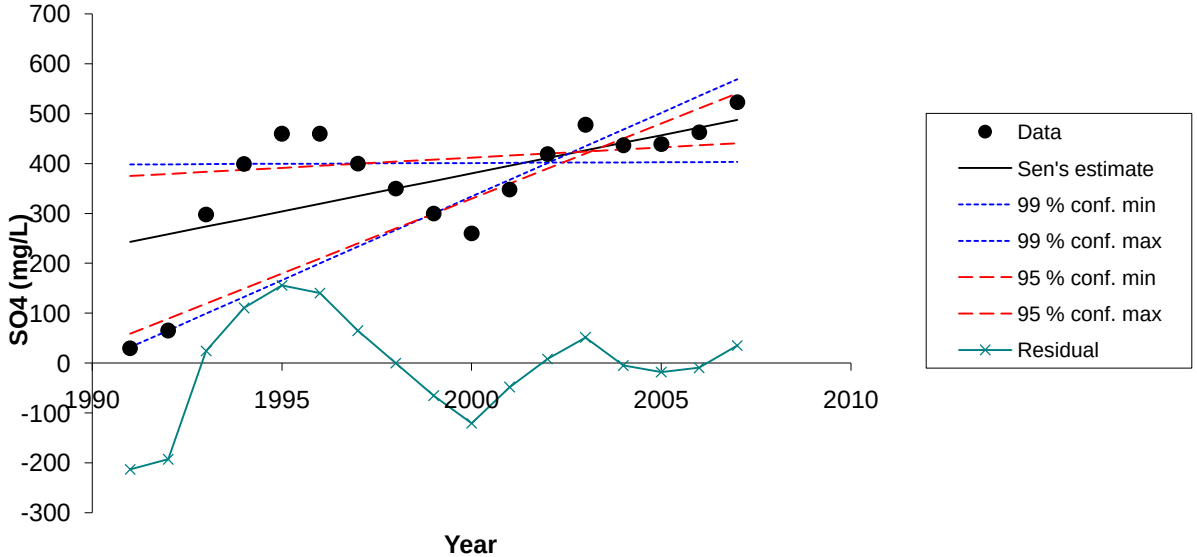

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	30.00	243.00	398.52	31.94	375.36	59.07	-213.00
1992	65.50	258.29	398.85	65.50	379.47	89.19	-192.79
1993	298.00	273.57	399.17	99.06	383.57	119.30	24.43
1994	399.50	288.86	399.50	132.62	387.68	149.42	110.64
1995	460.00	304.14	399.83	166.18	391.79	179.54	155.86
1996	460.00	319.43	400.15	199.74	395.89	209.65	140.57
1997	400.00	334.71	400.48	233.30	400.00	239.77	65.29
1998	350.00	350.00	400.80	266.86	404.11	269.88	0.00
1999	300.00	365.29	401.13	300.42	408.21	300.00	-65.29
2000	260.00	380.57	401.45	333.98	412.32	330.12	-120.57
2001	348.00	395.86	401.78	367.54	416.43	360.23	-47.86
2002	419.39	411.14	402.10	401.10	420.53	390.35	8.24
2003	478.00	426.43	402.43	434.66	424.64	420.46	51.57
2004	437.00	441.71	402.75	468.22	428.74	450.58	-4.71
2005	439.00	457.00	403.08	501.78	432.85	480.70	-18.00
2006	463.00	472.29	403.40	535.34	436.96	510.81	-9.29
2007	523.00	487.57	403.73	568.90	441.06	540.93	35.43

FIGURE

< Previous Time Series | Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.41
Signific.	
Q	4.15E-05
Qmin99	-3.03E-04
Qmax99	4.53E-04
Qmin95	-2.46E-04
Qmax95	2.88E-04
B	1.40E-02
Bmin99	1.80E-02
Bmax99	1.04E-02
Bmin95	1.75E-02
Bmax95	1.21E-02

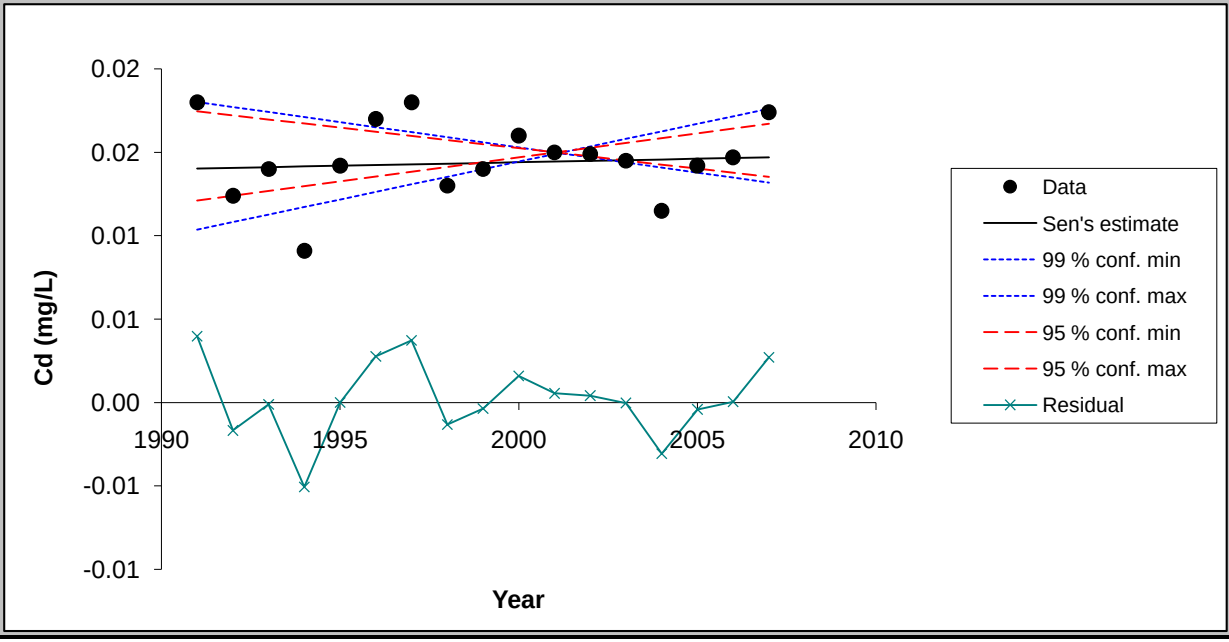

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.01	0.02	0.01	0.02	0.01	0.00
1992	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1993	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1994	0.01	0.01	0.02	0.01	0.02	0.01	-0.01
1995	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1996	0.02	0.01	0.02	0.01	0.02	0.01	0.00
1997	0.02	0.01	0.02	0.01	0.02	0.01	0.00
1998	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1999	0.01	0.01	0.02	0.01	0.02	0.01	0.00
2000	0.02	0.01	0.02	0.01	0.02	0.01	0.00
2001	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2002	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2003	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2004	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2005	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2006	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2007	0.02	0.01	0.01	0.02	0.01	0.02	0.00

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.20
Signific.	
Q	-8.09E-02
Qmin99	-2.69E-01
Qmax99	8.69E-02
Qmin95	-2.22E-01
Qmax95	4.27E-02
B	4.23E+00
Bmin99	6.02E+00
Bmax99	2.63E+00
Bmin95	5.49E+00
Bmax95	3.07E+00

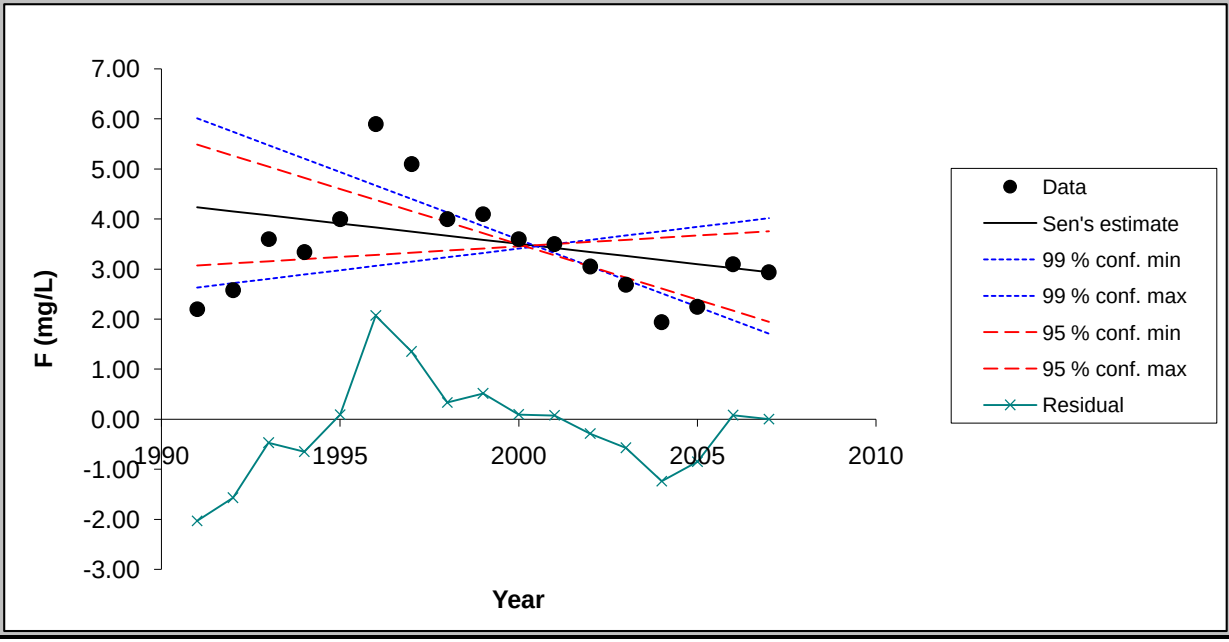

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	2.20	4.23	6.02	2.63	5.49	3.07	-2.03
1992	2.58	4.15	5.75	2.72	5.27	3.12	-1.57
1993	3.60	4.07	5.48	2.80	5.05	3.16	-0.47
1994	3.34	3.99	5.21	2.89	4.83	3.20	-0.65
1995	4.00	3.91	4.94	2.98	4.61	3.24	0.09
1996	5.90	3.83	4.67	3.07	4.38	3.29	2.07
1997	5.10	3.75	4.40	3.15	4.16	3.33	1.35
1998	4.00	3.67	4.13	3.24	3.94	3.37	0.33
1999	4.10	3.59	3.86	3.33	3.72	3.41	0.51
2000	3.60	3.51	3.59	3.41	3.50	3.46	0.09
2001	3.50	3.43	3.32	3.50	3.28	3.50	0.07
2002	3.05	3.34	3.05	3.59	3.05	3.54	-0.29
2003	2.69	3.26	2.78	3.67	2.83	3.59	-0.57
2004	1.94	3.18	2.52	3.76	2.61	3.63	-1.24
2005	2.25	3.10	2.25	3.85	2.39	3.67	-0.85
2006	3.10	3.02	1.98	3.93	2.17	3.71	0.08
2007	2.94	2.94	1.71	4.02	1.95	3.76	0.00

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.47
Signific.	
Q	0.00E+00
Qmin99	-2.23E-04
Qmax99	1.75E-04
Qmin95	-1.02E-04
Qmax95	1.38E-04
B	1.00E-03
Bmin99	2.51E-03
Bmax99	-4.52E-04
Bmin95	2.23E-03
Bmax95	-7.32E-05

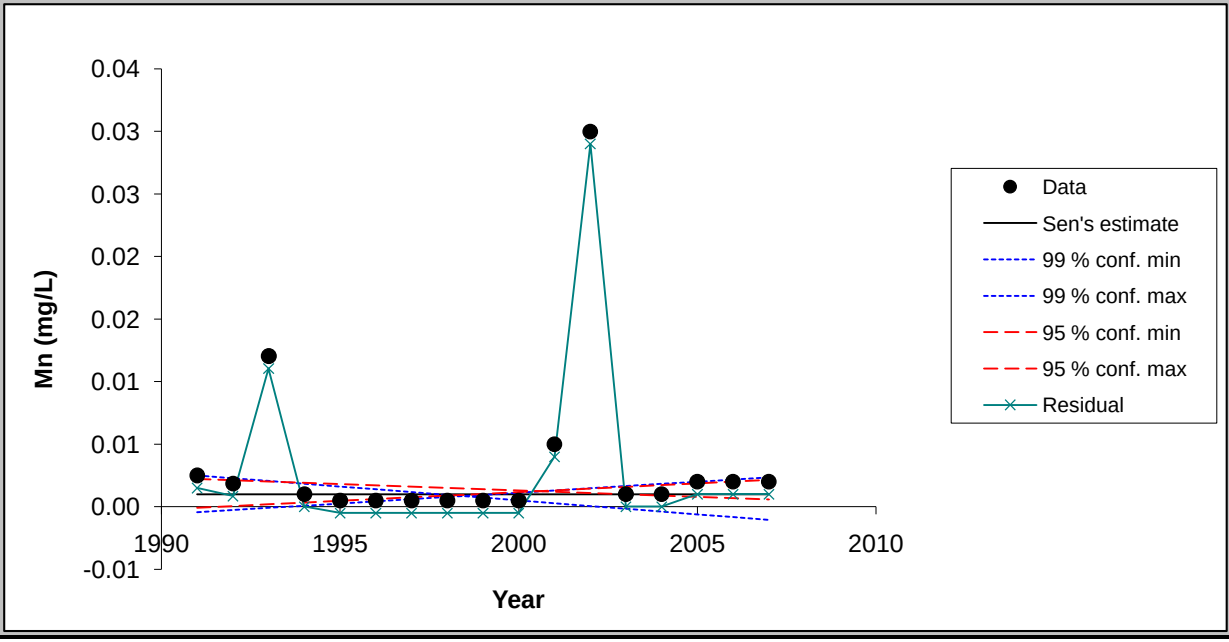

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	3.17
Signific.	**
Q	2.78E-01
Qmin99	6.40E-02
Qmax99	4.67E-01
Qmin95	9.37E-02
Qmax95	4.01E-01
B	4.27E+00
Bmin99	5.74E+00
Bmax99	2.80E+00
Bmin95	5.50E+00
Bmax95	3.24E+00

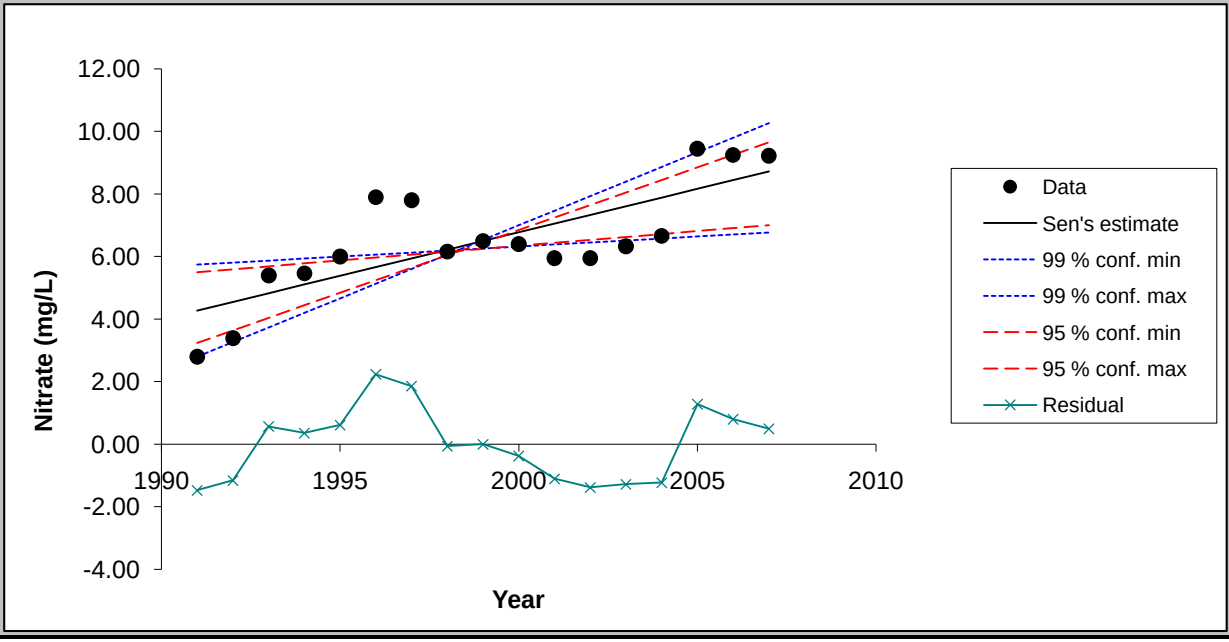

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	2.80	4.27	5.74	2.80	5.50	3.24	-1.47
1992	3.40	4.55	5.81	3.27	5.60	3.64	-1.16
1993	5.40	4.83	5.87	3.73	5.69	4.04	0.57
1994	5.47	5.11	5.94	4.20	5.79	4.44	0.36
1995	6.00	5.39	6.00	4.67	5.88	4.84	0.61
1996	7.90	5.66	6.06	5.13	5.97	5.24	2.24
1997	7.80	5.94	6.13	5.60	6.07	5.64	1.86
1998	6.16	6.22	6.19	6.07	6.16	6.04	-0.06
1999	6.50	6.50	6.26	6.54	6.25	6.44	0.00
2000	6.40	6.78	6.32	7.00	6.35	6.84	-0.38
2001	5.95	7.06	6.38	7.47	6.44	7.25	-1.11
2002	5.95	7.34	6.45	7.94	6.53	7.65	-1.39
2003	6.33	7.61	6.51	8.40	6.63	8.05	-1.28
2004	6.66	7.89	6.58	8.87	6.72	8.45	-1.23
2005	9.45	8.17	6.64	9.34	6.82	8.85	1.28
2006	9.25	8.45	6.70	9.80	6.91	9.25	0.80
2007	9.22	8.73	6.77	10.27	7.00	9.65	0.49

FIGURE

< Previous Time Series | Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.72
Signific.	**
Q	8.38E-03
Qmin99	2.77E-04
Qmax99	1.74E-02
Qmin95	3.50E-03
Qmax95	1.48E-02
B	1.38E-01
Bmin99	2.02E-01
Bmax99	4.06E-02
Bmin95	1.70E-01
Bmax95	7.17E-02

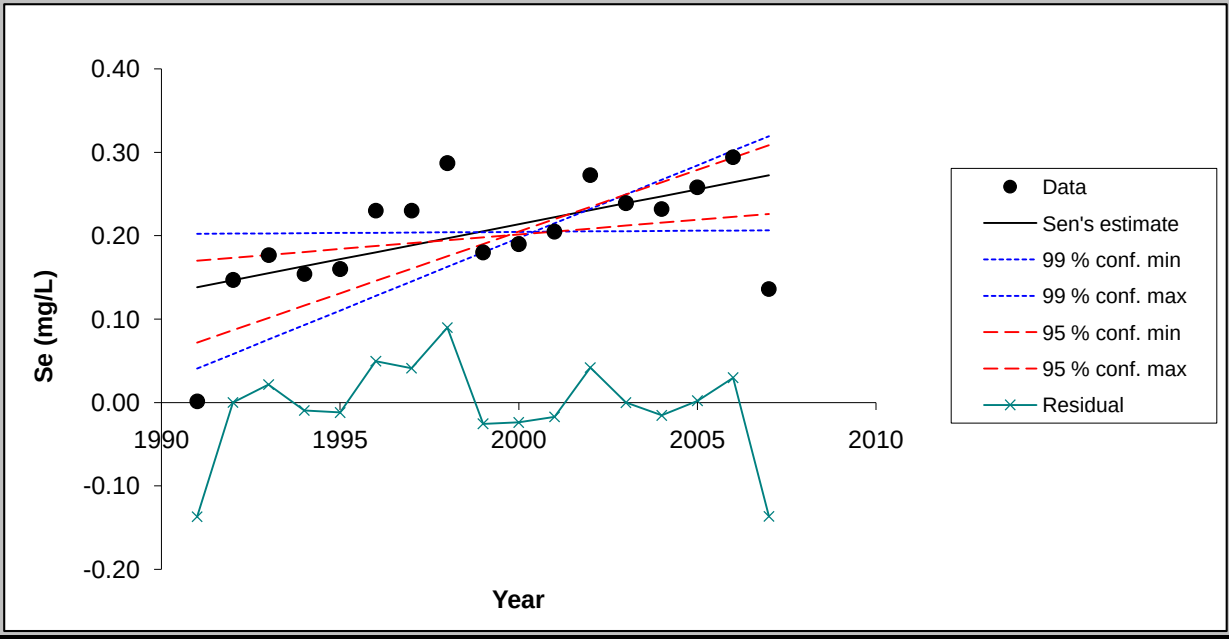

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.14	0.20	0.04	0.17	0.07	-0.14
1992	0.15	0.15	0.20	0.06	0.17	0.09	0.00
1993	0.18	0.16	0.20	0.08	0.18	0.10	0.02
1994	0.15	0.16	0.20	0.09	0.18	0.12	-0.01
1995	0.16	0.17	0.20	0.11	0.18	0.13	-0.01
1996	0.23	0.18	0.20	0.13	0.19	0.15	0.05
1997	0.23	0.19	0.20	0.15	0.19	0.16	0.04
1998	0.29	0.20	0.20	0.16	0.19	0.18	0.09
1999	0.18	0.21	0.20	0.18	0.20	0.19	-0.03
2000	0.19	0.21	0.20	0.20	0.20	0.21	-0.02
2001	0.20	0.22	0.20	0.21	0.20	0.22	-0.02
2002	0.27	0.23	0.21	0.23	0.21	0.23	0.04
2003	0.24	0.24	0.21	0.25	0.21	0.25	0.00
2004	0.23	0.25	0.21	0.27	0.22	0.26	-0.02
2005	0.26	0.26	0.21	0.28	0.22	0.28	0.00
2006	0.29	0.26	0.21	0.30	0.22	0.29	0.03
2007	0.14	0.27	0.21	0.32	0.23	0.31	-0.14

FIGURE

< Previous Time Series | Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.65
Signific.	+
Q	-1.73E+00
Qmin99	-5.31E+00
Qmax99	2.15E+00
Qmin95	-4.23E+00
Qmax95	4.35E-01
B	1.30E+02
Bmin99	1.60E+02
Bmax99	8.78E+01
Bmin95	1.48E+02
Bmax95	1.13E+02

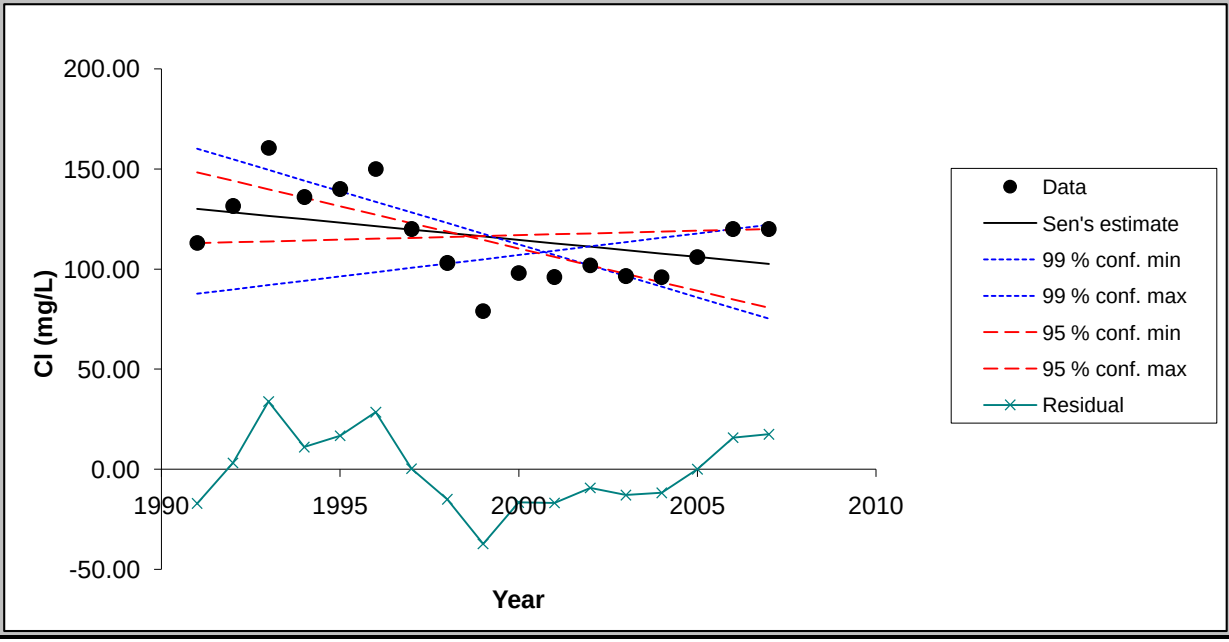

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	113.00	130.15	160.16	87.81	148.36	113.00	-17.15
1992	131.50	128.43	154.86	89.95	144.12	113.43	3.07
1993	160.50	126.70	149.55	92.10	139.89	113.87	33.80
1994	136.00	124.98	144.25	94.24	135.66	114.30	11.03
1995	140.00	123.25	138.94	96.39	131.43	114.74	16.75
1996	150.00	121.53	133.63	98.54	127.19	115.17	28.48
1997	120.00	119.80	128.33	100.68	122.96	115.61	0.20
1998	103.00	118.08	123.02	102.83	118.73	116.04	-15.08
1999	79.00	116.35	117.72	104.98	114.50	116.48	-37.35
2000	98.00	114.63	112.41	107.12	110.26	116.91	-16.63
2001	96.00	112.90	107.11	109.27	106.03	117.35	-16.90
2002	101.80	111.18	101.80	111.41	101.80	117.78	-9.37
2003	96.50	109.45	96.49	113.56	97.57	118.22	-12.95
2004	95.90	107.73	91.19	115.71	93.34	118.65	-11.83
2005	106.00	106.00	85.88	117.85	89.10	119.09	0.00
2006	120.00	104.28	80.58	120.00	84.87	119.52	15.73
2007	120.00	102.55	75.27	122.15	80.64	119.96	17.45

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.44
Signific.	
Q	-1.64E-03
Qmin99	-4.72E-03
Qmax99	1.28E-03
Qmin95	-3.35E-03
Qmax95	6.35E-04
B	8.46E-02
Bmin99	1.16E-01
Bmax99	6.34E-02
Bmin95	1.02E-01
Bmax95	7.12E-02

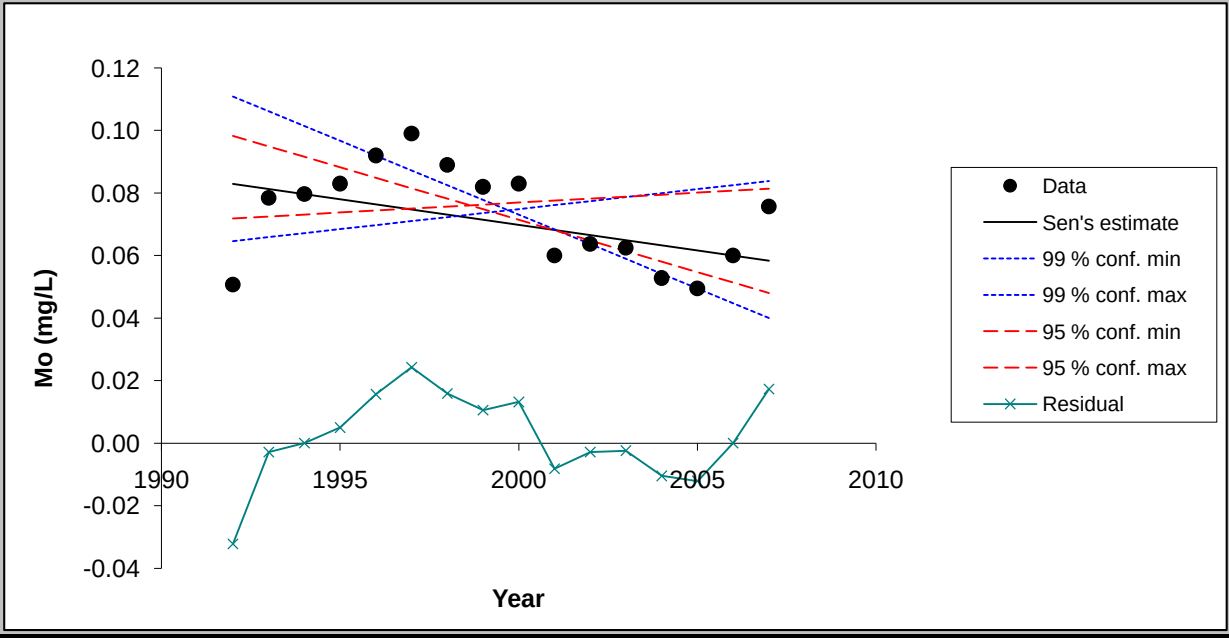

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.05	0.08	0.11	0.06	0.10	0.07	-0.03
1993	0.08	0.08	0.11	0.07	0.09	0.07	0.00
1994	0.08	0.08	0.10	0.07	0.09	0.07	0.00
1995	0.08	0.08	0.10	0.07	0.09	0.07	0.00
1996	0.09	0.08	0.09	0.07	0.08	0.07	0.02
1997	0.10	0.07	0.09	0.07	0.08	0.08	0.02
1998	0.09	0.07	0.08	0.07	0.08	0.08	0.02
1999	0.08	0.07	0.08	0.07	0.07	0.08	0.01
2000	0.08	0.07	0.07	0.07	0.07	0.08	0.01
2001	0.06	0.07	0.07	0.08	0.07	0.08	-0.01
2002	0.06	0.07	0.06	0.08	0.06	0.08	0.00
2003	0.06	0.06	0.06	0.08	0.06	0.08	0.00
2004	0.05	0.06	0.05	0.08	0.06	0.08	-0.01
2005	0.05	0.06	0.05	0.08	0.05	0.08	-0.01
2006	0.06	0.06	0.04	0.08	0.05	0.08	0.00
2007	0.08	0.06	0.04	0.08	0.05	0.08	0.02

FIGURE

< Previous Time Series | Next Time Series >

Mormon A Spring (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.64
Signific.	**
Q	1.57E+01
Qmin99	7.59E-01
Qmax99	3.08E+01
Qmin95	5.05E+00
Qmax95	2.53E+01
B	2.37E+02
Bmin99	4.05E+02
Bmax99	1.34E+02
Bmin95	3.45E+02
Bmax95	1.72E+02

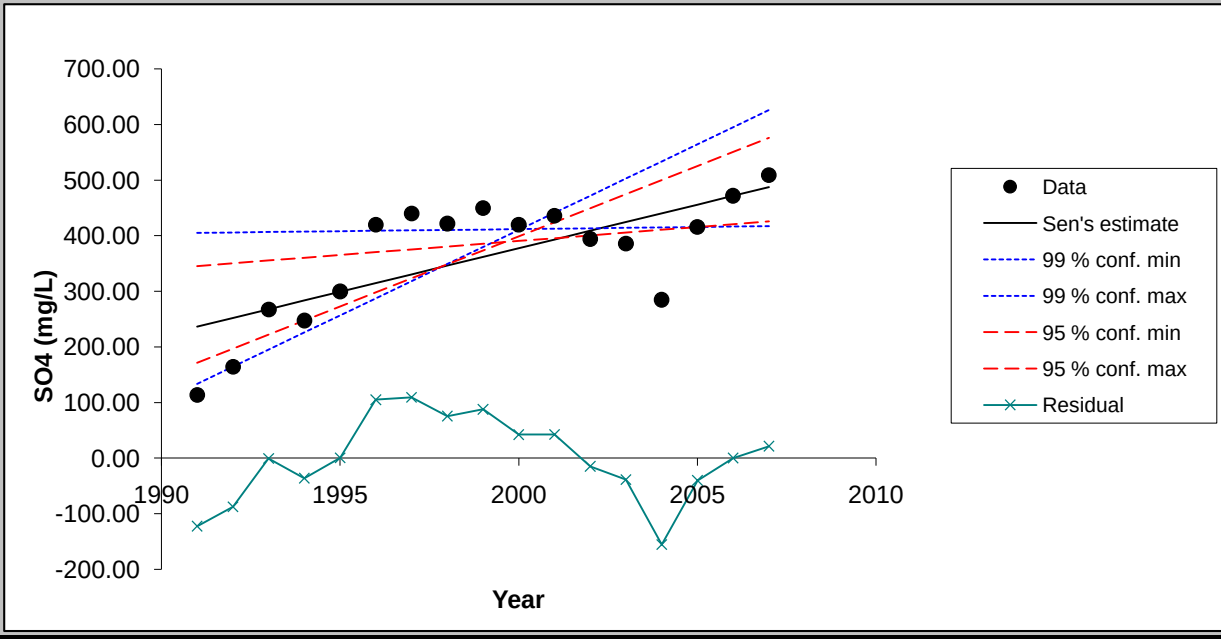

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	114.00	236.75	405.38	133.71	345.36	171.61	-122.75
1992	164.50	252.43	406.14	164.50	350.40	196.91	-87.93
1993	267.50	268.11	406.89	195.29	355.45	222.20	-0.61
1994	247.50	283.80	407.65	226.07	360.50	247.50	-36.30
1995	300.00	299.48	408.41	256.86	365.54	272.80	0.52
1996	420.00	315.16	409.17	287.64	370.59	298.09	104.84
1997	440.00	330.85	409.93	318.43	375.63	323.39	109.15
1998	422.00	346.53	410.69	349.22	380.68	348.69	75.47
1999	450.00	362.22	411.45	380.00	385.72	373.98	87.78
2000	420.00	377.90	412.21	410.79	390.77	399.28	42.10
2001	436.00	393.58	412.96	441.58	395.82	424.58	42.42
2002	394.26	409.27	413.72	472.36	400.86	449.87	-15.01
2003	386.00	424.95	414.48	503.15	405.91	475.17	-38.95
2004	285.00	440.63	415.24	533.93	410.95	500.47	-155.63
2005	416.00	456.32	416.00	564.72	416.00	525.76	-40.32
2006	472.00	472.00	416.76	595.51	421.05	551.06	0.00
2007	509.00	487.68	417.52	626.29	426.09	576.36	21.32

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-16 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.626	4.1	0.078	5.2	0.09	46		150
1992	0.614	3.49	0.0681	5.28	0.423	38.4	0.0349	137.5
1993	0.651	3.46	0.05415	7.41	0.4065	50.45	0.02145	198.5
1994	0.6535	3.52	0.0276	6.57	0.232	45.2	0.01375	163
1995	0.653	3.7	0.017	5.8	0.2	40	0.016	170
1996	0.627	3.4	0.008	6.6	0.3	45	0.017	170
1997	0.6	3.6	0.001	7.5	0.26	47	0.014	200
1998	0.6	2.7	0.0005	6.1	0.199	45	0.012	260
1999	0.6	2.8	0.0005	6	0.25	34	0.01	180
2000	0.59	2.8	0.0005	4.9	0.25	48	0.011	180
2001	0.508	2.5	0.005	5.08	0.253	39	0.005	147
2002	0.481	2.508	0.03	4.54	0.3603	35.878	0.0148	137.075
2003	0.462	1.81	0.001	4.71	0.246	46.2	0.019	156
2004	0.445	2.1	0.001	4.36	0.241	39.9	0.0246	138
2005	0.476	2.08	0.002	5.86	0.252	63.8	0.0193	181
2006	0.49	2.3	0.002	6.91	0.209	87.6	0.012	190
2007	0.513	2.16	0.002	6.38	0.0566	78.1	0.0216	161

TREND STATISTICS

TW-16 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-3.64	***	-0.013	-0.019	-0.004	-0.018	-0.009	0.676	0.716	0.626	0.707	0.652
F (mg/L)	*1991*	*2007*	*17*		-3.88	***	-0.122	-0.163	-0.078	-0.150	-0.090	3.85	4.22	3.47	4.10	3.60
Mn (mg/L)	*1991*	*2007*	*17*		-2.36	*	-0.002	-0.007	0.000	-0.005	0.000	0.030	0.073	0.002	0.065	0.002
Nitrate (mg/L)	*1991*	*2007*	*17*		-0.87		-0.056	-0.256	0.120	-0.204	0.079	6.45	7.78	5.11	7.18	5.20
Se (mg/L)	*1991*	*2007*	*17*		-1.15		-0.0037	-0.0190	0.0071	-0.0153	0.0030	0.2837	0.4206	0.1816	0.3874	0.2230
Cl (mg/L)	*1991*	*2007*	*17*		1.07		0.61	-0.74	3.06	-0.41	2.47	41.94	49.47	27.74	47.04	30.11
Mo (mg/L)	*1992*	*2007*	*16*		-0.23		-0.0002	-0.0019	0.0010	-0.0014	0.0007	0.0167	0.0270	0.0059	0.0242	0.0102
SO4 (mg/L)	*1991*	*2007*	*17*		0.12		0.10	-4.62	3.80	-3.06	2.79	169.48	207.74	145.77	192.75	150.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.64
Signific.	***
Q	-1.27E-02
Qmin99	-1.93E-02
Qmax99	-4.28E-03
Qmin95	-1.77E-02
Qmax95	-8.70E-03
B	6.76E-01
Bmin99	7.16E-01
Bmax99	6.26E-01
Bmin95	7.07E-01
Bmax95	6.52E-01

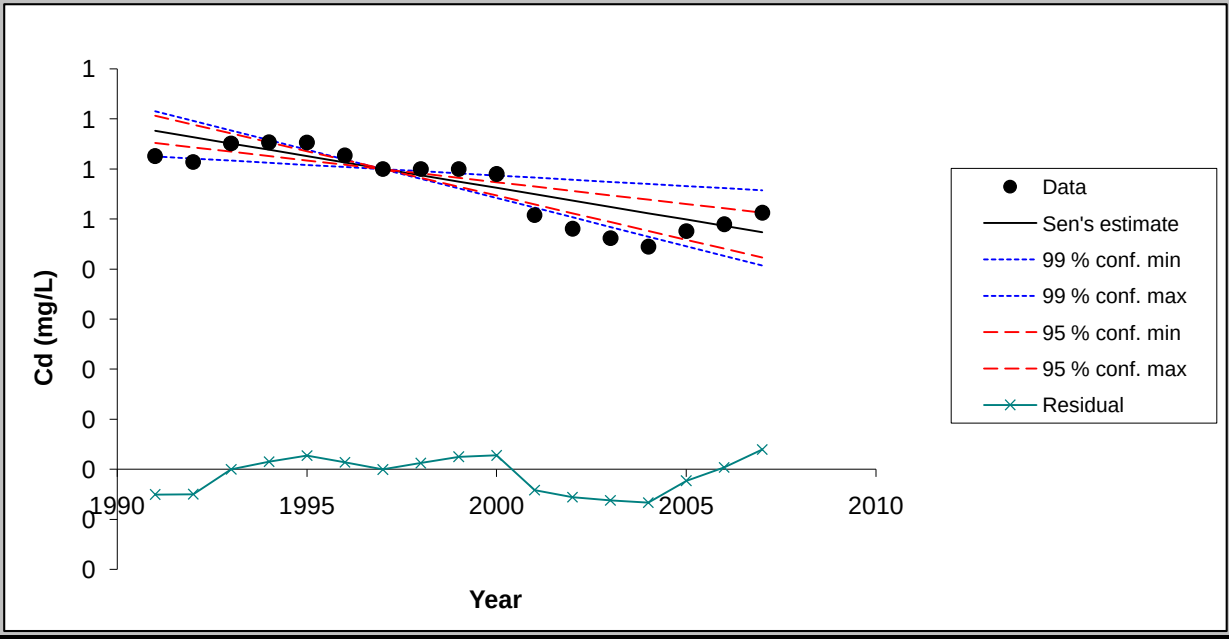

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.63	0.68	0.72	0.63	0.71	0.65	-0.05
1992	0.61	0.66	0.70	0.62	0.69	0.64	-0.05
1993	0.65	0.65	0.68	0.62	0.67	0.63	0.00
1994	0.65	0.64	0.66	0.61	0.65	0.63	0.02
1995	0.65	0.63	0.64	0.61	0.64	0.62	0.03
1996	0.63	0.61	0.62	0.60	0.62	0.61	0.01
1997	0.60	0.60	0.60	0.60	0.60	0.60	0.00
1998	0.60	0.59	0.58	0.60	0.58	0.59	0.01
1999	0.60	0.57	0.56	0.59	0.56	0.58	0.03
2000	0.59	0.56	0.54	0.59	0.55	0.57	0.03
2001	0.51	0.55	0.52	0.58	0.53	0.57	-0.04
2002	0.48	0.54	0.50	0.58	0.51	0.56	-0.06
2003	0.46	0.52	0.48	0.57	0.49	0.55	-0.06
2004	0.45	0.51	0.47	0.57	0.48	0.54	-0.07
2005	0.48	0.50	0.45	0.57	0.46	0.53	-0.02
2006	0.49	0.49	0.43	0.56	0.44	0.52	0.00
2007	0.51	0.47	0.41	0.56	0.42	0.51	0.04

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.88
Signific.	***
Q	-1.22E-01
Qmin99	-1.63E-01
Qmax99	-7.79E-02
Qmin95	-1.50E-01
Qmax95	-8.97E-02
B	3.85E+00
Bmin99	4.22E+00
Bmax99	3.47E+00
Bmin95	4.10E+00
Bmax95	3.60E+00

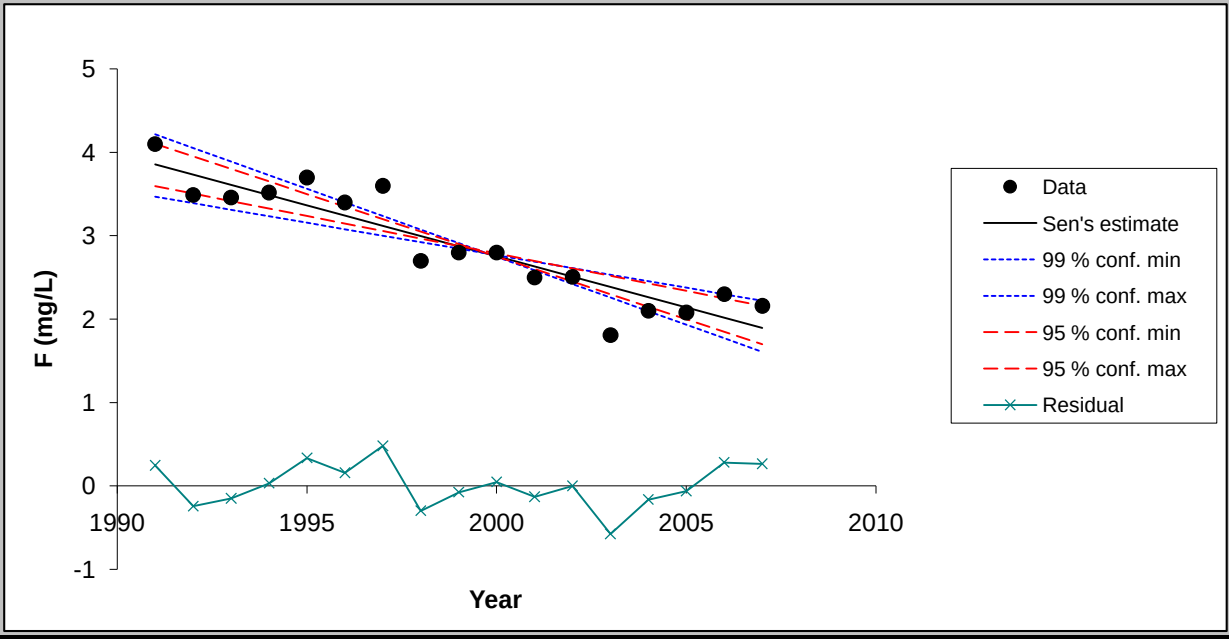

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	4.10	3.85	4.22	3.47	4.10	3.60	0.25
1992	3.49	3.73	4.05	3.39	3.95	3.51	-0.24
1993	3.46	3.61	3.89	3.31	3.80	3.42	-0.15
1994	3.52	3.49	3.73	3.24	3.65	3.33	0.03
1995	3.70	3.37	3.56	3.16	3.50	3.24	0.33
1996	3.40	3.24	3.40	3.08	3.35	3.15	0.16
1997	3.60	3.12	3.24	3.00	3.20	3.06	0.48
1998	2.70	3.00	3.07	2.92	3.05	2.97	-0.30
1999	2.80	2.88	2.91	2.85	2.90	2.88	-0.08
2000	2.80	2.75	2.75	2.77	2.75	2.79	0.05
2001	2.50	2.63	2.58	2.69	2.60	2.70	-0.13
2002	2.51	2.51	2.42	2.61	2.45	2.61	0.00
2003	1.81	2.39	2.26	2.53	2.30	2.52	-0.58
2004	2.10	2.26	2.10	2.46	2.15	2.43	-0.16
2005	2.08	2.14	1.93	2.38	2.00	2.34	-0.06
2006	2.30	2.02	1.77	2.30	1.85	2.25	0.28
2007	2.16	1.90	1.61	2.22	1.70	2.16	0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.36
Signific.	*
Q	-2.23E-03
Qmin99	-6.79E-03
Qmax99	6.05E-06
Qmin95	-5.47E-03
Qmax95	-2.14E-11
B	3.00E-02
Bmin99	7.29E-02
Bmax99	1.92E-03
Bmin95	6.51E-02
Bmax95	2.00E-03

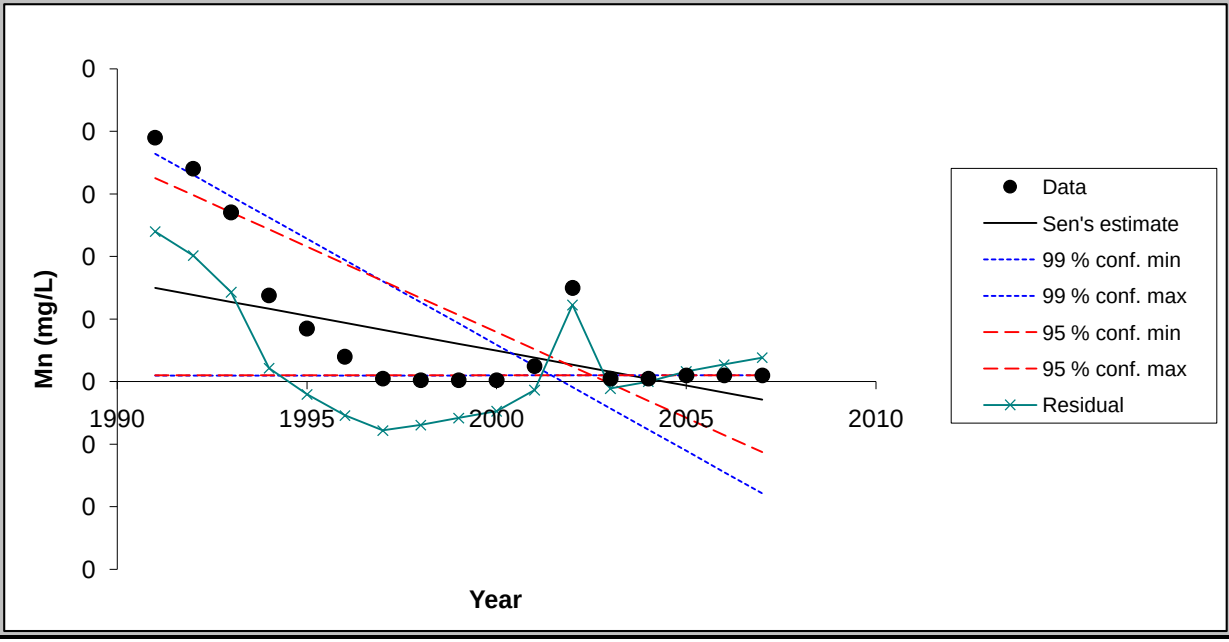

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.08	0.03	0.07	0.00	0.07	0.00	0.05
1992	0.07	0.03	0.07	0.00	0.06	0.00	0.04
1993	0.05	0.03	0.06	0.00	0.05	0.00	0.03
1994	0.03	0.02	0.05	0.00	0.05	0.00	0.00
1995	0.02	0.02	0.05	0.00	0.04	0.00	0.00
1996	0.01	0.02	0.04	0.00	0.04	0.00	-0.01
1997	0.00	0.02	0.03	0.00	0.03	0.00	-0.02
1998	0.00	0.01	0.03	0.00	0.03	0.00	-0.01
1999	0.00	0.01	0.02	0.00	0.02	0.00	-0.01
2000	0.00	0.01	0.01	0.00	0.02	0.00	-0.01
2001	0.00	0.01	0.00	0.00	0.01	0.00	0.00
2002	0.03	0.01	0.00	0.00	0.00	0.00	0.02
2003	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
2004	0.00	0.00	-0.02	0.00	-0.01	0.00	0.00
2005	0.00	0.00	-0.02	0.00	-0.01	0.00	0.00
2006	0.00	0.00	-0.03	0.00	-0.02	0.00	0.01
2007	0.00	-0.01	-0.04	0.00	-0.02	0.00	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.87
Signific.	
Q	-5.59E-02
Qmin99	-2.56E-01
Qmax99	1.20E-01
Qmin95	-2.04E-01
Qmax95	7.87E-02
B	6.45E+00
Bmin99	7.78E+00
Bmax99	5.11E+00
Bmin95	7.18E+00
Bmax95	5.20E+00

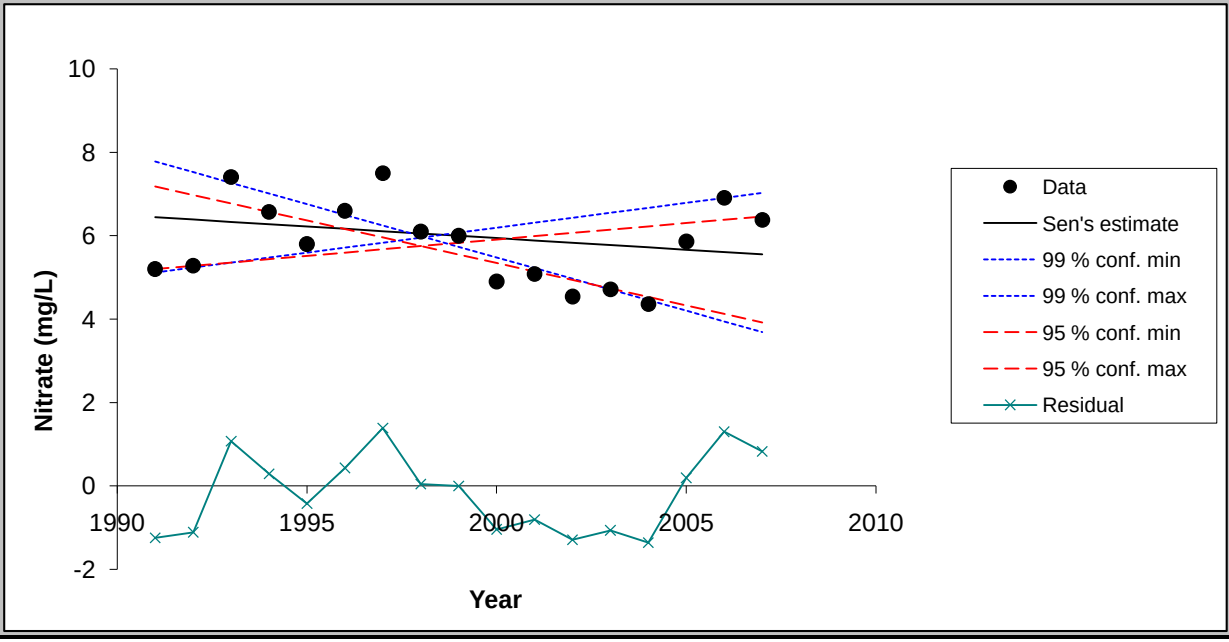

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.20	6.45	7.78	5.11	7.18	5.20	-1.25
1992	5.28	6.39	7.53	5.23	6.98	5.28	-1.11
1993	7.41	6.34	7.27	5.35	6.77	5.36	1.07
1994	6.57	6.28	7.01	5.47	6.57	5.44	0.29
1995	5.80	6.22	6.76	5.59	6.37	5.52	-0.42
1996	6.60	6.17	6.50	5.71	6.16	5.59	0.43
1997	7.50	6.11	6.25	5.83	5.96	5.67	1.39
1998	6.10	6.06	5.99	5.95	5.75	5.75	0.04
1999	6.00	6.00	5.73	6.07	5.55	5.83	0.00
2000	4.90	5.94	5.48	6.19	5.35	5.91	-1.04
2001	5.08	5.89	5.22	6.31	5.14	5.99	-0.81
2002	4.54	5.83	4.97	6.43	4.94	6.07	-1.29
2003	4.71	5.78	4.71	6.55	4.73	6.15	-1.07
2004	4.36	5.72	4.45	6.67	4.53	6.22	-1.36
2005	5.86	5.66	4.20	6.79	4.33	6.30	0.20
2006	6.91	5.61	3.94	6.91	4.12	6.38	1.30
2007	6.38	5.55	3.69	7.03	3.92	6.46	0.83

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.15
Signific.	
Q	-3.75E-03
Qmin99	-1.90E-02
Qmax99	7.14E-03
Qmin95	-1.53E-02
Qmax95	3.00E-03
B	2.84E-01
Bmin99	4.21E-01
Bmax99	1.82E-01
Bmin95	3.87E-01
Bmax95	2.23E-01

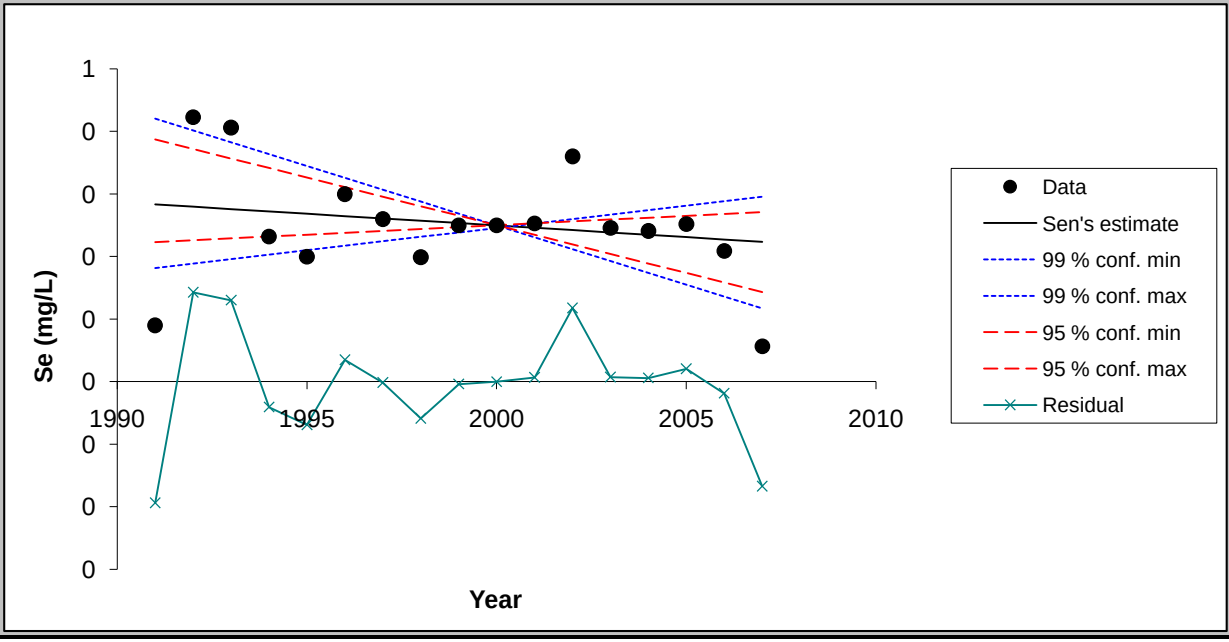

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.09	0.28	0.42	0.18	0.39	0.22	-0.19
1992	0.42	0.28	0.40	0.19	0.37	0.23	0.14
1993	0.41	0.28	0.38	0.20	0.36	0.23	0.13
1994	0.23	0.27	0.36	0.20	0.34	0.23	-0.04
1995	0.20	0.27	0.34	0.21	0.33	0.23	-0.07
1996	0.30	0.26	0.33	0.22	0.31	0.24	0.04
1997	0.26	0.26	0.31	0.22	0.30	0.24	0.00
1998	0.20	0.26	0.29	0.23	0.28	0.24	-0.06
1999	0.25	0.25	0.27	0.24	0.27	0.25	0.00
2000	0.25	0.25	0.25	0.25	0.25	0.25	0.00
2001	0.25	0.25	0.23	0.25	0.23	0.25	0.01
2002	0.36	0.24	0.21	0.26	0.22	0.26	0.12
2003	0.25	0.24	0.19	0.27	0.20	0.26	0.01
2004	0.24	0.24	0.17	0.27	0.19	0.26	0.01
2005	0.25	0.23	0.16	0.28	0.17	0.26	0.02
2006	0.21	0.23	0.14	0.29	0.16	0.27	-0.02
2007	0.06	0.22	0.12	0.30	0.14	0.27	-0.17

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.07
Signific.	
Q	6.13E-01
Qmin99	-7.36E-01
Qmax99	3.06E+00
Qmin95	-4.08E-01
Qmax95	2.47E+00
B	4.19E+01
Bmin99	4.95E+01
Bmax99	2.77E+01
Bmin95	4.70E+01
Bmax95	3.01E+01

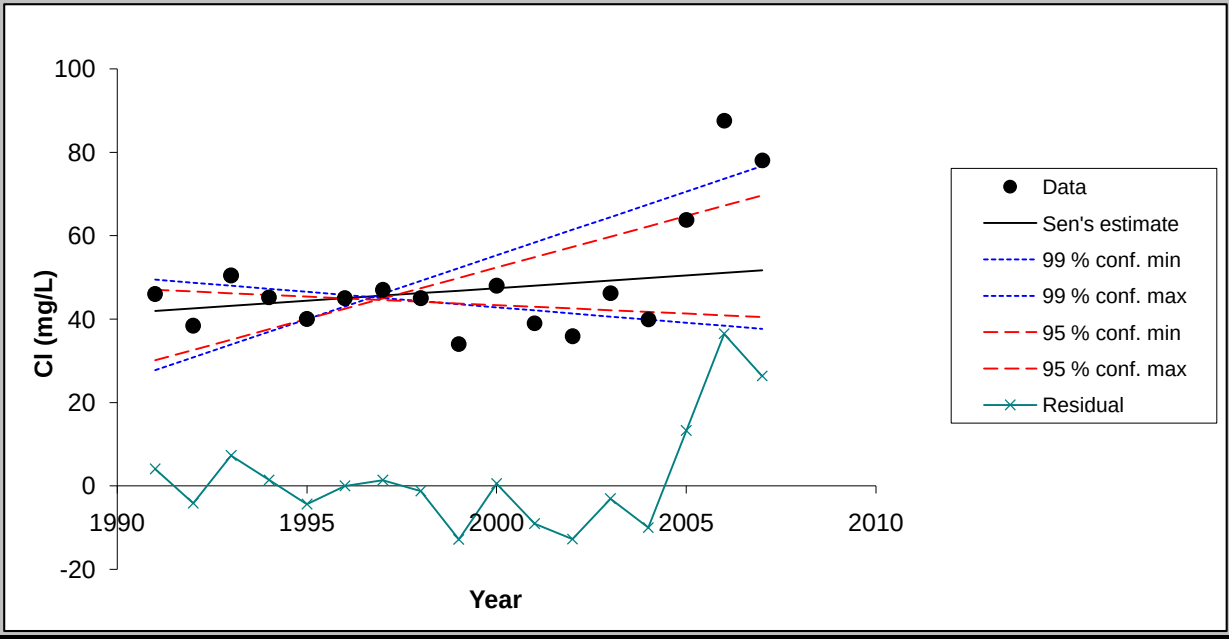

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	46.00	41.94	49.47	27.74	47.04	30.11	4.06
1992	38.40	42.55	48.73	30.81	46.63	32.58	-4.15
1993	50.45	43.16	48.00	33.87	46.22	35.06	7.29
1994	45.20	43.77	47.26	36.94	45.82	37.53	1.43
1995	40.00	44.39	46.53	40.00	45.41	40.00	-4.39
1996	45.00	45.00	45.79	43.06	45.00	42.47	0.00
1997	47.00	45.61	45.05	46.13	44.59	44.94	1.39
1998	45.00	46.23	44.32	49.19	44.18	47.42	-1.23
1999	34.00	46.84	43.58	52.26	43.78	49.89	-12.84
2000	48.00	47.45	42.84	55.32	43.37	52.36	0.55
2001	39.00	48.06	42.11	58.39	42.96	54.83	-9.06
2002	35.88	48.68	41.37	61.45	42.55	57.31	-12.80
2003	46.20	49.29	40.64	64.52	42.15	59.78	-3.09
2004	39.90	49.90	39.90	67.58	41.74	62.25	-10.00
2005	63.80	50.52	39.16	70.64	41.33	64.72	13.28
2006	87.60	51.13	38.43	73.71	40.92	67.20	36.47
2007	78.10	51.74	37.69	76.77	40.51	69.67	26.36

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.23
Signific.	
Q	-1.75E-04
Qmin99	-1.85E-03
Qmax99	1.03E-03
Qmin95	-1.42E-03
Qmax95	6.91E-04
B	1.67E-02
Bmin99	2.70E-02
Bmax99	5.94E-03
Bmin95	2.42E-02
Bmax95	1.02E-02

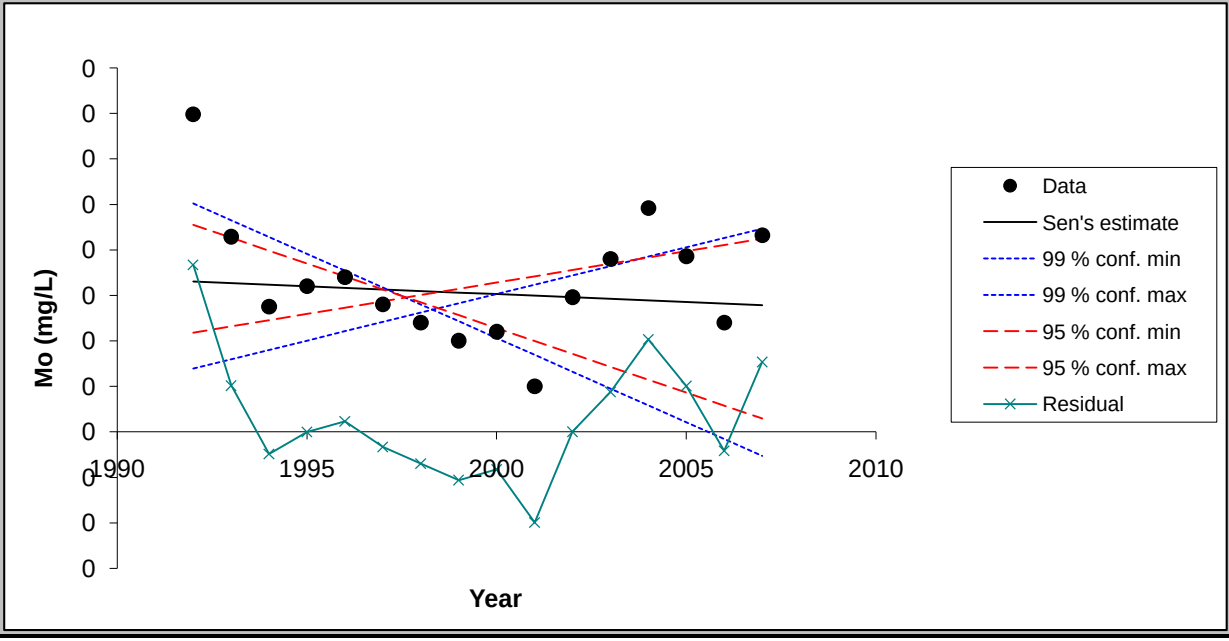

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.02	0.03	0.01	0.02	0.01	0.02
1993	0.02	0.02	0.02	0.01	0.02	0.01	0.01
1994	0.01	0.02	0.02	0.01	0.02	0.01	0.00
1995	0.02	0.02	0.02	0.01	0.02	0.01	0.00
1996	0.02	0.02	0.02	0.01	0.02	0.01	0.00
1997	0.01	0.02	0.02	0.01	0.02	0.01	0.00
1998	0.01	0.02	0.01	0.01	0.01	0.02	0.00
1999	0.01	0.02	0.01	0.01	0.01	0.02	-0.01
2000	0.01	0.02	0.01	0.02	0.01	0.02	0.00
2001	0.00	0.01	0.01	0.02	0.01	0.02	-0.01
2002	0.01	0.01	0.01	0.02	0.01	0.02	0.00
2003	0.02	0.01	0.00	0.02	0.01	0.02	0.00
2004	0.02	0.01	0.00	0.02	0.01	0.02	0.01
2005	0.02	0.01	0.00	0.02	0.00	0.02	0.01
2006	0.01	0.01	0.00	0.02	0.00	0.02	0.00
2007	0.02	0.01	0.00	0.02	0.00	0.02	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-16 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.12
Signific.	
Q	1.04E-01
Qmin99	-4.62E+00
Qmax99	3.80E+00
Qmin95	-3.06E+00
Qmax95	2.79E+00
B	1.69E+02
Bmin99	2.08E+02
Bmax99	1.46E+02
Bmin95	1.93E+02
Bmax95	1.50E+02

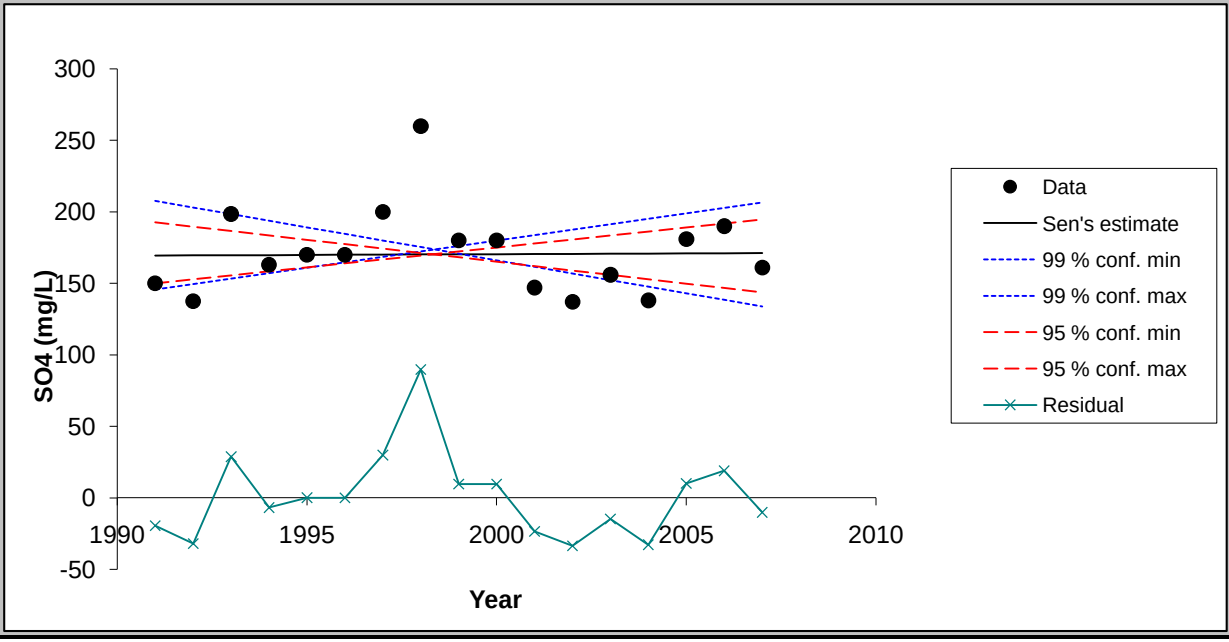

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	150.00	169.48	207.74	145.77	192.75	150.00	-19.48
1992	137.50	169.58	203.12	149.57	189.69	152.79	-32.08
1993	198.50	169.69	198.50	153.37	186.63	155.58	28.81
1994	163.00	169.79	193.88	157.18	183.56	158.38	-6.79
1995	170.00	169.90	189.26	160.98	180.50	161.17	0.10
1996	170.00	170.00	184.63	164.79	177.44	163.96	0.00
1997	200.00	170.10	180.01	168.59	174.38	166.75	29.90
1998	260.00	170.21	175.39	172.39	171.31	169.54	89.79
1999	180.00	170.31	170.77	176.20	168.25	172.33	9.69
2000	180.00	170.42	166.14	180.00	165.19	175.13	9.58
2001	147.00	170.52	161.52	183.80	162.13	177.92	-23.52
2002	137.07	170.63	156.90	187.61	159.06	180.71	-33.55
2003	156.00	170.73	152.28	191.41	156.00	183.50	-14.73
2004	138.00	170.83	147.66	195.21	152.94	186.29	-32.83
2005	181.00	170.94	143.03	199.02	149.87	189.08	10.06
2006	190.00	171.04	138.41	202.82	146.81	191.88	18.96
2007	161.00	171.15	133.79	206.63	143.75	194.67	-10.15

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-17 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	16	16
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991								
1992	0.0036	2.715	1.365	0.08	0.0061	220.5	0.0554	238.5
1993	0.00292	2.485	1.51	0.08	0.00465	209	0.0663	250
1994	0.0053	2.455	1.56	0.0625	0.00475	210	0.058	221
1995	0.0039	2.9	1.62	0.005	0.01	180	0.06	240
1996	0.0031	2.6	1.65	0.005	0.005	190	0.06	210
1997	0.0029	2.7	1.62	0.005	0.007	180	0.05	210
1998	0.0025	2.2	1.82	0.031	0.007	160	0.049	220
1999	0.003	2.4	1.91	0.005	0.002	140	0.048	200
2000	0.0034	2.2	1.85	0.033	0.001	140	0.045	210
2001	0.003	2.3	2.15	0.025	0.009	153	0.02	186
2002	0.0051	1.615	2.484	0.025	0.009	145.767	0.049	193.586
2003	0.0026	2.205	2.235	0.01	0.008	150.5	0.04225	180
2004	0.0045	1.62	2.35	0.01	0.0015	143	0.0549	180
2005	0.0035	1.63	2.54	0.01	0.0015	138	0.0429	160
2006	0.0046	2.4	2.52	0.09	0.003	116	0.028	142
2007	0.00075	2.39	2.55	0.01	0.0012	125	0.044	155

TREND STATISTICS

TW-17 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		-0.27		0.0000	-0.0002	0.0002	-0.0002	0.0001	0.0034	0.0050	0.0021	0.0047	0.0026
F (mg/L)	*1992*	*2007*	*16*		-2.52	*	-0.05	-0.11	0.00	-0.10	-0.01	2.76	3.21	2.39	3.09	2.46
Mn (mg/L)	*1992*	*2007*	*16*		4.87	***	0.082	0.067	0.100	0.073	0.092	1.28	1.38	1.13	1.35	1.19
Nitrate (mg/L)	*1992*	*2007*	*16*		-0.41		-0.001	-0.006	0.001	-0.005	0.001	0.03	0.09	0.01	0.08	0.01
Se (mg/L)	*1992*	*2007*	*16*		-1.17		-0.0002	-0.0008	0.0003	-0.0006	0.0001	0.0063	0.0121	0.0039	0.0106	0.0043
Cl (mg/L)	*1992*	*2007*	*16*		-4.20	***	-6.365	-8.016	-3.939	-7.458	-4.729	219.96	231.62	193.68	227.69	202.43
Mo (mg/L)	*1992*	*2007*	*16*		-3.11	**	-0.001	-0.003	0.000	-0.003	-0.001	0.06	0.07	0.05	0.07	0.06
SO4 (mg/L)	*1992*	*2007*	*16*		-4.48	***	-6.250	-8.098	-4.394	-7.500	-5.000	252.50	269.68	235.76	265.00	240.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.27
Signific.	
Q	-2.25E-05
Qmin99	-2.21E-04
Qmax99	1.60E-04
Qmin95	-1.78E-04
Qmax95	9.57E-05
B	3.41E-03
Bmin99	5.00E-03
Bmax99	2.08E-03
Bmin95	4.68E-03
Bmax95	2.58E-03

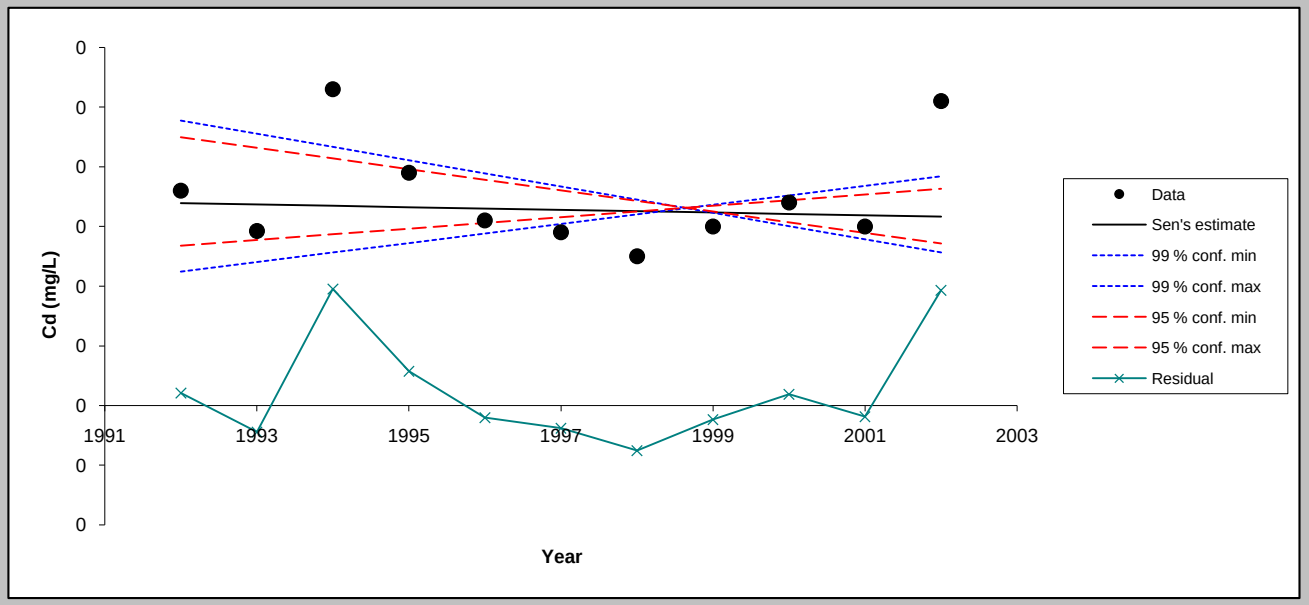

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-2.52
Signific.	*
Q	-4.62E-02
Qmin99	-1.12E-01
Qmax99	5.79E-04
Qmin95	-9.91E-02
Qmax95	-6.60E-03
B	2.76E+00
Bmin99	3.21E+00
Bmax99	2.39E+00
Bmin95	3.09E+00
Bmax95	2.46E+00

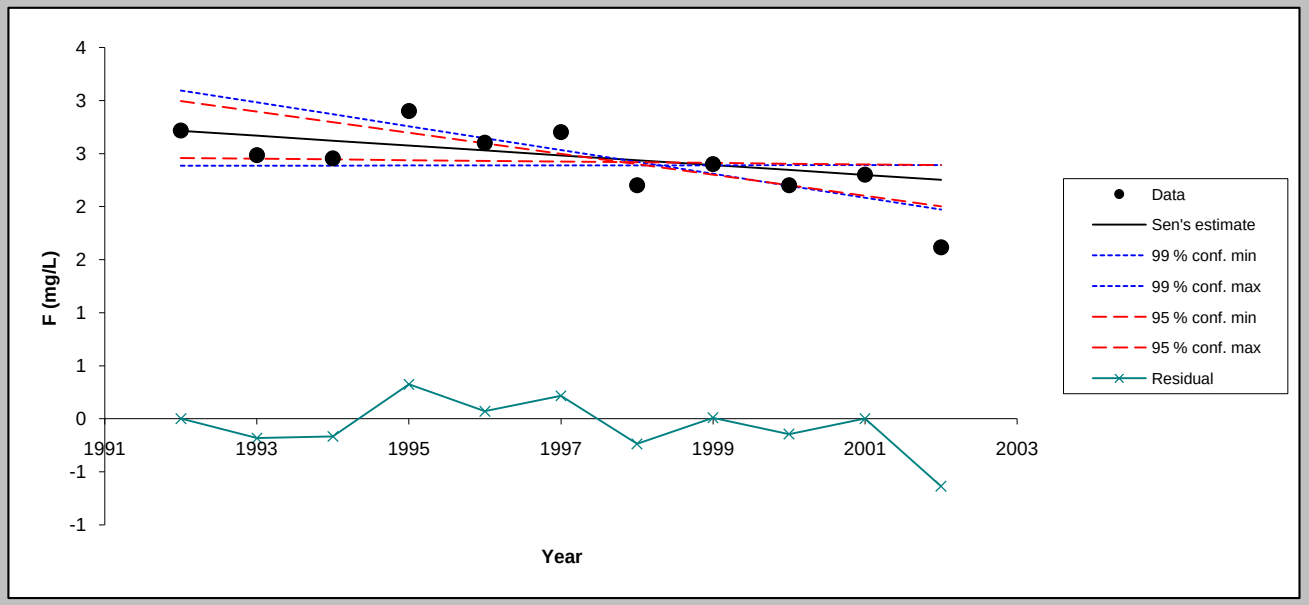

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	2.72	2.71	3.09	2.39	2.99	2.46	0.00
1993	2.49	2.67	2.98	2.39	2.90	2.45	-0.18
1994	2.45	2.62	2.87	2.39	2.80	2.44	-0.17
1995	2.90	2.58	2.76	2.39	2.70	2.44	0.32
1996	2.60	2.53	2.65	2.39	2.60	2.43	0.07
1997	2.70	2.48	2.53	2.39	2.50	2.42	0.22
1998	2.20	2.44	2.42	2.39	2.40	2.42	-0.24
1999	2.40	2.39	2.31	2.39	2.30	2.41	0.01
2000	2.20	2.34	2.20	2.39	2.20	2.40	-0.14
2001	2.30	2.30	2.08	2.39	2.10	2.40	0.00
2002	1.62	2.25	1.97	2.39	2.00	2.39	-0.64
2003	2.21	2.21	1.86	2.39	1.90	2.38	0.00
2004	1.62	2.16	1.75	2.39	1.81	2.38	-0.54
2005	1.63	2.11	1.63	2.39	1.71	2.37	-0.48
2006	2.40	2.07	1.52	2.39	1.61	2.36	0.33
2007	2.39	2.02	1.41	2.40	1.51	2.36	0.37

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	4.87
Signific.	***
Q	8.18E-02
Qmin99	6.67E-02
Qmax99	1.00E-01
Qmin95	7.29E-02
Qmax95	9.16E-02
B	1.28E+00
Bmin99	1.38E+00
Bmax99	1.13E+00
Bmin95	1.35E+00
Bmax95	1.19E+00

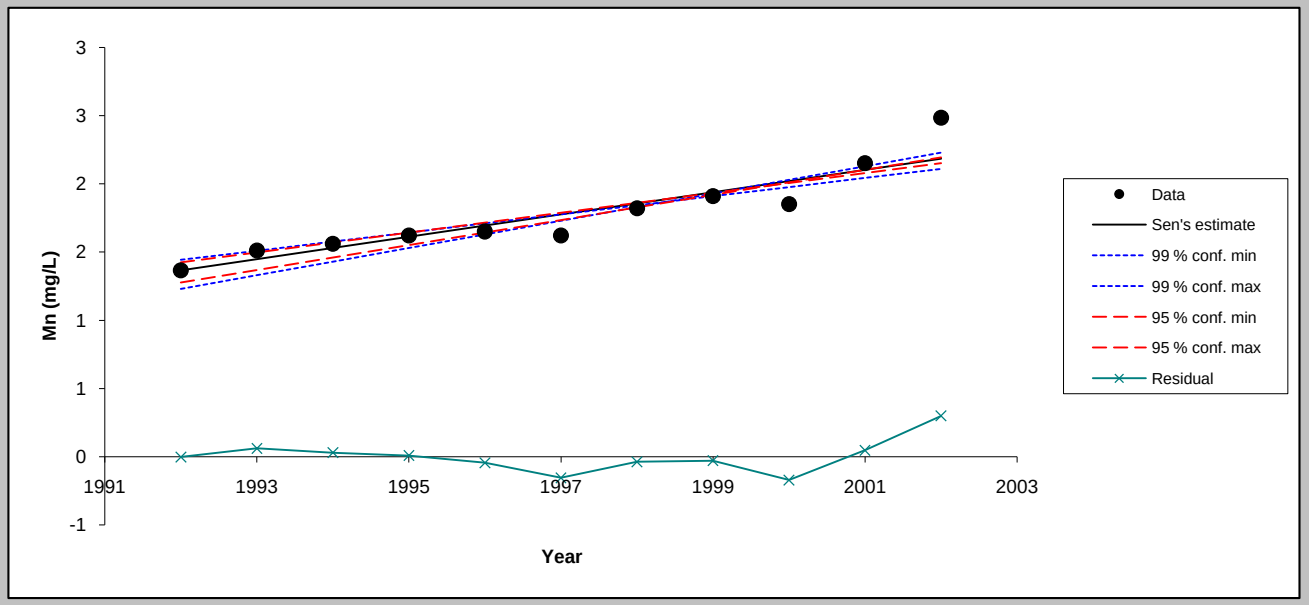

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	1.37	1.37	1.44	1.23	1.42	1.28	0.00
1993	1.51	1.45	1.51	1.33	1.50	1.37	0.06
1994	1.56	1.53	1.58	1.43	1.57	1.46	0.03
1995	1.62	1.61	1.64	1.53	1.64	1.55	0.01
1996	1.65	1.69	1.71	1.63	1.72	1.64	-0.04
1997	1.62	1.78	1.78	1.73	1.79	1.74	-0.16
1998	1.82	1.86	1.84	1.83	1.86	1.83	-0.04
1999	1.91	1.94	1.91	1.93	1.93	1.92	-0.03
2000	1.85	2.02	1.98	2.03	2.01	2.01	-0.17
2001	2.15	2.10	2.04	2.13	2.08	2.10	0.05
2002	2.48	2.18	2.11	2.23	2.15	2.19	0.30
2003	2.24	2.27	2.18	2.33	2.23	2.28	-0.03
2004	2.35	2.35	2.24	2.43	2.30	2.38	0.00
2005	2.54	2.43	2.31	2.53	2.37	2.47	0.11
2006	2.52	2.51	2.38	2.63	2.44	2.56	0.01
2007	2.55	2.59	2.44	2.73	2.52	2.65	-0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.41
Signific.	
Q	-7.50E-04
Qmin99	-5.93E-03
Qmax99	8.33E-04
Qmin95	-5.37E-03
Qmax95	6.25E-04
B	2.72E-02
Bmin99	8.51E-02
Bmax99	8.75E-03
Bmin95	7.93E-02
Bmax95	1.03E-02

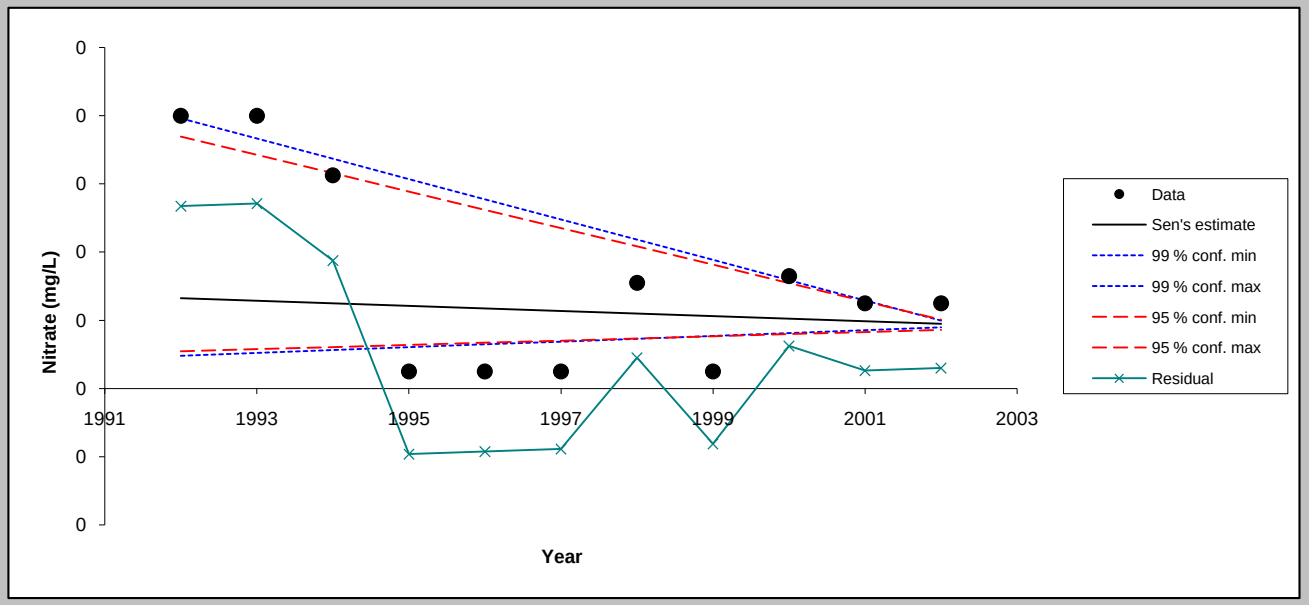

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.08	0.03	0.08	0.01	0.07	0.01	0.05
1993	0.08	0.03	0.07	0.01	0.07	0.01	0.05
1994	0.06	0.02	0.07	0.01	0.06	0.01	0.04
1995	0.00	0.02	0.06	0.01	0.06	0.01	-0.02
1996	0.00	0.02	0.06	0.01	0.05	0.01	-0.02
1997	0.00	0.02	0.05	0.01	0.05	0.01	-0.02
1998	0.03	0.02	0.04	0.01	0.04	0.01	0.01
1999	0.00	0.02	0.04	0.02	0.04	0.02	-0.02
2000	0.03	0.02	0.03	0.02	0.03	0.02	0.01
2001	0.03	0.02	0.03	0.02	0.03	0.02	0.01
2002	0.03	0.02	0.02	0.02	0.02	0.02	0.01
2003	0.01	0.02	0.01	0.02	0.01	0.02	-0.01
2004	0.01	0.02	0.01	0.02	0.01	0.02	-0.01
2005	0.01	0.02	0.00	0.02	0.00	0.02	-0.01
2006	0.09	0.02	0.00	0.02	0.00	0.02	0.07
2007	0.01	0.02	-0.01	0.02	-0.01	0.02	-0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.17
Signific.	
Q	-2.48E-04
Qmin99	-7.86E-04
Qmax99	3.28E-04
Qmin95	-6.33E-04
Qmax95	1.48E-04
B	6.29E-03
Bmin99	1.21E-02
Bmax99	3.88E-03
Bmin95	1.06E-02
Bmax95	4.33E-03

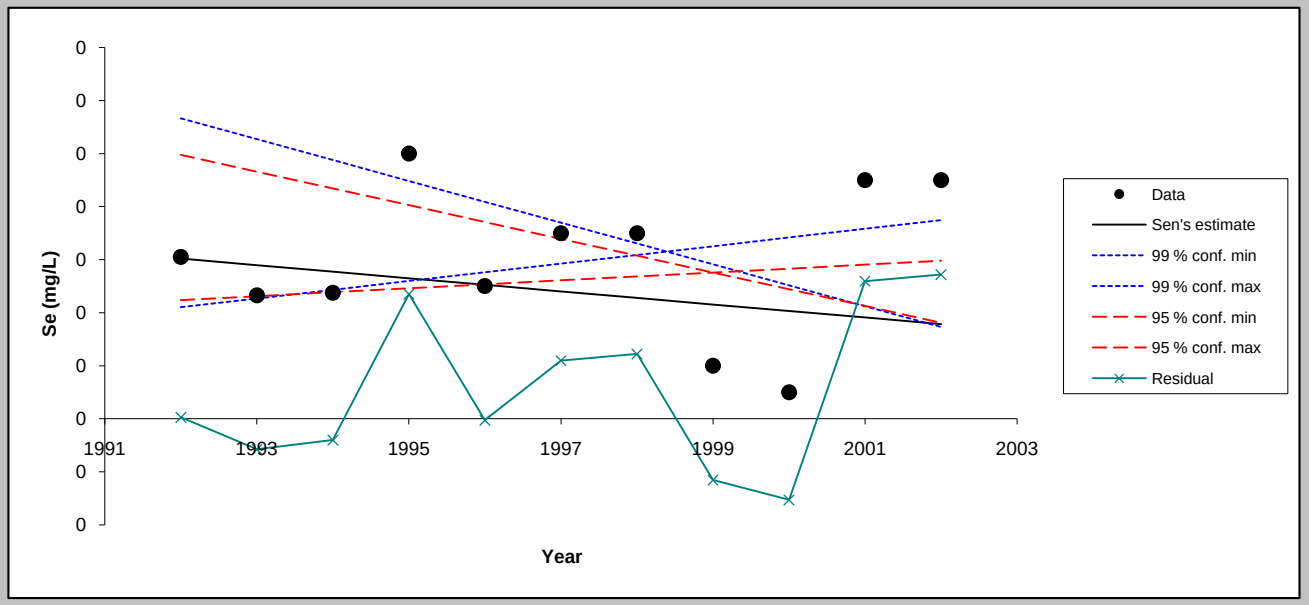

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.01	0.01	0.01	0.00	0.01	0.00	0.00
1993	0.00	0.01	0.01	0.00	0.01	0.00	0.00
1994	0.00	0.01	0.01	0.00	0.01	0.00	0.00
1995	0.01	0.01	0.01	0.01	0.01	0.00	0.00
1996	0.00	0.01	0.01	0.01	0.01	0.01	0.00
1997	0.01	0.00	0.01	0.01	0.01	0.01	0.00
1998	0.01	0.00	0.01	0.01	0.01	0.01	0.00
1999	0.00	0.00	0.01	0.01	0.01	0.01	0.00
2000	0.00	0.00	0.01	0.01	0.00	0.01	0.00
2001	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2002	0.01	0.00	0.00	0.01	0.00	0.01	0.01
2003	0.01	0.00	0.00	0.01	0.00	0.01	0.00
2004	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2005	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2006	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2007	0.00	0.00	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-4.20
Signific.	***
Q	-6.37E+00
Qmin99	-8.02E+00
Qmax99	-3.94E+00
Qmin95	-7.46E+00
Qmax95	-4.73E+00
B	2.20E+02
Bmin99	2.32E+02
Bmax99	1.94E+02
Bmin95	2.28E+02
Bmax95	2.02E+02

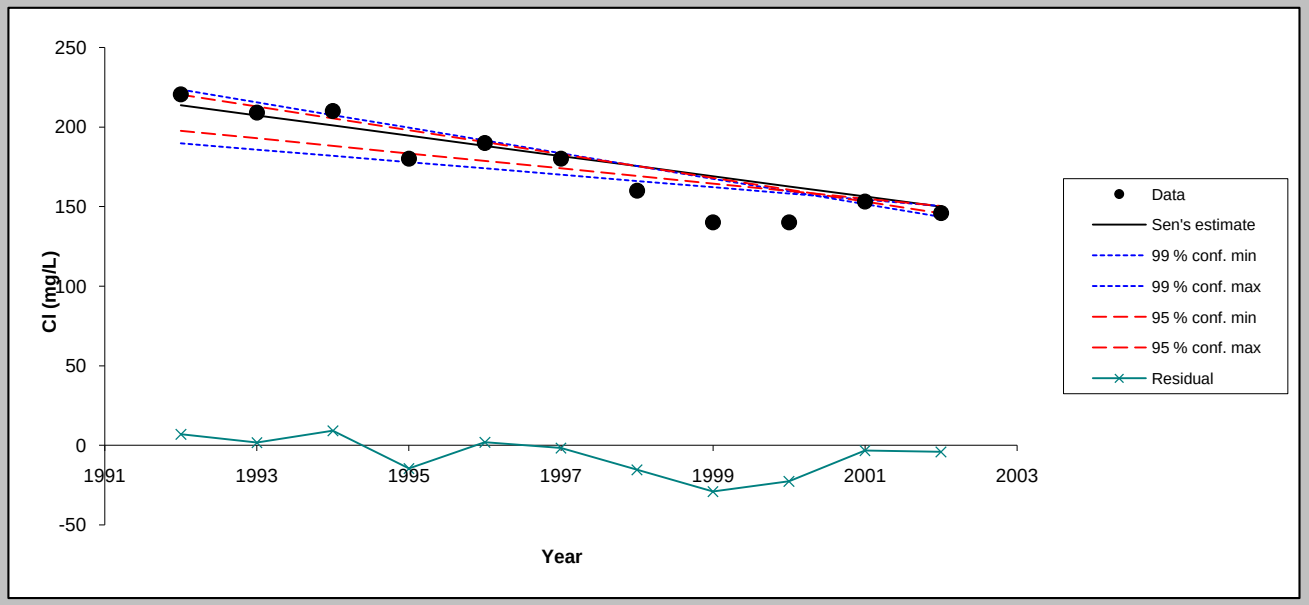

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	220.50	213.60	223.60	189.74	220.23	197.70	6.90
1993	209.00	207.23	215.59	185.80	212.78	192.97	1.77
1994	210.00	200.87	207.57	181.86	205.32	188.24	9.13
1995	180.00	194.50	199.56	177.92	197.86	183.52	-14.50
1996	190.00	188.13	191.54	173.98	190.40	178.79	1.87
1997	180.00	181.77	183.52	170.04	182.94	174.06	-1.77
1998	160.00	175.40	175.51	166.10	175.49	169.33	-15.40
1999	140.00	169.04	167.49	162.16	168.03	164.60	-29.04
2000	140.00	162.67	159.48	158.23	160.57	159.87	-22.67
2001	153.00	156.31	151.46	154.29	153.11	155.14	-3.31
2002	145.77	149.94	143.44	150.35	145.65	150.41	-4.18
2003	150.50	143.58	135.43	146.41	138.20	145.69	6.92
2004	143.00	137.21	127.41	142.47	130.74	140.96	5.79
2005	138.00	130.85	119.40	138.53	123.28	136.23	7.15
2006	116.00	124.48	111.38	134.59	115.82	131.50	-8.48
2007	125.00	118.12	103.36	130.65	108.36	126.77	6.88

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.11
Signific.	**
Q	-1.45E-03
Qmin99	-3.00E-03
Qmax99	-4.56E-04
Qmin95	-2.60E-03
Qmax95	-7.85E-04
B	6.10E-02
Bmin99	7.21E-02
Bmax99	5.25E-02
Bmin95	6.96E-02
Bmax95	5.54E-02

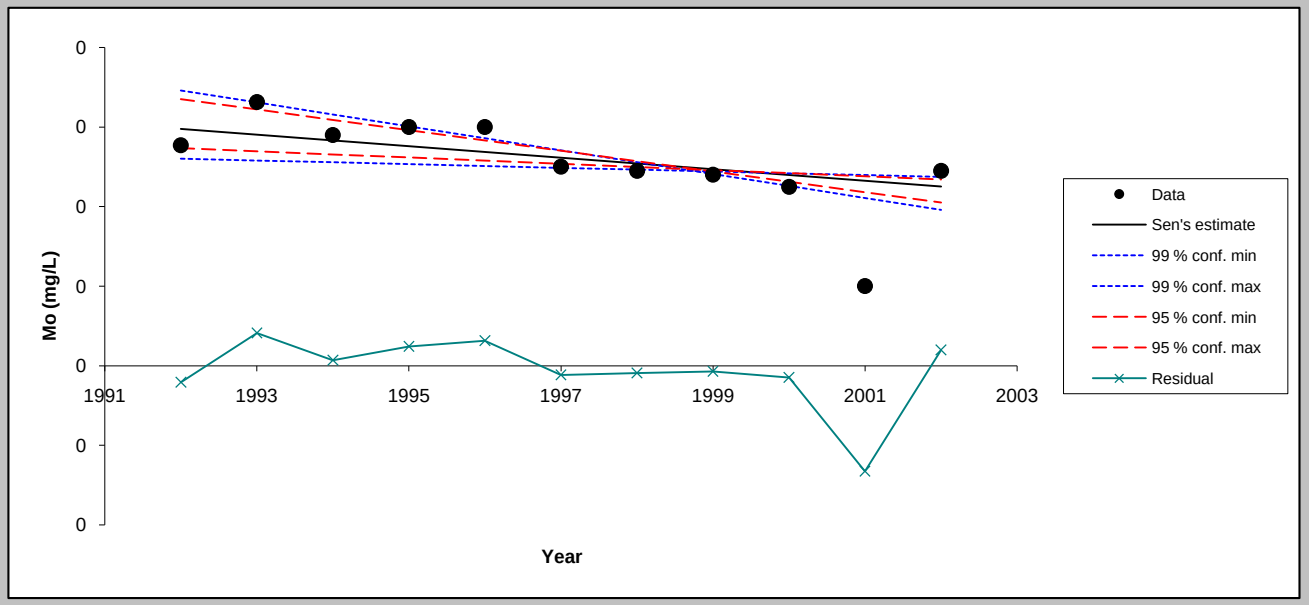

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.06	0.06	0.07	0.05	0.07	0.05	0.00
1993	0.07	0.06	0.07	0.05	0.06	0.05	0.01
1994	0.06	0.06	0.06	0.05	0.06	0.05	0.00
1995	0.06	0.06	0.06	0.05	0.06	0.05	0.00
1996	0.06	0.05	0.06	0.05	0.06	0.05	0.01
1997	0.05	0.05	0.05	0.05	0.05	0.05	0.00
1998	0.05	0.05	0.05	0.05	0.05	0.05	0.00
1999	0.05	0.05	0.05	0.05	0.05	0.05	0.00
2000	0.05	0.05	0.05	0.05	0.05	0.05	0.00
2001	0.02	0.05	0.04	0.05	0.04	0.05	-0.03
2002	0.05	0.05	0.04	0.05	0.04	0.05	0.00
2003	0.04	0.04	0.04	0.05	0.04	0.05	0.00
2004	0.05	0.04	0.03	0.05	0.04	0.05	0.01
2005	0.04	0.04	0.03	0.05	0.03	0.04	0.00
2006	0.03	0.04	0.03	0.05	0.03	0.04	-0.01
2007	0.04	0.04	0.02	0.05	0.03	0.04	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-4.48
Signific.	***
Q	-6.25E+00
Qmin99	-8.10E+00
Qmax99	-4.39E+00
Qmin95	-7.50E+00
Qmax95	-5.00E+00
B	2.53E+02
Bmin99	2.70E+02
Bmax99	2.36E+02
Bmin95	2.65E+02
Bmax95	2.40E+02

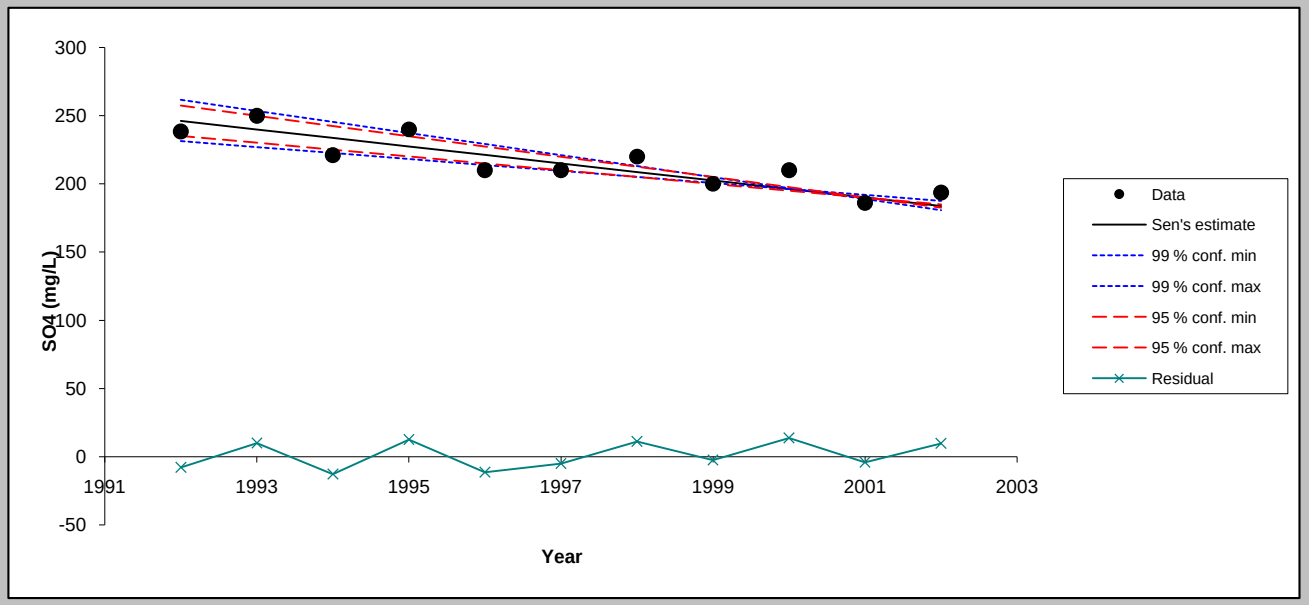

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	238.50	246.25	261.59	231.37	257.50	235.00	-7.75
1993	250.00	240.00	253.49	226.97	250.00	230.00	10.00
1994	221.00	233.75	245.39	222.58	242.50	225.00	-12.75
1995	240.00	227.50	237.29	218.18	235.00	220.00	12.50
1996	210.00	221.25	229.20	213.79	227.50	215.00	-11.25
1997	210.00	215.00	221.10	209.39	220.00	210.00	-5.00
1998	220.00	208.75	213.00	205.00	212.50	205.00	11.25
1999	200.00	202.50	204.90	200.61	205.00	200.00	-2.50
2000	210.00	196.25	196.80	196.21	197.50	195.00	13.75
2001	186.00	190.00	188.71	191.82	190.00	190.00	-4.00
2002	193.59	183.75	180.61	187.42	182.50	185.00	9.84
2003	180.00	177.50	172.51	183.03	175.00	180.00	2.50
2004	180.00	171.25	164.41	178.63	167.50	175.00	8.75
2005	160.00	165.00	156.32	174.24	160.00	170.00	-5.00
2006	142.00	158.75	148.22	169.85	152.50	165.00	-16.75
2007	155.00	152.50	140.12	165.45	145.00	160.00	2.50

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

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ANNUAL DATA

TW-18 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	15	16
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.23	0.29	0.25	0.0015	17		60
1992	0.0015	0.215	0.282	0.3	0.0075	14.3	0.0269	61.75
1993	0.00285	0.205	0.382	0.08	0.00175	13.55	0.00483	63.4
1994								
1995	0.0003	0.27	0.363	0.024	0.002	15	0.0025	57
1996	0.0001	0.33	0.384	0.026	0.0005	18	0.0025	63
1997	0.0001	0.3	0.352	0.005	0.005	13	0.0025	58
1998	0.0001	0.3	0.376	0.019	0.001	15	0.0025	69
1999	0.0001	0.31	0.366	0.013	0.0025	14	0.0025	76
2000	0.0001	0.26	0.371	0.019	0.005	15	0.0025	86
2001	0.001	0.5	0.38	0.025	0.0025	18	0.005	57
2002	0.001	0.578	0.418	0.025	0.0025	15.943	0.005	58.873
2003	0.001	0.05	0.378	0.007	0.005	14.7	0.01	60.7
2004	0.001	0.11	0.402	0.01	0.0015	12.6	0.018	65.4
2005	0.001	0.25	0.389	0.01	0.0015	15.3	0.009	61.2
2006	0.001	0.05	0.376	0.01	0.0015	15.5	0.011	59.6
2007	0.001	0.19	0.4	0.01	0.0001	15.3	0.015	60.7

TREND STATISTICS

TW-18 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*16*		-0.47		0.0000	-0.0001	0.0001	0.0000	0.0001	0.0010	0.0021	-0.0004	0.0015	-0.0002
F (mg/L)	*1991*	*2007*	*16*		-0.63		-0.004	-0.024	0.020	-0.015	0.013	0.29	0.45	0.16	0.39	0.20
Mn (mg/L)	*1991*	*2007*	*16*		2.57	*	0.004	0.000	0.008	0.001	0.007	0.33	0.38	0.30	0.37	0.31
Nitrate (mg/L)	*1991*	*2007*	*16*		-2.78	**	-0.002	-0.016	0.000	-0.008	-0.001	0.04	0.20	0.02	0.11	0.02
Se (mg/L)	*1991*	*2007*	*16*		-0.91		0.0000	-0.0005	0.0001	-0.0004	0.0001	0.0021	0.0076	0.0014	0.0062	0.0016
Cl (mg/L)	*1991*	*2007*	*16*		0.36		0.032	-0.263	0.223	-0.197	0.164	14.79	17.18	13.05	16.89	13.37
Mo (mg/L)	*1992*	*2007*	*15*		2.05	*	0.0006	0.0000	0.0013	0.0000	0.0012	0.0000	0.0050	-0.0055	0.0050	-0.0047
SO4 (mg/L)	*1991*	*2007*	*16*		0.09		0.051	-0.750	1.112	-0.338	0.580	60.29	68.41	51.94	64.68	56.27
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.47
Signific.	
Q	0.00E+00
Qmin99	-1.04E-04
Qmax99	1.07E-04
Qmin95	-5.00E-05
Qmax95	8.75E-05
B	1.00E-03
Bmin99	2.09E-03
Bmax99	-4.17E-04
Bmin95	1.55E-03
Bmax95	-1.81E-04

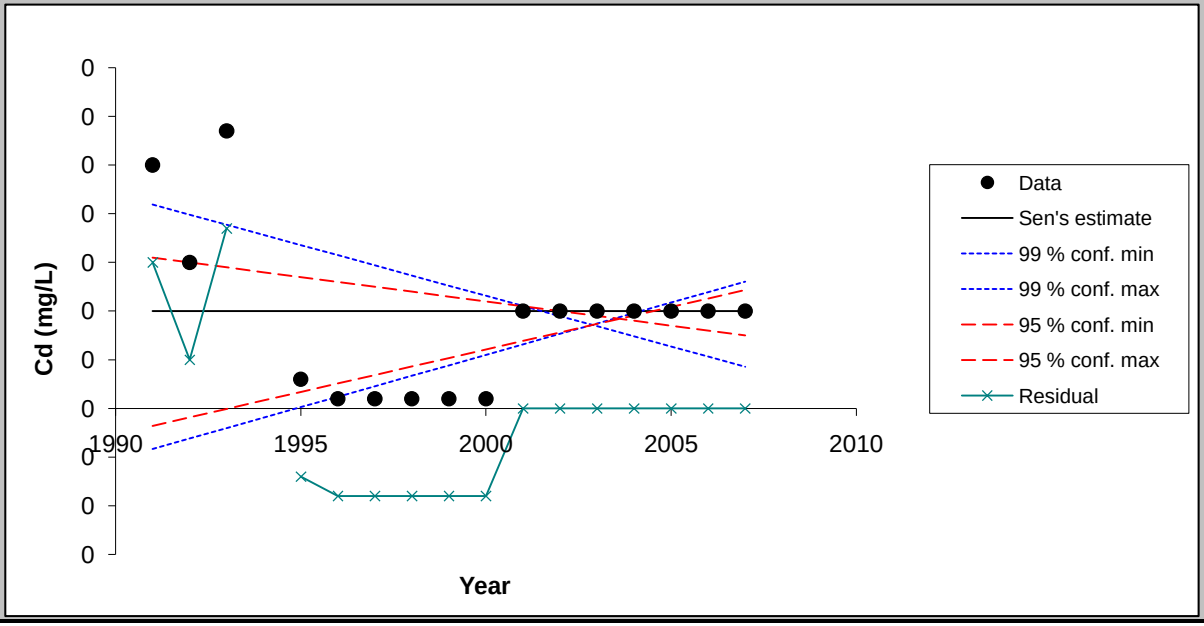

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994		0.00	0.00	0.00	0.00	0.00	
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.63
Signific.	
Q	-4.38E-03
Qmin99	-2.41E-02
Qmax99	1.96E-02
Qmin95	-1.50E-02
Qmax95	1.31E-02
B	2.93E-01
Bmin99	4.48E-01
Bmax99	1.64E-01
Bmin95	3.93E-01
Bmax95	2.04E-01

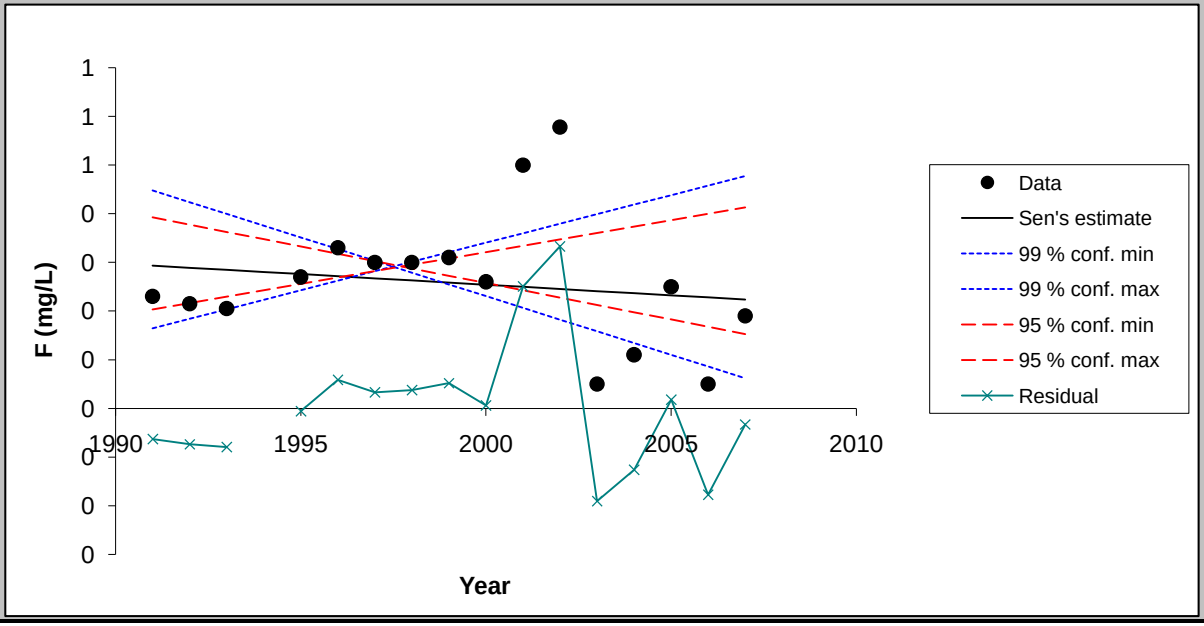

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.23	0.29	0.45	0.16	0.39	0.20	-0.06
1992	0.21	0.29	0.42	0.18	0.38	0.22	-0.07
1993	0.20	0.28	0.40	0.20	0.36	0.23	-0.08
1994		0.28	0.38	0.22	0.35	0.24	
1995	0.27	0.28	0.35	0.24	0.33	0.26	-0.01
1996	0.33	0.27	0.33	0.26	0.32	0.27	0.06
1997	0.30	0.27	0.30	0.28	0.30	0.28	0.03
1998	0.30	0.26	0.28	0.30	0.29	0.30	0.04
1999	0.31	0.26	0.25	0.32	0.27	0.31	0.05
2000	0.26	0.25	0.23	0.34	0.26	0.32	0.01
2001	0.50	0.25	0.21	0.36	0.24	0.33	0.25
2002	0.58	0.25	0.18	0.38	0.23	0.35	0.33
2003	0.05	0.24	0.16	0.40	0.21	0.36	-0.19
2004	0.11	0.24	0.13	0.42	0.20	0.37	-0.13
2005	0.25	0.23	0.11	0.44	0.18	0.39	0.02
2006	0.05	0.23	0.09	0.46	0.17	0.40	-0.18
2007	0.19	0.22	0.06	0.48	0.15	0.41	-0.03

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	2.57
Signific.	*
Q	4.07E-03
Qmin99	-1.52E-04
Qmax99	8.46E-03
Qmin95	9.15E-04
Qmax95	7.19E-03
B	3.35E-01
Bmin99	3.79E-01
Bmax99	2.95E-01
Bmin95	3.68E-01
Bmax95	3.08E-01

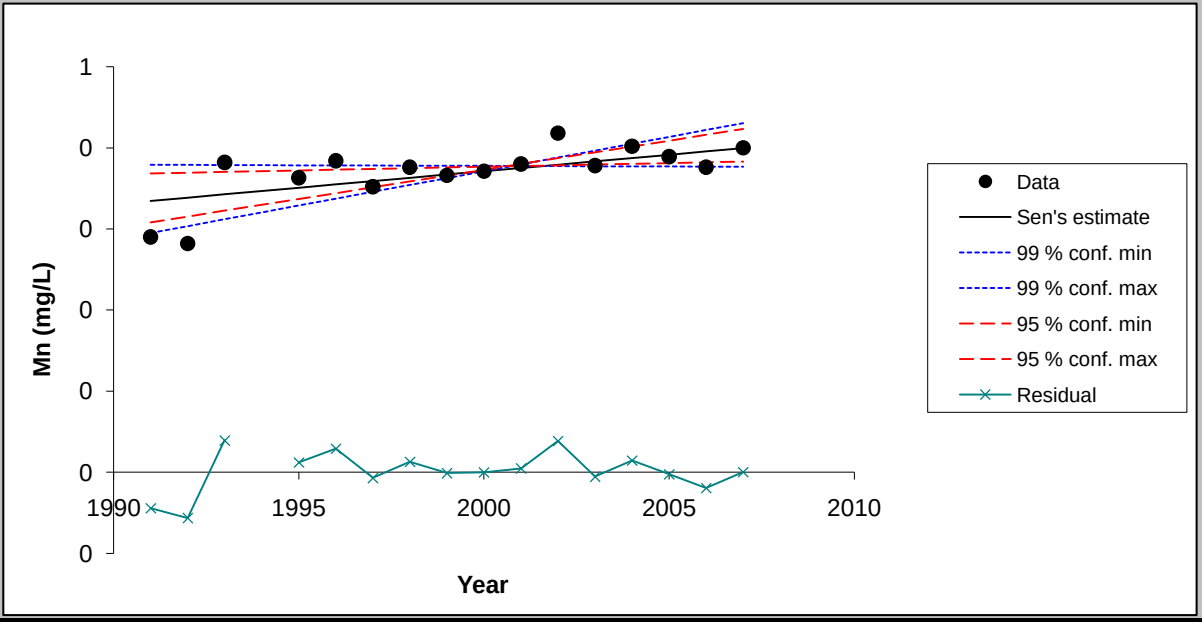

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.29	0.33	0.38	0.30	0.37	0.31	-0.04
1992	0.28	0.34	0.38	0.30	0.37	0.32	-0.06
1993	0.38	0.34	0.38	0.31	0.37	0.32	0.04
1994		0.35	0.38	0.32	0.37	0.33	
1995	0.36	0.35	0.38	0.33	0.37	0.34	0.01
1996	0.38	0.35	0.38	0.34	0.37	0.34	0.03
1997	0.35	0.36	0.38	0.35	0.37	0.35	-0.01
1998	0.38	0.36	0.38	0.35	0.37	0.36	0.01
1999	0.37	0.37	0.38	0.36	0.38	0.37	0.00
2000	0.37	0.37	0.38	0.37	0.38	0.37	0.00
2001	0.38	0.38	0.38	0.38	0.38	0.38	0.00
2002	0.42	0.38	0.38	0.39	0.38	0.39	0.04
2003	0.38	0.38	0.38	0.40	0.38	0.39	-0.01
2004	0.40	0.39	0.38	0.41	0.38	0.40	0.01
2005	0.39	0.39	0.38	0.41	0.38	0.41	0.00
2006	0.38	0.40	0.38	0.42	0.38	0.42	-0.02
2007	0.40	0.40	0.38	0.43	0.38	0.42	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	0.36
Signific.	
Q	3.17E-02
Qmin99	-2.63E-01
Qmax99	2.23E-01
Qmin95	-1.97E-01
Qmax95	1.64E-01
B	1.48E+01
Bmin99	1.72E+01
Bmax99	1.31E+01
Bmin95	1.69E+01
Bmax95	1.34E+01

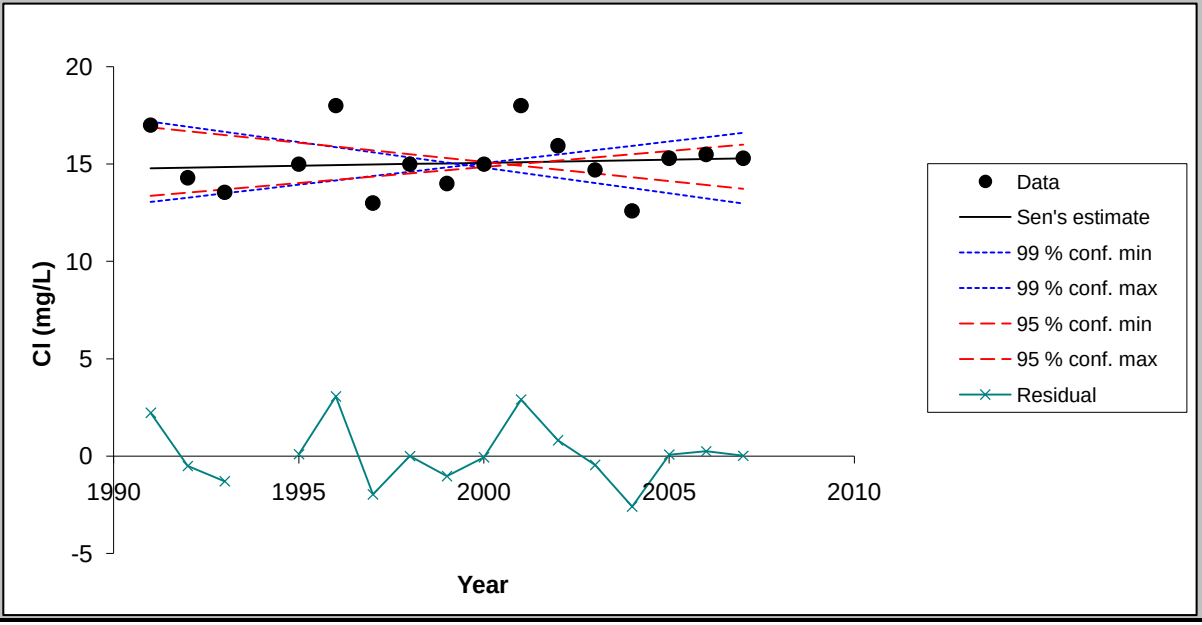

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	17.00	14.79	17.18	13.05	16.89	13.37	2.21
1992	14.30	14.82	16.92	13.27	16.69	13.54	-0.52
1993	13.55	14.85	16.66	13.50	16.49	13.70	-1.30
1994		14.88	16.39	13.72	16.30	13.87	
1995	15.00	14.91	16.13	13.94	16.10	14.03	0.09
1996	18.00	14.94	15.87	14.16	15.90	14.19	3.06
1997	13.00	14.98	15.61	14.39	15.70	14.36	-1.98
1998	15.00	15.01	15.34	14.61	15.51	14.52	-0.01
1999	14.00	15.04	15.08	14.83	15.31	14.68	-1.04
2000	15.00	15.07	14.82	15.05	15.11	14.85	-0.07
2001	18.00	15.10	14.55	15.28	14.92	15.01	2.90
2002	15.94	15.13	14.29	15.50	14.72	15.18	0.81
2003	14.70	15.17	14.03	15.72	14.52	15.34	-0.47
2004	12.60	15.20	13.76	15.94	14.33	15.50	-2.60
2005	15.30	15.23	13.50	16.17	14.13	15.67	0.07
2006	15.50	15.26	13.24	16.39	13.93	15.83	0.24
2007	15.30	15.29	12.98	16.61	13.73	15.99	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.91
Signific.	
Q	-4.09E-05
Qmin99	-4.72E-04
Qmax99	1.25E-04
Qmin95	-3.66E-04
Qmax95	8.77E-05
B	2.14E-03
Bmin99	7.64E-03
Bmax99	1.38E-03
Bmin95	6.21E-03
Bmax95	1.55E-03

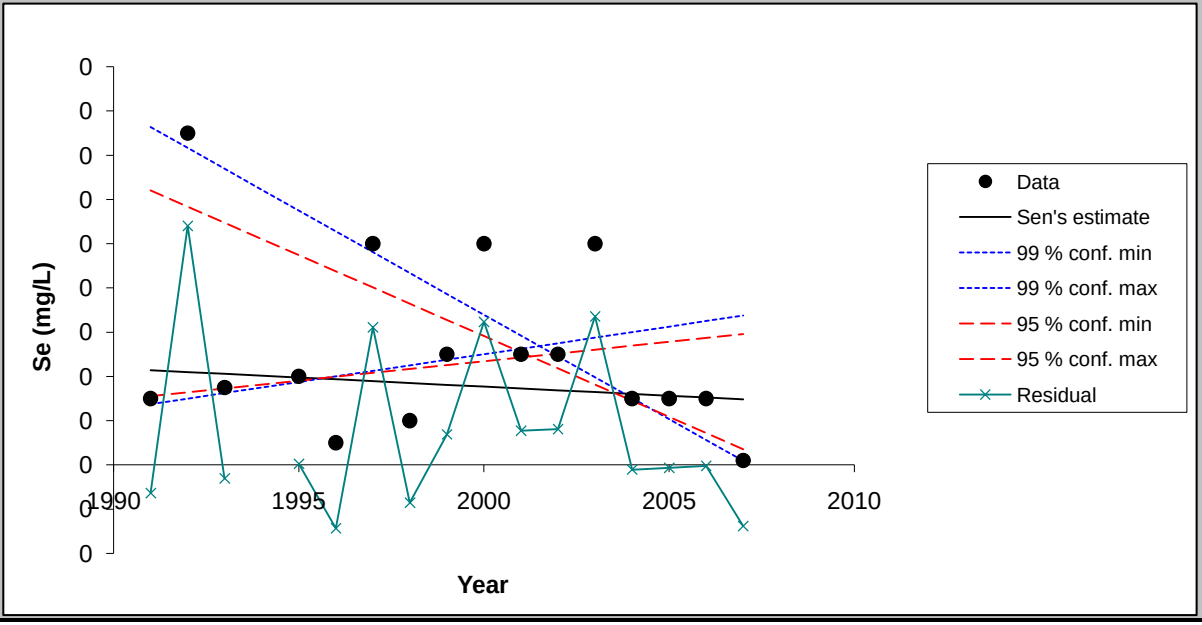

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1993	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1994		0.00	0.01	0.00	0.01	0.00	
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-2.78
Signific.	**
Q	-2.32E-03
Qmin99	-1.63E-02
Qmax99	0.00E+00
Qmin95	-8.14E-03
Qmax95	-5.47E-04
B	4.14E-02
Bmin99	1.96E-01
Bmax99	1.90E-02
Bmin95	1.06E-01
Bmax95	2.34E-02

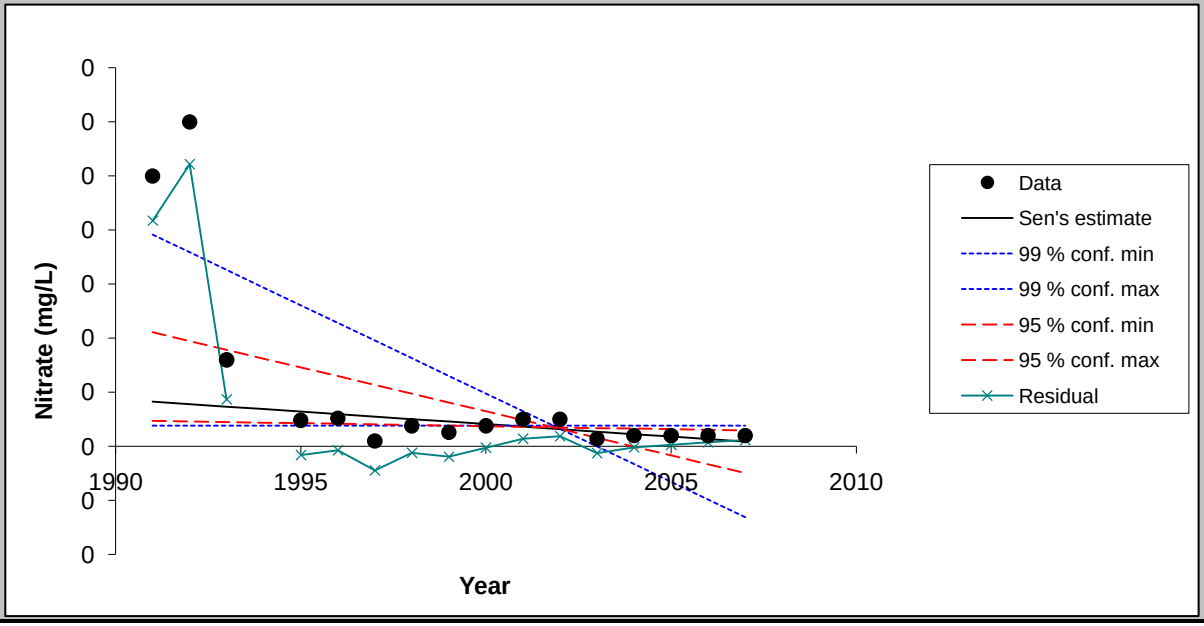

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	0.04	0.20	0.02	0.11	0.02	0.21
1992	0.30	0.04	0.18	0.02	0.10	0.02	0.26
1993	0.08	0.04	0.16	0.02	0.09	0.02	0.04
1994		0.03	0.15	0.02	0.08	0.02	
1995	0.02	0.03	0.13	0.02	0.07	0.02	-0.01
1996	0.03	0.03	0.11	0.02	0.06	0.02	0.00
1997	0.00	0.03	0.10	0.02	0.06	0.02	-0.02
1998	0.02	0.03	0.08	0.02	0.05	0.02	-0.01
1999	0.01	0.02	0.07	0.02	0.04	0.02	-0.01
2000	0.02	0.02	0.05	0.02	0.03	0.02	0.00
2001	0.03	0.02	0.03	0.02	0.02	0.02	0.01
2002	0.03	0.02	0.02	0.02	0.02	0.02	0.01
2003	0.01	0.01	0.00	0.02	0.01	0.02	-0.01
2004	0.01	0.01	-0.02	0.02	0.00	0.02	0.00
2005	0.01	0.01	-0.03	0.02	-0.01	0.02	0.00
2006	0.01	0.01	-0.05	0.02	-0.02	0.02	0.00
2007	0.01	0.00	-0.07	0.02	-0.02	0.01	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	15
Test S	
Test Z	2.05
Signific.	*
Q	6.25E-04
Qmin99	0.00E+00
Qmax99	1.28E-03
Qmin95	0.00E+00
Qmax95	1.21E-03
B	0.00E+00
Bmin99	5.00E-03
Bmax99	-5.46E-03
Bmin95	5.00E-03
Bmax95	-4.75E-03

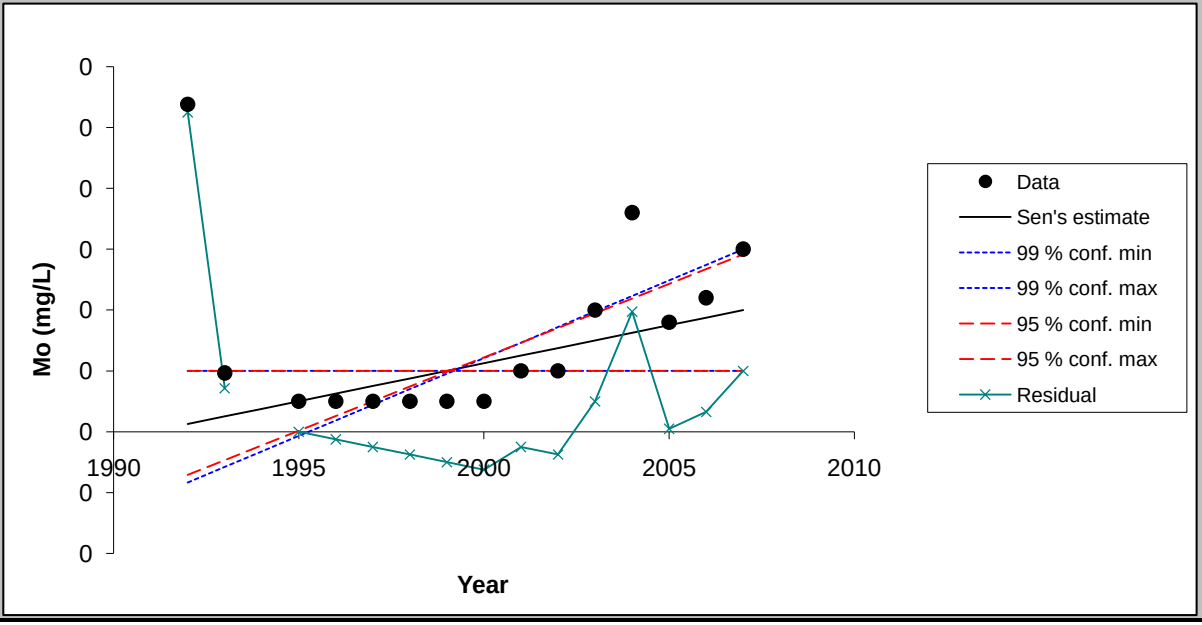

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.00	0.00	0.00	0.00	0.00	0.03
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994		0.00	0.00	0.00	0.00	0.00	
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2001	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.02	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2007	0.02	0.01	0.00	0.02	0.00	0.01	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	0.09
Signific.	
Q	5.10E-02
Qmin99	-7.50E-01
Qmax99	1.11E+00
Qmin95	-3.38E-01
Qmax95	5.80E-01
B	6.03E+01
Bmin99	6.84E+01
Bmax99	5.19E+01
Bmin95	6.47E+01
Bmax95	5.63E+01

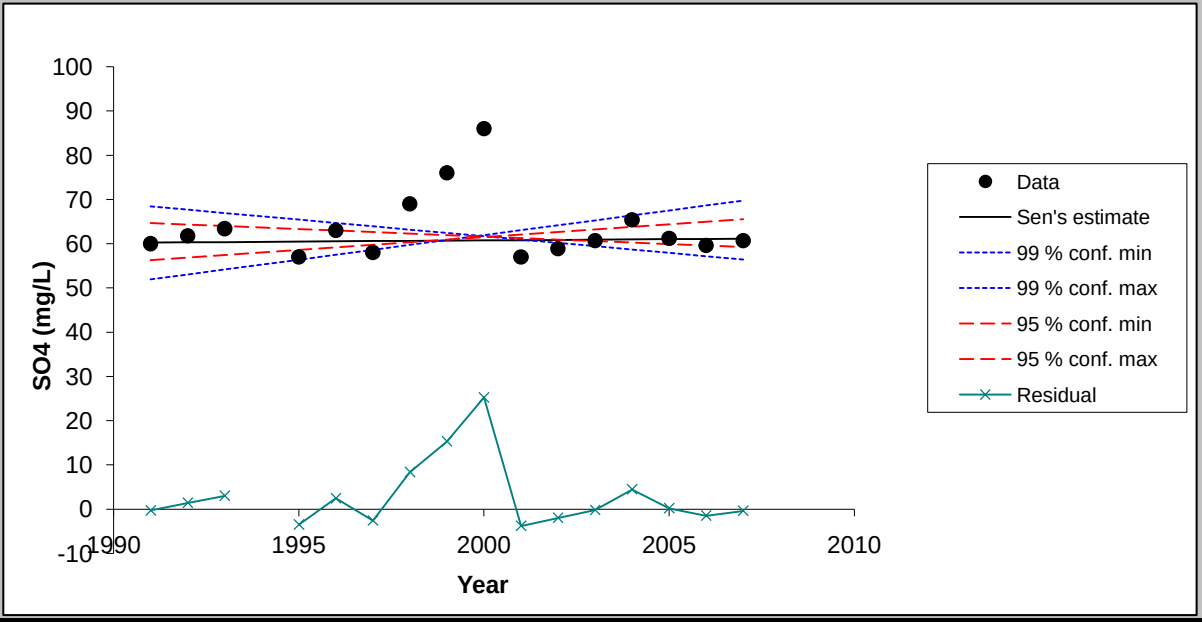

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	60.00	60.29	68.41	51.94	64.68	56.27	-0.29
1992	61.75	60.34	67.66	53.05	64.34	56.85	1.41
1993	63.40	60.39	66.91	54.17	64.01	57.43	3.01
1994		60.44	66.16	55.28	63.67	58.01	
1995	57.00	60.49	65.41	56.39	63.33	58.59	-3.49
1996	63.00	60.54	64.66	57.50	62.99	59.17	2.46
1997	58.00	60.59	63.91	58.61	62.65	59.75	-2.59
1998	69.00	60.64	63.16	59.72	62.31	60.33	8.36
1999	76.00	60.69	62.41	60.83	61.98	60.91	15.31
2000	86.00	60.75	61.66	61.95	61.64	61.49	25.25
2001	57.00	60.80	60.91	63.06	61.30	62.07	-3.80
2002	58.87	60.85	60.16	64.17	60.96	62.65	-1.97
2003	60.70	60.90	59.41	65.28	60.62	63.23	-0.20
2004	65.40	60.95	58.66	66.39	60.29	63.81	4.45
2005	61.20	61.00	57.91	67.50	59.95	64.39	0.20
2006	59.60	61.05	57.16	68.62	59.61	64.97	-1.45
2007	60.70	61.10	56.41	69.73	59.27	65.55	-0.40

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-40 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	15	15	15	15	15	15	14	15
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	5.95	7.89	0.982	35.2	0.289	679		680
1992	6.31	7.035	0.4275	26.2	0.424	581.5	0.341	509.5
1993	1.71	3	0.3365	7.01	0.1735	231	0.261	430
1994	1.167	2.63	0.1345	6.52	0.1005	144.5	0.135	240
1995	0.809	2.6	0.072	5.2	0.11	85	0.086	150
1996								
1997	3.06	6.3	0.184	16	0.48	410	0.161	680
1998	3.5	4.2	0.194	16	0.63	420	0.162	850
1999	2.9	5.7	0.163	17	0.82	340	0.172	900
2000	1.2	4.7	0.107	11	1.1	320	0.159	770
2001	2.273	4.8	0.07	12.04	0.865	287	0.16	649
2002	1.838	6.078	0.03	11.42	0.8987	289.3	0.170	600.3
2003	2.19	4.75	0.0667	13.9	1.12	280	0.181	555
2004								
2005	2.46	3.54	0.047	18	0.75	473	0.157	758
2006	2.22	4.43	0.0512	19.2	0.624	421	0.147	736
2007	2.41	4.65	0.0365	16.2	0.282	369	0.167	696

TREND STATISTICS

TW-40 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*15*		-0.49		-0.073	-0.371	0.134	-0.301	0.096	3.31	5.95	0.76	5.31	1.12
F (mg/L)	*1991*	*2007*	*15*		-0.69		-0.074	-0.296	0.231	-0.259	0.159	5.54	7.76	2.54	7.39	3.09
Mn (mg/L)	*1991*	*2007*	*15*		-3.86	***	-0.024	-0.041	-0.006	-0.039	-0.009	0.36	0.48	0.15	0.46	0.19
Nitrate (mg/L)	*1991*	*2007*	*15*		0.55		0.286	-1.317	1.042	-1.081	0.920	11.63	25.91	3.41	23.57	5.11
Se (mg/L)	*1991*	*2007*	*15*		1.88	+	0.044	-0.030	0.099	-0.001	0.085	0.29	0.84	-0.11	0.63	0.00
Cl (mg/L)	*1991*	*2007*	*15*		-0.10		-4.100	-33.132	22.211	-29.457	16.965	372.80	618.32	120.10	610.96	167.31
Mo (mg/L)	*1992*	*2007*	*14*		-0.55		-0.001	-0.012	0.005	-0.009	0.003	0.17	0.28	0.12	0.26	0.13
SO4 (mg/L)	*1991*	*2007*	*15*		0.94		10.000	-28.223	47.824	-16.271	35.021	549.00	910.72	170.76	779.25	298.79
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-40 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-0.49
Signific.	
Q	-7.29E-02
Qmin99	-3.71E-01
Qmax99	1.34E-01
Qmin95	-3.01E-01
Qmax95	9.55E-02
B	3.31E+00
Bmin99	5.95E+00
Bmax99	7.64E-01
Bmin95	5.31E+00
Bmax95	1.12E+00

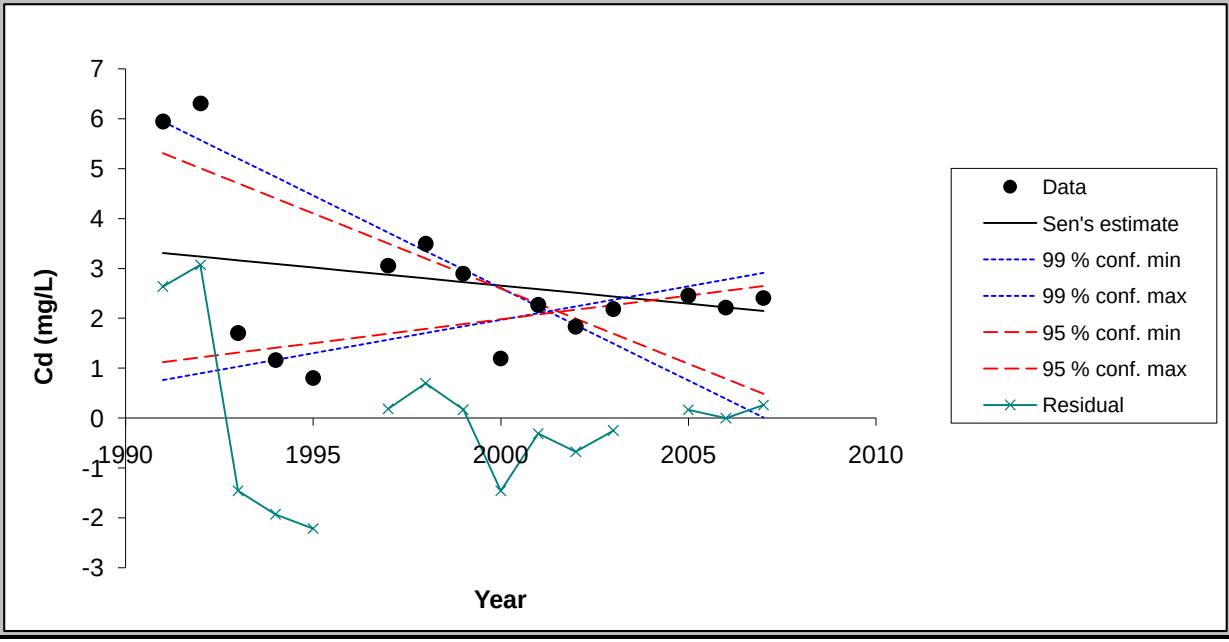

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.95	3.31	5.95	0.76	5.31	1.12	2.64
1992	6.31	3.24	5.58	0.90	5.01	1.22	3.07
1993	1.71	3.17	5.21	1.03	4.71	1.31	-1.46
1994	1.17	3.09	4.84	1.17	4.41	1.41	-1.93
1995	0.81	3.02	4.47	1.30	4.11	1.50	-2.21
1996		2.95	4.10	1.44	3.80	1.60	
1997	3.06	2.88	3.72	1.57	3.50	1.70	0.18
1998	3.50	2.80	3.35	1.70	3.20	1.79	0.70
1999	2.90	2.73	2.98	1.84	2.90	1.89	0.17
2000	1.20	2.66	2.61	1.97	2.60	1.98	-1.46
2001	2.27	2.58	2.24	2.11	2.30	2.08	-0.31
2002	1.84	2.51	1.87	2.24	2.00	2.17	-0.67
2003	2.19	2.44	1.50	2.38	1.69	2.27	-0.25
2004		2.37	1.13	2.51	1.39	2.36	
2005	2.46	2.29	0.76	2.64	1.09	2.46	0.17
2006	2.22	2.22	0.39	2.78	0.79	2.56	0.00
2007	2.41	2.15	0.02	2.91	0.49	2.65	0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-0.69
Signific.	
Q	-7.40E-02
Qmin99	-2.96E-01
Qmax99	2.31E-01
Qmin95	-2.59E-01
Qmax95	1.59E-01
B	5.54E+00
Bmin99	7.76E+00
Bmax99	2.54E+00
Bmin95	7.39E+00
Bmax95	3.09E+00

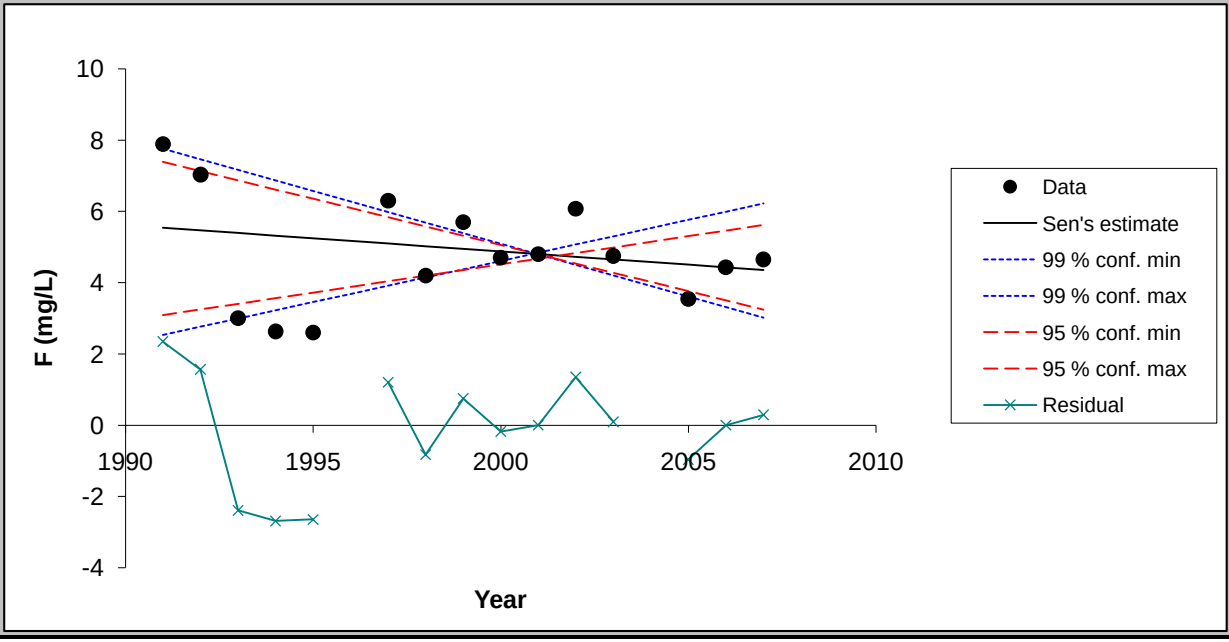

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	7.89	5.54	7.76	2.54	7.39	3.09	2.35
1992	7.04	5.47	7.47	2.77	7.13	3.25	1.57
1993	3.00	5.39	7.17	3.00	6.87	3.41	-2.39
1994	2.63	5.32	6.87	3.23	6.62	3.57	-2.69
1995	2.60	5.24	6.58	3.46	6.36	3.72	-2.64
1996		5.17	6.28	3.69	6.10	3.88	
1997	6.30	5.10	5.98	3.92	5.84	4.04	1.20
1998	4.20	5.02	5.69	4.15	5.58	4.20	-0.82
1999	5.70	4.95	5.39	4.38	5.32	4.36	0.75
2000	4.70	4.87	5.10	4.61	5.06	4.52	-0.17
2001	4.80	4.80	4.80	4.84	4.80	4.68	0.00
2002	6.08	4.73	4.50	5.08	4.54	4.83	1.35
2003	4.75	4.65	4.21	5.31	4.28	4.99	0.10
2004		4.58	3.91	5.54	4.02	5.15	
2005	3.54	4.50	3.62	5.77	3.76	5.31	-0.96
2006	4.43	4.43	3.32	6.00	3.50	5.47	0.00
2007	4.65	4.36	3.02	6.23	3.24	5.63	0.29

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-3.86
Signific.	***
Q	-2.41E-02
Qmin99	-4.12E-02
Qmax99	-6.45E-03
Qmin95	-3.86E-02
Qmax95	-9.27E-03
B	3.56E-01
Bmin99	4.82E-01
Bmax99	1.54E-01
Bmin95	4.64E-01
Bmax95	1.90E-01

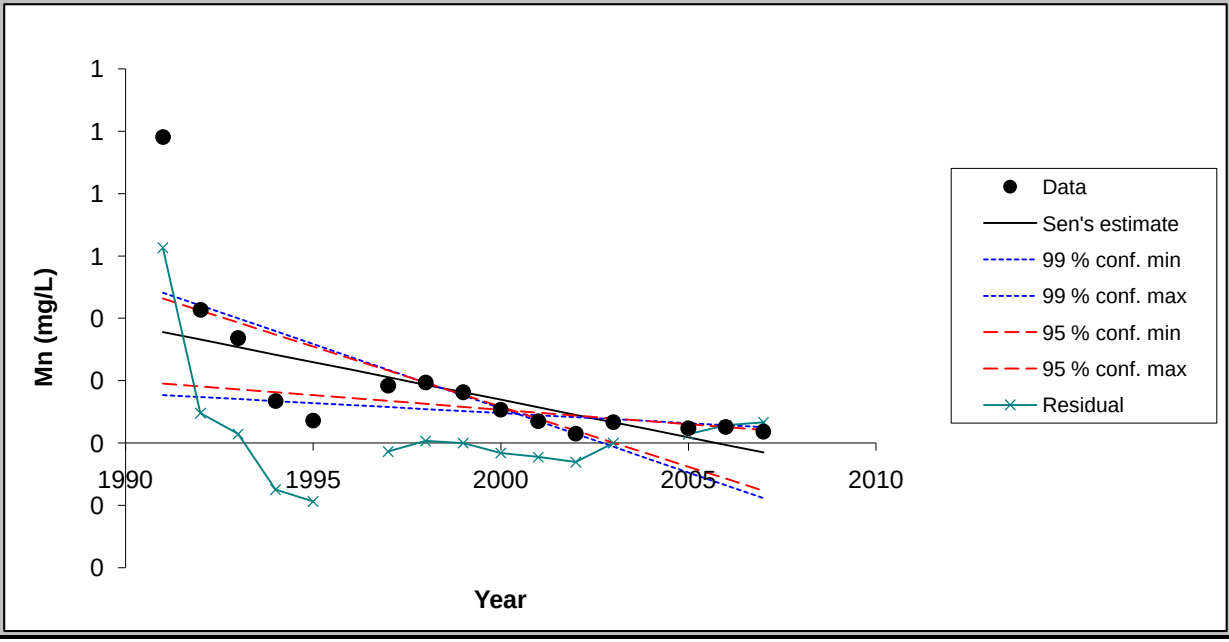

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.98	0.36	0.48	0.15	0.46	0.19	0.63
1992	0.43	0.33	0.44	0.15	0.43	0.18	0.10
1993	0.34	0.31	0.40	0.14	0.39	0.17	0.03
1994	0.13	0.28	0.36	0.13	0.35	0.16	-0.15
1995	0.07	0.26	0.32	0.13	0.31	0.15	-0.19
1996		0.24	0.28	0.12	0.27	0.14	
1997	0.18	0.21	0.24	0.12	0.23	0.13	-0.03
1998	0.19	0.19	0.19	0.11	0.19	0.13	0.01
1999	0.16	0.16	0.15	0.10	0.16	0.12	0.00
2000	0.11	0.14	0.11	0.10	0.12	0.11	-0.03
2001	0.07	0.11	0.07	0.09	0.08	0.10	-0.04
2002	0.03	0.09	0.03	0.08	0.04	0.09	-0.06
2003	0.07	0.07	-0.01	0.08	0.00	0.08	0.00
2004		0.04	-0.05	0.07	-0.04	0.07	
2005	0.05	0.02	-0.09	0.06	-0.08	0.06	0.03
2006	0.05	-0.01	-0.14	0.06	-0.12	0.05	0.06
2007	0.04	-0.03	-0.18	0.05	-0.15	0.04	0.07

FIGURE

< Previous Time Series | Next Time Series >

TW-40 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	0.55
Signific.	
Q	2.86E-01
Qmin99	-1.32E+00
Qmax99	1.04E+00
Qmin95	-1.08E+00
Qmax95	9.20E-01
B	1.16E+01
Bmin99	2.59E+01
Bmax99	3.41E+00
Bmin95	2.36E+01
Bmax95	5.11E+00

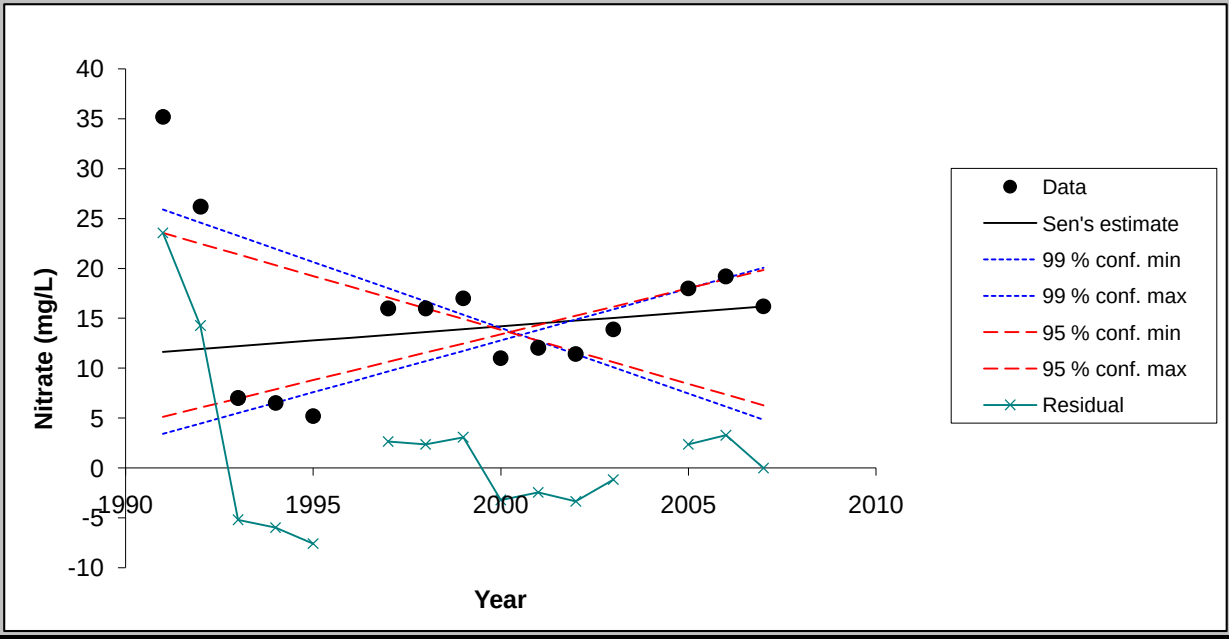

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	35.20	11.63	25.91	3.41	23.57	5.11	23.57
1992	26.20	11.91	24.59	4.45	22.49	6.03	14.29
1993	7.01	12.20	23.28	5.50	21.41	6.96	-5.19
1994	6.52	12.49	21.96	6.54	20.32	7.88	-5.97
1995	5.20	12.77	20.64	7.58	19.24	8.80	-7.57
1996		13.06	19.32	8.62	18.16	9.72	
1997	16.00	13.34	18.01	9.66	17.08	10.64	2.66
1998	16.00	13.63	16.69	10.71	16.00	11.56	2.37
1999	17.00	13.91	15.37	11.75	14.92	12.48	3.09
2000	11.00	14.20	14.05	12.79	13.84	13.40	-3.20
2001	12.04	14.49	12.74	13.83	12.76	14.32	-2.45
2002	11.42	14.77	11.42	14.87	11.68	15.24	-3.35
2003	13.90	15.06	10.10	15.92	10.59	16.16	-1.16
2004		15.34	8.79	16.96	9.51	17.08	
2005	18.00	15.63	7.47	18.00	8.43	18.00	2.37
2006	19.20	15.91	6.15	19.04	7.35	18.92	3.29
2007	16.20	16.20	4.83	20.08	6.27	19.84	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-40 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	1.88
Signific.	+
Q	4.36E-02
Qmin99	-3.03E-02
Qmax99	9.89E-02
Qmin95	-5.32E-04
Qmax95	8.51E-02
B	2.89E-01
Bmin99	8.42E-01
Bmax99	-1.14E-01
Bmin95	6.32E-01
Bmax95	3.33E-03

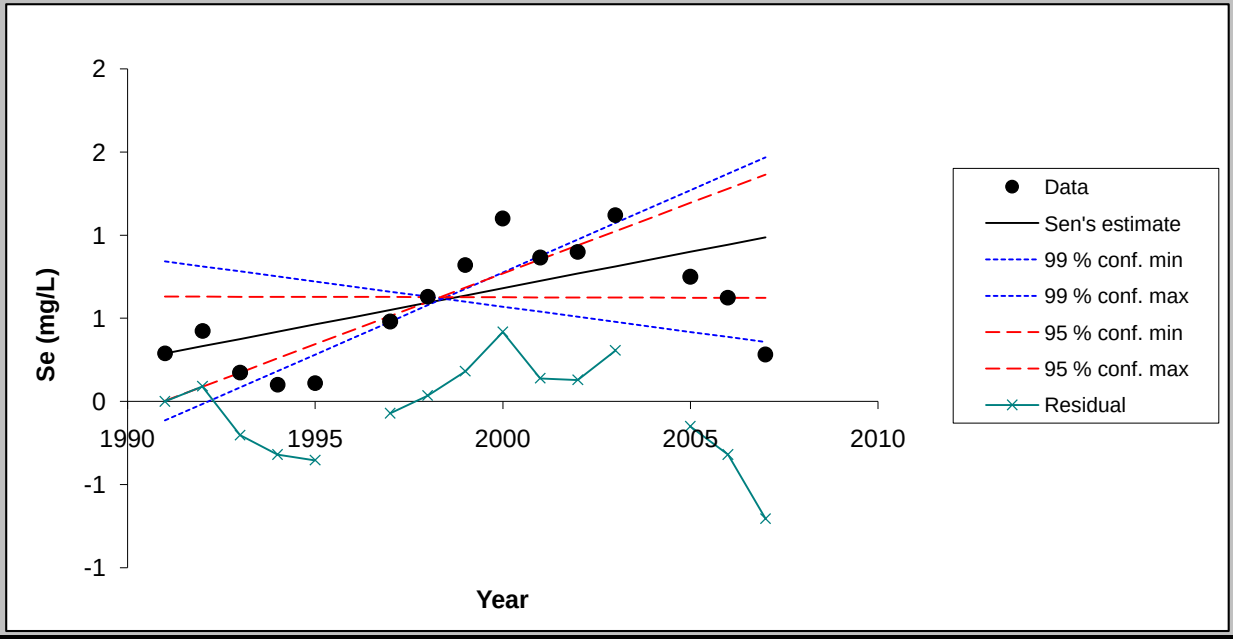

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.29	0.29	0.84	-0.11	0.63	0.00	0.00
1992	0.42	0.33	0.81	-0.01	0.63	0.09	0.09
1993	0.17	0.38	0.78	0.08	0.63	0.17	-0.20
1994	0.10	0.42	0.75	0.18	0.63	0.26	-0.32
1995	0.11	0.46	0.72	0.28	0.63	0.34	-0.35
1996		0.51	0.69	0.38	0.63	0.43	
1997	0.48	0.55	0.66	0.48	0.63	0.51	-0.07
1998	0.63	0.59	0.63	0.58	0.63	0.60	0.04
1999	0.82	0.64	0.60	0.68	0.63	0.68	0.18
2000	1.10	0.68	0.57	0.78	0.63	0.77	0.42
2001	0.87	0.73	0.54	0.88	0.63	0.85	0.14
2002	0.90	0.77	0.51	0.97	0.63	0.94	0.13
2003	1.12	0.81	0.48	1.07	0.63	1.02	0.31
2004		0.86	0.45	1.17	0.63	1.11	
2005	0.75	0.90	0.42	1.27	0.62	1.19	-0.15
2006	0.62	0.94	0.39	1.37	0.62	1.28	-0.32
2007	0.28	0.99	0.36	1.47	0.62	1.36	-0.71

FIGURE

< Previous Time Series | Next Time Series >

TW-40 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-0.10
Signific.	
Q	-4.10E+00
Qmin99	-3.31E+01
Qmax99	2.22E+01
Qmin95	-2.95E+01
Qmax95	1.70E+01
B	3.73E+02
Bmin99	6.18E+02
Bmax99	1.20E+02
Bmin95	6.11E+02
Bmax95	1.67E+02

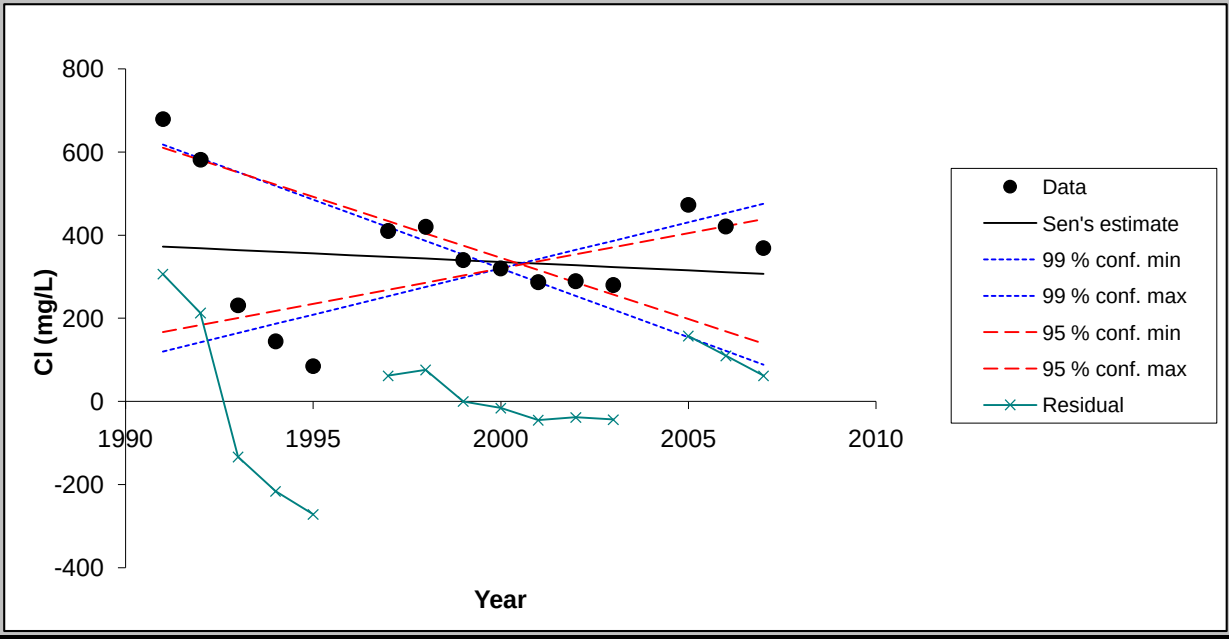

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	679.00	372.80	618.32	120.10	610.96	167.31	306.20
1992	581.50	368.70	585.19	142.32	581.50	184.28	212.80
1993	231.00	364.60	552.05	164.53	552.04	201.24	-133.60
1994	144.50	360.50	518.92	186.74	522.59	218.21	-216.00
1995	85.00	356.40	485.79	208.95	493.13	235.17	-271.40
1996		352.30	452.66	231.16	463.67	252.14	
1997	410.00	348.20	419.53	253.37	434.21	269.10	61.80
1998	420.00	344.10	386.40	275.58	404.76	286.07	75.90
1999	340.00	340.00	353.26	297.79	375.30	303.03	0.00
2000	320.00	335.90	320.13	320.00	345.84	320.00	-15.90
2001	287.00	331.80	287.00	342.21	316.38	336.97	-44.80
2002	289.29	327.70	253.87	364.42	286.93	353.93	-38.41
2003	280.00	323.60	220.74	386.63	257.47	370.90	-43.60
2004		319.50	187.60	408.84	228.01	387.86	
2005	473.00	315.40	154.47	431.05	198.55	404.83	157.60
2006	421.00	311.30	121.34	453.26	169.10	421.79	109.70
2007	369.00	307.20	88.21	475.47	139.64	438.76	61.80

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	14
Test S	
Test Z	-0.55
Signific.	
Q	-6.67E-04
Qmin99	-1.20E-02
Qmax99	5.06E-03
Qmin95	-8.71E-03
Qmax95	3.40E-03
B	1.67E-01
Bmin99	2.83E-01
Bmax99	1.17E-01
Bmin95	2.56E-01
Bmax95	1.30E-01

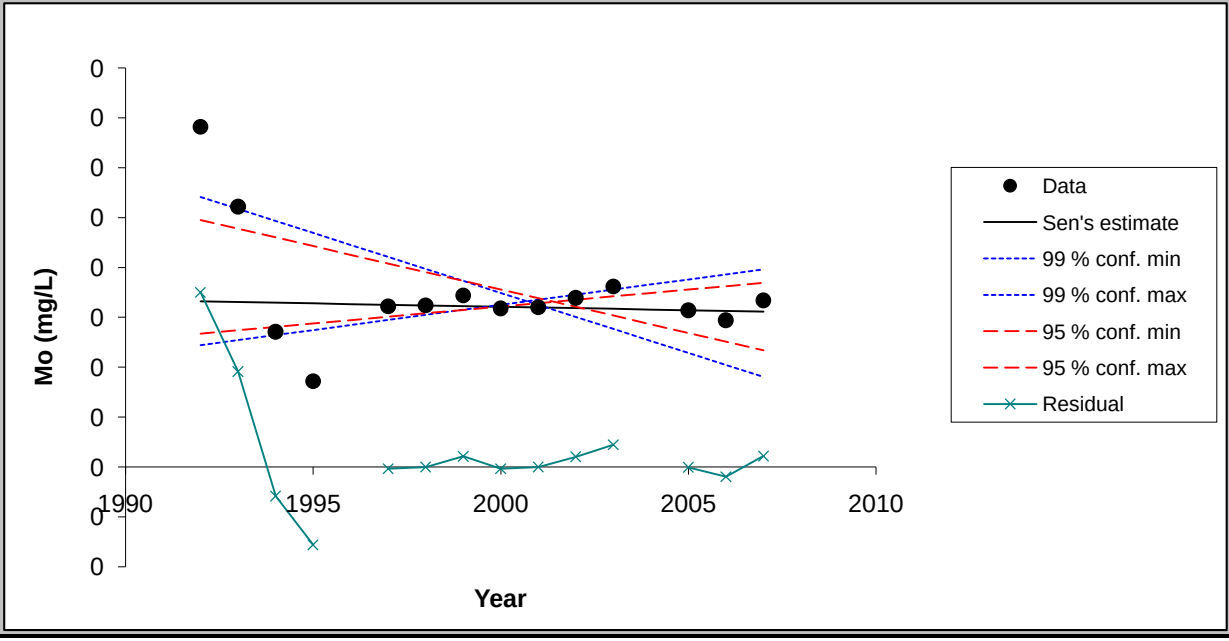

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.34	0.17	0.27	0.12	0.25	0.13	0.17
1993	0.26	0.17	0.26	0.13	0.24	0.14	0.10
1994	0.14	0.16	0.25	0.13	0.23	0.14	-0.03
1995	0.09	0.16	0.23	0.14	0.22	0.14	-0.08
1996		0.16	0.22	0.14	0.21	0.15	
1997	0.16	0.16	0.21	0.15	0.20	0.15	0.00
1998	0.16	0.16	0.20	0.15	0.20	0.15	0.00
1999	0.17	0.16	0.19	0.16	0.19	0.16	0.01
2000	0.16	0.16	0.17	0.16	0.18	0.16	0.00
2001	0.16	0.16	0.16	0.17	0.17	0.16	0.00
2002	0.17	0.16	0.15	0.17	0.16	0.17	0.01
2003	0.18	0.16	0.14	0.18	0.15	0.17	0.02
2004		0.16	0.13	0.18	0.14	0.17	
2005	0.16	0.16	0.11	0.19	0.13	0.18	0.00
2006	0.15	0.16	0.10	0.19	0.13	0.18	-0.01
2007	0.17	0.16	0.09	0.20	0.12	0.18	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-40 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	0.94
Signific.	
Q	1.00E+01
Qmin99	-2.82E+01
Qmax99	4.78E+01
Qmin95	-1.63E+01
Qmax95	3.50E+01
B	5.49E+02
Bmin99	9.11E+02
Bmax99	1.71E+02
Bmin95	7.79E+02
Bmax95	2.99E+02

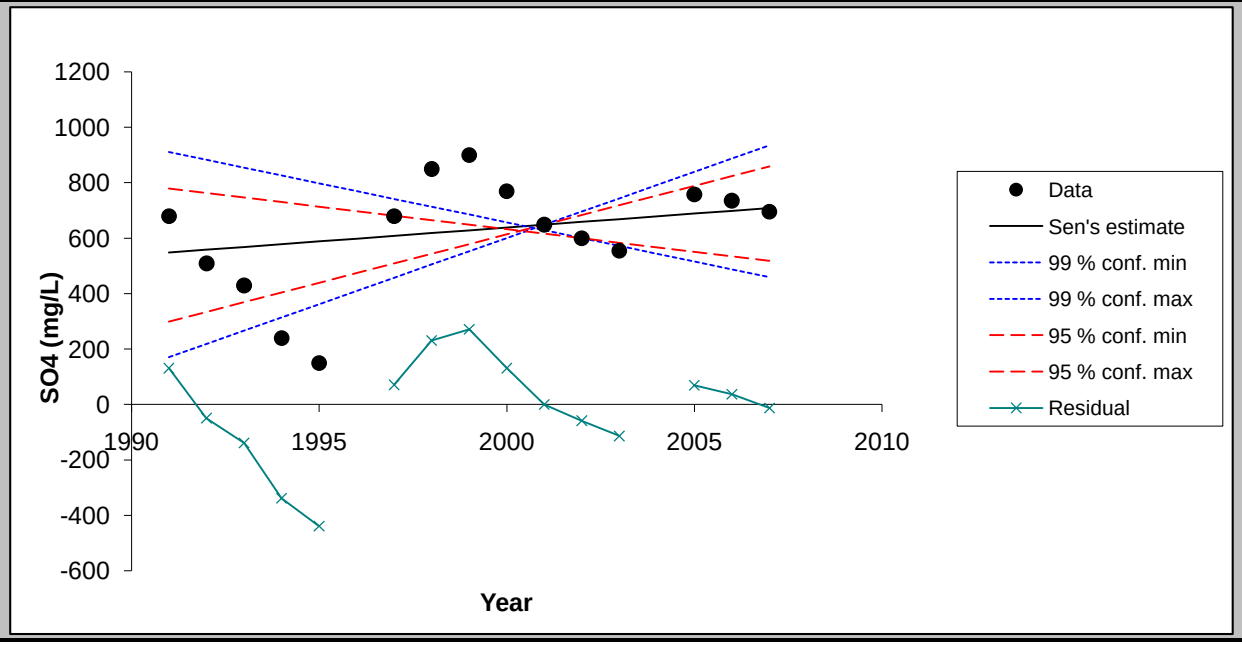

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	680.00	549.00	910.72	170.76	779.25	298.79	131.00
1992	509.50	559.00	882.50	218.59	762.98	333.81	-49.50
1993	430.00	569.00	854.28	266.41	746.71	368.83	-139.00
1994	240.00	579.00	826.05	314.23	730.44	403.85	-339.00
1995	150.00	589.00	797.83	362.06	714.17	438.87	-439.00
1996		599.00	769.61	409.88	697.90	473.89	
1997	680.00	609.00	741.39	457.70	681.62	508.91	71.00
1998	850.00	619.00	713.16	505.53	665.35	543.94	231.00
1999	900.00	629.00	684.94	553.35	649.08	578.96	271.00
2000	770.00	639.00	656.72	601.18	632.81	613.98	131.00
2001	649.00	649.00	628.49	649.00	616.54	649.00	0.00
2002	600.27	659.00	600.27	696.82	600.27	684.02	-58.73
2003	555.00	669.00	572.05	744.65	584.00	719.04	-114.00
2004		679.00	543.83	792.47	567.73	754.06	
2005	758.00	689.00	515.60	840.30	551.46	789.09	69.00
2006	736.00	699.00	487.38	888.12	535.19	824.11	37.00
2007	696.00	709.00	459.16	935.94	518.92	859.13	-13.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-44 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1991	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.46	0.17	0.5	0.0015	23		54
1992	0.0049	0.345	0.213	0.185	0.0075	14.95	0.0275	116.8
1993	0.0080	0.36	0.203	0.08	0.0027	19.05	0.0123	55.3
1994	0.0153	0.415	0.198	0.063	0.0073	20.6	0.0112	54
1995	0.0029	0.37	0.196	0.019	0.0025	21	0.006	62
1996	0.0008	0.44	0.194	0.023	0.001	23	0.007	85
1997	0.0005	0.43	0.178	0.005	0.0025	20	0.005	57
1998	0.0005	0.5	0.189	0.017	0.0025	27	0.006	78
1999	0.0008	0.49	0.184	0.005	0.0025	24	0.0025	80
2000	0.12	1.4	0.236	1.5	0.08	56	0.038	190
2001	0.005	0.5	0.2	0.025	0.0025	30	0.005	70
2002	0.0026	0.637	0.230	0.983	0.0025	28.5	0.005	74.7
2003	0.001	0.49	0.216	0.01	0.005	24.7	0.0255	77.2
2004	0.0045	0.3	0.215	0.01	0.0015	26.5	0.0197	84.6
2005	0.0034	0.288	0.202	0.01	0.0015	24.2	0.012	81
2006	0.001	0.72	0.2	0.01	0.003	23	0.004	81.2
2007	0.001	0.85	0.22	0.01	0.00035	26.7	0.0201	90

TREND STATISTICS

TW-44 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.58		0.000	-0.001	0.000	-0.001	0.000	0.00	0.01	0.00	0.01	0.00
F (mg/L)	*1991*	*2007*	*17*		1.81	+	0.017	-0.006	0.034	-0.002	0.030	0.35	0.47	0.27	0.46	0.29
Mn (mg/L)	*1991*	*2007*	*17*		1.36		0.001	-0.002	0.004	-0.001	0.003	0.19	0.22	0.17	0.21	0.18
Nitrate (mg/L)	*1991*	*2007*	*17*		-2.17	*	-0.004	-0.019	0.000	-0.014	0.000	0.06	0.22	0.02	0.18	0.02
Se (mg/L)	*1991*	*2007*	*17*		-1.14		0.000	0.000	0.000	0.000	0.000	0.00	0.01	0.00	0.01	0.00
Cl (mg/L)	*1991*	*2007*	*17*		2.31	*	0.472	-0.093	1.257	0.097	0.971	19.18	24.75	14.67	23.00	17.11
Mo (mg/L)	*1991*	*2007*	*16*		-0.59		0.000	-0.002	0.002	-0.001	0.001	0.01	0.02	0.00	0.02	0.00
SO4 (mg/L)	*1991*	*2007*	*17*		2.23	*	1.914	-0.506	3.308	0.246	2.765	54.23	83.27	44.08	76.28	48.66
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.58
Signific.	
Q	-1.20E-04
Qmin99	-8.09E-04
Qmax99	2.69E-04
Qmin95	-5.71E-04
Qmax95	7.72E-05
B	3.38E-03
Bmin99	1.07E-02
Bmax99	-3.62E-04
Bmin95	8.88E-03
Bmax95	2.32E-03

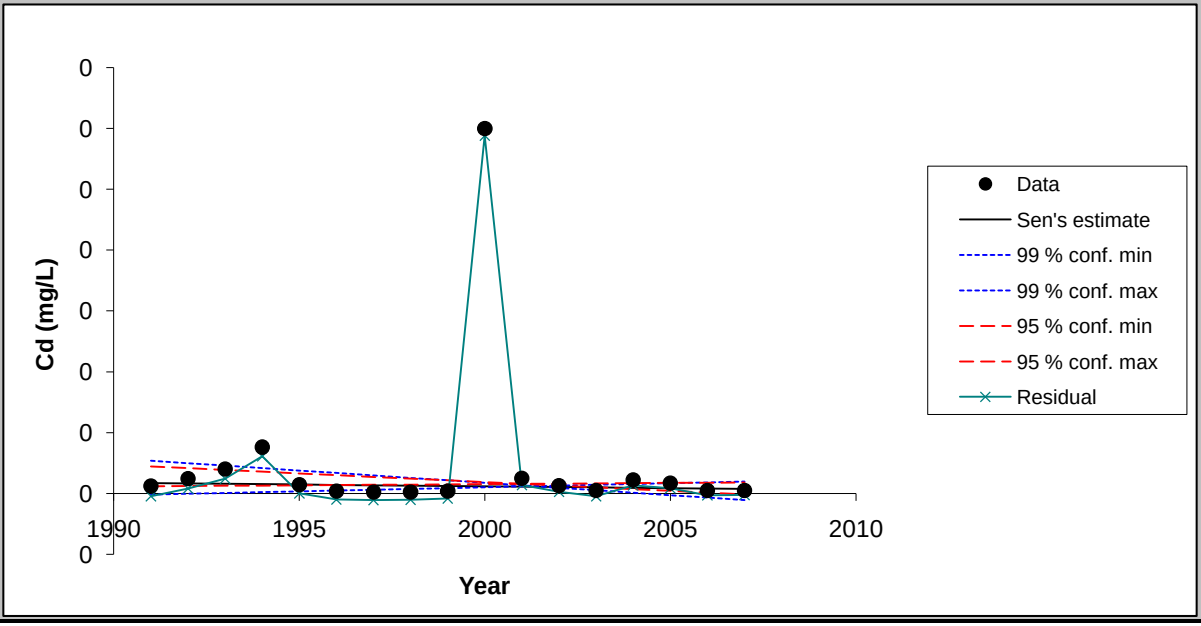

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1993	0.01	0.00	0.01	0.00	0.01	0.00	0.00
1994	0.02	0.00	0.01	0.00	0.01	0.00	0.01
1995	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.12	0.00	0.00	0.00	0.00	0.00	0.12
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.81
Signific.	+
Q	1.72E-02
Qmin99	-6.43E-03
Qmax99	3.35E-02
Qmin95	-1.54E-03
Qmax95	3.00E-02
B	3.52E-01
Bmin99	4.72E-01
Bmax99	2.65E-01
Bmin95	4.60E-01
Bmax95	2.90E-01

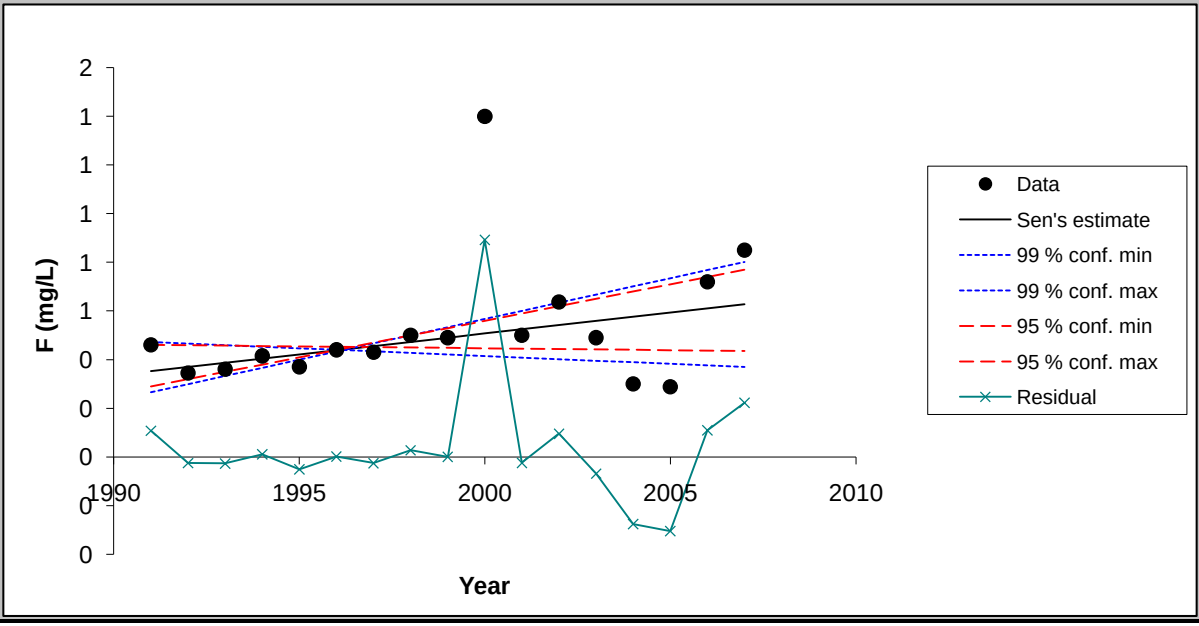

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.46	0.35	0.47	0.27	0.46	0.29	0.11
1992	0.34	0.37	0.47	0.30	0.46	0.32	-0.03
1993	0.36	0.39	0.46	0.33	0.46	0.35	-0.03
1994	0.41	0.40	0.45	0.37	0.46	0.38	0.01
1995	0.37	0.42	0.45	0.40	0.45	0.41	-0.05
1996	0.44	0.44	0.44	0.43	0.45	0.44	0.00
1997	0.43	0.46	0.43	0.47	0.45	0.47	-0.03
1998	0.50	0.47	0.43	0.50	0.45	0.50	0.03
1999	0.49	0.49	0.42	0.53	0.45	0.53	0.00
2000	1.40	0.51	0.41	0.57	0.45	0.56	0.89
2001	0.50	0.52	0.41	0.60	0.44	0.59	-0.02
2002	0.64	0.54	0.40	0.63	0.44	0.62	0.10
2003	0.49	0.56	0.39	0.67	0.44	0.65	-0.07
2004	0.30	0.58	0.39	0.70	0.44	0.68	-0.28
2005	0.29	0.59	0.38	0.73	0.44	0.71	-0.31
2006	0.72	0.61	0.38	0.77	0.44	0.74	0.11
2007	0.85	0.63	0.37	0.80	0.44	0.77	0.22

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.36
Signific.	
Q	1.29E-03
Qmin99	-2.41E-03
Qmax99	3.85E-03
Qmin95	-1.35E-03
Qmax95	3.00E-03
B	1.91E-01
Bmin99	2.15E-01
Bmax99	1.70E-01
Bmin95	2.14E-01
Bmax95	1.76E-01

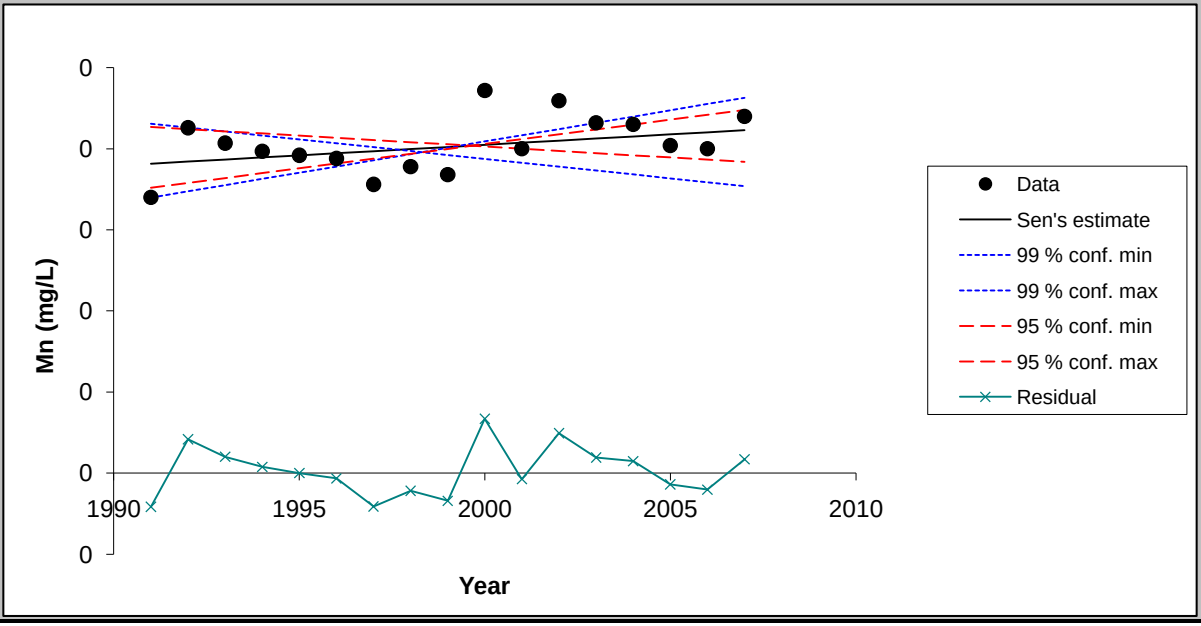

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.17	0.19	0.22	0.17	0.21	0.18	-0.02
1992	0.21	0.19	0.21	0.17	0.21	0.18	0.02
1993	0.20	0.19	0.21	0.18	0.21	0.18	0.01
1994	0.20	0.19	0.21	0.18	0.21	0.18	0.00
1995	0.20	0.20	0.21	0.19	0.21	0.19	0.00
1996	0.19	0.20	0.20	0.19	0.21	0.19	0.00
1997	0.18	0.20	0.20	0.19	0.21	0.19	-0.02
1998	0.19	0.20	0.20	0.20	0.20	0.20	-0.01
1999	0.18	0.20	0.20	0.20	0.20	0.20	-0.02
2000	0.24	0.20	0.19	0.20	0.20	0.20	0.03
2001	0.20	0.20	0.19	0.21	0.20	0.21	0.00
2002	0.23	0.21	0.19	0.21	0.20	0.21	0.02
2003	0.22	0.21	0.19	0.22	0.20	0.21	0.01
2004	0.22	0.21	0.18	0.22	0.20	0.22	0.01
2005	0.20	0.21	0.18	0.22	0.19	0.22	-0.01
2006	0.20	0.21	0.18	0.23	0.19	0.22	-0.01
2007	0.22	0.21	0.18	0.23	0.19	0.22	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.17
Signific.	*
Q	-3.89E-03
Qmin99	-1.91E-02
Qmax99	0.00E+00
Qmin95	-1.39E-02
Qmax95	0.00E+00
B	6.45E-02
Bmin99	2.16E-01
Bmax99	1.90E-02
Bmin95	1.77E-01
Bmax95	1.90E-02

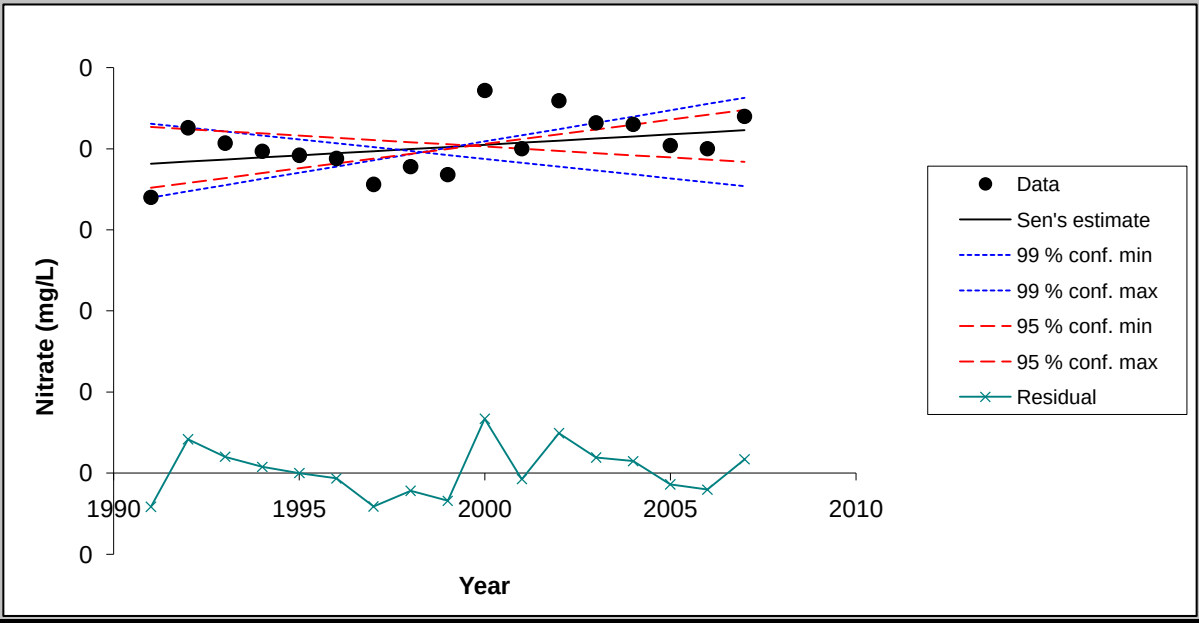

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.50	0.06	0.22	0.02	0.18	0.02	0.44
1992	0.19	0.06	0.20	0.02	0.16	0.02	0.12
1993	0.08	0.06	0.18	0.02	0.15	0.02	0.02
1994	0.06	0.05	0.16	0.02	0.14	0.02	0.01
1995	0.02	0.05	0.14	0.02	0.12	0.02	-0.03
1996	0.02	0.05	0.12	0.02	0.11	0.02	-0.02
1997	0.00	0.04	0.10	0.02	0.09	0.02	-0.04
1998	0.02	0.04	0.08	0.02	0.08	0.02	-0.02
1999	0.00	0.03	0.06	0.02	0.07	0.02	-0.03
2000	1.50	0.03	0.04	0.02	0.05	0.02	1.47
2001	0.03	0.03	0.03	0.02	0.04	0.02	0.00
2002	0.98	0.02	0.01	0.02	0.02	0.02	0.96
2003	0.01	0.02	-0.01	0.02	0.01	0.02	-0.01
2004	0.01	0.01	-0.03	0.02	0.00	0.02	0.00
2005	0.01	0.01	-0.05	0.02	-0.02	0.02	0.00
2006	0.01	0.01	-0.07	0.02	-0.03	0.02	0.00
2007	0.01	0.00	-0.09	0.02	-0.05	0.02	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.14
Signific.	
Q	-5.45E-05
Qmin99	-4.45E-04
Qmax99	1.00E-04
Qmin95	-2.79E-04
Qmax95	4.74E-05
B	2.88E-03
Bmin99	7.29E-03
Bmax99	1.70E-03
Bmin95	5.12E-03
Bmax95	2.17E-03

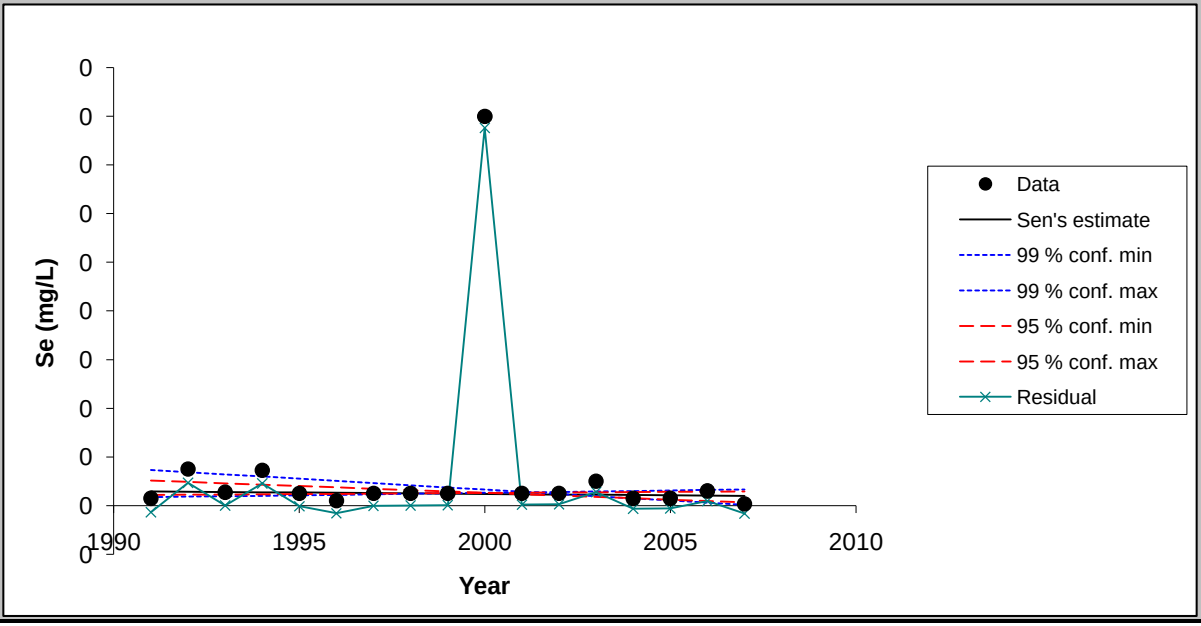

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1994	0.01	0.00	0.01	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.08	0.00	0.00	0.00	0.00	0.00	0.08
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.31
Signific.	*
Q	4.72E-01
Qmin99	-9.35E-02
Qmax99	1.26E+00
Qmin95	9.69E-02
Qmax95	9.71E-01
B	1.92E+01
Bmin99	2.47E+01
Bmax99	1.47E+01
Bmin95	2.30E+01
Bmax95	1.71E+01

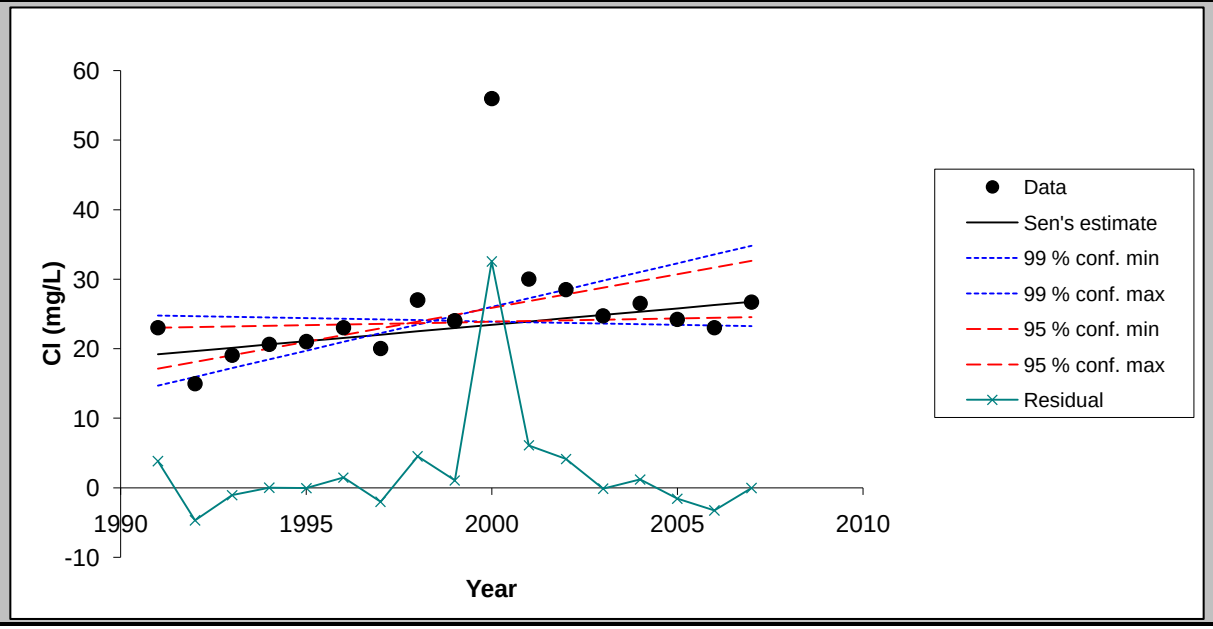

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	23.00	19.18	24.75	14.67	23.00	17.11	3.82
1992	14.95	19.66	24.65	15.93	23.10	18.08	-4.71
1993	19.05	20.13	24.56	17.18	23.19	19.05	-1.08
1994	20.60	20.60	24.47	18.44	23.29	20.02	0.00
1995	21.00	21.07	24.37	19.70	23.39	20.99	-0.07
1996	23.00	21.54	24.28	20.96	23.48	21.96	1.46
1997	20.00	22.02	24.19	22.21	23.58	22.94	-2.02
1998	27.00	22.49	24.09	23.47	23.68	23.91	4.51
1999	24.00	22.96	24.00	24.73	23.77	24.88	1.04
2000	56.00	23.43	23.91	25.99	23.87	25.85	32.57
2001	30.00	23.90	23.81	27.24	23.97	26.82	6.10
2002	28.50	24.38	23.72	28.50	24.07	27.79	4.12
2003	24.70	24.85	23.63	29.76	24.16	28.76	-0.15
2004	26.50	25.32	23.53	31.01	24.26	29.74	1.18
2005	24.20	25.79	23.44	32.27	24.36	30.71	-1.59
2006	23.00	26.27	23.35	33.53	24.45	31.68	-3.27
2007	26.70	26.74	23.25	34.79	24.55	32.65	-0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1991 - 2007
n	16
Test S	
Test Z	-0.59
Signific.	
Q	-1.82E-04
Qmin99	-1.71E-03
Qmax99	1.52E-03
Qmin95	-1.23E-03
Qmax95	1.00E-03
B	9.85E-03
Bmin99	2.30E-02
Bmax99	-2.34E-03
Bmin95	1.79E-02
Bmax95	2.00E-03

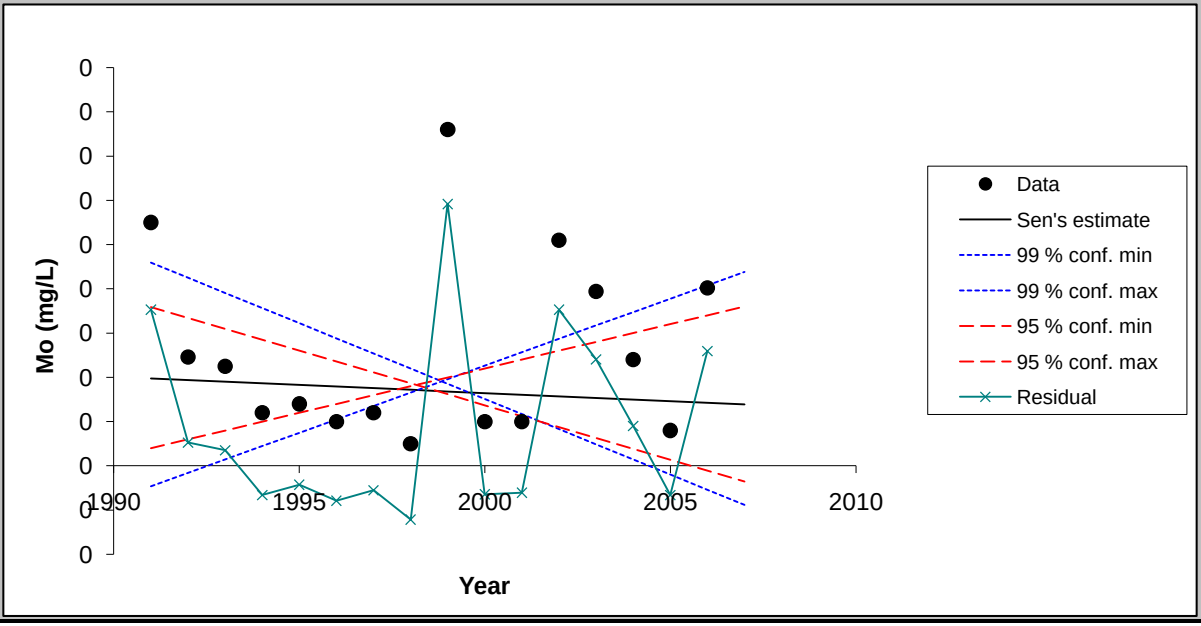

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.03	0.01	0.02	0.00	0.02	0.00	0.02
1992	0.01	0.01	0.02	0.00	0.02	0.00	0.00
1993	0.01	0.01	0.02	0.00	0.02	0.00	0.00
1994	0.01	0.01	0.02	0.00	0.01	0.00	0.00
1995	0.01	0.01	0.02	0.00	0.01	0.01	0.00
1996	0.00	0.01	0.01	0.01	0.01	0.01	0.00
1997	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1998	0.00	0.01	0.01	0.01	0.01	0.01	-0.01
1999	0.04	0.01	0.01	0.01	0.01	0.01	0.03
2000	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2002	0.03	0.01	0.00	0.01	0.00	0.01	0.02
2003	0.02	0.01	0.00	0.02	0.00	0.01	0.01
2004	0.01	0.01	0.00	0.02	0.00	0.02	0.00
2005	0.00	0.01	0.00	0.02	0.00	0.02	0.00
2006	0.02	0.01	0.00	0.02	0.00	0.02	0.01
2007		0.01	0.00	0.02	0.00	0.02	

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.23
Signific.	*
Q	1.91E+00
Qmin99	-5.06E-01
Qmax99	3.31E+00
Qmin95	2.46E-01
Qmax95	2.76E+00
B	5.42E+01
Bmin99	8.33E+01
Bmax99	4.41E+01
Bmin95	7.63E+01
Bmax95	4.87E+01

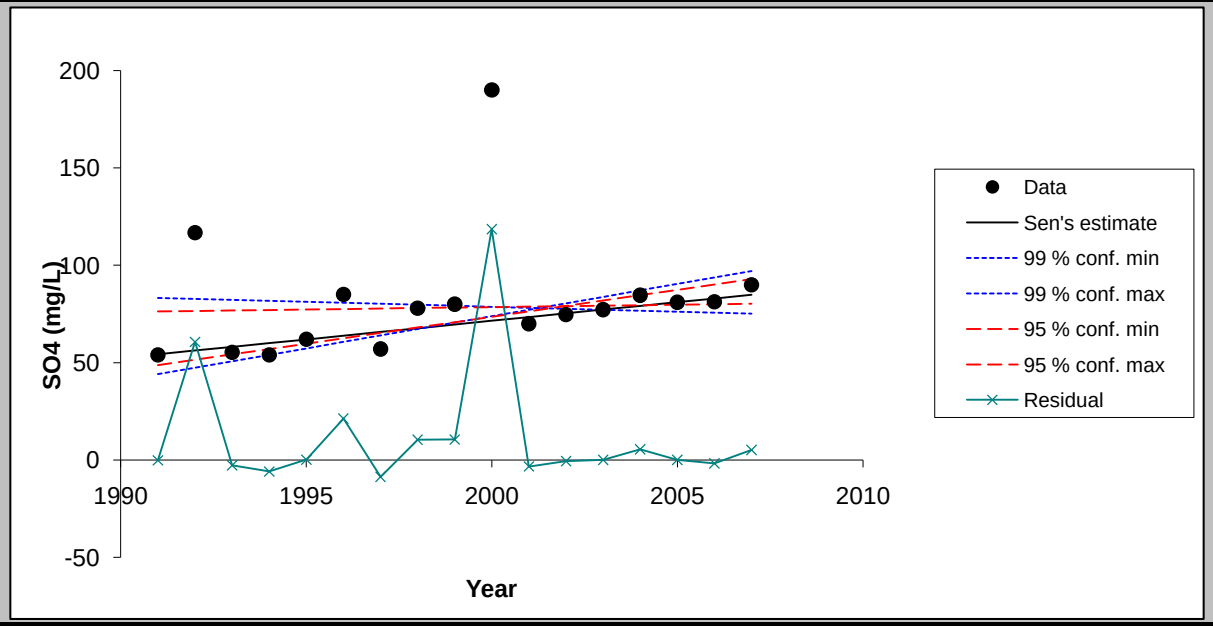

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	54.00	54.23	83.27	44.08	76.28	48.66	-0.23
1992	116.75	56.14	82.77	47.38	76.52	51.42	60.61
1993	55.30	58.06	82.26	50.69	76.77	54.19	-2.76
1994	54.00	59.97	81.75	54.00	77.02	56.95	-5.97
1995	62.00	61.89	81.25	57.31	77.26	59.72	0.11
1996	85.00	63.80	80.74	60.62	77.51	62.48	21.20
1997	57.00	65.71	80.24	63.92	77.75	65.25	-8.71
1998	78.00	67.63	79.73	67.23	78.00	68.01	10.37
1999	80.00	69.54	79.22	70.54	78.25	70.78	10.46
2000	190.00	71.46	78.72	73.85	78.49	73.54	118.54
2001	70.00	73.37	78.21	77.16	78.74	76.31	-3.37
2002	74.66	75.29	77.71	80.46	78.98	79.07	-0.62
2003	77.20	77.20	77.20	83.77	79.23	81.84	0.00
2004	84.60	79.11	76.69	87.08	79.48	84.60	5.49
2005	81.00	81.03	76.19	90.39	79.72	87.36	-0.03
2006	81.20	82.94	75.68	93.70	79.97	90.13	-1.74
2007	90.00	84.86	75.18	97.00	80.21	92.89	5.14

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-01 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	15	15	15	15	15	15	14	15
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.08	1.3	0.0025	5.1	0.007	136		162
1992	0.0632	0.76	0.0014	5.04	0.0659	89	0.0393	128.5
1993	0.0907	0.93	0.00915	5.5	0.04175	87.55	0.04015	156.5
1994	0.08165	1.065	0.0018	4.995	0.0489	72	0.0295	126.5
1995								
1996	0.064	0.05	0.0005	5.1	0.03	78	0.016	140
1997								
1998	0.087	1.2	0.0005	5.7	0.072	120	0.024	180
1999	0.061	0.9	0.0005	5	0.06	82	0.02	170
2000	0.042	0.92	0.0005	4.7	0.04	69	0.016	140
2001	0.037	0.6	0.005	3.51	0.056	32	0.005	82
2002	0.0405	0.951	0.03	4.47	0.061	55.525	0.02	134.007
2003	0.0261	0.46	0.001	4.1	0.037	57.5	0.021	134
2004	0.0294	0.44	0.001	4.495	0.018	52.8	0.0276	122
2005	0.0435	0.66	0.002	5.225	0.098	91	0.028	170
2006	0.0272	0.72	0.002	4.975	0.053	72.7	0.02	141
2007	0.0314	0.89	0.002	4.56	0.0167	99.3	0.0386	136

TREND STATISTICS

PW-01 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*15*		-3.17	**	-0.004	-0.006	-0.001	-0.005	-0.002	0.083	0.103	0.062	0.100	0.068
F (mg/L)	*1991*	*2007*	*15*		-1.48		-0.024	-0.067	0.041	-0.055	0.018	1.083	1.309	0.495	1.300	0.742
Mn (mg/L)	*1991*	*2007*	*15*		0.30		0.0000	-0.0003	0.0002	-0.0001	0.0002	0.0018	0.0042	-0.0012	0.0028	-0.0006
Nitrate (mg/L)	*1991*	*2007*	*15*		-1.73	+	-0.044	-0.121	0.021	-0.100	0.010	5.128	5.787	4.830	5.598	4.921
Se (mg/L)	*1991*	*2007*	*15*		-0.10		0.000	-0.005	0.005	-0.003	0.003	0.050	0.090	0.007	0.069	0.024
Cl (mg/L)	*1991*	*2007*	*15*		-1.29		-2.286	-6.368	2.053	-4.365	1.367	91.286	132.948	65.578	109.551	71.064
Mo (mg/L)	*1992*	*2007*	*14*		-0.22		0.000	-0.003	0.002	-0.002	0.001	0.024	0.044	0.003	0.041	0.009
SO4 (mg/L)	*1991*	*2007*	*15*		-0.50		-0.571	-4.940	2.444	-3.393	1.146	145.14	186.22	119.17	170.53	127.35
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-3.17
Signific.	**
Q	-3.70E-03
Qmin99	-6.11E-03
Qmax99	-1.30E-03
Qmin95	-5.43E-03
Qmax95	-2.28E-03
B	8.25E-02
Bmin99	1.03E-01
Bmax99	6.16E-02
Bmin95	9.99E-02
Bmax95	6.78E-02

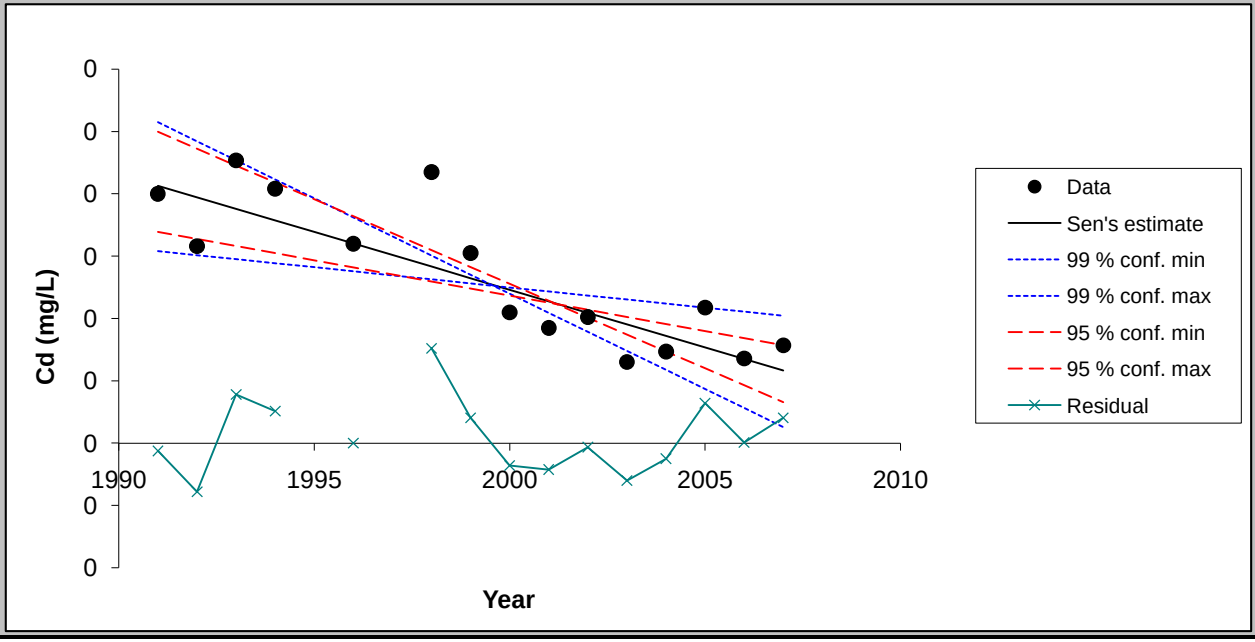

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.08	0.08	0.10	0.06	0.10	0.07	0.00
1992	0.06	0.08	0.10	0.06	0.09	0.07	-0.02
1993	0.09	0.08	0.09	0.06	0.09	0.06	0.02
1994	0.08	0.07	0.08	0.06	0.08	0.06	0.01
1995		0.07	0.08	0.06	0.08	0.06	
1996	0.06	0.06	0.07	0.06	0.07	0.06	0.00
1997		0.06	0.07	0.05	0.07	0.05	
1998	0.09	0.06	0.06	0.05	0.06	0.05	0.03
1999	0.06	0.05	0.05	0.05	0.06	0.05	0.01
2000	0.04	0.05	0.05	0.05	0.05	0.05	-0.01
2001	0.04	0.05	0.04	0.05	0.05	0.05	-0.01
2002	0.04	0.04	0.04	0.05	0.04	0.04	0.00
2003	0.03	0.04	0.03	0.05	0.03	0.04	-0.01
2004	0.03	0.03	0.02	0.04	0.03	0.04	-0.01
2005	0.04	0.03	0.02	0.04	0.02	0.04	0.01
2006	0.03	0.03	0.01	0.04	0.02	0.03	0.00
2007	0.03	0.02	0.01	0.04	0.01	0.03	0.01

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-1.48
Signific.	
Q	-2.42E-02
Qmin99	-6.68E-02
Qmax99	4.14E-02
Qmin95	-5.47E-02
Qmax95	1.76E-02
B	1.08E+00
Bmin99	1.31E+00
Bmax99	4.95E-01
Bmin95	1.30E+00
Bmax95	7.42E-01

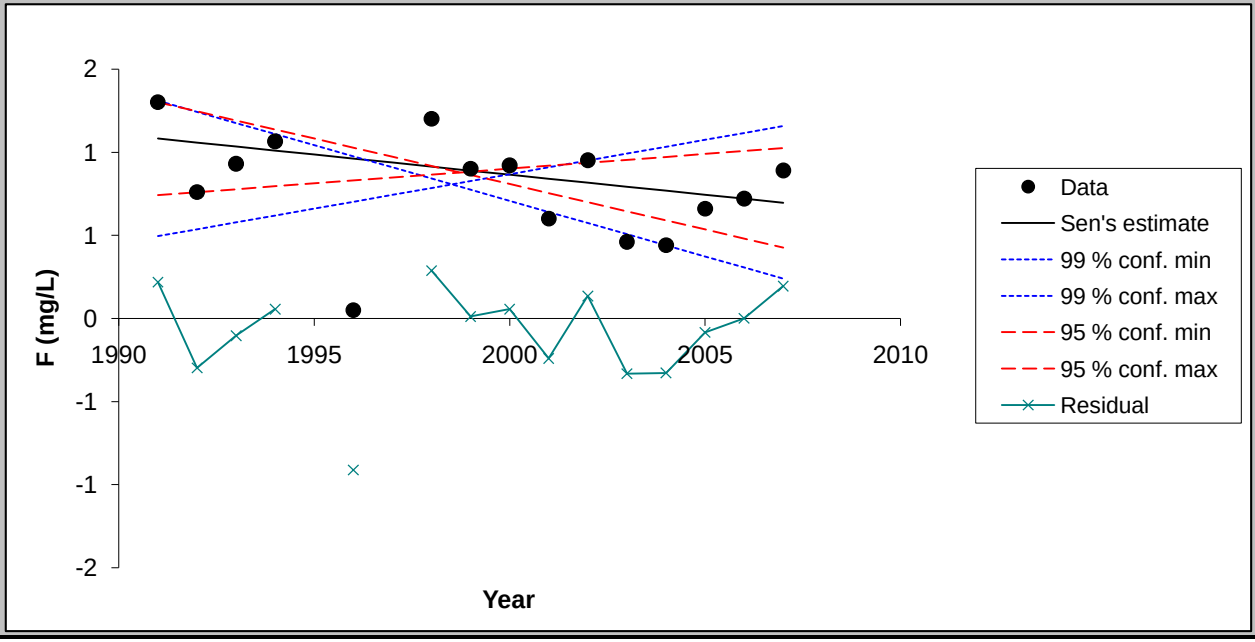

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	1.30	1.08	1.31	0.50	1.30	0.74	0.22
1992	0.76	1.06	1.24	0.54	1.25	0.76	-0.30
1993	0.93	1.03	1.18	0.58	1.19	0.78	-0.10
1994	1.07	1.01	1.11	0.62	1.14	0.80	0.06
1995		0.99	1.04	0.66	1.08	0.81	
1996	0.05	0.96	0.97	0.70	1.03	0.83	-0.91
1997		0.94	0.91	0.74	0.97	0.85	
1998	1.20	0.91	0.84	0.79	0.92	0.87	0.29
1999	0.90	0.89	0.77	0.83	0.86	0.88	0.01
2000	0.92	0.87	0.71	0.87	0.81	0.90	0.06
2001	0.60	0.84	0.64	0.91	0.75	0.92	-0.24
2002	0.95	0.82	0.57	0.95	0.70	0.94	0.13
2003	0.46	0.79	0.51	0.99	0.64	0.95	-0.33
2004	0.44	0.77	0.44	1.03	0.59	0.97	-0.33
2005	0.66	0.74	0.37	1.08	0.53	0.99	-0.08
2006	0.72	0.72	0.31	1.12	0.48	1.01	0.00
2007	0.89	0.70	0.24	1.16	0.43	1.02	0.19

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	0.30
Signific.	
Q	0.00E+00
Qmin99	-2.63E-04
Qmax99	2.50E-04
Qmin95	-1.50E-04
Qmax95	1.87E-04
B	1.80E-03
Bmin99	4.15E-03
Bmax99	-1.25E-03
Bmin95	2.79E-03
Bmax95	-6.18E-04

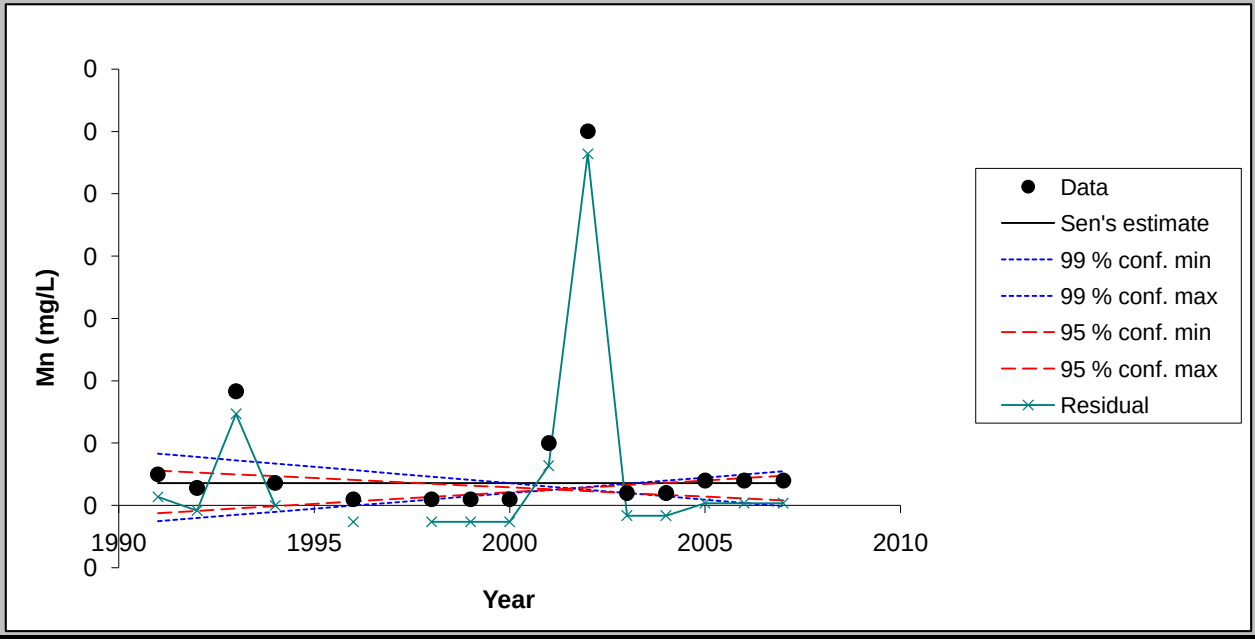

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995		0.00	0.00	0.00	0.00	0.00	
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997		0.00	0.00	0.00	0.00	0.00	
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-1.73
Signific.	+
Q	-4.44E-02
Qmin99	-1.21E-01
Qmax99	2.13E-02
Qmin95	-9.96E-02
Qmax95	9.92E-03
B	5.13E+00
Bmin99	5.79E+00
Bmax99	4.83E+00
Bmin95	5.60E+00
Bmax95	4.92E+00

