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Kennedy/Jenks Consultants

Remedial Investigation/Feasibility Study
South Tacoma Field Superfund Site
Tacoma, WA

Remedial Investigation Report
Appendices
Volume 4 of 6

Appendix GW - Groundwater Investigation Report
Appendix HC - Hydraulic Characterization Report

SOUTH TACOMA FIELD

K/J Project No. 916055.19

Kennedy/Jenks Consultants

Remedial Investigation/Feasibility Study
South Tacoma Field Superfund Site
Tacoma, WA

Remedial Investigation Report
Appendix GW

GROUNDWATER INVESTIGATION REPORT

K/J Project No. 916055.08

Final Report

APPENDIX GW

PHASE I GROUNDWATER INVESTIGATION REPORT

SOUTH TACOMA FIELD
SUPERFUND SITE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

FINAL

Prepared for

SOUTH TACOMA FIELD SITE GROUP

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K/J 916055.08

24 August 1992

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1.0 INTRODUCTION

This report describes findings associated with the Phase I Groundwater Investigation conducted as part of the South Tacoma Field (STF) Remedial Investigation. The STF site, located in Tacoma, Washington, is an industrial property approximately 260 acres in size. The site is in western Washington State (Figure G-1) in the southwestern section of the City of Tacoma (Figure G-2). Currently, the STF site is largely vacant with some remnant structures and recently constructed industrial buildings.

On 23 November 1981, the U.S. Environmental Protection Agency (EPA) published an "interim priority list" of 115 top priority hazardous waste sites targeted for action under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The STF site was listed on the initial National Priorities List (NPL) as a portion of the Commencement Bay-South Tacoma Channel site. On 30 December 1982, EPA proposed modifications to the NPL. The list increased to 418 sites and the Commencement Bay-South Tacoma Channel site was divided into four separate sites: the Deepwater, the Nearshore, the Tideflats Industrial, and the South Tacoma Channel. On 8 September 1983 (48 FR 40658), the South Tacoma Channel site was further divided into separate operable units (e.g., STF, Tacoma Well 12-A, Tacoma Landfill) with unique NPL site numbers (Bennett, D., 3 January 1992, personal communication).

On 12 October 1990, EPA and the potentially responsible parties (PRPs) signed an Administrative Order on Consent (Consent Order) for the STF site. The Consent Order, among other requirements, directed that a remedial investigation be conducted to determine the nature and extent of environmental contamination by hazardous substances at the STF site.

RECOMMENDATION

Based on the results of the Phase I Groundwater Investigation and the Phase I Soil Investigation, the following recommendation is proposed for further groundwater investigations at the STF site:

- Abandon monitoring well CBS-8A in the Former Swamp/Lakebed area. Analytical constituents detected in groundwater samples collected from CBS-8A may be attributed to surface water infiltration through the surface housing or well seal.

NMW-1A at Pioneer Builders Supply contained the highest concentrations of VOCs detected during this investigation. Low concentrations of VOCs (usually less than 10 μg/L) were detected in some onsite wells in the south-central portion of the site. Low concentrations of VOCs were also detected in offsite and upgradient wells TL-12A and CBS-10A and in background wells TL-16A and WCC-2. Concentrations of ethyl benzene in groundwater samples collected from one onsite well exceeded the existing MCL during one quarter. Concentrations of benzene and 1,1,2-trichloroethane each exceeded the existing or proposed MCL in one onsite monitoring well. However, comparisons of sample results from the remaining monitoring wells to these MCLs were not possible because the detection limits exceeded the MCLs for those compounds. Similarly, comparisons of groundwater results from onsite wells with existing and proposed MCLGs for other VOCs was often not possible because the detection limits usually exceeded the MCLGs. Concentrations of toluene, ethyl benzene, and xylene exceeded the proposed SMCLs in one well, NMW-1A, during all four quarters.