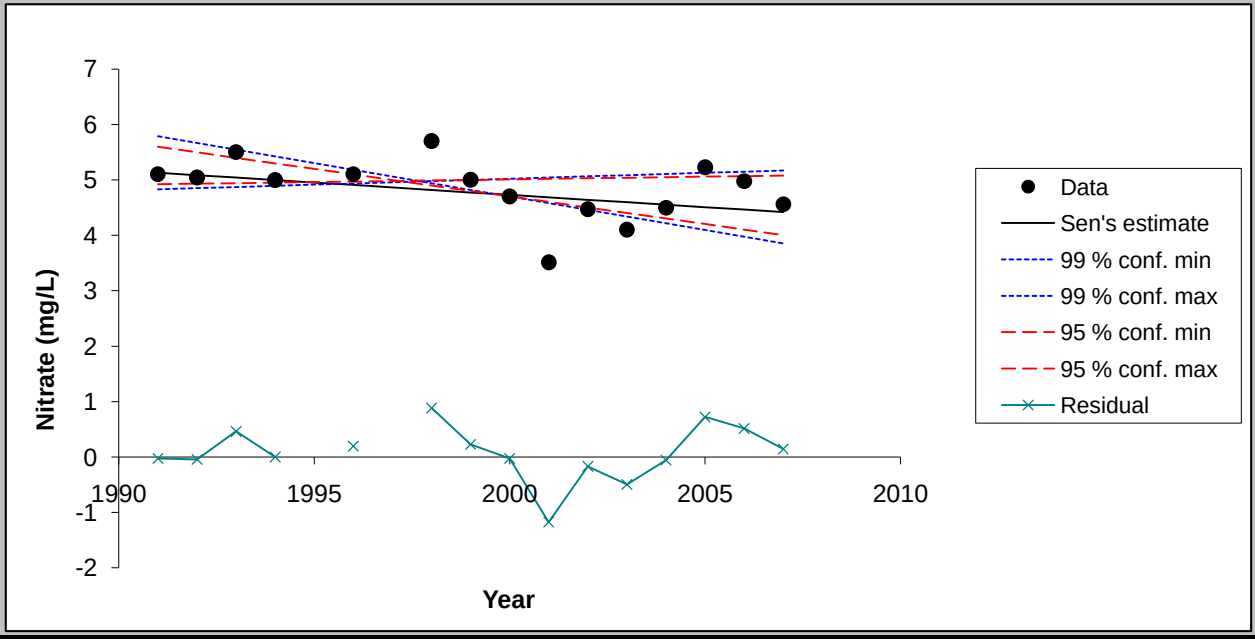

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.10	5.13	5.79	4.83	5.60	4.92	-0.03
1992	5.04	5.08	5.67	4.85	5.50	4.93	-0.04
1993	5.50	5.04	5.55	4.87	5.40	4.94	0.46
1994	5.00	5.00	5.42	4.89	5.30	4.95	0.00
1995		4.95	5.30	4.91	5.20	4.96	
1996	5.10	4.91	5.18	4.94	5.10	4.97	0.19
1997		4.86	5.06	4.96	5.00	4.98	
1998	5.70	4.82	4.94	4.98	4.90	4.99	0.88
1999	5.00	4.77	4.82	5.00	4.80	5.00	0.23
2000	4.70	4.73	4.70	5.02	4.70	5.01	-0.03
2001	3.51	4.68	4.58	5.04	4.60	5.02	-1.17
2002	4.47	4.64	4.46	5.06	4.50	5.03	-0.17
2003	4.10	4.60	4.34	5.09	4.40	5.04	-0.50
2004	4.50	4.55	4.22	5.11	4.30	5.05	-0.06
2005	5.23	4.51	4.10	5.13	4.20	5.06	0.72
2006	4.98	4.46	3.98	5.15	4.10	5.07	0.51
2007	4.56	4.42	3.85	5.17	4.00	5.08	0.14

FIGURE

< Previous Time Series | Next Time Series >

PW-01 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-0.10
Signific.	
Q	-4.33E-04
Qmin99	-4.56E-03
Qmax99	4.90E-03
Qmin95	-2.85E-03
Qmax95	3.25E-03
B	5.02E-02
Bmin99	8.97E-02
Bmax99	7.00E-03
Bmin95	6.88E-02
Bmax95	2.35E-02

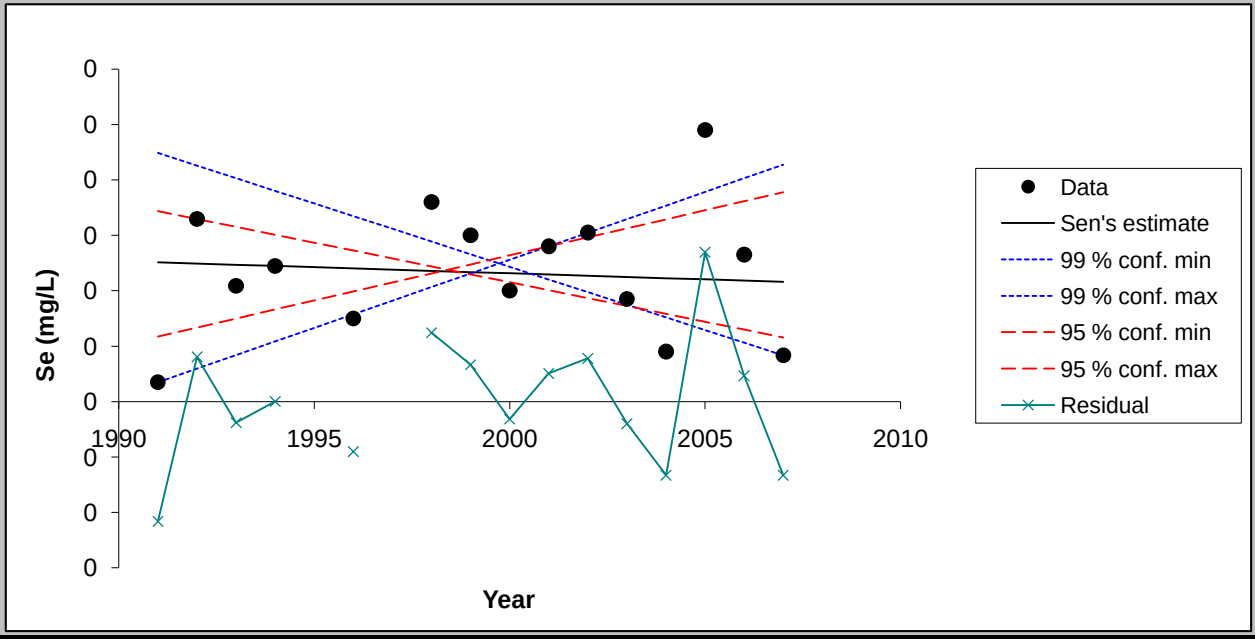

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.05	0.09	0.01	0.07	0.02	-0.04
1992	0.07	0.05	0.09	0.01	0.07	0.03	0.02
1993	0.04	0.05	0.08	0.02	0.06	0.03	-0.01
1994	0.05	0.05	0.08	0.02	0.06	0.03	0.00
1995		0.05	0.07	0.03	0.06	0.04	
1996	0.03	0.05	0.07	0.03	0.05	0.04	-0.02
1997		0.05	0.06	0.04	0.05	0.04	
1998	0.07	0.05	0.06	0.04	0.05	0.05	0.02
1999	0.06	0.05	0.05	0.05	0.05	0.05	0.01
2000	0.04	0.05	0.05	0.05	0.04	0.05	-0.01
2001	0.06	0.05	0.04	0.06	0.04	0.06	0.01
2002	0.06	0.05	0.04	0.06	0.04	0.06	0.02
2003	0.04	0.05	0.03	0.07	0.03	0.06	-0.01
2004	0.02	0.04	0.03	0.07	0.03	0.07	-0.03
2005	0.10	0.04	0.03	0.08	0.03	0.07	0.05
2006	0.05	0.04	0.02	0.08	0.03	0.07	0.01
2007	0.02	0.04	0.02	0.09	0.02	0.08	-0.03

FIGURE

< Previous Time Series | Next Time Series >

PW-01 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-1.29
Signific.	
Q	-2.29E+00
Qmin99	-6.37E+00
Qmax99	2.05E+00
Qmin95	-4.37E+00
Qmax95	1.37E+00
B	9.13E+01
Bmin99	1.33E+02
Bmax99	6.56E+01
Bmin95	1.10E+02
Bmax95	7.11E+01

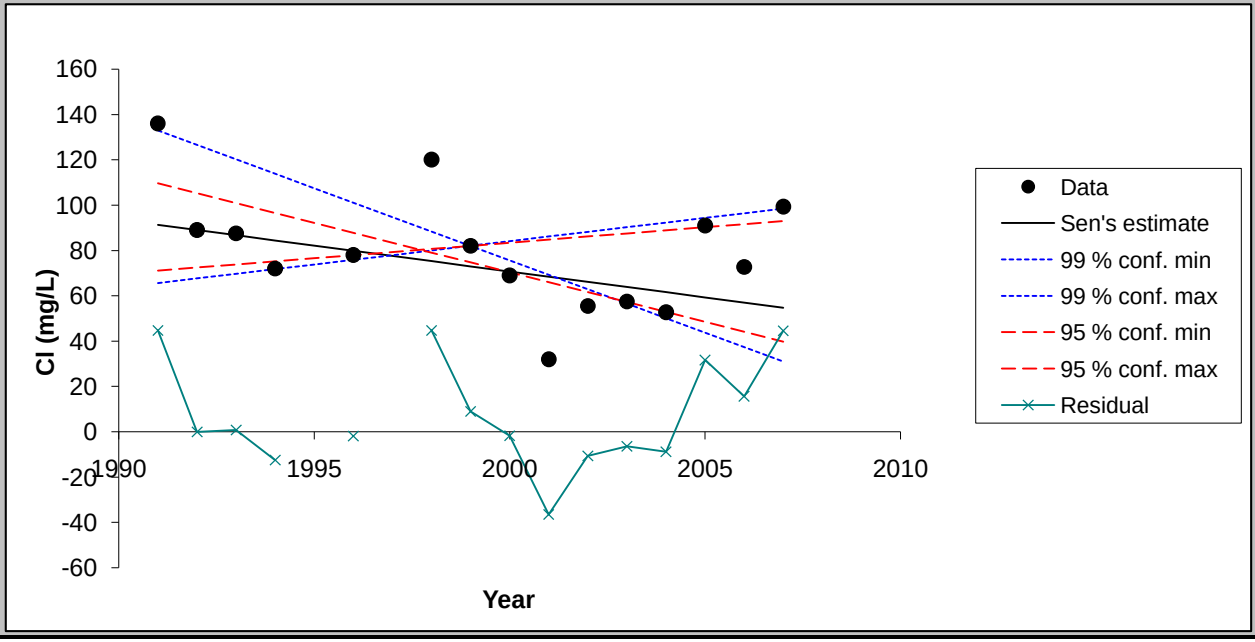

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	136.00	91.29	132.95	65.58	109.55	71.06	44.71
1992	89.00	89.00	126.58	67.63	105.19	72.43	0.00
1993	87.55	86.71	120.21	69.68	100.82	73.80	0.84
1994	72.00	84.43	113.84	71.74	96.45	75.16	-12.43
1995		82.14	107.47	73.79	92.09	76.53	
1996	78.00	79.86	101.11	75.84	87.72	77.90	-1.86
1997		77.57	94.74	77.89	83.36	79.27	
1998	120.00	75.29	88.37	79.95	78.99	80.63	44.71
1999	82.00	73.00	82.00	82.00	74.63	82.00	9.00
2000	69.00	70.71	75.63	84.05	70.26	83.37	-1.71
2001	32.00	68.43	69.26	86.11	65.90	84.73	-36.43
2002	55.53	66.14	62.89	88.16	61.53	86.10	-10.62
2003	57.50	63.86	56.53	90.21	57.17	87.47	-6.36
2004	52.80	61.57	50.16	92.26	52.80	88.84	-8.77
2005	91.00	59.29	43.79	94.32	48.43	90.20	31.71
2006	72.70	57.00	37.42	96.37	44.07	91.57	15.70
2007	99.30	54.71	31.05	98.42	39.70	92.94	44.59

FIGURE

< Previous Time Series | Next Time Series >

PW-01 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	14
Test S	
Test Z	-0.22
Signific.	
Q	-1.11E-04
Qmin99	-2.54E-03
Qmax99	1.99E-03
Qmin95	-1.91E-03
Qmax95	1.33E-03
B	2.36E-02
Bmin99	4.35E-02
Bmax99	2.95E-03
Bmin95	4.11E-02
Bmax95	9.33E-03

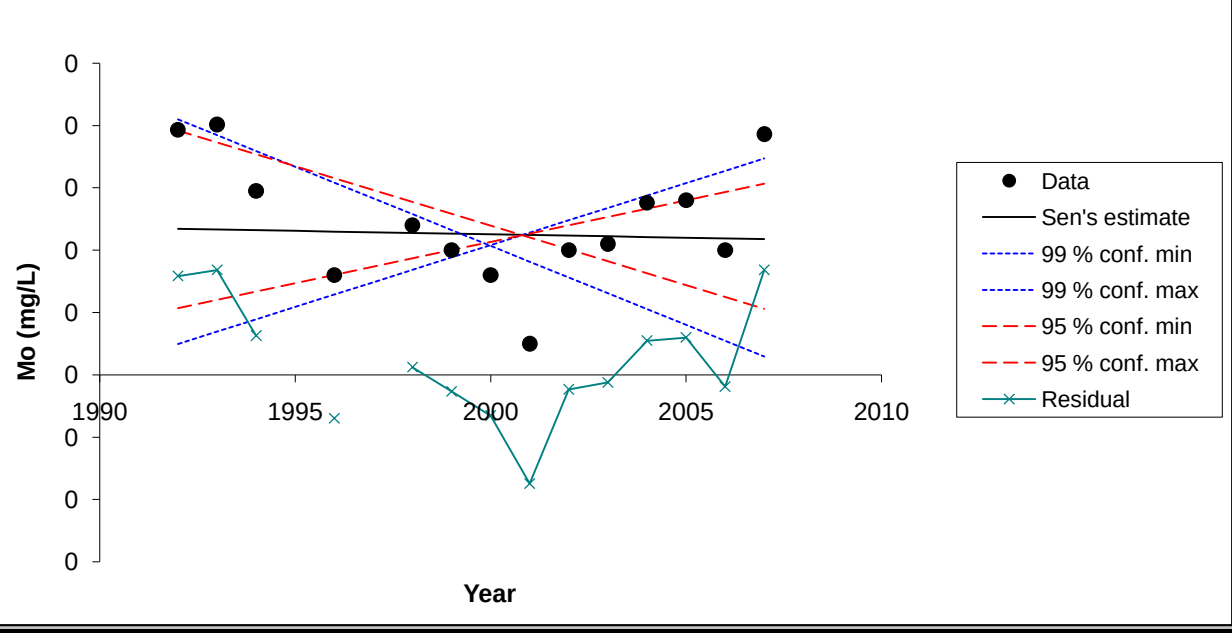

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.04	0.02	0.04	0.00	0.04	0.01	0.02
1993	0.04	0.02	0.04	0.01	0.04	0.01	0.02
1994	0.03	0.02	0.04	0.01	0.04	0.01	0.01
1995		0.02	0.03	0.01	0.03	0.01	
1996	0.02	0.02	0.03	0.01	0.03	0.02	-0.01
1997		0.02	0.03	0.01	0.03	0.02	
1998	0.02	0.02	0.03	0.02	0.03	0.02	0.00
1999	0.02	0.02	0.02	0.02	0.03	0.02	0.00
2000	0.02	0.02	0.02	0.02	0.02	0.02	-0.01
2001	0.00	0.02	0.02	0.02	0.02	0.02	-0.02
2002	0.02	0.02	0.02	0.02	0.02	0.02	0.00
2003	0.02	0.02	0.01	0.03	0.02	0.03	0.00
2004	0.03	0.02	0.01	0.03	0.02	0.03	0.01
2005	0.03	0.02	0.01	0.03	0.01	0.03	0.01
2006	0.02	0.02	0.01	0.03	0.01	0.03	0.00
2007	0.04	0.02	0.00	0.03	0.01	0.03	0.02

FIGURE

< Previous Time Series | Next Time Series >

PW-01 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	15
Test S	
Test Z	-0.50
Signific.	
Q	-5.71E-01
Qmin99	-4.94E+00
Qmax99	2.44E+00
Qmin95	-3.39E+00
Qmax95	1.15E+00
B	1.45E+02
Bmin99	1.86E+02
Bmax99	1.19E+02
Bmin95	1.71E+02
Bmax95	1.27E+02

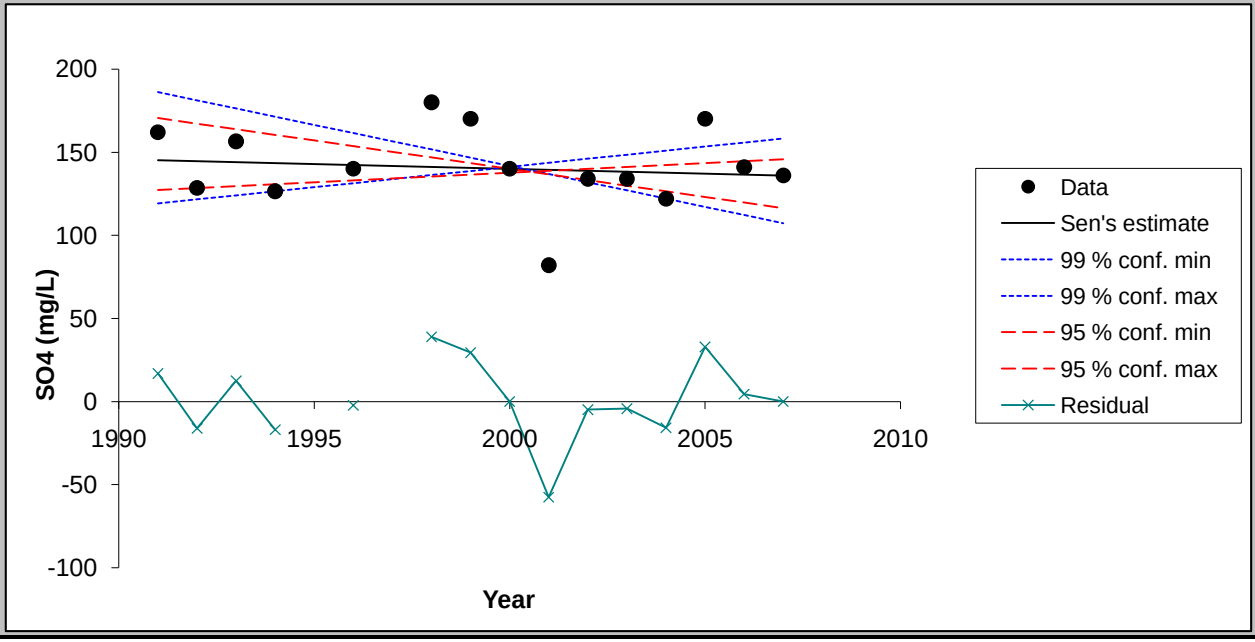

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	162.00	145.14	186.22	119.17	170.53	127.35	16.86
1992	128.50	144.57	181.28	121.61	167.14	128.50	-16.07
1993	156.50	144.00	176.34	124.06	163.75	129.65	12.50
1994	126.50	143.43	171.40	126.50	160.36	130.79	-16.93
1995		142.86	166.46	128.94	156.96	131.94	
1996	140.00	142.29	161.52	131.39	153.57	133.08	-2.29
1997		141.71	156.58	133.83	150.18	134.23	
1998	180.00	141.14	151.64	136.27	146.79	135.38	38.86
1999	170.00	140.57	146.70	138.72	143.39	136.52	29.43
2000	140.00	140.00	141.76	141.16	140.00	137.67	0.00
2001	82.00	139.43	136.82	143.61	136.61	138.82	-57.43
2002	134.01	138.86	131.88	146.05	133.21	139.96	-4.85
2003	134.00	138.29	126.94	148.49	129.82	141.11	-4.29
2004	122.00	137.71	122.00	150.94	126.43	142.25	-15.71
2005	170.00	137.14	117.06	153.38	123.04	143.40	32.86
2006	141.00	136.57	112.12	155.82	119.64	144.55	4.43
2007	136.00	136.00	107.18	158.27	116.25	145.69	0.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-02 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.02	0.4	0.0025	4.05	0.0015	28		84
1992	0.0116	0.325	0.00505	4	0.01165	27.05	0.0356	86.5
1993	0.00985	0.33	0.01165	4.685	0.0164	40.05	0.01525	97
1994	0.0129	0.455	0.0025	4.125	0.0202	42.25	0.01325	88.3
1995	0.0076	0.49	0.0005	17	0.027	44	0.015	110
1996	0.0069	0.42	0.0005	5.1	0.009	37	0.012	94
1997	0.009	0.48	0.0005	5	0.03	49	0.015	120
1998	0.013	0.5	0.0005	4.9	0.026	65	0.016	150
1999	0.006	0.55	0.001	4.8	0.016	39	0.013	130
2000	0.0031	0.44	0.0005	3.8	0.01	36	0.018	100
2001	0.003	0.9	0.005	4.62	0.013	50	0.02	125
2002	0.003	0.643	0.03	3.38	0.01	32.639	0.0275	80.558
2003	0.0049	0.23	0.001	3.47	0.014	38.4	0.024	99.9
2004	0.0053	0.26	0.001	3.31	0.0075	41.2	0.033	98.5
2005	0.0035	0.175	0.002	4.34	0.019	61.5	0.025	120
2006	0.0035	0.32	0.002	4.22	0.0131	58.5	0.031	116
2007	0.0016	0.46	0.002	3.74	0.0064	54.4	0.05	102

TREND STATISTICS

PW-02 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-3.59	***	-0.001	-0.001	0.000	-0.001	0.000	0.01	0.02	0.01	0.02	0.01
F (mg/L)	*1991*	*2007*	*17*		0.04		0.002	-0.025	0.031	-0.017	0.023	0.43	0.59	0.28	0.56	0.30
Mn (mg/L)	*1991*	*2007*	*17*		0.00		0.000	0.000	0.000	0.000	0.000	0.00	0.01	0.00	0.00	0.00
Nitrate (mg/L)	*1991*	*2007*	*17*		-1.77	+	-0.078	-0.150	0.058	-0.123	0.015	4.99	5.85	3.95	5.71	4.08
Se (mg/L)	*1991*	*2007*	*17*		-0.74		0.000	-0.002	0.001	-0.001	0.001	0.02	0.03	0.00	0.03	0.01
Cl (mg/L)	*1991*	*2007*	*17*		1.94	+	1.272	-0.521	2.669	-0.061	2.249	34.05	44.65	23.65	41.99	25.75
Mo (mg/L)	*1992*	*2007*	*16*		2.70	**	0.001	0.000	0.003	0.001	0.002	0.01	0.02	0.00	0.01	0.00
SO4 (mg/L)	*1991*	*2007*	*17*		1.48		1.146	-1.699	5.000	-0.650	2.875	89.69	120.29	73.30	107.70	79.76
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.59
Signific.	***
Q	-7.00E-04
Qmin99	-1.21E-03
Qmax99	-2.97E-04
Qmin95	-1.09E-03
Qmax95	-4.11E-04
B	1.28E-02
Bmin99	1.63E-02
Bmax99	8.46E-03
Bmin95	1.55E-02
Bmax95	9.66E-03

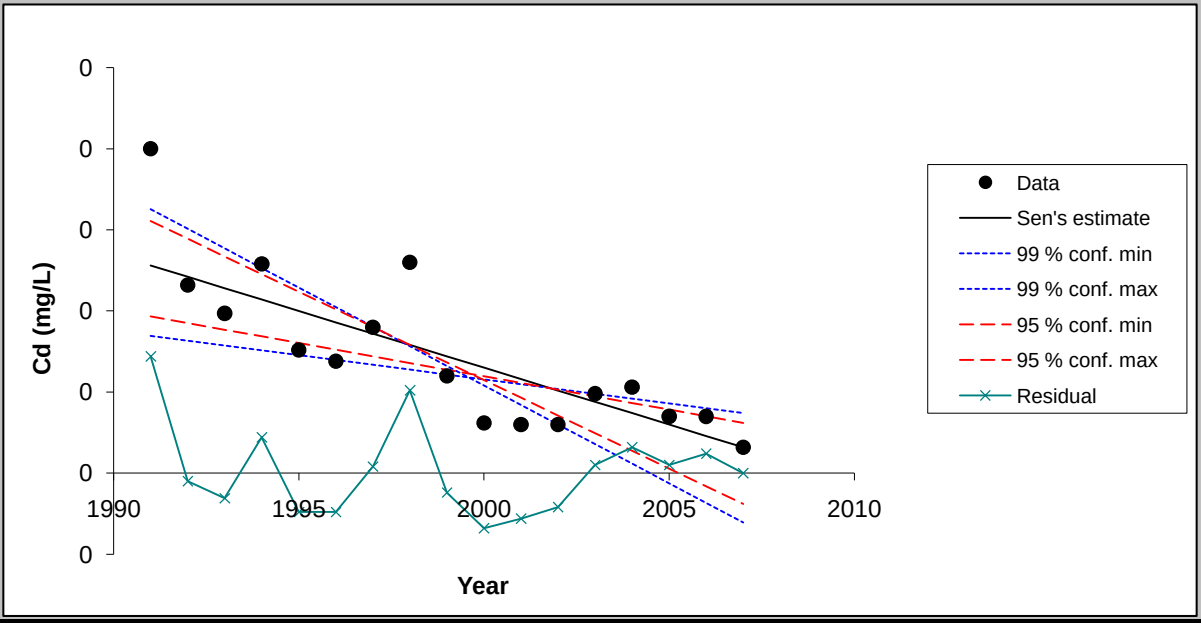

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.01	0.02	0.01	0.02	0.01	0.01
1992	0.01	0.01	0.02	0.01	0.01	0.01	0.00
1993	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1994	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1995	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1996	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1997	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1998	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1999	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.04
Signific.	
Q	1.62E-03
Qmin99	-2.55E-02
Qmax99	3.10E-02
Qmin95	-1.72E-02
Qmax95	2.33E-02
B	4.25E-01
Bmin99	5.92E-01
Bmax99	2.83E-01
Bmin95	5.59E-01
Bmax95	3.04E-01

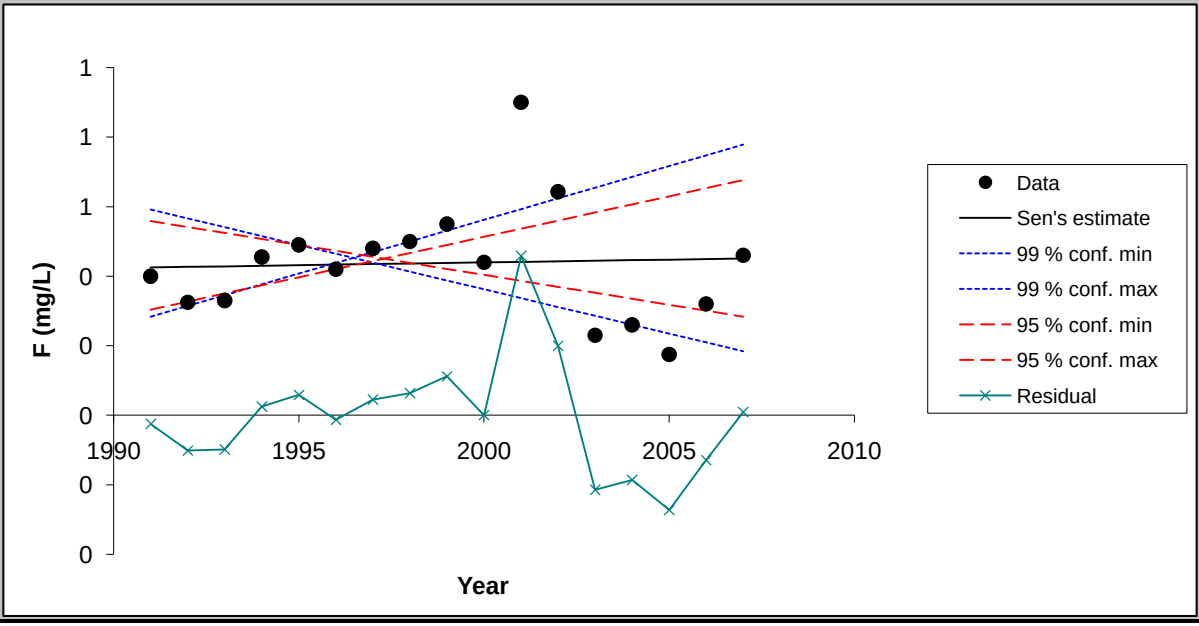

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.40	0.43	0.59	0.28	0.56	0.30	-0.03
1992	0.33	0.43	0.57	0.31	0.54	0.33	-0.10
1993	0.33	0.43	0.54	0.35	0.52	0.35	-0.10
1994	0.46	0.43	0.52	0.38	0.51	0.37	0.02
1995	0.49	0.43	0.49	0.41	0.49	0.40	0.06
1996	0.42	0.43	0.46	0.44	0.47	0.42	-0.01
1997	0.48	0.44	0.44	0.47	0.46	0.44	0.04
1998	0.50	0.44	0.41	0.50	0.44	0.47	0.06
1999	0.55	0.44	0.39	0.53	0.42	0.49	0.11
2000	0.44	0.44	0.36	0.56	0.40	0.51	0.00
2001	0.90	0.44	0.34	0.59	0.39	0.54	0.46
2002	0.64	0.44	0.31	0.62	0.37	0.56	0.20
2003	0.23	0.44	0.29	0.65	0.35	0.58	-0.21
2004	0.26	0.45	0.26	0.69	0.34	0.61	-0.19
2005	0.18	0.45	0.24	0.72	0.32	0.63	-0.27
2006	0.32	0.45	0.21	0.75	0.30	0.65	-0.13
2007	0.46	0.45	0.18	0.78	0.28	0.68	0.01

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.00
Signific.	
Q	0.00E+00
Qmin99	-3.90E-04
Qmax99	1.67E-04
Qmin95	-2.27E-04
Qmax95	1.50E-04
B	2.00E-03
Bmin99	5.44E-03
Bmax99	-3.33E-04
Bmin95	3.72E-03
Bmax95	-2.00E-04

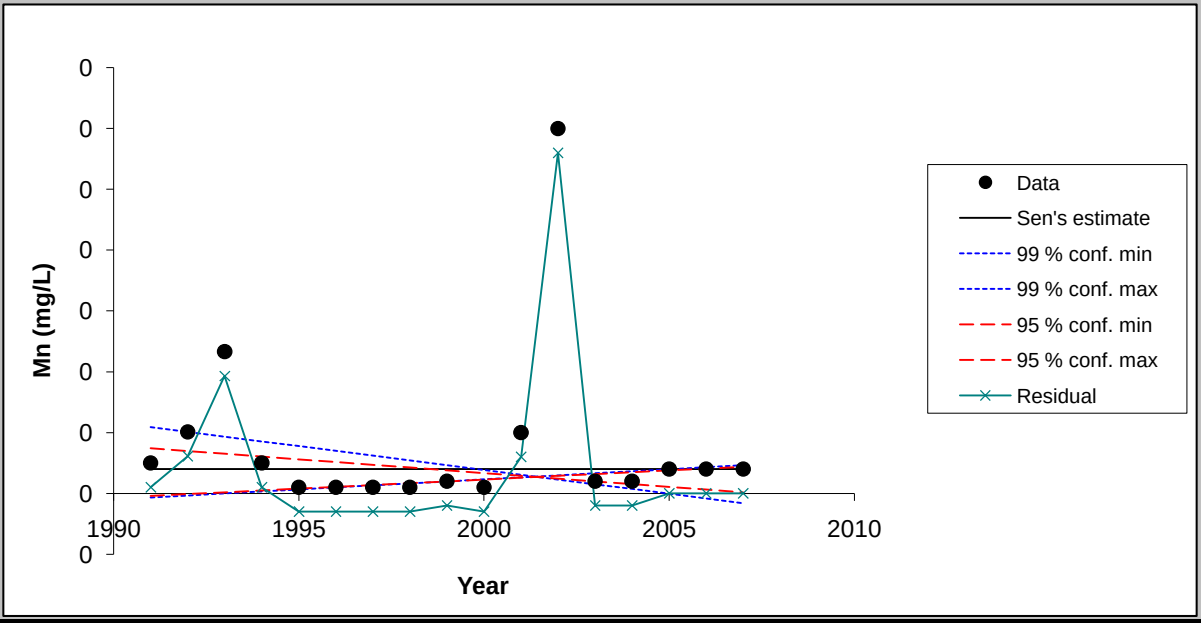

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.77
Signific.	+
Q	-7.83E-02
Qmin99	-1.50E-01
Qmax99	5.85E-02
Qmin95	-1.23E-01
Qmax95	1.48E-02
B	4.99E+00
Bmin99	5.85E+00
Bmax99	3.95E+00
Bmin95	5.71E+00
Bmax95	4.08E+00

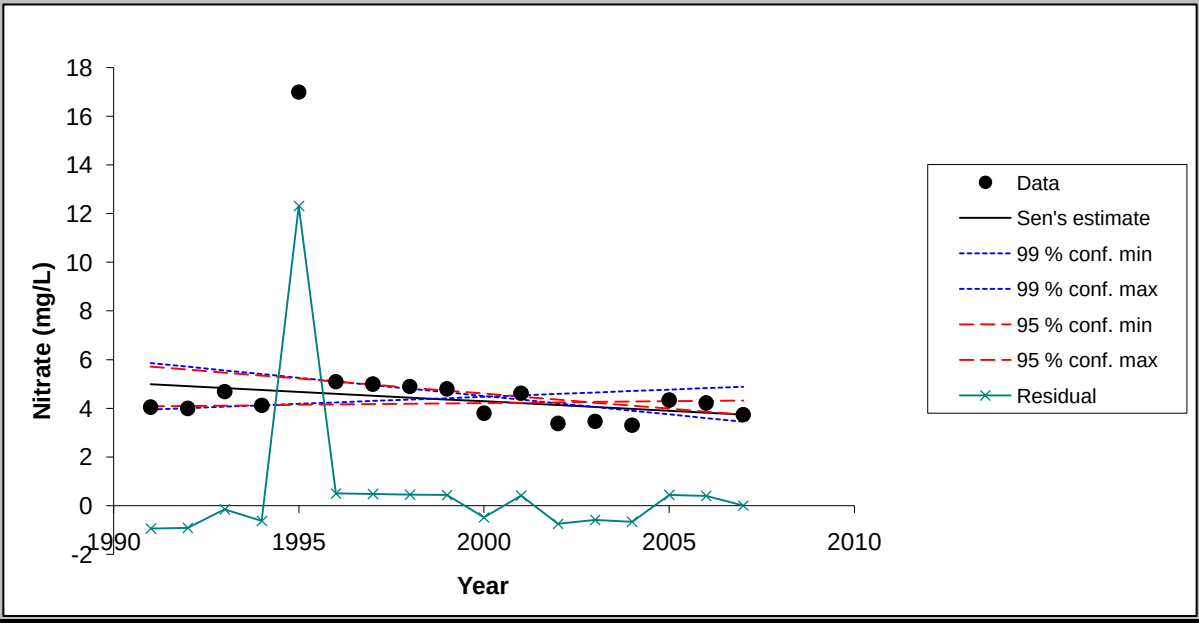

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	4.05	4.99	5.85	3.95	5.71	4.08	-0.94
1992	4.00	4.92	5.70	4.01	5.59	4.10	-0.91
1993	4.69	4.84	5.55	4.07	5.47	4.11	-0.15
1994	4.13	4.76	5.40	4.13	5.34	4.13	-0.63
1995	17.00	4.68	5.25	4.18	5.22	4.14	12.32
1996	5.10	4.60	5.10	4.24	5.10	4.15	0.50
1997	5.00	4.52	4.95	4.30	4.97	4.17	0.48
1998	4.90	4.45	4.80	4.36	4.85	4.18	0.46
1999	4.80	4.37	4.65	4.42	4.73	4.20	0.43
2000	3.80	4.29	4.50	4.48	4.60	4.21	-0.49
2001	4.62	4.21	4.35	4.53	4.48	4.23	0.41
2002	3.38	4.13	4.20	4.59	4.36	4.24	-0.75
2003	3.47	4.05	4.05	4.65	4.23	4.26	-0.58
2004	3.31	3.98	3.90	4.71	4.11	4.27	-0.67
2005	4.34	3.90	3.75	4.77	3.99	4.29	0.44
2006	4.22	3.82	3.60	4.83	3.86	4.30	0.40
2007	3.74	3.74	3.45	4.89	3.74	4.32	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.74
Signific.	
Q	-3.17E-04
Qmin99	-1.64E-03
Qmax99	1.06E-03
Qmin95	-1.24E-03
Qmax95	6.09E-04
B	1.70E-02
Bmin99	2.91E-02
Bmax99	3.71E-03
Bmin95	2.54E-02
Bmax95	6.91E-03

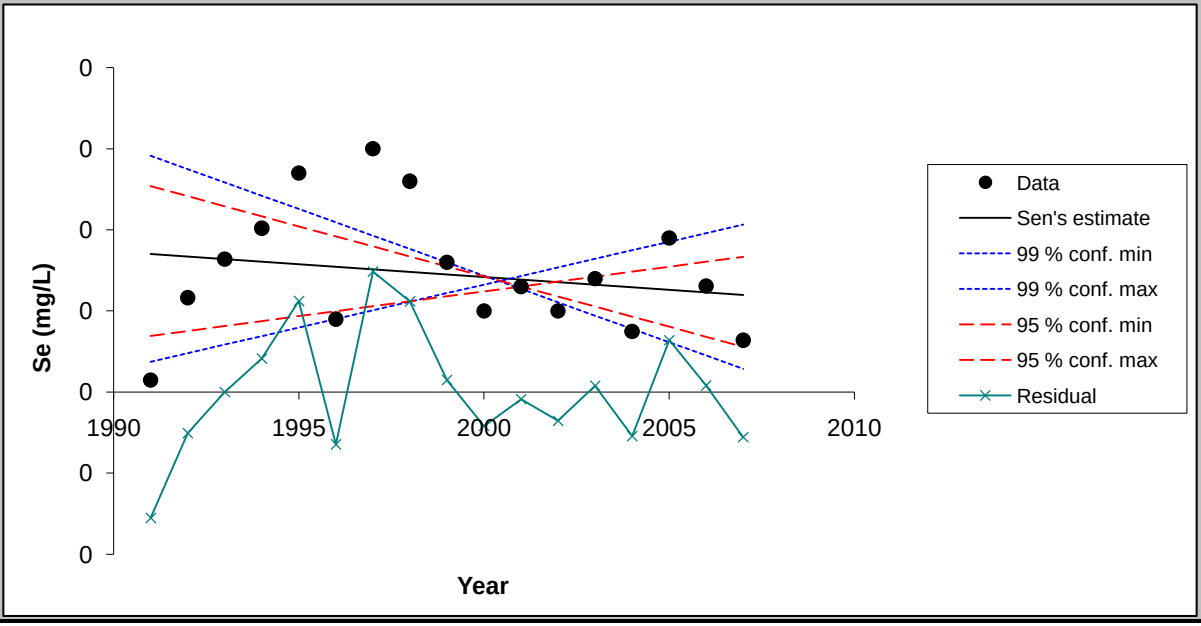

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.02	0.03	0.00	0.03	0.01	-0.02
1992	0.01	0.02	0.03	0.00	0.02	0.01	-0.01
1993	0.02	0.02	0.03	0.01	0.02	0.01	0.00
1994	0.02	0.02	0.02	0.01	0.02	0.01	0.00
1995	0.03	0.02	0.02	0.01	0.02	0.01	0.01
1996	0.01	0.02	0.02	0.01	0.02	0.01	-0.01
1997	0.03	0.02	0.02	0.01	0.02	0.01	0.01
1998	0.03	0.01	0.02	0.01	0.02	0.01	0.01
1999	0.02	0.01	0.02	0.01	0.02	0.01	0.00
2000	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2002	0.01	0.01	0.01	0.02	0.01	0.01	0.00
2003	0.01	0.01	0.01	0.02	0.01	0.01	0.00
2004	0.01	0.01	0.01	0.02	0.01	0.01	-0.01
2005	0.02	0.01	0.01	0.02	0.01	0.02	0.01
2006	0.01	0.01	0.00	0.02	0.01	0.02	0.00
2007	0.01	0.01	0.00	0.02	0.01	0.02	-0.01

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.94
Signific.	+
Q	1.27E+00
Qmin99	-5.21E-01
Qmax99	2.67E+00
Qmin95	-6.11E-02
Qmax95	2.25E+00
B	3.40E+01
Bmin99	4.47E+01
Bmax99	2.37E+01
Bmin95	4.20E+01
Bmax95	2.58E+01

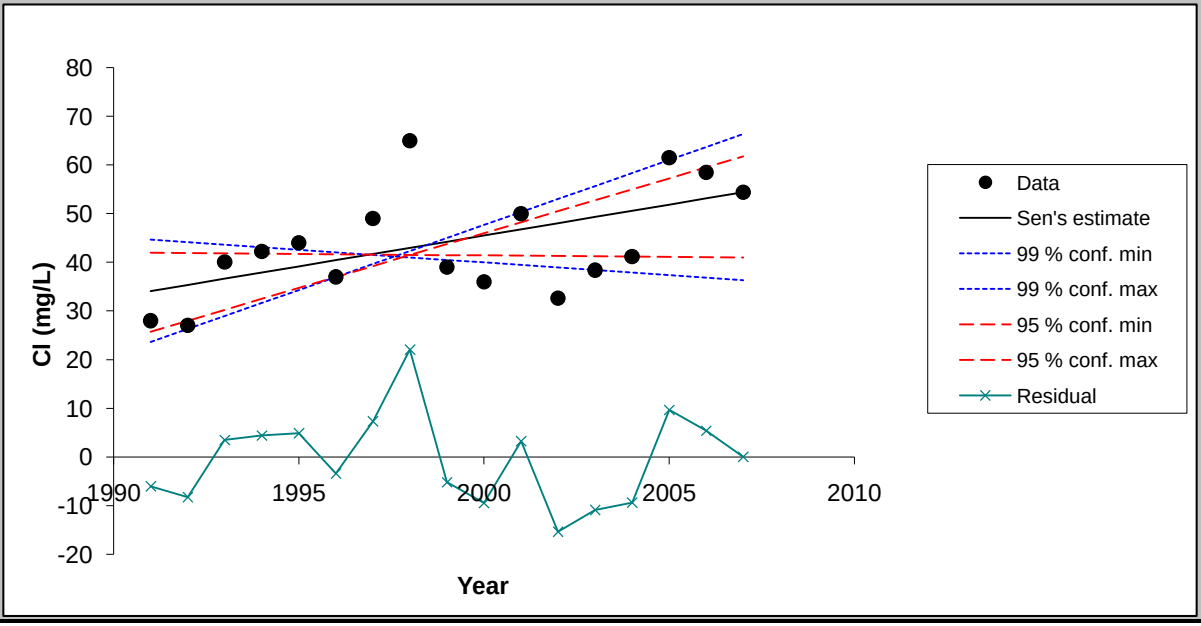

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	28.00	34.05	44.65	23.65	41.99	25.75	-6.05
1992	27.05	35.32	44.13	26.32	41.93	28.00	-8.27
1993	40.05	36.59	43.61	28.99	41.87	30.25	3.46
1994	42.25	37.87	43.09	31.66	41.81	32.50	4.38
1995	44.00	39.14	42.57	34.33	41.75	34.75	4.86
1996	37.00	40.41	42.05	37.00	41.69	37.00	-3.41
1997	49.00	41.68	41.53	39.67	41.63	39.25	7.32
1998	65.00	42.95	41.01	42.34	41.57	41.50	22.05
1999	39.00	44.22	40.48	45.01	41.51	43.75	-5.22
2000	36.00	45.50	39.96	47.68	41.44	46.00	-9.50
2001	50.00	46.77	39.44	50.35	41.38	48.25	3.23
2002	32.64	48.04	38.92	53.02	41.32	50.50	-15.40
2003	38.40	49.31	38.40	55.69	41.26	52.74	-10.91
2004	41.20	50.58	37.88	58.35	41.20	54.99	-9.38
2005	61.50	51.86	37.36	61.02	41.14	57.24	9.64
2006	58.50	53.13	36.84	63.69	41.08	59.49	5.37
2007	54.40	54.40	36.32	66.36	41.02	61.74	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	2.70
Signific.	**
Q	1.38E-03
Qmin99	2.27E-04
Qmax99	2.57E-03
Qmin95	6.22E-04
Qmax95	2.00E-03
B	8.27E-03
Bmin99	1.68E-02
Bmax99	-8.21E-04
Bmin95	1.39E-02
Bmax95	2.50E-03

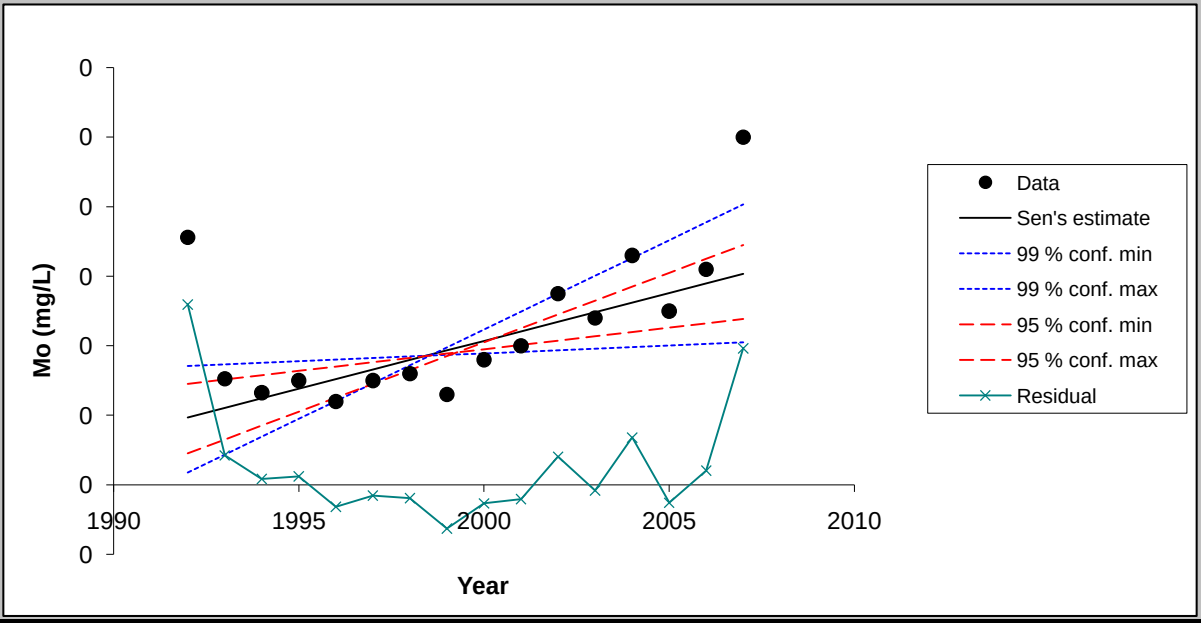

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.04	0.01	0.02	0.00	0.01	0.00	0.03
1993	0.02	0.01	0.02	0.00	0.02	0.01	0.00
1994	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1995	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1996	0.01	0.02	0.02	0.01	0.02	0.01	0.00
1997	0.01	0.02	0.02	0.01	0.02	0.01	0.00
1998	0.02	0.02	0.02	0.02	0.02	0.02	0.00
1999	0.01	0.02	0.02	0.02	0.02	0.02	-0.01
2000	0.02	0.02	0.02	0.02	0.02	0.02	0.00
2001	0.02	0.02	0.02	0.02	0.02	0.02	0.00
2002	0.03	0.02	0.02	0.03	0.02	0.02	0.00
2003	0.02	0.02	0.02	0.03	0.02	0.03	0.00
2004	0.03	0.03	0.02	0.03	0.02	0.03	0.01
2005	0.03	0.03	0.02	0.04	0.02	0.03	0.00
2006	0.03	0.03	0.02	0.04	0.02	0.03	0.00
2007	0.05	0.03	0.02	0.04	0.02	0.03	0.02

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.48
Signific.	
Q	1.15E+00
Qmin99	-1.70E+00
Qmax99	5.00E+00
Qmin95	-6.50E-01
Qmax95	2.87E+00
B	8.97E+01
Bmin99	1.20E+02
Bmax99	7.33E+01
Bmin95	1.08E+02
Bmax95	7.98E+01

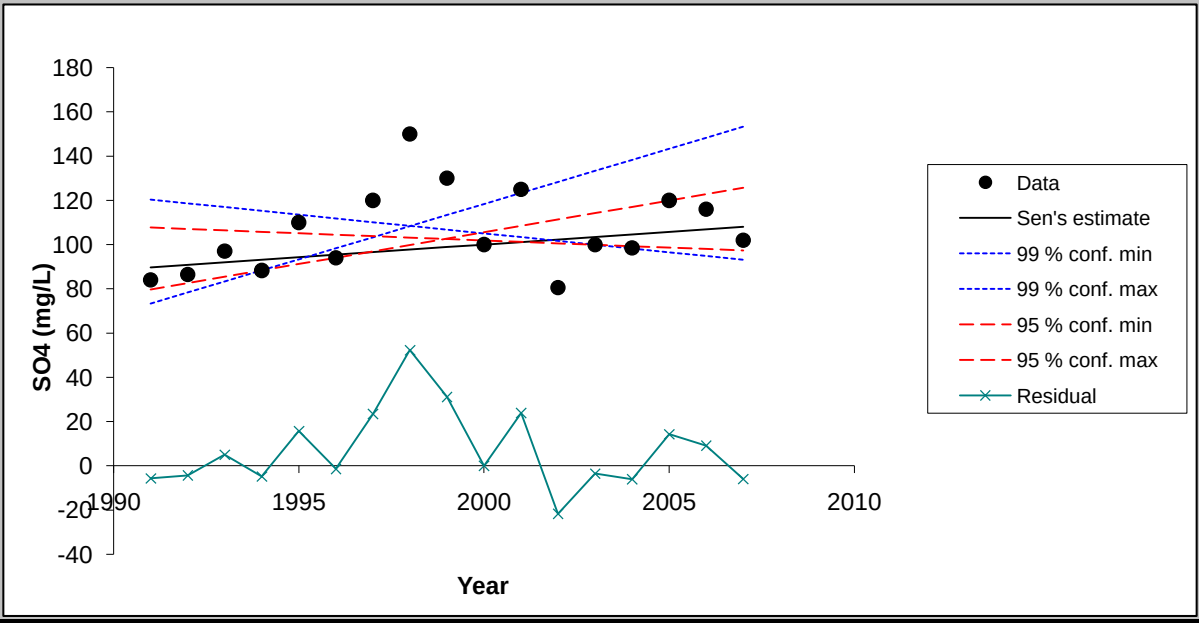

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	84.00	89.69	120.29	73.30	107.70	79.76	-5.69
1992	86.50	90.83	118.59	78.30	107.05	82.63	-4.33
1993	97.00	91.98	116.89	83.30	106.40	85.51	5.02
1994	88.30	93.13	115.19	88.30	105.75	88.38	-4.83
1995	110.00	94.27	113.49	93.30	105.10	91.25	15.73
1996	94.00	95.42	111.79	98.30	104.45	94.13	-1.42
1997	120.00	96.56	110.09	103.30	103.80	97.00	23.44
1998	150.00	97.71	108.39	108.30	103.15	99.88	52.29
1999	130.00	98.85	106.70	113.30	102.50	102.75	31.15
2000	100.00	100.00	105.00	118.30	101.85	105.63	0.00
2001	125.00	101.15	103.30	123.30	101.20	108.50	23.85
2002	80.56	102.29	101.60	128.30	100.55	111.38	-21.73
2003	99.90	103.44	99.90	133.30	99.90	114.25	-3.54
2004	98.50	104.58	98.20	138.30	99.25	117.13	-6.08
2005	120.00	105.73	96.50	143.30	98.60	120.00	14.27
2006	116.00	106.88	94.80	148.30	97.95	122.87	9.13
2007	102.00	108.02	93.10	153.30	97.30	125.75	-6.02

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-03 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.007	0.34	0.003	4.45	0.0015	35		90
1992	0.00515	0.32	0.00215	4.125	0.0115	33.85	0.074	84.7
1993	0.00475	0.295	0.00805	4.945	0.01425	39.45	0.0575	93.4
1994	0.00395	2.2	0.001	4.305	0.0175	48.2	0.03995	69.4
1995	0.0044	0.47	0.0005	4.1	0.022	47	0.036	100
1996	0.0032	0.45	0.0005	4.3	0.009	34	0.025	88
1997	0.0048	0.45	0.0005	4.7	0.021	57	0.021	110
1998	0.002	0.5	0.0005	4.5	0.019	53	0.018	130
1999	0.004	0.47	0.005	4.5	0.012	34	0.018	110
2000	0.0025	0.47	0.0005	3.5	0.009	36	0.019	100
2001	0.001	0.6	0.005	3.56	0.0025	33	0.005	82
2002	0.0025	0.661	0.03	3.36	0.01	32.597	0.0253	80.417
2003	0.0021	0.25	0.001	3.09	0.011	36.6	0.035	83.1
2004	0.0025	0.28	0.001	3.16	0.0075	35.3	0.049	81.4
2005	0.0023	0.217	0.002	4.31	0.012	58.1	0.037	101
2006	0.001	0.13	0.002	4.45	0.01	54	0.041	99.7
2007	0.0014	0.21	0.002	3.64	0.0043	62	0.045	103

TREND STATISTICS

PW-03 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-3.63	***	-0.0003	0.000	0.000	0.000	0.000	0.01	0.01	0.00	0.01	0.00
F (mg/L)	*1991*	*2007*	*17*		-1.36		-0.011	-0.040	0.023	-0.032	0.013	0.51	0.78	0.30	0.67	0.35
Mn (mg/L)	*1991*	*2007*	*17*		0.08		0.000	0.000	0.000	0.000	0.000	0.00	0.01	0.00	0.00	0.00
Nitrate (mg/L)	*1991*	*2007*	*17*		-1.65	+	-0.066	-0.138	0.022	-0.114	0.005	4.50	4.95	4.10	4.70	4.24
Se (mg/L)	*1991*	*2007*	*17*		-1.15		0.000	-0.001	0.001	-0.001	0.000	0.01	0.02	0.00	0.02	0.01
Cl (mg/L)	*1991*	*2007*	*17*		1.15		0.427	-0.772	2.686	-0.273	1.933	35.00	45.34	20.50	39.88	31.04
Mo (mg/L)	*1992*	*2007*	*16*		-0.18		0.000	-0.004	0.003	-0.004	0.002	0.04	0.06	0.00	0.06	0.01
SO4 (mg/L)	*1991*	*2007*	*17*		0.37		0.457	-1.478	2.900	-1.116	2.353	92.49	100.83	73.50	96.50	76.23
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.63
Signific.	***
Q	-2.74E-04
Qmin99	-4.24E-04
Qmax99	-1.42E-04
Qmin95	-3.95E-04
Qmax95	-1.75E-04
B	5.42E-03
Bmin99	7.00E-03
Bmax99	4.29E-03
Bmin95	6.84E-03
Bmax95	4.48E-03

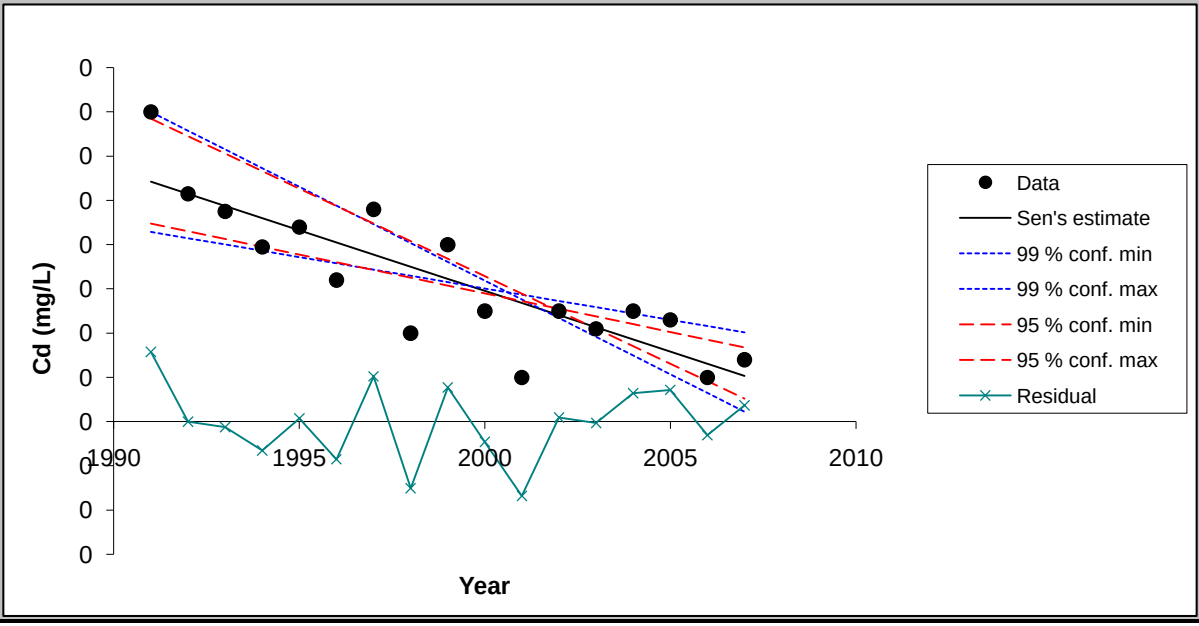

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.01	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.01	0.01	0.00	0.01	0.00	0.00
1993	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1994	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.36
Signific.	
Q	-1.13E-02
Qmin99	-4.01E-02
Qmax99	2.32E-02
Qmin95	-3.22E-02
Qmax95	1.31E-02
B	5.07E-01
Bmin99	7.78E-01
Bmax99	2.97E-01
Bmin95	6.67E-01
Bmax95	3.52E-01

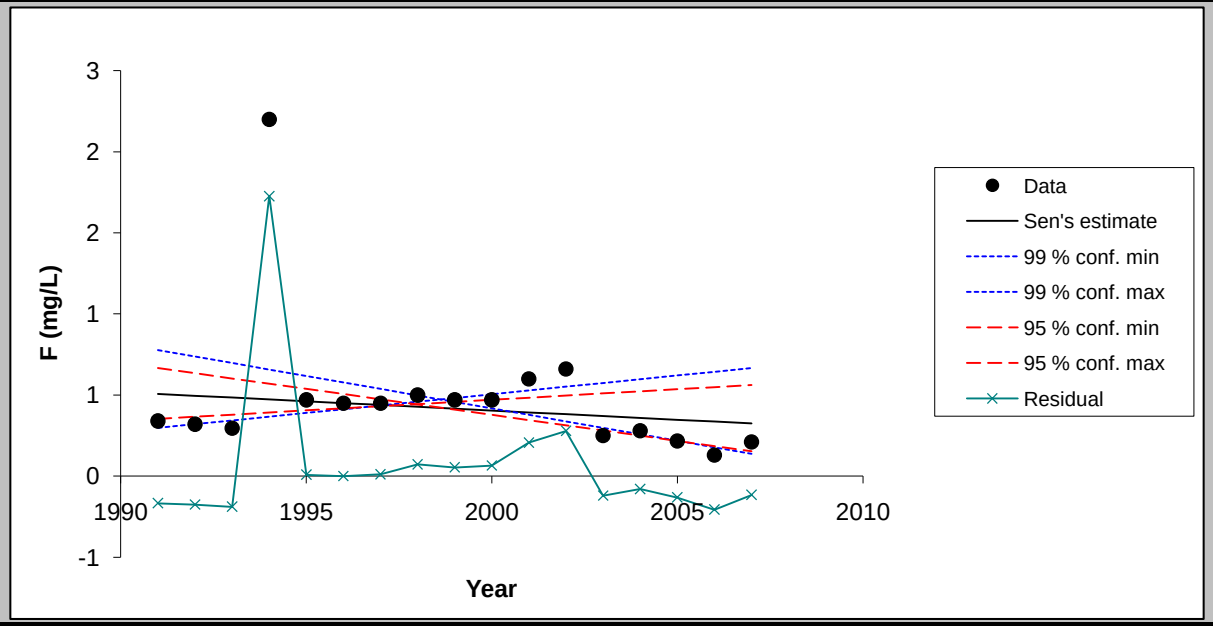

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.34	0.51	0.78	0.30	0.67	0.35	-0.17
1992	0.32	0.50	0.74	0.32	0.64	0.37	-0.18
1993	0.30	0.48	0.70	0.34	0.60	0.38	-0.19
1994	2.20	0.47	0.66	0.37	0.57	0.39	1.73
1995	0.47	0.46	0.62	0.39	0.54	0.40	0.01
1996	0.45	0.45	0.58	0.41	0.51	0.42	0.00
1997	0.45	0.44	0.54	0.44	0.47	0.43	0.01
1998	0.50	0.43	0.50	0.46	0.44	0.44	0.07
1999	0.47	0.42	0.46	0.48	0.41	0.46	0.05
2000	0.47	0.40	0.42	0.51	0.38	0.47	0.07
2001	0.60	0.39	0.38	0.53	0.35	0.48	0.21
2002	0.66	0.38	0.34	0.55	0.31	0.50	0.28
2003	0.25	0.37	0.30	0.57	0.28	0.51	-0.12
2004	0.28	0.36	0.26	0.60	0.25	0.52	-0.08
2005	0.22	0.35	0.22	0.62	0.22	0.54	-0.13
2006	0.13	0.34	0.18	0.64	0.18	0.55	-0.21
2007	0.21	0.33	0.14	0.67	0.15	0.56	-0.12

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.08
Signific.	
Q	0.00E+00
Qmin99	-3.79E-04
Qmax99	2.10E-04
Qmin95	-1.80E-04
Qmax95	1.56E-04
B	2.00E-03
Bmin99	5.55E-03
Bmax99	-5.48E-04
Bmin95	3.16E-03
Bmax95	-1.78E-04

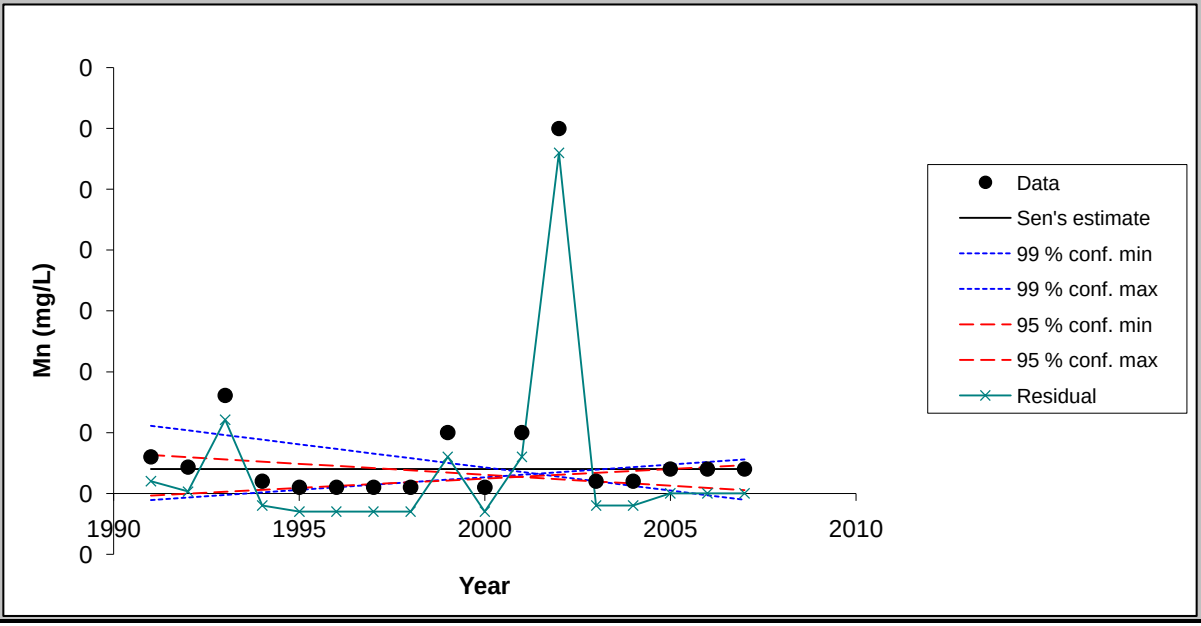

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.01
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.65
Signific.	+
Q	-6.64E-02
Qmin99	-1.38E-01
Qmax99	2.15E-02
Qmin95	-1.14E-01
Qmax95	5.07E-03
B	4.50E+00
Bmin99	4.95E+00
Bmax99	4.10E+00
Bmin95	4.70E+00
Bmax95	4.24E+00

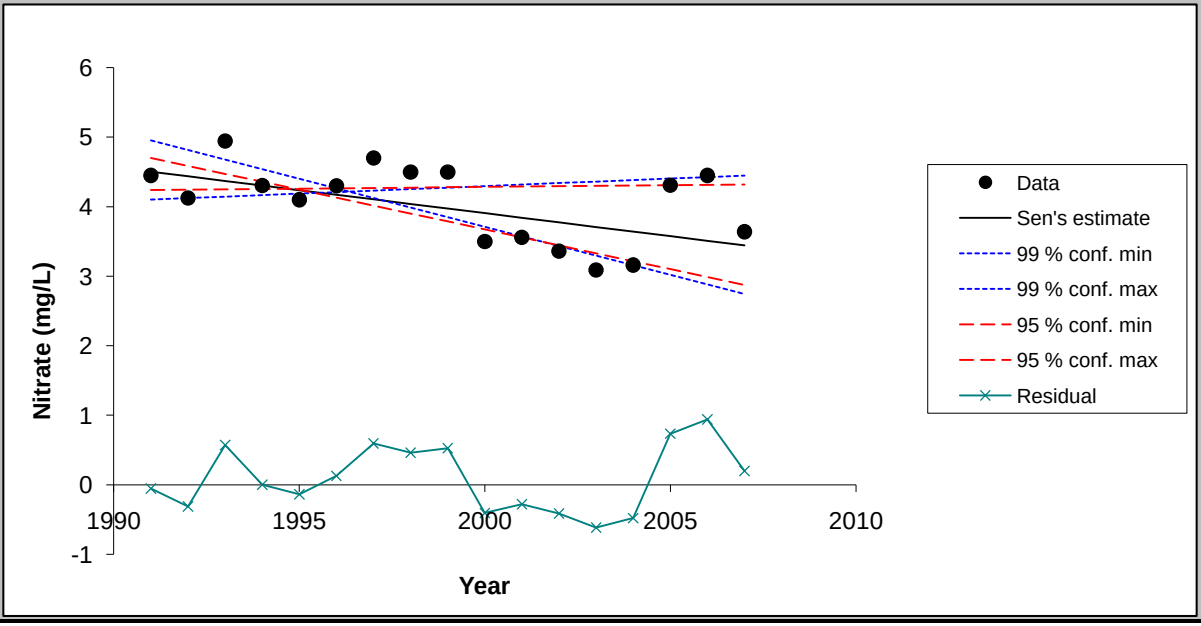

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	4.45	4.50	4.95	4.10	4.70	4.24	-0.05
1992	4.13	4.44	4.82	4.13	4.59	4.24	-0.31
1993	4.94	4.37	4.68	4.15	4.47	4.25	0.57
1994	4.31	4.31	4.54	4.17	4.36	4.25	0.00
1995	4.10	4.24	4.40	4.19	4.25	4.26	-0.14
1996	4.30	4.17	4.26	4.21	4.13	4.26	0.13
1997	4.70	4.11	4.13	4.23	4.02	4.27	0.59
1998	4.50	4.04	3.99	4.25	3.90	4.27	0.46
1999	4.50	3.97	3.85	4.28	3.79	4.28	0.53
2000	3.50	3.91	3.71	4.30	3.67	4.28	-0.41
2001	3.56	3.84	3.57	4.32	3.56	4.29	-0.28
2002	3.36	3.77	3.44	4.34	3.45	4.29	-0.41
2003	3.09	3.71	3.30	4.36	3.33	4.30	-0.62
2004	3.16	3.64	3.16	4.38	3.22	4.30	-0.48
2005	4.31	3.57	3.02	4.40	3.10	4.31	0.74
2006	4.45	3.51	2.88	4.43	2.99	4.32	0.94
2007	3.64	3.44	2.75	4.45	2.87	4.32	0.20

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.15
Signific.	
Q	-3.75E-04
Qmin99	-1.32E-03
Qmax99	6.16E-04
Qmin95	-1.09E-03
Qmax95	2.97E-04
B	1.50E-02
Bmin99	2.45E-02
Bmax99	3.61E-03
Bmin95	2.16E-02
Bmax95	7.52E-03

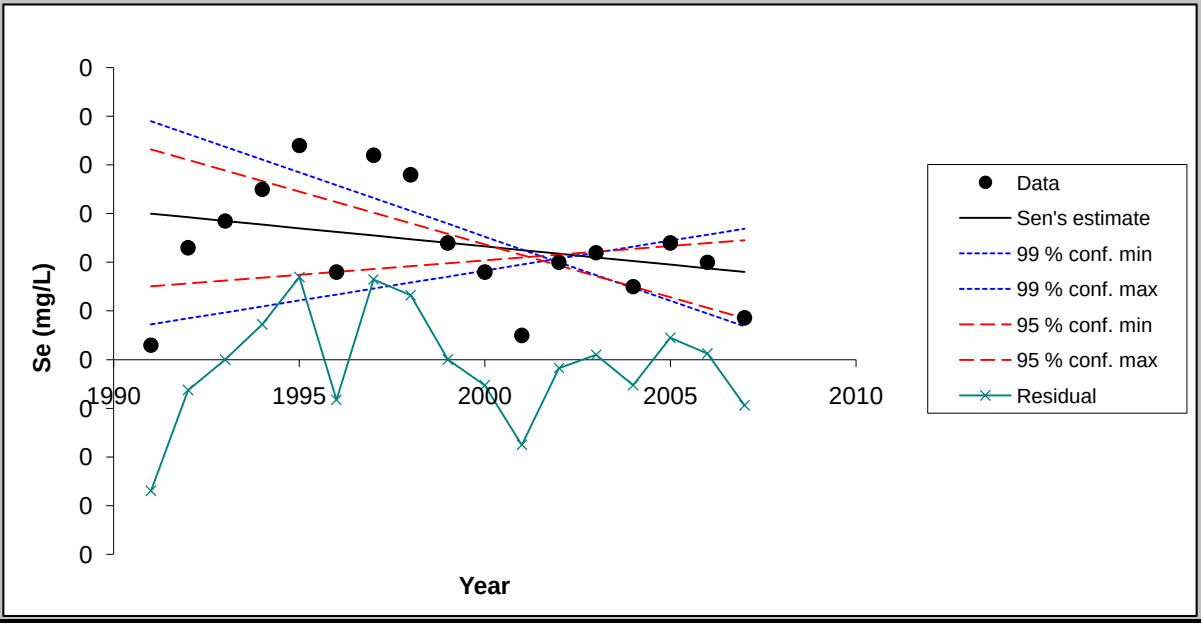

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.01	0.02	0.00	0.02	0.01	-0.01
1992	0.01	0.01	0.02	0.00	0.02	0.01	0.00
1993	0.01	0.01	0.02	0.00	0.02	0.01	0.00
1994	0.02	0.01	0.02	0.01	0.02	0.01	0.00
1995	0.02	0.01	0.02	0.01	0.02	0.01	0.01
1996	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1997	0.02	0.01	0.02	0.01	0.02	0.01	0.01
1998	0.02	0.01	0.02	0.01	0.01	0.01	0.01
1999	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.00	0.01	0.01	0.01	0.01	0.01	-0.01
2002	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2003	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2004	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2005	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.01	0.01	0.00
2007	0.00	0.01	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.15
Signific.	
Q	4.27E-01
Qmin99	-7.72E-01
Qmax99	2.69E+00
Qmin95	-2.73E-01
Qmax95	1.93E+00
B	3.50E+01
Bmin99	4.53E+01
Bmax99	2.05E+01
Bmin95	3.99E+01
Bmax95	3.10E+01

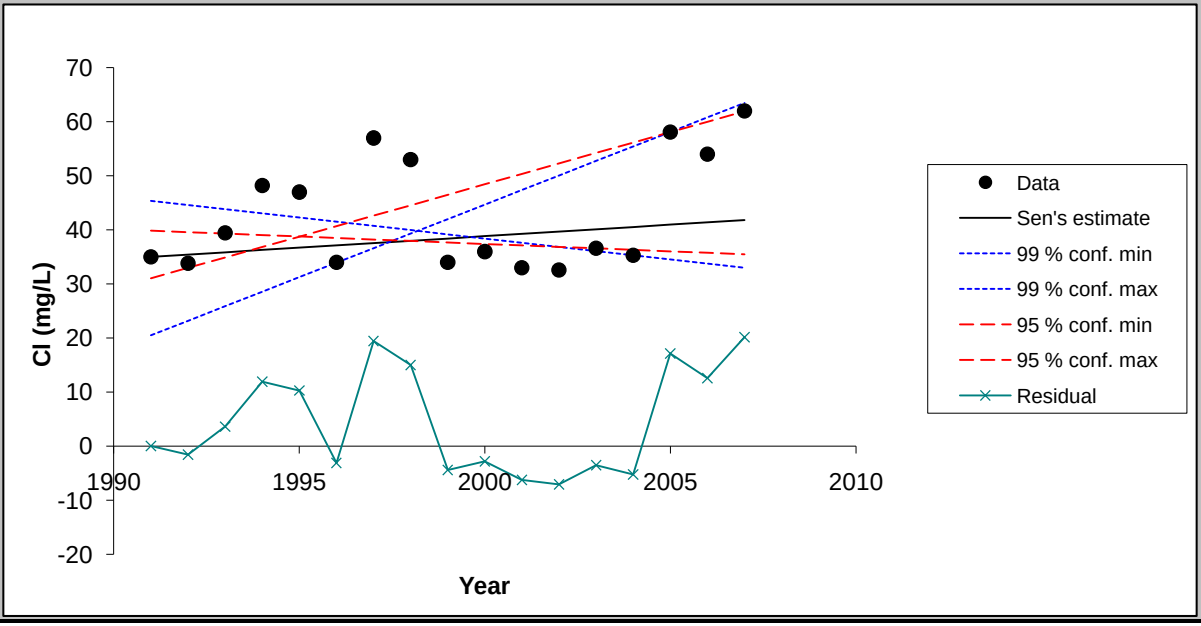

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	35.00	35.00	45.34	20.50	39.88	31.04	0.00
1992	33.85	35.43	44.57	23.19	39.61	32.97	-1.58
1993	39.45	35.85	43.79	25.87	39.33	34.90	3.60
1994	48.20	36.28	43.02	28.56	39.06	36.84	11.92
1995	47.00	36.71	42.25	31.24	38.79	38.77	10.29
1996	34.00	37.14	41.48	33.93	38.51	40.70	-3.14
1997	57.00	37.56	40.71	36.62	38.24	42.63	19.44
1998	53.00	37.99	39.93	39.30	37.97	44.57	15.01
1999	34.00	38.42	39.16	41.99	37.69	46.50	-4.42
2000	36.00	38.85	38.39	44.67	37.42	48.43	-2.85
2001	33.00	39.27	37.62	47.36	37.15	50.37	-6.27
2002	32.60	39.70	36.84	50.04	36.87	52.30	-7.10
2003	36.60	40.13	36.07	52.73	36.60	54.23	-3.53
2004	35.30	40.56	35.30	55.41	36.33	56.17	-5.26
2005	58.10	40.98	34.53	58.10	36.05	58.10	17.12
2006	54.00	41.41	33.76	60.79	35.78	60.03	12.59
2007	62.00	41.84	32.98	63.47	35.51	61.97	20.16

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.18
Signific.	
Q	-4.09E-04
Qmin99	-4.37E-03
Qmax99	2.95E-03
Qmin95	-3.57E-03
Qmax95	2.17E-03
B	3.88E-02
Bmin99	6.23E-02
Bmax99	-1.26E-03
Bmin95	5.78E-02
Bmax95	8.77E-03

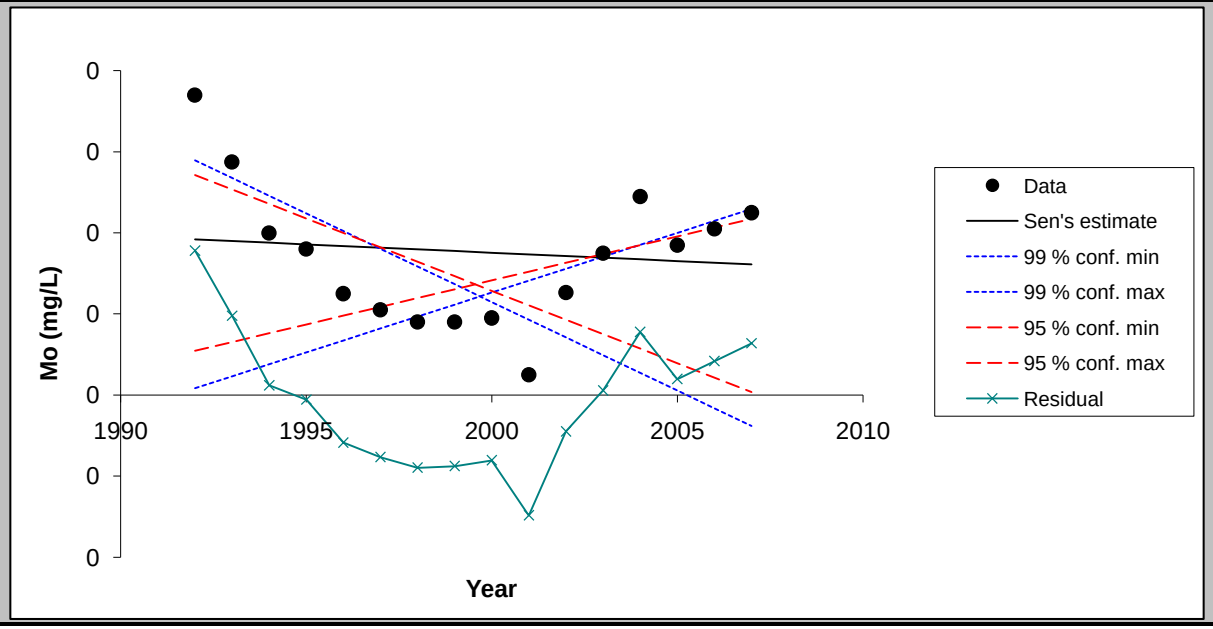

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.07	0.04	0.06	0.00	0.05	0.01	0.04
1993	0.06	0.04	0.05	0.00	0.05	0.01	0.02
1994	0.04	0.04	0.05	0.01	0.05	0.02	0.00
1995	0.04	0.04	0.04	0.01	0.04	0.02	0.00
1996	0.03	0.04	0.04	0.01	0.04	0.02	-0.01
1997	0.02	0.04	0.04	0.02	0.04	0.02	-0.02
1998	0.02	0.04	0.03	0.02	0.03	0.02	-0.02
1999	0.02	0.04	0.03	0.02	0.03	0.03	-0.02
2000	0.02	0.04	0.02	0.03	0.03	0.03	-0.02
2001	0.00	0.03	0.02	0.03	0.02	0.03	-0.03
2002	0.03	0.03	0.01	0.03	0.02	0.03	-0.01
2003	0.04	0.03	0.01	0.03	0.02	0.03	0.00
2004	0.05	0.03	0.01	0.04	0.01	0.04	0.02
2005	0.04	0.03	0.00	0.04	0.01	0.04	0.00
2006	0.04	0.03	0.00	0.04	0.00	0.04	0.01
2007	0.05	0.03	-0.01	0.05	0.00	0.04	0.01

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.37
Signific.	
Q	4.57E-01
Qmin99	-1.48E+00
Qmax99	2.90E+00
Qmin95	-1.12E+00
Qmax95	2.35E+00
B	9.25E+01
Bmin99	1.01E+02
Bmax99	7.35E+01
Bmin95	9.65E+01
Bmax95	7.62E+01

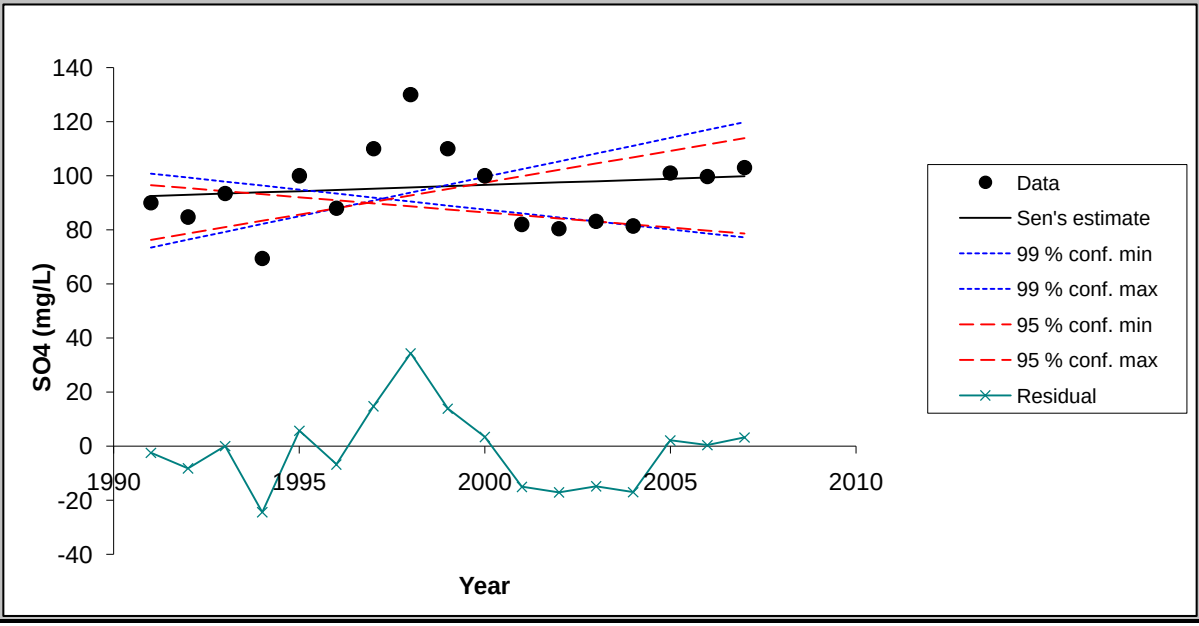

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	90.00	92.49	100.83	73.50	96.50	76.23	-2.49
1992	84.70	92.94	99.35	76.40	95.38	78.59	-8.24
1993	93.40	93.40	97.88	79.30	94.26	80.94	0.00
1994	69.40	93.86	96.40	82.20	93.15	83.29	-24.46
1995	100.00	94.31	94.92	85.10	92.03	85.65	5.69
1996	88.00	94.77	93.44	88.00	90.92	88.00	-6.77
1997	110.00	95.23	91.97	90.90	89.80	90.35	14.77
1998	130.00	95.68	90.49	93.80	88.68	92.71	34.32
1999	110.00	96.14	89.01	96.70	87.57	95.06	13.86
2000	100.00	96.60	87.53	99.60	86.45	97.41	3.40
2001	82.00	97.05	86.06	102.50	85.33	99.77	-15.05
2002	80.42	97.51	84.58	105.40	84.22	102.12	-17.09
2003	83.10	97.97	83.10	108.30	83.10	104.47	-14.87
2004	81.40	98.42	81.62	111.20	81.98	106.83	-17.02
2005	101.00	98.88	80.14	114.10	80.87	109.18	2.12
2006	99.70	99.34	78.67	117.00	79.75	111.53	0.36
2007	103.00	99.79	77.19	119.90	78.63	113.89	3.21

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-04 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.23	0.0035	3.8	0.0015	14		78
1992	0.00425	0.1525	0.00365	3.58	0.00335	15.1	0.00335	83.73
1993	0.00292	0.165	0.0061	3.98	0.00085	14.6	0.00483	74.35
1994	0.0005	0.24	0.001	3.915	0.002	14.6	0.0065	82.95
1995	0.0001	0.25	0.0005	3.5	0.0005	15	0.0025	77
1996	0.0001	0.32	0.0005	3.8	0.001	20	0.0025	90
1997	0.0001	0.32	0.016	4.4	0.001	16	0.0025	74
1998	0.0001	0.3	0.0005	4.4	0.002	16	0.0025	93
1999	0.0001	0.29	0.0005	4.2	0.0005	14	0.0025	110
2000	0.0001	0.3	0.0005	4	0.004	17	0.0025	100
2001	0.001	0.4	0.005	4.21	0.0025	16	0.005	84
2002	0.006	0.575	0.03	3.8	0.0025	15.56	0.005	77.989
2003	0.001	0.29	0.00075	3.54	0.003	13.4	0.01	73.55
2004	0.001	0.2	0.001	3.42	0.005	12	0.013	77.7
2005	0.001	0.15	0.002	3.73	0.0015	14.3	0.008	72.3
2006	0.001	0.31	0.002	4.32	0.0015	14.1	0.008	68.6
2007	0.001	0.41	0.002	4.23	0.0029	32.4	0.006	82.2

TREND STATISTICS

PW-04 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.21		0.0000	-0.0002	0.0001	-0.0001	0.0001	0.0010	0.0028	-0.0005	0.0024	-0.0003
F (mg/L)	*1991*	*2007*	*17*		1.77	+	0.0100	-0.0044	0.0247	-0.0008	0.0179	0.2100	0.3311	0.1273	0.2996	0.1470
Mn (mg/L)	*1991*	*2007*	*17*		0.08		0.0000	-0.0004	0.0002	-0.0003	0.0001	0.0020	0.0058	-0.0006	0.0039	-0.0001
Nitrate (mg/L)	*1991*	*2007*	*17*		0.37		0.004	-0.055	0.058	-0.035	0.048	3.90	4.40	3.51	4.18	3.57
Se (mg/L)	*1991*	*2007*	*17*		1.32		0.0001	-0.0001	0.0003	0.0000	0.0002	0.0015	0.0028	-0.0004	0.0021	0.0001
Cl (mg/L)	*1991*	*2007*	*17*		-0.04		0.000	-0.259	0.344	-0.208	0.271	15.00	17.55	13.59	17.21	13.92
Mo (mg/L)	*1992*	*2007*	*16*		2.04	*	0.0003	0.0000	0.0008	0.0000	0.0006	0.0016	0.0049	-0.0025	0.0049	-0.0010
SO4 (mg/L)	*1991*	*2007*	*17*		-1.11		-0.399	-2.168	1.500	-1.626	0.592	82.88	101.11	71.00	95.07	74.63
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.21
Signific.	
Q	0.00E+00
Qmin99	-1.81E-04
Qmax99	1.13E-04
Qmin95	-1.16E-04
Qmax95	9.00E-05
B	1.00E-03
Bmin99	2.81E-03
Bmax99	-4.63E-04
Bmin95	2.40E-03
Bmax95	-2.60E-04

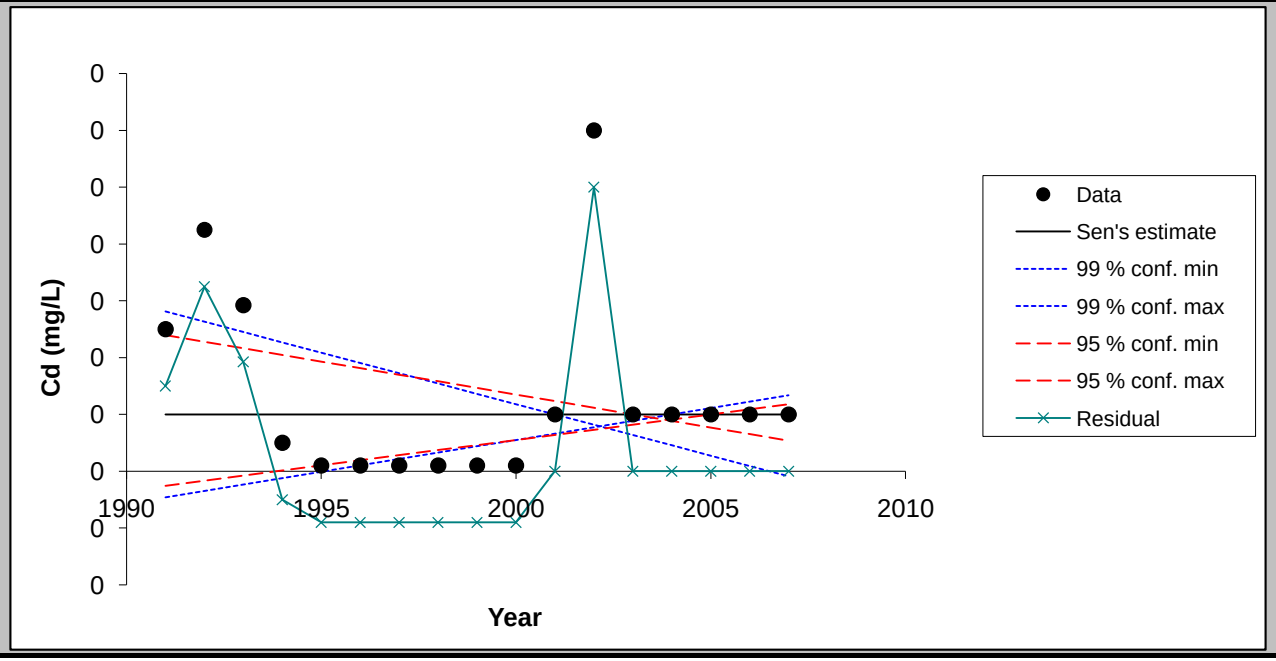

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.00	0.00	0.00	0.00	0.00	0.01
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.77
Signific.	+
Q	1.00E-02
Qmin99	-4.44E-03
Qmax99	2.47E-02
Qmin95	-7.98E-04
Qmax95	1.79E-02
B	2.10E-01
Bmin99	3.31E-01
Bmax99	1.27E-01
Bmin95	3.00E-01
Bmax95	1.47E-01

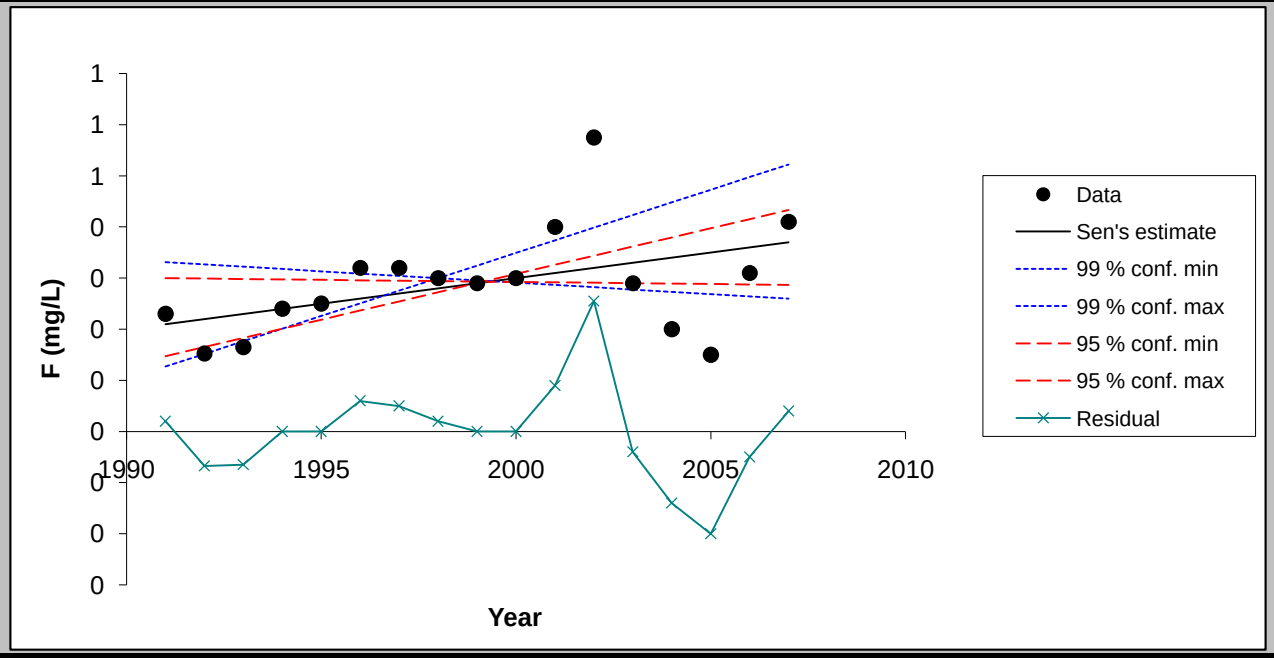

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.23	0.21	0.33	0.13	0.30	0.15	0.02
1992	0.15	0.22	0.33	0.15	0.30	0.16	-0.07
1993	0.16	0.23	0.32	0.18	0.30	0.18	-0.07
1994	0.24	0.24	0.32	0.20	0.30	0.20	0.00
1995	0.25	0.25	0.31	0.23	0.30	0.22	0.00
1996	0.32	0.26	0.31	0.25	0.30	0.24	0.06
1997	0.32	0.27	0.30	0.28	0.29	0.25	0.05
1998	0.30	0.28	0.30	0.30	0.29	0.27	0.02
1999	0.29	0.29	0.30	0.32	0.29	0.29	0.00
2000	0.30	0.30	0.29	0.35	0.29	0.31	0.00
2001	0.40	0.31	0.29	0.37	0.29	0.33	0.09
2002	0.57	0.32	0.28	0.40	0.29	0.34	0.26
2003	0.29	0.33	0.28	0.42	0.29	0.36	-0.04
2004	0.20	0.34	0.27	0.45	0.29	0.38	-0.14
2005	0.15	0.35	0.27	0.47	0.29	0.40	-0.20
2006	0.31	0.36	0.26	0.50	0.29	0.42	-0.05
2007	0.41	0.37	0.26	0.52	0.29	0.43	0.04

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.08
Signific.	
Q	0.00E+00
Qmin99	-4.19E-04
Qmax99	2.14E-04
Qmin95	-2.55E-04
Qmax95	1.50E-04
B	2.00E-03
Bmin99	5.78E-03
Bmax99	-5.71E-04
Bmin95	3.91E-03
Bmax95	-1.00E-04

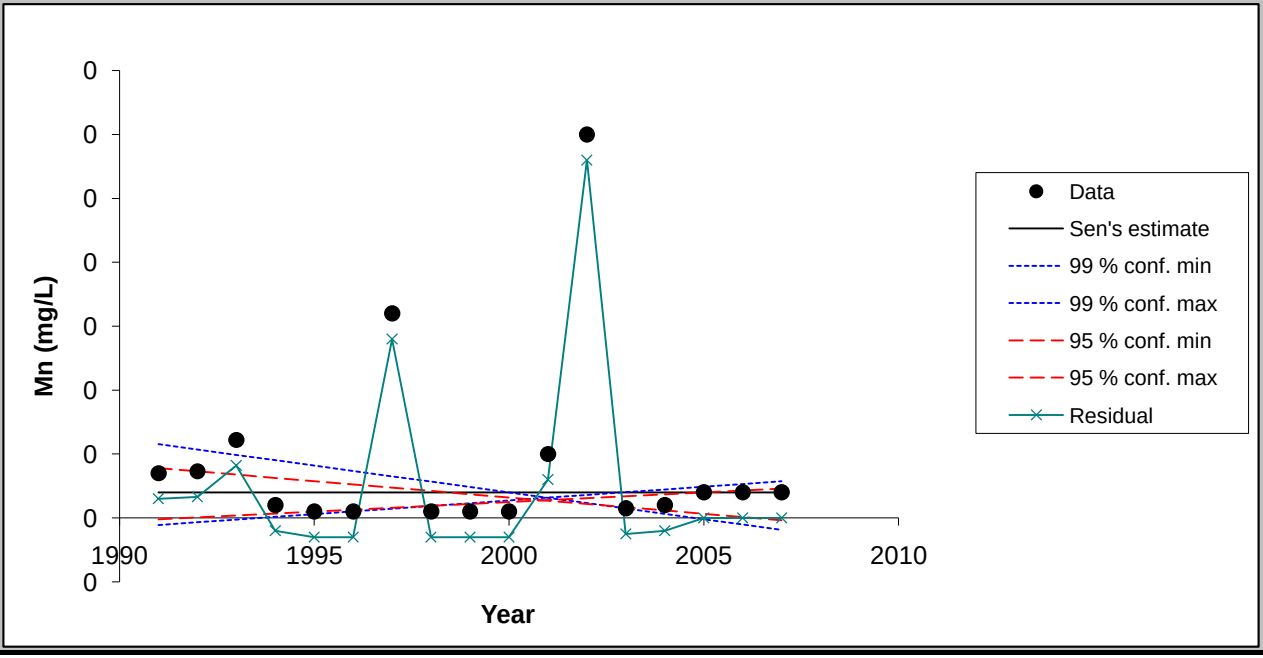

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.02	0.00	0.00	0.00	0.00	0.00	0.01
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.37
Signific.	
Q	4.38E-03
Qmin99	-5.45E-02
Qmax99	5.76E-02
Qmin95	-3.47E-02
Qmax95	4.80E-02
B	3.90E+00
Bmin99	4.40E+00
Bmax99	3.51E+00
Bmin95	4.18E+00
Bmax95	3.57E+00

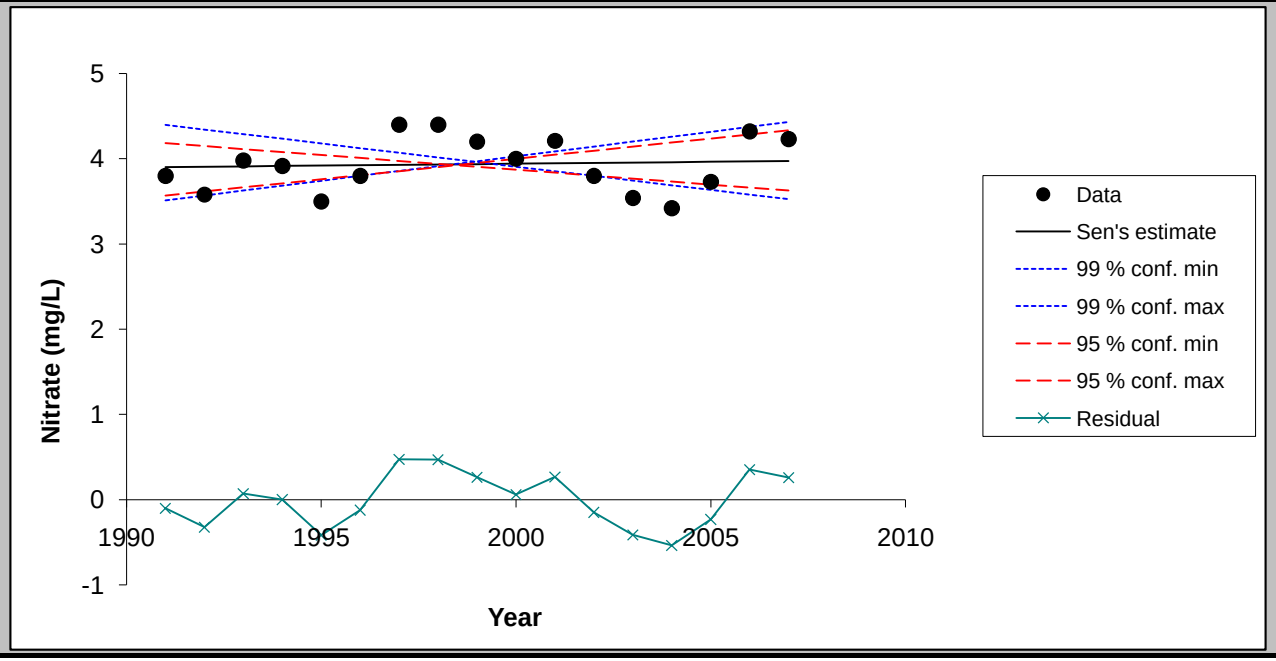

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	3.80	3.90	4.40	3.51	4.18	3.57	-0.10
1992	3.58	3.91	4.35	3.57	4.15	3.62	-0.33
1993	3.98	3.91	4.29	3.63	4.11	3.66	0.07
1994	3.91	3.91	4.24	3.68	4.08	3.71	0.00
1995	3.50	3.92	4.18	3.74	4.04	3.76	-0.42
1996	3.80	3.92	4.13	3.80	4.01	3.81	-0.12
1997	4.40	3.93	4.07	3.86	3.97	3.86	0.47
1998	4.40	3.93	4.02	3.92	3.94	3.90	0.47
1999	4.20	3.94	3.96	3.97	3.90	3.95	0.26
2000	4.00	3.94	3.91	4.03	3.87	4.00	0.06
2001	4.21	3.95	3.85	4.09	3.83	4.05	0.26
2002	3.80	3.95	3.80	4.15	3.80	4.10	-0.15
2003	3.54	3.95	3.75	4.20	3.77	4.14	-0.41
2004	3.42	3.96	3.69	4.26	3.73	4.19	-0.54
2005	3.73	3.96	3.64	4.32	3.70	4.24	-0.23
2006	4.32	3.97	3.58	4.38	3.66	4.29	0.35
2007	4.23	3.97	3.53	4.43	3.63	4.34	0.26

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	1.32
Signific.	
Q	8.06E-05
Qmin99	-9.52E-05
Qmax99	2.88E-04
Qmin95	-3.86E-05
Qmax95	2.44E-04
B	1.50E-03
Bmin99	2.83E-03
Bmax99	-4.38E-04
Bmin95	2.12E-03
Bmax95	6.21E-05

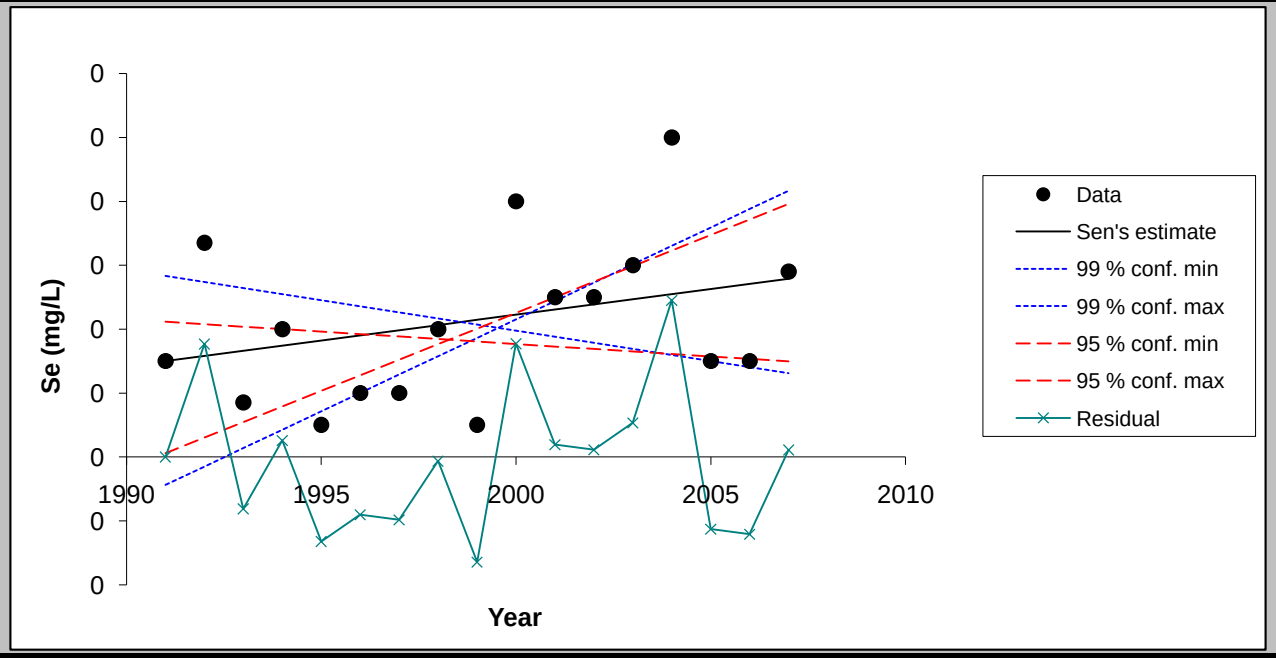

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.04
Signific.	
Q	0.00E+00
Qmin99	-2.59E-01
Qmax99	3.44E-01
Qmin95	-2.08E-01
Qmax95	2.71E-01
B	1.50E+01
Bmin99	1.76E+01
Bmax99	1.36E+01
Bmin95	1.72E+01
Bmax95	1.39E+01

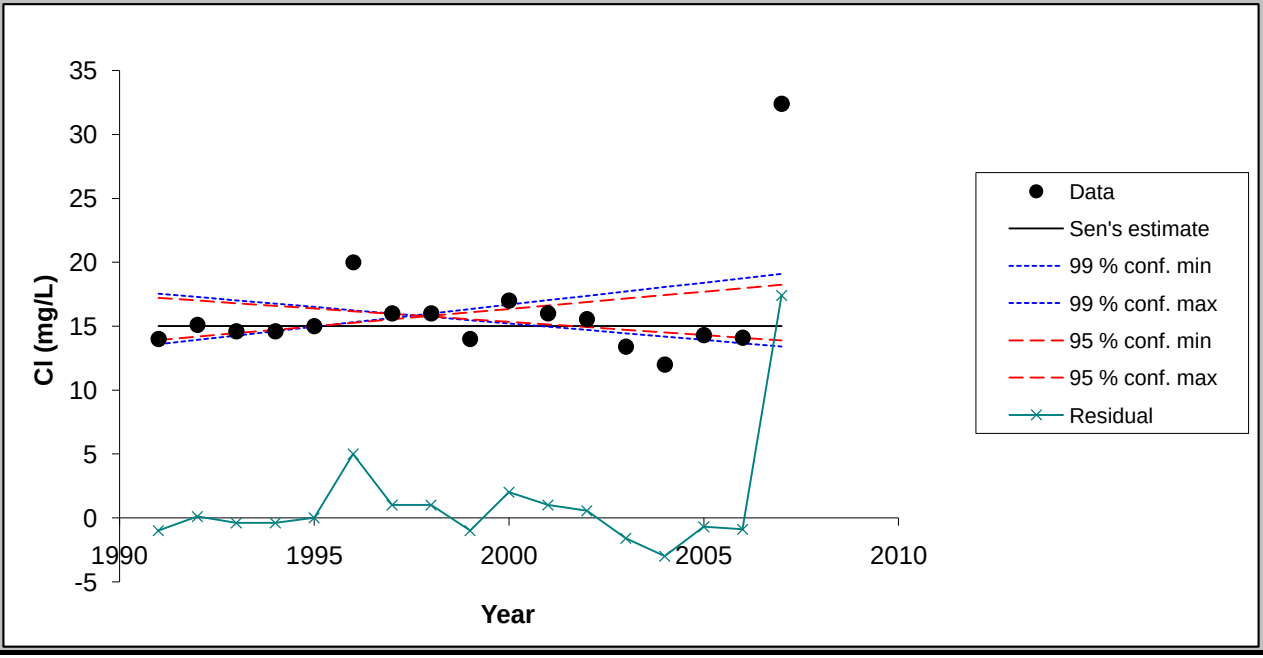

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	14.00	15.00	17.55	13.59	17.21	13.92	-1.00
1992	15.10	15.00	17.29	13.94	17.00	14.19	0.10
1993	14.60	15.00	17.03	14.28	16.79	14.46	-0.40
1994	14.60	15.00	16.78	14.62	16.59	14.73	-0.40
1995	15.00	15.00	16.52	14.97	16.38	15.00	0.00
1996	20.00	15.00	16.26	15.31	16.17	15.27	5.00
1997	16.00	15.00	16.00	15.66	15.96	15.54	1.00
1998	16.00	15.00	15.74	16.00	15.75	15.81	1.00
1999	14.00	15.00	15.48	16.34	15.55	16.08	-1.00
2000	17.00	15.00	15.22	16.69	15.34	16.35	2.00
2001	16.00	15.00	14.97	17.03	15.13	16.63	1.00
2002	15.56	15.00	14.71	17.38	14.92	16.90	0.56
2003	13.40	15.00	14.45	17.72	14.72	17.17	-1.60
2004	12.00	15.00	14.19	18.06	14.51	17.44	-3.00
2005	14.30	15.00	13.93	18.41	14.30	17.71	-0.70
2006	14.10	15.00	13.67	18.75	14.09	17.98	-0.90
2007	32.40	15.00	13.41	19.09	13.88	18.25	17.40

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	2.04
Signific.	*
Q	3.25E-04
Qmin99	0.00E+00
Qmax99	7.76E-04
Qmin95	0.00E+00
Qmax95	6.27E-04
B	1.59E-03
Bmin99	4.91E-03
Bmax99	-2.45E-03
Bmin95	4.91E-03
Bmax95	-1.02E-03

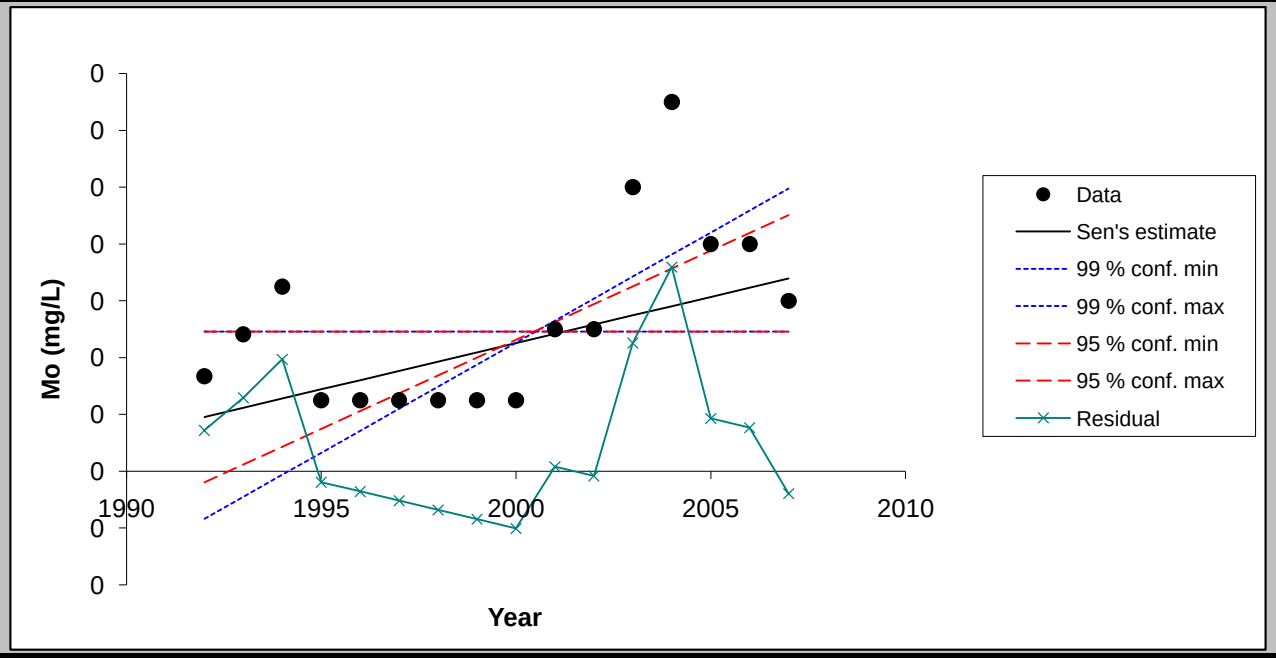

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2004	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2007	0.01	0.01	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.11
Signific.	
Q	-3.99E-01
Qmin99	-2.17E+00
Qmax99	1.50E+00
Qmin95	-1.63E+00
Qmax95	5.92E-01
B	8.29E+01
Bmin99	1.01E+02
Bmax99	7.10E+01
Bmin95	9.51E+01
Bmax95	7.46E+01

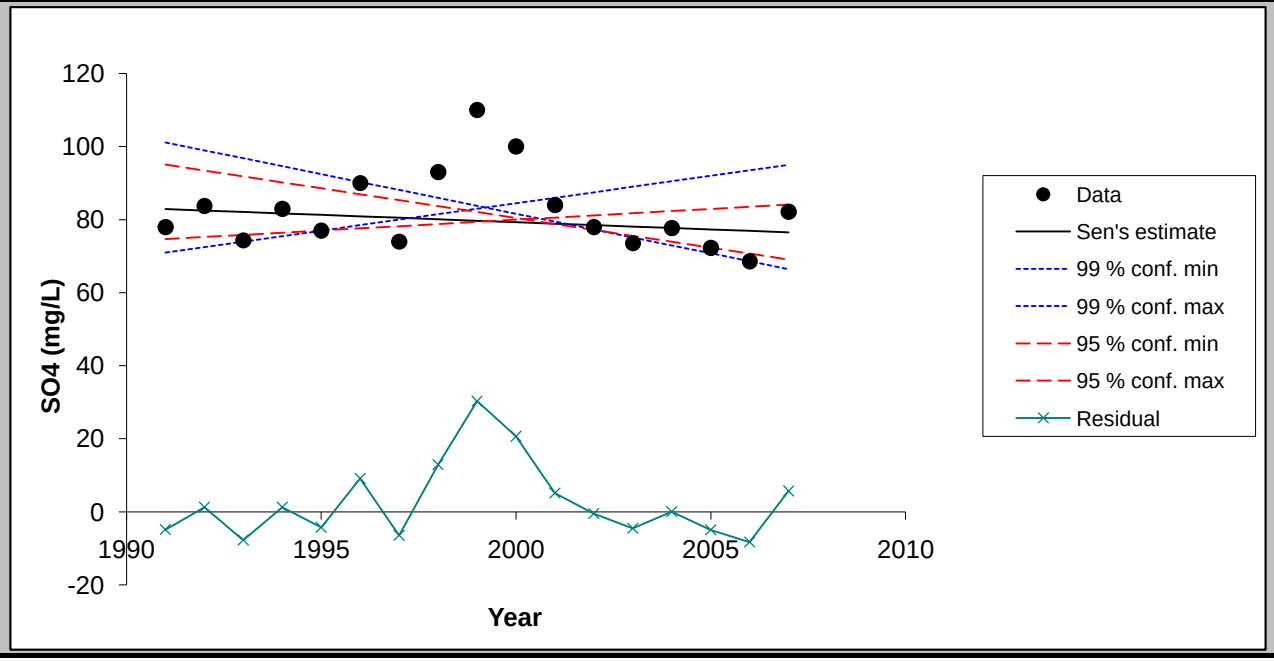

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	78.00	82.88	101.11	71.00	95.07	74.63	-4.88
1992	83.73	82.48	98.95	72.50	93.44	75.22	1.25
1993	74.35	82.08	96.78	74.00	91.82	75.82	-7.73
1994	82.95	81.69	94.61	75.50	90.19	76.41	1.26
1995	77.00	81.29	92.44	77.00	88.56	77.00	-4.29
1996	90.00	80.89	90.28	78.50	86.94	77.59	9.11
1997	74.00	80.49	88.11	80.00	85.31	78.18	-6.49
1998	93.00	80.09	85.94	81.50	83.69	78.78	12.91
1999	110.00	79.69	83.77	83.00	82.06	79.37	30.31
2000	100.00	79.29	81.61	84.50	80.43	79.96	20.71
2001	84.00	78.90	79.44	86.00	78.81	80.55	5.10
2002	77.99	78.50	77.27	87.50	77.18	81.14	-0.51
2003	73.55	78.10	75.10	89.00	75.55	81.73	-4.55
2004	77.70	77.70	72.94	90.50	73.93	82.33	0.00
2005	72.30	77.30	70.77	92.00	72.30	82.92	-5.00
2006	68.60	76.90	68.60	93.50	70.67	83.51	-8.30
2007	82.20	76.50	66.43	95.00	69.05	84.10	5.70

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-53 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	16	16
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0011	0.862	0.0188	0.516	0.0262	11.5	0.0174	53.5
1993	0.0029	0.945	0.0094	7.47	0.1431	72	0.0214	235.5
1994	0.0018	1.27	0.001	6.02	0.254	120.5	0.0309	359.5
1995	0.0001	1.7	0.01	7.7	0.25	100	0.041	390
1996	0.0001	2.4	0.011	0.34	0.19	91	0.044	320
1997	0.0001	3.1	0.0005	7.2	0.17	75	0.048	300
1998	0.0001	2.7	0.0005	7	0.138	79	0.061	240
1999	0.0001	3.6	0.0005	6.7	0.11	52	0.072	280
2000	0.0001	3.4	0.015	5	0.09	60	0.08	260
2001	0.001	3.2	0.03	4.49	0.08	62	0.05	298
2002	0.001	2.81	0.03	5.11	0.0909	75.7	0.0552	360.5
2003	0.001	2.15	0.001	5.73	0.219	84.6	0.0615	421
2004	0.001	1.74	0.0032	5.35	0.222	84.3	0.0487	388
2005	0.001	2.04	0.002	5.43	0.15	82.4	0.0459	331
2006	0.001	1.78	0.002	5.01	0.172	76.1	0.044	334
2007	0.001	2.92	0.002	7.15	0.115	111	0.0581	472

TREND STATISTICS

TW-53 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		-0.24		0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
F (mg/L)	*1992*	*2007*	*16*		1.40		0.071	-0.120	0.293	-0.061	0.240	1.67	3.47	0.67	2.83	0.83
Mn (mg/L)	*1992*	*2007*	*16*		-0.27		0.000	-0.002	0.001	-0.001	0.000	0.00	0.02	0.00	0.02	0.00
Nitrate (mg/L)	*1992*	*2007*	*16*		-0.50		-0.050	-0.250	0.406	-0.241	0.277	6.10	8.40	1.16	8.31	2.73
Se (mg/L)	*1992*	*2007*	*16*		-0.32		-0.003	-0.020	0.010	-0.014	0.007	0.17	0.28	0.06	0.24	0.08
Cl (mg/L)	*1992*	*2007*	*16*		0.77		0.900	-3.413	6.072	-1.867	5.051	70.90	107.22	16.38	96.41	27.10
Mo (mg/L)	*1992*	*2007*	*16*		2.21	*	0.002	-0.001	0.006	0.000	0.004	0.03	0.06	0.02	0.05	0.02
SO4 (mg/L)	*1992*	*2007*	*16*		2.21	*	10.875	-3.574	27.890	1.264	23.602	235.13	350.47	77.15	314.76	116.38
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.24
Signific.	
Q	0.00E+00
Qmin99	-6.28E-05
Qmax99	1.13E-04
Qmin95	-7.01E-06
Qmax95	9.00E-05
B	1.00E-03
Bmin99	1.60E-03
Bmax99	-3.50E-04
Bmin95	1.07E-03
Bmax95	-1.70E-04

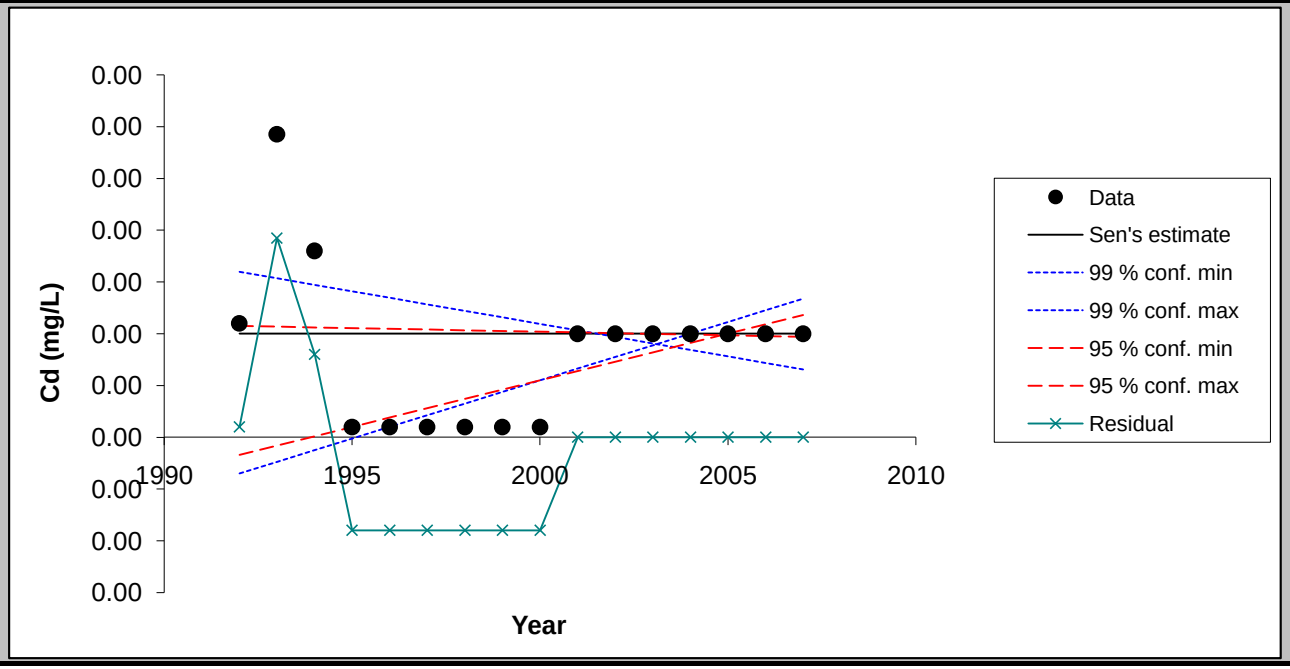

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.40
Signific.	
Q	7.11E-02
Qmin99	-1.20E-01
Qmax99	2.93E-01
Qmin95	-6.13E-02
Qmax95	2.40E-01
B	1.67E+00
Bmin99	3.47E+00
Bmax99	6.68E-01
Bmin95	2.83E+00
Bmax95	8.26E-01

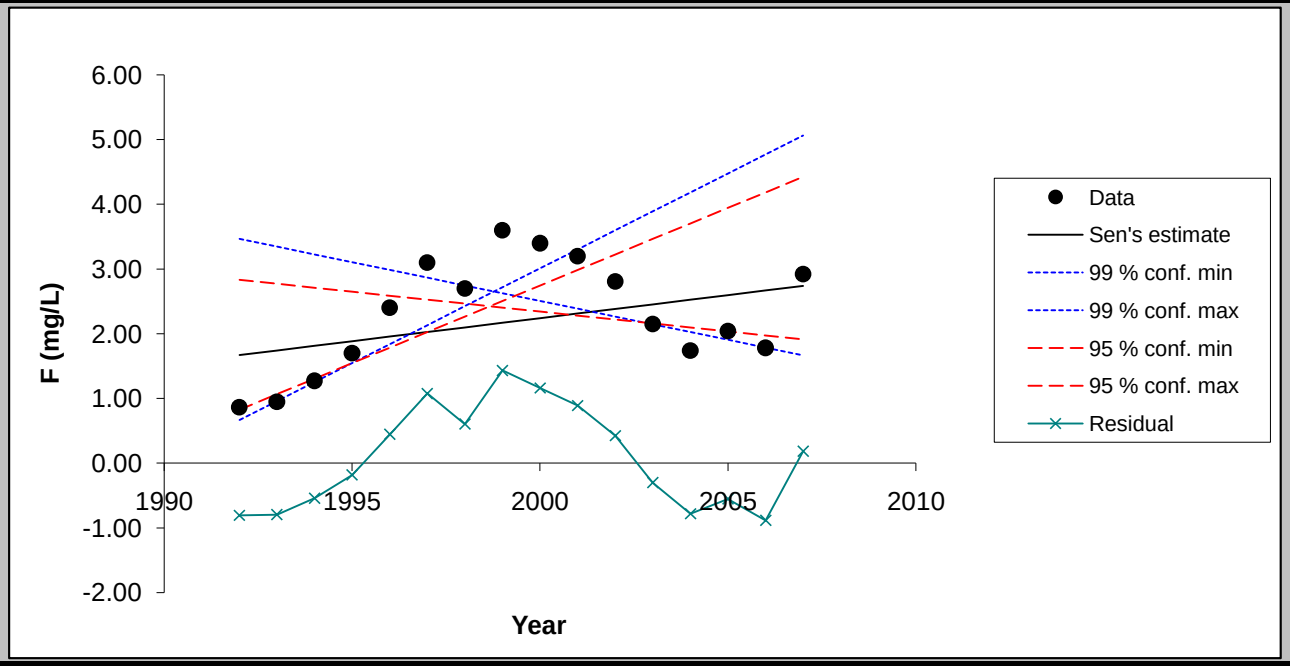

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.86	1.67	3.47	0.67	2.83	0.83	-0.81
1993	0.95	1.74	3.35	0.96	2.77	1.07	-0.80
1994	1.27	1.81	3.23	1.25	2.71	1.31	-0.54
1995	1.70	1.88	3.11	1.55	2.65	1.55	-0.18
1996	2.40	1.95	2.99	1.84	2.59	1.79	0.45
1997	3.10	2.03	2.87	2.13	2.52	2.03	1.07
1998	2.70	2.10	2.75	2.43	2.46	2.27	0.60
1999	3.60	2.17	2.63	2.72	2.40	2.51	1.43
2000	3.40	2.24	2.51	3.01	2.34	2.75	1.16
2001	3.20	2.31	2.39	3.30	2.28	2.99	0.89
2002	2.81	2.38	2.27	3.60	2.22	3.23	0.42
2003	2.15	2.45	2.15	3.89	2.16	3.47	-0.30
2004	1.74	2.52	2.03	4.18	2.10	3.71	-0.78
2005	2.04	2.59	1.90	4.48	2.03	3.95	-0.55
2006	1.78	2.67	1.78	4.77	1.97	4.19	-0.89
2007	2.92	2.74	1.66	5.06	1.91	4.42	0.18

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.27
Signific.	
Q	-1.02E-12
Qmin99	-1.68E-03
Qmax99	5.12E-04
Qmin95	-1.17E-03
Qmax95	2.37E-04
B	2.60E-03
Bmin99	1.91E-02
Bmax99	-1.04E-03
Bmin95	1.64E-02
Bmax95	4.38E-04

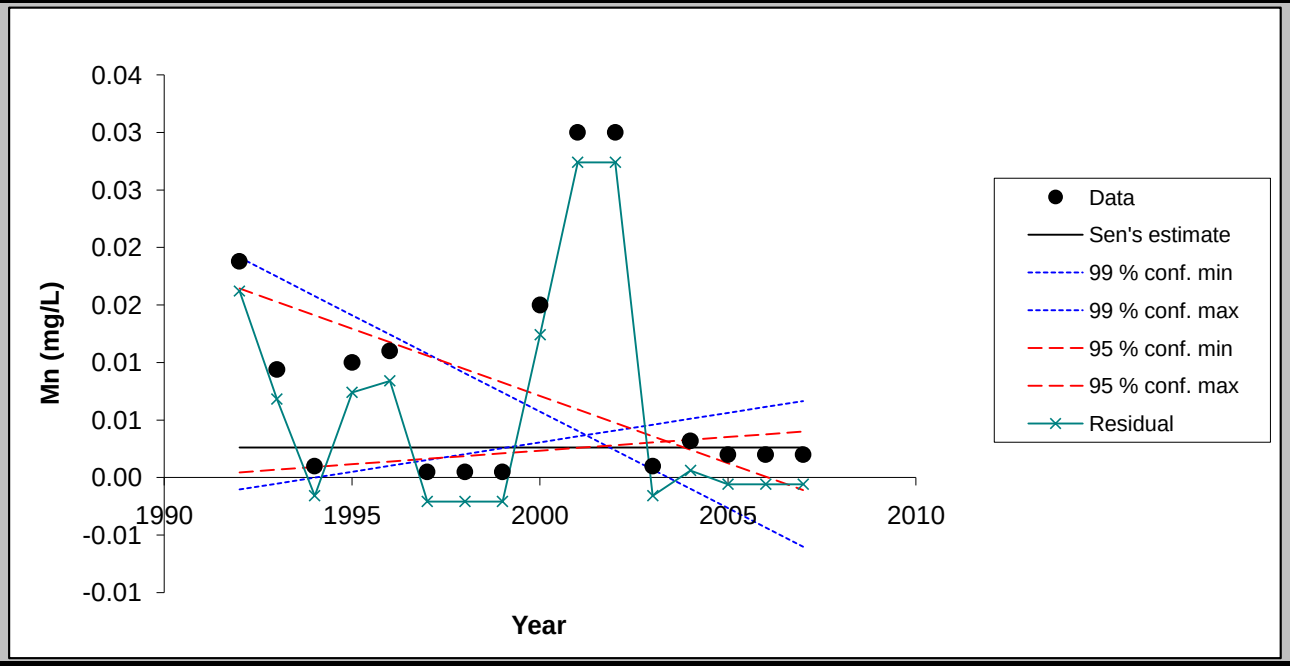

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.02	0.00	0.02	0.00	0.02	0.00	0.02
1993	0.01	0.00	0.02	0.00	0.02	0.00	0.01
1994	0.00	0.00	0.02	0.00	0.01	0.00	0.00
1995	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1996	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1997	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1999	0.00	0.00	0.01	0.00	0.01	0.00	0.00
2000	0.01	0.00	0.01	0.00	0.01	0.00	0.01
2001	0.03	0.00	0.00	0.00	0.01	0.00	0.03
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2007	0.00	0.00	-0.01	0.01	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.50
Signific.	
Q	-4.97E-02
Qmin99	-2.50E-01
Qmax99	4.06E-01
Qmin95	-2.41E-01
Qmax95	2.77E-01
B	6.10E+00
Bmin99	8.40E+00
Bmax99	1.16E+00
Bmin95	8.31E+00
Bmax95	2.73E+00

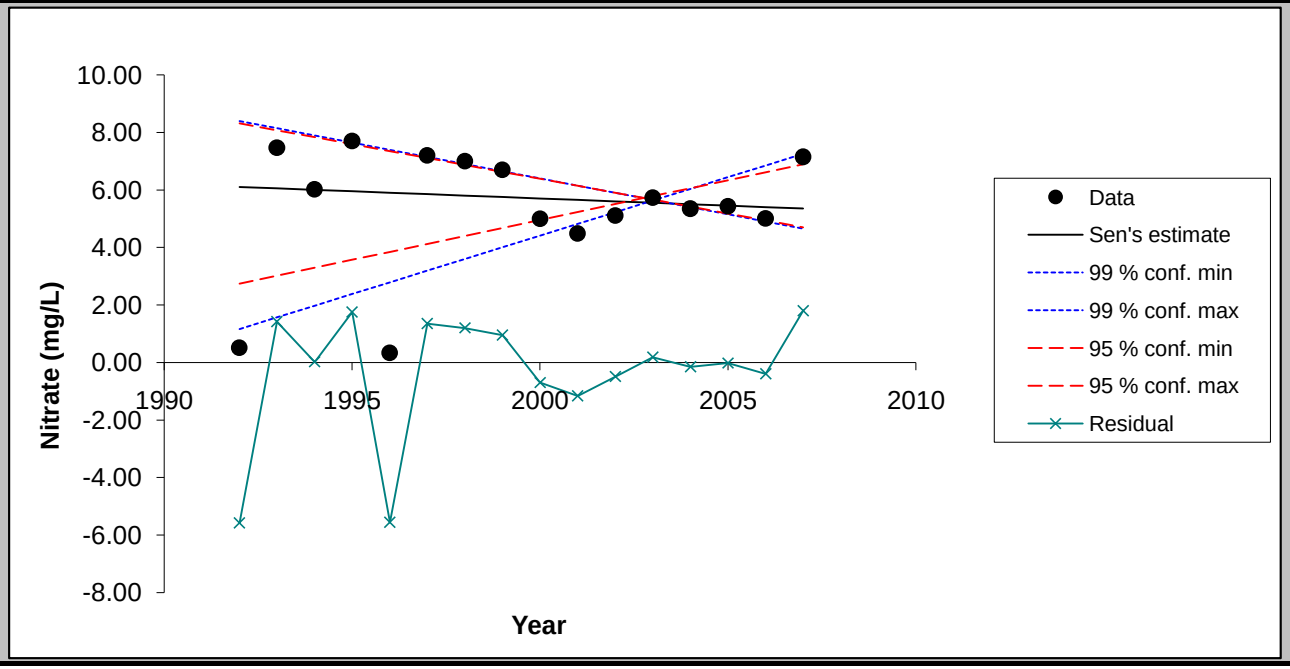

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.52	6.10	8.40	1.16	8.31	2.73	-5.58
1993	7.47	6.05	8.15	1.57	8.07	3.01	1.42
1994	6.02	6.00	7.90	1.97	7.83	3.29	0.02
1995	7.70	5.95	7.65	2.38	7.59	3.56	1.75
1996	0.34	5.90	7.40	2.79	7.35	3.84	-5.56
1997	7.20	5.85	7.15	3.19	7.11	4.12	1.35
1998	7.00	5.80	6.90	3.60	6.87	4.40	1.20
1999	6.70	5.75	6.65	4.00	6.62	4.67	0.95
2000	5.00	5.70	6.40	4.41	6.38	4.95	-0.70
2001	4.49	5.65	6.15	4.82	6.14	5.23	-1.16
2002	5.11	5.60	5.90	5.22	5.90	5.50	-0.49
2003	5.73	5.55	5.65	5.63	5.66	5.78	0.18
2004	5.35	5.50	5.40	6.03	5.42	6.06	-0.15
2005	5.43	5.45	5.15	6.44	5.18	6.33	-0.02
2006	5.01	5.40	4.90	6.85	4.94	6.61	-0.39
2007	7.15	5.35	4.65	7.25	4.70	6.89	1.80

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.32
Signific.	
Q	-2.53E-03
Qmin99	-2.00E-02
Qmax99	1.01E-02
Qmin95	-1.42E-02
Qmax95	7.07E-03
B	1.68E-01
Bmin99	2.80E-01
Bmax99	5.86E-02
Bmin95	2.44E-01
Bmax95	8.43E-02

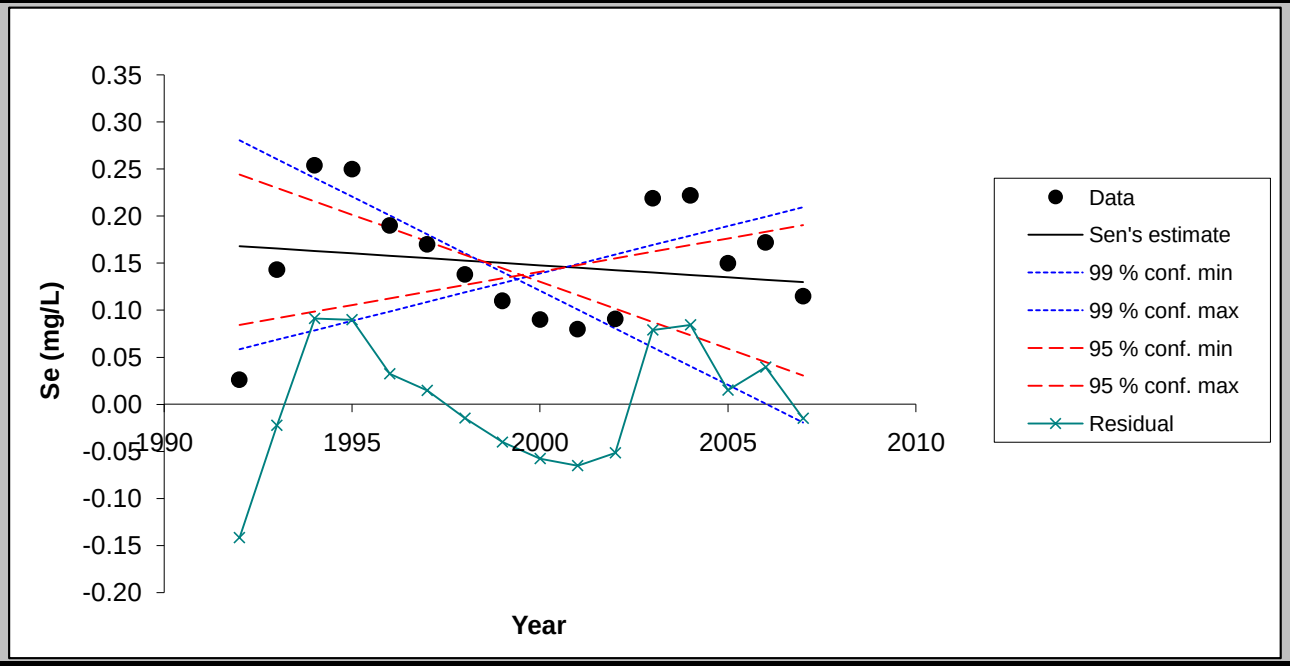

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.17	0.28	0.06	0.24	0.08	-0.14
1993	0.14	0.17	0.26	0.07	0.23	0.09	-0.02
1994	0.25	0.16	0.24	0.08	0.22	0.10	0.09
1995	0.25	0.16	0.22	0.09	0.20	0.11	0.09
1996	0.19	0.16	0.20	0.10	0.19	0.11	0.03
1997	0.17	0.16	0.18	0.11	0.17	0.12	0.01
1998	0.14	0.15	0.16	0.12	0.16	0.13	-0.01
1999	0.11	0.15	0.14	0.13	0.14	0.13	-0.04
2000	0.09	0.15	0.12	0.14	0.13	0.14	-0.06
2001	0.08	0.15	0.10	0.15	0.12	0.15	-0.07
2002	0.09	0.14	0.08	0.16	0.10	0.15	-0.05
2003	0.22	0.14	0.06	0.17	0.09	0.16	0.08
2004	0.22	0.14	0.04	0.18	0.07	0.17	0.08
2005	0.15	0.14	0.02	0.19	0.06	0.18	0.01
2006	0.17	0.13	0.00	0.20	0.04	0.18	0.04
2007	0.12	0.13	-0.02	0.21	0.03	0.19	-0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.77
Signific.	
Q	9.00E-01
Qmin99	-3.41E+00
Qmax99	6.07E+00
Qmin95	-1.87E+00
Qmax95	5.05E+00
B	7.09E+01
Bmin99	1.07E+02
Bmax99	1.64E+01
Bmin95	9.64E+01
Bmax95	2.71E+01

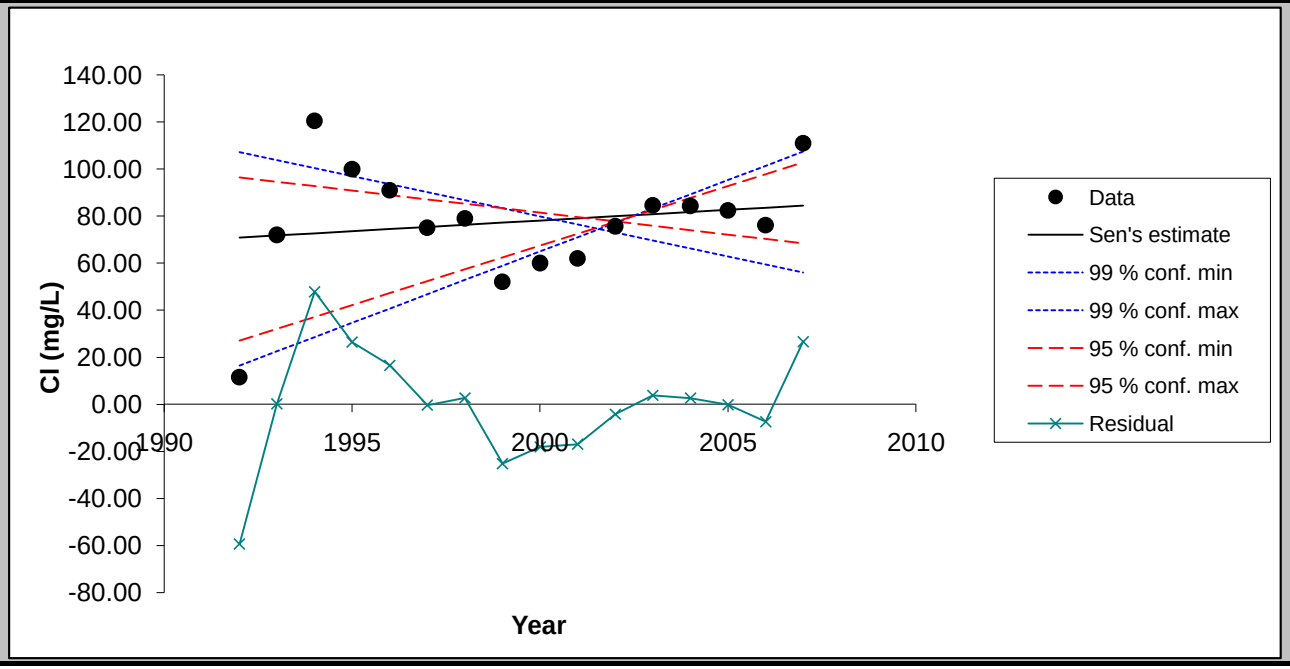

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	11.50	70.90	107.22	16.38	96.41	27.10	-59.40
1993	72.00	71.80	103.81	22.45	94.54	32.15	0.20
1994	120.50	72.70	100.40	28.53	92.67	37.20	47.80
1995	100.00	73.60	96.99	34.60	90.80	42.25	26.40
1996	91.00	74.50	93.57	40.67	88.94	47.30	16.50
1997	75.00	75.40	90.16	46.74	87.07	52.35	-0.40
1998	79.00	76.30	86.75	52.81	85.20	57.41	2.70
1999	52.00	77.20	83.34	58.88	83.34	62.46	-25.20
2000	60.00	78.10	79.92	64.96	81.47	67.51	-18.10
2001	62.00	79.00	76.51	71.03	79.60	72.56	-17.00
2002	75.67	79.90	73.10	77.10	77.73	77.61	-4.23
2003	84.60	80.80	69.69	83.17	75.87	82.66	3.80
2004	84.30	81.70	66.27	89.24	74.00	87.71	2.60
2005	82.40	82.60	62.86	95.31	72.13	92.76	-0.20
2006	76.10	83.50	59.45	101.39	70.26	97.81	-7.40
2007	111.00	84.40	56.04	107.46	68.40	102.87	26.60

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	2.21
Signific.	*
Q	2.07E-03
Qmin99	-6.91E-04
Qmax99	6.47E-03
Qmin95	1.26E-04
Qmax95	4.01E-03
B	3.29E-02
Bmin99	5.56E-02
Bmax99	1.53E-02
Bmin95	4.73E-02
Bmax95	1.74E-02

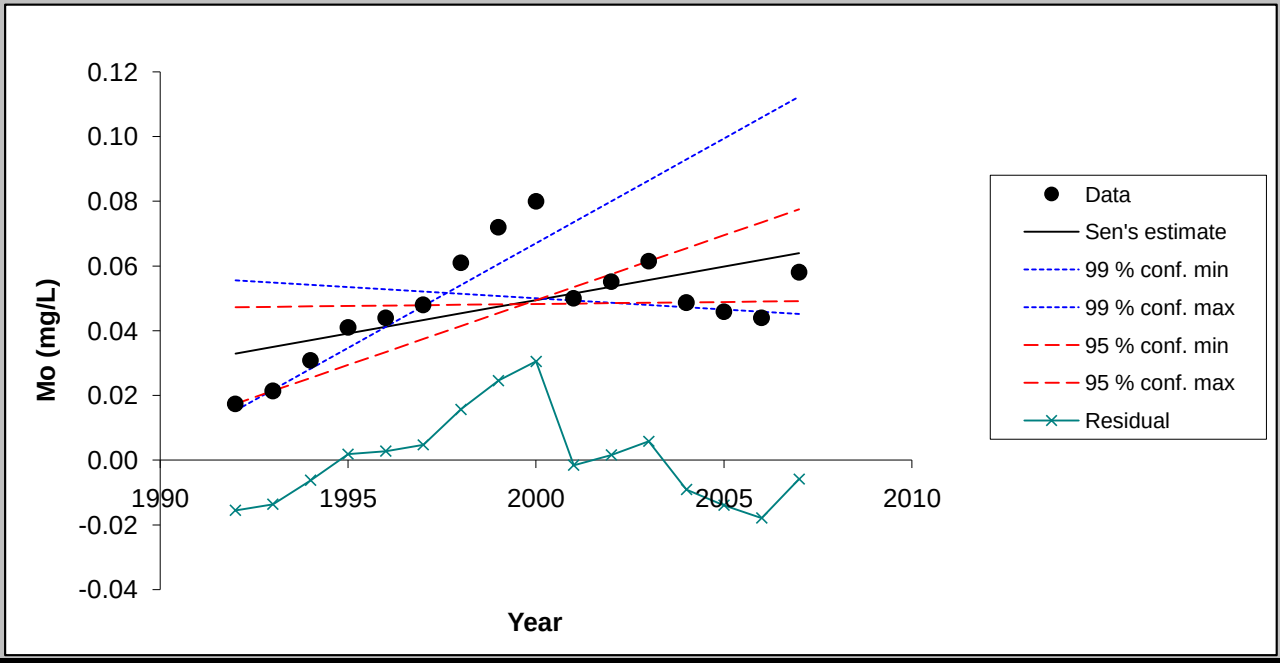

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.02	0.03	0.06	0.02	0.05	0.02	-0.02
1993	0.02	0.04	0.05	0.02	0.05	0.02	-0.01
1994	0.03	0.04	0.05	0.03	0.05	0.03	-0.01
1995	0.04	0.04	0.05	0.03	0.05	0.03	0.00
1996	0.04	0.04	0.05	0.04	0.05	0.03	0.00
1997	0.05	0.04	0.05	0.05	0.05	0.04	0.00
1998	0.06	0.05	0.05	0.05	0.05	0.04	0.02
1999	0.07	0.05	0.05	0.06	0.05	0.05	0.02
2000	0.08	0.05	0.05	0.07	0.05	0.05	0.03
2001	0.05	0.05	0.05	0.07	0.05	0.05	0.00
2002	0.06	0.05	0.05	0.08	0.05	0.06	0.00
2003	0.06	0.06	0.05	0.09	0.05	0.06	0.01
2004	0.05	0.06	0.05	0.09	0.05	0.07	-0.01
2005	0.05	0.06	0.05	0.10	0.05	0.07	-0.01
2006	0.04	0.06	0.05	0.11	0.05	0.07	-0.02
2007	0.06	0.06	0.05	0.11	0.05	0.08	-0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	2.21
Signific.	*
Q	1.09E+01
Qmin99	-3.57E+00
Qmax99	2.79E+01
Qmin95	1.26E+00
Qmax95	2.36E+01
B	2.35E+02
Bmin99	3.50E+02
Bmax99	7.72E+01
Bmin95	3.15E+02
Bmax95	1.16E+02

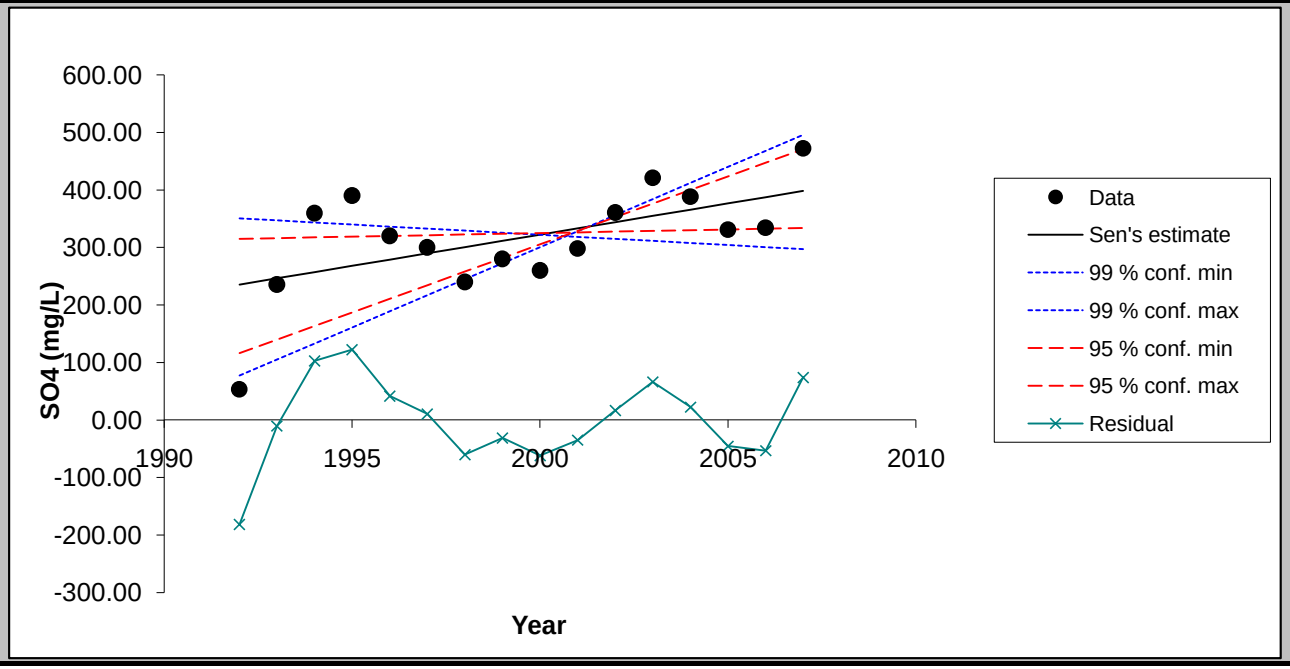

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	53.50	235.13	350.47	77.15	314.76	116.38	-181.63
1993	235.50	246.00	346.90	105.04	316.02	139.98	-10.50
1994	359.50	256.88	343.32	132.93	317.29	163.59	102.63
1995	390.00	267.75	339.75	160.82	318.55	187.19	122.25
1996	320.00	278.63	336.18	188.71	319.81	210.79	41.38
1997	300.00	289.50	332.60	216.60	321.08	234.39	10.50
1998	240.00	300.38	329.03	244.49	322.34	257.99	-60.38
1999	280.00	311.25	325.45	272.38	323.60	281.59	-31.25
2000	260.00	322.13	321.88	300.27	324.87	305.20	-62.13
2001	298.00	333.00	318.31	328.16	326.13	328.80	-35.00
2002	360.54	343.88	314.73	356.05	327.40	352.40	16.67
2003	421.00	354.75	311.16	383.94	328.66	376.00	66.25
2004	388.00	365.63	307.58	411.83	329.92	399.60	22.38
2005	331.00	376.50	304.01	439.72	331.19	423.20	-45.50
2006	334.00	387.38	300.44	467.61	332.45	446.80	-53.38
2007	472.00	398.25	296.86	495.50	333.71	470.41	73.75

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-54 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	16	16
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0043	5.1	0.0022	6.42	0.233	166	0.123	432
1993	0.0029	5.3	0.0188	7.67	0.45	139.5	0.102	454
1994	0.0029	5.7	0.0041	7.4	0.314	159	0.109	499.5
1995	0.0005	5.4	0.012	4.3	0.38	140	0.126	540
1996	0.0006	6.3	0.002	8.8	0.27	110	0.122	460
1997	0.0005	7.4	0.001	7.5	0.13	77	0.125	350
1998	0.0004	4.6	0.004	5.3	0.105	64	0.113	220
1999	0.0004	4.3	0.002	5.3	0.066	45	0.092	190
2000	0.0004	3	0.005	4.2	0.05	51	0.073	170
2001	0.001	2.7	0.005	5	0.092	67	0.06	319
2002	0.0176	2.6	0.03	1.04	0.338	109.1	0.058	529.9
2003	0.001	2.24	0.0029	7.15	0.314	122	0.0675	541
2004	0.0023	2.23	0.001	7.05	0.374	109	0.0581	508
2005	0.001	2.43	0.002	7.93	0.315	120.5	0.0511	504.5
2006	0.001	2.63	0.002	12.5	0.3415	122	0.0565	628.5
2007	0.001	3.67	0.002	9.695	0.08495	98.8	0.0882	491

TREND STATISTICS

TW-54 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		-0.50		0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
F (mg/L)	*1992*	*2007*	*16*		-3.02	**	-0.253	-0.400	-0.064	-0.364	-0.114	5.89	6.82	4.69	6.54	5.10
Mn (mg/L)	*1992*	*2007*	*16*		-1.54		0.000	-0.001	0.000	-0.001	0.000	0.00	0.01	0.00	0.01	0.00
Nitrate (mg/L)	*1992*	*2007*	*16*		0.63		0.099	-0.373	0.578	-0.180	0.437	6.24	8.25	1.54	7.80	2.83
Se (mg/L)	*1992*	*2007*	*16*		-0.50		-0.004	-0.032	0.023	-0.024	0.010	0.31	0.44	0.04	0.40	0.20
Cl (mg/L)	*1992*	*2007*	*16*		-1.26		-2.840	-12.442	5.763	-8.650	2.963	141.87	178.15	46.88	165.97	79.99
Mo (mg/L)	*1992*	*2007*	*16*		-3.38	***	-0.005	-0.008	-0.001	-0.007	-0.002	0.12	0.15	0.10	0.15	0.11
SO4 (mg/L)	*1992*	*2007*	*16*		0.95		4.927	-19.902	35.106	-10.372	27.730	440.37	539.46	145.93	510.87	223.66
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.50
Signific.	
Q	-8.71E-12
Qmin99	-2.56E-04
Qmax99	8.57E-05
Qmin95	-1.67E-04
Qmax95	6.45E-05
B	1.00E-03
Bmin99	3.33E-03
Bmax99	1.50E-04
Bmin95	2.97E-03
Bmax95	2.99E-04

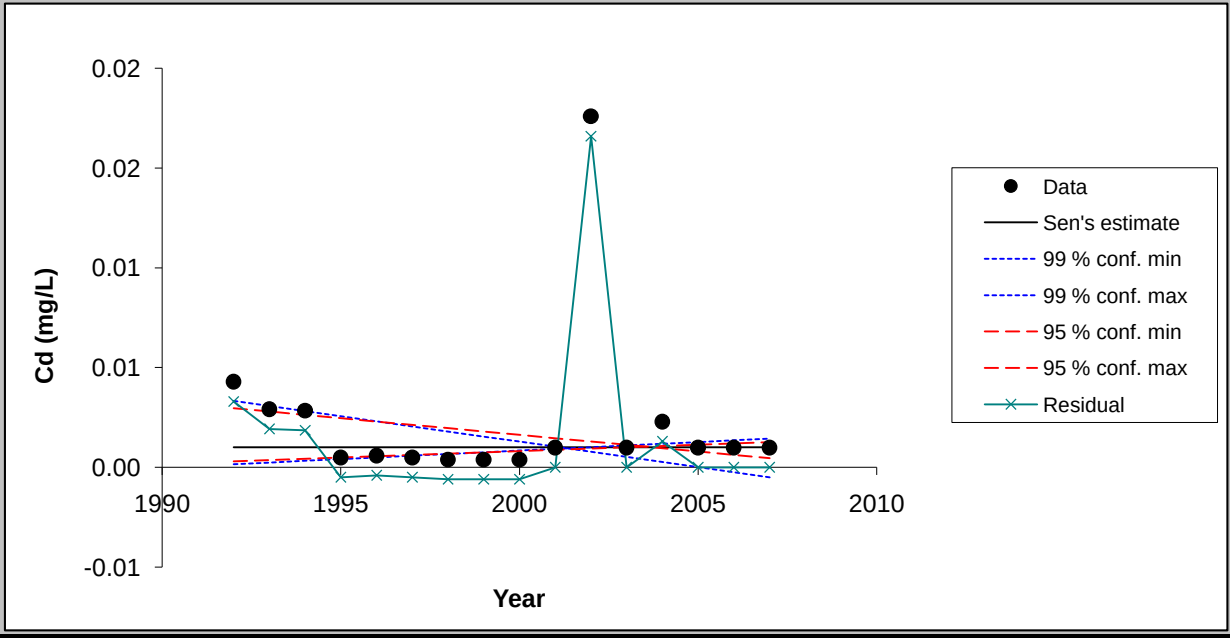

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.00	0.00	0.00	0.00	0.00	0.02
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.02
Signific.	**
Q	-2.53E-01
Qmin99	-4.00E-01
Qmax99	-6.40E-02
Qmin95	-3.64E-01
Qmax95	-1.14E-01
B	5.89E+00
Bmin99	6.82E+00
Bmax99	4.69E+00
Bmin95	6.54E+00
Bmax95	5.10E+00

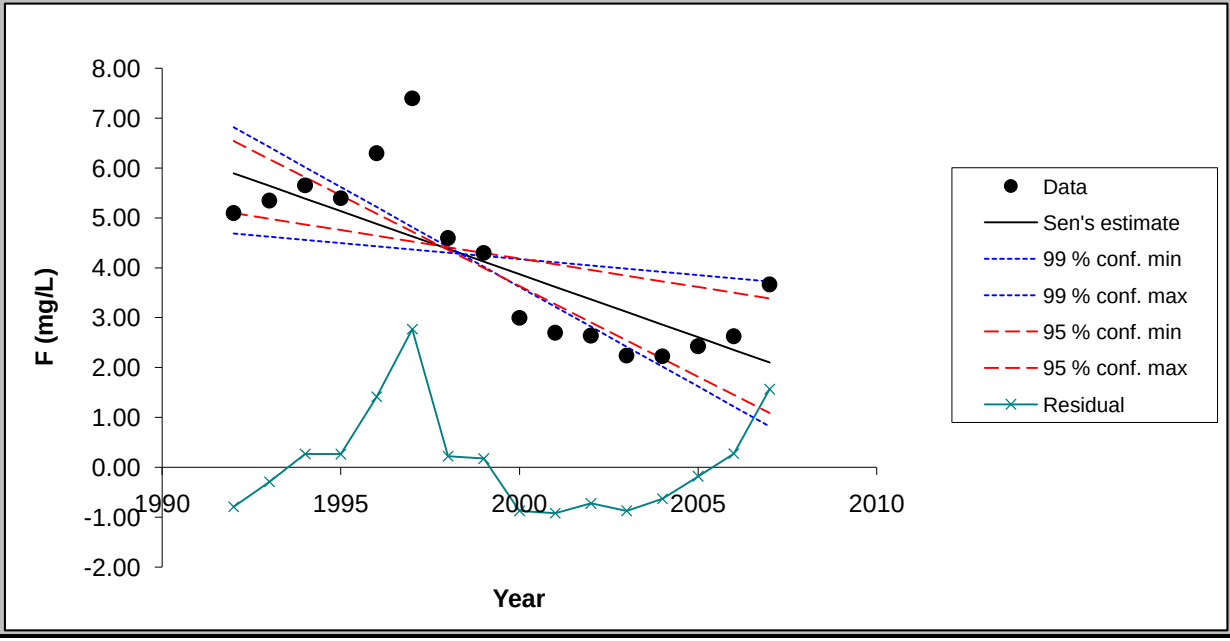

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	5.10	5.89	6.82	4.69	6.54	5.10	-0.79
1993	5.35	5.64	6.42	4.62	6.18	4.99	-0.29
1994	5.65	5.39	6.02	4.56	5.81	4.87	0.27
1995	5.40	5.13	5.62	4.50	5.45	4.76	0.27
1996	6.30	4.88	5.22	4.43	5.09	4.64	1.42
1997	7.40	4.63	4.82	4.37	4.72	4.53	2.77
1998	4.60	4.38	4.42	4.30	4.36	4.41	0.22
1999	4.30	4.12	4.02	4.24	4.00	4.30	0.18
2000	3.00	3.87	3.62	4.18	3.63	4.19	-0.87
2001	2.70	3.62	3.22	4.11	3.27	4.07	-0.92
2002	2.64	3.37	2.82	4.05	2.91	3.96	-0.72
2003	2.24	3.11	2.42	3.99	2.54	3.84	-0.87
2004	2.23	2.86	2.02	3.92	2.18	3.73	-0.63
2005	2.43	2.61	1.62	3.86	1.82	3.62	-0.18
2006	2.63	2.35	1.22	3.79	1.45	3.50	0.28
2007	3.67	2.10	0.82	3.73	1.09	3.39	1.57

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.54
Signific.	
Q	-1.32E-04
Qmin99	-1.05E-03
Qmax99	3.05E-04
Qmin95	-7.32E-04
Qmax95	1.07E-04
B	4.17E-03
Bmin99	1.40E-02
Bmax99	1.48E-03
Bmin95	1.09E-02
Bmax95	1.96E-03

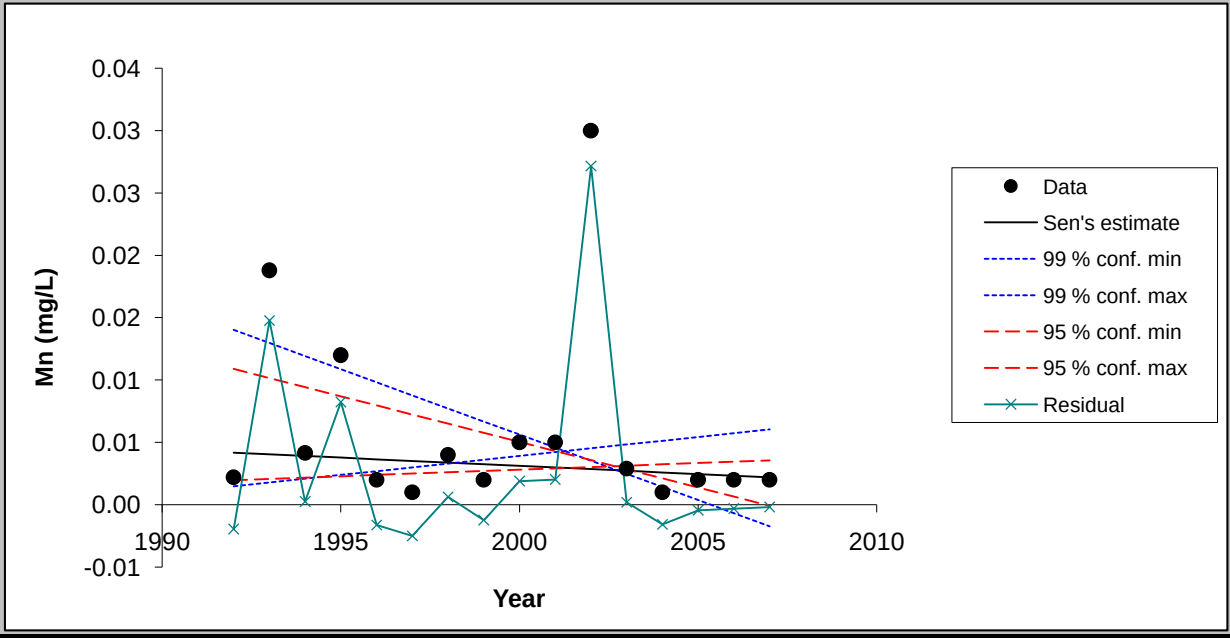

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1993	0.02	0.00	0.01	0.00	0.01	0.00	0.01
1994	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1995	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1996	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1999	0.00	0.00	0.01	0.00	0.01	0.00	0.00
2000	0.00	0.00	0.01	0.00	0.01	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.01	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.63
Signific.	
Q	9.88E-02
Qmin99	-3.73E-01
Qmax99	5.78E-01
Qmin95	-1.80E-01
Qmax95	4.37E-01
B	6.24E+00
Bmin99	8.25E+00
Bmax99	1.54E+00
Bmin95	7.80E+00
Bmax95	2.83E+00

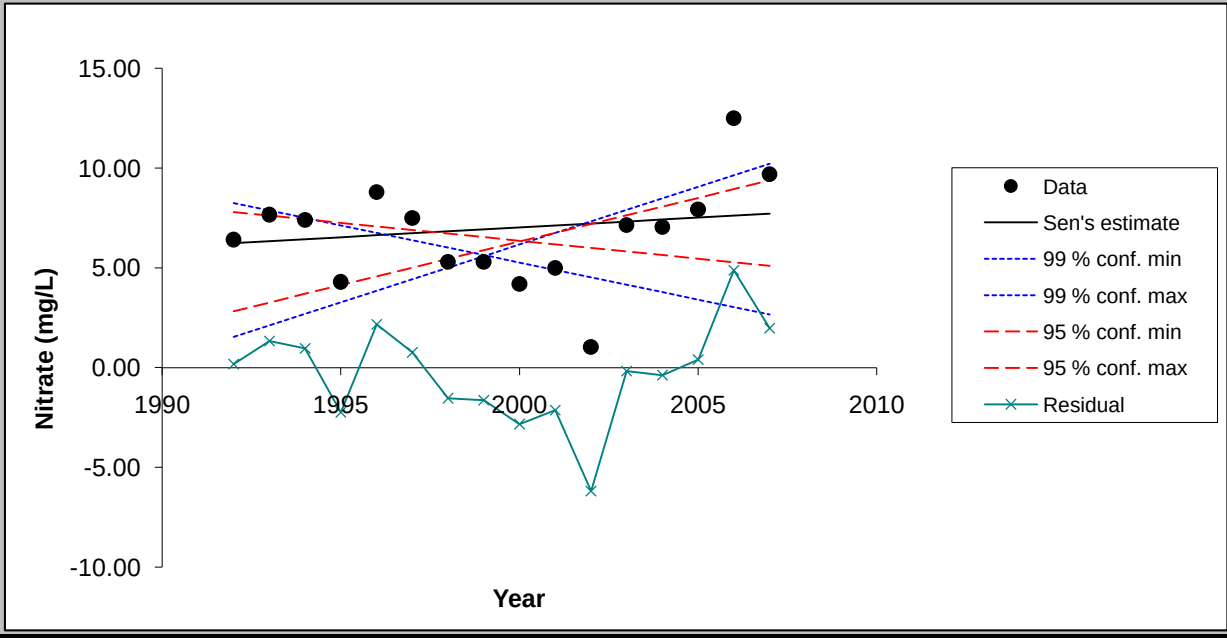

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	6.42	6.24	8.25	1.54	7.80	2.83	0.18
1993	7.67	6.34	7.88	2.12	7.62	3.27	1.33
1994	7.40	6.44	7.51	2.70	7.45	3.71	0.96
1995	4.30	6.54	7.13	3.28	7.27	4.14	-2.24
1996	8.80	6.64	6.76	3.85	7.09	4.58	2.16
1997	7.50	6.74	6.39	4.43	6.91	5.02	0.76
1998	5.30	6.83	6.01	5.01	6.73	5.46	-1.53
1999	5.30	6.93	5.64	5.59	6.55	5.89	-1.63
2000	4.20	7.03	5.27	6.17	6.37	6.33	-2.83
2001	5.00	7.13	4.89	6.75	6.19	6.77	-2.13
2002	1.04	7.23	4.52	7.32	6.01	7.21	-6.19
2003	7.15	7.33	4.15	7.90	5.83	7.64	-0.18
2004	7.05	7.43	3.78	8.48	5.65	8.08	-0.38
2005	7.93	7.53	3.40	9.06	5.47	8.52	0.40
2006	12.50	7.62	3.03	9.64	5.29	8.95	4.88
2007	9.70	7.72	2.66	10.22	5.11	9.39	1.97

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.50
Signific.	
Q	-4.42E-03
Qmin99	-3.19E-02
Qmax99	2.34E-02
Qmin95	-2.38E-02
Qmax95	1.02E-02
B	3.06E-01
Bmin99	4.37E-01
Bmax99	3.58E-02
Bmin95	4.04E-01
Bmax95	2.00E-01

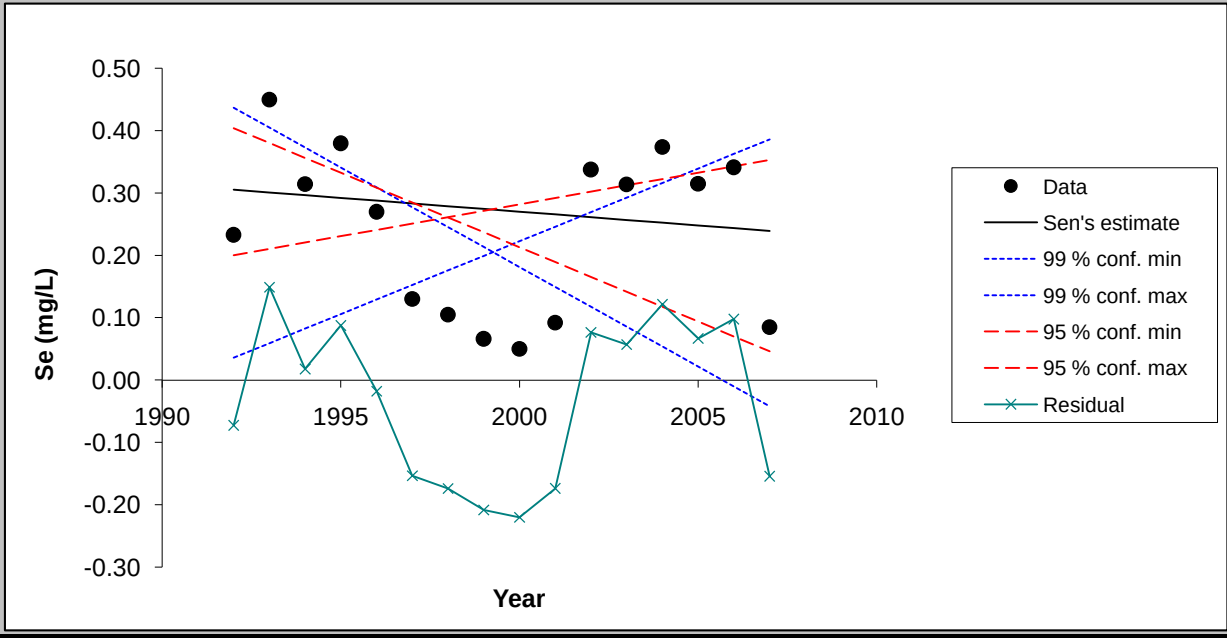

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.23	0.31	0.44	0.04	0.40	0.20	-0.07
1993	0.45	0.30	0.40	0.06	0.38	0.21	0.15
1994	0.31	0.30	0.37	0.08	0.36	0.22	0.02
1995	0.38	0.29	0.34	0.11	0.33	0.23	0.09
1996	0.27	0.29	0.31	0.13	0.31	0.24	-0.02
1997	0.13	0.28	0.28	0.15	0.28	0.25	-0.15
1998	0.10	0.28	0.25	0.18	0.26	0.26	-0.17
1999	0.07	0.27	0.21	0.20	0.24	0.27	-0.21
2000	0.05	0.27	0.18	0.22	0.21	0.28	-0.22
2001	0.09	0.27	0.15	0.25	0.19	0.29	-0.17
2002	0.34	0.26	0.12	0.27	0.17	0.30	0.08
2003	0.31	0.26	0.09	0.29	0.14	0.31	0.06
2004	0.37	0.25	0.05	0.32	0.12	0.32	0.12
2005	0.32	0.25	0.02	0.34	0.09	0.33	0.07
2006	0.34	0.24	-0.01	0.36	0.07	0.34	0.10
2007	0.08	0.24	-0.04	0.39	0.05	0.35	-0.15

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.26
Signific.	
Q	-2.84E+00
Qmin99	-1.24E+01
Qmax99	5.76E+00
Qmin95	-8.65E+00
Qmax95	2.96E+00
B	1.42E+02
Bmin99	1.78E+02
Bmax99	4.69E+01
Bmin95	1.66E+02
Bmax95	8.00E+01

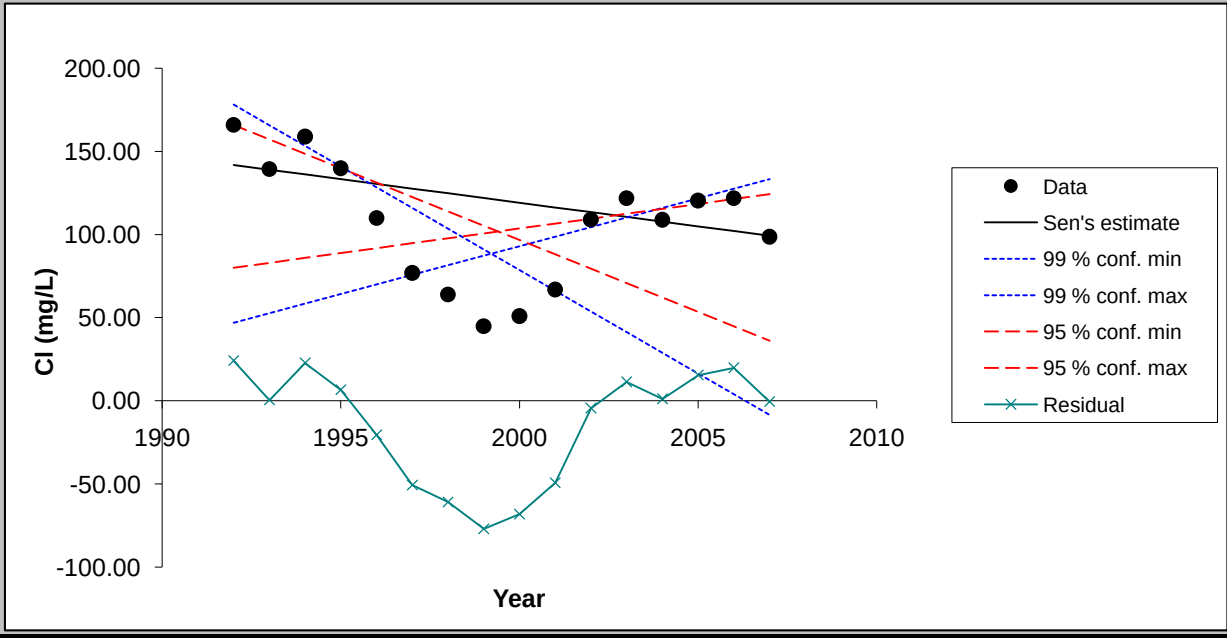

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	166.00	141.87	178.15	46.88	165.97	79.99	24.13
1993	139.50	139.03	165.71	52.64	157.32	82.95	0.47
1994	159.00	136.19	153.27	58.41	148.68	85.91	22.81
1995	140.00	133.35	140.83	64.17	140.03	88.87	6.65
1996	110.00	130.51	128.38	69.93	131.38	91.84	-20.51
1997	77.00	127.67	115.94	75.70	122.73	94.80	-50.67
1998	64.00	124.83	103.50	81.46	114.08	97.76	-60.83
1999	45.00	121.99	91.06	87.22	105.43	100.73	-76.99
2000	51.00	119.15	78.62	92.99	96.78	103.69	-68.15
2001	67.00	116.31	66.17	98.75	88.13	106.65	-49.31
2002	109.08	113.47	53.73	104.51	79.48	109.61	-4.39
2003	122.00	110.63	41.29	110.28	70.83	112.58	11.37
2004	109.00	107.79	28.85	116.04	62.18	115.54	1.21
2005	120.50	104.95	16.40	121.80	53.53	118.50	15.55
2006	122.00	102.11	3.96	127.57	44.88	121.46	19.89
2007	98.80	99.27	-8.48	133.33	36.23	124.43	-0.47

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.38
Signific.	***
Q	-4.82E-03
Qmin99	-7.94E-03
Qmax99	-1.23E-03
Qmin95	-7.29E-03
Qmax95	-2.35E-03
B	1.22E-01
Bmin99	1.52E-01
Bmax99	1.02E-01
Bmin95	1.46E-01
Bmax95	1.07E-01

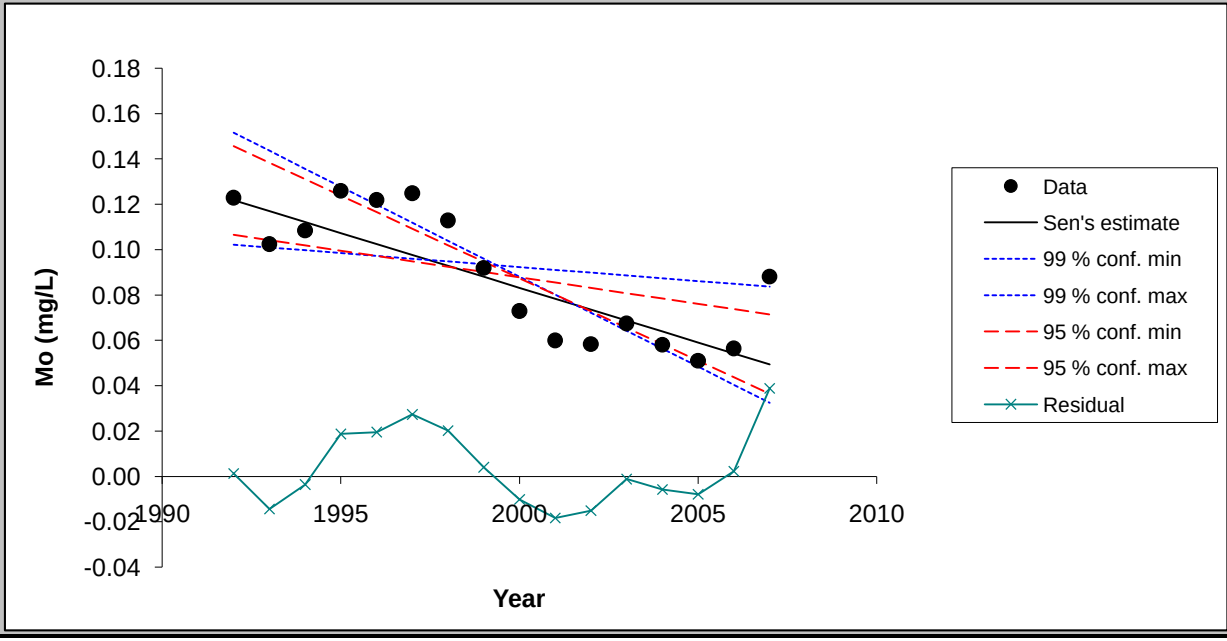

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.12	0.12	0.15	0.10	0.15	0.11	0.00
1993	0.10	0.12	0.14	0.10	0.14	0.10	-0.01
1994	0.11	0.11	0.14	0.10	0.13	0.10	0.00
1995	0.13	0.11	0.13	0.10	0.12	0.10	0.02
1996	0.12	0.10	0.12	0.10	0.12	0.10	0.02
1997	0.13	0.10	0.11	0.10	0.11	0.09	0.03
1998	0.11	0.09	0.10	0.09	0.10	0.09	0.02
1999	0.09	0.09	0.10	0.09	0.09	0.09	0.00
2000	0.07	0.08	0.09	0.09	0.09	0.09	-0.01
2001	0.06	0.08	0.08	0.09	0.08	0.09	-0.02
2002	0.06	0.07	0.07	0.09	0.07	0.08	-0.02
2003	0.07	0.07	0.06	0.09	0.07	0.08	0.00
2004	0.06	0.06	0.06	0.09	0.06	0.08	-0.01
2005	0.05	0.06	0.05	0.09	0.05	0.08	-0.01
2006	0.06	0.05	0.04	0.08	0.04	0.07	0.00
2007	0.09	0.05	0.03	0.08	0.04	0.07	0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.95
Signific.	
Q	4.93E+00
Qmin99	-1.99E+01
Qmax99	3.51E+01
Qmin95	-1.04E+01
Qmax95	2.77E+01
B	4.40E+02
Bmin99	5.39E+02
Bmax99	1.46E+02
Bmin95	5.11E+02
Bmax95	2.24E+02

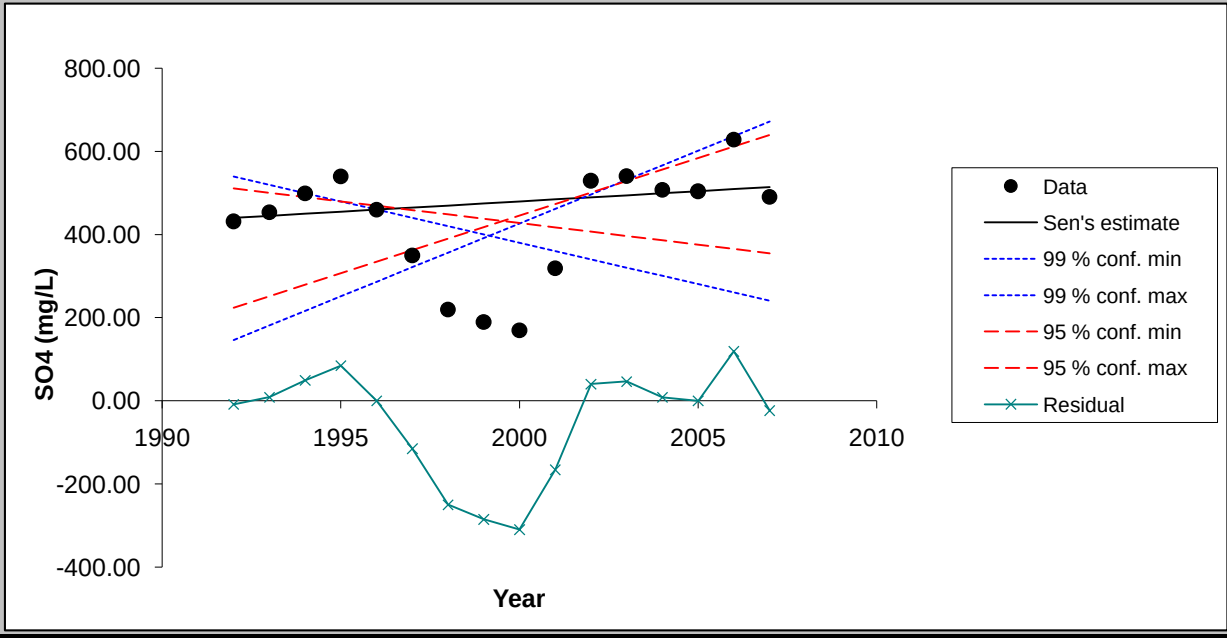

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	432.00	440.37	539.46	145.93	510.87	223.66	-8.37
1993	454.00	445.30	519.55	181.03	500.49	251.39	8.70
1994	499.50	450.23	499.65	216.14	490.12	279.12	49.27
1995	540.00	455.15	479.75	251.24	479.75	306.85	84.85
1996	460.00	460.08	459.85	286.35	469.38	334.58	-0.08
1997	350.00	465.01	439.95	321.46	459.01	362.31	-115.01
1998	220.00	469.93	420.04	356.56	448.63	390.04	-249.93
1999	190.00	474.86	400.14	391.67	438.26	417.77	-284.86
2000	170.00	479.79	380.24	426.77	427.89	445.50	-309.79
2001	319.00	484.71	360.34	461.88	417.52	473.23	-165.71
2002	529.90	489.64	340.44	496.99	407.15	500.96	40.26
2003	541.00	494.57	320.53	532.09	396.77	528.69	46.43
2004	508.00	499.49	300.63	567.20	386.40	556.42	8.51
2005	504.50	504.42	280.73	602.30	376.03	584.15	0.08
2006	628.50	509.35	260.83	637.41	365.66	611.88	119.15
2007	491.00	514.27	240.93	672.51	355.29	639.61	-23.27

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-55 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	16	16
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0046	0.15	0.0026	2.96	0.248	75.3	0.0085	242
1993	0.0029	0.21	0.0184	2.88	0.172	68.2	0.0048	223
1994	0.0024	0.24	0.001	3.42	0.144	61.2	0.0065	219
1995	0.0001	0.29	0.0005	3.4	0.097	82	0.0025	190
1996	0.0001	0.26	0.001	3.7	0.068	47	0.0025	230
1997	0.0001	0.32	0.0005	3.4	0.06	50	0.0025	180
1998	0.0001	0.3	0.0005	2.9	0.036	48	0.0025	180
1999	0.0001	0.36	0.0005	2.9	0.021	34	0.0025	160
2000	0.0001	0.32	0.0005	2.9	0.014	44	0.0025	160
2001	0.001	0.6	0.005	2.98	0.013	36	0.005	117
2002	0.001	0.69	0.03	2.91	0.017	36.7	0.005	127.8
2003	0.001	0.39	0.001	2.58	0.026	38.4	0.021	150
2004	0.001	0.115	0.001	2.69	0.074	42.1	0.016	174
2005	0.001	0.23	0.001	3.06	0.084	58.7	0.0054	230
2006	0.0006	0.05	0.002	3.64	0.115	59.1	0.008	252
2007	0.001	0.26	0.002	4.15	0.0413	59.4	0.012	252

TREND STATISTICS

TW-55 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		-0.52		0.0000	-0.0002	0.0001	-0.0002	0.0001	0.0010	0.0029	-0.0003	0.0026	0.0000
F (mg/L)	*1992*	*2007*	*16*		0.90		0.009	-0.019	0.034	-0.011	0.025	0.24	0.41	0.12	0.37	0.16
Mn (mg/L)	*1992*	*2007*	*16*		0.23		0.0000	-0.0003	0.0002	-0.0001	0.0001	0.0010	0.0032	-0.0003	0.0024	0.0001
Nitrate (mg/L)	*1992*	*2007*	*16*		0.14		0.001	-0.076	0.084	-0.064	0.050	2.97	3.62	2.43	3.55	2.71
Se (mg/L)	*1992*	*2007*	*16*		-1.76	+	-0.008	-0.019	0.004	-0.016	0.001	0.12	0.19	0.04	0.17	0.06
Cl (mg/L)	*1992*	*2007*	*16*		-1.22		-1.3	-3.8	1.3	-3.3	1.0	56.7	74.6	40.7	71.1	43.6
Mo (mg/L)	*1992*	*2007*	*16*		1.62		0.0003	-0.0002	0.0010	0.0000	0.0008	0.0018	0.0066	-0.0027	0.0050	-0.0011
SO4 (mg/L)	*1992*	*2007*	*16*		-0.68		-3.2	-10.7	7.2	-9.9	3.3	205.8	243.0	140.6	239.6	171.9
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.52
Signific.	
Q	0.00E+00
Qmin99	-2.00E-04
Qmax99	1.00E-04
Qmin95	-1.55E-04
Qmax95	7.06E-05
B	1.00E-03
Bmin99	2.90E-03
Bmax99	-2.50E-04
Bmin95	2.63E-03
Bmax95	1.10E-05

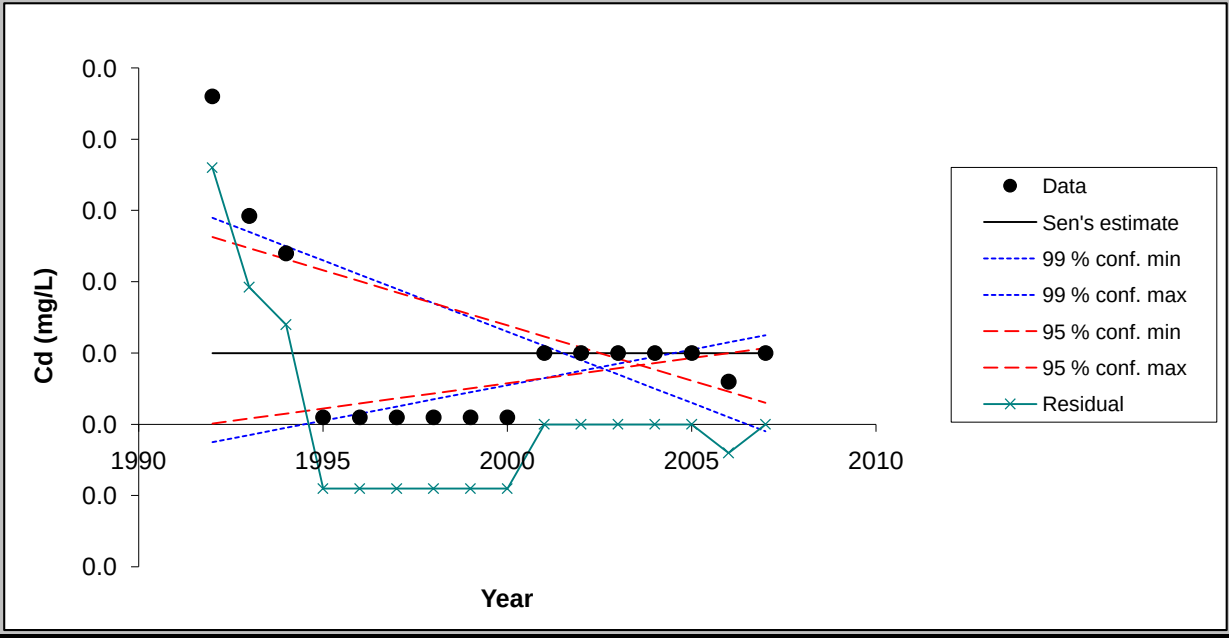

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.90
Signific.	
Q	8.75E-03
Qmin99	-1.89E-02
Qmax99	3.37E-02
Qmin95	-1.09E-02
Qmax95	2.46E-02
B	2.38E-01
Bmin99	4.14E-01
Bmax99	1.25E-01
Bmin95	3.69E-01
Bmax95	1.57E-01

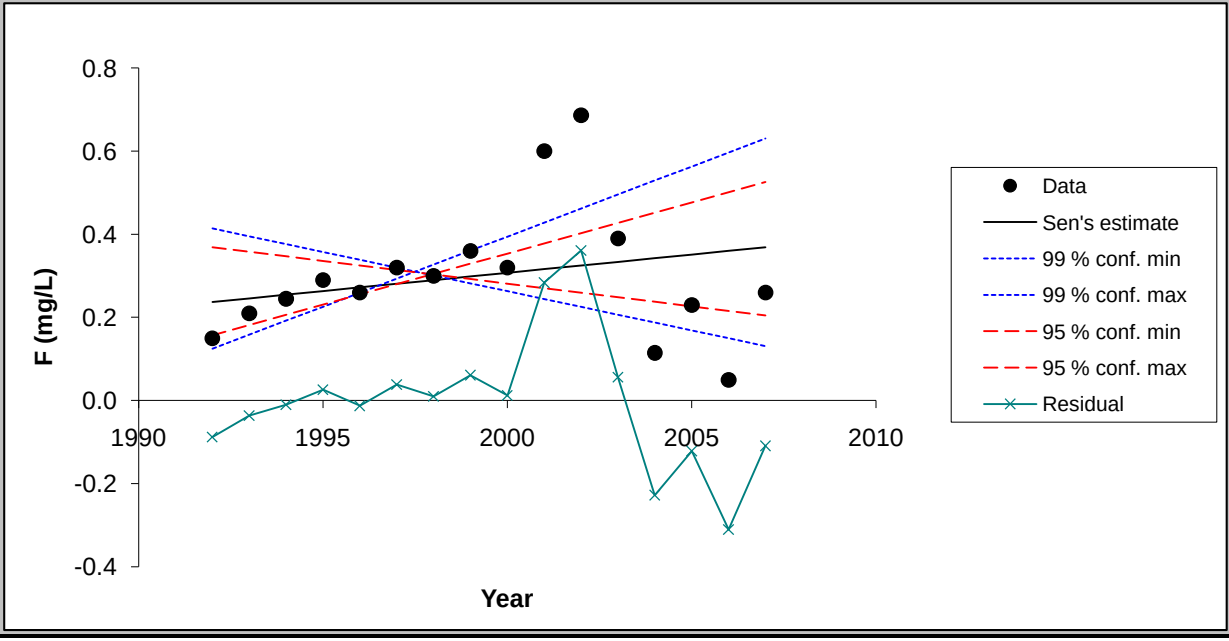

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.15	0.24	0.41	0.12	0.37	0.16	-0.09
1993	0.21	0.25	0.39	0.16	0.36	0.18	-0.04
1994	0.24	0.26	0.38	0.19	0.35	0.21	-0.01
1995	0.29	0.26	0.36	0.23	0.34	0.23	0.03
1996	0.26	0.27	0.34	0.26	0.33	0.26	-0.01
1997	0.32	0.28	0.32	0.29	0.31	0.28	0.04
1998	0.30	0.29	0.30	0.33	0.30	0.30	0.01
1999	0.36	0.30	0.28	0.36	0.29	0.33	0.06
2000	0.32	0.31	0.26	0.39	0.28	0.35	0.01
2001	0.60	0.32	0.24	0.43	0.27	0.38	0.28
2002	0.69	0.32	0.23	0.46	0.26	0.40	0.36
2003	0.39	0.33	0.21	0.50	0.25	0.43	0.06
2004	0.12	0.34	0.19	0.53	0.24	0.45	-0.23
2005	0.23	0.35	0.17	0.56	0.23	0.48	-0.12
2006	0.05	0.36	0.15	0.60	0.22	0.50	-0.31
2007	0.26	0.37	0.13	0.63	0.20	0.53	-0.11

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.23
Signific.	
Q	0.00E+00
Qmin99	-2.62E-04
Qmax99	1.67E-04
Qmin95	-1.25E-04
Qmax95	1.25E-04
B	1.00E-03
Bmin99	3.24E-03
Bmax99	-3.33E-04
Bmin95	2.44E-03
Bmax95	1.25E-04

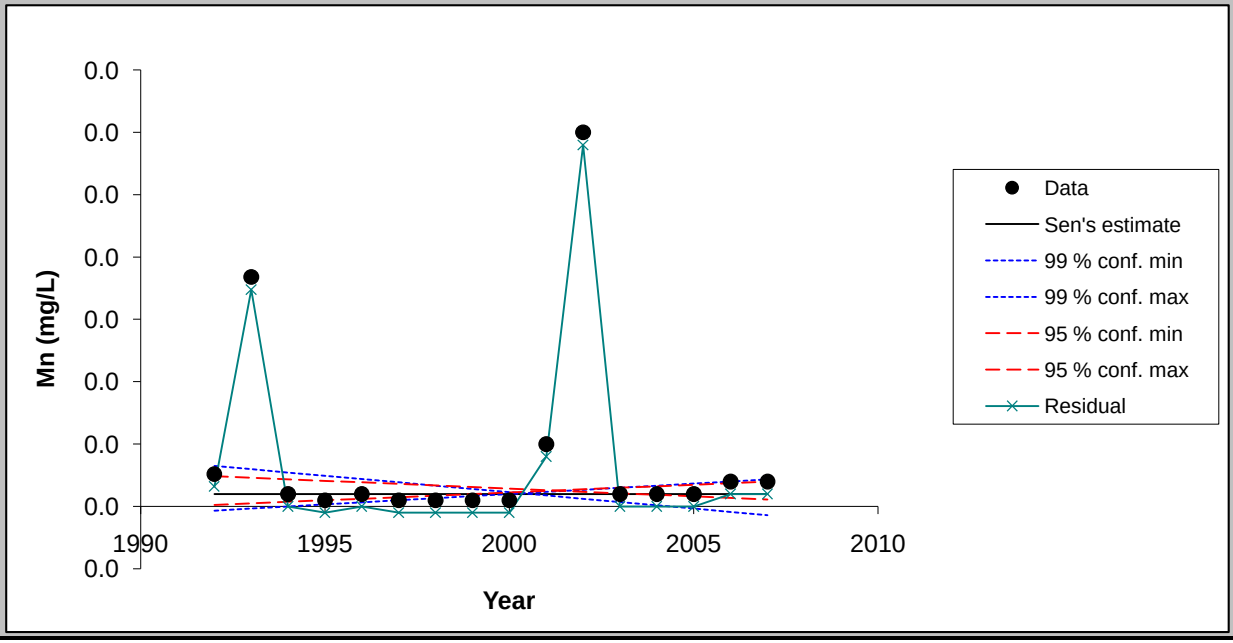

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.02	0.00	0.00	0.00	0.00	0.00	0.02
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.14
Signific.	
Q	1.11E-03
Qmin99	-7.60E-02
Qmax99	8.38E-02
Qmin95	-6.39E-02
Qmax95	4.95E-02
B	2.97E+00
Bmin99	3.62E+00
Bmax99	2.43E+00
Bmin95	3.55E+00
Bmax95	2.71E+00

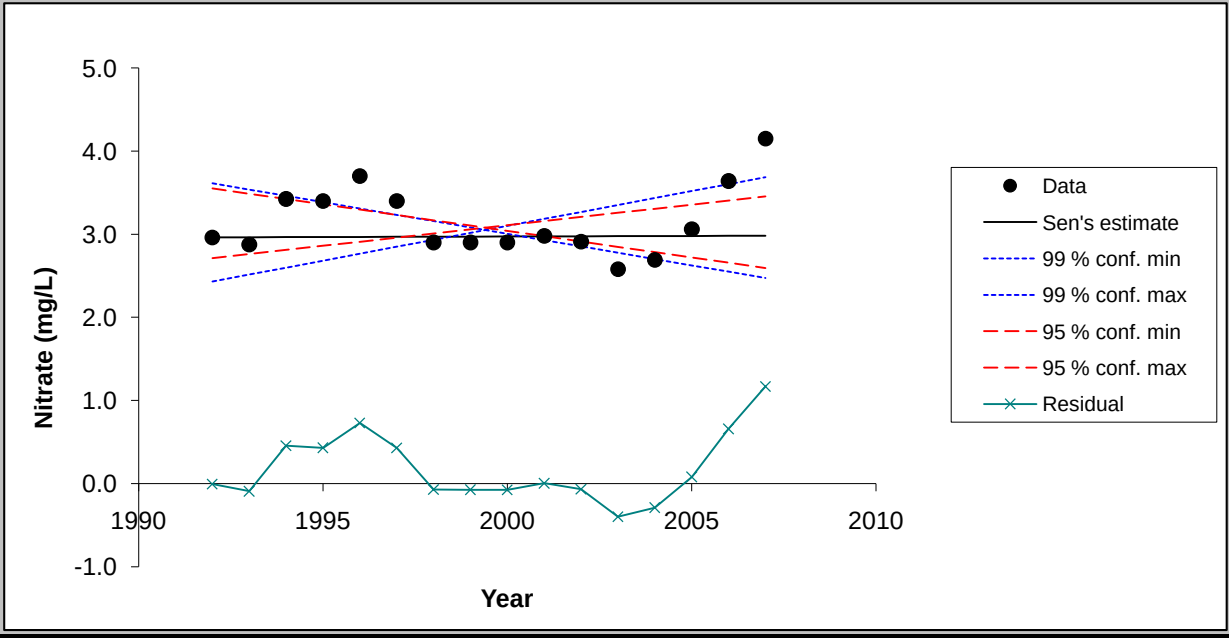

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	2.96	2.97	3.62	2.43	3.55	2.71	0.00
1993	2.88	2.97	3.54	2.52	3.49	2.76	-0.09
1994	3.42	2.97	3.46	2.60	3.42	2.81	0.46
1995	3.40	2.97	3.39	2.68	3.36	2.86	0.43
1996	3.70	2.97	3.31	2.77	3.30	2.91	0.73
1997	3.40	2.97	3.24	2.85	3.23	2.96	0.43
1998	2.90	2.97	3.16	2.93	3.17	3.01	-0.07
1999	2.90	2.97	3.08	3.02	3.10	3.06	-0.07
2000	2.90	2.97	3.01	3.10	3.04	3.11	-0.07
2001	2.98	2.98	2.93	3.19	2.98	3.16	0.00
2002	2.91	2.98	2.85	3.27	2.91	3.21	-0.07
2003	2.58	2.98	2.78	3.35	2.85	3.26	-0.40
2004	2.69	2.98	2.70	3.44	2.78	3.31	-0.29
2005	3.06	2.98	2.63	3.52	2.72	3.36	0.08
2006	3.64	2.98	2.55	3.61	2.66	3.41	0.66
2007	4.15	2.98	2.47	3.69	2.59	3.46	1.17

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.76
Signific.	+
Q	-7.93E-03
Qmin99	-1.93E-02
Qmax99	3.50E-03
Qmin95	-1.58E-02
Qmax95	1.13E-03
B	1.17E-01
Bmin99	1.89E-01
Bmax99	3.52E-02
Bmin95	1.75E-01
Bmax95	5.74E-02

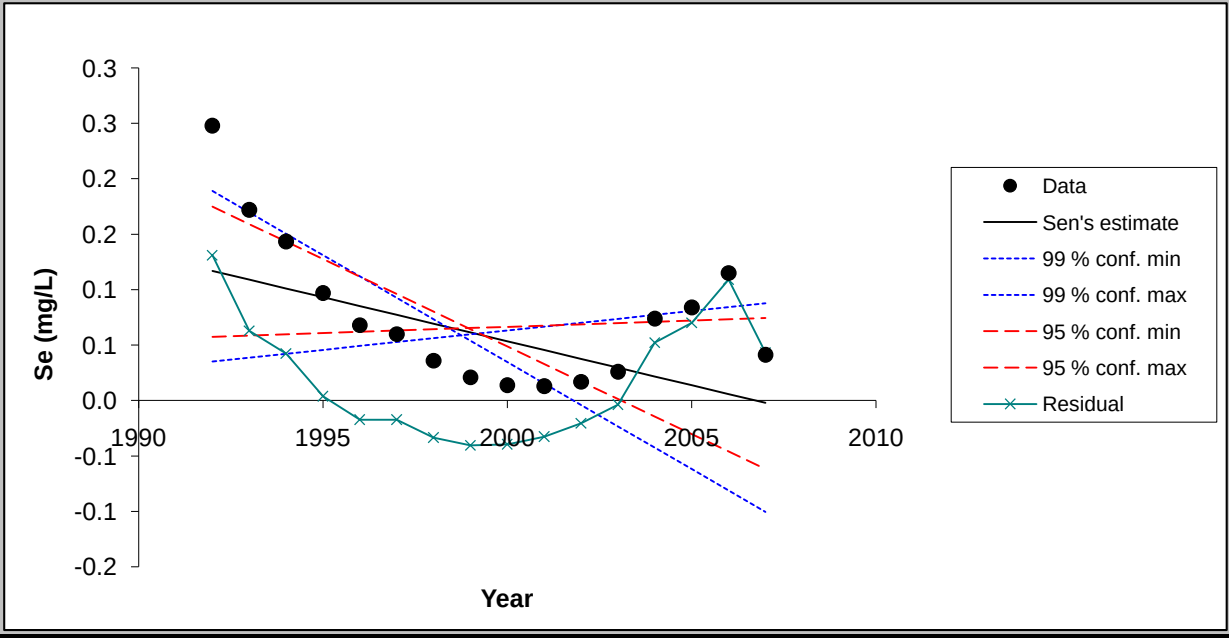

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.25	0.12	0.19	0.04	0.17	0.06	0.13
1993	0.17	0.11	0.17	0.04	0.16	0.06	0.06
1994	0.14	0.10	0.15	0.04	0.14	0.06	0.04
1995	0.10	0.09	0.13	0.05	0.13	0.06	0.00
1996	0.07	0.09	0.11	0.05	0.11	0.06	-0.02
1997	0.06	0.08	0.09	0.05	0.10	0.06	-0.02
1998	0.04	0.07	0.07	0.06	0.08	0.06	-0.03
1999	0.02	0.06	0.05	0.06	0.06	0.07	-0.04
2000	0.01	0.05	0.03	0.06	0.05	0.07	-0.04
2001	0.01	0.05	0.02	0.07	0.03	0.07	-0.03
2002	0.02	0.04	0.00	0.07	0.02	0.07	-0.02
2003	0.03	0.03	-0.02	0.07	0.00	0.07	0.00
2004	0.07	0.02	-0.04	0.08	-0.01	0.07	0.05
2005	0.08	0.01	-0.06	0.08	-0.03	0.07	0.07
2006	0.12	0.01	-0.08	0.08	-0.05	0.07	0.11
2007	0.04	0.00	-0.10	0.09	-0.06	0.07	0.04

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.22
Signific.	
Q	-1.25E+00
Qmin99	-3.81E+00
Qmax99	1.29E+00
Qmin95	-3.34E+00
Qmax95	1.01E+00
B	5.67E+01
Bmin99	7.46E+01
Bmax99	4.07E+01
Bmin95	7.11E+01
Bmax95	4.36E+01

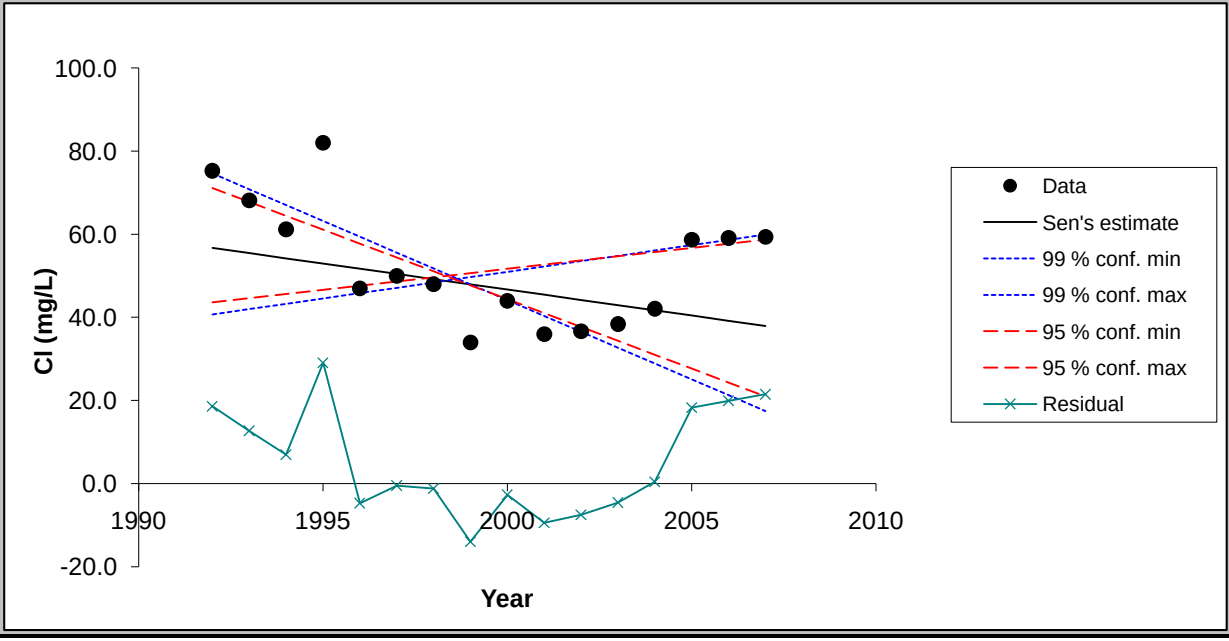

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	75.30	56.70	74.64	40.68	71.11	43.62	18.60
1993	68.15	55.45	70.83	41.97	67.77	44.63	12.70
1994	61.20	54.19	67.02	43.25	64.43	45.64	7.01
1995	82.00	52.94	63.21	44.54	61.09	46.64	29.06
1996	47.00	51.69	59.40	45.83	57.75	47.65	-4.69
1997	50.00	50.43	55.59	47.12	54.40	48.66	-0.43
1998	48.00	49.18	51.78	48.40	51.06	49.67	-1.18
1999	34.00	47.93	47.97	49.69	47.72	50.68	-13.93
2000	44.00	46.68	44.16	50.98	44.38	51.69	-2.68
2001	36.00	45.42	40.35	52.26	41.04	52.70	-9.42
2002	36.69	44.17	36.53	53.55	37.69	53.70	-7.48
2003	38.40	42.92	32.72	54.84	34.35	54.71	-4.52
2004	42.10	41.67	28.91	56.12	31.01	55.72	0.43
2005	58.70	40.41	25.10	57.41	27.67	56.73	18.29
2006	59.10	39.16	21.29	58.70	24.33	57.74	19.94
2007	59.40	37.91	17.48	59.98	20.99	58.75	21.49

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.62
Signific.	
Q	3.40E-04
Qmin99	-1.65E-04
Qmax99	9.99E-04
Qmin95	0.00E+00
Qmax95	7.96E-04
B	1.77E-03
Bmin99	6.57E-03
Bmax99	-2.74E-03
Bmin95	5.00E-03
Bmax95	-1.08E-03

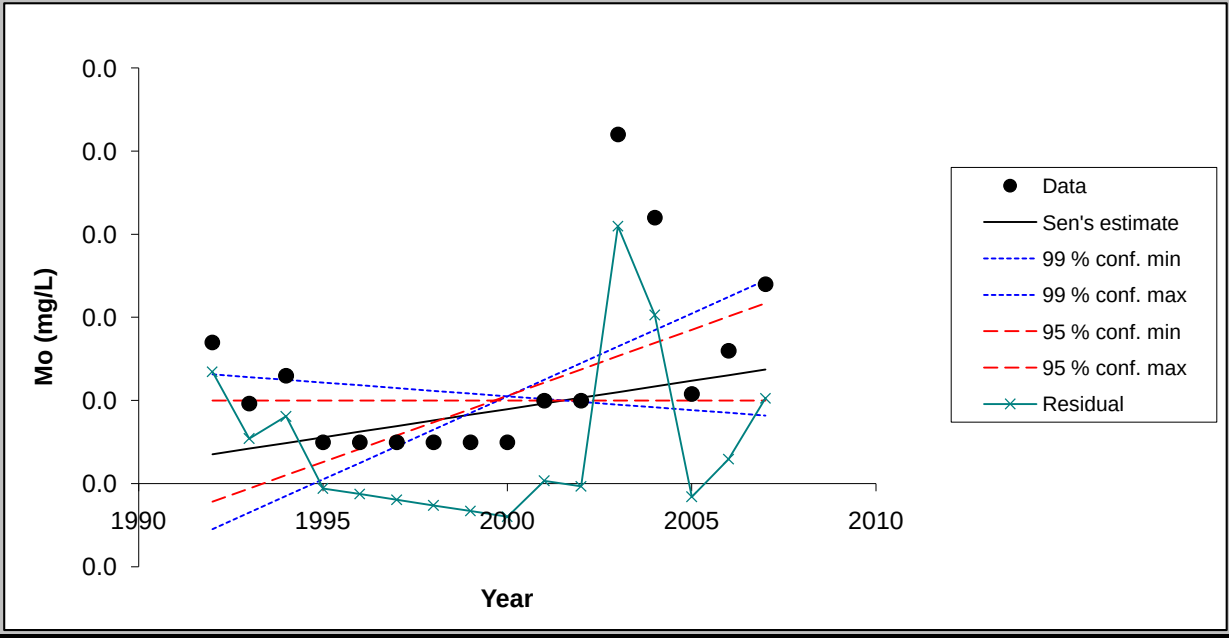

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.01	0.00	0.01	0.00	0.00	0.00	0.01
1993	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1994	0.01	0.00	0.01	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.01	0.01	0.00	0.01	0.00
2001	0.00	0.00	0.01	0.01	0.00	0.01	0.00
2002	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.02	0.01	0.00	0.01	0.00	0.01	0.02
2004	0.02	0.01	0.00	0.01	0.00	0.01	0.01
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2006	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2007	0.01	0.01	0.00	0.01	0.00	0.01	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-55 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.68
Signific.	
Q	-3.17E+00
Qmin99	-1.07E+01
Qmax99	7.17E+00
Qmin95	-9.95E+00
Qmax95	3.27E+00
B	2.06E+02
Bmin99	2.43E+02
Bmax99	1.41E+02
Bmin95	2.40E+02
Bmax95	1.72E+02

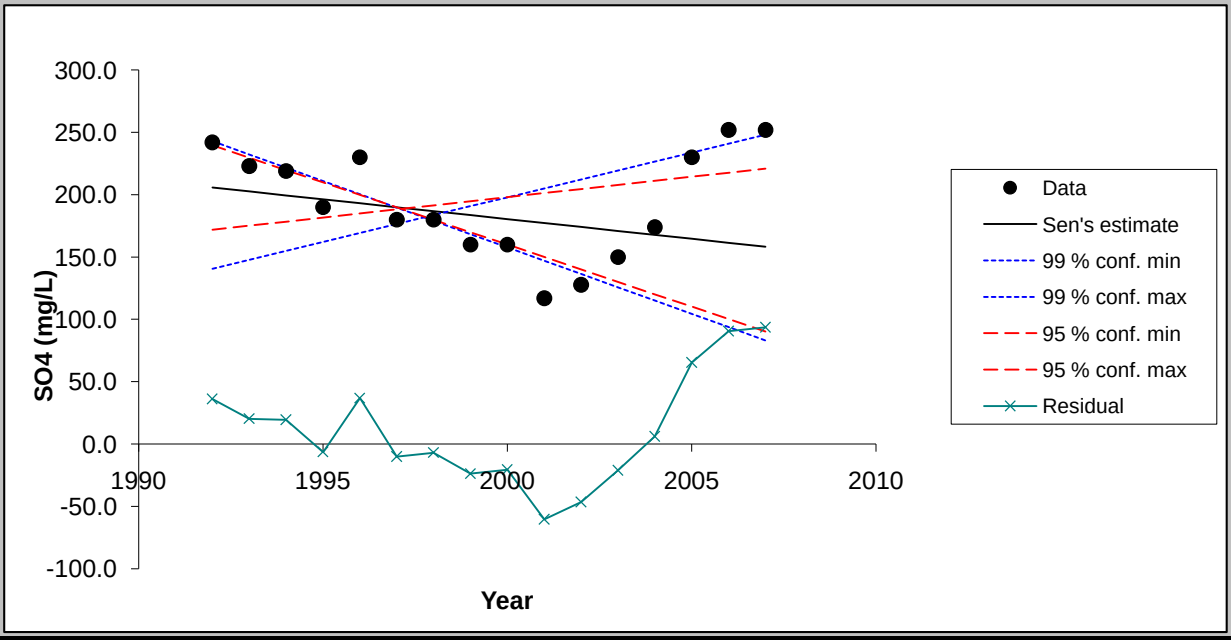

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	242.00	205.75	242.98	140.56	239.62	171.90	36.25
1993	223.00	202.58	232.32	147.73	229.68	175.18	20.42
1994	219.00	199.42	221.66	154.90	219.73	178.45	19.58
1995	190.00	196.25	211.00	162.07	209.79	181.73	-6.25
1996	230.00	193.08	200.34	169.24	199.84	185.00	36.92
1997	180.00	189.92	189.68	176.41	189.89	188.27	-9.92
1998	180.00	186.75	179.02	183.59	179.95	191.55	-6.75
1999	160.00	183.58	168.36	190.76	170.00	194.82	-23.58
2000	160.00	180.42	157.70	197.93	160.05	198.10	-20.42
2001	117.00	177.25	147.05	205.10	150.11	201.37	-60.25
2002	127.78	174.08	136.39	212.27	140.16	204.65	-46.31
2003	150.00	170.92	125.73	219.44	130.21	207.92	-20.92
2004	174.00	167.75	115.07	226.61	120.27	211.20	6.25
2005	230.00	164.58	104.41	233.78	110.32	214.47	65.42
2006	252.00	161.42	93.75	240.95	100.38	217.75	90.58
2007	252.00	158.25	83.09	248.12	90.43	221.02	93.75

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-56 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	16	16	16	16	16	16	16	16	
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0034	0.2	0.0246	5.28	0.005	87.4	0.088	188
1993	0.0029	0.23	0.0459	4.59	0.0006	77.8	0.0664	173
1994	0.0023	0.28	0.0319	5.24	0.0013	80.3	0.0747	169
1995	0.0001	0.33	0.039	5.5	0.0005	84	0.074	140
1996	0.0001	0.31	0.027	6.7	0.0005	78	0.088	180
1997	0.0001	0.32	0.028	6	0.0005	98	0.077	180
1998	0.0001	0.3	0.023	6.2	0.0005	78	0.075	220
1999	0.0001	0.36	0.027	6.6	0.0005	55	0.074	170
2000	0.0001	0.32	0.058	5.6	0.001	73	0.072	170
2001	0.001	0.5	0.03	5.23	0.0025	61	0.06	148
2002	0.001	0.63	0.03	5.15	0.0025	62.1	0.0731	147
2003	0.001	0.27	0.0176	6.06	0.005	55	0.101	134
2004	0.001	0.24	0.0198	6.47	0.0015	53.4	0.102	134
2005	0.001	0.19	0.0196	6.82	0.0045	58.2	0.091	134
2006	0.001	0.12	0.0198	6.27	0.0015	53.6	0.081	128
2007	0.001	0.39	0.0208	5.77	0.0007	52.9	0.091	128

TREND STATISTICS

TW-56 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		-0.43		0.0000	-0.0002	0.0001	-0.0001	0.0001	0.0010	0.0026	-0.0003	0.0023	-0.0002
F (mg/L)	*1992*	*2007*	*16*		0.36		0.004	-0.016	0.026	-0.010	0.017	0.28	0.40	0.18	0.36	0.21
Mn (mg/L)	*1992*	*2007*	*16*		-2.08	*	-0.001	-0.002	0.000	-0.002	0.000	0.03	0.05	0.02	0.04	0.03
Nitrate (mg/L)	*1992*	*2007*	*16*		1.49		0.070	-0.046	0.205	-0.022	0.146	5.29	6.35	4.27	6.11	4.82
Se (mg/L)	*1992*	*2007*	*16*		1.15		0.000	-0.0002	0.0003	0.0000	0.0002	0.0010	0.0026	-0.0008	0.0012	-0.0002
Cl (mg/L)	*1992*	*2007*	*16*		-3.65	***	-2.38	-3.58	-1.15	-3.07	-1.58	87.18	95.55	76.30	91.54	79.03
Mo (mg/L)	*1992*	*2007*	*16*		1.08		0.001	-0.002	0.003	-0.001	0.002	0.07	0.09	0.06	0.08	0.07
SO4 (mg/L)	*1992*	*2007*	*16*		-3.49	***	-3.89	-6.54	-1.05	-5.77	-2.35	185.30	212.45	164.34	203.96	172.09
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-56 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.43
Signific.	
Q	0.00E+00
Qmin99	-1.65E-04
Qmax99	1.03E-04
Qmin95	-1.27E-04
Qmax95	8.78E-05
B	1.00E-03
Bmin99	2.64E-03
Bmax99	-2.74E-04
Bmin95	2.33E-03
Bmax95	-1.52E-04

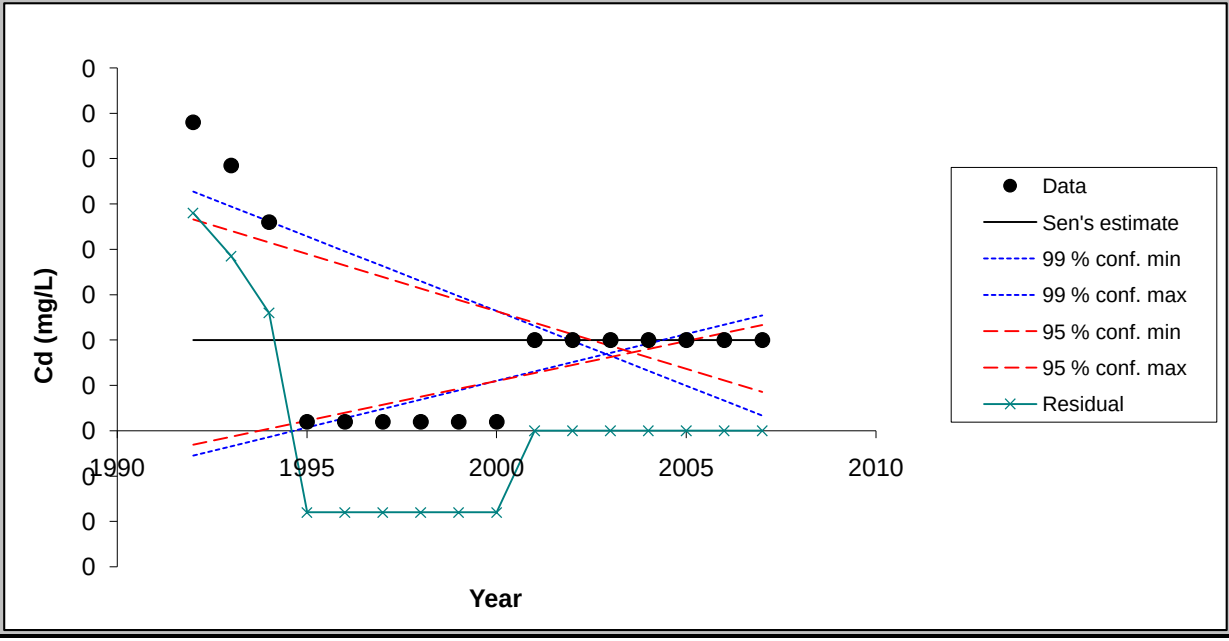

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.36
Signific.	
Q	3.62E-03
Qmin99	-1.65E-02
Qmax99	2.64E-02
Qmin95	-1.00E-02
Qmax95	1.74E-02
B	2.85E-01
Bmin99	4.03E-01
Bmax99	1.81E-01
Bmin95	3.60E-01
Bmax95	2.09E-01

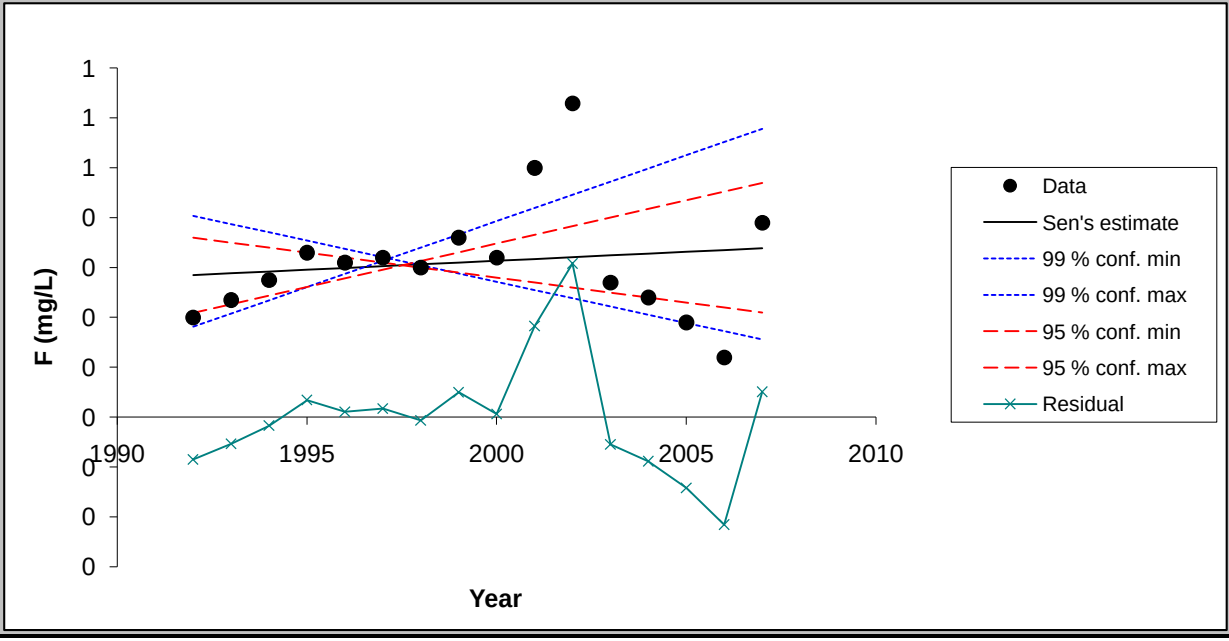

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.20	0.28	0.40	0.18	0.36	0.21	-0.08
1993	0.23	0.29	0.39	0.21	0.35	0.23	-0.05
1994	0.28	0.29	0.37	0.23	0.34	0.24	-0.02
1995	0.33	0.30	0.35	0.26	0.33	0.26	0.03
1996	0.31	0.30	0.34	0.29	0.32	0.28	0.01
1997	0.32	0.30	0.32	0.31	0.31	0.30	0.02
1998	0.30	0.31	0.30	0.34	0.30	0.31	-0.01
1999	0.36	0.31	0.29	0.37	0.29	0.33	0.05
2000	0.32	0.31	0.27	0.39	0.28	0.35	0.01
2001	0.50	0.32	0.25	0.42	0.27	0.37	0.18
2002	0.63	0.32	0.24	0.45	0.26	0.38	0.31
2003	0.27	0.32	0.22	0.47	0.25	0.40	-0.05
2004	0.24	0.33	0.21	0.50	0.24	0.42	-0.09
2005	0.19	0.33	0.19	0.53	0.23	0.43	-0.14
2006	0.12	0.34	0.17	0.55	0.22	0.45	-0.22
2007	0.39	0.34	0.16	0.58	0.21	0.47	0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-2.08
Signific.	*
Q	-9.46E-04
Qmin99	-2.21E-03
Qmax99	4.52E-04
Qmin95	-1.91E-03
Qmax95	-5.99E-05
B	3.33E-02
Bmin99	4.60E-02
Bmax99	2.49E-02
Bmin95	4.36E-02
Bmax95	2.73E-02

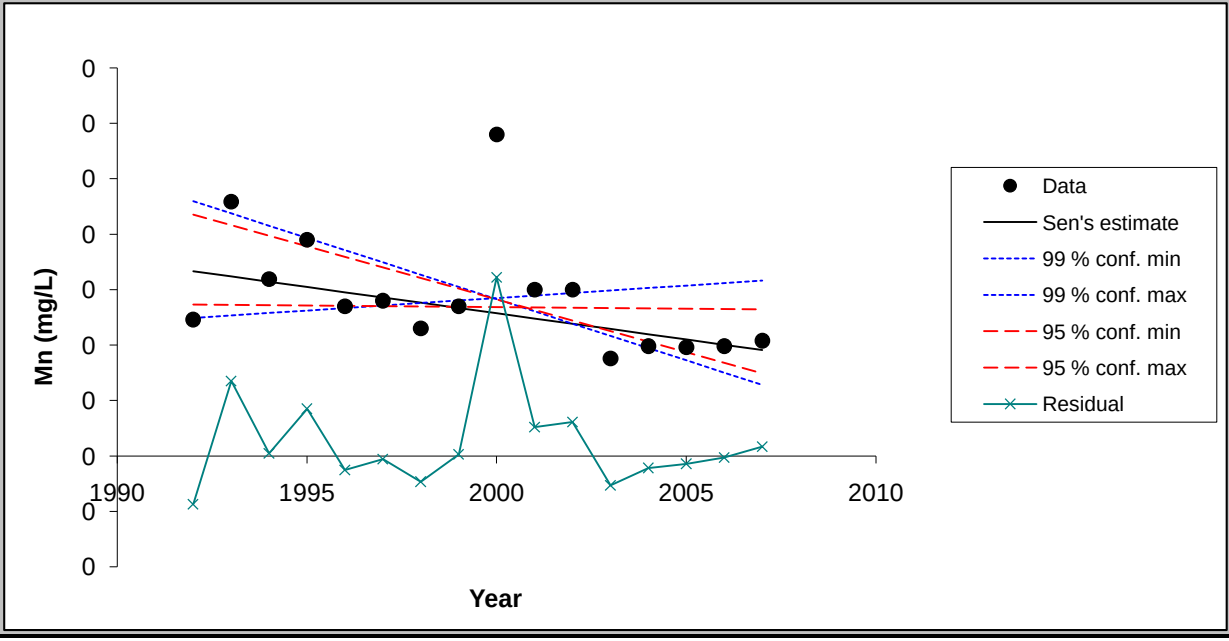

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.02	0.03	0.05	0.02	0.04	0.03	-0.01
1993	0.05	0.03	0.04	0.03	0.04	0.03	0.01
1994	0.03	0.03	0.04	0.03	0.04	0.03	0.00
1995	0.04	0.03	0.04	0.03	0.04	0.03	0.01
1996	0.03	0.03	0.04	0.03	0.04	0.03	0.00
1997	0.03	0.03	0.03	0.03	0.03	0.03	0.00
1998	0.02	0.03	0.03	0.03	0.03	0.03	0.00
1999	0.03	0.03	0.03	0.03	0.03	0.03	0.00
2000	0.06	0.03	0.03	0.03	0.03	0.03	0.03
2001	0.03	0.02	0.03	0.03	0.03	0.03	0.01
2002	0.03	0.02	0.02	0.03	0.02	0.03	0.01
2003	0.02	0.02	0.02	0.03	0.02	0.03	-0.01
2004	0.02	0.02	0.02	0.03	0.02	0.03	0.00
2005	0.02	0.02	0.02	0.03	0.02	0.03	0.00
2006	0.02	0.02	0.02	0.03	0.02	0.03	0.00
2007	0.02	0.02	0.01	0.03	0.01	0.03	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.49
Signific.	
Q	7.00E-02
Qmin99	-4.63E-02
Qmax99	2.05E-01
Qmin95	-2.23E-02
Qmax95	1.46E-01
B	5.29E+00
Bmin99	6.35E+00
Bmax99	4.27E+00
Bmin95	6.11E+00
Bmax95	4.82E+00

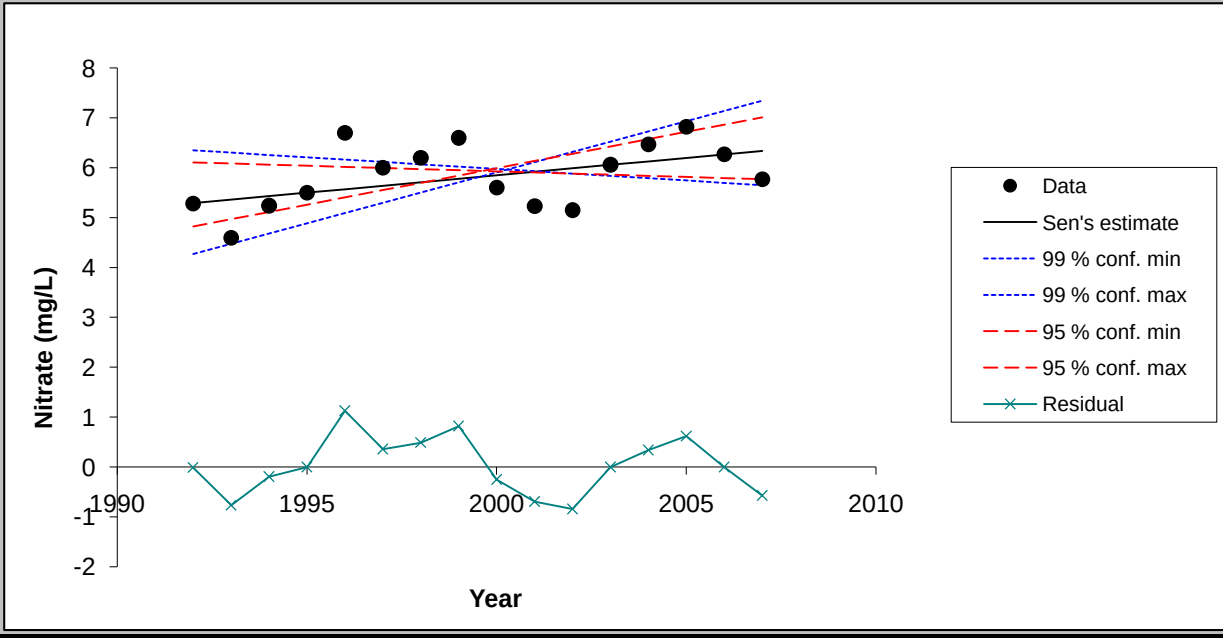

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	5.28	5.29	6.35	4.27	6.11	4.82	-0.01
1993	4.59	5.36	6.30	4.48	6.09	4.97	-0.77
1994	5.24	5.43	6.26	4.68	6.06	5.11	-0.19
1995	5.50	5.50	6.21	4.89	6.04	5.26	0.00
1996	6.70	5.57	6.16	5.09	6.02	5.40	1.13
1997	6.00	5.64	6.12	5.30	6.00	5.55	0.36
1998	6.20	5.71	6.07	5.50	5.97	5.70	0.49
1999	6.60	5.78	6.02	5.71	5.95	5.84	0.82
2000	5.60	5.85	5.98	5.91	5.93	5.99	-0.25
2001	5.23	5.92	5.93	6.12	5.91	6.13	-0.69
2002	5.15	5.99	5.89	6.32	5.89	6.28	-0.84
2003	6.06	6.06	5.84	6.53	5.86	6.43	0.00
2004	6.47	6.13	5.79	6.73	5.84	6.57	0.34
2005	6.82	6.20	5.75	6.94	5.82	6.72	0.62
2006	6.27	6.27	5.70	7.14	5.80	6.86	0.00
2007	5.77	6.34	5.65	7.35	5.77	7.01	-0.57

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.15
Signific.	
Q	2.36E-05
Qmin99	-1.52E-04
Qmax99	3.33E-04
Qmin95	-1.40E-05
Qmax95	2.06E-04
B	9.90E-04
Bmin99	2.60E-03
Bmax99	-8.33E-04
Bmin95	1.19E-03
Bmax95	-2.20E-04

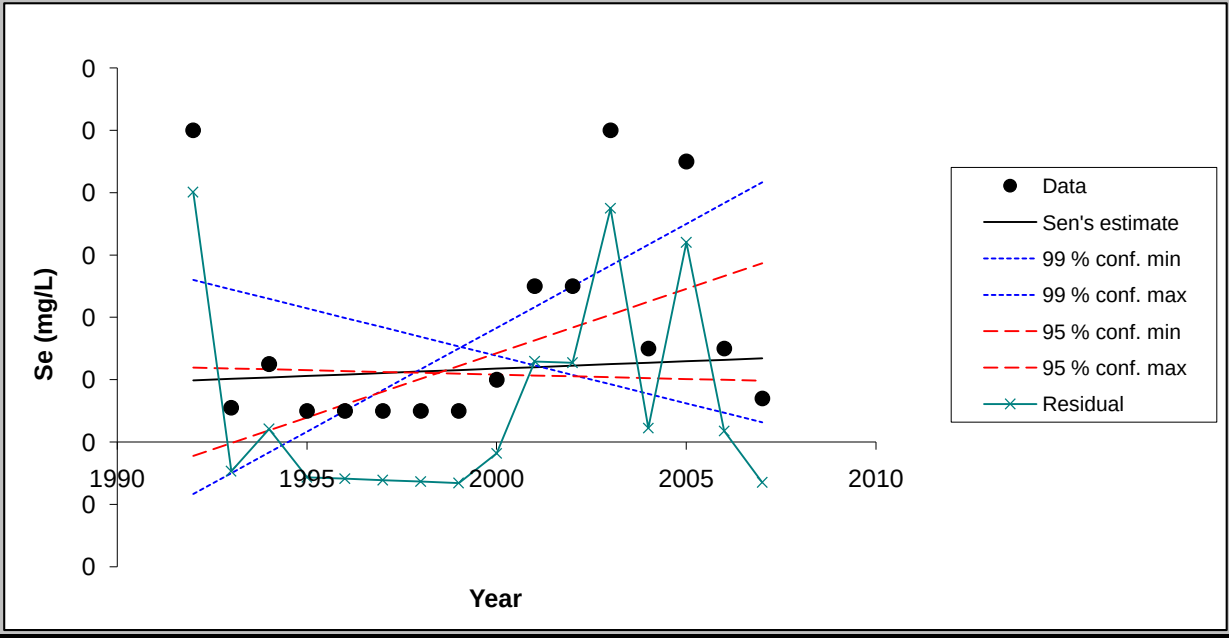

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.65
Signific.	***
Q	-2.38E+00
Qmin99	-3.58E+00
Qmax99	-1.15E+00
Qmin95	-3.07E+00
Qmax95	-1.58E+00
B	8.72E+01
Bmin99	9.55E+01
Bmax99	7.63E+01
Bmin95	9.15E+01
Bmax95	7.90E+01

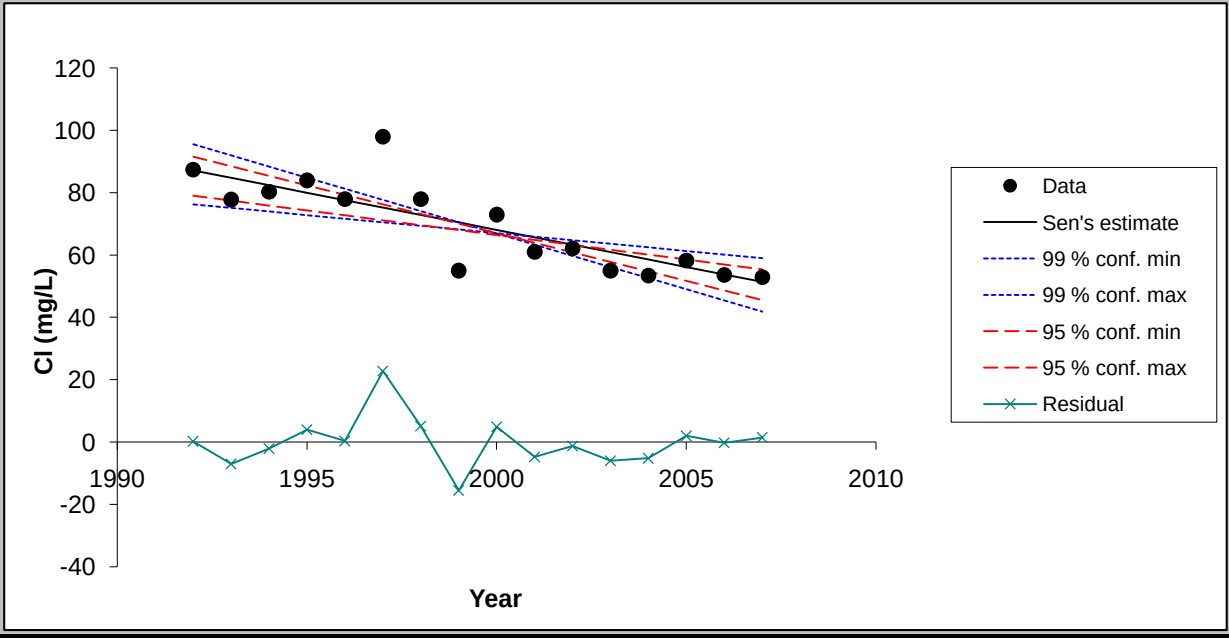

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	87.40	87.18	95.55	76.30	91.54	79.03	0.22
1993	77.80	84.79	91.97	75.15	88.47	77.46	-6.99
1994	80.35	82.41	88.39	73.99	85.40	75.88	-2.06
1995	84.00	80.03	84.81	72.84	82.33	74.30	3.97
1996	78.00	77.65	81.23	71.69	79.27	72.73	0.35
1997	98.00	75.26	77.65	70.54	76.20	71.15	22.74
1998	78.00	72.88	74.07	69.38	73.13	69.58	5.12
1999	55.00	70.50	70.49	68.23	70.06	68.00	-15.50
2000	73.00	68.12	66.91	67.08	66.99	66.42	4.88
2001	61.00	65.74	63.33	65.93	63.92	64.85	-4.74
2002	62.12	63.35	59.75	64.78	60.86	63.27	-1.23
2003	55.00	60.97	56.17	63.62	57.79	61.70	-5.97
2004	53.40	58.59	52.59	62.47	54.72	60.12	-5.19
2005	58.20	56.21	49.01	61.32	51.65	58.54	1.99
2006	53.60	53.82	45.43	60.17	48.58	56.97	-0.22
2007	52.90	51.44	41.85	59.02	45.52	55.39	1.46

FIGURE

< Previous Time Series | Next Time Series >

TW-56 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.08
Signific.	
Q	7.47E-04
Qmin99	-1.50E-03
Qmax99	2.79E-03
Qmin95	-6.05E-04
Qmax95	1.94E-03
B	7.25E-02
Bmin99	8.63E-02
Bmax99	6.07E-02
Bmin95	7.96E-02
Bmax95	6.51E-02

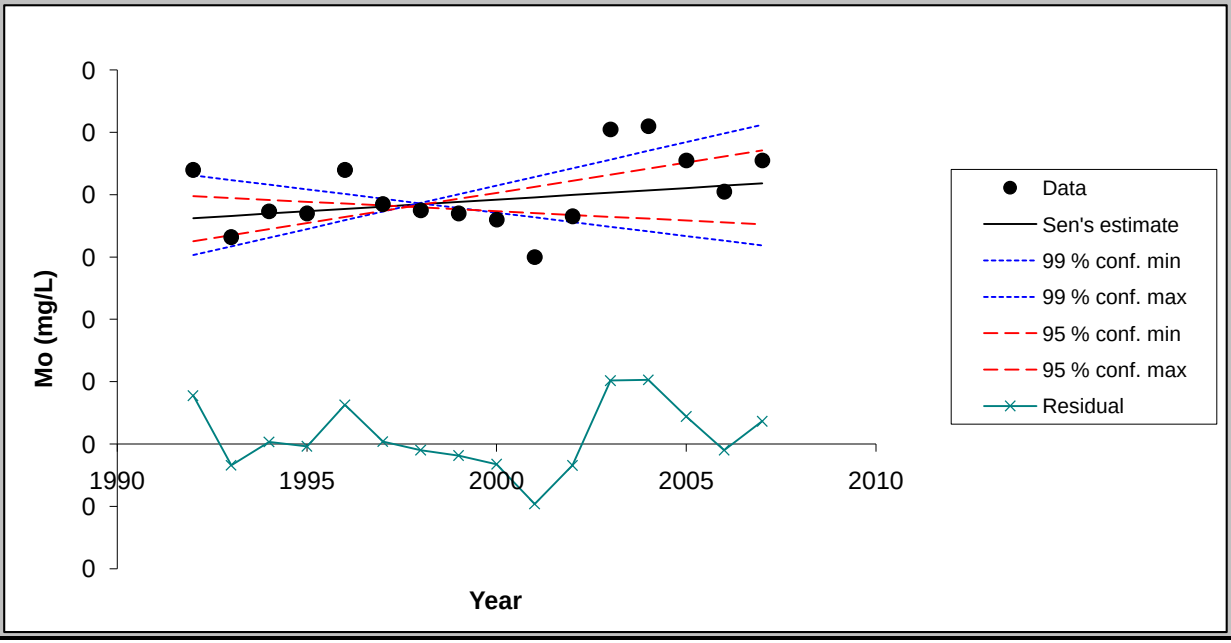

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.09	0.07	0.09	0.06	0.08	0.07	0.02
1993	0.07	0.07	0.08	0.06	0.08	0.07	-0.01
1994	0.07	0.07	0.08	0.07	0.08	0.07	0.00
1995	0.07	0.07	0.08	0.07	0.08	0.07	0.00
1996	0.09	0.08	0.08	0.07	0.08	0.07	0.01
1997	0.08	0.08	0.08	0.07	0.08	0.07	0.00
1998	0.08	0.08	0.08	0.08	0.08	0.08	0.00
1999	0.07	0.08	0.08	0.08	0.08	0.08	0.00
2000	0.07	0.08	0.07	0.08	0.07	0.08	-0.01
2001	0.06	0.08	0.07	0.09	0.07	0.08	-0.02
2002	0.07	0.08	0.07	0.09	0.07	0.08	-0.01
2003	0.10	0.08	0.07	0.09	0.07	0.09	0.02
2004	0.10	0.08	0.07	0.09	0.07	0.09	0.02
2005	0.09	0.08	0.07	0.10	0.07	0.09	0.01
2006	0.08	0.08	0.07	0.10	0.07	0.09	0.00
2007	0.09	0.08	0.06	0.10	0.07	0.09	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-56 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.49
Signific.	***
Q	-3.89E+00
Qmin99	-6.54E+00
Qmax99	-1.05E+00
Qmin95	-5.77E+00
Qmax95	-2.35E+00
B	1.85E+02
Bmin99	2.12E+02
Bmax99	1.64E+02
Bmin95	2.04E+02
Bmax95	1.72E+02

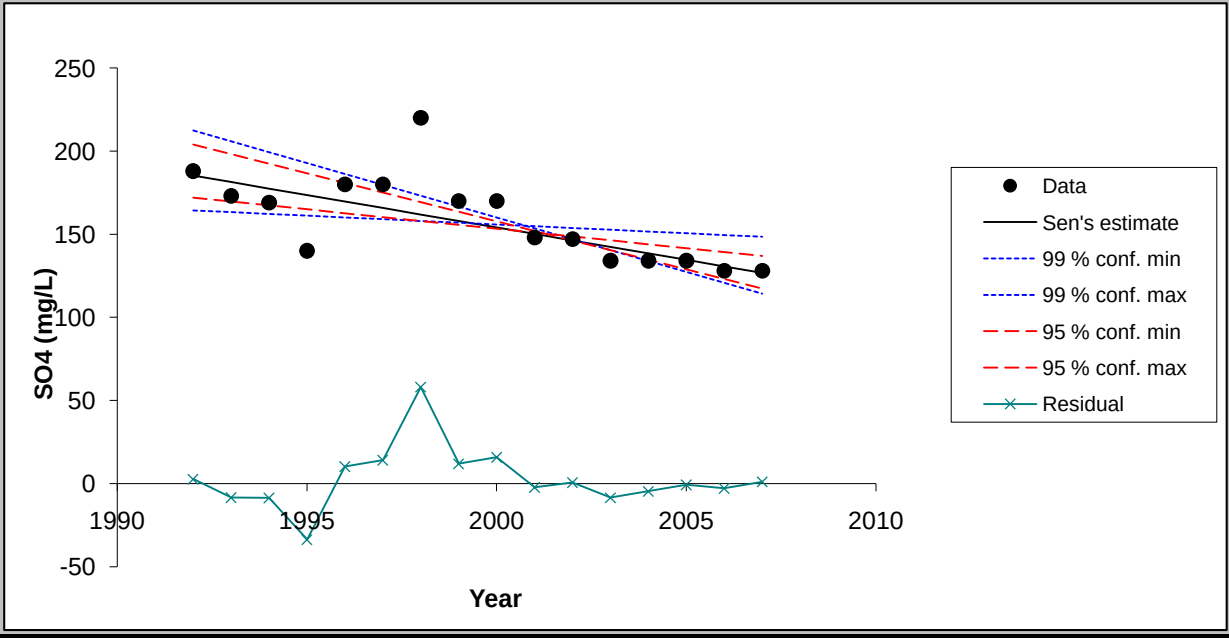

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	188.00	185.30	212.45	164.34	203.96	172.09	2.70
1993	173.00	181.41	205.91	163.28	198.19	169.74	-8.41
1994	169.00	177.51	199.37	162.23	192.42	167.40	-8.51
1995	140.00	173.62	192.83	161.18	186.65	165.05	-33.62
1996	180.00	169.73	186.29	160.12	180.89	162.71	10.27
1997	180.00	165.83	179.75	159.07	175.12	160.36	14.17
1998	220.00	161.94	173.21	158.02	169.35	158.02	58.06
1999	170.00	158.04	166.68	156.96	163.59	155.67	11.96
2000	170.00	154.15	160.14	155.91	157.82	153.33	15.85
2001	148.00	150.25	153.60	154.86	152.05	150.98	-2.25
2002	147.03	146.36	147.06	153.80	146.28	148.64	0.68
2003	134.00	142.46	140.52	152.75	140.52	146.29	-8.46
2004	134.00	138.57	133.98	151.70	134.75	143.95	-4.57
2005	134.00	134.68	127.44	150.64	128.98	141.60	-0.68
2006	128.00	130.78	120.90	149.59	123.22	139.26	-2.78
2007	128.00	126.89	114.36	148.54	117.45	136.91	1.11

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Calf Spring (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	13	13	13	13	13	13	12	13
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.006	3	0.0075	2.56	0.002	87		126
1992	0.0054	2.72	0.0038	2.64	0.183	114	0.0511	180
1993	0.0029	3.34	0.0126	6.67	0.288	134	0.0697	317.5
1994	0.0055	4.26	0.0032	5.96	0.279	148	0.0873	351
1995	0.005	4.4	0.0005	7.5	0.32	130	0.083	350
1996	0.0048	5.4	0.0005	8.1	0.25	130	0.085	480
1997	0.0052	4.9	0.0005	9.4	0.22	110	0.086	490
1998	0.005	4.7	0.0005	7.8	0.21	110	0.081	510
1999	0.0033	4.2	0.0005	6.3	0.14	71	0.077	410
2000	0.0031	3.8	0.0005	6	0.16	88	0.08	400
2001	0.006	3.8	0.005	6.51	0.188	100	0.06	508
2002								
2003								
2004								
2005	0.0115	2.51	0.0303	6.56	0.385	121	0.0492	487
2006								
2007	0.0095	3.09	14.7	8.8	0.137	128	0.0691	553

TREND STATISTICS

Calf Spring (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*13*		0.43		0.000	0.000	0.001	0.000	0.000	0.00	0.01	0.00	0.01	0.00
F (mg/L)	*1991*	*2007*	*13*		-0.24		-0.017	-0.275	0.274	-0.189	0.169	3.97	6.37	2.78	5.50	3.00
Mn (mg/L)	*1991*	*2007*	*13*		0.13		0.000	-0.001	0.004	-0.001	0.002	0.00	0.01	-0.02	0.01	-0.01
Nitrate (mg/L)	*1991*	*2007*	*13*		1.65	+	0.185	-0.166	0.761	-0.060	0.479	5.40	8.16	2.47	7.11	2.56
Se (mg/L)	*1991*	*2007*	*13*		-0.55		-0.007	-0.020	0.024	-0.016	0.017	0.26	0.34	0.05	0.32	0.12
Cl (mg/L)	*1991*	*2007*	*13*		-0.67		-0.850	-7.368	4.686	-6.000	2.565	115.95	159.47	81.88	152.00	92.05
Mo (mg/L)	*1992*	*2007*	*12*		-1.30		-0.001	-0.004	0.003	-0.003	0.001	0.09	0.10	0.06	0.10	0.07
SO4 (mg/L)	*1991*	*2007*	*13*		3.23	**	22.143	6.599	54.019	11.673	39.963	261.43	357.21	126.00	316.62	140.04
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	0.43
Signific.	
Q	6.18E-05
Qmin99	-3.23E-04
Qmax99	5.42E-04
Qmin95	-2.00E-04
Qmax95	4.27E-04
B	4.83E-03
Bmin99	6.41E-03
Bmax99	1.95E-03
Bmin95	6.00E-03
Bmax95	2.66E-03

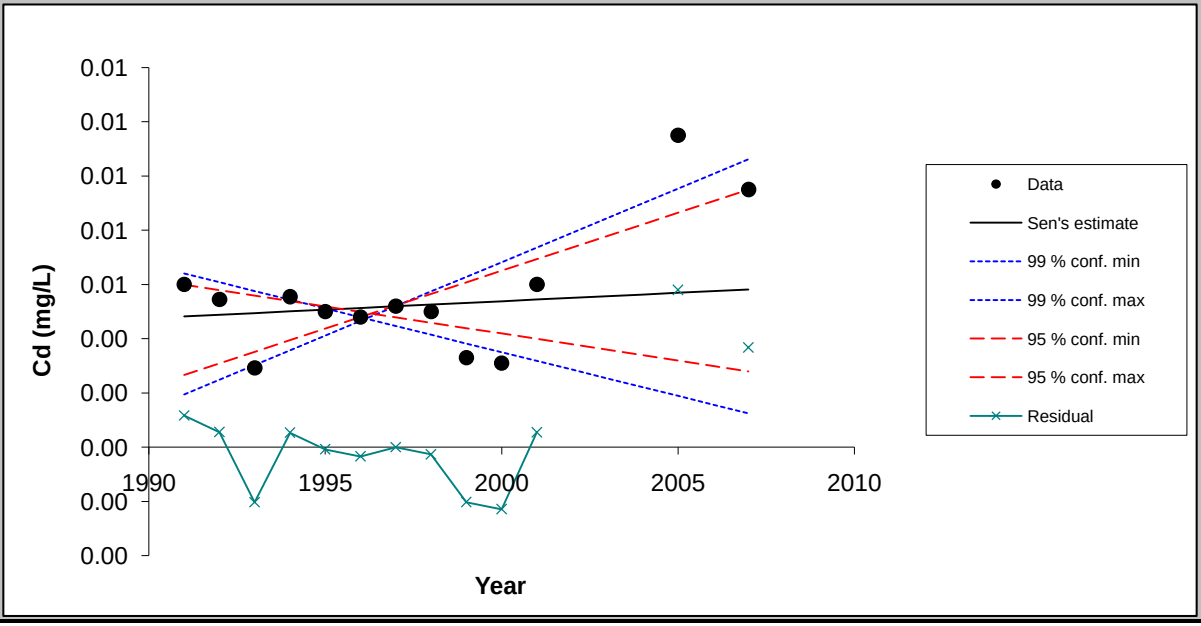

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.01	0.00	0.00
1993	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1994	0.01	0.01	0.01	0.00	0.01	0.00	0.00
1995	0.00	0.01	0.01	0.00	0.01	0.00	0.00
1996	0.00	0.01	0.00	0.00	0.00	0.00	0.00
1997	0.01	0.01	0.00	0.01	0.00	0.01	0.00
1998	0.00	0.01	0.00	0.01	0.00	0.01	0.00
1999	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2000	0.00	0.01	0.00	0.01	0.00	0.01	0.00
2001	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2002		0.01	0.00	0.01	0.00	0.01	
2003		0.01	0.00	0.01	0.00	0.01	
2004		0.01	0.00	0.01	0.00	0.01	
2005	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2006		0.01	0.00	0.01	0.00	0.01	
2007	0.01	0.01	0.00	0.01	0.00	0.01	0.00

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	-0.24
Signific.	
Q	-1.68E-02
Qmin99	-2.75E-01
Qmax99	2.74E-01
Qmin95	-1.89E-01
Qmax95	1.69E-01
B	3.97E+00
Bmin99	6.37E+00
Bmax99	2.78E+00
Bmin95	5.50E+00
Bmax95	3.00E+00

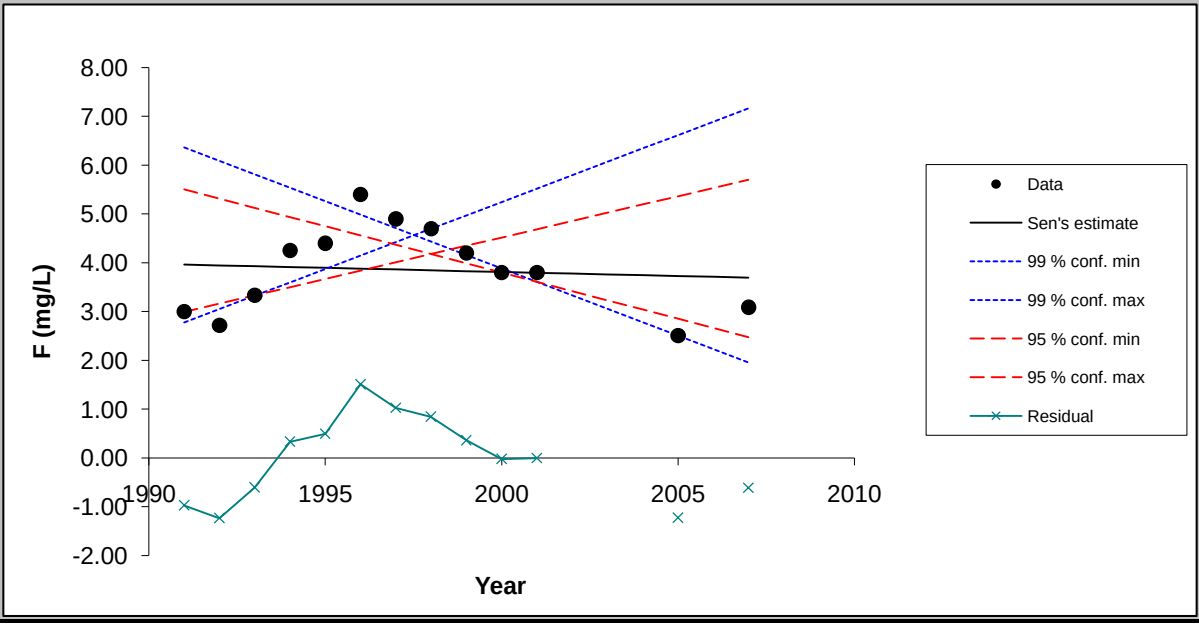

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	3.00	3.97	6.37	2.78	5.50	3.00	-0.97
1992	2.72	3.95	6.09	3.05	5.31	3.17	-1.23
1993	3.34	3.93	5.81	3.33	5.13	3.34	-0.60
1994	4.26	3.92	5.54	3.60	4.94	3.50	0.34
1995	4.40	3.90	5.26	3.88	4.75	3.67	0.50
1996	5.40	3.88	4.99	4.15	4.56	3.84	1.52
1997	4.90	3.87	4.71	4.43	4.37	4.01	1.03
1998	4.70	3.85	4.44	4.70	4.18	4.18	0.85
1999	4.20	3.83	4.16	4.97	3.99	4.35	0.37
2000	3.80	3.82	3.89	5.25	3.80	4.52	-0.02
2001	3.80	3.80	3.61	5.52	3.61	4.69	0.00
2002		3.78	3.34	5.80	3.42	4.86	
2003		3.77	3.06	6.07	3.23	5.02	
2004		3.75	2.79	6.35	3.04	5.19	
2005	2.51	3.73	2.51	6.62	2.85	5.36	-1.22
2006		3.72	2.23	6.89	2.66	5.53	
2007	3.09	3.70	1.96	7.17	2.47	5.70	-0.61

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	0.13
Signific.	
Q	0.00E+00
Qmin99	-8.74E-04
Qmax99	3.71E-03
Qmin95	-5.80E-04
Qmax95	2.29E-03
B	3.25E-03
Bmin99	7.49E-03
Bmax99	-1.81E-02
Bmin95	5.14E-03
Bmax95	-8.66E-03

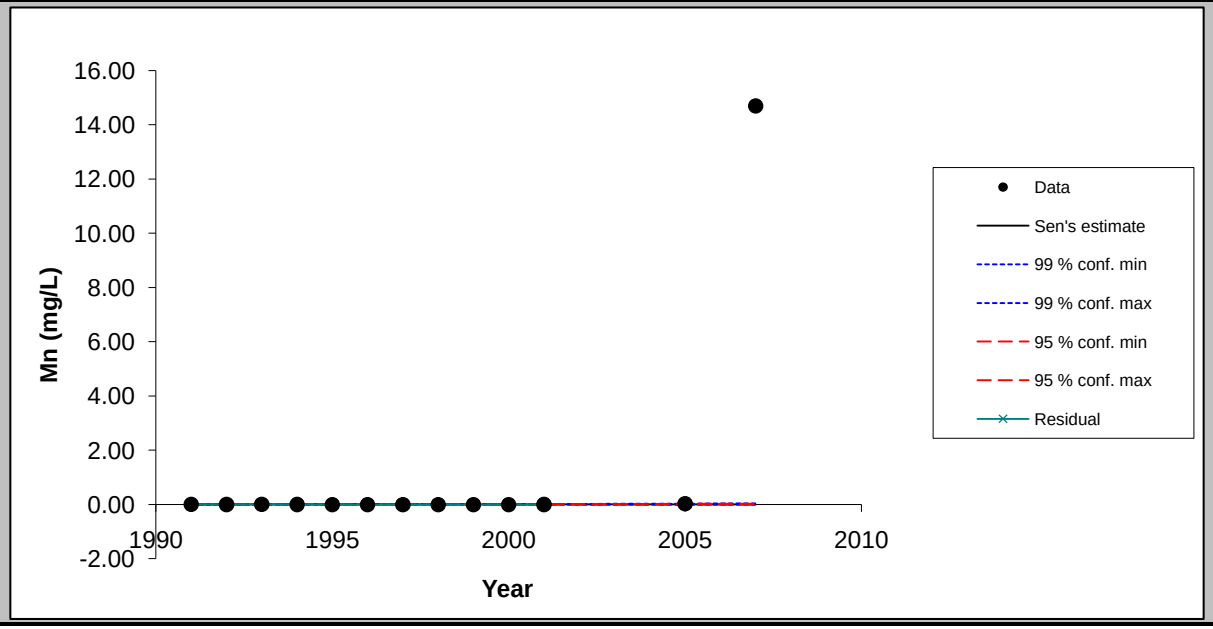

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.01	0.00	0.01	-0.02	0.01	-0.01	0.00
1992	0.00	0.00	0.01	-0.01	0.00	-0.01	0.00
1993	0.01	0.00	0.01	-0.01	0.00	0.00	0.01
1994	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.01	0.00
1998	0.00	0.00	0.00	0.01	0.00	0.01	0.00
1999	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2000	0.00	0.00	0.00	0.02	0.00	0.01	0.00
2001	0.00	0.00	0.00	0.02	0.00	0.01	0.00
2002		0.00	0.00	0.02	0.00	0.02	
2003		0.00	0.00	0.03	0.00	0.02	
2004		0.00	0.00	0.03	0.00	0.02	
2005	0.03	0.00	0.00	0.03	0.00	0.02	0.03
2006		0.00	-0.01	0.04	0.00	0.03	
2007	14.70	0.00	-0.01	0.04	0.00	0.03	14.70

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	1.65
Signific.	+
Q	1.85E-01
Qmin99	-1.66E-01
Qmax99	7.61E-01
Qmin95	-6.01E-02
Qmax95	4.79E-01
B	5.40E+00
Bmin99	8.16E+00
Bmax99	2.47E+00
Bmin95	7.11E+00
Bmax95	2.56E+00

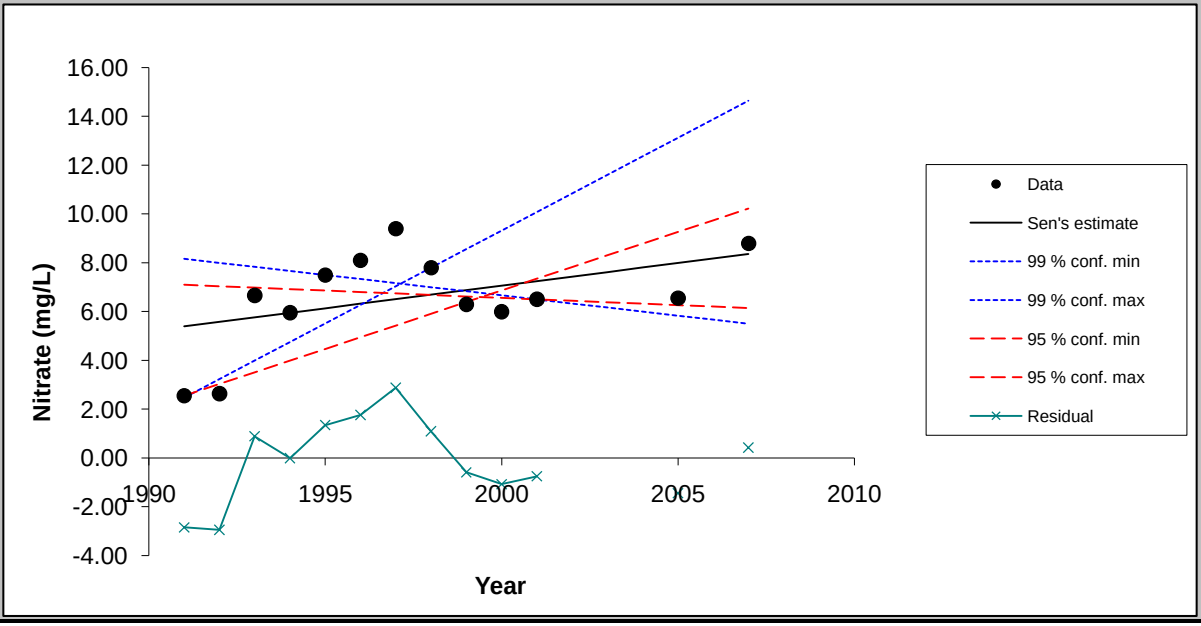

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	2.56	5.40	8.16	2.47	7.11	2.56	-2.84
1992	2.64	5.59	8.00	3.23	7.05	3.04	-2.94
1993	6.67	5.77	7.83	4.00	6.99	3.52	0.90
1994	5.96	5.96	7.67	4.76	6.93	4.00	0.00
1995	7.50	6.15	7.50	5.52	6.87	4.48	1.35
1996	8.10	6.33	7.33	6.28	6.81	4.95	1.77
1997	9.40	6.52	7.17	7.04	6.75	5.43	2.88
1998	7.80	6.70	7.00	7.80	6.69	5.91	1.10
1999	6.30	6.89	6.84	8.56	6.63	6.39	-0.59
2000	6.00	7.07	6.67	9.32	6.57	6.87	-1.07
2001	6.51	7.26	6.51	10.08	6.51	7.35	-0.75
2002		7.44	6.34	10.84	6.45	7.83	
2003		7.63	6.17	11.60	6.39	8.31	
2004		7.81	6.01	12.37	6.33	8.78	
2005	6.56	8.00	5.84	13.13	6.27	9.26	-1.44
2006		8.18	5.68	13.89	6.21	9.74	
2007	8.80	8.37	5.51	14.65	6.15	10.22	0.43

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	-0.55
Signific.	
Q	-6.74E-03
Qmin99	-1.99E-02
Qmax99	2.41E-02
Qmin95	-1.56E-02
Qmax95	1.73E-02
B	2.57E-01
Bmin99	3.39E-01
Bmax99	4.74E-02
Bmin95	3.19E-01
Bmax95	1.16E-01

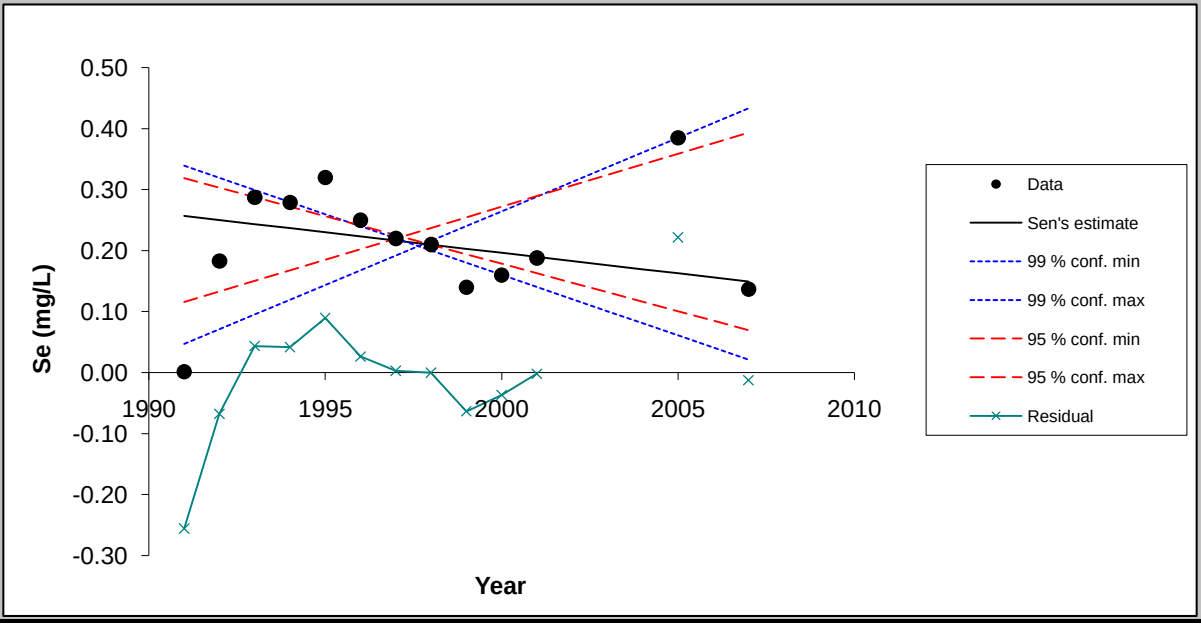

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.26	0.34	0.05	0.32	0.12	-0.26
1992	0.18	0.25	0.32	0.07	0.30	0.13	-0.07
1993	0.29	0.24	0.30	0.10	0.29	0.15	0.04
1994	0.28	0.24	0.28	0.12	0.27	0.17	0.04
1995	0.32	0.23	0.26	0.14	0.26	0.19	0.09
1996	0.25	0.22	0.24	0.17	0.24	0.20	0.03
1997	0.22	0.22	0.22	0.19	0.23	0.22	0.00
1998	0.21	0.21	0.20	0.22	0.21	0.24	0.00
1999	0.14	0.20	0.18	0.24	0.19	0.25	-0.06
2000	0.16	0.20	0.16	0.26	0.18	0.27	-0.04
2001	0.19	0.19	0.14	0.29	0.16	0.29	0.00
2002		0.18	0.12	0.31	0.15	0.31	
2003		0.18	0.10	0.34	0.13	0.32	
2004		0.17	0.08	0.36	0.12	0.34	
2005	0.39	0.16	0.06	0.39	0.10	0.36	0.22
2006		0.16	0.04	0.41	0.09	0.38	
2007	0.14	0.15	0.02	0.43	0.07	0.39	-0.01

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	-0.67
Signific.	
Q	-8.50E-01
Qmin99	-7.37E+00
Qmax99	4.69E+00
Qmin95	-6.00E+00
Qmax95	2.56E+00
B	1.16E+02
Bmin99	1.59E+02
Bmax99	8.19E+01
Bmin95	1.52E+02
Bmax95	9.20E+01

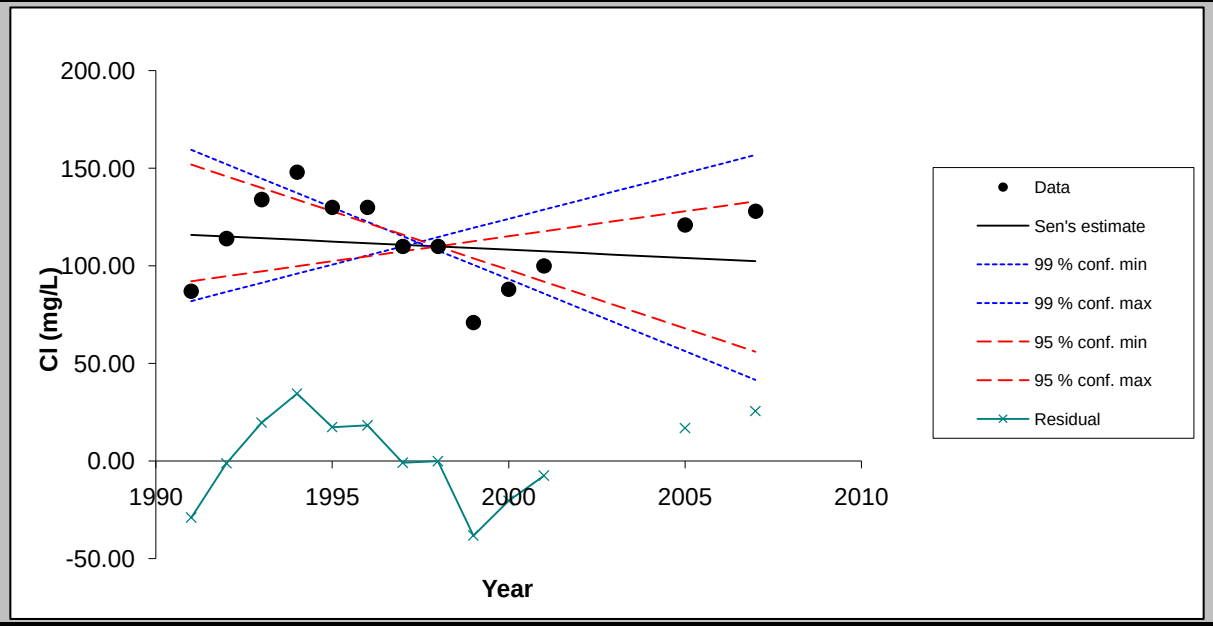

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	87.00	115.95	159.47	81.88	152.00	92.05	-28.95
1992	114.00	115.10	152.11	86.57	146.00	94.61	-1.10
1993	134.00	114.25	144.74	91.26	140.00	97.18	19.75
1994	148.00	113.40	137.37	95.94	134.00	99.74	34.60
1995	130.00	112.55	130.00	100.63	128.00	102.31	17.45
1996	130.00	111.70	122.63	105.31	122.00	104.87	18.30
1997	110.00	110.85	115.26	110.00	116.00	107.44	-0.85
1998	110.00	110.00	107.89	114.69	110.00	110.00	0.00
1999	71.00	109.15	100.53	119.37	104.00	112.56	-38.15
2000	88.00	108.30	93.16	124.06	98.00	115.13	-20.30
2001	100.00	107.45	85.79	128.74	92.00	117.69	-7.45
2002		106.60	78.42	133.43	86.00	120.26	
2003		105.75	71.05	138.12	80.00	122.82	
2004		104.90	63.68	142.80	74.00	125.39	
2005	121.00	104.05	56.32	147.49	68.00	127.95	16.95
2006		103.20	48.95	152.17	62.00	130.52	
2007	128.00	102.35	41.58	156.86	56.00	133.08	25.65

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	12
Test S	
Test Z	-1.30
Signific.	
Q	-1.21E-03
Qmin99	-3.96E-03
Qmax99	2.84E-03
Qmin95	-2.90E-03
Qmax95	1.48E-03
B	8.82E-02
Bmin99	1.05E-01
Bmax99	5.78E-02
Bmin95	9.77E-02
Bmax95	6.67E-02

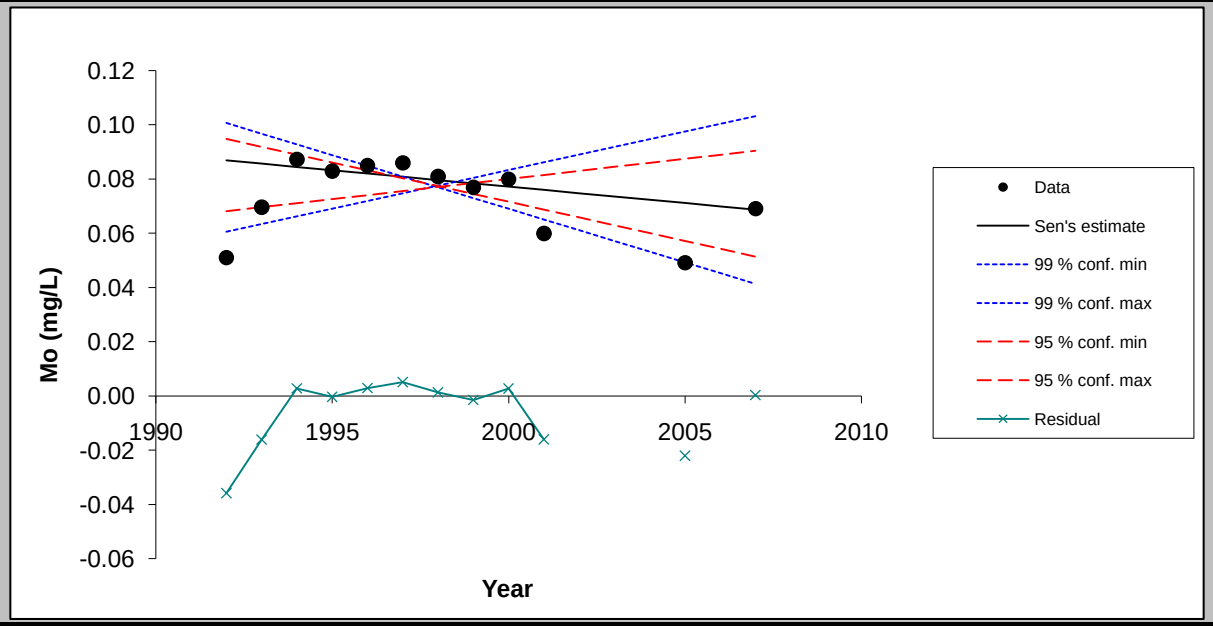

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.05	0.09	0.10	0.06	0.09	0.07	-0.04
1993	0.07	0.09	0.10	0.06	0.09	0.07	-0.02
1994	0.09	0.08	0.09	0.07	0.09	0.07	0.00
1995	0.08	0.08	0.09	0.07	0.09	0.07	0.00
1996	0.09	0.08	0.08	0.07	0.08	0.07	0.00
1997	0.09	0.08	0.08	0.07	0.08	0.08	0.01
1998	0.08	0.08	0.08	0.08	0.08	0.08	0.00
1999	0.08	0.08	0.07	0.08	0.07	0.08	0.00
2000	0.08	0.08	0.07	0.08	0.07	0.08	0.00
2001	0.06	0.08	0.07	0.09	0.07	0.08	-0.02
2002		0.07	0.06	0.09	0.07	0.08	
2003		0.07	0.06	0.09	0.06	0.08	
2004		0.07	0.05	0.09	0.06	0.09	
2005	0.05	0.07	0.05	0.10	0.06	0.09	-0.02
2006		0.07	0.05	0.10	0.05	0.09	
2007	0.07	0.07	0.04	0.10	0.05	0.09	0.00

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	13
Test S	
Test Z	3.23
Signific.	**
Q	2.21E+01
Qmin99	6.60E+00
Qmax99	5.40E+01
Qmin95	1.17E+01
Qmax95	4.00E+01
B	2.61E+02
Bmin99	3.57E+02
Bmax99	1.26E+02
Bmin95	3.17E+02
Bmax95	1.40E+02

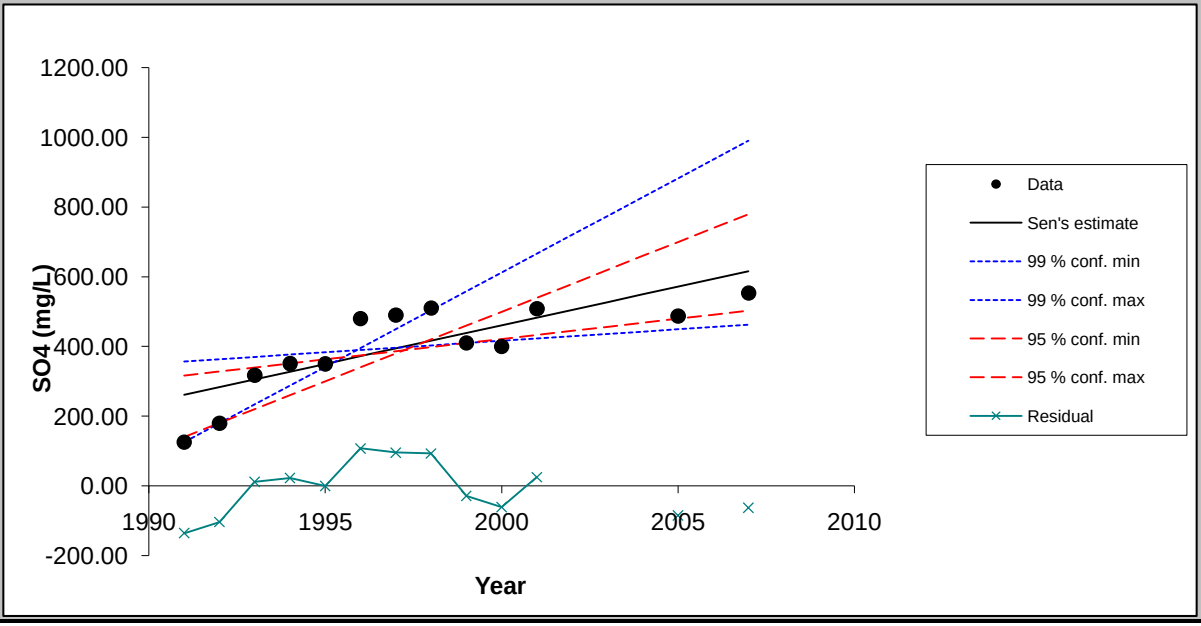

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	126.00	261.43	357.21	126.00	316.62	140.04	-135.43
1992	180.00	283.57	363.81	180.02	328.29	180.00	-103.57
1993	317.50	305.71	370.41	234.04	339.96	219.96	11.79
1994	351.00	327.86	377.01	288.06	351.64	259.93	23.14
1995	350.00	350.00	383.60	342.07	363.31	299.89	0.00
1996	480.00	372.14	390.20	396.09	374.98	339.85	107.86
1997	490.00	394.29	396.80	450.11	386.65	379.82	95.71
1998	510.00	416.43	403.40	504.13	398.33	419.78	93.57
1999	410.00	438.57	410.00	558.15	410.00	459.74	-28.57
2000	400.00	460.71	416.60	612.17	421.67	499.71	-60.71
2001	508.00	482.86	423.20	666.19	433.35	539.67	25.14
2002		505.00	429.80	720.20	445.02	579.63	
2003		527.14	436.40	774.22	456.69	619.60	
2004		549.29	442.99	828.24	468.36	659.56	
2005	487.00	571.43	449.59	882.26	480.04	699.52	-84.43
2006		593.57	456.19	936.28	491.71	739.49	
2007	553.00	615.71	462.79	990.30	503.38	779.45	-62.71

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Homestead Spring (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.4	0.0025	5.5	0.0015	17		54
1992	0.0036	0.34	0.0014	5.45	0.015	20.4	0.0293	59.5
1993	0.0028	0.36	0.0093	5.94	0.0149	18.4	0.0048	65
1994	0.0006	0.41	0.001	7.25	0.0128	18.9	0.0065	66.2
1995	0.0001	0.4	0.0005	6.2	0.014	20	0.0025	66
1996	0.0001	0.48	0.0005	6.9	0.009	20	0.0025	65
1997	0.0001	0.44	0.016	7.2	0.024	25	0.0025	80
1998	0.0001	0.4	0.009	6	0.028	29	0.0025	100
1999	0.0001	0.53	0.007	7.6	0.032	26	0.0025	120
2000	0.0001	0.42	0.025	9.6	0.03	28	0.0025	110
2001	0.001	0.6	0.005	5.87	0.018	23	0.005	81
2002	0.001	0.73	0.03	6.66	0.023	24.8	0.005	86.6
2003	0.001	0.31	0.0046	7.66	0.011	24.7	0.0204	88
2004	0.001	0.25	0.006	7.29	0.023	27	0.0084	98.1
2005	0.001	0.244	0.0247	9.35	0.015	30	0.004	85.5
2006	0.001	0.44	0.0048	15	0.011	27.1	0.004	81.9
2007	0.001	0.61	0.002	14.3	0.0071	27.6	0.0155	87.2

TREND STATISTICS

Homestead Spring (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.30		0.0000	-0.0001	0.0001	-0.0001	0.0001	0.001	0.002	0.000	0.002	0.000
F (mg/L)	*1991*	*2007*	*17*		0.99		0.006	-0.015	0.027	-0.010	0.021	0.38	0.51	0.29	0.47	0.32
Mn (mg/L)	*1991*	*2007*	*17*		0.74		0.0003	-0.0005	0.0022	-0.0004	0.0014	0.002	0.011	-0.006	0.010	-0.003
Nitrate (mg/L)	*1991*	*2007*	*17*		3.34	***	0.284	0.069	0.676	0.121	0.589	5.37	6.56	3.48	6.21	3.85
Se (mg/L)	*1991*	*2007*	*17*		0.00		0.0000	-0.0018	0.0018	-0.0011	0.0013	0.015	0.035	0.003	0.028	0.009
Cl (mg/L)	*1991*	*2007*	*17*		3.30	***	0.666	0.280	1.000	0.500	0.817	17.34	21.76	16.00	19.60	16.73
Mo (mg/L)	*1992*	*2007*	*16*		0.74		0.0000	-0.0004	0.0008	-0.0002	0.0006	0.004	0.008	-0.002	0.007	-0.001
SO4 (mg/L)	*1991*	*2007*	*17*		2.72	**	2.132	0.163	4.101	1.054	3.316	59.80	79.45	49.59	70.46	54.00
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.30
Signific.	
Q	0.00E+00
Qmin99	-1.50E-04
Qmax99	1.00E-04
Qmin95	-1.06E-04
Qmax95	6.30E-05
B	1.00E-03
Bmin99	2.50E-03
Bmax99	-3.00E-04
Bmin95	2.17E-03
Bmax95	1.18E-04

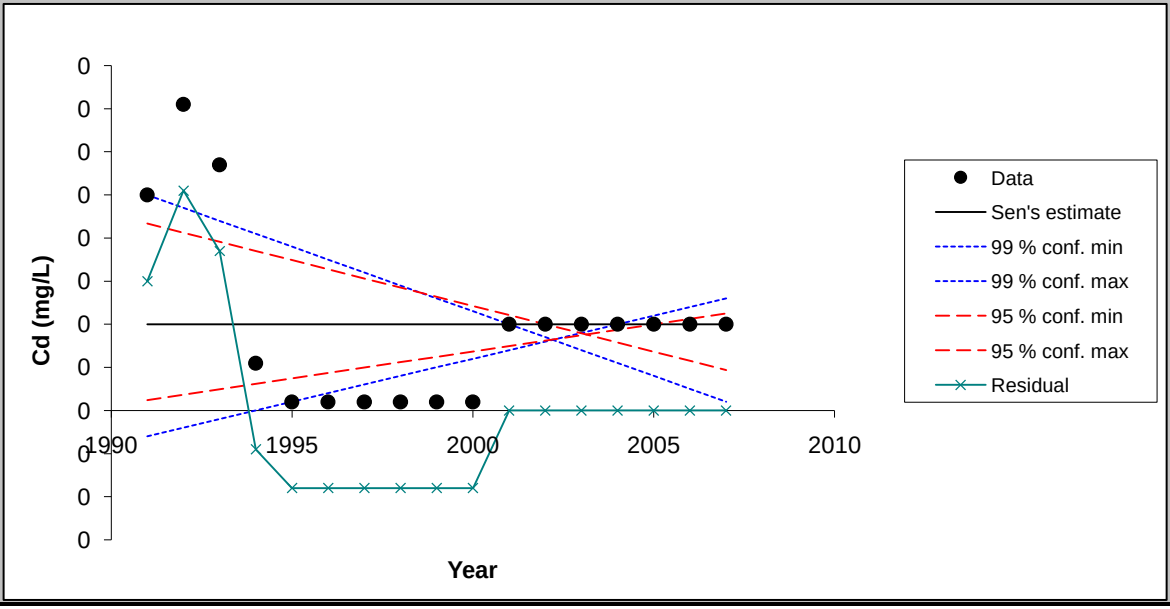

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.99
Signific.	
Q	5.58E-03
Qmin99	-1.50E-02
Qmax99	2.73E-02
Qmin95	-9.91E-03
Qmax95	2.07E-02
B	3.78E-01
Bmin99	5.05E-01
Bmax99	2.91E-01
Bmin95	4.69E-01
Bmax95	3.16E-01

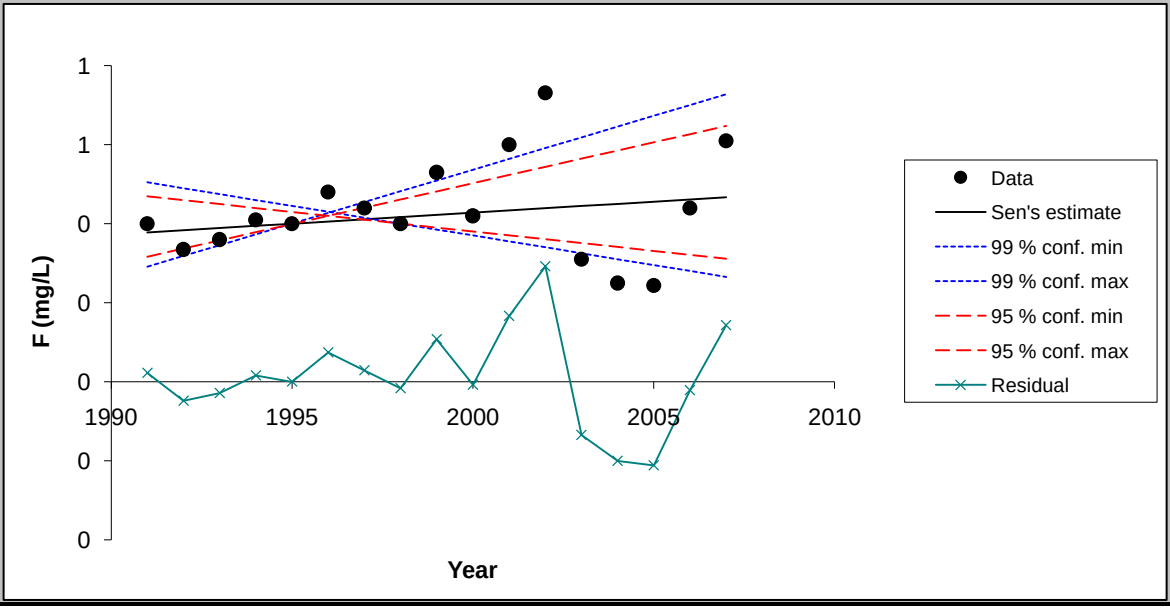

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.40	0.38	0.51	0.29	0.47	0.32	0.02
1992	0.34	0.38	0.49	0.32	0.46	0.34	-0.05
1993	0.36	0.39	0.48	0.35	0.45	0.36	-0.03
1994	0.41	0.39	0.46	0.37	0.44	0.38	0.02
1995	0.40	0.40	0.45	0.40	0.43	0.40	0.00
1996	0.48	0.41	0.43	0.43	0.42	0.42	0.07
1997	0.44	0.41	0.42	0.45	0.41	0.44	0.03
1998	0.40	0.42	0.40	0.48	0.40	0.46	-0.02
1999	0.53	0.42	0.38	0.51	0.39	0.48	0.11
2000	0.42	0.43	0.37	0.54	0.38	0.50	-0.01
2001	0.60	0.43	0.35	0.56	0.37	0.52	0.17
2002	0.73	0.44	0.34	0.59	0.36	0.54	0.29
2003	0.31	0.44	0.32	0.62	0.35	0.56	-0.13
2004	0.25	0.45	0.31	0.65	0.34	0.59	-0.20
2005	0.24	0.46	0.29	0.67	0.33	0.61	-0.21
2006	0.44	0.46	0.28	0.70	0.32	0.63	-0.02
2007	0.61	0.47	0.26	0.73	0.31	0.65	0.14

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.74
Signific.	
Q	2.60E-04
Qmin99	-5.20E-04
Qmax99	2.19E-03
Qmin95	-3.94E-04
Qmax95	1.37E-03
B	2.50E-03
Bmin99	1.08E-02
Bmax99	-6.30E-03
Bmin95	1.00E-02
Bmax95	-3.12E-03

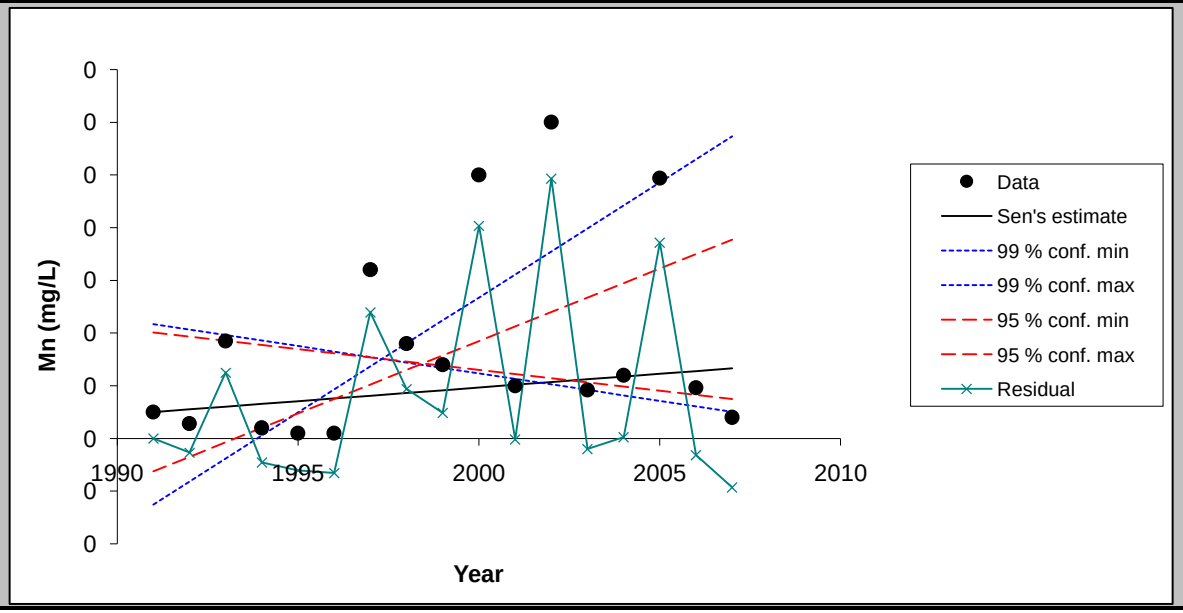

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	-0.01	0.01	0.00	0.00
1992	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1993	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1994	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1997	0.02	0.00	0.01	0.01	0.01	0.01	0.01
1998	0.01	0.00	0.01	0.01	0.01	0.01	0.00
1999	0.01	0.00	0.01	0.01	0.01	0.01	0.00
2000	0.03	0.00	0.01	0.01	0.01	0.01	0.02
2001	0.00	0.01	0.01	0.02	0.01	0.01	0.00
2002	0.03	0.01	0.01	0.02	0.01	0.01	0.02
2003	0.00	0.01	0.00	0.02	0.01	0.01	0.00
2004	0.01	0.01	0.00	0.02	0.00	0.01	0.00
2005	0.02	0.01	0.00	0.02	0.00	0.02	0.02
2006	0.00	0.01	0.00	0.03	0.00	0.02	0.00
2007	0.00	0.01	0.00	0.03	0.00	0.02	0.00

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	3.34
Signific.	***
Q	2.84E-01
Qmin99	6.89E-02
Qmax99	6.76E-01
Qmin95	1.21E-01
Qmax95	5.89E-01
B	5.37E+00
Bmin99	6.56E+00
Bmax99	3.48E+00
Bmin95	6.21E+00
Bmax95	3.85E+00

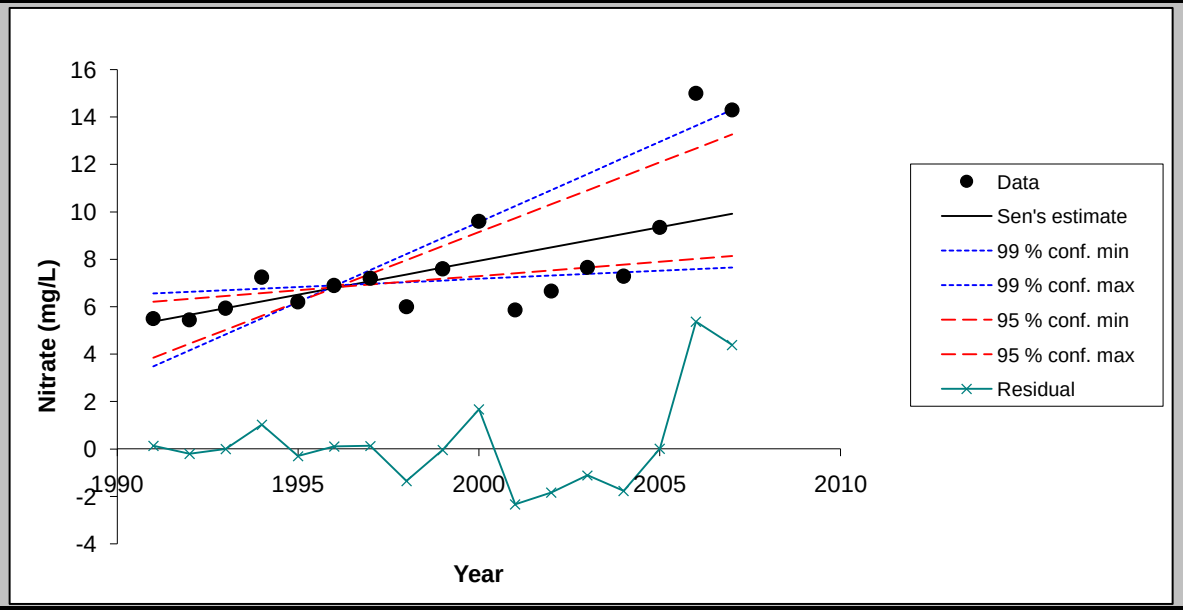

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.50	5.37	6.56	3.48	6.21	3.85	0.13
1992	5.45	5.66	6.62	4.15	6.33	4.43	-0.21
1993	5.94	5.94	6.69	4.83	6.45	5.02	0.00
1994	7.25	6.22	6.76	5.51	6.57	5.61	1.03
1995	6.20	6.51	6.83	6.18	6.69	6.20	-0.31
1996	6.90	6.79	6.90	6.86	6.81	6.79	0.11
1997	7.20	7.07	6.97	7.54	6.93	7.38	0.12
1998	6.00	7.36	7.04	8.21	7.05	7.97	-1.36
1999	7.60	7.64	7.11	8.89	7.18	8.55	-0.04
2000	9.60	7.93	7.18	9.57	7.30	9.14	1.67
2001	5.87	8.21	7.24	10.24	7.42	9.73	-2.34
2002	6.66	8.49	7.31	10.92	7.54	10.32	-1.83
2003	7.66	8.78	7.38	11.59	7.66	10.91	-1.12
2004	7.29	9.06	7.45	12.27	7.78	11.50	-1.77
2005	9.35	9.34	7.52	12.95	7.90	12.09	0.01
2006	15.00	9.63	7.59	13.62	8.02	12.67	5.37
2007	14.30	9.91	7.66	14.30	8.14	13.26	4.39

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.00
Signific.	
Q	-5.01E-12
Qmin99	-1.76E-03
Qmax99	1.82E-03
Qmin95	-1.11E-03
Qmax95	1.28E-03
B	1.50E-02
Bmin99	3.53E-02
Bmax99	3.00E-03
Bmin95	2.77E-02
Bmax95	8.87E-03

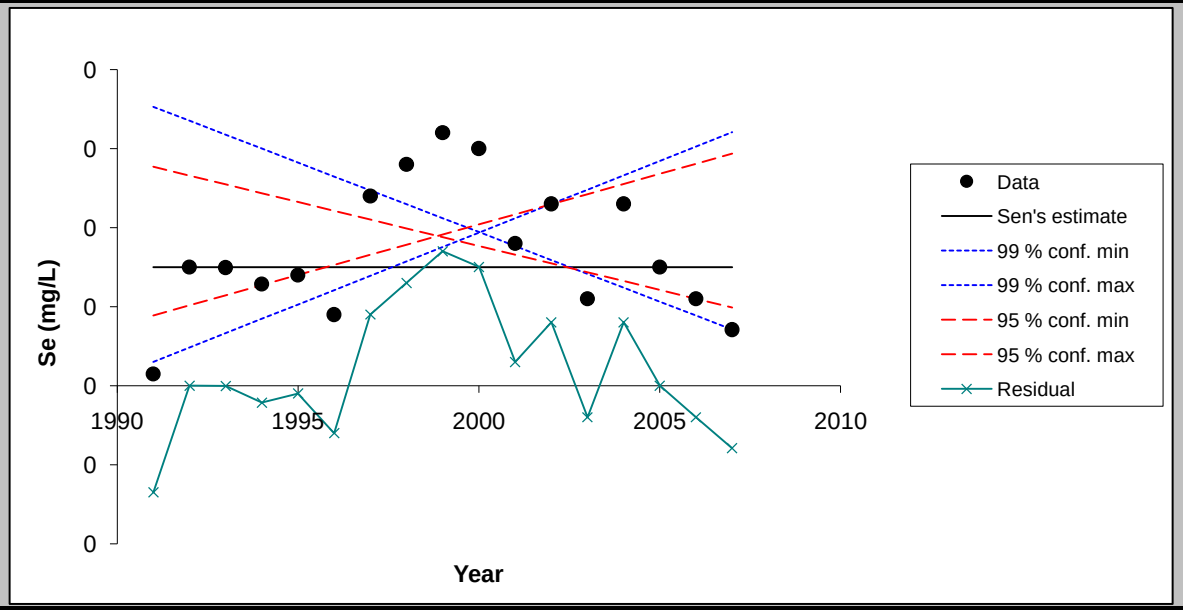

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.02	0.04	0.00	0.03	0.01	-0.01
1992	0.02	0.02	0.03	0.00	0.03	0.01	0.00
1993	0.01	0.02	0.03	0.01	0.03	0.01	0.00
1994	0.01	0.02	0.03	0.01	0.02	0.01	0.00
1995	0.01	0.02	0.03	0.01	0.02	0.01	0.00
1996	0.01	0.02	0.03	0.01	0.02	0.02	-0.01
1997	0.02	0.02	0.02	0.01	0.02	0.02	0.01
1998	0.03	0.02	0.02	0.02	0.02	0.02	0.01
1999	0.03	0.02	0.02	0.02	0.02	0.02	0.02
2000	0.03	0.02	0.02	0.02	0.02	0.02	0.01
2001	0.02	0.02	0.02	0.02	0.02	0.02	0.00
2002	0.02	0.02	0.02	0.02	0.02	0.02	0.01
2003	0.01	0.02	0.01	0.02	0.01	0.02	0.00
2004	0.02	0.02	0.01	0.03	0.01	0.03	0.01
2005	0.02	0.02	0.01	0.03	0.01	0.03	0.00
2006	0.01	0.01	0.01	0.03	0.01	0.03	0.00
2007	0.01	0.01	0.01	0.03	0.01	0.03	-0.01

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	3.30
Signific.	***
Q	6.66E-01
Qmin99	2.80E-01
Qmax99	1.00E+00
Qmin95	5.00E-01
Qmax95	8.17E-01
B	1.73E+01
Bmin99	2.18E+01
Bmax99	1.60E+01
Bmin95	1.96E+01
Bmax95	1.67E+01

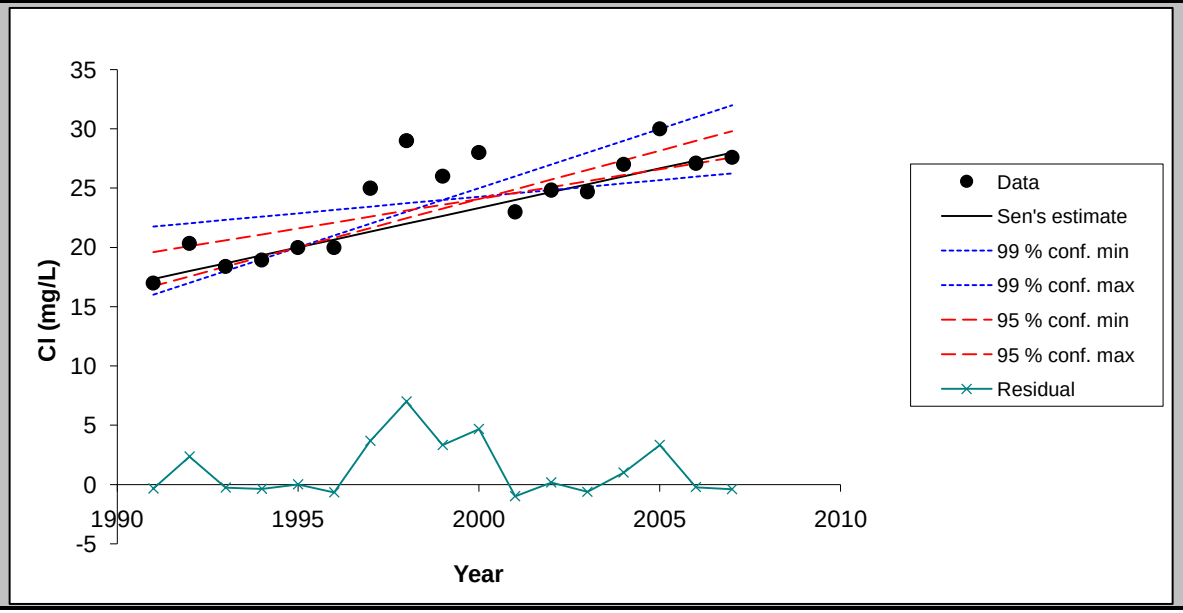

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	17.00	17.34	21.76	16.00	19.60	16.73	-0.34
1992	20.35	18.00	22.04	17.00	20.10	17.55	2.35
1993	18.40	18.67	22.32	18.00	20.60	18.37	-0.27
1994	18.95	19.33	22.60	19.00	21.10	19.18	-0.38
1995	20.00	20.00	22.88	20.00	21.60	20.00	0.00
1996	20.00	20.67	23.16	21.00	22.10	20.82	-0.67
1997	25.00	21.33	23.44	22.00	22.60	21.63	3.67
1998	29.00	22.00	23.72	23.00	23.10	22.45	7.00
1999	26.00	22.66	24.00	24.00	23.60	23.27	3.34
2000	28.00	23.33	24.28	25.00	24.10	24.09	4.67
2001	23.00	24.00	24.56	26.00	24.60	24.90	-1.00
2002	24.84	24.66	24.84	27.00	25.10	25.72	0.17
2003	24.70	25.33	25.12	28.00	25.60	26.54	-0.63
2004	27.00	25.99	25.40	29.00	26.10	27.35	1.01
2005	30.00	26.66	25.68	30.00	26.60	28.17	3.34
2006	27.10	27.33	25.96	31.00	27.10	28.99	-0.23
2007	27.60	27.99	26.23	32.00	27.60	29.80	-0.39

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.74
Signific.	
Q	9.72E-06
Qmin99	-3.72E-04
Qmax99	8.33E-04
Qmin95	-2.09E-04
Qmax95	6.25E-04
B	4.33E-03
Bmin99	8.17E-03
Bmax99	-2.47E-03
Bmin95	7.01E-03
Bmax95	-9.37E-04

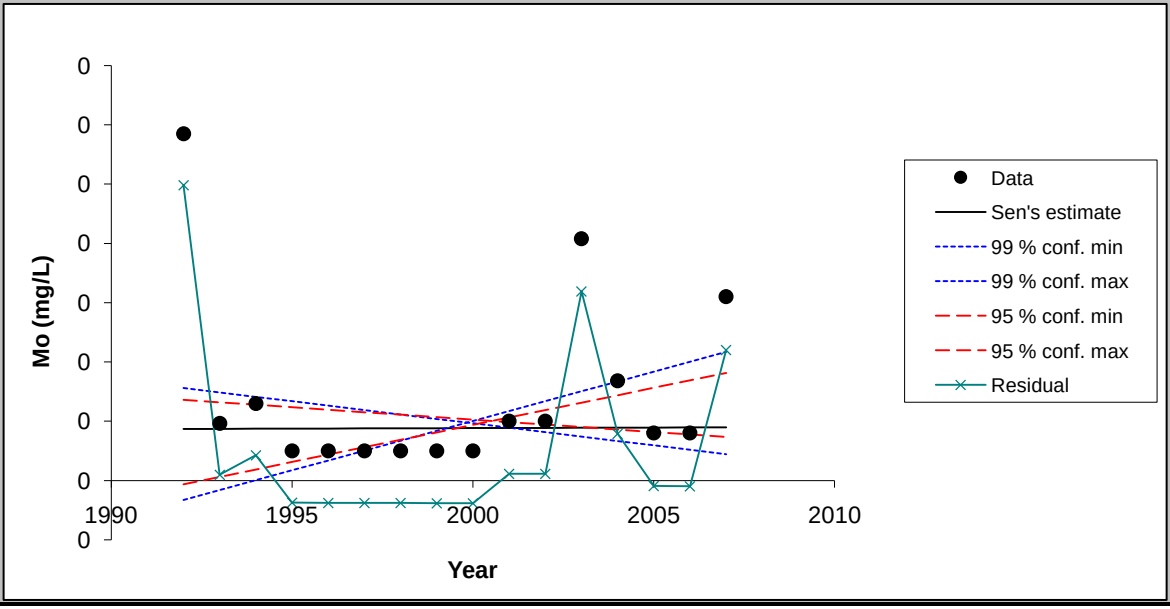

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.03	0.00	0.01	0.00	0.01	0.00	0.02
1993	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1994	0.01	0.00	0.01	0.00	0.01	0.00	0.00
1995	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1996	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1999	0.00	0.00	0.01	0.00	0.01	0.00	0.00
2000	0.00	0.00	0.00	0.01	0.01	0.00	0.00
2001	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2002	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2003	0.02	0.00	0.00	0.01	0.00	0.01	0.02
2004	0.01	0.00	0.00	0.01	0.00	0.01	0.00
2005	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2006	0.00	0.00	0.00	0.01	0.00	0.01	0.00
2007	0.02	0.00	0.00	0.01	0.00	0.01	0.01

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.72
Signific.	**
Q	2.13E+00
Qmin99	1.63E-01
Qmax99	4.10E+00
Qmin95	1.05E+00
Qmax95	3.32E+00
B	5.98E+01
Bmin99	7.94E+01
Bmax99	4.96E+01
Bmin95	7.05E+01
Bmax95	5.40E+01

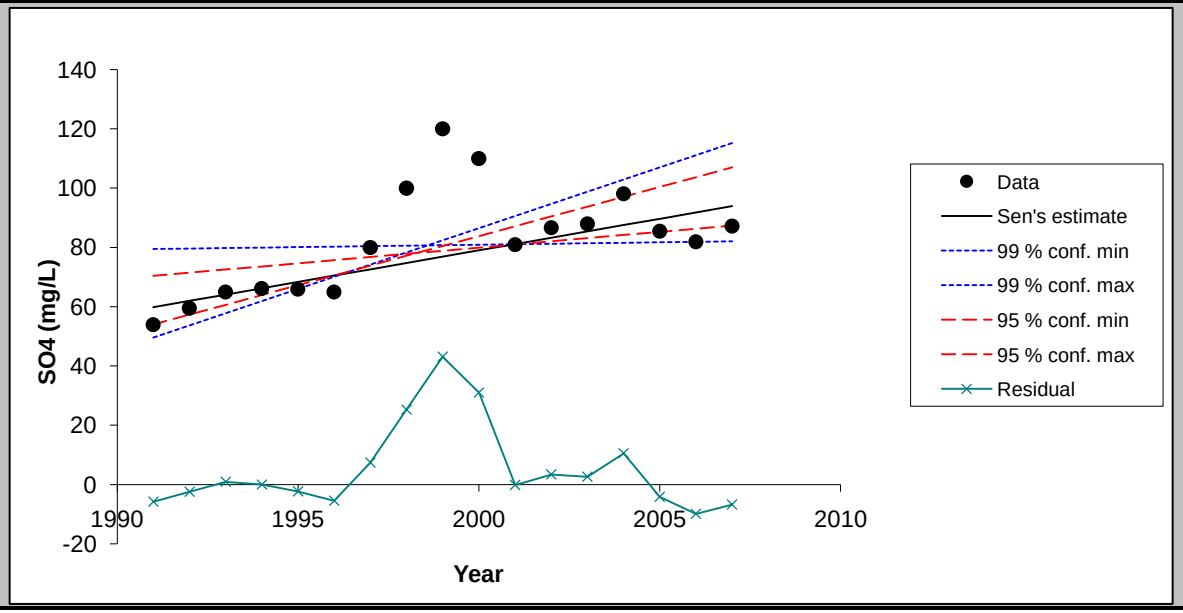

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	54.00	59.80	79.45	49.59	70.46	54.00	-5.80
1992	59.55	61.94	79.61	53.70	71.51	57.32	-2.39
1993	65.00	64.07	79.78	57.80	72.57	60.63	0.93
1994	66.20	66.20	79.94	61.90	73.62	63.95	0.00
1995	66.00	68.33	80.10	66.00	74.67	67.26	-2.33
1996	65.00	70.46	80.27	70.10	75.73	70.58	-5.46
1997	80.00	72.60	80.43	74.20	76.78	73.90	7.40
1998	100.00	74.73	80.59	78.30	77.84	77.21	25.27
1999	120.00	76.86	80.76	82.41	78.89	80.53	43.14
2000	110.00	78.99	80.92	86.51	79.95	83.84	31.01
2001	81.00	81.13	81.08	90.61	81.00	87.16	-0.13
2002	86.64	83.26	81.25	94.71	82.05	90.48	3.39
2003	88.00	85.39	81.41	98.81	83.11	93.79	2.61
2004	98.10	87.52	81.57	102.91	84.16	97.11	10.58
2005	85.50	89.65	81.74	107.01	85.22	100.42	-4.15
2006	81.90	91.79	81.90	111.12	86.27	103.74	-9.89
2007	87.20	93.92	82.06	115.22	87.33	107.06	-6.72

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Lewis Well 1991-2007

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	17	17	17	17	17	17	17	17	
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1991	1991	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0045	0.43	0.003	5.67	0.051	77.3	0.0556	237.5
1992	0.0032	0.4	0.003	5.92	0.09	87	0.054	269.8
1993	0.0046	0.38	0.006	9.85	0.062	90.9	0.115	278
1994	0.0044	0.42	0.002	7.83	0.062	88	0.107	290
1995	0.0002	0.45	0.0005	8.9	0.054	88	0.117	250
1996	0.0004	0.48	0.001	12	0.022	74	0.154	270
1997	0.0002	0.48	0.0005	10	0.016	66	0.267	220
1998	0.0002	0.5	0.0005	8.8	0.013	52	0.251	180
1999	0.0002	0.55	0.0005	7.55	0.009	37	0.211	150
2000	0.0002	0.47	0.0005	6.3	0.01	49	0.178	140
2001	0.002	0.7	0.005	8.86	0.01	38	0.13	133
2002	0.0155	0.727	0.03	7.19	0.02	42.938	0.1637	146.308
2003	0.002	0.37	0.001	5.3	0.01	43.7	0.114	161
2004	0.002	0.36	0.001	5.05	0.047	55.7	0.0857	227
2005	0.002	0.228	0.004	8.15	0.056	69.3	0.0779	250
2006	0.002	0.49	0.002	9.15	0.046	58.3	0.076	226
2007	0.0006	0.2	0.00035	8.48	0.0085	54.7	0.098	198

TREND STATISTICS

Lewis Well 1991-2007

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.80		0.000	0.000	0.000	0.000	0.000
F (mg/L)	*1991*	*2007*	*17*		0.00		0.001	-0.020	0.024	-0.015	0.017
Mn (mg/L)	*1991*	*2007*	*17*		-0.58		0.000	0.000	0.000	0.000	0.000
Nitrate (mg/L)	*1991*	*2007*	*17*		-0.37		-0.042	-0.409	0.252	-0.285	0.177
Se (mg/L)	*1991*	*2007*	*17*		-2.19	*	-0.002	-0.006	0.000	-0.005	0.000
Cl (mg/L)	*1991*	*2007*	*17*		-2.14	*	-2.491	-5.467	0.528	-4.654	-0.534
Mo (mg/L)	*1991*	*2007*	*17*		-0.37		-0.002	-0.016	0.010	-0.010	0.007
SO4 (mg/L)	*1991*	*2007*	*17*		-1.81	+	-5.060	-14.975	4.232	-12.200	0.525
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.80
Signific.	
Q	-3.17E-11
Qmin99	-2.90E-04
Qmax99	2.00E-04
Qmin95	-2.34E-04
Qmax95	9.38E-05
B	2.00E-03
Bmin99	4.90E-03
Bmax99	-6.00E-04
Bmin95	4.35E-03
Bmax95	6.87E-04

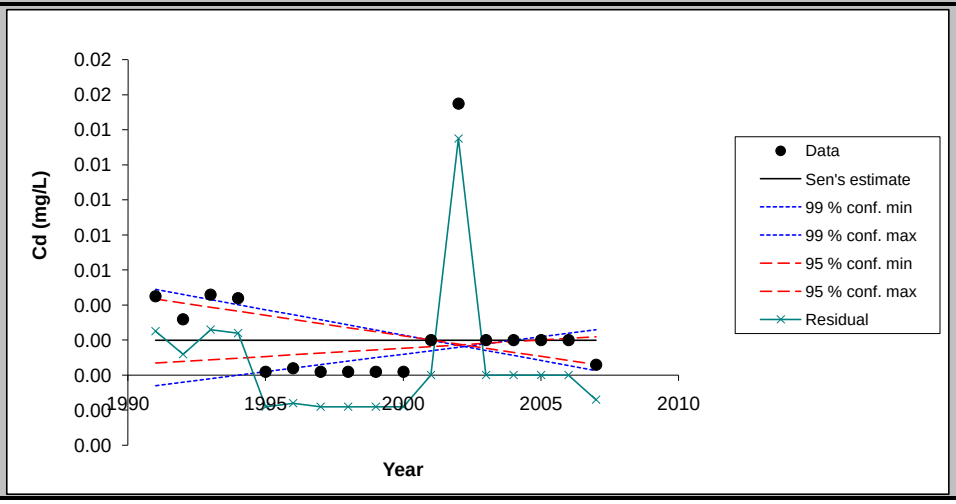

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estir	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.00	0.00	0.00	0.00	0.00	0.01
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.00
Signific.	
Q	5.00E-04
Qmin99	-2.02E-02
Qmax99	2.42E-02
Qmin95	-1.49E-02
Qmax95	1.67E-02
B	4.48E-01
Bmin99	6.01E-01
Bmax99	3.35E-01
Bmin95	5.53E-01
Bmax95	3.80E-01

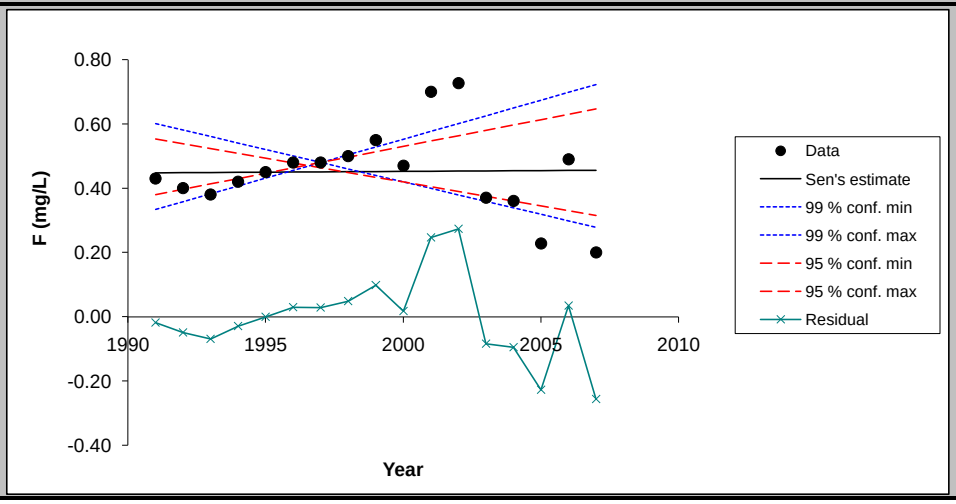

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estir	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.43	0.45	0.60	0.33	0.55	0.38	-0.02
1992	0.40	0.45	0.58	0.36	0.54	0.40	-0.05
1993	0.38	0.45	0.56	0.38	0.52	0.41	-0.07
1994	0.42	0.45	0.54	0.41	0.51	0.43	-0.03
1995	0.45	0.45	0.52	0.43	0.49	0.45	0.00
1996	0.48	0.45	0.50	0.46	0.48	0.46	0.03
1997	0.48	0.45	0.48	0.48	0.46	0.48	0.03
1998	0.50	0.45	0.46	0.50	0.45	0.50	0.05
1999	0.55	0.45	0.44	0.53	0.43	0.51	0.10
2000	0.47	0.45	0.42	0.55	0.42	0.53	0.02
2001	0.70	0.45	0.40	0.58	0.40	0.55	0.25
2002	0.73	0.45	0.38	0.60	0.39	0.56	0.27
2003	0.37	0.45	0.36	0.63	0.37	0.58	-0.08
2004	0.36	0.45	0.34	0.65	0.36	0.60	-0.09
2005	0.23	0.45	0.32	0.67	0.35	0.61	-0.23
2006	0.49	0.46	0.30	0.70	0.33	0.63	0.03
2007	0.20	0.46	0.28	0.72	0.32	0.65	-0.26

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.58
Signific.	
Q	-1.38E-05
Qmin99	-3.56E-04
Qmax99	1.81E-04
Qmin95	-2.50E-04
Qmax95	1.00E-04
B	1.18E-03
Bmin99	3.71E-03
Bmax99	-2.25E-04
Bmin95	3.25E-03
Bmax95	5.00E-04

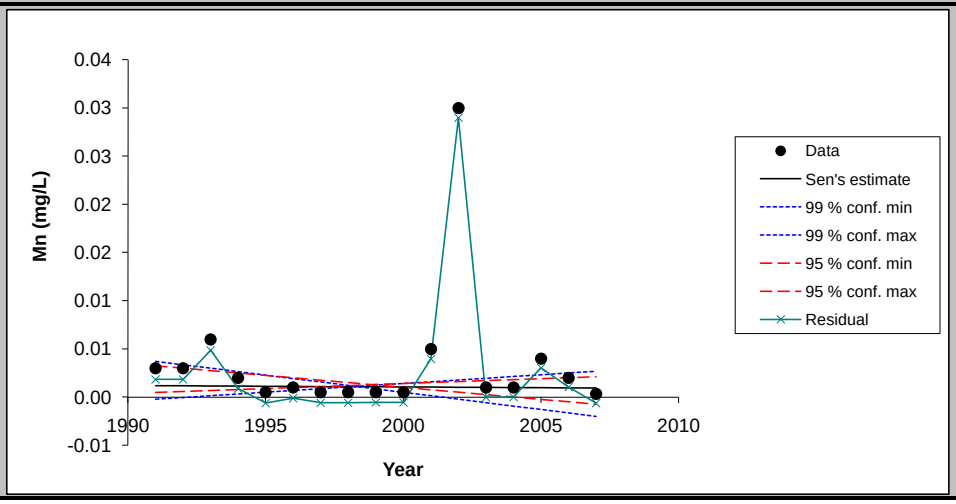

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estir	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.37
Signific.	
Q	-4.16E-02
Qmin99	-4.09E-01
Qmax99	2.52E-01
Qmin95	-2.85E-01
Qmax95	1.77E-01
B	8.73E+00
Bmin99	1.08E+01
Bmax99	5.67E+00
Bmin95	1.03E+01
Bmax95	6.14E+00

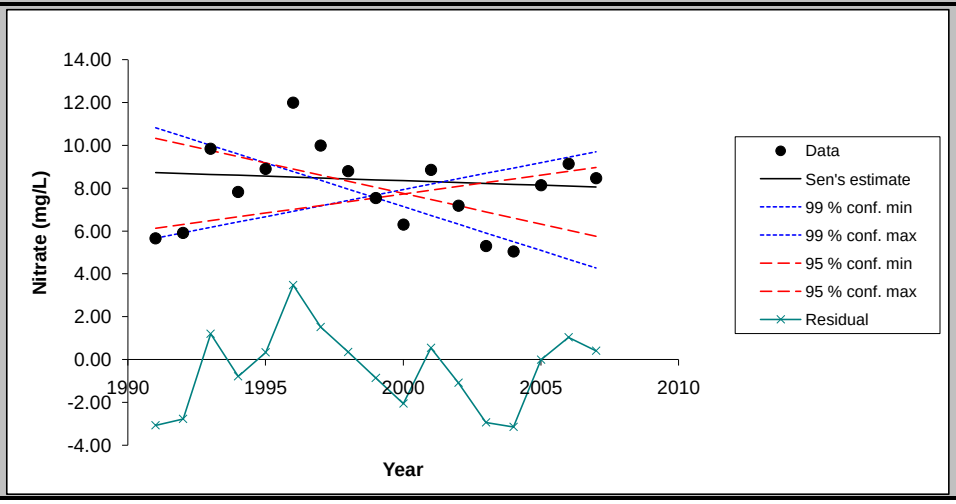

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.67	8.73	10.82	5.67	10.33	6.14	-3.06
1992	5.92	8.69	10.41	5.92	10.04	6.31	-2.77
1993	9.85	8.65	10.01	6.17	9.76	6.49	1.20
1994	7.83	8.61	9.60	6.42	9.47	6.67	-0.78
1995	8.90	8.57	9.19	6.68	9.19	6.84	0.33
1996	12.00	8.52	8.78	6.93	8.90	7.02	3.48
1997	10.00	8.48	8.37	7.18	8.62	7.20	1.52
1998	8.80	8.44	7.96	7.43	8.33	7.37	0.36
1999	7.55	8.40	7.55	7.68	8.05	7.55	-0.85
2000	6.30	8.36	7.14	7.94	7.76	7.73	-2.06
2001	8.86	8.32	6.73	8.19	7.48	7.90	0.54
2002	7.19	8.27	6.32	8.44	7.19	8.08	-1.08
2003	5.30	8.23	5.91	8.69	6.90	8.26	-2.93
2004	5.05	8.19	5.50	8.95	6.62	8.43	-3.14
2005	8.15	8.15	5.09	9.20	6.33	8.61	0.00
2006	9.15	8.11	4.69	9.45	6.05	8.79	1.04
2007	8.48	8.07	4.28	9.70	5.76	8.96	0.41

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.19
Signific.	*
Q	-1.86E-03
Qmin99	-5.86E-03
Qmax99	3.78E-04
Qmin95	-5.23E-03
Qmax95	-1.09E-04
B	4.04E-02
Bmin99	7.74E-02
Bmax99	2.01E-02
Bmin95	7.28E-02
Bmax95	2.25E-02

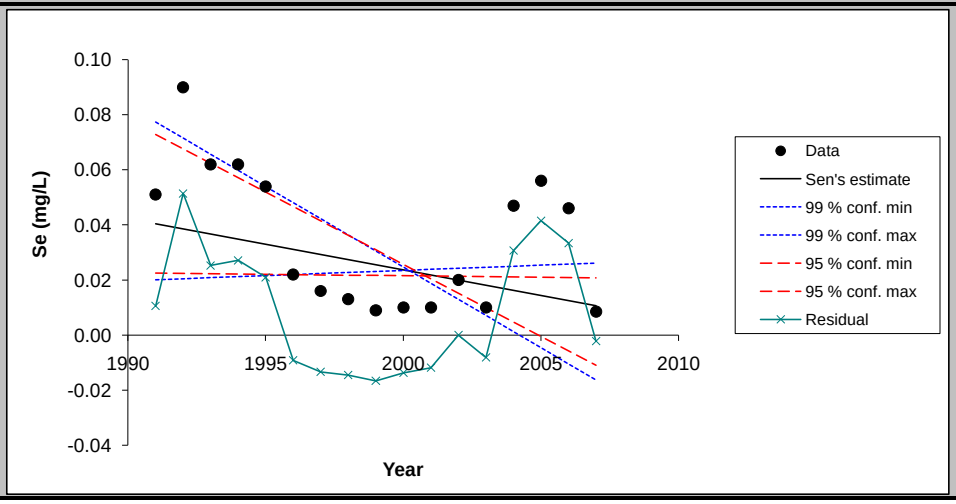

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.05	0.04	0.08	0.02	0.07	0.02	0.01
1992	0.09	0.04	0.07	0.02	0.07	0.02	0.05
1993	0.06	0.04	0.07	0.02	0.06	0.02	0.03
1994	0.06	0.03	0.06	0.02	0.06	0.02	0.03
1995	0.05	0.03	0.05	0.02	0.05	0.02	0.02
1996	0.02	0.03	0.05	0.02	0.05	0.02	-0.01
1997	0.02	0.03	0.04	0.02	0.04	0.02	-0.01
1998	0.01	0.03	0.04	0.02	0.04	0.02	-0.01
1999	0.01	0.03	0.03	0.02	0.03	0.02	-0.02
2000	0.01	0.02	0.02	0.02	0.03	0.02	-0.01
2001	0.01	0.02	0.02	0.02	0.02	0.02	-0.01
2002	0.02	0.02	0.01	0.02	0.02	0.02	0.00
2003	0.01	0.02	0.01	0.02	0.01	0.02	-0.01
2004	0.05	0.02	0.00	0.03	0.00	0.02	0.03
2005	0.06	0.01	0.00	0.03	0.00	0.02	0.04
2006	0.05	0.01	-0.01	0.03	-0.01	0.02	0.03
2007	0.01	0.01	-0.02	0.03	-0.01	0.02	0.00

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.14
Signific.	*
Q	-2.49E+00
Qmin99	-5.47E+00
Qmax99	5.28E-01
Qmin95	-4.65E+00
Qmax95	-5.34E-01
B	8.65E+01
Bmin99	1.02E+02
Bmax99	5.04E+01
Bmin95	9.73E+01
Bmax95	6.63E+01

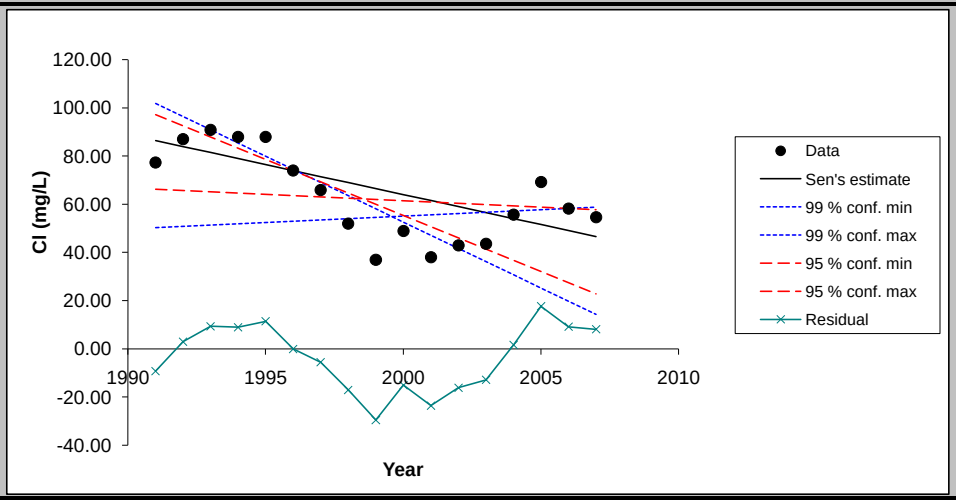

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	77.30	86.46	101.83	50.38	97.27	66.30	-9.16
1992	87.00	83.97	96.37	50.91	92.62	65.77	3.03
1993	90.90	81.47	90.90	51.43	87.96	65.24	9.43
1994	88.00	78.98	85.43	51.96	83.31	64.70	9.02
1995	88.00	76.49	79.97	52.49	78.65	64.17	11.51
1996	74.00	74.00	74.50	53.02	74.00	63.64	0.00
1997	66.00	71.51	69.03	53.55	69.35	63.10	-5.51
1998	52.00	69.02	63.57	54.07	64.69	62.57	-17.02
1999	37.00	66.53	58.10	54.60	60.04	62.03	-29.53
2000	49.00	64.03	52.63	55.13	55.38	61.50	-15.03
2001	38.00	61.54	47.16	55.66	50.73	60.97	-23.54
2002	42.94	59.05	41.70	56.19	46.07	60.43	-16.11
2003	43.70	56.56	36.23	56.72	41.42	59.90	-12.86
2004	55.70	54.07	30.76	57.24	36.77	59.37	1.63
2005	69.30	51.58	25.30	57.77	32.11	58.83	17.72
2006	58.30	49.09	19.83	58.30	27.46	58.30	9.21
2007	54.70	46.60	14.36	58.83	22.80	57.77	8.10

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	7
Name	Mo (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.37
Signific.	
Q	-1.59E-03
Qmin99	-1.58E-02
Qmax99	1.03E-02
Qmin95	-1.03E-02
Qmax95	6.53E-03
B	1.23E-01
Bmin99	3.00E-01
Bmax99	5.56E-02
Bmin95	2.31E-01
Bmax95	8.74E-02

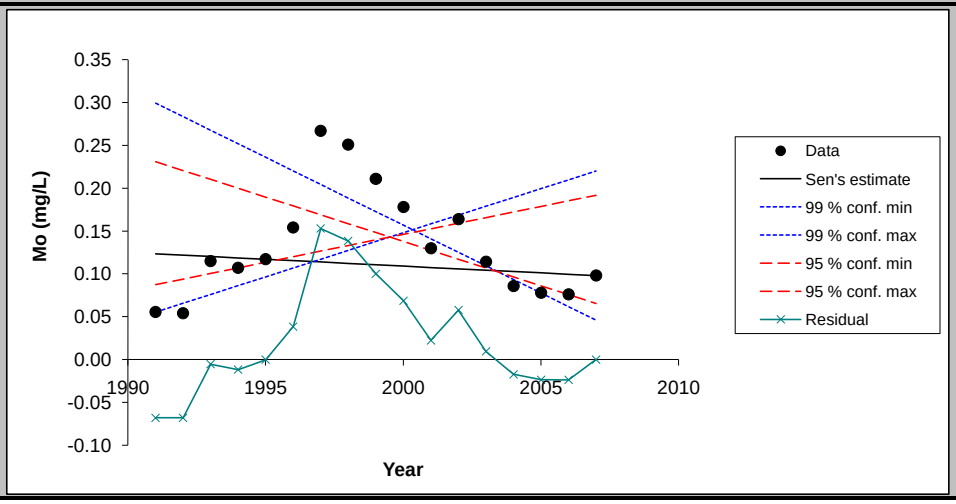

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.06	0.12	0.30	0.06	0.23	0.09	-0.07
1992	0.05	0.12	0.28	0.07	0.22	0.09	-0.07
1993	0.12	0.12	0.27	0.08	0.21	0.10	-0.01
1994	0.11	0.12	0.25	0.09	0.20	0.11	-0.01
1995	0.12	0.12	0.24	0.10	0.19	0.11	0.00
1996	0.15	0.12	0.22	0.11	0.18	0.12	0.04
1997	0.27	0.11	0.20	0.12	0.17	0.13	0.15
1998	0.25	0.11	0.19	0.13	0.16	0.13	0.14
1999	0.21	0.11	0.17	0.14	0.15	0.14	0.10
2000	0.18	0.11	0.16	0.15	0.14	0.15	0.07
2001	0.13	0.11	0.14	0.16	0.13	0.15	0.02
2002	0.16	0.11	0.13	0.17	0.12	0.16	0.06
2003	0.11	0.10	0.11	0.18	0.11	0.17	0.01
2004	0.09	0.10	0.09	0.19	0.10	0.17	-0.02
2005	0.08	0.10	0.08	0.20	0.09	0.18	-0.02
2006	0.08	0.10	0.06	0.21	0.08	0.19	-0.02
2007	0.10	0.10	0.05	0.22	0.07	0.19	0.00

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.81
Signific.	+
Q	-5.06E+00
Qmin99	-1.50E+01
Qmax99	4.23E+00
Qmin95	-1.22E+01
Qmax95	5.25E-01
B	2.70E+02
Bmin99	3.10E+02
Bmax99	1.72E+02
Bmin95	2.99E+02
Bmax95	2.18E+02

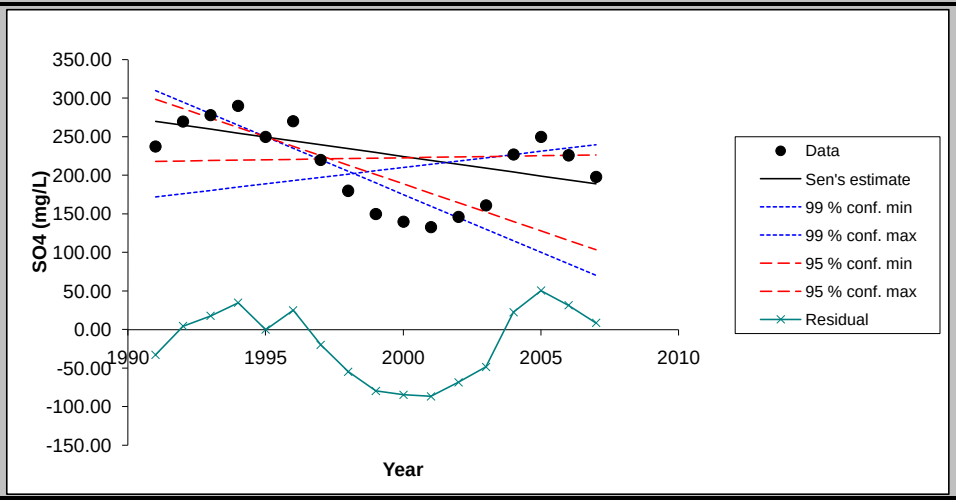

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	237.50	270.24	309.90	171.98	298.80	218.12	-32.74
1992	269.80	265.18	294.92	176.21	286.60	218.65	4.62
1993	278.00	260.12	279.95	180.44	274.40	219.17	17.88
1994	290.00	255.06	264.97	184.68	262.20	219.70	34.94
1995	250.00	250.00	250.00	188.91	250.00	220.22	0.00
1996	270.00	244.94	235.03	193.14	237.80	220.75	25.06
1997	220.00	239.88	220.05	197.37	225.60	221.27	-19.88
1998	180.00	234.82	205.08	201.61	213.40	221.80	-54.82
1999	150.00	229.76	190.10	205.84	201.20	222.32	-79.76
2000	140.00	224.70	175.13	210.07	189.00	222.85	-84.70
2001	133.00	219.64	160.15	214.30	176.80	223.37	-86.64
2002	146.31	214.58	145.18	218.54	164.60	223.90	-68.27
2003	161.00	209.52	130.20	222.77	152.40	224.42	-48.52
2004	227.00	204.46	115.23	227.00	140.20	224.95	22.54
2005	250.00	199.40	100.25	231.23	128.00	225.47	50.60
2006	226.00	194.34	85.28	235.46	115.80	226.00	31.66
2007	198.00	189.28	70.30	239.70	103.60	226.53	8.72

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-22 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	6.9	0.77	2.8	0.016	62		270
1992	0.0169	5.39	1.14	4.19	0.247	47.0	0.653	182
1993	0.0303	5.46	1.17	5.50	0.225	69.8	0.563	407.5
1994	0.0405	5.96	1.03	5.64	0.244	74.8	0.580	399
1995	0.023	5.3	0.94	5.3	0.22	52	0.556	260
1996	0.025	6	1.03	5.4	0.2	63	0.558	400
1997	0.04	8.3	1.34	8.7	0.29	93	0.62	690
1998	0.034	6.7	1.29	8.8	0.28	100	0.597	720
1999	0.035	6.9	1.23	9.3	0.33	79	0.628	810
2000	0.03	6.4	1.00	7.3	0.29	84	0.621	720
2001	0.023	5.3	0.93	5.07	0.213	37	0.55	241
2002	0.0279	4.49	1.10	4.32	0.189	28.4	0.471	168
2003	0.0235	3.9	0.988	4.41	0.242	23	0.398	136
2004	0.0244	3.37	0.933	3.77	0.245	24.8	0.328	127
2005	0.0267	3.66	0.956	4	0.197	26	0.338	133
2006	0.0249	3.82	0.919	4.6	0.282	38	0.312	183
2007	0.0234	4.17	0.786	4.63	0.105	32.2	0.328	148

TREND STATISTICS

TW-22 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-0.25		0.000	-0.002	0.001	-0.001	0.001	0.03	0.04	0.02	0.04	0.02
F (mg/L)	*1991*	*2007*	*17*		-2.52	*	-0.168	-0.417	0.004	-0.310	-0.057	6.46	9.07	5.39	7.90	5.57
Mn (mg/L)	*1991*	*2007*	*17*		-1.85	+	-0.014	-0.047	0.012	-0.041	0.001	1.12	1.54	0.89	1.44	0.99
Nitrate (mg/L)	*1991*	*2007*	*17*		-0.54		-0.063	-0.290	0.290	-0.164	0.131	5.63	7.89	3.90	6.30	4.06
Se (mg/L)	*1991*	*2007*	*17*		-0.16		0.000	-0.010	0.013	-0.008	0.009	0.24	0.31	0.13	0.29	0.16
Cl (mg/L)	*1991*	*2007*	*17*		-1.69	+	-2.586	-5.852	2.054	-5.358	0.822	73.57	95.52	44.90	90.87	48.71
Mo (mg/L)	*1992*	*2007*	*16*		-3.15	**	-0.022	-0.037	-0.004	-0.030	-0.010	0.67	0.85	0.57	0.76	0.60
SO4 (mg/L)	*1991*	*2007*	*17*		-1.65	+	-11.083	-37.783	26.000	-28.491	3.578	349.25	618.18	156.00	525.91	245.69
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.25
Signific.	
Q	-6.25E-05
Qmin99	-1.51E-03
Qmax99	1.33E-03
Qmin95	-1.24E-03
Qmax95	7.48E-04
B	2.58E-02
Bmin99	4.40E-02
Bmax99	1.56E-02
Bmin95	4.12E-02
Bmax95	1.97E-02

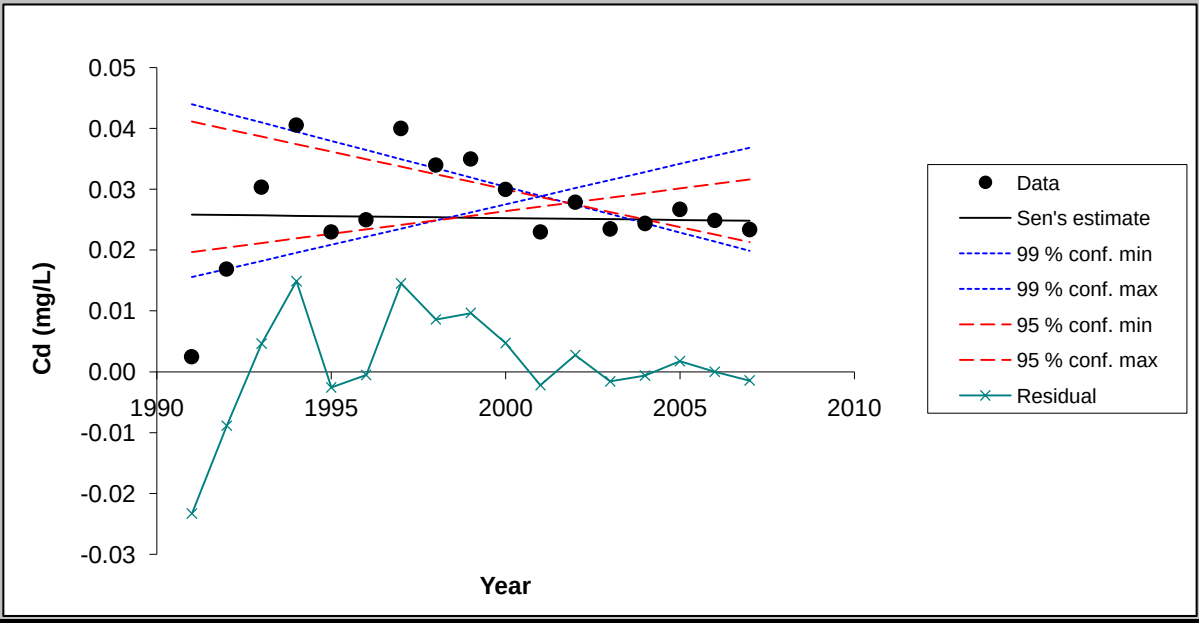

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.03	0.04	0.02	0.04	0.02	-0.02
1992	0.02	0.03	0.04	0.02	0.04	0.02	-0.01
1993	0.03	0.03	0.04	0.02	0.04	0.02	0.00
1994	0.04	0.03	0.04	0.02	0.04	0.02	0.01
1995	0.02	0.03	0.04	0.02	0.04	0.02	0.00
1996	0.03	0.03	0.04	0.02	0.03	0.02	0.00
1997	0.04	0.03	0.03	0.02	0.03	0.02	0.01
1998	0.03	0.03	0.03	0.02	0.03	0.02	0.01
1999	0.04	0.03	0.03	0.03	0.03	0.03	0.01
2000	0.03	0.03	0.03	0.03	0.03	0.03	0.00
2001	0.02	0.03	0.03	0.03	0.03	0.03	0.00
2002	0.03	0.03	0.03	0.03	0.03	0.03	0.00
2003	0.02	0.03	0.03	0.03	0.03	0.03	0.00
2004	0.02	0.03	0.02	0.03	0.03	0.03	0.00
2005	0.03	0.02	0.02	0.03	0.02	0.03	0.00
2006	0.02	0.02	0.02	0.04	0.02	0.03	0.00
2007	0.02	0.02	0.02	0.04	0.02	0.03	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.52
Signific.	*
Q	-1.68E-01
Qmin99	-4.17E-01
Qmax99	4.29E-03
Qmin95	-3.10E-01
Qmax95	-5.75E-02
B	6.46E+00
Bmin99	9.07E+00
Bmax99	5.39E+00
Bmin95	7.90E+00
Bmax95	5.57E+00

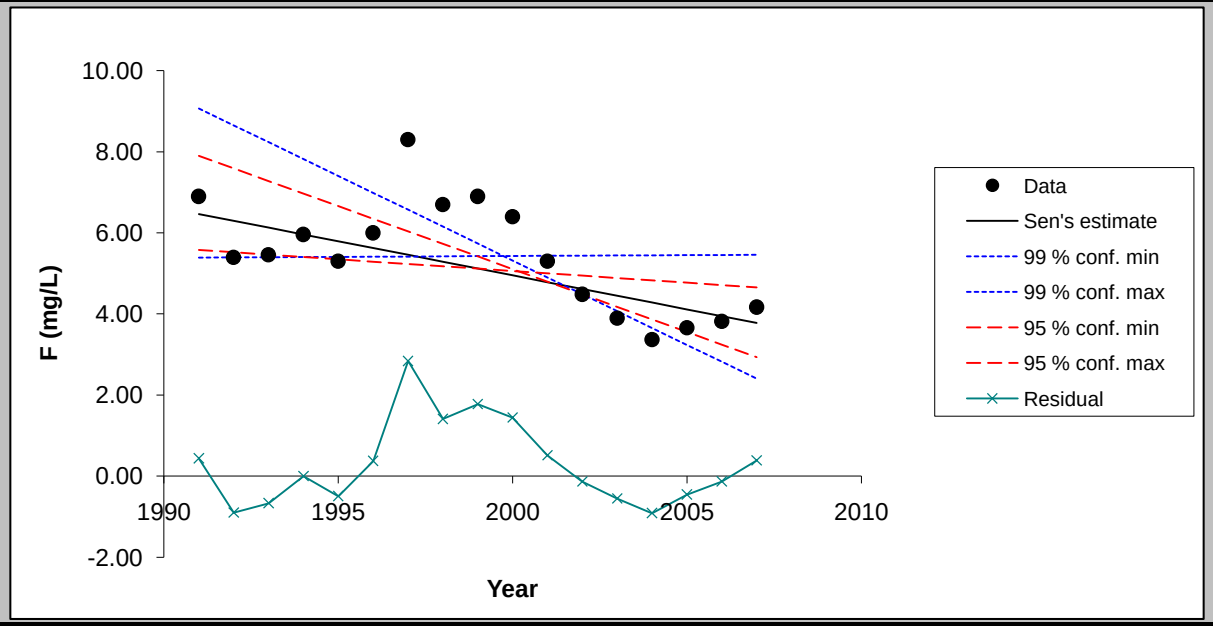

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	6.90	6.46	9.07	5.39	7.90	5.57	0.44
1992	5.39	6.30	8.65	5.39	7.59	5.52	-0.90
1993	5.46	6.13	8.24	5.40	7.28	5.46	-0.67
1994	5.96	5.96	7.82	5.40	6.97	5.40	0.00
1995	5.30	5.79	7.40	5.41	6.66	5.35	-0.49
1996	6.00	5.62	6.99	5.41	6.35	5.29	0.38
1997	8.30	5.46	6.57	5.42	6.04	5.23	2.84
1998	6.70	5.29	6.15	5.42	5.73	5.17	1.41
1999	6.90	5.12	5.74	5.43	5.42	5.12	1.78
2000	6.40	4.95	5.32	5.43	5.11	5.06	1.45
2001	5.30	4.79	4.90	5.43	4.80	5.00	0.51
2002	4.49	4.62	4.49	5.44	4.49	4.94	-0.13
2003	3.90	4.45	4.07	5.44	4.18	4.89	-0.55
2004	3.37	4.28	3.65	5.45	3.87	4.83	-0.91
2005	3.66	4.12	3.24	5.45	3.56	4.77	-0.46
2006	3.82	3.95	2.82	5.46	3.25	4.71	-0.13
2007	4.17	3.78	2.40	5.46	2.94	4.66	0.39

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.85
Signific.	+
Q	-1.37E-02
Qmin99	-4.69E-02
Qmax99	1.16E-02
Qmin95	-4.10E-02
Qmax95	1.00E-03
B	1.12E+00
Bmin99	1.54E+00
Bmax99	8.92E-01
Bmin95	1.44E+00
Bmax95	9.87E-01

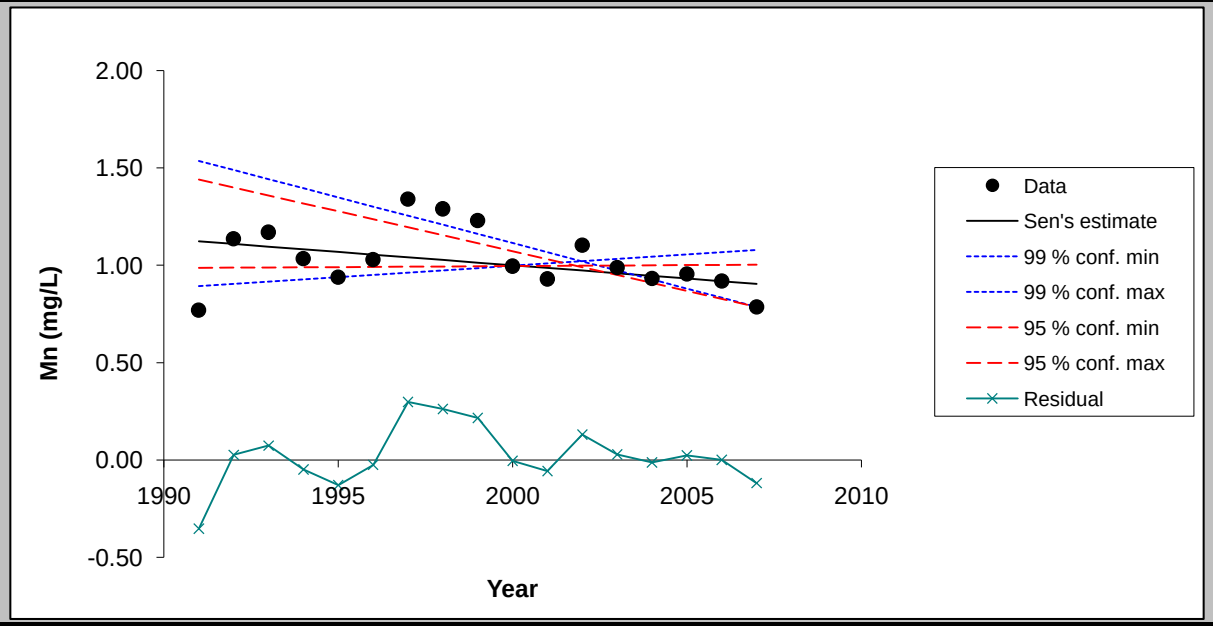

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.77	1.12	1.54	0.89	1.44	0.99	-0.35
1992	1.14	1.11	1.49	0.90	1.40	0.99	0.03
1993	1.17	1.10	1.44	0.92	1.36	0.99	0.07
1994	1.03	1.08	1.40	0.93	1.32	0.99	-0.05
1995	0.94	1.07	1.35	0.94	1.28	0.99	-0.13
1996	1.03	1.06	1.30	0.95	1.24	0.99	-0.03
1997	1.34	1.04	1.25	0.96	1.20	0.99	0.30
1998	1.29	1.03	1.21	0.97	1.15	0.99	0.26
1999	1.23	1.01	1.16	0.99	1.11	0.99	0.22
2000	1.00	1.00	1.11	1.00	1.07	1.00	0.00
2001	0.93	0.99	1.07	1.01	1.03	1.00	-0.06
2002	1.10	0.97	1.02	1.02	0.99	1.00	0.13
2003	0.99	0.96	0.97	1.03	0.95	1.00	0.03
2004	0.93	0.95	0.93	1.04	0.91	1.00	-0.01
2005	0.96	0.93	0.88	1.06	0.87	1.00	0.02
2006	0.92	0.92	0.83	1.07	0.83	1.00	0.00
2007	0.79	0.91	0.79	1.08	0.79	1.00	-0.12

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.54
Signific.	
Q	-6.31E-02
Qmin99	-2.90E-01
Qmax99	2.90E-01
Qmin95	-1.64E-01
Qmax95	1.31E-01
B	5.63E+00
Bmin99	7.89E+00
Bmax99	3.90E+00
Bmin95	6.30E+00
Bmax95	4.06E+00

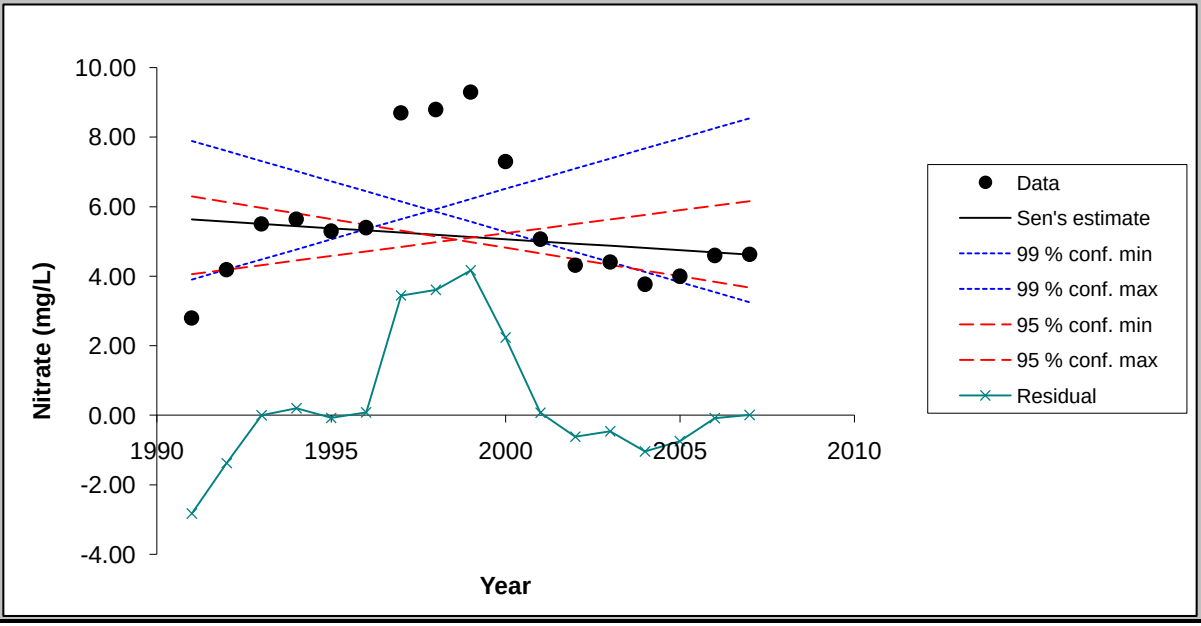

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	2.80	5.63	7.89	3.90	6.30	4.06	-2.83
1992	4.19	5.57	7.60	4.19	6.13	4.19	-1.38
1993	5.50	5.50	7.31	4.48	5.97	4.32	0.00
1994	5.64	5.44	7.02	4.77	5.80	4.45	0.20
1995	5.30	5.38	6.73	5.06	5.64	4.58	-0.08
1996	5.40	5.32	6.44	5.35	5.48	4.71	0.08
1997	8.70	5.25	6.15	5.64	5.31	4.85	3.45
1998	8.80	5.19	5.86	5.93	5.15	4.98	3.61
1999	9.30	5.13	5.57	6.22	4.98	5.11	4.17
2000	7.30	5.06	5.28	6.51	4.82	5.24	2.24
2001	5.07	5.00	4.99	6.80	4.66	5.37	0.07
2002	4.32	4.94	4.70	7.09	4.49	5.50	-0.62
2003	4.41	4.87	4.41	7.38	4.33	5.63	-0.46
2004	3.77	4.81	4.12	7.67	4.16	5.76	-1.04
2005	4.00	4.75	3.83	7.96	4.00	5.90	-0.75
2006	4.60	4.69	3.54	8.25	3.84	6.03	-0.09
2007	4.63	4.62	3.25	8.54	3.67	6.16	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.16
Signific.	
Q	-2.78E-04
Qmin99	-1.02E-02
Qmax99	1.34E-02
Qmin95	-7.91E-03
Qmax95	8.51E-03
B	2.45E-01
Bmin99	3.15E-01
Bmax99	1.33E-01
Bmin95	2.92E-01
Bmax95	1.57E-01

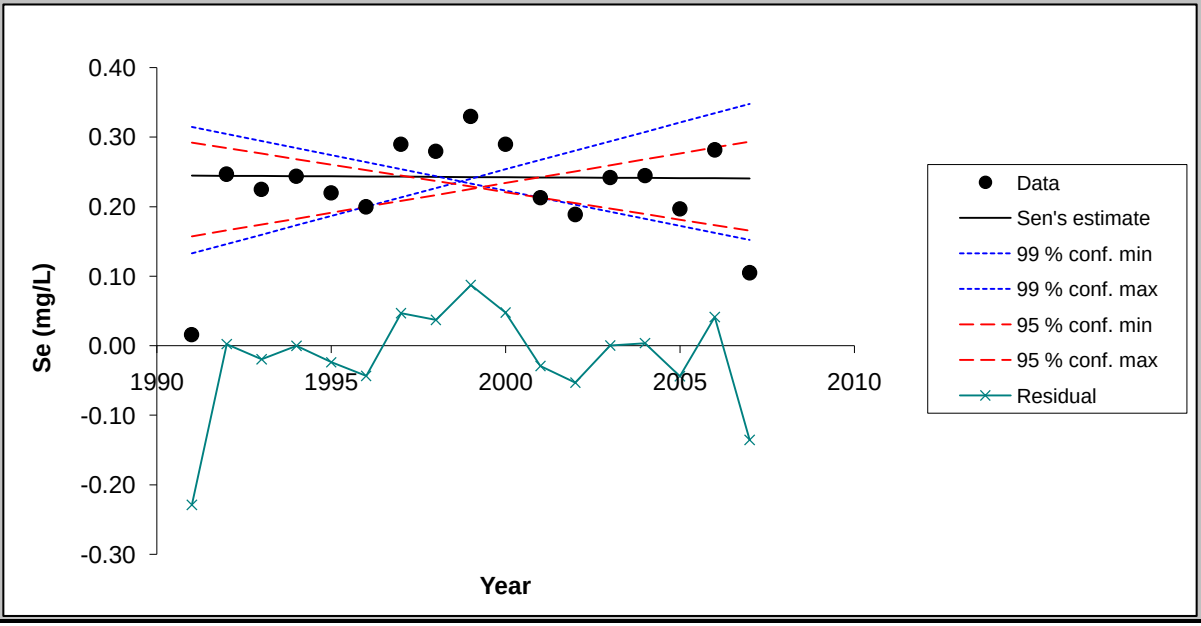

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.02	0.24	0.31	0.13	0.29	0.16	-0.23
1992	0.25	0.24	0.30	0.15	0.28	0.17	0.00
1993	0.22	0.24	0.29	0.16	0.28	0.17	-0.02
1994	0.24	0.24	0.28	0.17	0.27	0.18	0.00
1995	0.22	0.24	0.27	0.19	0.26	0.19	-0.02
1996	0.20	0.24	0.26	0.20	0.25	0.20	-0.04
1997	0.29	0.24	0.25	0.21	0.24	0.21	0.05
1998	0.28	0.24	0.24	0.23	0.24	0.22	0.04
1999	0.33	0.24	0.23	0.24	0.23	0.23	0.09
2000	0.29	0.24	0.22	0.25	0.22	0.23	0.05
2001	0.21	0.24	0.21	0.27	0.21	0.24	-0.03
2002	0.19	0.24	0.20	0.28	0.21	0.25	-0.05
2003	0.24	0.24	0.19	0.29	0.20	0.26	0.00
2004	0.25	0.24	0.18	0.31	0.19	0.27	0.00
2005	0.20	0.24	0.17	0.32	0.18	0.28	-0.04
2006	0.28	0.24	0.16	0.33	0.17	0.29	0.04
2007	0.11	0.24	0.15	0.35	0.17	0.29	-0.14

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.69
Signific.	+
Q	-2.59E+00
Qmin99	-5.85E+00
Qmax99	2.05E+00
Qmin95	-5.36E+00
Qmax95	8.22E-01
B	7.36E+01
Bmin99	9.55E+01
Bmax99	4.49E+01
Bmin95	9.09E+01
Bmax95	4.87E+01

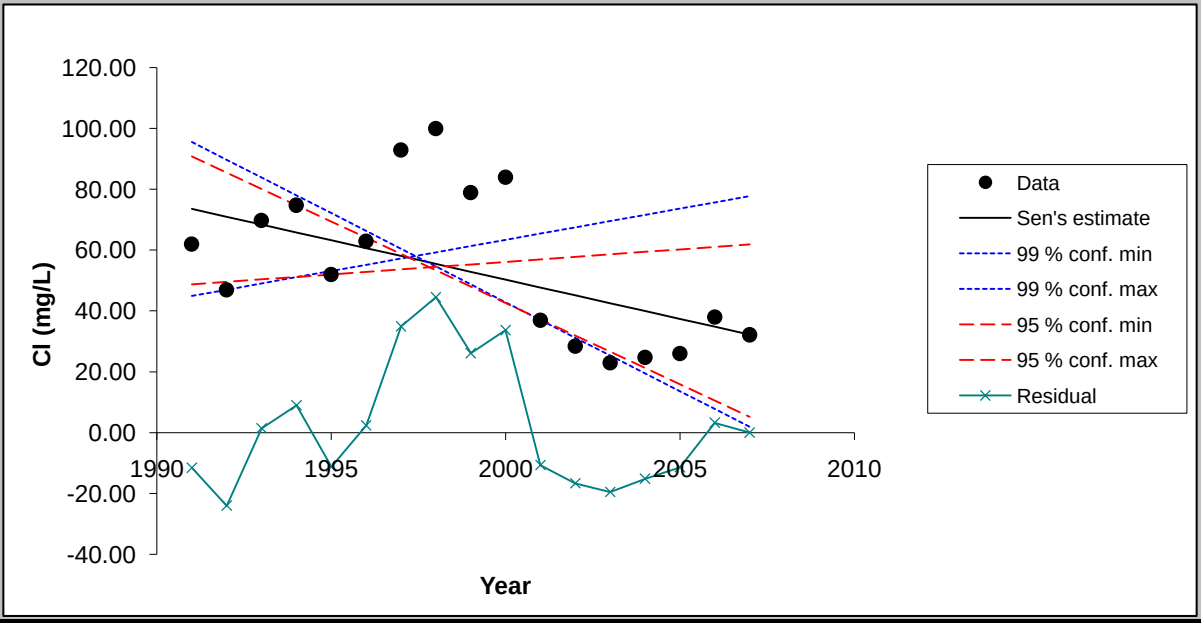

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	62.00	73.57	95.52	44.90	90.87	48.71	-11.57
1992	46.95	70.99	89.67	46.95	85.52	49.53	-24.04
1993	69.80	68.40	83.82	49.00	80.16	50.36	1.40
1994	74.80	65.81	77.96	51.06	74.80	51.18	8.99
1995	52.00	63.23	72.11	53.11	69.44	52.00	-11.23
1996	63.00	60.64	66.26	55.17	64.08	52.82	2.36
1997	93.00	58.06	60.41	57.22	58.73	53.64	34.94
1998	100.00	55.47	54.56	59.28	53.37	54.47	44.53
1999	79.00	52.89	48.70	61.33	48.01	55.29	26.11
2000	84.00	50.30	42.85	63.39	42.65	56.11	33.70
2001	37.00	47.71	37.00	65.44	37.29	56.93	-10.71
2002	28.43	45.13	31.15	67.49	31.93	57.75	-16.70
2003	23.00	42.54	25.30	69.55	26.58	58.58	-19.54
2004	24.80	39.96	19.44	71.60	21.22	59.40	-15.16
2005	26.00	37.37	13.59	73.66	15.86	60.22	-11.37
2006	38.00	34.79	7.74	75.71	10.50	61.04	3.21
2007	32.20	32.20	1.89	77.77	5.14	61.86	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-22 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.15
Signific.	**
Q	-2.19E-02
Qmin99	-3.67E-02
Qmax99	-3.75E-03
Qmin95	-3.00E-02
Qmax95	-9.54E-03
B	6.71E-01
Bmin99	8.46E-01
Bmax99	5.74E-01
Bmin95	7.60E-01
Bmax95	6.00E-01

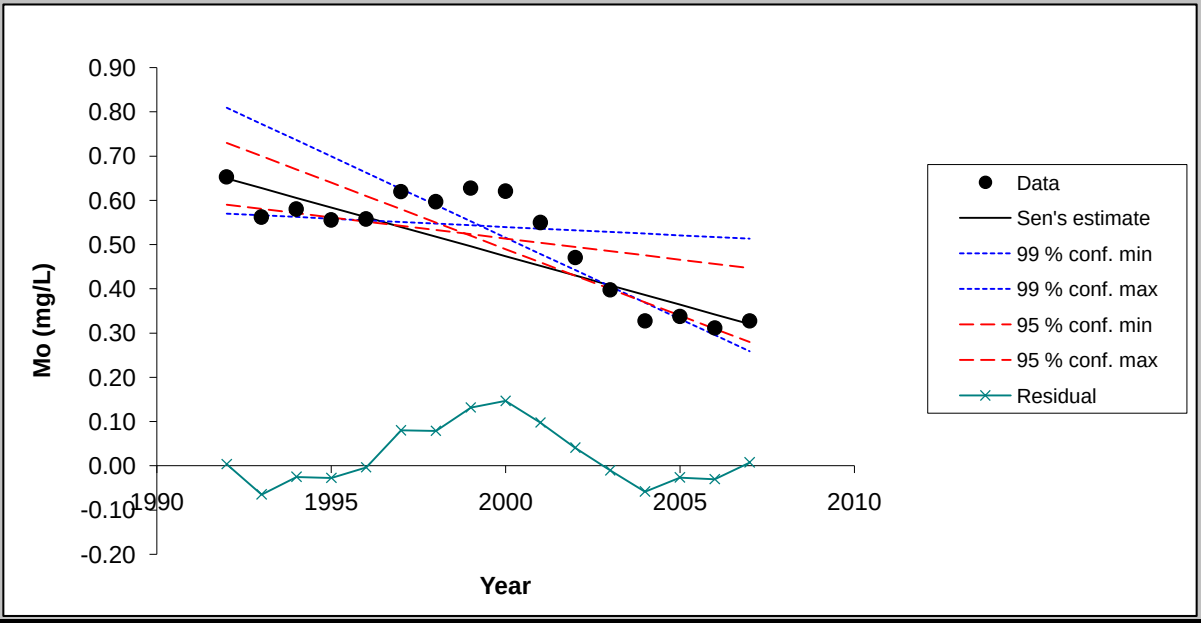

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.65	0.65	0.81	0.57	0.73	0.59	0.00
1993	0.56	0.63	0.77	0.57	0.70	0.58	-0.06
1994	0.58	0.61	0.74	0.56	0.67	0.57	-0.03
1995	0.56	0.58	0.70	0.56	0.64	0.56	-0.03
1996	0.56	0.56	0.66	0.56	0.61	0.55	0.00
1997	0.62	0.54	0.63	0.55	0.58	0.54	0.08
1998	0.60	0.52	0.59	0.55	0.55	0.53	0.08
1999	0.63	0.50	0.55	0.54	0.52	0.52	0.13
2000	0.62	0.47	0.52	0.54	0.49	0.51	0.15
2001	0.55	0.45	0.48	0.54	0.46	0.50	0.10
2002	0.47	0.43	0.44	0.53	0.43	0.49	0.04
2003	0.40	0.41	0.41	0.53	0.40	0.49	-0.01
2004	0.33	0.39	0.37	0.53	0.37	0.48	-0.06
2005	0.34	0.36	0.33	0.52	0.34	0.47	-0.03
2006	0.31	0.34	0.30	0.52	0.31	0.46	-0.03
2007	0.33	0.32	0.26	0.51	0.28	0.45	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.65
Signific.	+
Q	-1.11E+01
Qmin99	-3.78E+01
Qmax99	2.60E+01
Qmin95	-2.85E+01
Qmax95	3.58E+00
B	3.49E+02
Bmin99	6.18E+02
Bmax99	1.56E+02
Bmin95	5.26E+02
Bmax95	2.46E+02

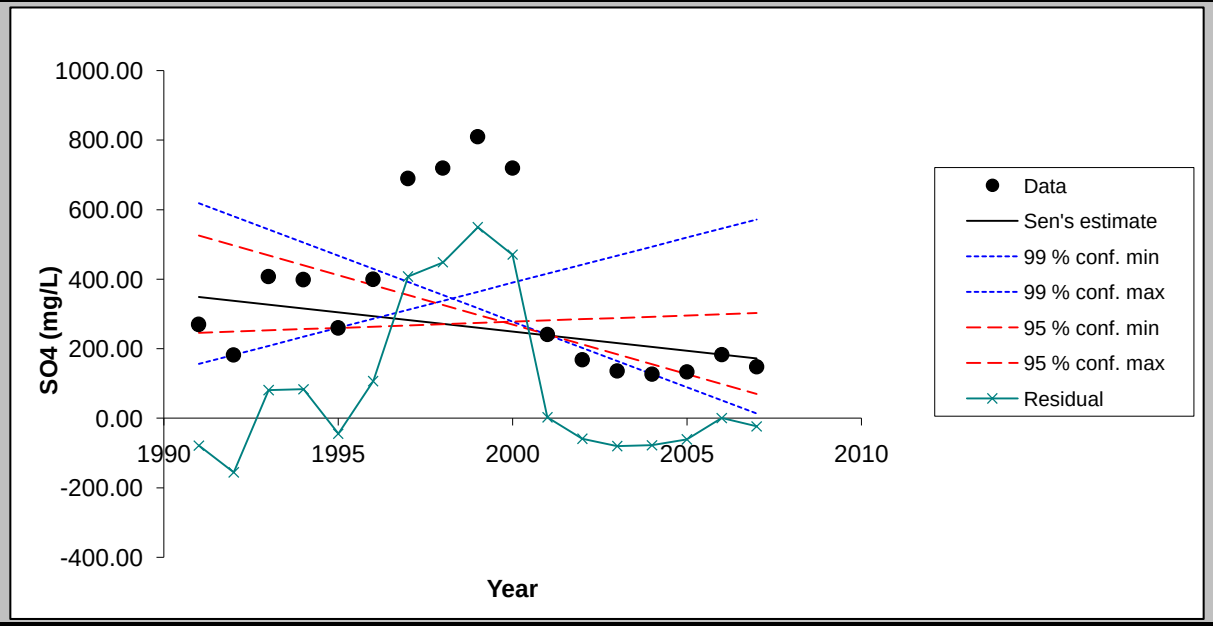

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	270.00	349.25	618.18	156.00	525.91	245.69	-79.25
1992	182.00	338.17	580.40	182.00	497.41	249.27	-156.17
1993	407.50	327.08	542.62	208.00	468.92	252.84	80.42
1994	399.00	316.00	504.83	234.00	440.43	256.42	83.00
1995	260.00	304.92	467.05	260.00	411.94	260.00	-44.92
1996	400.00	293.83	429.27	286.00	383.45	263.58	106.17
1997	690.00	282.75	391.48	312.00	354.96	267.16	407.25
1998	720.00	271.67	353.70	338.00	326.47	270.73	448.33
1999	810.00	260.58	315.92	364.00	297.98	274.31	549.42
2000	720.00	249.50	278.13	390.00	269.49	277.89	470.50
2001	241.00	238.42	240.35	416.00	241.00	281.47	2.58
2002	168.00	227.33	202.57	442.00	212.51	285.04	-59.33
2003	136.00	216.25	164.78	468.00	184.02	288.62	-80.25
2004	127.00	205.17	127.00	494.00	155.53	292.20	-78.17
2005	133.00	194.08	89.22	520.00	127.04	295.78	-61.08
2006	183.00	183.00	51.43	546.00	98.55	299.36	0.00
2007	148.00	171.92	13.65	572.00	70.06	302.93	-23.92

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-24 (1992-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	16	16	16	16	16	16	16	16
Select the FIRST YEAR of the calculation:	1992	1992	1992	1992	1992	1992	1992	1992
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991								
1992	0.222	5.1	0.378	4.38	0.307	50.3	0.058	245
1993	0.238	7.0	0.271	6.86	0.406	60.7	0.502	454.5
1994	0.295	7.2	0.263	5.76	0.309	45	0.380	288
1995	0.29	6.7	0.275	5.8	0.33	37	0.495	340
1996	0.25	9	0.245	6.3	0.37	45	0.722	520
1997	0.22	8.7	0.143	7.9	0.47	50	1.35	810
1998	0.24	8	0.153	8.2	0.42	64	1.12	840
1999	0.19	8.2	0.136	7.9	0.39	58	1.17	790
2000	0.26	8.4	0.183	8.4	0.45	61	0.961	580
2001	0.309	5.9	0.28	5.31	0.234	32	0.38	216
2002	0.294	5.3	0.320	4.77	0.212	29.9	0.340	201
2003	0.295	5.06	0.308	5.05	0.317	25.3	0.334	170
2004	0.315	4.99	0.329	4.32	0.352	24.9	0.276	156
2005	0.331	6.42	0.278	6.24	0.359	142	0.829	327
2006	0.295	6.53	0.255	6.23	0.036	107	0.57	315
2007	0.244	5.95	0.199	6.06	0.171	48.3	0.431	189

TREND STATISTICS

TW-24 (1992-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1992*	*2007*	*16*		1.89	+	0.004	-0.003	0.012	0.000	0.009	0.23	0.30	0.16	0.27	0.20
F (mg/L)	*1992*	*2007*	*16*		-1.31		-0.136	-0.299	0.202	-0.263	0.122	7.84	9.49	5.39	9.18	5.59
Mn (mg/L)	*1992*	*2007*	*16*		0.00		0.000	-0.017	0.012	-0.013	0.007	0.27	0.37	0.16	0.36	0.21
Nitrate (mg/L)	*1992*	*2007*	*16*		-0.27		-0.009	-0.238	0.277	-0.197	0.211	6.27	7.80	4.40	7.35	4.56
Se (mg/L)	*1992*	*2007*	*16*		-1.22		-0.009	-0.028	0.014	-0.023	0.004	0.42	0.56	0.27	0.51	0.30
Cl (mg/L)	*1992*	*2007*	*16*		-0.27		-0.285	-3.069	5.322	-2.473	4.037	51.15	65.82	16.89	61.10	25.26
Mo (mg/L)	*1992*	*2007*	*16*		-0.23		-0.005	-0.073	0.077	-0.057	0.048	0.51	1.22	0.07	1.01	0.20
SO4 (mg/L)	*1992*	*2007*	*16*		-1.49		-12.847	-59.150	28.206	-48.951	9.906	437.38	902.37	210.09	778.56	246.69
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	1.89
Signific.	+
Q	4.24E-03
Qmin99	-3.40E-03
Qmax99	1.21E-02
Qmin95	-1.11E-10
Qmax95	8.97E-03
B	2.30E-01
Bmin99	3.01E-01
Bmax99	1.59E-01
Bmin95	2.75E-01
Bmax95	1.97E-01

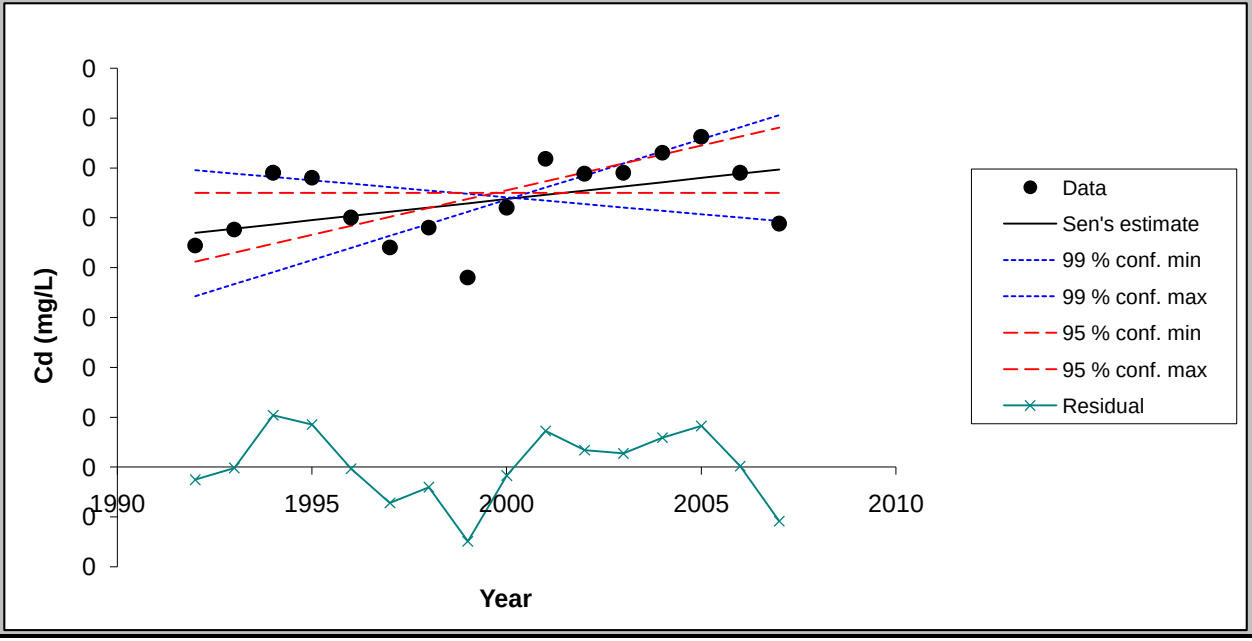

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.22	0.23	0.30	0.17	0.27	0.21	-0.01
1993	0.24	0.24	0.29	0.18	0.27	0.21	0.00
1994	0.30	0.24	0.29	0.20	0.27	0.22	0.05
1995	0.29	0.25	0.29	0.21	0.27	0.23	0.04
1996	0.25	0.25	0.28	0.22	0.27	0.24	0.00
1997	0.22	0.26	0.28	0.23	0.27	0.25	-0.04
1998	0.24	0.26	0.28	0.24	0.27	0.26	-0.02
1999	0.19	0.26	0.27	0.26	0.27	0.27	-0.07
2000	0.26	0.27	0.27	0.27	0.27	0.28	-0.01
2001	0.31	0.27	0.27	0.28	0.27	0.29	0.04
2002	0.29	0.28	0.26	0.29	0.27	0.30	0.02
2003	0.30	0.28	0.26	0.30	0.27	0.30	0.01
2004	0.32	0.29	0.26	0.32	0.27	0.31	0.03
2005	0.33	0.29	0.25	0.33	0.27	0.32	0.04
2006	0.30	0.29	0.25	0.34	0.27	0.33	0.00
2007	0.24	0.30	0.25	0.35	0.27	0.34	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	2
Name	F (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.31
Signific.	
Q	-1.36E-01
Qmin99	-2.99E-01
Qmax99	2.02E-01
Qmin95	-2.63E-01
Qmax95	1.22E-01
B	7.84E+00
Bmin99	9.49E+00
Bmax99	5.39E+00
Bmin95	9.18E+00
Bmax95	5.59E+00

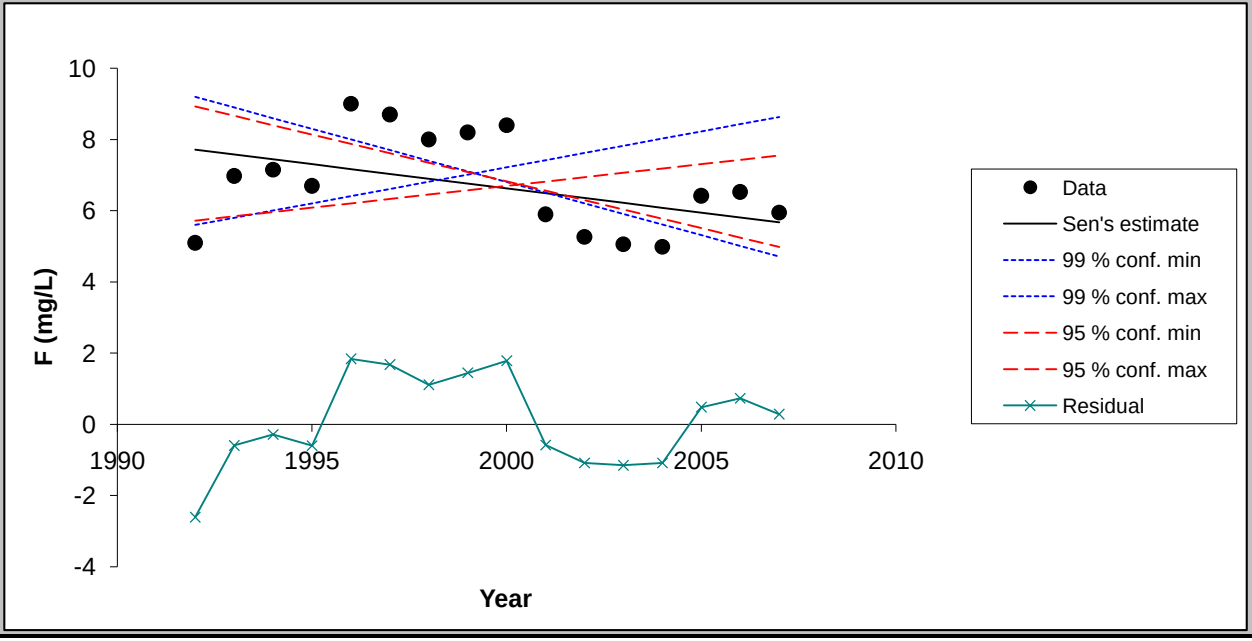

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	5.10	7.71	9.19	5.60	8.92	5.72	-2.61
1993	6.98	7.57	8.89	5.80	8.66	5.84	-0.59
1994	7.15	7.43	8.59	6.00	8.40	5.96	-0.28
1995	6.70	7.30	8.29	6.20	8.13	6.08	-0.60
1996	9.00	7.16	8.00	6.41	7.87	6.21	1.84
1997	8.70	7.03	7.70	6.61	7.61	6.33	1.67
1998	8.00	6.89	7.40	6.81	7.34	6.45	1.11
1999	8.20	6.75	7.10	7.01	7.08	6.57	1.45
2000	8.40	6.62	6.80	7.21	6.82	6.69	1.78
2001	5.90	6.48	6.50	7.42	6.56	6.82	-0.58
2002	5.26	6.35	6.20	7.62	6.29	6.94	-1.08
2003	5.06	6.21	5.90	7.82	6.03	7.06	-1.15
2004	4.99	6.07	5.61	8.02	5.77	7.18	-1.08
2005	6.42	5.94	5.31	8.22	5.50	7.31	0.48
2006	6.53	5.80	5.01	8.43	5.24	7.43	0.73
2007	5.95	5.67	4.71	8.63	4.98	7.55	0.28

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	0.00
Signific.	
Q	-1.00E-04
Qmin99	-1.74E-02
Qmax99	1.23E-02
Qmin95	-1.31E-02
Qmax95	7.12E-03
B	2.67E-01
Bmin99	3.70E-01
Bmax99	1.59E-01
Bmin95	3.59E-01
Bmax95	2.09E-01

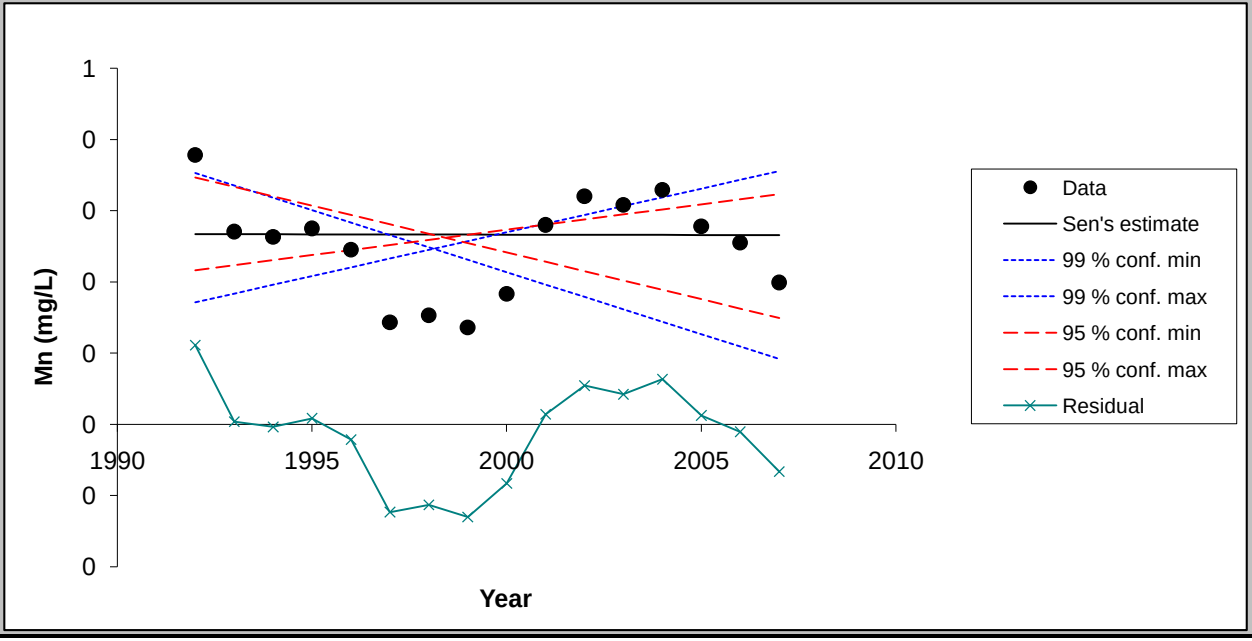

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.38	0.27	0.35	0.17	0.35	0.22	0.11
1993	0.27	0.27	0.34	0.18	0.33	0.22	0.00
1994	0.26	0.27	0.32	0.20	0.32	0.23	0.00
1995	0.28	0.27	0.30	0.21	0.31	0.24	0.01
1996	0.25	0.27	0.28	0.22	0.29	0.24	-0.02
1997	0.14	0.27	0.27	0.23	0.28	0.25	-0.12
1998	0.15	0.27	0.25	0.24	0.27	0.26	-0.11
1999	0.14	0.27	0.23	0.26	0.25	0.27	-0.13
2000	0.18	0.27	0.21	0.27	0.24	0.27	-0.08
2001	0.28	0.27	0.20	0.28	0.23	0.28	0.01
2002	0.32	0.27	0.18	0.29	0.21	0.29	0.05
2003	0.31	0.27	0.16	0.31	0.20	0.29	0.04
2004	0.33	0.27	0.14	0.32	0.19	0.30	0.06
2005	0.28	0.27	0.13	0.33	0.18	0.31	0.01
2006	0.26	0.27	0.11	0.34	0.16	0.32	-0.01
2007	0.20	0.27	0.09	0.36	0.15	0.32	-0.07

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.27
Signific.	
Q	-8.50E-03
Qmin99	-2.38E-01
Qmax99	2.77E-01
Qmin95	-1.97E-01
Qmax95	2.11E-01
B	6.27E+00
Bmin99	7.80E+00
Bmax99	4.40E+00
Bmin95	7.35E+00
Bmax95	4.56E+00

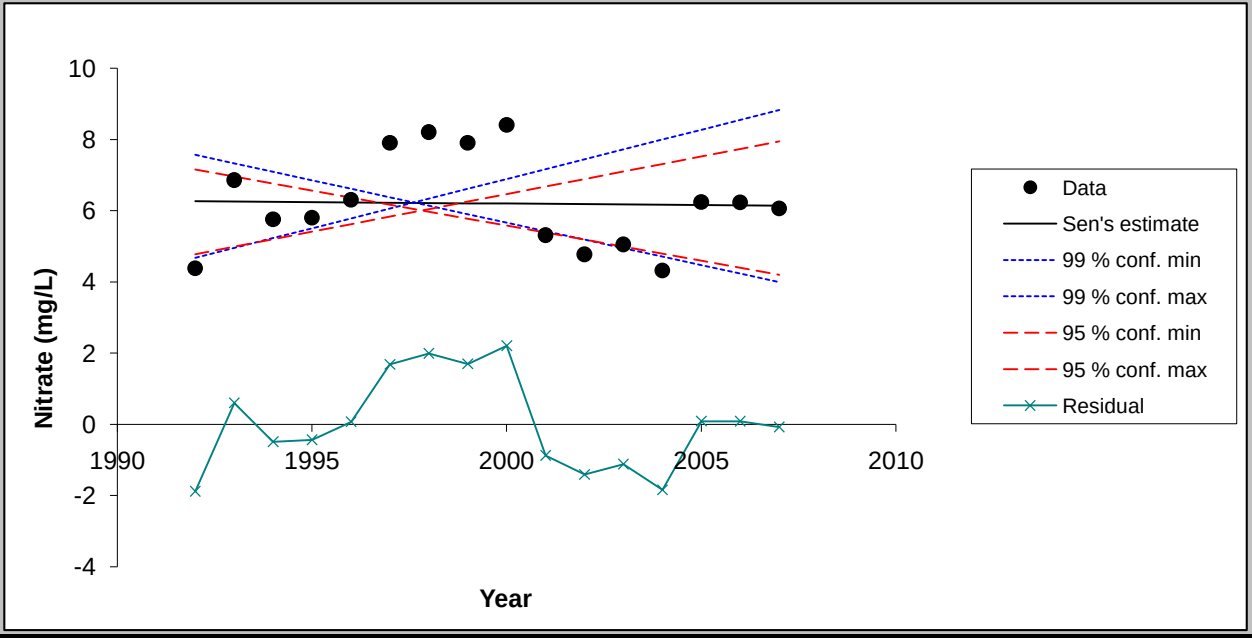

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	4.38	6.26	7.56	4.67	7.15	4.77	-1.88
1993	6.86	6.25	7.32	4.95	6.95	4.98	0.60
1994	5.76	6.24	7.09	5.23	6.76	5.20	-0.49
1995	5.80	6.24	6.85	5.51	6.56	5.41	-0.44
1996	6.30	6.23	6.61	5.78	6.36	5.62	0.07
1997	7.90	6.22	6.37	6.06	6.17	5.83	1.68
1998	8.20	6.21	6.13	6.34	5.97	6.04	1.99
1999	7.90	6.20	5.89	6.61	5.77	6.25	1.70
2000	8.40	6.19	5.66	6.89	5.58	6.46	2.21
2001	5.31	6.18	5.42	7.17	5.38	6.68	-0.87
2002	4.77	6.18	5.18	7.44	5.18	6.89	-1.41
2003	5.05	6.17	4.94	7.72	4.99	7.10	-1.12
2004	4.32	6.16	4.70	8.00	4.79	7.31	-1.84
2005	6.24	6.15	4.47	8.27	4.59	7.52	0.09
2006	6.23	6.14	4.23	8.55	4.40	7.73	0.09
2007	6.06	6.13	3.99	8.83	4.20	7.94	-0.07

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	5
Name	Se (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.22
Signific.	
Q	-8.98E-03
Qmin99	-2.76E-02
Qmax99	1.38E-02
Qmin95	-2.27E-02
Qmax95	4.19E-03
B	4.19E-01
Bmin99	5.62E-01
Bmax99	2.72E-01
Bmin95	5.09E-01
Bmax95	3.02E-01

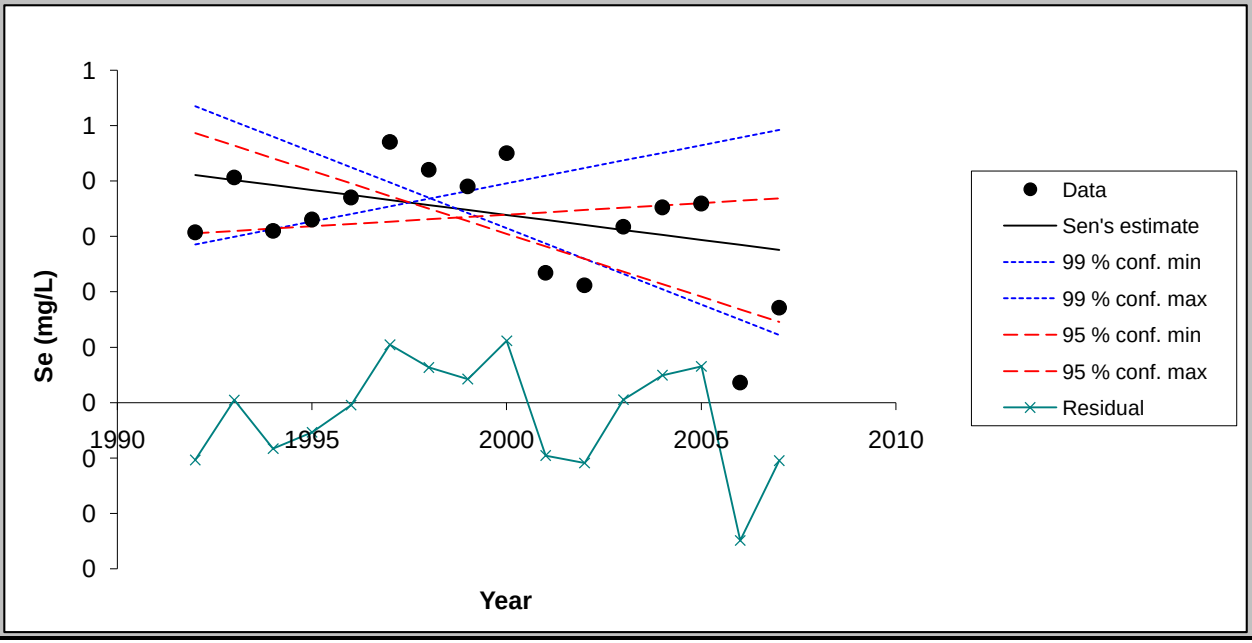

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.31	0.41	0.53	0.29	0.49	0.31	-0.10
1993	0.41	0.40	0.51	0.30	0.46	0.31	0.00
1994	0.31	0.39	0.48	0.31	0.44	0.31	-0.08
1995	0.33	0.38	0.45	0.33	0.42	0.32	-0.05
1996	0.37	0.37	0.42	0.34	0.40	0.32	0.00
1997	0.47	0.37	0.40	0.35	0.37	0.33	0.10
1998	0.42	0.36	0.37	0.37	0.35	0.33	0.06
1999	0.39	0.35	0.34	0.38	0.33	0.34	0.04
2000	0.45	0.34	0.31	0.40	0.30	0.34	0.11
2001	0.23	0.33	0.29	0.41	0.28	0.34	-0.10
2002	0.21	0.32	0.26	0.42	0.26	0.35	-0.11
2003	0.32	0.31	0.23	0.44	0.24	0.35	0.01
2004	0.35	0.30	0.20	0.45	0.21	0.36	0.05
2005	0.36	0.29	0.18	0.46	0.19	0.36	0.07
2006	0.04	0.28	0.15	0.48	0.17	0.36	-0.25
2007	0.17	0.28	0.12	0.49	0.15	0.37	-0.10

FIGURE

< Previous Time Series | Next Time Series >

TW-24 (1992-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.27
Signific.	
Q	-2.85E-01
Qmin99	-3.07E+00
Qmax99	5.32E+00
Qmin95	-2.47E+00
Qmax95	4.04E+00
B	5.11E+01
Bmin99	6.58E+01
Bmax99	1.69E+01
Bmin95	6.11E+01
Bmax95	2.53E+01

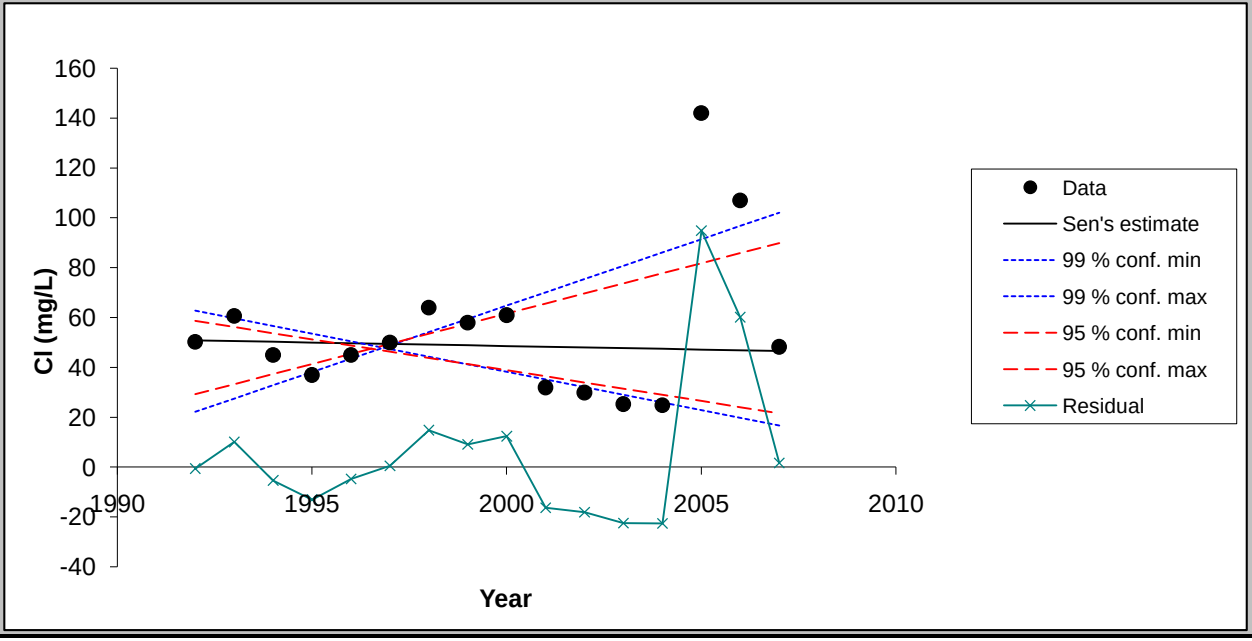

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	50.30	50.86	62.75	22.21	58.63	29.30	-0.56
1993	60.70	50.58	59.68	27.53	56.16	33.33	10.12
1994	45.00	50.29	56.61	32.86	53.68	37.37	-5.29
1995	37.00	50.01	53.54	38.18	51.21	41.41	-13.01
1996	45.00	49.72	50.47	43.50	48.74	45.44	-4.72
1997	50.00	49.44	47.40	48.82	46.26	49.48	0.56
1998	64.00	49.15	44.33	54.14	43.79	53.52	14.85
1999	58.00	48.87	41.27	59.47	41.32	57.56	9.13
2000	61.00	48.58	38.20	64.79	38.84	61.59	12.42
2001	32.00	48.30	35.13	70.11	36.37	65.63	-16.30
2002	29.94	48.01	32.06	75.43	33.90	69.67	-18.07
2003	25.30	47.73	28.99	80.76	31.43	73.70	-22.43
2004	24.90	47.44	25.92	86.08	28.95	77.74	-22.54
2005	142.00	47.16	22.85	91.40	26.48	81.78	94.84
2006	107.00	46.87	19.78	96.72	24.01	85.82	60.13
2007	48.30	46.59	16.71	102.05	21.53	89.85	1.71

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-0.23
Signific.	
Q	-5.05E-03
Qmin99	-7.30E-02
Qmax99	7.66E-02
Qmin95	-5.66E-02
Qmax95	4.79E-02
B	5.13E-01
Bmin99	1.22E+00
Bmax99	6.53E-02
Bmin95	1.01E+00
Bmax95	1.97E-01

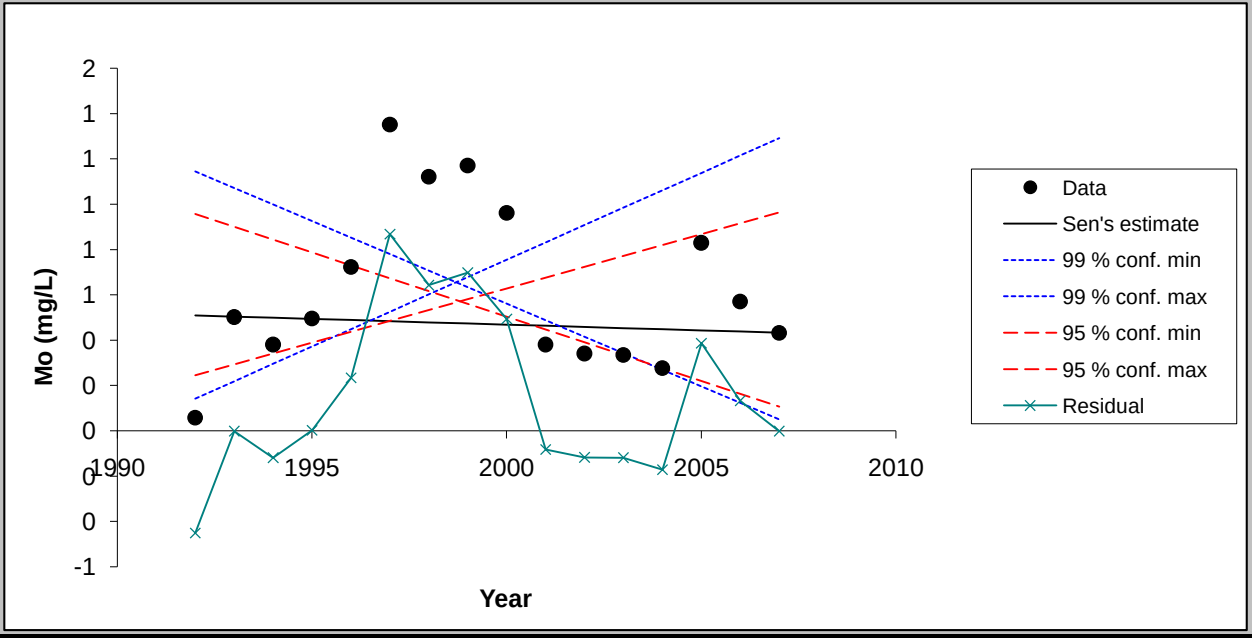

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.06	0.51	1.14	0.14	0.96	0.25	-0.45
1993	0.50	0.50	1.07	0.22	0.90	0.29	0.00
1994	0.38	0.50	1.00	0.30	0.84	0.34	-0.12
1995	0.50	0.49	0.93	0.37	0.79	0.39	0.00
1996	0.72	0.49	0.85	0.45	0.73	0.44	0.23
1997	1.35	0.48	0.78	0.53	0.67	0.48	0.87
1998	1.12	0.48	0.71	0.60	0.62	0.53	0.64
1999	1.17	0.47	0.63	0.68	0.56	0.58	0.70
2000	0.96	0.47	0.56	0.76	0.50	0.63	0.49
2001	0.38	0.46	0.49	0.83	0.45	0.68	-0.08
2002	0.34	0.46	0.41	0.91	0.39	0.72	-0.12
2003	0.33	0.45	0.34	0.98	0.33	0.77	-0.12
2004	0.28	0.45	0.27	1.06	0.28	0.82	-0.17
2005	0.83	0.44	0.20	1.14	0.22	0.87	0.39
2006	0.57	0.44	0.12	1.21	0.16	0.92	0.13
2007	0.43	0.43	0.05	1.29	0.11	0.96	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (1992-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.49
Signific.	
Q	-1.28E+01
Qmin99	-5.91E+01
Qmax99	2.82E+01
Qmin95	-4.90E+01
Qmax95	9.91E+00
B	4.37E+02
Bmin99	9.02E+02
Bmax99	2.10E+02
Bmin95	7.79E+02
Bmax95	2.47E+02

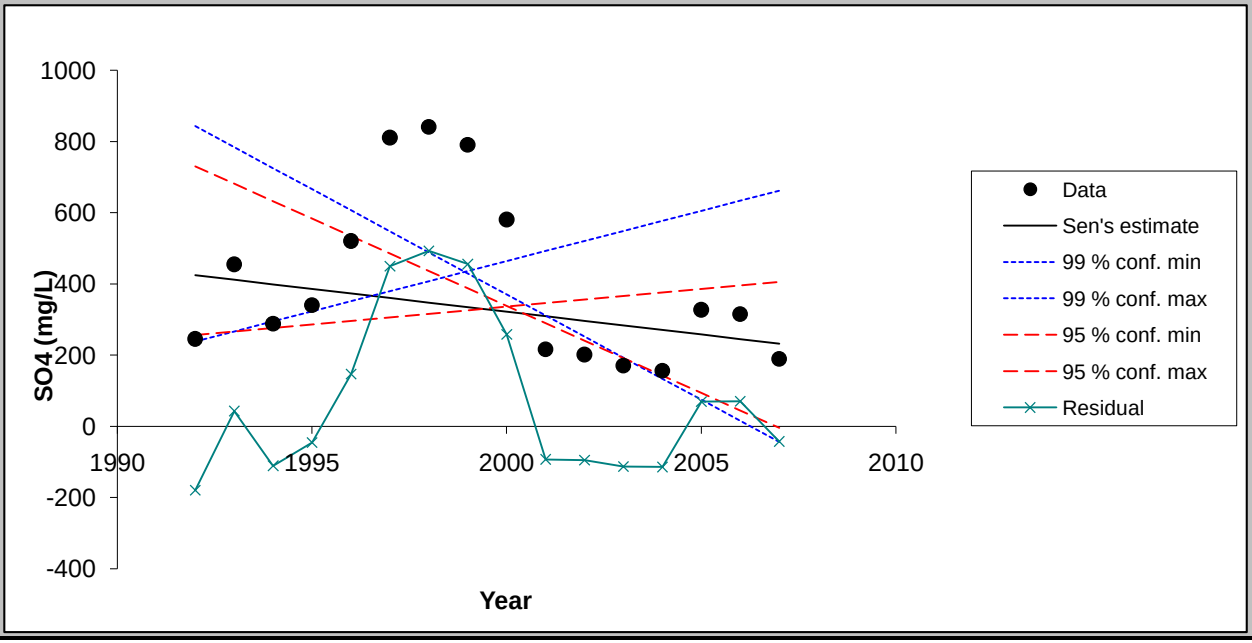

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	245.00	424.53	843.22	238.29	729.61	256.59	-179.53
1993	454.50	411.68	784.07	266.50	680.66	266.50	42.82
1994	288.00	398.83	724.92	294.71	631.71	276.41	-110.83
1995	340.00	385.99	665.77	322.91	582.75	286.31	-45.99
1996	520.00	373.14	606.62	351.12	533.80	296.22	146.86
1997	810.00	360.29	547.47	379.32	484.85	306.12	449.71
1998	840.00	347.44	488.32	407.53	435.90	316.03	492.56
1999	790.00	334.60	429.17	435.74	386.95	325.94	455.40
2000	580.00	321.75	370.02	463.94	338.00	335.84	258.25
2001	216.00	308.90	310.87	492.15	289.05	345.75	-92.90
2002	201.00	296.06	251.72	520.35	240.10	355.66	-95.06
2003	170.00	283.21	192.57	548.56	191.15	365.56	-113.21
2004	156.00	270.36	133.43	576.77	142.20	375.47	-114.36
2005	327.00	257.51	74.28	604.97	93.25	385.37	69.49
2006	315.00	244.67	15.13	633.18	44.29	395.28	70.33
2007	189.00	231.82	-44.02	661.38	-4.66	405.19	-42.82

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-37 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.389	19.93	1.07	5.5	0.076	59		200
1992	0.455	13.35	1.21	6.72	0.497	75.8	0.715	256
1993	0.4055	13.88	0.999	7.03	0.706	54.3	0.647	233.5
1994	0.4965	14.9	1.19	8.2	0.567	79.5	0.641	297
1995	0.387	15	0.798	6.6	0.53	36	0.542	180
1996	0.36	14	0.7	6.2	0.35	39	0.489	190
1997	0.31	16	0.494	6.7	0.46	28	0.401	170
1998	0.34	12	0.668	7.2	0.33	36	0.423	420
1999	0.34	13	0.615	6.9	0.31	25	0.419	210
2000	0.43	12	0.680	7.6	0.37	40	0.383	280
2001	0.397	11.7	0.8	7.1	0.389	31	0.45	214
2002	0.3400	12.96	0.701	6.08	0.357	25	0.439	188.1
2003	0.394	10.8	0.771	9.53	0.553	32.1	0.427	255
2004	0.399	11.8	0.768	8.91	0.445	35.8	0.412	307
2005	0.452	10.8	0.548	9.42	0.493	76.8	0.336	351
2006	0.539	9.67	0.614	11.2	0.5	139	0.312	361
2007	0.577	9.77	0.589	10.8	0.162	130	0.299	407

TREND STATISTICS

TW-37 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		0.99		0.005	-0.007	0.018	-0.004	0.014	0.37	0.46	0.26	0.44	0.29
F (mg/L)	*1991*	*2007*	*17*		-3.84	***	-0.378	-0.627	-0.195	-0.544	-0.241	15.89	18.02	14.27	17.33	14.36
Mn (mg/L)	*1991*	*2007*	*17*		-2.60	**	-0.026	-0.053	0.000	-0.046	-0.009	1.00	1.26	0.70	1.19	0.80
Nitrate (mg/L)	*1991*	*2007*	*17*		3.01	**	0.259	0.052	0.460	0.100	0.377	5.54	6.84	3.94	6.62	4.56
Se (mg/L)	*1991*	*2007*	*17*		-0.37		-0.004	-0.030	0.024	-0.024	0.019	0.48	0.65	0.16	0.62	0.22
Cl (mg/L)	*1991*	*2007*	*17*		-0.12		-0.028	-3.719	5.887	-2.750	4.170	39.14	68.19	-5.21	59.75	18.15
Mo (mg/L)	*1992*	*2007*	*16*		-3.92	***	-0.023	-0.034	-0.012	-0.029	-0.013	0.67	0.75	0.55	0.73	0.57
SO4 (mg/L)	*1991*	*2007*	*17*		2.02	*	9.330	-3.123	21.316	1.032	19.299	196.03	259.12	65.95	242.62	93.51
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	0.99
Signific.	
Q	4.53E-03
Qmin99	-6.78E-03
Qmax99	1.83E-02
Qmin95	-4.36E-03
Qmax95	1.40E-02
B	3.69E-01
Bmin99	4.62E-01
Bmax99	2.65E-01
Bmin95	4.41E-01
Bmax95	2.90E-01

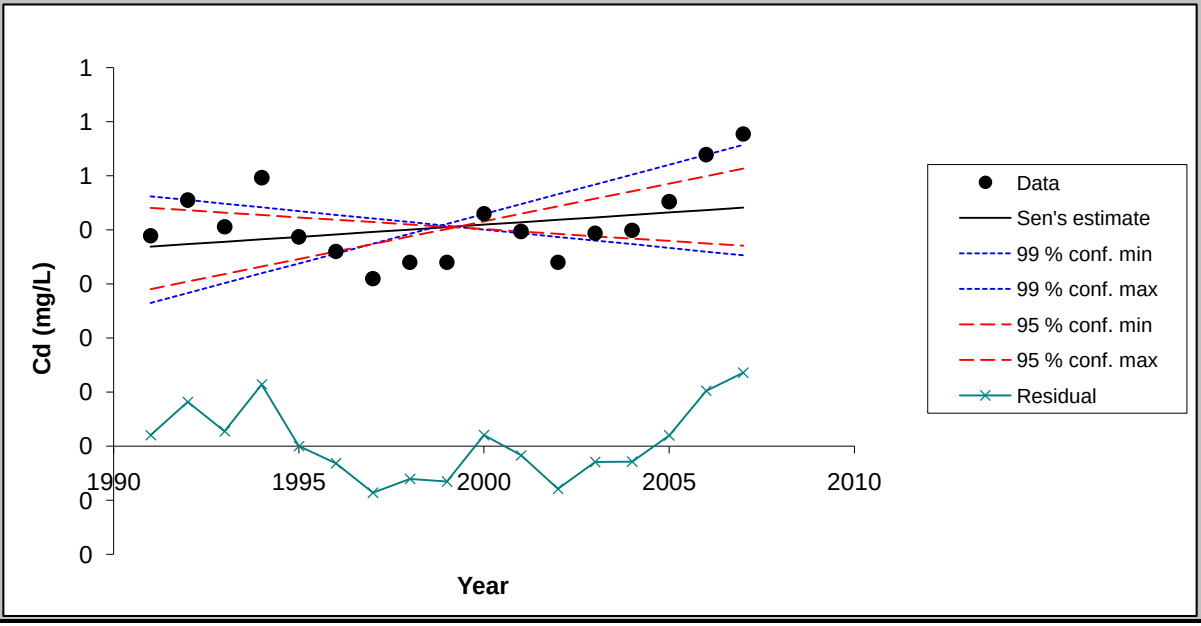

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.39	0.37	0.46	0.26	0.44	0.29	0.02
1992	0.45	0.37	0.45	0.28	0.44	0.30	0.08
1993	0.41	0.38	0.45	0.30	0.43	0.32	0.03
1994	0.50	0.38	0.44	0.32	0.43	0.33	0.11
1995	0.39	0.39	0.43	0.34	0.42	0.35	0.00
1996	0.36	0.39	0.43	0.36	0.42	0.36	-0.03
1997	0.31	0.40	0.42	0.37	0.41	0.37	-0.09
1998	0.34	0.40	0.41	0.39	0.41	0.39	-0.06
1999	0.34	0.41	0.41	0.41	0.41	0.40	-0.07
2000	0.43	0.41	0.40	0.43	0.40	0.42	0.02
2001	0.40	0.41	0.39	0.45	0.40	0.43	-0.02
2002	0.34	0.42	0.39	0.47	0.39	0.44	-0.08
2003	0.39	0.42	0.38	0.48	0.39	0.46	-0.03
2004	0.40	0.43	0.37	0.50	0.38	0.47	-0.03
2005	0.45	0.43	0.37	0.52	0.38	0.49	0.02
2006	0.54	0.44	0.36	0.54	0.38	0.50	0.10
2007	0.58	0.44	0.35	0.56	0.37	0.51	0.14

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.84
Signific.	***
Q	-3.78E-01
Qmin99	-6.27E-01
Qmax99	-1.95E-01
Qmin95	-5.44E-01
Qmax95	-2.41E-01
B	1.59E+01
Bmin99	1.80E+01
Bmax99	1.43E+01
Bmin95	1.73E+01
Bmax95	1.44E+01

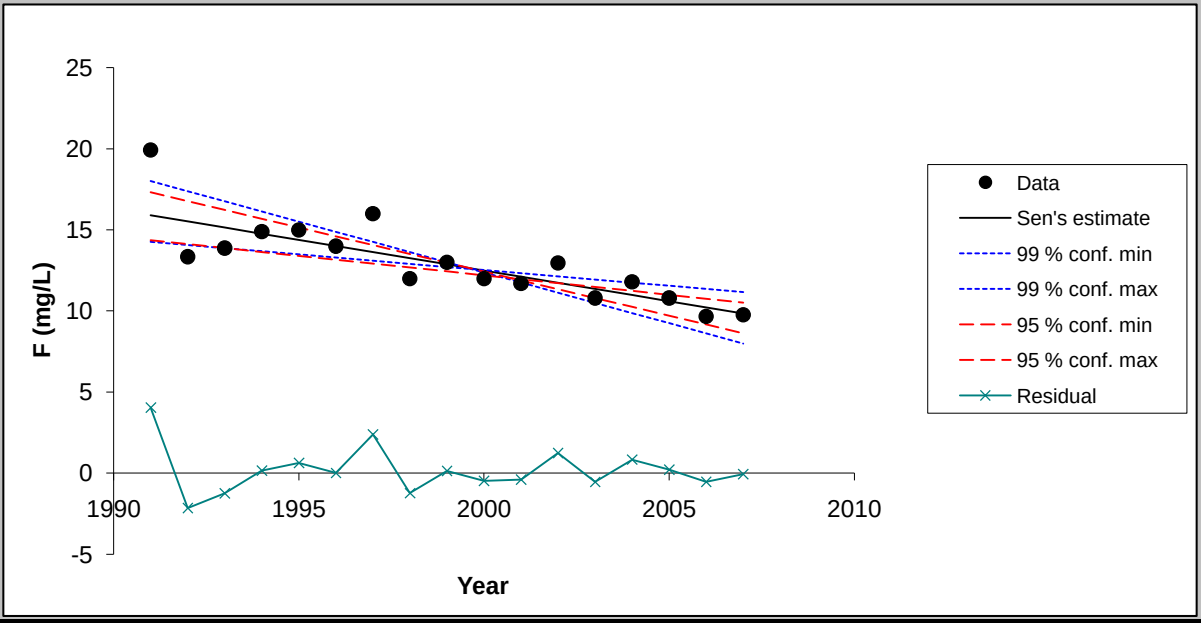

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	19.93	15.89	18.02	14.27	17.33	14.36	4.04
1992	13.35	15.51	17.39	14.07	16.78	14.12	-2.16
1993	13.88	15.14	16.76	13.88	16.24	13.88	-1.25
1994	14.90	14.76	16.14	13.69	15.69	13.64	0.14
1995	15.00	14.38	15.51	13.49	15.15	13.40	0.62
1996	14.00	14.00	14.88	13.30	14.61	13.16	0.00
1997	16.00	13.62	14.25	13.10	14.06	12.92	2.38
1998	12.00	13.24	13.63	12.91	13.52	12.68	-1.24
1999	13.00	12.86	13.00	12.71	12.98	12.44	0.14
2000	12.00	12.49	12.37	12.52	12.43	12.20	-0.49
2001	11.70	12.11	11.75	12.32	11.89	11.95	-0.41
2002	12.96	11.73	11.12	12.13	11.34	11.71	1.23
2003	10.80	11.35	10.49	11.93	10.80	11.47	-0.55
2004	11.80	10.97	9.86	11.74	10.26	11.23	0.83
2005	10.80	10.59	9.24	11.54	9.71	10.99	0.21
2006	9.67	10.22	8.61	11.35	9.17	10.75	-0.55
2007	9.77	9.84	7.98	11.16	8.62	10.51	-0.07

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.60
Signific.	**
Q	-2.57E-02
Qmin99	-5.25E-02
Qmax99	-6.00E-05
Qmin95	-4.57E-02
Qmax95	-8.64E-03
B	1.00E+00
Bmin99	1.26E+00
Bmax99	7.02E-01
Bmin95	1.19E+00
Bmax95	7.96E-01

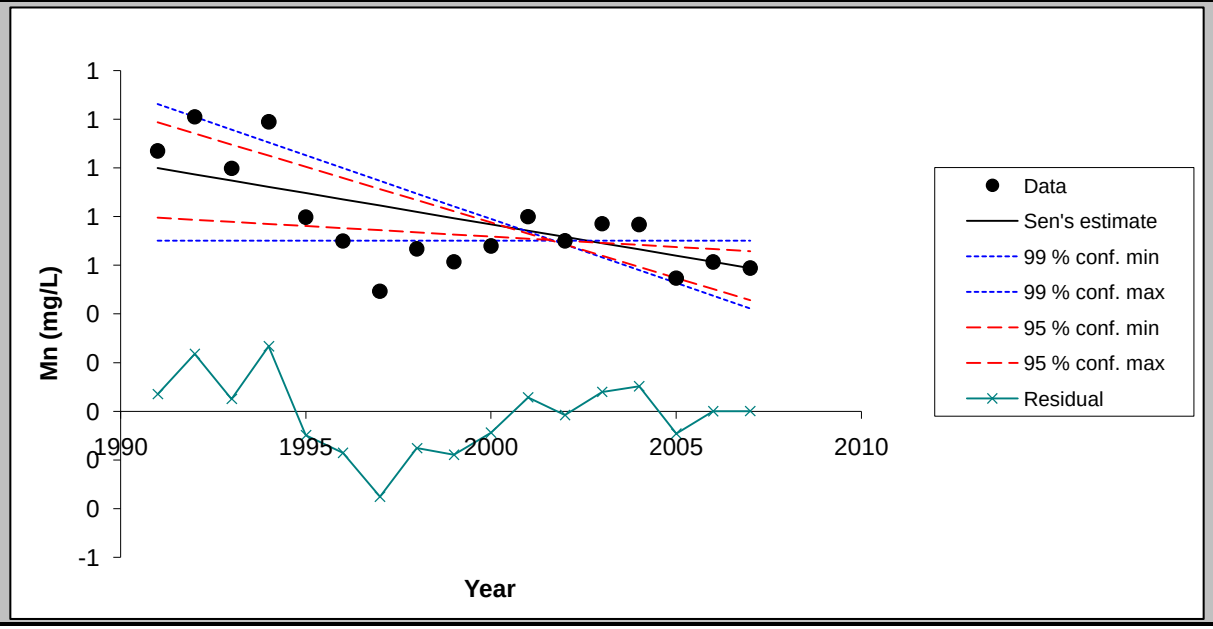

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	1.07	1.00	1.26	0.70	1.19	0.80	0.07
1992	1.21	0.97	1.21	0.70	1.14	0.79	0.24
1993	1.00	0.95	1.16	0.70	1.10	0.78	0.05
1994	1.19	0.92	1.10	0.70	1.05	0.77	0.27
1995	0.80	0.90	1.05	0.70	1.01	0.76	-0.10
1996	0.70	0.87	1.00	0.70	0.96	0.75	-0.17
1997	0.49	0.85	0.95	0.70	0.91	0.74	-0.35
1998	0.67	0.82	0.89	0.70	0.87	0.74	-0.15
1999	0.62	0.79	0.84	0.70	0.82	0.73	-0.18
2000	0.68	0.77	0.79	0.70	0.78	0.72	-0.09
2001	0.80	0.74	0.74	0.70	0.73	0.71	0.06
2002	0.70	0.72	0.68	0.70	0.69	0.70	-0.02
2003	0.77	0.69	0.63	0.70	0.64	0.69	0.08
2004	0.77	0.67	0.58	0.70	0.59	0.68	0.10
2005	0.55	0.64	0.53	0.70	0.55	0.68	-0.09
2006	0.61	0.61	0.47	0.70	0.50	0.67	0.00
2007	0.59	0.59	0.42	0.70	0.46	0.66	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-37 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	3.01
Signific.	**
Q	2.59E-01
Qmin99	5.20E-02
Qmax99	4.60E-01
Qmin95	1.00E-01
Qmax95	3.77E-01
B	5.54E+00
Bmin99	6.84E+00
Bmax99	3.94E+00
Bmin95	6.62E+00
Bmax95	4.56E+00

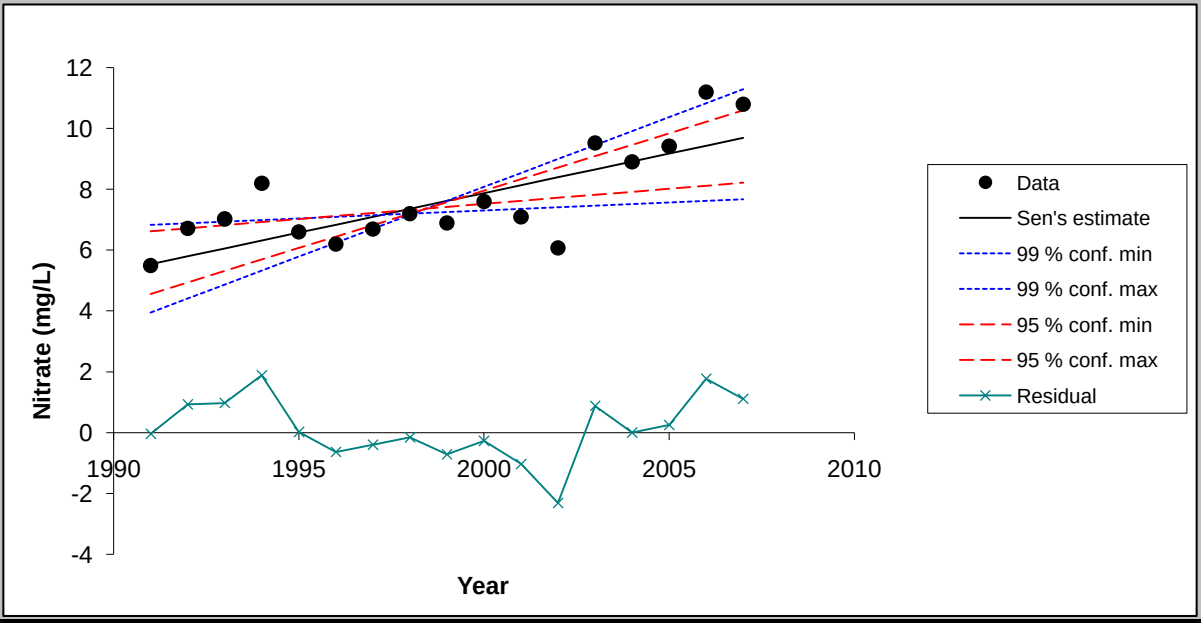

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	5.50	5.54	6.84	3.94	6.62	4.56	-0.04
1992	6.72	5.80	6.89	4.40	6.72	4.94	0.92
1993	7.03	6.06	6.94	4.86	6.82	5.31	0.97
1994	8.20	6.32	6.99	5.32	6.92	5.69	1.88
1995	6.60	6.57	7.04	5.78	7.02	6.07	0.03
1996	6.20	6.83	7.10	6.24	7.12	6.45	-0.63
1997	6.70	7.09	7.15	6.70	7.22	6.82	-0.39
1998	7.20	7.35	7.20	7.16	7.32	7.20	-0.15
1999	6.90	7.61	7.25	7.62	7.42	7.58	-0.71
2000	7.60	7.87	7.30	8.08	7.52	7.95	-0.27
2001	7.10	8.13	7.36	8.54	7.62	8.33	-1.03
2002	6.08	8.39	7.41	9.00	7.72	8.71	-2.31
2003	9.53	8.65	7.46	9.46	7.82	9.09	0.88
2004	8.91	8.91	7.51	9.92	7.92	9.46	0.00
2005	9.42	9.17	7.56	10.38	8.02	9.84	0.25
2006	11.20	9.43	7.62	10.84	8.12	10.22	1.77
2007	10.80	9.69	7.67	11.30	8.22	10.59	1.11

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.37
Signific.	
Q	-4.00E-03
Qmin99	-2.99E-02
Qmax99	2.36E-02
Qmin95	-2.36E-02
Qmax95	1.89E-02
B	4.84E-01
Bmin99	6.49E-01
Bmax99	1.62E-01
Bmin95	6.17E-01
Bmax95	2.16E-01