A few semivolatile organic compounds were detected in two onsite wells (NMW-1A and CBS-8A) during the second, third, and fourth quarters; and in NMW-2A during the fourth quarter. Semivolatiles were detected in one offsite and upgradient well during the second and fourth quarters. Semivolatiles were detected in one background well during the fourth quarter. Concentrations of bis(2)ethylhexylphthalate exceeded the proposed MCLG of 0 in one onsite well during the third quarter and in three onsite wells during the fourth quarter. Comparisons of the remaining results for bis(2)ethylhexylphthalate were not possible because the detection limit exceeded the MCL of 4 μg/L and the MCLG of 0.

Pesticides and PCBs were not detected in groundwater samples collected from onsite, background, or upgradient wells during this investigation.

Arsenic and nickel concentrations each exceeded Federal regulatory criteria [existing and proposed Maximum Contaminant Levels (MCLs), respectively] in one onsite monitoring well during this investigation (for a total of two wells). Lead concentrations detected in one additional well exceeded the existing Action Level (AL) of 15 μg/L and the MCL of 50 μg/L. Nickel and lead concentrations detected in samples collected from onsite wells also exceeded the proposed and existing Maximum Contaminant Level Goals (MCLGs). Comparison of other detected inorganic concentrations to MCLGs is not possible because the detection limits exceeded the regulatory criteria. Iron, manganese, and aluminum concentrations exceeded Secondary Maximum Contaminant Levels (SMCLs) in approximately one-half the onsite monitoring wells.

ORGANIC ANALYTICAL RESULTS

PAHs were detected in groundwater samples collected from nine onsite monitoring wells during this investigation. However, in seven of these nine wells, anthracene was the only PAH detected and at low concentrations that are suspected to be the result of laboratory contamination based on the detection of anthracene in laboratory method blanks. PAHs detected in samples collected from the remaining two onsite wells (NMW-1A at Pioneer Builders Supply and CBS-8A in the Former Swamp/ Lakebed Area) included naphthalene, acenaphthene, fluorene, phenanthrene, acenaphthylene, anthracene, fluoranthene, and pyrene. Except for naphthalene, PAH concentrations were generally low (i.e., <5 μg/L). Carcinogenic PAHs were not detected in groundwater samples collected from onsite wells during this investigation. MCLs, MCLGs, and SMCLs do not exist and have not been proposed for the PAHs detected in onsite groundwater samples collected during this investigation.

VOCs were generally not detected in upper aquifer groundwater samples from wells in the northern and extreme southern portions of the STF site. Onsite well

A groundwater divide/recharge area for the upper aquifer is located in the vicinity of the STF site. The regional groundwater gradient in the upper aquifer appears to be from the southeast to the northwest. However, hydraulic gradient reversals occur in the upper aquifer at the STF site during pumping of City of Tacoma production wells 4A, 6A, and 11A. A cone of depression is created in the upper aquifer across the STF site during pumping, and the hydraulic gradient reverses to a direction toward the production wells. The hydraulic gradient direction in the extreme southwest portion of the STF site does not appear to be affected by this gradient reversal, although the gradient there appears to become less steep during the pumping events.

Further characterization of the hydraulic properties of aquifer zones at the STF site was conducted as part of the Hydraulic Characterization Investigation. Results of the Hydraulic Characterization Investigation are presented in Appendix HC of the RI Report.

INORGANIC ANALYTICAL RESULTS

Concentrations of naturally occurring inorganics were generally within the range of background concentrations detected in upper aquifer groundwater collected from wells in the northern and eastern portions of the STF site. Upper aquifer groundwater samples collected from onsite wells in the Airport and Former Swamp/Lakebed areas, the railcar cleanout area (southern end of the BNR Railyard area), and Pioneer Builders Supply contained concentrations of some inorganics that were greater than the range of background concentrations. Concentrations of some inorganics detected in samples collected from upgradient wells TL-12A, TL-13A, and TL-23A were also greater than the range of background concentrations. The highest concentrations of some of the inorganics were detected in samples collected from offsite and upgradient well CBS-10A outside the southeast corner of the site.

background monitoring wells, and five upgradient monitoring wells during the second and fourth quarters (July/August 1991 and January 1992).