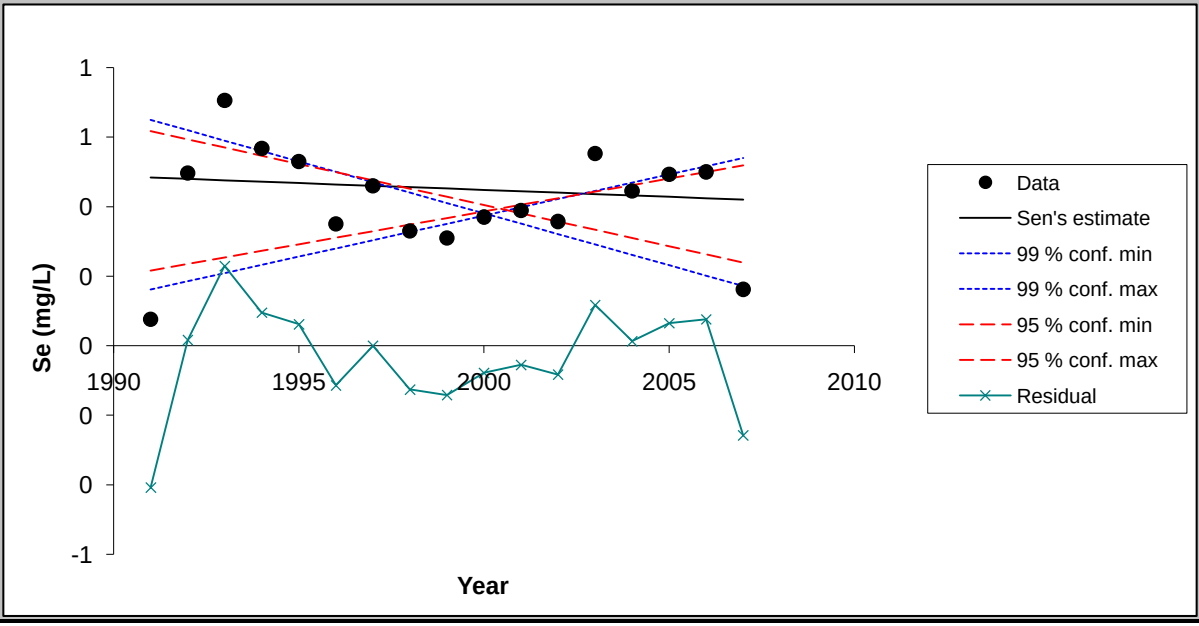

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.08	0.48	0.65	0.16	0.62	0.22	-0.41
1992	0.50	0.48	0.62	0.19	0.59	0.23	0.02
1993	0.71	0.48	0.59	0.21	0.57	0.25	0.23
1994	0.57	0.47	0.56	0.23	0.55	0.27	0.10
1995	0.53	0.47	0.53	0.26	0.52	0.29	0.06
1996	0.35	0.46	0.50	0.28	0.50	0.31	-0.11
1997	0.46	0.46	0.47	0.30	0.48	0.33	0.00
1998	0.33	0.46	0.44	0.33	0.45	0.35	-0.13
1999	0.31	0.45	0.41	0.35	0.43	0.37	-0.14
2000	0.37	0.45	0.38	0.37	0.40	0.39	-0.08
2001	0.39	0.44	0.35	0.40	0.38	0.41	-0.06
2002	0.36	0.44	0.32	0.42	0.36	0.42	-0.08
2003	0.55	0.44	0.29	0.45	0.33	0.44	0.12
2004	0.45	0.43	0.26	0.47	0.31	0.46	0.01
2005	0.49	0.43	0.23	0.49	0.29	0.48	0.06
2006	0.50	0.42	0.20	0.52	0.26	0.50	0.08
2007	0.16	0.42	0.17	0.54	0.24	0.52	-0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.12
Signific.	
Q	-2.78E-02
Qmin99	-3.72E+00
Qmax99	5.89E+00
Qmin95	-2.75E+00
Qmax95	4.17E+00
B	3.91E+01
Bmin99	6.82E+01
Bmax99	-5.21E+00
Bmin95	5.98E+01
Bmax95	1.81E+01

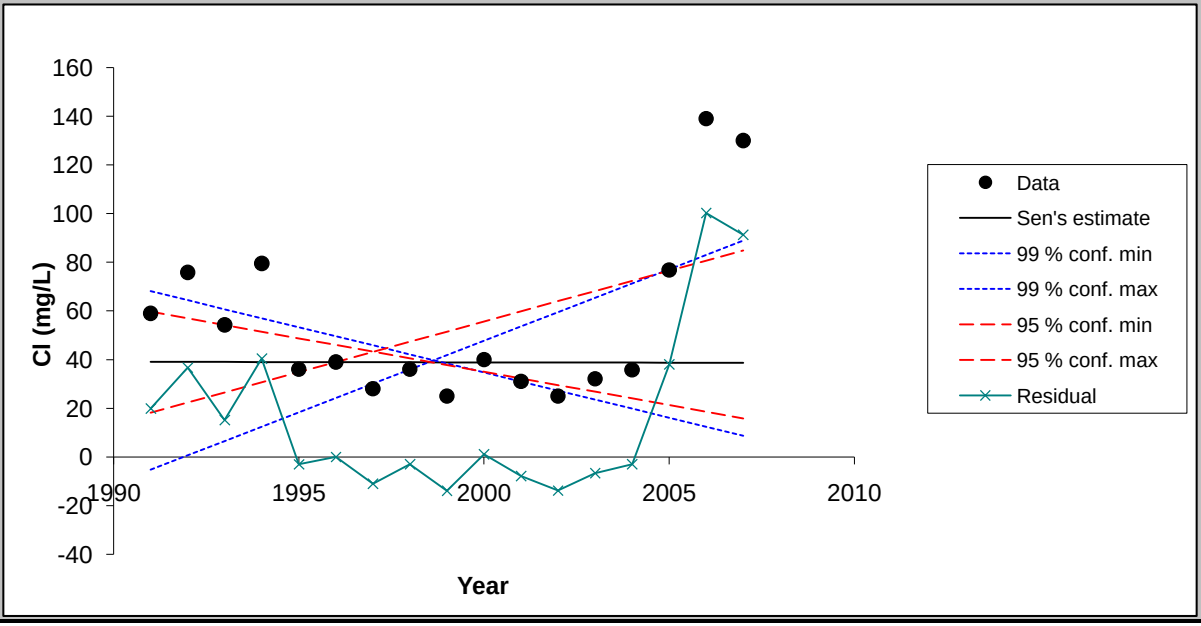

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	59.00	39.14	68.19	-5.21	59.75	18.15	19.86
1992	75.80	39.11	64.47	0.68	57.00	22.32	36.69
1993	54.25	39.08	60.75	6.57	54.25	26.49	15.17
1994	79.50	39.06	57.03	12.45	51.50	30.66	40.44
1995	36.00	39.03	53.32	18.34	48.75	34.83	-3.03
1996	39.00	39.00	49.60	24.23	46.00	39.00	0.00
1997	28.00	38.97	45.88	30.11	43.25	43.17	-10.97
1998	36.00	38.94	42.16	36.00	40.50	47.34	-2.94
1999	25.00	38.92	38.44	41.89	37.75	51.51	-13.92
2000	40.00	38.89	34.72	47.77	35.00	55.68	1.11
2001	31.00	38.86	31.00	53.66	32.25	59.85	-7.86
2002	25.00	38.83	27.28	59.55	29.50	64.02	-13.83
2003	32.10	38.81	23.56	65.43	26.75	68.19	-6.71
2004	35.80	38.78	19.84	71.32	24.00	72.36	-2.98
2005	76.80	38.75	16.12	77.21	21.25	76.53	38.05
2006	139.00	38.72	12.40	83.09	18.50	80.70	100.28
2007	130.00	38.69	8.68	88.98	15.75	84.87	91.31

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-3.92
Signific.	***
Q	-2.33E-02
Qmin99	-3.37E-02
Qmax99	-1.16E-02
Qmin95	-2.91E-02
Qmax95	-1.34E-02
B	6.66E-01
Bmin99	7.45E-01
Bmax99	5.55E-01
Bmin95	7.34E-01
Bmax95	5.70E-01

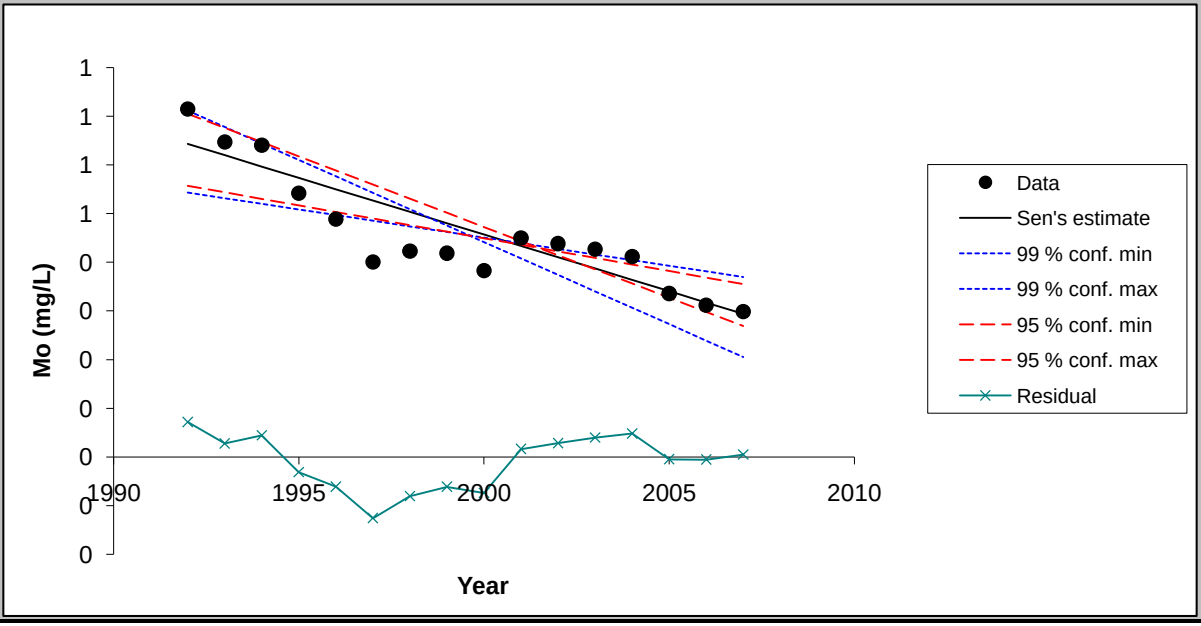

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.72	0.64	0.71	0.54	0.71	0.56	0.07
1993	0.65	0.62	0.68	0.53	0.68	0.54	0.03
1994	0.64	0.60	0.64	0.52	0.65	0.53	0.04
1995	0.54	0.57	0.61	0.51	0.62	0.52	-0.03
1996	0.49	0.55	0.58	0.50	0.59	0.50	-0.06
1997	0.40	0.53	0.54	0.49	0.56	0.49	-0.13
1998	0.42	0.50	0.51	0.47	0.53	0.48	-0.08
1999	0.42	0.48	0.48	0.46	0.50	0.46	-0.06
2000	0.38	0.46	0.44	0.45	0.47	0.45	-0.07
2001	0.45	0.43	0.41	0.44	0.44	0.44	0.02
2002	0.44	0.41	0.37	0.43	0.41	0.42	0.03
2003	0.43	0.39	0.34	0.42	0.39	0.41	0.04
2004	0.41	0.36	0.31	0.40	0.36	0.40	0.05
2005	0.34	0.34	0.27	0.39	0.33	0.38	0.00
2006	0.31	0.32	0.24	0.38	0.30	0.37	-0.01
2007	0.30	0.29	0.21	0.37	0.27	0.36	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-37 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	2.02
Signific.	*
Q	9.33E+00
Qmin99	-3.12E+00
Qmax99	2.13E+01
Qmin95	1.03E+00
Qmax95	1.93E+01
B	1.96E+02
Bmin99	2.59E+02
Bmax99	6.59E+01
Bmin95	2.43E+02
Bmax95	9.35E+01

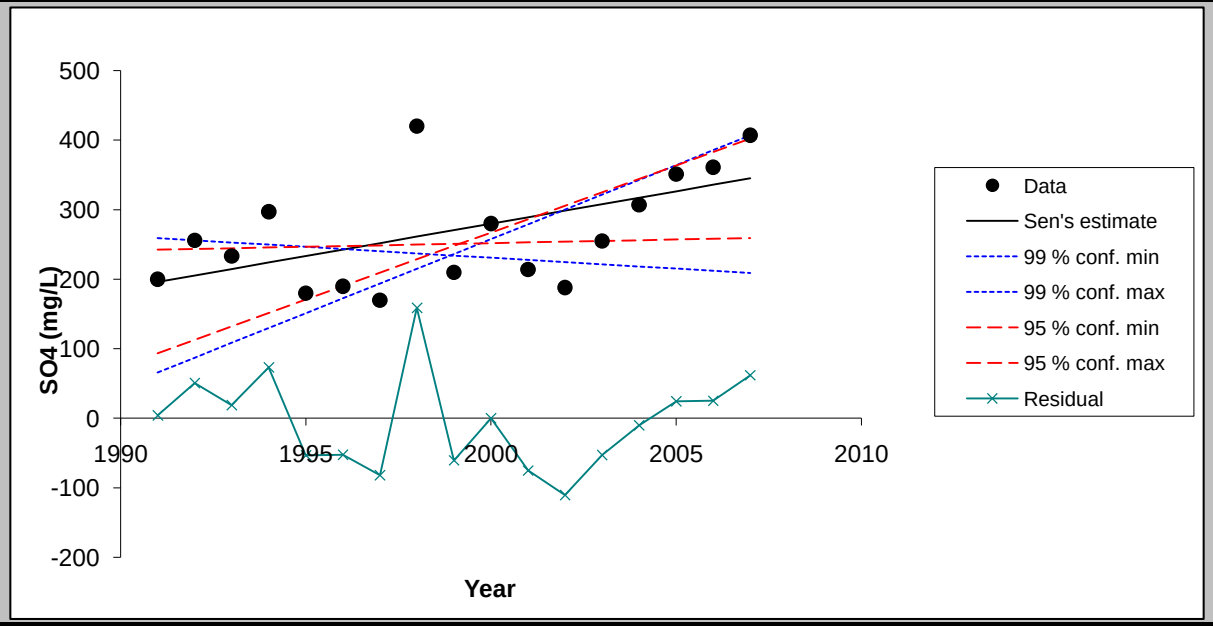

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	200.00	196.03	259.12	65.95	242.62	93.51	3.97
1992	256.00	205.36	256.00	87.26	243.65	112.80	50.64
1993	233.50	214.69	252.88	108.58	244.68	132.10	18.81
1994	297.00	224.02	249.75	129.90	245.71	151.40	72.98
1995	180.00	233.35	246.63	151.21	246.74	170.70	-53.35
1996	190.00	242.68	243.51	172.53	247.78	190.00	-52.68
1997	170.00	252.01	240.38	193.84	248.81	209.30	-82.01
1998	420.00	261.34	237.26	215.16	249.84	228.60	158.66
1999	210.00	270.67	234.14	236.47	250.87	247.90	-60.67
2000	280.00	280.00	231.01	257.79	251.90	267.20	0.00
2001	214.00	289.33	227.89	279.11	252.94	286.49	-75.33
2002	188.07	298.66	224.77	300.42	253.97	305.79	-110.59
2003	255.00	307.99	221.64	321.74	255.00	325.09	-52.99
2004	307.00	317.32	218.52	343.05	256.03	344.39	-10.32
2005	351.00	326.65	215.40	364.37	257.06	363.69	24.35
2006	361.00	335.98	212.27	385.68	258.10	382.99	25.02
2007	407.00	345.31	209.15	407.00	259.13	402.29	61.69

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-45 (1991-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	17	17	17	17	17	17	16	17
Select the FIRST YEAR of the calculation:	1991	1991	1991	1991	1991	1991	1992	1991
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.03	1.21	0.64	0.25	0.0015	65		70
1992	0.0123	0.865	0.506	0.3	0.009	61.8	0.0445	195.5
1993	0.0099	0.78	0.671	0.08	0.0035	53.6	0.0308	175.5
1994	0.0197	0.895	0.593	0.156	0.0092	63.8	0.0315	183.5
1995	0.008	0.92	0.584	0.014	0.017	46	0.033	140
1996	0.0036	0.87	0.554	0.061	0.0005	43	0.031	140
1997	0.007	0.83	0.527	0.016	0.0005	43	0.027	140
1998	0.006	0.8	0.487	0.035	0.001	41	0.024	140
1999	0.004	0.81	0.488	0.011	0.0005	32	0.023	150
2000	0.007	0.79	0.452	0.024	0.005	38	0.024	160
2001	0.006	0.8	0.49	0.025	0.0025	35	0.005	122
2002	0.0062	0.973	0.498	0.025	0.0025	29.1	0.0248	115.8
2003	0.0038	0.55	0.47	0.01	0.005	33.3	0.041	135
2004	0.0043	0.33	0.469	0.01	0.0015	30.9	0.027	132
2005	0.0046	0.33	0.458	0.01	0.0045	33.8	0.026	125
2006	0.0035	0.82	0.439	0.01	0.003	25.5	0.019	110
2007	0.002	0.93	0.432	0.01	0.0003	30.1	0.029	120

TREND STATISTICS

TW-45 (1991-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*1991*	*2007*	*17*		-3.67	***	-0.0006	-0.0014	-0.0003	-0.0011	-0.0004	0.012	0.020	0.009	0.017	0.010
F (mg/L)	*1991*	*2007*	*17*		-1.69	+	-0.017	-0.050	0.004	-0.044	0.001	0.95	1.15	0.78	1.09	0.80
Mn (mg/L)	*1991*	*2007*	*17*		-4.16	***	-0.012	-0.018	-0.006	-0.015	-0.007	0.62	0.66	0.55	0.64	0.56
Nitrate (mg/L)	*1991*	*2007*	*17*		-3.76	***	-0.005	-0.018	0.000	-0.015	-0.002	0.08	0.21	0.03	0.19	0.04
Se (mg/L)	*1991*	*2007*	*17*		-0.70		-0.0001	-0.0007	0.0003	-0.0005	0.0002	0.003	0.010	-0.001	0.008	0.000
Cl (mg/L)	*1991*	*2007*	*17*		-4.45	***	-2.073	-3.036	-1.317	-2.775	-1.571	56.66	65.00	50.22	62.97	52.16
Mo (mg/L)	*1992*	*2007*	*16*		-1.80	+	-0.0008	-0.0020	0.0005	-0.0016	0.0002	0.03	0.04	0.02	0.04	0.03
SO4 (mg/L)	*1991*	*2007*	*17*		-2.53	*	-3.600	-6.048	0.000	-5.362	-0.855	175.40	198.38	140.00	190.43	144.27
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	1
Name	Cd (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.67
Signific.	***
Q	-6.01E-04
Qmin99	-1.36E-03
Qmax99	-2.96E-04
Qmin95	-1.06E-03
Qmax95	-4.00E-04
B	1.20E-02
Bmin99	1.96E-02
Bmax99	8.78E-03
Bmin95	1.65E-02
Bmax95	9.60E-03

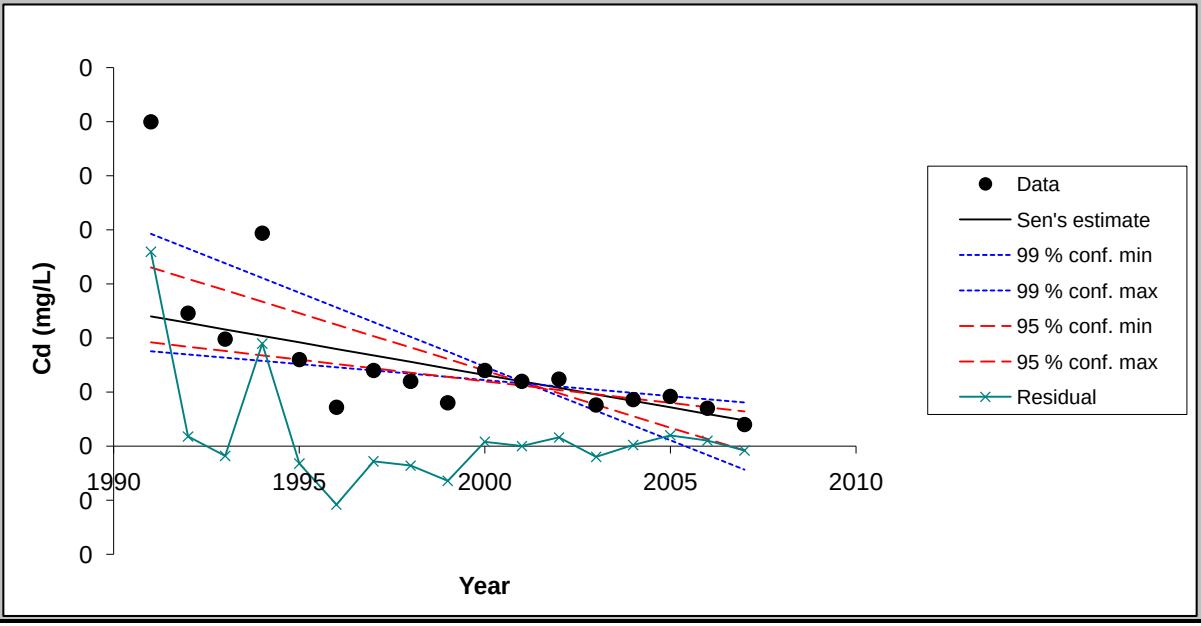

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.03	0.01	0.02	0.01	0.02	0.01	0.02
1992	0.01	0.01	0.02	0.01	0.02	0.01	0.00
1993	0.01	0.01	0.02	0.01	0.01	0.01	0.00
1994	0.02	0.01	0.02	0.01	0.01	0.01	0.01
1995	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1996	0.00	0.01	0.01	0.01	0.01	0.01	-0.01
1997	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1998	0.01	0.01	0.01	0.01	0.01	0.01	0.00
1999	0.00	0.01	0.01	0.01	0.01	0.01	0.00
2000	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2001	0.01	0.01	0.01	0.01	0.01	0.01	0.00
2002	0.01	0.01	0.00	0.01	0.00	0.01	0.00
2003	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	2
Name	F (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-1.69
Signific.	+
Q	-1.72E-02
Qmin99	-5.00E-02
Qmax99	4.07E-03
Qmin95	-4.37E-02
Qmax95	1.38E-03
B	9.47E-01
Bmin99	1.15E+00
Bmax99	7.77E-01
Bmin95	1.09E+00
Bmax95	7.99E-01

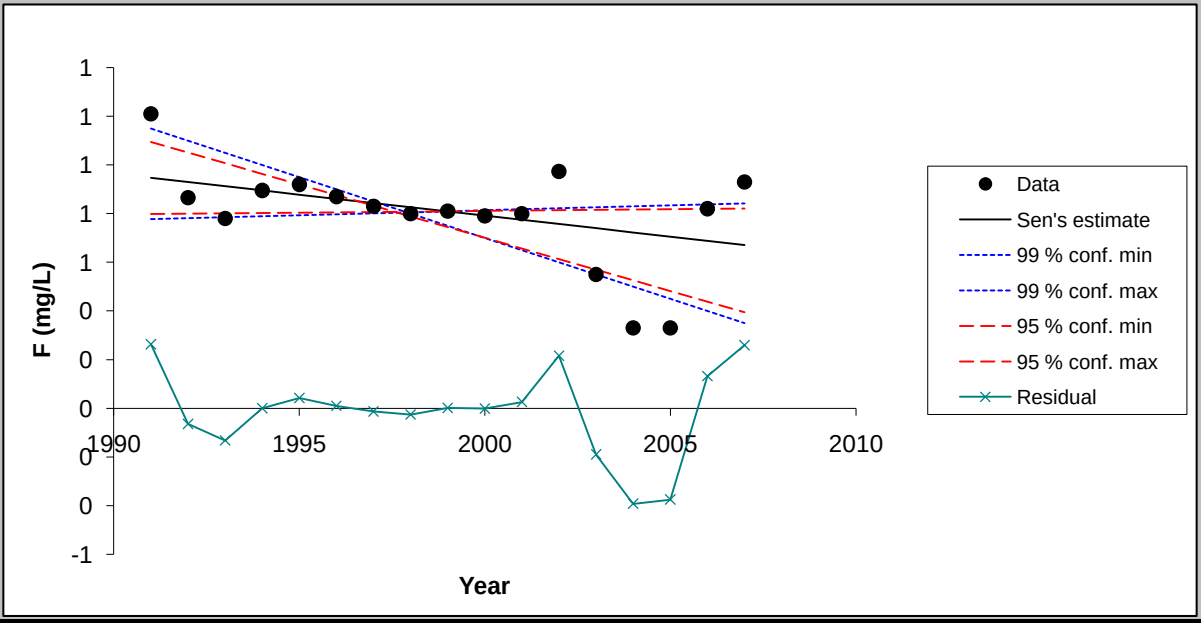

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	1.21	0.95	1.15	0.78	1.09	0.80	0.26
1992	0.86	0.93	1.10	0.78	1.05	0.80	-0.06
1993	0.78	0.91	1.05	0.79	1.01	0.80	-0.13
1994	0.90	0.90	1.00	0.79	0.96	0.80	0.00
1995	0.92	0.88	0.95	0.79	0.92	0.80	0.04
1996	0.87	0.86	0.90	0.80	0.88	0.81	0.01
1997	0.83	0.84	0.85	0.80	0.83	0.81	-0.01
1998	0.80	0.83	0.80	0.81	0.79	0.81	-0.03
1999	0.81	0.81	0.75	0.81	0.75	0.81	0.00
2000	0.79	0.79	0.70	0.81	0.70	0.81	0.00
2001	0.80	0.77	0.65	0.82	0.66	0.81	0.03
2002	0.97	0.76	0.60	0.82	0.61	0.81	0.22
2003	0.55	0.74	0.55	0.83	0.57	0.82	-0.19
2004	0.33	0.72	0.50	0.83	0.53	0.82	-0.39
2005	0.33	0.71	0.45	0.83	0.48	0.82	-0.38
2006	0.82	0.69	0.40	0.84	0.44	0.82	0.13
2007	0.93	0.67	0.35	0.84	0.40	0.82	0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	3
Name	Mn (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-4.16
Signific.	***
Q	-1.24E-02
Qmin99	-1.80E-02
Qmax99	-5.96E-03
Qmin95	-1.50E-02
Qmax95	-7.21E-03
B	6.24E-01
Bmin99	6.56E-01
Bmax99	5.46E-01
Bmin95	6.40E-01
Bmax95	5.62E-01

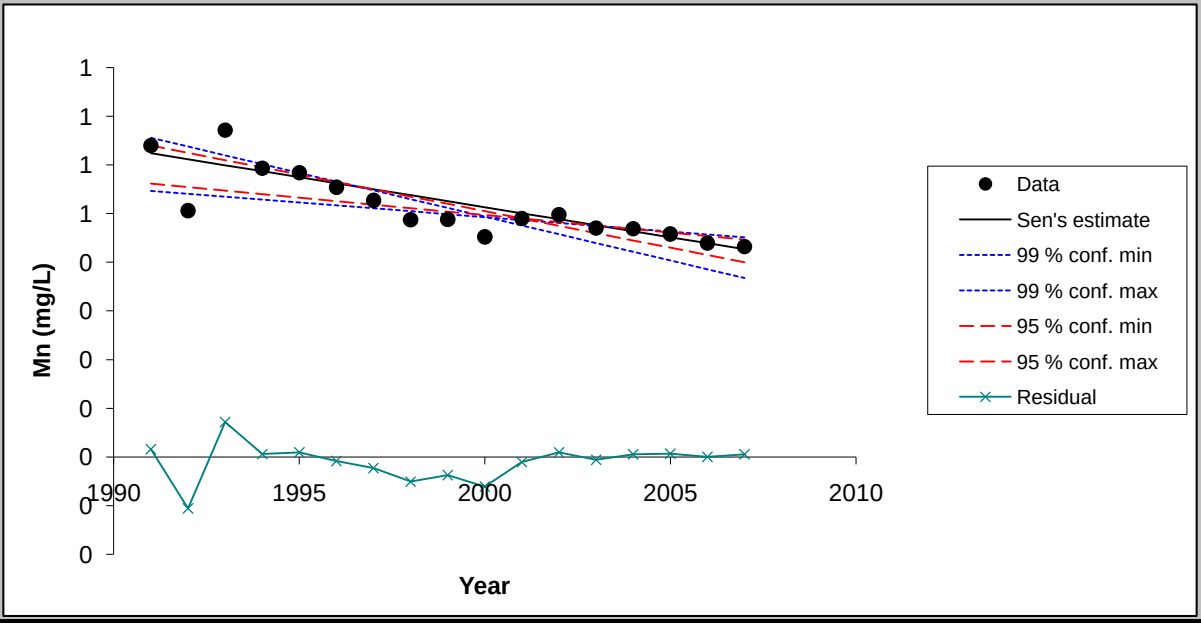

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.64	0.62	0.66	0.55	0.64	0.56	0.02
1992	0.51	0.61	0.64	0.54	0.63	0.55	-0.11
1993	0.67	0.60	0.62	0.53	0.61	0.55	0.07
1994	0.59	0.59	0.60	0.53	0.60	0.54	0.01
1995	0.58	0.57	0.58	0.52	0.58	0.53	0.01
1996	0.55	0.56	0.57	0.52	0.57	0.53	-0.01
1997	0.53	0.55	0.55	0.51	0.55	0.52	-0.02
1998	0.49	0.54	0.53	0.50	0.54	0.51	-0.05
1999	0.49	0.53	0.51	0.50	0.52	0.50	-0.04
2000	0.45	0.51	0.49	0.49	0.51	0.50	-0.06
2001	0.49	0.50	0.48	0.49	0.49	0.49	-0.01
2002	0.50	0.49	0.46	0.48	0.48	0.48	0.01
2003	0.47	0.48	0.44	0.47	0.46	0.48	-0.01
2004	0.47	0.46	0.42	0.47	0.45	0.47	0.01
2005	0.46	0.45	0.40	0.46	0.43	0.46	0.01
2006	0.44	0.44	0.39	0.46	0.42	0.45	0.00
2007	0.43	0.43	0.37	0.45	0.40	0.45	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-3.76
Signific.	***
Q	-5.44E-03
Qmin99	-1.82E-02
Qmax99	-4.56E-04
Qmin95	-1.50E-02
Qmax95	-1.57E-03
B	8.49E-02
Bmin99	2.11E-01
Bmax99	2.81E-02
Bmin95	1.90E-01
Bmax95	3.81E-02

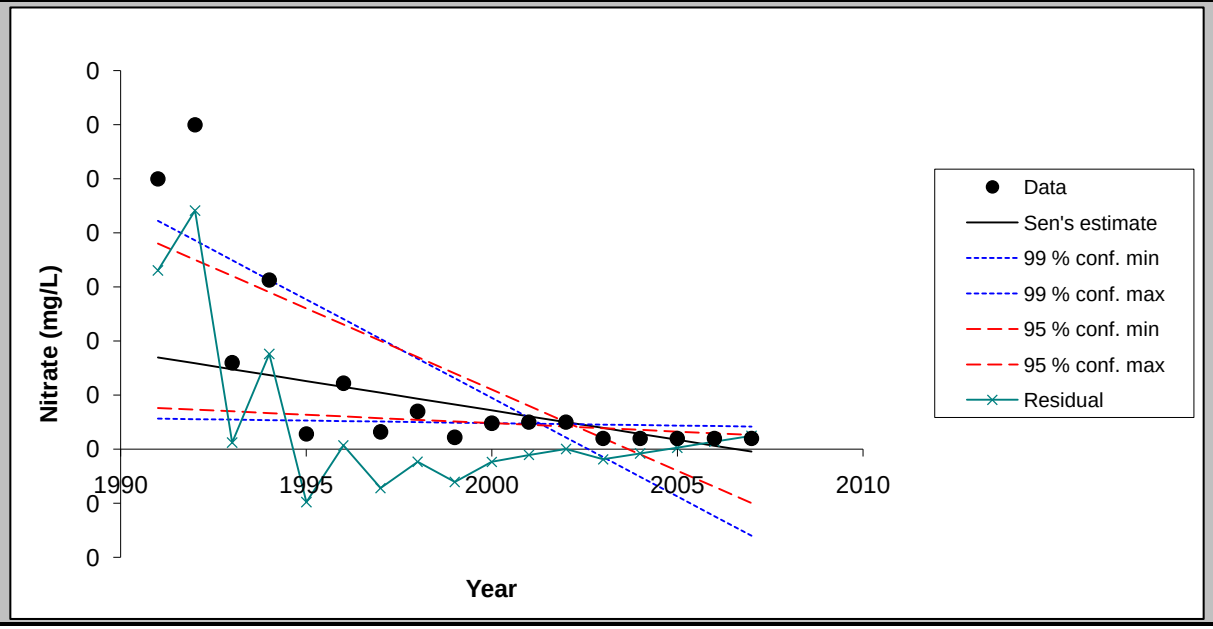

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.25	0.08	0.21	0.03	0.19	0.04	0.17
1992	0.30	0.08	0.19	0.03	0.18	0.04	0.22
1993	0.08	0.07	0.17	0.03	0.16	0.03	0.01
1994	0.16	0.07	0.16	0.03	0.15	0.03	0.09
1995	0.01	0.06	0.14	0.03	0.13	0.03	-0.05
1996	0.06	0.06	0.12	0.03	0.12	0.03	0.00
1997	0.02	0.05	0.10	0.03	0.10	0.03	-0.04
1998	0.04	0.05	0.08	0.02	0.09	0.03	-0.01
1999	0.01	0.04	0.07	0.02	0.07	0.03	-0.03
2000	0.02	0.04	0.05	0.02	0.06	0.02	-0.01
2001	0.03	0.03	0.03	0.02	0.04	0.02	-0.01
2002	0.03	0.03	0.01	0.02	0.03	0.02	0.00
2003	0.01	0.02	-0.01	0.02	0.01	0.02	-0.01
2004	0.01	0.01	-0.03	0.02	-0.01	0.02	0.00
2005	0.01	0.01	-0.04	0.02	-0.02	0.02	0.00
2006	0.01	0.00	-0.06	0.02	-0.04	0.01	0.01
2007	0.01	0.00	-0.08	0.02	-0.05	0.01	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	5
Name	Se (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-0.70
Signific.	
Q	-7.64E-05
Qmin99	-6.91E-04
Qmax99	3.37E-04
Qmin95	-5.00E-04
Qmax95	2.10E-04
B	3.34E-03
Bmin99	1.01E-02
Bmax99	-8.68E-04
Bmin95	8.00E-03
Bmax95	4.01E-04

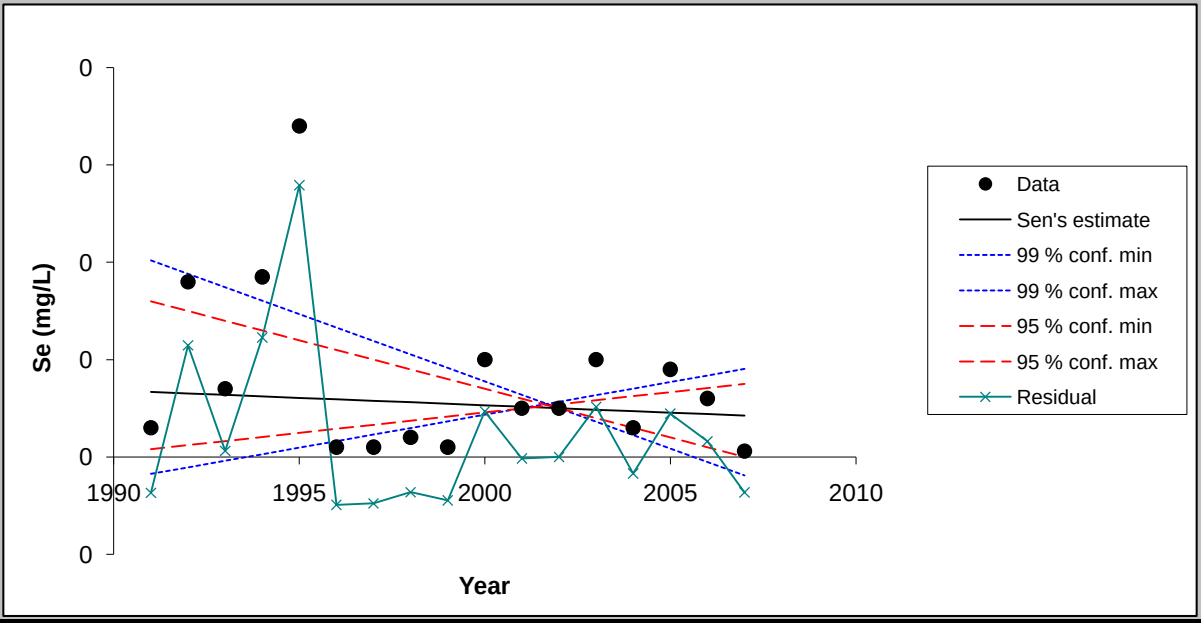

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1992	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1993	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1994	0.01	0.00	0.01	0.00	0.01	0.00	0.01
1995	0.02	0.00	0.01	0.00	0.01	0.00	0.01
1996	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1997	0.00	0.00	0.01	0.00	0.01	0.00	0.00
1998	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	6
Name	Cl (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-4.45
Signific.	***
Q	-2.07E+00
Qmin99	-3.04E+00
Qmax99	-1.32E+00
Qmin95	-2.77E+00
Qmax95	-1.57E+00
B	5.67E+01
Bmin99	6.50E+01
Bmax99	5.02E+01
Bmin95	6.30E+01
Bmax95	5.22E+01

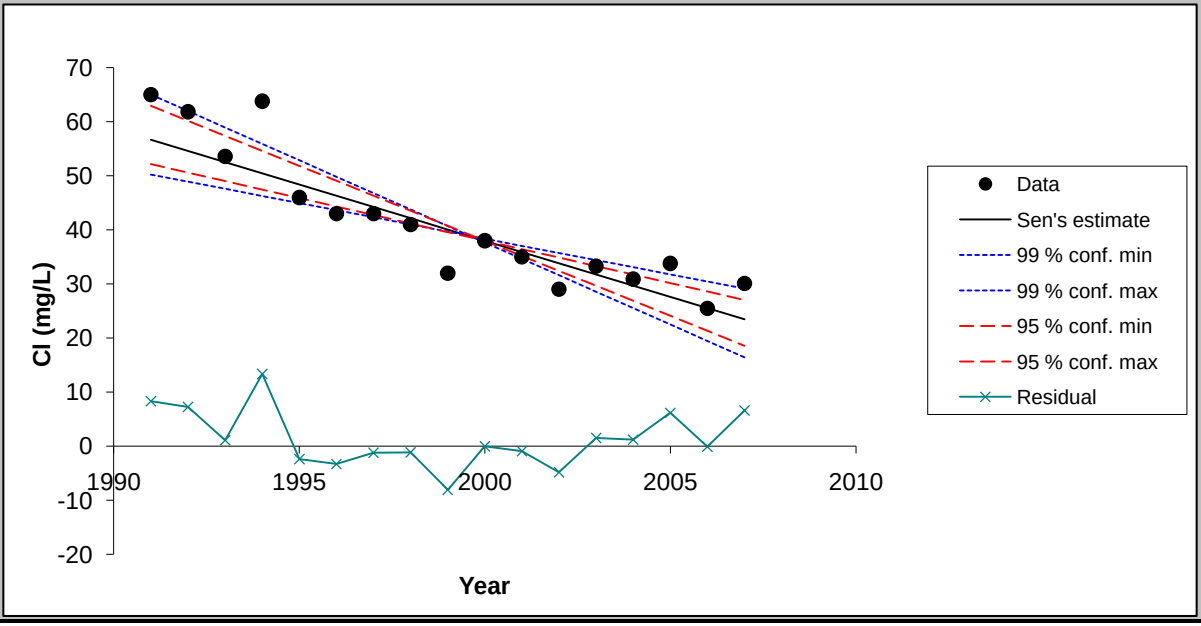

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	65.00	56.66	65.00	50.22	62.97	52.16	8.34
1992	61.85	54.59	61.96	48.90	60.20	50.59	7.26
1993	53.60	52.51	58.93	47.58	57.42	49.01	1.09
1994	63.80	50.44	55.89	46.27	54.65	47.44	13.36
1995	46.00	48.37	52.86	44.95	51.87	45.87	-2.37
1996	43.00	46.29	49.82	43.63	49.10	44.30	-3.29
1997	43.00	44.22	46.78	42.32	46.32	42.73	-1.22
1998	41.00	42.15	43.75	41.00	43.55	41.16	-1.15
1999	32.00	40.07	40.71	39.68	40.77	39.59	-8.07
2000	38.00	38.00	37.67	38.37	38.00	38.01	0.00
2001	35.00	35.93	34.64	37.05	35.23	36.44	-0.93
2002	29.06	33.85	31.60	35.73	32.45	34.87	-4.80
2003	33.30	31.78	28.57	34.42	29.68	33.30	1.52
2004	30.90	29.71	25.53	33.10	26.90	31.73	1.19
2005	33.80	27.63	22.49	31.78	24.13	30.16	6.17
2006	25.50	25.56	19.46	30.47	21.35	28.59	-0.06
2007	30.10	23.49	16.42	29.15	18.58	27.01	6.61

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	7
Name	Mo (mg/L)
Years	1992 - 2007
n	16
Test S	
Test Z	-1.80
Signific.	+
Q	-7.67E-04
Qmin99	-2.00E-03
Qmax99	5.00E-04
Qmin95	-1.65E-03
Qmax95	1.64E-04
B	3.35E-02
Bmin99	4.15E-02
Bmax99	2.08E-02
Bmin95	3.94E-02
Bmax95	2.54E-02

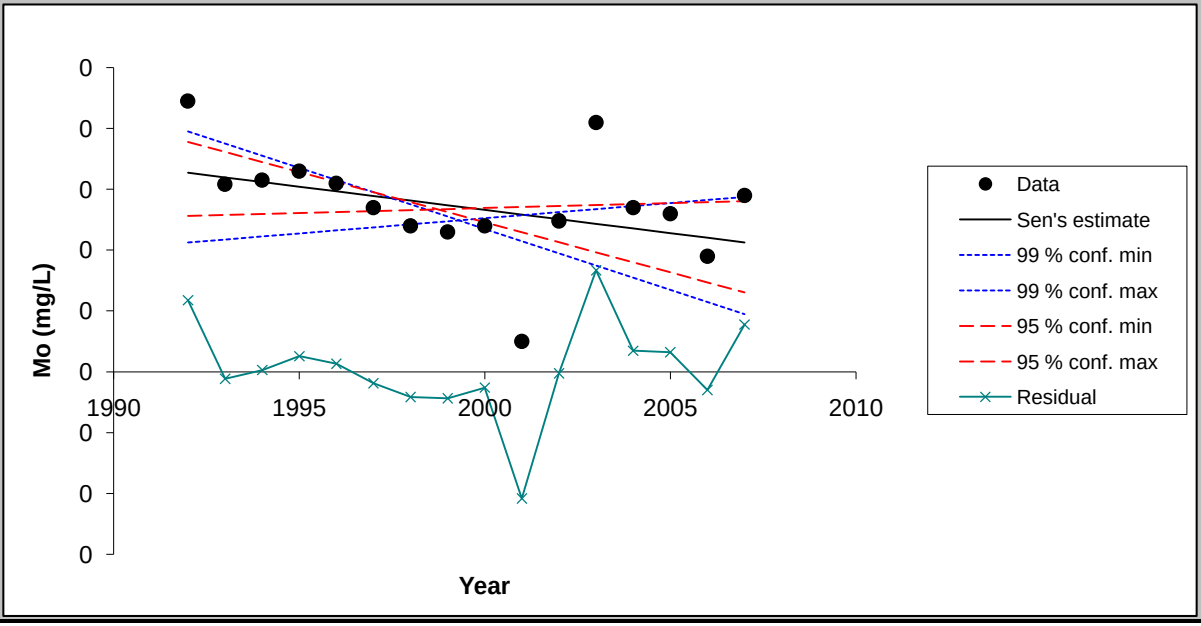

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1992	0.04	0.03	0.04	0.02	0.04	0.03	0.01
1993	0.03	0.03	0.04	0.02	0.04	0.03	0.00
1994	0.03	0.03	0.04	0.02	0.03	0.03	0.00
1995	0.03	0.03	0.03	0.02	0.03	0.03	0.00
1996	0.03	0.03	0.03	0.02	0.03	0.03	0.00
1997	0.03	0.03	0.03	0.02	0.03	0.03	0.00
1998	0.02	0.03	0.03	0.02	0.03	0.03	0.00
1999	0.02	0.03	0.03	0.02	0.03	0.03	0.00
2000	0.02	0.03	0.02	0.03	0.02	0.03	0.00
2001	0.00	0.03	0.02	0.03	0.02	0.03	-0.02
2002	0.02	0.03	0.02	0.03	0.02	0.03	0.00
2003	0.04	0.02	0.02	0.03	0.02	0.03	0.02
2004	0.03	0.02	0.02	0.03	0.02	0.03	0.00
2005	0.03	0.02	0.01	0.03	0.02	0.03	0.00
2006	0.02	0.02	0.01	0.03	0.01	0.03	0.00
2007	0.03	0.02	0.01	0.03	0.01	0.03	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (1991-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	1991 - 2007
n	17
Test S	
Test Z	-2.53
Signific.	*
Q	-3.60E+00
Qmin99	-6.05E+00
Qmax99	0.00E+00
Qmin95	-5.36E+00
Qmax95	-8.55E-01
B	1.75E+02
Bmin99	1.98E+02
Bmax99	1.40E+02
Bmin95	1.90E+02
Bmax95	1.44E+02

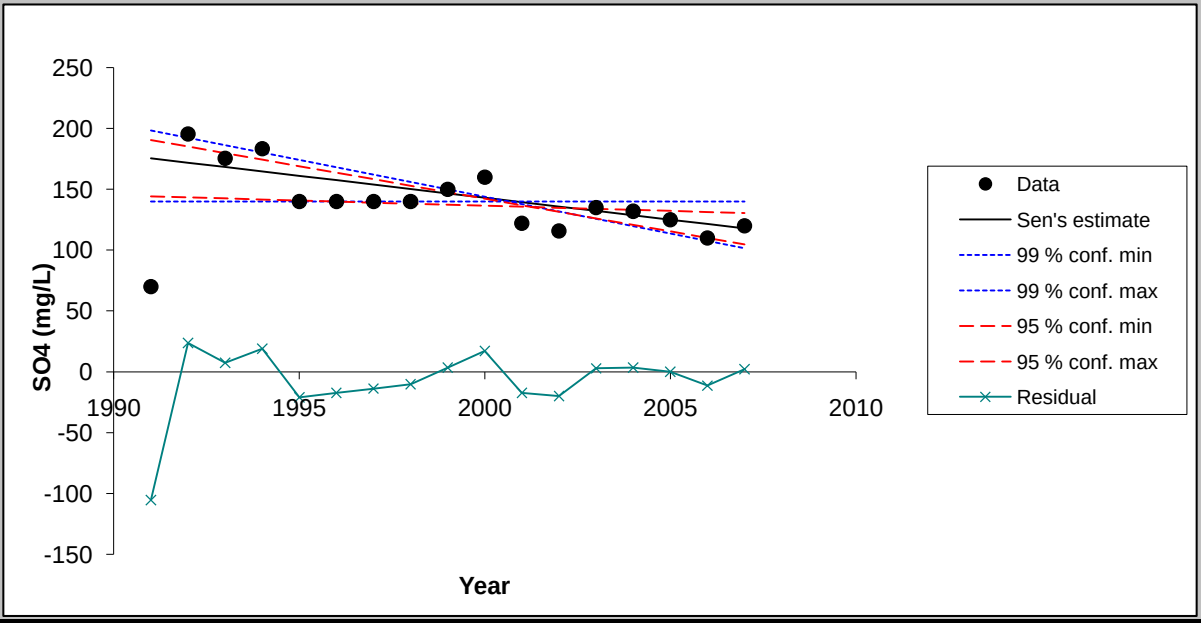

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
1991	70.00	175.40	198.38	140.00	190.43	144.27	-105.40
1992	195.50	171.80	192.34	140.00	185.06	143.42	23.70
1993	175.50	168.20	186.29	140.00	179.70	142.56	7.30
1994	183.50	164.60	180.24	140.00	174.34	141.71	18.90
1995	140.00	161.00	174.19	140.00	168.98	140.85	-21.00
1996	140.00	157.40	168.14	140.00	163.62	140.00	-17.40
1997	140.00	153.80	162.10	140.00	158.26	139.15	-13.80
1998	140.00	150.20	156.05	140.00	152.89	138.29	-10.20
1999	150.00	146.60	150.00	140.00	147.53	137.44	3.40
2000	160.00	143.00	143.95	140.00	142.17	136.58	17.00
2001	122.00	139.40	137.90	140.00	136.81	135.73	-17.40
2002	115.82	135.80	131.86	140.00	131.45	134.87	-19.98
2003	135.00	132.20	125.81	140.00	126.09	134.02	2.80
2004	132.00	128.60	119.76	140.00	120.72	133.16	3.40
2005	125.00	125.00	113.71	140.00	115.36	132.31	0.00
2006	110.00	121.40	107.66	140.00	110.00	131.45	-11.40
2007	120.00	117.80	101.62	140.00	104.64	130.60	2.20

ATTACHMENT C

OUTPUT OF STATISTICAL ANALYSES—MAKESENS GRAPHS 2000 TO 2007

(PLEASE SEE ATTACHED CD)

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

TREND STATISTICS

TW-20 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*18*		*	0.0013					-0.0083				
F (mg/L)	*2000*	*2007*	*8*	*22*		**	0.168					-0.06				
Mn (mg/L)	*2000*	*2007*	*8*	*3*			0.0001					0.0010				
Nitrate (mg/L)	*2000*	*2007*	*8*	*22*		**	1.130					-5.54				
Se (mg/L)	*2000*	*2007*	*8*	*12*			0.031					-0.14				
Cl (mg/L)	*2000*	*2007*	*8*	*12*			10.183					-20.22				
Mo (mg/L)	*2000*	*2007*	*8*	*22*		**	0.005					-0.018				
SO4 (mg/L)	*2000*	*2007*	*8*	*20*		*	93.673					-572.58				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

ANNUAL DATA

TW-20 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.019	6.97	0.0025	7.55	0.011	176		500
1992	0.0168	6.37	0.0023	8.13	0.702	174.5	0.106	528
1993	0.0092	4.88	0.0151	9.03	0.229	100	0.090	524
1994	0.0071	5.18	0.0241	9.65	0.315	117.5	0.066	552
1995	0.009	5.3	0.0005	8.7	0.33	91	0.087	520
1996	0.008	3.9	0.001	8.9	0.14	91	0.06	520
1997	0.006	4.6	0.0005	6.9	0.058	140	0.051	380
1998	0.004	2.6	0.0005	6.6	0.066	76	0.049	320
1999	0.0032	2	0.001	5	0.04	58	0.039	240
2000	0.0028	1.5	0.0005	4.9	0.03	55	0.032	220
2001	0.004	1.6	0.005	4.57	0.055	63	0.03	262
2002	0.0059	1.80	0.03	6.95	0.304	101.9	0.04	552
2003	0.0063	1.81	0.001	7.965	0.34	105	0.0509	634
2004	0.0096	1.67	0.001	8.16	0.392	139.5	0.0547	640
2005	0.0111	2.37	0.002	12.95	0.429	138.5	0.0626	744
2006	0.0106	3.605	0.002	20.25	0.079	129.5	0.063	920
2007	0.0060	2.57	0.002	10.95	0.08225	100.15	0.05795	555

FIGURE

< Previous Time Series | Next Time Series >

TW-20 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	18
Test Z	
Signific.	*
Q	1.25E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-8.30E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

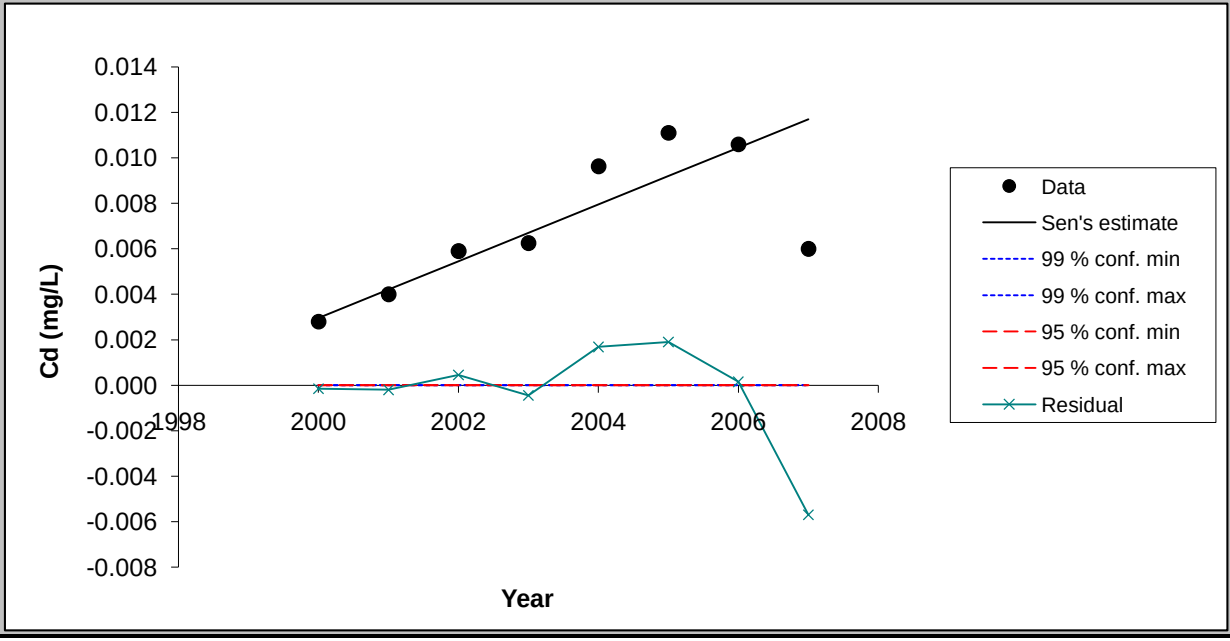

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	-0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	1.68E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-6.07E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

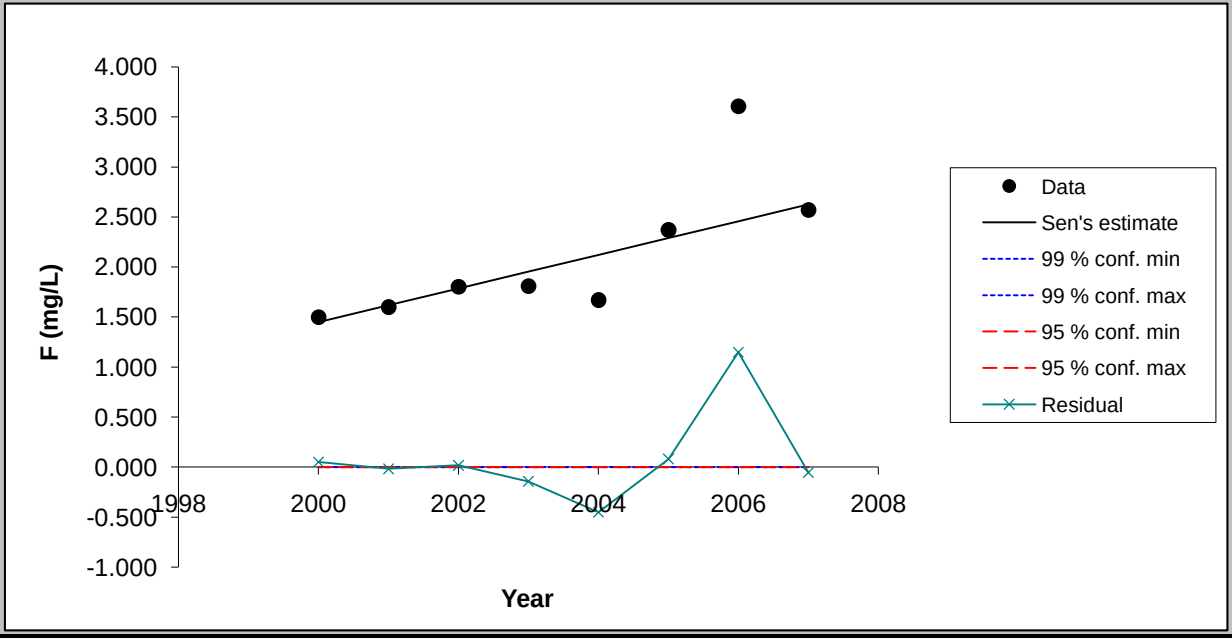

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.50	1.45	0.00	0.00	0.00	0.00	0.05
2001	1.60	1.62	0.00	0.00	0.00	0.00	-0.02
2002	1.80	1.79	0.00	0.00	0.00	0.00	0.02
2003	1.81	1.95	0.00	0.00	0.00	0.00	-0.14
2004	1.67	2.12	0.00	0.00	0.00	0.00	-0.45
2005	2.37	2.29	0.00	0.00	0.00	0.00	0.08
2006	3.61	2.46	0.00	0.00	0.00	0.00	1.15
2007	2.57	2.62	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	3
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

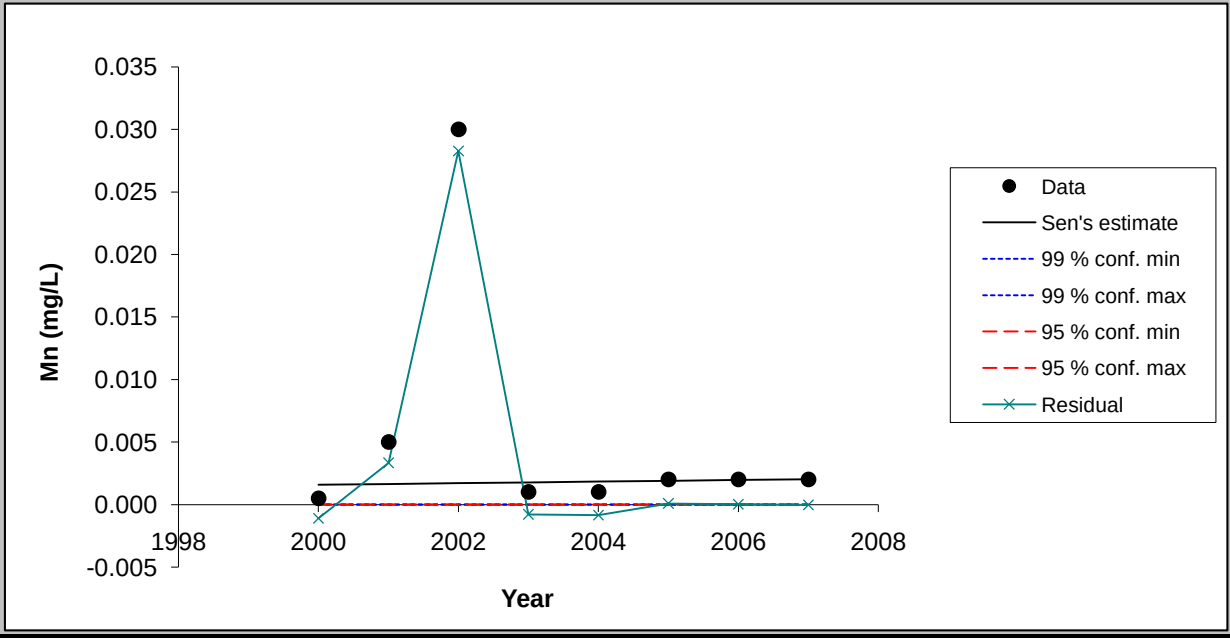

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	1.13E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-5.54E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

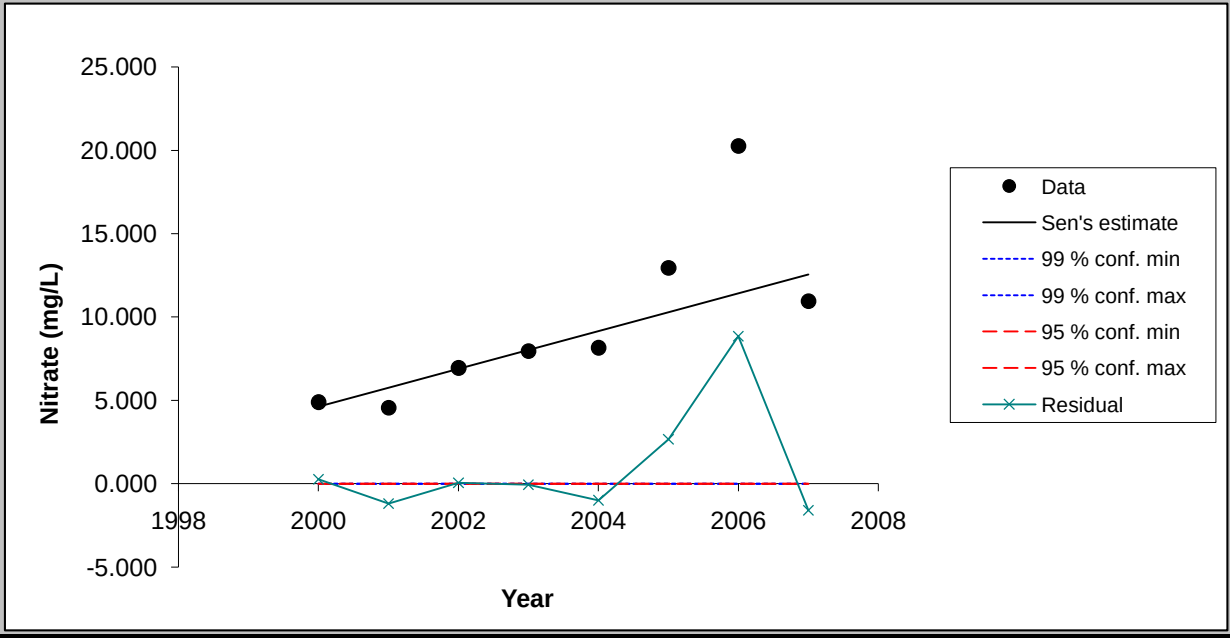

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.90	4.63	0.00	0.00	0.00	0.00	0.27
2001	4.57	5.76	0.00	0.00	0.00	0.00	-1.19
2002	6.95	6.89	0.00	0.00	0.00	0.00	0.06
2003	7.96	8.02	0.00	0.00	0.00	0.00	-0.06
2004	8.16	9.15	0.00	0.00	0.00	0.00	-0.99
2005	12.95	10.28	0.00	0.00	0.00	0.00	2.67
2006	20.25	11.41	0.00	0.00	0.00	0.00	8.84
2007	10.95	12.54	0.00	0.00	0.00	0.00	-1.59

FIGURE

< Previous Time Series | Next Time Series >

TW-20 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	12
Test Z	
Signific.	
Q	3.06E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.39E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

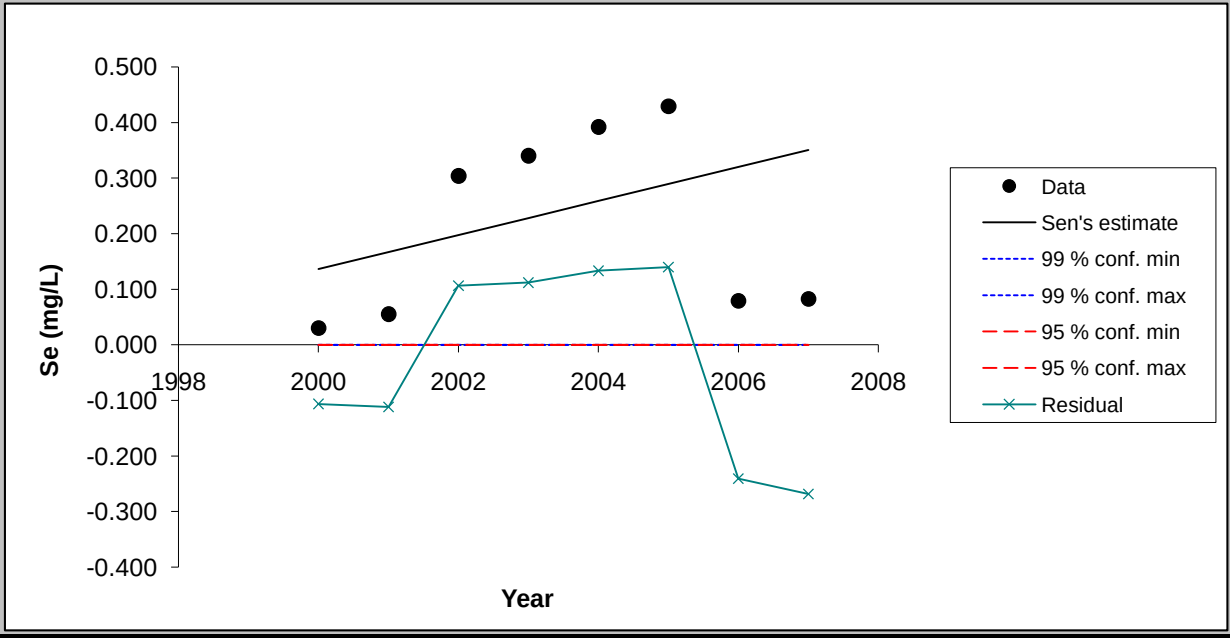

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.14	0.00	0.00	0.00	0.00	-0.11
2001	0.05	0.17	0.00	0.00	0.00	0.00	-0.11
2002	0.30	0.20	0.00	0.00	0.00	0.00	0.11
2003	0.34	0.23	0.00	0.00	0.00	0.00	0.11
2004	0.39	0.26	0.00	0.00	0.00	0.00	0.13
2005	0.43	0.29	0.00	0.00	0.00	0.00	0.14
2006	0.08	0.32	0.00	0.00	0.00	0.00	-0.24
2007	0.08	0.35	0.00	0.00	0.00	0.00	-0.27

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	12
Test Z	
Signific.	
Q	1.02E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-2.02E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

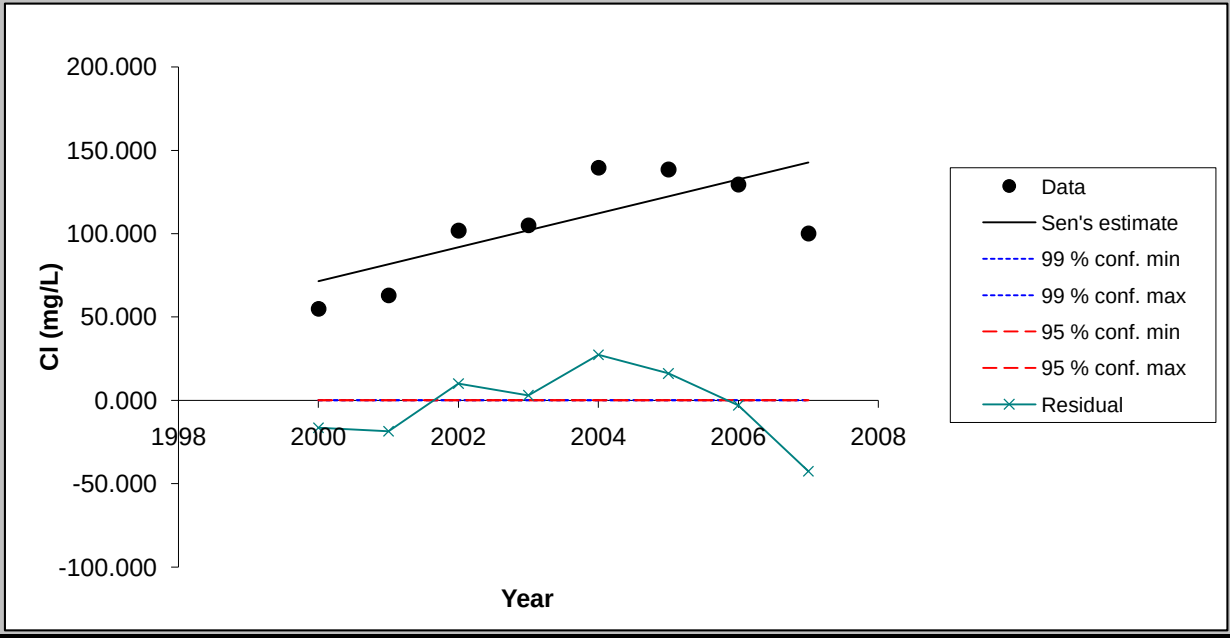

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	55.00	71.43	0.00	0.00	0.00	0.00	-16.43
2001	63.00	81.61	0.00	0.00	0.00	0.00	-18.61
2002	101.90	91.79	0.00	0.00	0.00	0.00	10.11
2003	105.00	101.98	0.00	0.00	0.00	0.00	3.02
2004	139.50	112.16	0.00	0.00	0.00	0.00	27.34
2005	138.50	122.34	0.00	0.00	0.00	0.00	16.16
2006	129.50	132.52	0.00	0.00	0.00	0.00	-3.02
2007	100.15	142.71	0.00	0.00	0.00	0.00	-42.56

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	5.42E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.75E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

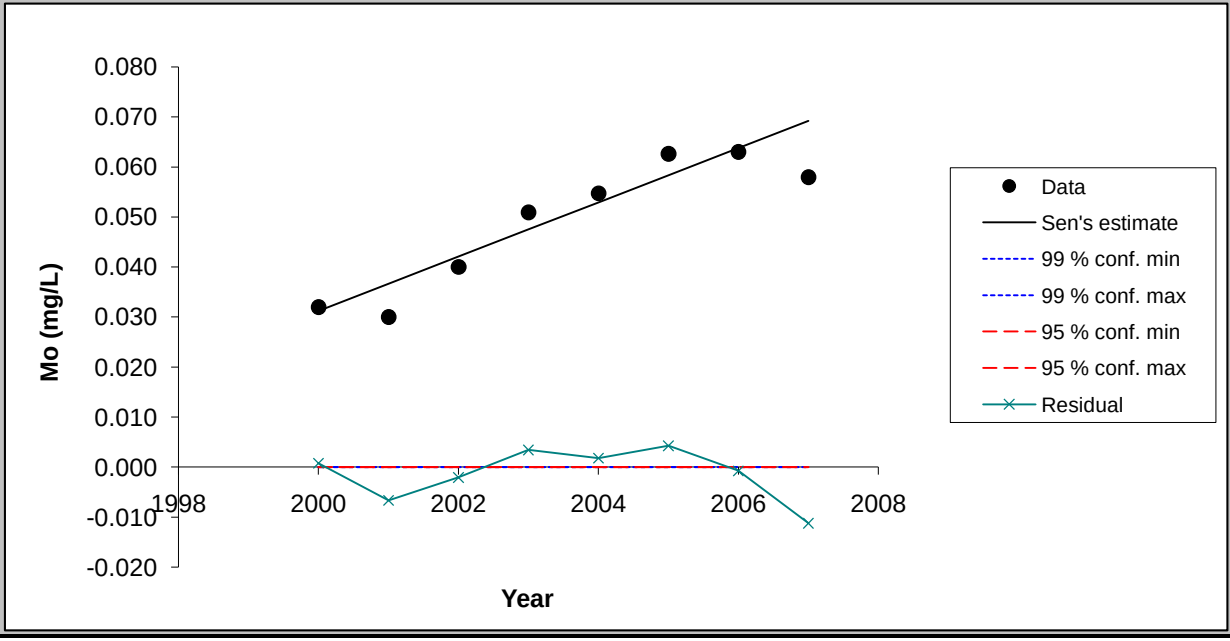

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.04	0.00	0.00	0.00	0.00	-0.01
2002	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2003	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2004	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2005	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2006	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2007	0.06	0.07	0.00	0.00	0.00	0.00	-0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-20 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	9.37E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-5.73E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

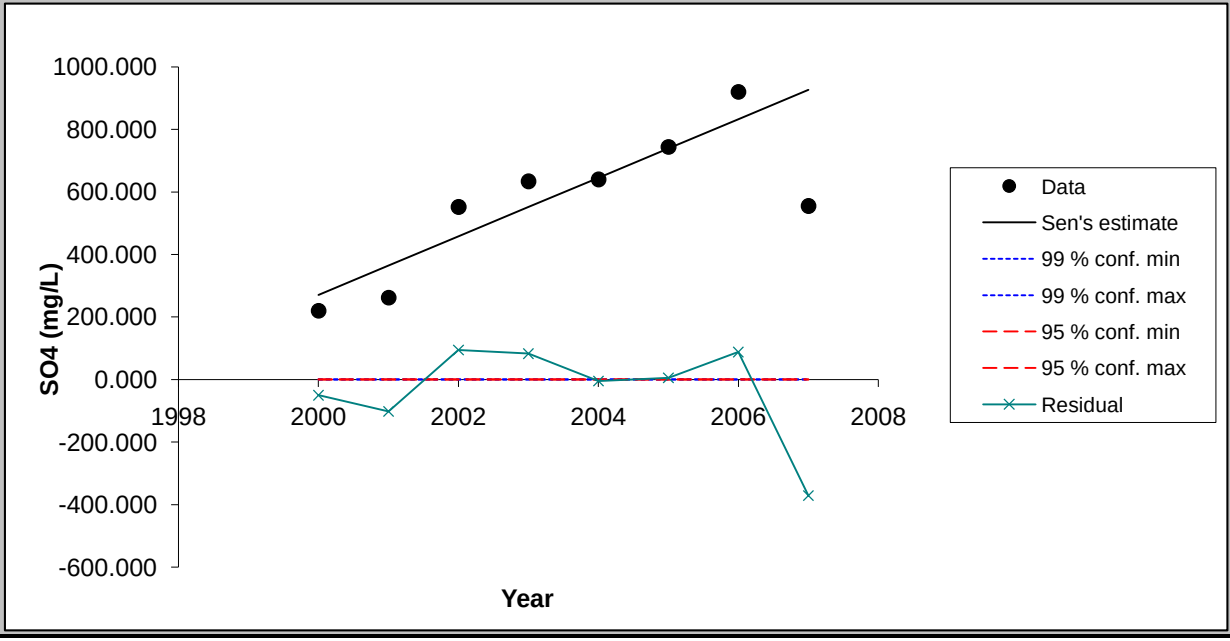

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	220.00	270.47	0.00	0.00	0.00	0.00	-50.47
2001	262.00	364.14	0.00	0.00	0.00	0.00	-102.14
2002	551.95	457.82	0.00	0.00	0.00	0.00	94.13
2003	634.00	551.49	0.00	0.00	0.00	0.00	82.51
2004	640.00	645.16	0.00	0.00	0.00	0.00	-5.16
2005	744.00	738.84	0.00	0.00	0.00	0.00	5.16
2006	920.00	832.51	0.00	0.00	0.00	0.00	87.49
2007	555.00	926.18	0.00	0.00	0.00	0.00	-371.18

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-34 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.94	0.25	0.25	0.002	21		138
1992	0.0015	0.41	0.207	0.125	0.007	51.0	0.0276	207.5
1993	0.0029	0.43	0.344	0.03	0.001	46	0.0048	185.5
1994	0.0006	0.42	0.178	0.10	0.003	43.6	0.0065	184.5
1995	0.0001	0.63	0.516	0.024	0.001	42	0.0025	72
1996	0.0001	0.67	0.189	0.09	0.002	43	0.0025	170
1997	0.0001	0.60	0.228	0.072	0.001	39	0.0025	140
1998	0.0001	0.05	0.154	0.17	0.011	44	0.0025	180
1999	0.0001	0.57	0.268	0.11	0.004	33	0.0025	150
2000	0.0001	0.47	0.204	0.23	0.009	40	0.0025	180
2001	0.001	0.7	0.22	0.95	0.009	38	0.005	150
2002	0.001	0.71	0.191	1.12	0.013	45	0.005	195.1
2003	0.00100	0.41	0.18	0.29	0.012	43.7	0.011	192
2004	0.00100	0.33	0.236	0.1	0.015	44.6	0.016	206
2005	0.00100	0.244	0.238	0.11	0.0046	47.7	0.01	199
2006	0.00100	0.63	0.206	0.05	0.0011	40.5	0.011	175
2007	0.00100	0.6	0.222	0.034	0.00055	39.3	0.0081	161

TREND STATISTICS

TW-34 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-7*			0.0000					0.0010				
F (mg/L)	*2000*	*2007*	*8*	*-6*			-0.02					0.78				
Mn (mg/L)	*2000*	*2007*	*8*	*8*			0.003					0.17				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-18*		*	-0.062					1.003				
Se (mg/L)	*2000*	*2007*	*8*	*-11*			-0.0013					0.0219				
Cl (mg/L)	*2000*	*2007*	*8*	*2*			0.150					40.28				
Mo (mg/L)	*2000*	*2007*	*8*	*13*			0.0012					-0.0073				
SO4 (mg/L)	*2000*	*2007*	*8*	*0*			0.240					183.48				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-7
Test Z	
Signific.	
Q	-3.25E-19
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

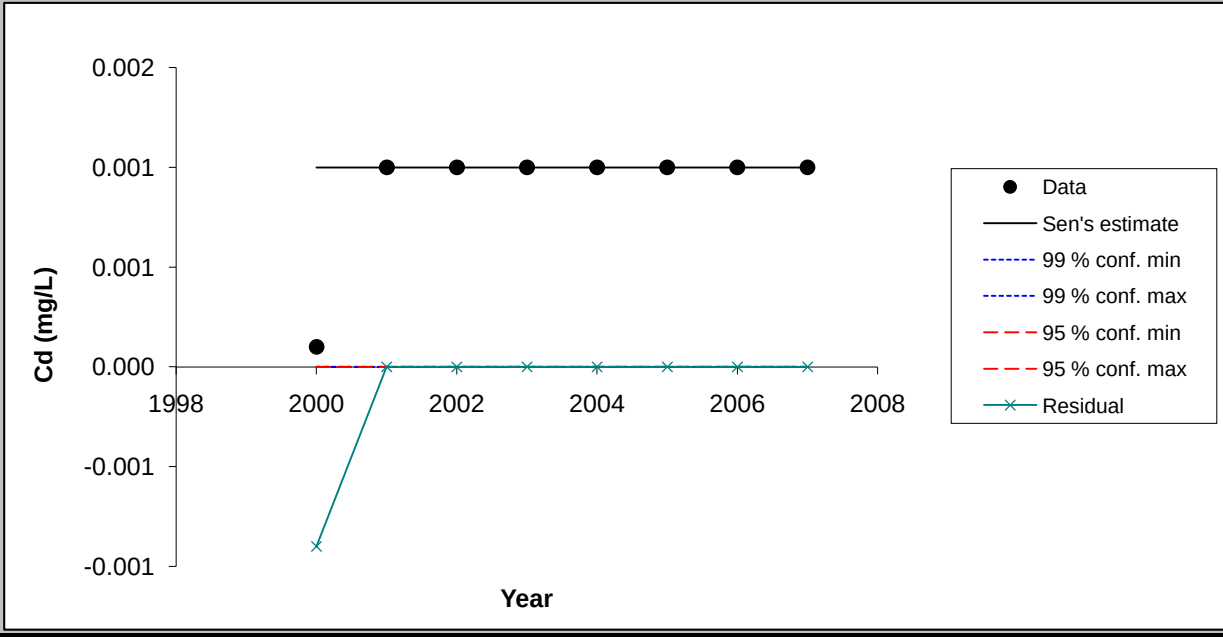

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-2.01E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.76E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

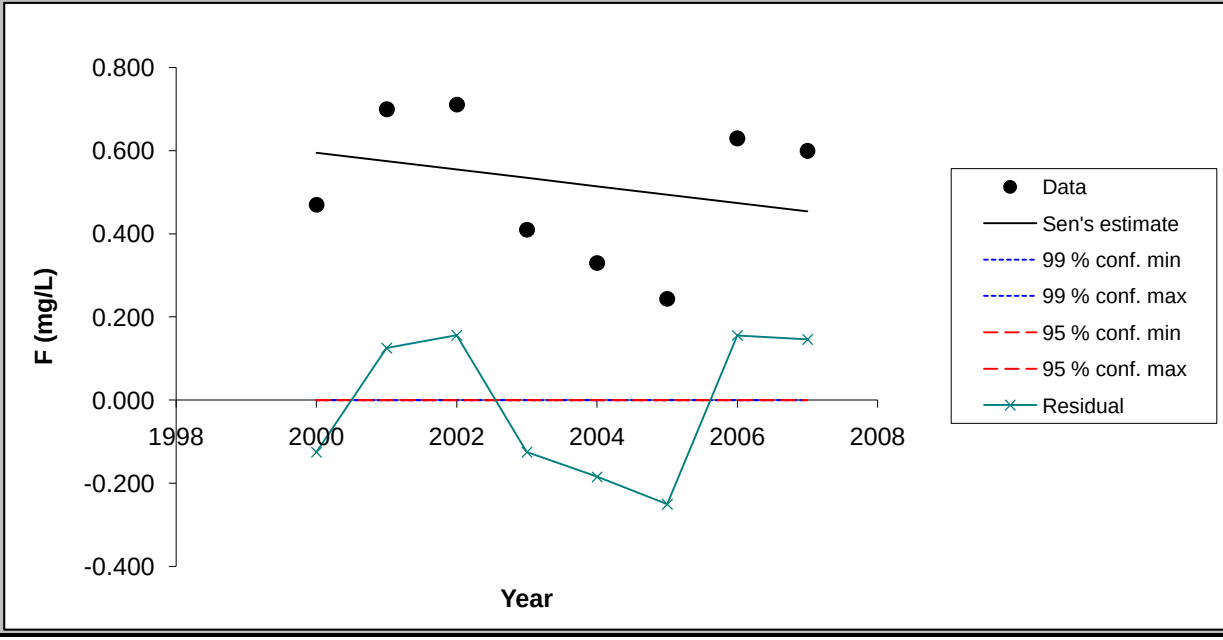

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.47	0.60	0.00	0.00	0.00	0.00	-0.13
2001	0.70	0.58	0.00	0.00	0.00	0.00	0.12
2002	0.71	0.55	0.00	0.00	0.00	0.00	0.16
2003	0.41	0.53	0.00	0.00	0.00	0.00	-0.12
2004	0.33	0.51	0.00	0.00	0.00	0.00	-0.18
2005	0.24	0.49	0.00	0.00	0.00	0.00	-0.25
2006	0.63	0.47	0.00	0.00	0.00	0.00	0.16
2007	0.60	0.45	0.00	0.00	0.00	0.00	0.15

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	3.16E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.73E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

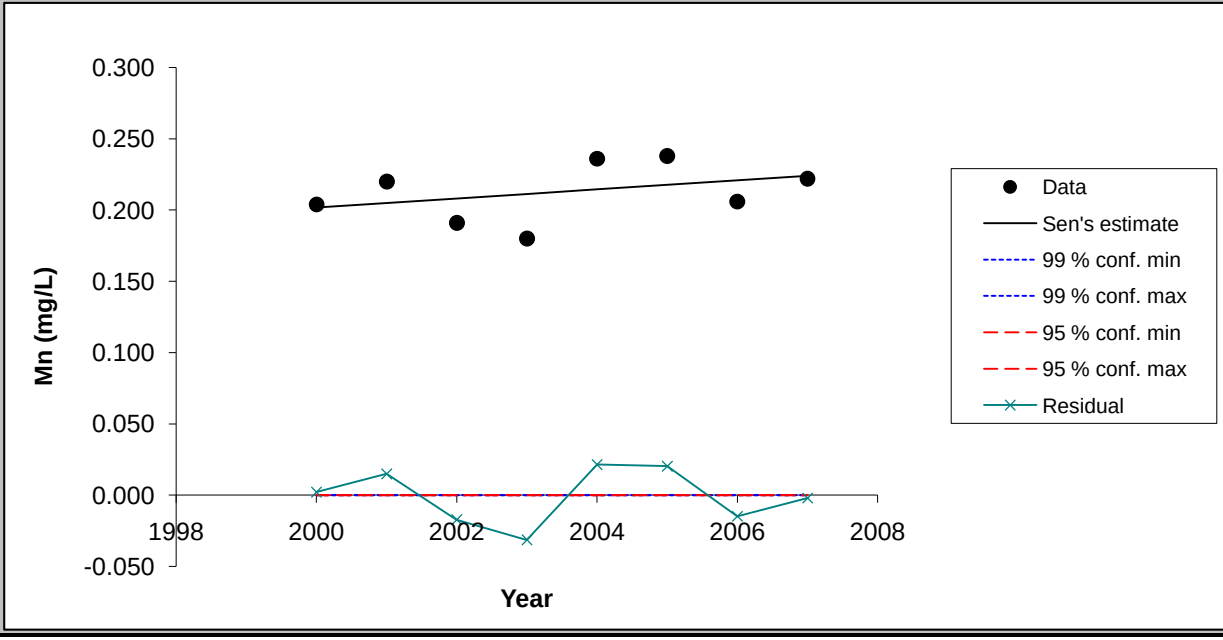

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.20	0.20	0.00	0.00	0.00	0.00	0.00
2001	0.22	0.21	0.00	0.00	0.00	0.00	0.01
2002	0.19	0.21	0.00	0.00	0.00	0.00	-0.02
2003	0.18	0.21	0.00	0.00	0.00	0.00	-0.03
2004	0.24	0.21	0.00	0.00	0.00	0.00	0.02
2005	0.24	0.22	0.00	0.00	0.00	0.00	0.02
2006	0.21	0.22	0.00	0.00	0.00	0.00	-0.01
2007	0.22	0.22	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-18
Test Z	
Signific.	*
Q	-6.20E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

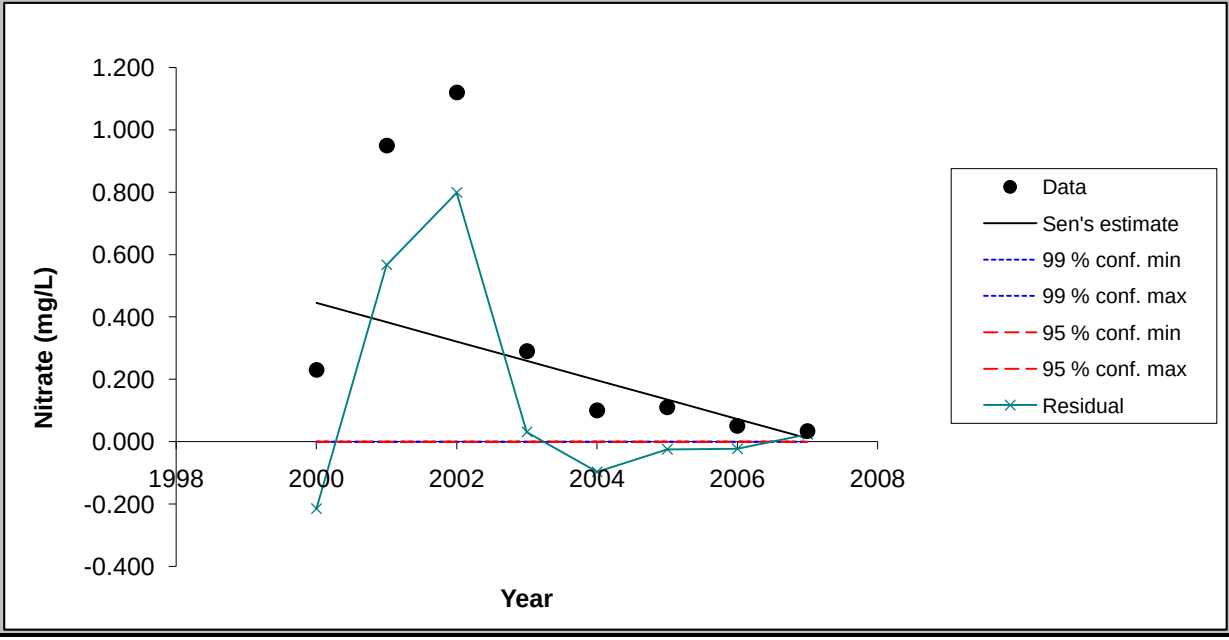

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.23	0.44	0.00	0.00	0.00	0.00	-0.21
2001	0.95	0.38	0.00	0.00	0.00	0.00	0.57
2002	1.12	0.32	0.00	0.00	0.00	0.00	0.80
2003	0.29	0.26	0.00	0.00	0.00	0.00	0.03
2004	0.10	0.20	0.00	0.00	0.00	0.00	-0.10
2005	0.11	0.13	0.00	0.00	0.00	0.00	-0.02
2006	0.05	0.07	0.00	0.00	0.00	0.00	-0.02
2007	0.03	0.01	0.00	0.00	0.00	0.00	0.02

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-11
Test Z	
Signific.	
Q	-1.26E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.19E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

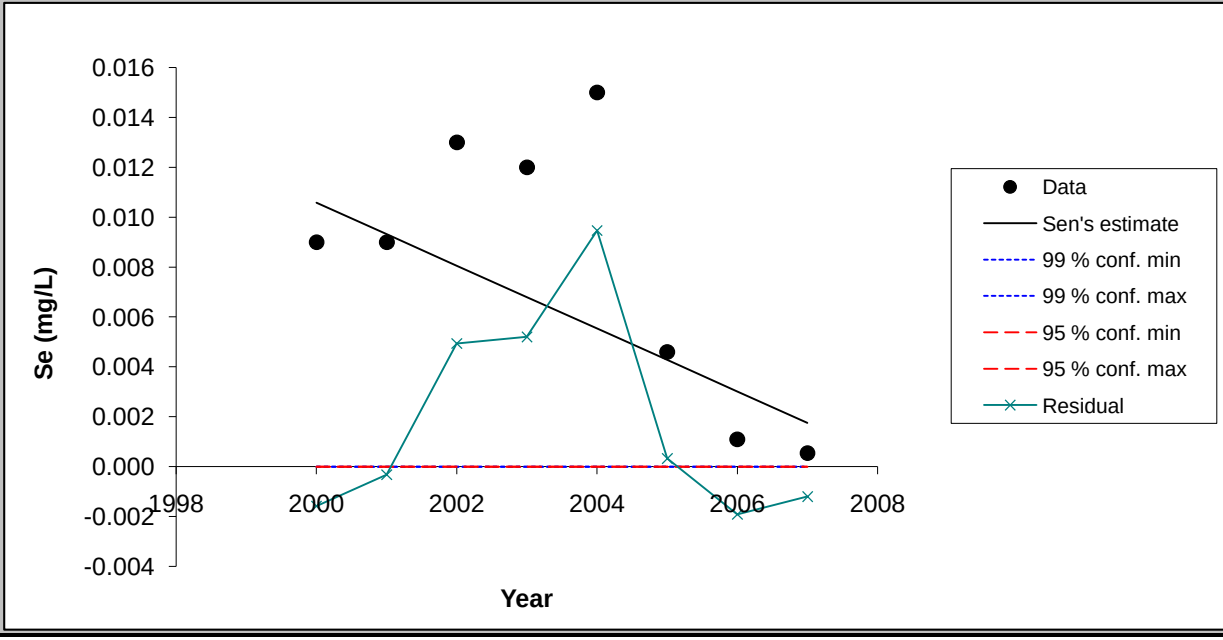

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.01
2004	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	1.50E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.03E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

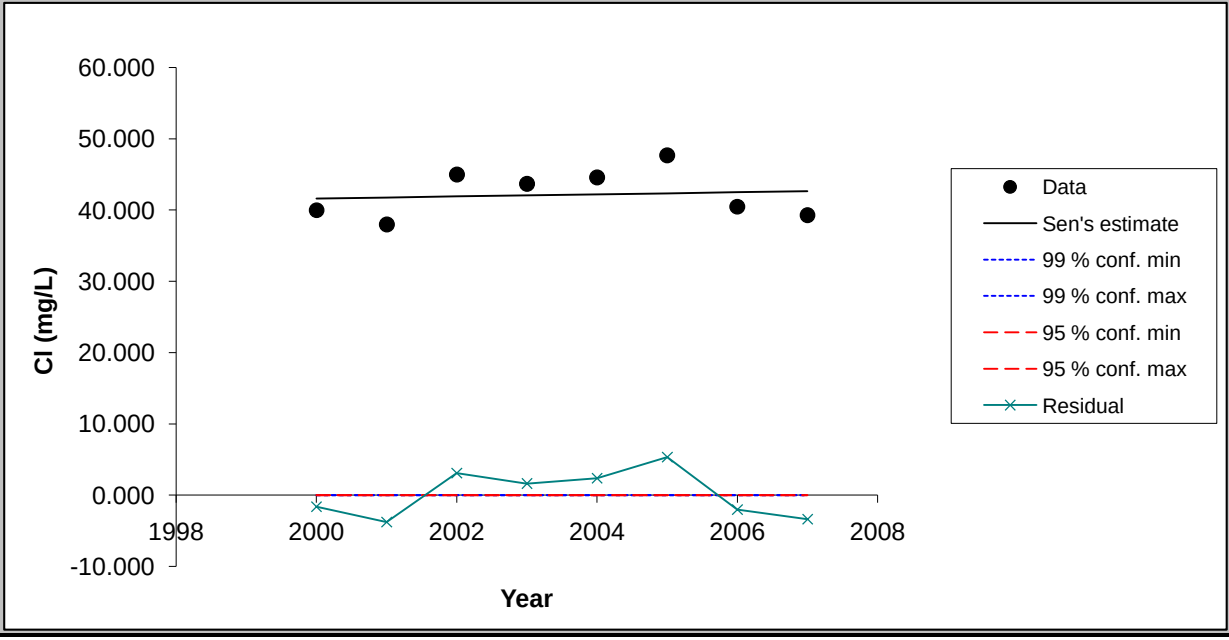

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	40.00	41.63	0.00	0.00	0.00	0.00	-1.63
2001	38.00	41.78	0.00	0.00	0.00	0.00	-3.78
2002	45.01	41.93	0.00	0.00	0.00	0.00	3.08
2003	43.70	42.08	0.00	0.00	0.00	0.00	1.63
2004	44.60	42.23	0.00	0.00	0.00	0.00	2.37
2005	47.70	42.38	0.00	0.00	0.00	0.00	5.32
2006	40.50	42.53	0.00	0.00	0.00	0.00	-2.03
2007	39.30	42.68	0.00	0.00	0.00	0.00	-3.38

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	13
Test Z	
Signific.	
Q	1.22E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-7.31E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

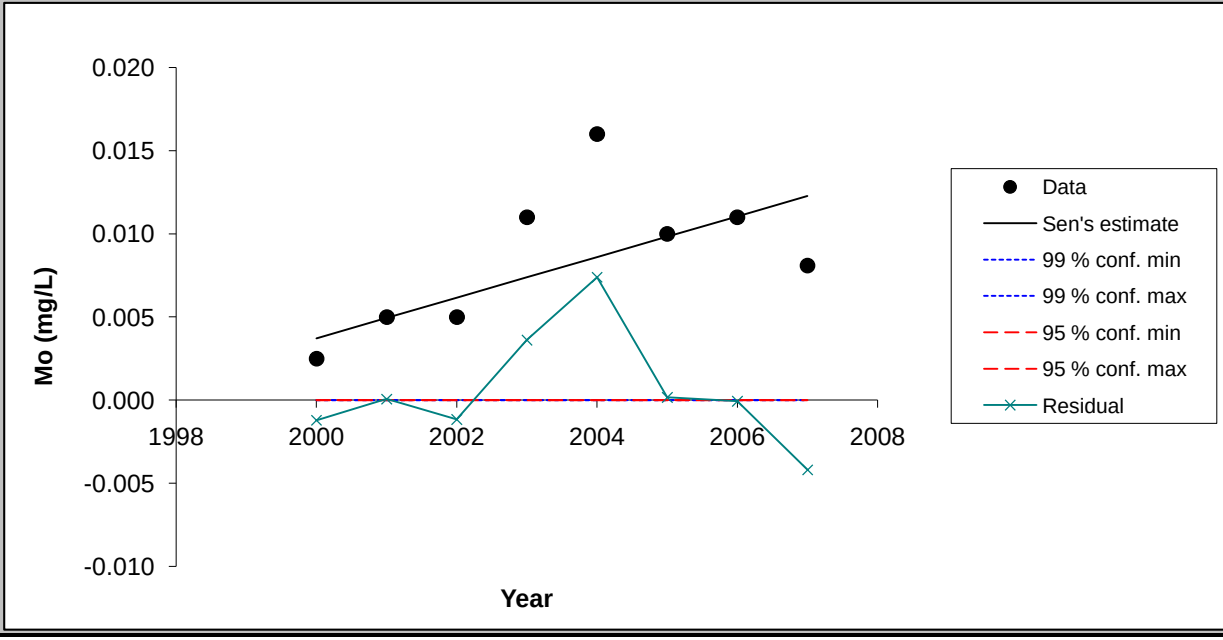

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-34 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	2.40E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.83E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

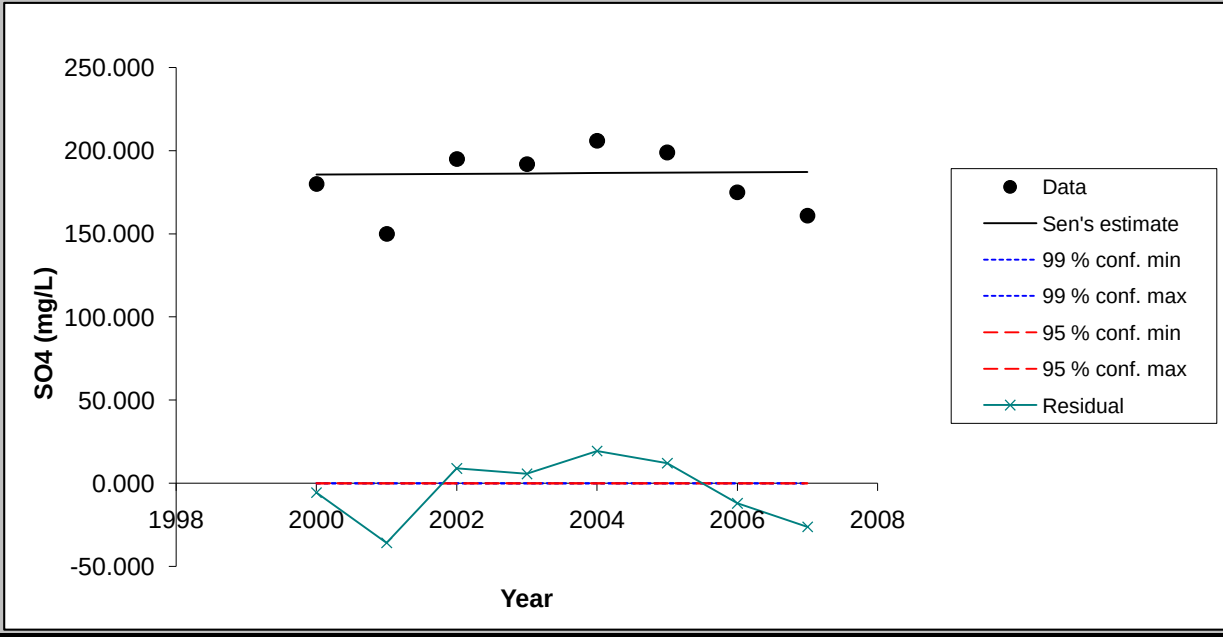

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	180.00	185.64	0.00	0.00	0.00	0.00	-5.64
2001	150.00	185.88	0.00	0.00	0.00	0.00	-35.88
2002	195.06	186.12	0.00	0.00	0.00	0.00	8.94
2003	192.00	186.36	0.00	0.00	0.00	0.00	5.64
2004	206.00	186.60	0.00	0.00	0.00	0.00	19.40
2005	199.00	186.84	0.00	0.00	0.00	0.00	12.16
2006	175.00	187.08	0.00	0.00	0.00	0.00	-12.08
2007	161.00	187.32	0.00	0.00	0.00	0.00	-26.32

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-35 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.24	0.12	0.25	0.0015	39		96
1992	0.0015	0.27	0.0683	0.08	0.012	42.9	0.0259	100
1993	0.0029	0.205	0.1605	0.08	0.0006	36.9	0.0048	94.0
1994	0.0001	0.26	0.145	0.005	0.001	50	0.0025	110
1995	0.0001	0.28	0.153	0.005	0.002	41	0.0025	100
1996	0.0001	0.3	0.153	0.005	0.0005	37	0.0025	96
1997	0.0001	0.34	0.155	0.005	0.0025	32	0.0025	100
1998	0.0001	0.3	0.162	0.03	0.001	31	0.0025	110
1999	0.0001	0.26	0.139	0.17	0.005	23	0.0025	130
2000	0.0001	0.23	0.138	0.19	0.005	27	0.0025	140
2001	0.001	0.5	0.14	0.025	0.0025	32	0.005	94
2002	0.001	0.601	0.1682	0.025	0.005	34.7	0.005	99.4
2003	0.001	0.37	0.157	0.01	0.005	35.6	0.0101	103
2004	0.001	0.05	0.1415	0.01	0.00125	38.83333	0.0139	107
2005	0.001	0.185	0.141	0.055	0.00125	38.95	0.0054	112.5
2006	2.12E-05	0.05	0.161	0.01	0.0015	38.5	0.01	114
2007	0.001	0.05	0.158	0.021	0.000145	36.8	0.0091	111

TREND STATISTICS

TW-35 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-10*			0.0000					0.0010				
F (mg/L)	*2000*	*2007*	*8*	*-15*			-0.071					1.19				
Mn (mg/L)	*2000*	*2007*	*8*	*10*			0.001					0.13				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-8*			-0.003					0.06				
Se (mg/L)	*2000*	*2007*	*8*	*-18*		*	-0.0006					0.01				
Cl (mg/L)	*2000*	*2007*	*8*	*18*		*	1.412					18.26				
Mo (mg/L)	*2000*	*2007*	*8*	*13*			0.0010					-0.0052				
SO4 (mg/L)	*2000*	*2007*	*8*	*10*			3.167					65.42				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-10
Test Z	
Signific.	
Q	-8.71E-12
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

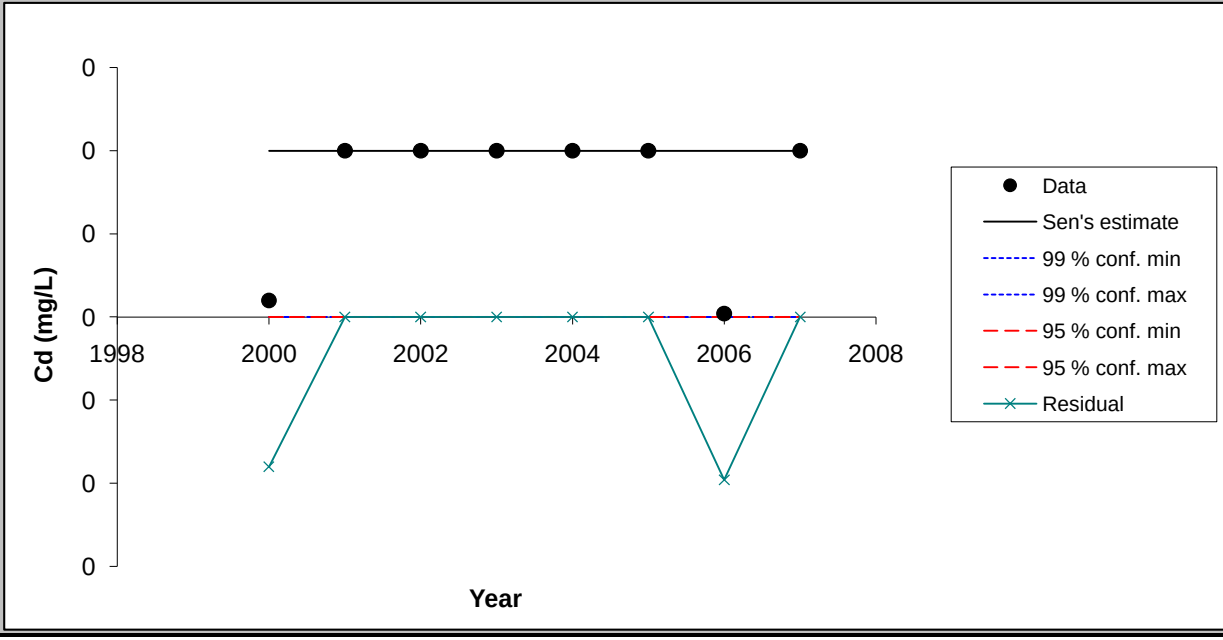

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-15
Test Z	
Signific.	
Q	-7.13E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.19E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

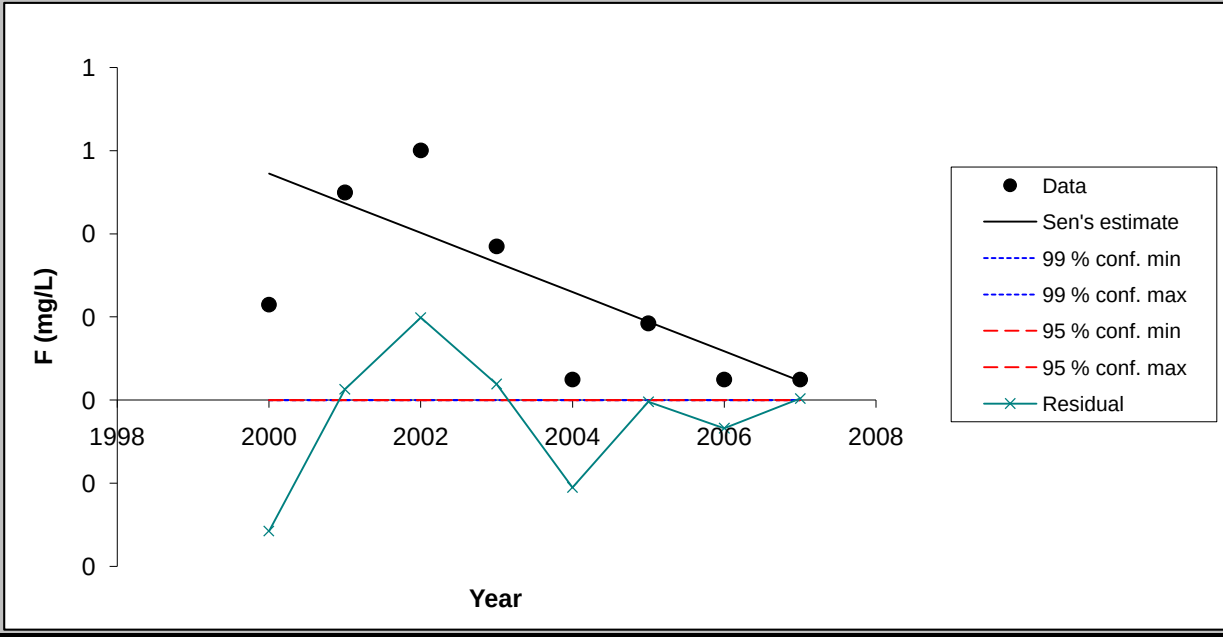

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.23	0.55	0.00	0.00	0.00	0.00	-0.31
2001	0.50	0.47	0.00	0.00	0.00	0.00	0.03
2002	0.60	0.40	0.00	0.00	0.00	0.00	0.20
2003	0.37	0.33	0.00	0.00	0.00	0.00	0.04
2004	0.05	0.26	0.00	0.00	0.00	0.00	-0.21
2005	0.19	0.19	0.00	0.00	0.00	0.00	0.00
2006	0.05	0.12	0.00	0.00	0.00	0.00	-0.07
2007	0.05	0.05	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	1.10E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.35E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

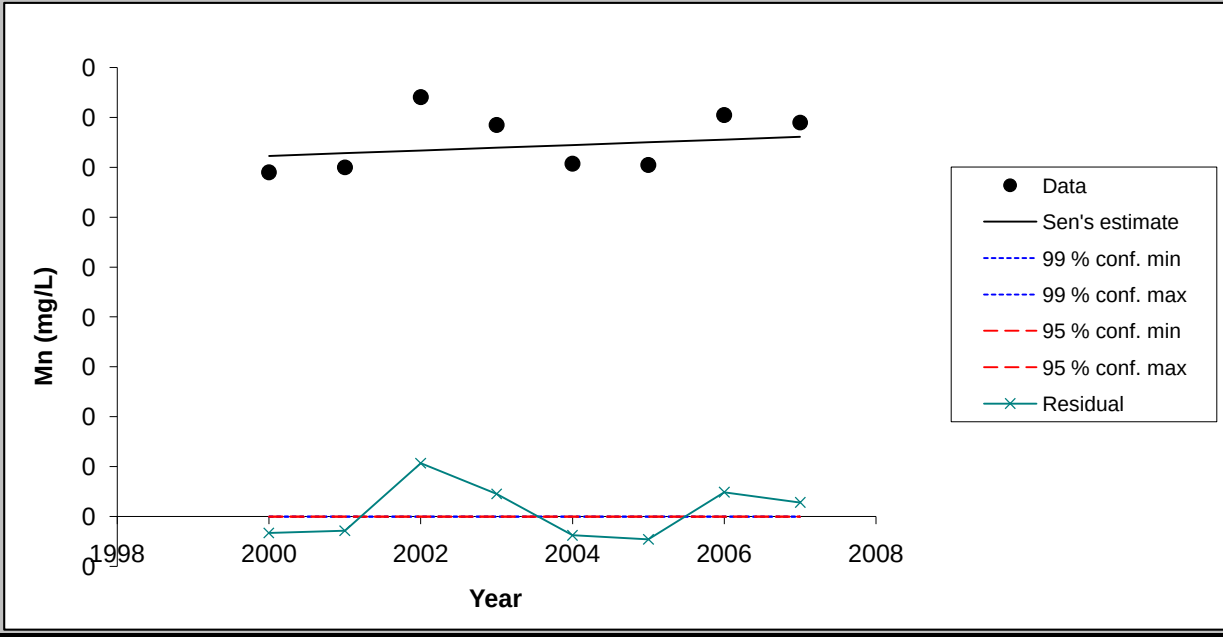

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.14	0.14	0.00	0.00	0.00	0.00	-0.01
2001	0.14	0.15	0.00	0.00	0.00	0.00	-0.01
2002	0.17	0.15	0.00	0.00	0.00	0.00	0.02
2003	0.16	0.15	0.00	0.00	0.00	0.00	0.01
2004	0.14	0.15	0.00	0.00	0.00	0.00	-0.01
2005	0.14	0.15	0.00	0.00	0.00	0.00	-0.01
2006	0.16	0.15	0.00	0.00	0.00	0.00	0.01
2007	0.16	0.15	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-3.38E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.14E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

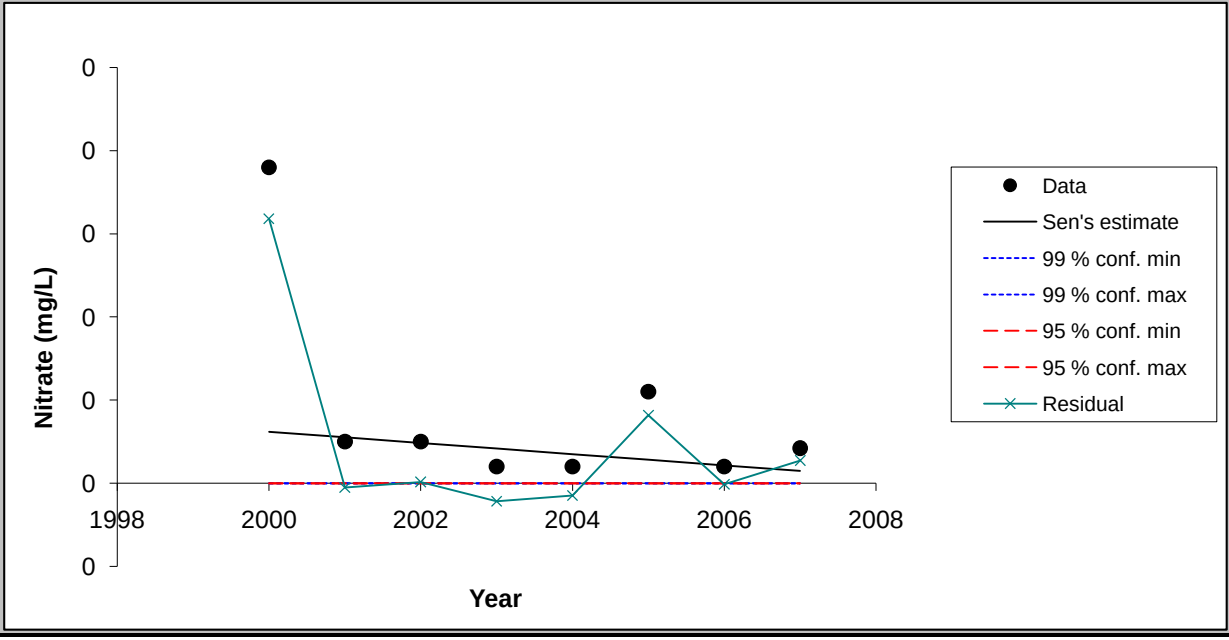

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.19	0.03	0.00	0.00	0.00	0.00	0.16
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2005	0.06	0.01	0.00	0.00	0.00	0.00	0.04
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.02	0.01	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-18
Test Z	
Signific.	*
Q	-5.68E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.63E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

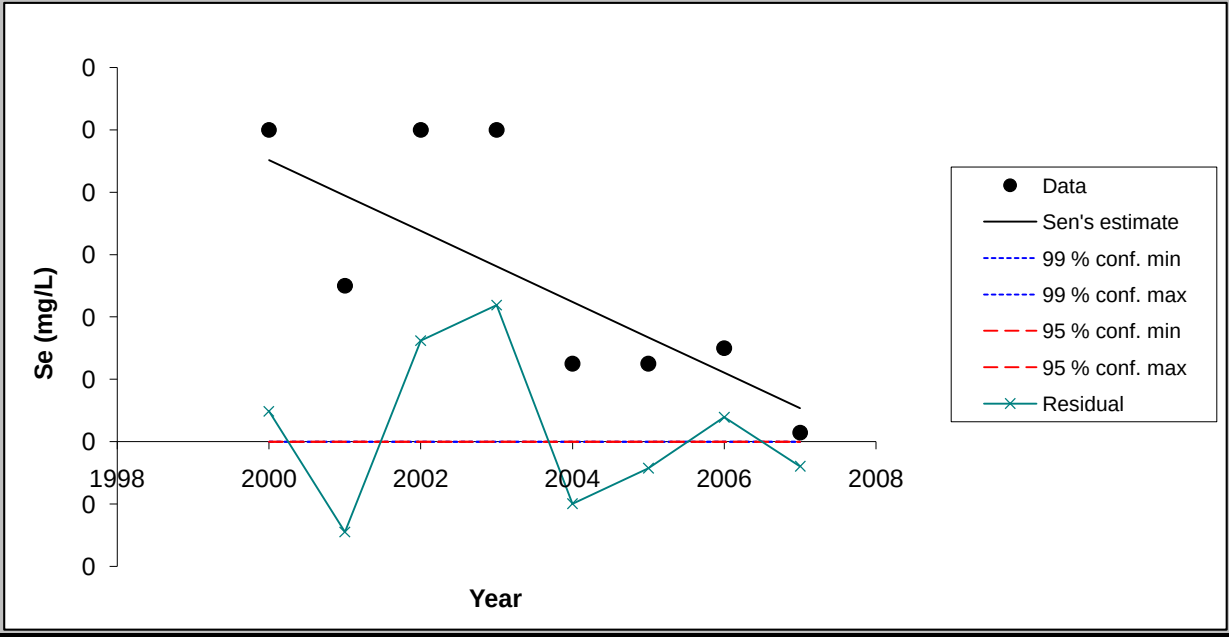

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	18
Test Z	
Signific.	*
Q	1.41E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.83E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

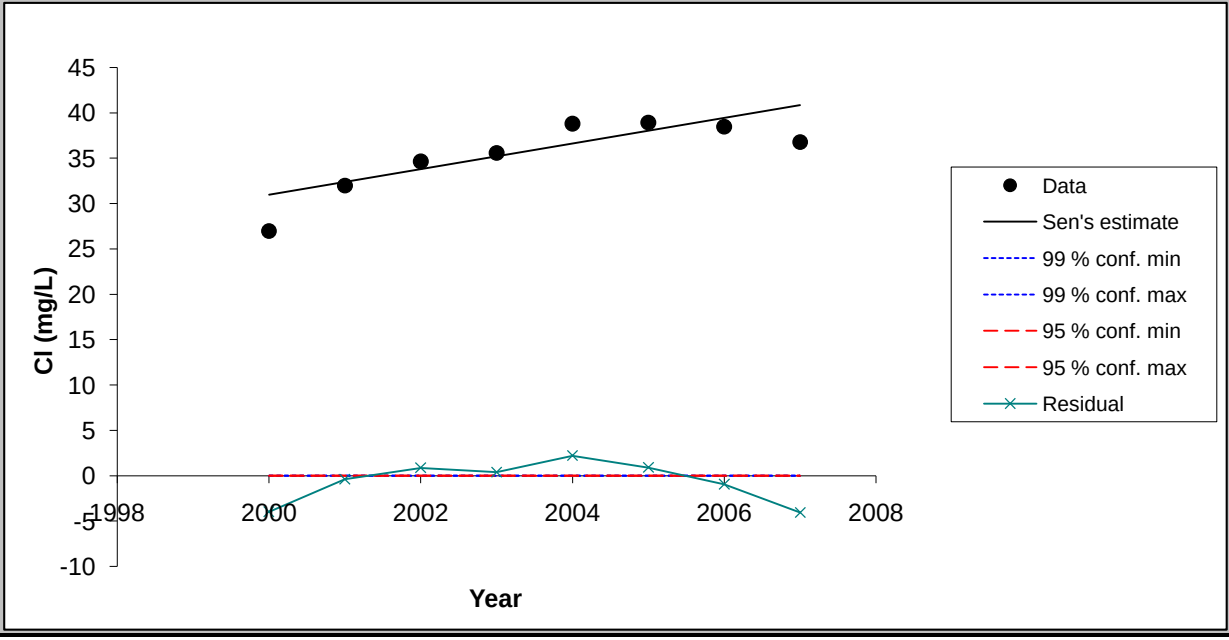

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	27.00	30.98	0.00	0.00	0.00	0.00	-3.98
2001	32.00	32.39	0.00	0.00	0.00	0.00	-0.39
2002	34.68	33.80	0.00	0.00	0.00	0.00	0.88
2003	35.60	35.21	0.00	0.00	0.00	0.00	0.39
2004	38.83	36.62	0.00	0.00	0.00	0.00	2.21
2005	38.95	38.04	0.00	0.00	0.00	0.00	0.91
2006	38.50	39.45	0.00	0.00	0.00	0.00	-0.95
2007	36.80	40.86	0.00	0.00	0.00	0.00	-4.06

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	13
Test Z	
Signific.	
Q	9.71E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-5.20E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

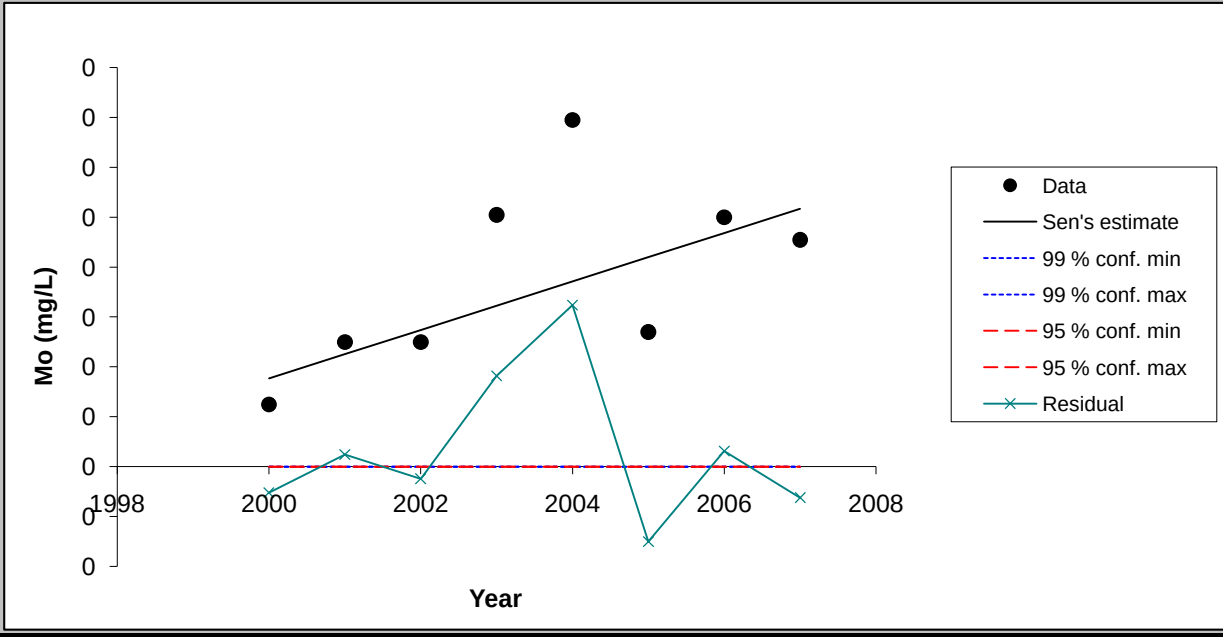

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-35 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	3.17E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.54E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

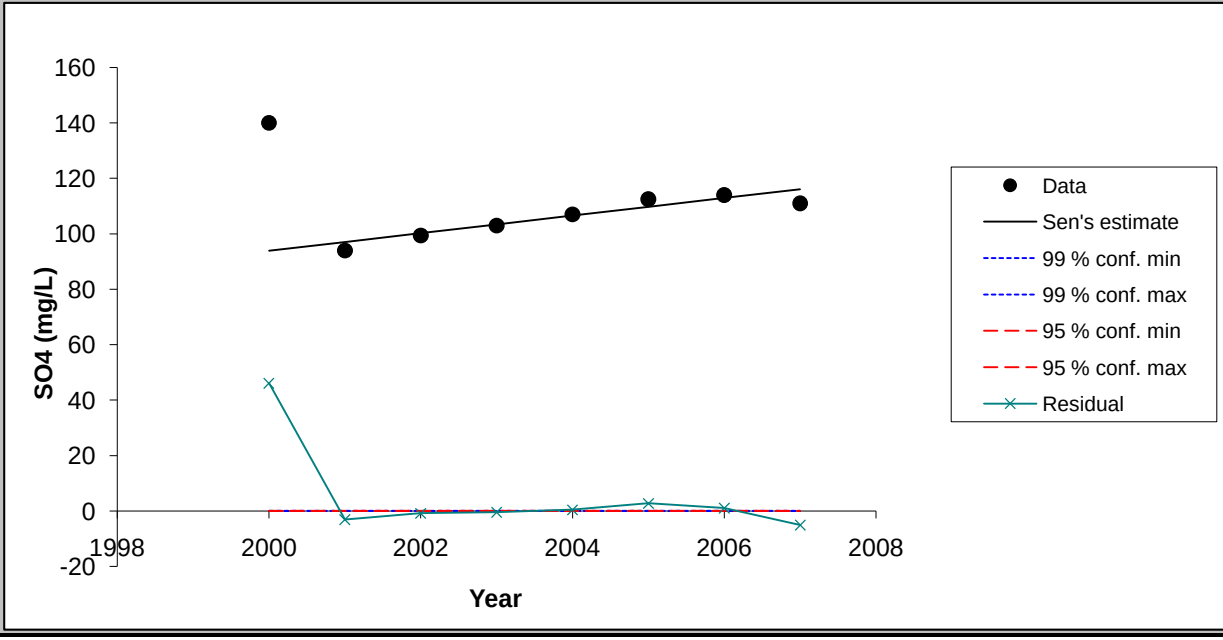

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	140.00	93.92	0.00	0.00	0.00	0.00	46.08
2001	94.00	97.08	0.00	0.00	0.00	0.00	-3.08
2002	99.40	100.25	0.00	0.00	0.00	0.00	-0.85
2003	103.00	103.42	0.00	0.00	0.00	0.00	-0.42
2004	107.00	106.58	0.00	0.00	0.00	0.00	0.42
2005	112.50	109.75	0.00	0.00	0.00	0.00	2.75
2006	114.00	112.92	0.00	0.00	0.00	0.00	1.08
2007	111.00	116.08	0.00	0.00	0.00	0.00	-5.08

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-39 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.02	6.34	0.0025	5.9	0.007	183		420
1992	0.0041	5.42	0.0045	6.0	0.463	174	0.0575	407.5
1993	0.0156	4.69	0.0151	7.2	0.249	172	0.0892	372.5
1994	0.0219	4.92	0.001	7.2	0.32	177.5	0.088	407.5
1995	0.0145	5.3	0.0005	9.4	0.35	170	0.08	440
1996	0.014	4.6	0.0005	12	0.21	150	0.076	470
1997	0.013	2.7	0.0005	15	0.28	140	0.078	570
1998	0.011	4.5	0.0005	12	0.23	160	0.075	550
1999	0.013	4.6	0.0005	11	0.28	100	0.087	630
2000	0.015	4.5	0.0005	12	0.3	120	0.083	640
2001	0.016	3.9	0.005	7.1	0.217	124	0.06	481
2002	0.012	3.38	0.03	3.8	0.087	110.4	0.052	330.4
2003	0.011	2.71	0.001	4.565	0.123	100	0.0491	332
2004	0.0119	1.96	0.001	4.22	0.105	95.1	0.0459	321
2005	0.013	2.05	0.002	11.2	0.139	87.7	0.0437	439
2006	0.0122	2.76	0.002	12.2	0.03	91	0.039	505
2007	0.0093	3.34	0.002	9.56	0.125	115	0.0662	527

TREND STATISTICS

TW-39 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-12*			-0.0008					0.0218				
F (mg/L)	*2000*	*2007*	*8*	*-12*			-0.310					6.89				
Mn (mg/L)	*2000*	*2007*	*8*	*3*			0.0001					0.0010				
Nitrate (mg/L)	*2000*	*2007*	*8*	*4*			0.316					4.20				
Se (mg/L)	*2000*	*2007*	*8*	*-10*			-0.022					0.42				
Cl (mg/L)	*2000*	*2007*	*8*	*-14*			-4.875					163.95				
Mo (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.003					0.09				
SO4 (mg/L)	*2000*	*2007*	*8*	*2*			3.220					421.36				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-7.55E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.18E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

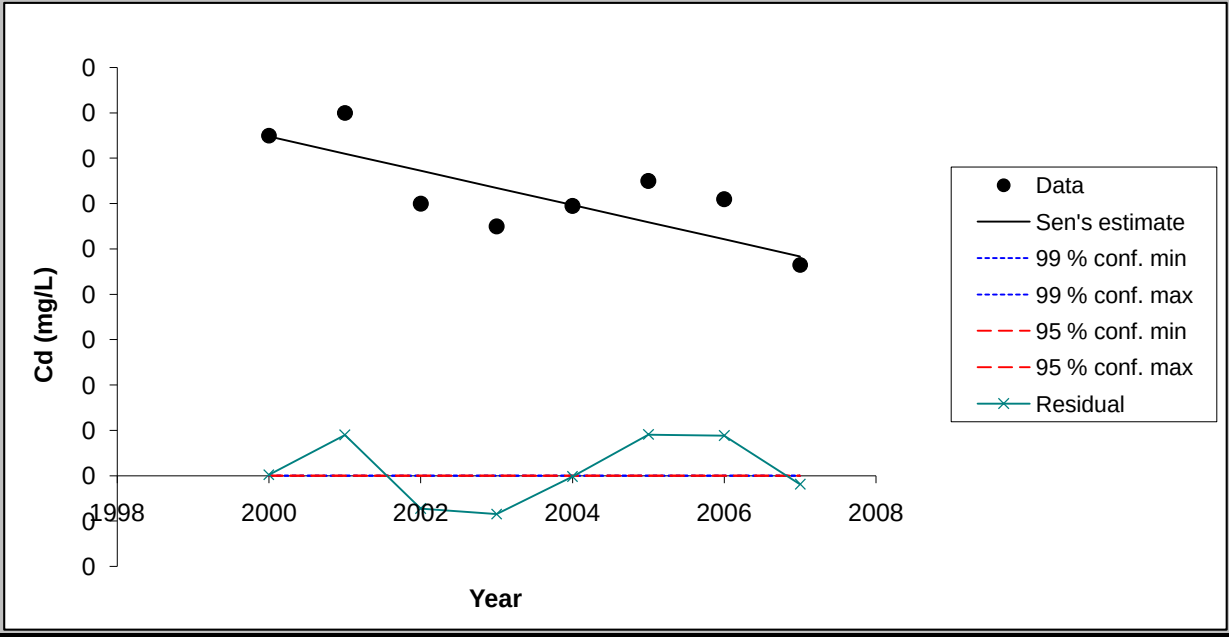

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-3.10E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.89E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

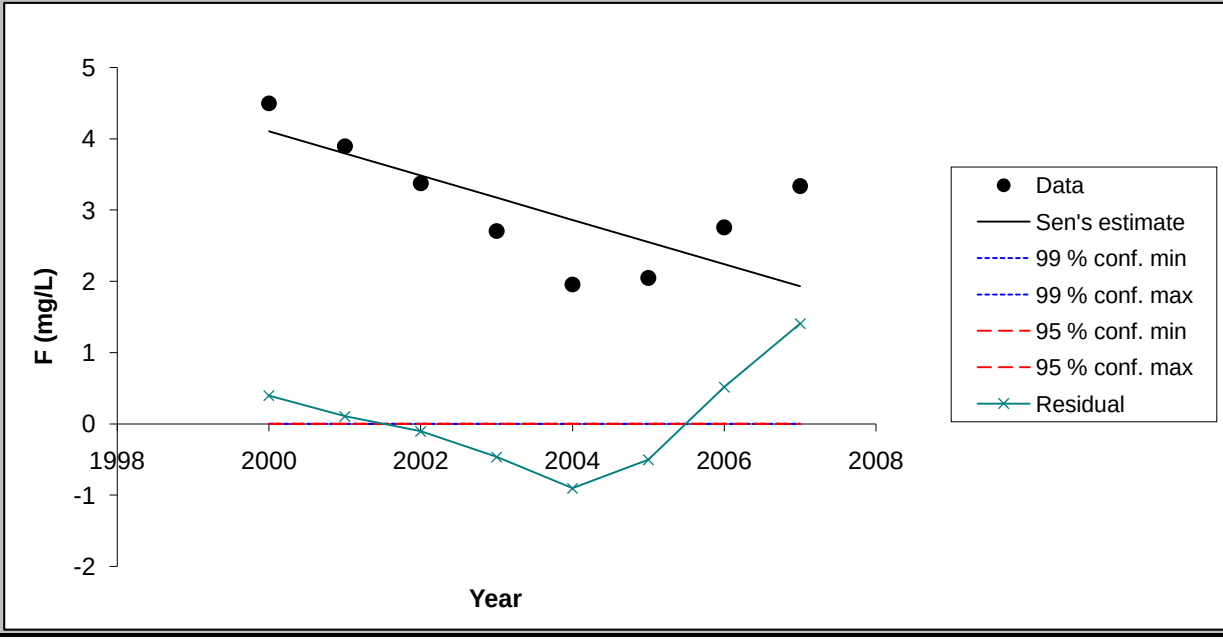

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.50	4.10	0.00	0.00	0.00	0.00	0.40
2001	3.90	3.79	0.00	0.00	0.00	0.00	0.11
2002	3.38	3.48	0.00	0.00	0.00	0.00	-0.11
2003	2.71	3.17	0.00	0.00	0.00	0.00	-0.46
2004	1.96	2.86	0.00	0.00	0.00	0.00	-0.90
2005	2.05	2.55	0.00	0.00	0.00	0.00	-0.50
2006	2.76	2.24	0.00	0.00	0.00	0.00	0.52
2007	3.34	1.93	0.00	0.00	0.00	0.00	1.41

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	3
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

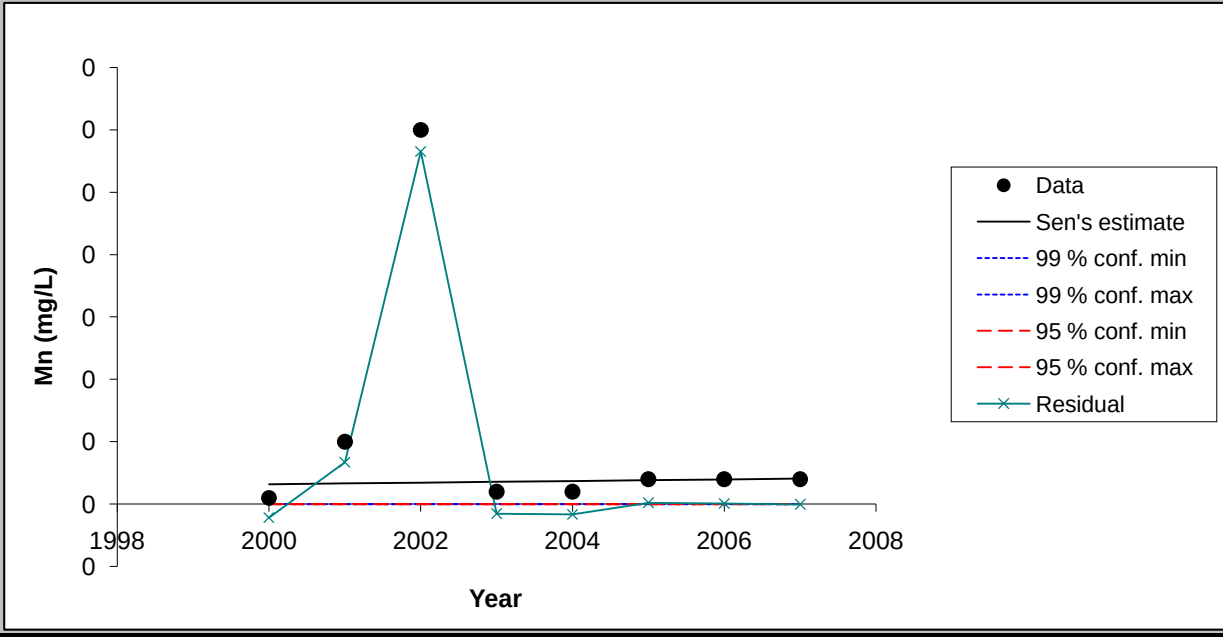

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	3.16E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.20E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

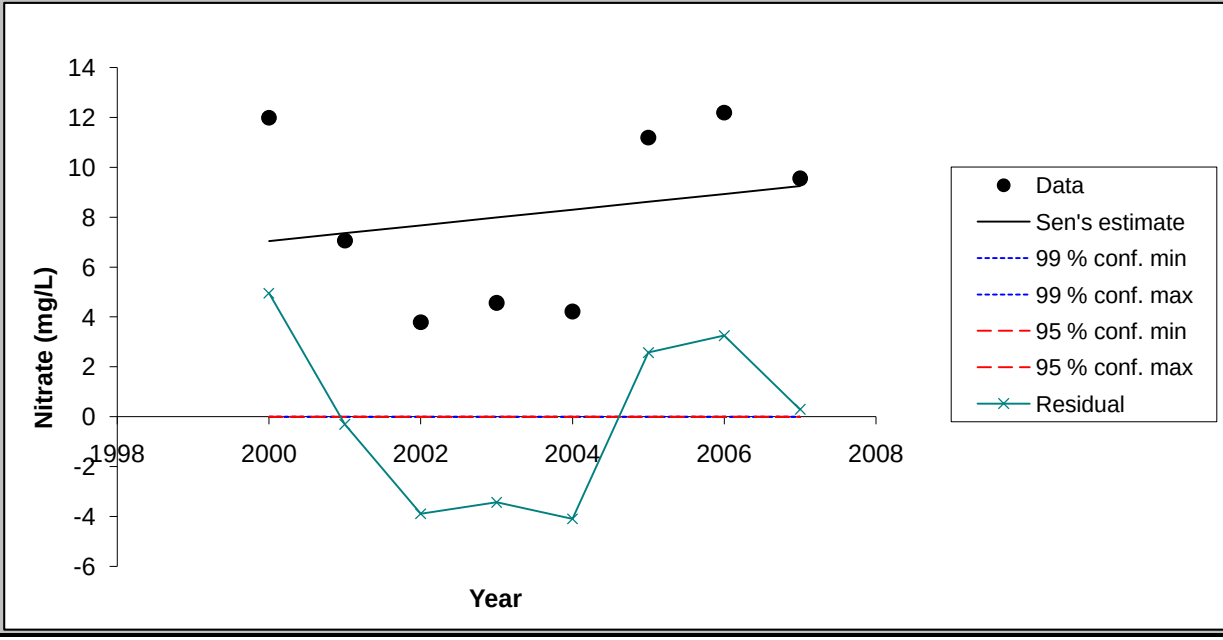

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	12.00	7.05	0.00	0.00	0.00	0.00	4.95
2001	7.06	7.36	0.00	0.00	0.00	0.00	-0.30
2002	3.79	7.68	0.00	0.00	0.00	0.00	-3.89
2003	4.57	7.99	0.00	0.00	0.00	0.00	-3.43
2004	4.22	8.31	0.00	0.00	0.00	0.00	-4.09
2005	11.20	8.63	0.00	0.00	0.00	0.00	2.57
2006	12.20	8.94	0.00	0.00	0.00	0.00	3.26
2007	9.56	9.26	0.00	0.00	0.00	0.00	0.30

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-10
Test Z	
Signific.	
Q	-2.22E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.17E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

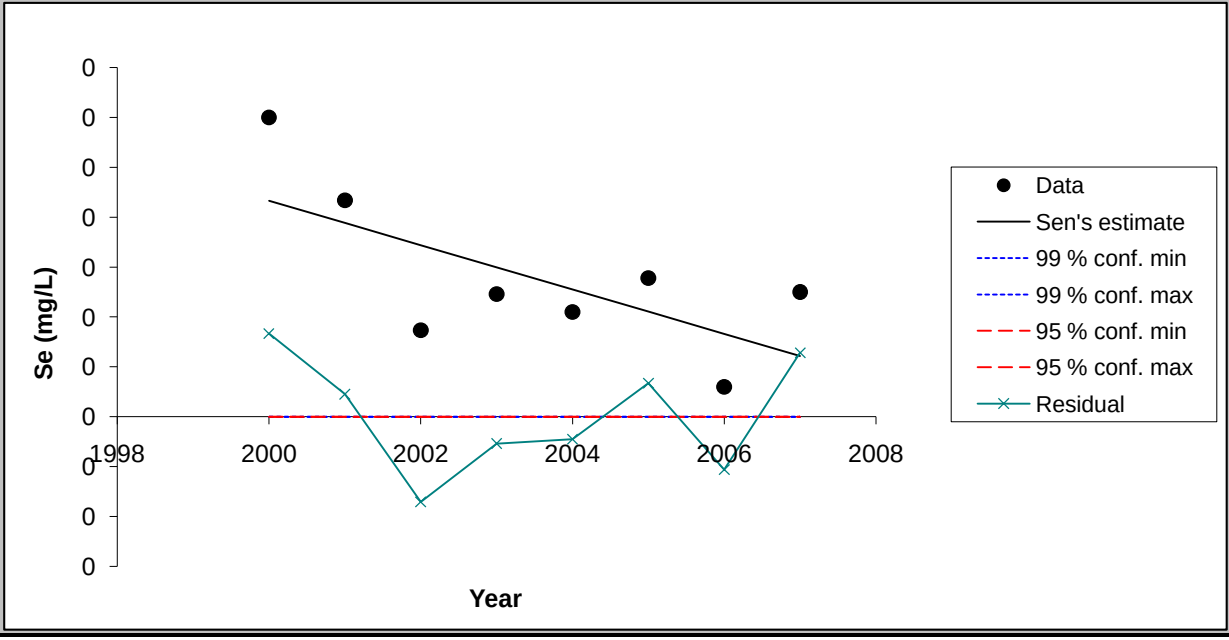

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.30	0.22	0.00	0.00	0.00	0.00	0.08
2001	0.22	0.19	0.00	0.00	0.00	0.00	0.02
2002	0.09	0.17	0.00	0.00	0.00	0.00	-0.09
2003	0.12	0.15	0.00	0.00	0.00	0.00	-0.03
2004	0.11	0.13	0.00	0.00	0.00	0.00	-0.02
2005	0.14	0.11	0.00	0.00	0.00	0.00	0.03
2006	0.03	0.08	0.00	0.00	0.00	0.00	-0.05
2007	0.13	0.06	0.00	0.00	0.00	0.00	0.06

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-4.88E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.64E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

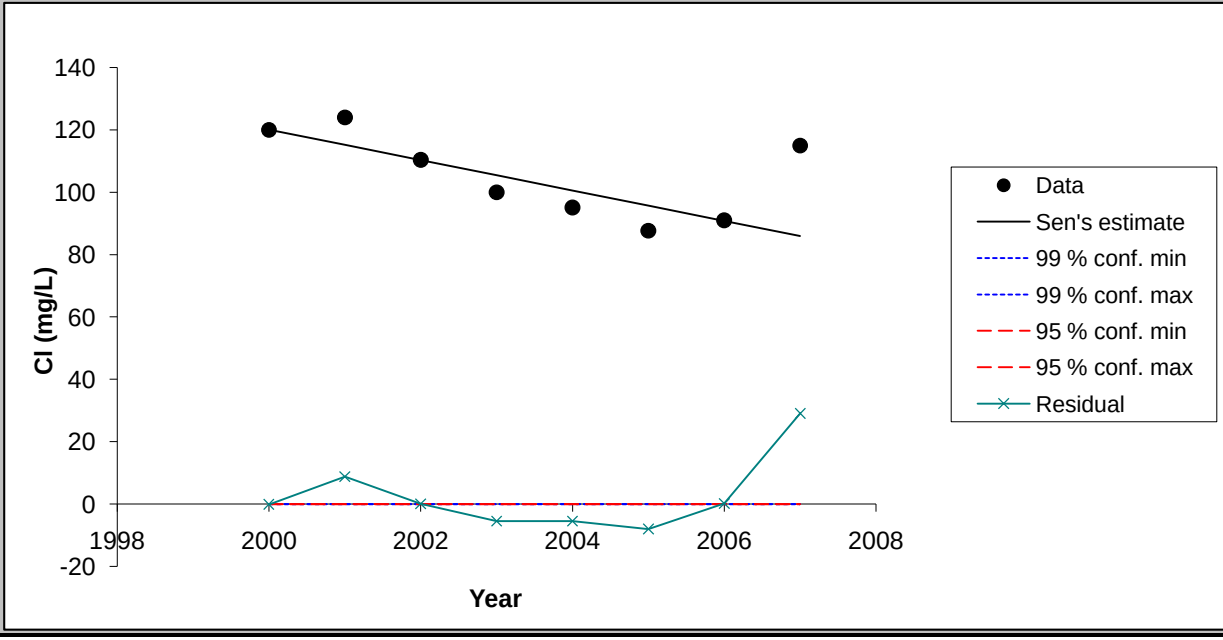

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	120.00	120.08	0.00	0.00	0.00	0.00	-0.08
2001	124.00	115.20	0.00	0.00	0.00	0.00	8.80
2002	110.40	110.33	0.00	0.00	0.00	0.00	0.08
2003	100.00	105.45	0.00	0.00	0.00	0.00	-5.45
2004	95.10	100.58	0.00	0.00	0.00	0.00	-5.48
2005	87.70	95.70	0.00	0.00	0.00	0.00	-8.00
2006	91.00	90.82	0.00	0.00	0.00	0.00	0.18
2007	115.00	85.95	0.00	0.00	0.00	0.00	29.05

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-3.28E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.91E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

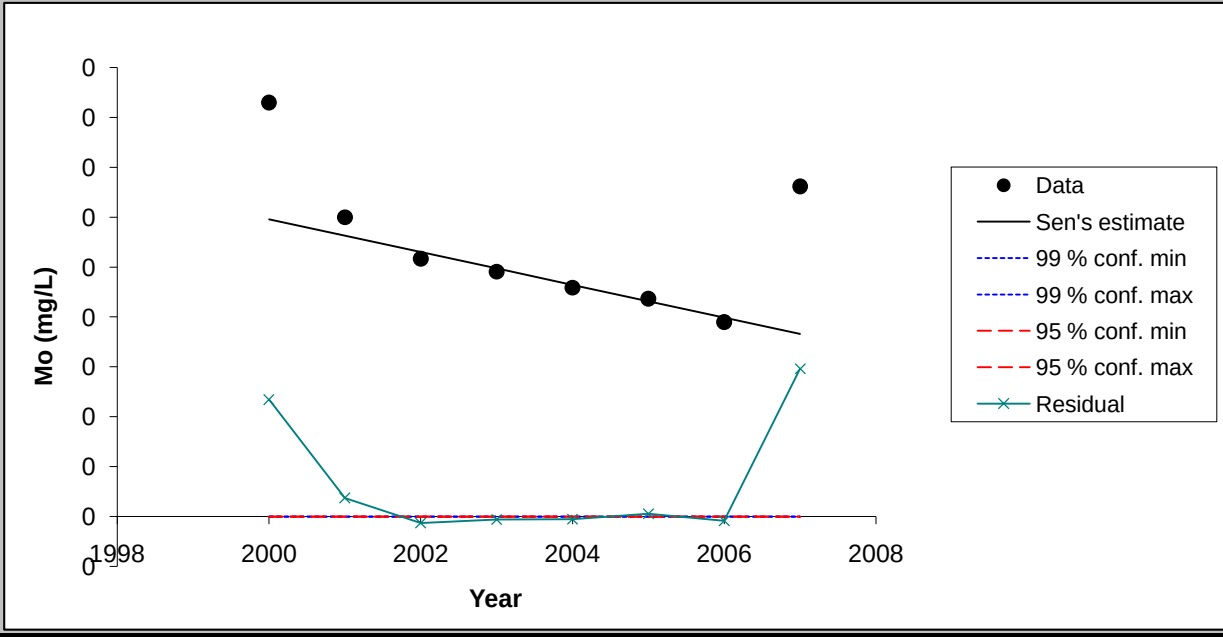

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.06	0.00	0.00	0.00	0.00	0.02
2001	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2002	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2003	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2004	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2005	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2006	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2007	0.07	0.04	0.00	0.00	0.00	0.00	0.03

FIGURE

< Previous Time Series

Next Time Series >

TW-39 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	3.22E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.21E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

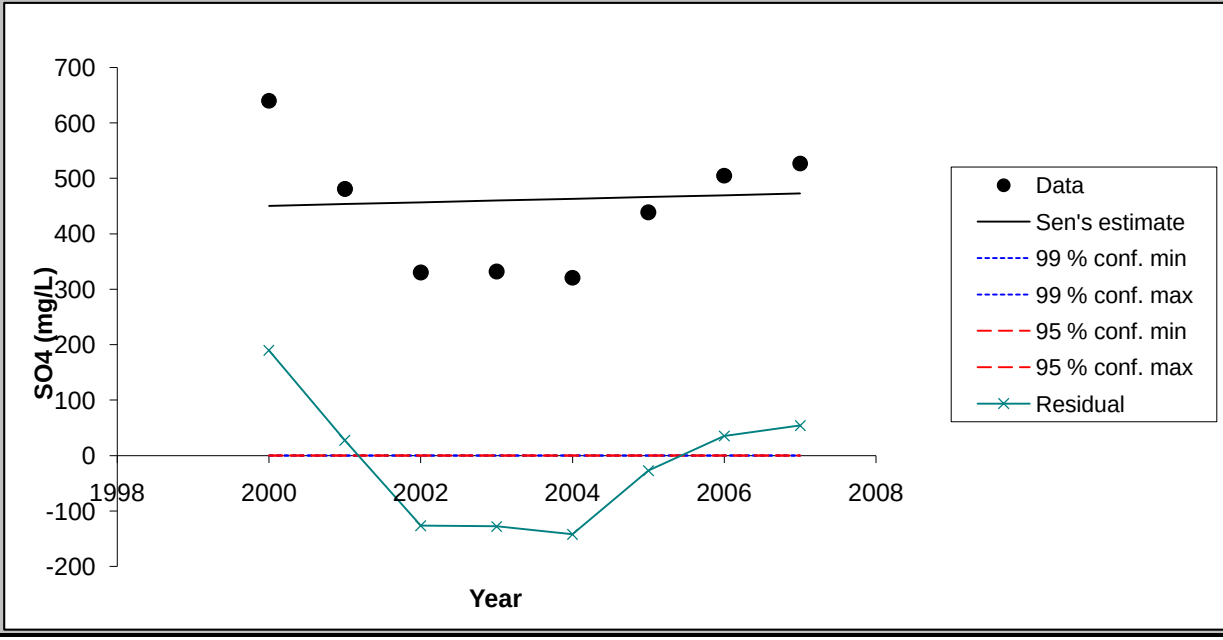

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	640.00	450.34	0.00	0.00	0.00	0.00	189.66
2001	481.00	453.56	0.00	0.00	0.00	0.00	27.44
2002	330.36	456.78	0.00	0.00	0.00	0.00	-126.42
2003	332.00	460.00	0.00	0.00	0.00	0.00	-128.00
2004	321.00	463.22	0.00	0.00	0.00	0.00	-142.22
2005	439.00	466.44	0.00	0.00	0.00	0.00	-27.44
2006	505.00	469.66	0.00	0.00	0.00	0.00	35.34
2007	527.00	472.88	0.00	0.00	0.00	0.00	54.12

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Harris Well (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.66	0.001	0.25	0.0015	7		30
1992	0.0023	0.6625	0.00315	0.72	0.01705	19	0.0308	65.5
1993	0.00292	1.195	0.01505	5.25	0.262	83.1	0.034	298
1994	0.00235	2.31	0.00275	6.465	0.379	134	0.054	399.5
1995	0.0001	2.9	0.0005	8.1	0.34	120	0.074	460
1996	0.0001	4.1	0.0005	7.4	0.26	120	0.074	460
1997	0.0001	4.4	0.002	7.2	0.2	81	0.078	400
1998	0.0001	4.3	0.0005	6.5	0.13	89	0.086	350
1999	0.0001	4.4	0.0005	4.9	0.12	56	0.086	300
2000	0.0003	4.2	0.0005	4.8	0.08	64	0.092	260
2001	0.001	3.6	0.005	5.5	0.102	74	0.06	348
2002	0.001	3.111	0.03	5.76	0.1068	89.312	0.0622	419.387
2003	0.001	2.5	0.0033	6.89	0.255	98.3	0.0763	478
2004	0.001	2	0.0039	6.09	0.273	98.2	0.0554	437
2005	0.001	2.58	0.002	6.32	0.24	106	0.06	439
2006	0.001	2.49	0.002	7.47	0.286	103	0.047	463
2007	0.00016	2.54	0.0013	8.96	0.123	121	0.0652	523

TREND STATISTICS

Harris Well (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-12*			0.00000					######				
F (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.230					5.84				
Mn (mg/L)	*2000*	*2007*	*8*	*-9*			-0.0005					0.0102				
Nitrate (mg/L)	*2000*	*2007*	*8*	*24*		**	0.462					0.66				
Se (mg/L)	*2000*	*2007*	*8*	*16*		+	0.020					-0.07				
Cl (mg/L)	*2000*	*2007*	*8*	*24*		**	7.700					-2.05				
Mo (mg/L)	*2000*	*2007*	*8*	*-8*			-0.003					0.100				
SO4 (mg/L)	*2000*	*2007*	*8*	*22*		**	28.917					59.58				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-1.19E-11
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

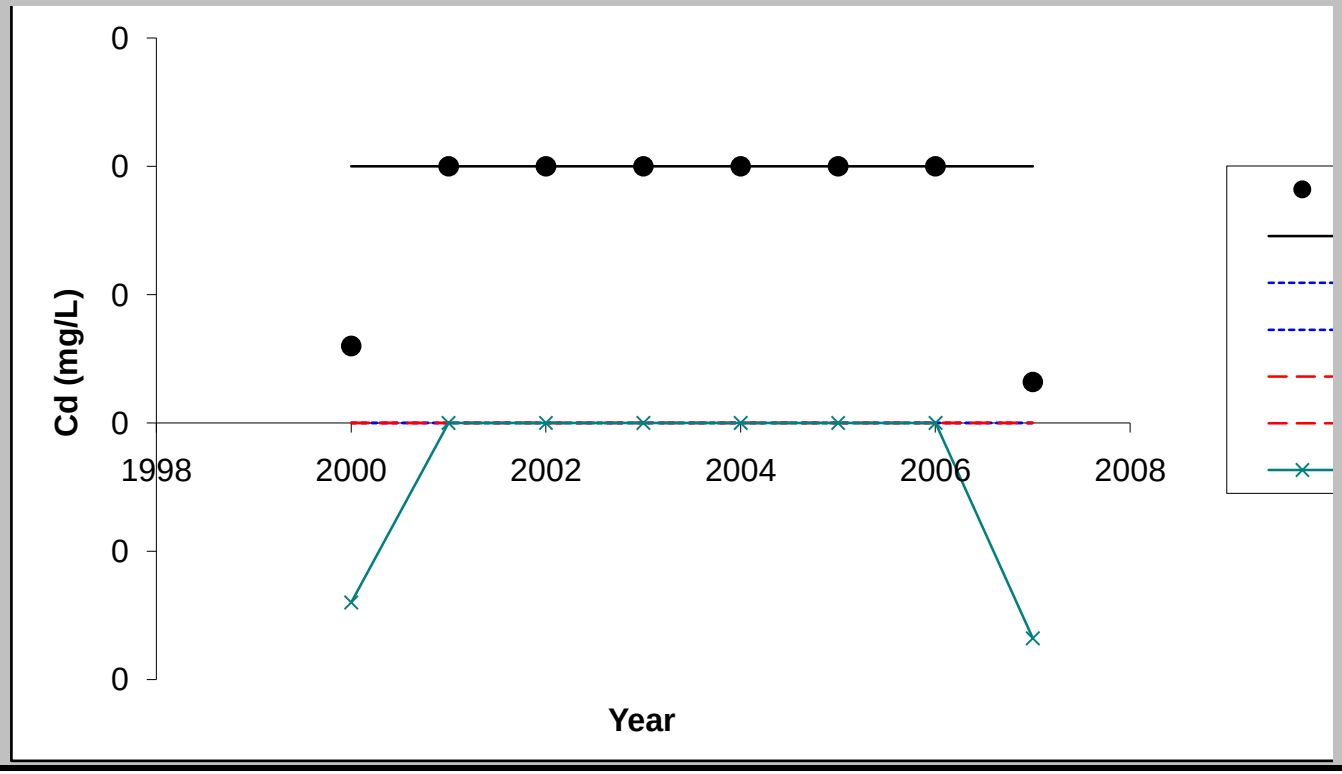

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-2.30E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.84E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

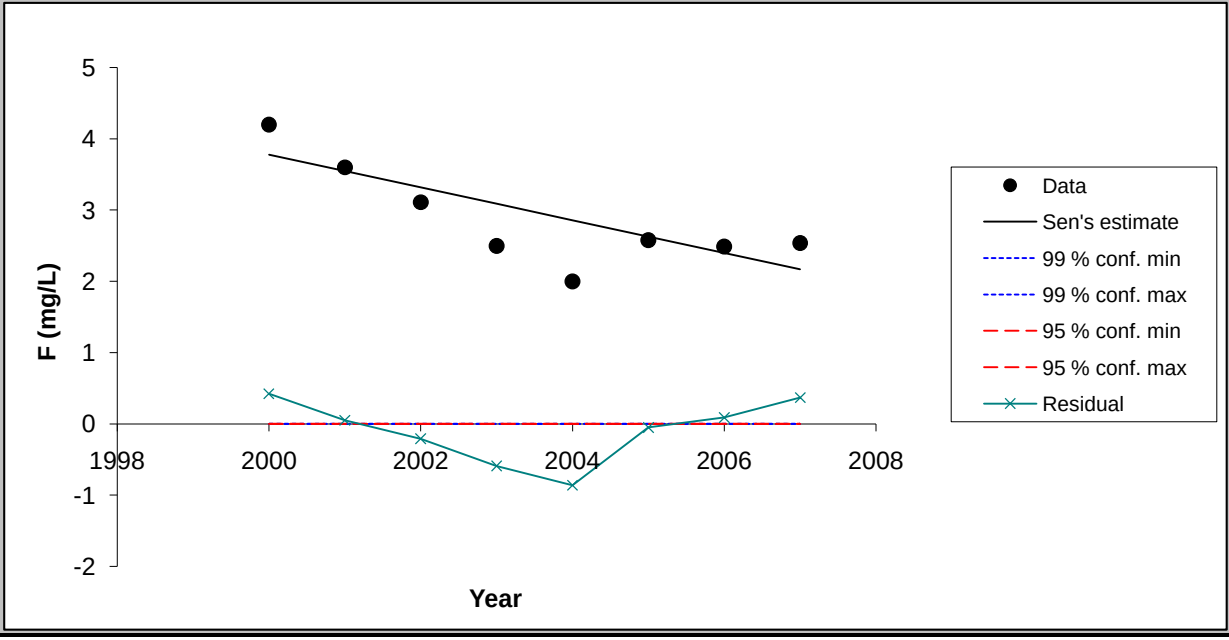

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.20	3.78	0.00	0.00	0.00	0.00	0.42
2001	3.60	3.55	0.00	0.00	0.00	0.00	0.05
2002	3.11	3.32	0.00	0.00	0.00	0.00	-0.21
2003	2.50	3.09	0.00	0.00	0.00	0.00	-0.59
2004	2.00	2.86	0.00	0.00	0.00	0.00	-0.86
2005	2.58	2.63	0.00	0.00	0.00	0.00	-0.05
2006	2.49	2.40	0.00	0.00	0.00	0.00	0.09
2007	2.54	2.17	0.00	0.00	0.00	0.00	0.37

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-9
Test Z	
Signific.	
Q	-5.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.02E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

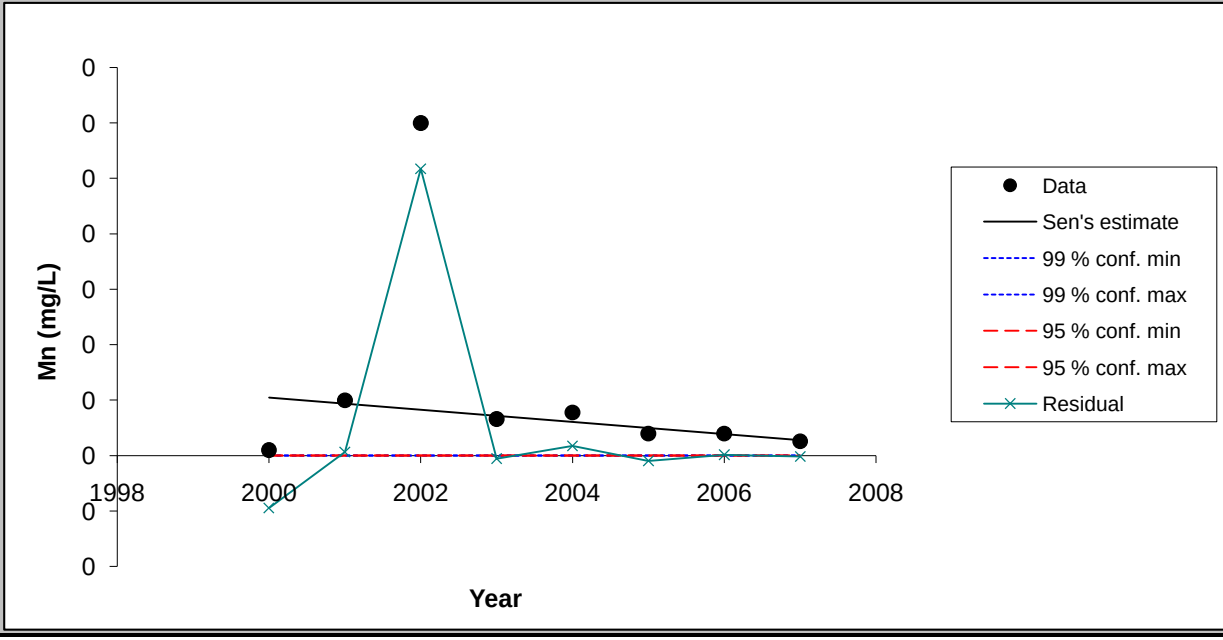

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	24
Test Z	
Signific.	**
Q	4.62E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.55E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

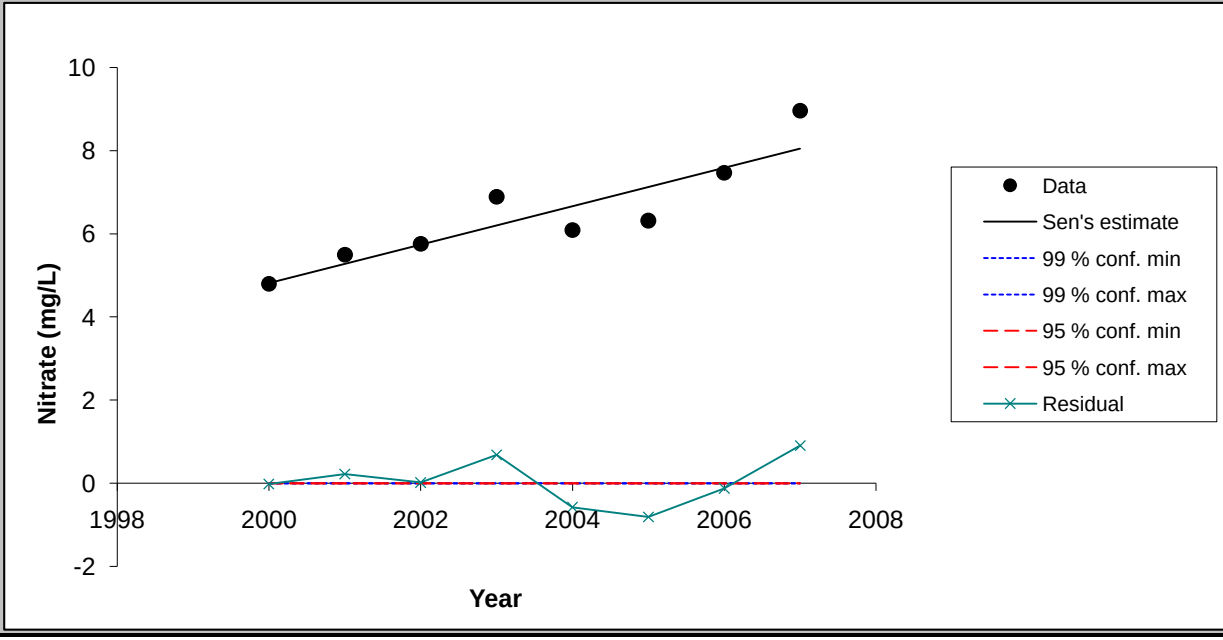

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.80	4.82	0.00	0.00	0.00	0.00	-0.02
2001	5.50	5.28	0.00	0.00	0.00	0.00	0.22
2002	5.76	5.74	0.00	0.00	0.00	0.00	0.02
2003	6.89	6.21	0.00	0.00	0.00	0.00	0.68
2004	6.09	6.67	0.00	0.00	0.00	0.00	-0.58
2005	6.32	7.13	0.00	0.00	0.00	0.00	-0.81
2006	7.47	7.59	0.00	0.00	0.00	0.00	-0.12
2007	8.96	8.06	0.00	0.00	0.00	0.00	0.90

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	2.00E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-6.90E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

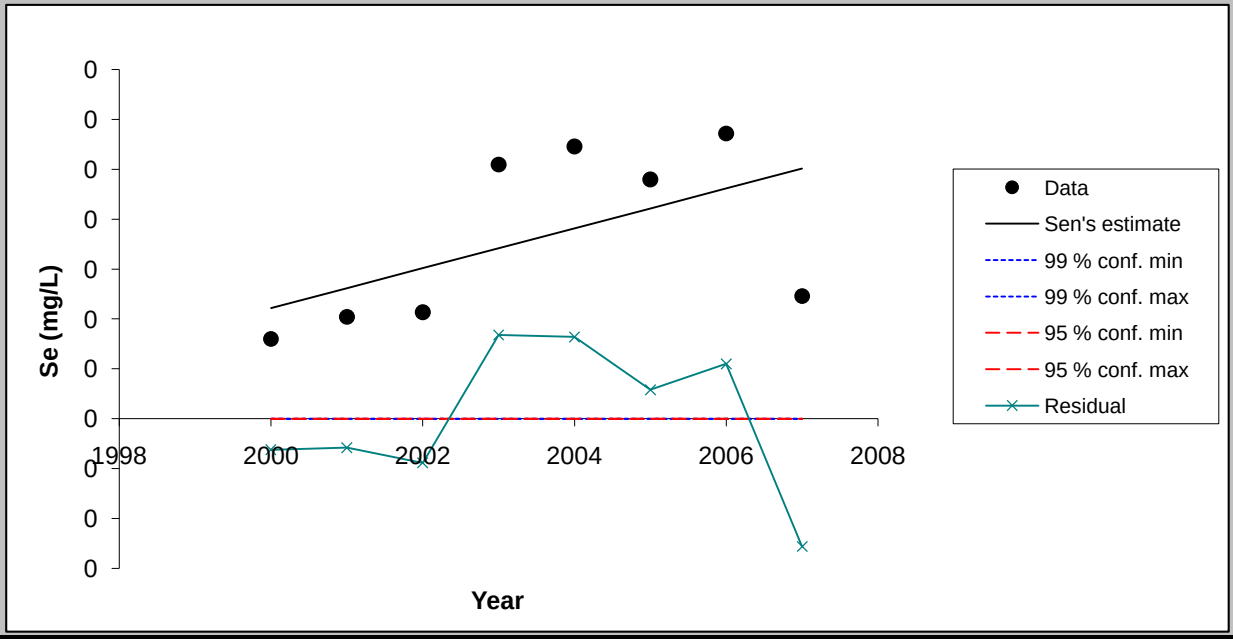

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.11	0.00	0.00	0.00	0.00	-0.03
2001	0.10	0.13	0.00	0.00	0.00	0.00	-0.03
2002	0.11	0.15	0.00	0.00	0.00	0.00	-0.04
2003	0.25	0.17	0.00	0.00	0.00	0.00	0.08
2004	0.27	0.19	0.00	0.00	0.00	0.00	0.08
2005	0.24	0.21	0.00	0.00	0.00	0.00	0.03
2006	0.29	0.23	0.00	0.00	0.00	0.00	0.05
2007	0.12	0.25	0.00	0.00	0.00	0.00	-0.13

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	24
Test Z	
Signific.	**
Q	7.70E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-2.05E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

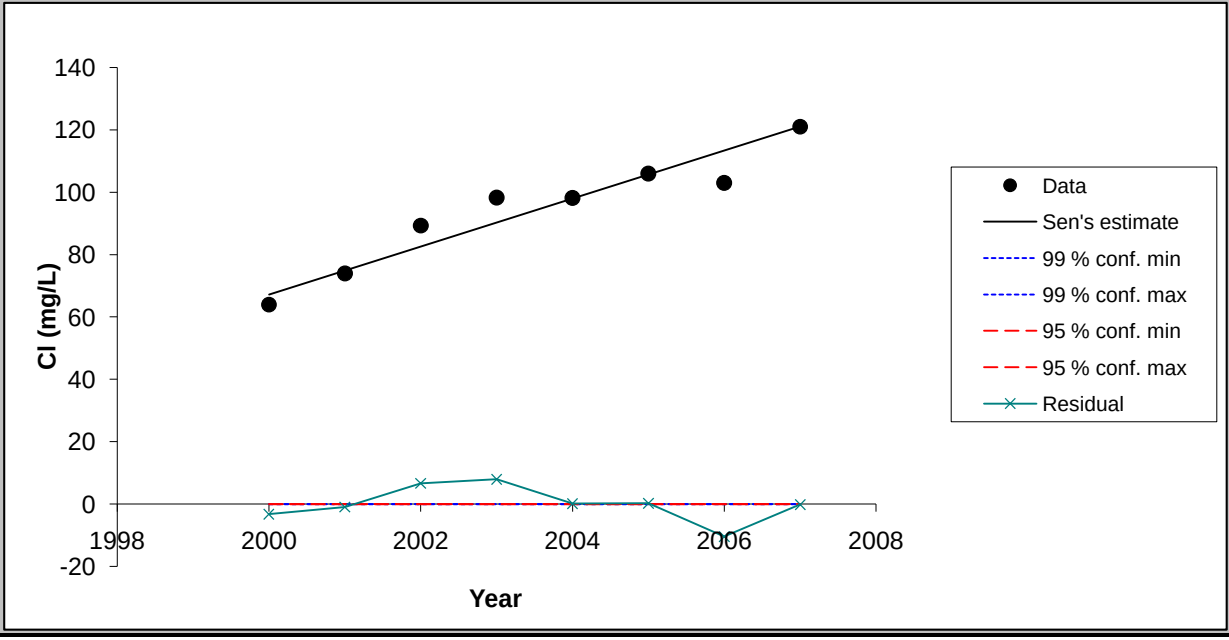

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	64.00	67.25	0.00	0.00	0.00	0.00	-3.25
2001	74.00	74.95	0.00	0.00	0.00	0.00	-0.95
2002	89.31	82.65	0.00	0.00	0.00	0.00	6.66
2003	98.30	90.35	0.00	0.00	0.00	0.00	7.95
2004	98.20	98.05	0.00	0.00	0.00	0.00	0.15
2005	106.00	105.75	0.00	0.00	0.00	0.00	0.25
2006	103.00	113.45	0.00	0.00	0.00	0.00	-10.45
2007	121.00	121.15	0.00	0.00	0.00	0.00	-0.15

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-3.09E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.97E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

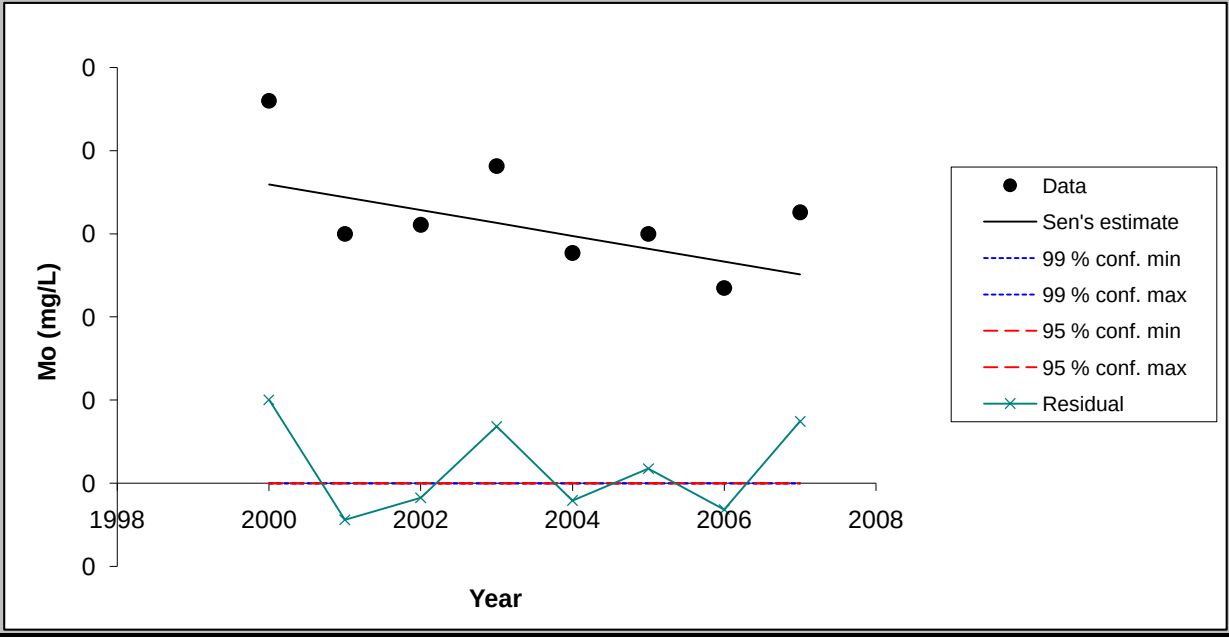

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.09	0.07	0.00	0.00	0.00	0.00	0.02
2001	0.06	0.07	0.00	0.00	0.00	0.00	-0.01
2002	0.06	0.07	0.00	0.00	0.00	0.00	0.00
2003	0.08	0.06	0.00	0.00	0.00	0.00	0.01
2004	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2005	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2006	0.05	0.05	0.00	0.00	0.00	0.00	-0.01
2007	0.07	0.05	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

Harris Well (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	2.89E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.96E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

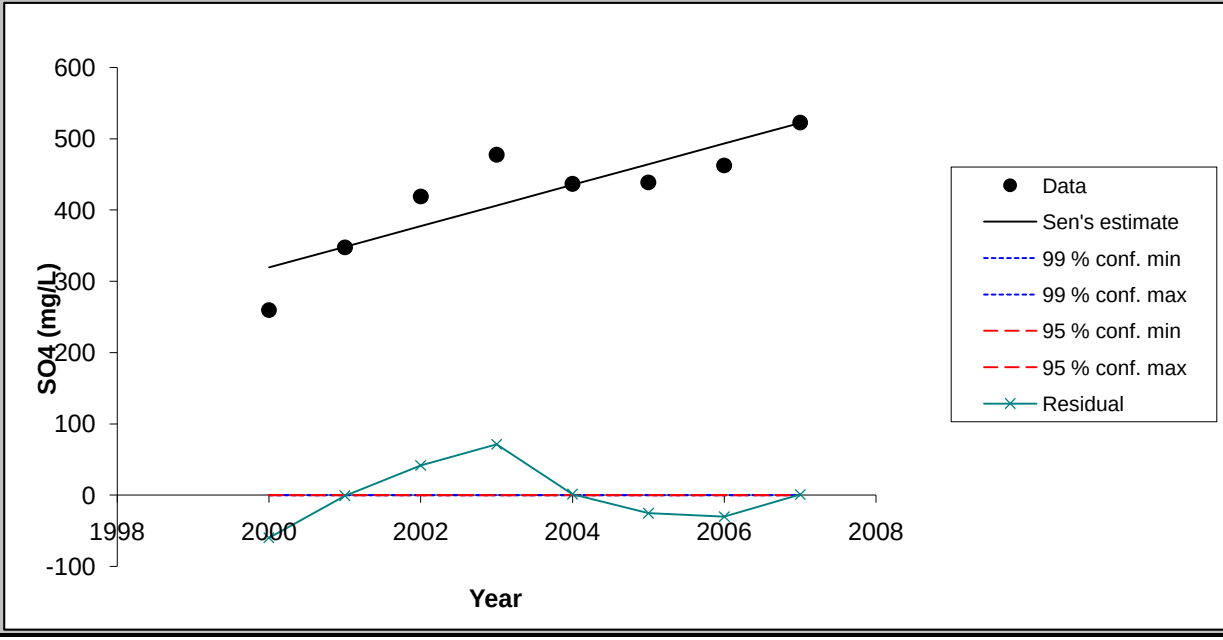

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	260.00	319.83	0.00	0.00	0.00	0.00	-59.83
2001	348.00	348.75	0.00	0.00	0.00	0.00	-0.75
2002	419.39	377.67	0.00	0.00	0.00	0.00	41.72
2003	478.00	406.58	0.00	0.00	0.00	0.00	71.42
2004	437.00	435.50	0.00	0.00	0.00	0.00	1.50
2005	439.00	464.42	0.00	0.00	0.00	0.00	-25.42
2006	463.00	493.33	0.00	0.00	0.00	0.00	-30.33
2007	523.00	522.25	0.00	0.00	0.00	0.00	0.75

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

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ANNUAL DATA

Mormon A Spring (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.018	2.2	0.0025	2.8	0.0015	113		114
1992	0.0124	2.58	0.00185	3.395	0.147	131.5	0.0507	164.5
1993	0.014	3.6	0.01205	5.4	0.1768	160.5	0.07845	267.5
1994	0.0091	3.34	0.001	5.465	0.154	136	0.07965	247.5
1995	0.0142	4	0.0005	6	0.16	140	0.083	300
1996	0.017	5.9	0.0005	7.9	0.23	150	0.092	420
1997	0.018	5.1	0.0005	7.8	0.23	120	0.099	440
1998	0.013	4	0.0005	6.16	0.287	103	0.089	422
1999	0.014	4.1	0.0005	6.5	0.18	79	0.082	450
2000	0.016	3.6	0.0005	6.4	0.19	98	0.083	420
2001	0.015	3.5	0.005	5.95	0.205	96	0.06	436
2002	0.0149	3.054	0.03	5.95	0.2727	101.8	0.0637	394.259
2003	0.0145	2.69	0.001	6.33	0.239	96.5	0.0625	386
2004	0.0115	1.94	0.001	6.66	0.232	95.9	0.0528	285
2005	0.0142	2.25	0.002	9.45	0.258	106	0.0495	416
2006	0.0147	3.1	0.002	9.25	0.294	120	0.06	472
2007	0.0174	2.94	0.002	9.22	0.136	120	0.0757	509

TREND STATISTICS

Mormon A Spring (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-6*			-0.0001					0.0163				
F (mg/L)	*2000*	*2007*	*8*	*-12*			-0.130					4.63				
Mn (mg/L)	*2000*	*2007*	*8*	*3*			0.0001					0.0010				
Nitrate (mg/L)	*2000*	*2007*	*8*	*16*		+	0.439					1.88				
Se (mg/L)	*2000*	*2007*	*8*	*6*			0.010					0.11				
Cl (mg/L)	*2000*	*2007*	*8*	*13*			3.391					63.29				
Mo (mg/L)	*2000*	*2007*	*8*	*-6*			-0.001					0.08				
SO4 (mg/L)	*2000*	*2007*	*8*	*6*			10.417					297.71				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.25E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.63E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

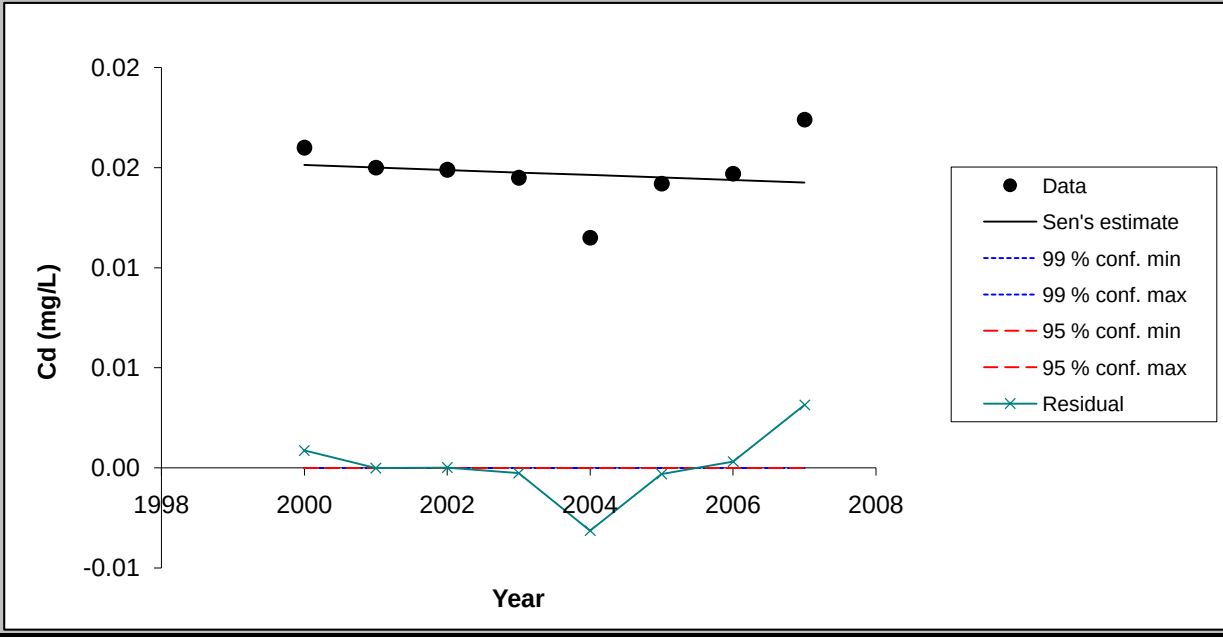

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.02	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.02	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-1.30E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.63E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

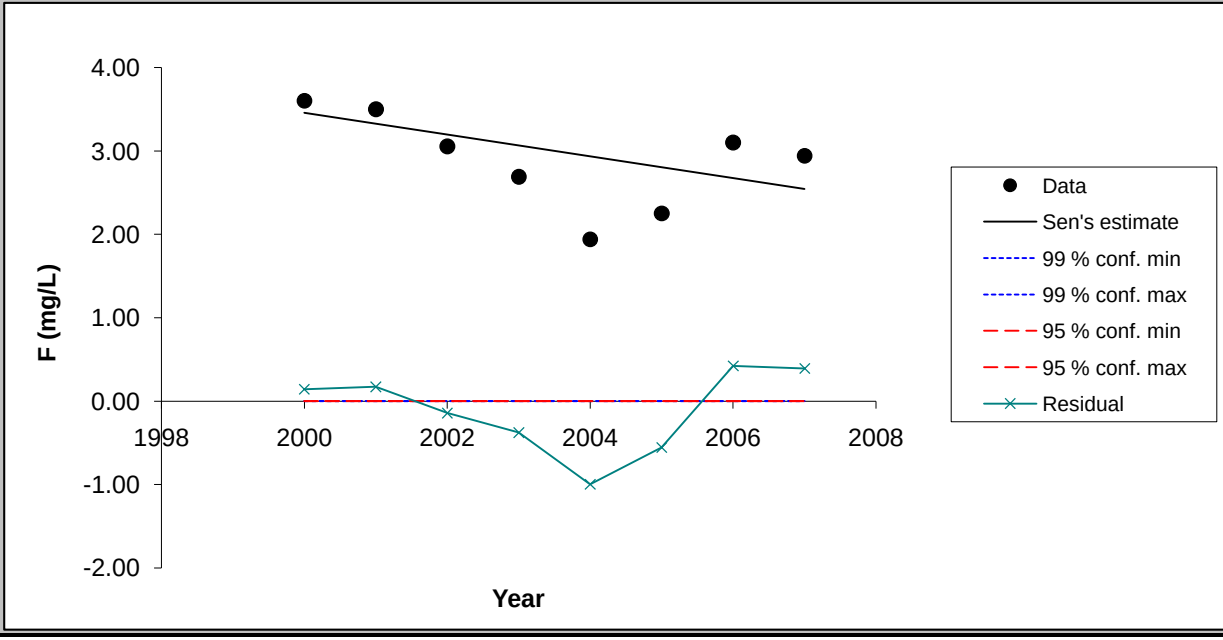

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.60	3.46	0.00	0.00	0.00	0.00	0.14
2001	3.50	3.33	0.00	0.00	0.00	0.00	0.17
2002	3.05	3.20	0.00	0.00	0.00	0.00	-0.14
2003	2.69	3.07	0.00	0.00	0.00	0.00	-0.38
2004	1.94	2.94	0.00	0.00	0.00	0.00	-1.00
2005	2.25	2.81	0.00	0.00	0.00	0.00	-0.56
2006	3.10	2.68	0.00	0.00	0.00	0.00	0.42
2007	2.94	2.55	0.00	0.00	0.00	0.00	0.39

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	3
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

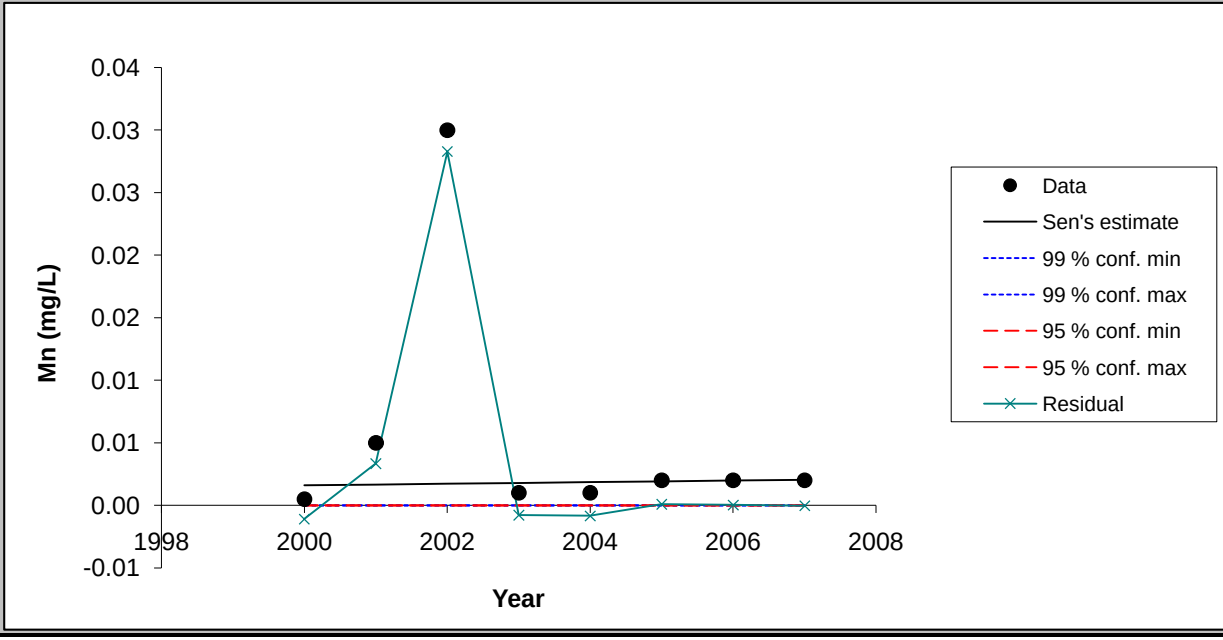

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	4.39E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.88E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

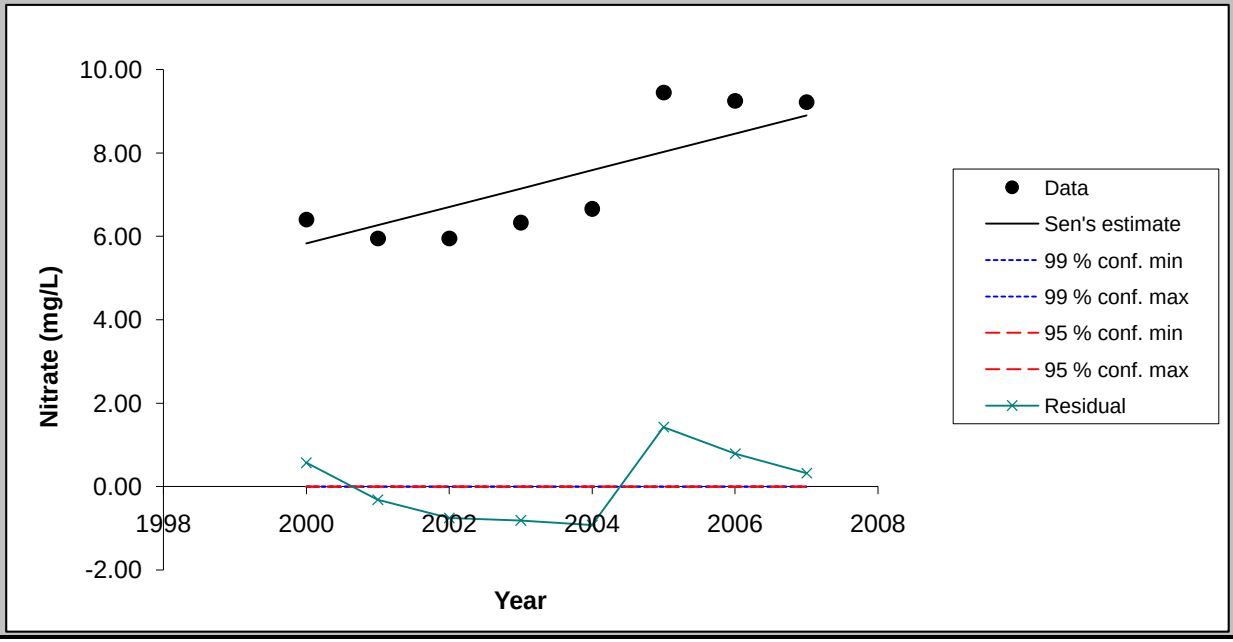

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	6.40	5.83	0.00	0.00	0.00	0.00	0.57
2001	5.95	6.27	0.00	0.00	0.00	0.00	-0.32
2002	5.95	6.71	0.00	0.00	0.00	0.00	-0.76
2003	6.33	7.15	0.00	0.00	0.00	0.00	-0.82
2004	6.66	7.58	0.00	0.00	0.00	0.00	-0.92
2005	9.45	8.02	0.00	0.00	0.00	0.00	1.43
2006	9.25	8.46	0.00	0.00	0.00	0.00	0.79
2007	9.22	8.90	0.00	0.00	0.00	0.00	0.32

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	6
Test Z	
Signific.	
Q	1.00E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.11E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

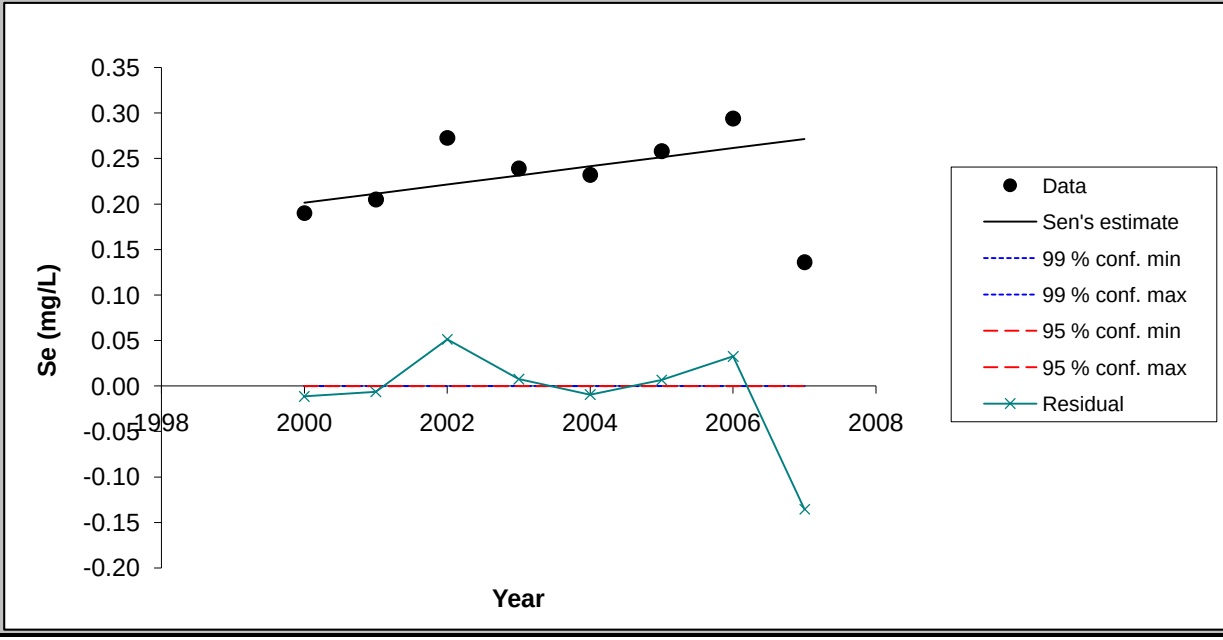

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.19	0.20	0.00	0.00	0.00	0.00	-0.01
2001	0.20	0.21	0.00	0.00	0.00	0.00	-0.01
2002	0.27	0.22	0.00	0.00	0.00	0.00	0.05
2003	0.24	0.23	0.00	0.00	0.00	0.00	0.01
2004	0.23	0.24	0.00	0.00	0.00	0.00	-0.01
2005	0.26	0.25	0.00	0.00	0.00	0.00	0.01
2006	0.29	0.26	0.00	0.00	0.00	0.00	0.03
2007	0.14	0.27	0.00	0.00	0.00	0.00	-0.14

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	13
Test Z	
Signific.	
Q	3.39E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.33E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

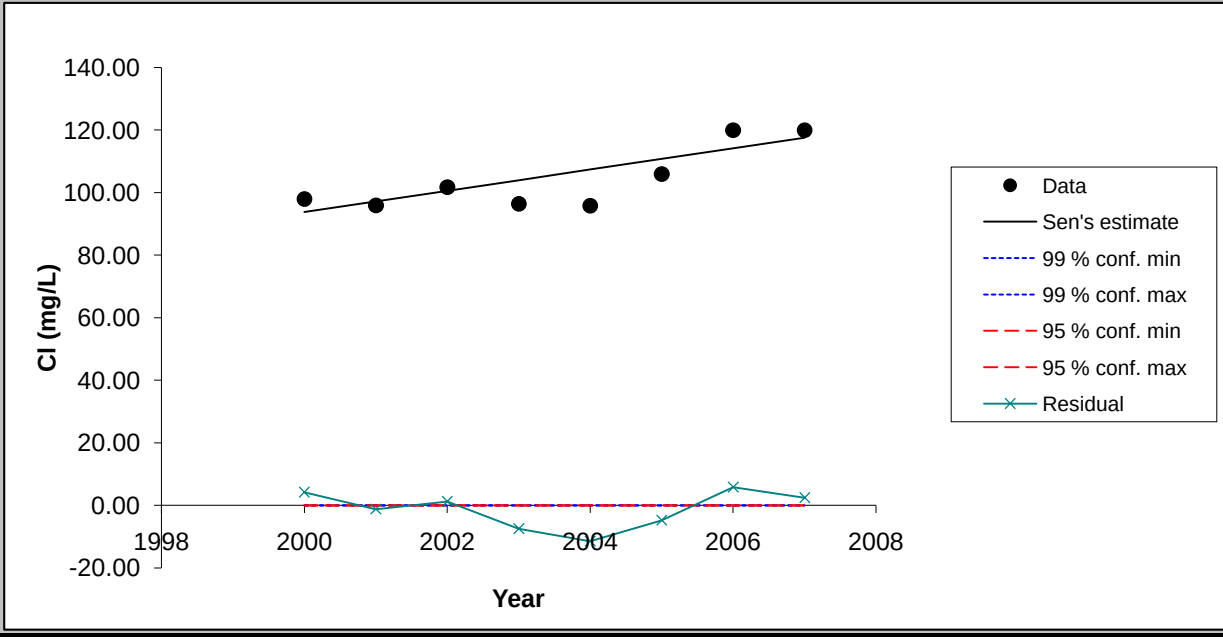

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	98.00	93.81	0.00	0.00	0.00	0.00	4.19
2001	96.00	97.20	0.00	0.00	0.00	0.00	-1.20
2002	101.80	100.60	0.00	0.00	0.00	0.00	1.20
2003	96.50	103.99	0.00	0.00	0.00	0.00	-7.49
2004	95.90	107.38	0.00	0.00	0.00	0.00	-11.48
2005	106.00	110.77	0.00	0.00	0.00	0.00	-4.77
2006	120.00	114.16	0.00	0.00	0.00	0.00	5.84
2007	120.00	117.55	0.00	0.00	0.00	0.00	2.45

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.12E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.60E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

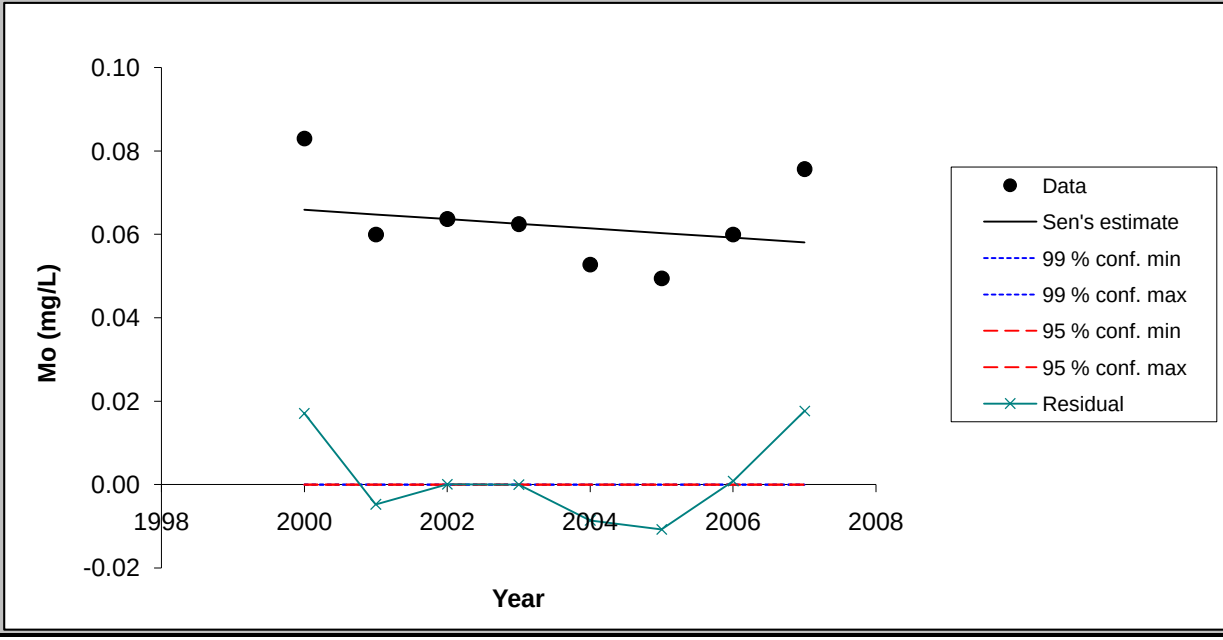

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.07	0.00	0.00	0.00	0.00	0.02
2001	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2002	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2003	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2004	0.05	0.06	0.00	0.00	0.00	0.00	-0.01
2005	0.05	0.06	0.00	0.00	0.00	0.00	-0.01
2006	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2007	0.08	0.06	0.00	0.00	0.00	0.00	0.02

FIGURE

< Previous Time Series

Next Time Series >

Mormon A Spring (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	6
Test Z	
Signific.	
Q	1.04E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.98E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

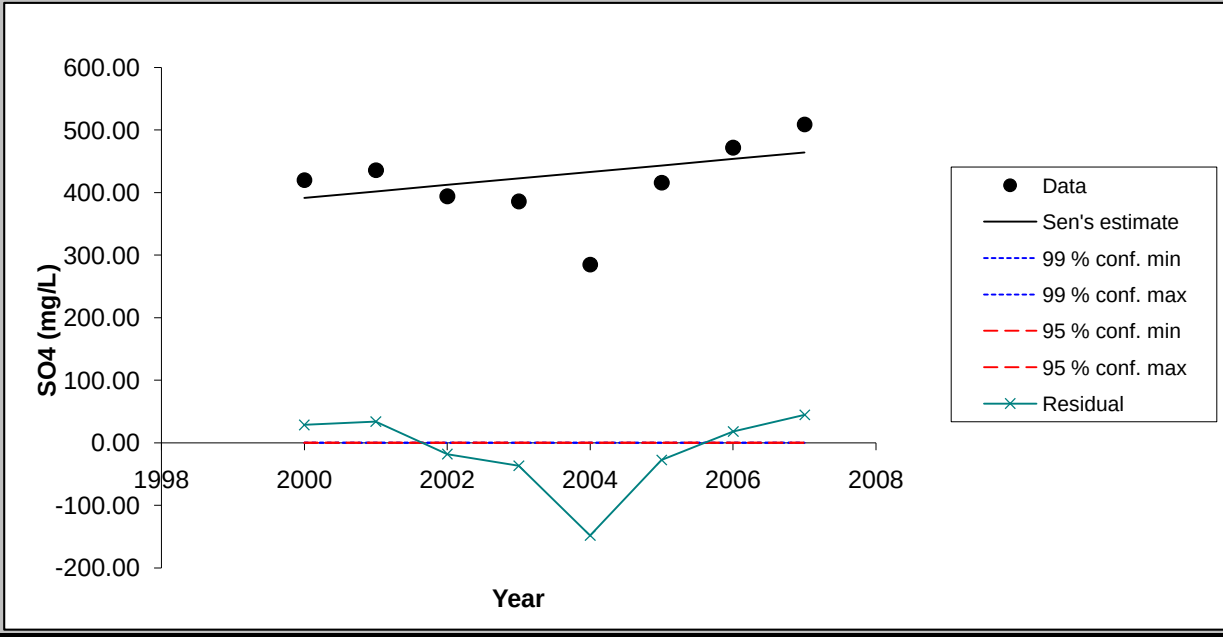

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	420.00	391.46	0.00	0.00	0.00	0.00	28.54
2001	436.00	401.88	0.00	0.00	0.00	0.00	34.12
2002	394.26	412.30	0.00	0.00	0.00	0.00	-18.04
2003	386.00	422.71	0.00	0.00	0.00	0.00	-36.71
2004	285.00	433.13	0.00	0.00	0.00	0.00	-148.13
2005	416.00	443.55	0.00	0.00	0.00	0.00	-27.55
2006	472.00	453.96	0.00	0.00	0.00	0.00	18.04
2007	509.00	464.38	0.00	0.00	0.00	0.00	44.62

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-16 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.626	4.1	0.078	5.2	0.09	46		150
1992	0.614	3.49	0.0681	5.28	0.423	38.4	0.0349	137.5
1993	0.651	3.46	0.05415	7.41	0.4065	50.45	0.02145	198.5
1994	0.6535	3.52	0.0276	6.57	0.232	45.2	0.01375	163
1995	0.653	3.7	0.017	5.8	0.2	40	0.016	170
1996	0.627	3.4	0.008	6.6	0.3	45	0.017	170
1997	0.6	3.6	0.001	7.5	0.26	47	0.014	200
1998	0.6	2.7	0.0005	6.1	0.199	45	0.012	260
1999	0.6	2.8	0.0005	6	0.25	34	0.01	180
2000	0.59	2.8	0.0005	4.9	0.25	48	0.011	180
2001	0.508	2.5	0.005	5.08	0.253	39	0.005	147
2002	0.481	2.508	0.03	4.54	0.3603	35.878	0.0148	137.075
2003	0.462	1.81	0.001	4.71	0.246	46.2	0.019	156
2004	0.445	2.1	0.001	4.36	0.241	39.9	0.0246	138
2005	0.476	2.08	0.002	5.86	0.252	63.8	0.0193	181
2006	0.49	2.3	0.002	6.91	0.209	87.6	0.012	190
2007	0.513	2.16	0.002	6.38	0.0566	78.1	0.0216	161

TREND STATISTICS

TW-16 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-4*			-0.006					0.562				
F (mg/L)	*2000*	*2007*	*8*	*-10*			-0.076					3.31				
Mn (mg/L)	*2000*	*2007*	*8*	*3*			0.000					0.001				
Nitrate (mg/L)	*2000*	*2007*	*8*	*10*			0.214					2.90				
Se (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.0106					0.3702				
Cl (mg/L)	*2000*	*2007*	*8*	*14*			6.56					-27.43				
Mo (mg/L)	*2000*	*2007*	*8*	*14*			0.0015					-0.0022				
SO4 (mg/L)	*2000*	*2007*	*8*	*8*			2.00					130.50				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-5.80E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.62E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

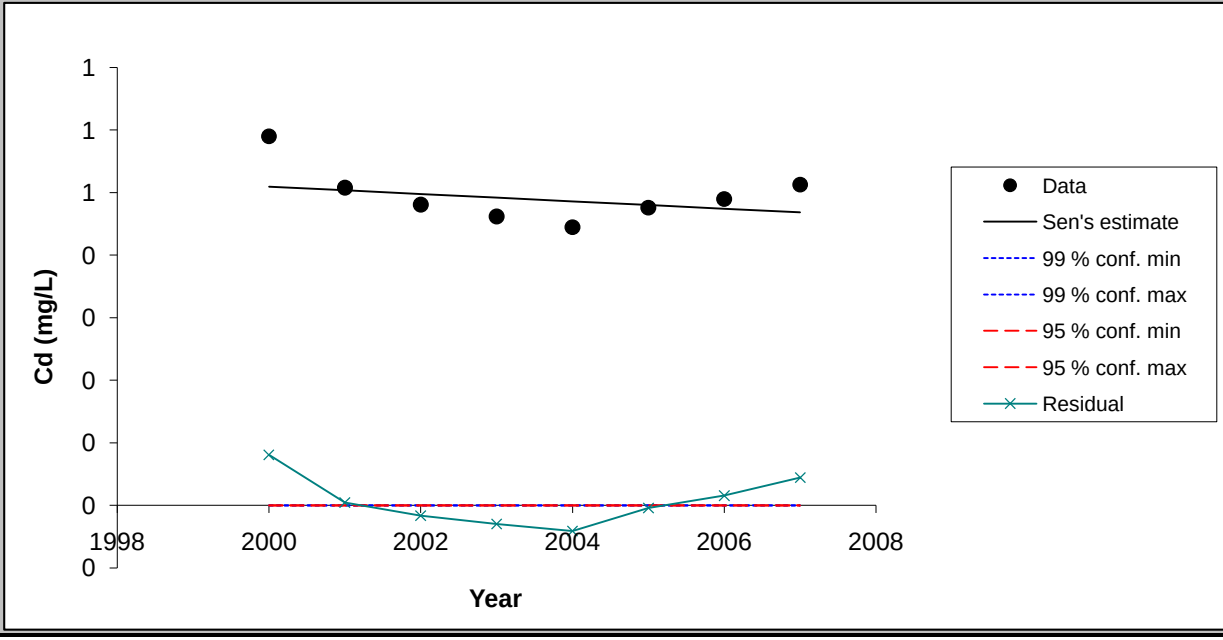

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.59	0.51	0.00	0.00	0.00	0.00	0.08
2001	0.51	0.50	0.00	0.00	0.00	0.00	0.00
2002	0.48	0.50	0.00	0.00	0.00	0.00	-0.02
2003	0.46	0.49	0.00	0.00	0.00	0.00	-0.03
2004	0.45	0.49	0.00	0.00	0.00	0.00	-0.04
2005	0.48	0.48	0.00	0.00	0.00	0.00	0.00
2006	0.49	0.47	0.00	0.00	0.00	0.00	0.02
2007	0.51	0.47	0.00	0.00	0.00	0.00	0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-10
Test Z	
Signific.	
Q	-7.65E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.31E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

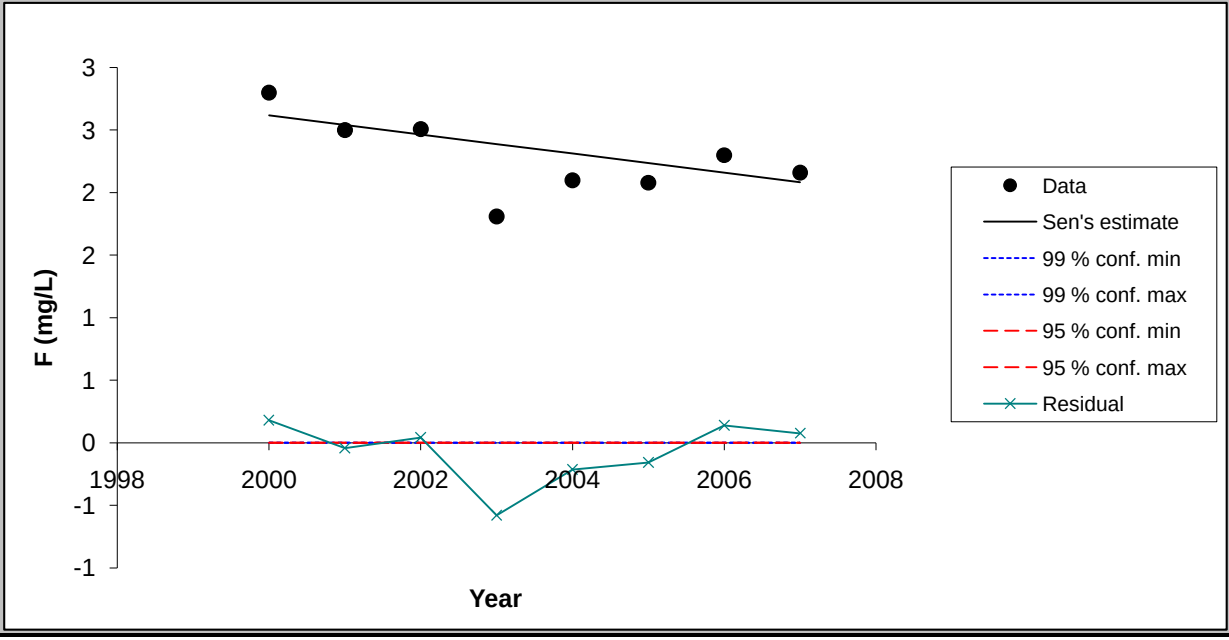

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	2.80	2.62	0.00	0.00	0.00	0.00	0.18
2001	2.50	2.54	0.00	0.00	0.00	0.00	-0.04
2002	2.51	2.47	0.00	0.00	0.00	0.00	0.04
2003	1.81	2.39	0.00	0.00	0.00	0.00	-0.58
2004	2.10	2.31	0.00	0.00	0.00	0.00	-0.21
2005	2.08	2.24	0.00	0.00	0.00	0.00	-0.16
2006	2.30	2.16	0.00	0.00	0.00	0.00	0.14
2007	2.16	2.08	0.00	0.00	0.00	0.00	0.08

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	3
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

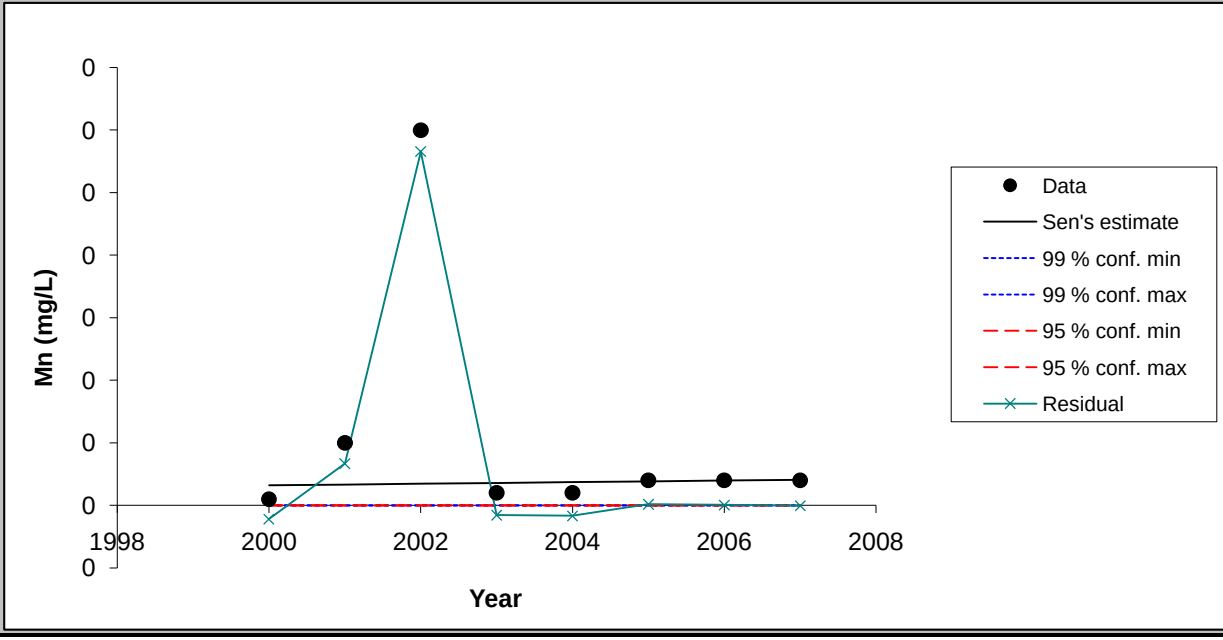

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	2.14E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.90E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

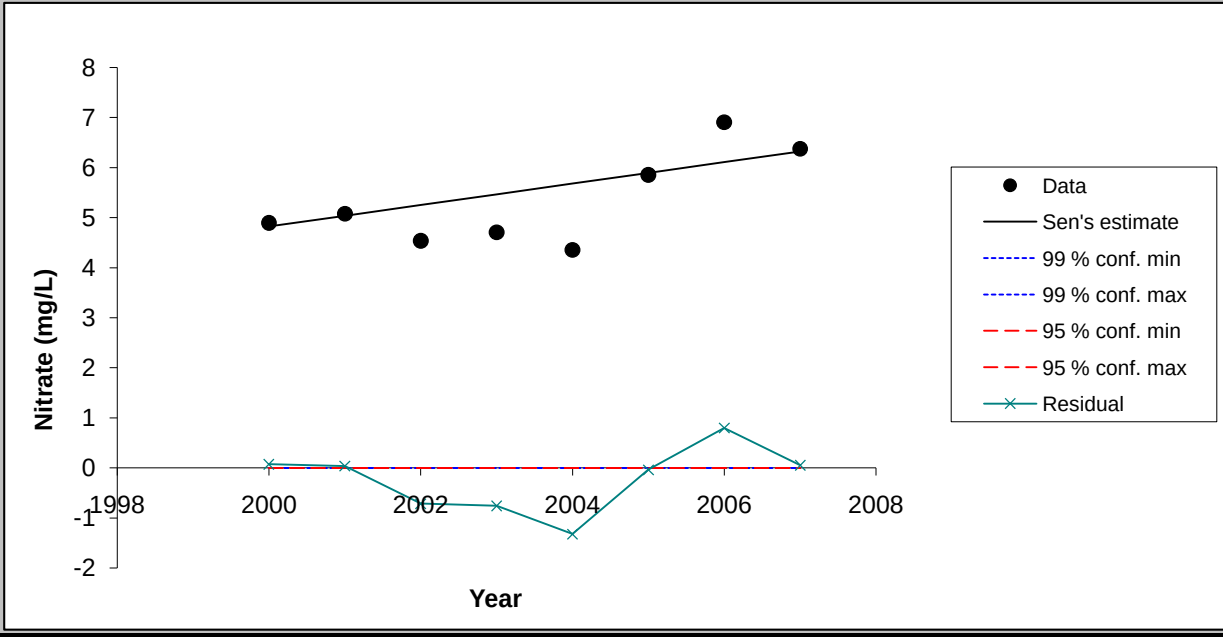

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.90	4.83	0.00	0.00	0.00	0.00	0.07
2001	5.08	5.04	0.00	0.00	0.00	0.00	0.04
2002	4.54	5.26	0.00	0.00	0.00	0.00	-0.72
2003	4.71	5.47	0.00	0.00	0.00	0.00	-0.76
2004	4.36	5.68	0.00	0.00	0.00	0.00	-1.32
2005	5.86	5.90	0.00	0.00	0.00	0.00	-0.04
2006	6.91	6.11	0.00	0.00	0.00	0.00	0.80
2007	6.38	6.33	0.00	0.00	0.00	0.00	0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-1.06E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.70E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

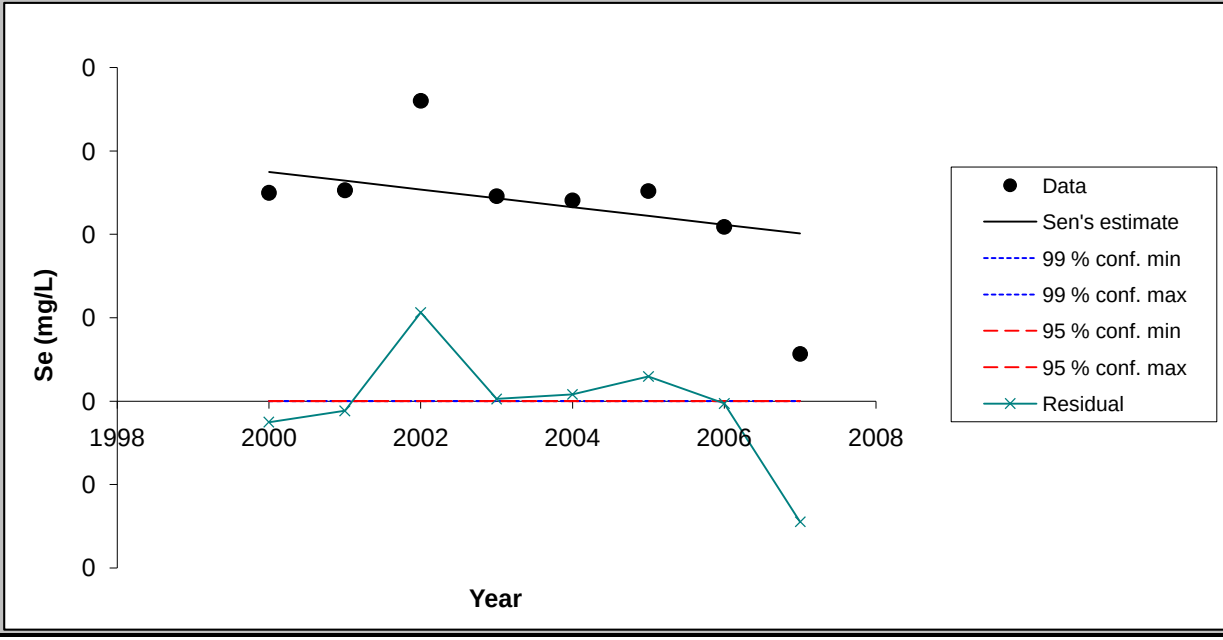

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.25	0.28	0.00	0.00	0.00	0.00	-0.03
2001	0.25	0.26	0.00	0.00	0.00	0.00	-0.01
2002	0.36	0.25	0.00	0.00	0.00	0.00	0.11
2003	0.25	0.24	0.00	0.00	0.00	0.00	0.00
2004	0.24	0.23	0.00	0.00	0.00	0.00	0.01
2005	0.25	0.22	0.00	0.00	0.00	0.00	0.03
2006	0.21	0.21	0.00	0.00	0.00	0.00	0.00
2007	0.06	0.20	0.00	0.00	0.00	0.00	-0.14

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	6.56E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-2.74E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

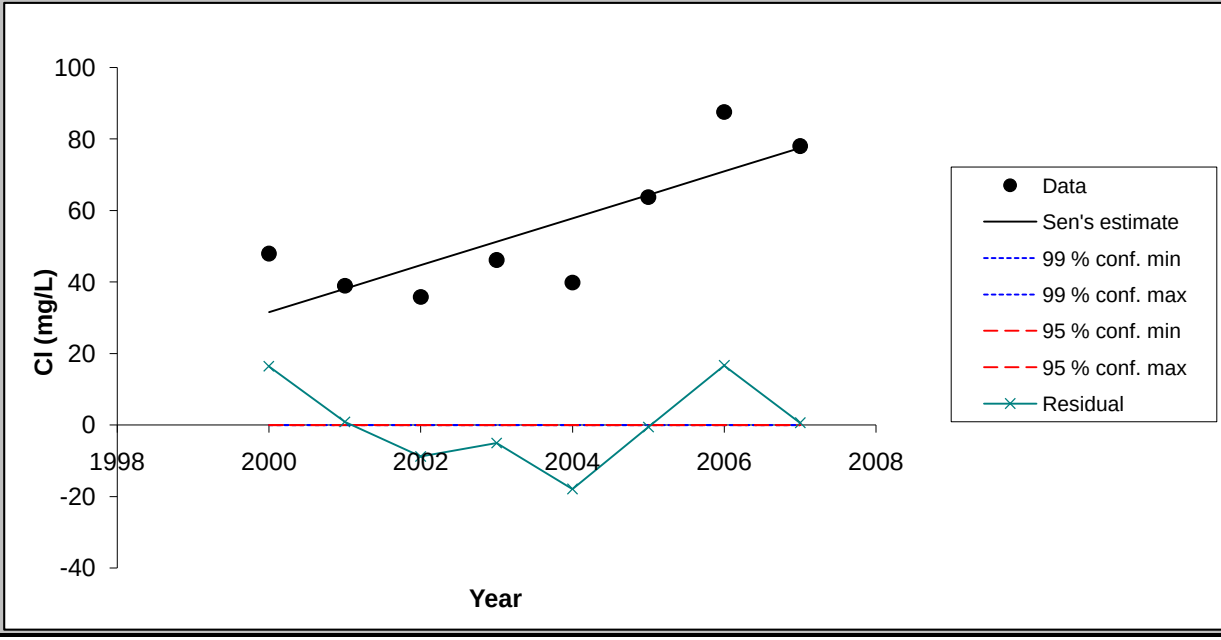

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	48.00	31.60	0.00	0.00	0.00	0.00	16.40
2001	39.00	38.16	0.00	0.00	0.00	0.00	0.84
2002	35.88	44.72	0.00	0.00	0.00	0.00	-8.84
2003	46.20	51.28	0.00	0.00	0.00	0.00	-5.07
2004	39.90	57.83	0.00	0.00	0.00	0.00	-17.93
2005	63.80	64.39	0.00	0.00	0.00	0.00	-0.59
2006	87.60	70.95	0.00	0.00	0.00	0.00	16.65
2007	78.10	77.51	0.00	0.00	0.00	0.00	0.59

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	1.51E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-2.16E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

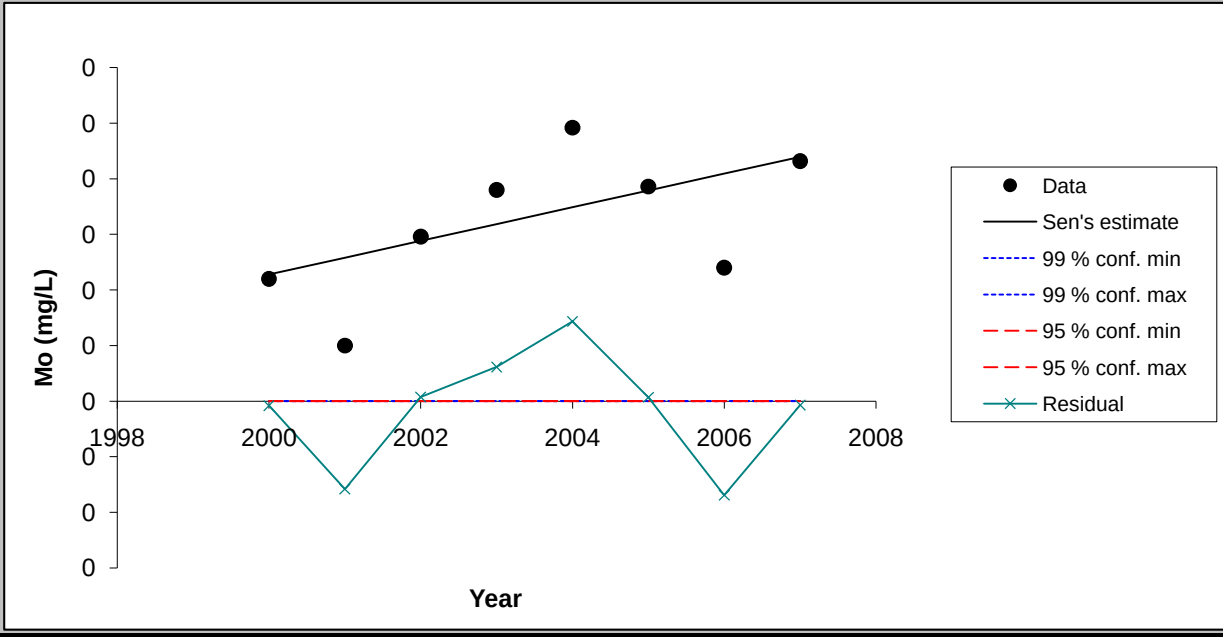

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.01
2005	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2007	0.02	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-16 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	2.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.31E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

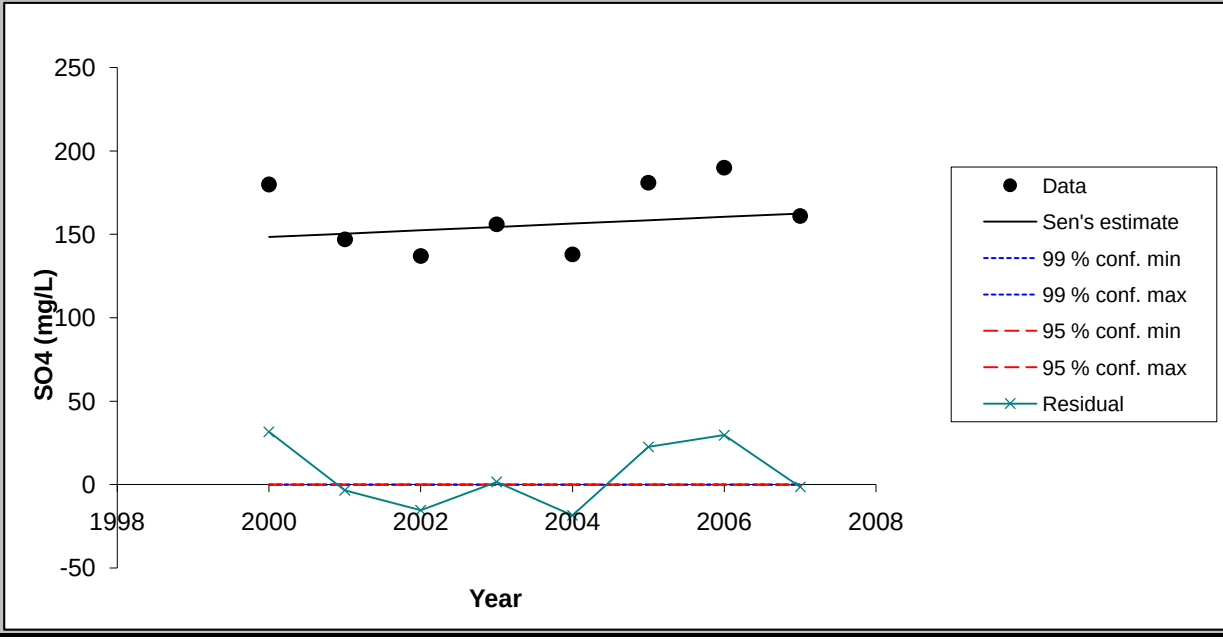

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	180.00	148.50	0.00	0.00	0.00	0.00	31.50
2001	147.00	150.50	0.00	0.00	0.00	0.00	-3.50
2002	137.07	152.50	0.00	0.00	0.00	0.00	-15.43
2003	156.00	154.50	0.00	0.00	0.00	0.00	1.50
2004	138.00	156.50	0.00	0.00	0.00	0.00	-18.50
2005	181.00	158.50	0.00	0.00	0.00	0.00	22.50
2006	190.00	160.50	0.00	0.00	0.00	0.00	29.50
2007	161.00	162.50	0.00	0.00	0.00	0.00	-1.50

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-17 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991								
1992	0.0036	2.715	1.365	0.1	0.0061	220.5	0.0554	238.50
1993	0.00292	2.485	1.510	0.08	0.00465	209.00	0.06630	250.0
1994	0.0053	2.455	1.56	0.0625	0.00475	210	0.058	221
1995	0.0039	2.90	1.620	0.005	0.010	180	0.0600	240
1996	0.0031	2.60	1.650	0.005	0.0050	190	0.0600	210
1997	0.0029	2.7	1.620	0.005	0.007	180	0.0500	210
1998	0.0025	2.2	1.820	0.031	0.007	160	0.0490	220
1999	0.0030	2.40	1.910	0.005	0.0020	140	0.0480	200
2000	0.0034	2.20	1.850	0.033	0.001	140	0.0450	210
2001	0.003	2.3	2.15	0.025	0.0090	153	0.020	186
2002	0.005	1.615	2.484	0.025	0.0090	145.767	0.049	193.586
2003	0.0026	2.205	2.235	0.01	0.008	150.5	0.04225	180
2004	0.0045	1.62	2.35	0.01	0.0015	143	0.0549	180
2005	0.0035	1.63	2.54	0.01	0.0015	138	0.0429	160
2006	0.0046	2.4	2.52	0.09	0.003	116	0.028	142
2007	0.00075	2.39	2.55	0.01	0.0012	125	0.044	155

TREND STATISTICS

TW-17 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-2*			-0.0002					0.0053				
F (mg/L)	*2000*	*2007*	*8*	*8*			0.013					2.07				
Mn (mg/L)	*2000*	*2007*	*8*	*22*		**	0.082					1.29				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-6*			-0.003					0.05				
Se (mg/L)	*2000*	*2007*	*8*	*-8*			-0.0007					0.0137				
Cl (mg/L)	*2000*	*2007*	*8*	*-16*		+	-4.077					192.19				
Mo (mg/L)	*2000*	*2007*	*8*	*0*			0.0001					0.0421				
SO4 (mg/L)	*2000*	*2007*	*8*	*-23*		**	-8.270					281.84				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-1.63E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.32E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

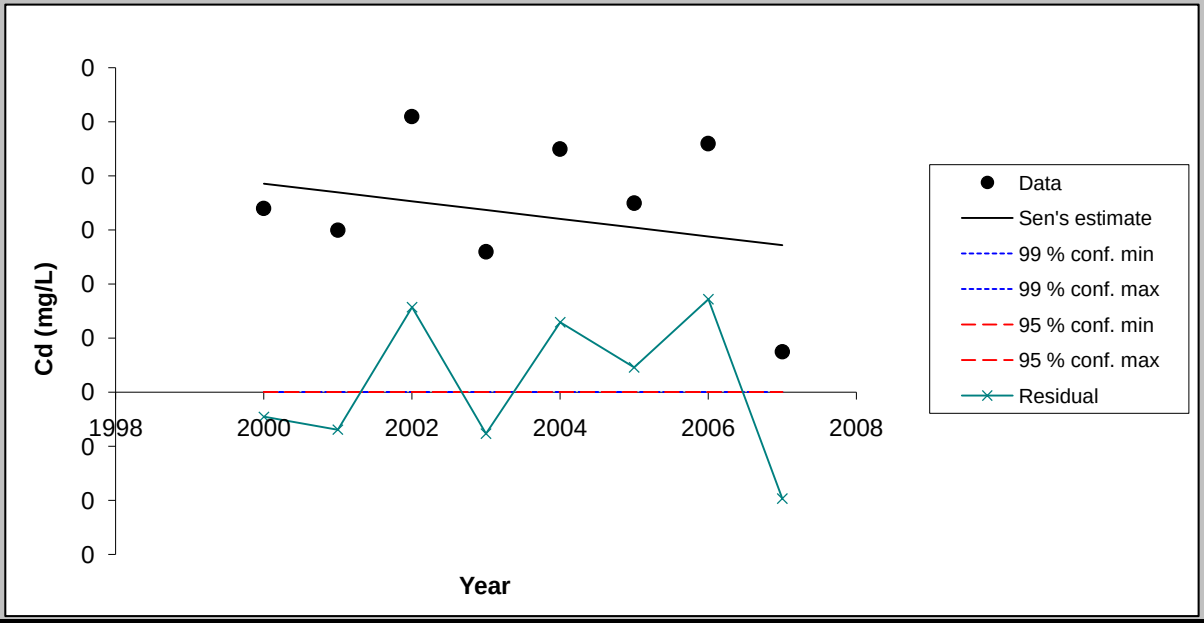

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	1.25E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.07E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

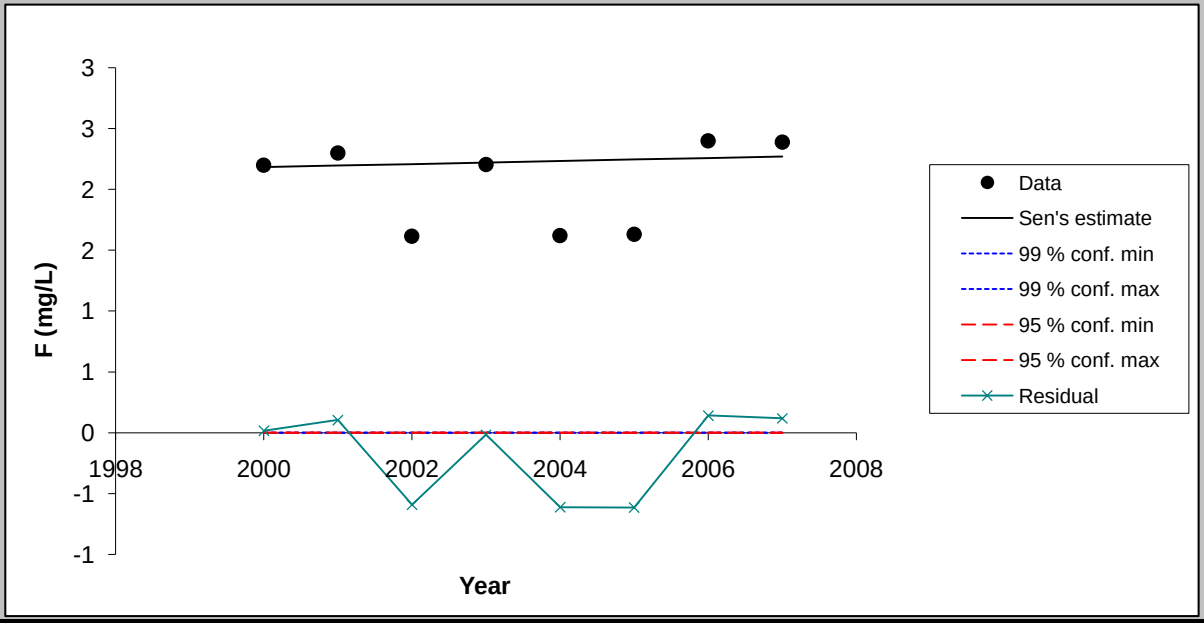

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	2.20	2.18	0.00	0.00	0.00	0.00	0.02
2001	2.30	2.20	0.00	0.00	0.00	0.00	0.10
2002	1.62	2.21	0.00	0.00	0.00	0.00	-0.59
2003	2.21	2.22	0.00	0.00	0.00	0.00	-0.02
2004	1.62	2.23	0.00	0.00	0.00	0.00	-0.61
2005	1.63	2.25	0.00	0.00	0.00	0.00	-0.62
2006	2.40	2.26	0.00	0.00	0.00	0.00	0.14
2007	2.39	2.27	0.00	0.00	0.00	0.00	0.12

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	8.19E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.29E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

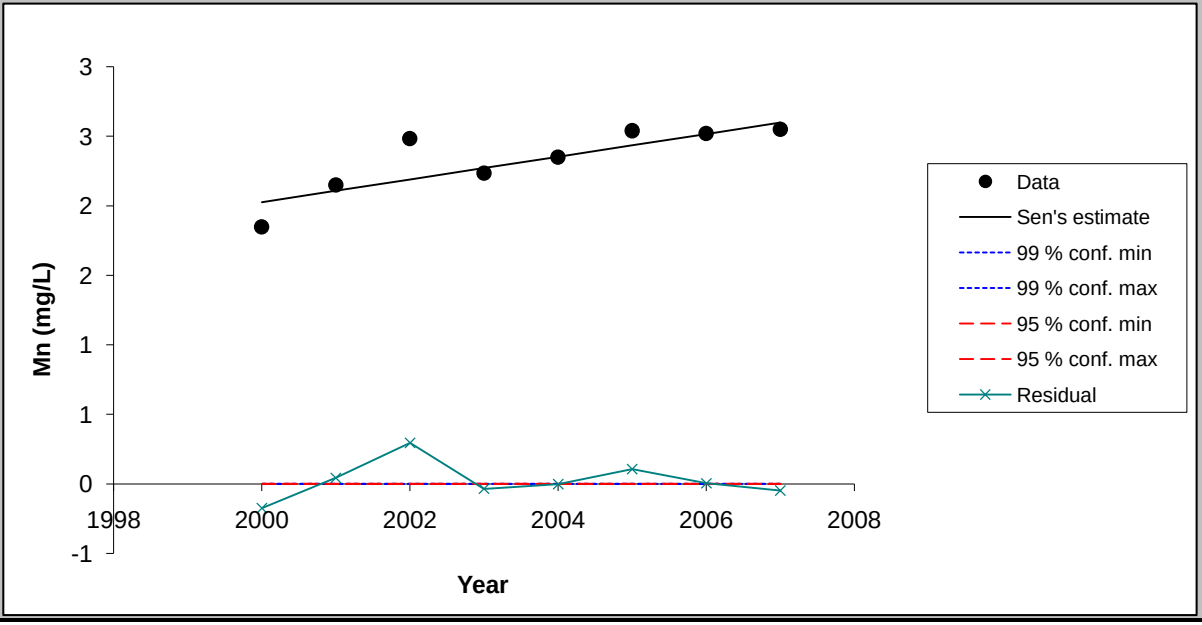

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.85	2.03	0.00	0.00	0.00	0.00	-0.18
2001	2.15	2.11	0.00	0.00	0.00	0.00	0.04
2002	2.48	2.19	0.00	0.00	0.00	0.00	0.29
2003	2.24	2.27	0.00	0.00	0.00	0.00	-0.04
2004	2.35	2.35	0.00	0.00	0.00	0.00	0.00
2005	2.54	2.44	0.00	0.00	0.00	0.00	0.11
2006	2.52	2.52	0.00	0.00	0.00	0.00	0.00
2007	2.55	2.60	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-2.75E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.33E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

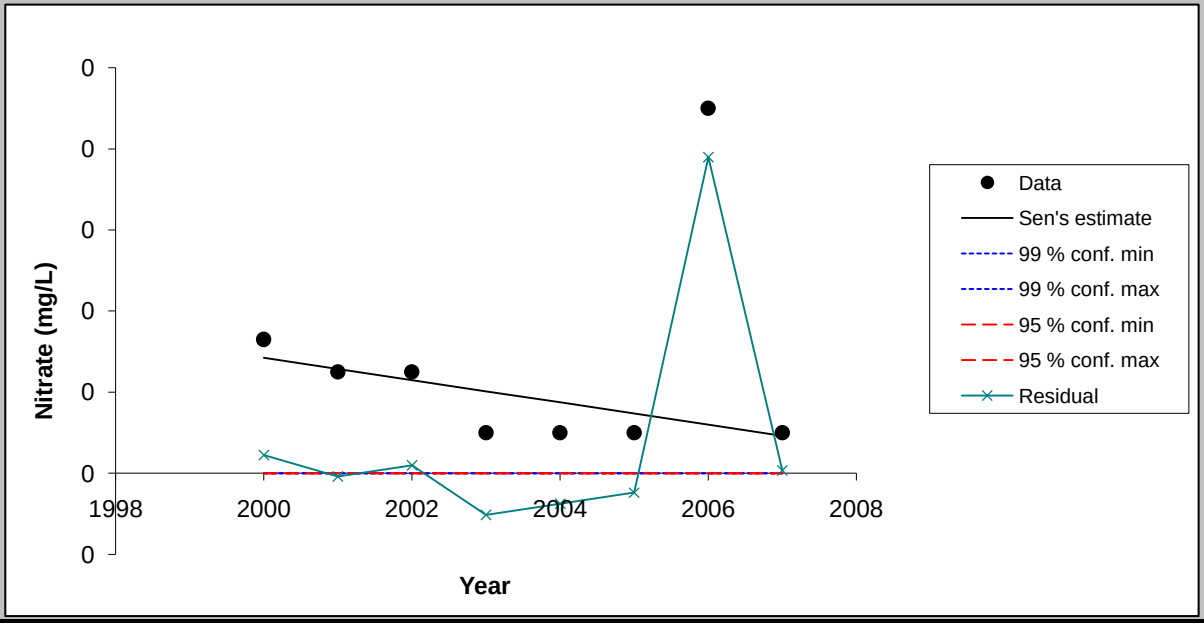

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.09	0.01	0.00	0.00	0.00	0.00	0.08
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-7.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.37E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

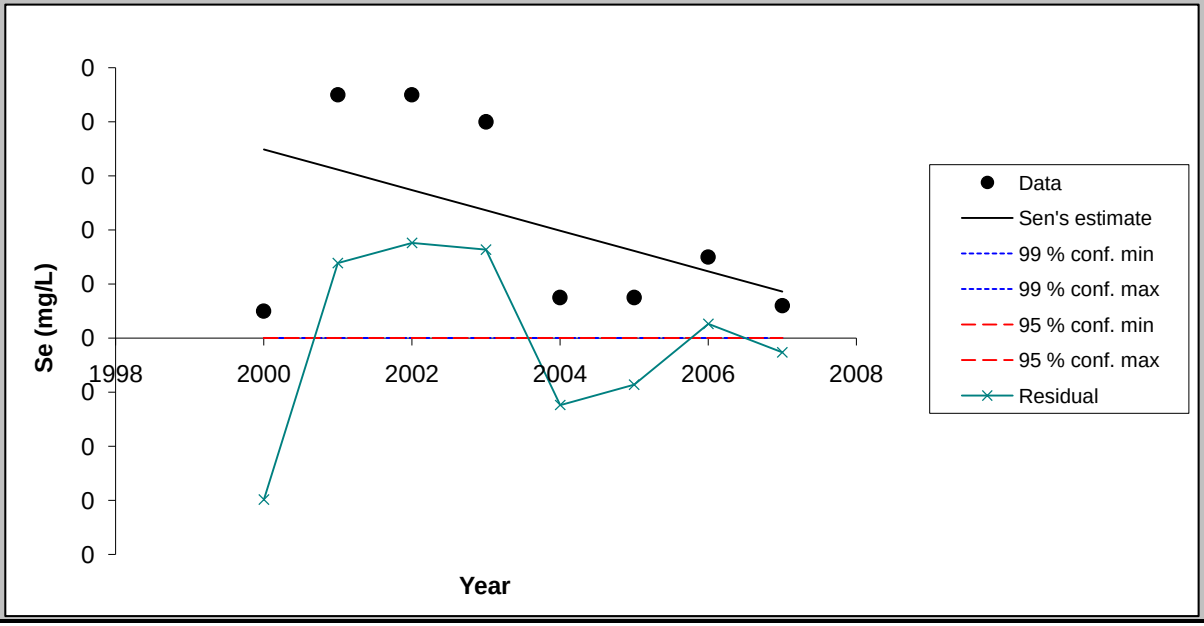

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-17 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-4.08E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.92E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

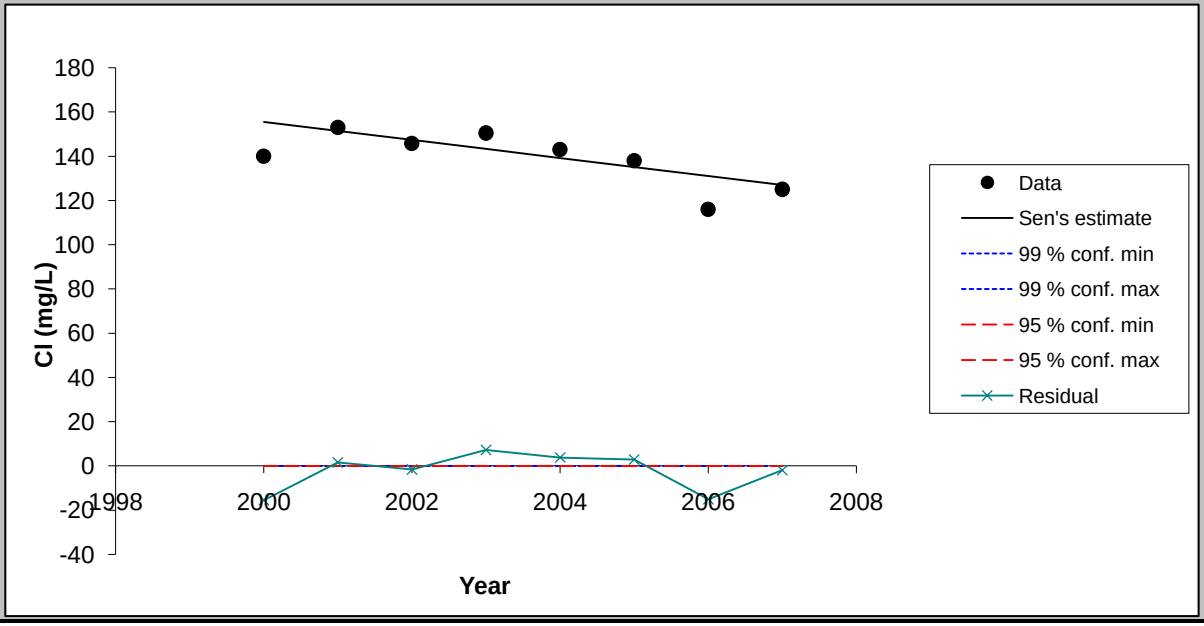

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	140.00	155.50	0.00	0.00	0.00	0.00	-15.50
2001	153.00	151.42	0.00	0.00	0.00	0.00	1.58
2002	145.77	147.35	0.00	0.00	0.00	0.00	-1.58
2003	150.50	143.27	0.00	0.00	0.00	0.00	7.23
2004	143.00	139.19	0.00	0.00	0.00	0.00	3.81
2005	138.00	135.12	0.00	0.00	0.00	0.00	2.88
2006	116.00	131.04	0.00	0.00	0.00	0.00	-15.04
2007	125.00	126.96	0.00	0.00	0.00	0.00	-1.96

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	9.11E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.21E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

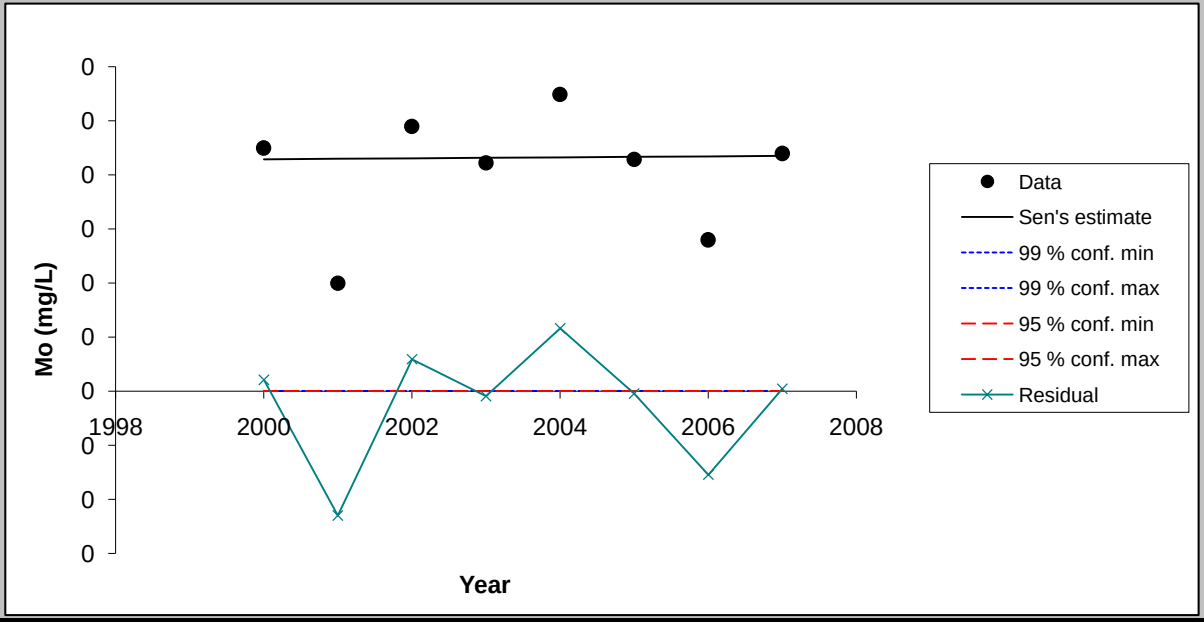

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.05	0.04	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.04	0.00	0.00	0.00	0.00	-0.02
2002	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2003	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2004	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2005	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2006	0.03	0.04	0.00	0.00	0.00	0.00	-0.02
2007	0.04	0.04	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-17 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-23
Test Z	
Signific.	**
Q	-8.27E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.82E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

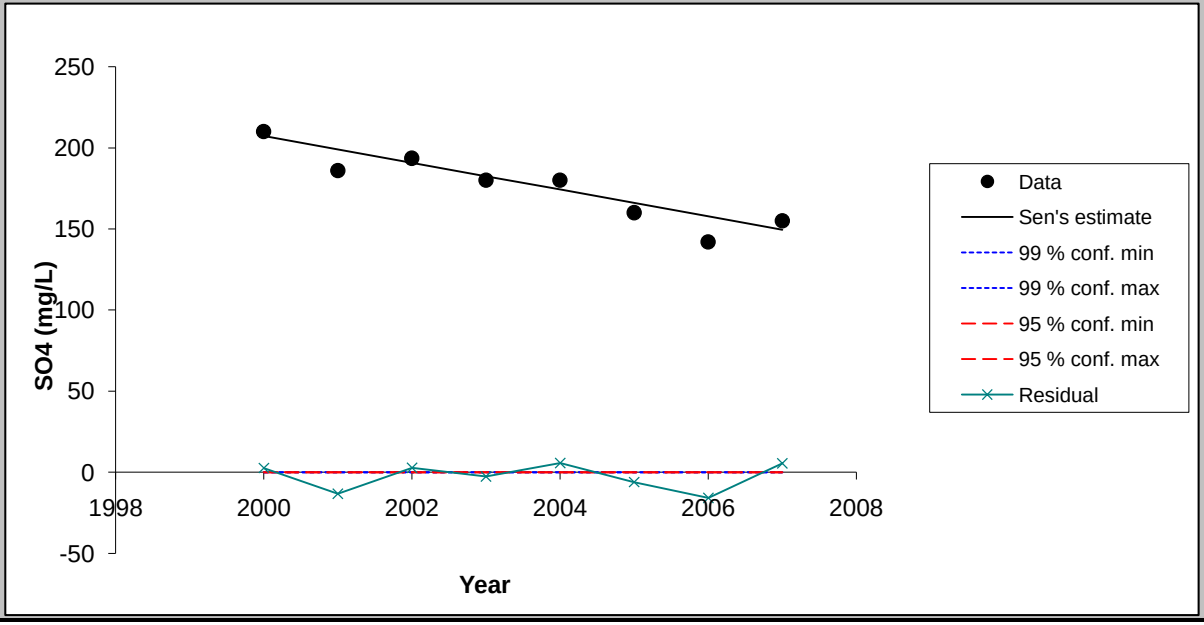

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	210.00	207.41	0.00	0.00	0.00	0.00	2.59
2001	186.00	199.14	0.00	0.00	0.00	0.00	-13.14
2002	193.59	190.86	0.00	0.00	0.00	0.00	2.72
2003	180.00	182.59	0.00	0.00	0.00	0.00	-2.59
2004	180.00	174.32	0.00	0.00	0.00	0.00	5.68
2005	160.00	166.05	0.00	0.00	0.00	0.00	-6.05
2006	142.00	157.78	0.00	0.00	0.00	0.00	-15.78
2007	155.00	149.51	0.00	0.00	0.00	0.00	5.49

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-18 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991								
1992	0.0036	2.715	1.365	0.1	0.0061	220.5	0.0554	238.50
1993	0.00292	2.485	1.510	0.08	0.00465	209.00	0.06630	250.0
1994	0.0053	2.455	1.56	0.0625	0.00475	210	0.058	221
1995	0.0039	2.90	1.620	0.005	0.010	180	0.0600	240
1996	0.0031	2.60	1.650	0.005	0.0050	190	0.0600	210
1997	0.0029	2.7	1.620	0.005	0.007	180	0.0500	210
1998	0.0025	2.2	1.820	0.031	0.007	160	0.0490	220
1999	0.0030	2.40	1.910	0.005	0.0020	140	0.0480	200
2000	0.0034	2.20	1.850	0.033	0.001	140	0.0450	210
2001	0.003	2.3	2.15	0.025	0.0090	153	0.020	186
2002	0.005	1.615	2.484	0.025	0.0090	145.767	0.049	193.586
2003	0.0026	2.205	2.235	0.01	0.008	150.5	0.04225	180
2004	0.0045	1.62	2.35	0.01	0.0015	143	0.0549	180
2005	0.0035	1.63	2.54	0.01	0.0015	138	0.0429	160
2006	0.0046	2.4	2.52	0.09	0.003	116	0.028	142
2007	0.00075	2.39	2.55	0.01	0.0012	125	0.044	155

TREND STATISTICS

TW-18 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-2*			-0.0002					0.0053				
F (mg/L)	*2000*	*2007*	*8*	*8*			0.013					2.07				
Mn (mg/L)	*2000*	*2007*	*8*	*22*		**	0.082					1.29				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-6*			-0.003					0.05				
Se (mg/L)	*2000*	*2007*	*8*	*-8*			-0.0007					0.0137				
Cl (mg/L)	*2000*	*2007*	*8*	*-16*		+	-4.077					192.19				
Mo (mg/L)	*2000*	*2007*	*8*	*0*			0.0001					0.0421				
SO4 (mg/L)	*2000*	*2007*	*8*	*-23*		**	-8.270					281.84				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-1.63E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.32E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

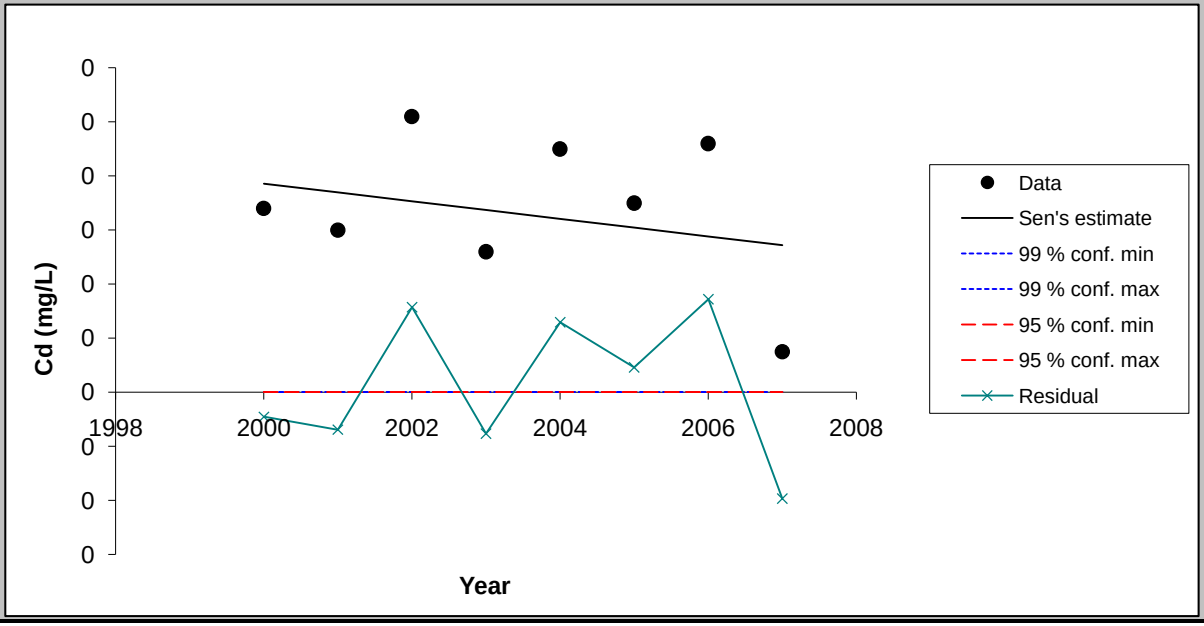

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	1.25E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.07E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

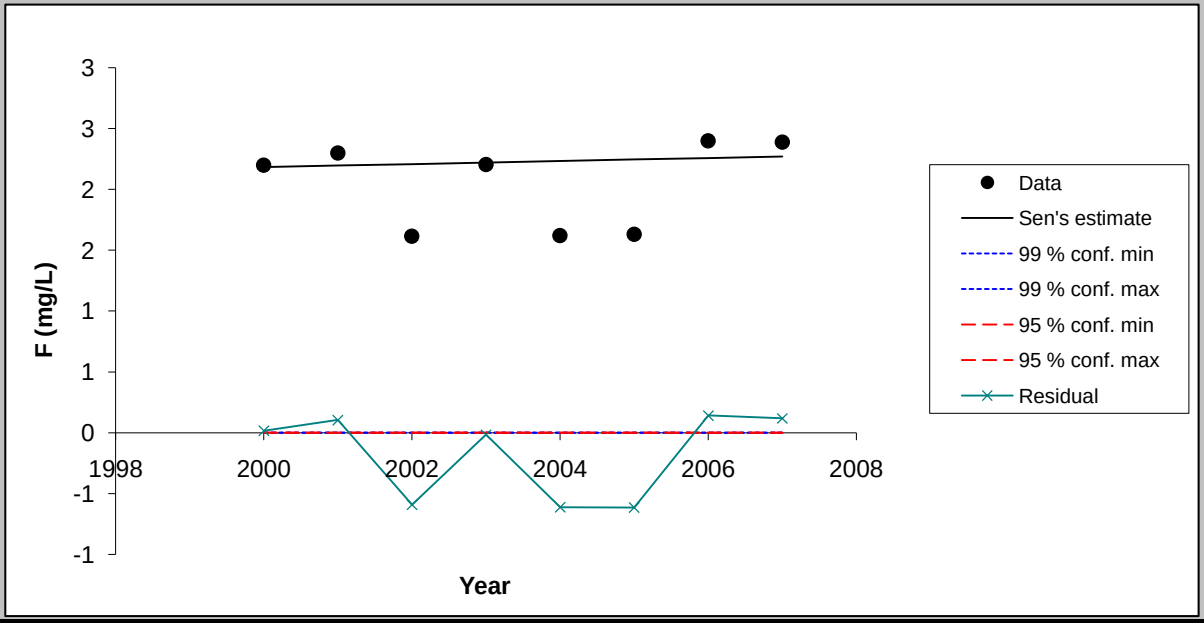

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	2.20	2.18	0.00	0.00	0.00	0.00	0.02
2001	2.30	2.20	0.00	0.00	0.00	0.00	0.10
2002	1.62	2.21	0.00	0.00	0.00	0.00	-0.59
2003	2.21	2.22	0.00	0.00	0.00	0.00	-0.02
2004	1.62	2.23	0.00	0.00	0.00	0.00	-0.61
2005	1.63	2.25	0.00	0.00	0.00	0.00	-0.62
2006	2.40	2.26	0.00	0.00	0.00	0.00	0.14
2007	2.39	2.27	0.00	0.00	0.00	0.00	0.12

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	22
Test Z	
Signific.	**
Q	8.19E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.29E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

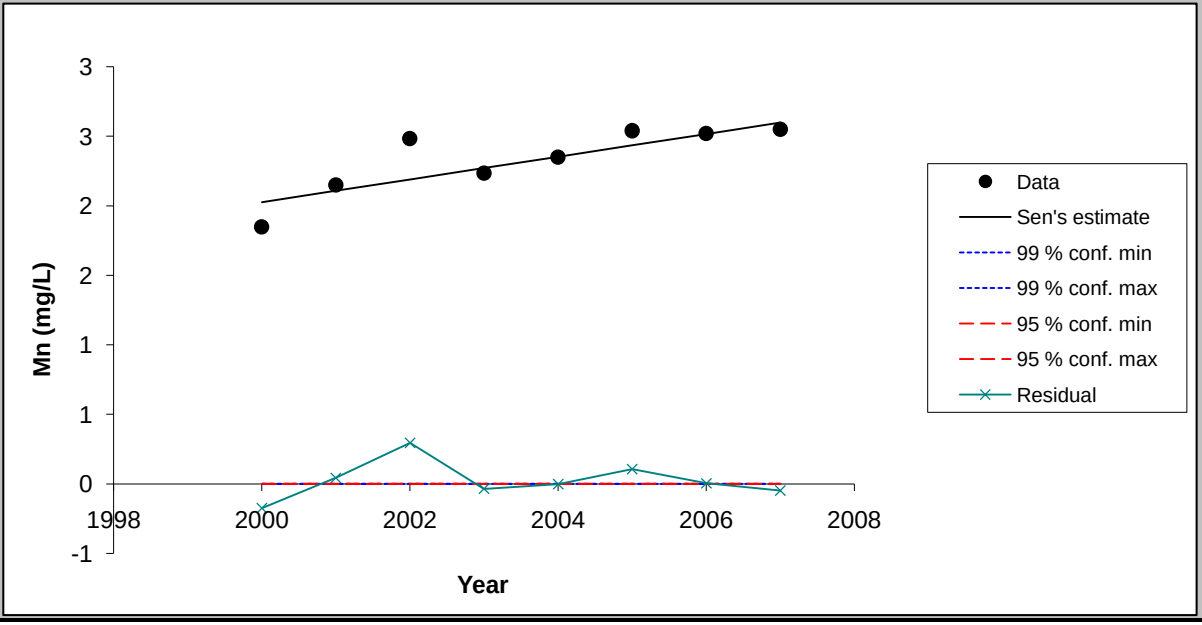

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.85	2.03	0.00	0.00	0.00	0.00	-0.18
2001	2.15	2.11	0.00	0.00	0.00	0.00	0.04
2002	2.48	2.19	0.00	0.00	0.00	0.00	0.29
2003	2.24	2.27	0.00	0.00	0.00	0.00	-0.04
2004	2.35	2.35	0.00	0.00	0.00	0.00	0.00
2005	2.54	2.44	0.00	0.00	0.00	0.00	0.11
2006	2.52	2.52	0.00	0.00	0.00	0.00	0.00
2007	2.55	2.60	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-2.75E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.33E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

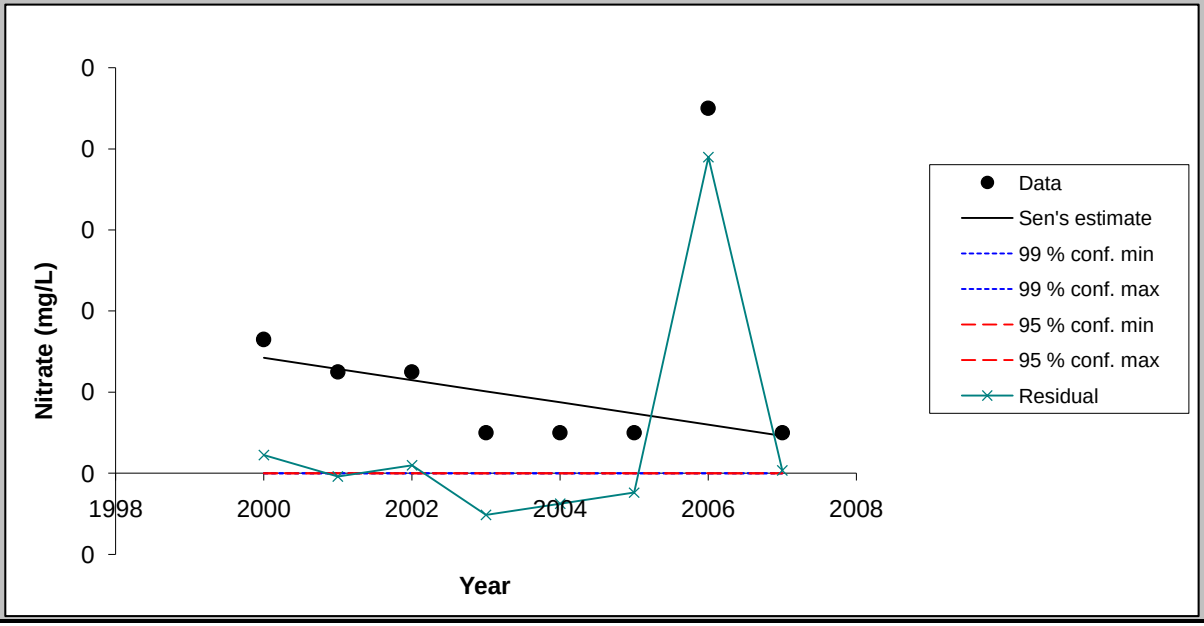

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.09	0.01	0.00	0.00	0.00	0.00	0.08
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-7.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.37E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

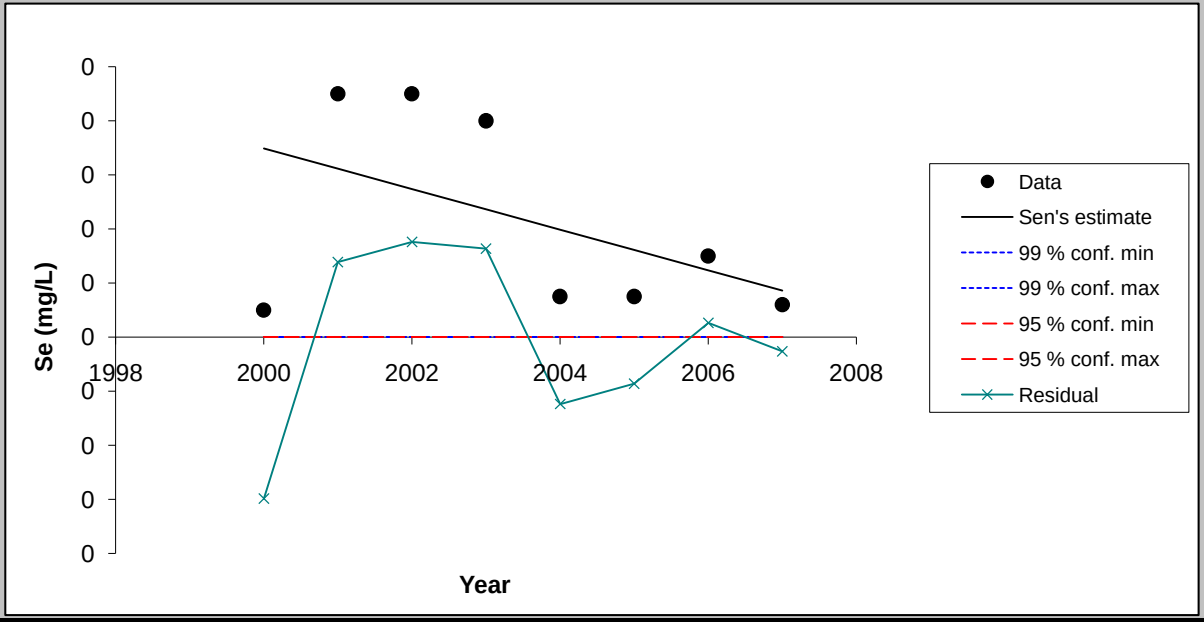

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-18 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-4.08E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.92E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

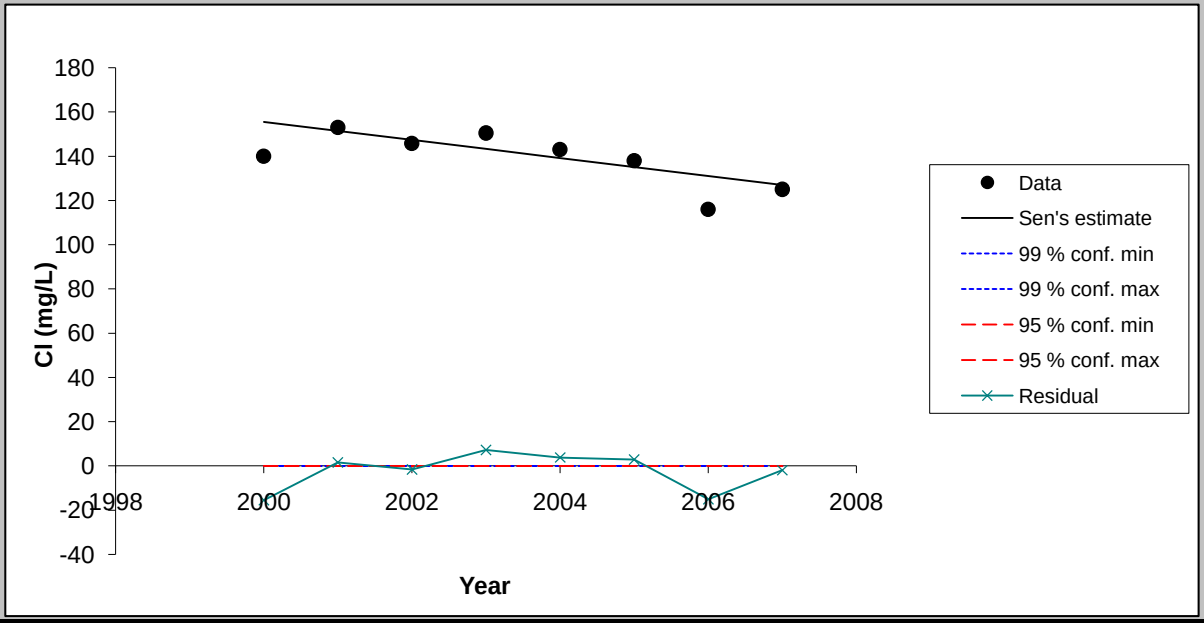

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	140.00	155.50	0.00	0.00	0.00	0.00	-15.50
2001	153.00	151.42	0.00	0.00	0.00	0.00	1.58
2002	145.77	147.35	0.00	0.00	0.00	0.00	-1.58
2003	150.50	143.27	0.00	0.00	0.00	0.00	7.23
2004	143.00	139.19	0.00	0.00	0.00	0.00	3.81
2005	138.00	135.12	0.00	0.00	0.00	0.00	2.88
2006	116.00	131.04	0.00	0.00	0.00	0.00	-15.04
2007	125.00	126.96	0.00	0.00	0.00	0.00	-1.96

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	9.11E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.21E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

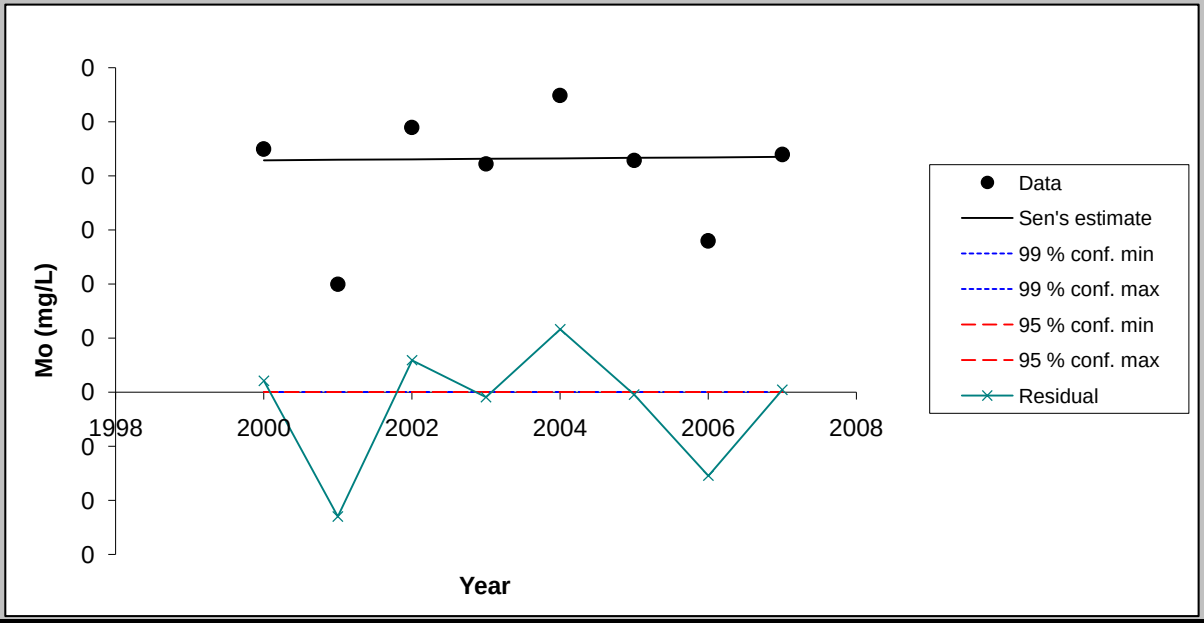

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.05	0.04	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.04	0.00	0.00	0.00	0.00	-0.02
2002	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2003	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2004	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2005	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2006	0.03	0.04	0.00	0.00	0.00	0.00	-0.02
2007	0.04	0.04	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-18 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-23
Test Z	
Signific.	**
Q	-8.27E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.82E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

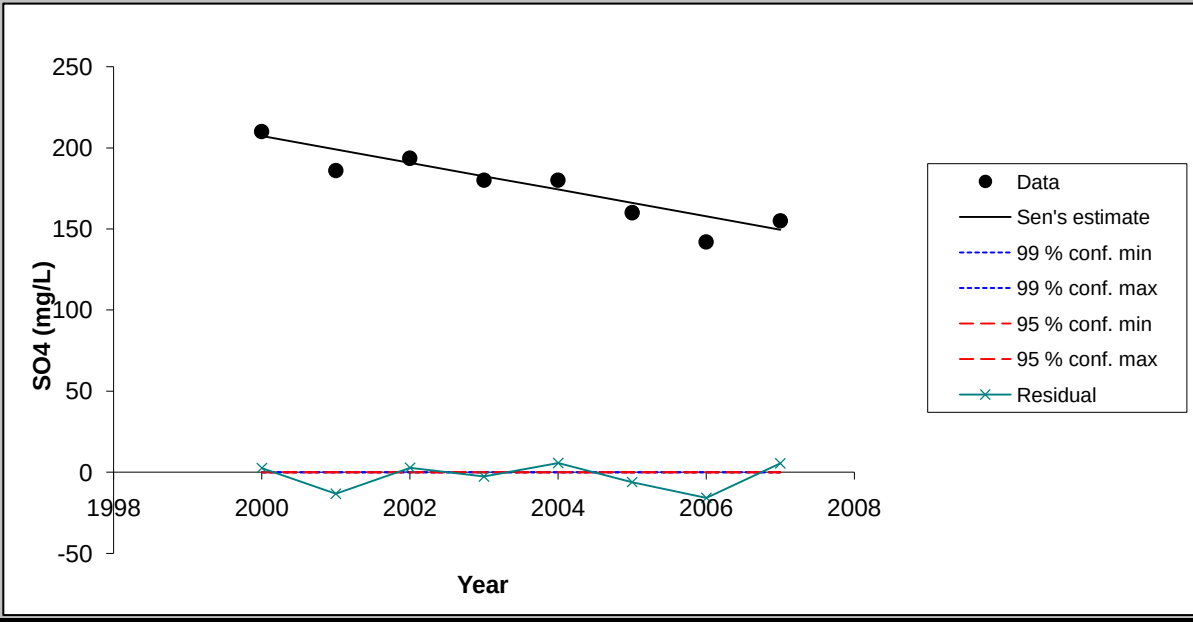

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	210.00	207.41	0.00	0.00	0.00	0.00	2.59
2001	186.00	199.14	0.00	0.00	0.00	0.00	-13.14
2002	193.59	190.86	0.00	0.00	0.00	0.00	2.72
2003	180.00	182.59	0.00	0.00	0.00	0.00	-2.59
2004	180.00	174.32	0.00	0.00	0.00	0.00	5.68
2005	160.00	166.05	0.00	0.00	0.00	0.00	-6.05
2006	142.00	157.78	0.00	0.00	0.00	0.00	-15.78
2007	155.00	149.51	0.00	0.00	0.00	0.00	5.49

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-40 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	7	7	7	7	7	7	7	7
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	5.95	7.89	0.982	35.2	0.289	679		680
1992	6.31	7.035	0.4275	26.2	0.424	581.5	0.341	509.5
1993	1.71	3	0.3365	7.01	0.1735	231	0.261	430
1994	1.167	2.63	0.1345	6.52	0.1005	144.5	0.135	240
1995	0.809	2.6	0.072	5.2	0.11	85	0.086	150
1996								
1997	3.06	6.3	0.184	16	0.48	410	0.161	680
1998	3.5	4.2	0.194	16	0.63	420	0.162	850
1999	2.9	5.7	0.163	17	0.82	340	0.172	900
2000	1.2	4.7	0.107	11	1.1	320	0.159	770
2001	2.273	4.8	0.07	12.04	0.865	287	0.16	649
2002	1.838	6.078	0.03	11.42	0.8987	289.3	0.170	600.3
2003	2.19	4.75	0.0667	13.9	1.12	280	0.181	555
2004								
2005	2.46	3.54	0.047	18	0.75	473	0.157	758
2006	2.22	4.43	0.0512	19.2	0.624	421	0.147	736
2007	2.41	4.65	0.0365	16.2	0.282	369	0.167	696

TREND STATISTICS

TW-40 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*7*	*11*			0.114					0.58				
F (mg/L)	*2000*	*2007*	*7*	*-7*			-0.025					5.05				
Mn (mg/L)	*2000*	*2007*	*7*	*-11*			-0.006					0.13				
Nitrate (mg/L)	*2000*	*2007*	*7*	*15*		*	1.040					1.64				
Se (mg/L)	*2000*	*2007*	*7*	*-13*		+	-0.097					1.97				
Cl (mg/L)	*2000*	*2007*	*7*	*5*			13.667					150.33				
Mo (mg/L)	*2000*	*2007*	*7*	*-1*			0.000					0.16				
SO4 (mg/L)	*2000*	*2007*	*7*	*-3*			-5.667					786.67				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	7
Test S	11
Test Z	
Signific.	
Q	1.14E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.80E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

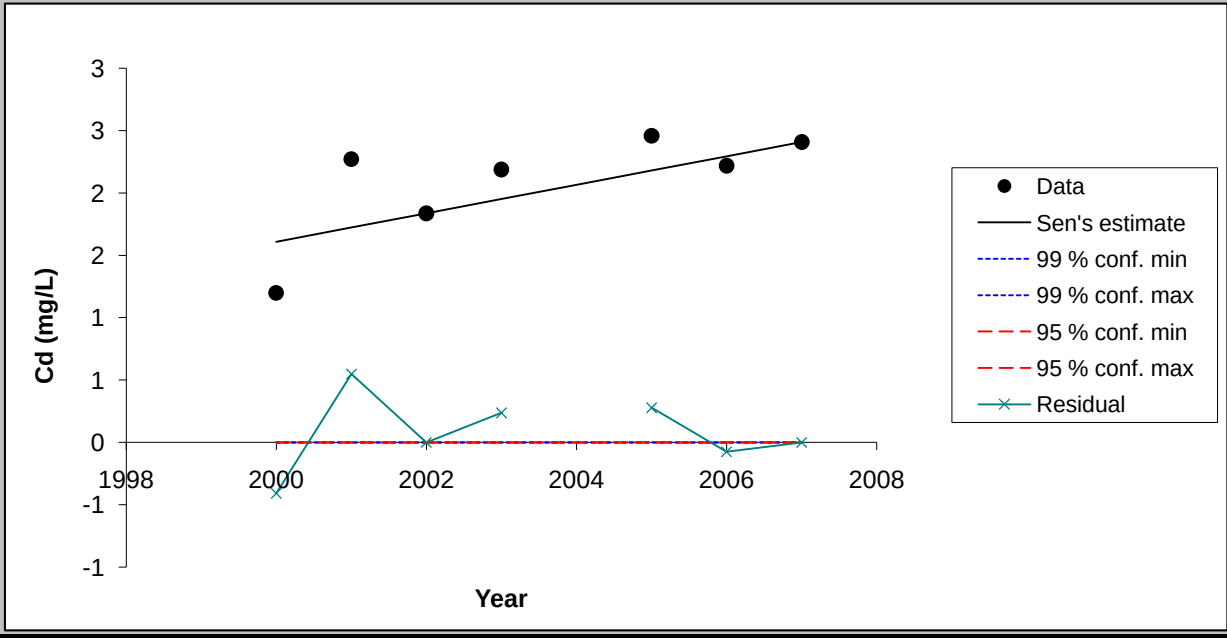

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.20	1.61	0.00	0.00	0.00	0.00	-0.41
2001	2.27	1.72	0.00	0.00	0.00	0.00	0.55
2002	1.84	1.84	0.00	0.00	0.00	0.00	0.00
2003	2.19	1.95	0.00	0.00	0.00	0.00	0.24
2004		2.07	0.00	0.00	0.00	0.00	
2005	2.46	2.18	0.00	0.00	0.00	0.00	0.28
2006	2.22	2.30	0.00	0.00	0.00	0.00	-0.08
2007	2.41	2.41	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	7
Test S	-7
Test Z	
Signific.	
Q	-2.50E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.05E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

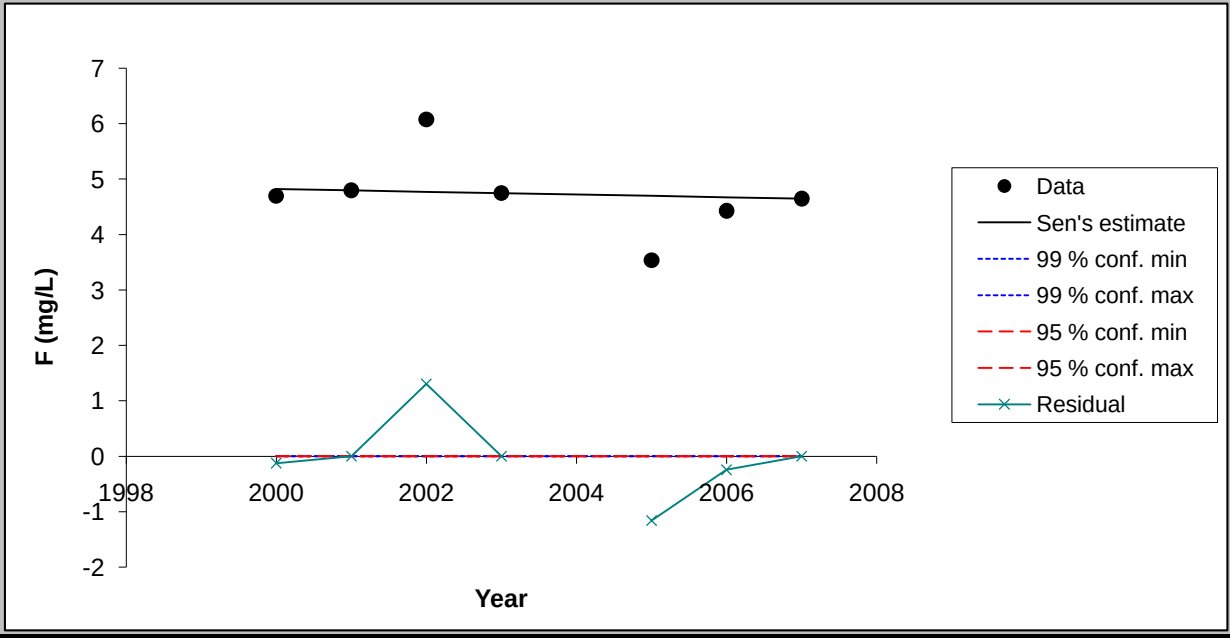

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.70	4.83	0.00	0.00	0.00	0.00	-0.13
2001	4.80	4.80	0.00	0.00	0.00	0.00	0.00
2002	6.08	4.78	0.00	0.00	0.00	0.00	1.30
2003	4.75	4.75	0.00	0.00	0.00	0.00	0.00
2004		4.72	0.00	0.00	0.00	0.00	
2005	3.54	4.70	0.00	0.00	0.00	0.00	-1.16
2006	4.43	4.67	0.00	0.00	0.00	0.00	-0.24
2007	4.65	4.65	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	7
Test S	-11
Test Z	
Signific.	
Q	-5.75E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.29E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

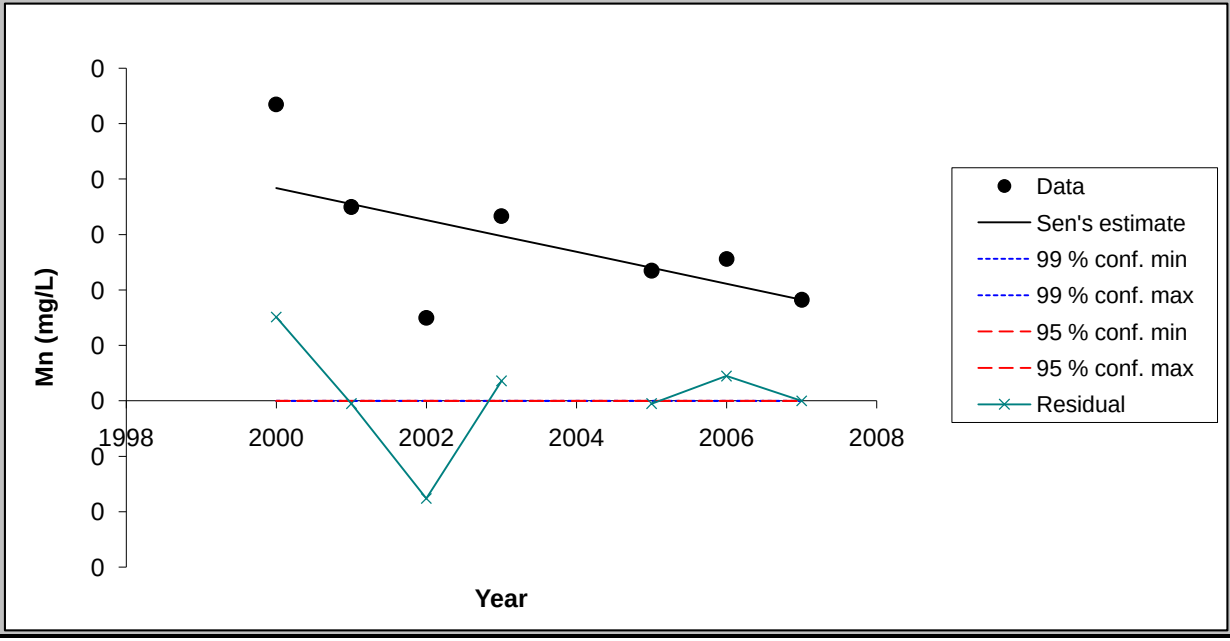

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.11	0.08	0.00	0.00	0.00	0.00	0.03
2001	0.07	0.07	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.07	0.00	0.00	0.00	0.00	-0.04
2003	0.07	0.06	0.00	0.00	0.00	0.00	0.01
2004		0.05	0.00	0.00	0.00	0.00	
2005	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2006	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2007	0.04	0.04	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	7
Test S	15
Test Z	
Signific.	*
Q	1.04E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.64E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

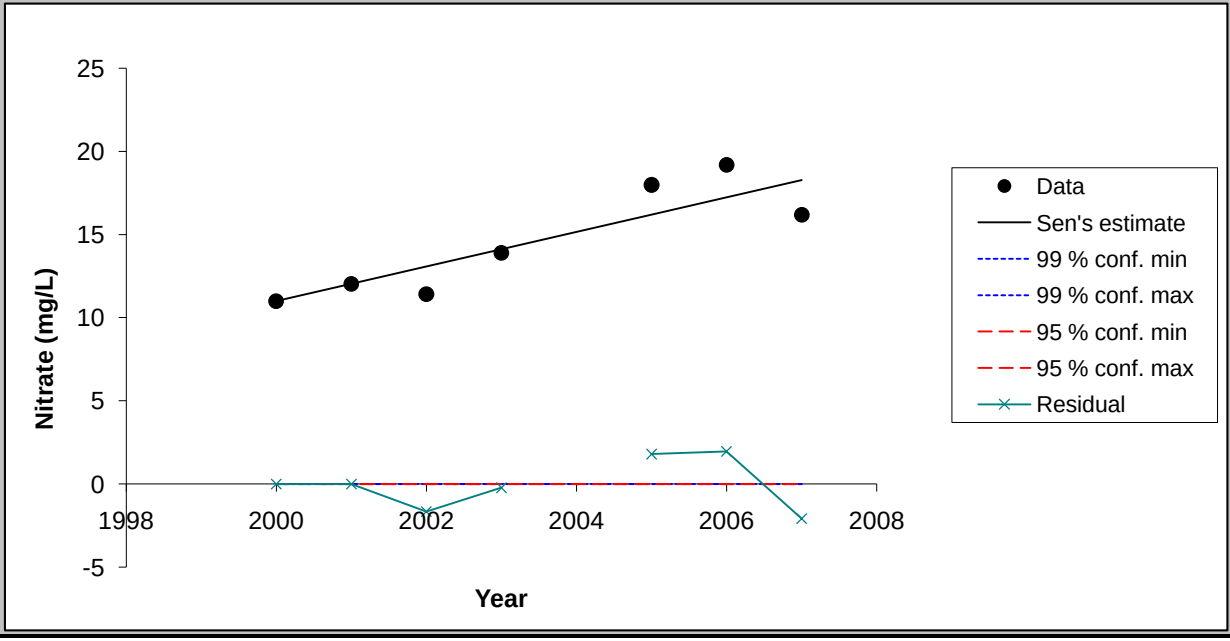

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	11.00	11.00	0.00	0.00	0.00	0.00	0.00
2001	12.04	12.04	0.00	0.00	0.00	0.00	0.00
2002	11.42	13.08	0.00	0.00	0.00	0.00	-1.66
2003	13.90	14.12	0.00	0.00	0.00	0.00	-0.22
2004		15.16	0.00	0.00	0.00	0.00	
2005	18.00	16.20	0.00	0.00	0.00	0.00	1.80
2006	19.20	17.24	0.00	0.00	0.00	0.00	1.96
2007	16.20	18.28	0.00	0.00	0.00	0.00	-2.08

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	7
Test S	-13
Test Z	
Signific.	+
Q	-9.72E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.97E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

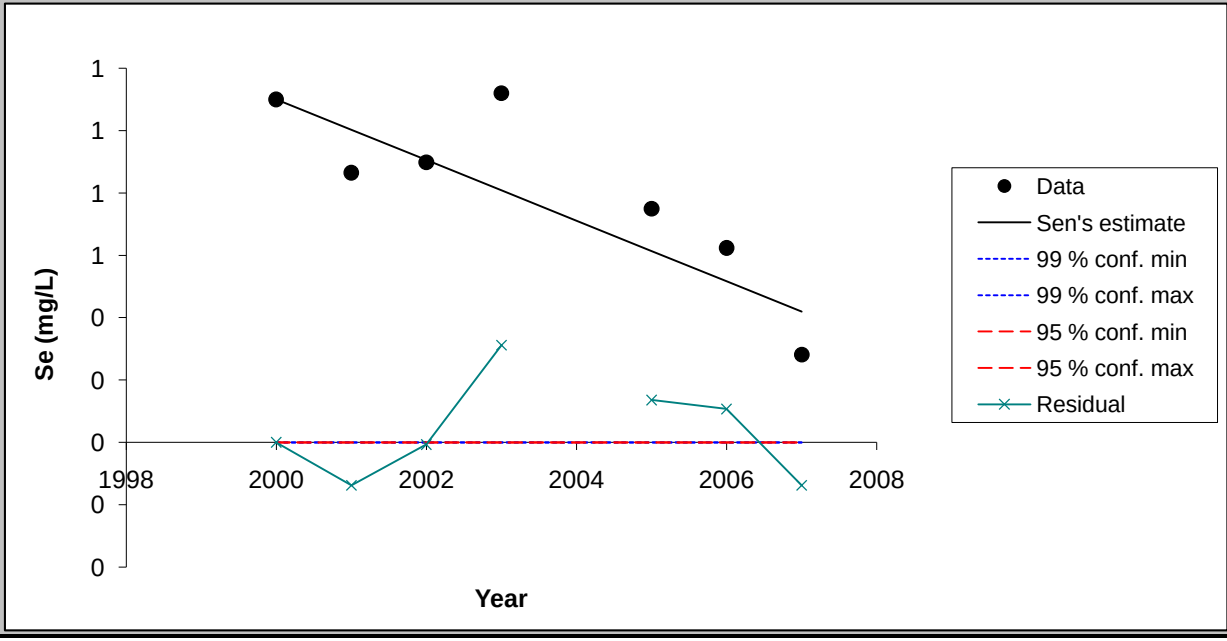

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.10	1.10	0.00	0.00	0.00	0.00	0.00
2001	0.87	1.00	0.00	0.00	0.00	0.00	-0.14
2002	0.90	0.91	0.00	0.00	0.00	0.00	-0.01
2003	1.12	0.81	0.00	0.00	0.00	0.00	0.31
2004		0.71	0.00	0.00	0.00	0.00	
2005	0.75	0.61	0.00	0.00	0.00	0.00	0.14
2006	0.62	0.52	0.00	0.00	0.00	0.00	0.11
2007	0.28	0.42	0.00	0.00	0.00	0.00	-0.14

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	7
Test S	5
Test Z	
Signific.	
Q	1.37E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.50E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

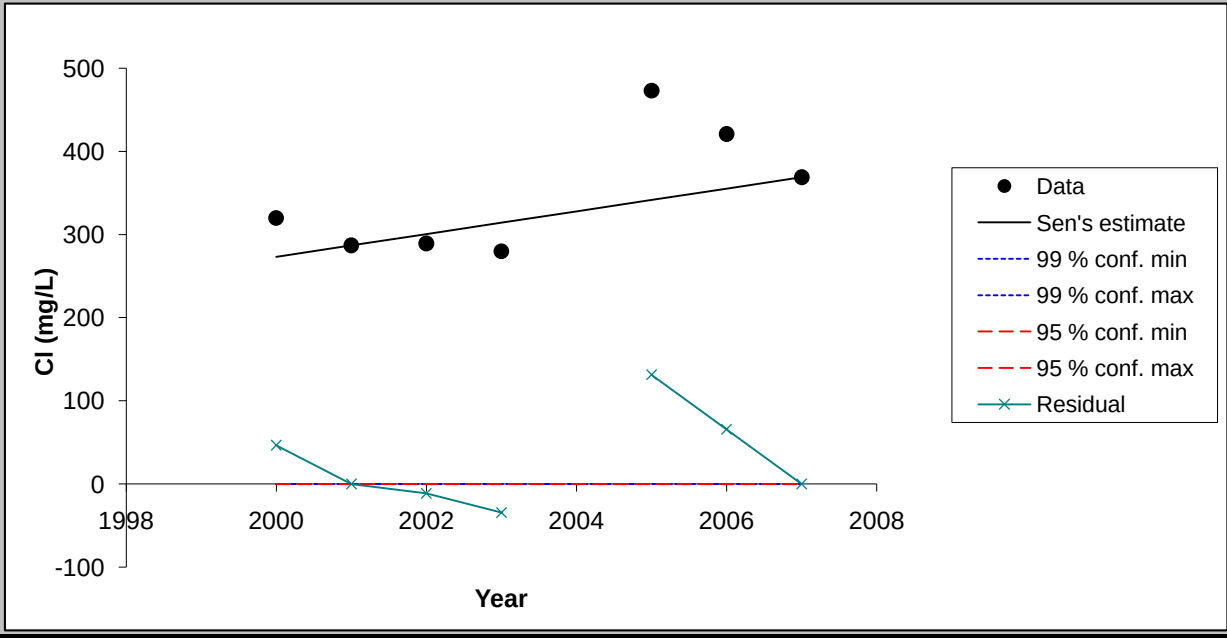

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	320.00	273.33	0.00	0.00	0.00	0.00	46.67
2001	287.00	287.00	0.00	0.00	0.00	0.00	0.00
2002	289.29	300.67	0.00	0.00	0.00	0.00	-11.38
2003	280.00	314.33	0.00	0.00	0.00	0.00	-34.33
2004		328.00	0.00	0.00	0.00	0.00	
2005	473.00	341.67	0.00	0.00	0.00	0.00	131.33
2006	421.00	355.33	0.00	0.00	0.00	0.00	65.67
2007	369.00	369.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	7
Test S	-1
Test Z	
Signific.	
Q	-4.00E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.64E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

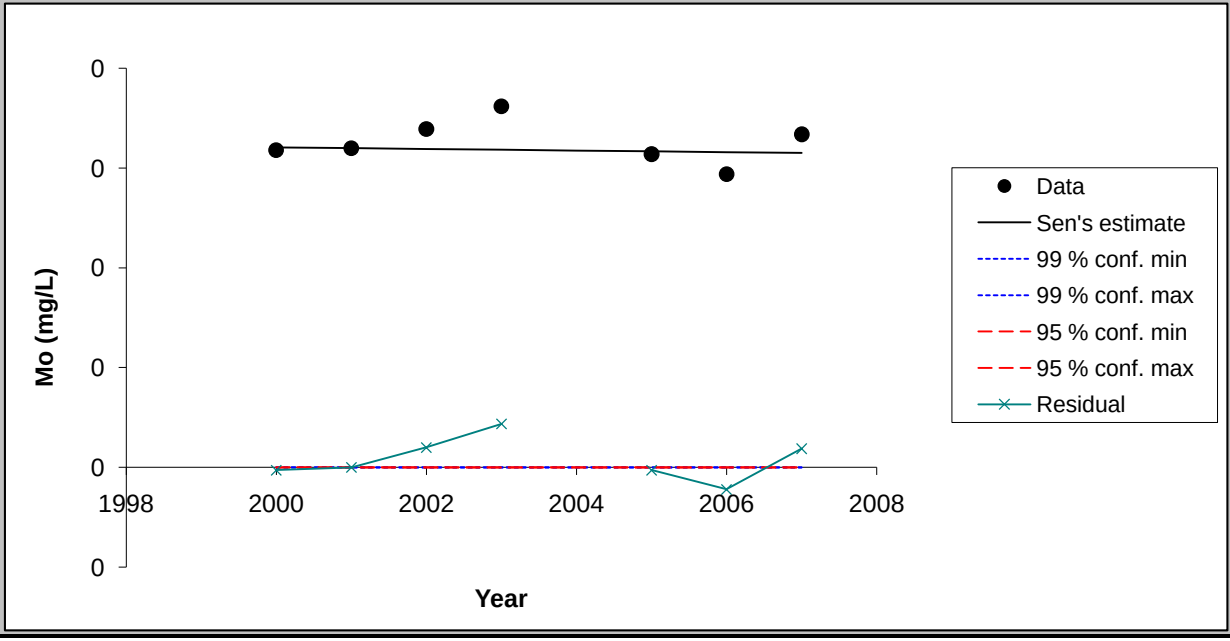

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.16	0.16	0.00	0.00	0.00	0.00	0.00
2001	0.16	0.16	0.00	0.00	0.00	0.00	0.00
2002	0.17	0.16	0.00	0.00	0.00	0.00	0.01
2003	0.18	0.16	0.00	0.00	0.00	0.00	0.02
2004		0.16	0.00	0.00	0.00	0.00	
2005	0.16	0.16	0.00	0.00	0.00	0.00	0.00
2006	0.15	0.16	0.00	0.00	0.00	0.00	-0.01
2007	0.17	0.16	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-40 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	7
Test S	-3
Test Z	
Signific.	
Q	-5.67E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.87E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

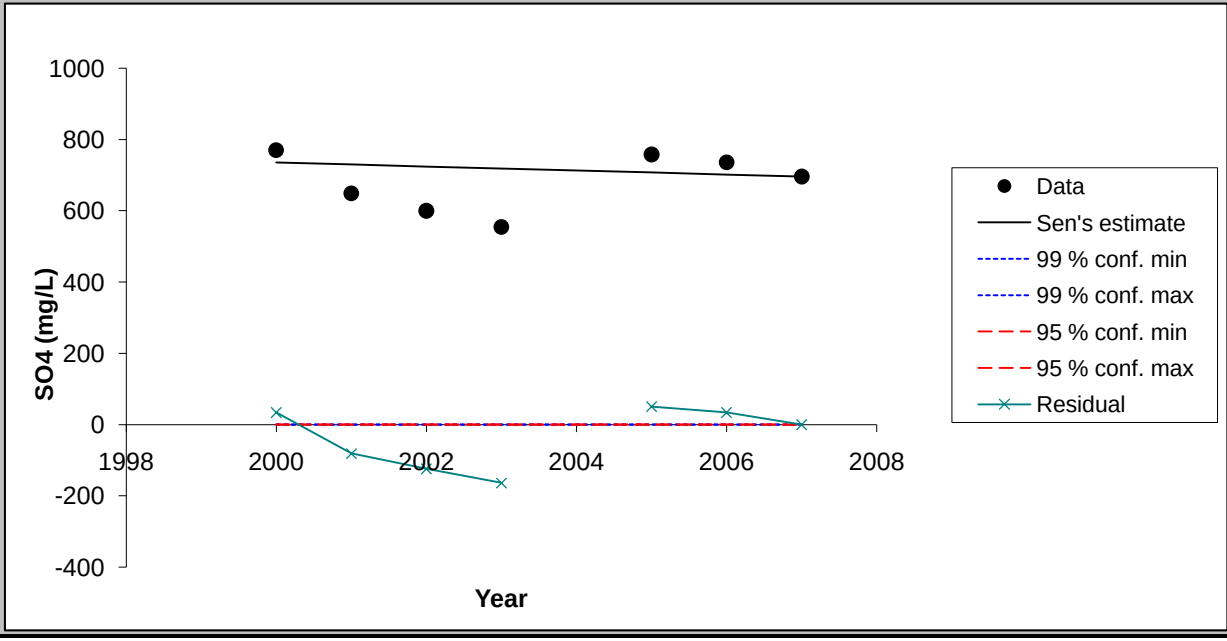

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	770.00	735.67	0.00	0.00	0.00	0.00	34.33
2001	649.00	730.00	0.00	0.00	0.00	0.00	-81.00
2002	600.27	724.33	0.00	0.00	0.00	0.00	-124.06
2003	555.00	718.67	0.00	0.00	0.00	0.00	-163.67
2004		713.00	0.00	0.00	0.00	0.00	
2005	758.00	707.33	0.00	0.00	0.00	0.00	50.67
2006	736.00	701.67	0.00	0.00	0.00	0.00	34.33
2007	696.00	696.00	0.00	0.00	0.00	0.00	0.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-44 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.46	0.17	0.5	0.0015	23		54
1992	0.0049	0.345	0.213	0.185	0.0075	14.95	0.0275	116.8
1993	0.0080	0.36	0.203	0.08	0.0027	19.05	0.0123	55.3
1994	0.0153	0.415	0.198	0.063	0.0073	20.6	0.0112	54
1995	0.0029	0.37	0.196	0.019	0.0025	21	0.006	62
1996	0.0008	0.44	0.194	0.023	0.001	23	0.007	85
1997	0.0005	0.43	0.178	0.005	0.0025	20	0.005	57
1998	0.0005	0.5	0.189	0.017	0.0025	27	0.006	78
1999	0.0008	0.49	0.184	0.005	0.0025	24	0.0025	80
2000	0.12	1.4	0.236	1.5	0.08	56	0.038	190
2001	0.005	0.5	0.2	0.025	0.0025	30	0.005	70
2002	0.0026	0.637	0.230	0.983	0.0025	28.5	0.005	74.7
2003	0.001	0.49	0.216	0.01	0.005	24.7	0.0255	77.2
2004	0.0045	0.3	0.215	0.01	0.0015	26.5	0.0197	84.6
2005	0.0034	0.288	0.202	0.01	0.0015	24.2	0.012	81
2006	0.001	0.72	0.2	0.01	0.003	23	0.004	81.2
2007	0.001	0.85	0.22	0.01	0.00035	26.7	0.0201	90

TREND STATISTICS

TW-44 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-17*		+	-0.001					0.02				
F (mg/L)	*2000*	*2007*	*8*	*-4*			-0.033					0.94				
Mn (mg/L)	*2000*	*2007*	*8*	*-10*			-0.003					0.25				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.004					0.07				
Se (mg/L)	*2000*	*2007*	*8*	*-14*			0.000					0.01				
Cl (mg/L)	*2000*	*2007*	*8*	*-18*		*	-1.417					44.21				
Mo (mg/L)	*2000*	*2007*	*8*	*-5*			-0.001					0.03				
SO4 (mg/L)	*2000*	*2007*	*8*	*10*			2.006					53.02				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-44 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-17
Test Z	
Signific.	+
Q	-1.13E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.86E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

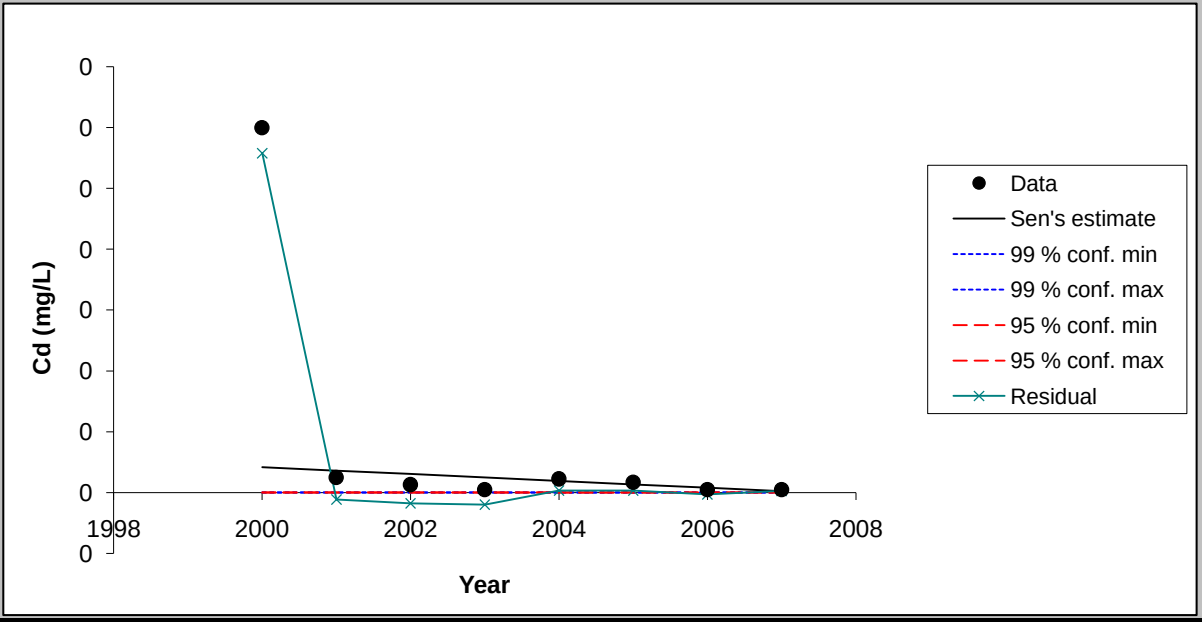

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.12	0.01	0.00	0.00	0.00	0.00	0.11
2001	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-44 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-3.25E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.37E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

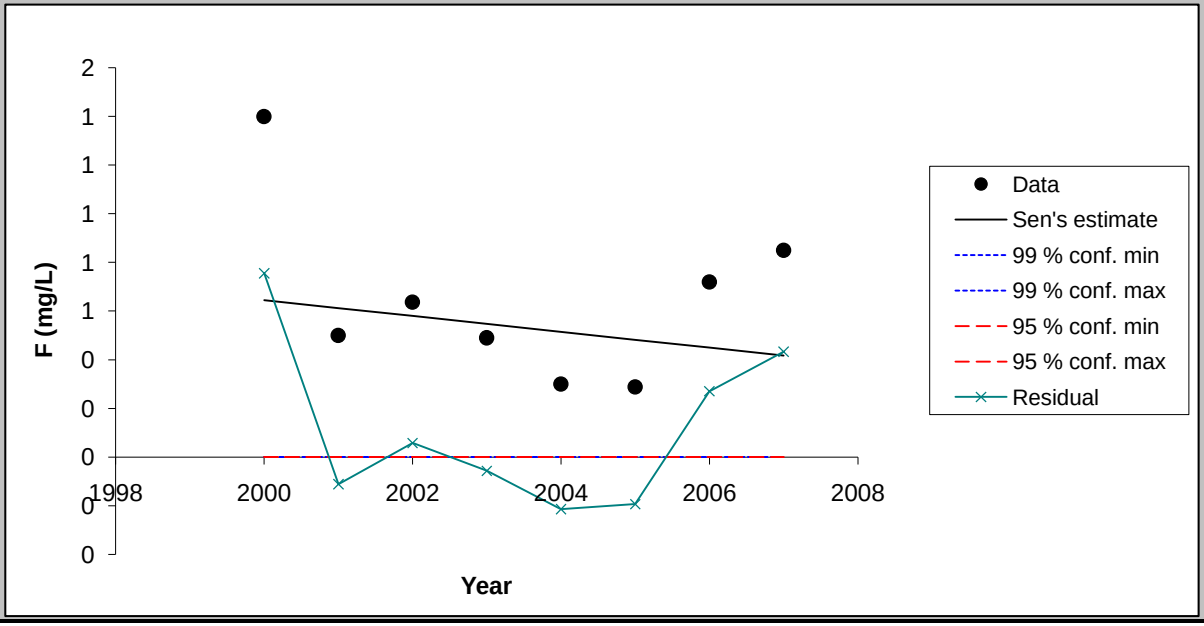

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.40	0.64	0.00	0.00	0.00	0.00	0.76
2001	0.50	0.61	0.00	0.00	0.00	0.00	-0.11
2002	0.64	0.58	0.00	0.00	0.00	0.00	0.06
2003	0.49	0.55	0.00	0.00	0.00	0.00	-0.06
2004	0.30	0.51	0.00	0.00	0.00	0.00	-0.21
2005	0.29	0.48	0.00	0.00	0.00	0.00	-0.19
2006	0.72	0.45	0.00	0.00	0.00	0.00	0.27
2007	0.85	0.42	0.00	0.00	0.00	0.00	0.43

FIGURE

< Previous Time Series | Next Time Series >

TW-44 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-10
Test Z	
Signific.	
Q	-2.72E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.49E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

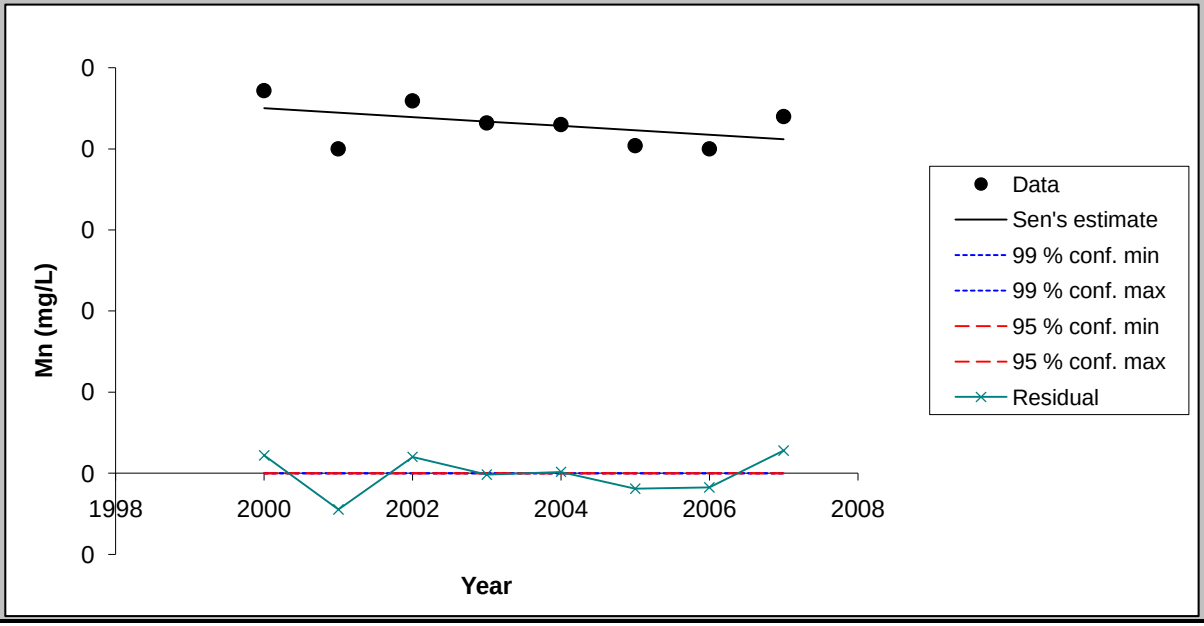

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.24	0.23	0.00	0.00	0.00	0.00	0.01
2001	0.20	0.22	0.00	0.00	0.00	0.00	-0.02
2002	0.23	0.22	0.00	0.00	0.00	0.00	0.01
2003	0.22	0.22	0.00	0.00	0.00	0.00	0.00
2004	0.22	0.21	0.00	0.00	0.00	0.00	0.00
2005	0.20	0.21	0.00	0.00	0.00	0.00	-0.01
2006	0.20	0.21	0.00	0.00	0.00	0.00	-0.01
2007	0.22	0.21	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-44 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-4.38E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.34E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

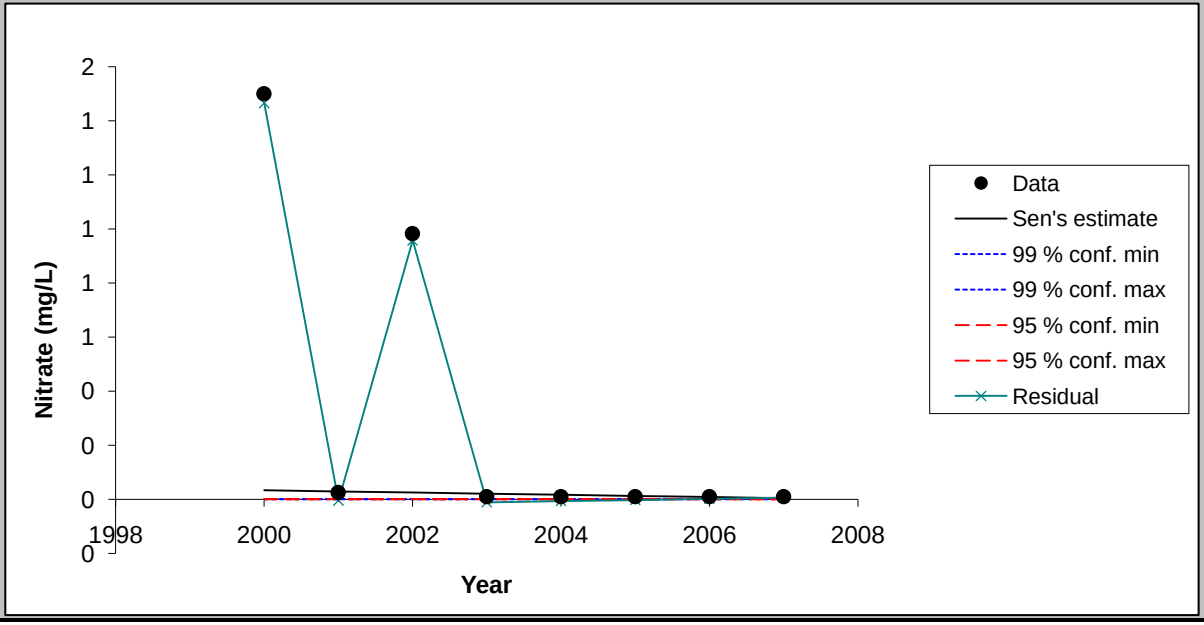

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.50	0.03	0.00	0.00	0.00	0.00	1.47
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.98	0.03	0.00	0.00	0.00	0.00	0.96
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.00	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-4.65E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.90E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

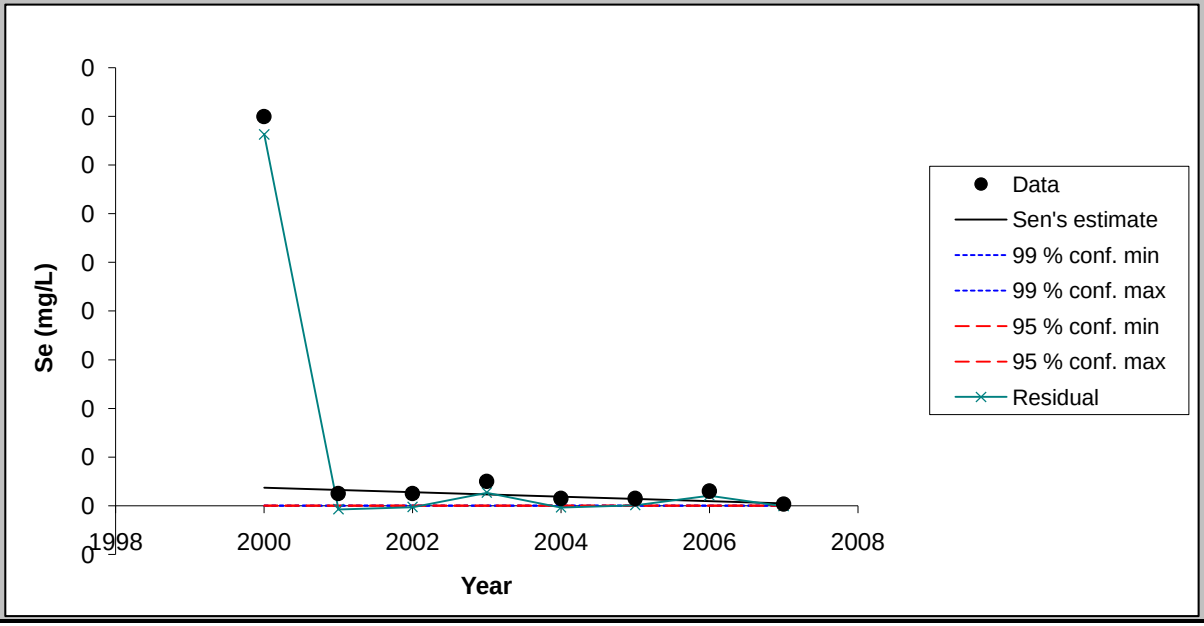

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.00	0.00	0.00	0.00	0.00	0.08
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-18
Test Z	
Signific.	*
Q	-1.42E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.42E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

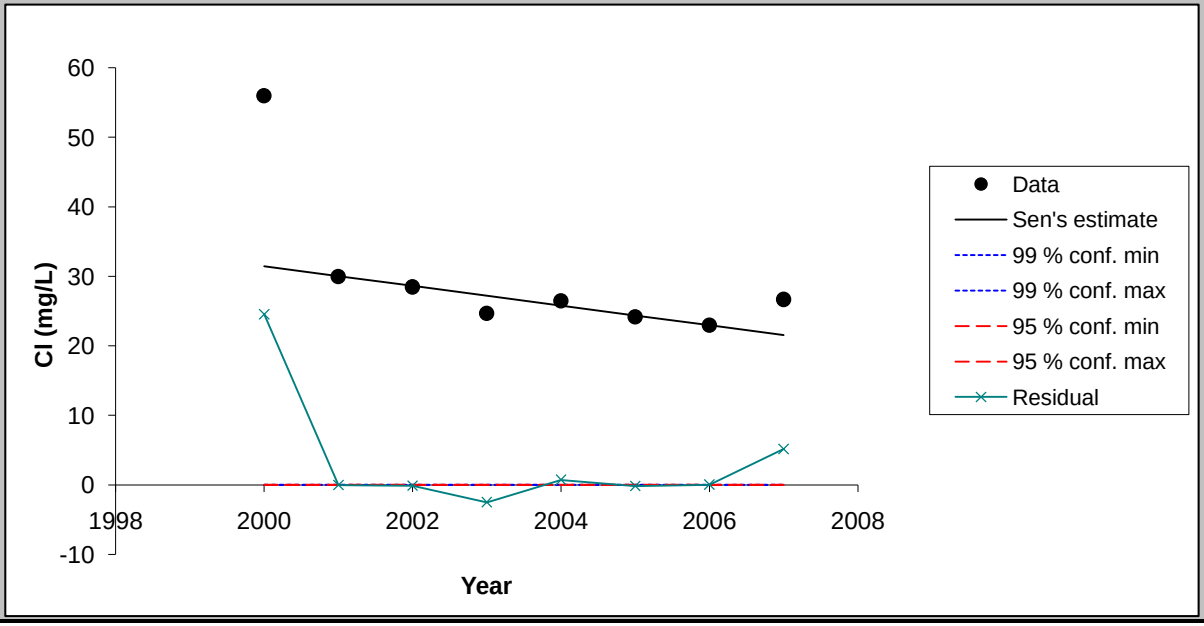

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	56.00	31.46	0.00	0.00	0.00	0.00	24.54
2001	30.00	30.04	0.00	0.00	0.00	0.00	-0.04
2002	28.50	28.63	0.00	0.00	0.00	0.00	-0.12
2003	24.70	27.21	0.00	0.00	0.00	0.00	-2.51
2004	26.50	25.79	0.00	0.00	0.00	0.00	0.71
2005	24.20	24.38	0.00	0.00	0.00	0.00	-0.17
2006	23.00	22.96	0.00	0.00	0.00	0.00	0.04
2007	26.70	21.54	0.00	0.00	0.00	0.00	5.16

FIGURE

< Previous Time Series

Next Time Series >

TW-44 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-5
Test Z	
Signific.	
Q	-8.00E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.66E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

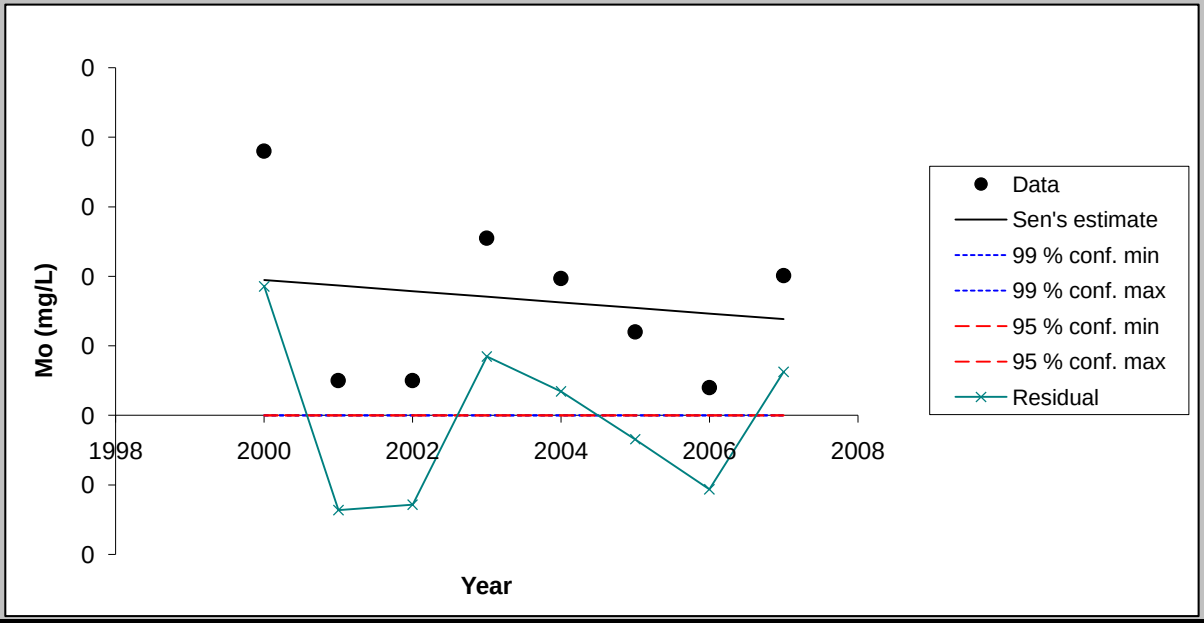

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.04	0.02	0.00	0.00	0.00	0.00	0.02
2001	0.00	0.02	0.00	0.00	0.00	0.00	-0.01
2002	0.00	0.02	0.00	0.00	0.00	0.00	-0.01
2003	0.03	0.02	0.00	0.00	0.00	0.00	0.01
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.02	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2007	0.02	0.01	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series | Next Time Series >

TW-44 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	2.01E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.30E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

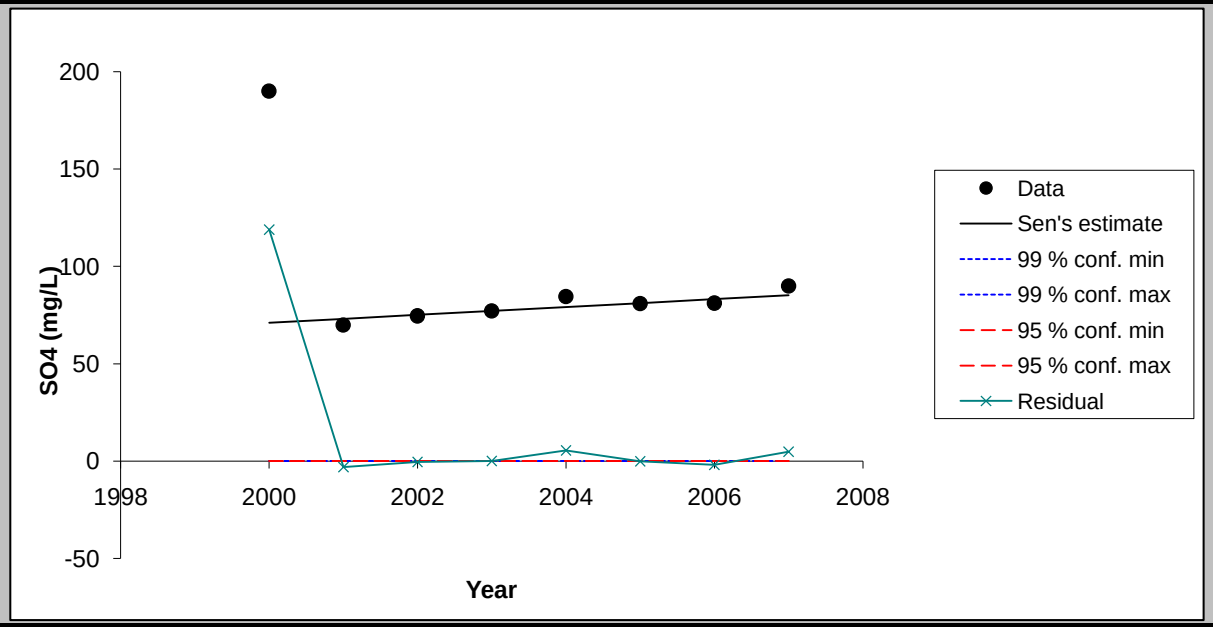

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	190.00	71.08	0.00	0.00	0.00	0.00	118.92
2001	70.00	73.08	0.00	0.00	0.00	0.00	-3.08
2002	74.66	75.09	0.00	0.00	0.00	0.00	-0.42
2003	77.20	77.09	0.00	0.00	0.00	0.00	0.11
2004	84.60	79.10	0.00	0.00	0.00	0.00	5.50
2005	81.00	81.11	0.00	0.00	0.00	0.00	-0.11
2006	81.20	83.11	0.00	0.00	0.00	0.00	-1.91
2007	90.00	85.12	0.00	0.00	0.00	0.00	4.88

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

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ANNUAL DATA

PW-01 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.08	1.3	0.0025	5.1	0.007	136		162
1992	0.0632	0.76	0.0014	5.04	0.0659	89	0.0393	128.5
1993	0.0907	0.93	0.00915	5.5	0.04175	87.55	0.04015	156.5
1994	0.08165	1.065	0.0018	4.995	0.0489	72	0.0295	126.5
1995								
1996	0.064	0.05	0.0005	5.1	0.03	78	0.016	140
1997								
1998	0.087	1.2	0.0005	5.7	0.072	120	0.024	180
1999	0.061	0.9	0.0005	5	0.06	82	0.02	170
2000	0.042	0.92	0.0005	4.7	0.04	69	0.016	140
2001	0.037	0.6	0.005	3.51	0.056	32	0.005	82
2002	0.0405	0.951	0.03	4.47	0.061	55.525	0.02	134.007
2003	0.0261	0.46	0.001	4.1	0.037	57.5	0.021	134
2004	0.0294	0.44	0.001	4.495	0.018	52.8	0.0276	122
2005	0.0435	0.66	0.002	5.225	0.098	91	0.028	170
2006	0.0272	0.72	0.002	4.975	0.053	72.7	0.02	141
2007	0.0314	0.89	0.002	4.56	0.0167	99.3	0.0386	136

TREND STATISTICS

PW-01 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-6*			-0.001					0.051				
F (mg/L)	*2000*	*2007*	*8*	*0*			0.005					0.612				
Mn (mg/L)	*2000*	*2007*	*8*	*4*			0.0001					0.0010				
Nitrate (mg/L)	*2000*	*2007*	*8*	*10*			0.110					3.162				
Se (mg/L)	*2000*	*2007*	*8*	*-6*			-0.001					0.063				
Cl (mg/L)	*2000*	*2007*	*8*	*14*			6.000					-12.487				
Mo (mg/L)	*2000*	*2007*	*8*	*20*		*	0.003					-0.015				
SO4 (mg/L)	*2000*	*2007*	*8*	*6*			1.124					121.08				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.31E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.12E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

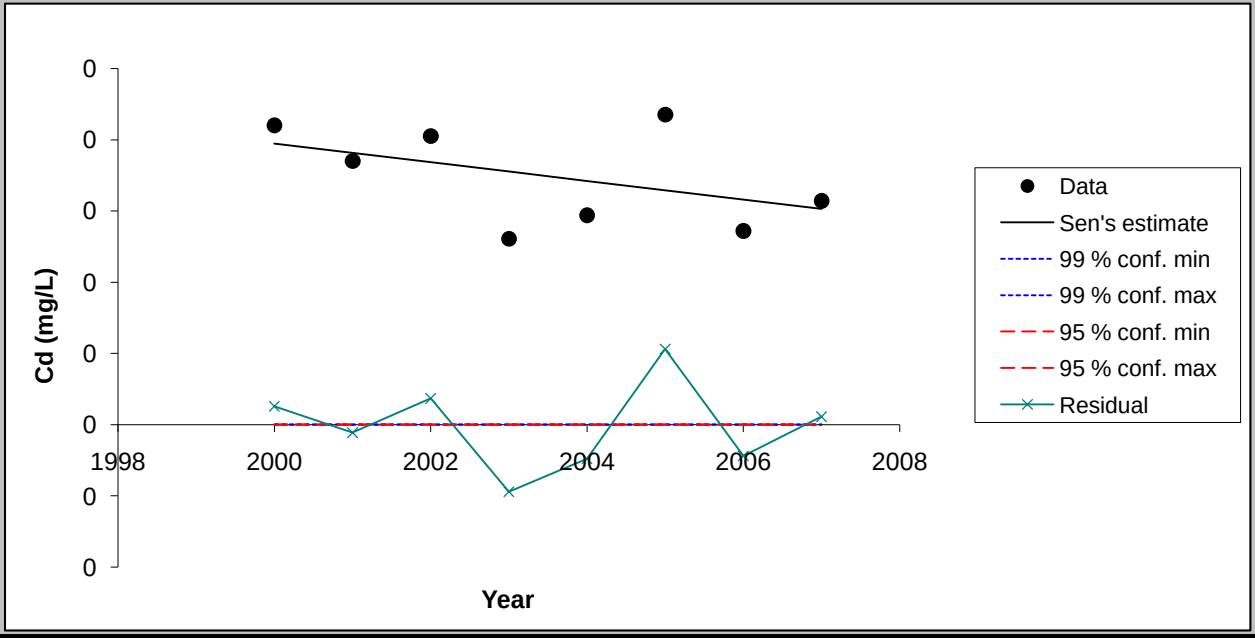

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2001	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2002	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2003	0.03	0.04	0.00	0.00	0.00	0.00	-0.01
2004	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2005	0.04	0.03	0.00	0.00	0.00	0.00	0.01
2006	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2007	0.03	0.03	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	5.36E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.12E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

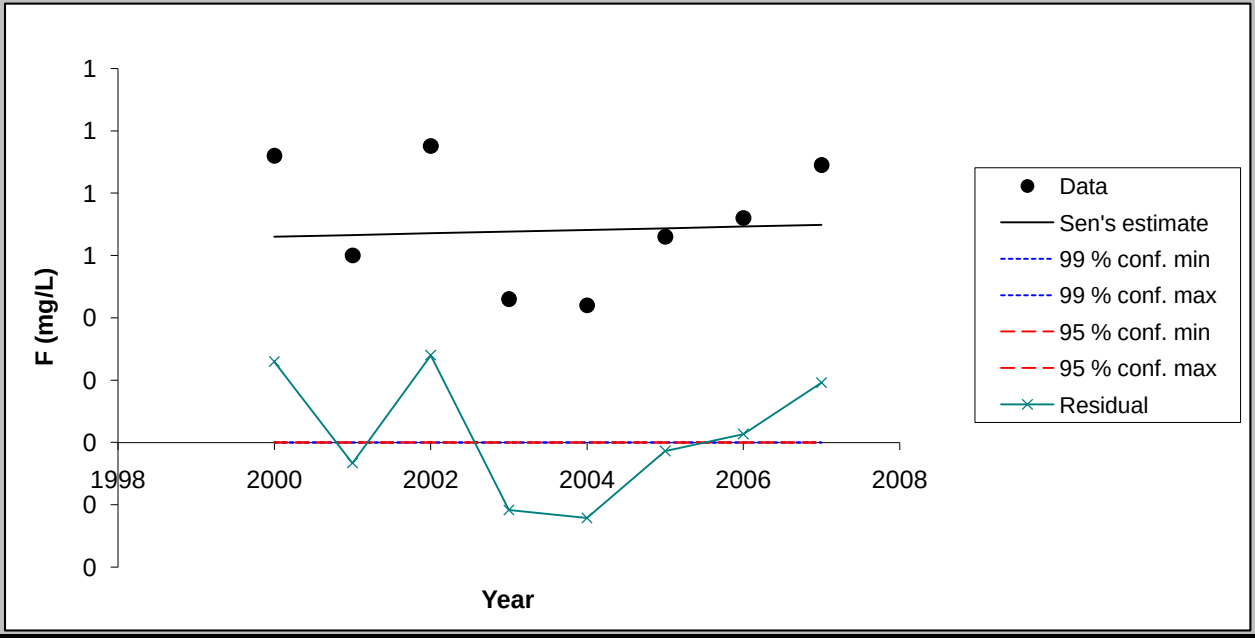

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.92	0.66	0.00	0.00	0.00	0.00	0.26
2001	0.60	0.67	0.00	0.00	0.00	0.00	-0.07
2002	0.95	0.67	0.00	0.00	0.00	0.00	0.28
2003	0.46	0.68	0.00	0.00	0.00	0.00	-0.22
2004	0.44	0.68	0.00	0.00	0.00	0.00	-0.24
2005	0.66	0.69	0.00	0.00	0.00	0.00	-0.03
2006	0.72	0.69	0.00	0.00	0.00	0.00	0.03
2007	0.89	0.70	0.00	0.00	0.00	0.00	0.19

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

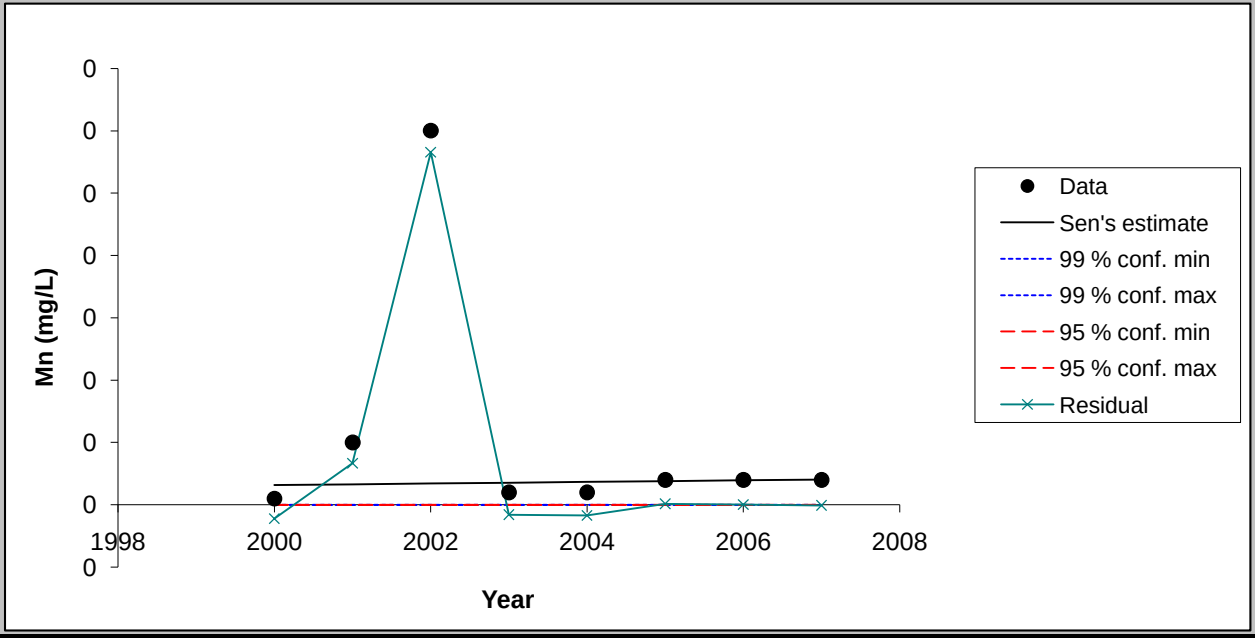

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	1.10E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.16E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

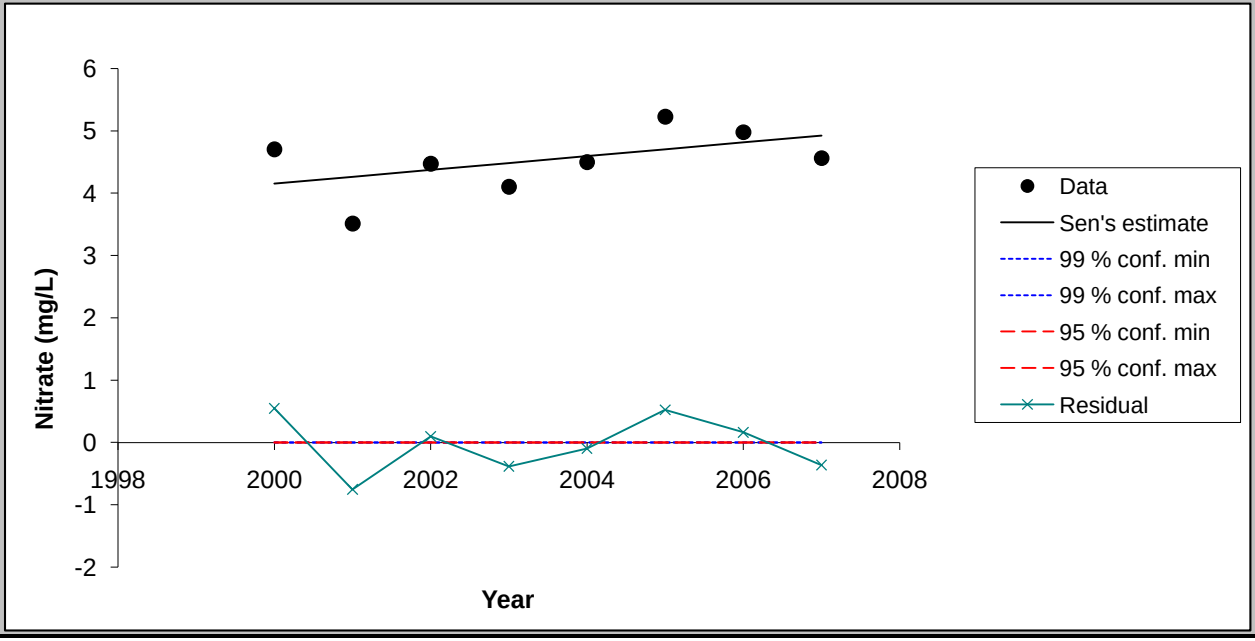

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.70	4.15	0.00	0.00	0.00	0.00	0.55
2001	3.51	4.26	0.00	0.00	0.00	0.00	-0.75
2002	4.47	4.37	0.00	0.00	0.00	0.00	0.10
2003	4.10	4.48	0.00	0.00	0.00	0.00	-0.38
2004	4.50	4.59	0.00	0.00	0.00	0.00	-0.10
2005	5.23	4.70	0.00	0.00	0.00	0.00	0.52
2006	4.98	4.81	0.00	0.00	0.00	0.00	0.16
2007	4.56	4.92	0.00	0.00	0.00	0.00	-0.36

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.50E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.30E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

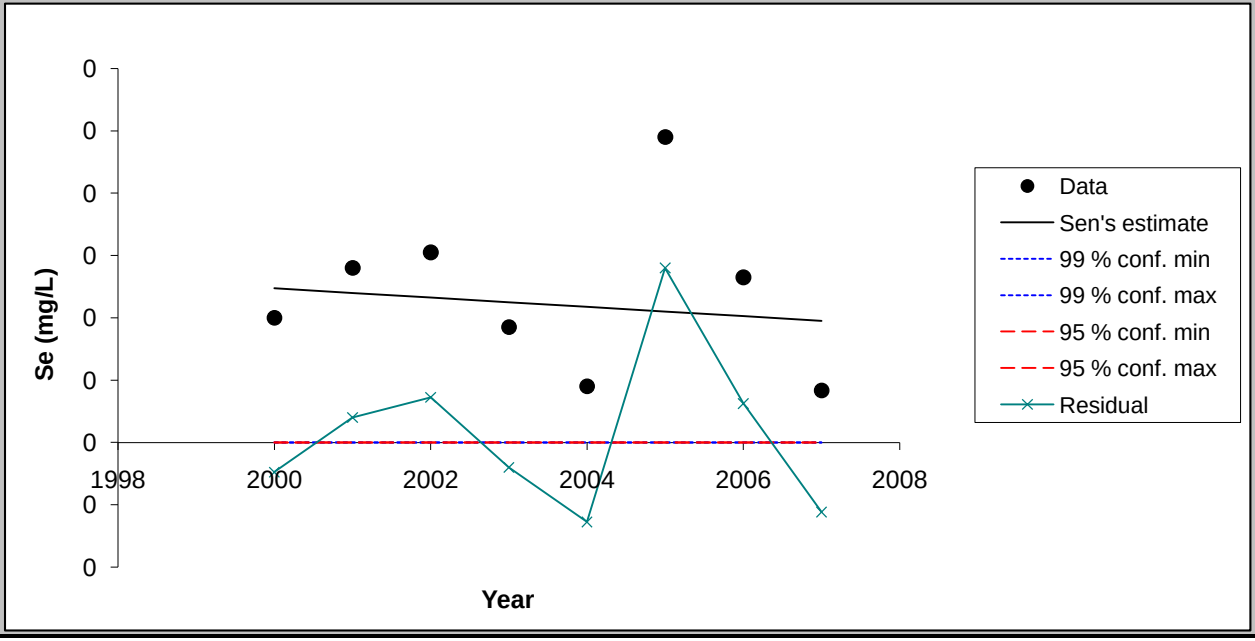

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.04	0.05	0.00	0.00	0.00	0.00	-0.01
2001	0.06	0.05	0.00	0.00	0.00	0.00	0.01
2002	0.06	0.05	0.00	0.00	0.00	0.00	0.01
2003	0.04	0.05	0.00	0.00	0.00	0.00	-0.01
2004	0.02	0.04	0.00	0.00	0.00	0.00	-0.03
2005	0.10	0.04	0.00	0.00	0.00	0.00	0.06
2006	0.05	0.04	0.00	0.00	0.00	0.00	0.01
2007	0.02	0.04	0.00	0.00	0.00	0.00	-0.02

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	6.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.25E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

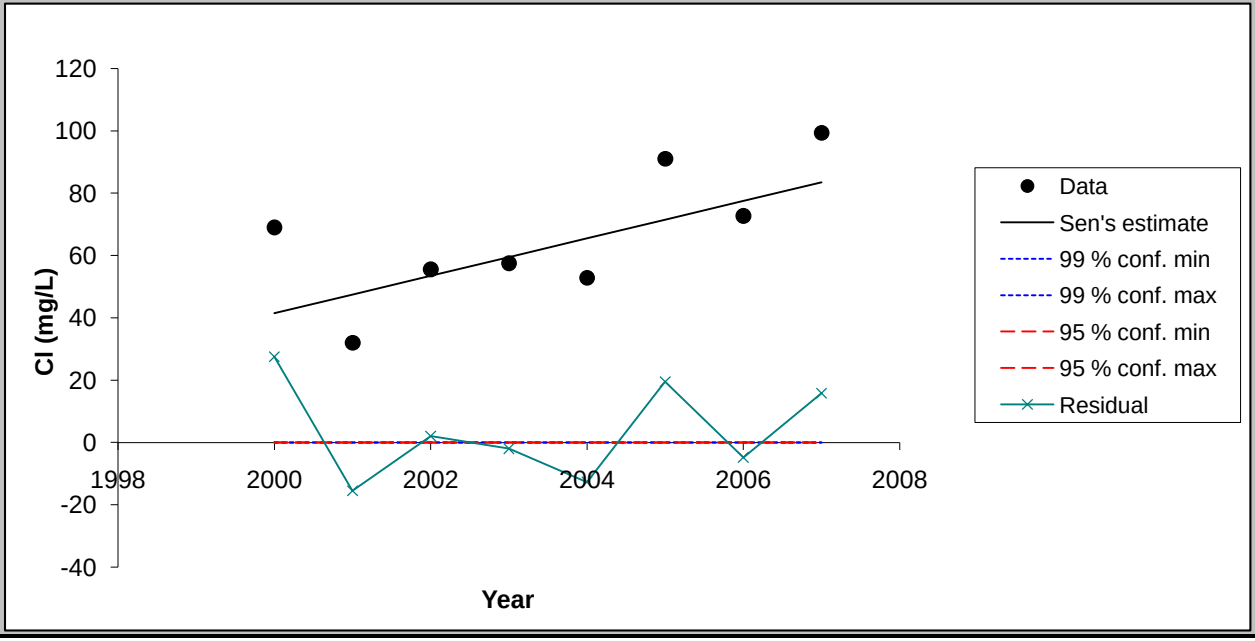

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	69.00	41.51	0.00	0.00	0.00	0.00	27.49
2001	32.00	47.51	0.00	0.00	0.00	0.00	-15.51
2002	55.53	53.51	0.00	0.00	0.00	0.00	2.01
2003	57.50	59.51	0.00	0.00	0.00	0.00	-2.01
2004	52.80	65.51	0.00	0.00	0.00	0.00	-12.71
2005	91.00	71.51	0.00	0.00	0.00	0.00	19.49
2006	72.70	77.51	0.00	0.00	0.00	0.00	-4.81
2007	99.30	83.51	0.00	0.00	0.00	0.00	15.79

FIGURE

< Previous Time Series

Next Time Series >

PW-01 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	3.11E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.49E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

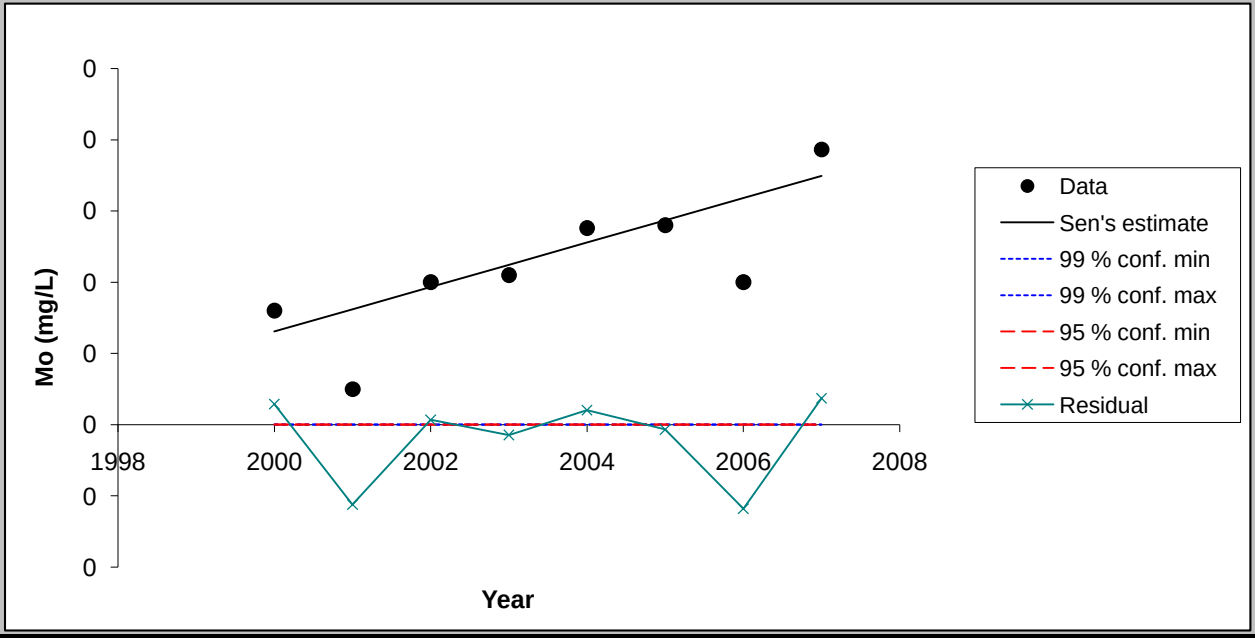

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.02	0.00	0.00	0.00	0.00	-0.01
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2004	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2005	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2006	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2007	0.04	0.03	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-01 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	6
Test Z	
Signific.	
Q	1.12E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.21E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

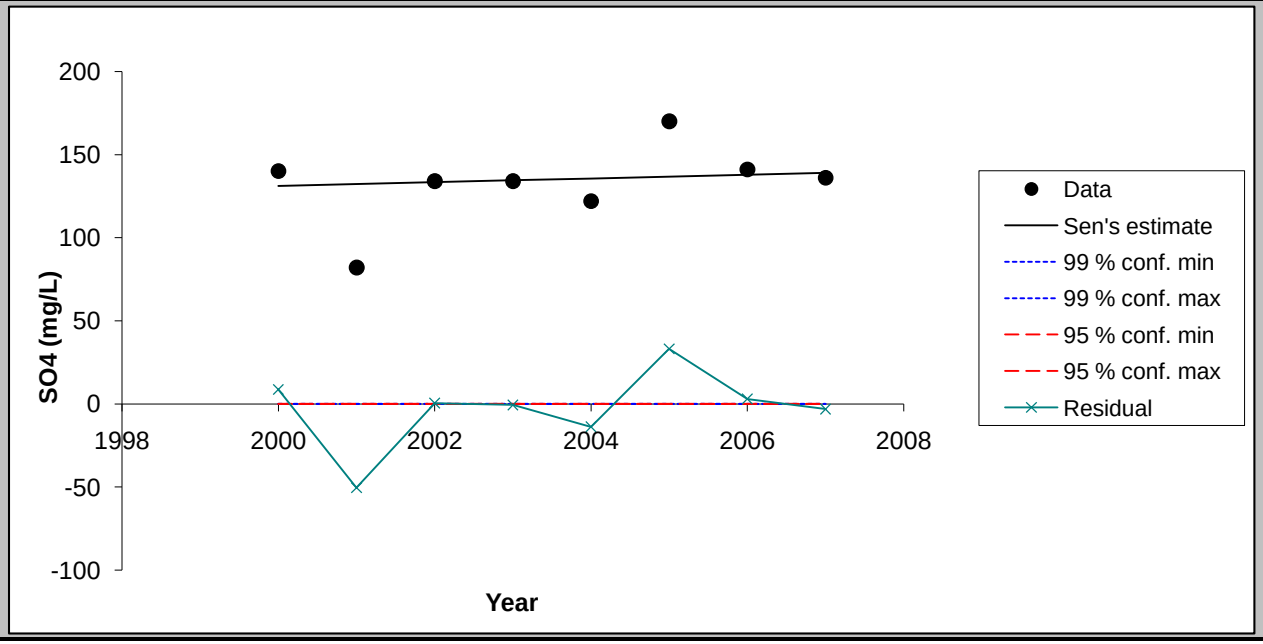

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	140.00	131.19	0.00	0.00	0.00	0.00	8.81
2001	82.00	132.32	0.00	0.00	0.00	0.00	-50.32
2002	134.01	133.44	0.00	0.00	0.00	0.00	0.57
2003	134.00	134.57	0.00	0.00	0.00	0.00	-0.57
2004	122.00	135.69	0.00	0.00	0.00	0.00	-13.69
2005	170.00	136.81	0.00	0.00	0.00	0.00	33.19
2006	141.00	137.94	0.00	0.00	0.00	0.00	3.06
2007	136.00	139.06	0.00	0.00	0.00	0.00	-3.06

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-02 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.02	0.4	0.0025	4.05	0.0015	28		84
1992	0.0116	0.325	0.00505	4	0.01165	27.05	0.0356	86.5
1993	0.00985	0.33	0.01165	4.685	0.0164	40.05	0.01525	97
1994	0.0129	0.455	0.0025	4.125	0.0202	42.25	0.01325	88.3
1995	0.0076	0.49	0.0005	17	0.027	44	0.015	110
1996	0.0069	0.42	0.0005	5.1	0.009	37	0.012	94
1997	0.009	0.48	0.0005	5	0.03	49	0.015	120
1998	0.013	0.5	0.0005	4.9	0.026	65	0.016	150
1999	0.006	0.55	0.001	4.8	0.016	39	0.013	130
2000	0.0031	0.44	0.0005	3.8	0.01	36	0.018	100
2001	0.003	0.9	0.005	4.62	0.013	50	0.02	125
2002	0.003	0.643	0.03	3.38	0.01	32.639	0.0275	80.558
2003	0.0049	0.23	0.001	3.47	0.014	38.4	0.024	99.9
2004	0.0053	0.26	0.001	3.31	0.0075	41.2	0.033	98.5
2005	0.0035	0.175	0.002	4.34	0.019	61.5	0.025	120
2006	0.0035	0.32	0.002	4.22	0.0131	58.5	0.031	116
2007	0.0016	0.46	0.002	3.74	0.0064	54.4	0.05	102

TREND STATISTICS

PW-02 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*0*			0.000					0.00				
F (mg/L)	*2000*	*2007*	*8*	*-6*			-0.041					0.87				
Mn (mg/L)	*2000*	*2007*	*8*	*4*			0.000					0.00				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-2*			-0.022					4.04				
Se (mg/L)	*2000*	*2007*	*8*	*-1*			0.000					0.01				
Cl (mg/L)	*2000*	*2007*	*8*	*14*			3.313					3.79				
Mo (mg/L)	*2000*	*2007*	*8*	*20*		*	0.003					-0.01				
SO4 (mg/L)	*2000*	*2007*	*8*	*2*			0.405					95.93				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.30E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

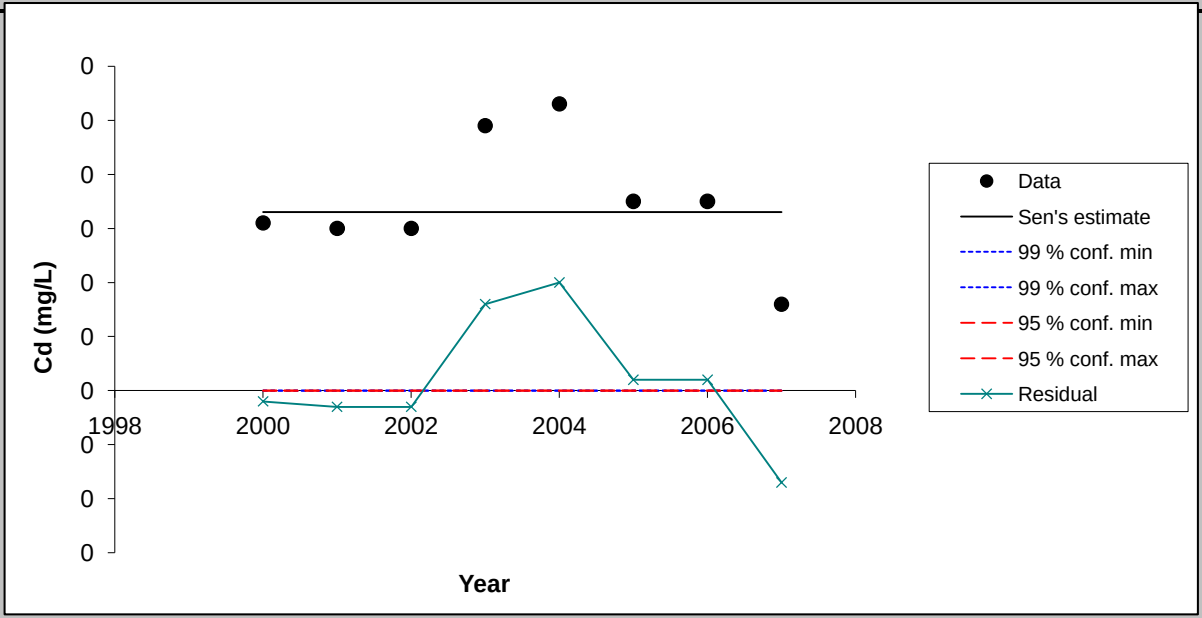

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-02 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-4.08E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.70E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

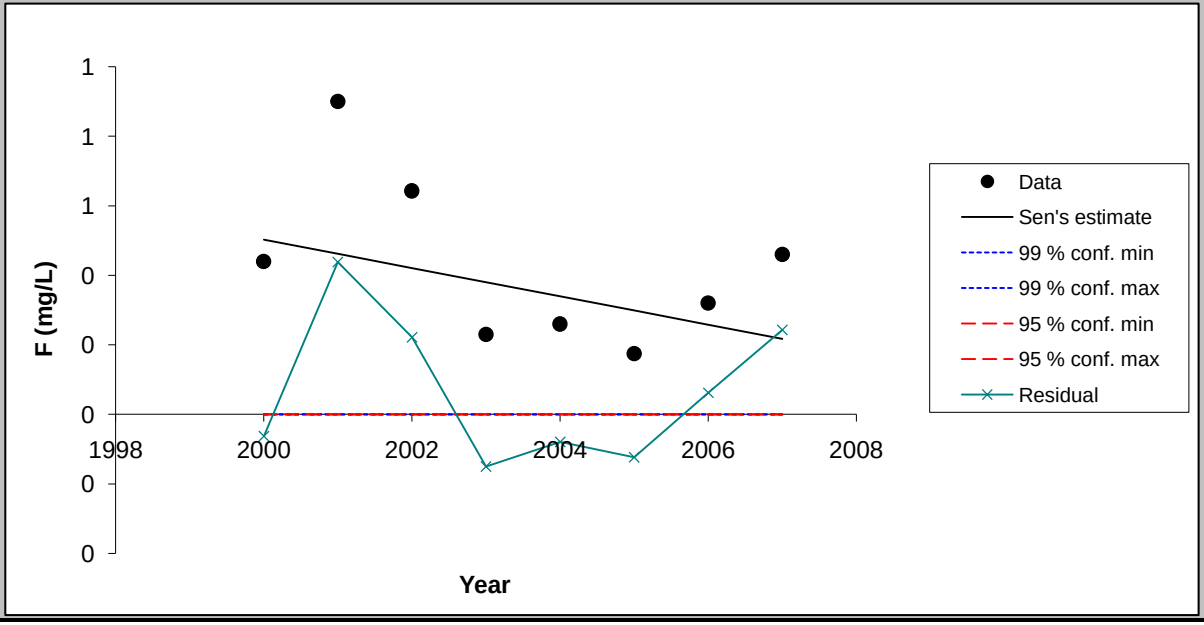

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.44	0.50	0.00	0.00	0.00	0.00	-0.06
2001	0.90	0.46	0.00	0.00	0.00	0.00	0.44
2002	0.64	0.42	0.00	0.00	0.00	0.00	0.22
2003	0.23	0.38	0.00	0.00	0.00	0.00	-0.15
2004	0.26	0.34	0.00	0.00	0.00	0.00	-0.08
2005	0.18	0.30	0.00	0.00	0.00	0.00	-0.12
2006	0.32	0.26	0.00	0.00	0.00	0.00	0.06
2007	0.46	0.22	0.00	0.00	0.00	0.00	0.24

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

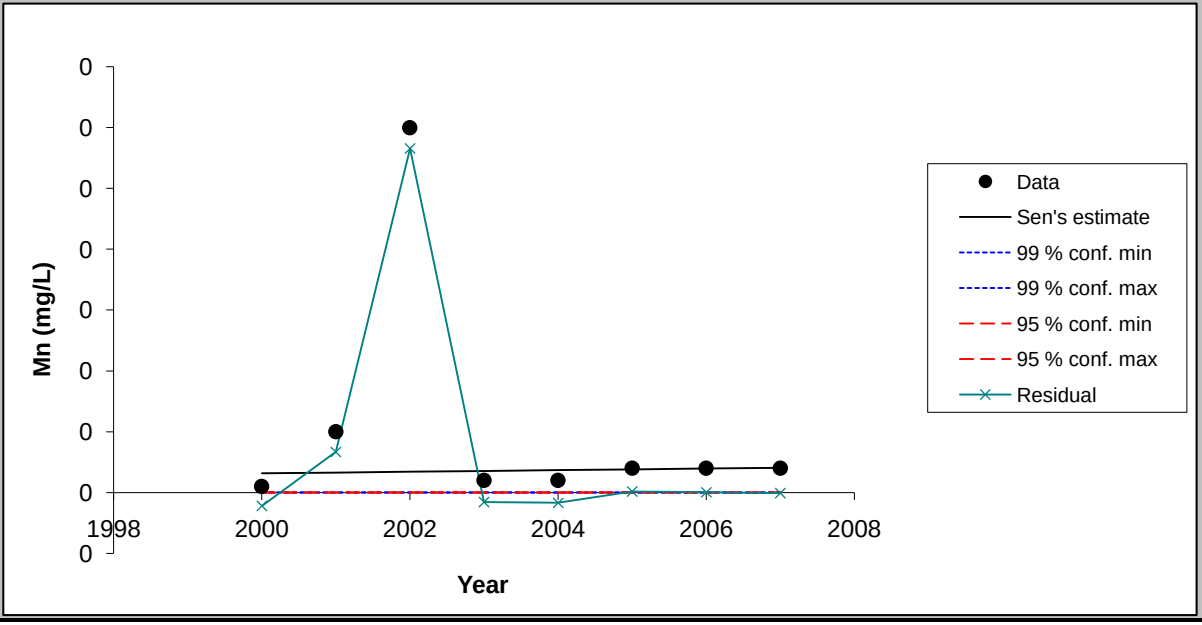

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-2.18E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.04E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

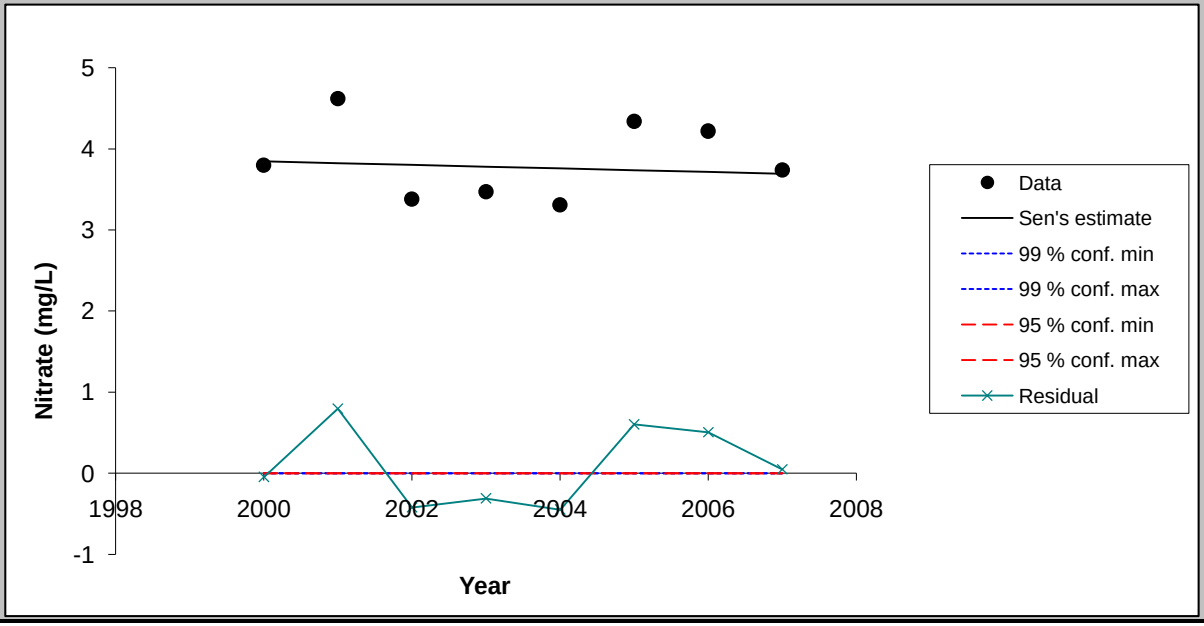

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.80	3.85	0.00	0.00	0.00	0.00	-0.05
2001	4.62	3.82	0.00	0.00	0.00	0.00	0.80
2002	3.38	3.80	0.00	0.00	0.00	0.00	-0.42
2003	3.47	3.78	0.00	0.00	0.00	0.00	-0.31
2004	3.31	3.76	0.00	0.00	0.00	0.00	-0.45
2005	4.34	3.74	0.00	0.00	0.00	0.00	0.60
2006	4.22	3.72	0.00	0.00	0.00	0.00	0.50
2007	3.74	3.69	0.00	0.00	0.00	0.00	0.05

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-1
Test Z	
Signific.	
Q	-1.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.31E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

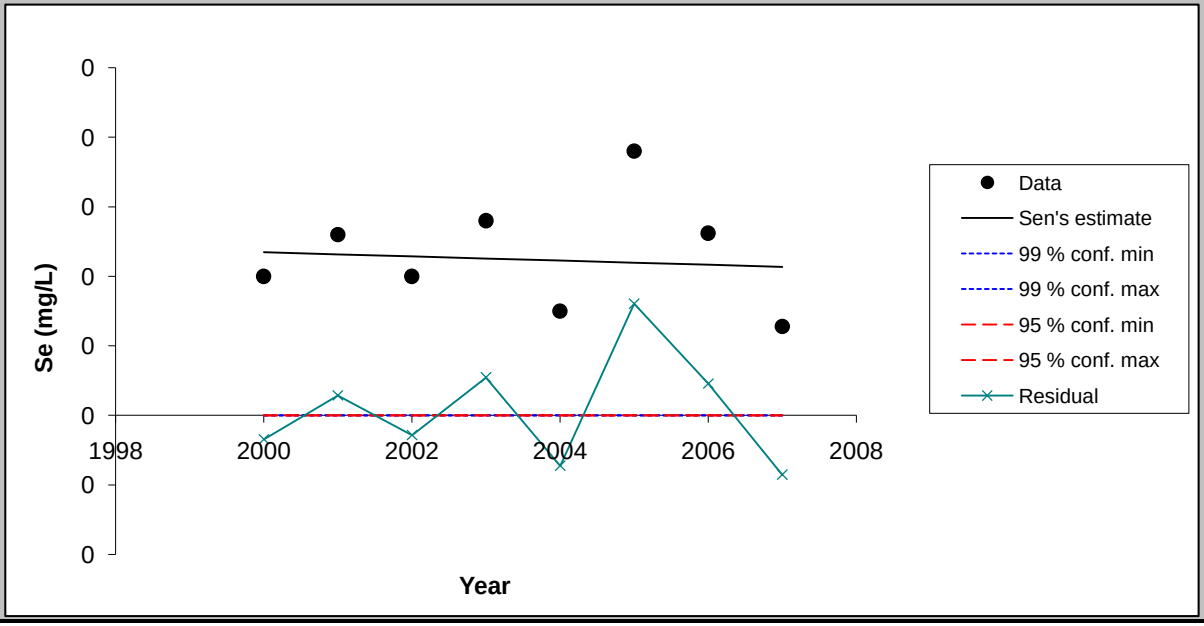

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	3.31E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.79E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

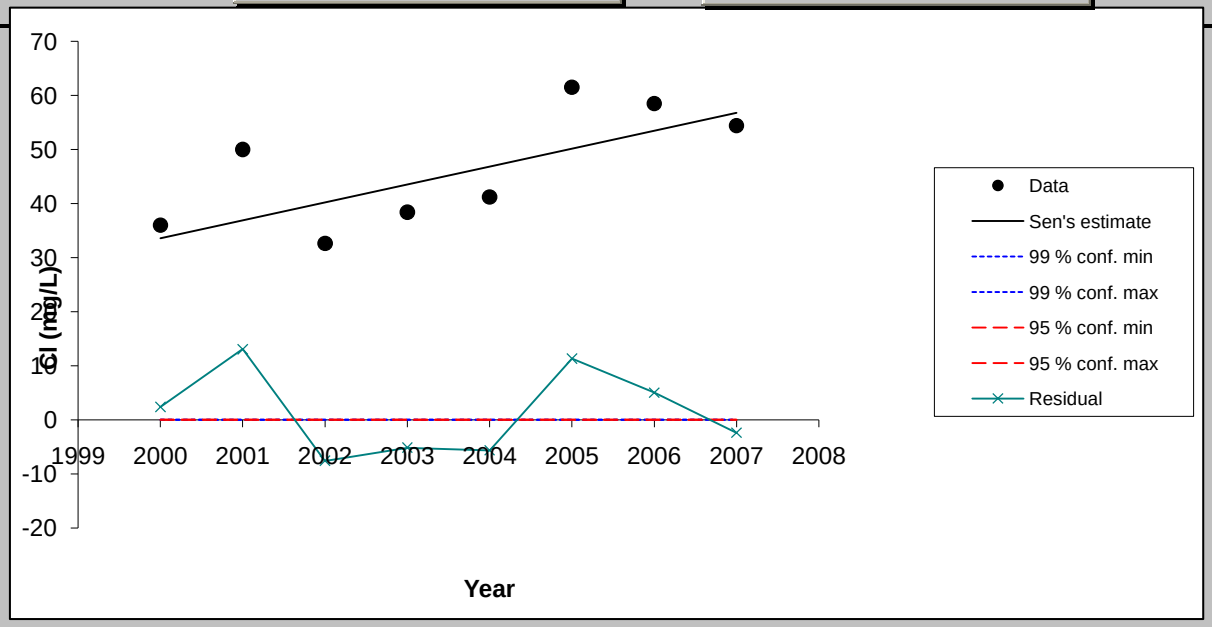

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	36.00	33.61	0.00	0.00	0.00	0.00	2.39
2001	50.00	36.92	0.00	0.00	0.00	0.00	13.08
2002	32.64	40.23	0.00	0.00	0.00	0.00	-7.59
2003	38.40	43.54	0.00	0.00	0.00	0.00	-5.14
2004	41.20	46.86	0.00	0.00	0.00	0.00	-5.66
2005	61.50	50.17	0.00	0.00	0.00	0.00	11.33
2006	58.50	53.48	0.00	0.00	0.00	0.00	5.02
2007	54.40	56.79	0.00	0.00	0.00	0.00	-2.39

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	2.54E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-5.15E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

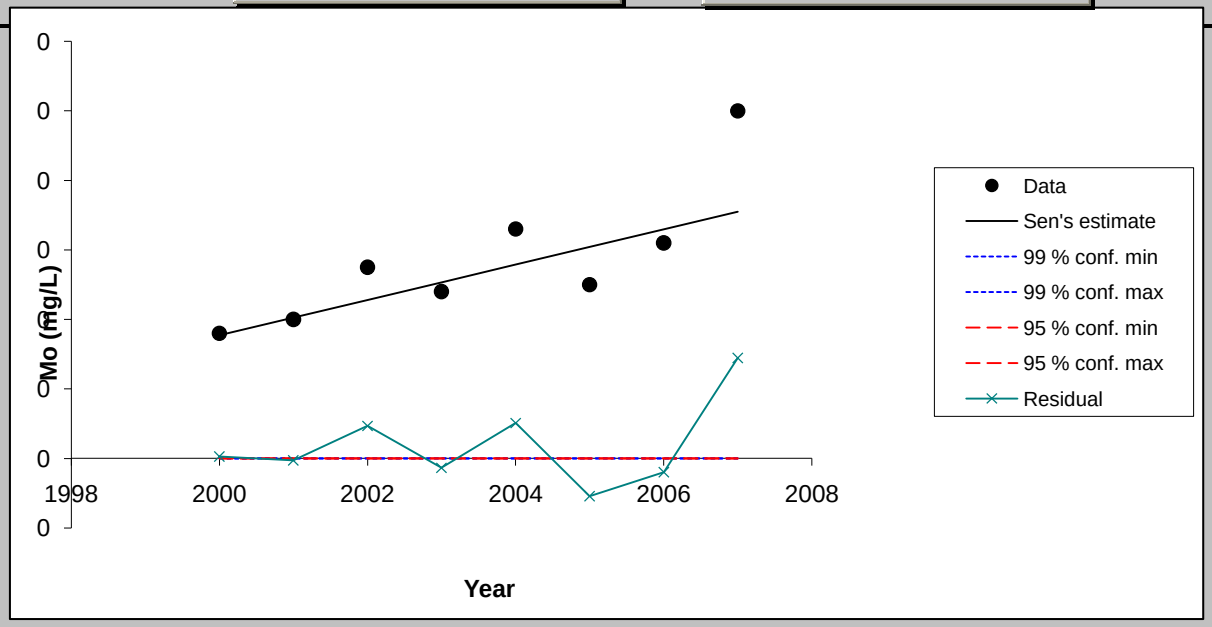

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.03	0.00	0.00	0.00	0.00	0.00
2004	0.03	0.03	0.00	0.00	0.00	0.00	0.01
2005	0.03	0.03	0.00	0.00	0.00	0.00	-0.01
2006	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2007	0.05	0.04	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series | Next Time Series >

PW-02 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	4.05E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.59E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

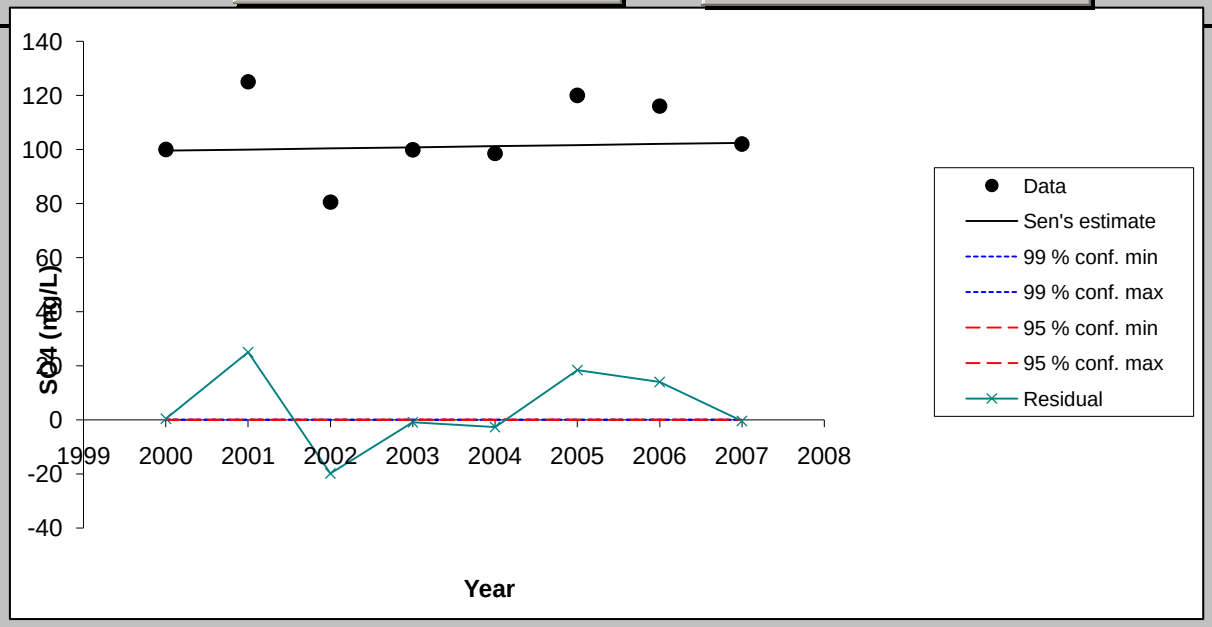

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	100.00	99.58	0.00	0.00	0.00	0.00	0.42
2001	125.00	99.99	0.00	0.00	0.00	0.00	25.01
2002	80.56	100.39	0.00	0.00	0.00	0.00	-19.83
2003	99.90	100.80	0.00	0.00	0.00	0.00	-0.90
2004	98.50	101.20	0.00	0.00	0.00	0.00	-2.70
2005	120.00	101.61	0.00	0.00	0.00	0.00	18.39
2006	116.00	102.01	0.00	0.00	0.00	0.00	13.99
2007	102.00	102.42	0.00	0.00	0.00	0.00	-0.42

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-03 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.007	0.34	0.003	4.45	0.0015	35		90
1992	0.00515	0.32	0.00215	4.125	0.0115	33.85	0.074	84.7
1993	0.00475	0.295	0.00805	4.945	0.01425	39.45	0.0575	93.4
1994	0.00395	2.2	0.001	4.305	0.0175	48.2	0.03995	69.4
1995	0.0044	0.47	0.0005	4.1	0.022	47	0.036	100
1996	0.0032	0.45	0.0005	4.3	0.009	34	0.025	88
1997	0.0048	0.45	0.0005	4.7	0.021	57	0.021	110
1998	0.002	0.5	0.0005	4.5	0.019	53	0.018	130
1999	0.004	0.47	0.005	4.5	0.012	34	0.018	110
2000	0.0025	0.47	0.0005	3.5	0.009	36	0.019	100
2001	0.001	0.6	0.005	3.56	0.0025	33	0.005	82
2002	0.0025	0.661	0.03	3.36	0.01	32.597	0.0253	80.417
2003	0.0021	0.25	0.001	3.09	0.011	36.6	0.035	83.1
2004	0.0025	0.28	0.001	3.16	0.0075	35.3	0.049	81.4
2005	0.0023	0.217	0.002	4.31	0.012	58.1	0.037	101
2006	0.001	0.13	0.002	4.45	0.01	54	0.041	99.7
2007	0.0014	0.21	0.002	3.64	0.0043	62	0.045	103

TREND STATISTICS

PW-03 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-7*			-0.0001					0.00				
F (mg/L)	*2000*	*2007*	*8*	*-18*		*	-0.060					1.06				
Mn (mg/L)	*2000*	*2007*	*8*	*4*			0.000					0.00				
Nitrate (mg/L)	*2000*	*2007*	*8*	*8*			0.065					2.78				
Se (mg/L)	*2000*	*2007*	*8*	*4*			0.000					0.01				
Cl (mg/L)	*2000*	*2007*	*8*	*16*		+	4.101					-7.77				
Mo (mg/L)	*2000*	*2007*	*8*	*20*		*	0.004					-0.02				
SO4 (mg/L)	*2000*	*2007*	*8*	*10*			1.841					67.83				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-7
Test Z	
Signific.	
Q	-1.00E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.35E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

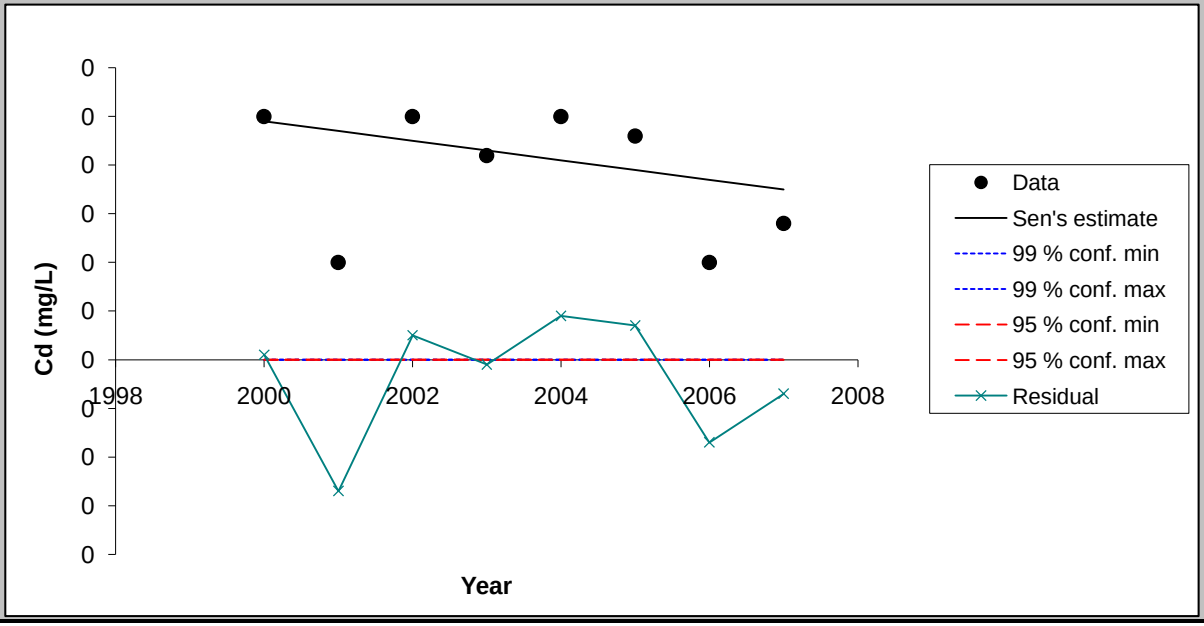

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-03 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-18
Test Z	
Signific.	*
Q	-5.98E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.06E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

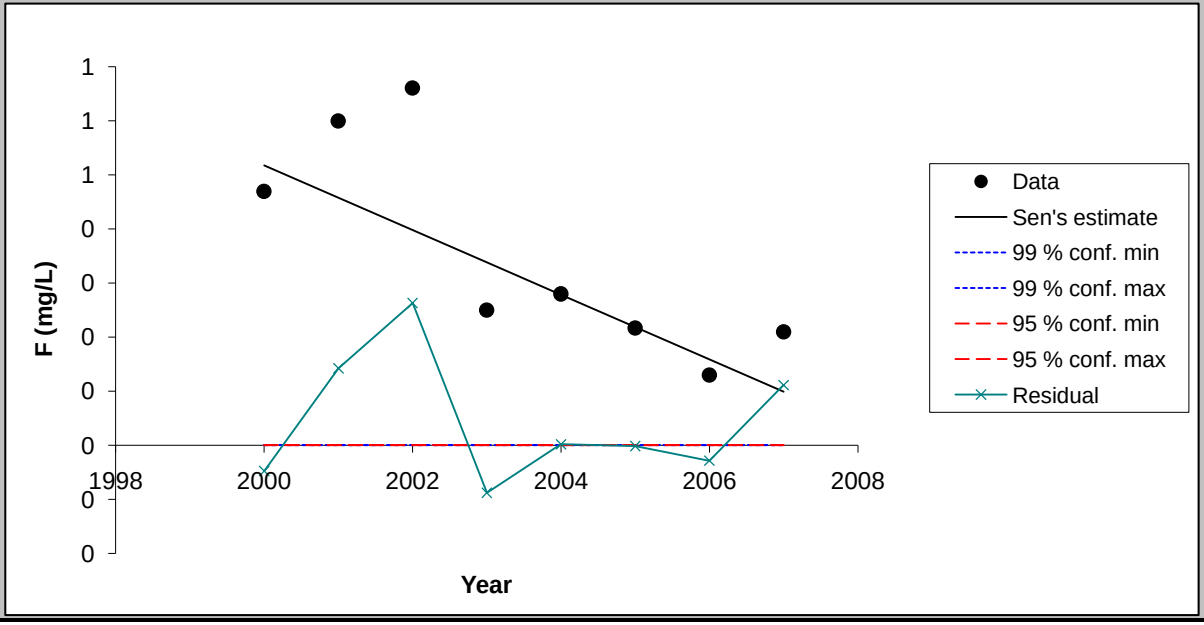

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.47	0.52	0.00	0.00	0.00	0.00	-0.05
2001	0.60	0.46	0.00	0.00	0.00	0.00	0.14
2002	0.66	0.40	0.00	0.00	0.00	0.00	0.26
2003	0.25	0.34	0.00	0.00	0.00	0.00	-0.09
2004	0.28	0.28	0.00	0.00	0.00	0.00	0.00
2005	0.22	0.22	0.00	0.00	0.00	0.00	0.00
2006	0.13	0.16	0.00	0.00	0.00	0.00	-0.03
2007	0.21	0.10	0.00	0.00	0.00	0.00	0.11

FIGURE

< Previous Time Series | Next Time Series >

PW-03 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	6.25E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.03E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

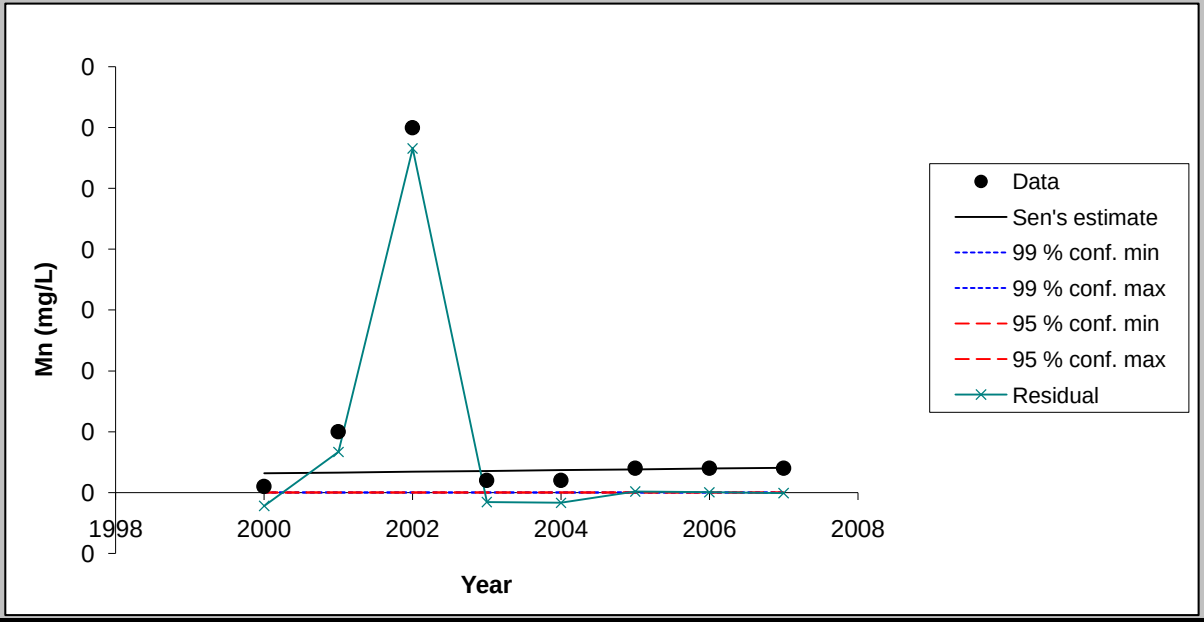

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	6.50E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.78E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

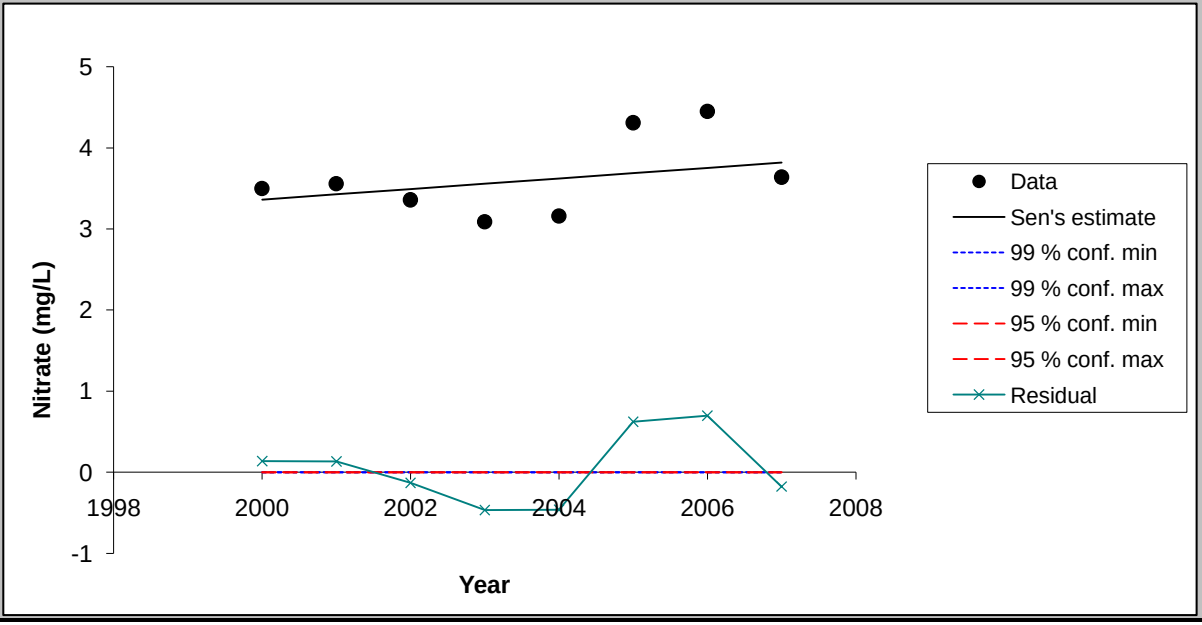

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.50	3.36	0.00	0.00	0.00	0.00	0.14
2001	3.56	3.43	0.00	0.00	0.00	0.00	0.13
2002	3.36	3.49	0.00	0.00	0.00	0.00	-0.13
2003	3.09	3.56	0.00	0.00	0.00	0.00	-0.47
2004	3.16	3.62	0.00	0.00	0.00	0.00	-0.46
2005	4.31	3.69	0.00	0.00	0.00	0.00	0.62
2006	4.45	3.75	0.00	0.00	0.00	0.00	0.70
2007	3.64	3.82	0.00	0.00	0.00	0.00	-0.18

FIGURE

< Previous Time Series | Next Time Series >

PW-03 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	2.33E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.70E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

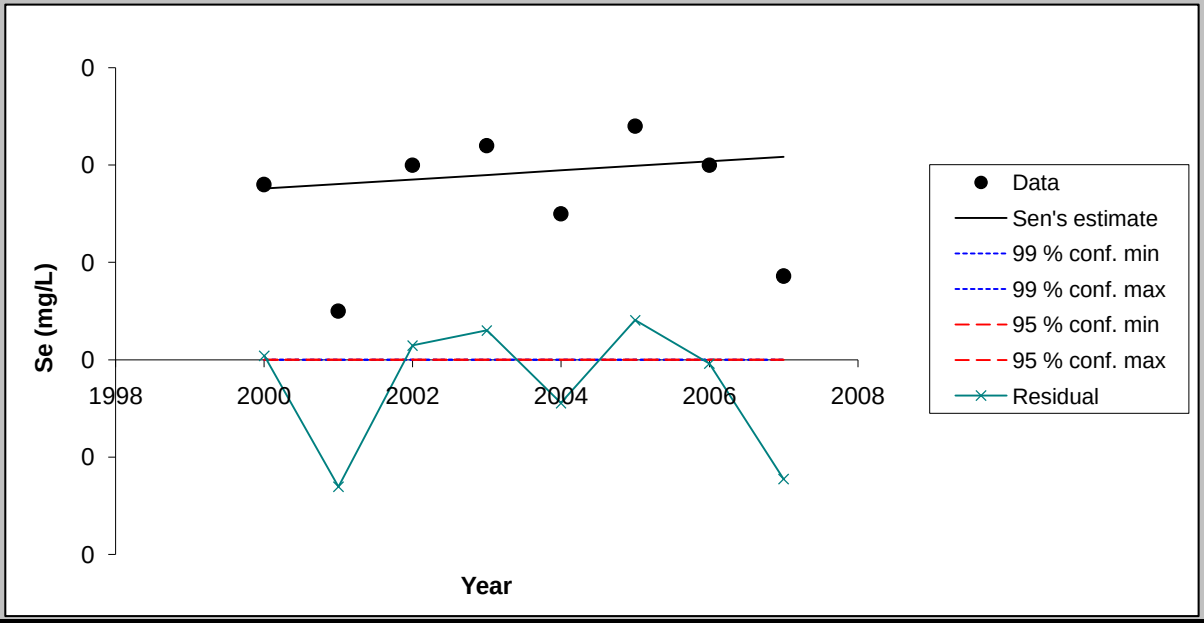

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.01	0.00	0.00	0.00	0.00	-0.01

FIGURE

< Previous Time Series | Next Time Series >

PW-03 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	4.10E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-7.77E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

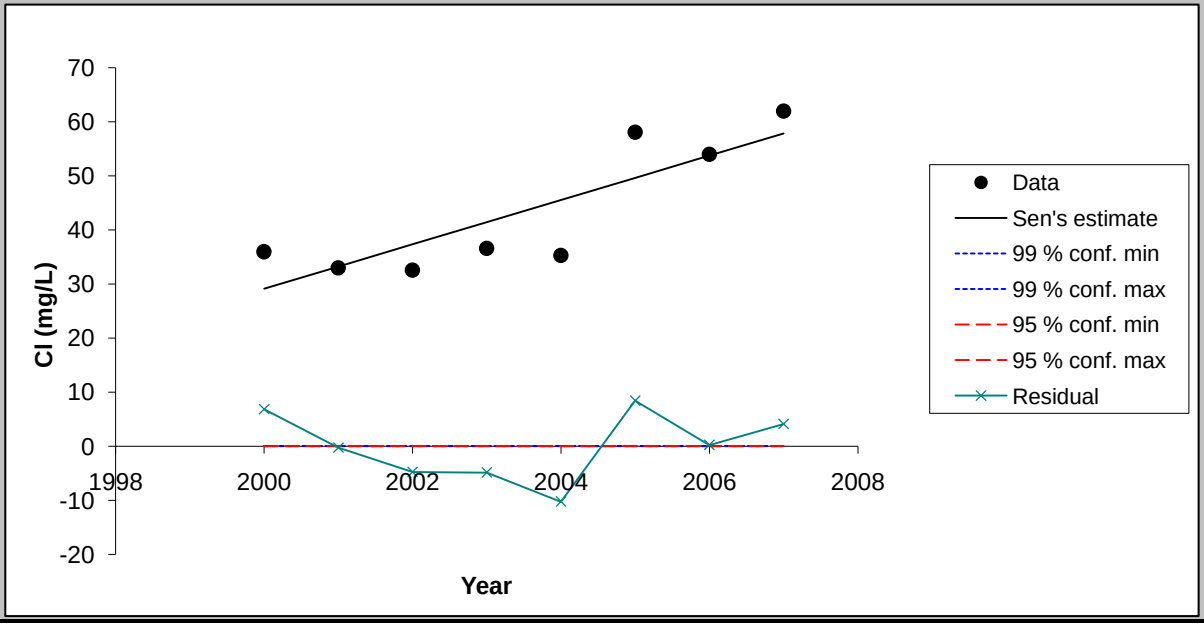

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	36.00	29.14	0.00	0.00	0.00	0.00	6.86
2001	33.00	33.25	0.00	0.00	0.00	0.00	-0.25
2002	32.60	37.35	0.00	0.00	0.00	0.00	-4.75
2003	36.60	41.45	0.00	0.00	0.00	0.00	-4.85
2004	35.30	45.55	0.00	0.00	0.00	0.00	-10.25
2005	58.10	49.65	0.00	0.00	0.00	0.00	8.45
2006	54.00	53.75	0.00	0.00	0.00	0.00	0.25
2007	62.00	57.86	0.00	0.00	0.00	0.00	4.14

FIGURE

< Previous Time Series

Next Time Series >

PW-03 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	3.97E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.84E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

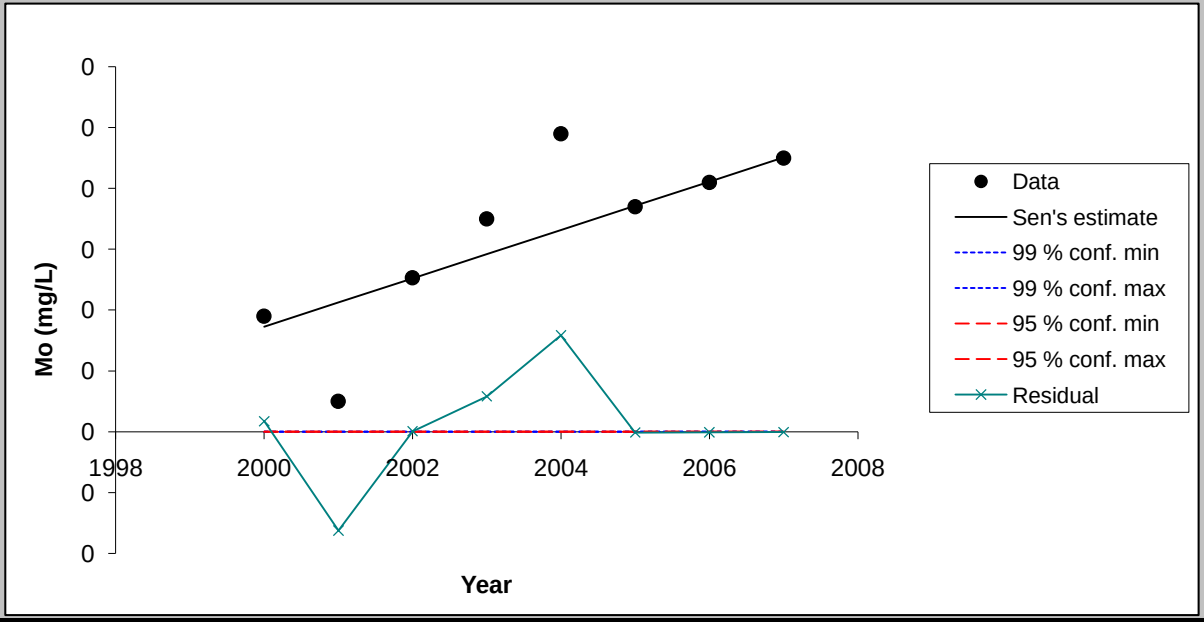

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.02	0.00	0.00	0.00	0.00	-0.02
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.04	0.03	0.00	0.00	0.00	0.00	0.01
2004	0.05	0.03	0.00	0.00	0.00	0.00	0.02
2005	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2006	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2007	0.05	0.05	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-03 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	1.84E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.78E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

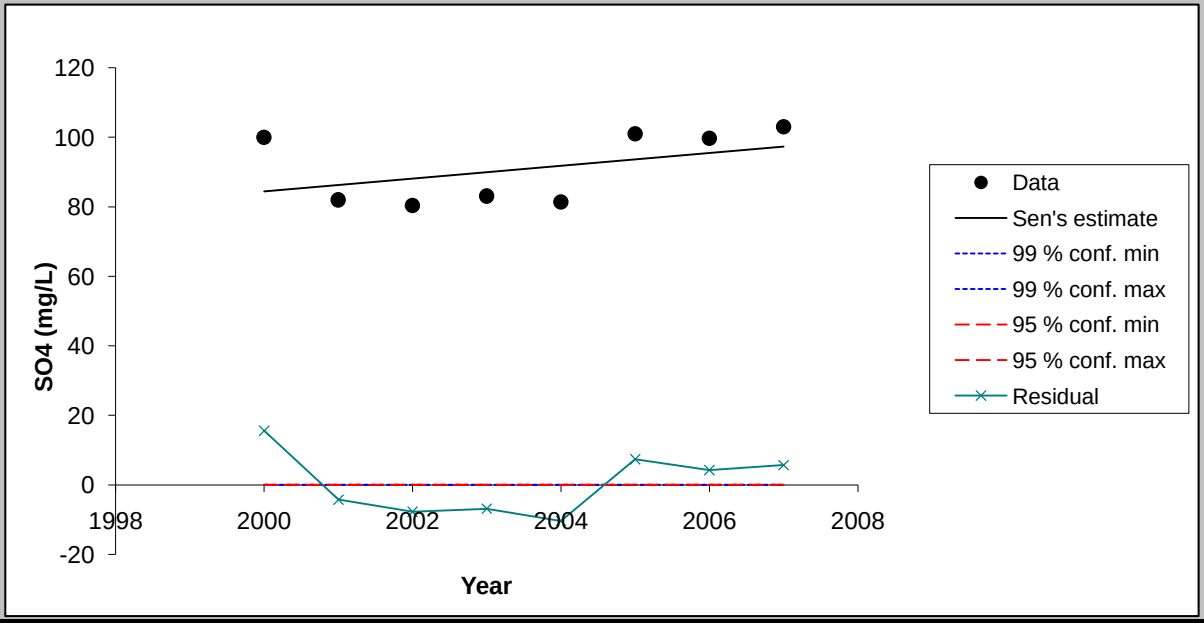

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	100.00	84.40	0.00	0.00	0.00	0.00	15.60
2001	82.00	86.25	0.00	0.00	0.00	0.00	-4.25
2002	80.42	88.09	0.00	0.00	0.00	0.00	-7.67
2003	83.10	89.93	0.00	0.00	0.00	0.00	-6.83
2004	81.40	91.77	0.00	0.00	0.00	0.00	-10.37
2005	101.00	93.61	0.00	0.00	0.00	0.00	7.39
2006	99.70	95.45	0.00	0.00	0.00	0.00	4.25
2007	103.00	97.30	0.00	0.00	0.00	0.00	5.70

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

PW-04 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.23	0.0035	3.8	0.0015	14		78
1992	0.00425	0.1525	0.00365	3.58	0.00335	15.1	0.00335	83.73
1993	0.00292	0.165	0.0061	3.98	0.00085	14.6	0.00483	74.35
1994	0.0005	0.24	0.001	3.915	0.002	14.6	0.0065	82.95
1995	0.0001	0.25	0.0005	3.5	0.0005	15	0.0025	77
1996	0.0001	0.32	0.0005	3.8	0.001	20	0.0025	90
1997	0.0001	0.32	0.016	4.4	0.001	16	0.0025	74
1998	0.0001	0.3	0.0005	4.4	0.002	16	0.0025	93
1999	0.0001	0.29	0.0005	4.2	0.0005	14	0.0025	110
2000	0.0001	0.3	0.0005	4	0.004	17	0.0025	100
2001	0.001	0.4	0.005	4.21	0.0025	16	0.005	84
2002	0.006	0.575	0.03	3.8	0.0025	15.56	0.005	77.989
2003	0.001	0.29	0.00075	3.54	0.003	13.4	0.01	73.55
2004	0.001	0.2	0.001	3.42	0.005	12	0.013	77.7
2005	0.001	0.15	0.002	3.73	0.0015	14.3	0.008	72.3
2006	0.001	0.31	0.002	4.32	0.0015	14.1	0.008	68.6
2007	0.001	0.41	0.002	4.23	0.0029	32.4	0.006	82.2

TREND STATISTICS

PW-04 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-2*			0.0000					0.0010				
F (mg/L)	*2000*	*2007*	*8*	*-2*			-0.0107					0.4440				
Mn (mg/L)	*2000*	*2007*	*8*	*5*			0.0001					0.0004				
Nitrate (mg/L)	*2000*	*2007*	*8*	*2*			0.013					3.77				
Se (mg/L)	*2000*	*2007*	*8*	*-6*			-0.0002					0.0048				
Cl (mg/L)	*2000*	*2007*	*8*	*-6*			-0.400					19.98				
Mo (mg/L)	*2000*	*2007*	*8*	*10*			0.0007					-0.0019				
SO4 (mg/L)	*2000*	*2007*	*8*	*-16*		+	-2.734					110.96				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

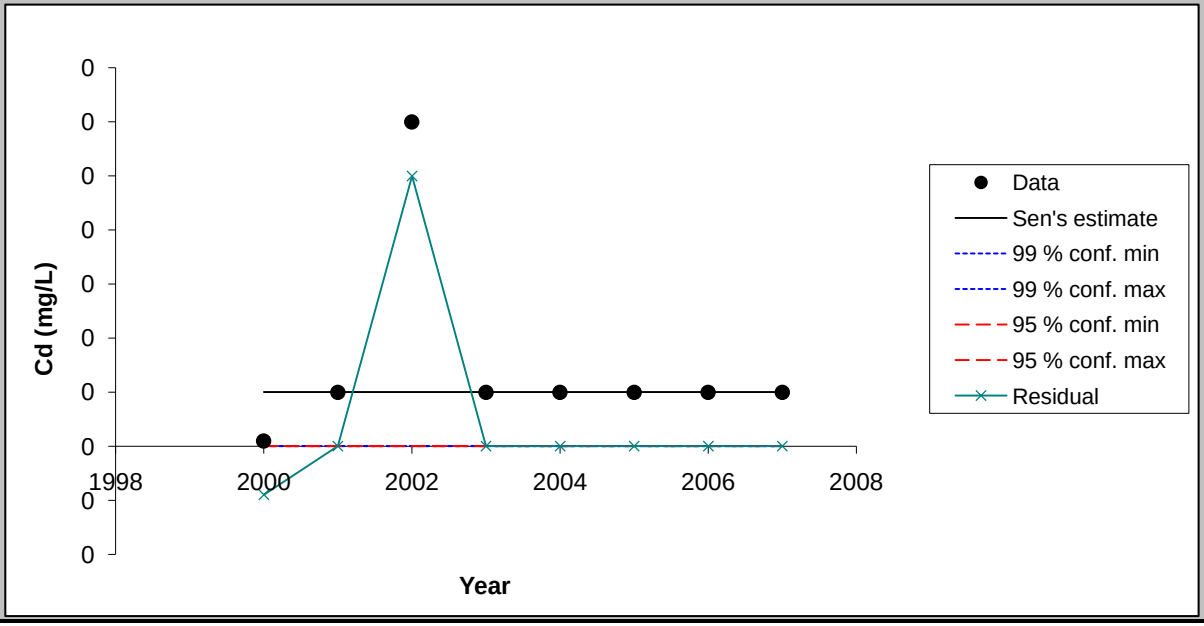

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.00	0.00	0.00	0.00	0.00	0.01
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-04 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-1.07E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.44E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

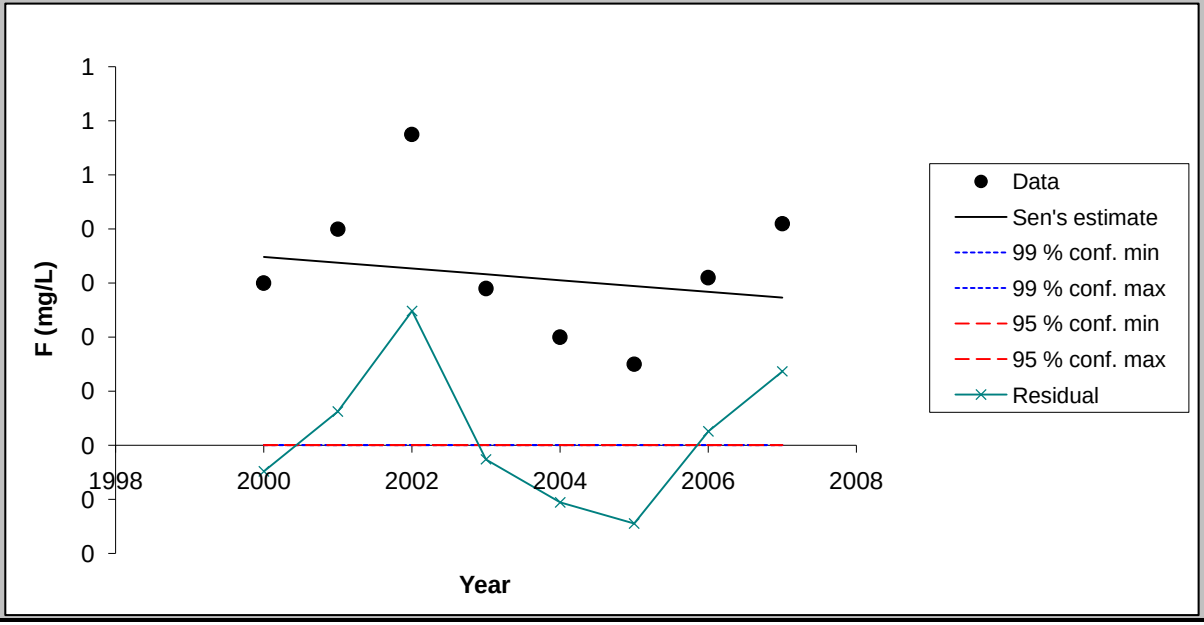

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.30	0.35	0.00	0.00	0.00	0.00	-0.05
2001	0.40	0.34	0.00	0.00	0.00	0.00	0.06
2002	0.57	0.33	0.00	0.00	0.00	0.00	0.25
2003	0.29	0.32	0.00	0.00	0.00	0.00	-0.03
2004	0.20	0.31	0.00	0.00	0.00	0.00	-0.11
2005	0.15	0.29	0.00	0.00	0.00	0.00	-0.14
2006	0.31	0.28	0.00	0.00	0.00	0.00	0.03
2007	0.41	0.27	0.00	0.00	0.00	0.00	0.14

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	5
Test Z	
Signific.	
Q	1.04E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.85E-04
Bmin99	
Bmax99	
Bmin95	
Bmax95	

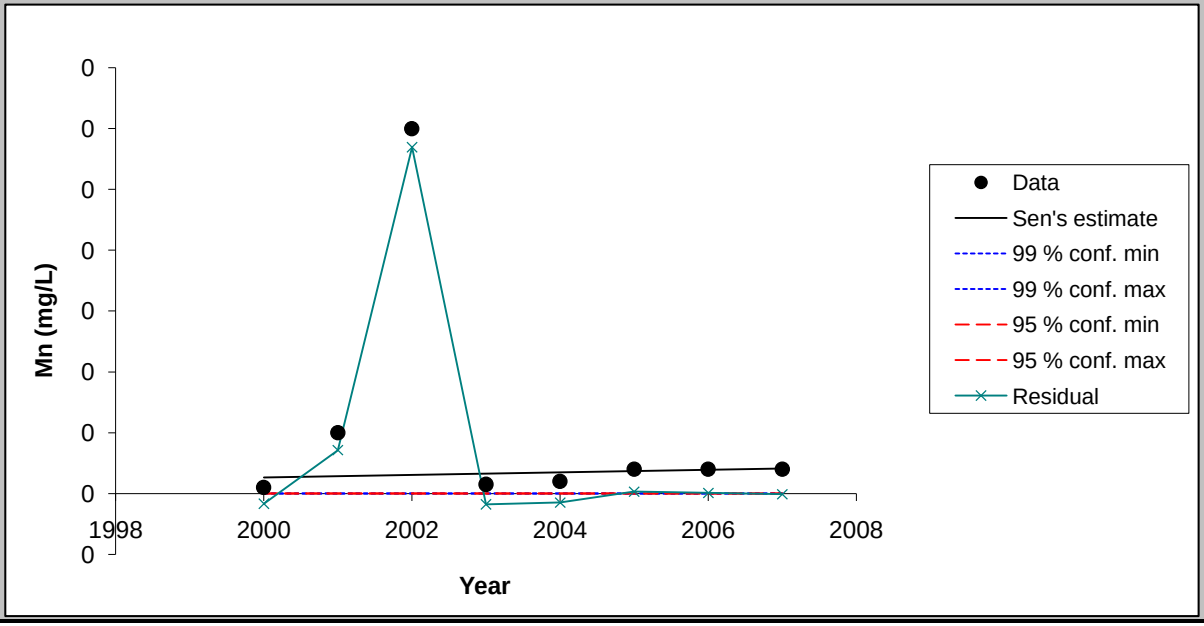

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-04 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	1.27E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.77E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

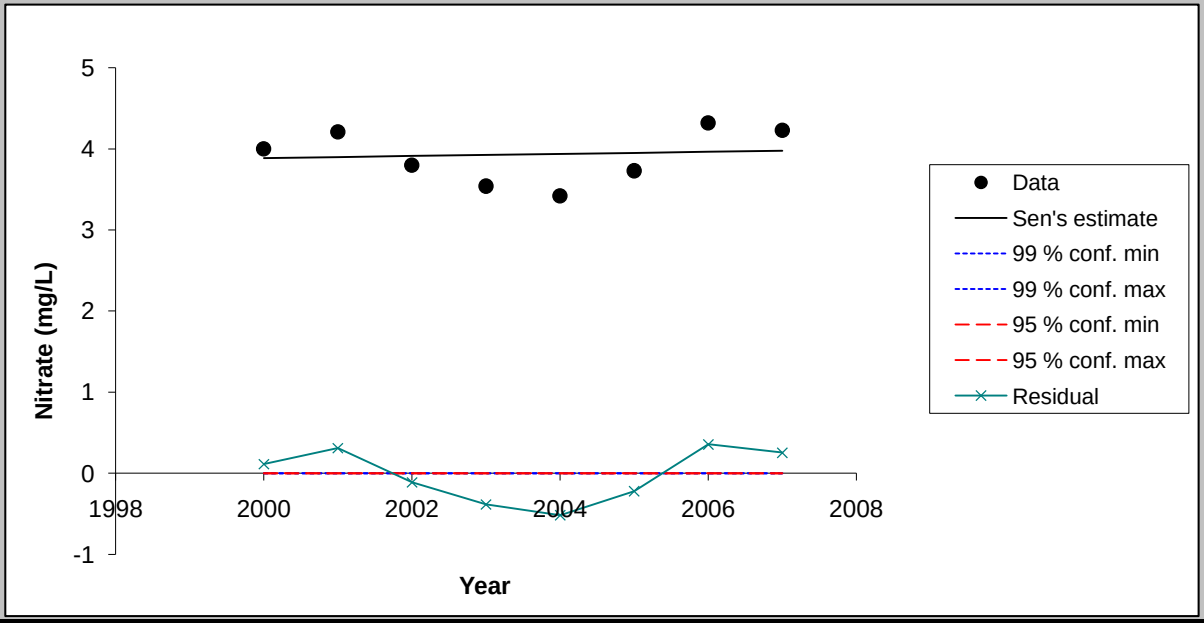

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.00	3.89	0.00	0.00	0.00	0.00	0.11
2001	4.21	3.90	0.00	0.00	0.00	0.00	0.31
2002	3.80	3.91	0.00	0.00	0.00	0.00	-0.11
2003	3.54	3.93	0.00	0.00	0.00	0.00	-0.39
2004	3.42	3.94	0.00	0.00	0.00	0.00	-0.52
2005	3.73	3.95	0.00	0.00	0.00	0.00	-0.22
2006	4.32	3.96	0.00	0.00	0.00	0.00	0.36
2007	4.23	3.98	0.00	0.00	0.00	0.00	0.25

FIGURE

< Previous Time Series | Next Time Series >

PW-04 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.79E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.80E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

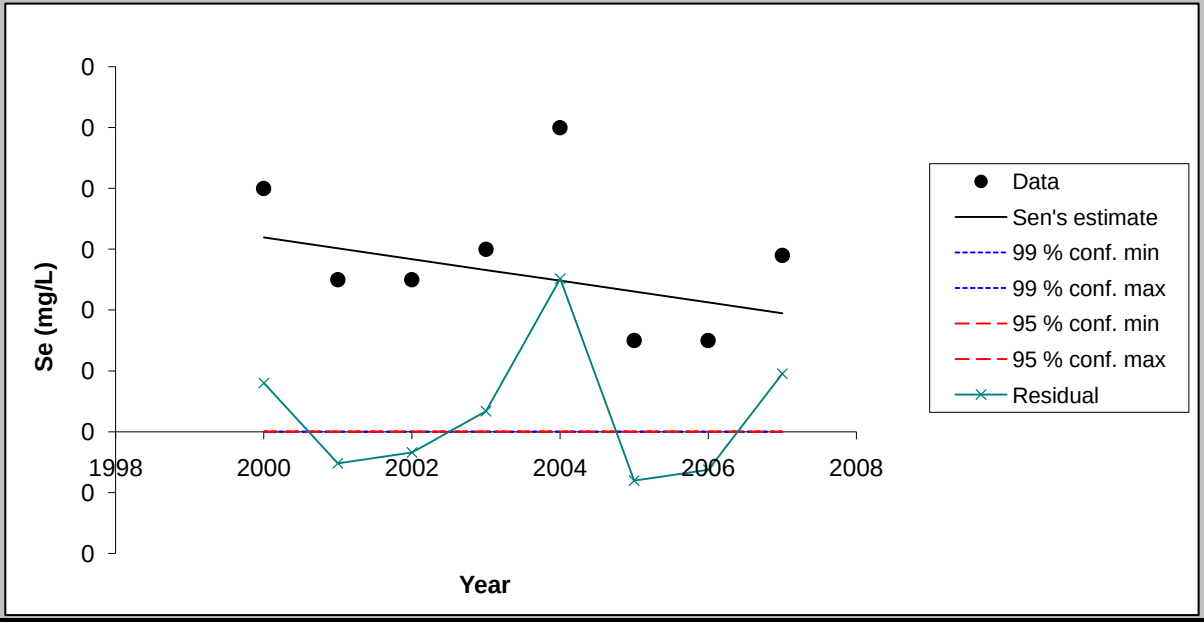

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

PW-04 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-4.00E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.00E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

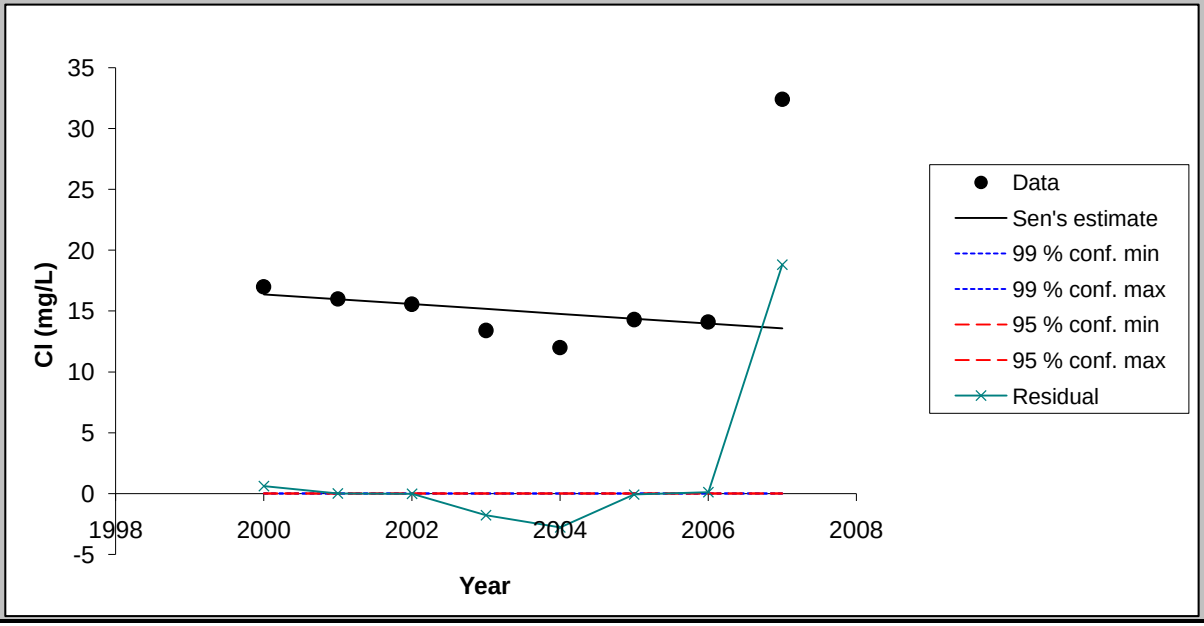

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	17.00	16.38	0.00	0.00	0.00	0.00	0.62
2001	16.00	15.98	0.00	0.00	0.00	0.00	0.02
2002	15.56	15.58	0.00	0.00	0.00	0.00	-0.02
2003	13.40	15.18	0.00	0.00	0.00	0.00	-1.78
2004	12.00	14.78	0.00	0.00	0.00	0.00	-2.78
2005	14.30	14.38	0.00	0.00	0.00	0.00	-0.08
2006	14.10	13.98	0.00	0.00	0.00	0.00	0.12
2007	32.40	13.58	0.00	0.00	0.00	0.00	18.82

FIGURE

< Previous Time Series | Next Time Series >

PW-04 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	6.75E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.94E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

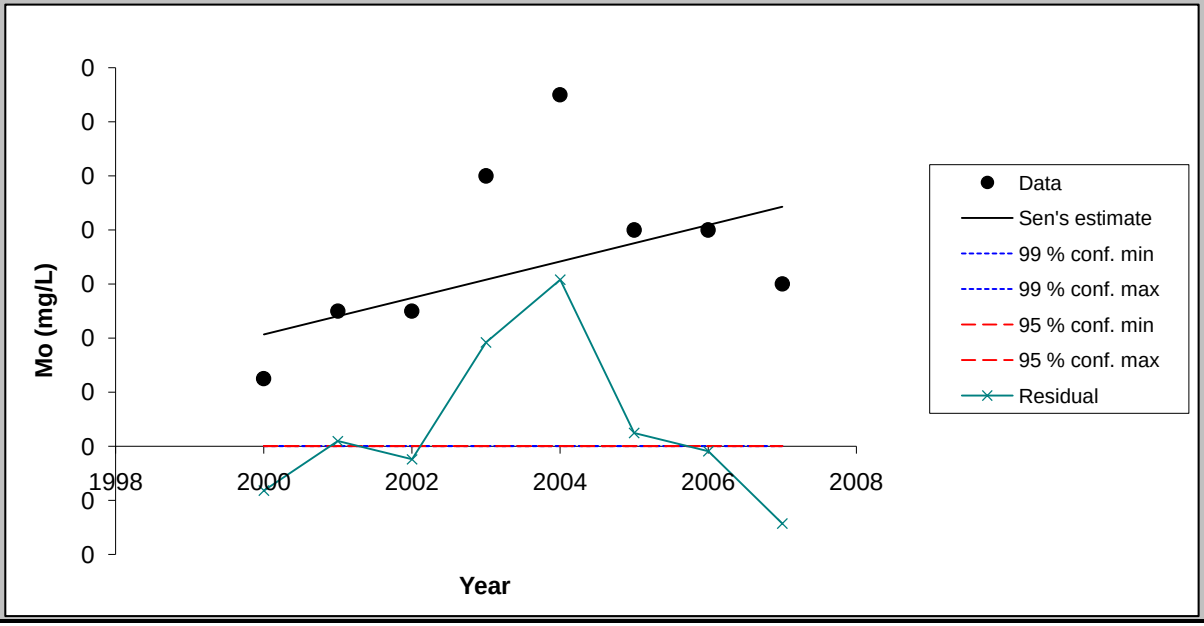

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

PW-04 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-2.73E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.11E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

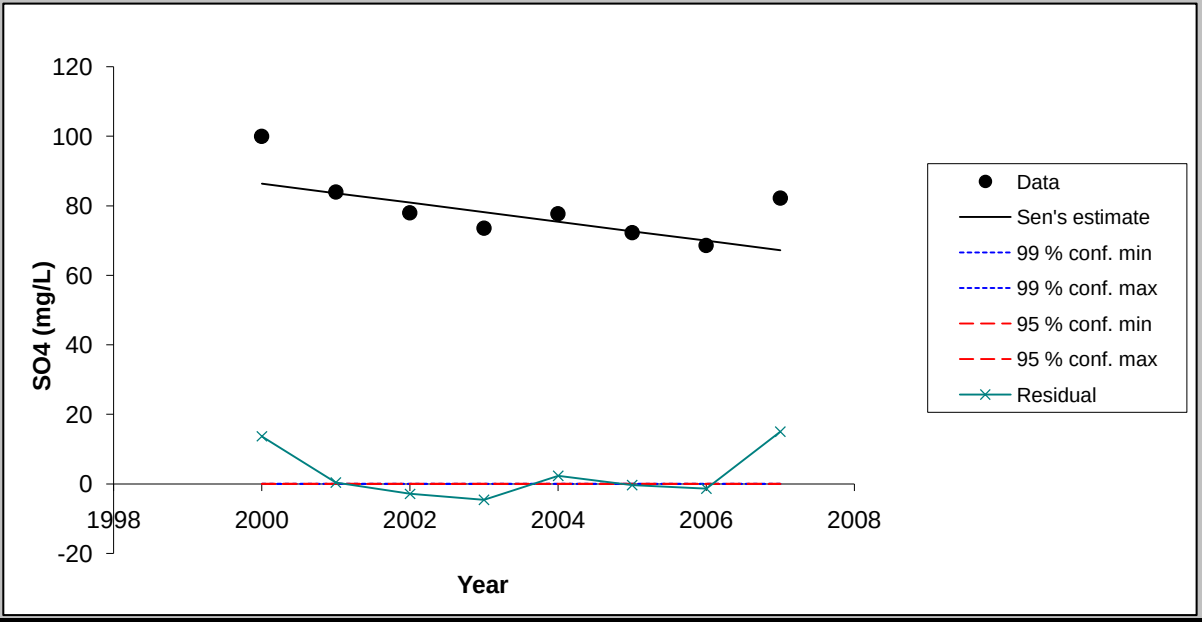

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	100.00	86.35	0.00	0.00	0.00	0.00	13.65
2001	84.00	83.62	0.00	0.00	0.00	0.00	0.38
2002	77.99	80.88	0.00	0.00	0.00	0.00	-2.89
2003	73.55	78.15	0.00	0.00	0.00	0.00	-4.60
2004	77.70	75.42	0.00	0.00	0.00	0.00	2.28
2005	72.30	72.68	0.00	0.00	0.00	0.00	-0.38
2006	68.60	69.95	0.00	0.00	0.00	0.00	-1.35
2007	82.20	67.21	0.00	0.00	0.00	0.00	14.99

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Effluent Discharge

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
2000	0.017	0.61	0.0005	4.3	0.026	310	0.016	130
2001	0.004667	0.666667	0.005	3.71	0.019	285	0.01	90.33333
2002	0.0079	0.744333	0.03	3.35	0.015333	365.4523	0.021867	91.63333
2003	0.0044	0.34	0.001	3.116667	0.010333	185	0.0401	91.63333
2004	0.006267	0.363333	0.001	3.28	0.017667	117.3333	0.0375	91.6
2005	0.0026	0.283	0.004	4.063333	0.024	93.86667	0.031367	103.3333
2006	0.0082	0.65	0.002	4.48	0.039667	210.3333	0.032667	110.6667
2007	0.011833	0.8	0.00035	4.05	0.012667	209.3333	0.0388	122.3333

TREND STATISTICS

Effluent Discharge

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*0*			0.000				
F (mg/L)	*2000*	*2007*	*8*	*2*			0.009				
Mn (mg/L)	*2000*	*2007*	*8*	*-6*			0.000				
Nitrate (mg/L)	*2000*	*2007*	*8*	*2*			0.043				
Se (mg/L)	*2000*	*2007*	*8*	*-2*			0.000				
Cl (mg/L)	*2000*	*2007*	*8*	*-12*			-24.233				
Mo (mg/L)	*2000*	*2007*	*8*	*14*			0.003				
SO4 (mg/L)	*2000*	*2007*	*8*	*9*			3.575				
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								
#N/A	*#N/A*	*#N/A*	*###*								

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	-2.92E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.17E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

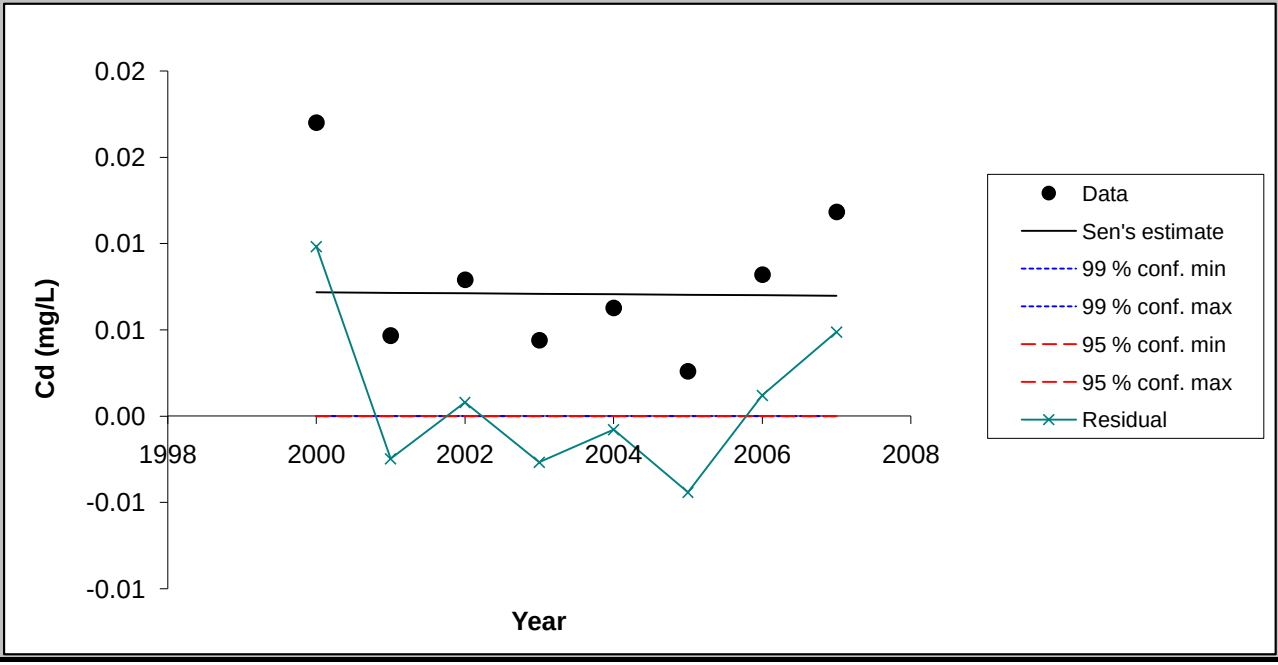

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2001	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	8.90E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.03E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