Onsite groundwater samples collected during the first and third quarters were analyzed for inorganics, polynuclear aromatic compounds (PAHs), and volatile organic compounds (VOCs). Samples collected during the third quarter were also analyzed for boron and cyanide. In addition, two samples were analyzed for semivolatile organic compounds and 12 samples were analyzed for dissolved metals.

Onsite, background, and upgradient groundwater samples collected during the second and fourth quarters were analyzed for inorganics, PAHs, VOCs, semivolatile organic compounds, boron, cyanide, pesticides and polychlorinated biphenyls (PCBs), total dissolved solids (TDS), total suspended solids (TSS), and total organic carbon (TOC). The same 12 groundwater wells sampled for dissolved metals analyses during the third quarter were also sampled and analyzed for dissolved metals during the fourth quarter.

HYDROGEOLOGY

The geologic units encountered during drilling beneath the STF site are correlative with the regional stratigraphy and appear to be laterally continuous with units described beneath the Tacoma Landfill to the west. The upper aquifer at the STF site is located in the Colvos Sand unit of the Vashon Drift, also the unit in which the upper aquifer at the Tacoma Landfill is located (Black & Veatch 1990). The Colvos Sand unit is composed of fine to medium, poorly graded to well-graded sand overlying a gravel unit. The regional confining layers identified as hydrostratigraphic layers A_1 and B by Brown and Caldwell (1985) were also encountered beneath the STF site.

- Collect groundwater vertical hydraulic gradient information and vertical chemical distribution information by installing and monitoring well clusters at two onsite locations.

- Evaluate chemical concentration data (in conjunction with data from the Phase I and Phase II Soil Investigations, Geophysical Survey, and the Soil Gas Survey) to determine the need for additional monitoring wells.

The following tasks were completed during the Phase I Groundwater Investigation:

- Installed and developed 11 new monitoring wells at the STF site, including two well clusters consisting of three wells per cluster.

- Collected seven undisturbed soil samples from the upper aquifer during well installation to characterize physical soil properties, including vertical hydraulic conductivity, porosity, and particle size distribution.

- Measured water levels monthly in 30 groundwater monitoring wells (i.e., 29 onsite wells and 1 upgradient well) from April 1991 through March 1992. Additional measurements were made in late August 1991, January 1992, and March 1992. Measurements of water levels in upper aquifer wells in the vicinity of the Tacoma Landfill were provided by Tacoma Landfill personnel for the May, late August, November, and February events. These measurements were incorporated into upper aquifer water level contour maps prepared for this report.

- Collected groundwater samples from 26 onsite monitoring wells during the first and third quarters (April and October/November 1991).

- Collected groundwater samples from 26 onsite monitoring wells (two of the wells are also considered to be background wells), three additional

EXECUTIVE SUMMARY

This report describes findings associated with the Phase I Groundwater Investigation performed as part of the South Tacoma Field (STF) Remedial Investigation/Feasibility Study (RI/FS). The Phase I Groundwater Investigation was performed as outlined in the Final Work Plan (ICF 1990b), which established the level of effort required by the U.S. Environmental Protection Agency (EPA) to complete the RI/FS.

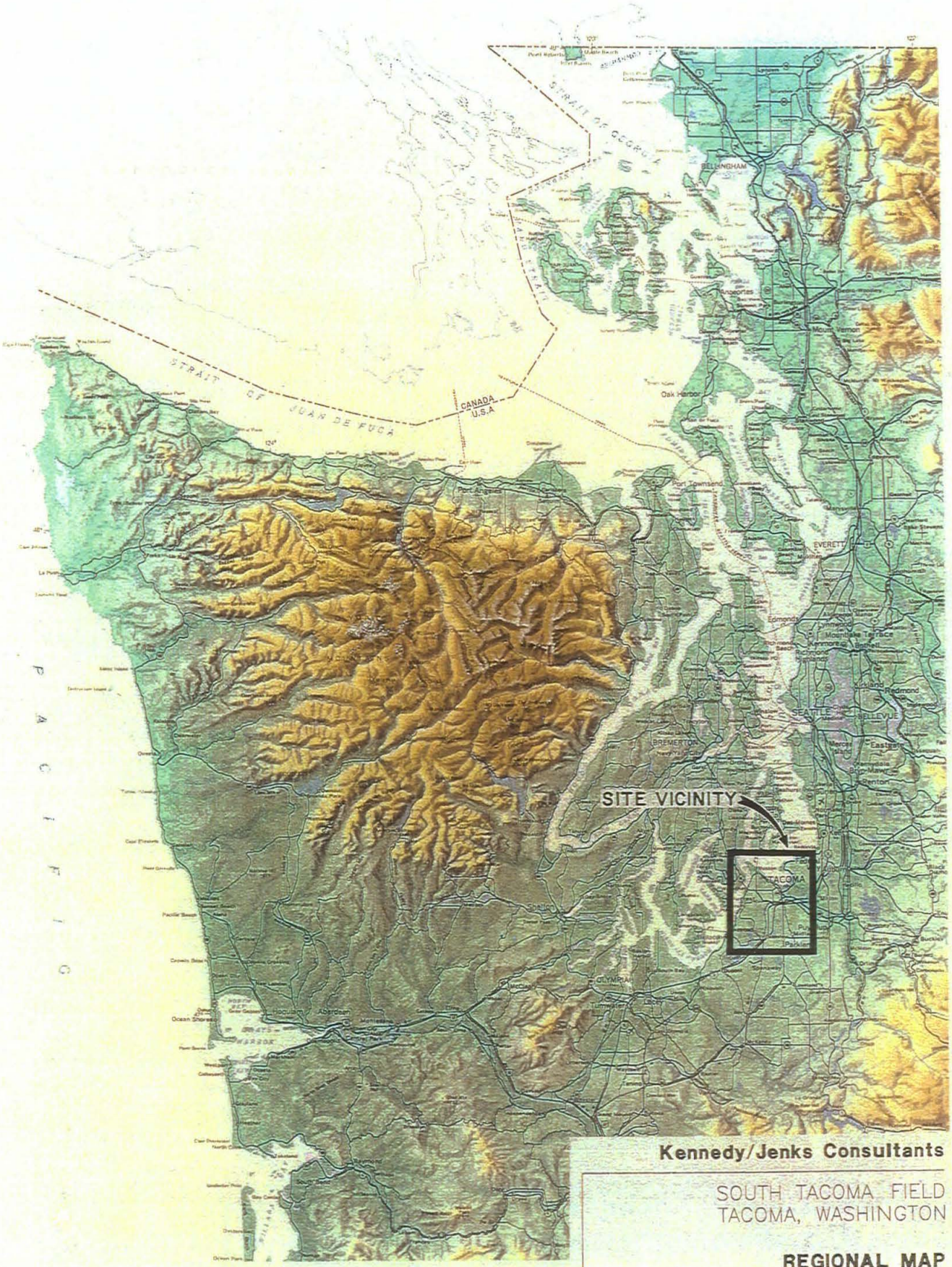
PURPOSE AND INVESTIGATIVE ACTIONS

The primary purpose of the Phase I Groundwater Investigation was to collect hydrogeologic and groundwater quality data to characterize groundwater beneath the STF site. Specific objectives of the Phase I Groundwater Investigation were to:

- Characterize the types and concentration distributions of chemicals of concern detected in groundwater samples collected from onsite monitoring wells during four quarterly events.

- Collect geologic information on hydrostratigraphic units beneath the STF site to assess the potential for intercommunication between the A and C aquifers (hydrostratigraphic designations according to Brown and Caldwell 1985).

- Collect groundwater hydraulic gradient information for the upper aquifer on a monthly basis for 1 year to assess seasonal effects and the effects of pumping City of Tacoma production wells on the hydraulic gradient at the STF site.