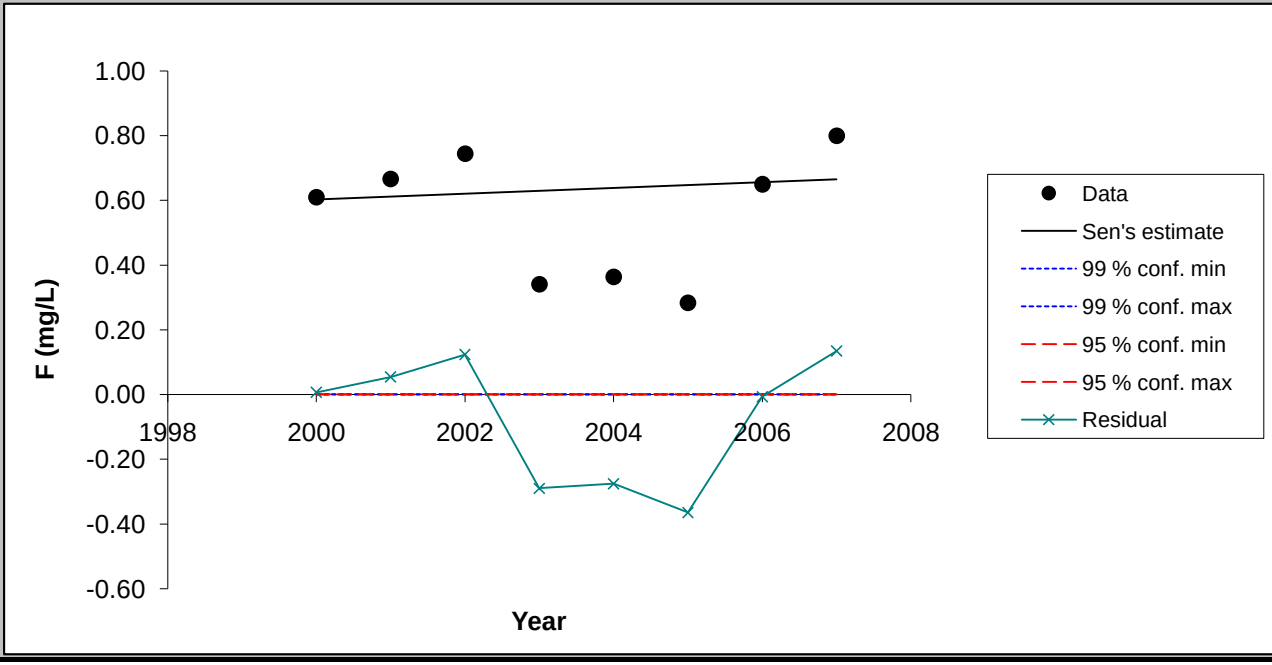

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.61	0.60	0.00	0.00	0.00	0.00	0.01
2001	0.67	0.61	0.00	0.00	0.00	0.00	0.05
2002	0.74	0.62	0.00	0.00	0.00	0.00	0.12
2003	0.34	0.63	0.00	0.00	0.00	0.00	-0.29
2004	0.36	0.64	0.00	0.00	0.00	0.00	-0.28
2005	0.28	0.65	0.00	0.00	0.00	0.00	-0.36
2006	0.65	0.66	0.00	0.00	0.00	0.00	-0.01
2007	0.80	0.67	0.00	0.00	0.00	0.00	0.13

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.90E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.45E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

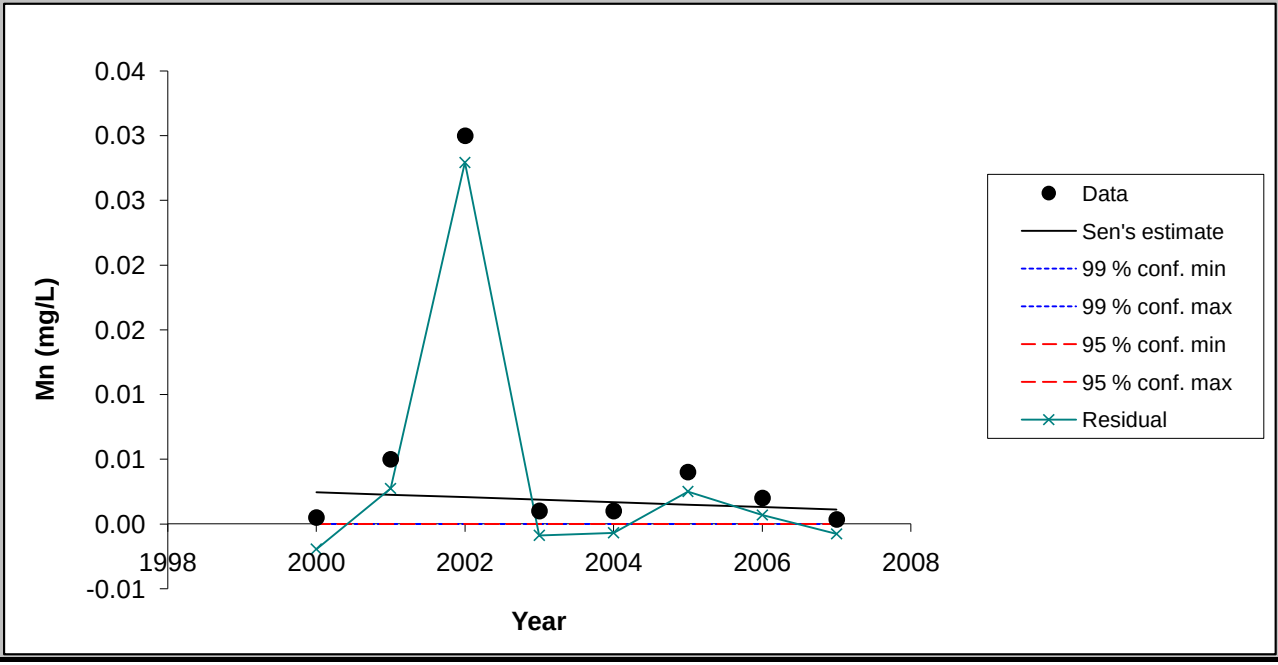

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	2
Test Z	
Signific.	
Q	4.33E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.71E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

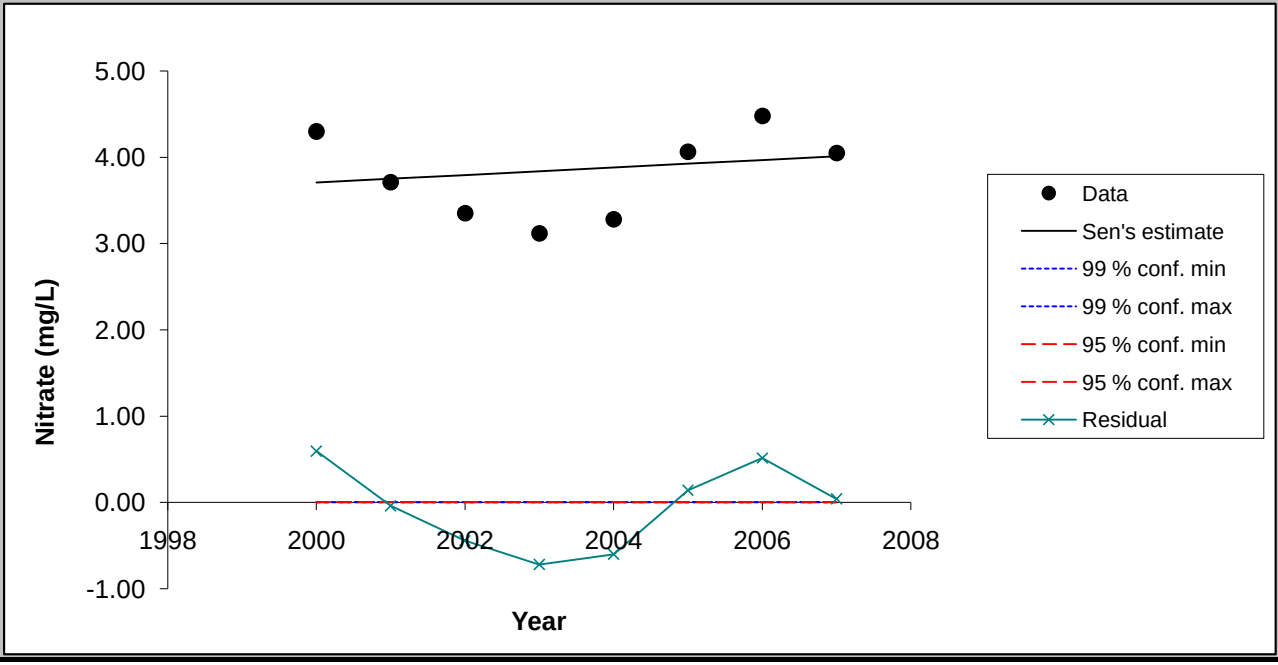

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.30	3.71	0.00	0.00	0.00	0.00	0.59
2001	3.71	3.75	0.00	0.00	0.00	0.00	-0.04
2002	3.35	3.79	0.00	0.00	0.00	0.00	-0.44
2003	3.12	3.84	0.00	0.00	0.00	0.00	-0.72
2004	3.28	3.88	0.00	0.00	0.00	0.00	-0.60
2005	4.06	3.92	0.00	0.00	0.00	0.00	0.14
2006	4.48	3.97	0.00	0.00	0.00	0.00	0.51
2007	4.05	4.01	0.00	0.00	0.00	0.00	0.04

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-4.22E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.94E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

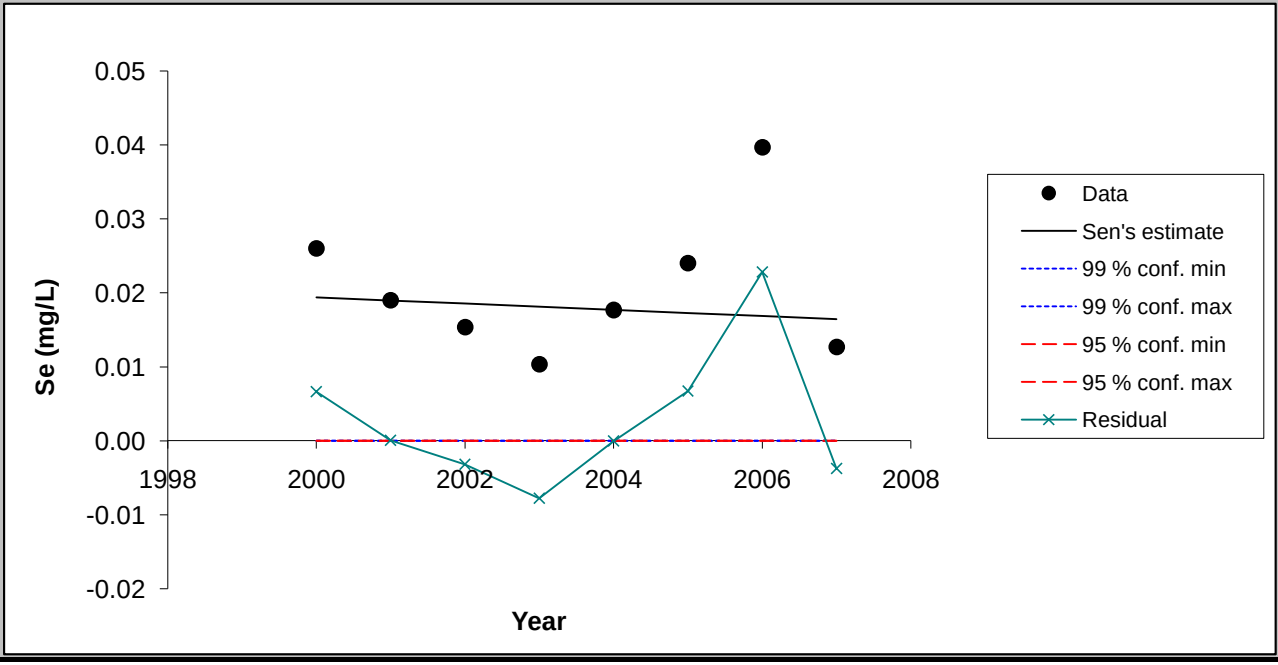

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.02	0.00	0.00	0.00	0.00	0.01
2001	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2005	0.02	0.02	0.00	0.00	0.00	0.00	0.01
2006	0.04	0.02	0.00	0.00	0.00	0.00	0.02
2007	0.01	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-2.42E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.10E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

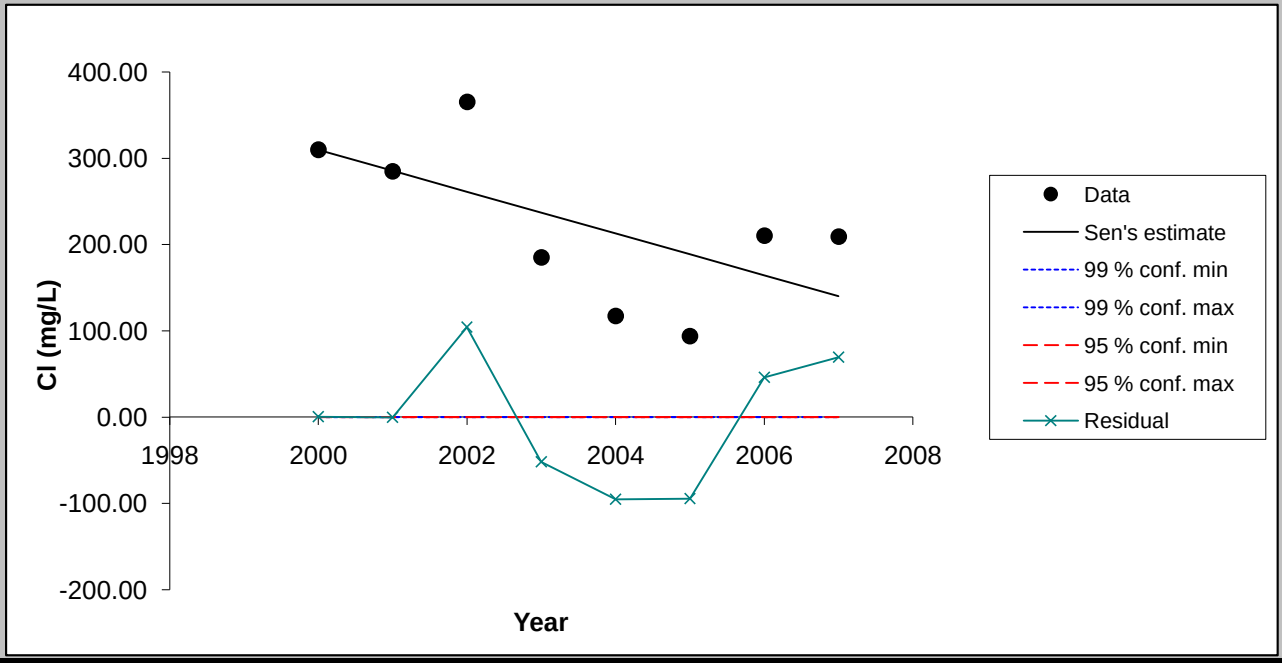

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	310.00	309.62	0.00	0.00	0.00	0.00	0.38
2001	285.00	285.38	0.00	0.00	0.00	0.00	-0.38
2002	365.45	261.15	0.00	0.00	0.00	0.00	104.30
2003	185.00	236.92	0.00	0.00	0.00	0.00	-51.92
2004	117.33	212.68	0.00	0.00	0.00	0.00	-95.35
2005	93.87	188.45	0.00	0.00	0.00	0.00	-94.58
2006	210.33	164.22	0.00	0.00	0.00	0.00	46.12
2007	209.33	139.98	0.00	0.00	0.00	0.00	69.35

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	3.21E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.57E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

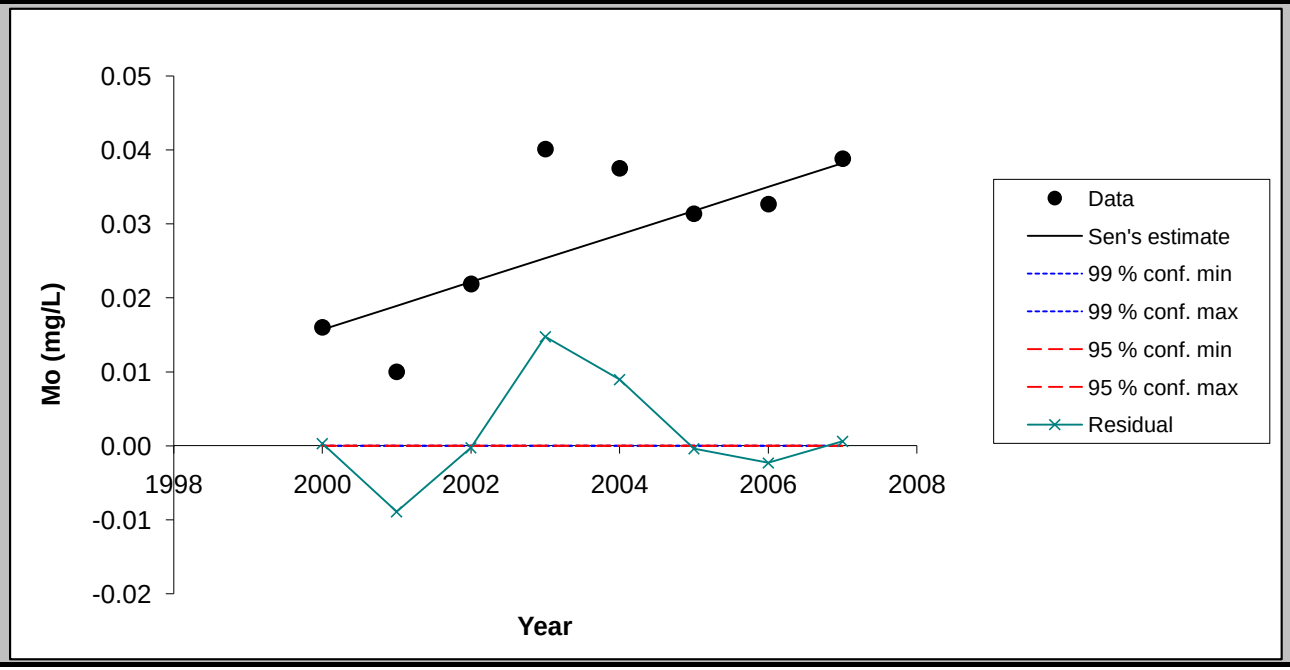

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.04	0.03	0.00	0.00	0.00	0.00	0.01
2004	0.04	0.03	0.00	0.00	0.00	0.00	0.01
2005	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2006	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2007	0.04	0.04	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Effluent Discharge

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	9
Test Z	
Signific.	
Q	3.57E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.61E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

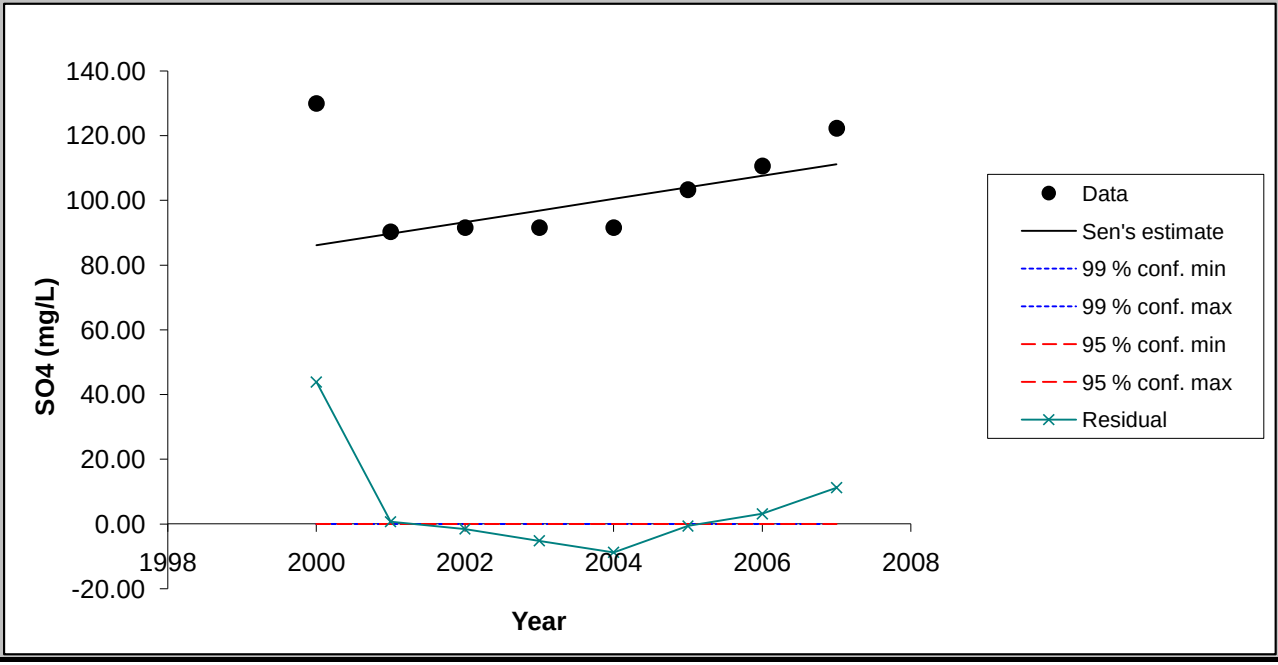

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2000

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	130.00	86.11	0.00	0.00	0.00	0.00	43.89
2001	90.33	89.68	0.00	0.00	0.00	0.00	0.65
2002	91.63	93.26	0.00	0.00	0.00	0.00	-1.62
2003	91.63	96.83	0.00	0.00	0.00	0.00	-5.20
2004	91.60	100.41	0.00	0.00	0.00	0.00	-8.81
2005	103.33	103.98	0.00	0.00	0.00	0.00	-0.65
2006	110.67	107.56	0.00	0.00	0.00	0.00	3.11
2007	122.33	111.13	0.00	0.00	0.00	0.00	11.20

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Mormon Creek

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	6	6	6	6	6	6	6	6
Select the FIRST YEAR of the calculation:	2002	2002	2002	2002	2002	2002	2002	2002
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
2002	0.0023	1.958	0.03	2.85	0.0707	310.276	0.0357	236.587
2003	0.001	1.59	0.0089	2.69	0.129	261	0.0499	232
2004	0.0034	1	0.024	1.48	0.124	358	0.03	147
2005	0.002	1.62	0.0284	5.41	0.151	230	0.0343	268
2006	0.001	1.83	0.0097	4.49	0.177	194	0.033	302
2007	0.0036	2.86	0.0195	4.54	0.106	171	0.0623	490

TREND STATISTICS

Mormon Creek

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*2002*	*2007*	*6*	*1*			0.000				
F (mg/L)	*2002*	*2007*	*6*	*5*			0.180				
Mn (mg/L)	*2002*	*2007*	*6*	*-3*			-0.002				
Nitrate (mg/L)	*2002*	*2007*	*6*	*5*			0.410				
Se (mg/L)	*2002*	*2007*	*6*	*5*			0.016				
Cl (mg/L)	*2002*	*2007*	*6*	*-11*		*	-27.855				
Mo (mg/L)	*2002*	*2007*	*6*	*1*			0.002				
SO4 (mg/L)	*2002*	*2007*	*6*	*9*			34.000				
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
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0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	1
Name	Cd (mg/L)
Years	2002 - 2007
n	6
Test S	1
Test Z	
Signific.	
Q	6.67E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.05E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

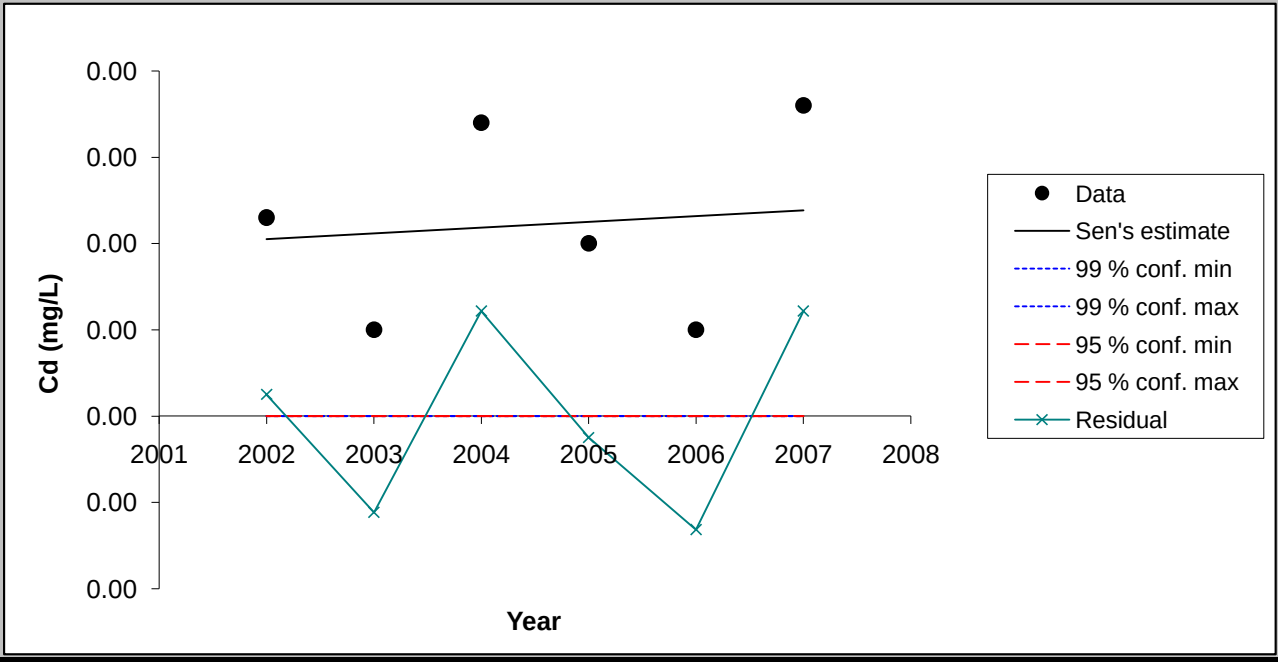

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	2
Name	F (mg/L)
Years	2002 - 2007
n	6
Test S	5
Test Z	
Signific.	
Q	1.80E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.26E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

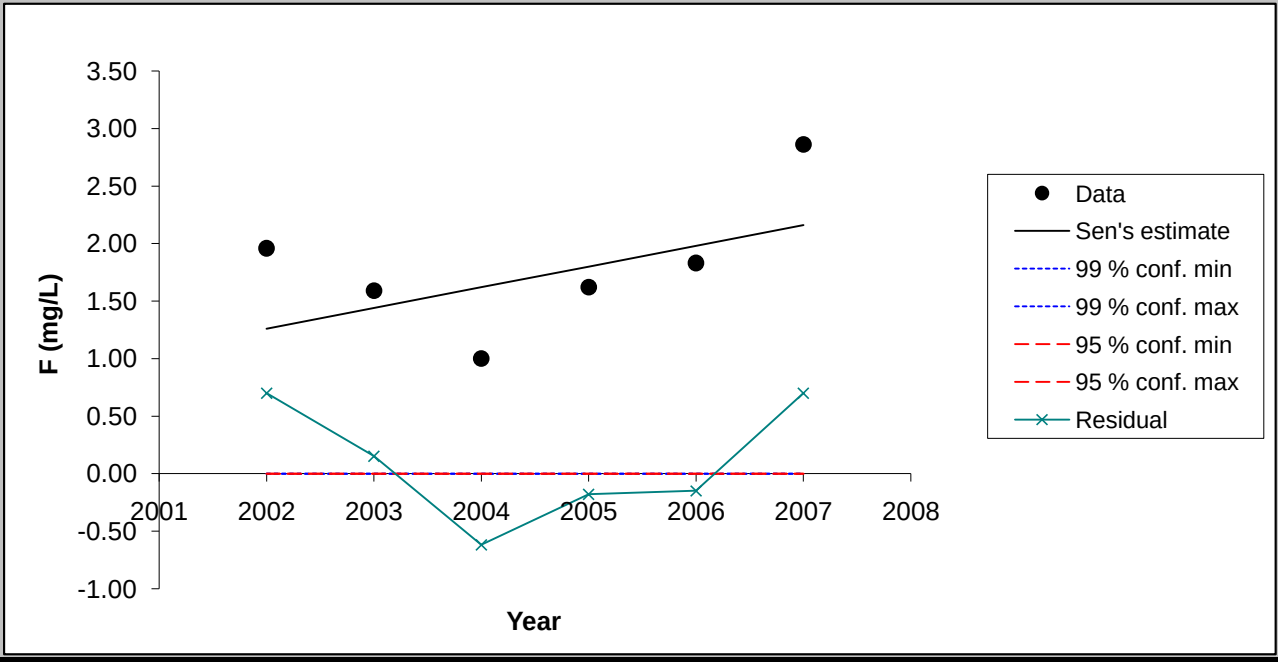

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	1.96	1.26	0.00	0.00	0.00	0.00	0.70
2003	1.59	1.44	0.00	0.00	0.00	0.00	0.15
2004	1.00	1.62	0.00	0.00	0.00	0.00	-0.62
2005	1.62	1.80	0.00	0.00	0.00	0.00	-0.18
2006	1.83	1.98	0.00	0.00	0.00	0.00	-0.15
2007	2.86	2.16	0.00	0.00	0.00	0.00	0.70

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	3
Name	Mn (mg/L)
Years	2002 - 2007
n	6
Test S	-3
Test Z	
Signific.	
Q	-1.50E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.70E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

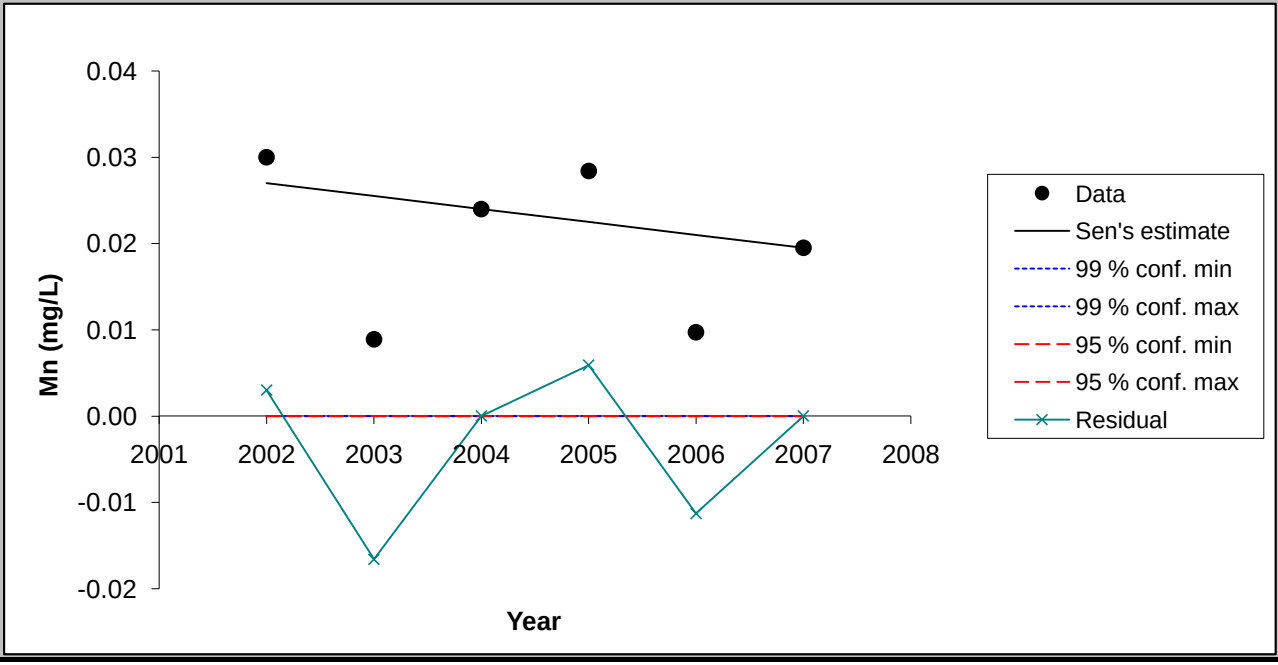

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.03	0.00	0.00	0.00	0.00	-0.02
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2005	0.03	0.02	0.00	0.00	0.00	0.00	0.01
2006	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2007	0.02	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	5
Name	Se (mg/L)
Years	2002 - 2007
n	6
Test S	5
Test Z	
Signific.	
Q	1.60E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.75E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

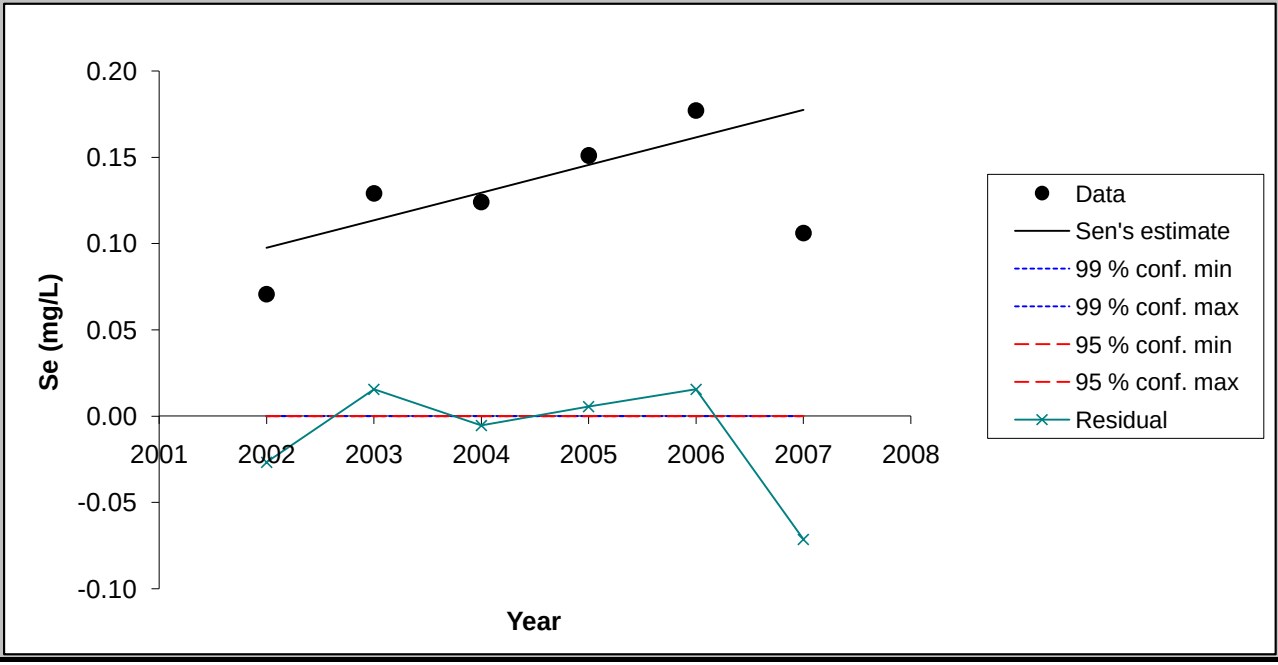

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	0.07	0.10	0.00	0.00	0.00	0.00	-0.03
2003	0.13	0.11	0.00	0.00	0.00	0.00	0.02
2004	0.12	0.13	0.00	0.00	0.00	0.00	-0.01
2005	0.15	0.15	0.00	0.00	0.00	0.00	0.01
2006	0.18	0.16	0.00	0.00	0.00	0.00	0.02
2007	0.11	0.18	0.00	0.00	0.00	0.00	-0.07

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	6
Name	Cl (mg/L)
Years	2002 - 2007
n	6
Test S	-11
Test Z	
Signific.	*
Q	-2.79E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.10E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

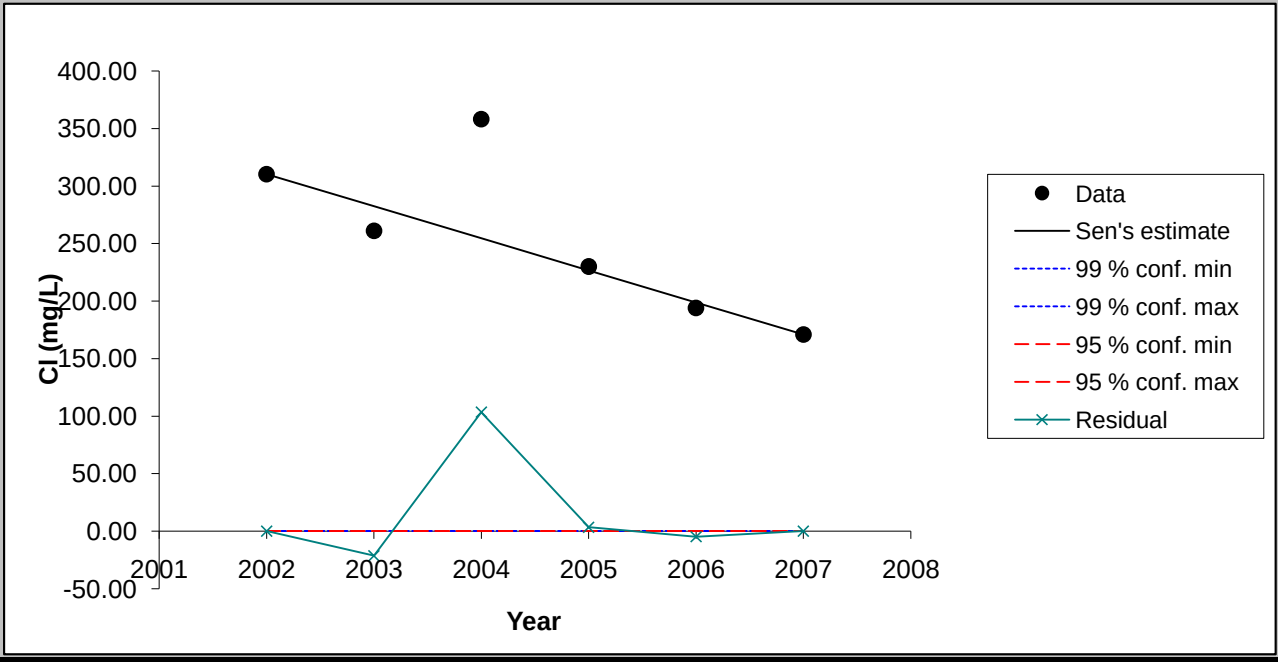

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	310.28	310.28	0.00	0.00	0.00	0.00	0.00
2003	261.00	282.42	0.00	0.00	0.00	0.00	-21.42
2004	358.00	254.57	0.00	0.00	0.00	0.00	103.43
2005	230.00	226.71	0.00	0.00	0.00	0.00	3.29
2006	194.00	198.86	0.00	0.00	0.00	0.00	-4.86
2007	171.00	171.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	7
Name	Mo (mg/L)
Years	2002 - 2007
n	6
Test S	1
Test Z	
Signific.	
Q	1.50E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.28E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

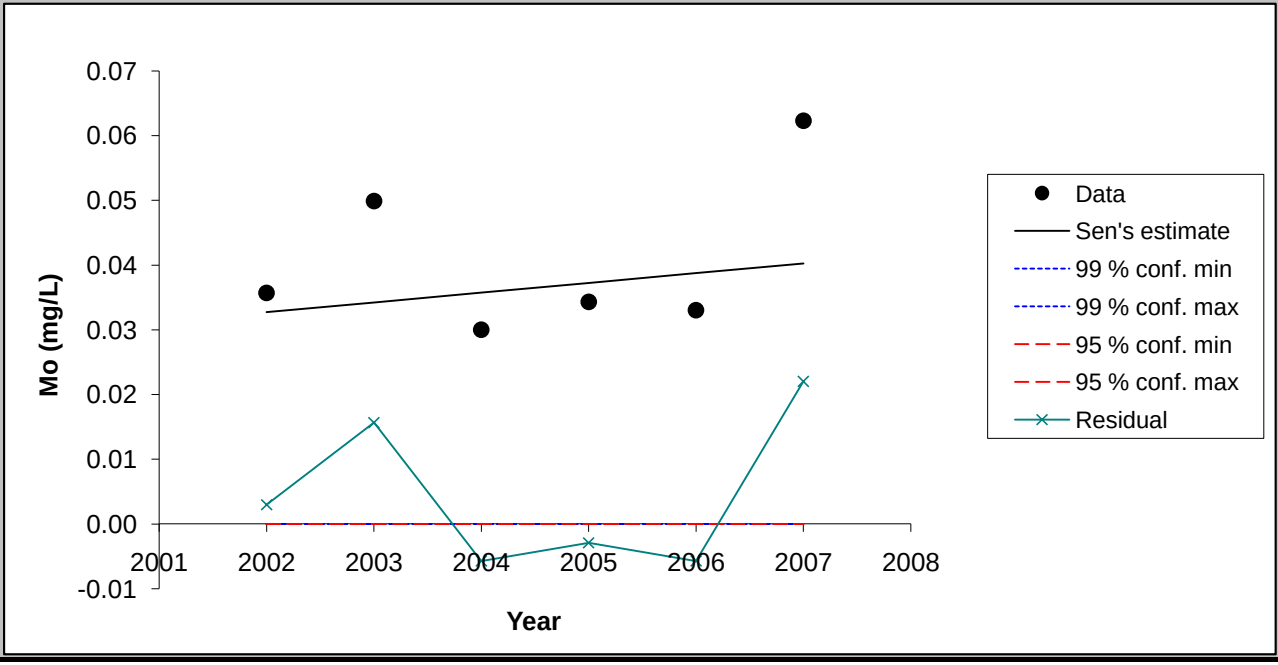

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	0.04	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.05	0.03	0.00	0.00	0.00	0.00	0.02
2004	0.03	0.04	0.00	0.00	0.00	0.00	-0.01
2005	0.03	0.04	0.00	0.00	0.00	0.00	0.00
2006	0.03	0.04	0.00	0.00	0.00	0.00	-0.01
2007	0.06	0.04	0.00	0.00	0.00	0.00	0.02

FIGURE

< Previous Time Series | Next Time Series >

Mormon Creek

TsNumber	8
Name	SO4 (mg/L)
Years	2002 - 2007
n	6
Test S	9
Test Z	
Signific.	
Q	3.40E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.82E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

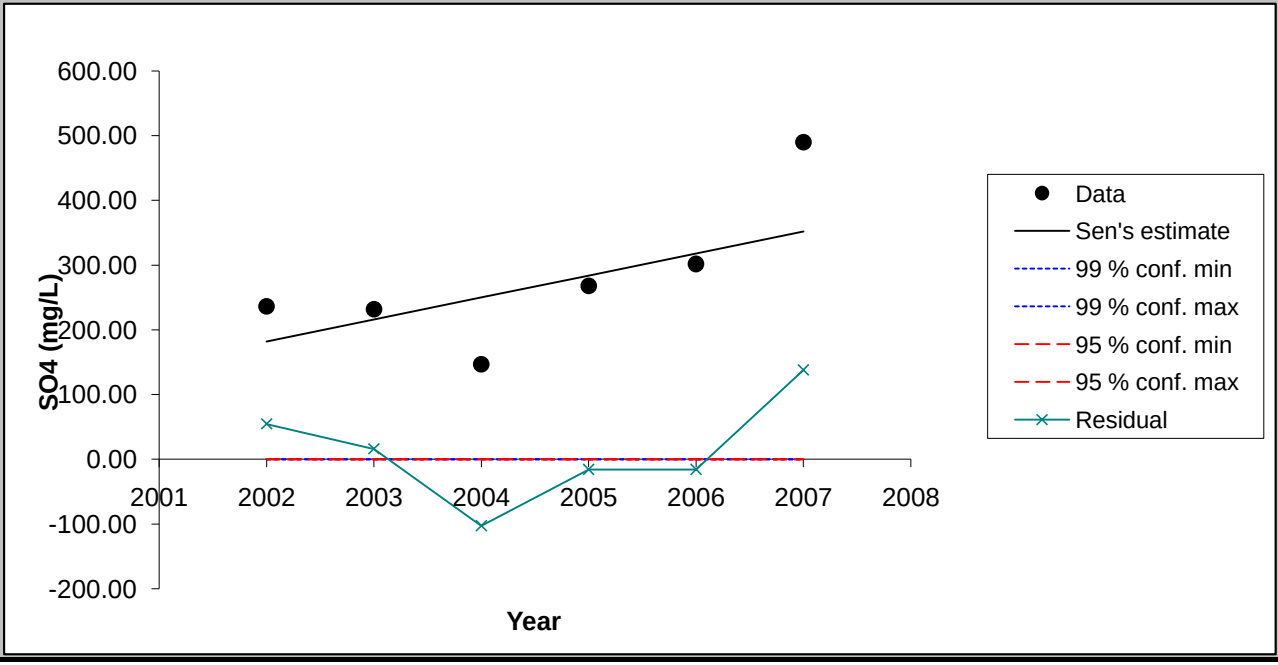

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2002

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2002	236.59	182.00	0.00	0.00	0.00	0.00	54.59
2003	232.00	216.00	0.00	0.00	0.00	0.00	16.00
2004	147.00	250.00	0.00	0.00	0.00	0.00	-103.00
2005	268.00	284.00	0.00	0.00	0.00	0.00	-16.00
2006	302.00	318.00	0.00	0.00	0.00	0.00	-16.00
2007	490.00	352.00	0.00	0.00	0.00	0.00	138.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

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ANNUAL DATA

Soda Down

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	7	7	7	7	7	7	7	7
Select the FIRST YEAR of the calculation:	2001	2001	2001	2001	2001	2001	2001	2001
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
2001	0.001	1.1	0.09	1.58	0.032	46	0.005	87
2002	0.001	0.992	0.0863	1.33	0.03	47.165	0.019	78.256
2003	0.001	0.65	0.0809	0.36	0.019	44.5	0.0325	76.9
2004	0.001	0.47	0.102	0.42	0.04	55.4	0.0198	69.8
2005	0.002	0.418	0.106	0.7	0.026	38.4	0.0123	70.3
2006	0.001	0.7	0.0661	0.76	0.035	34	0.013	80.3
2007	0.0003	0.71	0.114	0.993	0.0112	43.3	0.0294	116

TREND STATISTICS

Soda Down

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*2001*	*2007*	*7*	*-9*			0.000				
F (mg/L)	*2001*	*2007*	*7*	*-7*			-0.073				
Mn (mg/L)	*2001*	*2007*	*7*	*5*			0.004				
Nitrate (mg/L)	*2001*	*2007*	*7*	*-1*			-0.067				
Se (mg/L)	*2001*	*2007*	*7*	*-5*			-0.002				
Cl (mg/L)	*2001*	*2007*	*7*	*-9*			-1.900				
Mo (mg/L)	*2001*	*2007*	*7*	*5*			0.002				
SO4 (mg/L)	*2001*	*2007*	*7*	*1*			0.500				
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
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0	*0*	*0*	*0*								
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0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	1
Name	Cd (mg/L)
Years	2001 - 2007
n	7
Test S	-9
Test Z	
Signific.	
Q	-1.58E-11
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

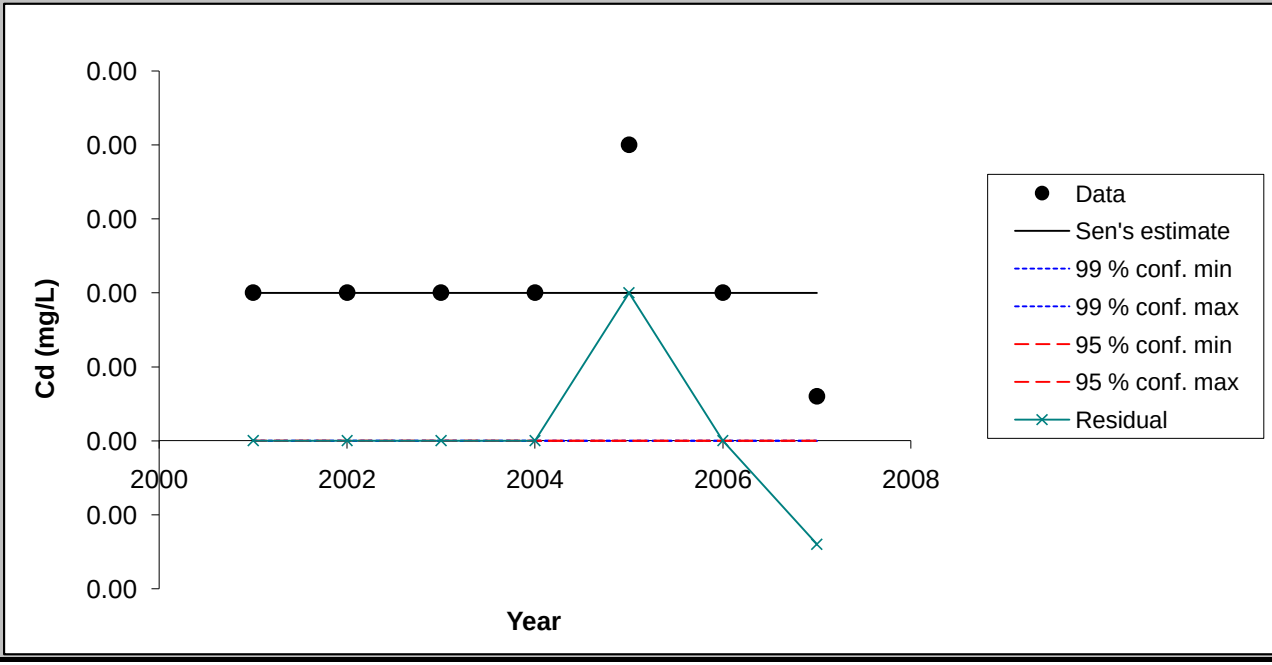

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	2
Name	F (mg/L)
Years	2001 - 2007
n	7
Test S	-7
Test Z	
Signific.	
Q	-7.30E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.06E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

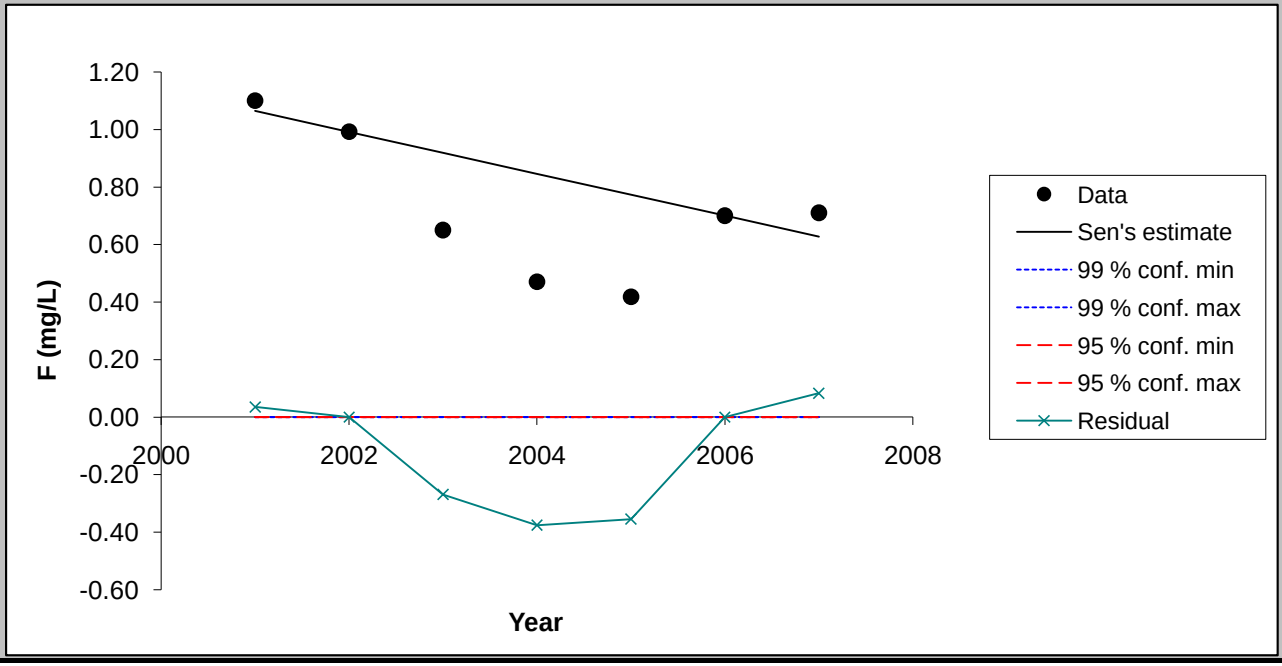

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	1.10	1.06	0.00	0.00	0.00	0.00	0.04
2002	0.99	0.99	0.00	0.00	0.00	0.00	0.00
2003	0.65	0.92	0.00	0.00	0.00	0.00	-0.27
2004	0.47	0.85	0.00	0.00	0.00	0.00	-0.38
2005	0.42	0.77	0.00	0.00	0.00	0.00	-0.35
2006	0.70	0.70	0.00	0.00	0.00	0.00	0.00
2007	0.71	0.63	0.00	0.00	0.00	0.00	0.08

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	3
Name	Mn (mg/L)
Years	2001 - 2007
n	7
Test S	5
Test Z	
Signific.	
Q	4.00E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.00E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

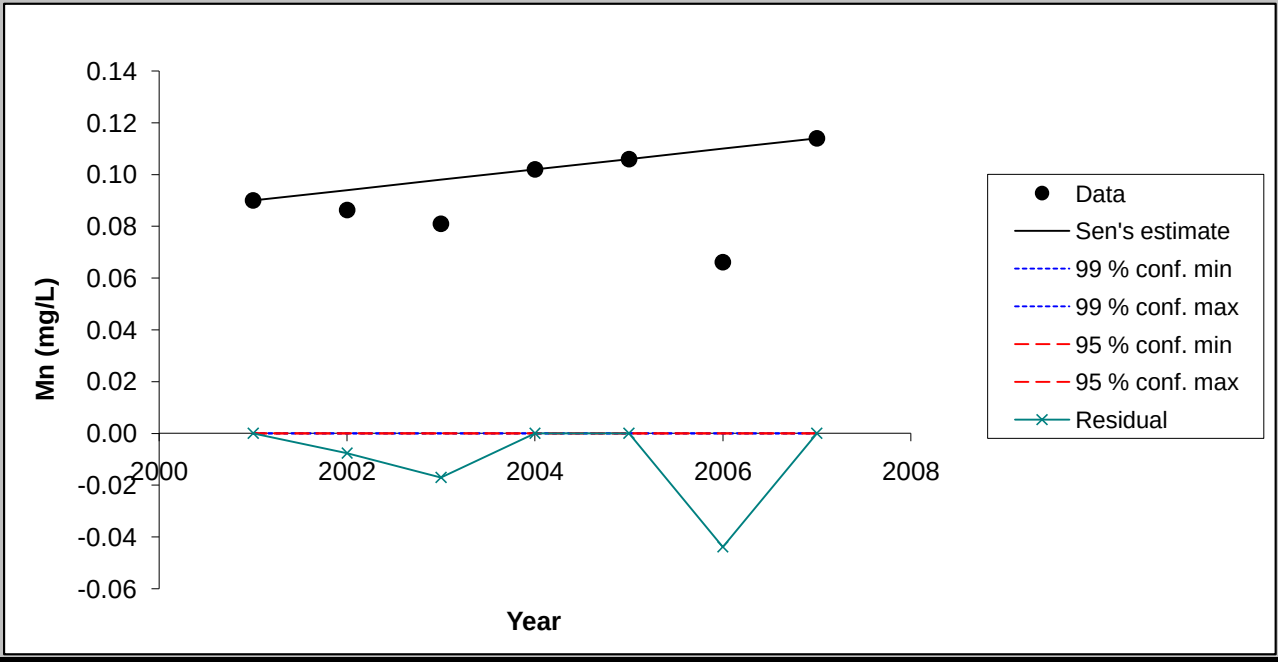

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.09	0.09	0.00	0.00	0.00	0.00	0.00
2002	0.09	0.09	0.00	0.00	0.00	0.00	-0.01
2003	0.08	0.10	0.00	0.00	0.00	0.00	-0.02
2004	0.10	0.10	0.00	0.00	0.00	0.00	0.00
2005	0.11	0.11	0.00	0.00	0.00	0.00	0.00
2006	0.07	0.11	0.00	0.00	0.00	0.00	-0.04
2007	0.11	0.11	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	4
Name	Nitrate (mg/L)
Years	2001 - 2007
n	7
Test S	-1
Test Z	
Signific.	
Q	-6.74E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.10E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

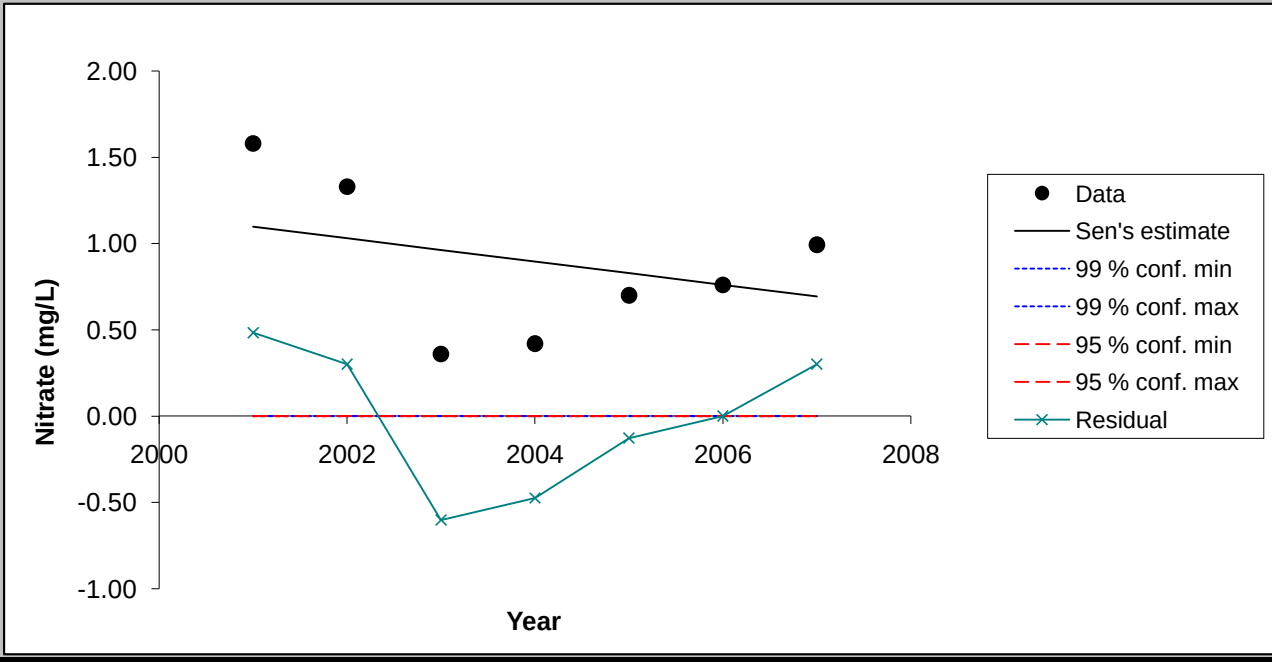

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	1.58	1.10	0.00	0.00	0.00	0.00	0.48
2002	1.33	1.03	0.00	0.00	0.00	0.00	0.30
2003	0.36	0.96	0.00	0.00	0.00	0.00	-0.60
2004	0.42	0.89	0.00	0.00	0.00	0.00	-0.47
2005	0.70	0.83	0.00	0.00	0.00	0.00	-0.13
2006	0.76	0.76	0.00	0.00	0.00	0.00	0.00
2007	0.99	0.69	0.00	0.00	0.00	0.00	0.30

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	5
Name	Se (mg/L)
Years	2001 - 2007
n	7
Test S	-5
Test Z	
Signific.	
Q	-1.95E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.20E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

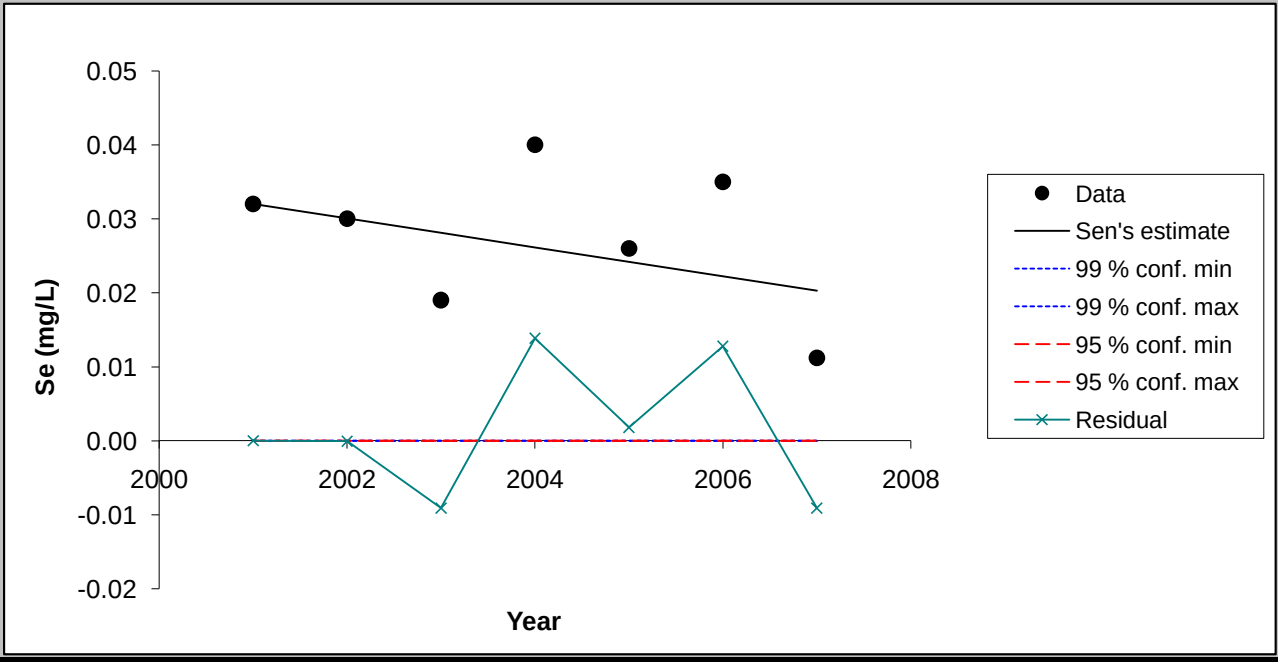

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2004	0.04	0.03	0.00	0.00	0.00	0.00	0.01
2005	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2006	0.04	0.02	0.00	0.00	0.00	0.00	0.01
2007	0.01	0.02	0.00	0.00	0.00	0.00	-0.01

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	6
Name	Cl (mg/L)
Years	2001 - 2007
n	7
Test S	-9
Test Z	
Signific.	
Q	-1.90E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.83E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

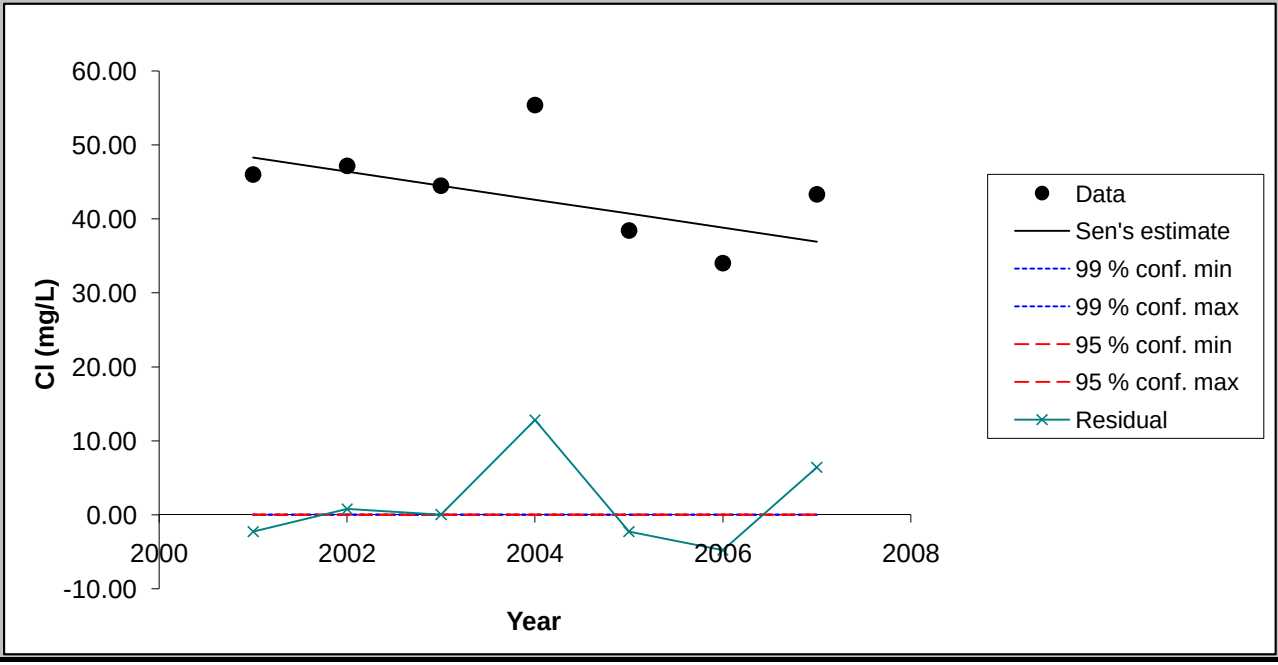

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	46.00	48.30	0.00	0.00	0.00	0.00	-2.30
2002	47.17	46.40	0.00	0.00	0.00	0.00	0.77
2003	44.50	44.50	0.00	0.00	0.00	0.00	0.00
2004	55.40	42.60	0.00	0.00	0.00	0.00	12.80
2005	38.40	40.70	0.00	0.00	0.00	0.00	-2.30
2006	34.00	38.80	0.00	0.00	0.00	0.00	-4.80
2007	43.30	36.90	0.00	0.00	0.00	0.00	6.40

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	7
Name	Mo (mg/L)
Years	2001 - 2007
n	7
Test S	5
Test Z	
Signific.	
Q	1.60E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.50E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

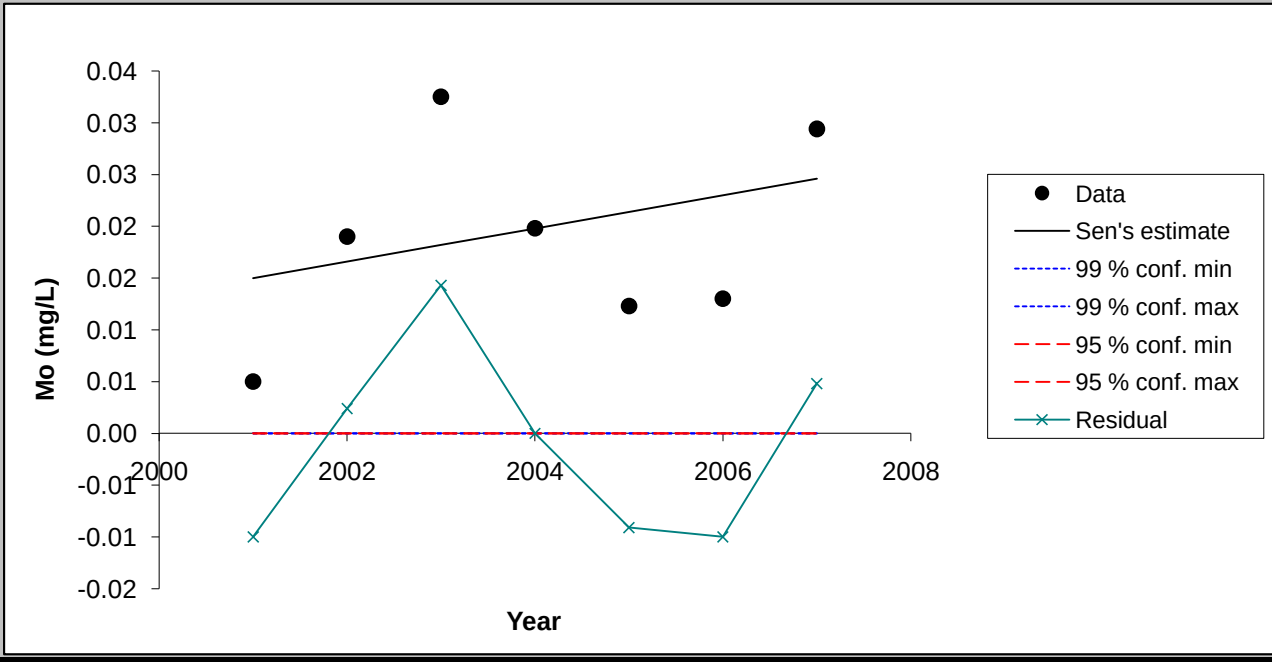

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.03	0.02	0.00	0.00	0.00	0.00	0.01
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2006	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2007	0.03	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Down

TsNumber	8
Name	SO4 (mg/L)
Years	2001 - 2007
n	7
Test S	1
Test Z	
Signific.	
Q	5.00E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.78E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

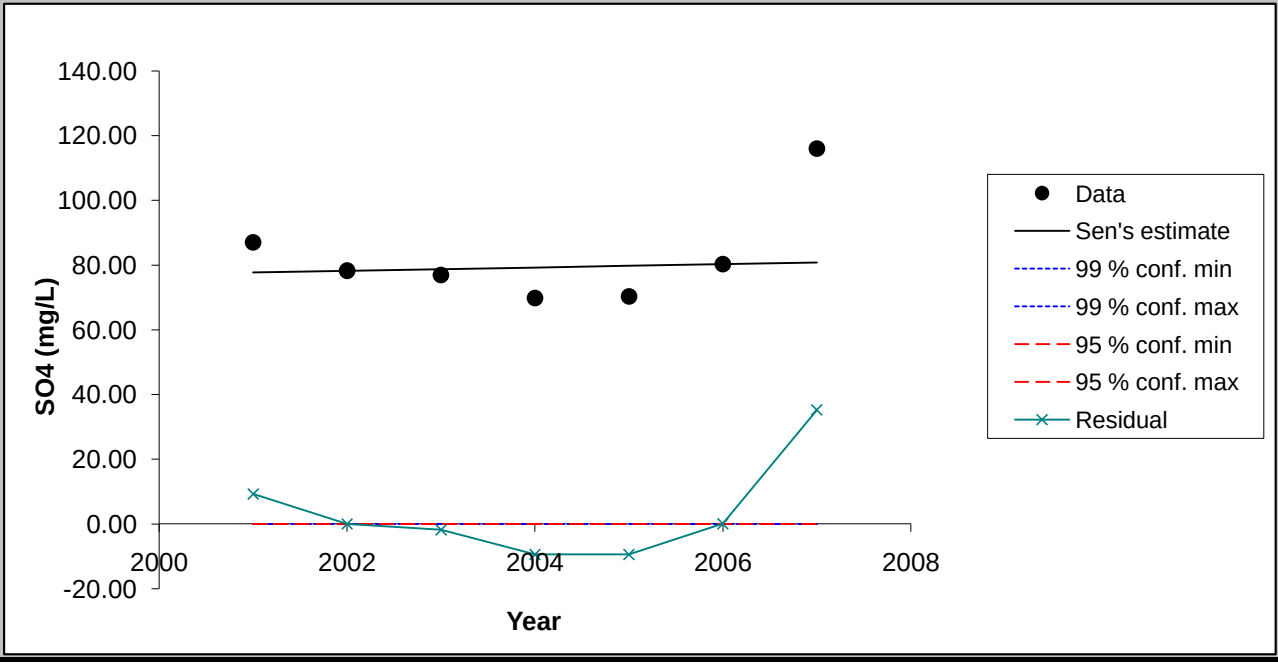

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	87.00	77.76	0.00	0.00	0.00	0.00	9.24
2002	78.26	78.26	0.00	0.00	0.00	0.00	0.00
2003	76.90	78.76	0.00	0.00	0.00	0.00	-1.86
2004	69.80	79.26	0.00	0.00	0.00	0.00	-9.46
2005	70.30	79.76	0.00	0.00	0.00	0.00	-9.46
2006	80.30	80.26	0.00	0.00	0.00	0.00	0.04
2007	116.00	80.76	0.00	0.00	0.00	0.00	35.24

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Soda Up

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	7	7	7	7	7	7	7	7
Select the FIRST YEAR of the calculation:	2001	2001	2001	2001	2001	2001	2001	2001
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
2001	0.001	0.6	0.1	1.14	0.0025	14	0.005	41
2002	0.003	0.674	0.07	1.37	0.0025	13.667	0.005	43.337
2003	0.001	0.3	0.0715	0.37	0.005	10.4	0.019	36.4
2004	0.001	0.28	0.0677	0.09	0.0015	10.2	0.0084	38.4
2005	0.002	0.257	0.0789	0.26	0.003	9.79	0.008	37.3
2006	0.001	0.44	0.112	0.47	0.0015	10.5	0.004	37
2007	0.0003	0.51	0.125	0.304	0.00042	10.1	0.0126	36.5

TREND STATISTICS

Soda Up

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*2001*	*2007*	*7*	*-11*			0.000				
F (mg/L)	*2001*	*2007*	*7*	*-5*			-0.022				
Mn (mg/L)	*2001*	*2007*	*7*	*9*			0.004				
Nitrate (mg/L)	*2001*	*2007*	*7*	*-7*			-0.139				
Se (mg/L)	*2001*	*2007*	*7*	*-9*			0.000				
Cl (mg/L)	*2001*	*2007*	*7*	*-13*		+	-0.410				
Mo (mg/L)	*2001*	*2007*	*7*	*2*			0.001				
SO4 (mg/L)	*2001*	*2007*	*7*	*-11*			-0.750				
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	1
Name	Cd (mg/L)
Years	2001 - 2007
n	7
Test S	-11
Test Z	
Signific.	
Q	-1.17E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.35E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

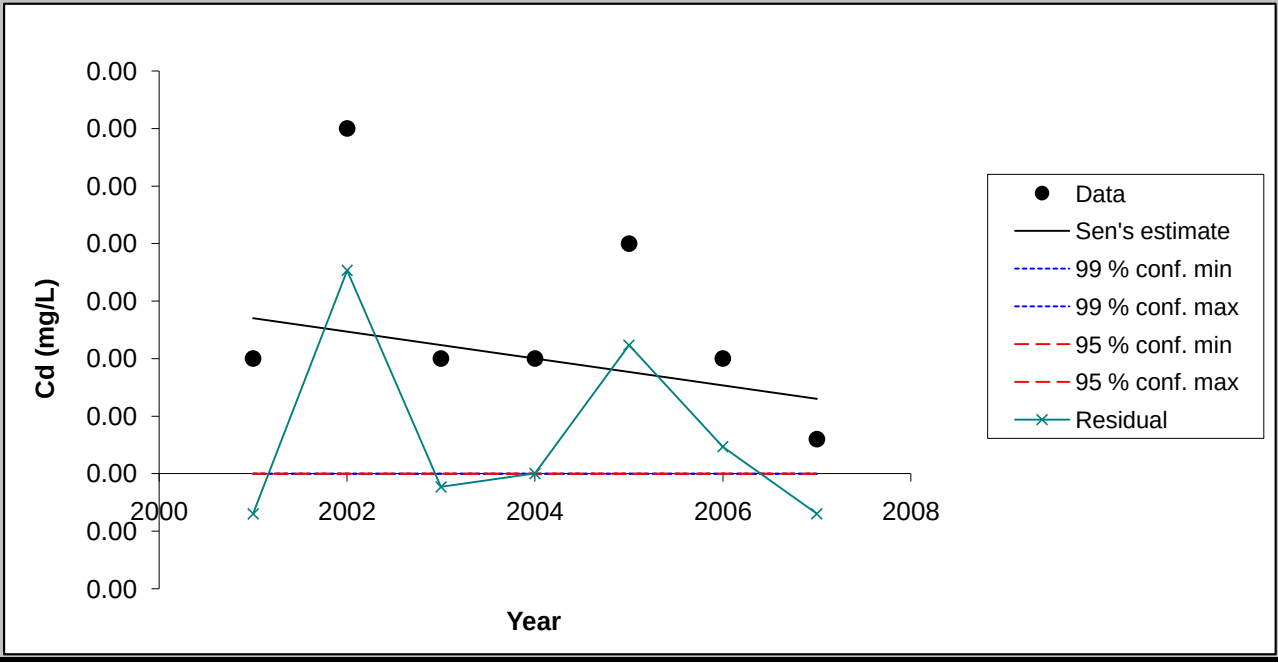

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	2
Name	F (mg/L)
Years	2001 - 2007
n	7
Test S	-5
Test Z	
Signific.	
Q	-2.15E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.48E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

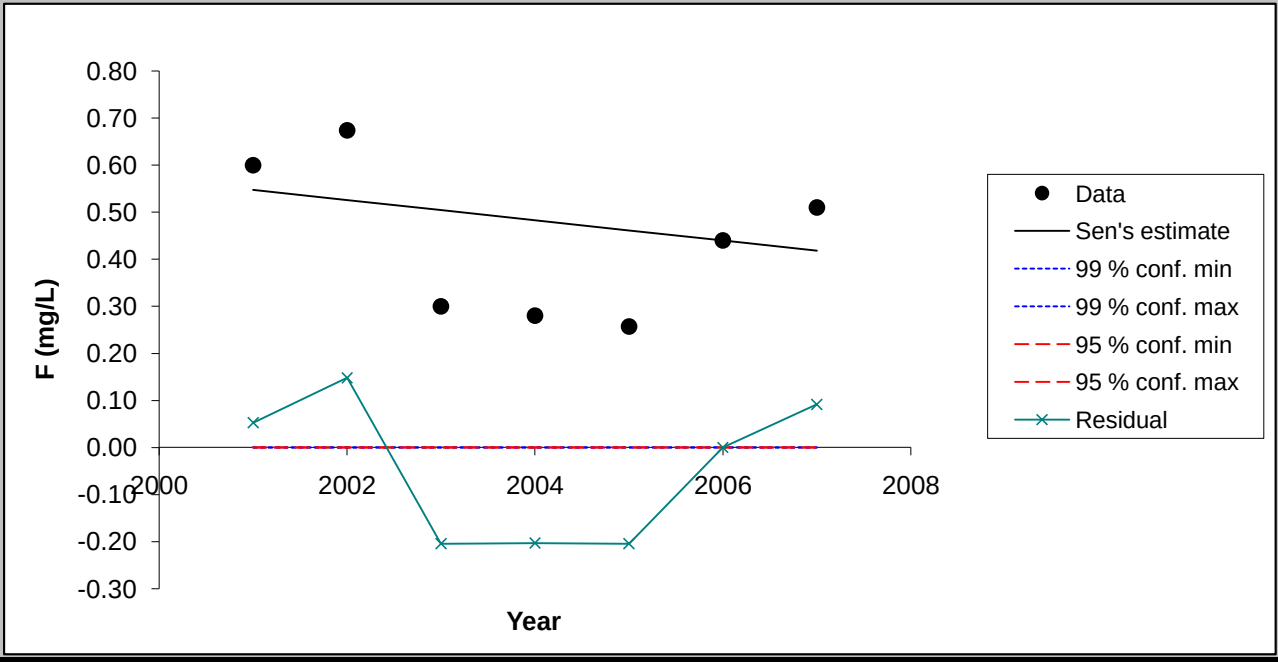

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.60	0.55	0.00	0.00	0.00	0.00	0.05
2002	0.67	0.53	0.00	0.00	0.00	0.00	0.15
2003	0.30	0.50	0.00	0.00	0.00	0.00	-0.20
2004	0.28	0.48	0.00	0.00	0.00	0.00	-0.20
2005	0.26	0.46	0.00	0.00	0.00	0.00	-0.20
2006	0.44	0.44	0.00	0.00	0.00	0.00	0.00
2007	0.51	0.42	0.00	0.00	0.00	0.00	0.09

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	3
Name	Mn (mg/L)
Years	2001 - 2007
n	7
Test S	9
Test Z	
Signific.	
Q	4.17E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.58E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

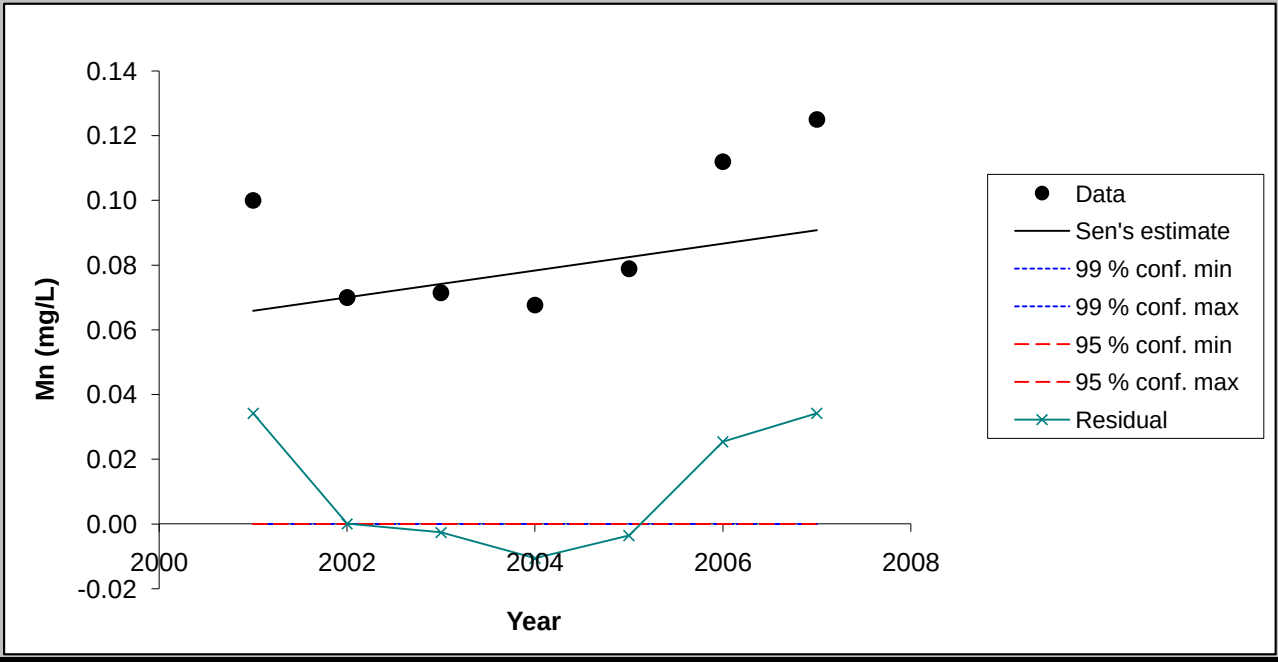

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.10	0.07	0.00	0.00	0.00	0.00	0.03
2002	0.07	0.07	0.00	0.00	0.00	0.00	0.00
2003	0.07	0.07	0.00	0.00	0.00	0.00	0.00
2004	0.07	0.08	0.00	0.00	0.00	0.00	-0.01
2005	0.08	0.08	0.00	0.00	0.00	0.00	0.00
2006	0.11	0.09	0.00	0.00	0.00	0.00	0.03
2007	0.13	0.09	0.00	0.00	0.00	0.00	0.03

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	4
Name	Nitrate (mg/L)
Years	2001 - 2007
n	7
Test S	-7
Test Z	
Signific.	
Q	-1.39E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.14E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

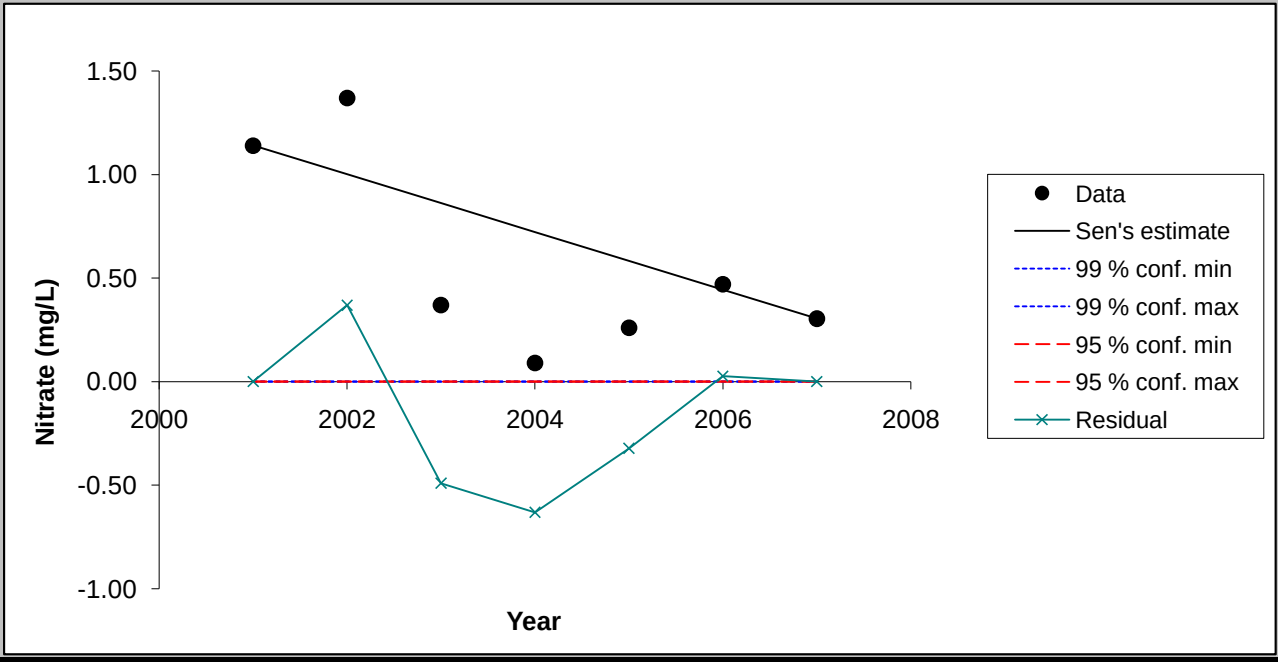

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	1.14	1.14	0.00	0.00	0.00	0.00	0.00
2002	1.37	1.00	0.00	0.00	0.00	0.00	0.37
2003	0.37	0.86	0.00	0.00	0.00	0.00	-0.49
2004	0.09	0.72	0.00	0.00	0.00	0.00	-0.63
2005	0.26	0.58	0.00	0.00	0.00	0.00	-0.32
2006	0.47	0.44	0.00	0.00	0.00	0.00	0.03
2007	0.30	0.30	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Soda Up

TsNumber	5
Name	Se (mg/L)
Years	2001 - 2007
n	7
Test S	-9
Test Z	
Signific.	
Q	-3.47E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.85E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

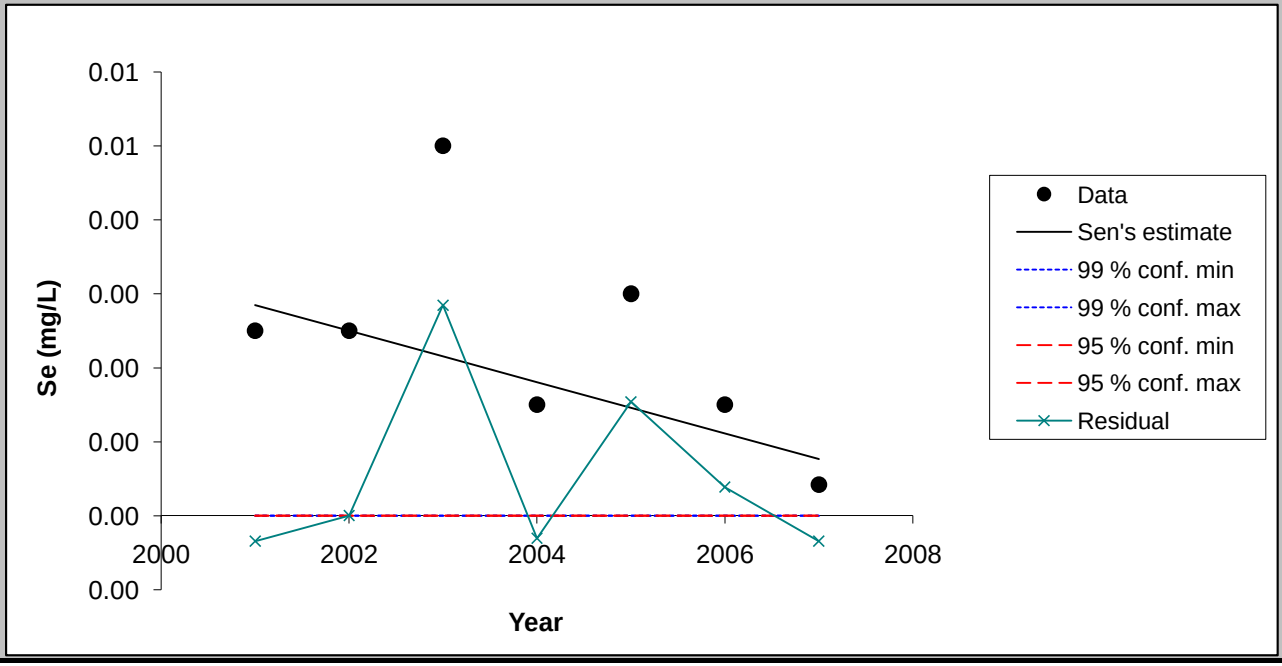

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	6
Name	Cl (mg/L)
Years	2001 - 2007
n	7
Test S	-13
Test Z	
Signific.	+
Q	-4.10E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.26E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

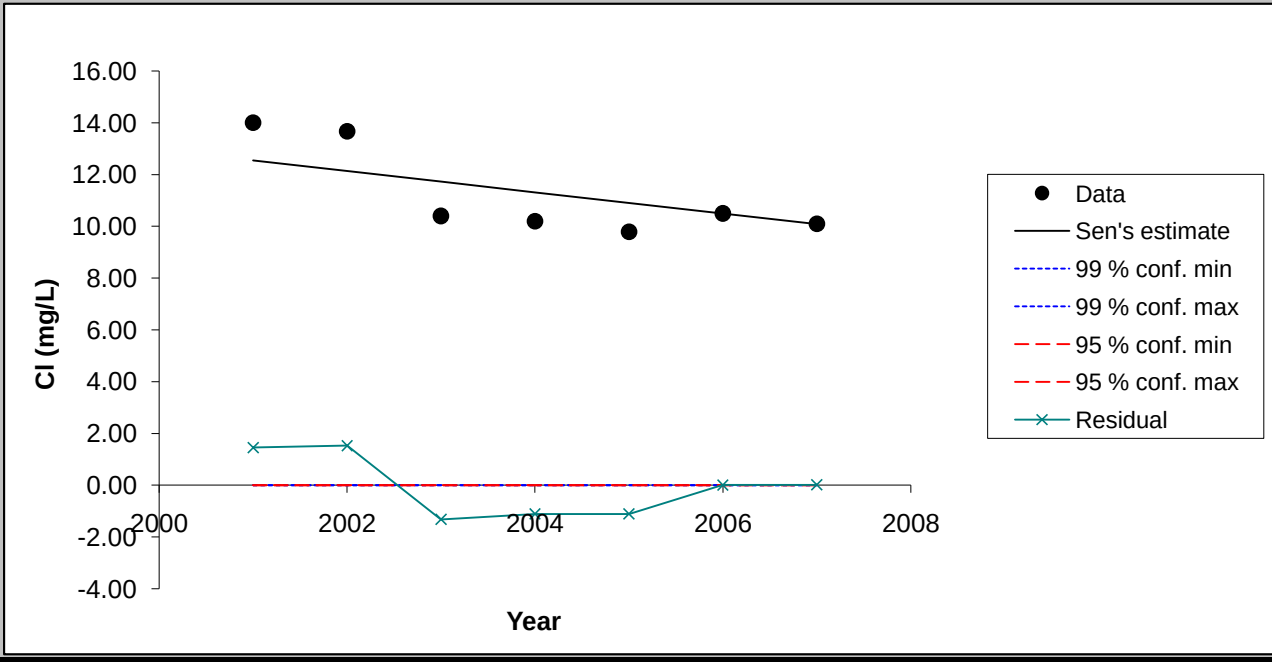

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	14.00	12.55	0.00	0.00	0.00	0.00	1.45
2002	13.67	12.14	0.00	0.00	0.00	0.00	1.53
2003	10.40	11.73	0.00	0.00	0.00	0.00	-1.33
2004	10.20	11.32	0.00	0.00	0.00	0.00	-1.12
2005	9.79	10.91	0.00	0.00	0.00	0.00	-1.12
2006	10.50	10.50	0.00	0.00	0.00	0.00	0.00
2007	10.10	10.09	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	7
Name	Mo (mg/L)
Years	2001 - 2007
n	7
Test S	2
Test Z	
Signific.	
Q	7.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

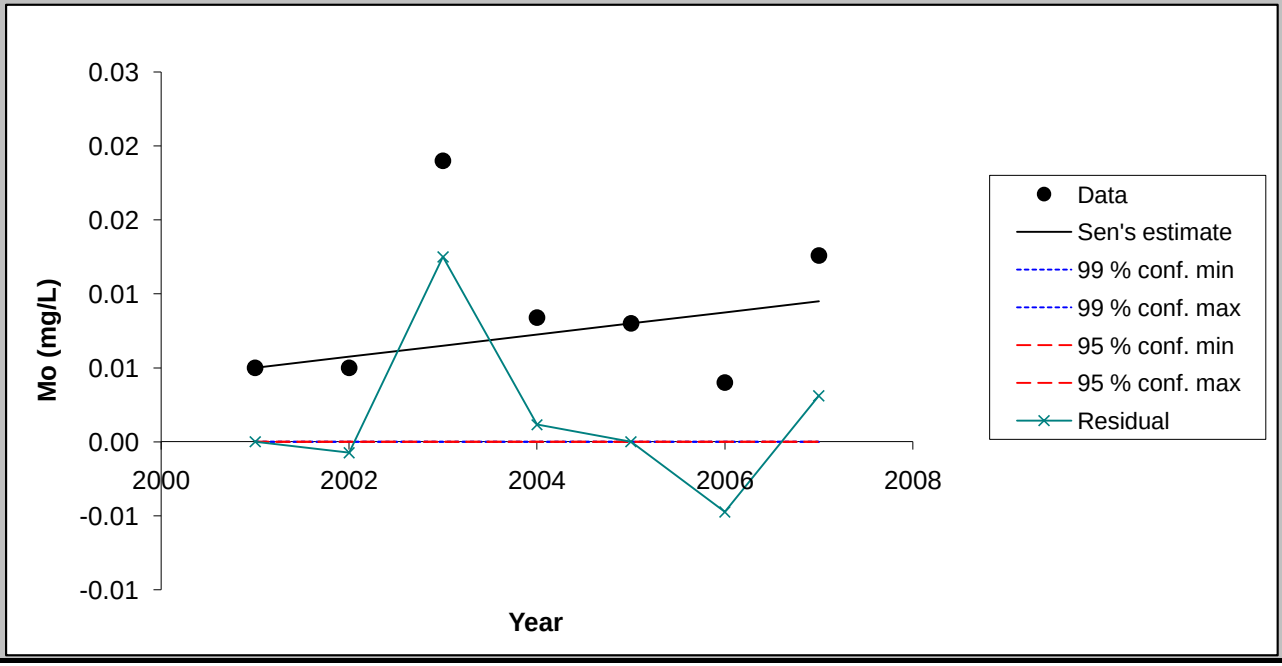

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

Soda Up

TsNumber	8
Name	SO4 (mg/L)
Years	2001 - 2007
n	7
Test S	-11
Test Z	
Signific.	
Q	-7.50E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.08E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

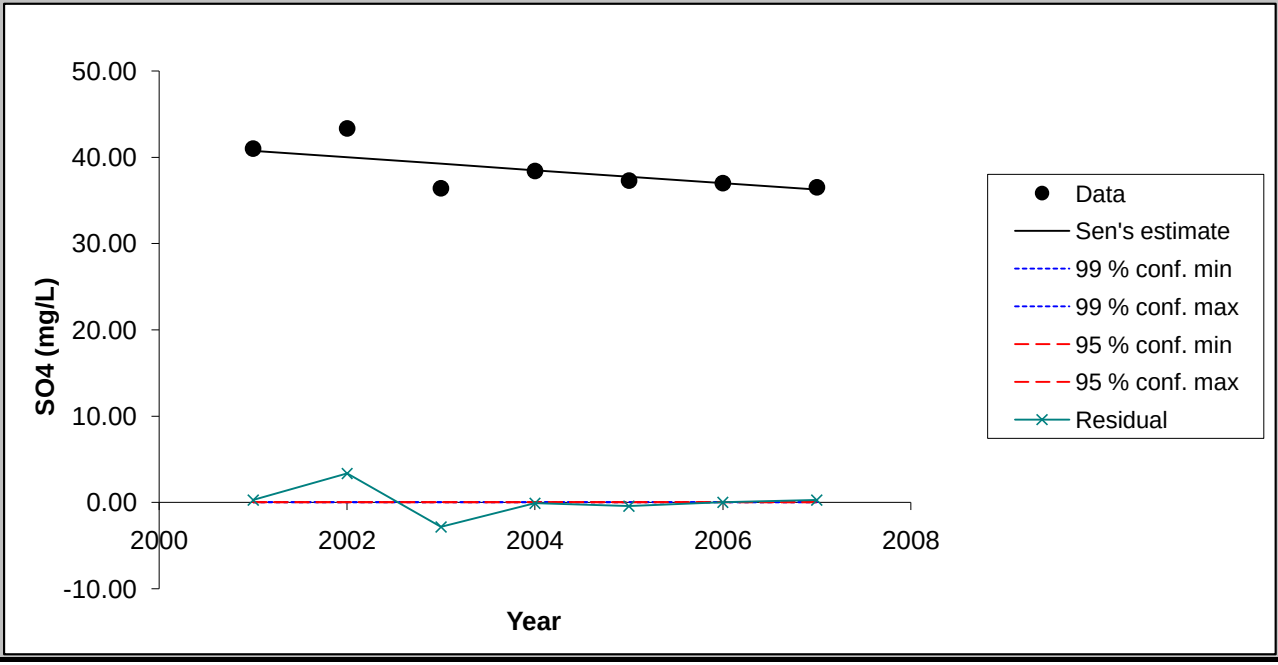

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 2001

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2001	41.00	40.75	0.00	0.00	0.00	0.00	0.25
2002	43.34	40.00	0.00	0.00	0.00	0.00	3.34
2003	36.40	39.25	0.00	0.00	0.00	0.00	-2.85
2004	38.40	38.50	0.00	0.00	0.00	0.00	-0.10
2005	37.30	37.75	0.00	0.00	0.00	0.00	-0.45
2006	37.00	37.00	0.00	0.00	0.00	0.00	0.00
2007	36.50	36.25	0.00	0.00	0.00	0.00	0.25

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-53 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0011	0.862	0.0188	0.516	0.0262	11.5	0.0174	53.5
1993	0.0029	0.945	0.0094	7.47	0.1431	72	0.0214	235.5
1994	0.0018	1.27	0.001	6.02	0.254	120.5	0.0309	359.5
1995	0.0001	1.7	0.01	7.7	0.25	100	0.041	390
1996	0.0001	2.4	0.011	0.34	0.19	91	0.044	320
1997	0.0001	3.1	0.0005	7.2	0.17	75	0.048	300
1998	0.0001	2.7	0.0005	7	0.138	79	0.061	240
1999	0.0001	3.6	0.0005	6.7	0.11	52	0.072	280
2000	0.0001	3.4	0.015	5	0.09	60	0.08	260
2001	0.001	3.2	0.03	4.49	0.08	62	0.05	298
2002	0.001	2.81	0.03	5.11	0.0909	75.7	0.0552	360.5
2003	0.001	2.15	0.001	5.73	0.219	84.6	0.0615	421
2004	0.001	1.74	0.0032	5.35	0.222	84.3	0.0487	388
2005	0.001	2.04	0.002	5.43	0.15	82.4	0.0459	331
2006	0.001	1.78	0.002	5.01	0.172	76.1	0.044	334
2007	0.001	2.92	0.002	7.15	0.115	111	0.0581	472

TREND STATISTICS

TW-53 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-3*			0.000					0.00				
F (mg/L)	*2000*	*2007*	*8*	*-14*			-0.258					5.40				
Mn (mg/L)	*2000*	*2007*	*8*	*-12*			-0.002					0.03				
Nitrate (mg/L)	*2000*	*2007*	*8*	*14*			0.113					3.98				
Se (mg/L)	*2000*	*2007*	*8*	*10*			0.008					0.03				
Cl (mg/L)	*2000*	*2007*	*8*	*16*		+	5.588					16.28				
Mo (mg/L)	*2000*	*2007*	*8*	*-12*			-0.003					0.08				
SO4 (mg/L)	*2000*	*2007*	*8*	*14*			18.246					151.42				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-3
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

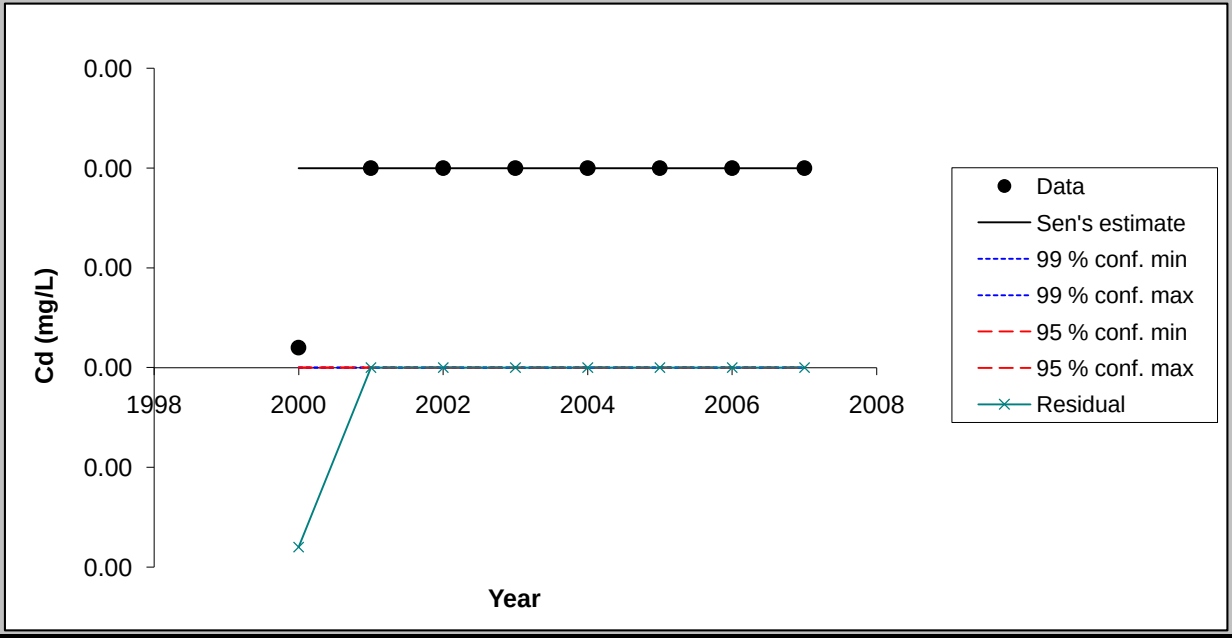

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-2.58E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.40E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

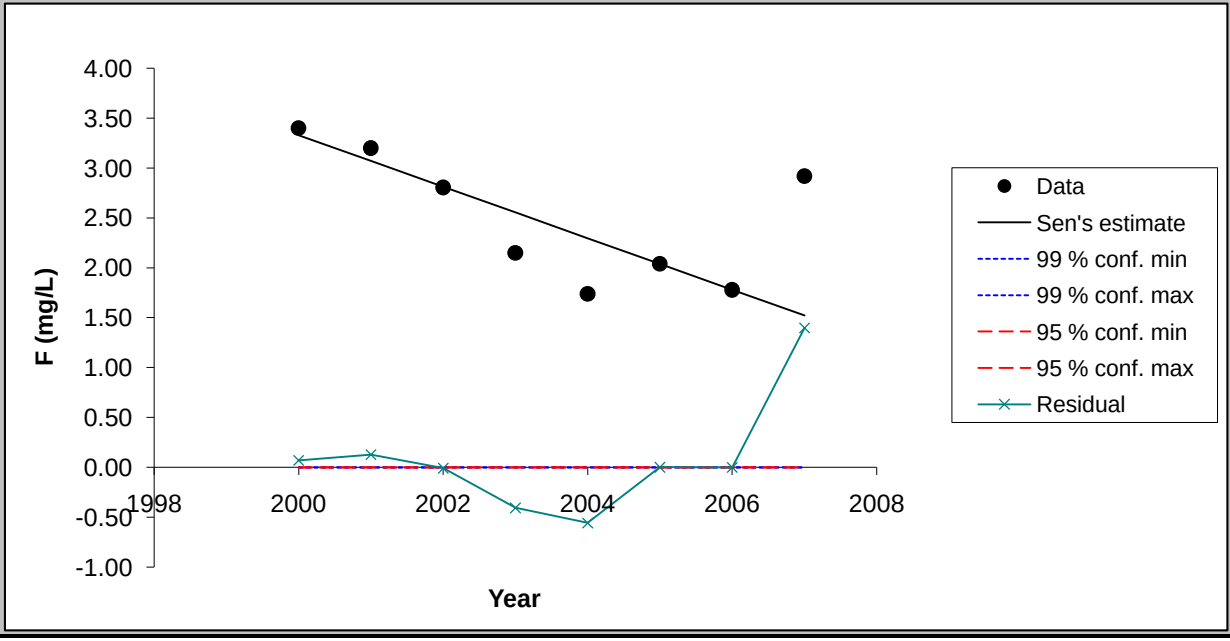

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.40	3.33	0.00	0.00	0.00	0.00	0.07
2001	3.20	3.07	0.00	0.00	0.00	0.00	0.13
2002	2.81	2.81	0.00	0.00	0.00	0.00	-0.01
2003	2.15	2.56	0.00	0.00	0.00	0.00	-0.41
2004	1.74	2.30	0.00	0.00	0.00	0.00	-0.56
2005	2.04	2.04	0.00	0.00	0.00	0.00	0.00
2006	1.78	1.78	0.00	0.00	0.00	0.00	0.00
2007	2.92	1.52	0.00	0.00	0.00	0.00	1.40

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-2.01E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.06E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

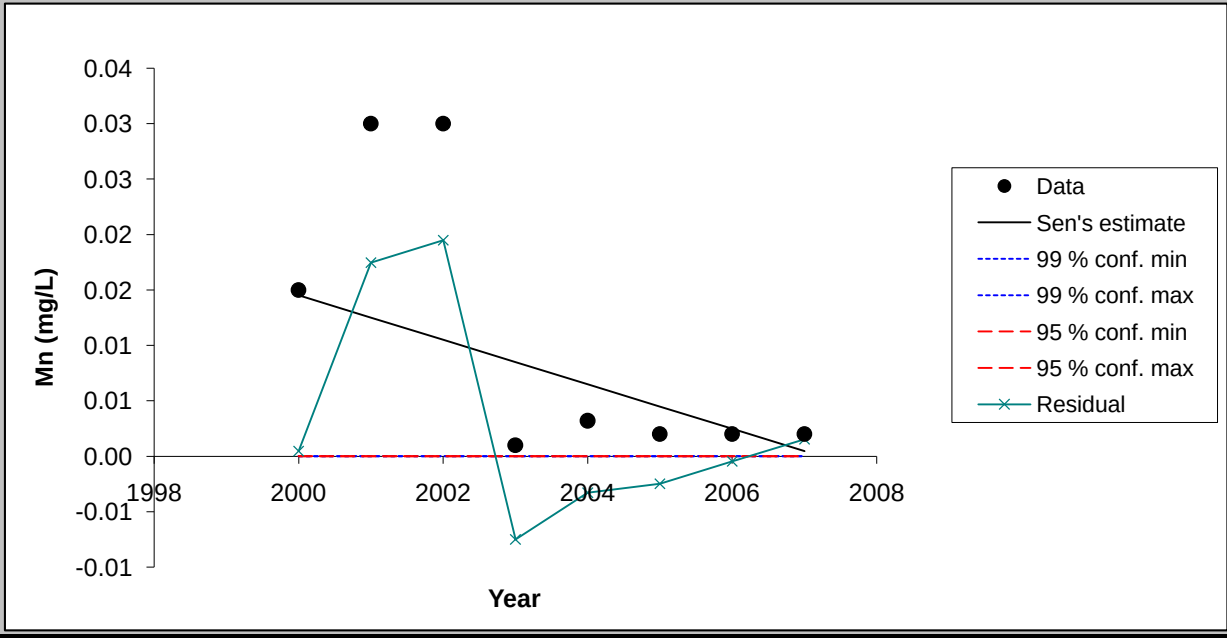

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.01	0.00	0.00	0.00	0.00	0.02
2002	0.03	0.01	0.00	0.00	0.00	0.00	0.02
2003	0.00	0.01	0.00	0.00	0.00	0.00	-0.01
2004	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	1.13E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.98E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

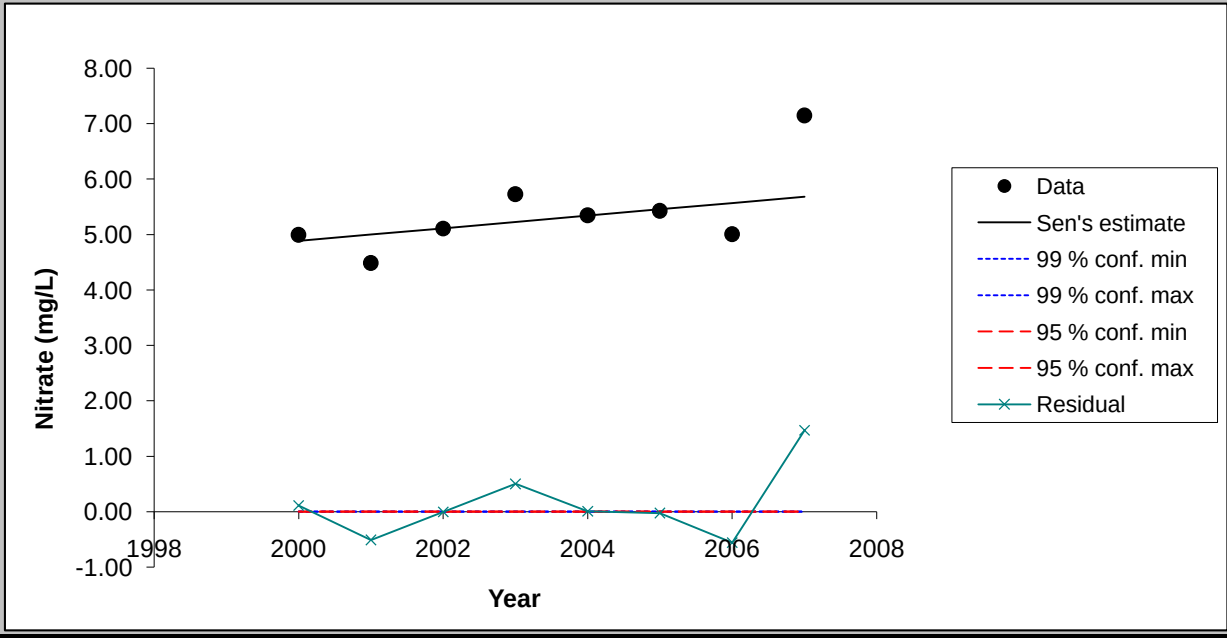

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	5.00	4.89	0.00	0.00	0.00	0.00	0.11
2001	4.49	5.00	0.00	0.00	0.00	0.00	-0.51
2002	5.11	5.12	0.00	0.00	0.00	0.00	-0.01
2003	5.73	5.23	0.00	0.00	0.00	0.00	0.50
2004	5.35	5.34	0.00	0.00	0.00	0.00	0.01
2005	5.43	5.46	0.00	0.00	0.00	0.00	-0.03
2006	5.01	5.57	0.00	0.00	0.00	0.00	-0.56
2007	7.15	5.68	0.00	0.00	0.00	0.00	1.47

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	8.37E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.22E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

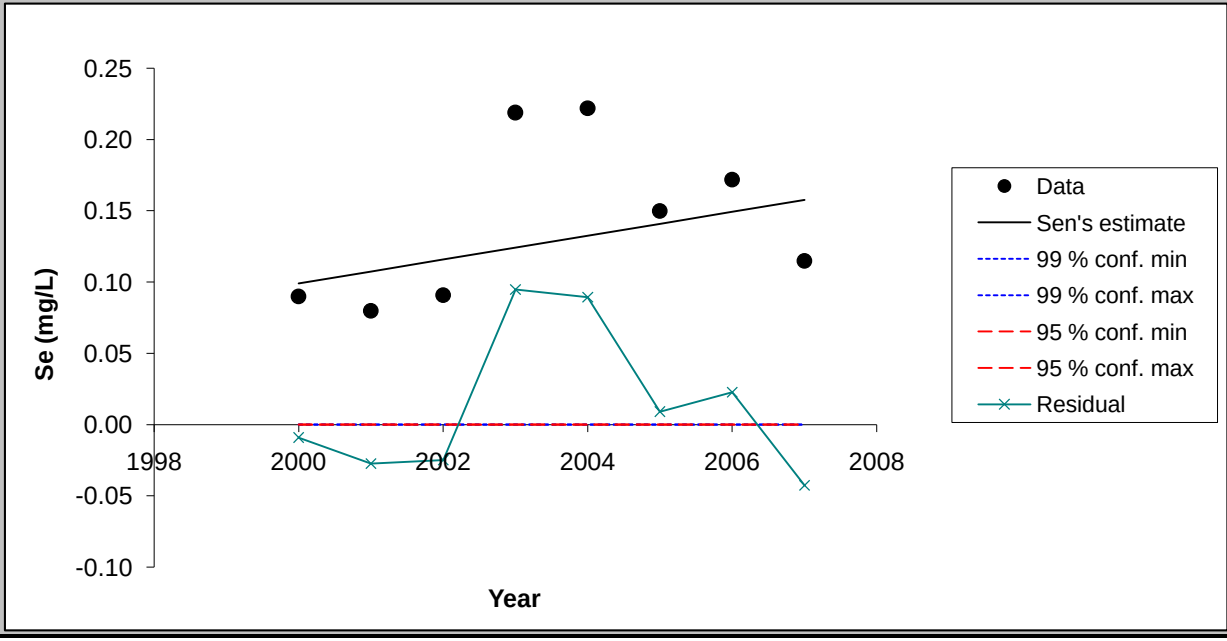

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.09	0.10	0.00	0.00	0.00	0.00	-0.01
2001	0.08	0.11	0.00	0.00	0.00	0.00	-0.03
2002	0.09	0.12	0.00	0.00	0.00	0.00	-0.02
2003	0.22	0.12	0.00	0.00	0.00	0.00	0.09
2004	0.22	0.13	0.00	0.00	0.00	0.00	0.09
2005	0.15	0.14	0.00	0.00	0.00	0.00	0.01
2006	0.17	0.15	0.00	0.00	0.00	0.00	0.02
2007	0.12	0.16	0.00	0.00	0.00	0.00	-0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	5.59E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.63E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

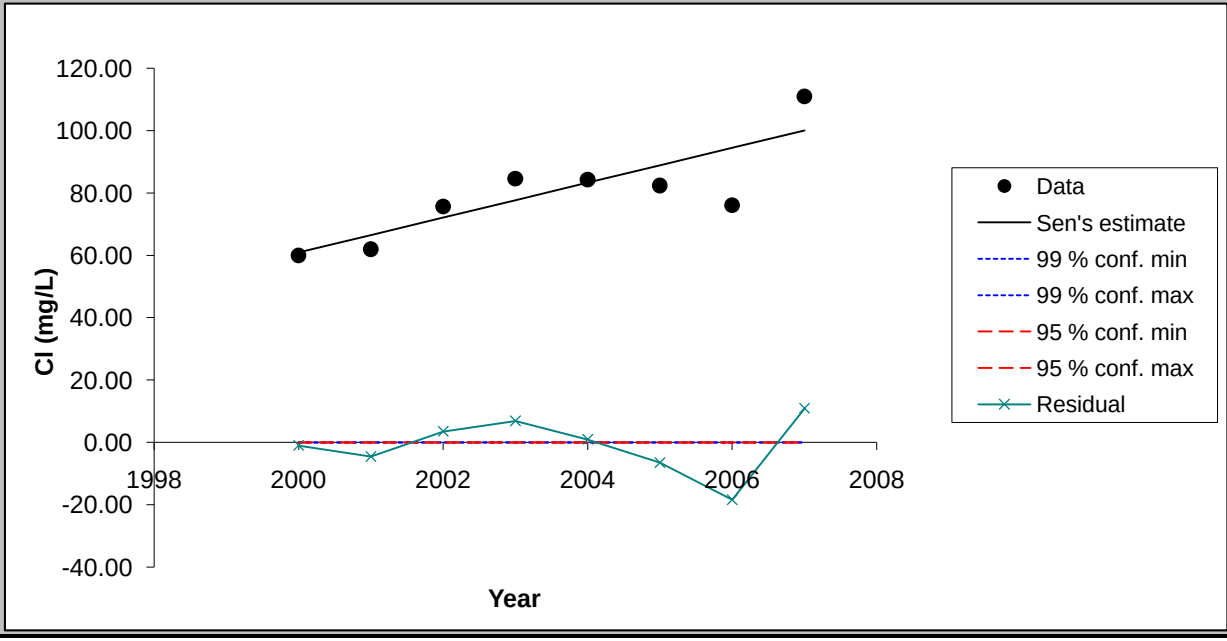

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	60.00	60.98	0.00	0.00	0.00	0.00	-0.98
2001	62.00	66.56	0.00	0.00	0.00	0.00	-4.56
2002	75.67	72.15	0.00	0.00	0.00	0.00	3.52
2003	84.60	77.74	0.00	0.00	0.00	0.00	6.86
2004	84.30	83.33	0.00	0.00	0.00	0.00	0.97
2005	82.40	88.91	0.00	0.00	0.00	0.00	-6.51
2006	76.10	94.50	0.00	0.00	0.00	0.00	-18.40
2007	111.00	100.09	0.00	0.00	0.00	0.00	10.91

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-2.57E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.05E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

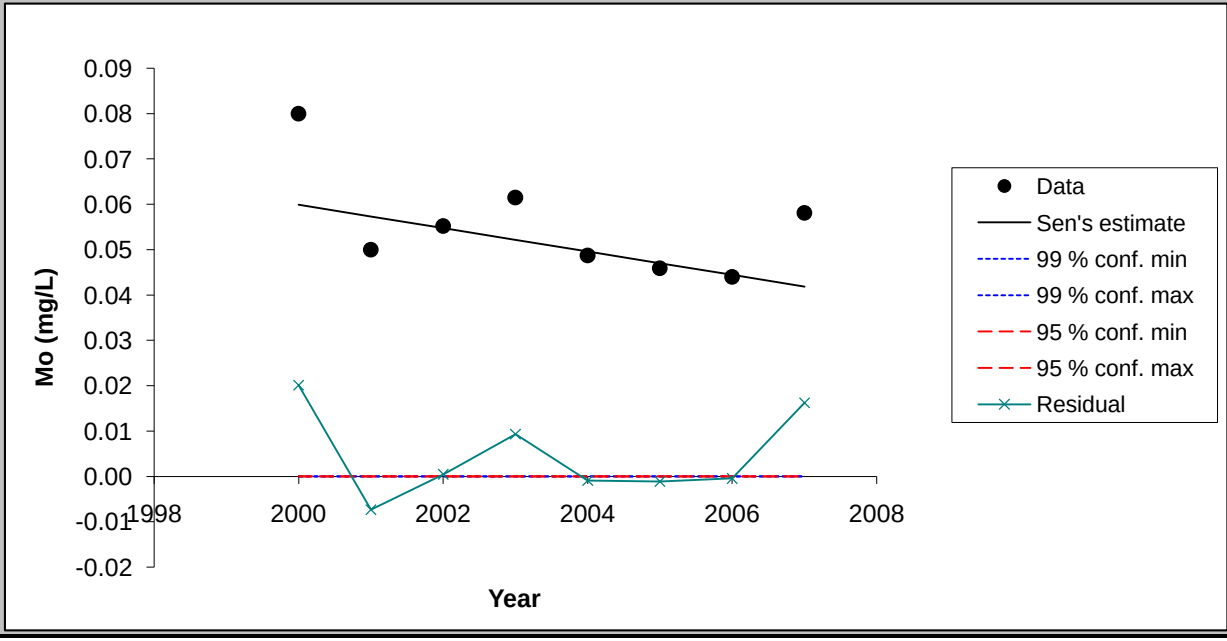

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.06	0.00	0.00	0.00	0.00	0.02
2001	0.05	0.06	0.00	0.00	0.00	0.00	-0.01
2002	0.06	0.05	0.00	0.00	0.00	0.00	0.00
2003	0.06	0.05	0.00	0.00	0.00	0.00	0.01
2004	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2005	0.05	0.05	0.00	0.00	0.00	0.00	0.00
2006	0.04	0.04	0.00	0.00	0.00	0.00	0.00
2007	0.06	0.04	0.00	0.00	0.00	0.00	0.02

FIGURE

< Previous Time Series

Next Time Series >

TW-53 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	1.82E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.51E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

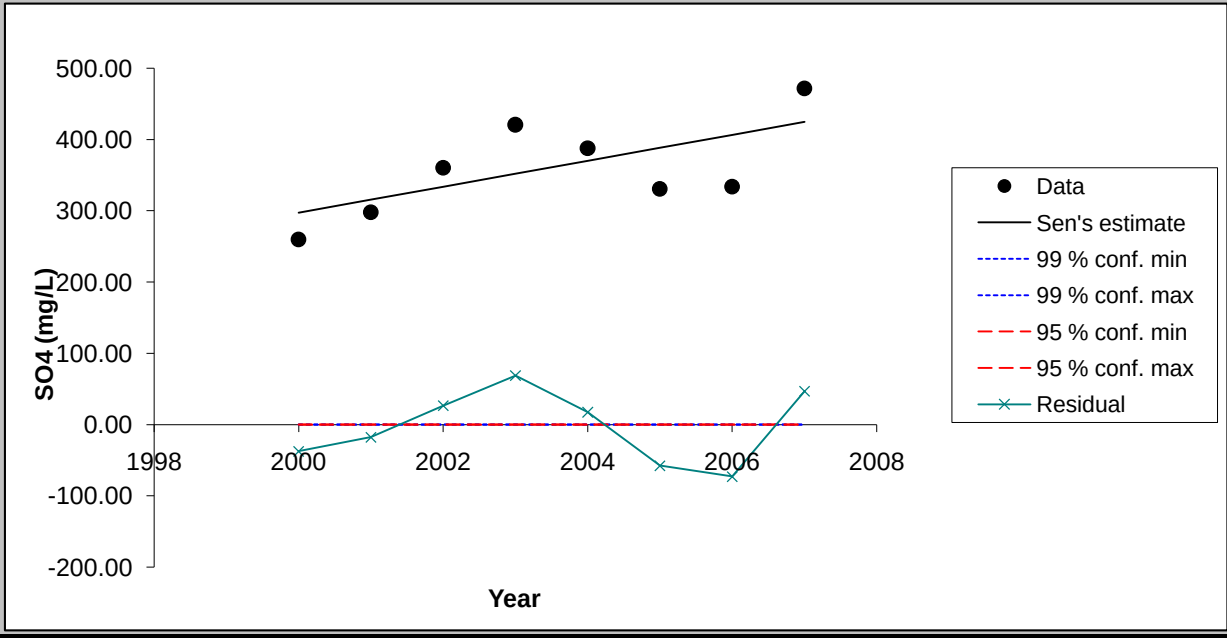

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	260.00	297.39	0.00	0.00	0.00	0.00	-37.39
2001	298.00	315.63	0.00	0.00	0.00	0.00	-17.63
2002	360.54	333.88	0.00	0.00	0.00	0.00	26.67
2003	421.00	352.12	0.00	0.00	0.00	0.00	68.88
2004	388.00	370.37	0.00	0.00	0.00	0.00	17.63
2005	331.00	388.61	0.00	0.00	0.00	0.00	-57.61
2006	334.00	406.86	0.00	0.00	0.00	0.00	-72.86
2007	472.00	425.11	0.00	0.00	0.00	0.00	46.89

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-54 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0043	5.1	0.0022	6.42	0.233	166	0.123	432
1993	0.0029	5.3	0.0188	7.67	0.45	139.5	0.102	454
1994	0.0029	5.7	0.0041	7.4	0.314	159	0.109	499.5
1995	0.0005	5.4	0.012	4.3	0.38	140	0.126	540
1996	0.0006	6.3	0.002	8.8	0.27	110	0.122	460
1997	0.0005	7.4	0.001	7.5	0.13	77	0.125	350
1998	0.0004	4.6	0.004	5.3	0.105	64	0.113	220
1999	0.0004	4.3	0.002	5.3	0.066	45	0.092	190
2000	0.0004	3	0.005	4.2	0.05	51	0.073	170
2001	0.001	2.7	0.005	5	0.092	67	0.06	319
2002	0.0176	2.6	0.03	1.04	0.338	109.1	0.058	529.9
2003	0.001	2.24	0.0029	7.15	0.314	122	0.0675	541
2004	0.0023	2.23	0.001	7.05	0.374	109	0.0581	508
2005	0.001	2.43	0.002	7.93	0.315	120.5	0.0511	504.5
2006	0.001	2.63	0.002	12.5	0.3415	122	0.0565	628.5
2007	0.001	3.67	0.002	9.695	0.08495	98.8	0.0882	491

TREND STATISTICS

TW-54 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-2*			0.000					0.00				
F (mg/L)	*2000*	*2007*	*8*	*-4*			-0.012					2.78				
Mn (mg/L)	*2000*	*2007*	*8*	*-14*			0.000					0.01				
Nitrate (mg/L)	*2000*	*2007*	*8*	*20*		*	0.881					-3.22				
Se (mg/L)	*2000*	*2007*	*8*	*8*			0.014					0.14				
Cl (mg/L)	*2000*	*2007*	*8*	*11*			6.664					28.86				
Mo (mg/L)	*2000*	*2007*	*8*	*-8*			-0.001					0.07				
SO4 (mg/L)	*2000*	*2007*	*8*	*8*			37.512					37.35				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

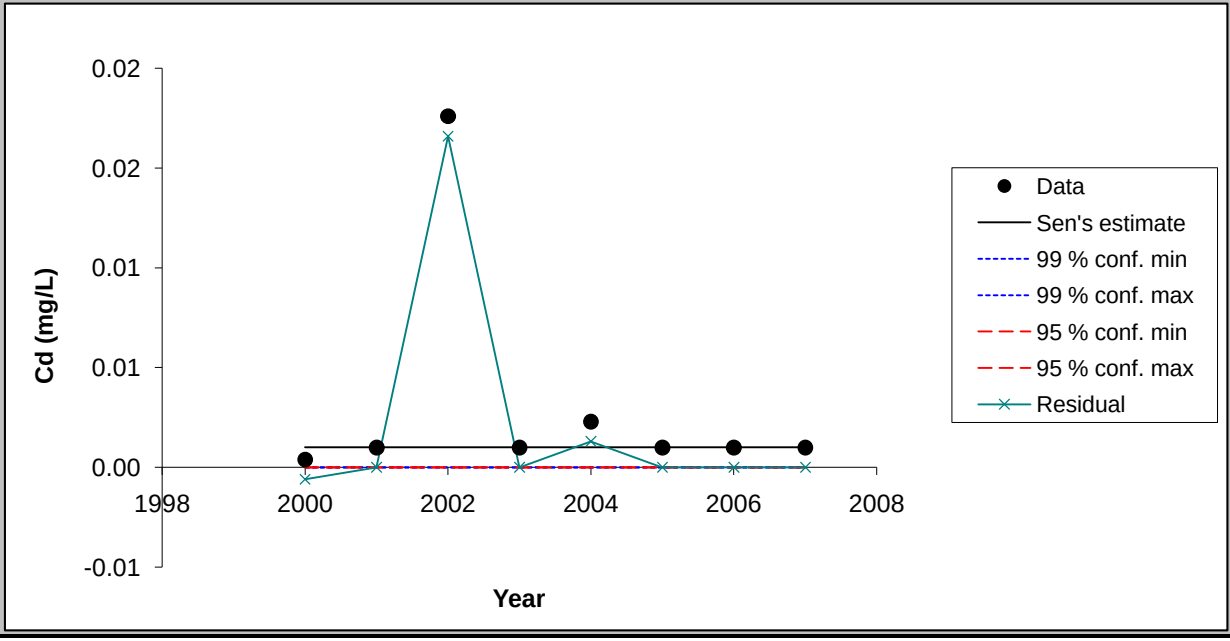

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.00	0.00	0.00	0.00	0.00	0.02
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-1.20E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.78E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

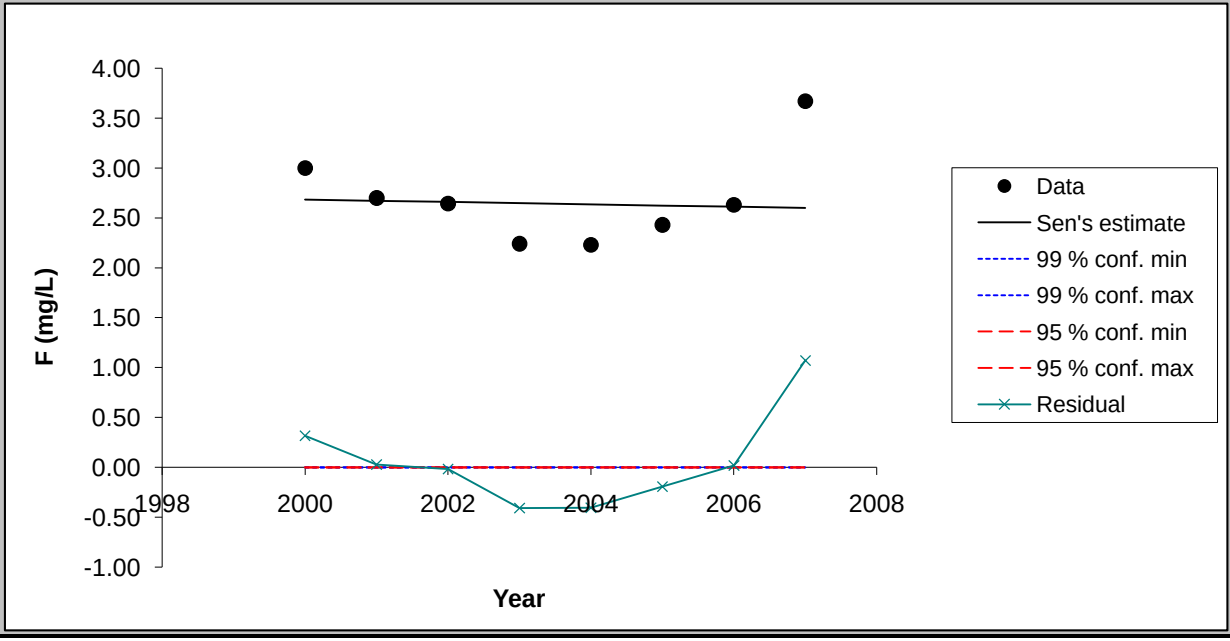

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.00	2.68	0.00	0.00	0.00	0.00	0.32
2001	2.70	2.67	0.00	0.00	0.00	0.00	0.03
2002	2.64	2.66	0.00	0.00	0.00	0.00	-0.02
2003	2.24	2.65	0.00	0.00	0.00	0.00	-0.41
2004	2.23	2.64	0.00	0.00	0.00	0.00	-0.41
2005	2.43	2.62	0.00	0.00	0.00	0.00	-0.19
2006	2.63	2.61	0.00	0.00	0.00	0.00	0.02
2007	3.67	2.60	0.00	0.00	0.00	0.00	1.07

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-5.00E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

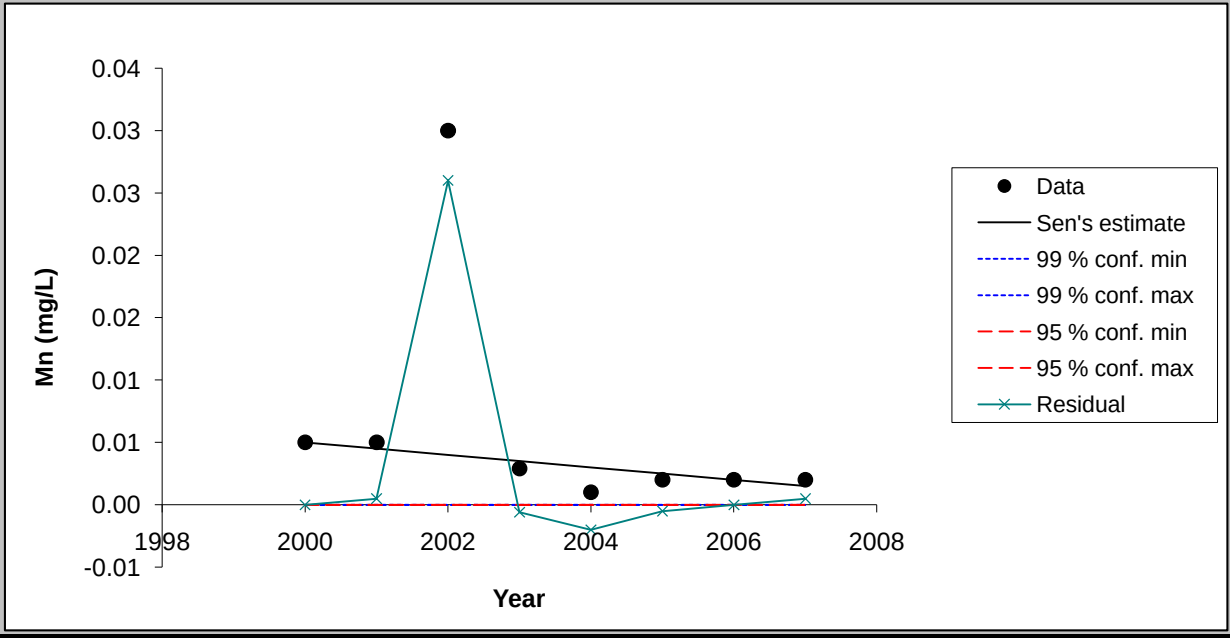

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	8.81E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-3.22E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

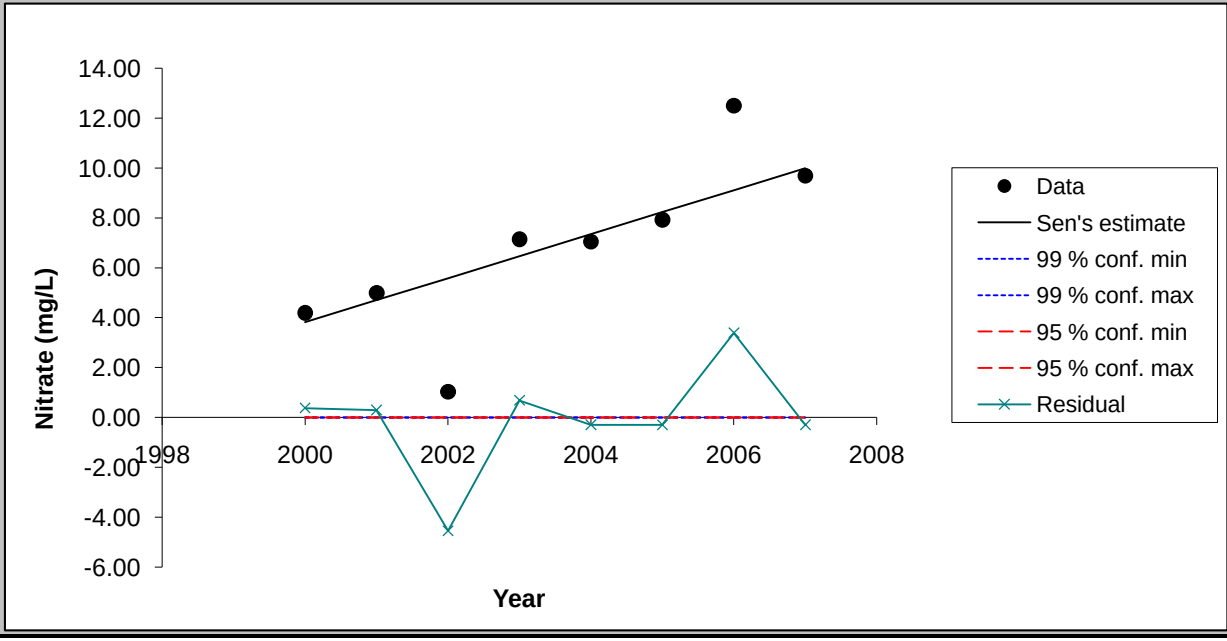

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	4.20	3.82	0.00	0.00	0.00	0.00	0.38
2001	5.00	4.71	0.00	0.00	0.00	0.00	0.30
2002	1.04	5.59	0.00	0.00	0.00	0.00	-4.55
2003	7.15	6.47	0.00	0.00	0.00	0.00	0.68
2004	7.05	7.35	0.00	0.00	0.00	0.00	-0.30
2005	7.93	8.23	0.00	0.00	0.00	0.00	-0.30
2006	12.50	9.11	0.00	0.00	0.00	0.00	3.39
2007	9.70	9.99	0.00	0.00	0.00	0.00	-0.30

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	1.36E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.44E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

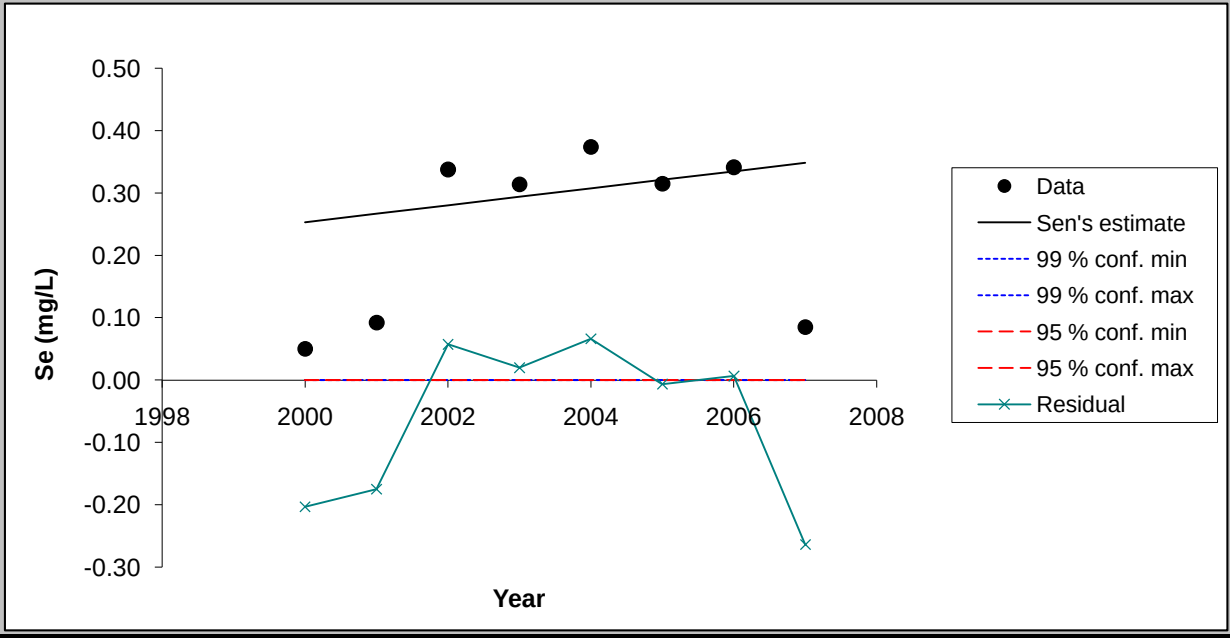

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.05	0.25	0.00	0.00	0.00	0.00	-0.20
2001	0.09	0.27	0.00	0.00	0.00	0.00	-0.17
2002	0.34	0.28	0.00	0.00	0.00	0.00	0.06
2003	0.31	0.29	0.00	0.00	0.00	0.00	0.02
2004	0.37	0.31	0.00	0.00	0.00	0.00	0.07
2005	0.32	0.32	0.00	0.00	0.00	0.00	-0.01
2006	0.34	0.34	0.00	0.00	0.00	0.00	0.01
2007	0.08	0.35	0.00	0.00	0.00	0.00	-0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	11
Test Z	
Signific.	
Q	6.66E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.89E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

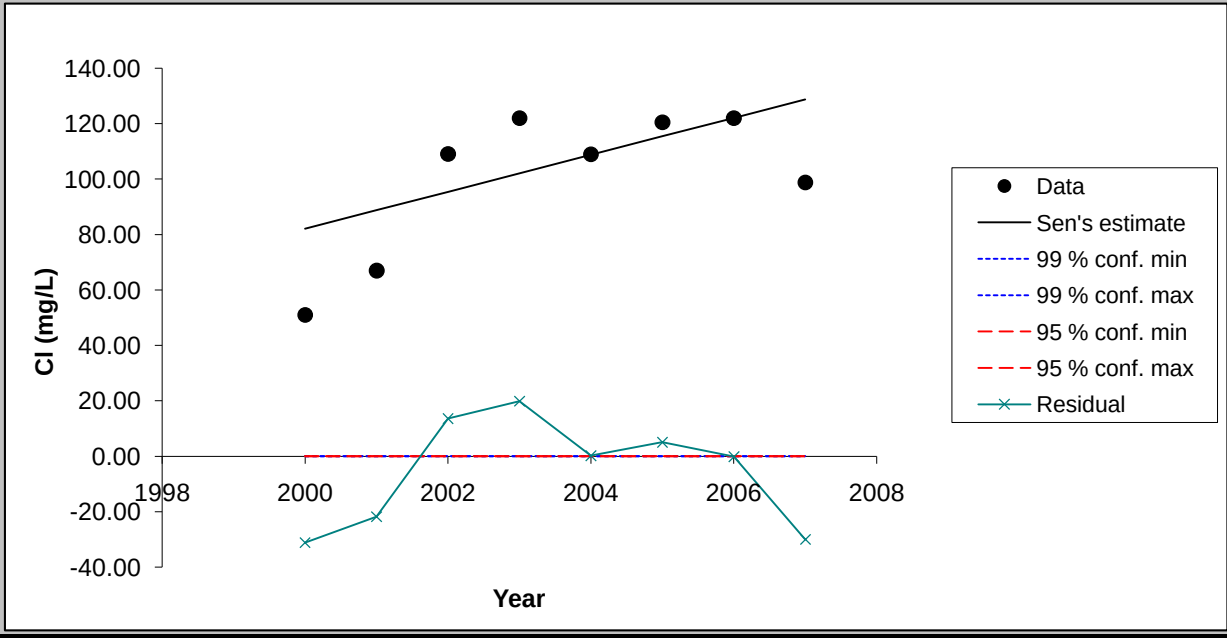

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	51.00	82.18	0.00	0.00	0.00	0.00	-31.18
2001	67.00	88.84	0.00	0.00	0.00	0.00	-21.84
2002	109.08	95.51	0.00	0.00	0.00	0.00	13.57
2003	122.00	102.17	0.00	0.00	0.00	0.00	19.83
2004	109.00	108.84	0.00	0.00	0.00	0.00	0.16
2005	120.50	115.50	0.00	0.00	0.00	0.00	5.00
2006	122.00	122.16	0.00	0.00	0.00	0.00	-0.16
2007	98.80	128.83	0.00	0.00	0.00	0.00	-30.03

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-7.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.70E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

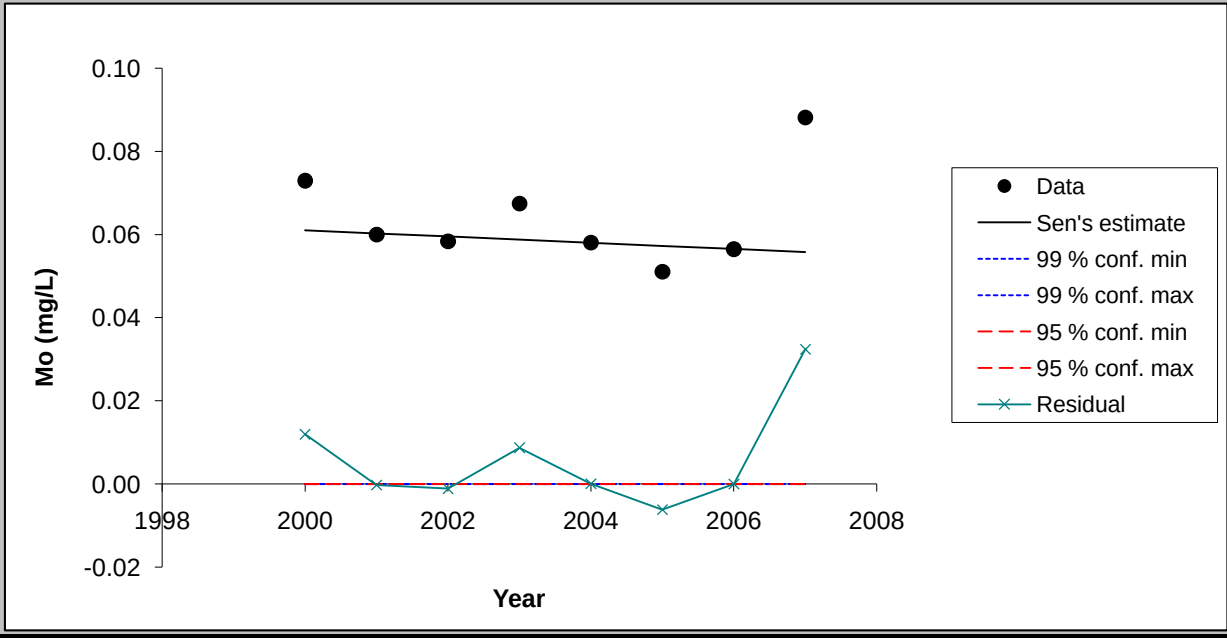

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.07	0.06	0.00	0.00	0.00	0.00	0.01
2001	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2002	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2003	0.07	0.06	0.00	0.00	0.00	0.00	0.01
2004	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2005	0.05	0.06	0.00	0.00	0.00	0.00	-0.01
2006	0.06	0.06	0.00	0.00	0.00	0.00	0.00
2007	0.09	0.06	0.00	0.00	0.00	0.00	0.03

FIGURE

< Previous Time Series

Next Time Series >

TW-54 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	3.75E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.74E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

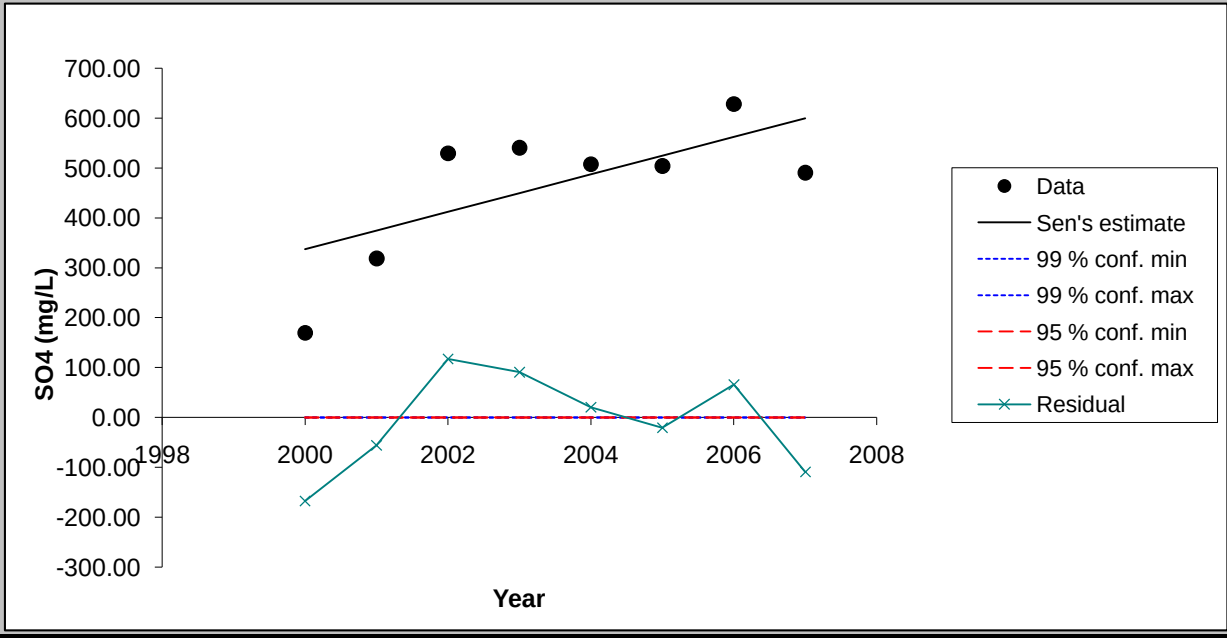

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	170.00	337.45	0.00	0.00	0.00	0.00	-167.45
2001	319.00	374.96	0.00	0.00	0.00	0.00	-55.96
2002	529.90	412.47	0.00	0.00	0.00	0.00	117.43
2003	541.00	449.98	0.00	0.00	0.00	0.00	91.02
2004	508.00	487.49	0.00	0.00	0.00	0.00	20.51
2005	504.50	525.01	0.00	0.00	0.00	0.00	-20.51
2006	628.50	562.52	0.00	0.00	0.00	0.00	65.98
2007	491.00	600.03	0.00	0.00	0.00	0.00	-109.03

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

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ANNUAL DATA

TW-55 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0046	0.15	0.0026	2.96	0.248	75.3	0.0085	242
1993	0.0029	0.21	0.0184	2.88	0.172	68.2	0.0048	223
1994	0.0024	0.24	0.001	3.42	0.144	61.2	0.0065	219
1995	0.0001	0.29	0.0005	3.4	0.097	82	0.0025	190
1996	0.0001	0.26	0.001	3.7	0.068	47	0.0025	230
1997	0.0001	0.32	0.0005	3.4	0.06	50	0.0025	180
1998	0.0001	0.3	0.0005	2.9	0.036	48	0.0025	180
1999	0.0001	0.36	0.0005	2.9	0.021	34	0.0025	160
2000	0.0001	0.32	0.0005	2.9	0.014	44	0.0025	160
2001	0.001	0.6	0.005	2.98	0.013	36	0.005	117
2002	0.001	0.69	0.03	2.91	0.017	36.7	0.005	127.8
2003	0.001	0.39	0.001	2.58	0.026	38.4	0.021	150
2004	0.001	0.115	0.001	2.69	0.074	42.1	0.016	174
2005	0.001	0.23	0.001	3.06	0.084	58.7	0.0054	230
2006	0.0006	0.05	0.002	3.64	0.115	59.1	0.008	252
2007	0.001	0.26	0.002	4.15	0.0413	59.4	0.012	252

TREND STATISTICS

TW-55 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-5*			0.0000					0.0010				
F (mg/L)	*2000*	*2007*	*8*	*-12*			-0.054					0.96				
Mn (mg/L)	*2000*	*2007*	*8*	*4*			0.0000					0.0009				
Nitrate (mg/L)	*2000*	*2007*	*8*	*14*			0.128					1.73				
Se (mg/L)	*2000*	*2007*	*8*	*20*		*	0.012					-0.09				
Cl (mg/L)	*2000*	*2007*	*8*	*20*		*	2.8					13.8				
Mo (mg/L)	*2000*	*2007*	*8*	*13*			0.0010					-0.0049				
SO4 (mg/L)	*2000*	*2007*	*8*	*21*		*	22.4					-83.8				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-5
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

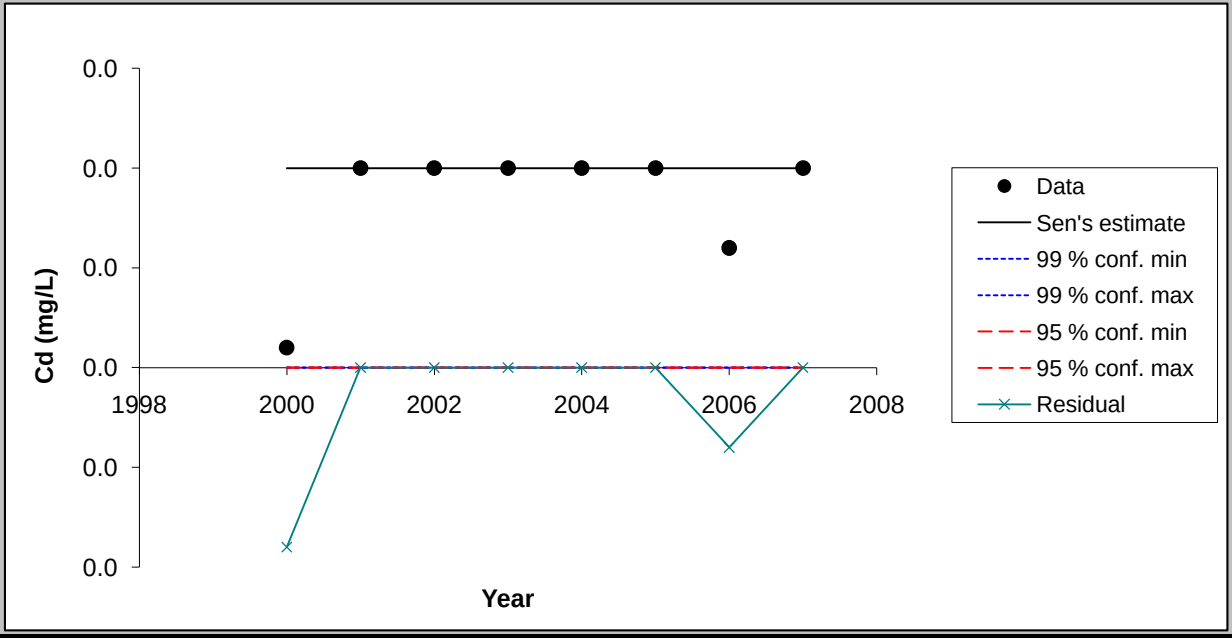

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-5.40E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.58E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

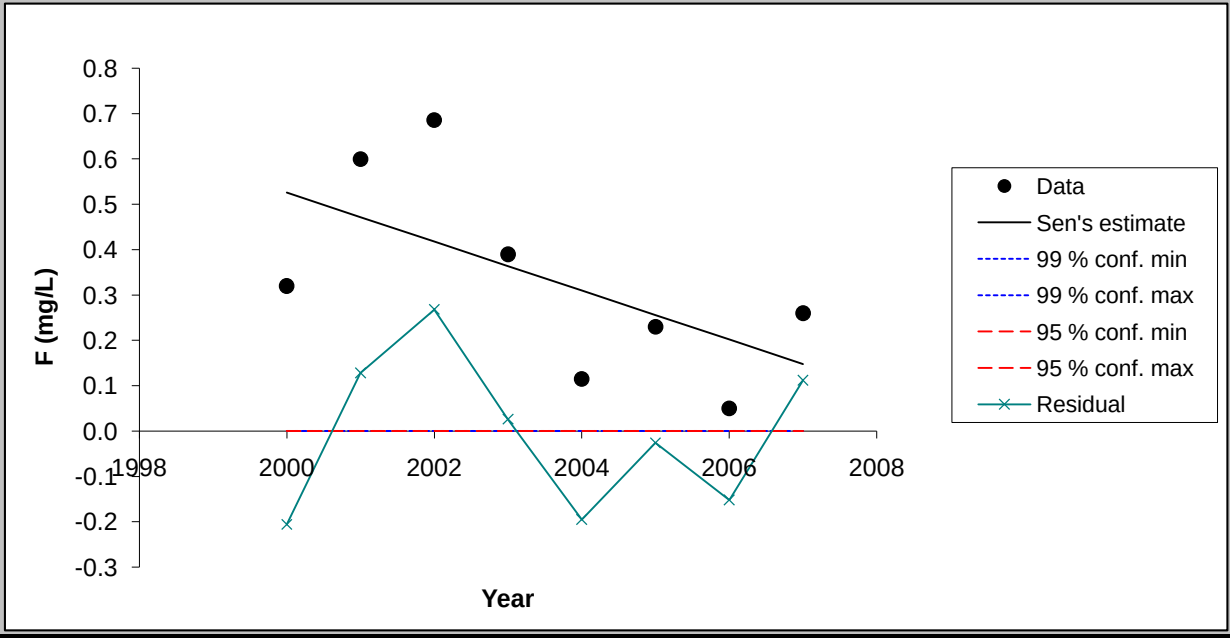

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.32	0.53	0.00	0.00	0.00	0.00	-0.21
2001	0.60	0.47	0.00	0.00	0.00	0.00	0.13
2002	0.69	0.42	0.00	0.00	0.00	0.00	0.27
2003	0.39	0.36	0.00	0.00	0.00	0.00	0.03
2004	0.12	0.31	0.00	0.00	0.00	0.00	-0.20
2005	0.23	0.26	0.00	0.00	0.00	0.00	-0.03
2006	0.05	0.20	0.00	0.00	0.00	0.00	-0.15
2007	0.26	0.15	0.00	0.00	0.00	0.00	0.11

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	5.00E-05
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.50E-04
Bmin99	
Bmax99	
Bmin95	
Bmax95	

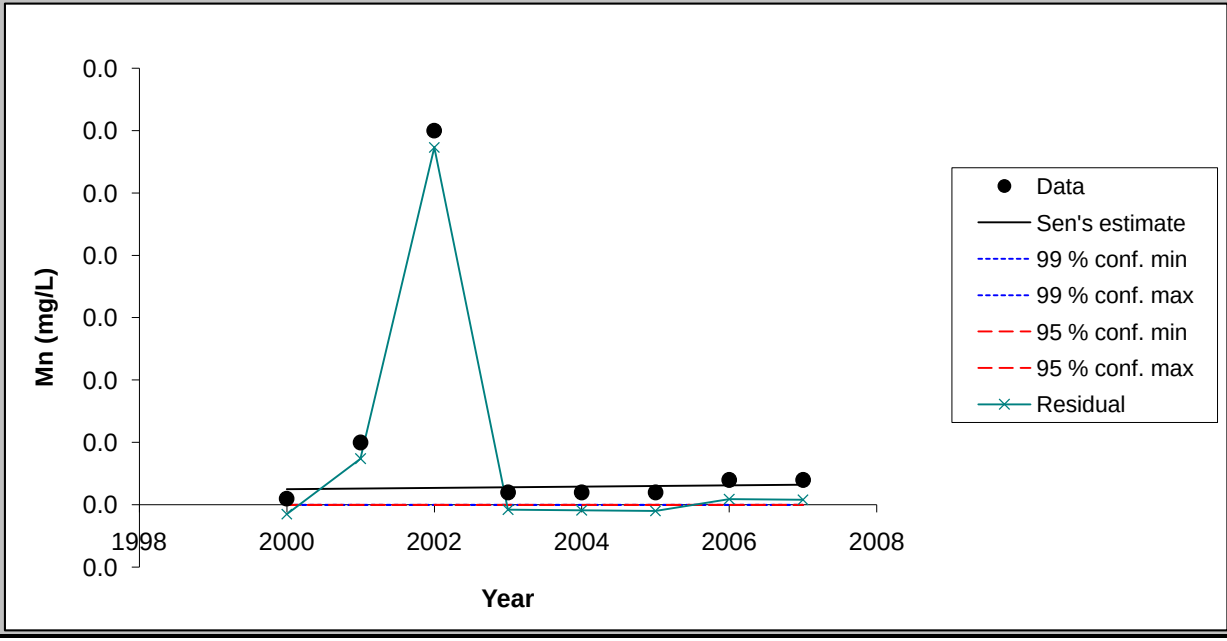

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	1.28E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.73E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

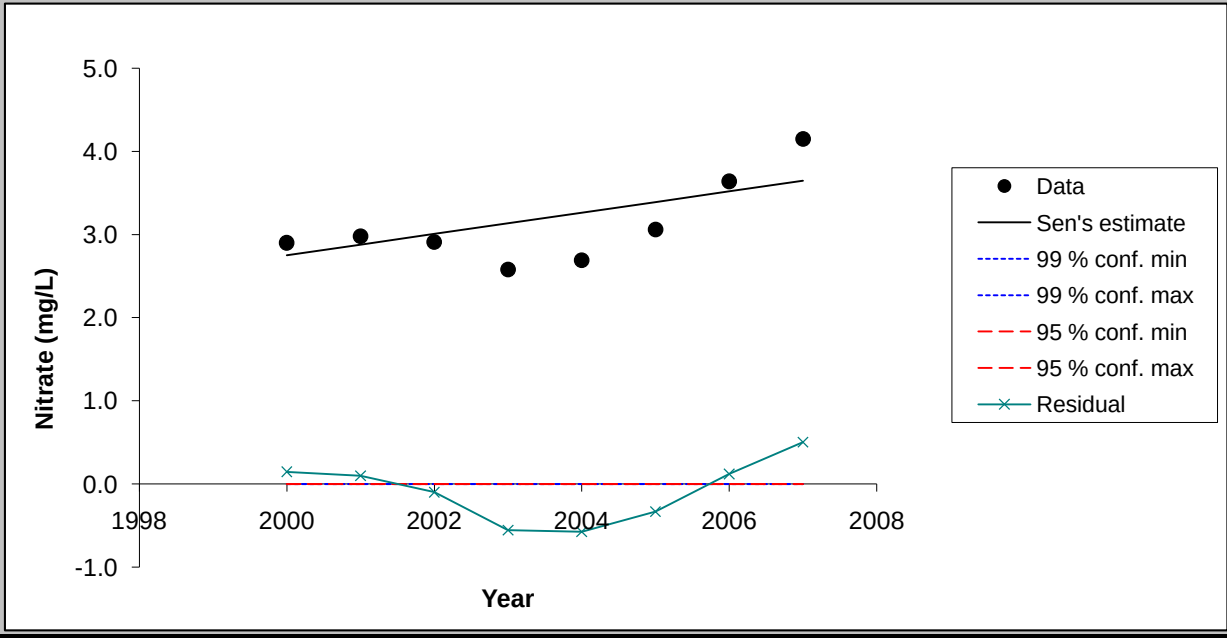

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	2.90	2.75	0.00	0.00	0.00	0.00	0.15
2001	2.98	2.88	0.00	0.00	0.00	0.00	0.10
2002	2.91	3.01	0.00	0.00	0.00	0.00	-0.10
2003	2.58	3.14	0.00	0.00	0.00	0.00	-0.56
2004	2.69	3.26	0.00	0.00	0.00	0.00	-0.57
2005	3.06	3.39	0.00	0.00	0.00	0.00	-0.33
2006	3.64	3.52	0.00	0.00	0.00	0.00	0.12
2007	4.15	3.65	0.00	0.00	0.00	0.00	0.50

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	1.20E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-8.85E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

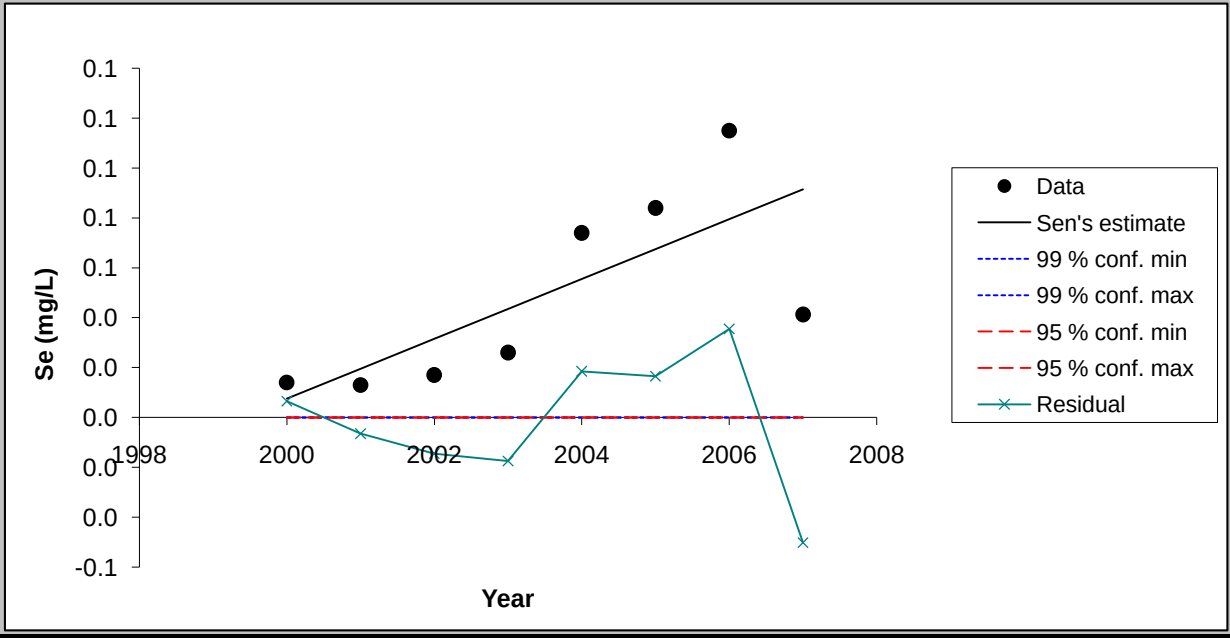

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.01
2001	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2002	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2003	0.03	0.04	0.00	0.00	0.00	0.00	-0.02
2004	0.07	0.06	0.00	0.00	0.00	0.00	0.02
2005	0.08	0.07	0.00	0.00	0.00	0.00	0.02
2006	0.12	0.08	0.00	0.00	0.00	0.00	0.04
2007	0.04	0.09	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	2.82E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.38E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

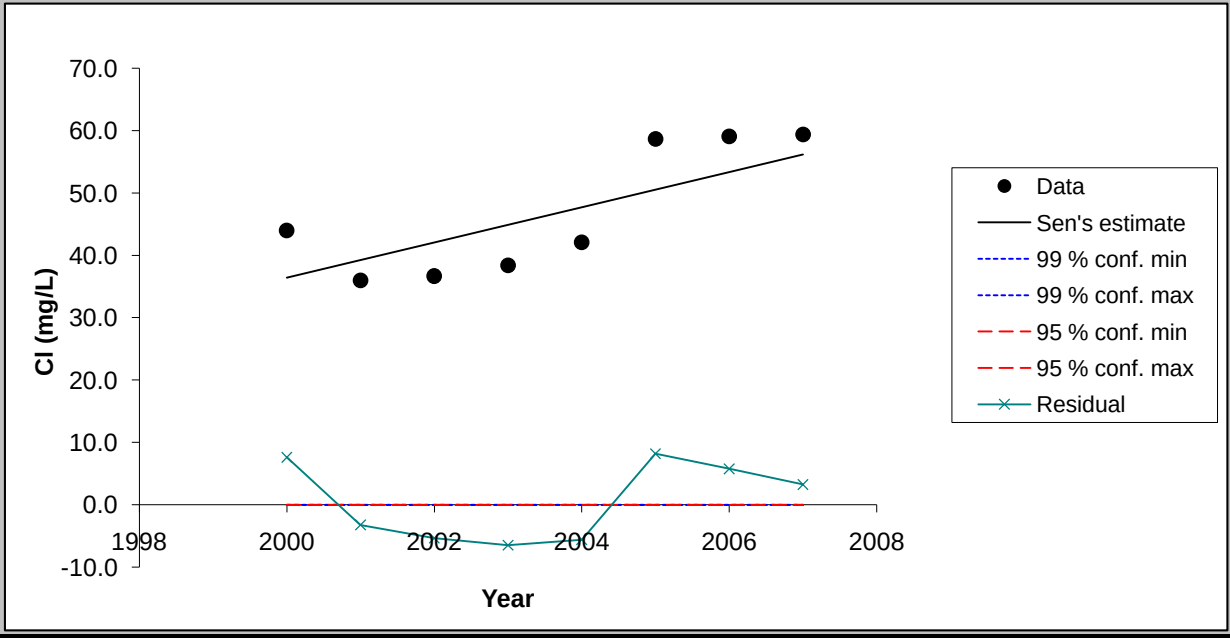

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	44.00	36.41	0.00	0.00	0.00	0.00	7.59
2001	36.00	39.23	0.00	0.00	0.00	0.00	-3.23
2002	36.69	42.06	0.00	0.00	0.00	0.00	-5.36
2003	38.40	44.88	0.00	0.00	0.00	0.00	-6.48
2004	42.10	47.70	0.00	0.00	0.00	0.00	-5.60
2005	58.70	50.52	0.00	0.00	0.00	0.00	8.18
2006	59.10	53.34	0.00	0.00	0.00	0.00	5.76
2007	59.40	56.17	0.00	0.00	0.00	0.00	3.23

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	13
Test Z	
Signific.	
Q	1.04E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-4.90E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

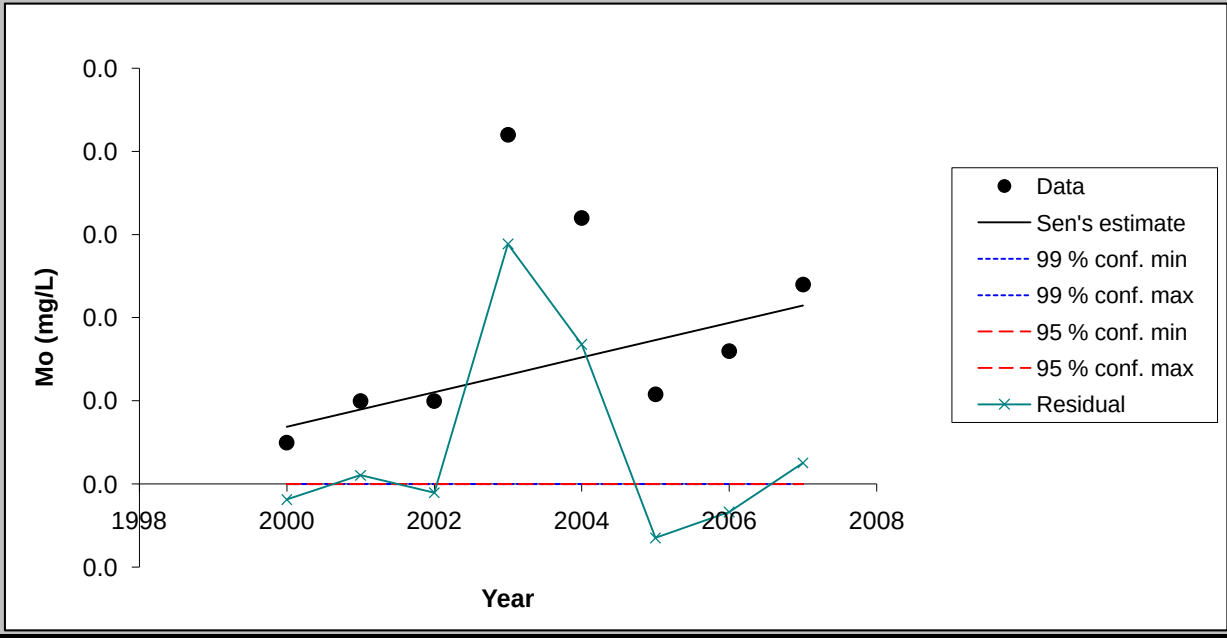

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2004	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-55 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	21
Test Z	
Signific.	*
Q	2.24E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-8.38E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

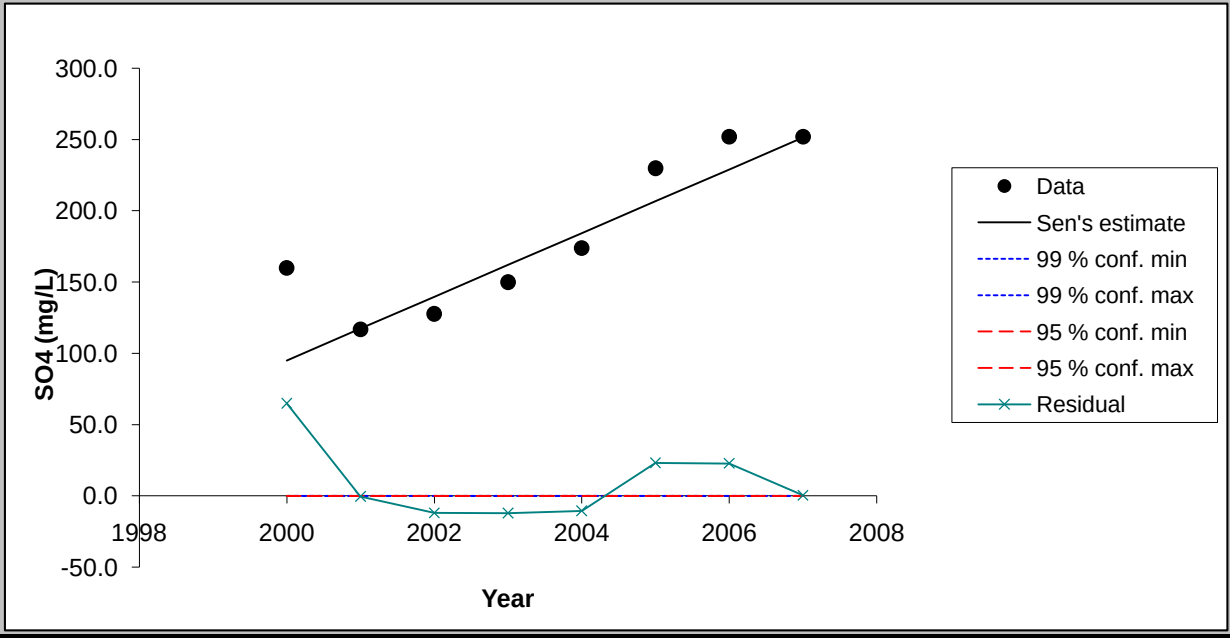

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	160.00	95.06	0.00	0.00	0.00	0.00	64.94
2001	117.00	117.42	0.00	0.00	0.00	0.00	-0.42
2002	127.78	139.78	0.00	0.00	0.00	0.00	-12.00
2003	150.00	162.14	0.00	0.00	0.00	0.00	-12.14
2004	174.00	184.50	0.00	0.00	0.00	0.00	-10.50
2005	230.00	206.86	0.00	0.00	0.00	0.00	23.14
2006	252.00	229.22	0.00	0.00	0.00	0.00	22.78
2007	252.00	251.58	0.00	0.00	0.00	0.00	0.42

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-56 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1992	0.0034	0.2	0.0246	5.28	0.005	87.4	0.088	188
1993	0.0029	0.23	0.0459	4.59	0.0006	77.8	0.0664	173
1994	0.0023	0.28	0.0319	5.24	0.0013	80.3	0.0747	169
1995	0.0001	0.33	0.039	5.5	0.0005	84	0.074	140
1996	0.0001	0.31	0.027	6.7	0.0005	78	0.088	180
1997	0.0001	0.32	0.028	6	0.0005	98	0.077	180
1998	0.0001	0.3	0.023	6.2	0.0005	78	0.075	220
1999	0.0001	0.36	0.027	6.6	0.0005	55	0.074	170
2000	0.0001	0.32	0.058	5.6	0.001	73	0.072	170
2001	0.001	0.5	0.03	5.23	0.0025	61	0.06	148
2002	0.001	0.63	0.03	5.15	0.0025	62.1	0.0731	147
2003	0.001	0.27	0.0176	6.06	0.005	55	0.101	134
2004	0.001	0.24	0.0198	6.47	0.0015	53.4	0.102	134
2005	0.001	0.19	0.0196	6.82	0.0045	58.2	0.091	134
2006	0.001	0.12	0.0198	6.27	0.0015	53.6	0.081	128
2007	0.001	0.39	0.0208	5.77	0.0007	52.9	0.091	128

TREND STATISTICS

TW-56 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-3*			0.0000					0.0010				
F (mg/L)	*2000*	*2007*	*8*	*-12*			-0.037					0.68				
Mn (mg/L)	*2000*	*2007*	*8*	*-10*			-0.002					0.05				
Nitrate (mg/L)	*2000*	*2007*	*8*	*10*			0.139					4.41				
Se (mg/L)	*2000*	*2007*	*8*	*-4*			0.000					0.0034				
Cl (mg/L)	*2000*	*2007*	*8*	*-20*		*	-1.99					81.71				
Mo (mg/L)	*2000*	*2007*	*8*	*11*			0.003					0.05				
SO4 (mg/L)	*2000*	*2007*	*8*	*-24*		**	-4.17					187.33				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-3
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

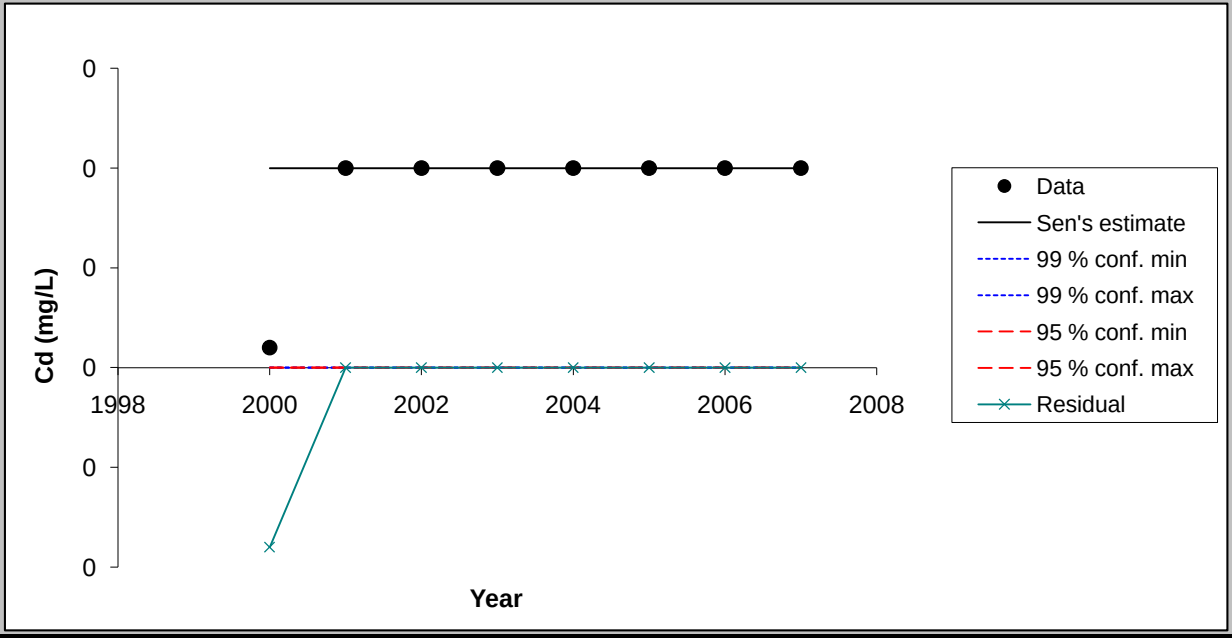

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-3.67E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.77E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

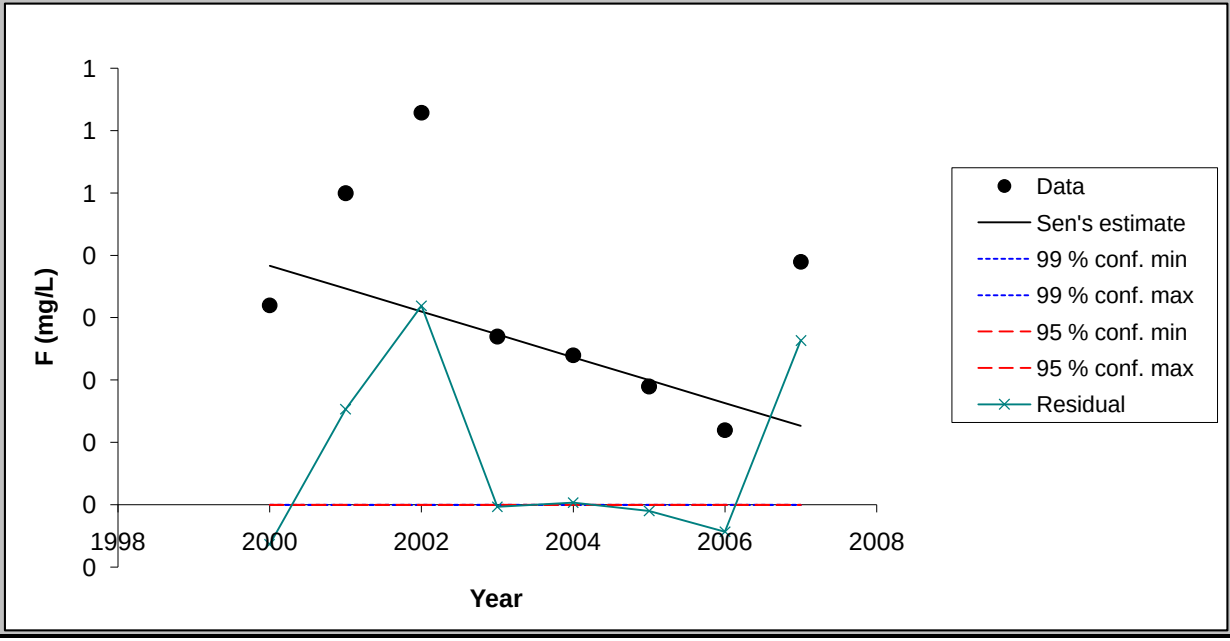

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.32	0.38	0.00	0.00	0.00	0.00	-0.06
2001	0.50	0.35	0.00	0.00	0.00	0.00	0.15
2002	0.63	0.31	0.00	0.00	0.00	0.00	0.32
2003	0.27	0.27	0.00	0.00	0.00	0.00	0.00
2004	0.24	0.24	0.00	0.00	0.00	0.00	0.00
2005	0.19	0.20	0.00	0.00	0.00	0.00	-0.01
2006	0.12	0.16	0.00	0.00	0.00	0.00	-0.04
2007	0.39	0.13	0.00	0.00	0.00	0.00	0.26

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-10
Test Z	
Signific.	
Q	-2.29E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.13E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

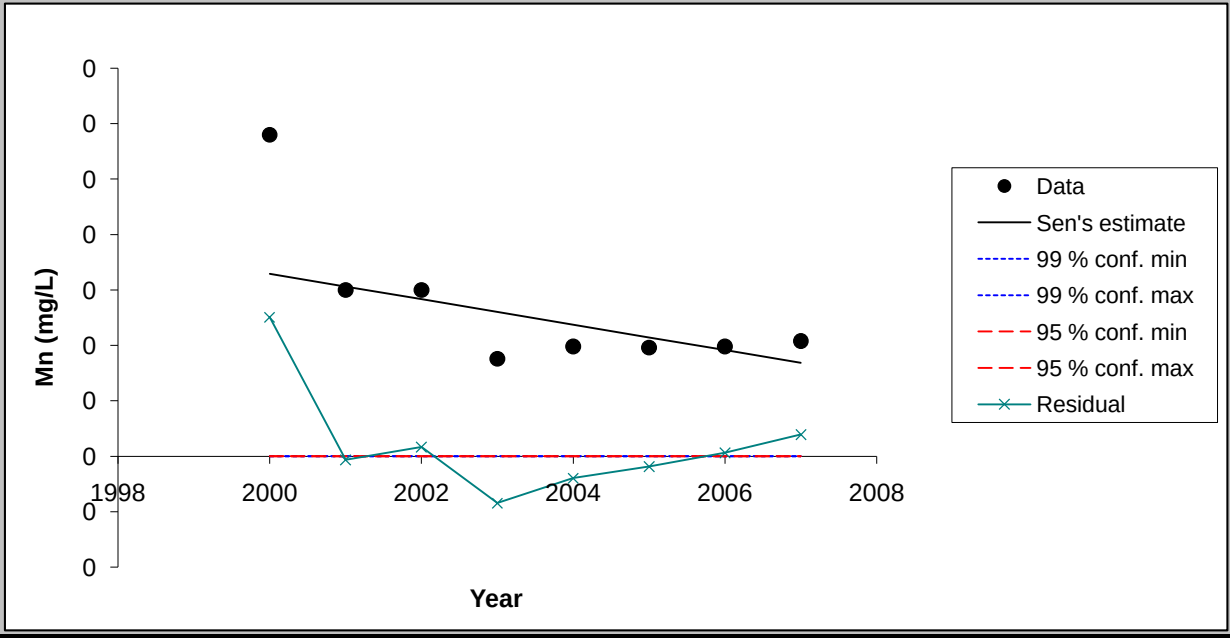

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.06	0.03	0.00	0.00	0.00	0.00	0.03
2001	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2005	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2006	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2007	0.02	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	1.39E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.41E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

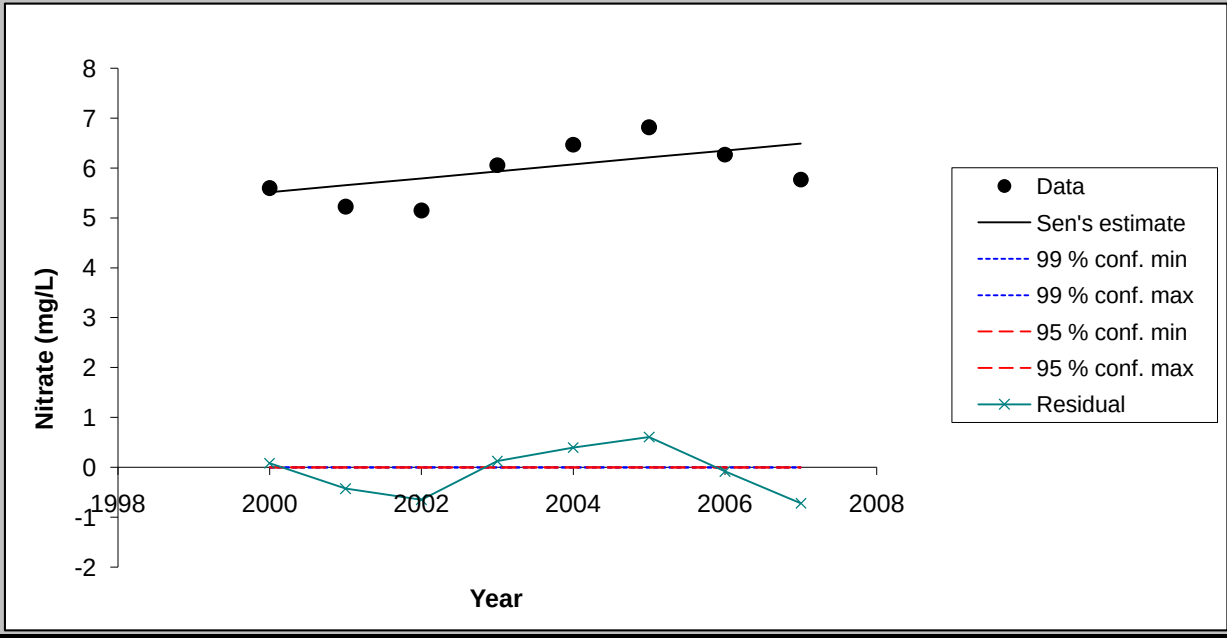

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	5.60	5.52	0.00	0.00	0.00	0.00	0.08
2001	5.23	5.66	0.00	0.00	0.00	0.00	-0.43
2002	5.15	5.80	0.00	0.00	0.00	0.00	-0.65
2003	6.06	5.93	0.00	0.00	0.00	0.00	0.12
2004	6.47	6.07	0.00	0.00	0.00	0.00	0.40
2005	6.82	6.21	0.00	0.00	0.00	0.00	0.61
2006	6.27	6.35	0.00	0.00	0.00	0.00	-0.08
2007	5.77	6.49	0.00	0.00	0.00	0.00	-0.72

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-1.21E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.40E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

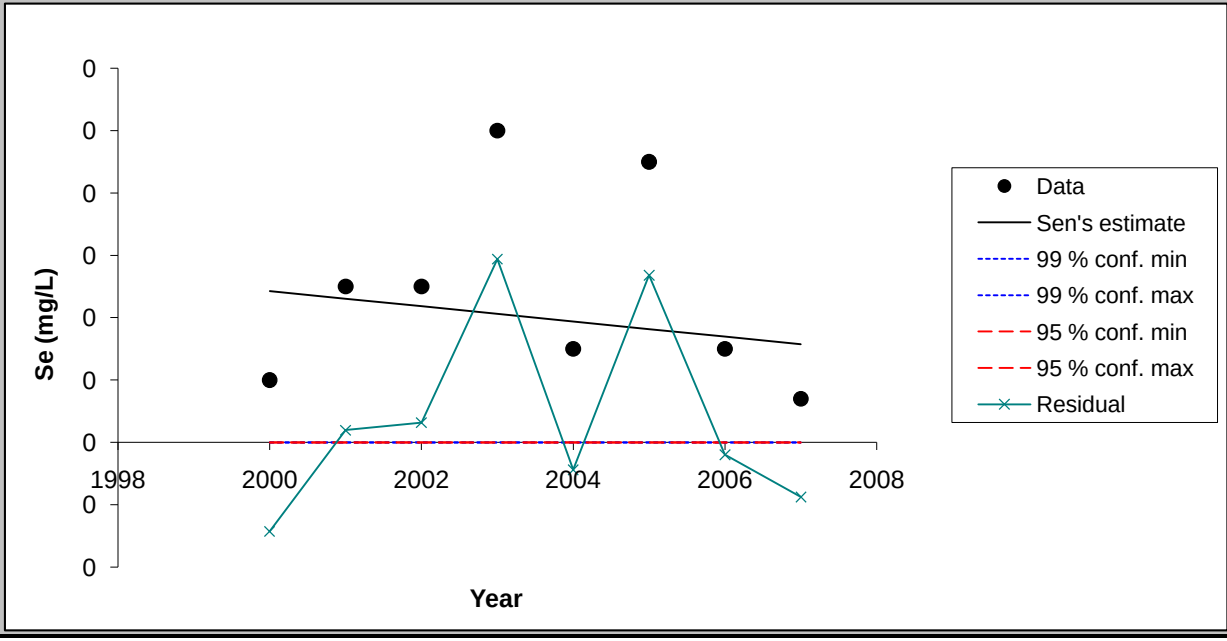

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-20
Test Z	
Signific.	*
Q	-1.99E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.17E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

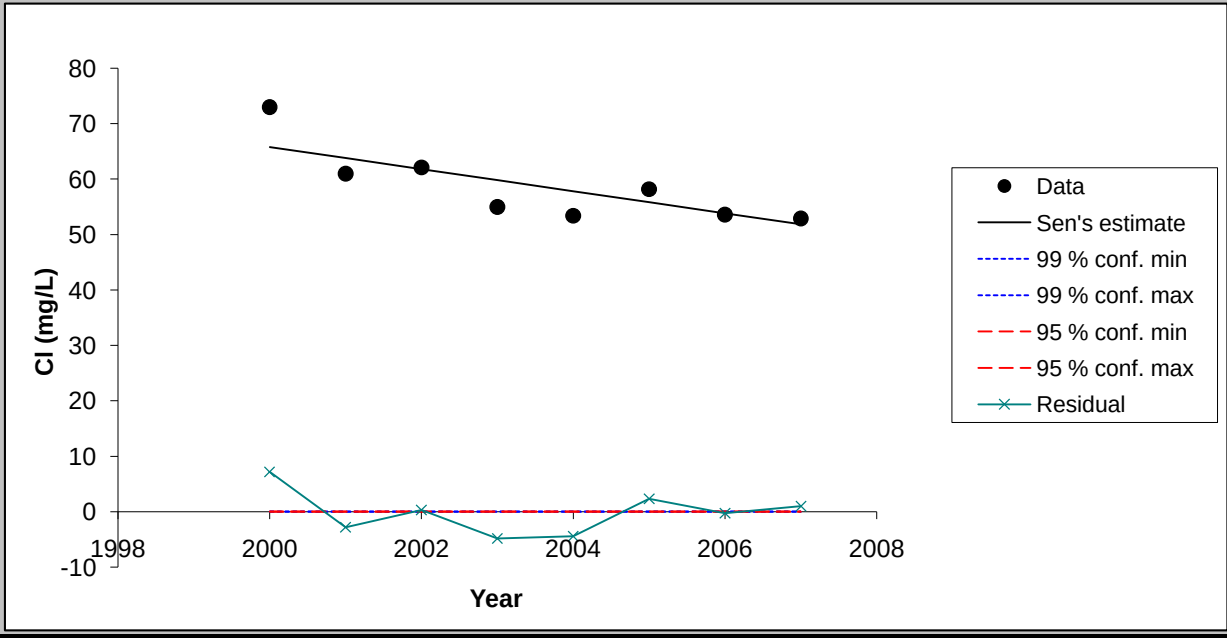

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	73.00	65.81	0.00	0.00	0.00	0.00	7.19
2001	61.00	63.82	0.00	0.00	0.00	0.00	-2.82
2002	62.12	61.84	0.00	0.00	0.00	0.00	0.29
2003	55.00	59.85	0.00	0.00	0.00	0.00	-4.85
2004	53.40	57.86	0.00	0.00	0.00	0.00	-4.46
2005	58.20	55.87	0.00	0.00	0.00	0.00	2.33
2006	53.60	53.89	0.00	0.00	0.00	0.00	-0.29
2007	52.90	51.90	0.00	0.00	0.00	0.00	1.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	11
Test Z	
Signific.	
Q	3.15E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.53E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

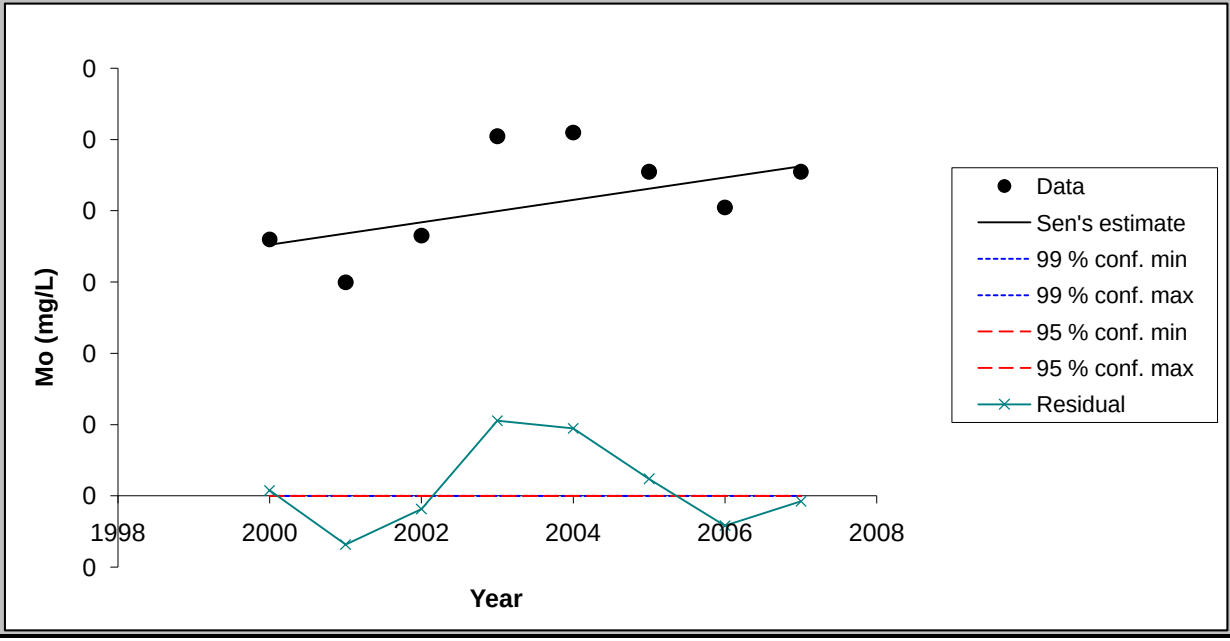

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.07	0.07	0.00	0.00	0.00	0.00	0.00
2001	0.06	0.07	0.00	0.00	0.00	0.00	-0.01
2002	0.07	0.08	0.00	0.00	0.00	0.00	0.00
2003	0.10	0.08	0.00	0.00	0.00	0.00	0.02
2004	0.10	0.08	0.00	0.00	0.00	0.00	0.02
2005	0.09	0.09	0.00	0.00	0.00	0.00	0.00
2006	0.08	0.09	0.00	0.00	0.00	0.00	-0.01
2007	0.09	0.09	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-56 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-24
Test Z	
Signific.	**
Q	-4.17E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.87E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

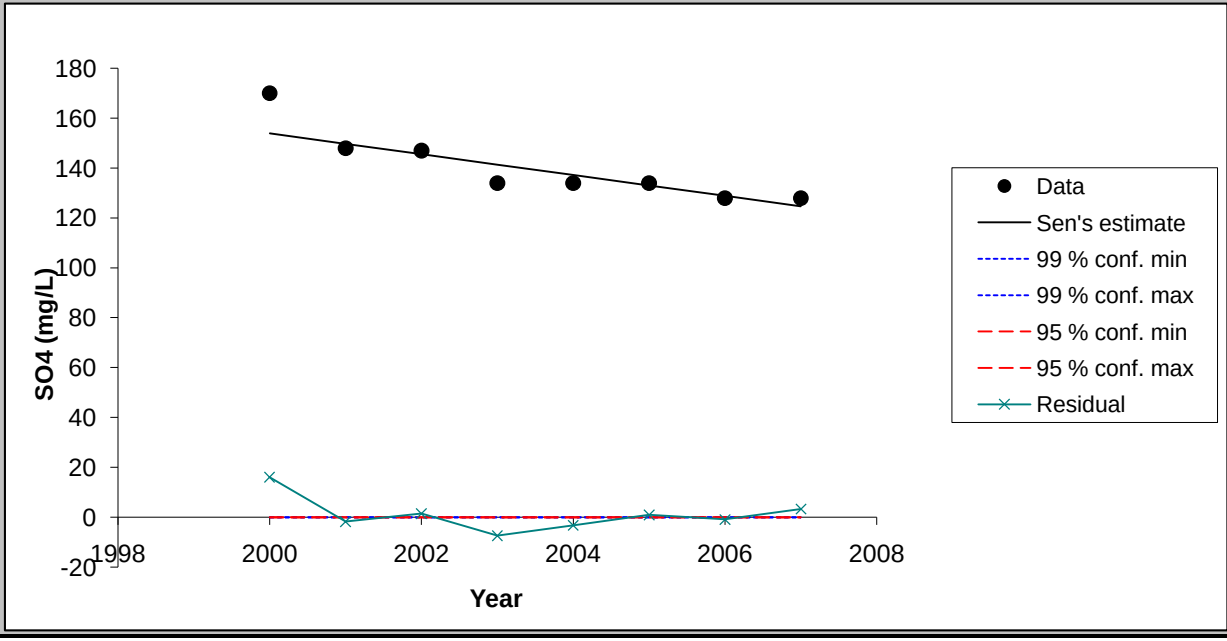

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1992

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	170.00	153.95	0.00	0.00	0.00	0.00	16.05
2001	148.00	149.78	0.00	0.00	0.00	0.00	-1.78
2002	147.03	145.60	0.00	0.00	0.00	0.00	1.43
2003	134.00	141.43	0.00	0.00	0.00	0.00	-7.43
2004	134.00	137.26	0.00	0.00	0.00	0.00	-3.26
2005	134.00	133.09	0.00	0.00	0.00	0.00	0.91
2006	128.00	128.91	0.00	0.00	0.00	0.00	-0.91
2007	128.00	124.74	0.00	0.00	0.00	0.00	3.26

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Calf Spring (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	4	4	4	4	4	4	4	4
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.006	3	0.0075	2.56	0.002	87		126
1992	0.0054	2.72	0.0038	2.64	0.183	114	0.0511	180
1993	0.0029	3.34	0.0126	6.67	0.288	134	0.0697	317.5
1994	0.0055	4.26	0.0032	5.96	0.279	148	0.0873	351
1995	0.005	4.4	0.0005	7.5	0.32	130	0.083	350
1996	0.0048	5.4	0.0005	8.1	0.25	130	0.085	480
1997	0.0052	4.9	0.0005	9.4	0.22	110	0.086	490
1998	0.005	4.7	0.0005	7.8	0.21	110	0.081	510
1999	0.0033	4.2	0.0005	6.3	0.14	71	0.077	410
2000	0.0031	3.8	0.0005	6	0.16	88	0.08	400
2001	0.006	3.8	0.005	6.51	0.188	100	0.06	508
2002								
2003								
2004								
2005	0.0115	2.51	0.0303	6.56	0.385	121	0.0492	487
2006								
2007	0.0095	3.09	14.7	8.8	0.137	128	0.0691	553

TREND STATISTICS

Calf Spring (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*4*	*4*			0.001					-0.01				
F (mg/L)	*2000*	*2007*	*4*	*-3*			-0.110					4.82				
Mn (mg/L)	*2000*	*2007*	*4*	*6*		+	1.053					-10.00				
Nitrate (mg/L)	*2000*	*2007*	*4*	*6*		+	0.391					2.51				
Se (mg/L)	*2000*	*2007*	*4*	*0*			0.012					0.06				
Cl (mg/L)	*2000*	*2007*	*4*	*6*		+	5.482					42.27				
Mo (mg/L)	*2000*	*2007*	*4*	*-2*			-0.002					0.09				
SO4 (mg/L)	*2000*	*2007*	*4*	*4*			19.629					231.14				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

Calf Spring (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	4
Test S	4
Test Z	
Signific.	
Q	1.14E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-6.32E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

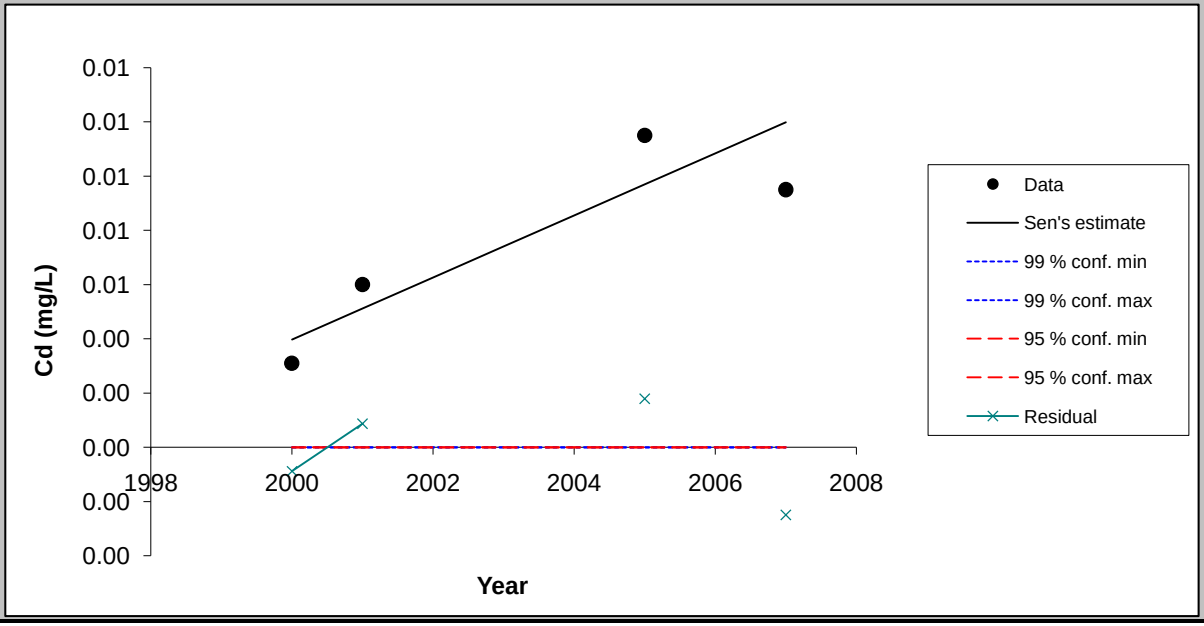

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002		0.01	0.00	0.00	0.00	0.00	
2003		0.01	0.00	0.00	0.00	0.00	
2004		0.01	0.00	0.00	0.00	0.00	
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006		0.01	0.00	0.00	0.00	0.00	
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	4
Test S	-3
Test Z	
Signific.	
Q	-1.10E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.82E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

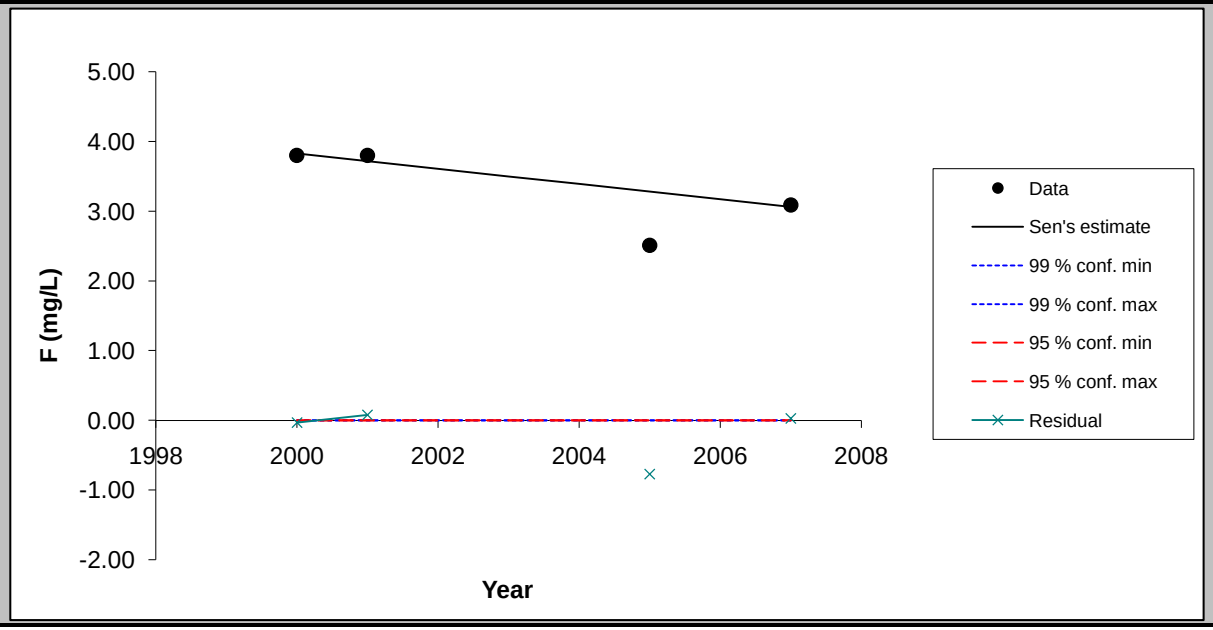

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	3.80	3.83	0.00	0.00	0.00	0.00	-0.03
2001	3.80	3.72	0.00	0.00	0.00	0.00	0.08
2002		3.61	0.00	0.00	0.00	0.00	
2003		3.50	0.00	0.00	0.00	0.00	
2004		3.39	0.00	0.00	0.00	0.00	
2005	2.51	3.28	0.00	0.00	0.00	0.00	-0.77
2006		3.17	0.00	0.00	0.00	0.00	
2007	3.09	3.06	0.00	0.00	0.00	0.00	0.03

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	4
Test S	6
Test Z	
Signific.	+
Q	1.05E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.00E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

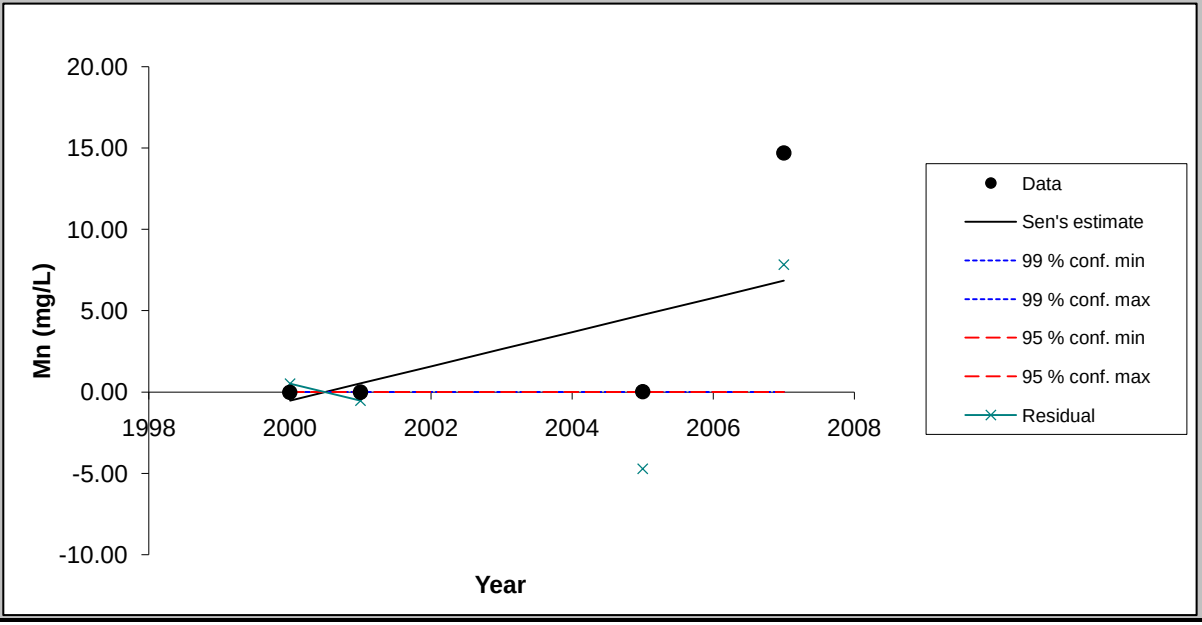

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	-0.52	0.00	0.00	0.00	0.00	0.52
2001	0.00	0.53	0.00	0.00	0.00	0.00	-0.52
2002		1.58	0.00	0.00	0.00	0.00	
2003		2.64	0.00	0.00	0.00	0.00	
2004		3.69	0.00	0.00	0.00	0.00	
2005	0.03	4.74	0.00	0.00	0.00	0.00	-4.71
2006		5.79	0.00	0.00	0.00	0.00	
2007	14.70	6.85	0.00	0.00	0.00	0.00	7.85

FIGURE

< Previous Time Series | Next Time Series >

Calf Spring (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	4
Test S	6
Test Z	
Signific.	+
Q	3.91E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.51E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

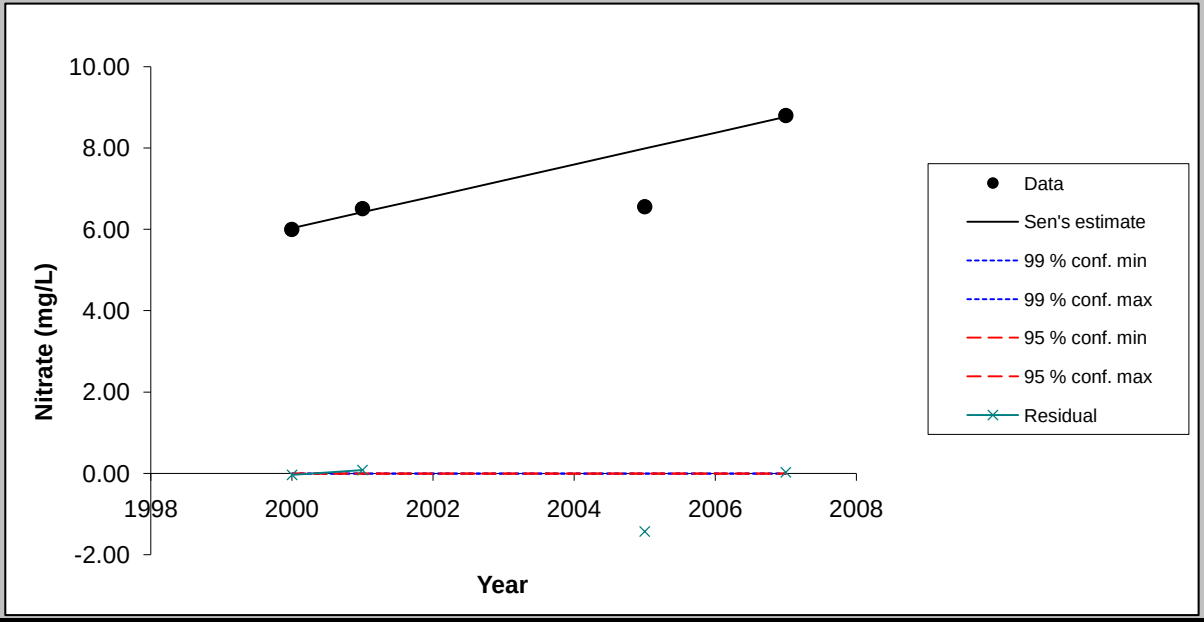

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	6.00	6.03	0.00	0.00	0.00	0.00	-0.03
2001	6.51	6.42	0.00	0.00	0.00	0.00	0.09
2002		6.81	0.00	0.00	0.00	0.00	
2003		7.20	0.00	0.00	0.00	0.00	
2004		7.60	0.00	0.00	0.00	0.00	
2005	6.56	7.99	0.00	0.00	0.00	0.00	-1.43
2006		8.38	0.00	0.00	0.00	0.00	
2007	8.80	8.77	0.00	0.00	0.00	0.00	0.03

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	4
Test S	0
Test Z	
Signific.	
Q	1.24E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.66E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