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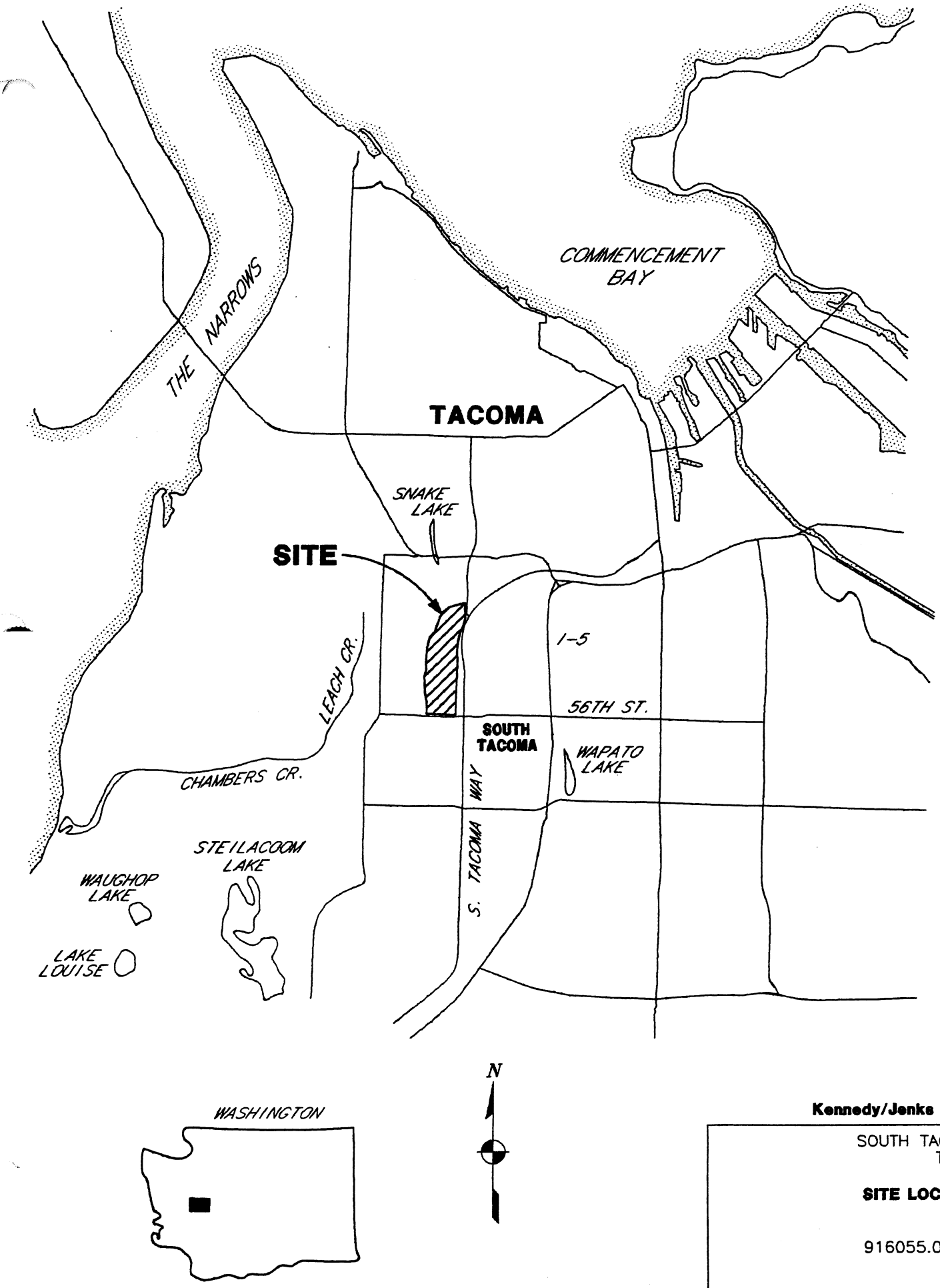
SOUTH TACOMA FIELD
TACOMA, WASHINGTON