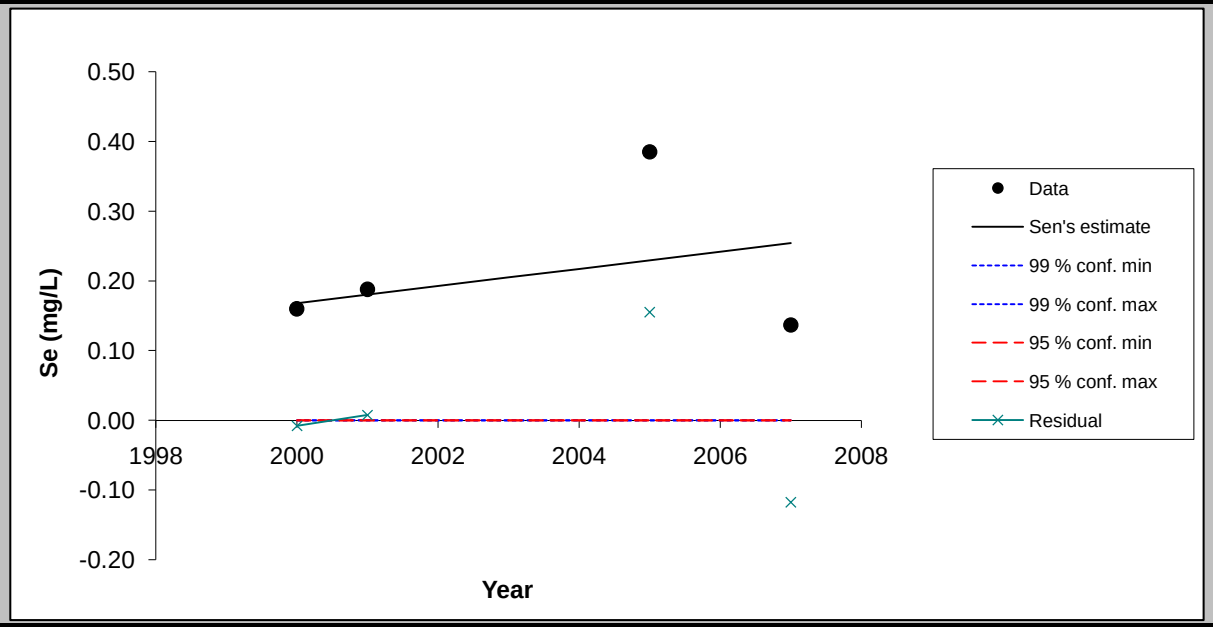

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.16	0.17	0.00	0.00	0.00	0.00	-0.01
2001	0.19	0.18	0.00	0.00	0.00	0.00	0.01
2002		0.19	0.00	0.00	0.00	0.00	
2003		0.20	0.00	0.00	0.00	0.00	
2004		0.22	0.00	0.00	0.00	0.00	
2005	0.39	0.23	0.00	0.00	0.00	0.00	0.16
2006		0.24	0.00	0.00	0.00	0.00	
2007	0.14	0.25	0.00	0.00	0.00	0.00	-0.12

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	4
Test S	6
Test Z	
Signific.	+
Q	5.48E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.23E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

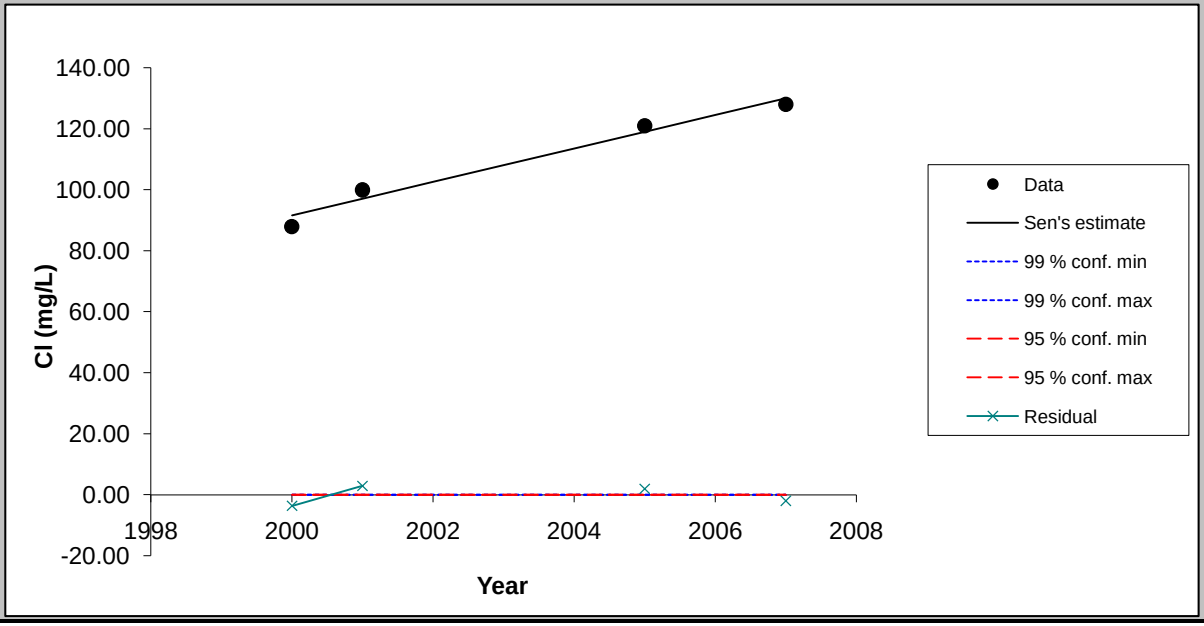

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	88.00	91.61	0.00	0.00	0.00	0.00	-3.61
2001	100.00	97.09	0.00	0.00	0.00	0.00	2.91
2002		102.57	0.00	0.00	0.00	0.00	
2003		108.05	0.00	0.00	0.00	0.00	
2004		113.54	0.00	0.00	0.00	0.00	
2005	121.00	119.02	0.00	0.00	0.00	0.00	1.98
2006		124.50	0.00	0.00	0.00	0.00	
2007	128.00	129.98	0.00	0.00	0.00	0.00	-1.98

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	4
Test S	-2
Test Z	
Signific.	
Q	-2.13E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.02E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

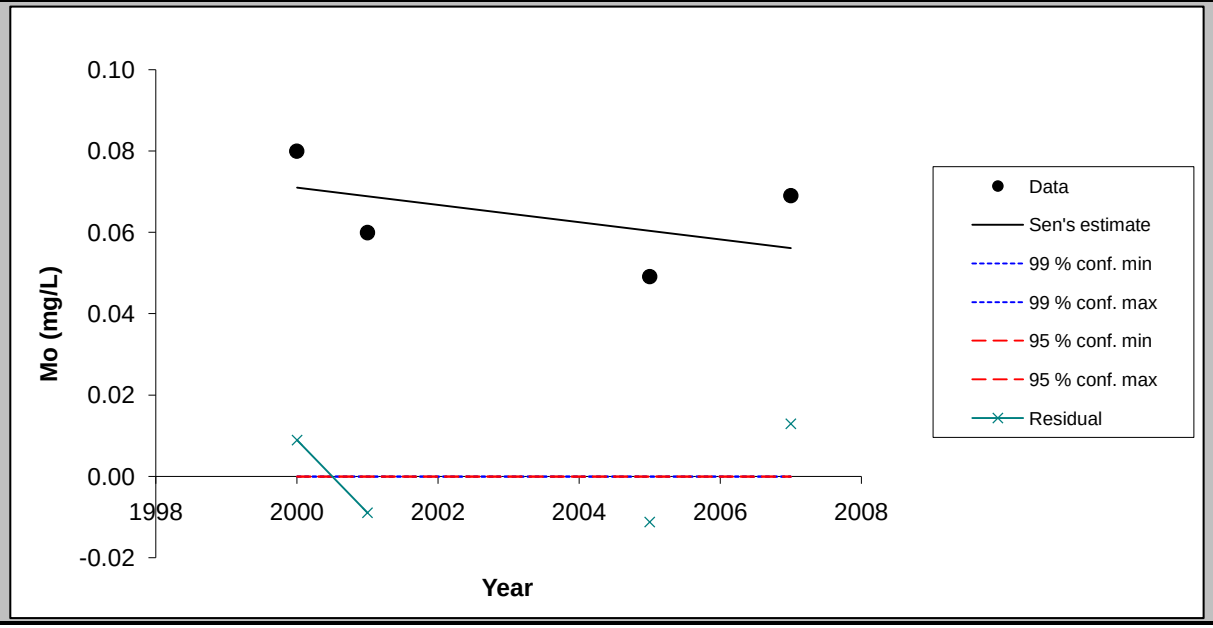

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.08	0.07	0.00	0.00	0.00	0.00	0.01
2001	0.06	0.07	0.00	0.00	0.00	0.00	-0.01
2002		0.07	0.00	0.00	0.00	0.00	
2003		0.06	0.00	0.00	0.00	0.00	
2004		0.06	0.00	0.00	0.00	0.00	
2005	0.05	0.06	0.00	0.00	0.00	0.00	-0.01
2006		0.06	0.00	0.00	0.00	0.00	
2007	0.07	0.06	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

Calf Spring (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	4
Test S	4
Test Z	
Signific.	
Q	1.96E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.31E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

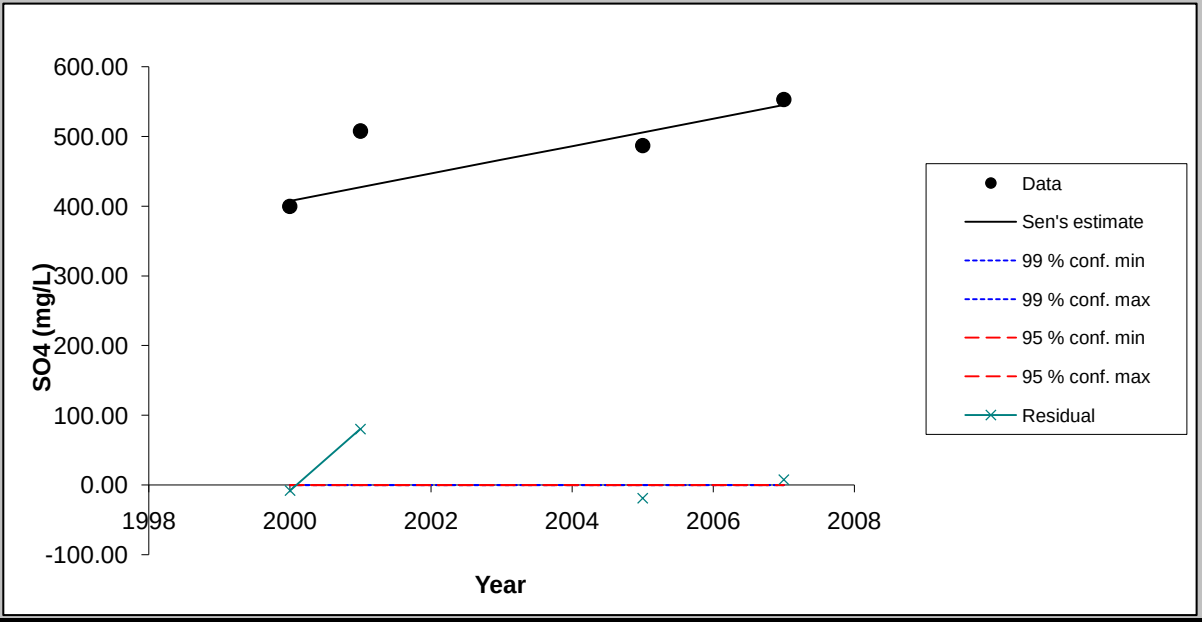

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	400.00	407.80	0.00	0.00	0.00	0.00	-7.80
2001	508.00	427.43	0.00	0.00	0.00	0.00	80.57
2002		447.06	0.00	0.00	0.00	0.00	
2003		466.69	0.00	0.00	0.00	0.00	
2004		486.31	0.00	0.00	0.00	0.00	
2005	487.00	505.94	0.00	0.00	0.00	0.00	-18.94
2006		525.57	0.00	0.00	0.00	0.00	
2007	553.00	545.20	0.00	0.00	0.00	0.00	7.80

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Homestead Spring (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	0.4	0.0025	5.5	0.0015	17		54
1992	0.0036	0.34	0.0014	5.45	0.015	20.4	0.0293	59.5
1993	0.0028	0.36	0.0093	5.94	0.0149	18.4	0.0048	65
1994	0.0006	0.41	0.001	7.25	0.0128	18.9	0.0065	66.2
1995	0.0001	0.4	0.0005	6.2	0.014	20	0.0025	66
1996	0.0001	0.48	0.0005	6.9	0.009	20	0.0025	65
1997	0.0001	0.44	0.016	7.2	0.024	25	0.0025	80
1998	0.0001	0.4	0.009	6	0.028	29	0.0025	100
1999	0.0001	0.53	0.007	7.6	0.032	26	0.0025	120
2000	0.0001	0.42	0.025	9.6	0.03	28	0.0025	110
2001	0.001	0.6	0.005	5.87	0.018	23	0.005	81
2002	0.001	0.73	0.03	6.66	0.023	24.8	0.005	86.6
2003	0.001	0.31	0.0046	7.66	0.011	24.7	0.0204	88
2004	0.001	0.25	0.006	7.29	0.023	27	0.0084	98.1
2005	0.001	0.244	0.0247	9.35	0.015	30	0.004	85.5
2006	0.001	0.44	0.0048	15	0.011	27.1	0.004	81.9
2007	0.001	0.61	0.002	14.3	0.0071	27.6	0.0155	87.2

TREND STATISTICS

Homestead Spring (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-3*			0.0000					0.001				
F (mg/L)	*2000*	*2007*	*8*	*-2*			-0.015					0.61				
Mn (mg/L)	*2000*	*2007*	*8*	*-12*			-0.0010					0.019				
Nitrate (mg/L)	*2000*	*2007*	*8*	*14*			0.896					-3.09				
Se (mg/L)	*2000*	*2007*	*8*	*-19*		*	-0.0031					0.057				
Cl (mg/L)	*2000*	*2007*	*8*	*10*			0.559					18.70				
Mo (mg/L)	*2000*	*2007*	*8*	*6*			0.0007					-0.003				
SO4 (mg/L)	*2000*	*2007*	*8*	*-4*			-0.783					96.93				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-3
Test Z	
Signific.	
Q	0.00E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

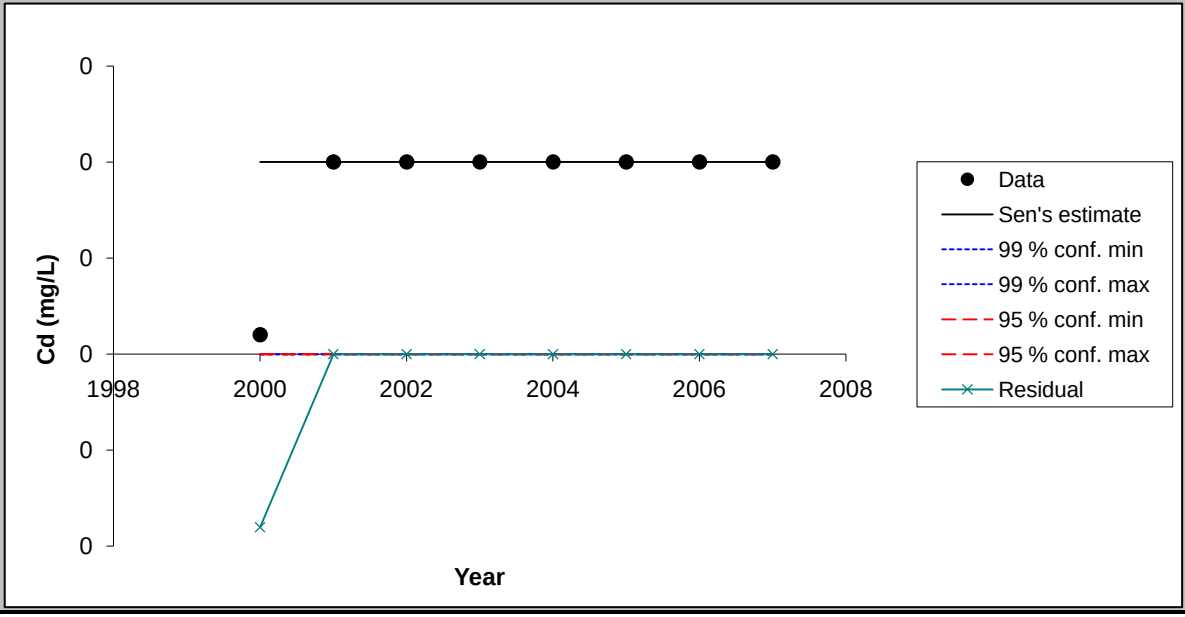

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-1.51E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.11E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

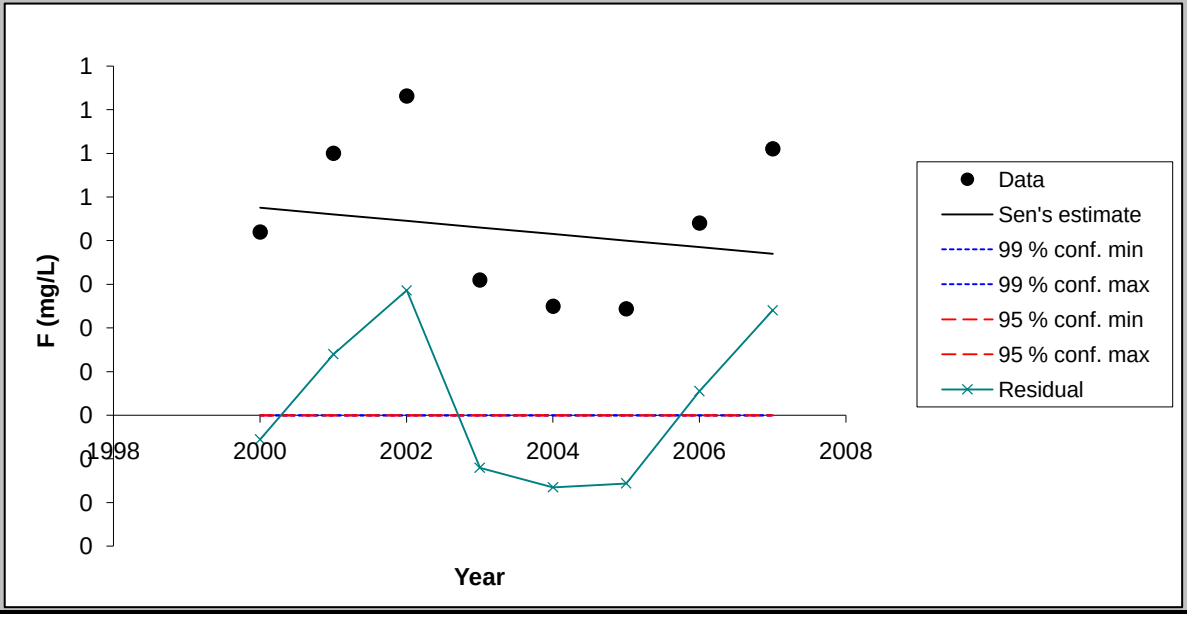

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.42	0.48	0.00	0.00	0.00	0.00	-0.06
2001	0.60	0.46	0.00	0.00	0.00	0.00	0.14
2002	0.73	0.45	0.00	0.00	0.00	0.00	0.29
2003	0.31	0.43	0.00	0.00	0.00	0.00	-0.12
2004	0.25	0.41	0.00	0.00	0.00	0.00	-0.16
2005	0.24	0.40	0.00	0.00	0.00	0.00	-0.16
2006	0.44	0.38	0.00	0.00	0.00	0.00	0.06
2007	0.61	0.37	0.00	0.00	0.00	0.00	0.24

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-9.92E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.93E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

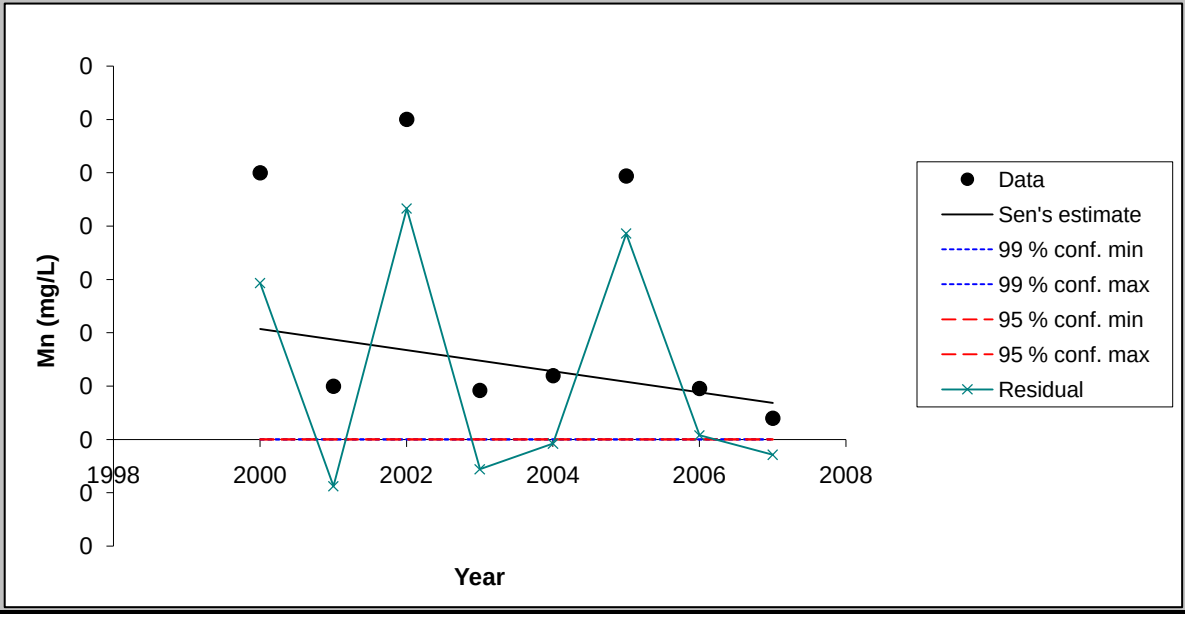

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.01	0.00	0.00	0.00	0.00	0.01
2001	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.01	0.00	0.00	0.00	0.00	0.02
2003	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.02	0.01	0.00	0.00	0.00	0.00	0.02
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	8.96E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-3.09E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

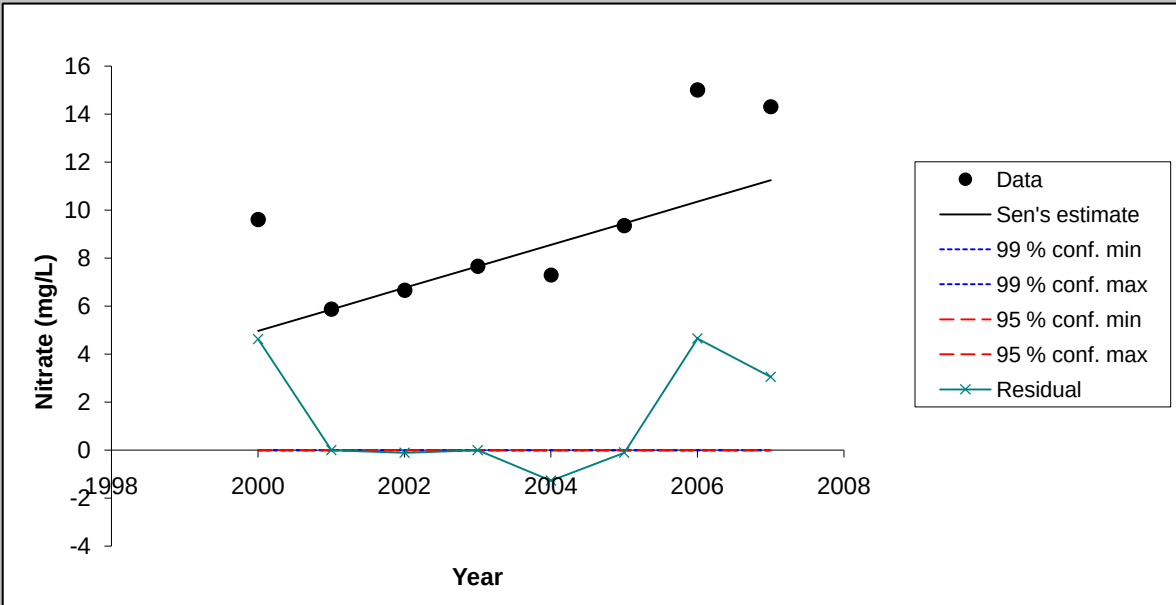

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	9.60	4.97	0.00	0.00	0.00	0.00	4.63
2001	5.87	5.87	0.00	0.00	0.00	0.00	0.00
2002	6.66	6.76	0.00	0.00	0.00	0.00	-0.11
2003	7.66	7.66	0.00	0.00	0.00	0.00	0.00
2004	7.29	8.56	0.00	0.00	0.00	0.00	-1.27
2005	9.35	9.45	0.00	0.00	0.00	0.00	-0.10
2006	15.00	10.35	0.00	0.00	0.00	0.00	4.65
2007	14.30	11.24	0.00	0.00	0.00	0.00	3.06

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-19
Test Z	
Signific.	*
Q	-3.08E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.71E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

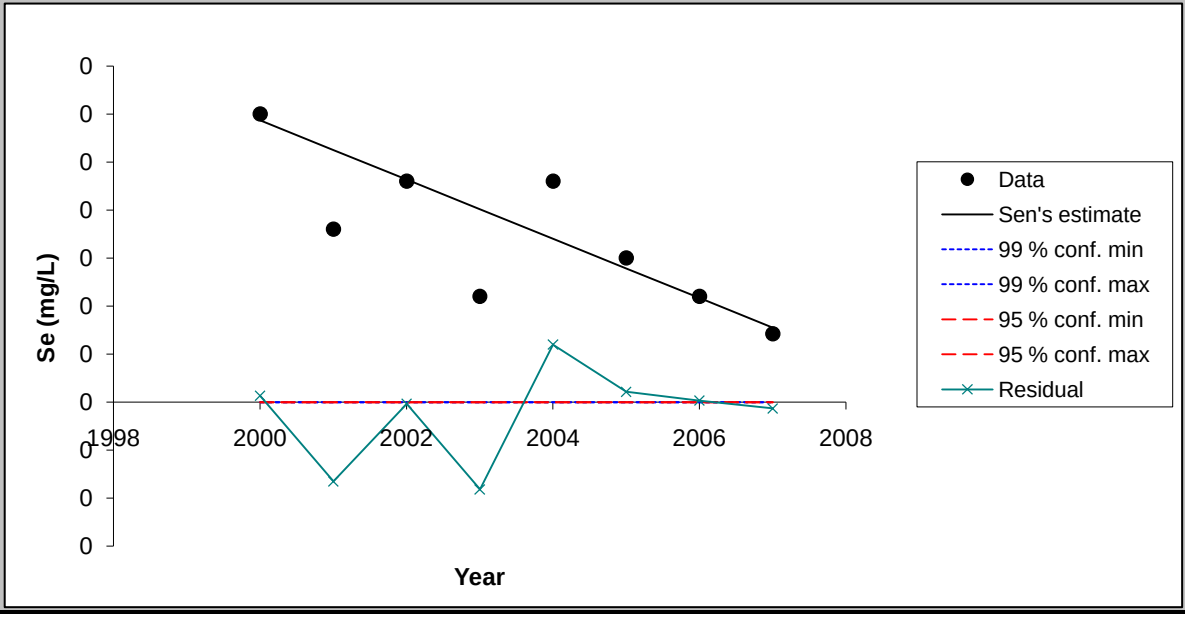

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.02	0.02	0.00	0.00	0.00	0.00	0.01
2005	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	10
Test Z	
Signific.	
Q	5.59E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.87E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

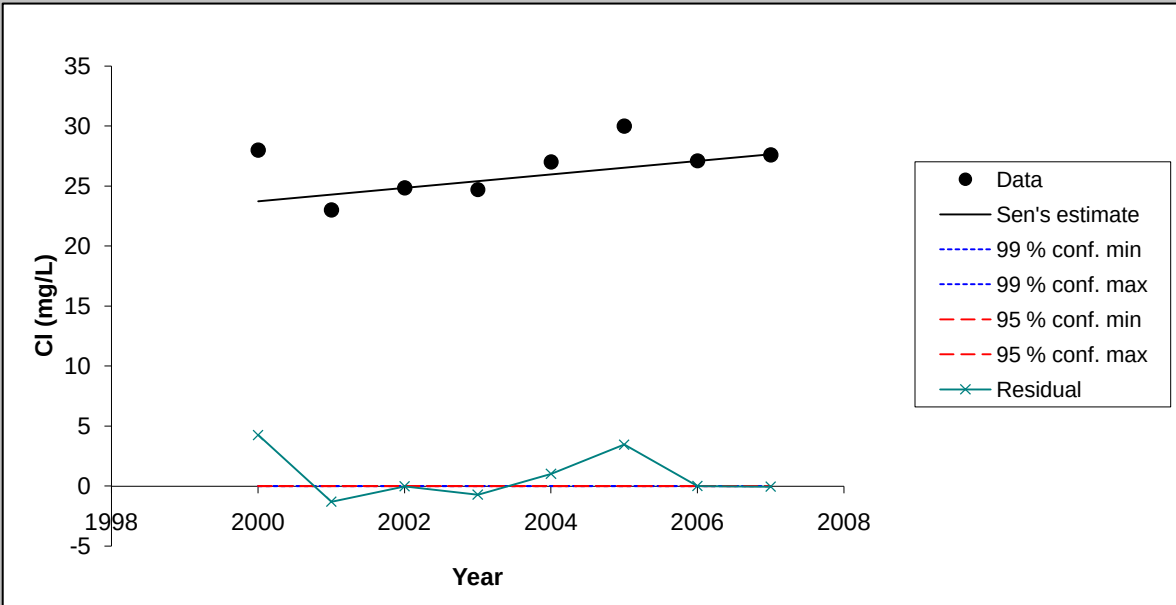

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	28.00	23.73	0.00	0.00	0.00	0.00	4.27
2001	23.00	24.29	0.00	0.00	0.00	0.00	-1.29
2002	24.84	24.85	0.00	0.00	0.00	0.00	-0.01
2003	24.70	25.41	0.00	0.00	0.00	0.00	-0.71
2004	27.00	25.97	0.00	0.00	0.00	0.00	1.03
2005	30.00	26.53	0.00	0.00	0.00	0.00	3.47
2006	27.10	27.09	0.00	0.00	0.00	0.00	0.01
2007	27.60	27.65	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	6
Test Z	
Signific.	
Q	7.17E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-2.53E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

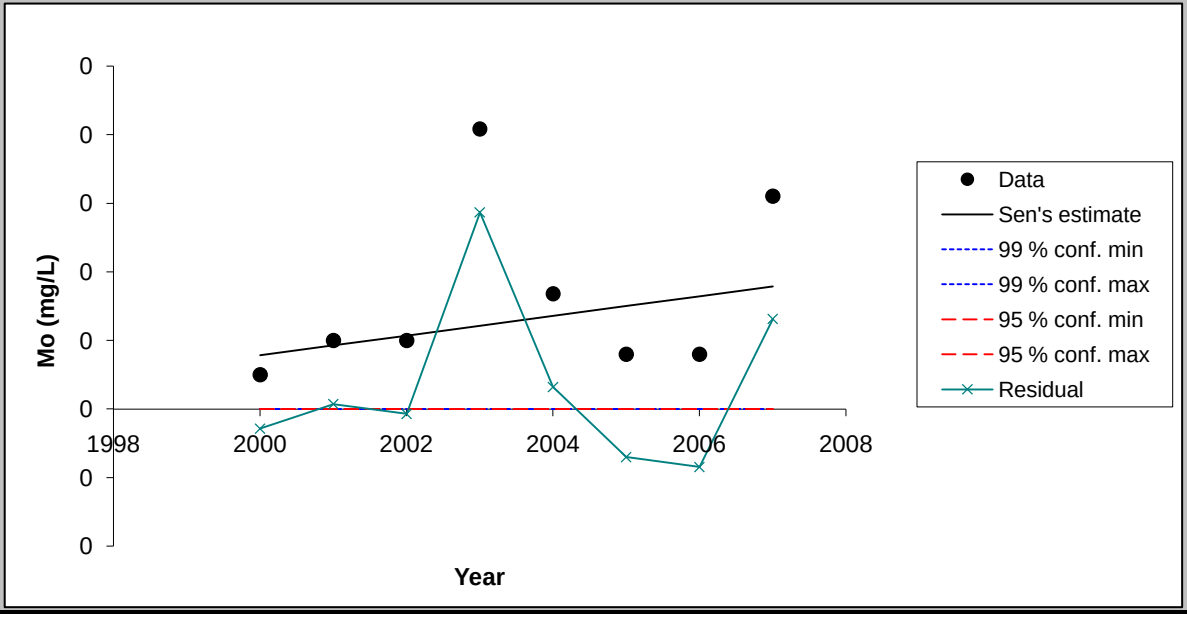

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.01	0.00	0.00	0.00	0.00	0.01
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.02	0.01	0.00	0.00	0.00	0.00	0.01

FIGURE

< Previous Time Series

Next Time Series >

Homestead Spring (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-7.83E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.69E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

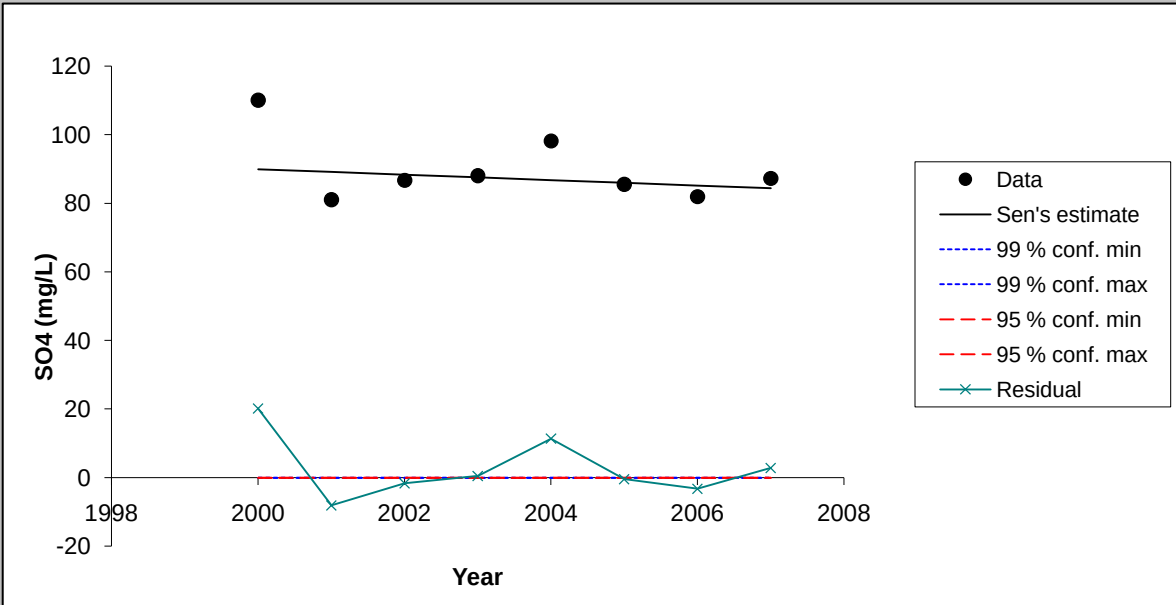

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	110.00	89.88	0.00	0.00	0.00	0.00	20.12
2001	81.00	89.10	0.00	0.00	0.00	0.00	-8.10
2002	86.64	88.32	0.00	0.00	0.00	0.00	-1.67
2003	88.00	87.53	0.00	0.00	0.00	0.00	0.47
2004	98.10	86.75	0.00	0.00	0.00	0.00	11.35
2005	85.50	85.97	0.00	0.00	0.00	0.00	-0.47
2006	81.90	85.18	0.00	0.00	0.00	0.00	-3.28
2007	87.20	84.40	0.00	0.00	0.00	0.00	2.80

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

Lewis Well 1991-2007

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0045	0.43	0.003	5.67	0.051	77.3	0.0556	237.5
1992	0.0032	0.4	0.003	5.92	0.09	87	0.054	269.8
1993	0.0046	0.38	0.006	9.85	0.062	90.9	0.115	278
1994	0.0044	0.42	0.002	7.83	0.062	88	0.107	290
1995	0.0002	0.45	0.0005	8.9	0.054	88	0.117	250
1996	0.0004	0.48	0.001	12	0.022	74	0.154	270
1997	0.0002	0.48	0.0005	10	0.016	66	0.267	220
1998	0.0002	0.5	0.0005	8.8	0.013	52	0.251	180
1999	0.0002	0.55	0.0005	7.55	0.009	37	0.211	150
2000	0.0002	0.47	0.0005	6.3	0.01	49	0.178	140
2001	0.002	0.7	0.005	8.86	0.01	38	0.13	133
2002	0.0155	0.727	0.03	7.19	0.02	42.938	0.1637	146.308
2003	0.002	0.37	0.001	5.3	0.01	43.7	0.114	161
2004	0.002	0.36	0.001	5.05	0.047	55.7	0.0857	227
2005	0.002	0.228	0.004	8.15	0.056	69.3	0.0779	250
2006	0.002	0.49	0.002	9.15	0.046	58.3	0.076	226
2007	0.0006	0.2	0.00035	8.48	0.0085	54.7	0.098	198

TREND STATISTICS

Lewis Well 1991-2007

				Mann-Kendall trend			Sen's slope estimate				
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-8*			0.000				
F (mg/L)	*2000*	*2007*	*8*	*-14*			-0.045				
Mn (mg/L)	*2000*	*2007*	*8*	*-6*			0.000				
Nitrate (mg/L)	*2000*	*2007*	*8*	*6*			0.285				
Se (mg/L)	*2000*	*2007*	*8*	*5*			0.005				
Cl (mg/L)	*2000*	*2007*	*8*	*14*			2.767				
Mo (mg/L)	*2000*	*2007*	*8*	*-20*		*	-0.013				
SO4 (mg/L)	*2000*	*2007*	*8*	*16*		+	14.167				
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								
0	*0*	*0*	*0*								

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-2.77E-11
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.00E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

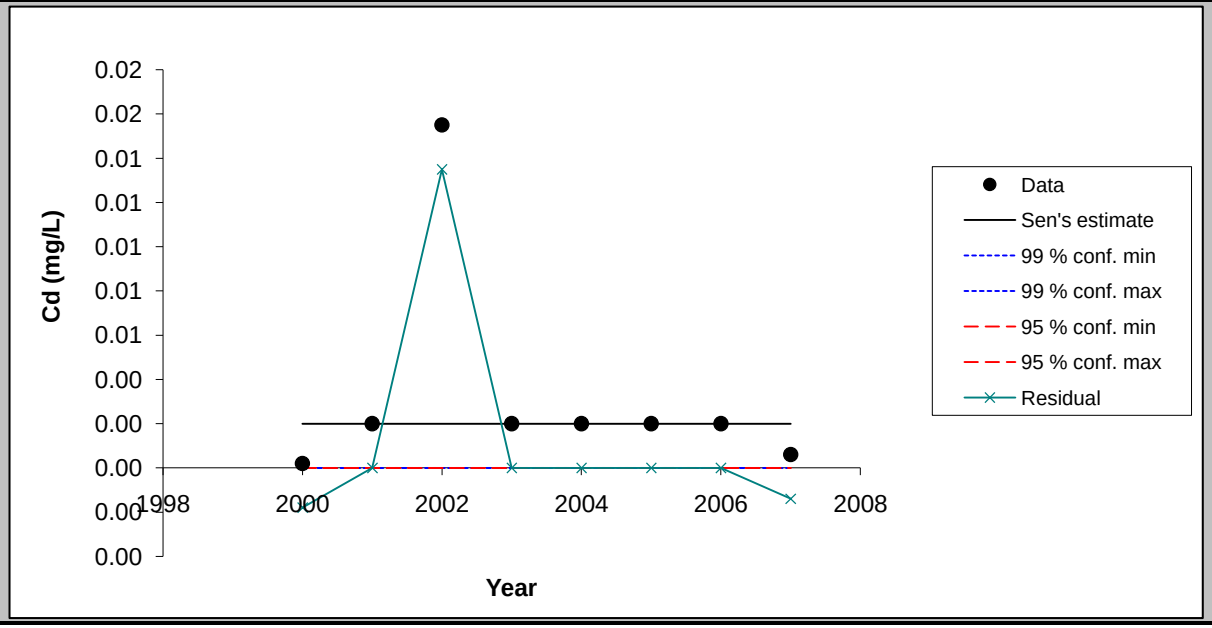

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.00	0.00	0.00	0.00	0.00	0.01
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-4.55E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.39E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

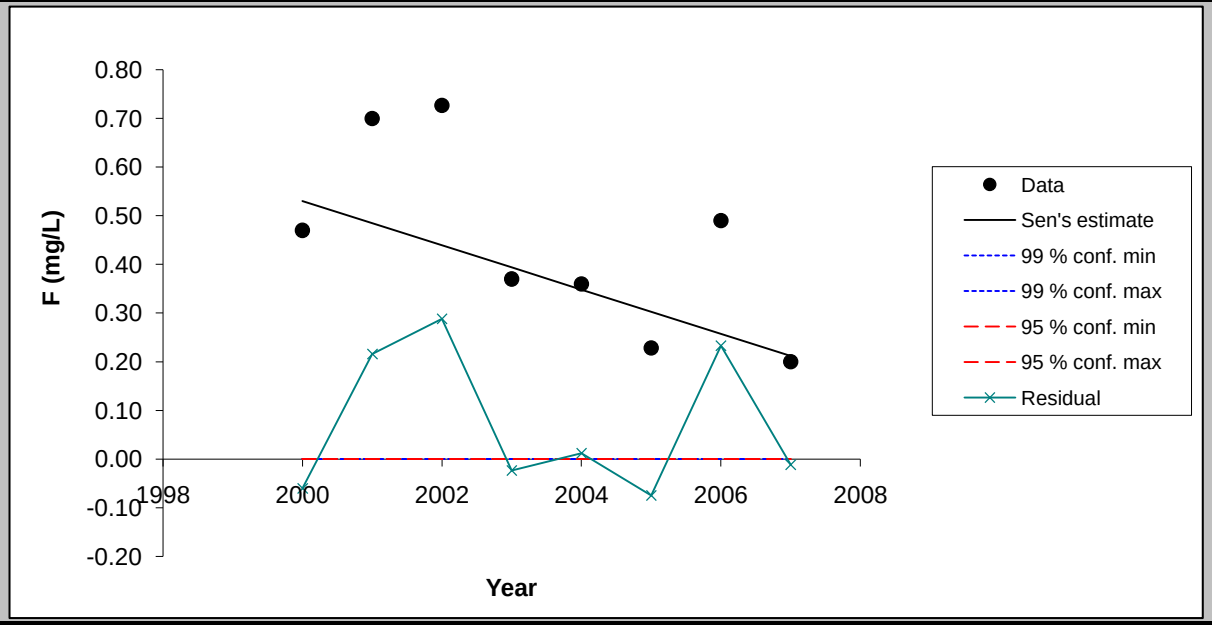

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.47	0.53	0.00	0.00	0.00	0.00	-0.06
2001	0.70	0.48	0.00	0.00	0.00	0.00	0.22
2002	0.73	0.44	0.00	0.00	0.00	0.00	0.29
2003	0.37	0.39	0.00	0.00	0.00	0.00	-0.02
2004	0.36	0.35	0.00	0.00	0.00	0.00	0.01
2005	0.23	0.30	0.00	0.00	0.00	0.00	-0.07
2006	0.49	0.26	0.00	0.00	0.00	0.00	0.23
2007	0.20	0.21	0.00	0.00	0.00	0.00	-0.01

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.90E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.15E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

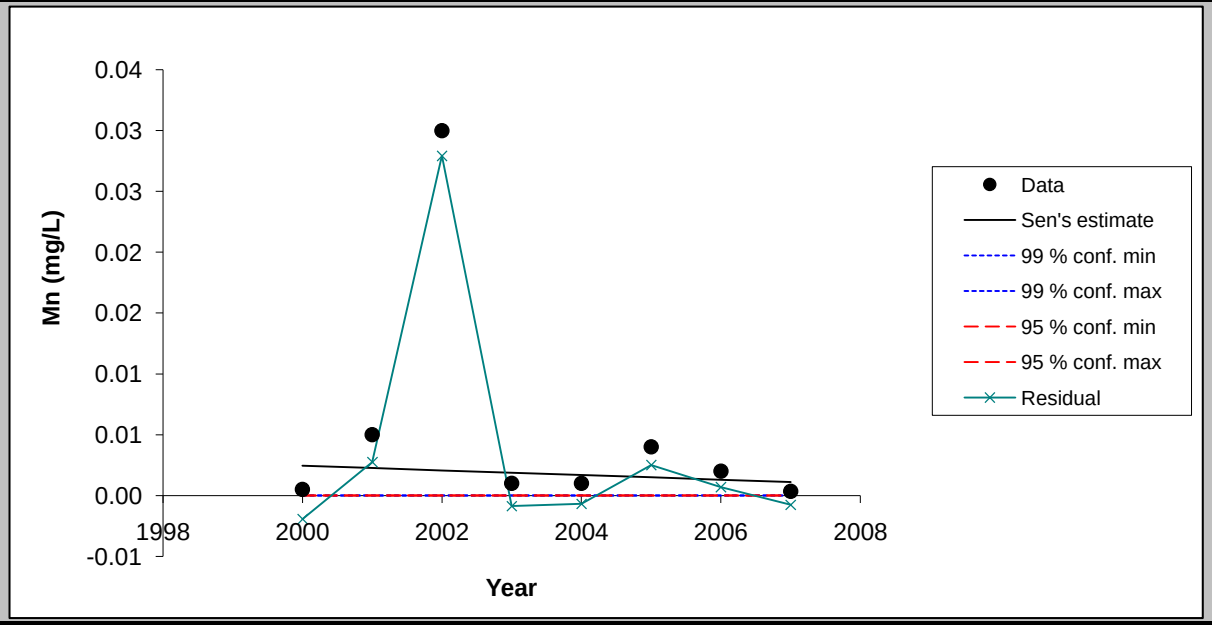

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.00	0.00	0.00	0.00	0.00	0.03
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	6
Test Z	
Signific.	
Q	2.85E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.99E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

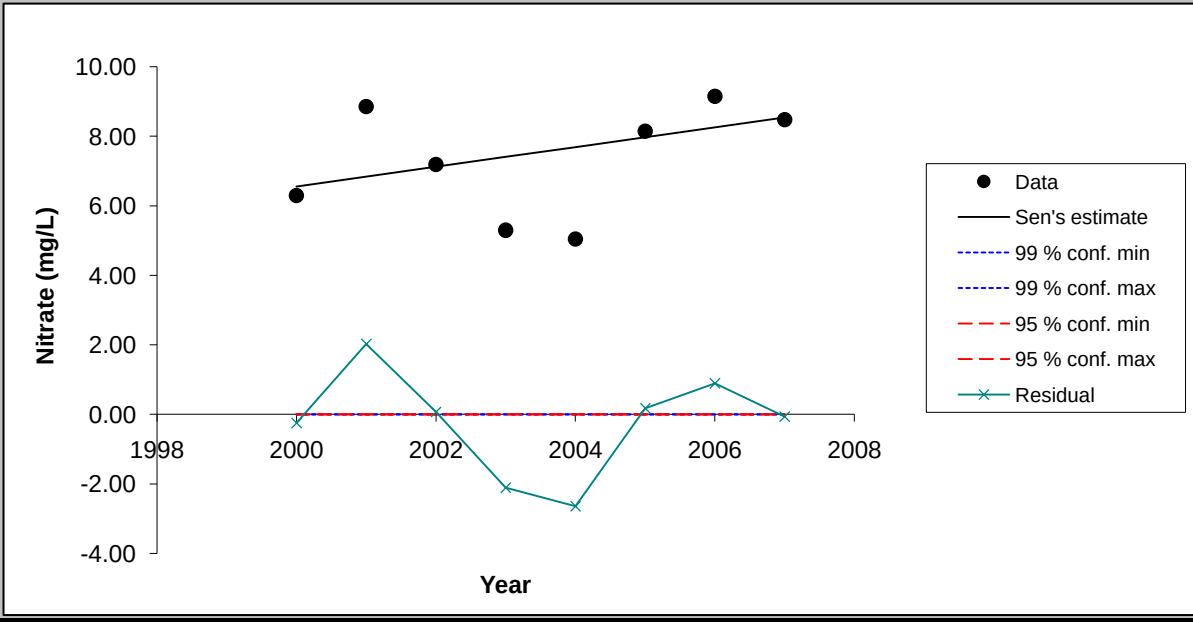

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	6.30	6.55	0.00	0.00	0.00	0.00	-0.25
2001	8.86	6.84	0.00	0.00	0.00	0.00	2.02
2002	7.19	7.12	0.00	0.00	0.00	0.00	0.07
2003	5.30	7.41	0.00	0.00	0.00	0.00	-2.11
2004	5.05	7.69	0.00	0.00	0.00	0.00	-2.64
2005	8.15	7.98	0.00	0.00	0.00	0.00	0.17
2006	9.15	8.26	0.00	0.00	0.00	0.00	0.89
2007	8.48	8.55	0.00	0.00	0.00	0.00	-0.07

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	5
Test Z	
Signific.	
Q	5.50E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-4.00E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

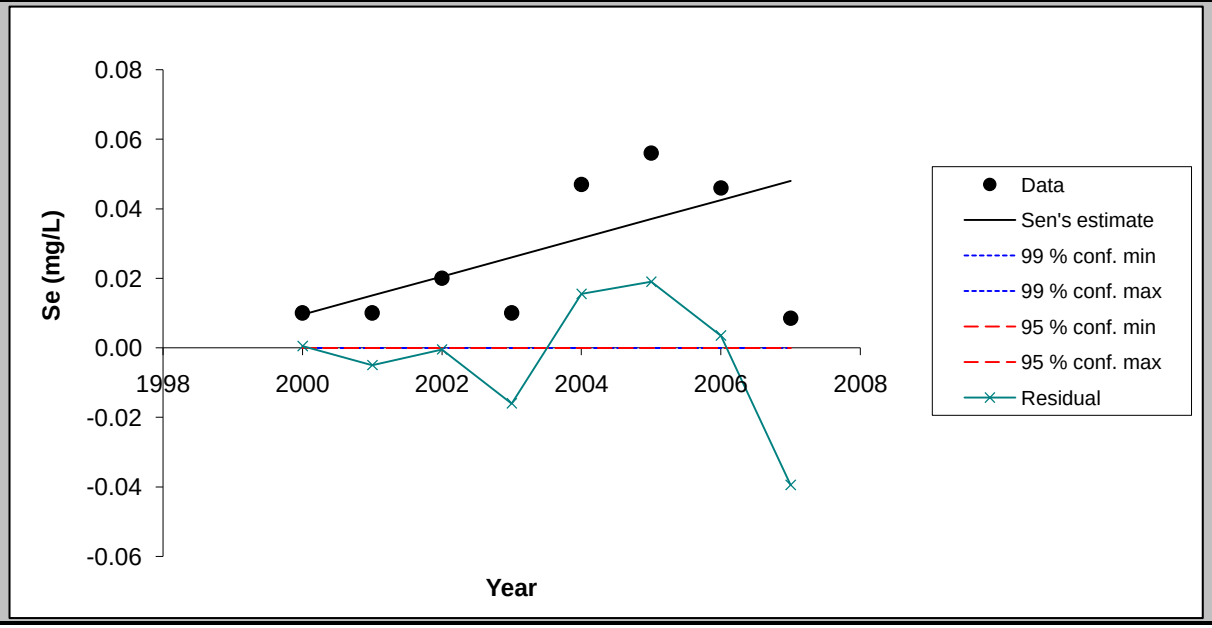

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.03	0.00	0.00	0.00	0.00	-0.02
2004	0.05	0.03	0.00	0.00	0.00	0.00	0.02
2005	0.06	0.04	0.00	0.00	0.00	0.00	0.02
2006	0.05	0.04	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.05	0.00	0.00	0.00	0.00	-0.04

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	14
Test Z	
Signific.	
Q	2.77E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.47E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

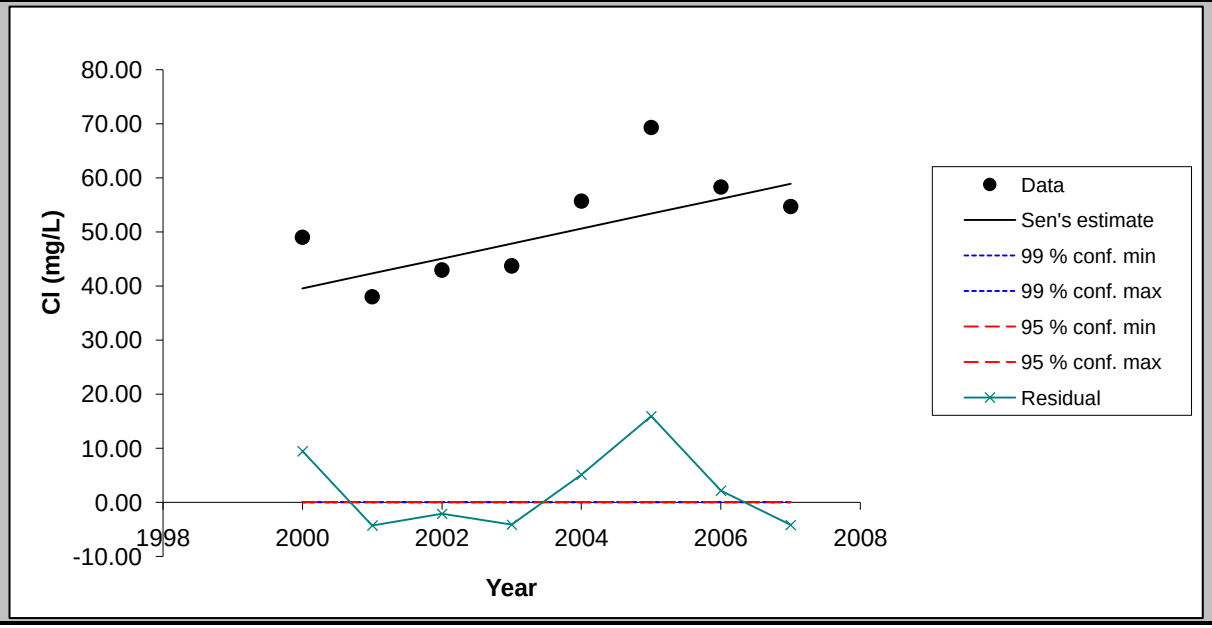

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	49.00	39.55	0.00	0.00	0.00	0.00	9.45
2001	38.00	42.32	0.00	0.00	0.00	0.00	-4.32
2002	42.94	45.09	0.00	0.00	0.00	0.00	-2.15
2003	43.70	47.85	0.00	0.00	0.00	0.00	-4.15
2004	55.70	50.62	0.00	0.00	0.00	0.00	5.08
2005	69.30	53.39	0.00	0.00	0.00	0.00	15.91
2006	58.30	56.15	0.00	0.00	0.00	0.00	2.15
2007	54.70	58.92	0.00	0.00	0.00	0.00	-4.22

FIGURE

< Previous Time Series

Next Time Series >

Lewis Well 1991-2007

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-20
Test Z	
Signific.	*
Q	-1.28E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.68E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

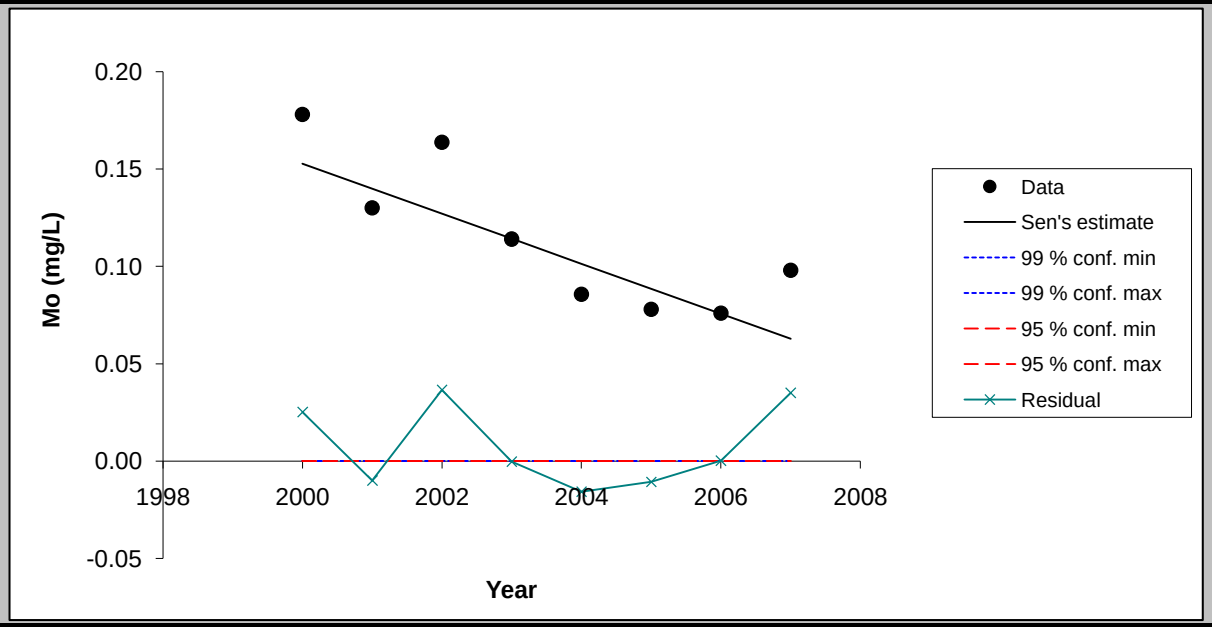

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.18	0.15	0.00	0.00	0.00	0.00	0.03
2001	0.13	0.14	0.00	0.00	0.00	0.00	-0.01
2002	0.16	0.13	0.00	0.00	0.00	0.00	0.04
2003	0.11	0.11	0.00	0.00	0.00	0.00	0.00
2004	0.09	0.10	0.00	0.00	0.00	0.00	-0.02
2005	0.08	0.09	0.00	0.00	0.00	0.00	-0.01
2006	0.08	0.08	0.00	0.00	0.00	0.00	0.00
2007	0.10	0.06	0.00	0.00	0.00	0.00	0.04

FIGURE

< Previous Time Series | Next Time Series >

Lewis Well 1991-2007

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	1.42E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.92E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

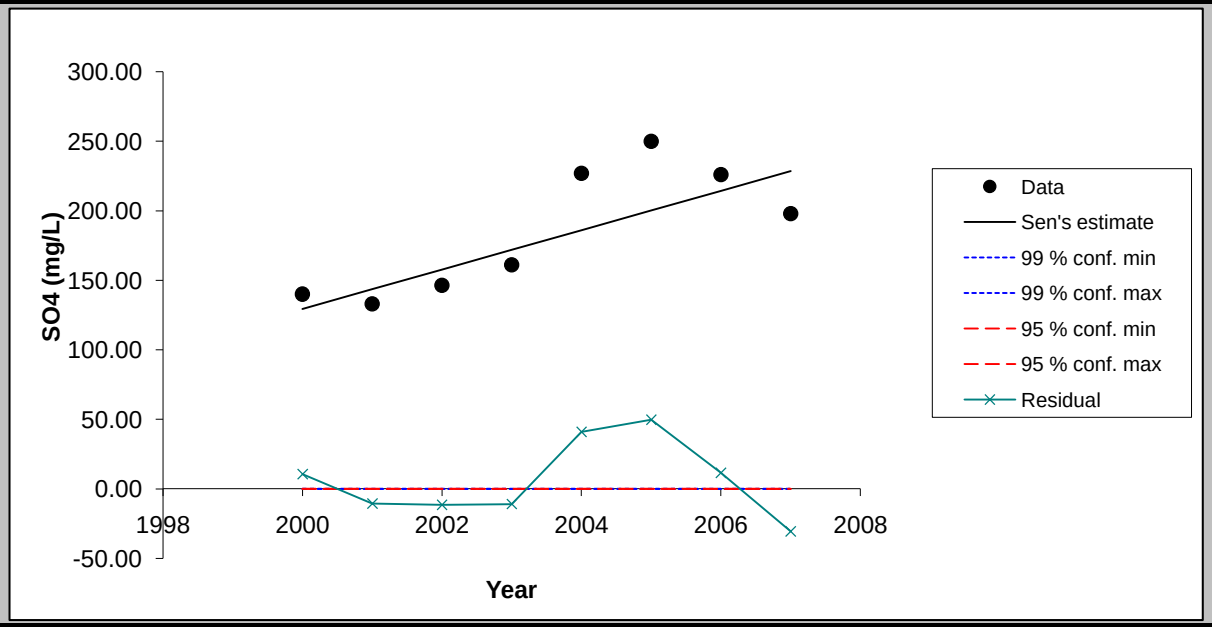

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	140.00	129.42	0.00	0.00	0.00	0.00	10.58
2001	133.00	143.58	0.00	0.00	0.00	0.00	-10.58
2002	146.31	157.75	0.00	0.00	0.00	0.00	-11.44
2003	161.00	171.92	0.00	0.00	0.00	0.00	-10.92
2004	227.00	186.08	0.00	0.00	0.00	0.00	40.92
2005	250.00	200.25	0.00	0.00	0.00	0.00	49.75
2006	226.00	214.42	0.00	0.00	0.00	0.00	11.58
2007	198.00	228.58	0.00	0.00	0.00	0.00	-30.58

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-22 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.0025	6.9	0.77	2.8	0.016	62		270
1992	0.0169	5.39	1.14	4.19	0.247	47.0	0.653	182
1993	0.0303	5.46	1.17	5.50	0.225	69.8	0.563	407.5
1994	0.0405	5.96	1.03	5.64	0.244	74.8	0.580	399
1995	0.023	5.3	0.94	5.3	0.22	52	0.556	260
1996	0.025	6	1.03	5.4	0.2	63	0.558	400
1997	0.04	8.3	1.34	8.7	0.29	93	0.62	690
1998	0.034	6.7	1.29	8.8	0.28	100	0.597	720
1999	0.035	6.9	1.23	9.3	0.33	79	0.628	810
2000	0.03	6.4	1.00	7.3	0.29	84	0.621	720
2001	0.023	5.3	0.93	5.07	0.213	37	0.55	241
2002	0.0279	4.49	1.10	4.32	0.189	28.4	0.471	168
2003	0.0235	3.9	0.988	4.41	0.242	23	0.398	136
2004	0.0244	3.37	0.933	3.77	0.245	24.8	0.328	127
2005	0.0267	3.66	0.956	4	0.197	26	0.338	133
2006	0.0249	3.82	0.919	4.6	0.282	38	0.312	183
2007	0.0234	4.17	0.786	4.63	0.105	32.2	0.328	148

TREND STATISTICS

TW-22 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-6*			-0.001					0.03				
F (mg/L)	*2000*	*2007*	*8*	*-14*			-0.307					8.17				
Mn (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.023					1.25				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-6*			-0.156					6.45				
Se (mg/L)	*2000*	*2007*	*8*	*-6*			-0.014					0.40				
Cl (mg/L)	*2000*	*2007*	*8*	*-4*			-1.312					47.25				
Mo (mg/L)	*2000*	*2007*	*8*	*-23*		**	-0.046					0.99				
SO4 (mg/L)	*2000*	*2007*	*8*	*-12*			-18.000					403.00				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-5.30E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.24E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

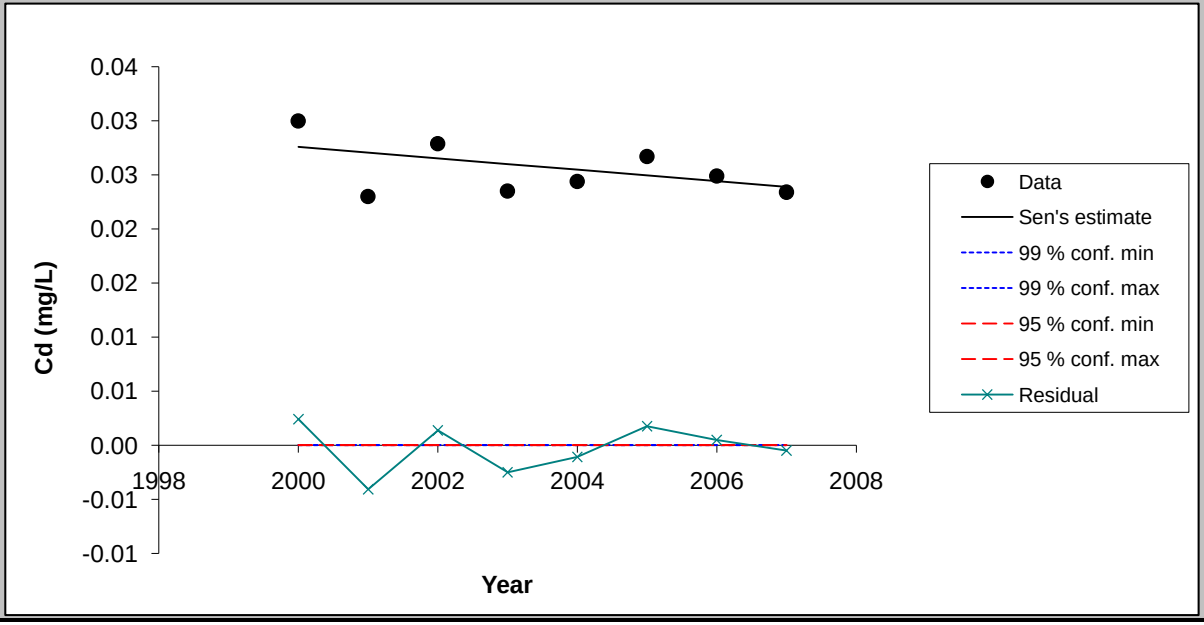

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2001	0.02	0.03	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.02	0.03	0.00	0.00	0.00	0.00	0.00
2004	0.02	0.03	0.00	0.00	0.00	0.00	0.00
2005	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2006	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2007	0.02	0.02	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-3.07E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	8.17E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

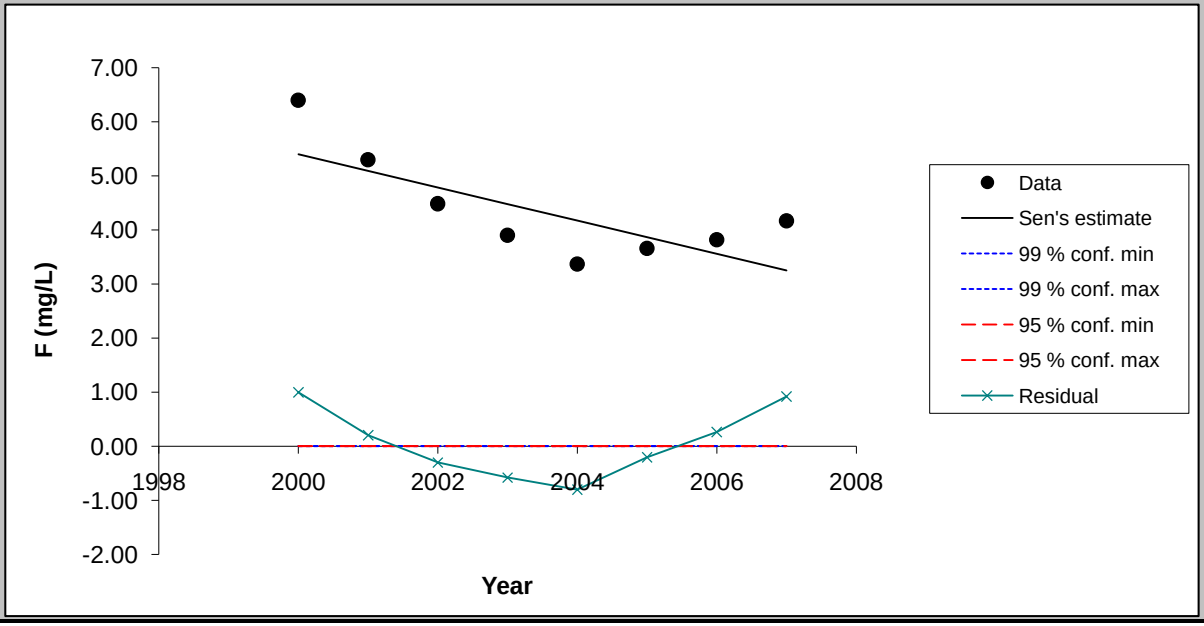

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	6.40	5.40	0.00	0.00	0.00	0.00	1.00
2001	5.30	5.09	0.00	0.00	0.00	0.00	0.21
2002	4.49	4.79	0.00	0.00	0.00	0.00	-0.30
2003	3.90	4.48	0.00	0.00	0.00	0.00	-0.58
2004	3.37	4.17	0.00	0.00	0.00	0.00	-0.80
2005	3.66	3.87	0.00	0.00	0.00	0.00	-0.21
2006	3.82	3.56	0.00	0.00	0.00	0.00	0.26
2007	4.17	3.25	0.00	0.00	0.00	0.00	0.92

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-2.35E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.25E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

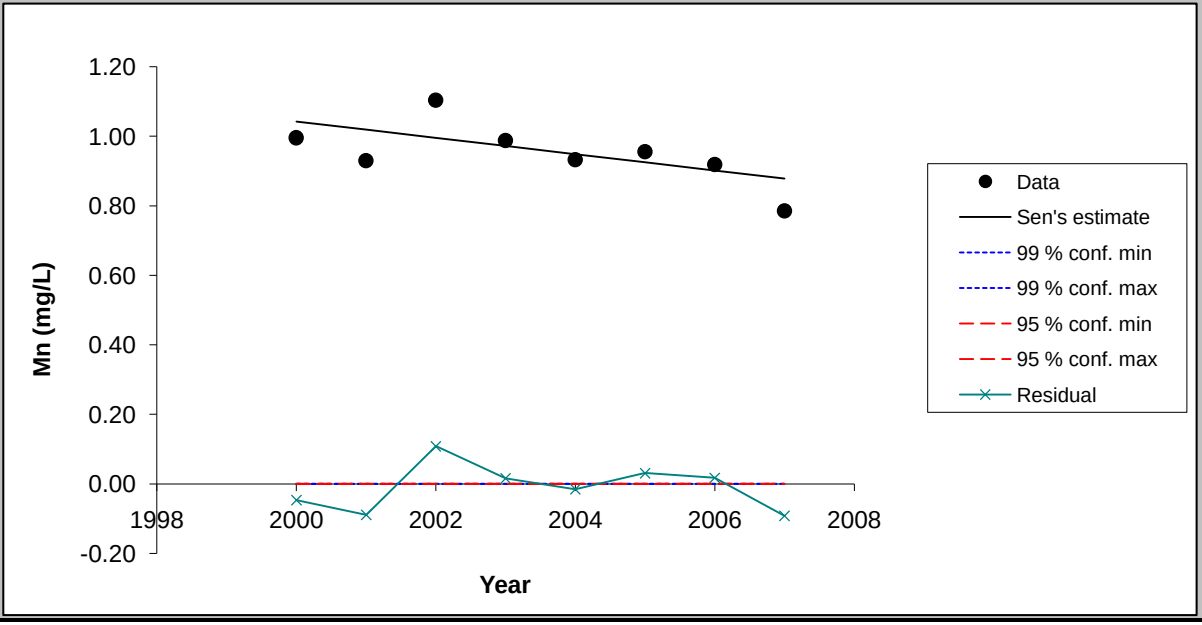

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	1.00	1.04	0.00	0.00	0.00	0.00	-0.05
2001	0.93	1.02	0.00	0.00	0.00	0.00	-0.09
2002	1.10	1.00	0.00	0.00	0.00	0.00	0.11
2003	0.99	0.97	0.00	0.00	0.00	0.00	0.02
2004	0.93	0.95	0.00	0.00	0.00	0.00	-0.02
2005	0.96	0.93	0.00	0.00	0.00	0.00	0.03
2006	0.92	0.90	0.00	0.00	0.00	0.00	0.02
2007	0.79	0.88	0.00	0.00	0.00	0.00	-0.09

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.56E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.45E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

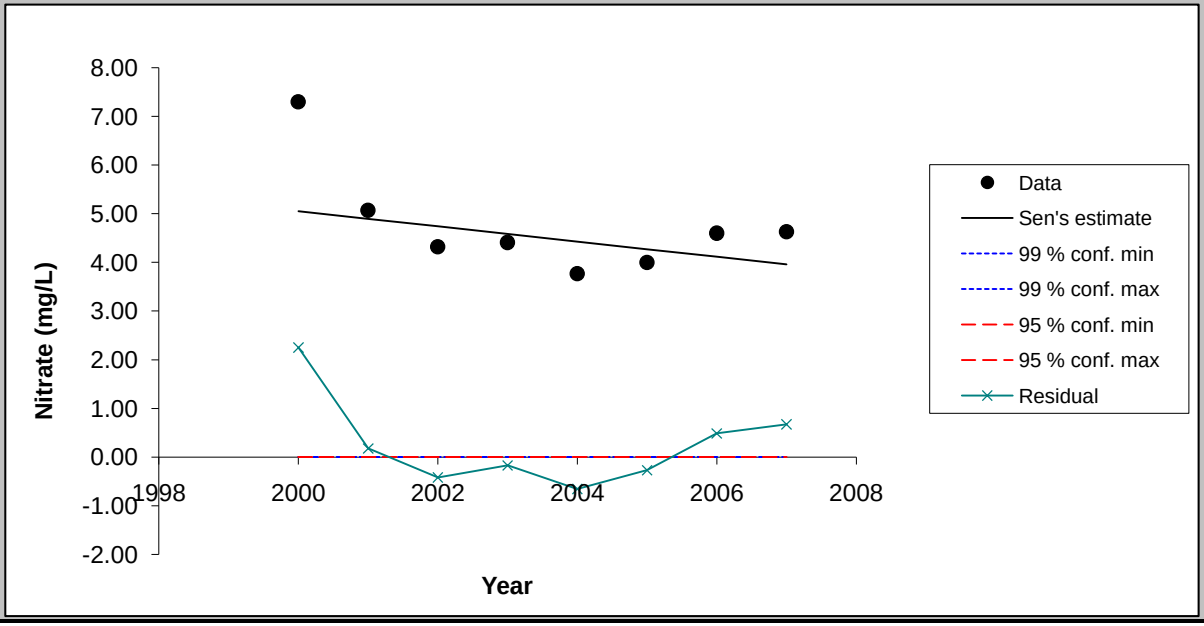

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	7.30	5.05	0.00	0.00	0.00	0.00	2.25
2001	5.07	4.90	0.00	0.00	0.00	0.00	0.17
2002	4.32	4.74	0.00	0.00	0.00	0.00	-0.42
2003	4.41	4.58	0.00	0.00	0.00	0.00	-0.17
2004	3.77	4.43	0.00	0.00	0.00	0.00	-0.66
2005	4.00	4.27	0.00	0.00	0.00	0.00	-0.27
2006	4.60	4.12	0.00	0.00	0.00	0.00	0.48
2007	4.63	3.96	0.00	0.00	0.00	0.00	0.67

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-6
Test Z	
Signific.	
Q	-1.36E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.97E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

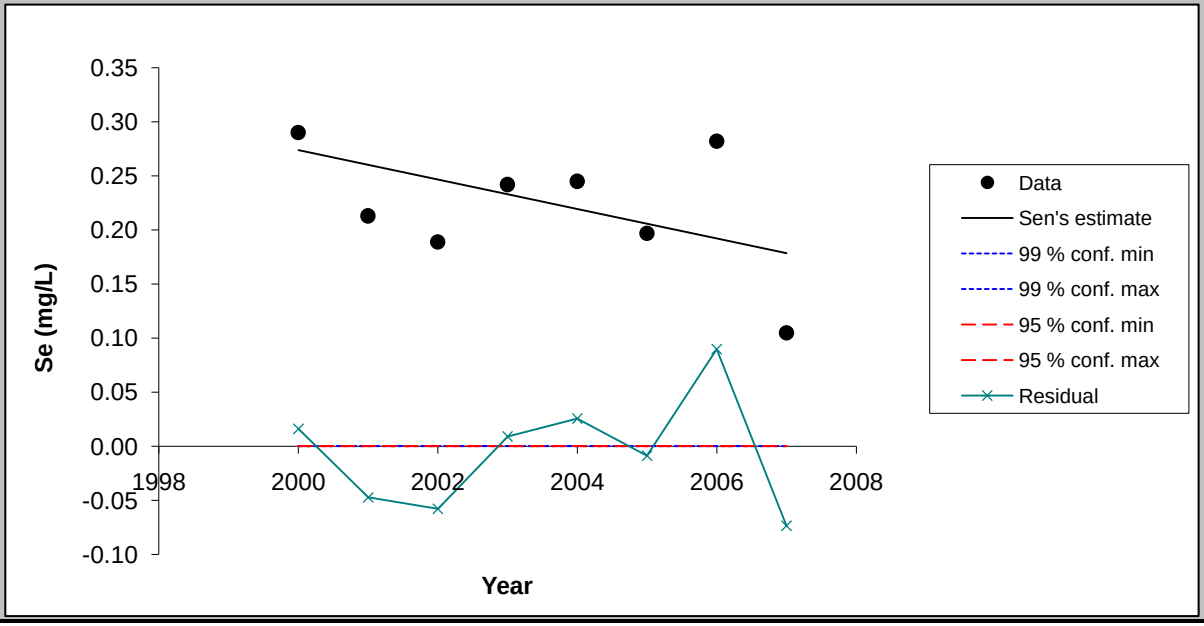

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.29	0.27	0.00	0.00	0.00	0.00	0.02
2001	0.21	0.26	0.00	0.00	0.00	0.00	-0.05
2002	0.19	0.25	0.00	0.00	0.00	0.00	-0.06
2003	0.24	0.23	0.00	0.00	0.00	0.00	0.01
2004	0.25	0.22	0.00	0.00	0.00	0.00	0.03
2005	0.20	0.21	0.00	0.00	0.00	0.00	-0.01
2006	0.28	0.19	0.00	0.00	0.00	0.00	0.09
2007	0.11	0.18	0.00	0.00	0.00	0.00	-0.07

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-1.31E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.72E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

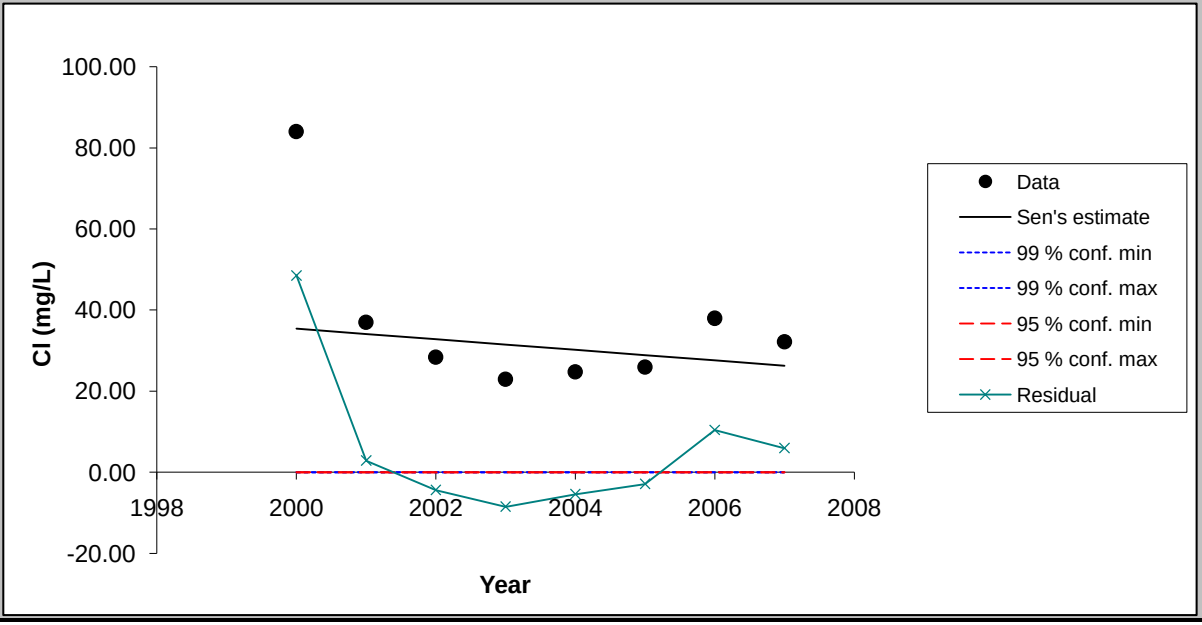

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	84.00	35.44	0.00	0.00	0.00	0.00	48.56
2001	37.00	34.12	0.00	0.00	0.00	0.00	2.88
2002	28.43	32.81	0.00	0.00	0.00	0.00	-4.38
2003	23.00	31.50	0.00	0.00	0.00	0.00	-8.50
2004	24.80	30.19	0.00	0.00	0.00	0.00	-5.39
2005	26.00	28.88	0.00	0.00	0.00	0.00	-2.88
2006	38.00	27.56	0.00	0.00	0.00	0.00	10.44
2007	32.20	26.25	0.00	0.00	0.00	0.00	5.95

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-23
Test Z	
Signific.	**
Q	-4.60E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.92E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

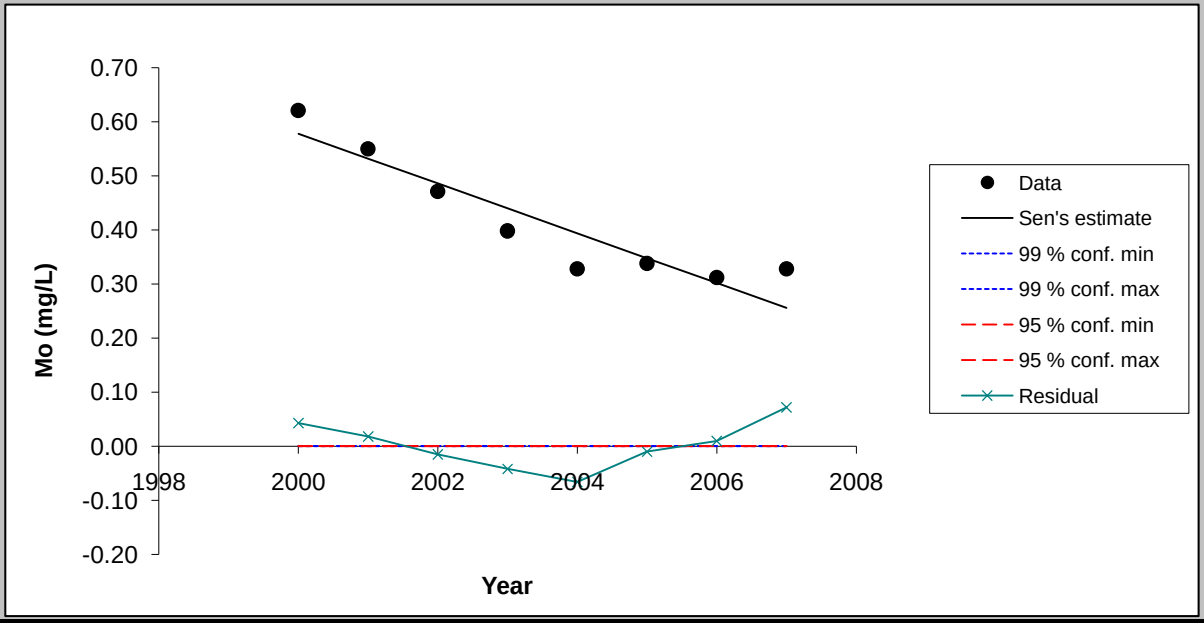

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.62	0.58	0.00	0.00	0.00	0.00	0.04
2001	0.55	0.53	0.00	0.00	0.00	0.00	0.02
2002	0.47	0.49	0.00	0.00	0.00	0.00	-0.01
2003	0.40	0.44	0.00	0.00	0.00	0.00	-0.04
2004	0.33	0.39	0.00	0.00	0.00	0.00	-0.07
2005	0.34	0.35	0.00	0.00	0.00	0.00	-0.01
2006	0.31	0.30	0.00	0.00	0.00	0.00	0.01
2007	0.33	0.26	0.00	0.00	0.00	0.00	0.07

FIGURE

< Previous Time Series | Next Time Series >

TW-22 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-1.80E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.03E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

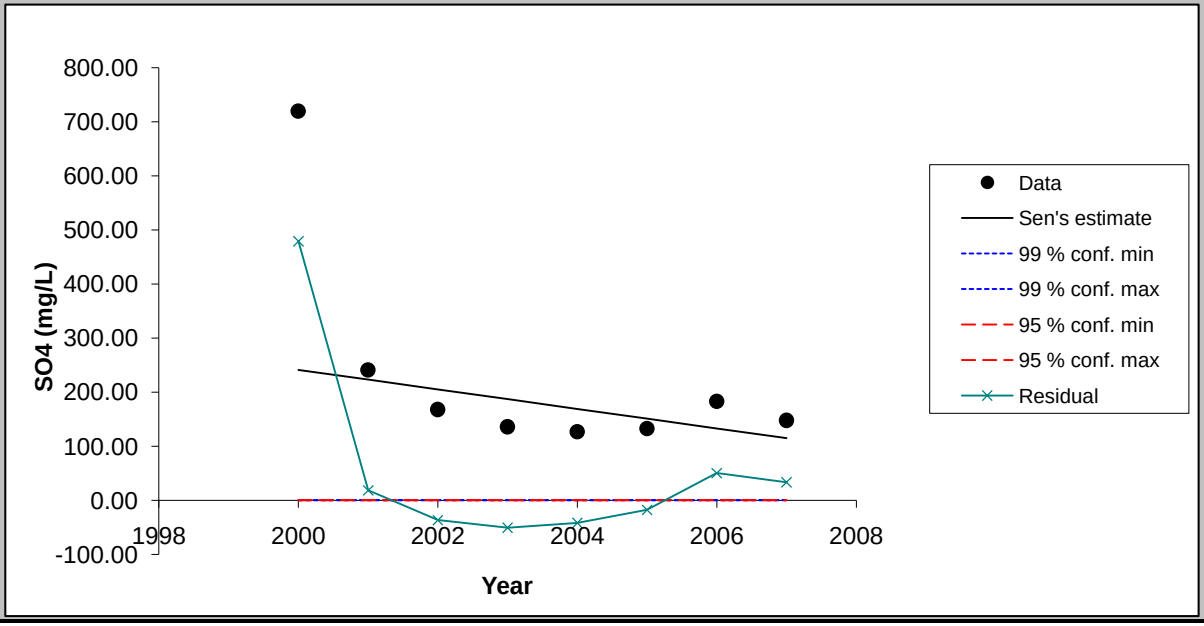

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	720.00	241.00	0.00	0.00	0.00	0.00	479.00
2001	241.00	223.00	0.00	0.00	0.00	0.00	18.00
2002	168.00	205.00	0.00	0.00	0.00	0.00	-37.00
2003	136.00	187.00	0.00	0.00	0.00	0.00	-51.00
2004	127.00	169.00	0.00	0.00	0.00	0.00	-42.00
2005	133.00	151.00	0.00	0.00	0.00	0.00	-18.00
2006	183.00	133.00	0.00	0.00	0.00	0.00	50.00
2007	148.00	115.00	0.00	0.00	0.00	0.00	33.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

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ANNUAL DATA

TW-24 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8							
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991								
1992	0.222	5.1	0.378	4.38	0.307	50.3	0.058	245
1993	0.238	7.0	0.271	6.86	0.406	60.7	0.502	454.5
1994	0.295	7.2	0.263	5.76	0.309	45	0.380	288
1995	0.29	6.7	0.275	5.8	0.33	37	0.495	340
1996	0.25	9	0.245	6.3	0.37	45	0.722	520
1997	0.22	8.7	0.143	7.9	0.47	50	1.35	810
1998	0.24	8	0.153	8.2	0.42	64	1.12	840
1999	0.19	8.2	0.136	7.9	0.39	58	1.17	790
2000	0.26	8.4	0.183	8.4	0.45	61	0.961	580
2001	0.309	5.9	0.28	5.31	0.234	32	0.38	216
2002	0.294	5.3	0.320	4.77	0.212	29.9	0.340	201
2003	0.295	5.06	0.308	5.05	0.317	25.3	0.334	170
2004	0.315	4.99	0.329	4.32	0.352	24.9	0.276	156
2005	0.331	6.42	0.278	6.24	0.359	142	0.829	327
2006	0.295	6.53	0.255	6.23	0.036	107	0.57	315
2007	0.244	5.95	0.199	6.06	0.171	48.3	0.431	189

TREND STATISTICS

TW-24 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*3*			0.001					0.29				
F (mg/L)	*2000*	*2007*	*8*	*-2*			-0.104					7.27				
Mn (mg/L)	*2000*	*2007*	*8*	*-4*			-0.009					0.39				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-2*			-0.050					6.33				
Se (mg/L)	*2000*	*2007*	*8*	*-8*			-0.023					0.57				
Cl (mg/L)	*2000*	*2007*	*8*	*0*			1.158					25.09				
Mo (mg/L)	*2000*	*2007*	*8*	*-4*			-0.025					0.73				
SO4 (mg/L)	*2000*	*2007*	*8*	*-8*			-14.500					391.00				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	3
Test Z	
Signific.	
Q	6.25E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.87E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

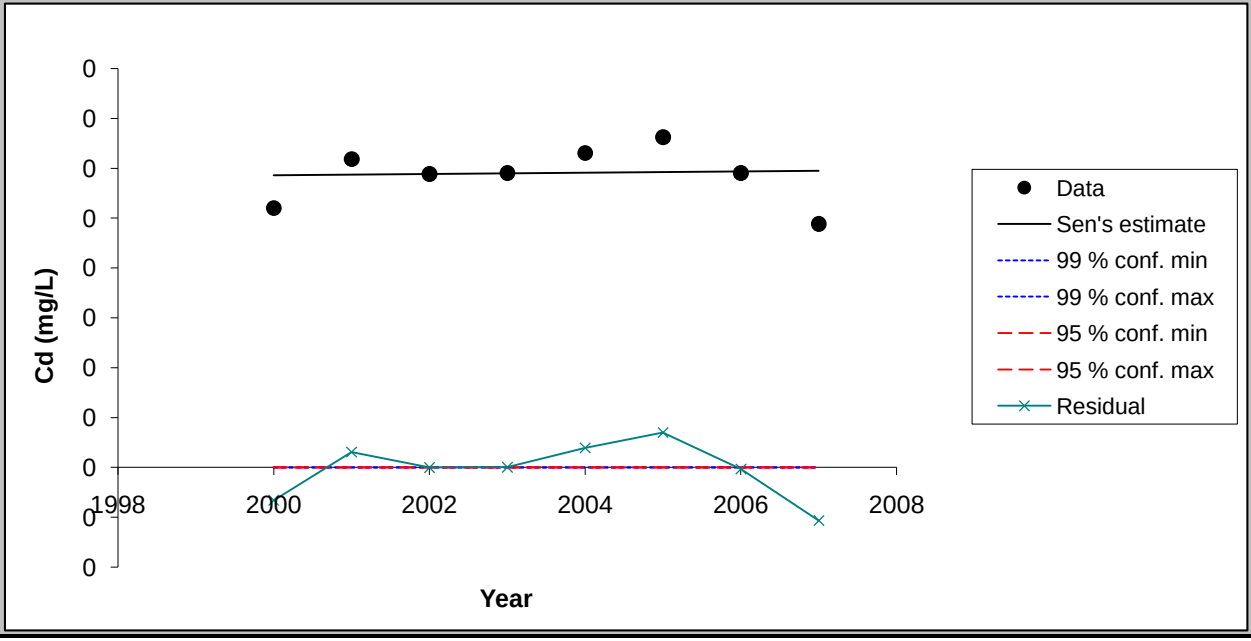

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.26	0.29	0.00	0.00	0.00	0.00	-0.03
2001	0.31	0.29	0.00	0.00	0.00	0.00	0.02
2002	0.29	0.29	0.00	0.00	0.00	0.00	0.00
2003	0.30	0.29	0.00	0.00	0.00	0.00	0.00
2004	0.32	0.30	0.00	0.00	0.00	0.00	0.02
2005	0.33	0.30	0.00	0.00	0.00	0.00	0.03
2006	0.30	0.30	0.00	0.00	0.00	0.00	0.00
2007	0.24	0.30	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-1.04E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.27E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

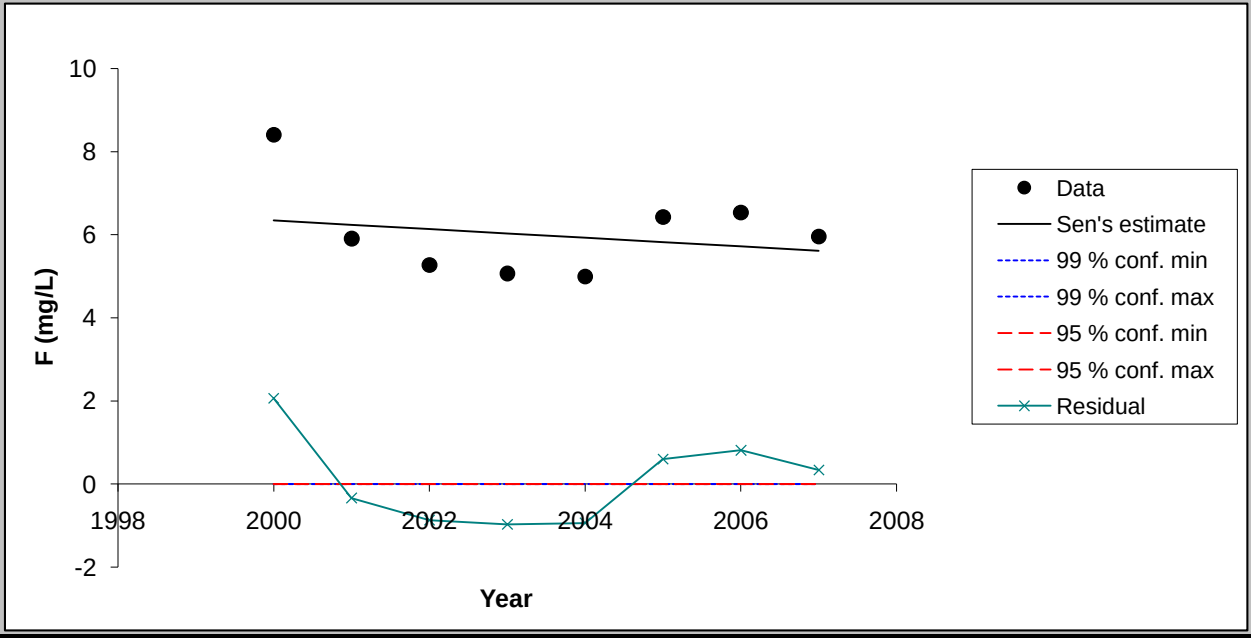

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	8.40	6.34	0.00	0.00	0.00	0.00	2.06
2001	5.90	6.24	0.00	0.00	0.00	0.00	-0.34
2002	5.26	6.13	0.00	0.00	0.00	0.00	-0.87
2003	5.06	6.03	0.00	0.00	0.00	0.00	-0.97
2004	4.99	5.93	0.00	0.00	0.00	0.00	-0.94
2005	6.42	5.82	0.00	0.00	0.00	0.00	0.60
2006	6.53	5.72	0.00	0.00	0.00	0.00	0.81
2007	5.95	5.61	0.00	0.00	0.00	0.00	0.34

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-8.60E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.91E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

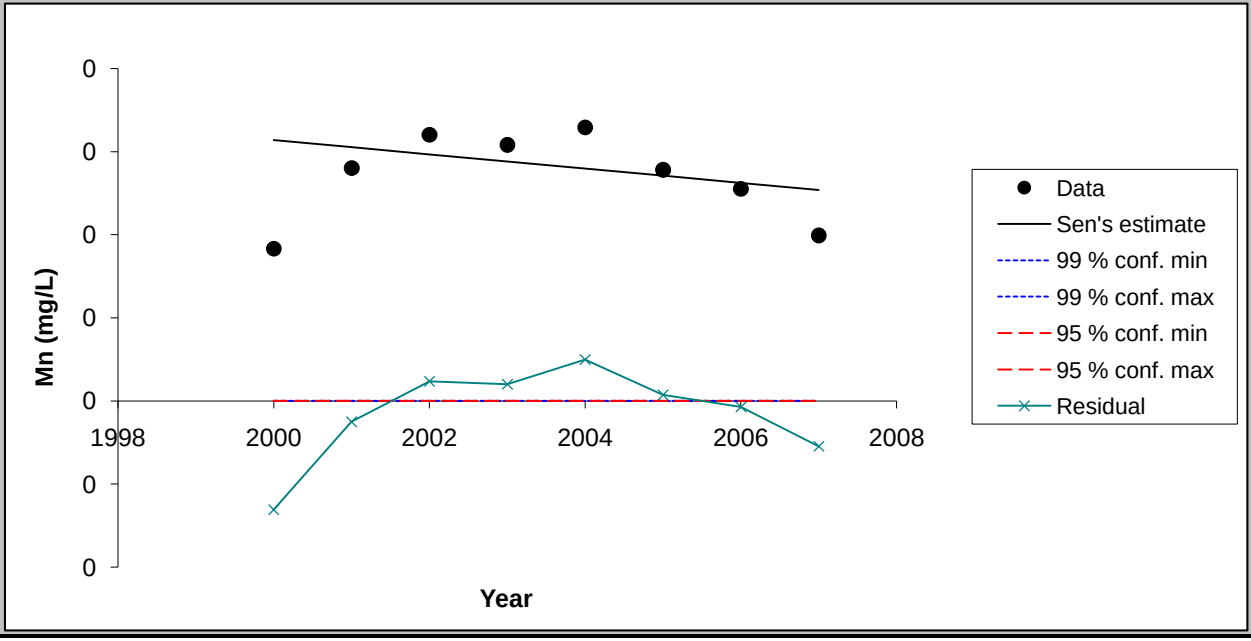

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.18	0.31	0.00	0.00	0.00	0.00	-0.13
2001	0.28	0.31	0.00	0.00	0.00	0.00	-0.03
2002	0.32	0.30	0.00	0.00	0.00	0.00	0.02
2003	0.31	0.29	0.00	0.00	0.00	0.00	0.02
2004	0.33	0.28	0.00	0.00	0.00	0.00	0.05
2005	0.28	0.27	0.00	0.00	0.00	0.00	0.01
2006	0.26	0.26	0.00	0.00	0.00	0.00	-0.01
2007	0.20	0.25	0.00	0.00	0.00	0.00	-0.05

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-2
Test Z	
Signific.	
Q	-5.00E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	6.33E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

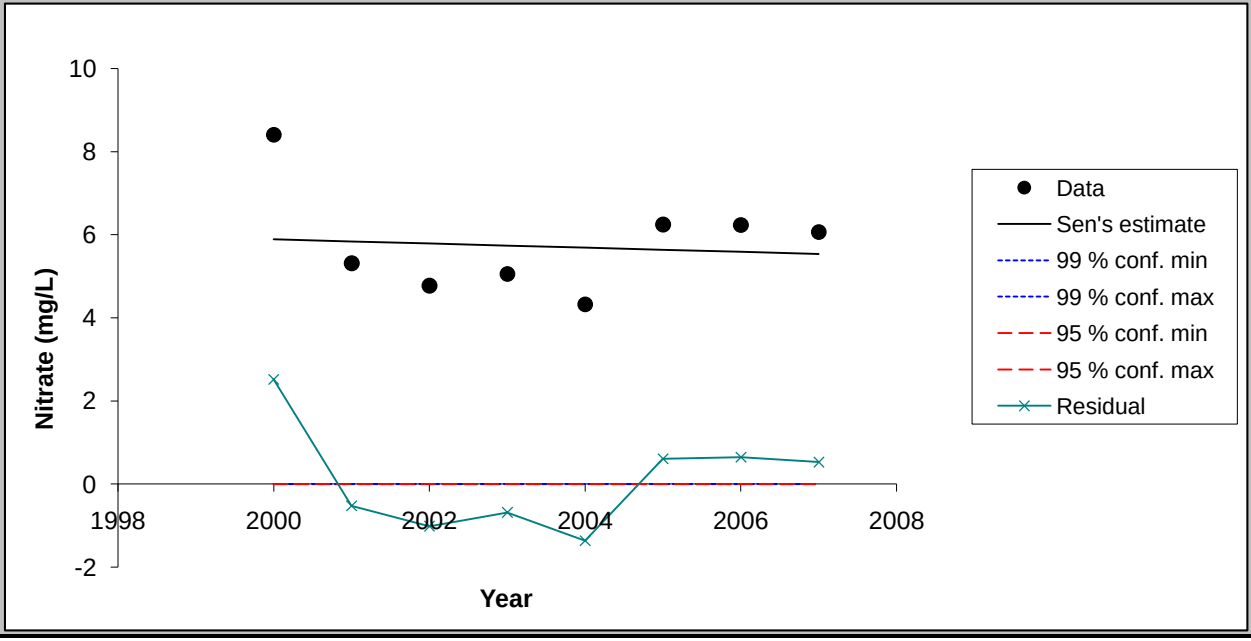

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	8.40	5.88	0.00	0.00	0.00	0.00	2.51
2001	5.31	5.83	0.00	0.00	0.00	0.00	-0.53
2002	4.77	5.78	0.00	0.00	0.00	0.00	-1.01
2003	5.05	5.73	0.00	0.00	0.00	0.00	-0.68
2004	4.32	5.68	0.00	0.00	0.00	0.00	-1.36
2005	6.24	5.63	0.00	0.00	0.00	0.00	0.61
2006	6.23	5.58	0.00	0.00	0.00	0.00	0.65
2007	6.06	5.53	0.00	0.00	0.00	0.00	0.53

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-2.35E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.73E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

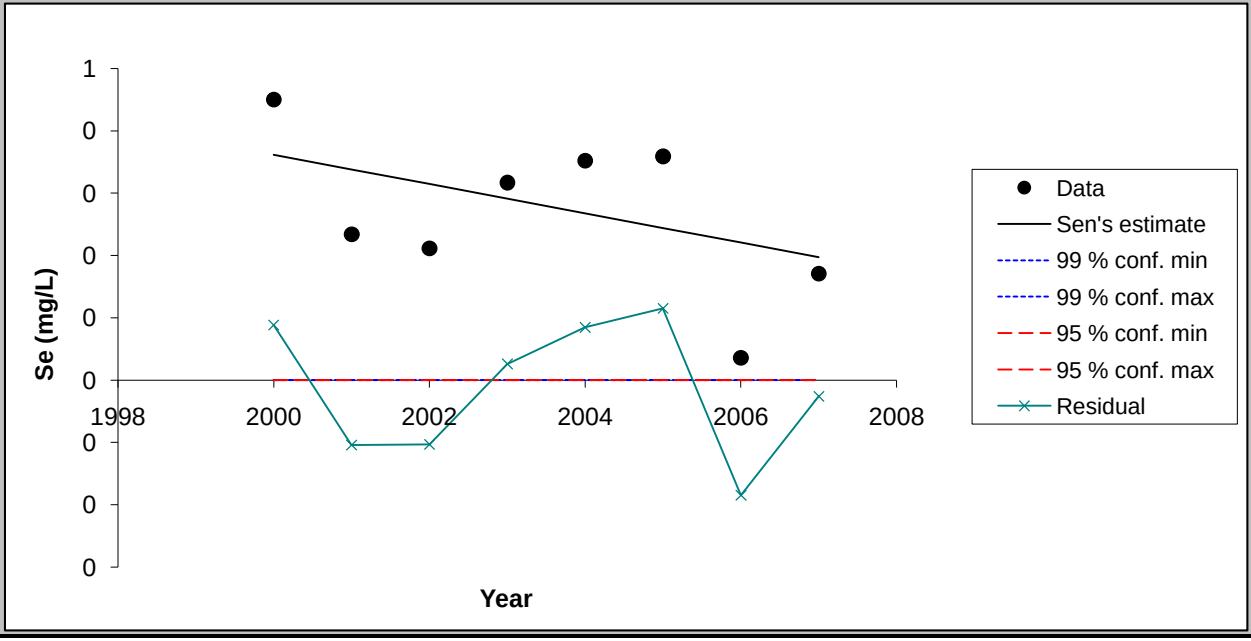

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.45	0.36	0.00	0.00	0.00	0.00	0.09
2001	0.23	0.34	0.00	0.00	0.00	0.00	-0.10
2002	0.21	0.31	0.00	0.00	0.00	0.00	-0.10
2003	0.32	0.29	0.00	0.00	0.00	0.00	0.03
2004	0.35	0.27	0.00	0.00	0.00	0.00	0.08
2005	0.36	0.24	0.00	0.00	0.00	0.00	0.11
2006	0.04	0.22	0.00	0.00	0.00	0.00	-0.18
2007	0.17	0.20	0.00	0.00	0.00	0.00	-0.03

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	0
Test Z	
Signific.	
Q	1.16E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.51E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

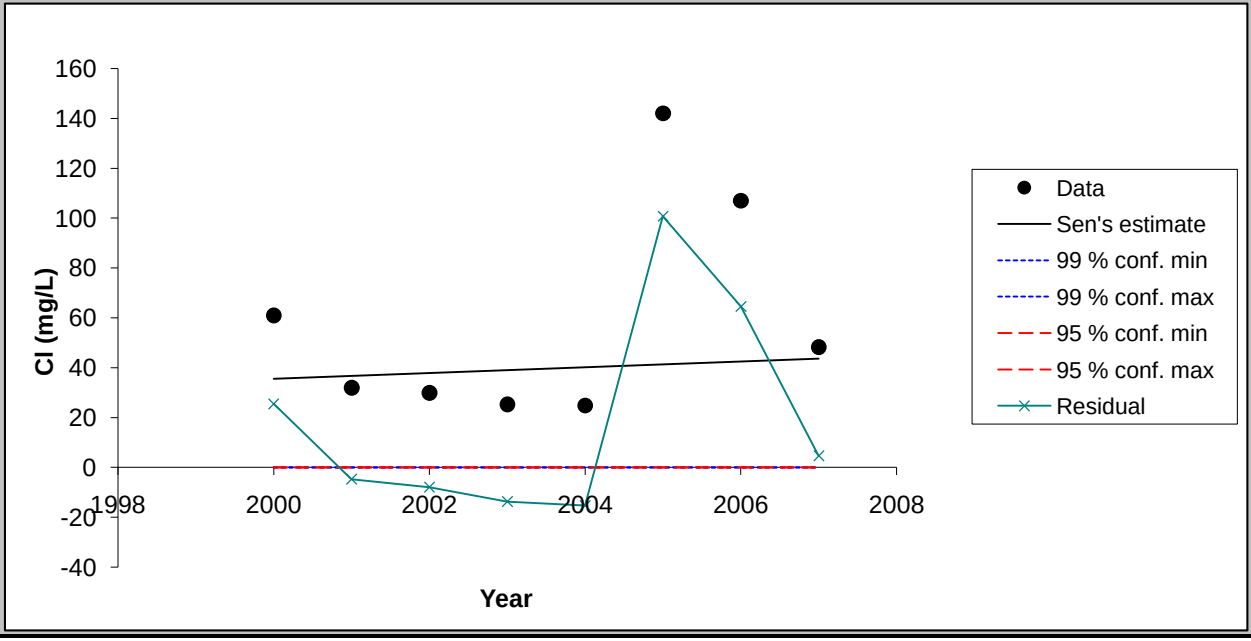

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	61.00	35.52	0.00	0.00	0.00	0.00	25.48
2001	32.00	36.67	0.00	0.00	0.00	0.00	-4.67
2002	29.94	37.83	0.00	0.00	0.00	0.00	-7.89
2003	25.30	38.99	0.00	0.00	0.00	0.00	-13.69
2004	24.90	40.15	0.00	0.00	0.00	0.00	-15.25
2005	142.00	41.31	0.00	0.00	0.00	0.00	100.69
2006	107.00	42.47	0.00	0.00	0.00	0.00	64.53
2007	48.30	43.63	0.00	0.00	0.00	0.00	4.67

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-4
Test Z	
Signific.	
Q	-2.47E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.28E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

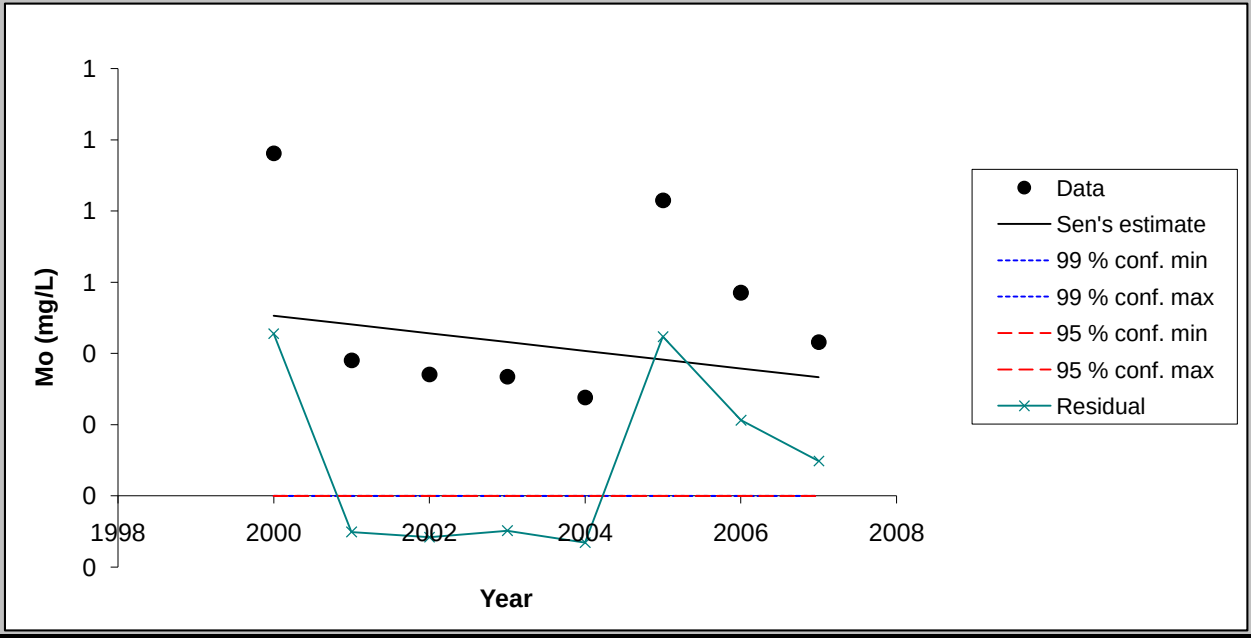

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.96	0.51	0.00	0.00	0.00	0.00	0.46
2001	0.38	0.48	0.00	0.00	0.00	0.00	-0.10
2002	0.34	0.46	0.00	0.00	0.00	0.00	-0.12
2003	0.33	0.43	0.00	0.00	0.00	0.00	-0.10
2004	0.28	0.41	0.00	0.00	0.00	0.00	-0.13
2005	0.83	0.38	0.00	0.00	0.00	0.00	0.45
2006	0.57	0.36	0.00	0.00	0.00	0.00	0.21
2007	0.43	0.33	0.00	0.00	0.00	0.00	0.10

FIGURE

< Previous Time Series

Next Time Series >

TW-24 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-8
Test Z	
Signific.	
Q	-1.45E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	3.91E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

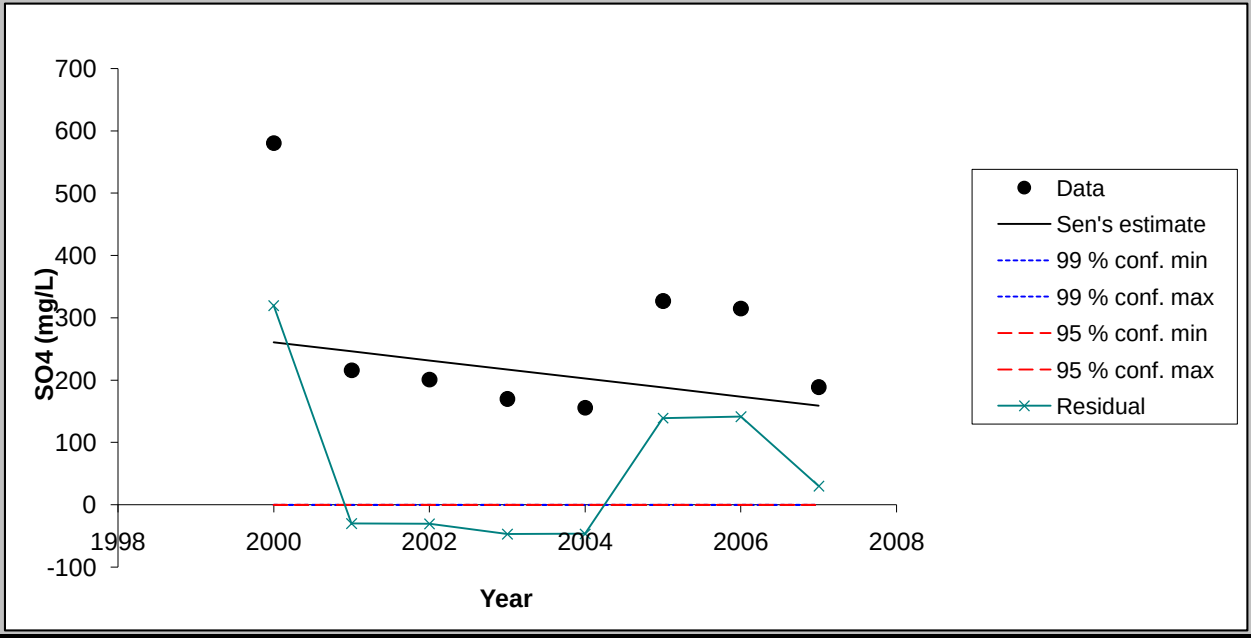

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estin	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	580.00	260.50	0.00	0.00	0.00	0.00	319.50
2001	216.00	246.00	0.00	0.00	0.00	0.00	-30.00
2002	201.00	231.50	0.00	0.00	0.00	0.00	-30.50
2003	170.00	217.00	0.00	0.00	0.00	0.00	-47.00
2004	156.00	202.50	0.00	0.00	0.00	0.00	-46.50
2005	327.00	188.00	0.00	0.00	0.00	0.00	139.00
2006	315.00	173.50	0.00	0.00	0.00	0.00	141.50
2007	189.00	159.00	0.00	0.00	0.00	0.00	30.00

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

Copyright Finnish Meteorological Institute 2002

This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-37 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8	
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000	
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007	

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.389	19.93	1.07	5.5	0.076	59		200
1992	0.455	13.35	1.21	6.72	0.497	75.8	0.715	256
1993	0.4055	13.88	0.999	7.03	0.706	54.3	0.647	233.5
1994	0.4965	14.9	1.19	8.2	0.567	79.5	0.641	297
1995	0.387	15	0.798	6.6	0.53	36	0.542	180
1996	0.36	14	0.7	6.2	0.35	39	0.489	190
1997	0.31	16	0.494	6.7	0.46	28	0.401	170
1998	0.34	12	0.668	7.2	0.33	36	0.423	420
1999	0.34	13	0.615	6.9	0.31	25	0.419	210
2000	0.43	12	0.680	7.6	0.37	40	0.383	280
2001	0.397	11.7	0.8	7.1	0.389	31	0.45	214
2002	0.3400	12.96	0.701	6.08	0.357	25	0.439	188.1
2003	0.394	10.8	0.771	9.53	0.553	32.1	0.427	255
2004	0.399	11.8	0.768	8.91	0.445	35.8	0.412	307
2005	0.452	10.8	0.548	9.42	0.493	76.8	0.336	351
2006	0.539	9.67	0.614	11.2	0.5	139	0.312	361
2007	0.577	9.77	0.589	10.8	0.162	130	0.299	407

TREND STATISTICS

TW-37 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*16*		+	0.029					0.07				
F (mg/L)	*2000*	*2007*	*8*	*-17*		+	-0.383					15.71				
Mn (mg/L)	*2000*	*2007*	*8*	*-12*			-0.022					0.94				
Nitrate (mg/L)	*2000*	*2007*	*8*	*16*		+	0.602					1.13				
Se (mg/L)	*2000*	*2007*	*8*	*4*			0.019					0.20				
Cl (mg/L)	*2000*	*2007*	*8*	*16*		+	14.679					-122.24				
Mo (mg/L)	*2000*	*2007*	*8*	*-20*		*	-0.017					0.59				
SO4 (mg/L)	*2000*	*2007*	*8*	*20*		*	31.583					-102.71				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series | Next Time Series >

TW-37 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	2.93E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.16E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

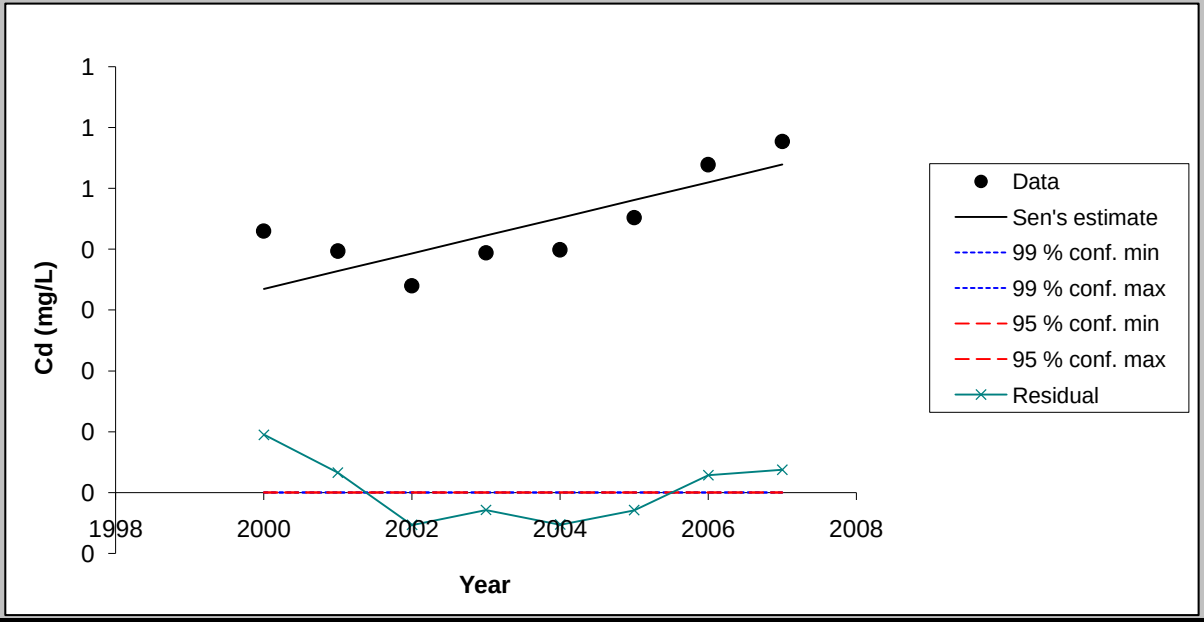

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.43	0.33	0.00	0.00	0.00	0.00	0.10
2001	0.40	0.36	0.00	0.00	0.00	0.00	0.03
2002	0.34	0.39	0.00	0.00	0.00	0.00	-0.05
2003	0.39	0.42	0.00	0.00	0.00	0.00	-0.03
2004	0.40	0.45	0.00	0.00	0.00	0.00	-0.05
2005	0.45	0.48	0.00	0.00	0.00	0.00	-0.03
2006	0.54	0.51	0.00	0.00	0.00	0.00	0.03
2007	0.58	0.54	0.00	0.00	0.00	0.00	0.04

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	-17
Test Z	
Signific.	+
Q	-3.83E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.57E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

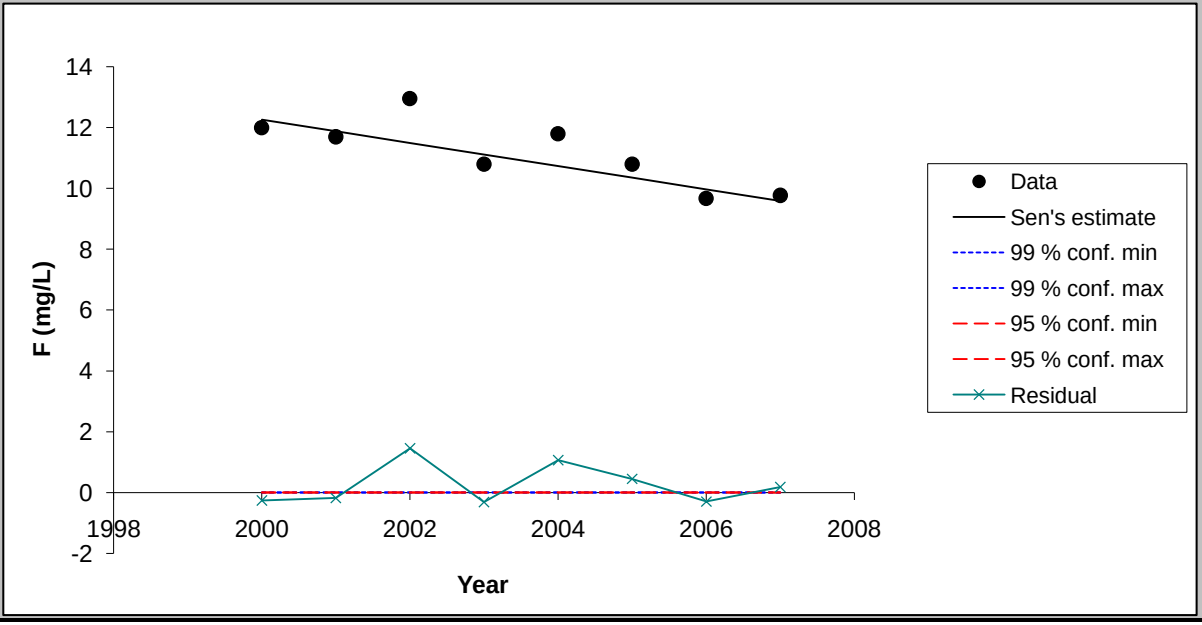

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	12.00	12.26	0.00	0.00	0.00	0.00	-0.26
2001	11.70	11.88	0.00	0.00	0.00	0.00	-0.18
2002	12.96	11.50	0.00	0.00	0.00	0.00	1.46
2003	10.80	11.12	0.00	0.00	0.00	0.00	-0.32
2004	11.80	10.73	0.00	0.00	0.00	0.00	1.07
2005	10.80	10.35	0.00	0.00	0.00	0.00	0.45
2006	9.67	9.97	0.00	0.00	0.00	0.00	-0.30
2007	9.77	9.59	0.00	0.00	0.00	0.00	0.18

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-2.21E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	9.44E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

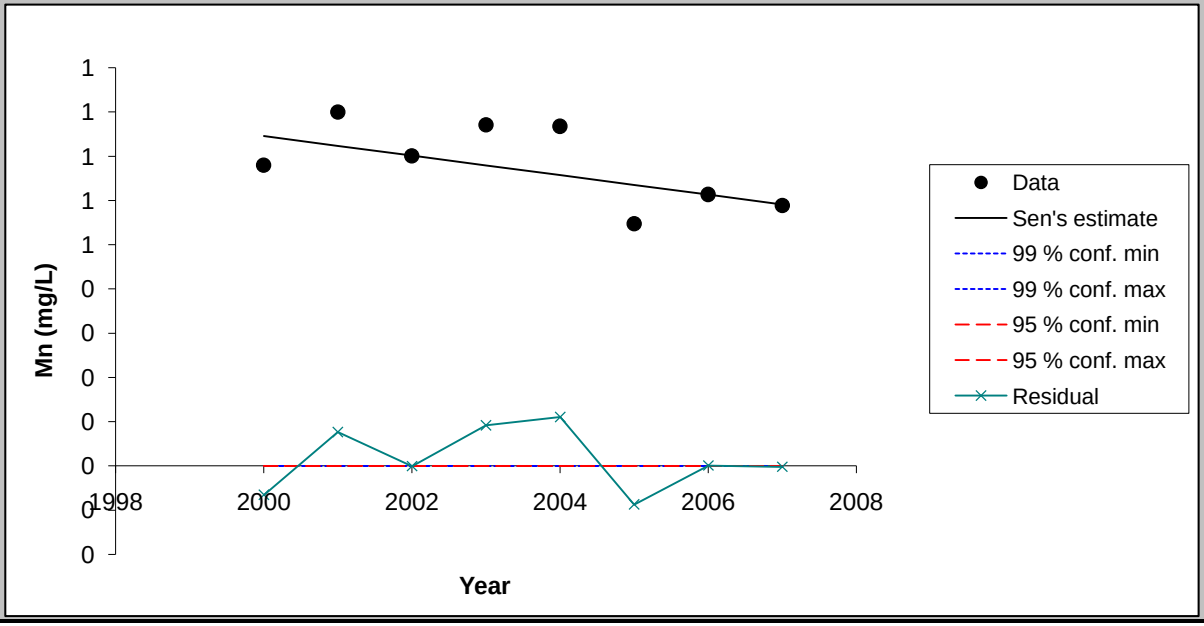

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.68	0.75	0.00	0.00	0.00	0.00	-0.07
2001	0.80	0.72	0.00	0.00	0.00	0.00	0.08
2002	0.70	0.70	0.00	0.00	0.00	0.00	0.00
2003	0.77	0.68	0.00	0.00	0.00	0.00	0.09
2004	0.77	0.66	0.00	0.00	0.00	0.00	0.11
2005	0.55	0.64	0.00	0.00	0.00	0.00	-0.09
2006	0.61	0.61	0.00	0.00	0.00	0.00	0.00
2007	0.59	0.59	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	6.02E-01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.13E+00
Bmin99	
Bmax99	
Bmin95	
Bmax95	

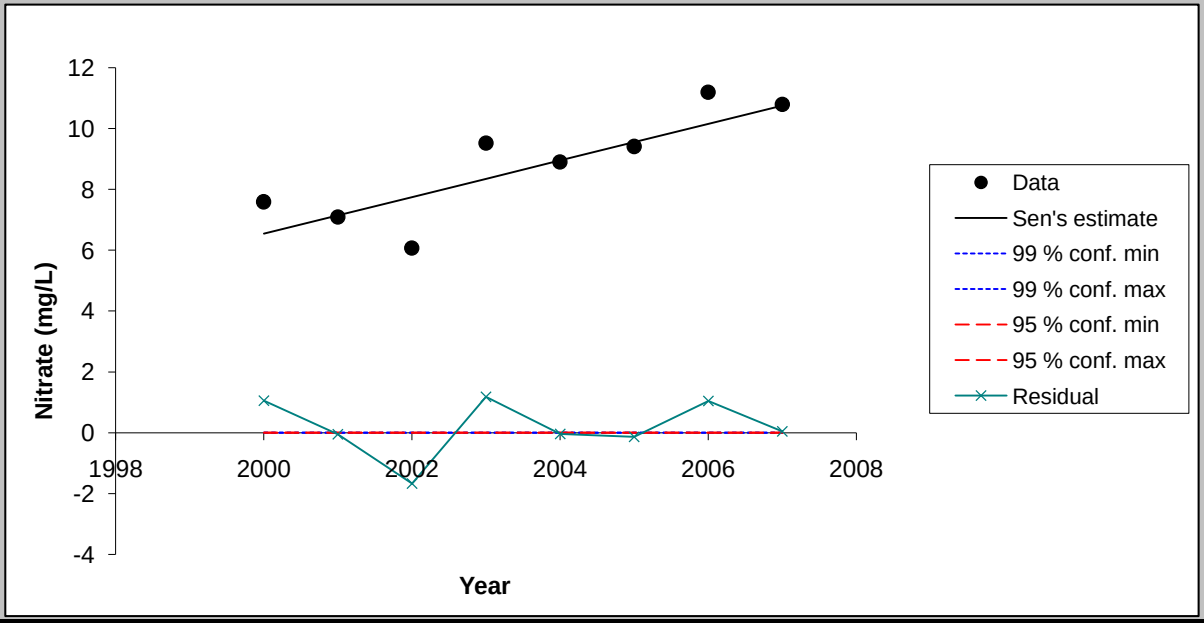

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	7.60	6.55	0.00	0.00	0.00	0.00	1.05
2001	7.10	7.15	0.00	0.00	0.00	0.00	-0.05
2002	6.08	7.75	0.00	0.00	0.00	0.00	-1.67
2003	9.53	8.35	0.00	0.00	0.00	0.00	1.18
2004	8.91	8.95	0.00	0.00	0.00	0.00	-0.04
2005	9.42	9.55	0.00	0.00	0.00	0.00	-0.13
2006	11.20	10.16	0.00	0.00	0.00	0.00	1.04
2007	10.80	10.76	0.00	0.00	0.00	0.00	0.04

FIGURE

< Previous Time Series | Next Time Series >

TW-37 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	4
Test Z	
Signific.	
Q	1.87E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	2.02E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

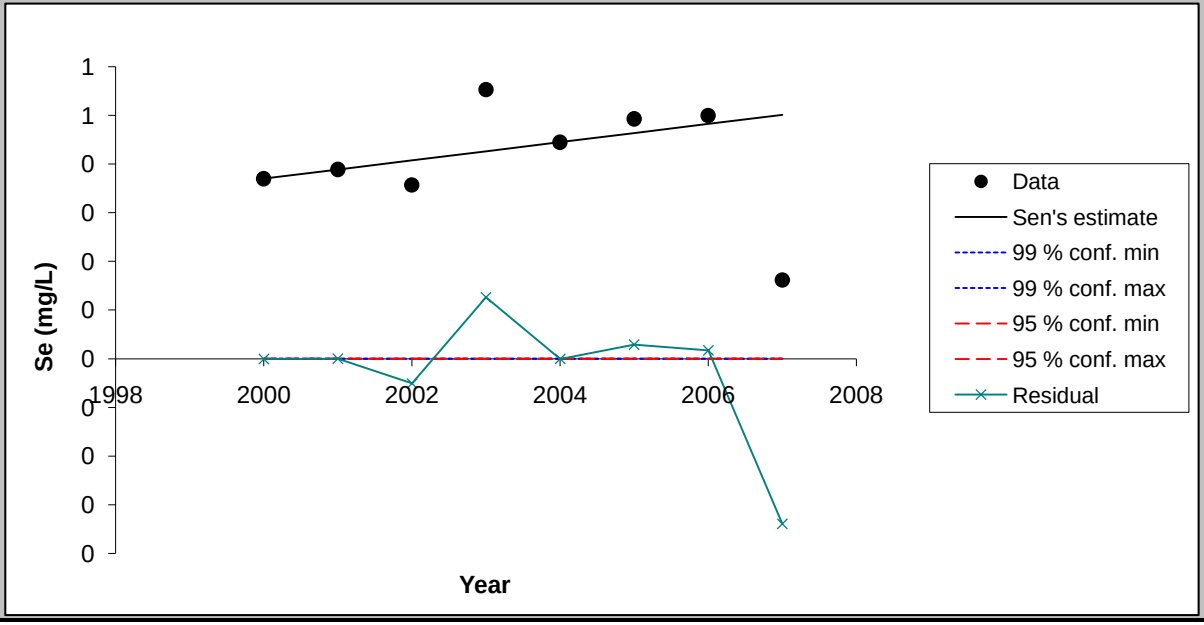

Chart options

- ☑ show 99 % confidence interval
- ☑ show 95 % confidence interval
- ☑ show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.37	0.37	0.00	0.00	0.00	0.00	0.00
2001	0.39	0.39	0.00	0.00	0.00	0.00	0.00
2002	0.36	0.41	0.00	0.00	0.00	0.00	-0.05
2003	0.55	0.43	0.00	0.00	0.00	0.00	0.13
2004	0.45	0.45	0.00	0.00	0.00	0.00	0.00
2005	0.49	0.46	0.00	0.00	0.00	0.00	0.03
2006	0.50	0.48	0.00	0.00	0.00	0.00	0.02
2007	0.16	0.50	0.00	0.00	0.00	0.00	-0.34

FIGURE

< Previous Time Series | Next Time Series >

TW-37 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	16
Test Z	
Signific.	+
Q	1.47E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.22E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

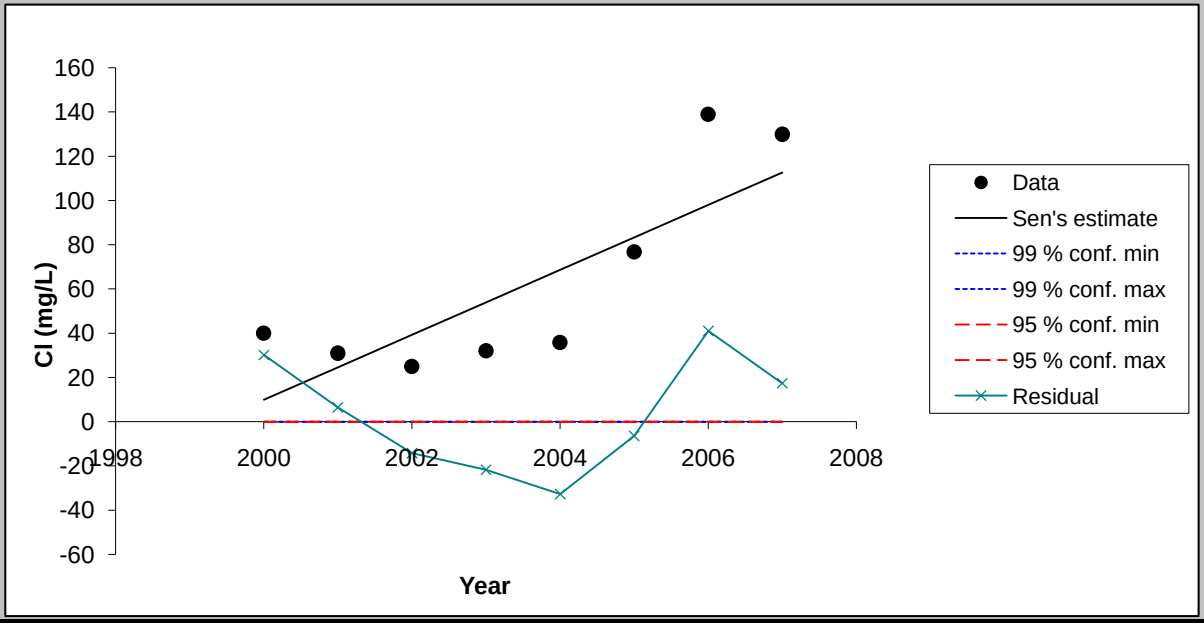

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	40.00	9.86	0.00	0.00	0.00	0.00	30.14
2001	31.00	24.54	0.00	0.00	0.00	0.00	6.46
2002	25.00	39.22	0.00	0.00	0.00	0.00	-14.22
2003	32.10	53.90	0.00	0.00	0.00	0.00	-21.80
2004	35.80	68.58	0.00	0.00	0.00	0.00	-32.78
2005	76.80	83.26	0.00	0.00	0.00	0.00	-6.46
2006	139.00	97.94	0.00	0.00	0.00	0.00	41.06
2007	130.00	112.61	0.00	0.00	0.00	0.00	17.39

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	-20
Test Z	
Signific.	*
Q	-1.68E-02
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.94E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

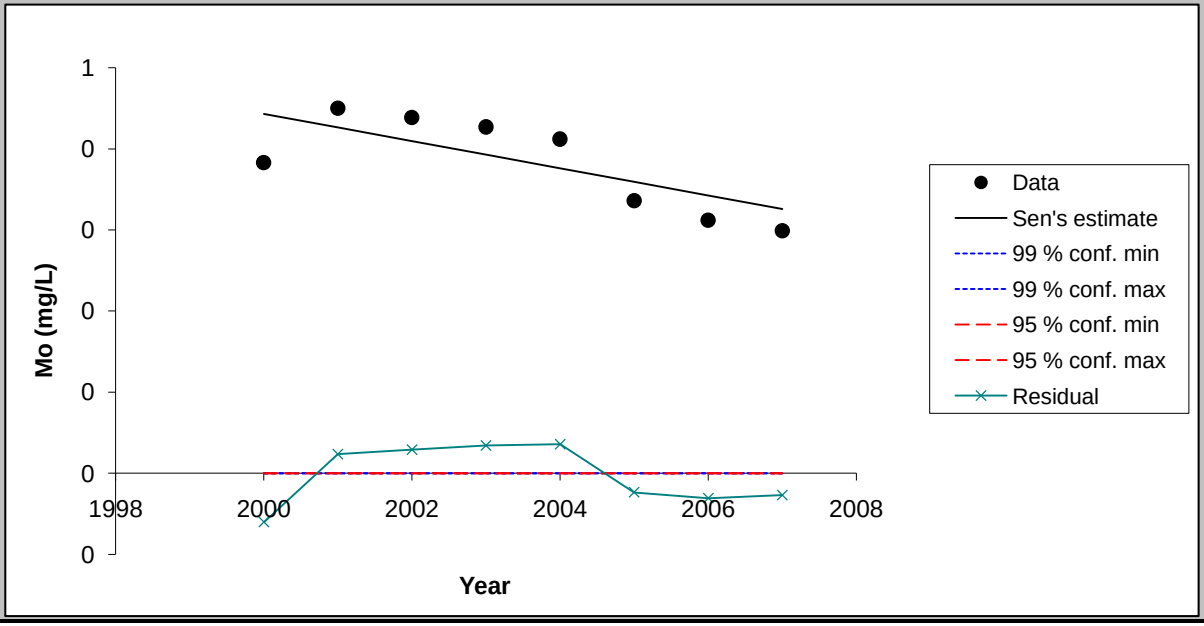

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.38	0.44	0.00	0.00	0.00	0.00	-0.06
2001	0.45	0.43	0.00	0.00	0.00	0.00	0.02
2002	0.44	0.41	0.00	0.00	0.00	0.00	0.03
2003	0.43	0.39	0.00	0.00	0.00	0.00	0.03
2004	0.41	0.38	0.00	0.00	0.00	0.00	0.04
2005	0.34	0.36	0.00	0.00	0.00	0.00	-0.02
2006	0.31	0.34	0.00	0.00	0.00	0.00	-0.03
2007	0.30	0.33	0.00	0.00	0.00	0.00	-0.03

FIGURE

< Previous Time Series

Next Time Series >

TW-37 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	20
Test Z	
Signific.	*
Q	3.16E+01
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	-1.03E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

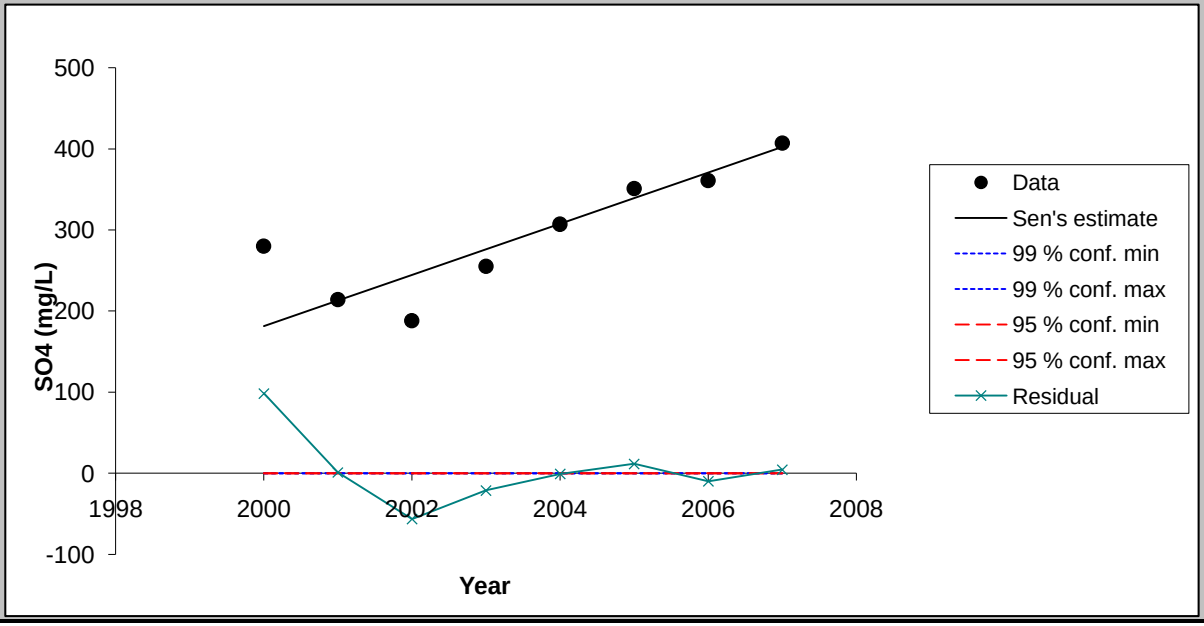

Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	280.00	181.54	0.00	0.00	0.00	0.00	98.46
2001	214.00	213.13	0.00	0.00	0.00	0.00	0.88
2002	188.07	244.71	0.00	0.00	0.00	0.00	-56.64
2003	255.00	276.29	0.00	0.00	0.00	0.00	-21.29
2004	307.00	307.88	0.00	0.00	0.00	0.00	-0.88
2005	351.00	339.46	0.00	0.00	0.00	0.00	11.54
2006	361.00	371.04	0.00	0.00	0.00	0.00	-10.04
2007	407.00	402.63	0.00	0.00	0.00	0.00	4.38

MAKESENS 1.0

Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data

Version 1.0 Freeware

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This MSExcel template is developed for detecting and estimating trend in time series of annual values of atmospheric chemistry. The used statistical methods are the nonparametric Mann-Kendall test for testing the presence of the monotonic increasing or decreasing trend and the nonparametric Sen's method for estimating the slope of a linear trend. The Mann-Kendall test requires at least 4 values and calculation of the confidence intervals for the Sen's slope estimate requires at least 10 values in a time series

The functional part of the template consists of three worksheets: **Annual data, Trend Statistics** and **Figure**. At first the data of time series are typed or copied to the worksheet **Annual data** and the periods to be included to the calculations are selected individually for each time series. Then the calculation macro can be activated by pushing the **Calculate Trend Statistics** button and the worksheet **Trend Statistics** will contain the results of the calculations. Finally the original data and the statistics of one time series at a time can be viewed numerically and visually on the worksheet **Figure.**

This template and accompanying written materials are provided "as is" without warranty of any kind.

ANNUAL DATA

TW-45 (2000-2007)

CALCULATE TREND STATISTICS

Number of time series in the calculation:	8								
Number of annual values in the calculation:	8	8	8	8	8	8	8	8
Select the FIRST YEAR of the calculation:	2000	2000	2000	2000	2000	2000	2000	2000
Select the LAST YEAR of the calculation:	2007	2007	2007	2007	2007	2007	2007	2007

Year	Cd (mg/L)	F (mg/L)	Mn (mg/L)	Nitrate (mg	Se (mg/L)	Cl (mg/L)	Mo (mg/L)	SO4 (mg/L)
1991	0.03	1.21	0.64	0.25	0.0015	65		70
1992	0.0123	0.865	0.506	0.3	0.009	61.8	0.0445	195.5
1993	0.0099	0.78	0.671	0.08	0.0035	53.6	0.0308	175.5
1994	0.0197	0.895	0.593	0.156	0.0092	63.8	0.0315	183.5
1995	0.008	0.92	0.584	0.014	0.017	46	0.033	140
1996	0.0036	0.87	0.554	0.061	0.0005	43	0.031	140
1997	0.007	0.83	0.527	0.016	0.0005	43	0.027	140
1998	0.006	0.8	0.487	0.035	0.001	41	0.024	140
1999	0.004	0.81	0.488	0.011	0.0005	32	0.023	150
2000	0.007	0.79	0.452	0.024	0.005	38	0.024	160
2001	0.006	0.8	0.49	0.025	0.0025	35	0.005	122
2002	0.0062	0.973	0.498	0.025	0.0025	29.1	0.0248	115.8
2003	0.0038	0.55	0.47	0.01	0.005	33.3	0.041	135
2004	0.0043	0.33	0.469	0.01	0.0015	30.9	0.027	132
2005	0.0046	0.33	0.458	0.01	0.0045	33.8	0.026	125
2006	0.0035	0.82	0.439	0.01	0.003	25.5	0.019	110
2007	0.002	0.93	0.432	0.01	0.0003	30.1	0.029	120

TREND STATISTICS

TW-45 (2000-2007)

				Mann-Kendall trend			Sen's slope estimate									
Time series	**First year**	**Last Year**	**n**	**Test S**	**Test Z**	**Signific.**	**Q**	**Qmin99**	**Qmax99**	**Qmin95**	**Qmax95**	**B**	**Bmin99**	**Bmax99**	**Bmin95**	**Bmax95**
Cd (mg/L)	*2000*	*2007*	*8*	*-20*		*	-0.0006					0.013				
F (mg/L)	*2000*	*2007*	*8*	*1*			0.002					0.78				
Mn (mg/L)	*2000*	*2007*	*8*	*-16*		+	-0.010					0.59				
Nitrate (mg/L)	*2000*	*2007*	*8*	*-13*			-0.002					0.04				
Se (mg/L)	*2000*	*2007*	*8*	*-9*			-0.0003					0.007				
Cl (mg/L)	*2000*	*2007*	*8*	*-14*			-1.009					45.25				
Mo (mg/L)	*2000*	*2007*	*8*	*8*			0.0007					0.02				
SO4 (mg/L)	*2000*	*2007*	*8*	*-12*			-3.875					180.38				
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
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0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													
0	*0*	*0*	*0*													

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (2000-2007)

TsNumber	1
Name	Cd (mg/L)
Years	2000 - 2007
n	8
Test S	-20
Test Z	
Signific.	*
Q	-6.25E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.25E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

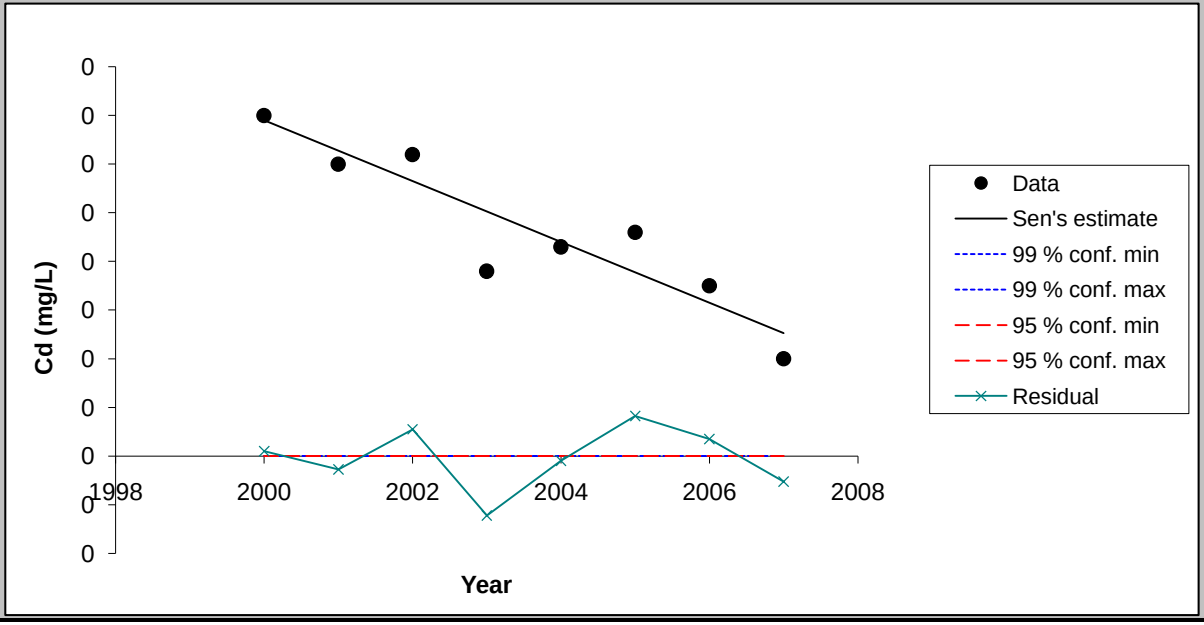


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2002	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series

Next Time Series >

TW-45 (2000-2007)

TsNumber	2
Name	F (mg/L)
Years	2000 - 2007
n	8
Test S	1
Test Z	
Signific.	
Q	2.00E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.76E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

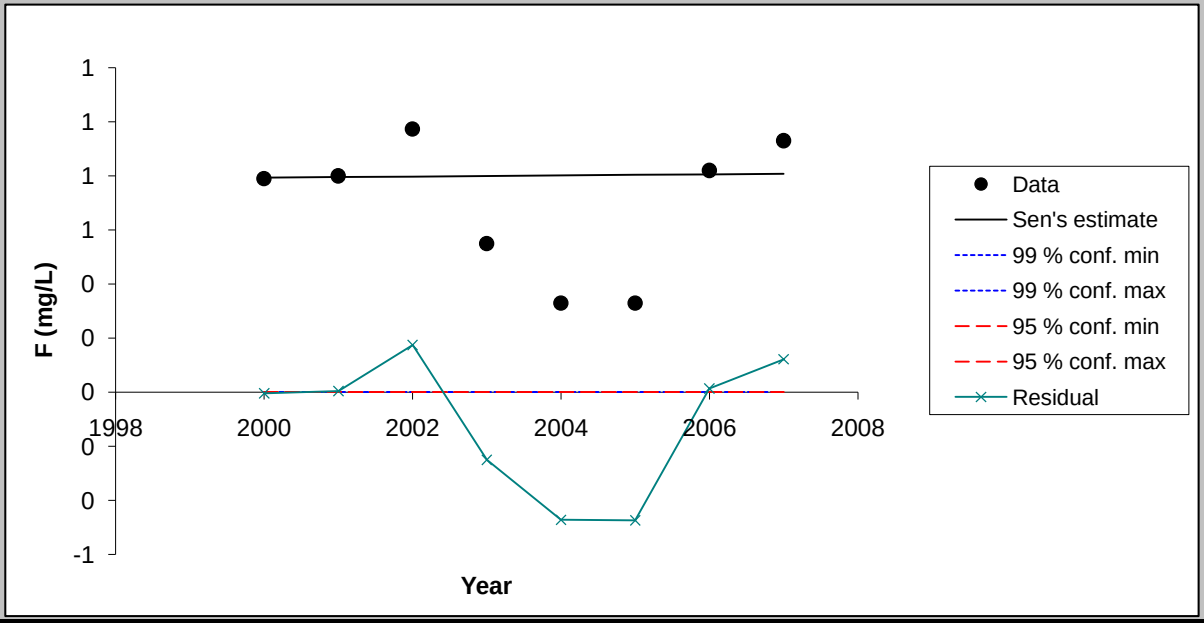


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.79	0.79	0.00	0.00	0.00	0.00	0.00
2001	0.80	0.80	0.00	0.00	0.00	0.00	0.00
2002	0.97	0.80	0.00	0.00	0.00	0.00	0.17
2003	0.55	0.80	0.00	0.00	0.00	0.00	-0.25
2004	0.33	0.80	0.00	0.00	0.00	0.00	-0.47
2005	0.33	0.80	0.00	0.00	0.00	0.00	-0.47
2006	0.82	0.81	0.00	0.00	0.00	0.00	0.01
2007	0.93	0.81	0.00	0.00	0.00	0.00	0.12

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	3
Name	Mn (mg/L)
Years	2000 - 2007
n	8
Test S	-16
Test Z	
Signific.	+
Q	-9.58E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	5.86E-01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

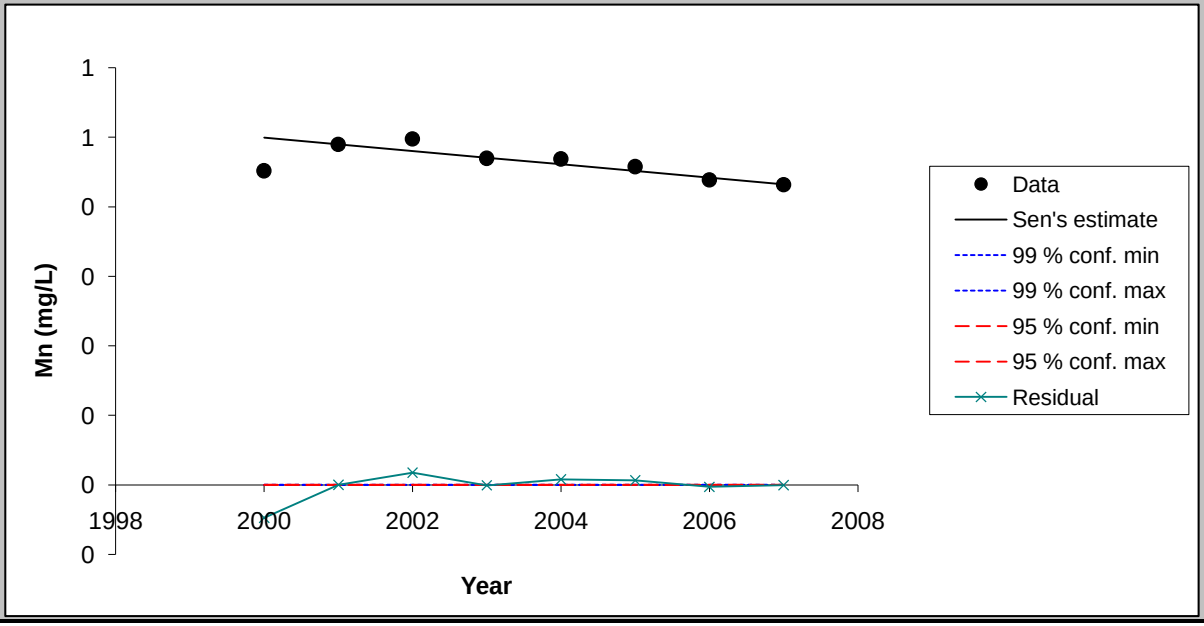


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.45	0.50	0.00	0.00	0.00	0.00	-0.05
2001	0.49	0.49	0.00	0.00	0.00	0.00	0.00
2002	0.50	0.48	0.00	0.00	0.00	0.00	0.02
2003	0.47	0.47	0.00	0.00	0.00	0.00	0.00
2004	0.47	0.46	0.00	0.00	0.00	0.00	0.01
2005	0.46	0.45	0.00	0.00	0.00	0.00	0.01
2006	0.44	0.44	0.00	0.00	0.00	0.00	0.00
2007	0.43	0.43	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	4
Name	Nitrate (mg/L)
Years	2000 - 2007
n	8
Test S	-13
Test Z	
Signific.	
Q	-2.17E-03
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.30E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

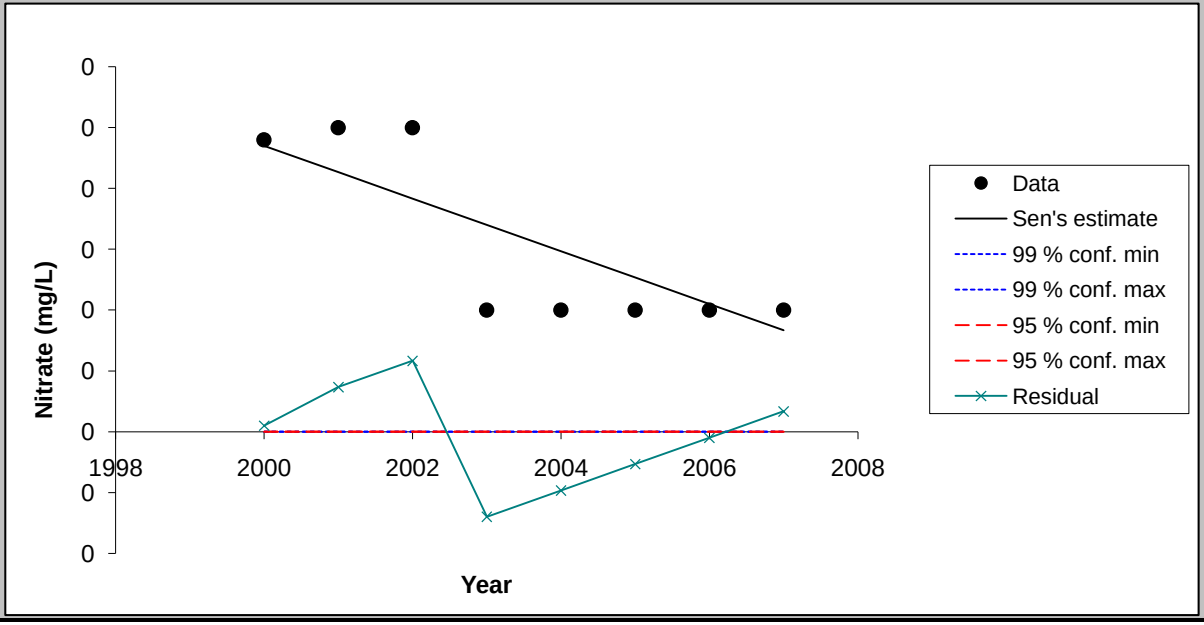


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.02	0.00	0.00	0.00	0.00	0.00
2002	0.03	0.02	0.00	0.00	0.00	0.00	0.01
2003	0.01	0.02	0.00	0.00	0.00	0.00	-0.01
2004	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2007	0.01	0.01	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	5
Name	Se (mg/L)
Years	2000 - 2007
n	8
Test S	-9
Test Z	
Signific.	
Q	-3.50E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	7.25E-03
Bmin99	
Bmax99	
Bmin95	
Bmax95	

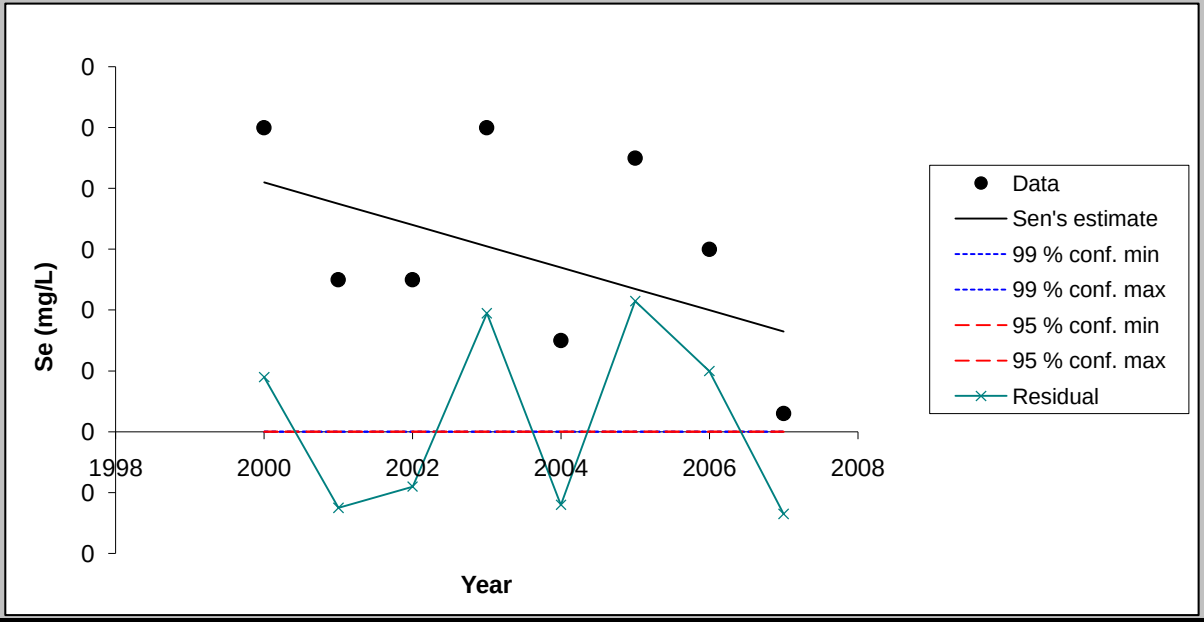


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	6
Name	Cl (mg/L)
Years	2000 - 2007
n	8
Test S	-14
Test Z	
Signific.	
Q	-1.01E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	4.52E+01
Bmin99	
Bmax99	
Bmin95	
Bmax95	

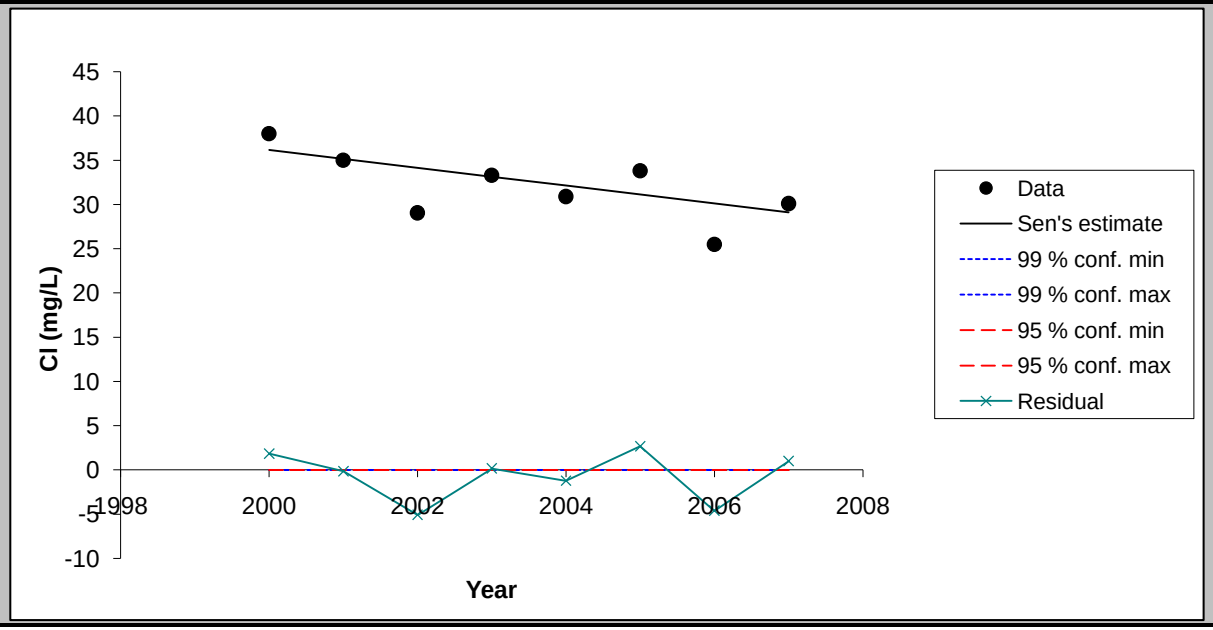


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	38.00	36.17	0.00	0.00	0.00	0.00	1.83
2001	35.00	35.16	0.00	0.00	0.00	0.00	-0.16
2002	29.06	34.15	0.00	0.00	0.00	0.00	-5.09
2003	33.30	33.14	0.00	0.00	0.00	0.00	0.16
2004	30.90	32.13	0.00	0.00	0.00	0.00	-1.23
2005	33.80	31.12	0.00	0.00	0.00	0.00	2.68
2006	25.50	30.11	0.00	0.00	0.00	0.00	-4.61
2007	30.10	29.11	0.00	0.00	0.00	0.00	0.99

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	7
Name	Mo (mg/L)
Years	2000 - 2007
n	8
Test S	8
Test Z	
Signific.	
Q	6.90E-04
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.75E-02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

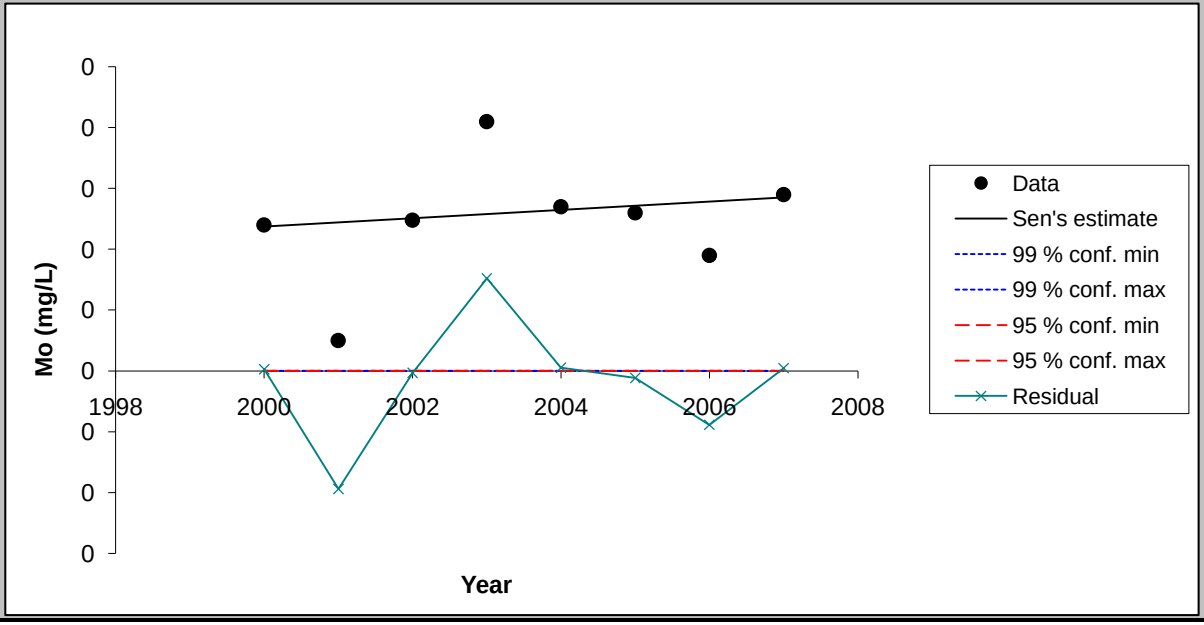


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.02	0.00	0.00	0.00	0.00	-0.02
2002	0.02	0.03	0.00	0.00	0.00	0.00	0.00
2003	0.04	0.03	0.00	0.00	0.00	0.00	0.02
2004	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2005	0.03	0.03	0.00	0.00	0.00	0.00	0.00
2006	0.02	0.03	0.00	0.00	0.00	0.00	-0.01
2007	0.03	0.03	0.00	0.00	0.00	0.00	0.00

FIGURE

< Previous Time Series | Next Time Series >

TW-45 (2000-2007)

TsNumber	8
Name	SO4 (mg/L)
Years	2000 - 2007
n	8
Test S	-12
Test Z	
Signific.	
Q	-3.88E+00
Qmin99	
Qmax99	
Qmin95	
Qmax95	
B	1.80E+02
Bmin99	
Bmax99	
Bmin95	
Bmax95	

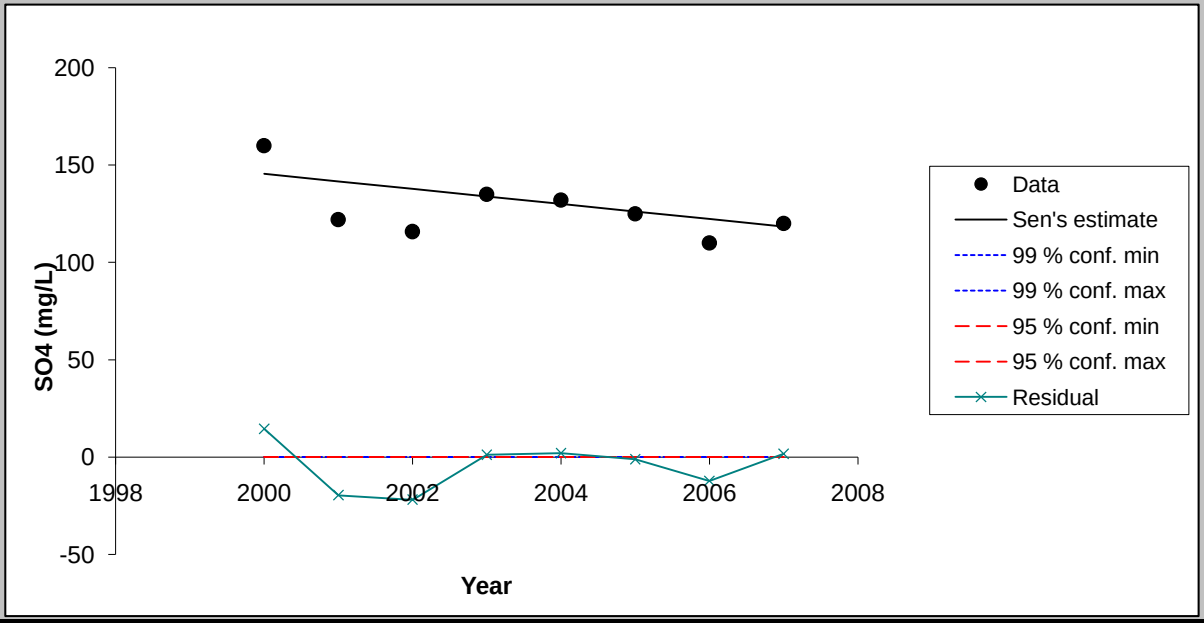


Chart options

- [x] show 99 % confidence interval
- [x] show 95 % confidence interval
- [x] show residuals

Update chart outlook

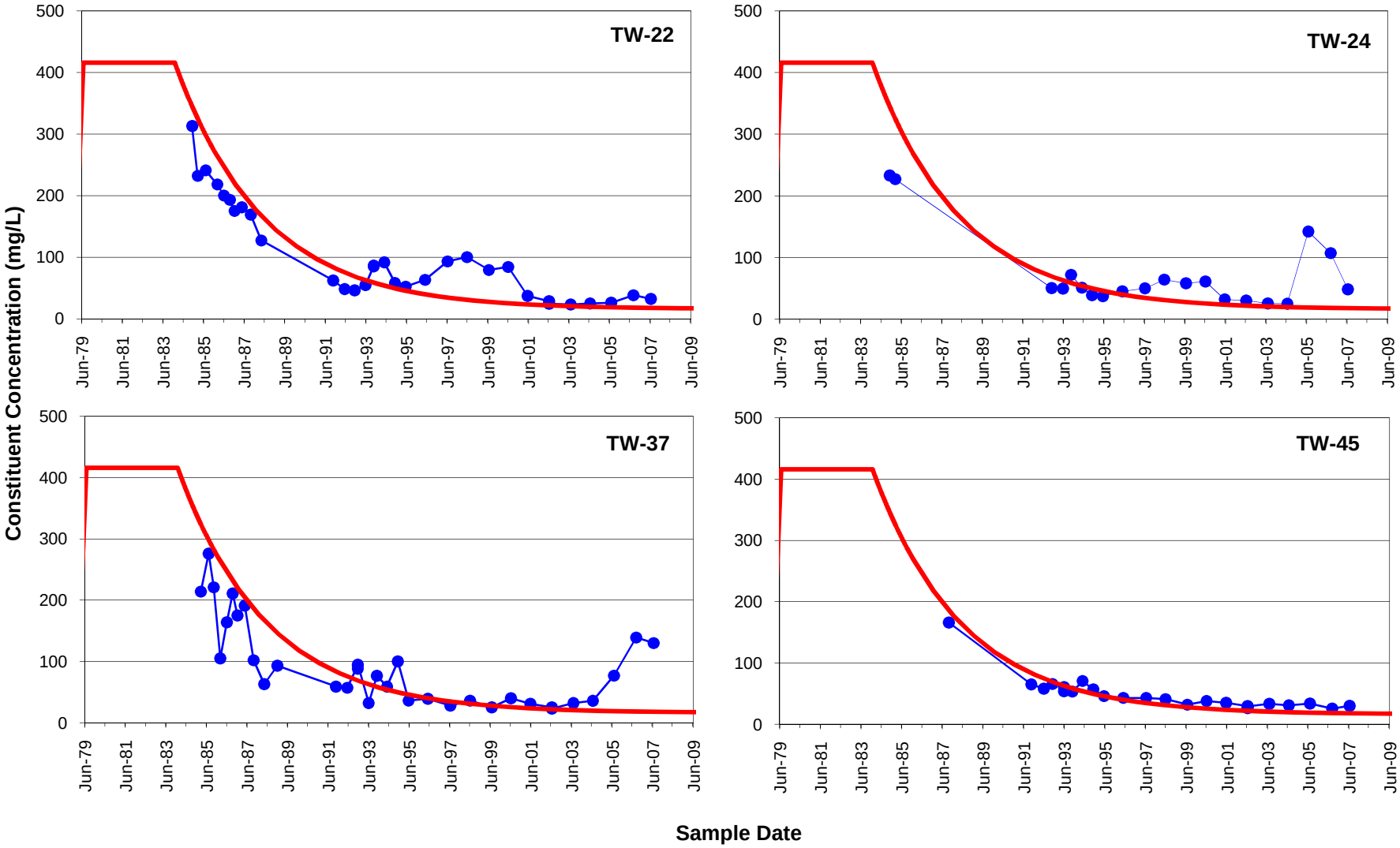
Equation of the lines:
f(year) = Q*(year-firstDataYear) + B
FirstDataYear= 1991

Point values for the chart

Year	Data	Sen's estim	99 % conf. m	99 % conf. m	95 % conf. m	95 % conf. m	Residual
2000	160.00	145.50	0.00	0.00	0.00	0.00	14.50
2001	122.00	141.63	0.00	0.00	0.00	0.00	-19.63
2002	115.82	137.75	0.00	0.00	0.00	0.00	-21.93
2003	135.00	133.88	0.00	0.00	0.00	0.00	1.13
2004	132.00	130.00	0.00	0.00	0.00	0.00	2.00
2005	125.00	126.13	0.00	0.00	0.00	0.00	-1.13
2006	110.00	122.25	0.00	0.00	0.00	0.00	-12.25
2007	120.00	118.38	0.00	0.00	0.00	0.00	1.63

ATTACHMENT D

GOLDSIM SOLUTE TRANSPORT MODEL OUTPUT



FILE NAME chloride

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

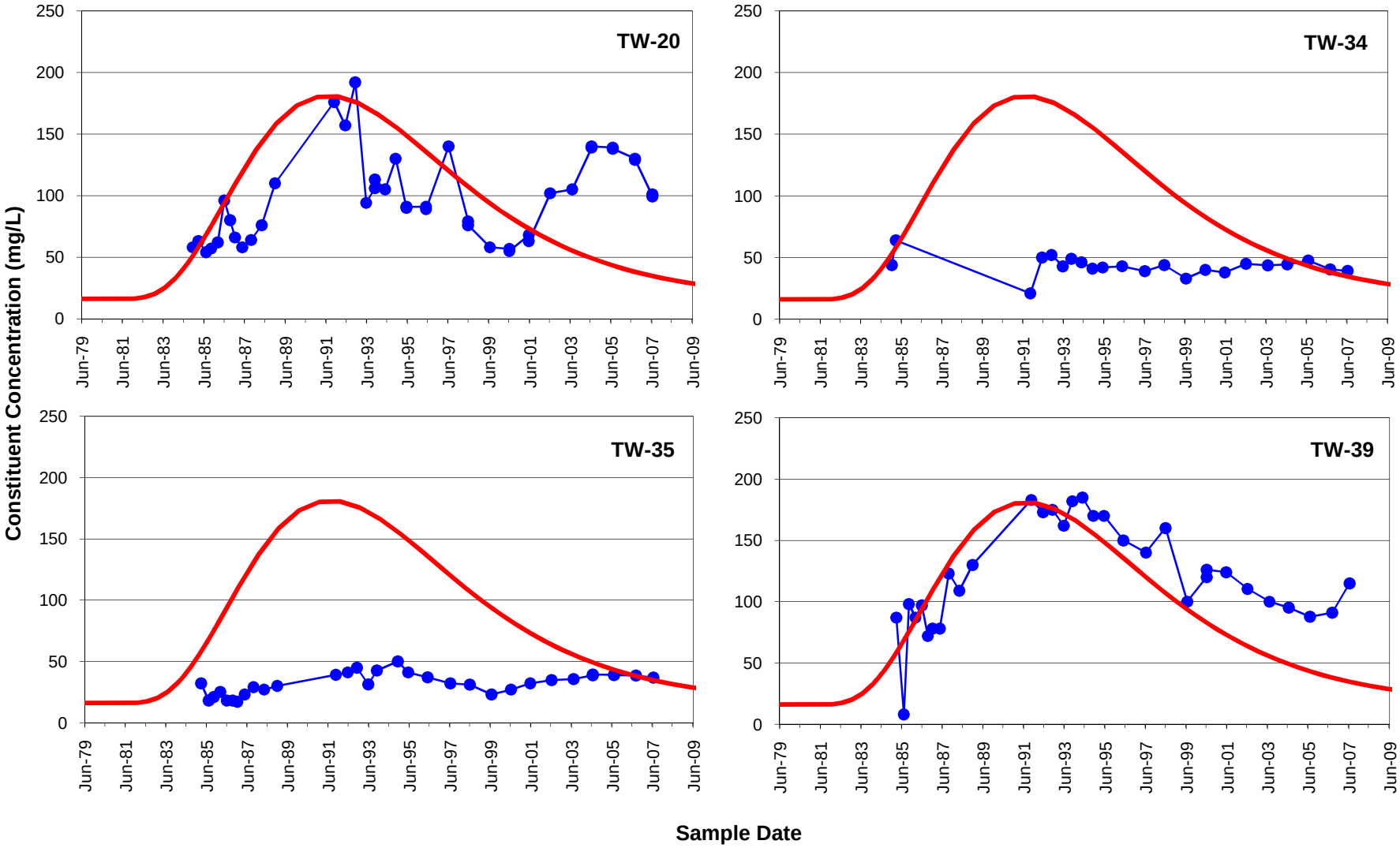
Chloride in Old Underflow Solids Pond Area Wells

FIGURE D-1

Constituent Concentration (mg/L)

GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME chloride

Remediation goals shown for point of compliance locations only

Golder Associates

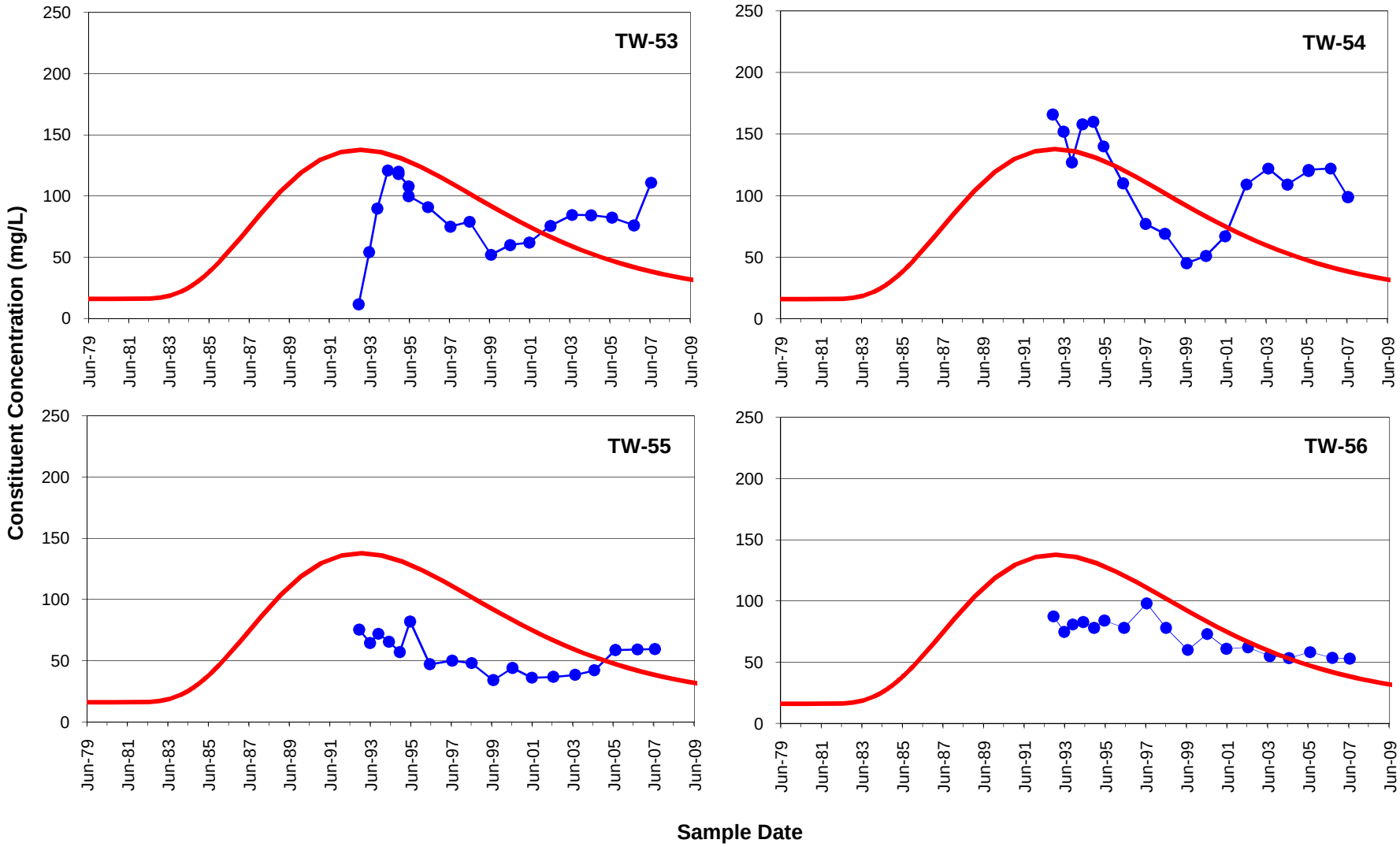
TITLE **Chloride in South Fenceline Wells**

FIGURE D-2

Constituent Concentration (mg/L)

GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME chloride

Remediation goals shown for point of compliance locations only

Golder Associates

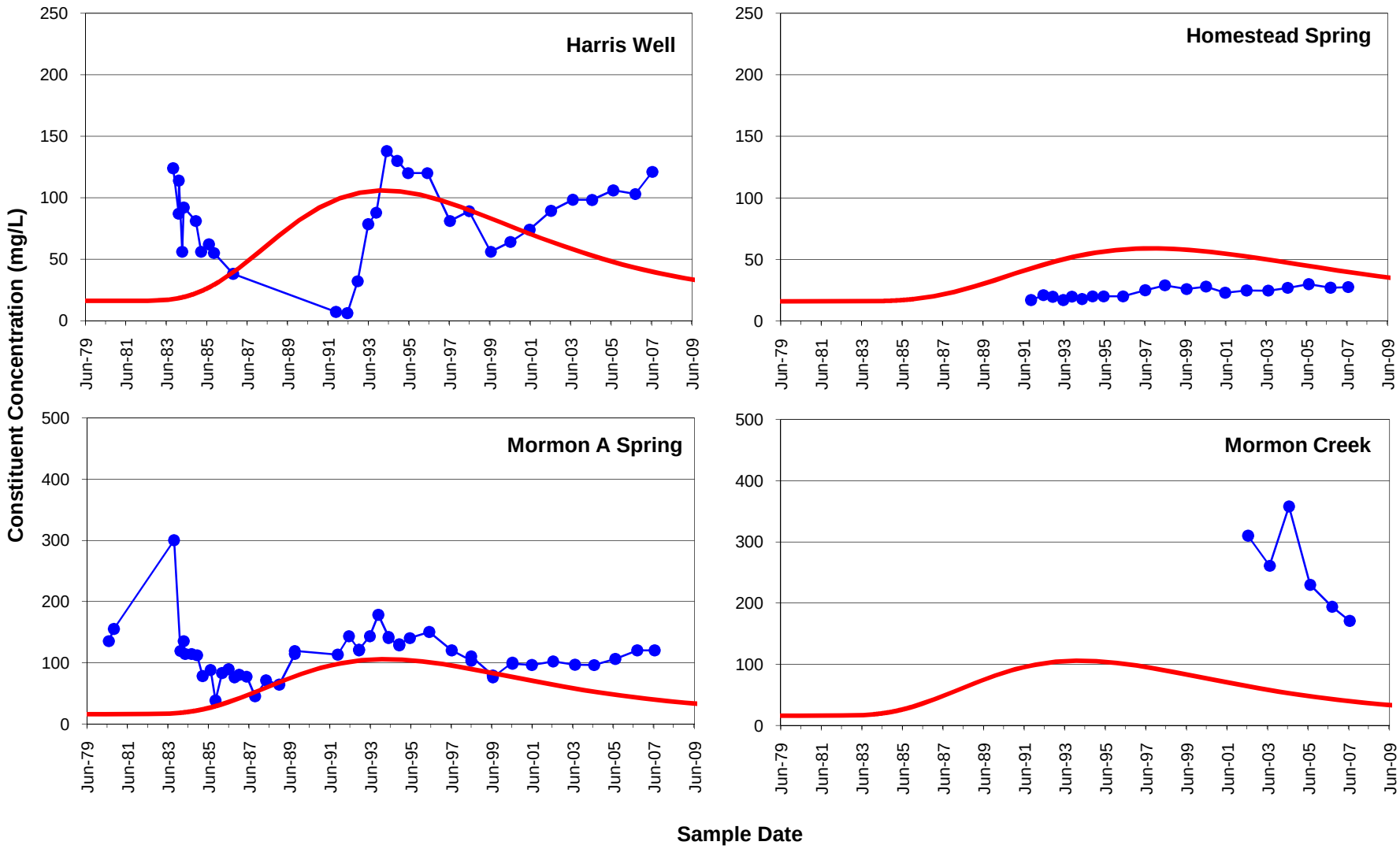
TITLE **Chloride in Southern Boundary Wells**

FIGURE D-3

Constituent Concentration (mg/L)

GoldSim

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME chloride

Remediation goals shown for point of compliance locations only

Golder Associates

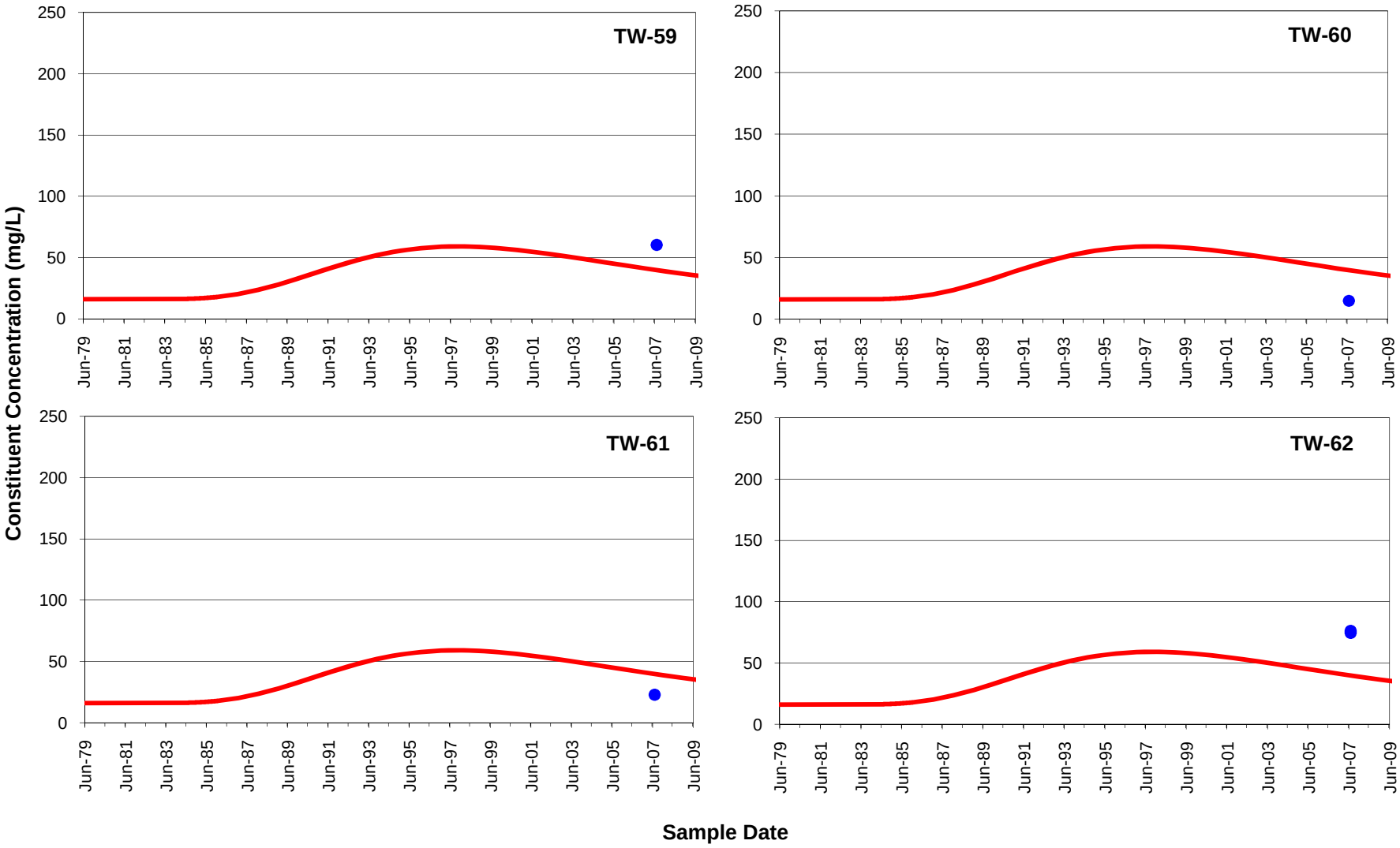
TITLE **Chloride in Harris Well and Springs South of Plant**

FIGURE D-4

Constituent Concentration (mg/L)

GoldSim

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME chloride

Remediation goals shown for point of compliance locations only

Golder Associates

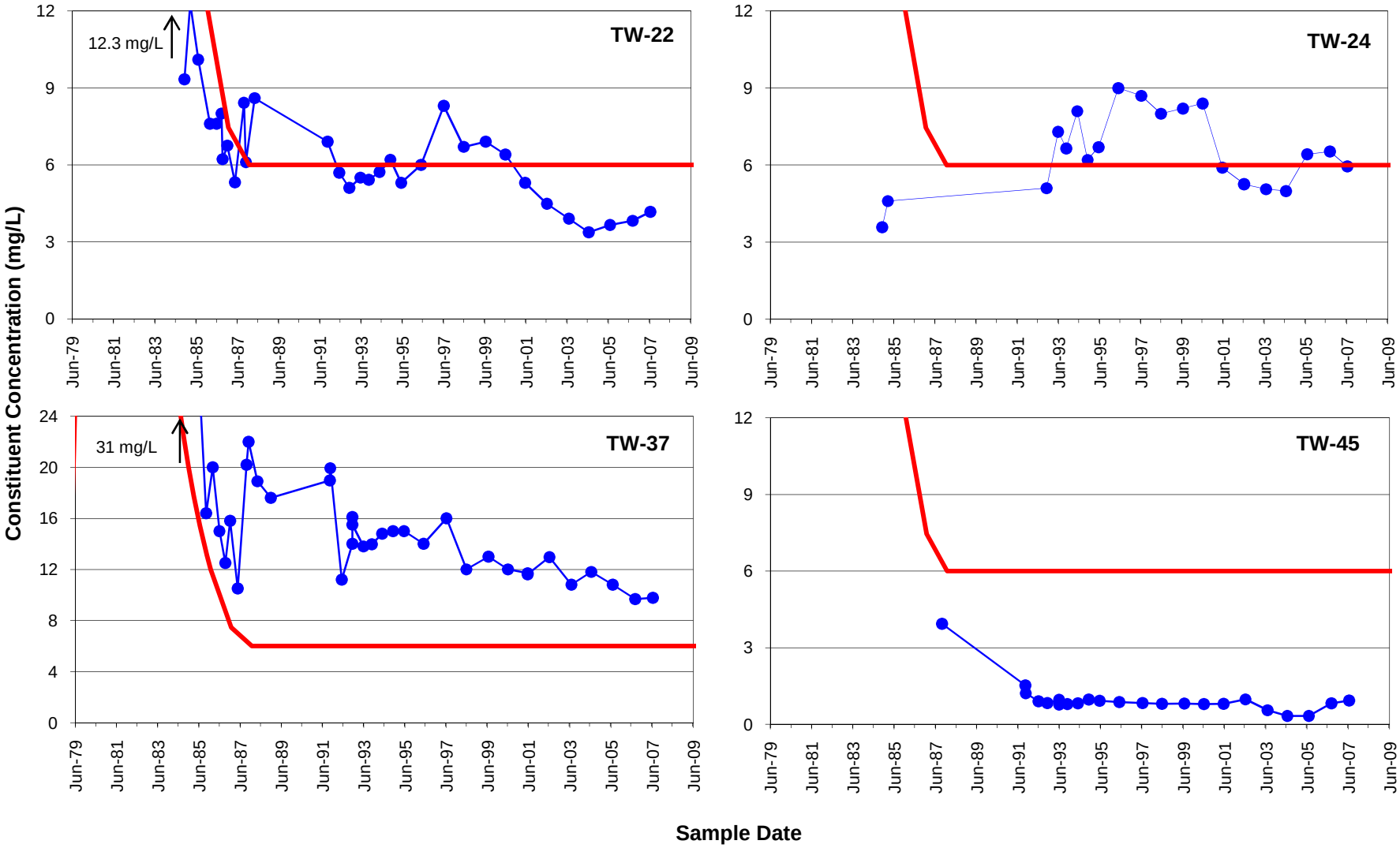
TITLE **Chloride in 2007 Monitoring Wells**

FIGURE D-5

Constituent Concentration (mg/L)

GoldSim

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME fluoride

Remediation goals shown for point of compliance locations only

Golder Associates

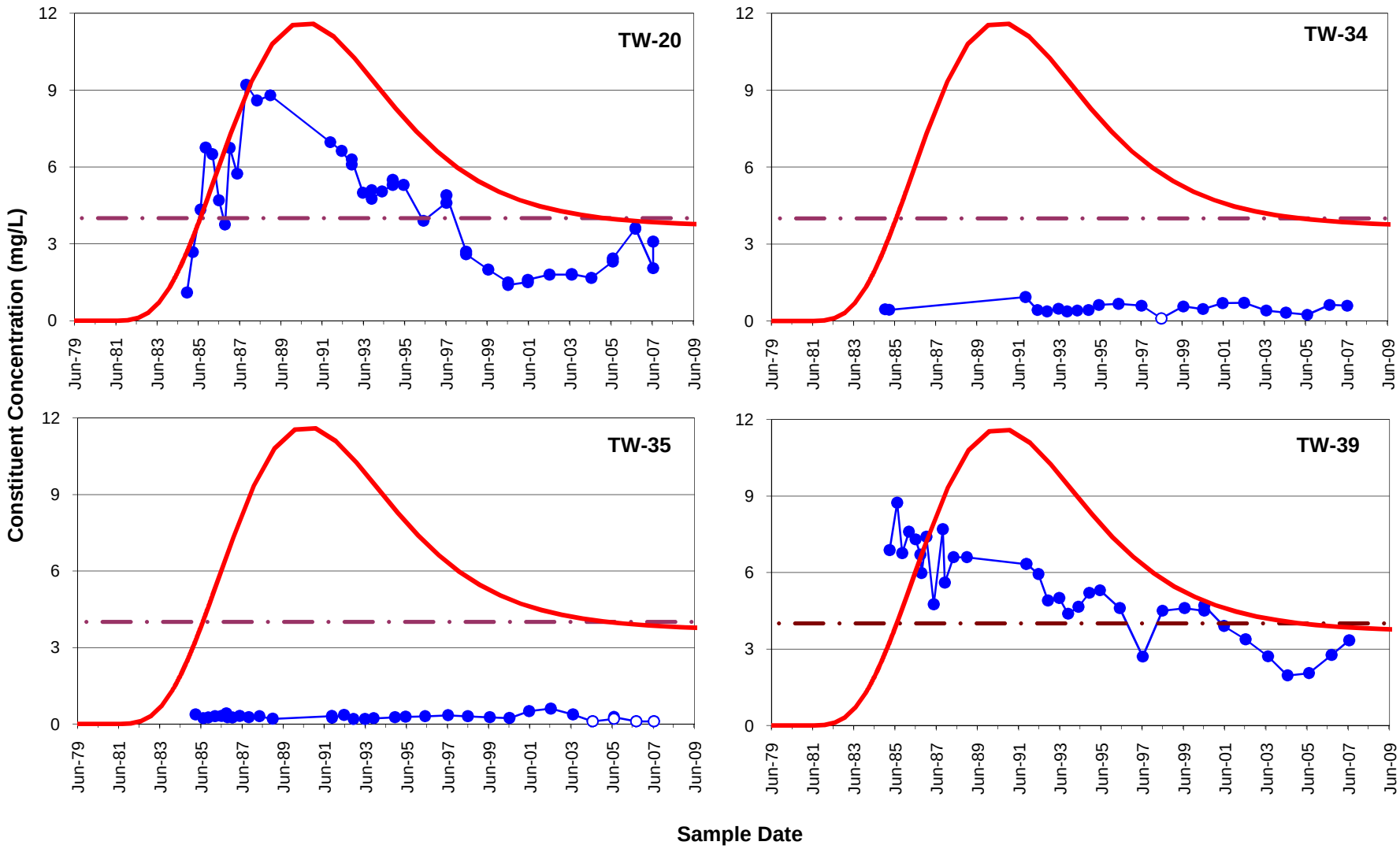
TITLE

Fluoride in Old Underflow Solids Pond Area Wells

FIGURE D-6

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME fluoride

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

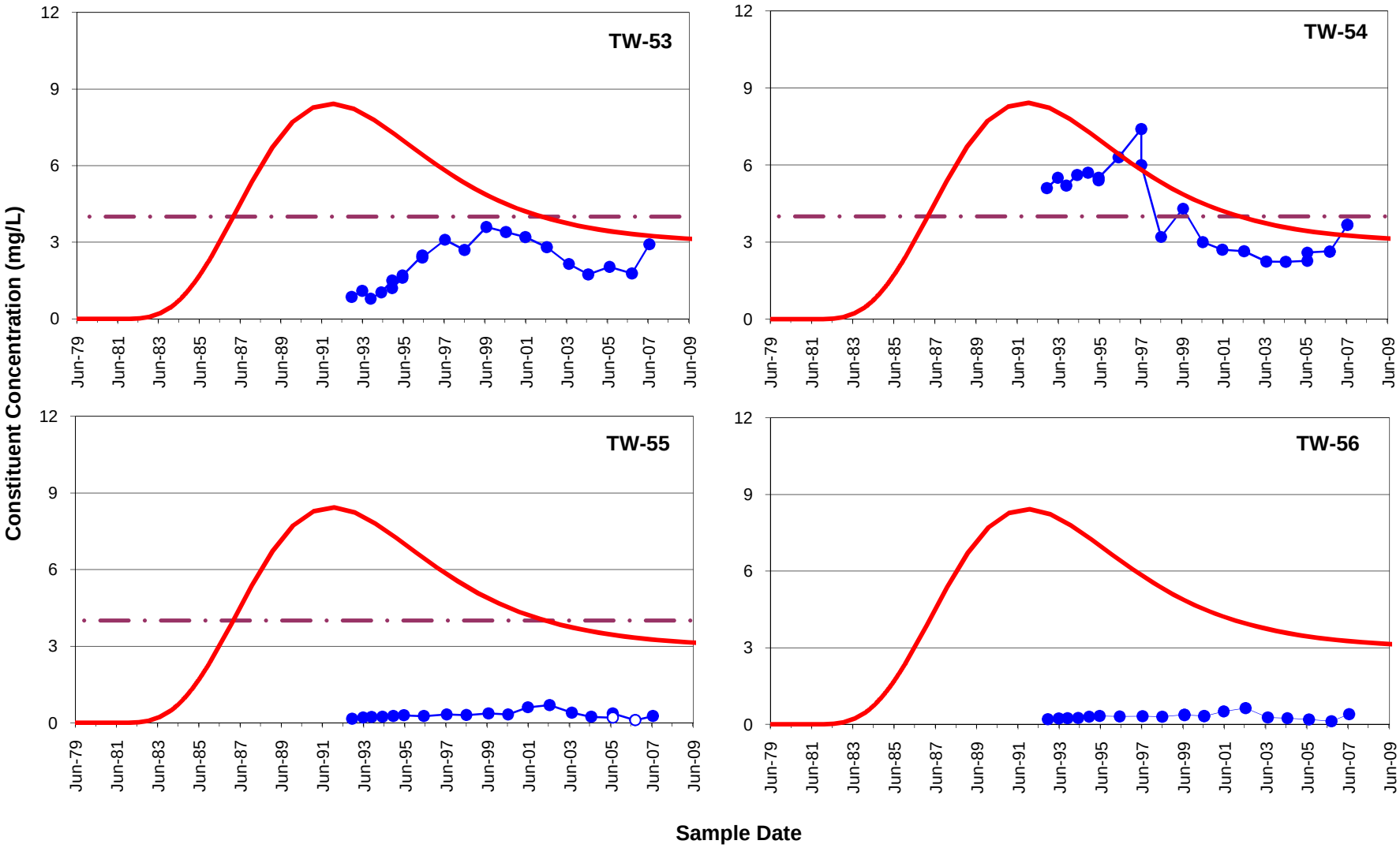
Fluoride in South Fenceline Wells

- Constituent Concentration (mg/L)
- Non-Detects
- Fluoride Remediation Goal (4 mg/L)
- GoldSim Model

CLIENT	Monsanto Company		
PROJECT	Monsanto Groundwater Monitoring		
PROJECT NO.	913-1101.605	DATE	3-Apr-08

FIGURE **D-7**

DRAWN	MPK
CHECKED	DH
REVIEWED	DB



FILE NAME fluoride

Remediation goals shown for point of compliance locations only

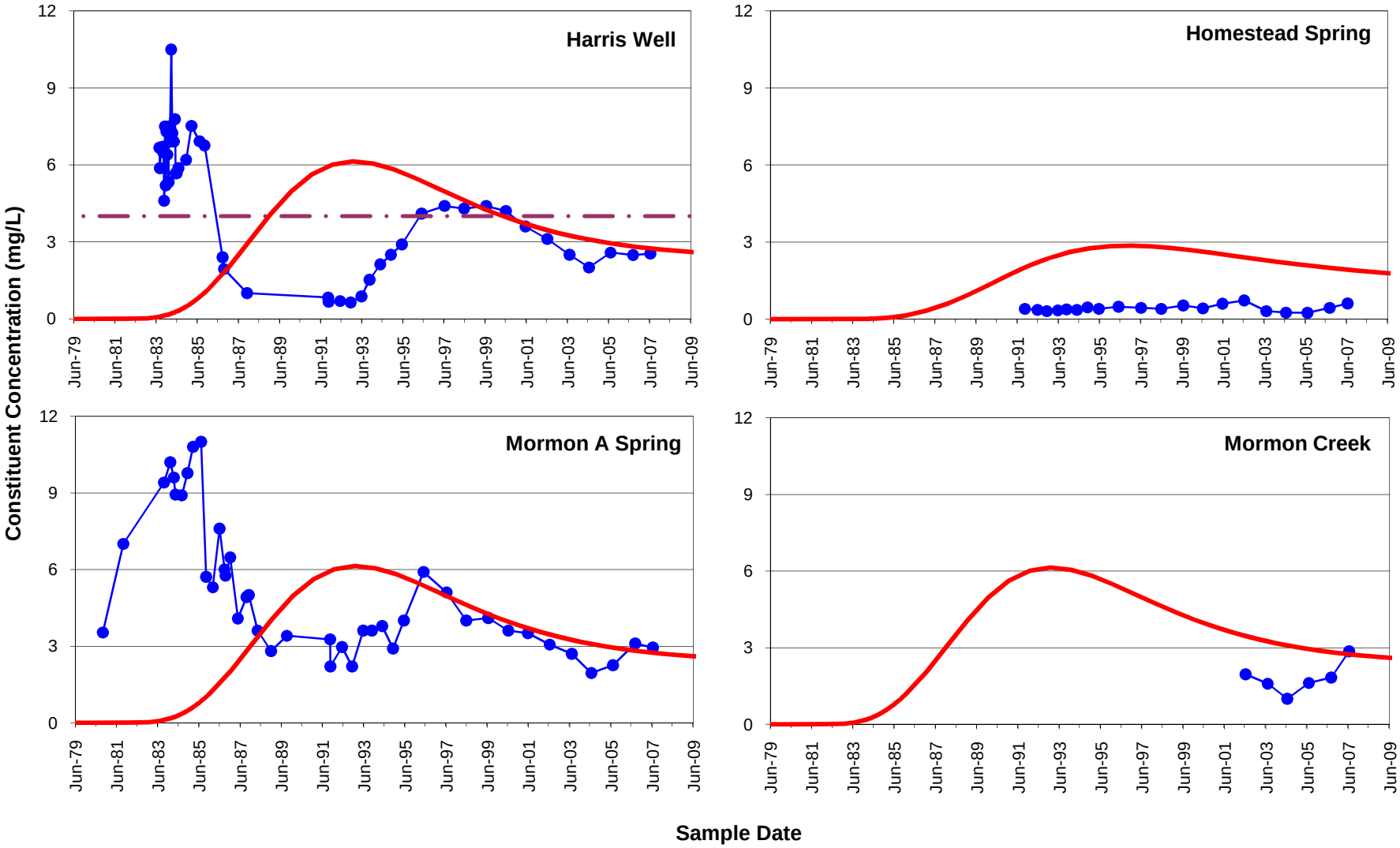
Golder Associates

TITLE **Fluoride in Southern Boundary Wells**

FIGURE D-8

- Constituent Concentration (mg/L)
- Non-Detects
- Fluoride Remediation Goal (4 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME fluoride

Remediation goals shown for point of compliance locations only

Golder Associates

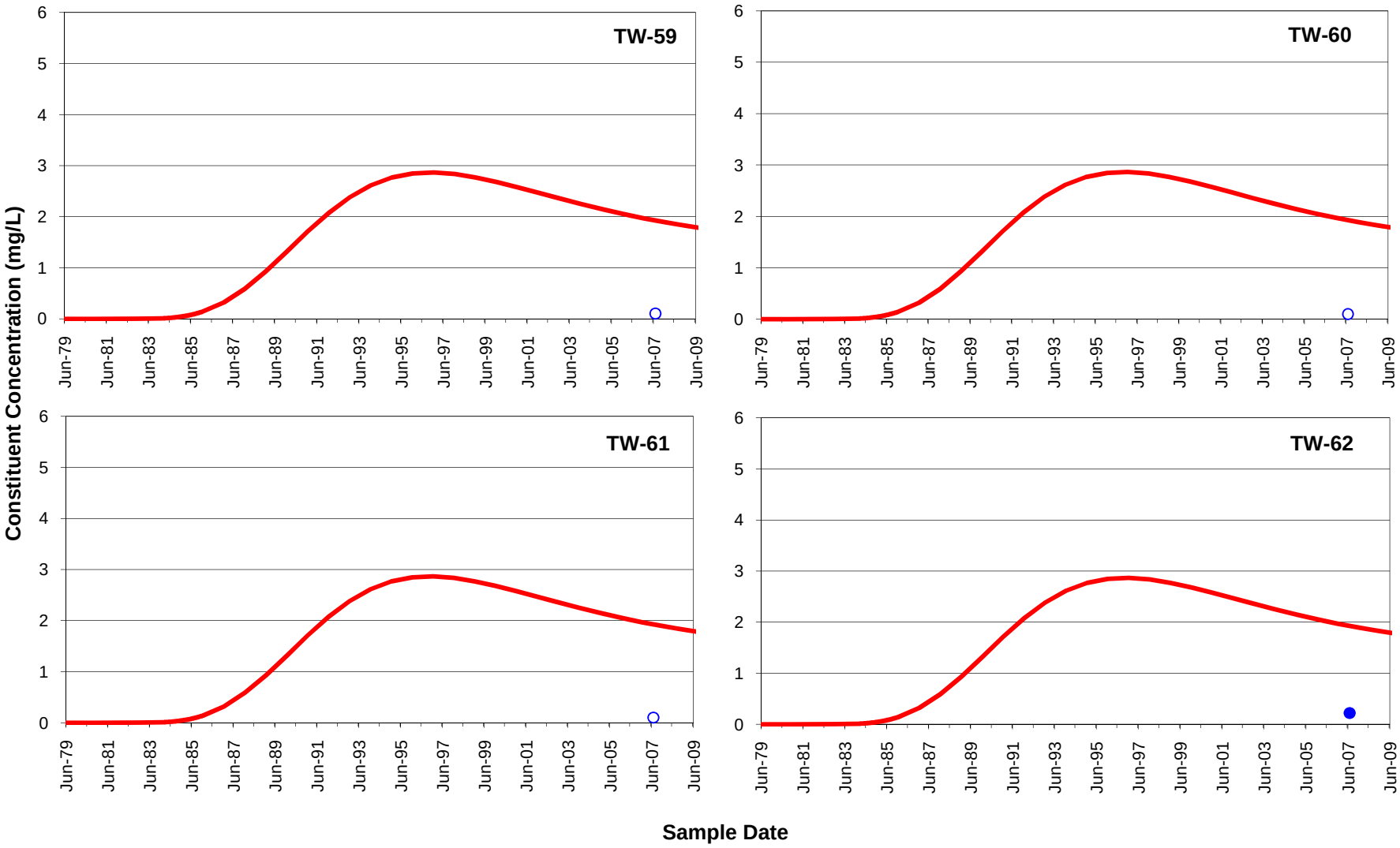
TITLE

Fluoride in Harris Well and Springs South of Plant

FIGURE D-9

Constituent Concentration (mg/L)
Fluoride Remediation Goal (4 mg/L)
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME fluoride

Remediation goals shown for point of compliance locations only

Golder Associates

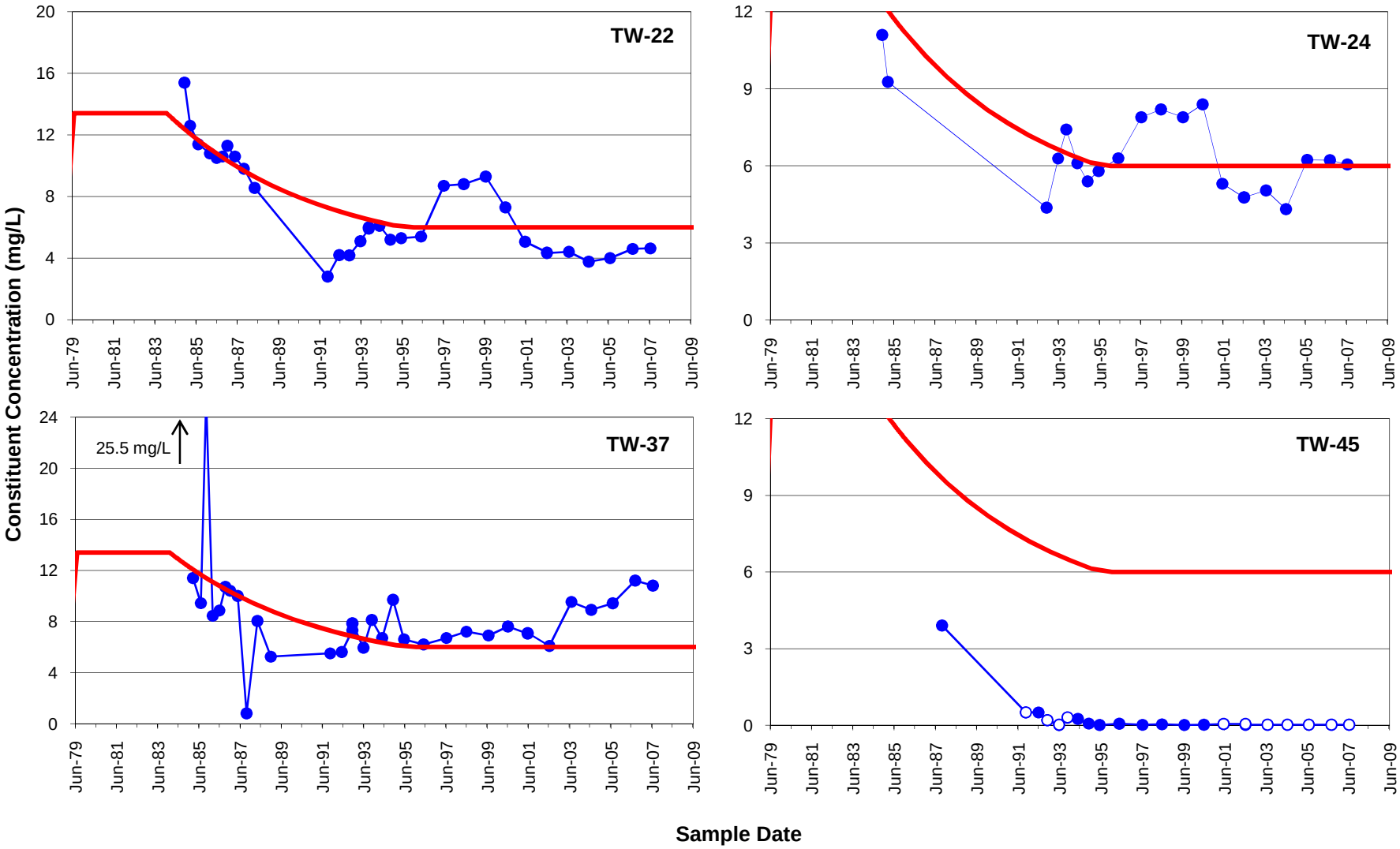
TITLE

Fluoride in 2007 Monitoring Wells

FIGURE D-10

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App D Nitrate Charts 2007.xls