REGIONAL MAP

916055.02/P1SK092

FIGURE G-1



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SOUTH TACOMA FIELD
TACOMA, WA

SITE LOCATION MAP

916055.08/P1SK139

FIGURE G-2

The Consent Order cites the Final Work Plan, which establishes the level of effort required by EPA to complete a Remedial Investigation/Feasibility Study (RI/FS) at the STF site. The Final Work Plan was prepared for EPA by ICF Technology, Inc. (ICF 1990b). Kennedy/Jenks Consultants was retained by the PRPs to conduct the RI/FS in accordance with the Final Work Plan, Revision 1, dated September 1990 (ICF 1990b).

The RI is composed of discrete investigations of surface soil, subsurface soil, groundwater, surface water, sediment, and blackberries. A soil gas survey, geophysical survey, wetland delineation and endangered plant species survey, and air modeling are also discrete components of the STF RI. Results of each of these investigations are presented separately as appendices to the RI Report. This report presents the findings of the STF Phase I Groundwater Investigation.

1.1 PURPOSE OF INVESTIGATION

The purpose of the Phase I Groundwater Investigation was to collect hydrogeologic and groundwater quality data to characterize the groundwater quality beneath the site. The Phase I Groundwater Investigation consisted of four quarters of sampling and subsequent laboratory analyses of these samples as detailed in the STF Field Sampling and Analysis Plan (FSAP) and the Quality Assurance Project Plan (QAPjP) (Kennedy/Jenks/Chilton 1991b,c). The following tasks were completed during the Phase I Groundwater Investigation:

- Installed and developed 11 new monitoring wells
- Abandoned one existing monitoring well
- Sampled 26 new and existing monitoring wells during four quarterly events
- Monitored water levels monthly in 30 monitoring wells

- Sampled 5 background wells during two quarterly events [dry season (July/August 1991) and wet season (January 1992)]

- Sampled 5 upgradient wells during two quarterly events [dry season (July/August 1991) and wet season (January 1992)].

1.2 REPORT ORGANIZATION

This report has been prepared in accordance with the EPA's (1988a) Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. The remaining sections of this report are summarized below:

- Section 1.0 concludes with a summary of the site background and current land use.

- Section 2.0 summarizes investigative methods used during this Phase I Groundwater Investigation, including a description of the drilling of soil borings, well installation, monthly water level monitoring, and the quarterly groundwater sampling activities. Analytical methods are also summarized in Section 2.0.

- Section 3.0 summarizes the quality assurance/quality control (QA/QC) program for field and laboratory data, and includes a discussion of the data validation process and the statistical analyses of laboratory analytical results. An explanation of the database printouts of analytical results is also presented.

- Section 4.0 includes the interpretative results for the field activities associated with the Phase I Groundwater Investigation, including a discussion of surface features as related to the geology of the site, a brief description of

surface water hydrology, a description of the geologic history and stratigraphy of the area, and a discussion of the hydrogeology of the site.

- Section 5.0 presents the investigative results (analytical data) for the groundwater samples collected for the four quarters of sampling. Site characterization as it pertains to groundwater quality at the site is presented, as well discussions of naturally occurring chemical constituents and chemicals of concern detected in samples collected from background, upgradient, and onsite wells.

- Section 6.0 presents conclusions regarding hydrogeologic conditions and chemical characteristics of groundwater at the STF site.

- Section 7.0 includes references for documents cited and used in the preparation of this report.

In addition, the Phase I Groundwater Investigation Report includes the following appendices:

- Appendix GW-A contains boring and well construction logs (bound at the end of this report).

- Appendix GW-B contains sieve analyses results for selection of filter and screen sizes (bound at the end of this report).

- Appendix GW-C contains 36 summary tables of detected analyte concentrations for each monitoring well sampled (bound at the end of this report).

- The Phase I Groundwater Investigation Data Appendix (Data Appendix; Kennedy/Jenks Consultants 1991) contains the analytical results for this investigation and was bound as a separate document.

1.3 SITE BACKGROUND

This section presents a brief site description and a discussion of historical activities at the STF site. More detailed information is provided in the Site Background Summary (ICF 1990a) and in the Final Work Plan (ICF 1990b).

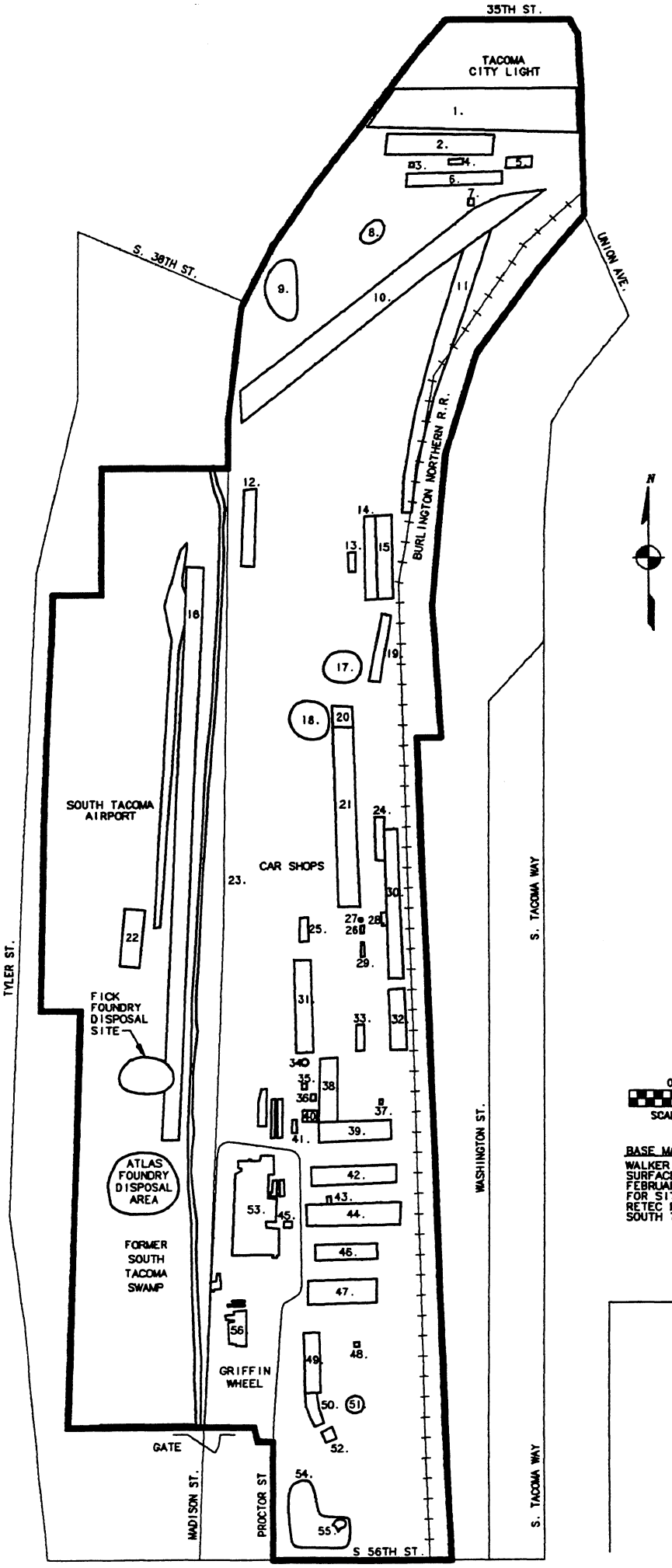
1.3.1 Site Description

The STF site is located on the floor of a topographic lowland area referred to as the South Tacoma Channel, which is as much as 150 feet lower than the surrounding uplands. The site, once covered with industrial structures, is now mostly open fields of grass with a few industrial and commercial facilities. Surface water is sometimes present in the western portion of the site, but no creeks, streams, or rivers
currently pass through the site.