Remediation goals shown for point of compliance locations only

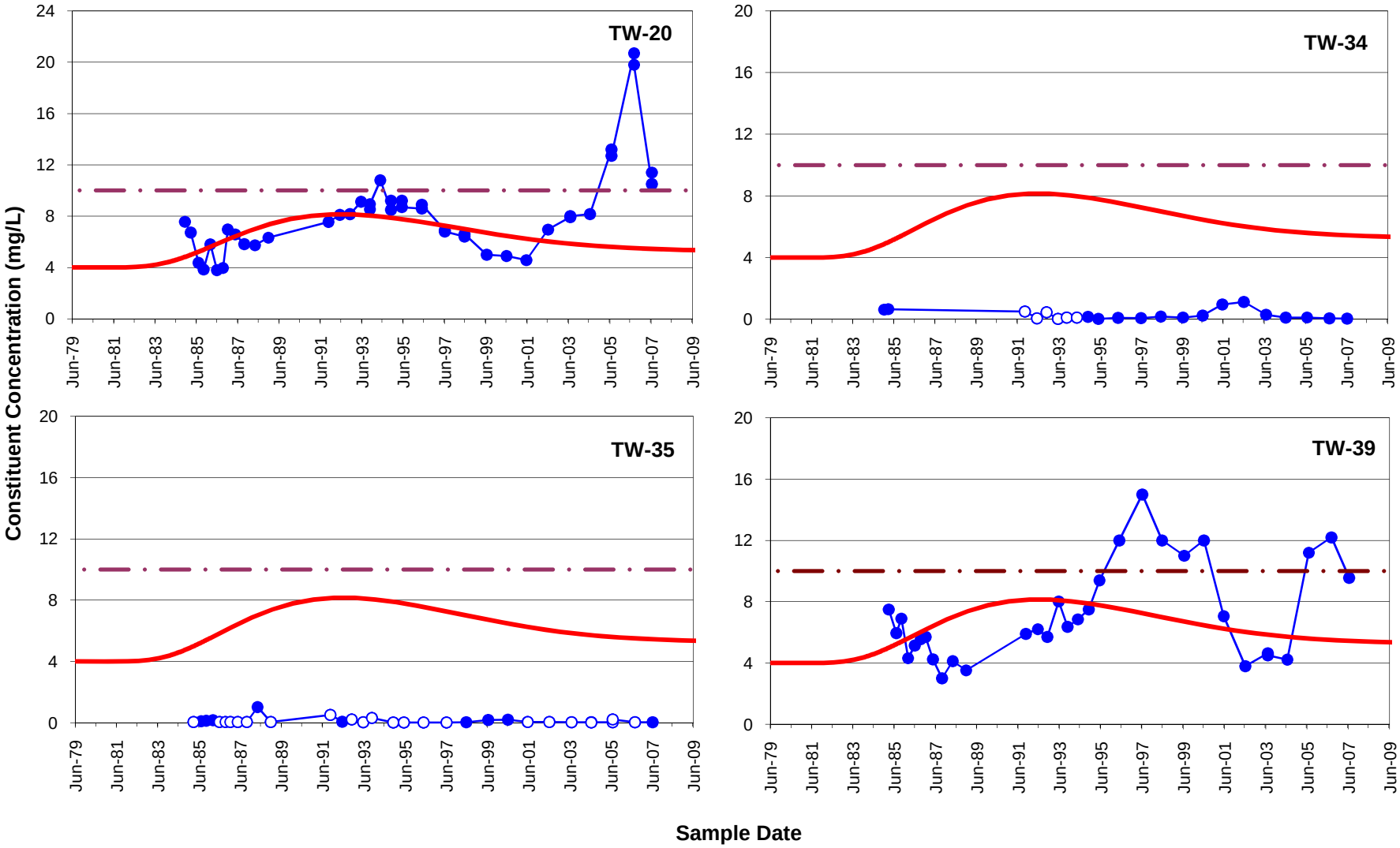
Golder Associates

TITLE **Nitrate in Old Underflow Solids Pond Area Wells**

FIGURE D-11

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App D Nitrate Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

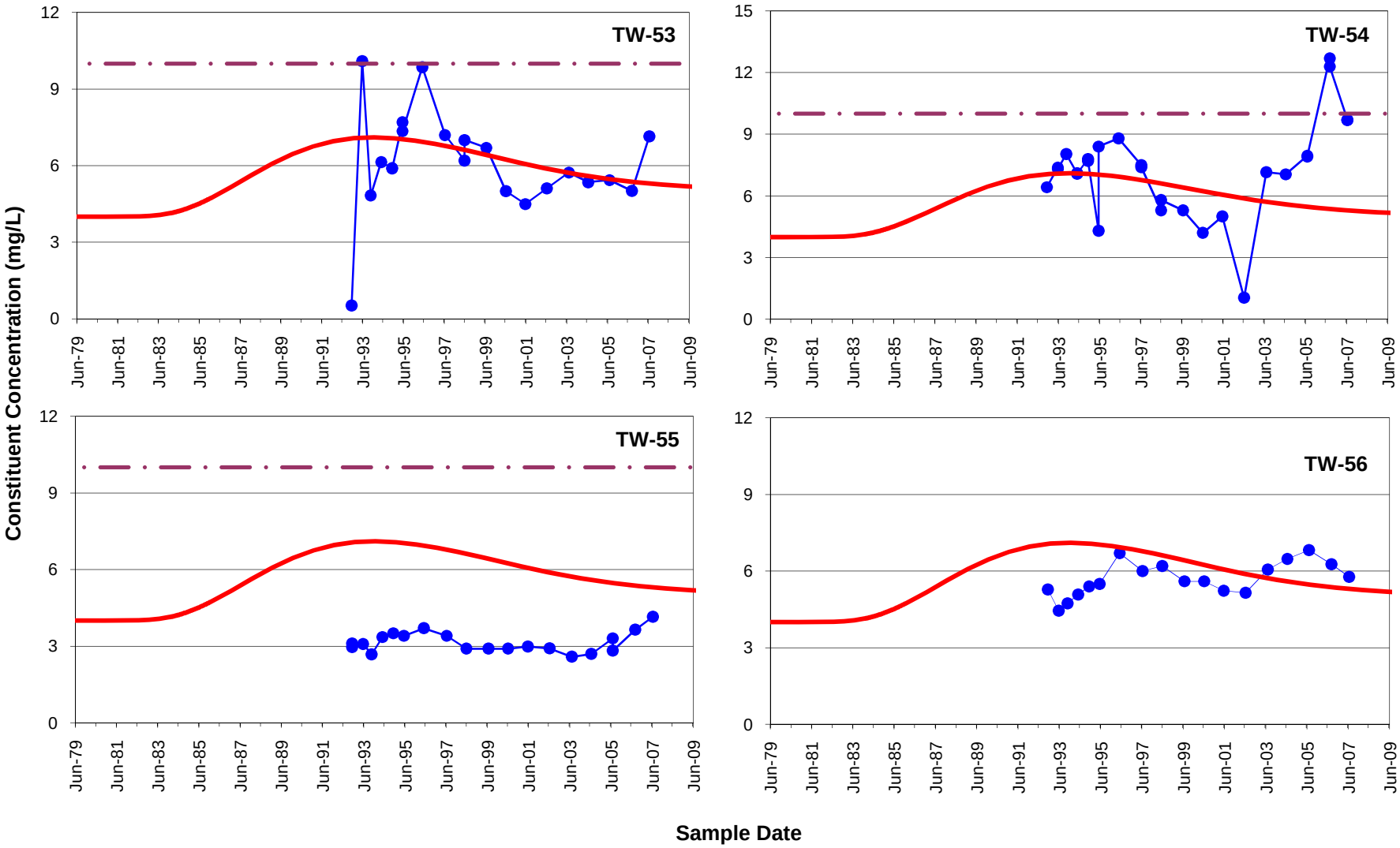
TITLE

Nitrate in South Fenceline Wells

FIGURE D-12

- Constituent Concentration (mg/L)
- Non-Detects
- Nitrate as N Remediation Goal (10 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App D Nitrate Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

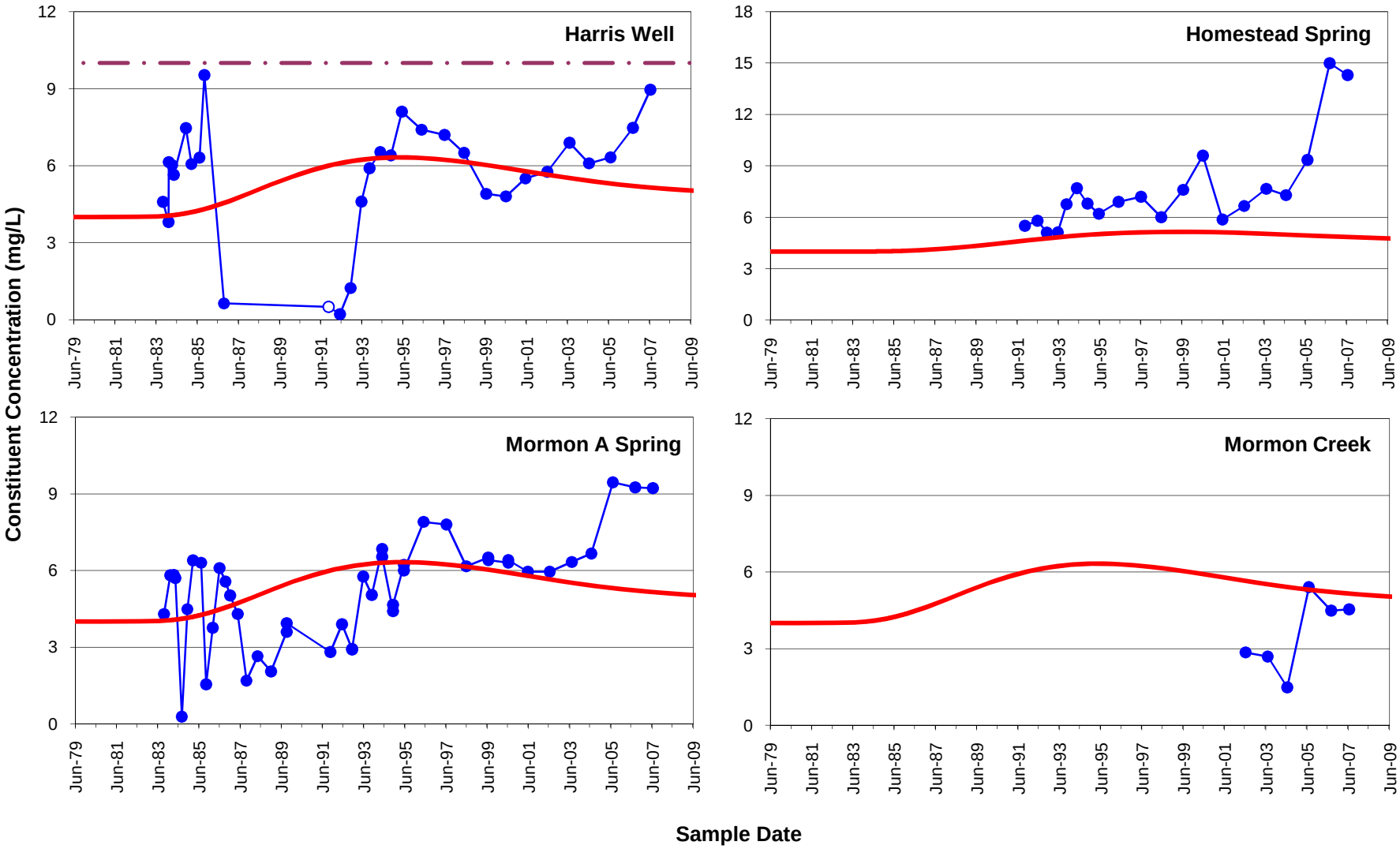
TITLE

Nitrate in Southern Boundary Wells

FIGURE D-13

- Constituent Concentration (mg/L)
- Nitrate as N Remediation Goal (10 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App D Nitrate Charts 2007.xls

Remediation goals shown for point of compliance locations only

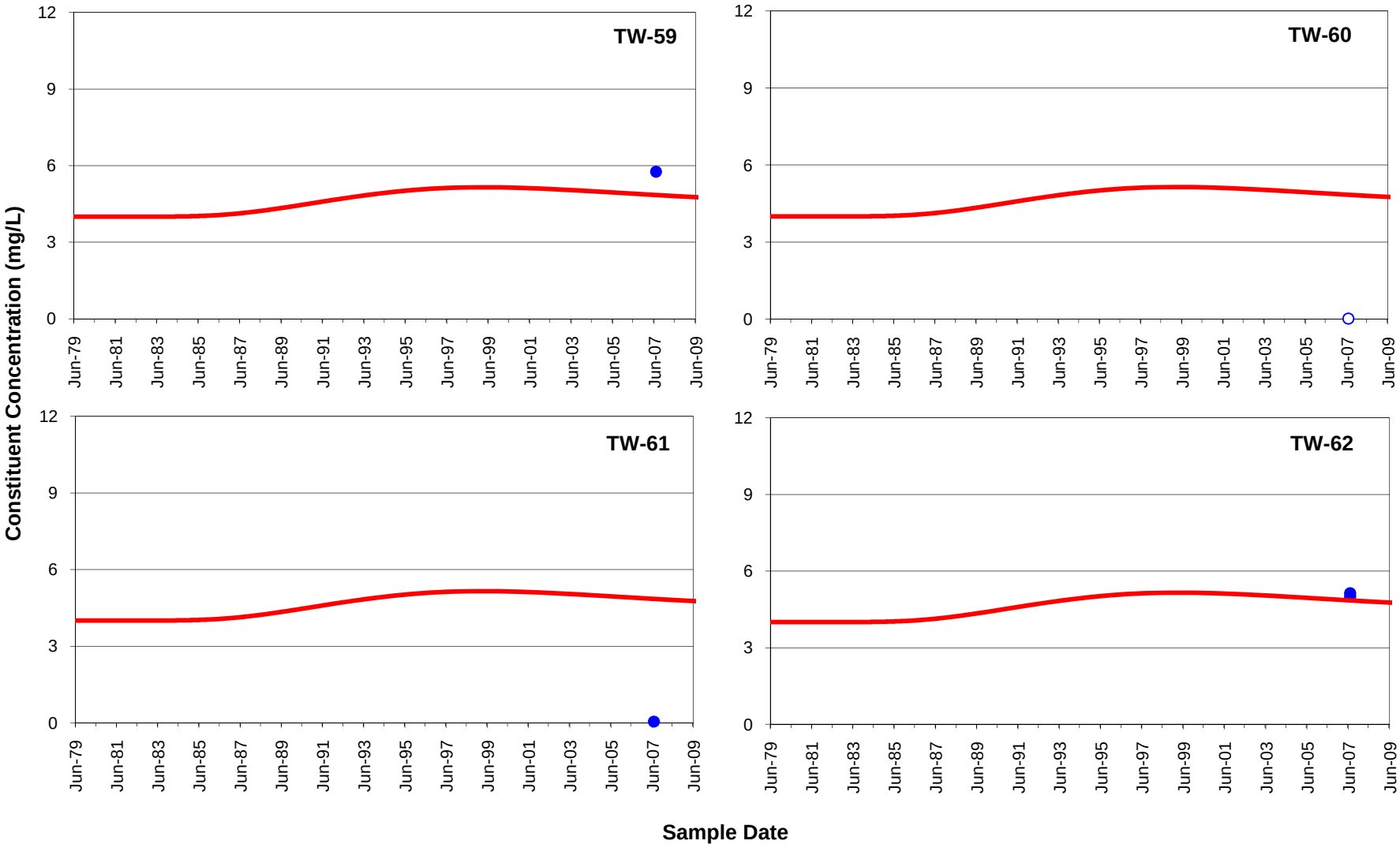
Golder Associates

TITLE **Nitrate in Harris Well and Springs South of Plant**

FIGURE D-14

- Constituent Concentration (mg/L)
- Non-Detects
- Nitrate as N Remediation Goal (10 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App D Nitrate Charts 2007.xls

Remediation goals shown for point of compliance locations only

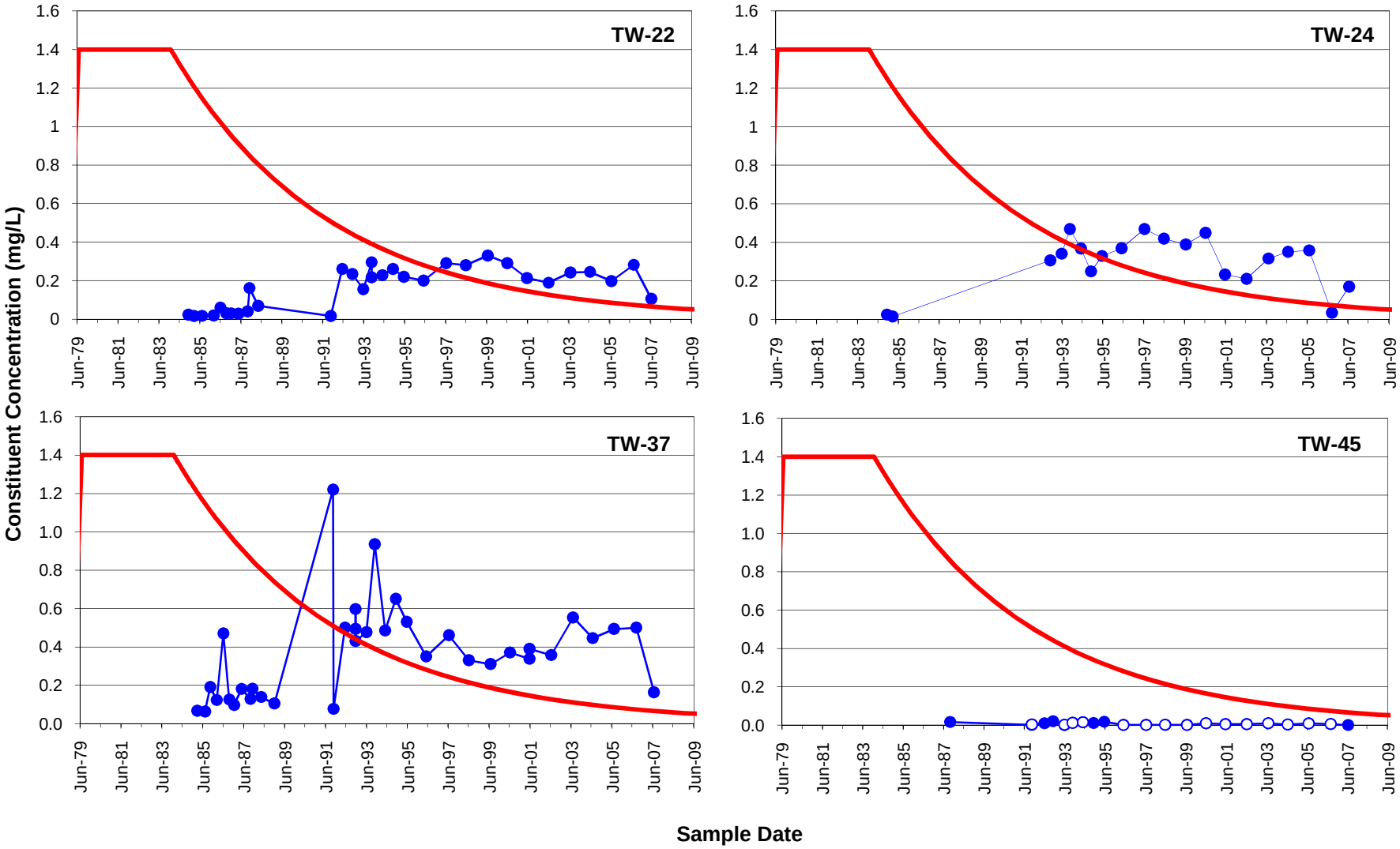
Golder Associates

TITLE **Nitrate in 2007 Monitoring Wells**

FIGURE D-15

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME selenium

Remediation goals shown for point of compliance locations only

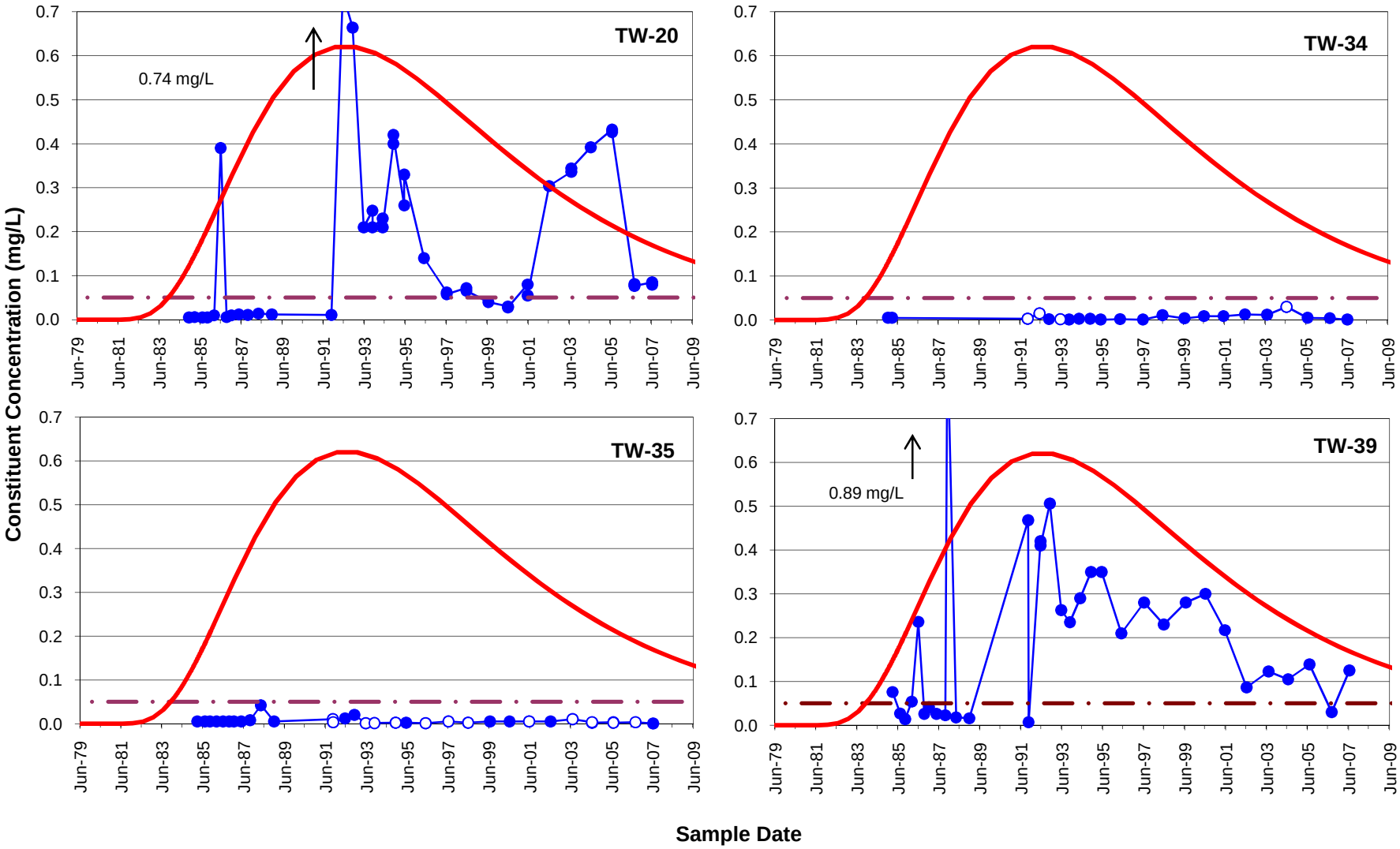
Golder Associates

TITLE **Selenium in Old Underflow Solids Pond Area Wells**

FIGURE D-16

Constituent Concentration (mg/L)
Non-detect
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME selenium

Remediation goals shown for point of compliance locations only

Golder Associates

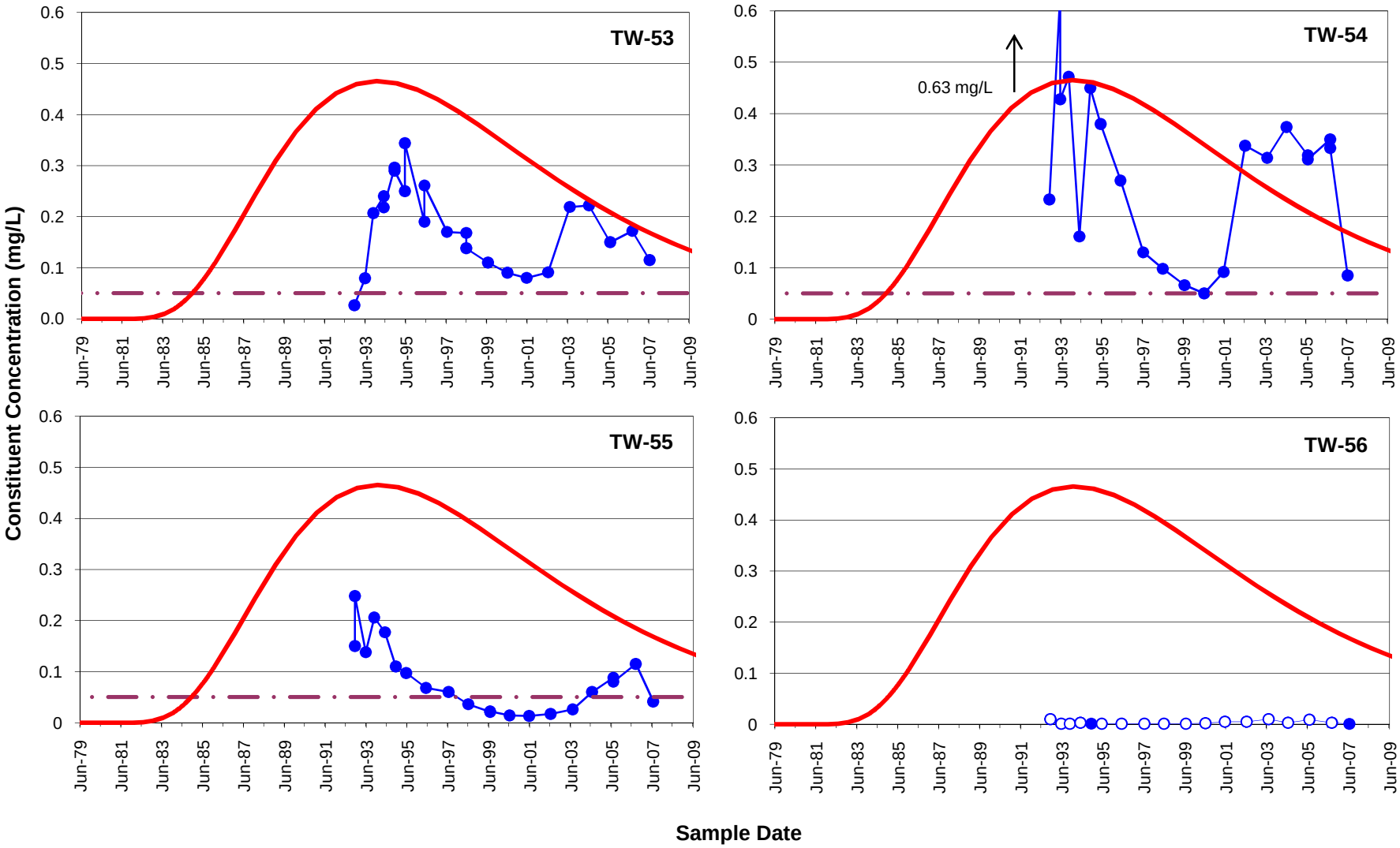
TITLE

Selenium in South Fenceline Wells

FIGURE D-17

- Constituent Concentration (mg/L)
- Non-Detects
- Selenium Remediation Goal (0.05 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME selenium

Remediation goals shown for point of compliance locations only

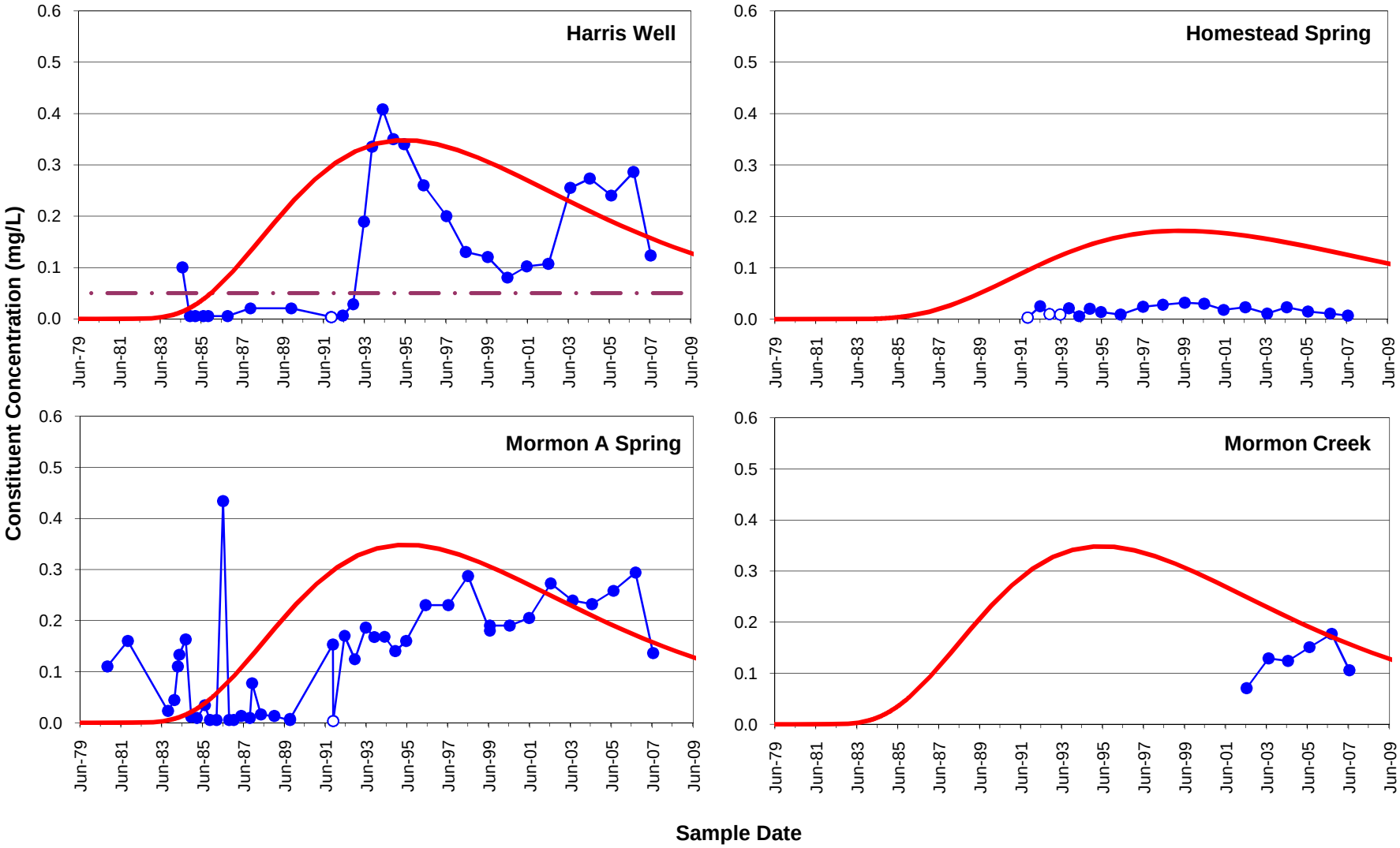
Golder Associates

TITLE **Selenium in Southern Boundary Wells**

FIGURE D-18

- Constituent Concentration (mg/L)
- Non-Detects
- Selenium Remediation Goal (0.05 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME selenium

Remediation goals shown for point of compliance locations only

Golder Associates

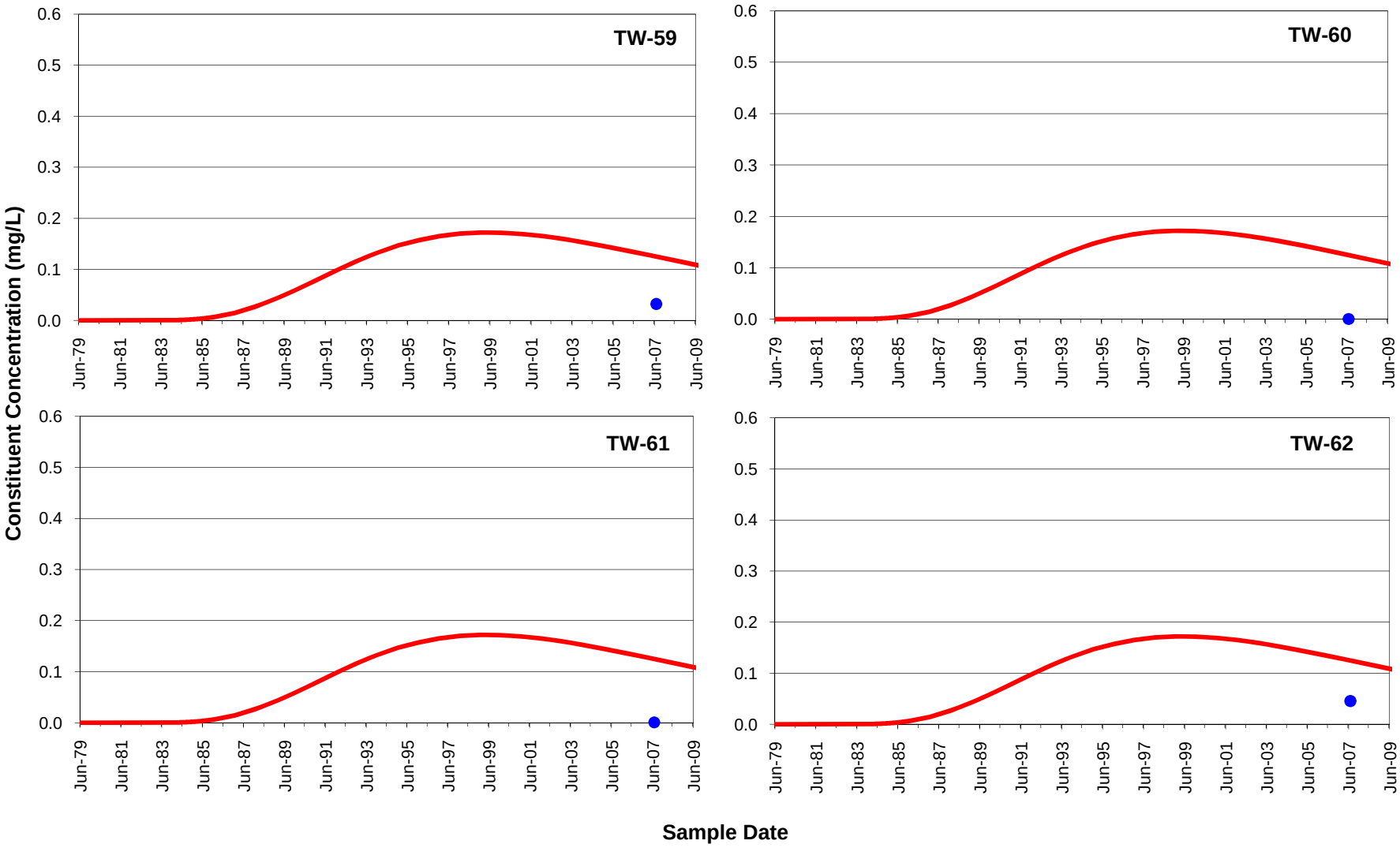
TITLE

Selenium in Harris Well and Springs South of Plant

FIGURE D-19

- Constituent Concentration (mg/L)
- Non-Detects
- Selenium Remediation Goal (0.05 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME selenium

Remediation goals shown for point of compliance locations only

Golder Associates

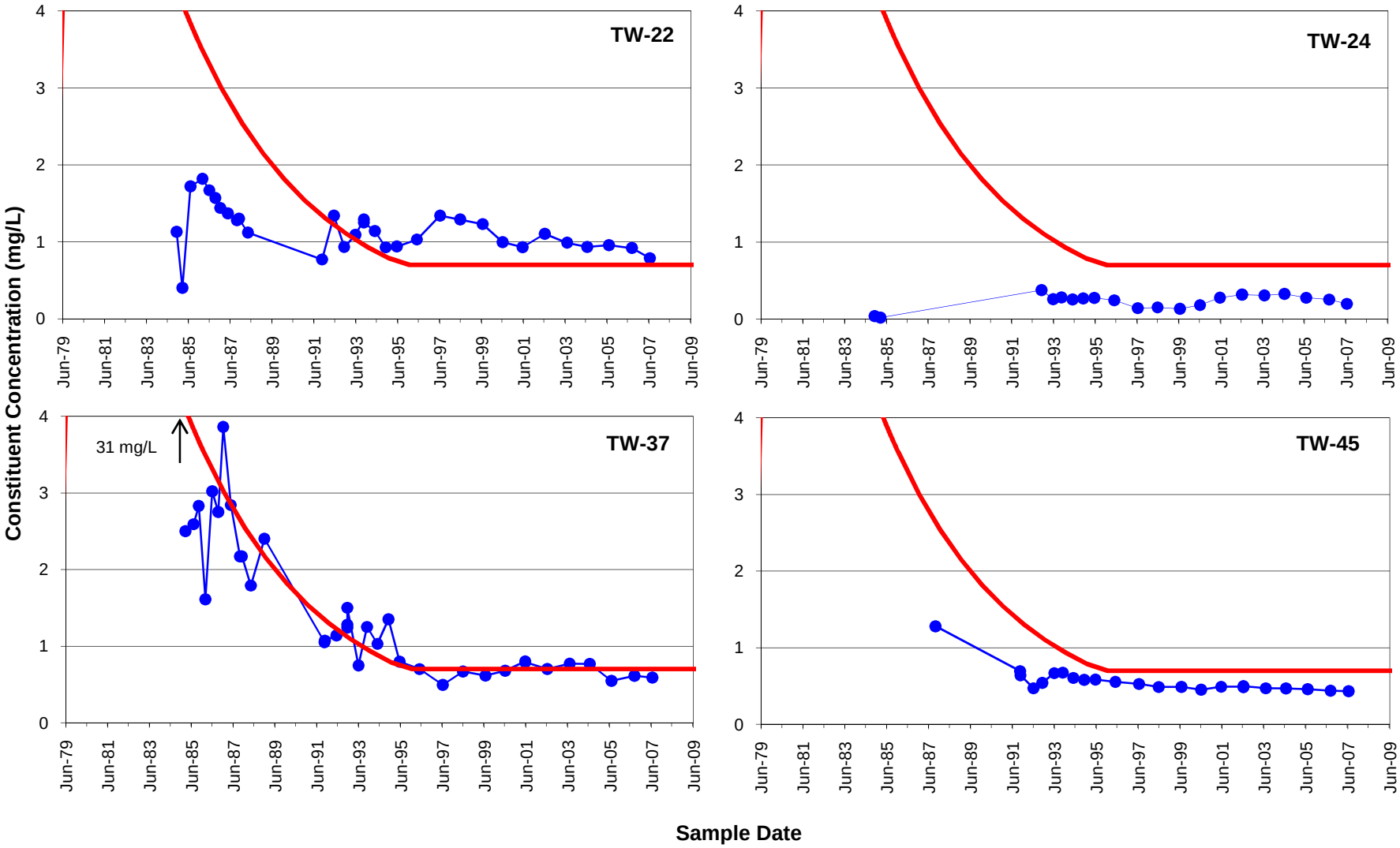
TITLE

Selenium in 2007 Monitoring Wells

FIGURE D-20

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME manganese

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

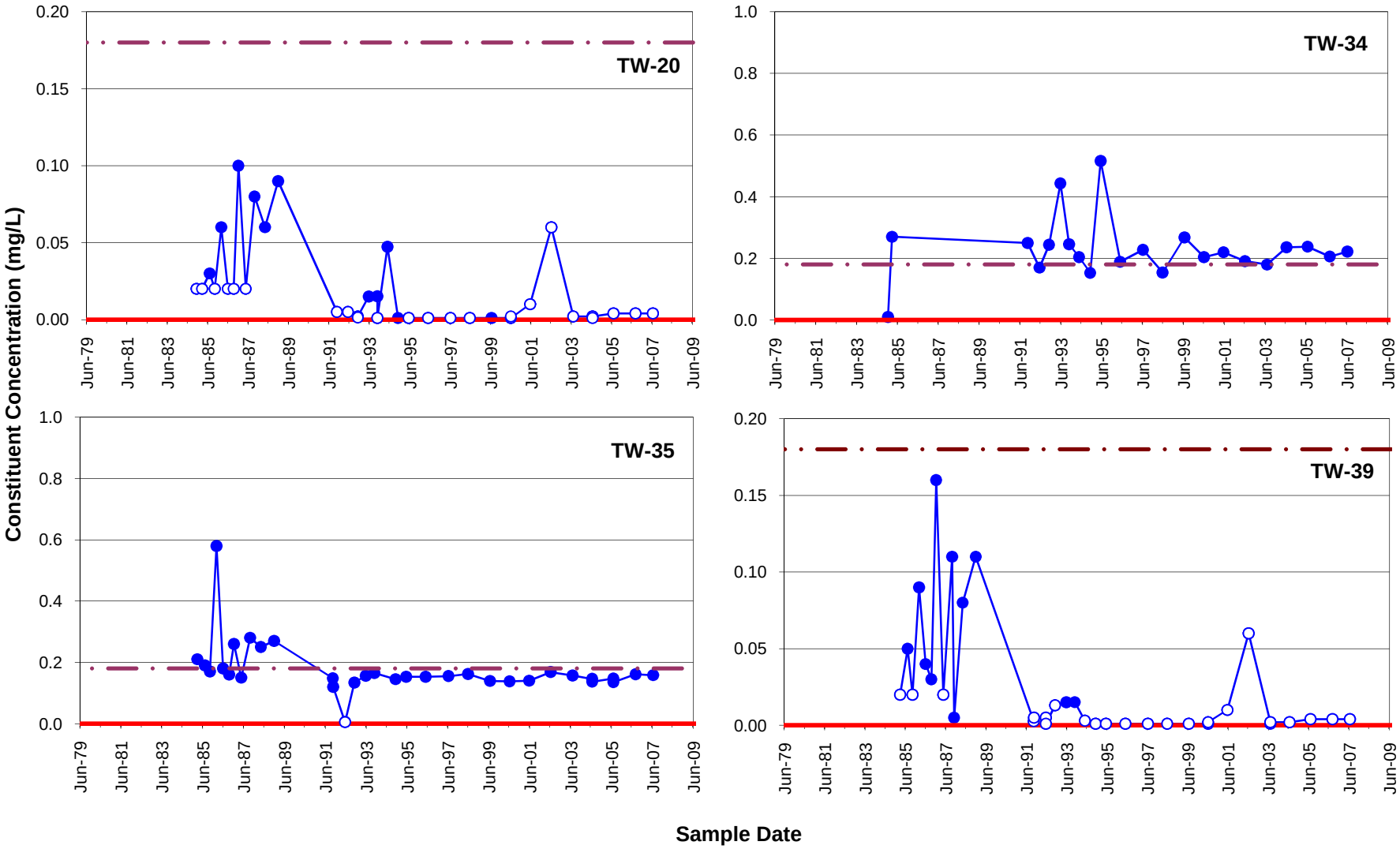
Manganese in Old Underflow Solids Pond Area Wells

FIGURE D-21

Constituent Concentration (mg/L)

GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME manganese

Remediation goals shown for point of compliance locations only

Golder Associates

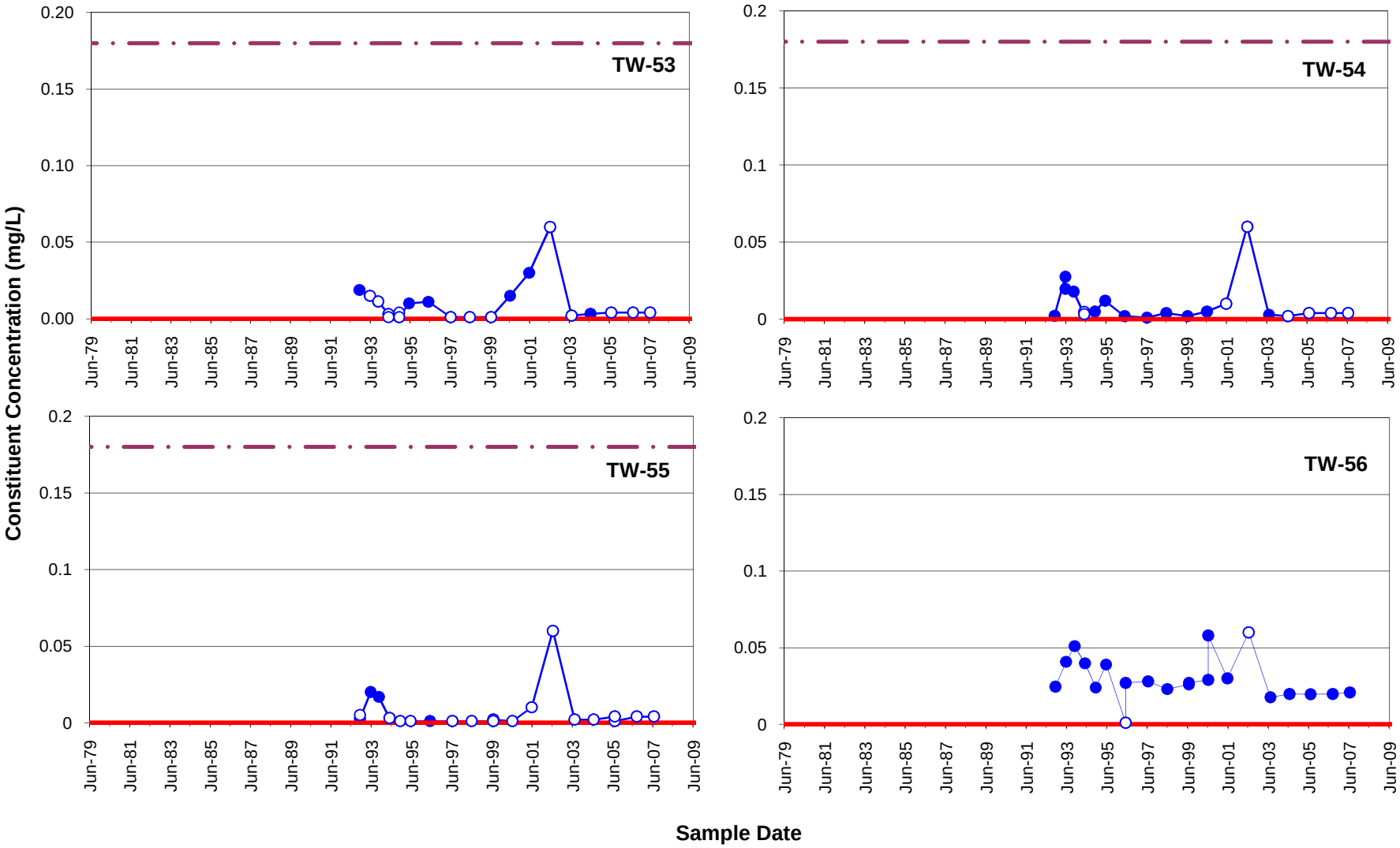
TITLE

Manganese in South Fenceline Wells

FIGURE D-22

Constituent Concentration (mg/L)
Non-Detects
Manganese Remediation Goal (0.18 mg/L)
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME manganese

Remediation goals shown for point of compliance locations only

Golder Associates

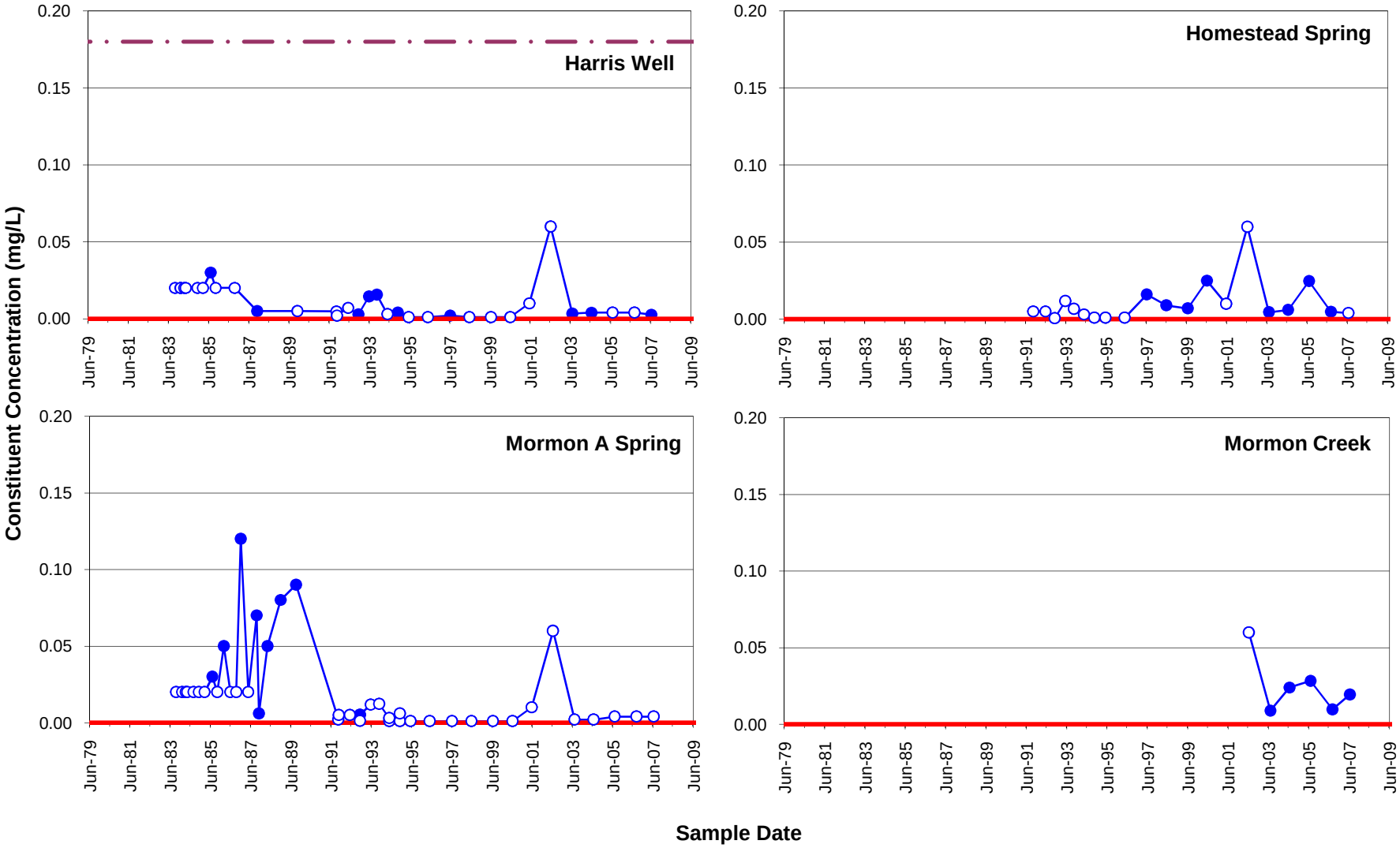
TITLE

Manganese in Southern Boundary Wells

FIGURE D-23

- Constituent Concentration (mg/L)
- Non-Detects
- Manganese Remediation Goal (0.18 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME manganese

Remediation goals shown for point of compliance locations only

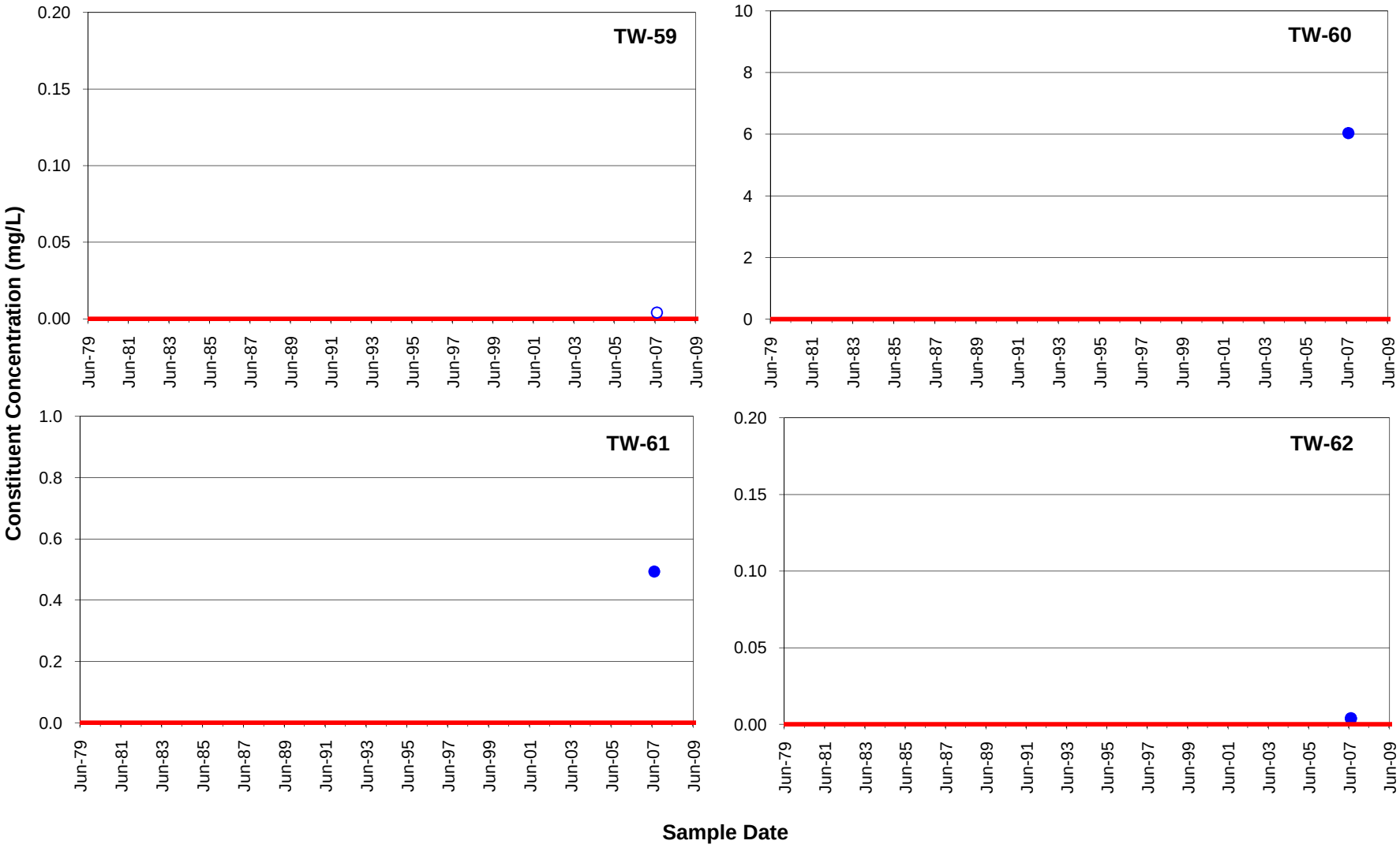
Golder Associates

TITLE **Manganese in Harris Well and Springs South of Plant**

FIGURE D-24

Constituent Concentration (mg/L)
Non-Detects
Manganese Remediation Goal (0.18 mg/L)
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME manganese

Remediation goals shown for point of compliance locations only

Golder Associates

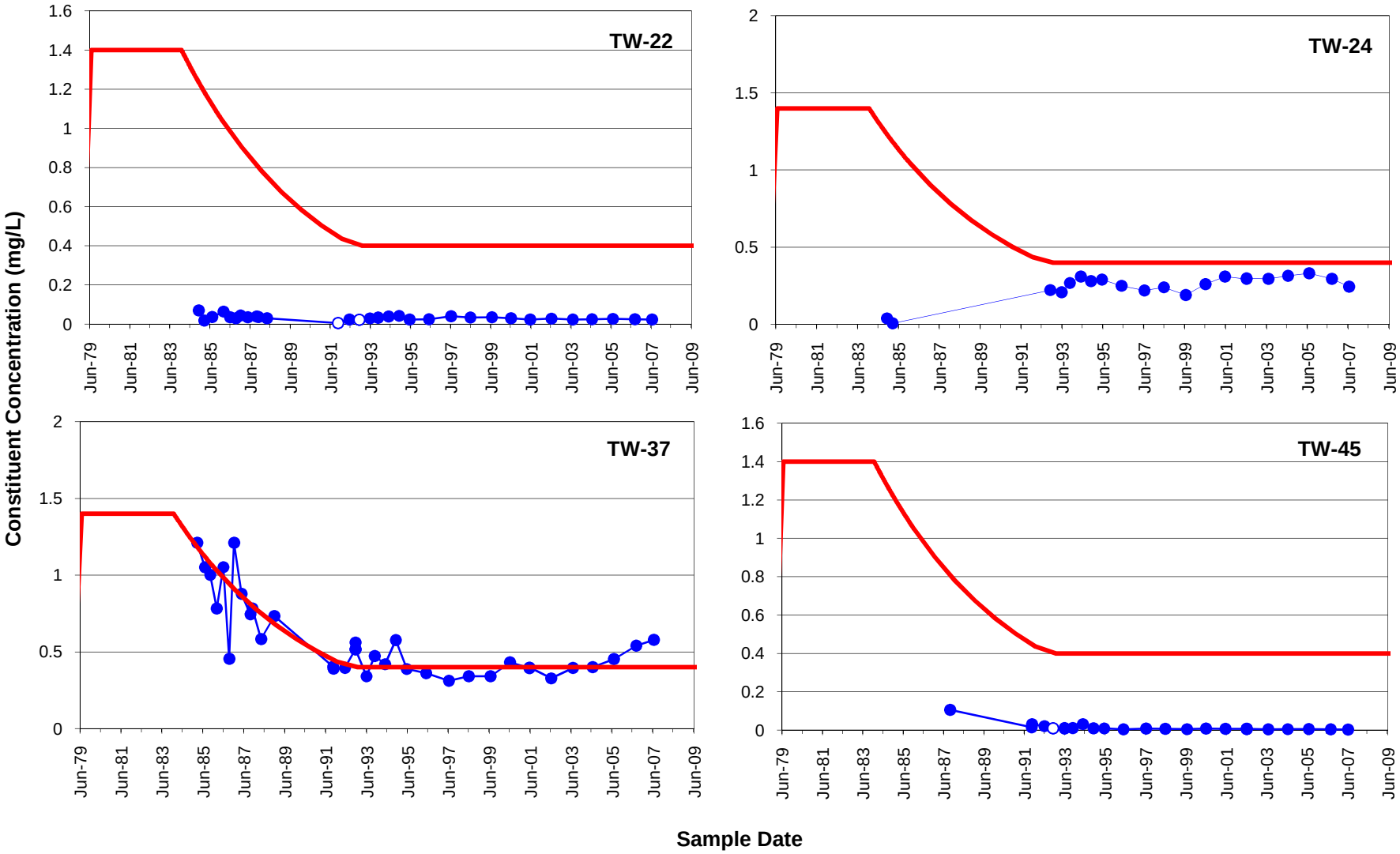
TITLE

Manganese in 2007 Monitoring Wells

FIGURE D-25

Constituent Concentration (mg/L)
Non-Detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME cadmium

Remediation goals shown for point of compliance locations only

Golder Associates

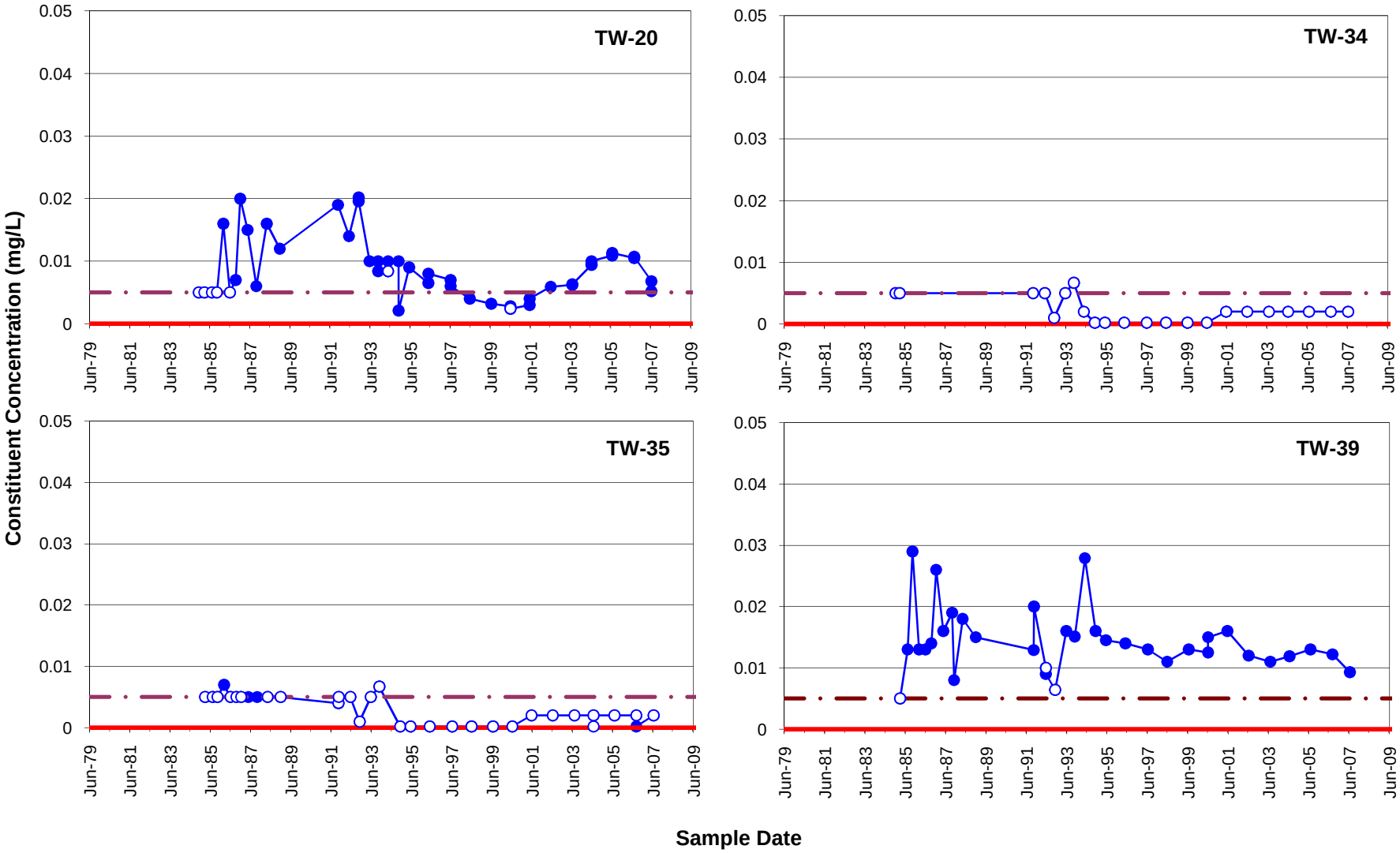
TITLE

Cadmium in Old Underflow Solids Pond Area Wells

FIGURE D-26

Constituent Concentration (mg/L)
Non-Detects
Goldsim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME cadmium

Remediation goals shown for point of compliance locations only

Golder Associates

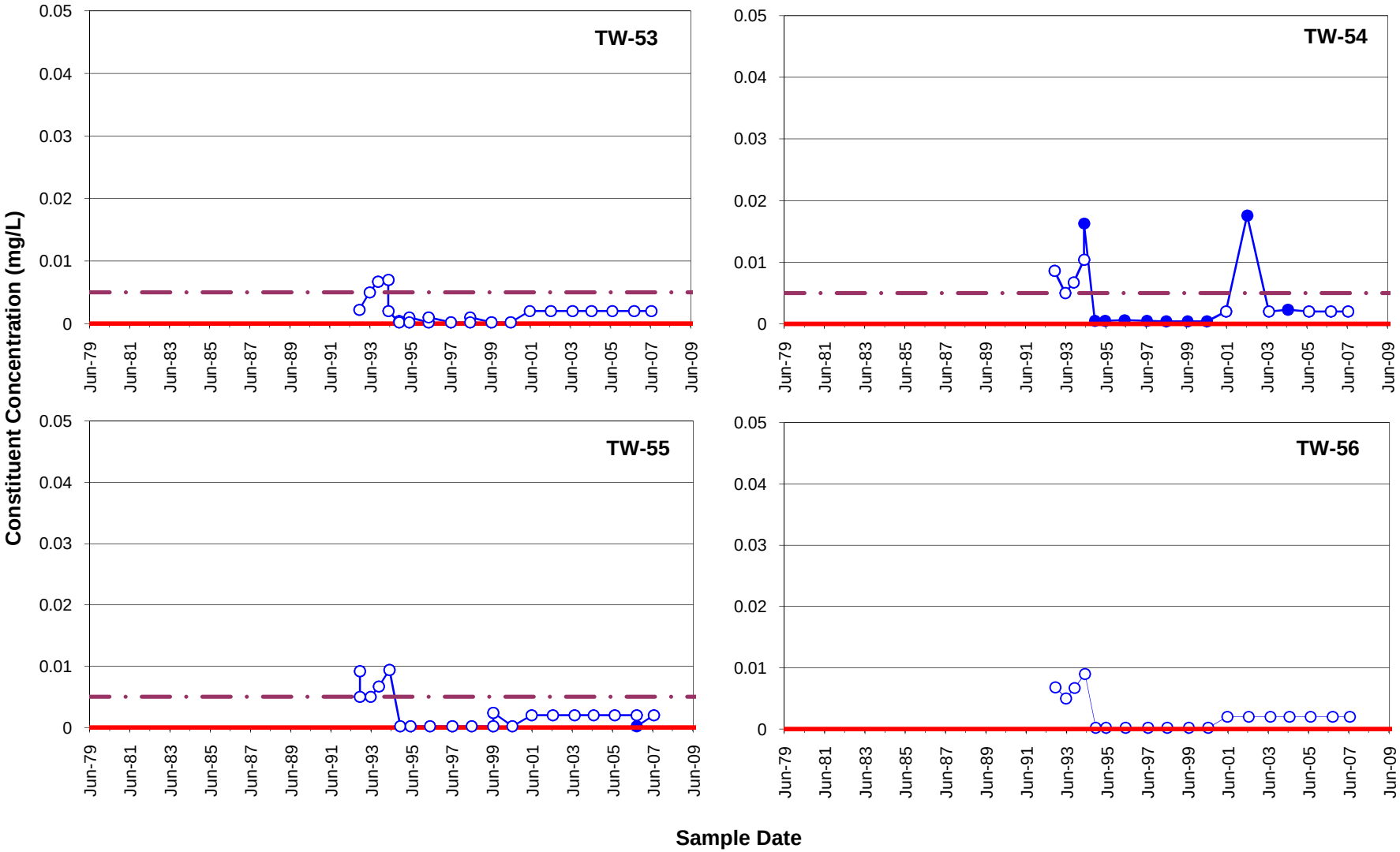
TITLE

Cadmium in South Fenceline Wells

FIGURE D-27

- Constituent Concentration (mg/L)
- Non-Detects
- Cadmium Remediation Goal (0.005 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME cadmium

Remediation goals shown for point of compliance locations only

Golder Associates

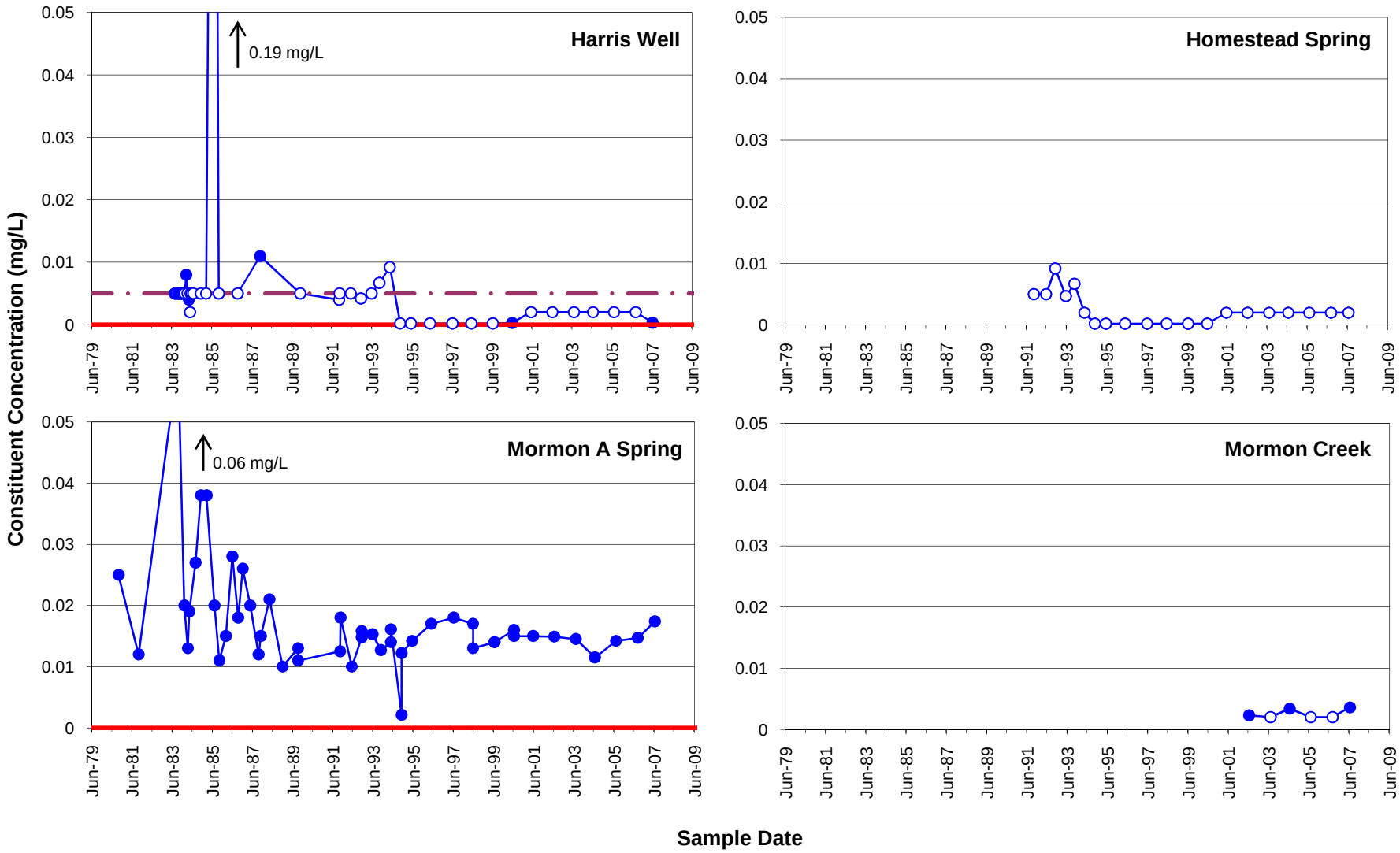
TITLE

Cadmium in Southern Boundary Wells

FIGURE D-28

- Constituent Concentration (mg/L)
- Non-Detects
- Cadmium Remediation Goal (0.005 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME cadmium

Remediation goals shown for point of compliance locations only

Golder Associates

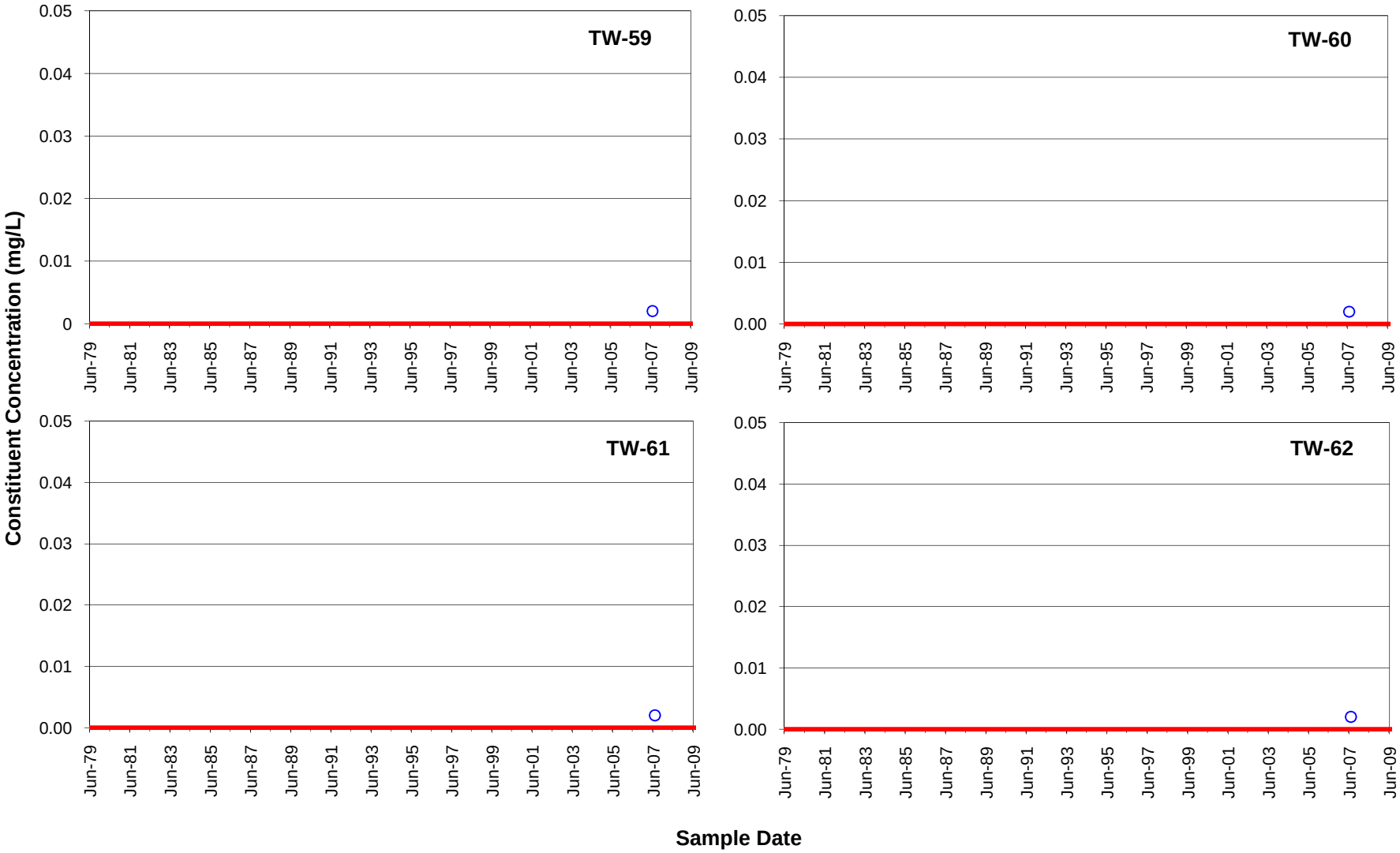
TITLE

Cadmium in Harris Well and Springs South of Plant

FIGURE D-29

- Constituent Concentration (mg/L)
- Non-Detects
- Cadmium Remediation Goal (0.005 mg/L)
- GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB



FILE NAME cadmium

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

Cadmium in 2007 Monitoring Wells

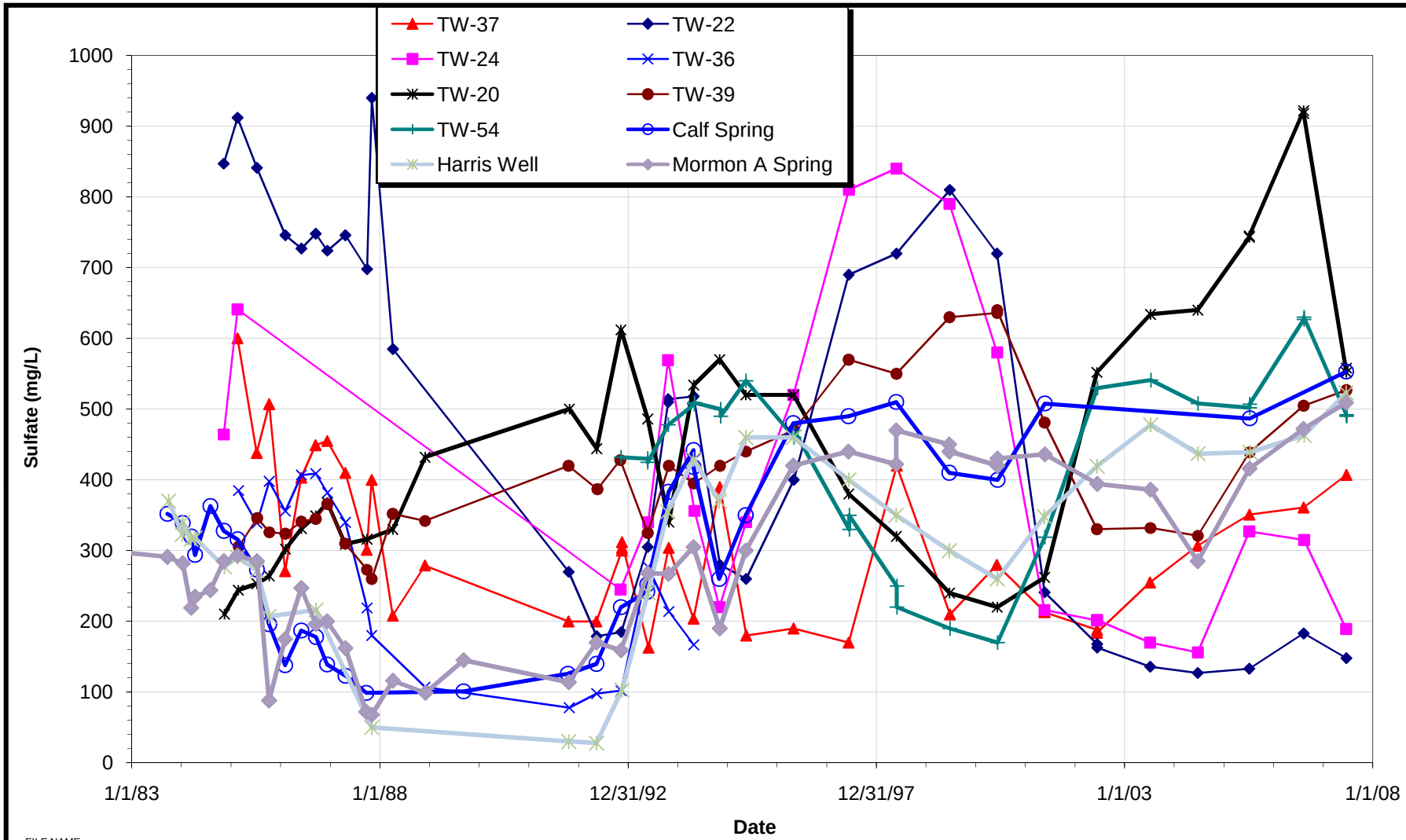
FIGURE D-30

Constituent Concentration (mg/L)
non-detects
GoldSim Model

CLIENT	Monsanto Company	DRAWN	MPK
PROJECT	Monsanto Groundwater Monitoring	CHECKED	DH
PROJECT NO. 913-1101.605	DATE 3-Apr-08	REVIEWED	DB

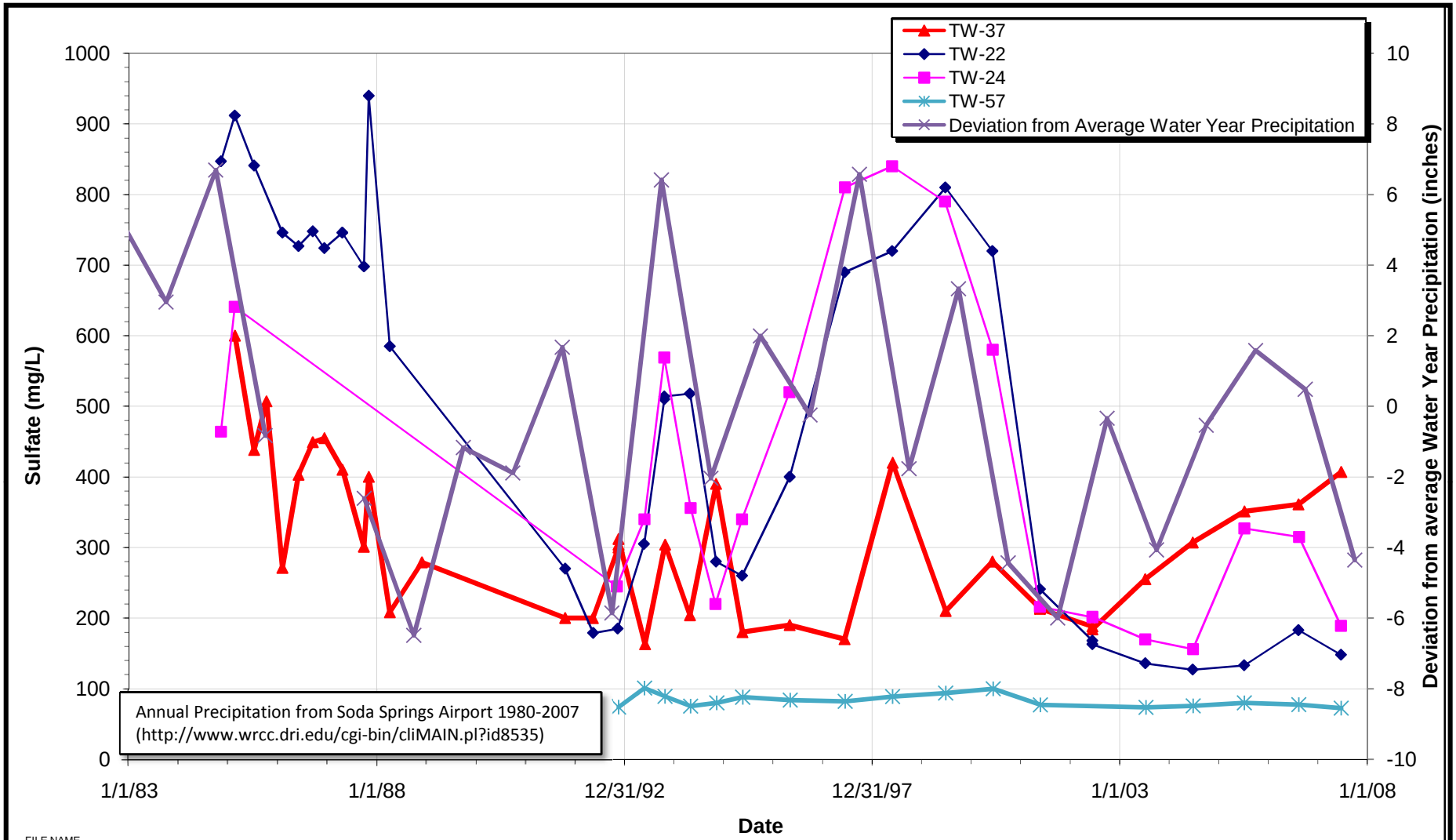
ATTACHMENT E

UBZ-2 CHEMICAL HYDROGRAPHS



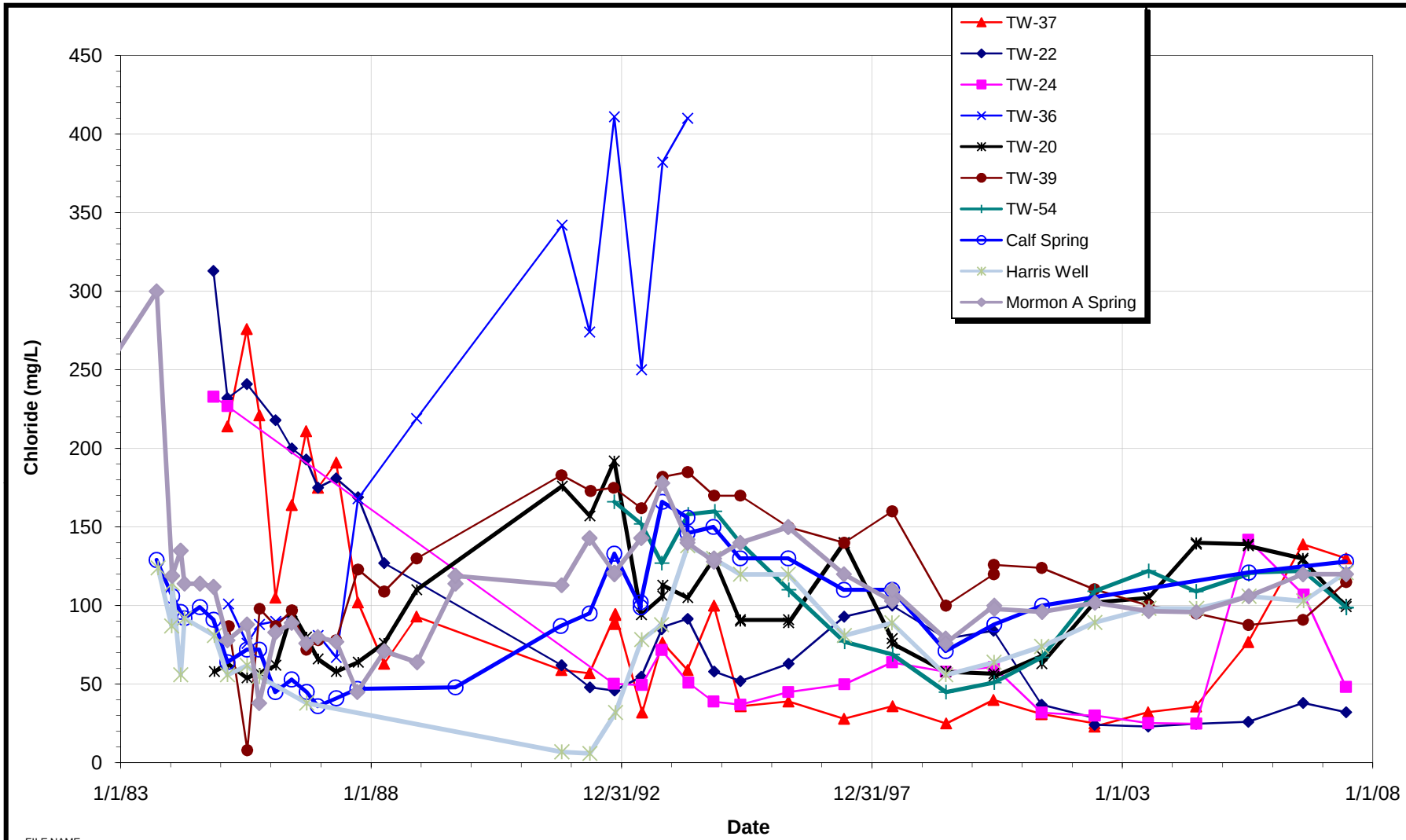
FILE NAME attachment F

Golder Associates	TITLE	Sulfate	FIGURE E-1
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



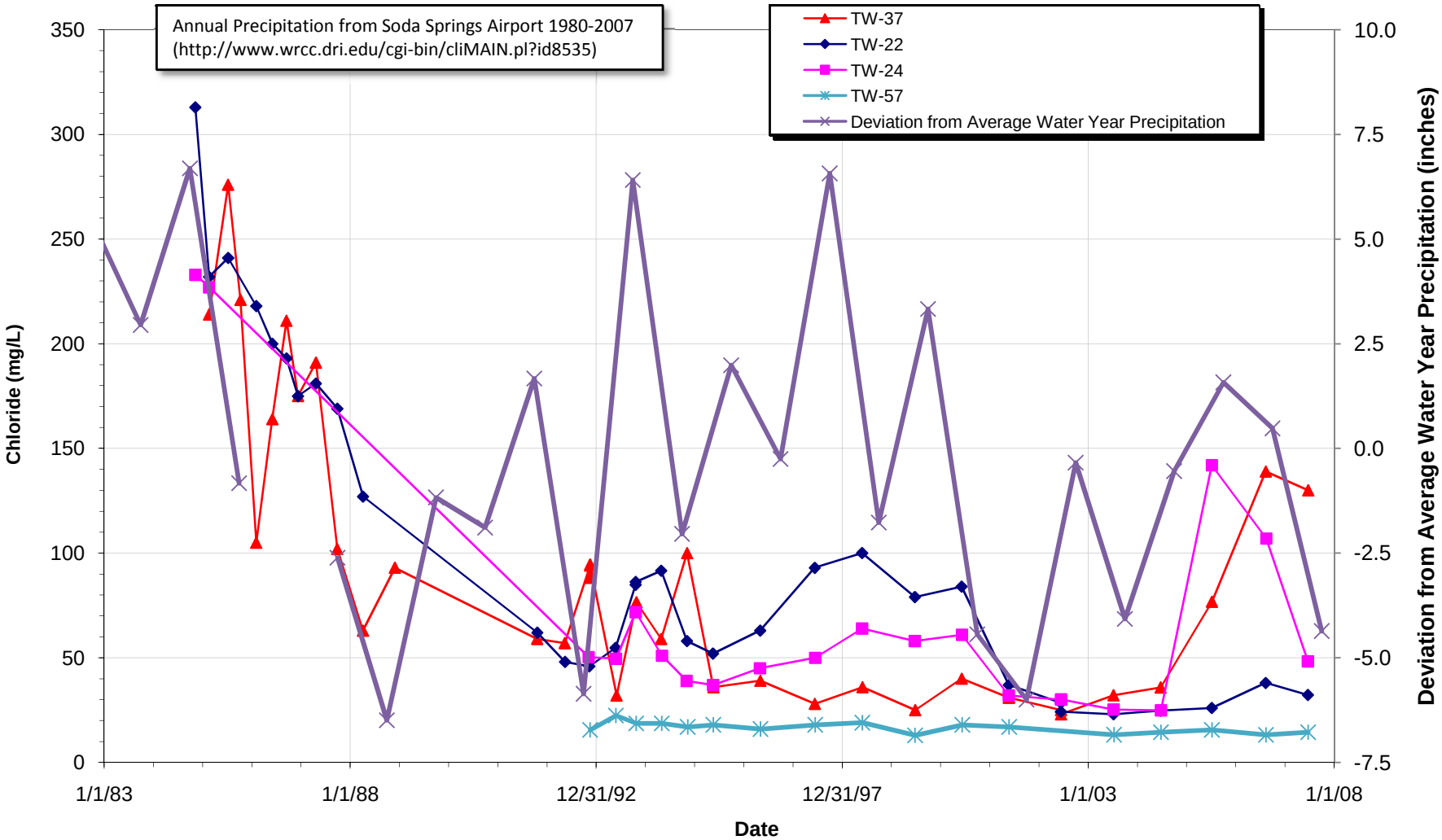
FILE NAME attachment F

Golder Associates	TITLE	Source Area Sulfate and Precipitation	FIGURE E-2
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



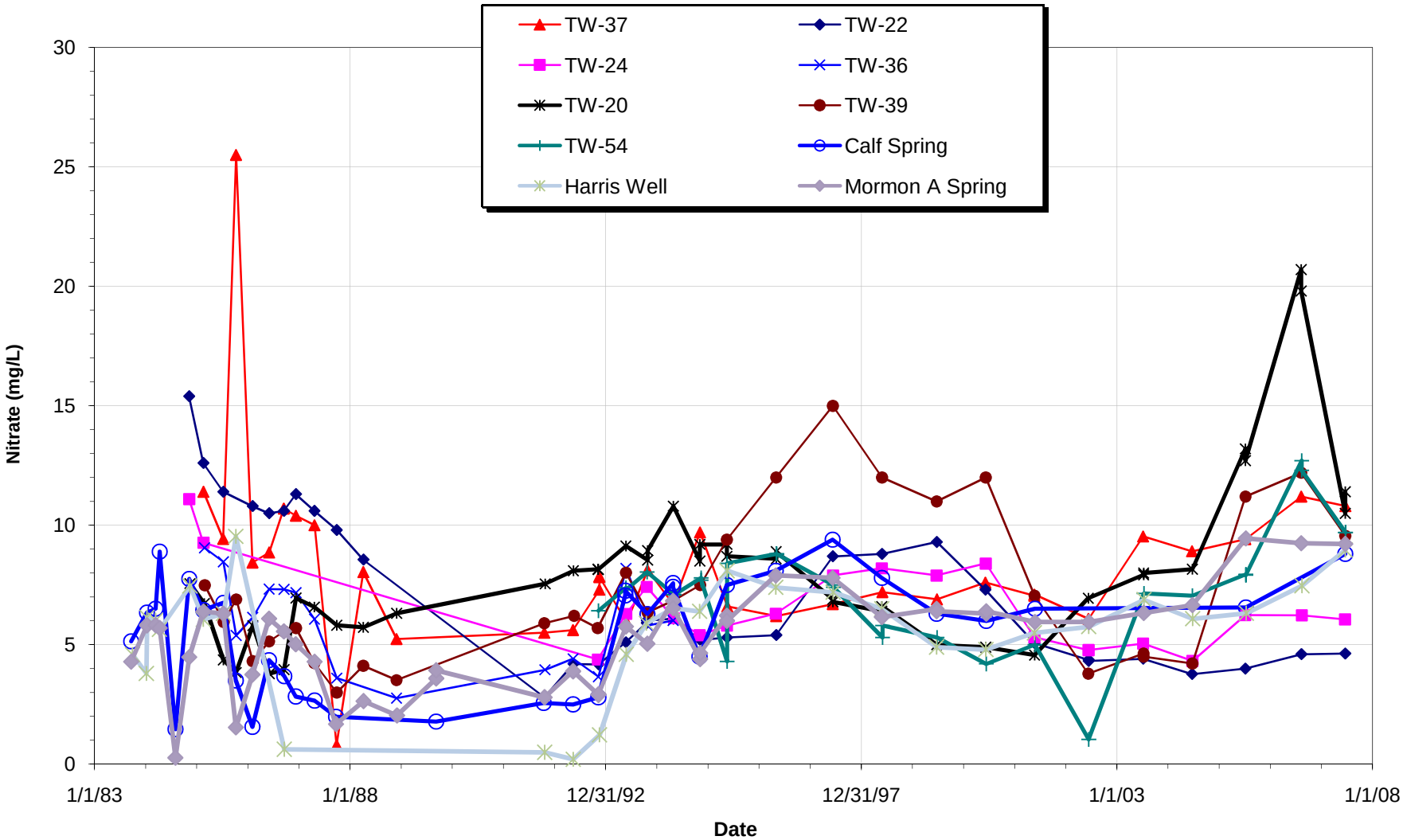
FILE NAME attachment F

Golder Associates	TITLE	Chloride	FIGURE E-3
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



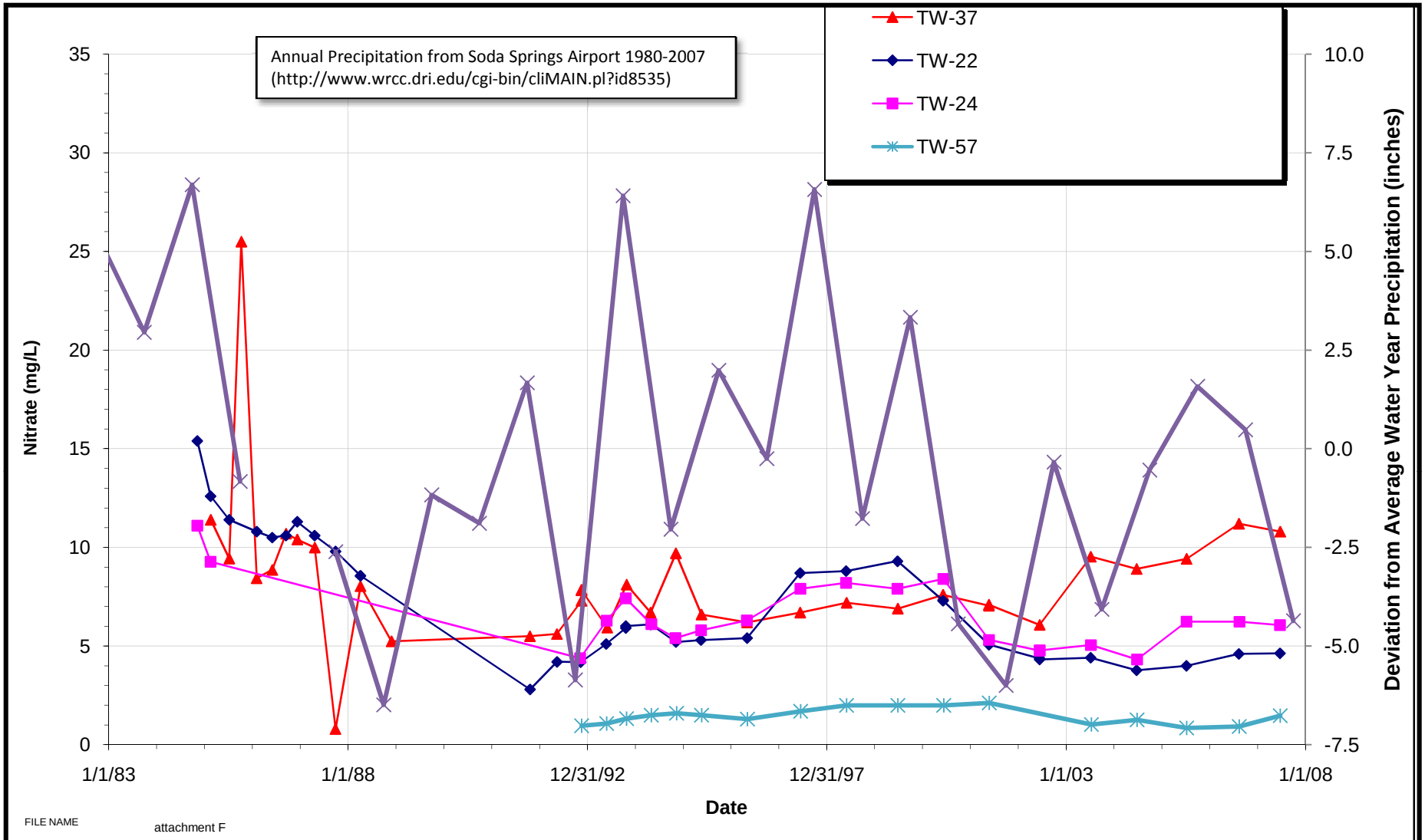
FILE NAME attachment F

Golder Associates	TITLE	Source Area Chloride and Precipitation	FIGURE E-4
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



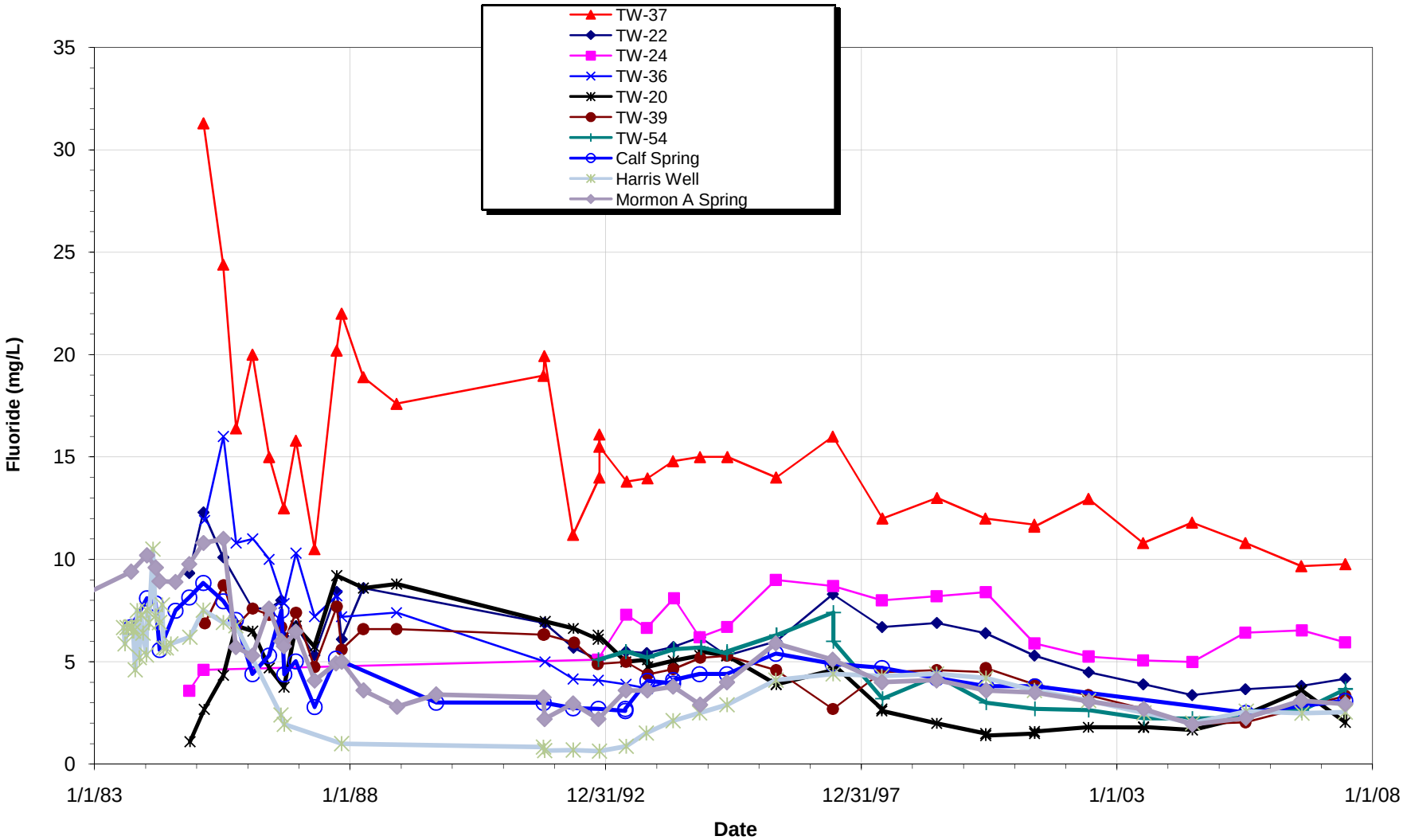
FILE NAME attachment F

Golder Associates	TITLE	Nitrate	FIGURE E-5
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



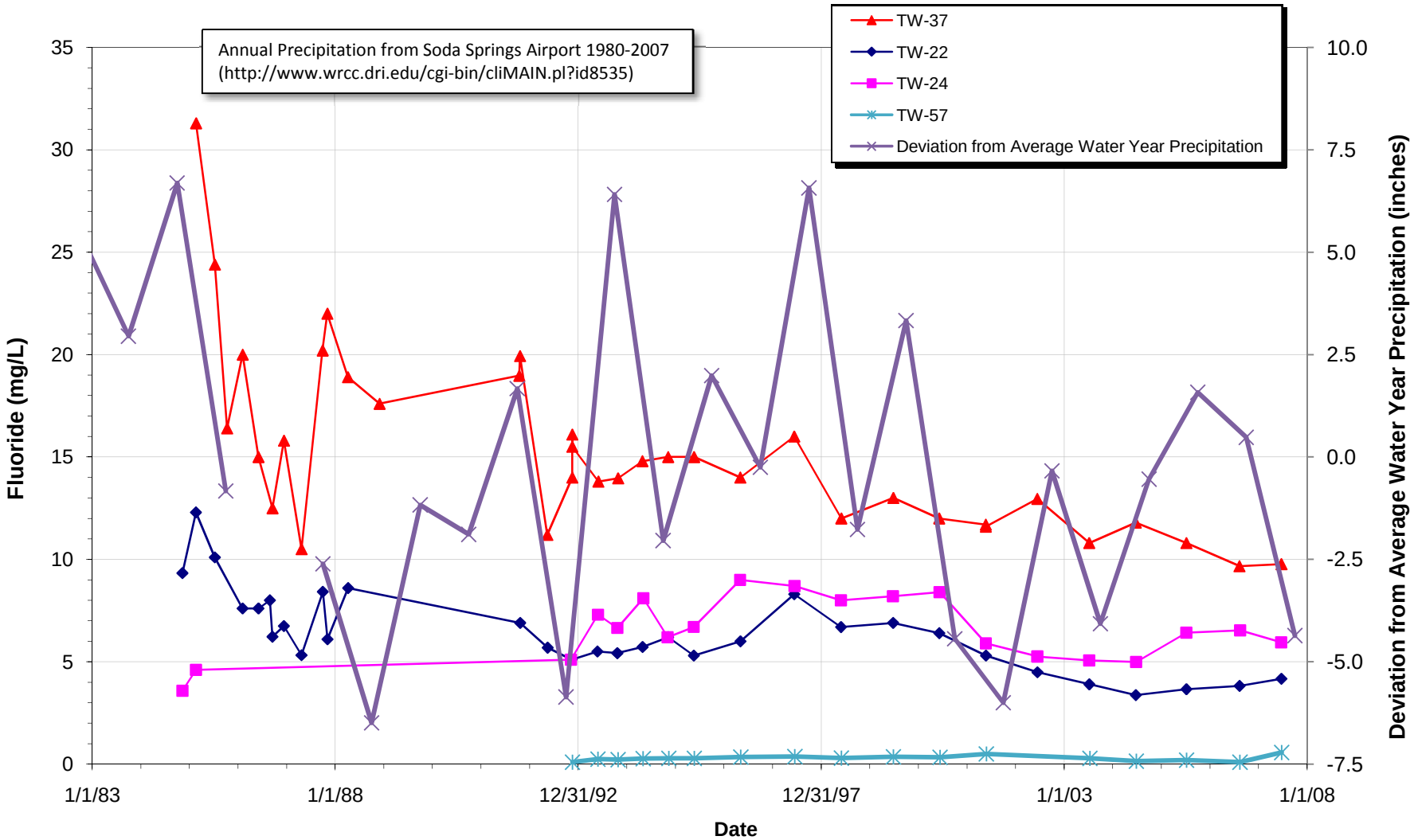
FILE NAME attachment F

Golder Associates	TITLE	Source Area Nitrate and Precipitation	FIGURE E-6
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



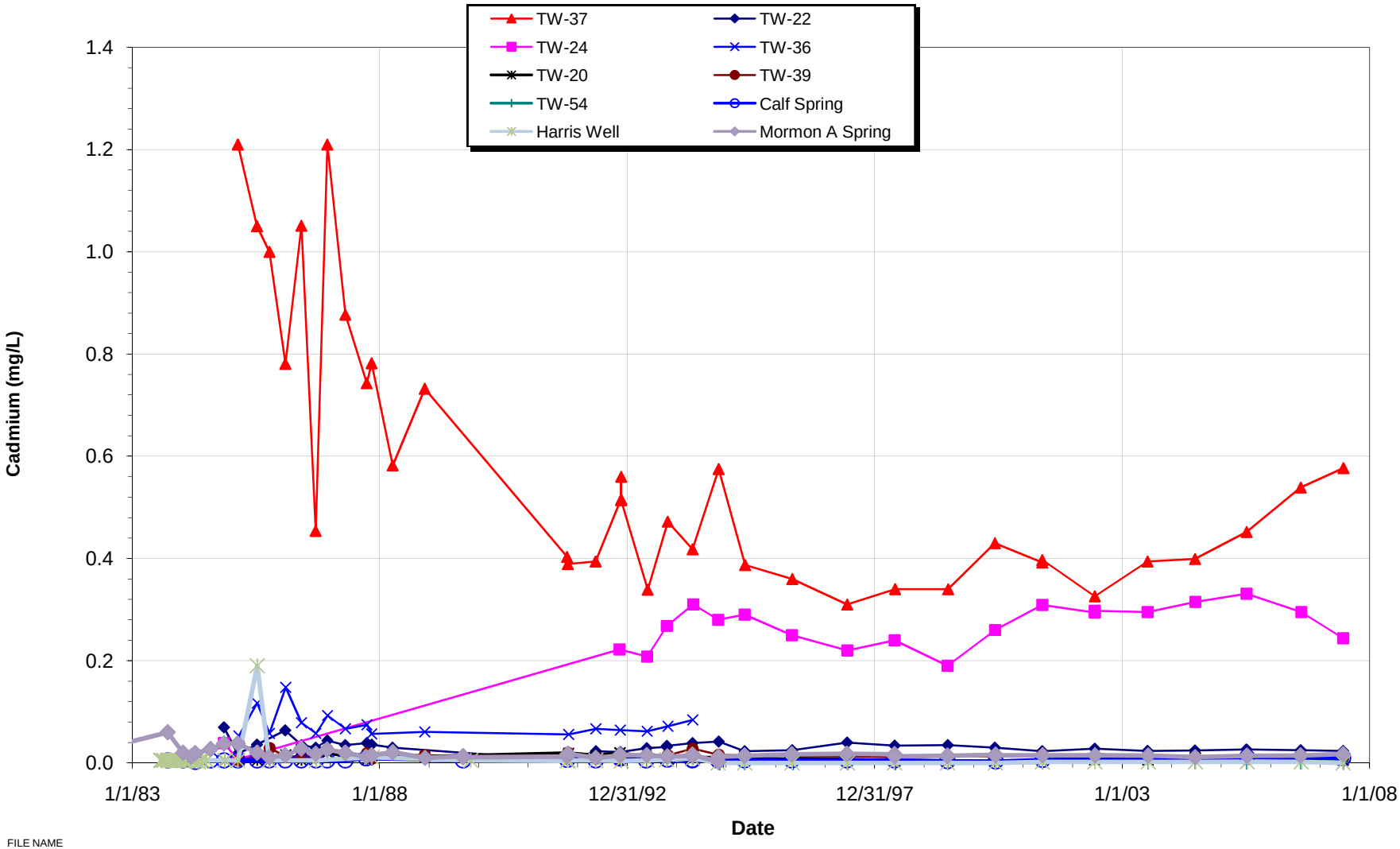
FILE NAME attachment F

Golder Associates	TITLE	**Fluoride**	**FIGURE E-7**
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



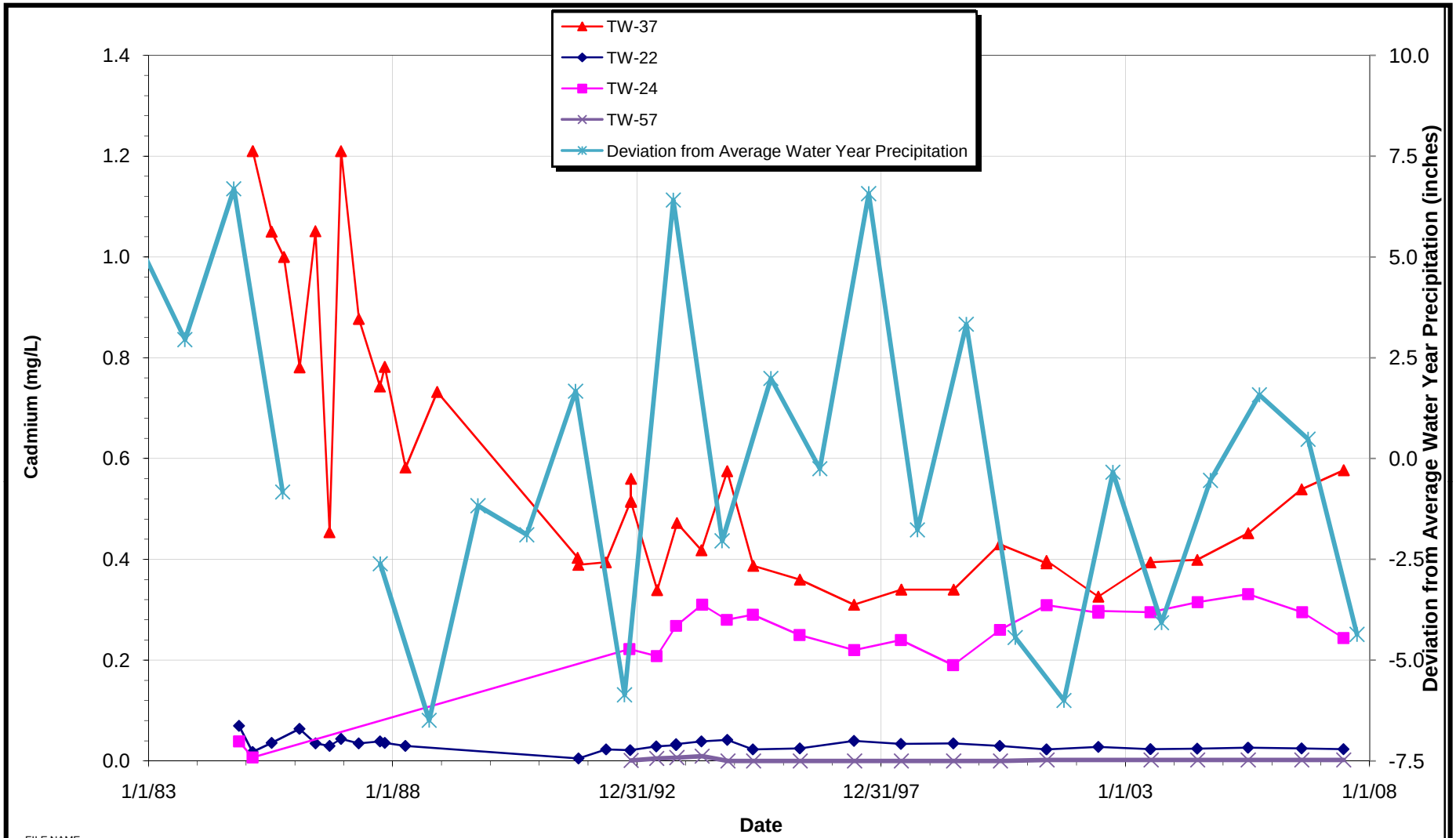
FILE NAME attachment F

Golder Associates	TITLE **Source Area Fluoride and Precipitation**		**FIGURE E-8**
	CLIENT Monsanto		DRAWN MPK
	PROJECT Second Five Year Review		CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



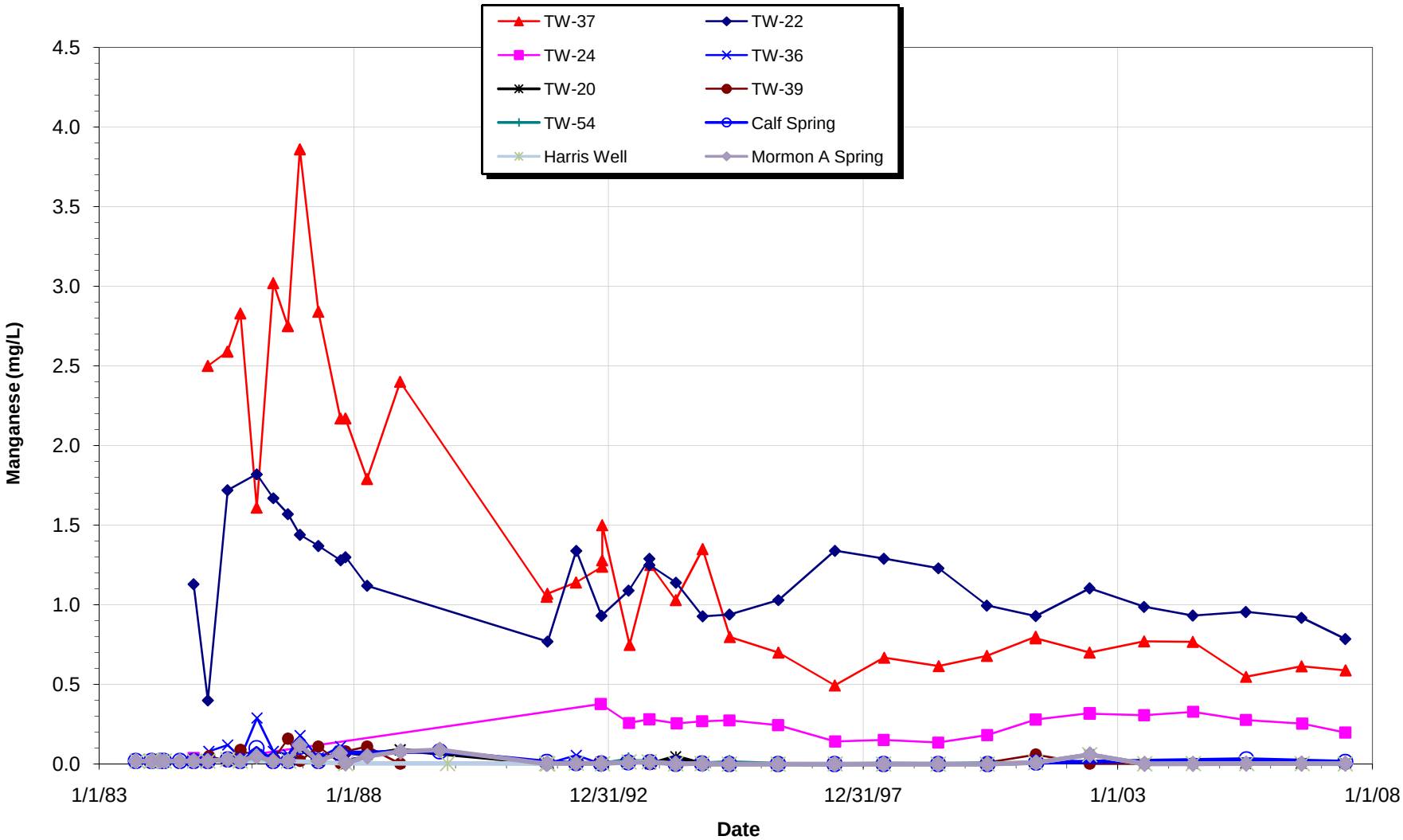
FILE NAME

Golder Associates	TITLE	Cadmium	FIGURE E-9
	CLIENT	Monsanto	DRAWN April 3,
	PROJECT	Second Five Year Review	CHECKED MPK
	PROJECT NO. 913-1101.605	DATE	REVIEWED DH



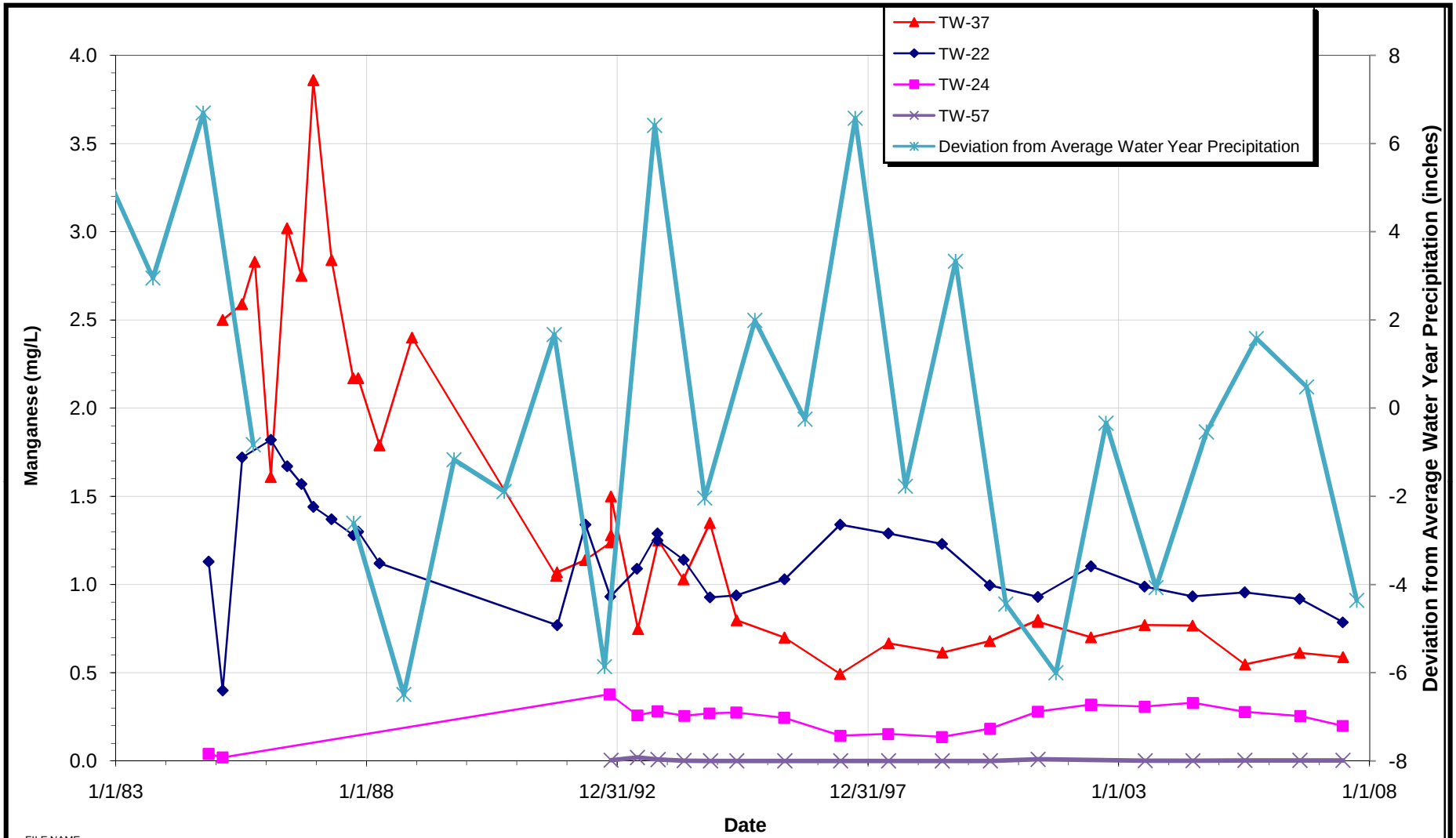
FILE NAME attachment F

Golder Associates	TITLE	Source Area Cadmium and Precipitation	FIGURE E-10
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



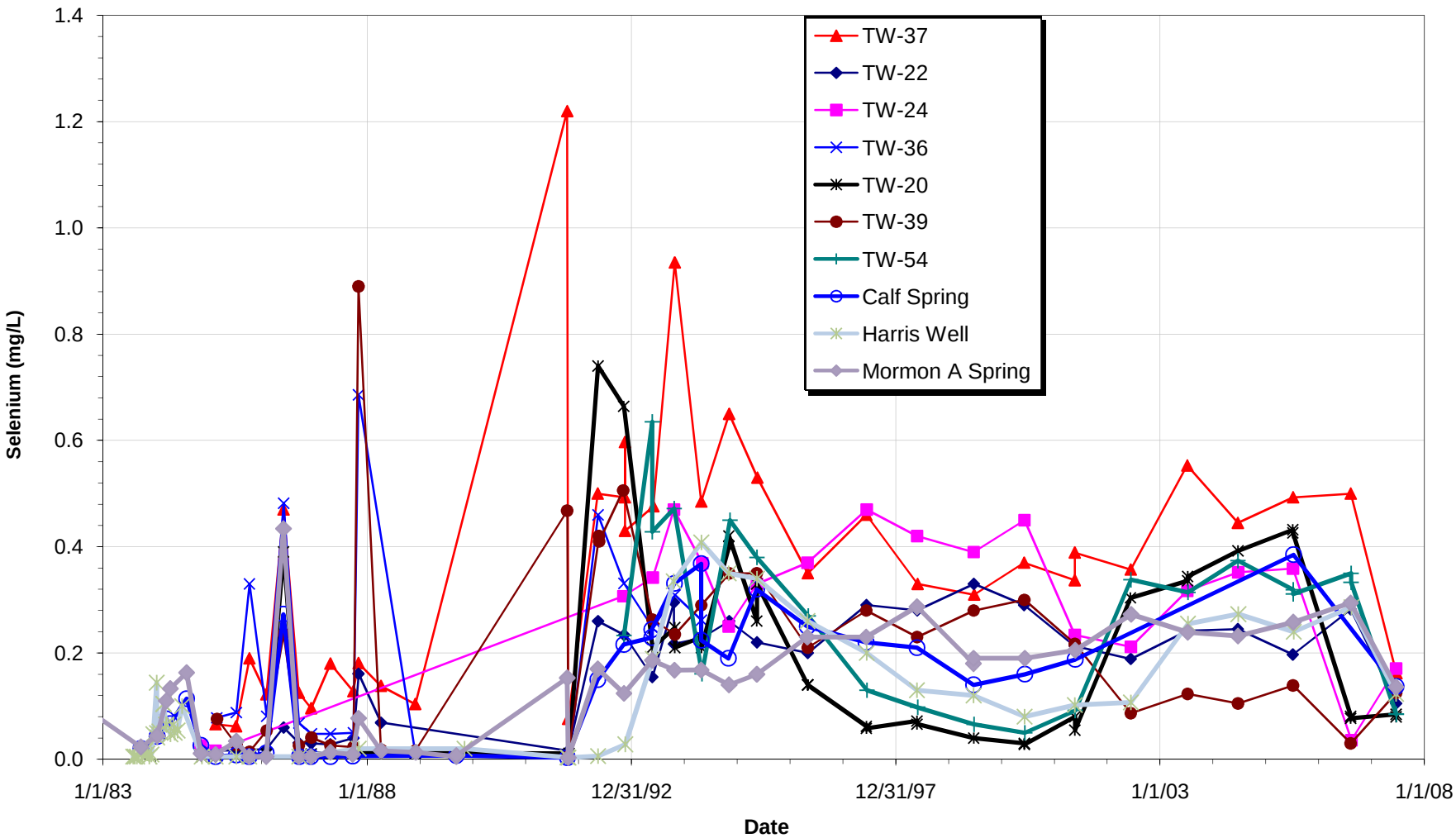
FILE NAME attachment F

Golder Associates	TITLE	Manganese	FIGURE E-11
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



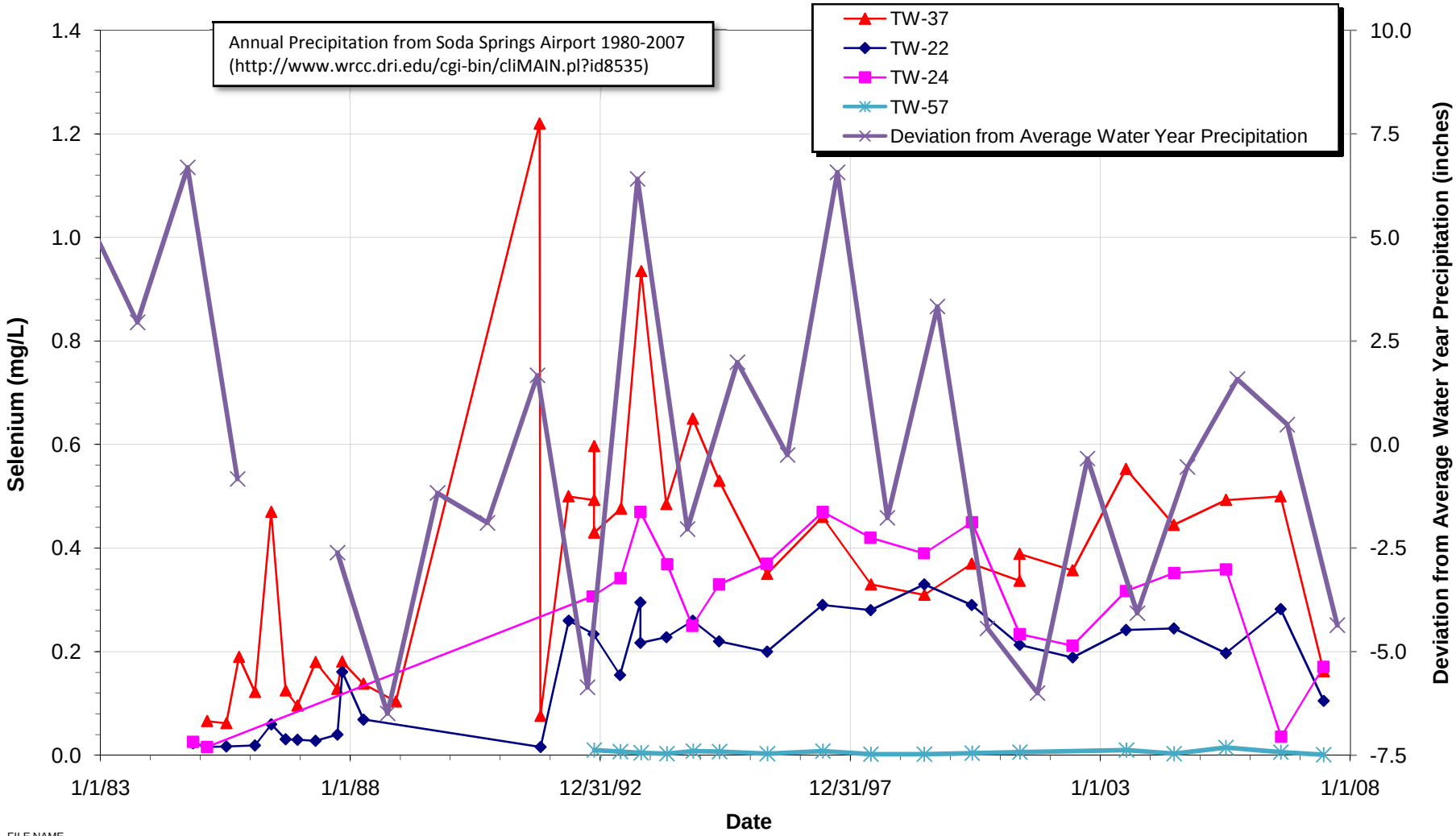
FILE NAME attachment F

Golder Associates	TITLE **Source Area Manganese and Precipitation**		**FIGURE E-12**
	CLIENT Monsanto		DRAWN MPK
	PROJECT Second Five Year Review		CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



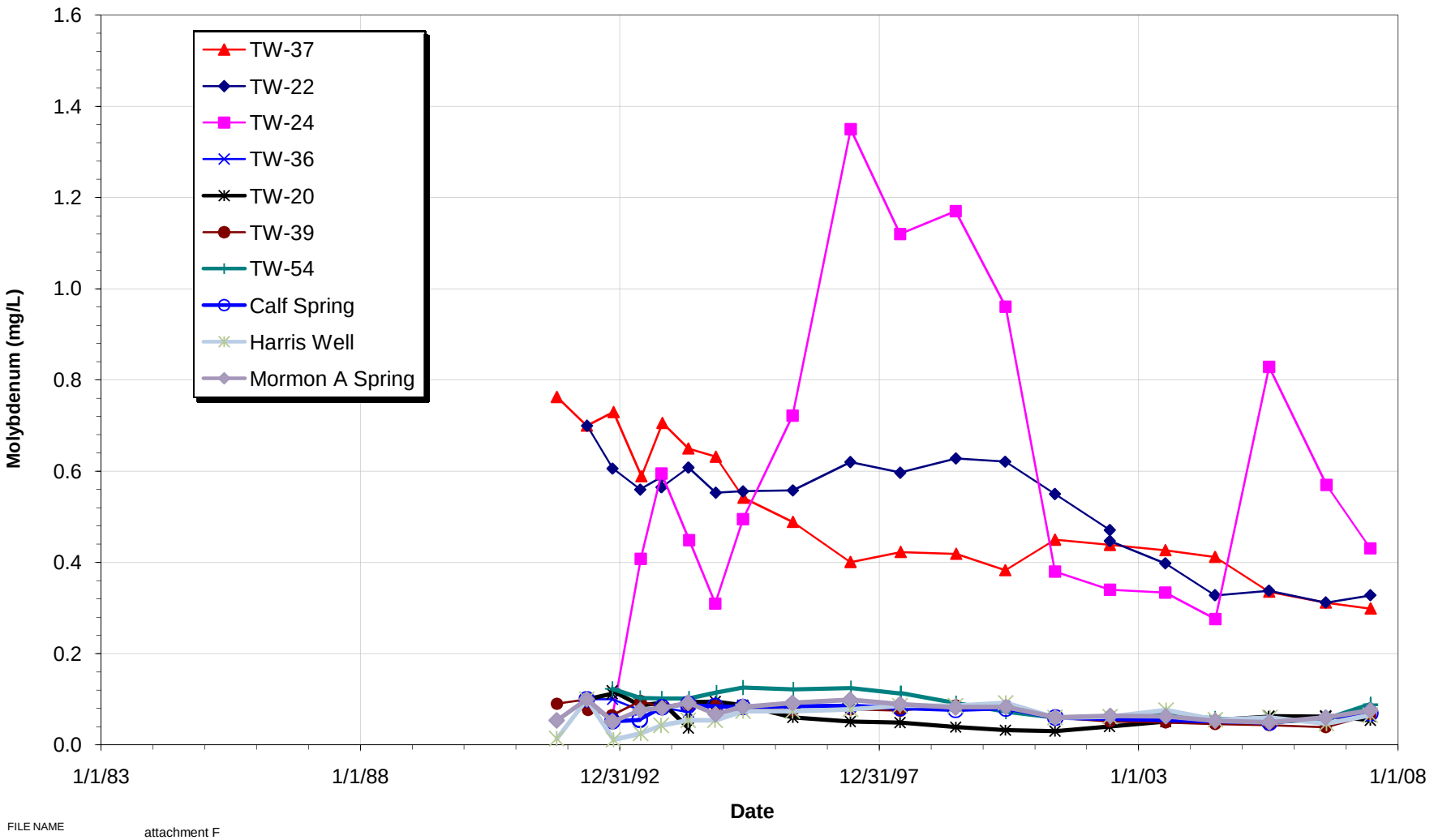
FILE NAME attachment F

Golder Associates	TITLE	Selenium	FIGURE E-13
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



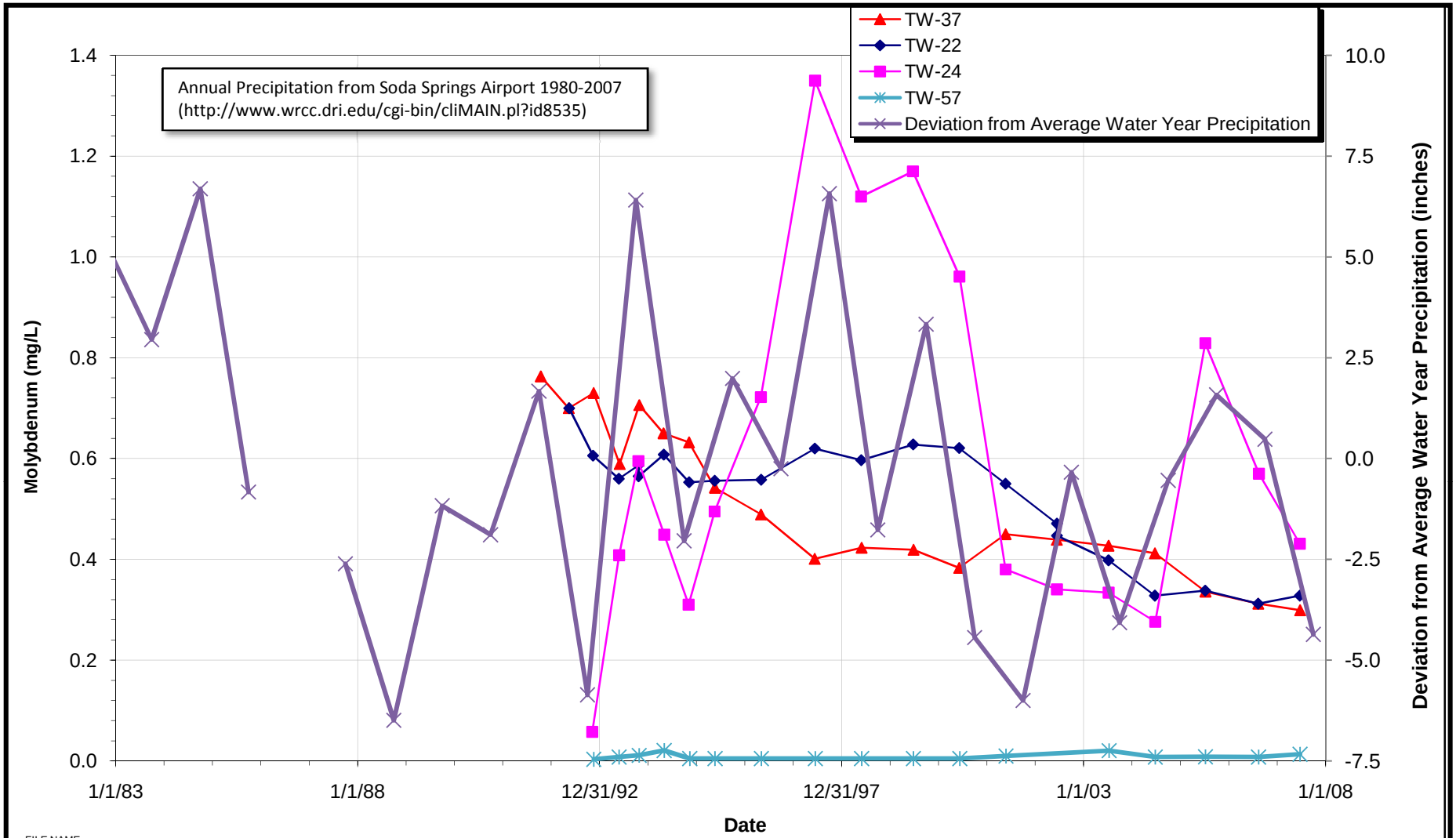
FILE NAME attachment F

Golder Associates	TITLE	Source Area Selenium and Precipitation	FIGURE E-14
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB



FILE NAME attachment F

Golder Associates	TITLE	**Molybdenum**	**FIGURE E-15**
	CLIENT	Monsanto	DRAWN MPK
	PROJECT	Second Five Year Review	CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB

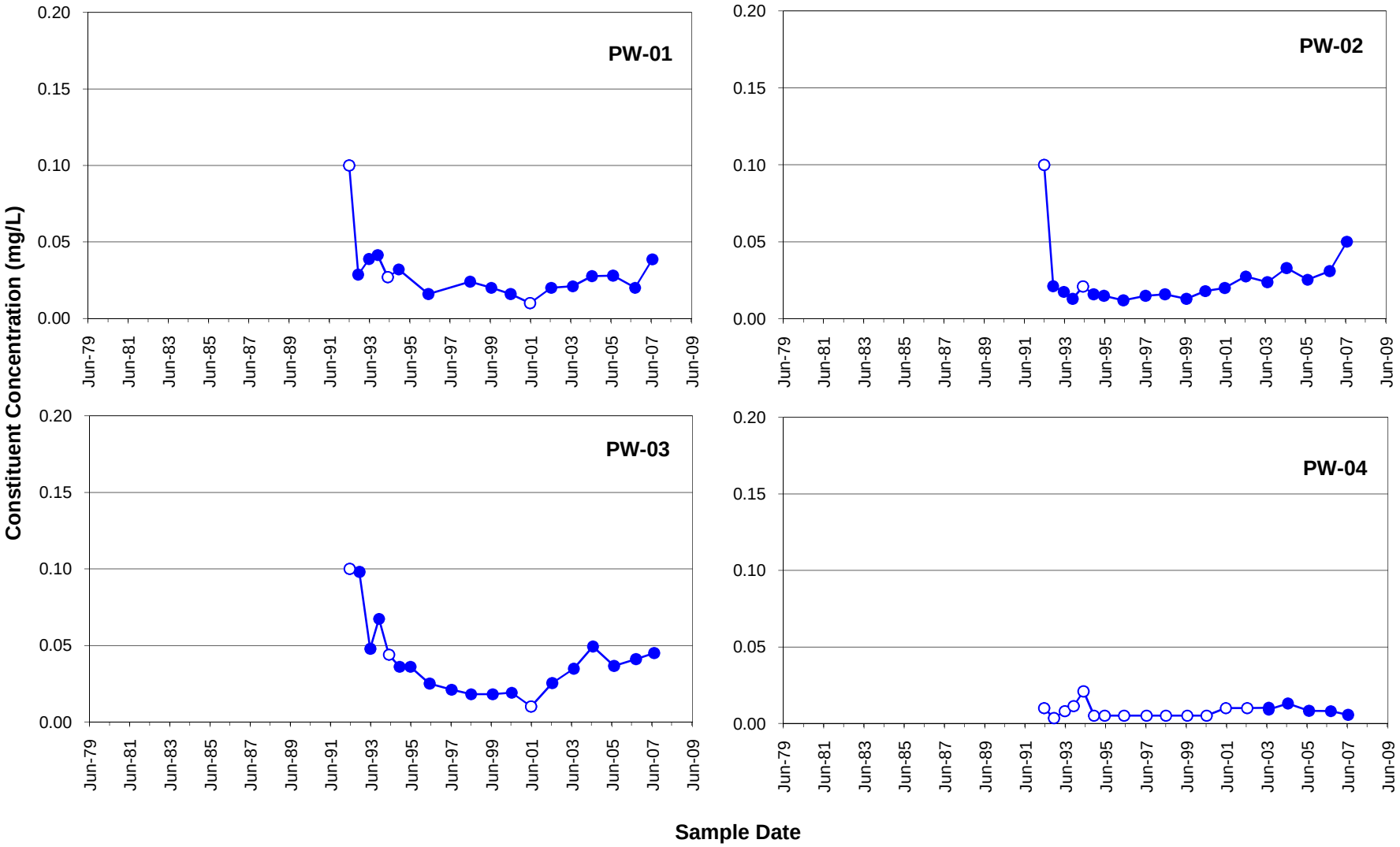


FILE NAME attachment F

Golder Associates	TITLE **Source Area Molybdenum and Precipitation**		**FIGURE E-16**
	CLIENT Monsanto		DRAWN MPK
	PROJECT Second Five Year Review		CHECKED DH
	PROJECT NO. 913-1101.605	DATE April 3, 2008	REVIEWED DB

ATTACHMENT F

MOLYBDENUM HYDROGRAPHS



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

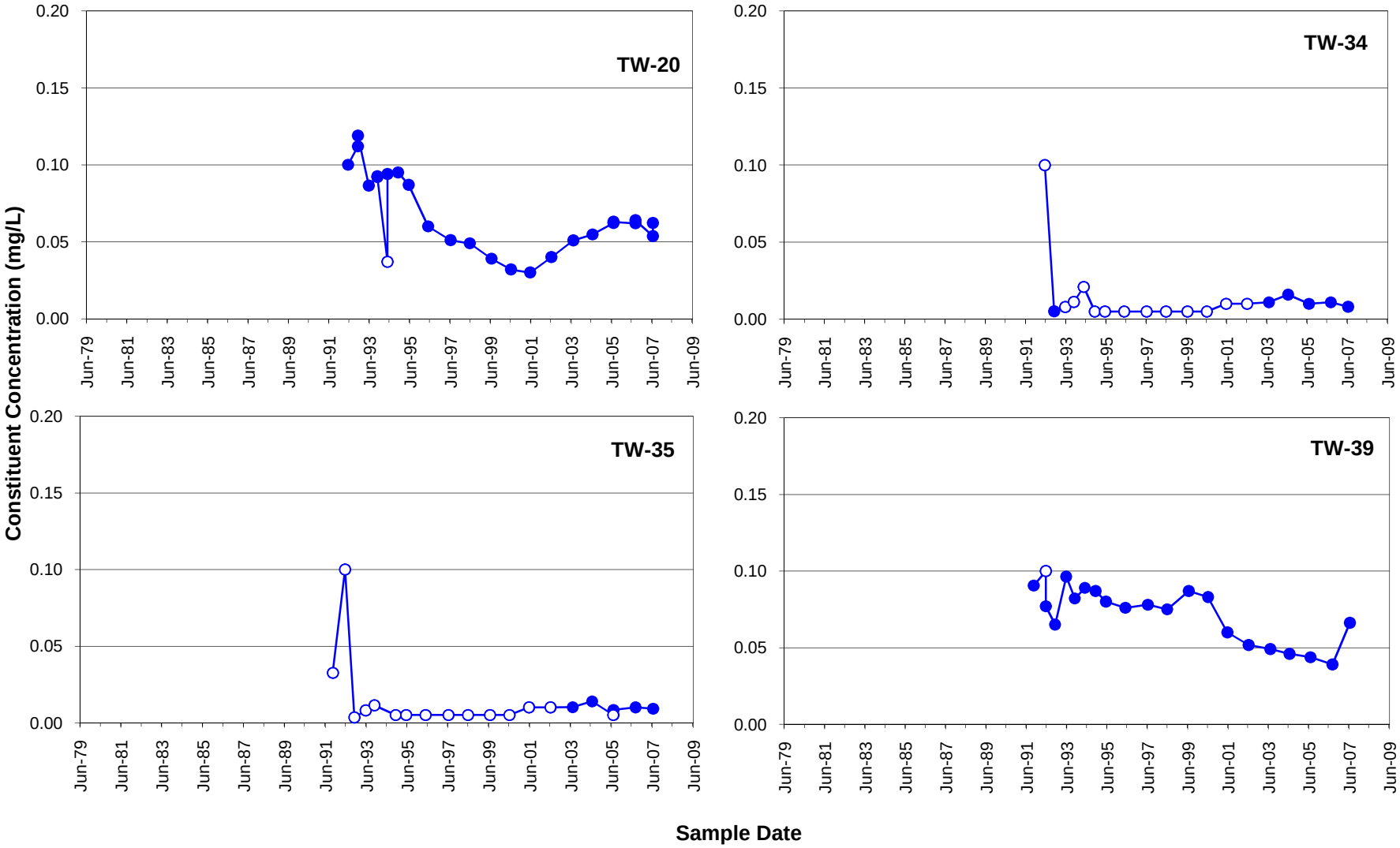
TITLE **Molybdenum in Production Wells**

FIGURE F-1

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company		DRAWN DH
PROJECT	Monsanto Groundwater Monitoring		CHECKED MPK
PROJECT NO.	913-1101.605A	DATE 3-Apr-08	REVIEWED DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

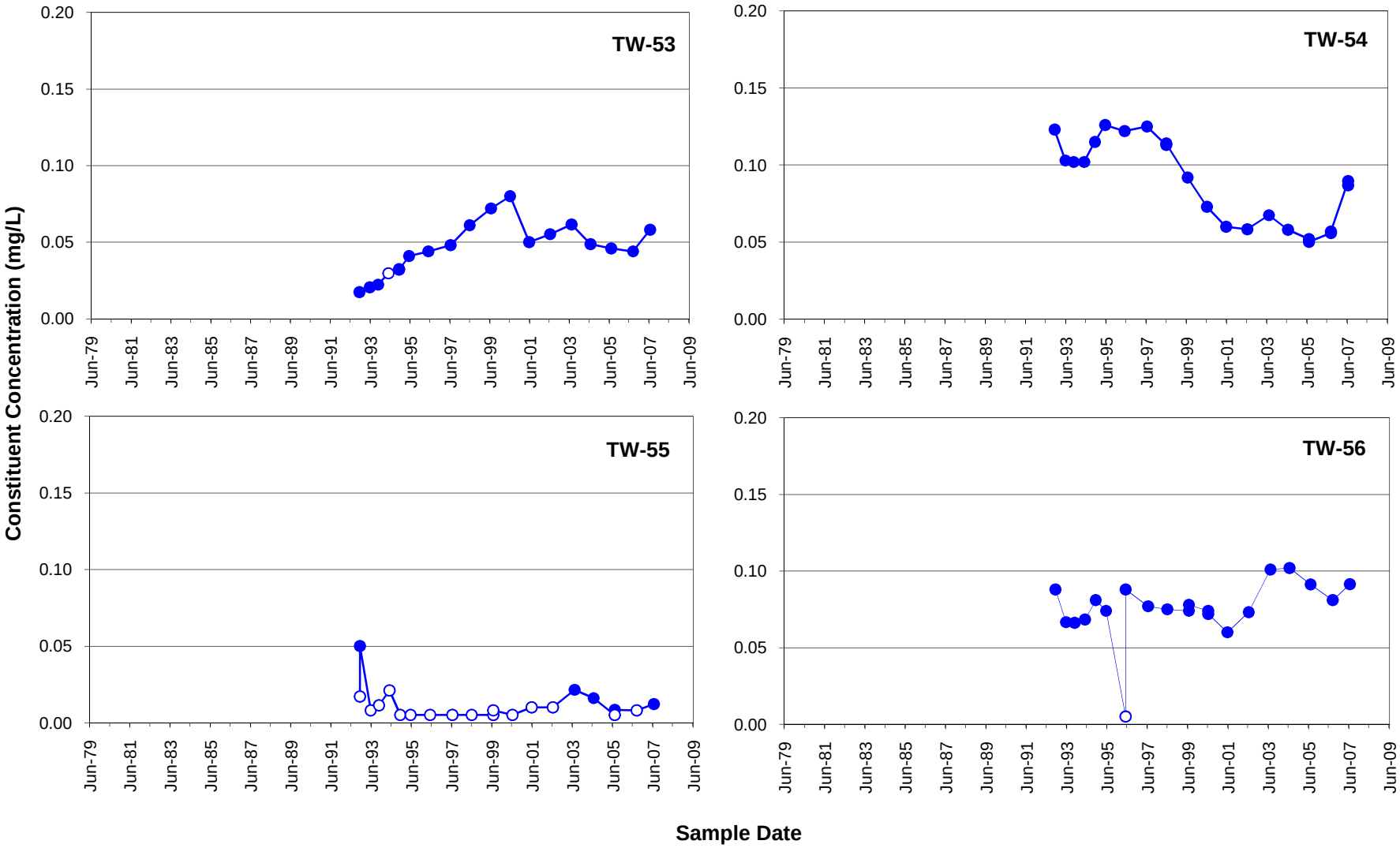
Molybdenum in South Fenceline Wells

FIGURE F-2

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

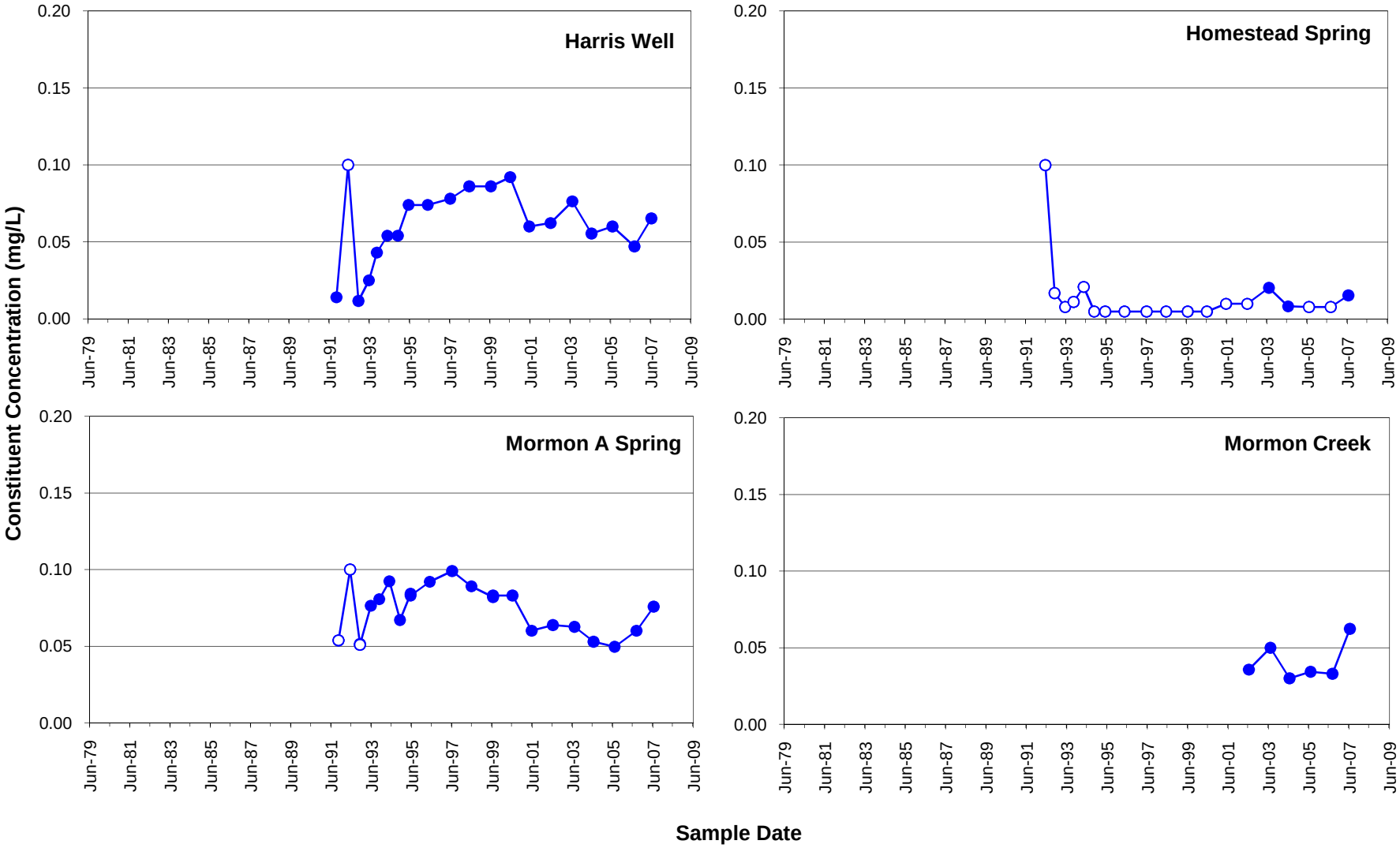
TITLE **Molybdenum in Southern Boundary Wells**

FIGURE F-3

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

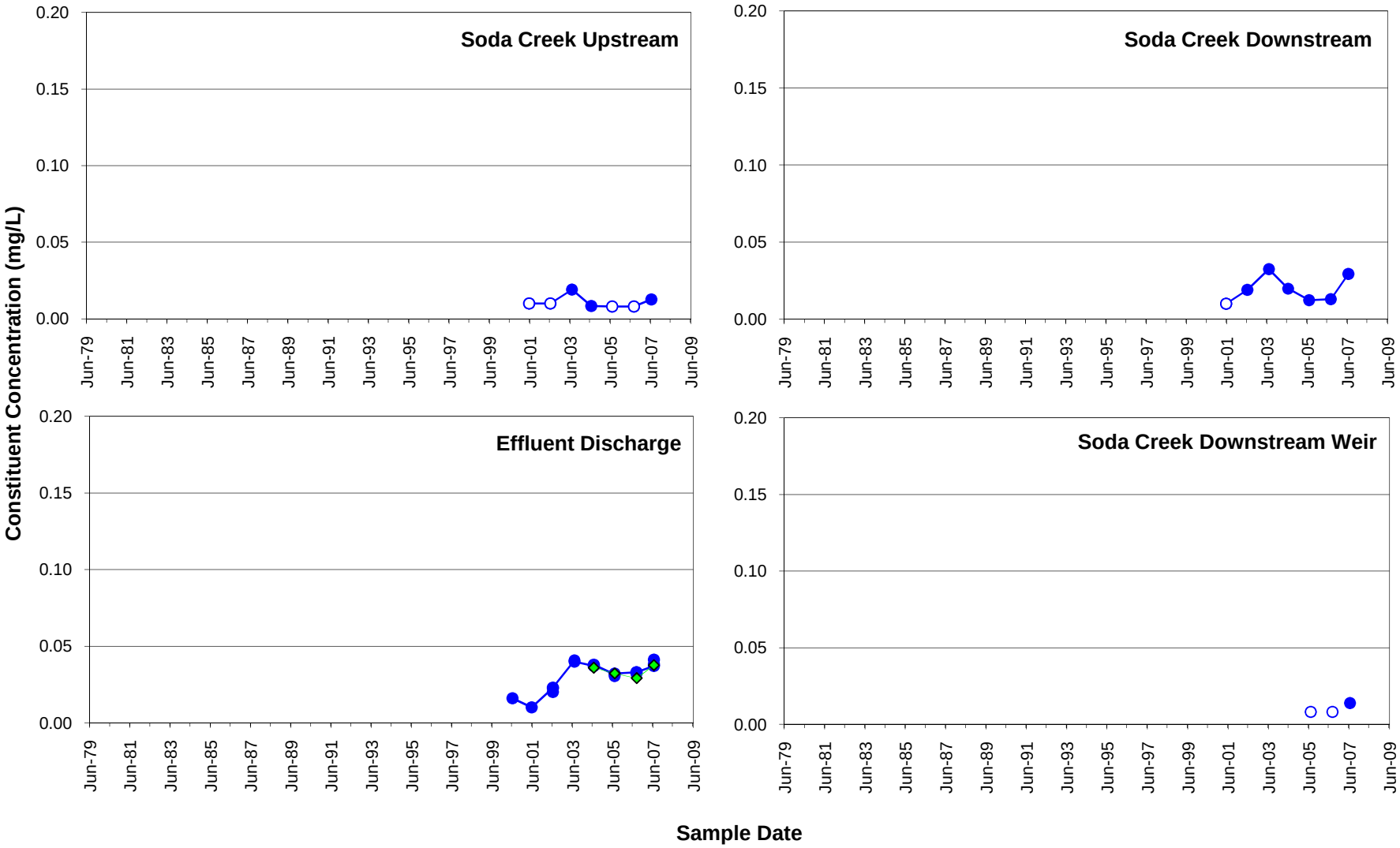
TITLE **Molybdenum in Harris Well and Springs South of Plant**

FIGURE F-4

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO.	913-1101.605A	DATE 3-Apr-08	REVIEWED DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

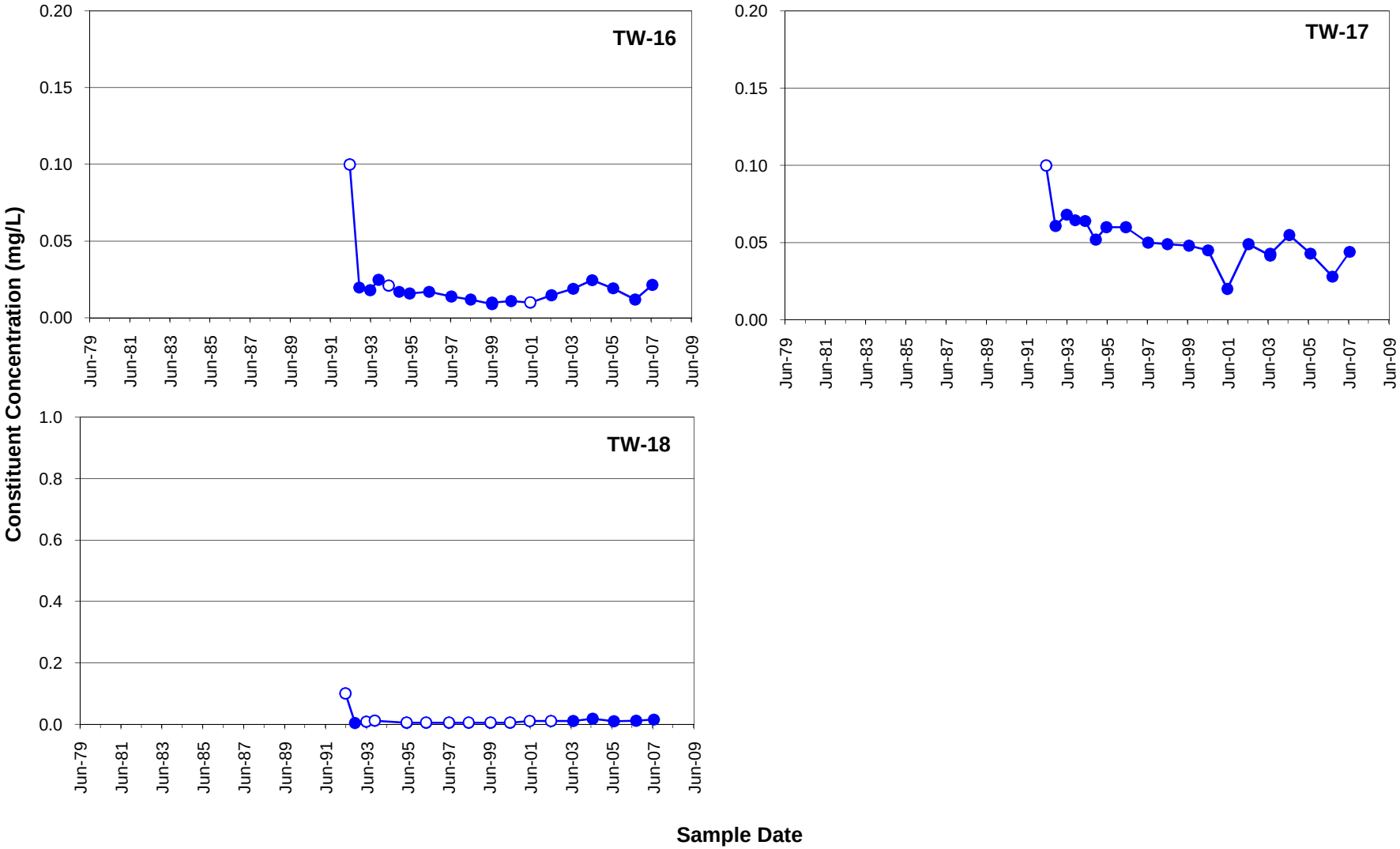
Golder Associates

TITLE **Molybdenum in Soda Creek and Treatment Plant Effluent**

FIGURE F-5

Constituent Concentration (mg/L)
Non-Detects
Pond Inlet

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

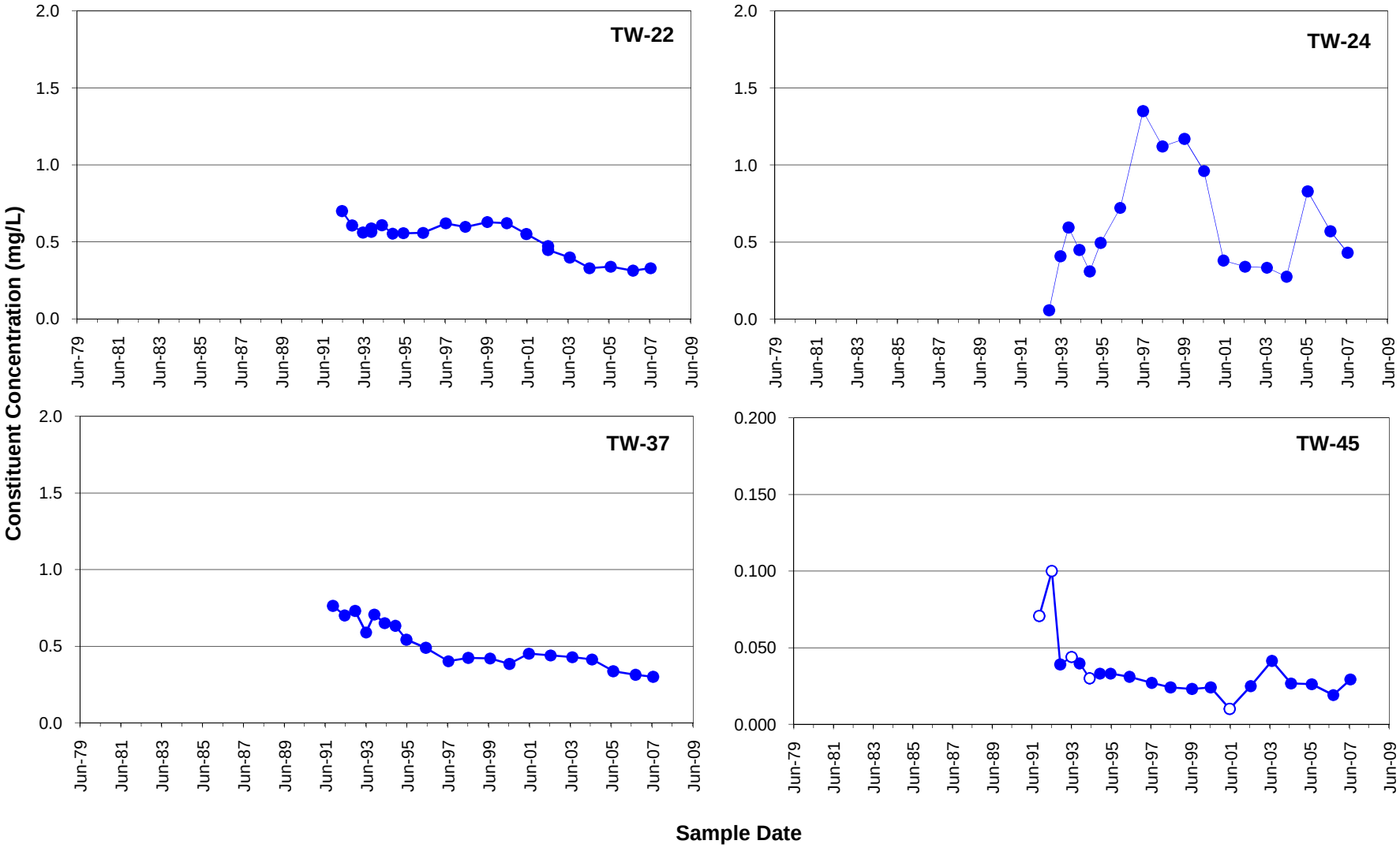
TITLE **Molybdenum in NW Pond Wells**

FIGURE F-6

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

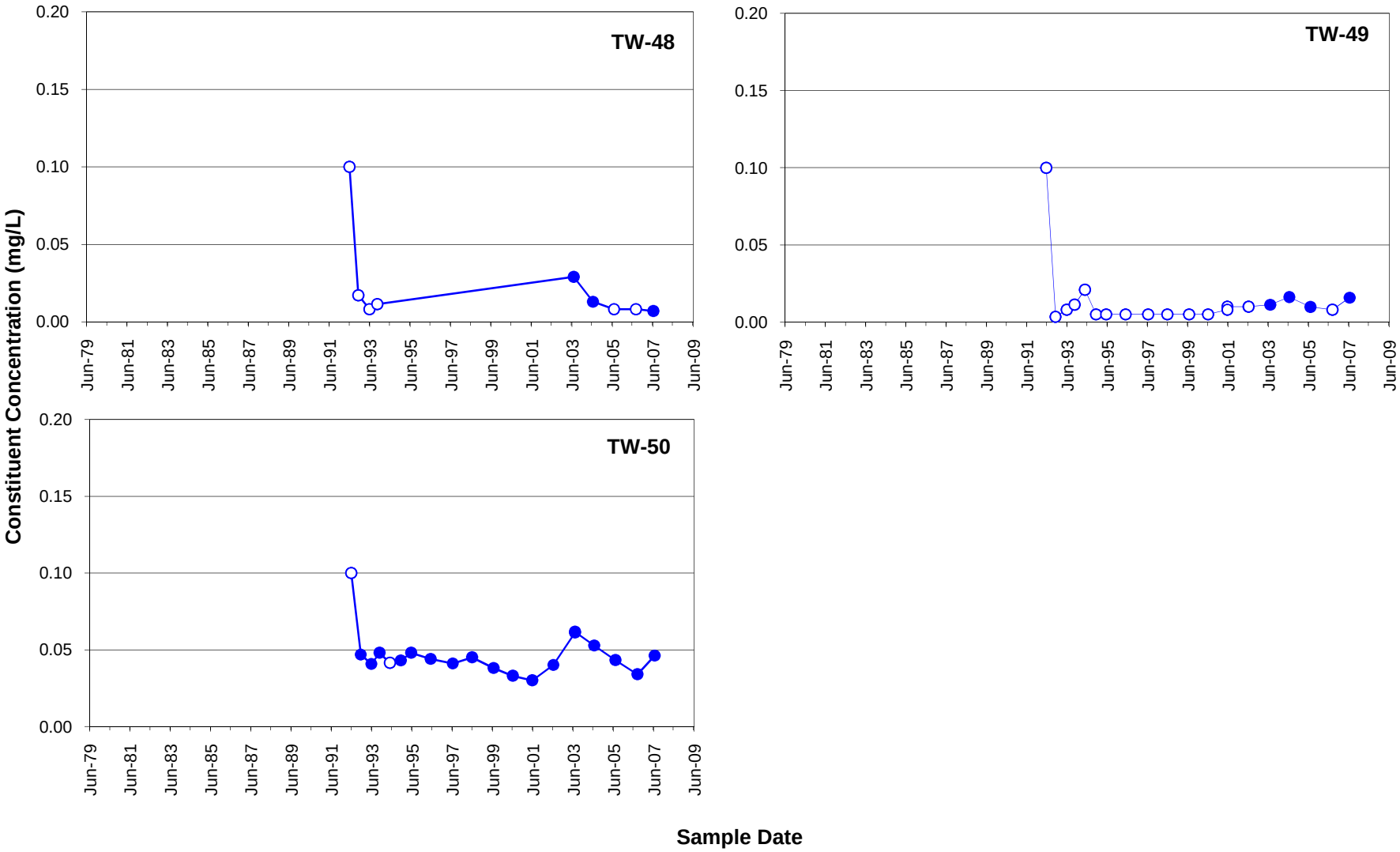
Golder Associates

TITLE **Molybdenum in Old Underflow Solids Pond Area Wells**

FIGURE F-7

Constituent Concentration (mg/L)

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

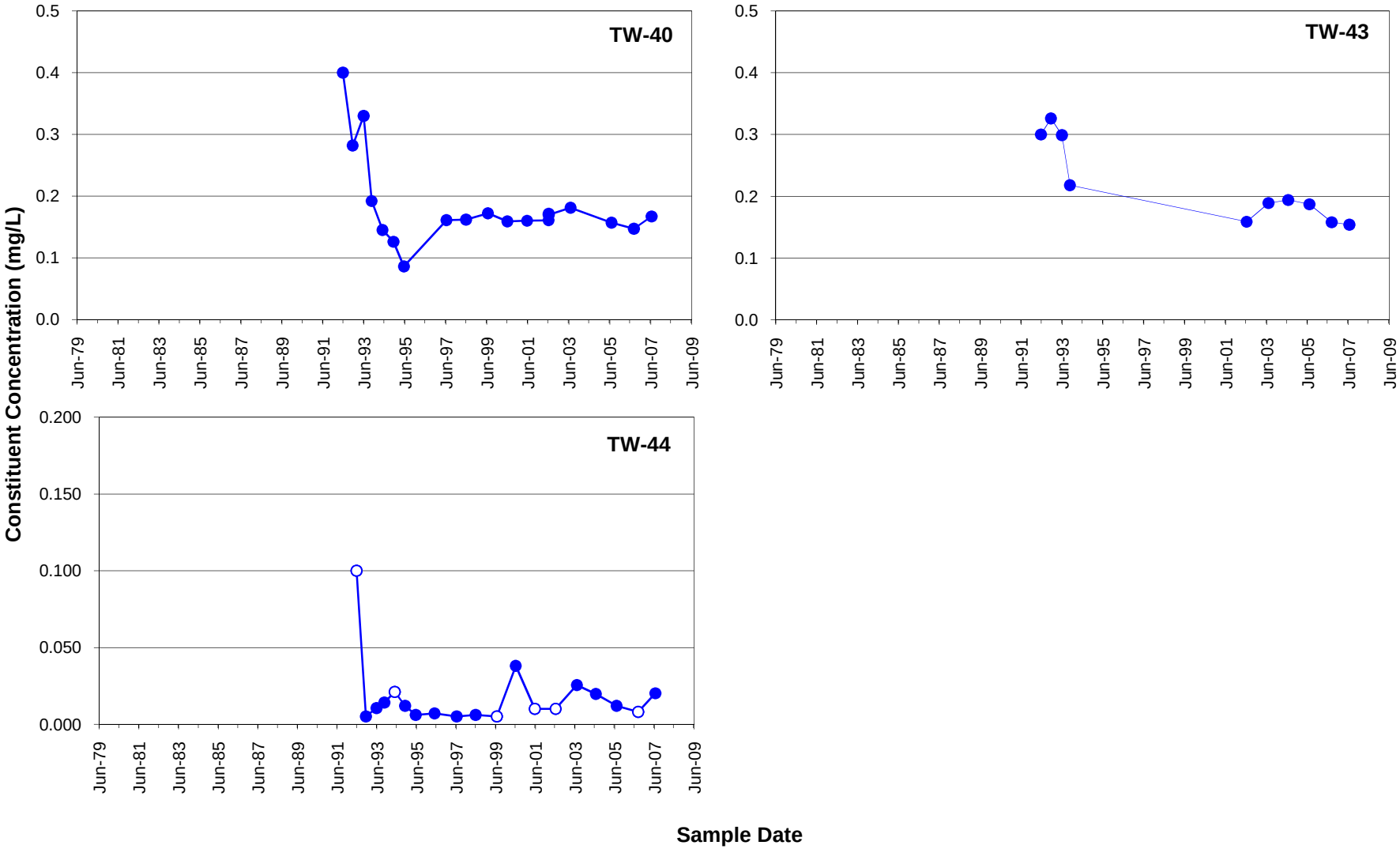
TITLE **Molybdenum in Underflow Solids Piles Area Wells**

FIGURE F-8

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

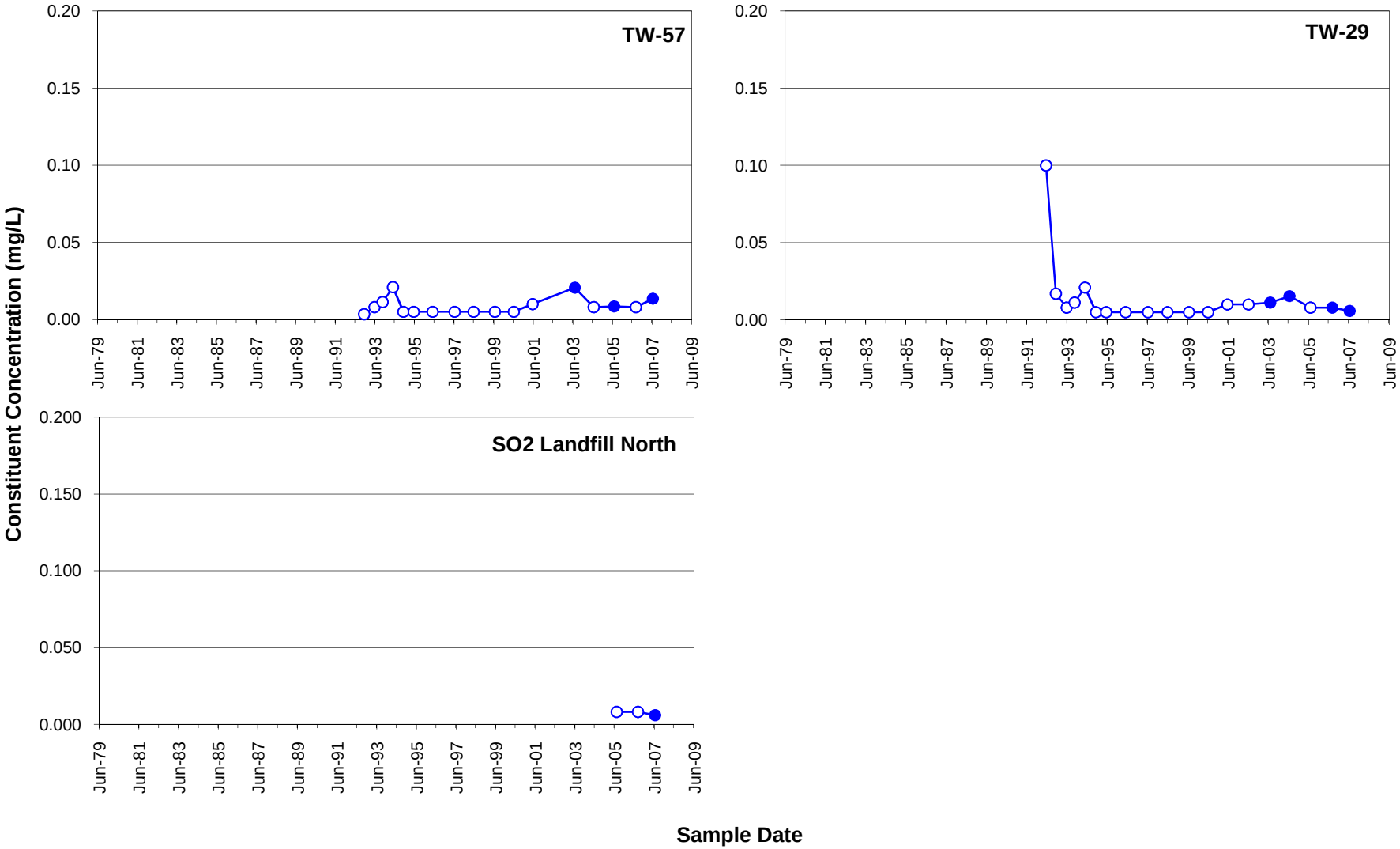
TITLE **Molybdenum in Hydroclarifier Area Wells**

FIGURE F-9

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

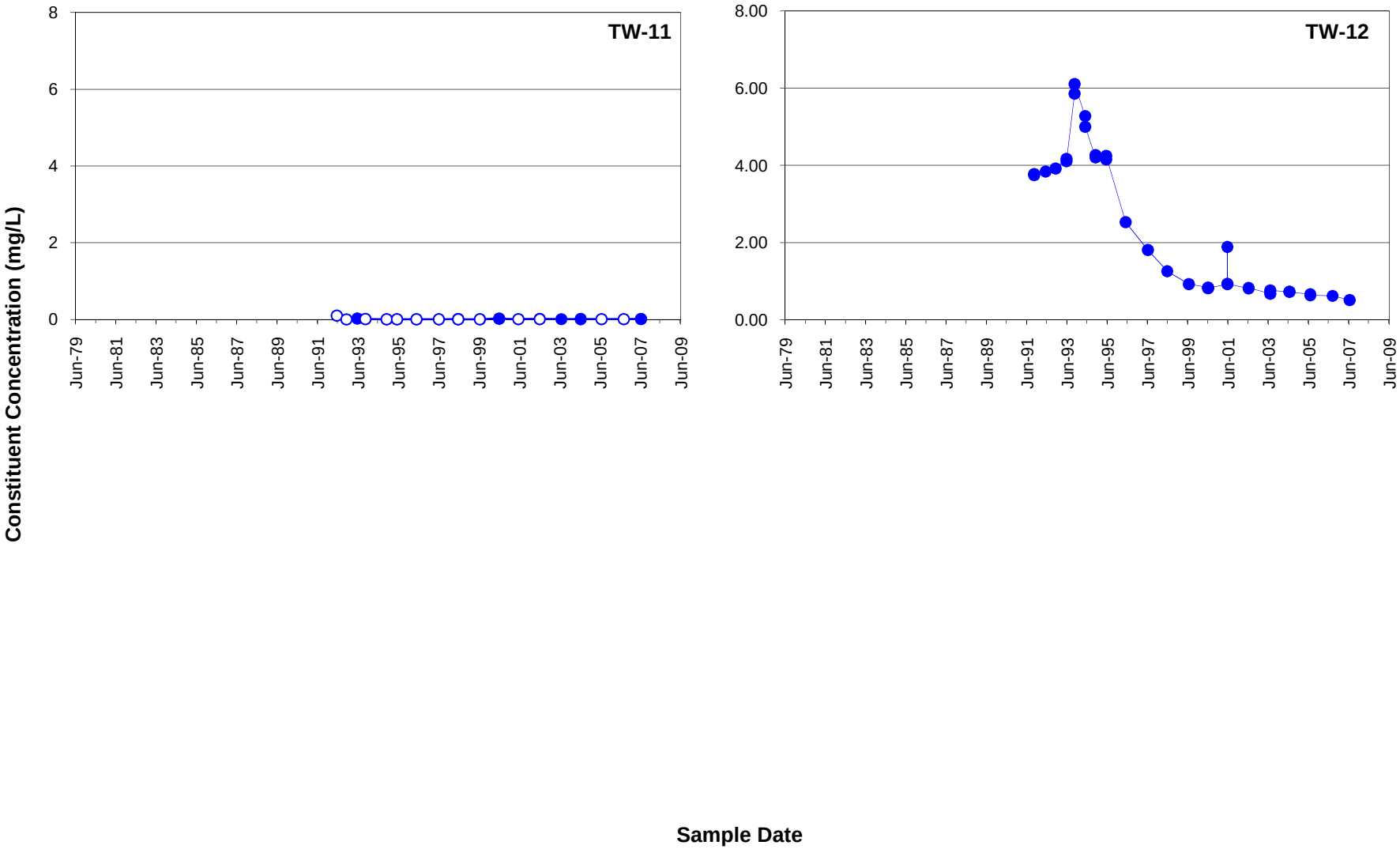
TITLE **Molybdenum in Background Wells**

FIGURE F-10

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company		DRAWN DH
PROJECT	Monsanto Groundwater Monitoring		CHECKED MPK
PROJECT NO.	913-1101.605A	DATE 3-Apr-08	REVIEWED DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

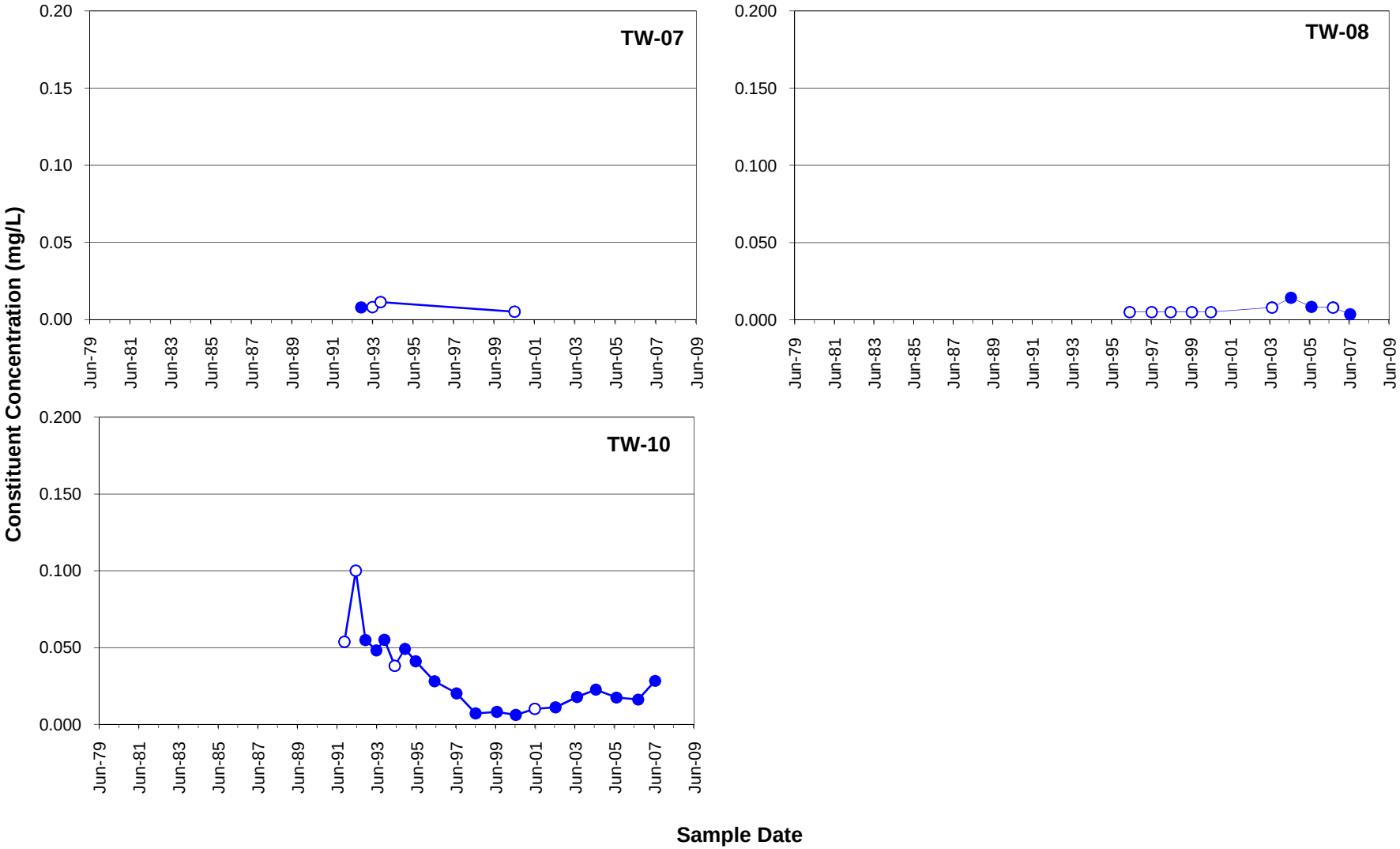
TITLE **Molybdenum in Southeast Corner Wells**

FIGURE F-11

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

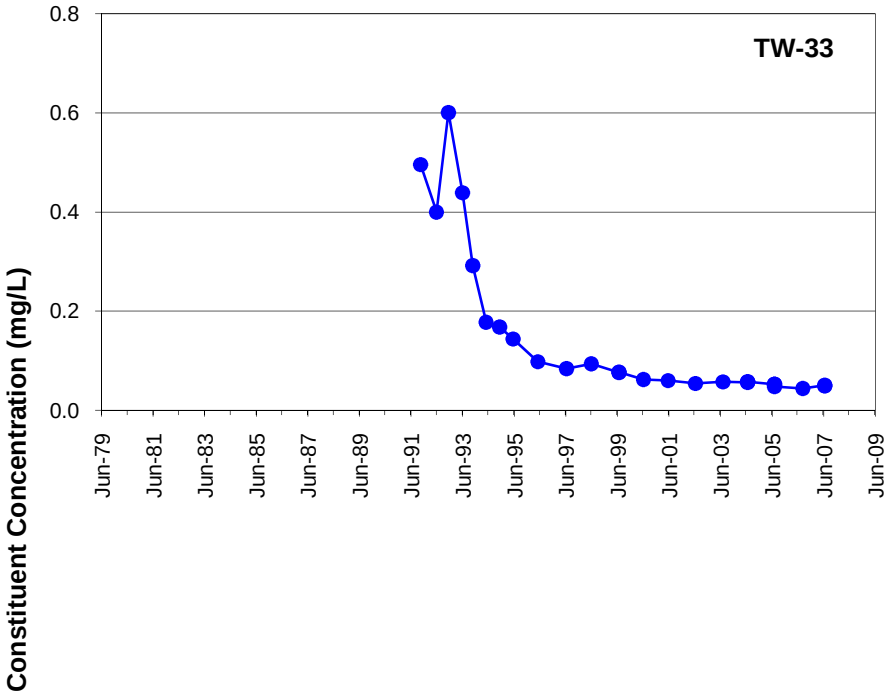
TITLE **Molybdenum in Southwest Corner Wells**

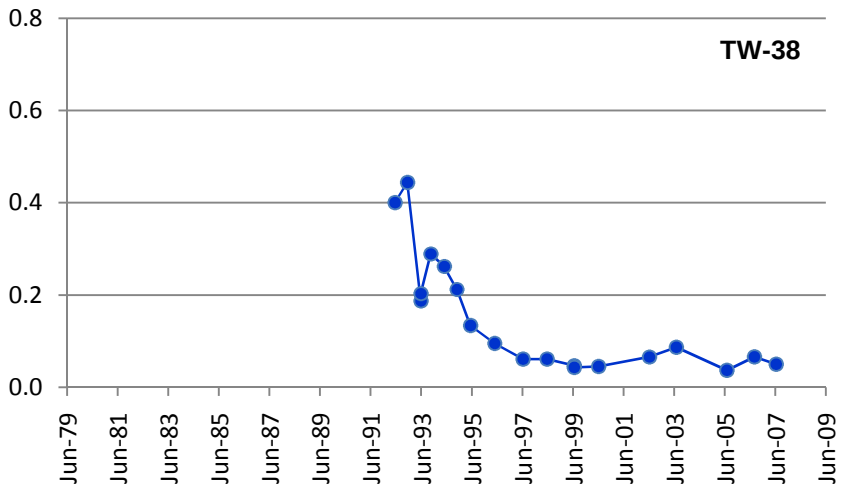
FIGURE F-12

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB





Sample Date

FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

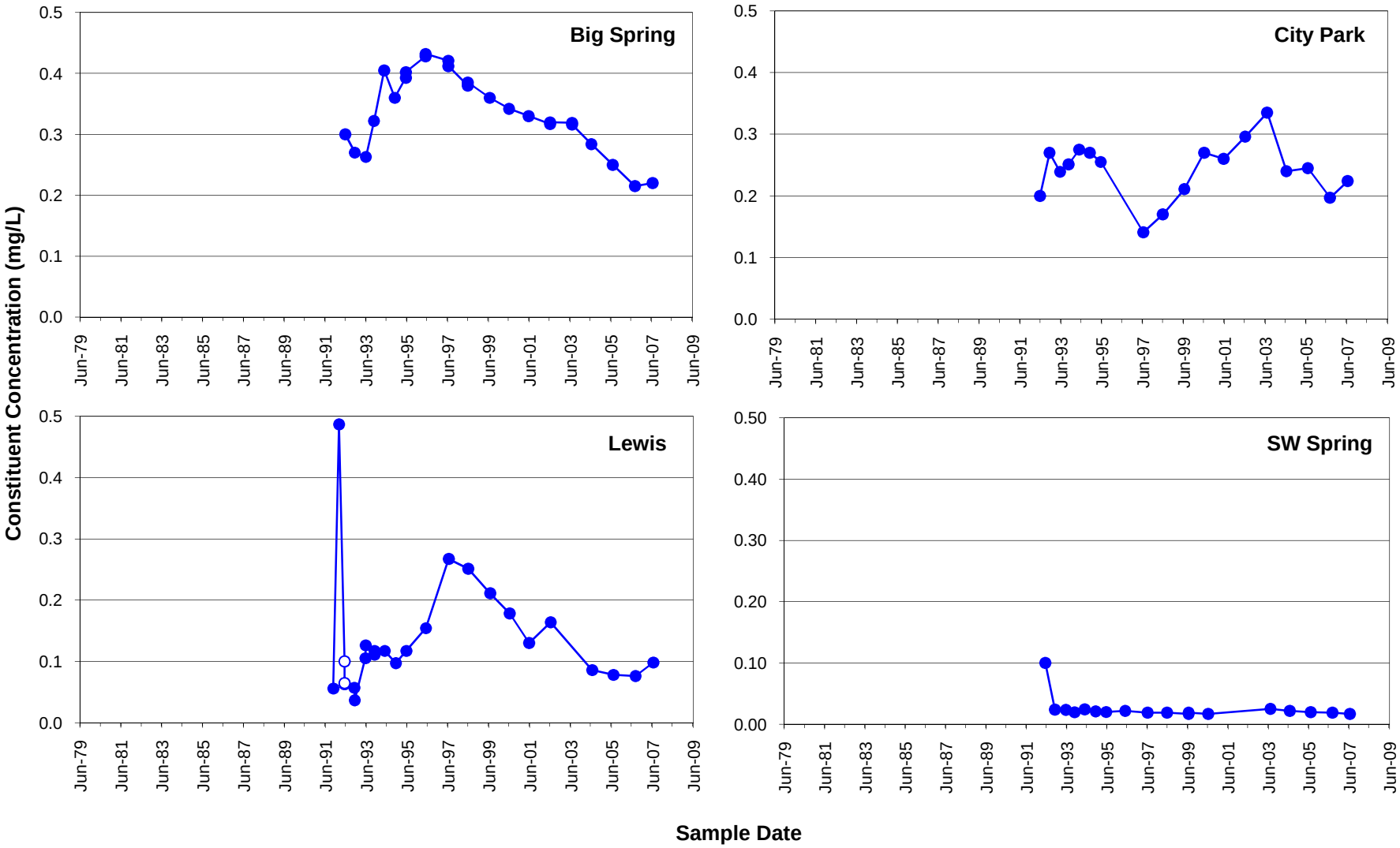
Golder Associates

TITLE **Molybdenum in East Wells**

FIGURE F-13

Constituent Concentration (mg/L)

CLIENT	Monsanto Company		DRAWN DH
PROJECT	Monsanto Groundwater Monitoring		CHECKED MPK
PROJECT NO.	913-1101.605A	DATE 3-Apr-08	REVIEWED DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE

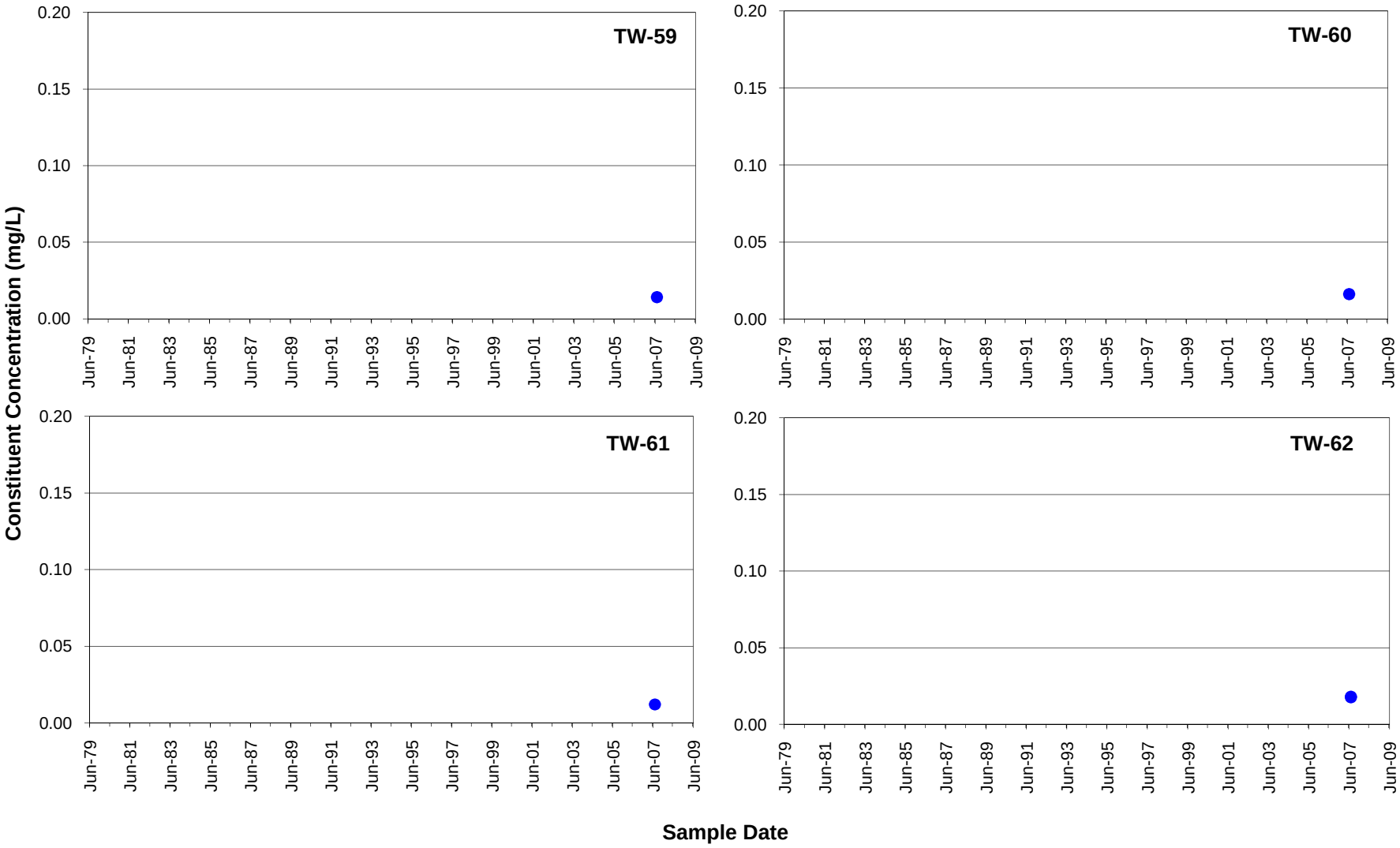
Molybdenum in Offsite Wells and Springs

FIGURE **F-14**

Constituent Concentration (mg/L)

Non-Detects

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB



FILE NAME App G Molybdenum Charts 2007.xls

Remediation goals shown for point of compliance locations only

Golder Associates

TITLE **Molybdenum in 2007 Monitoring Wells**

FIGURE F-15

Constituent Concentration (mg/L)

CLIENT	Monsanto Company	DRAWN	DH
PROJECT	Monsanto Groundwater Monitoring	CHECKED	MPK
PROJECT NO. 913-1101.605A	DATE 3-Apr-08	REVIEWED	DB

ATTACHMENT G

INSTITUTIONAL CONTROLS INFORMATION

P_4 Production, LLC

Soda Springs Plant
1853 Highway 34
P.O. Box 816
Soda Springs, Idaho 83276-0816
Phone: (208) 547-4300
Fax: (208) 547-3312

December 23, 1999

CERTIFIED MAIL

Mr. Wallace Reed
U.S. EPA Region 10
1200 Sixth Avenue, ECL-115
Seattle, Washington 98101

cc: J.P. Hyland, Solutia-St. Louis
D.K. Wilson, Solutia-St. Louis
R.L. Simmons, Solutia-Soda Springs
D.W. Farnsworth, Solutia-Soda Springs
G.R. MacIlwraith, Solutia-Soda Springs
R.C. Budge, Racine, Olson, Nye, Budge and Cooper
W.E. Wright, Montgomery Watson

Dear Mr. Reed,

Attached is a copy of the Environmental Protection Easement and Declaration of Restrictive Covenants that is associated with the plant site and property surrounding the Solutia (Monsanto) facility in Soda Springs, Idaho.

These easements and restrictive covenants were recorded on December 22, 1999, as official records at the Caribou County Courthouse. The conditions and restrictions, as agreed to by EPA Region 10 and P_4 Production, L.L.C. will apply to and run with the property as required by EPA's Record of Decision for the Monsanto Soda Springs, Idaho superfund site.

Efforts to monitor environmental conditions and the approved uses associated with these properties in order to assure protection to human health and the environment will continue.

If you have any questions regarding this significant milestone, please contact me.

Sincerely,

Robert L. Geddes
Superfund Project Manager

Enclosure

160535

STATE OF IDAHO
County of Caribou
Date: 12/22/99
Time: 9:45 AM
Official Records
Recorder: Edie Izatt
Deputy: Edie Izatt
Fee: 33.00

ENVIRONMENTAL PROTECTION EASEMENT AND DECLARATION OF RESTRICTIVE COVENANTS

This Environmental Protection Easement and Declaration of Restrictive Covenants (hereinafter "Agreement") is granted by P4 PRODUCTION, L.L.C., whose address is P.O. Box 816, Soda Springs, Idaho 83276 ("Grantor"), in favor of SOLUTIA INC., whose address is 10300 Olive Boulevard, St. Louis, Missouri 63166-6760, and MONSANTO, whose address is 800 N. Lindbergh Boulevard, St. Louis, Missouri 63167 ("Grantee"). Grantor being the owner of the real property located in Caribou County, Idaho, described in Exhibit "A" attached hereto and incorporated by reference as if set forth fully (the "Property"), for valuable consideration paid by Grantee, the receipt and sufficiency of which are hereby acknowledged, hereby Grants to Grantee an environmental protection easement and adopts the covenants, conditions and restrictions set forth herein which shall apply to and run with the Property.

1. **Background, Purpose.** The Property is located at or near the site of an elemental phosphorus plant near Soda Springs in Caribou County, Idaho (the "Facility") that was previously owned and operated by Monsanto Company from 1952 until 1997, and is now owned by Grantor and operated by Solutia Inc., as successors in interest. The covenants, conditions and restrictions set forth herein are necessary to ensure the development and use of the Property in a manner consistent with the current environmental law and the use and character of Grantee's Facility.

2. **Restrictive Covenant .** The Property shall not be used or developed for any residential use, including but not limited to single and multiple family dwelling units and other facilities used for living quarters. Additionally, affected ground water underlying the property shall not be consumed until EPA certifies that ground water beneath the Property meets the Performance Standards.

3. **Environmental Protection Easement.** Grantor grants to Grantee, the United States, the State of Idaho and their representatives, including, but not limited to, EPA and its contractors,

a continuing right of access to the Property to enforce the land use restrictions and conduct any related activity required by the RD/RA Consent Decree entered on June 29, 1998 in the United States District Court for the District of Idaho, in the matter of the United States of America, Plaintiff, v. Monsanto Company and P4 Production L.L.C., Defendants, Civil Action No. 98-154, recorded December 18, 1998, in the Public Land Records in the Office of the County Recorder of Caribou County, Idaho, as Recorder's Instrument No. 158132.

4. **No Public Access or Use.** The property will not be open to public access or use. Grantee may construct and maintain, at their expense, such fences, gates and signs as may be necessary to prevent public access or use. Access and use shall be limited to Grantor, Grantee, and their agents, representatives and employees.

5. **Application.** All real estate, lots, parcels or portions thereof located within or on the Property, and any conveyance or transfer covering or describing any part thereof, shall be subject to the environmental protection easement, covenants, conditions and restrictions contained herein. By acceptance of such conveyance or transfer, each transferee or grantee and each of their heirs, successors, transferees or assigns agrees with Grantor and each other to be bound by the covenants, conditions and restriction contained herein.

6. **Partial Resale, Lease or Sublease.** The sale, subdivision, leasing and subleasing of a portion of the Property shall be prohibited unless each such portion resulting from such sale, subdivision, leasing or subleasing meets all of the requirements contained herein and contained in any applicable, valid governmental ordinances and regulations.

7. **Notice Requirement.** Grantor agrees to include in any instrument conveying any interest in any portion of the property, including but not limited to deeds, leases and mortgages, a notice which is substantially in the following form:

> **NOTICE:** The interest conveyed hereby is subject to the effect of: (1) an Environmental Protection Easement and Declaration of Restrictive Covenants, dated 12-22-99, 1999, recorded in the Public Land Records in the Office of the County Recorder of Caribou County, Idaho, as Recorder's Instrument No. 160535 ; and, (2) the RD/RA Consent Decree entered on June 29, 1998 in the United States District Court for the District of Idaho in the matter of the United States Of America, Plaintiff, v. Monsanto Company and P4 Production, L.L.C., Defendants, Civil Action No.98-154, recorded

December 18, 1998, in the Public Land Records in the Office of the County Recorder of Caribou County, Idaho, as Recorder's Instrument No. 158132.

Within thirty (30) days of the date any such instrument of conveyance is executed, Grantor must provide Grantee with a certified true copy of said instrument and, if it has been recorded in the Public Land Records, its recording reference.

8. **Enforcement.** The environmental protection easement and restrictive covenants granted herein are contractual in nature. Grantor, Grantee and any person, corporation or other entity who hereafter asserts or claims any right, title, claim or interest in and to the Property, whether as successor in title or otherwise and whether voluntarily or by operation of law, and any person, corporation or other entity claiming by, through or under Grantor or Grantee, or their heirs, assigns or successors, or any of them severally, shall have the right to enforce the restrictions contained in this Agreement and to proceed at law or in equity to compel compliance with or prevent the violation or breach of the terms hereof. The prevailing party in any action to enforce any provision of this Agreement shall be entitled to recover all costs of such action, including reasonable attorney fees.

9. **Reserved Rights.** Grantor reserves all rights and privileges in and to the use of the property which are not incompatible with the restrictions granted herein.

10. **Notices.** Any notice, demand, request, consent, approval or communication that either party desires or is required to give shall be in writing and shall either be served personally or sent by first class mail postage prepaid at the address above indicated for each party.

11. **General Provisions.**

11.1 Controlling Law. The interpretation and enforcement of this Agreement shall be governed by the laws of the State of Idaho.

11.2 Binding Effect. This Agreement shall remain in full force and effect, run with the land and bind all persons obtaining or succeeding to an interest in the Property after the date hereof until released. Grantee may release this Agreement in full or in part at any time consistent with U.S. Environmental Protection Agency requirements.

11.3 Severability. The determination that any provision of this Covenant is invalid shall not affect any other provision of this Covenant and the other provisions of this Covenant shall remain in full force and effect.

11.4 No Forfeiture. No waiver of the breach of any provision of this Agreement shall constitute a waiver of a subsequent breach or forfeiture of any provision. No right of action shall accrue for or on account of the failure of any person to exercise any right created by this Agreement nor for imposing any provision, condition, restriction or covenant which may be unenforceable.

11.5 Liberal Construction. This Agreement shall be liberally construed to affect the purpose of this instrument. If any provision of this instrument is found to be ambiguous, an interpretation consistent with the purpose of this instrument that would render the provision valid shall be favored over any interpretation that would render it invalid.

11.6 Entire Agreement. This instrument sets forth the entire agreement between the parties with respect to the rights and restrictions created hereby, and supersedes all prior discussions, negotiations, understandings, or agreements relating thereto, all of which are merged herein.

IN WITNESS WHEREOF, GRANTOR HAS EXECUTED THIS AGREEMENT THIS 3 DAY OF December, 1999.

GRANTOR:

P4 PRODUCTION, L.L.C.

By _____ WDL

Vice President

160535

STATE OF)
: ss
County of)

I certify that I know or have satisfactory evidence that Marty Blaylock is the person who appeared before me, that said person acknowledged that he signed this instrument on behalf of MONSANTO COMPANY, and that the signing of the instrument was his free and voluntary act.

Given under my hand and official seal this 3rd day of December, 1999.

Ruth A. Dunlap

NOTARY PUBLIC FOR:

Residing at: 4867 Margaretta

RUTH A. DUNLAP
Notary Public, State of Missouri
St. Louis City
My Commission Expires 11/17/2001

(SEAL)

160535

STATE OF ~~IDAHO~~ MISSOURI)
County of ~~Caribou~~ St. Louis : ss)

I certify that I know or have satisfactory evidence that Dennis Cavner is the person who appeared before me, that said person acknowledged that he signed this instrument on behalf of SOLUTIA INC., and that the signing of the instrument was his free and voluntary act.

Given under my hand and official seal this 2nd day of December, 1999.

Joani M. Madden

NOTARY PUBLIC FOR ~~IDAHO~~ MISSOURI
Residing at:
My Commission Expires:

(SEAL)

JOANI M. MADDEN
NOTARY PUBLIC, STATE OF MISSOURI
MY COMMISSION EXPIRES JUNE 29, 2000
ST. CHARLES COUNTY

160535

GRANTEE'S ACCEPTANCE

Grantee, Solutia Inc., hereby accepts the foregoing grant of Environmental Protection Easement and Declaration of Restrictive Covenants and agrees to be bound by the terms and conditions thereof.

SOLUTIA INC.

By _____

Print Name: DENNIS CAVNER

Title: V.P. OPERATIONS EXCELLENCE

MONSANTO COMPANY

By _____

Print Name: M E BLAYLOCK

Title: VP MANUFACTURING OPERATIONS

160535

STATE OF MISSOURI)
: ss
County of St. Louis)

I certify that I know or have satisfactory evidence that Alan W. Seder is the person who appeared before me, that said person acknowledged that he signed this instrument on behalf of P4 PRODUCTION, L.L.C., and that the signing of the instrument was his free and voluntary act.

Given under my hand and official seal this 9th day of December, 1999.

Mary K. McBride

NOTARY PUBLIC FOR MISSOURI
Residing at:
My Commission Expires:

(SEAL)

MARY K. MC BRIDE
NOTARY PUBLIC - STATE OF MISSOURI
MY COMMISSION EXPIRES 2/12/2002
ST. LOUIS COUNTY

160535

EXHIBIT "A"

DESCRIPTION OF REAL PROPERTY IN CARIBOU COUNTY, IDAHO, SUBJECT TO ENVIRONMENTAL PROTECTION EASEMENT AND DECLARATION OF RESTRICTIVE COVENANTS

TOWNSHIP 8 SOUTH, RANGE 42 EAST OF THE BOISE MERIDIAN:

SECTION 29: W½SW¼, ALSO, ALL THAT PORTION OF THE SE¼SW¼ LYING WESTERLY OF THE WESTERLY RIGHT OF WAY LINE OF STATE HIGHWAY NO. 34.

SECTION 30: LOTS 2 AND 3, NE¼SW¼, SE¼
EXCEPT THEREFROM, A STRIP OF LAND 50 FEET WIDE, BEING 25 FEET ON EACH SIDE OF THE CENTERLINE LYING OVER AND ACROSS THE SE¼NE¼ OF SECTION 25, TOWNSHIP 8 SOUTH, RANGE 41 EAST OF THE BOISE MERIDIAN, AND OVER AND ACROSS LOTS 2 AND 3, AND THE NE¼SW¼ OF SECTION 30, TOWNSHIP 8 SOUTH, RANGE 42 EAST OF THE BOISE MERIDIAN, SAID CENTERLINE BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS:

BEGINNING AT A POINT ON THE WEST FENCE LINE OF GRANTOR'S LAND, WHICH POINT IS 25 FEET SOUTH OF THE INTERSECTION OF THE SAID WEST FENCE LINE WITH THE NORTH LINE OF THE SAID SE¼NE¼ OF SAID SECTION 25, AND 1285 FEET, MORE OR LESS, WEST OF THE EAST LINE OF SAID SECTION 25, AND RUNNING
THENCE EASTERLY, PARALLEL TO AND 25 FEET DISTANCE SOUTHERLY FROM THE SAID NORTH LINE OF SAID SE¼NE¼ OF SAID SECTION 25 AND 25 FEET DISTANT SOUTHERLY FROM AND PARALLEL TO THE NORTH LINE OF LOT 2 OF SAID SECTION 30, TO A POINT 25 FEET WEST OF THE WESTERLY BASE OF A LAVA REEF IN THE NORTHEASTERLY PORTION OF SAID LOT 2;

THENCE SOUTHEASTERLY PARALLEL TO AND 25 FEET DISTANT WESTERLY FROM THE BASE OF SAID LAVA REEF TO THE SOUTHERLY SURFACE END OF SAID LAVA REEF;

THENCE CONTINUING SOUTHEASTERLY TO AND AROUND AND 25 FEET DISTANT FROM THE SOUTHERLY AND WESTERLY SIDE OF A SECOND LAVA REEF SITUATED IN OR NEAR THE SOUTHEAST CORNER OF SAID LOT 2 AND IN OR NEAR THE NORTHEAST CORNER OF SAID LOT 3 OF SAID SECTION 30;

THENCE SOUTHEASTERLY BETWEEN TWO ADDITIONAL LAVA REEFS TO A POINT 25 FEET EAST OF THE EASTERLY SIDE THEREOF;

THENCE RUNNING NORTHEASTERLY TO A POINT 25 FEET SOUTH OF THE NORTH LINE OF SAID NE¼SW¼ OF SAID SECTION 30;

THENCE EASTERLY PARALLEL TO AND 25 FEET DISTANT SOUTHERLY FROM THE SAID NORTH LINE OF SAID NE¼SW¼ OF SAID SECTION 30, TO A POINT 25 FEET WEST OF THE EAST FENCE LINE OF GRANTOR'S LAND IN THE SAID NE¼SW¼ OF SAID SECTION 30;

THENCE SOUTHERLY, PARALLEL TO AND 25 FEET DISTANCE WESTERLY FROM SAID EAST FENCE LINE OF GRANTOR'S LAND TO THE SOUTH LINE OF THE SAID NE¼SW¼ OF SAID SECTION 30, TOWNSHIP 8 SOUTH, RANGE 42 EAST OF THE BOISE MERIDIAN, EXCEPTING ANY PROPERTIES LYING WITHIN THE COUNTY ROAD RIGHT OF WAYS.

SECTION 31: E½

SECTION 32: ALL THAT PORTION OF THE NW¼ AND THE W½SW¼ LYING WESTERLY OF THE WESTERLY RIGHT OF WAY OF STATE HIGHWAY 34 AS THE SAME NOW EXISTS.

ALSO, BEGINNING AT THE SOUTHWEST CORNER OF SECTION 32; THENCE NORTH 00°33'26" EAST 60 FEET TO A FOUND 5/8" REBAR, THE TRUE POINT OF BEGINNING, AND RUNNING

THENCE NORTH 00°25'51" WEST 654.08 FEET ALONG THE EAST RIGHT OF WAY LINE OF HIGHWAY NO. 34 TO A HIGHWAY RIGHT OF WAY MONUMENT, WHICH IS THE P.C. OF A 1860.00 FOOT RADIUS CURVE TO THE RIGHT;

THENCE NORTHERLY ALONG SAID CURVE THROUGH A CENTRAL ANGLE OF 02°05'01", AN ARC LENGTH OF 67.64 FEET, THE CHORD OF WHICH BEARS NORTH 01°17'53" EAST, AND HAVING A CHORD DISTANCE OF 67.64 FEET TO A POINT OF TANGENCY, WHICH IS A 5/8" REBAR WITH CAP LABELLED "A.A. HUDSON PLUS 4735";

THENCE SOUTH 37°20'30" EAST 804.98 FEET TO A 5/8" REBAR WITH CAP;

THENCE SOUTH 16°32'26" EAST 81.09 FEET TO A FOUND 5/8" REBAR;

THENCE SOUTH 90°33'07" WEST 507.99 FEET, TO THE TRUE POINT OF BEGINNING.
ALSO, A TRACT OF LAND 200 FEET IN WIDTH, ADJOINING THE WESTERLY SIDE OF THE CONDA-SODA SPRINGS RAILROAD RIGHT OF WAY AND RUNNING NORTHWESTERLY THEREFROM TO AND ADJOINING THE EASTERLY SIDE OF STATE HIGHWAY NO. 34 AND SITUATED IN THE SW¼SW¼ OF SECTION 32, AND FURTHER DESCRIBED AS SITUATED 100 FEET ON EACH SIDE OF THE FOLLOWING DESCRIBED CENTERLINE, TO-WIT:

BEGINNING AT A POINT ON THE WEST BOUNDARY LINE OF SAID CONDA-SODA SPRINGS RAILROAD RIGHT OF WAY LOCATED 439 FEET EAST AND 358 FEET NORTH OF THE SOUTHWEST CORNER OF SAID SECTION 32, AND RUNNING

THENCE NORTHWESTERLY TO A POINT 933.4 FEET NORTH OF SAID SOUTHWEST CORNER OF SECTION 32, WHICH LAST POINT INTERSECTS THE EASTERLY BOUNDARY LINE OF SAID STATE HIGHWAY NO. 34.

TOWNSHIP 9 SOUTH, RANGE 42 EAST OF THE BOISE MERIDIAN:

SECTION 6: LOTS 1, 2, AND 3
EXCEPT THEREFROM, THE FOLLOWING TRACT:

BEGINNING AT THE POINT OF INTERSECTION OF THE WEST LINE OF STATE HIGHWAY NO. 34, AND THE SOUTH LINE OF HOOPER SPRINGS ROAD, WHICH POINT IS APPROXIMATELY 86 FEET WEST AND 100 FEET SOUTH FROM THE NORTHEAST CORNER OF SAID SECTION 6; THENCE CONTINUING SOUTH ALONG THE WESTERLY RIGHT OF WAY LINE OF SAID HIGHWAY NO. 34, A DISTANCE OF 208.7 FEET, TO THE TRUE POINT OF BEGINNING, AND RUNNING

160535

THENCE CONTINUING SOUTH ALONG THE WESTERLY RIGHT OF WAY LINE OF HIGHWAY NO. 34, A DISTANCE OF 1011.3 FEET, MORE OR LESS, TO THE SOUTH LINE OF THE NE¼NE¼ OF SAID SECTION 6;

THENCE WEST ALONG SAID SOUTH LINE 440 FEET;

THENCE NORTH 1011.3 FEET;

THENCE EAST 440 FEET, TO THE POINT OF BEGINNING.
EXCEPTING ANY PROPERTIES LYING WITHIN THE COUNTY ROAD RIGHT OF WAYS.