1.3.2 Site History

This discussion of historical activities at the STF site is based on material contained in the Site Background Summary Report (ICF 1990a). A more complete description of STF site history is available in the Site Background Summary Report (ICF 1990a), along with references to other documents that provide additional information on historical site use.

The STF site has been used for a variety of industrial purposes for approximately 100 years. Locations where various activities have taken place at the site are shown in Figure GW-1. Areas where significant historical activities occurred are briefly discussed in the following paragraphs.



LEGEND

STF-NPL SITE BOUNDARY

1. TCL YARD AREA
2. GANTRY CRANE AREA
3. FUEL TANK
4. SHED
5. LANTERN SHED
6. STOREHOUSE, BELTHOUSE ROLLING MILL, STORAGE BLDG
7. FUEL CELLAR
8. BURN PIT
9. TRASH DUMP
10. STORAGE YARD
11. RUBBISH TRACK CORRIDOR
12. CONCRETE CASTING PLANT
13. SANDBLAST SHED
14. BLACKSMITH SHOP
15. CONCRETE FLOOR
16. LANDING STRIP
17. TRASH BURNING AREA
18. TRASH PIT (PAINT SHOP)
19. CAR CASTINGS PLATFORM
20. PAINT SHOP
21. CAR SHOP
22. AIRPORT BLDG
23. MADISON STREET
24. OPEN SHED
25. DRY KILN
26. WASTE SOAKING VAT
27. UST (OIL)
28. PAINT SHOP
29. PAINT HOUSE
30. FREIGHT REPAIR SHED
31. FINISHED LUMBER SHED
32. WHEEL SHOP
33. GENERATOR HOUSE
34. UST (OIL)
35. PUMPS
36. DIP TANK
37. DROP PIT
38. WOODWORKING SHOP
39. COACH SHOP
40. BOILER HOUSE
41. OIL TANKS
42. PAINT SHOP
43. BRASS
44. MACHINE SHOP
45. SOLVENT SHED
46. BOILER, TIN TANK, AND COPPER SHOP
47. SOUTH MACHINE SHOP
48. TRASH BURNER
49. BLACKSMITH SHOP
50. IRON & STEEL STORAGE
51. TURNTABLE
52. COKE & COAL
53. FORMER IRON FOUNDRY
54. RAILCAR CLEANOUT AREA
55. BURIED DRUMS (REMOVED)
56. FORMER BRASS FOUNDRY SITE

0 200 400
SCALE IN FEET

BASE MAP REFERENCE
WALKER & ASSOC. 10-22-86
SURFACE DEBRIS SAMPLING PLAN
FEBRUARY 1987
FOR SITTS & HILL ENGINEERS, INC
RETEC REMEDIATION TECHNOLOGIES, INC.
SOUTH TACOMA SWAMP

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

MAJOR HISTORICAL USES OF THE STF SITE

916055.08/P1SK140

FIGURE GW-1

The South Tacoma Car Shops area operated as a manufacturing and repair facility from 1892 until 1974. The area was used for manufacturing, repair, and maintenance of railroad equipment.

The BNR Dismantling Yard was located in the northern portion of the Car Shops area. Cars were cleaned out in this area.

Foundry facilities operated onsite from 1890 through 1980. An iron foundry produced iron wheels until 1957. A brass foundry produced journal bearings composed primarily of lead, tin, copper, zinc, and antimony until 1980.

The South Tacoma Airport operated from 1936 to 1973. Aircraft maintenance and refueling operations were performed at this location during those years. A lake was located beyond the south end of the former runway and, in the late 1940s, was used by seaplanes.

Reportedly, a variety of filling activities has occurred during the history of the site. Foundry, construction, and domestic wastes reportedly were disposed of as fill material in the Former Swamp/Lakebed area (ICF 1990a). In the 1930s and 1940s, portions of the site reportedly were used as unauthorized household and commercial waste dumping areas. Actual records of fill materials and volumes could not be obtained.

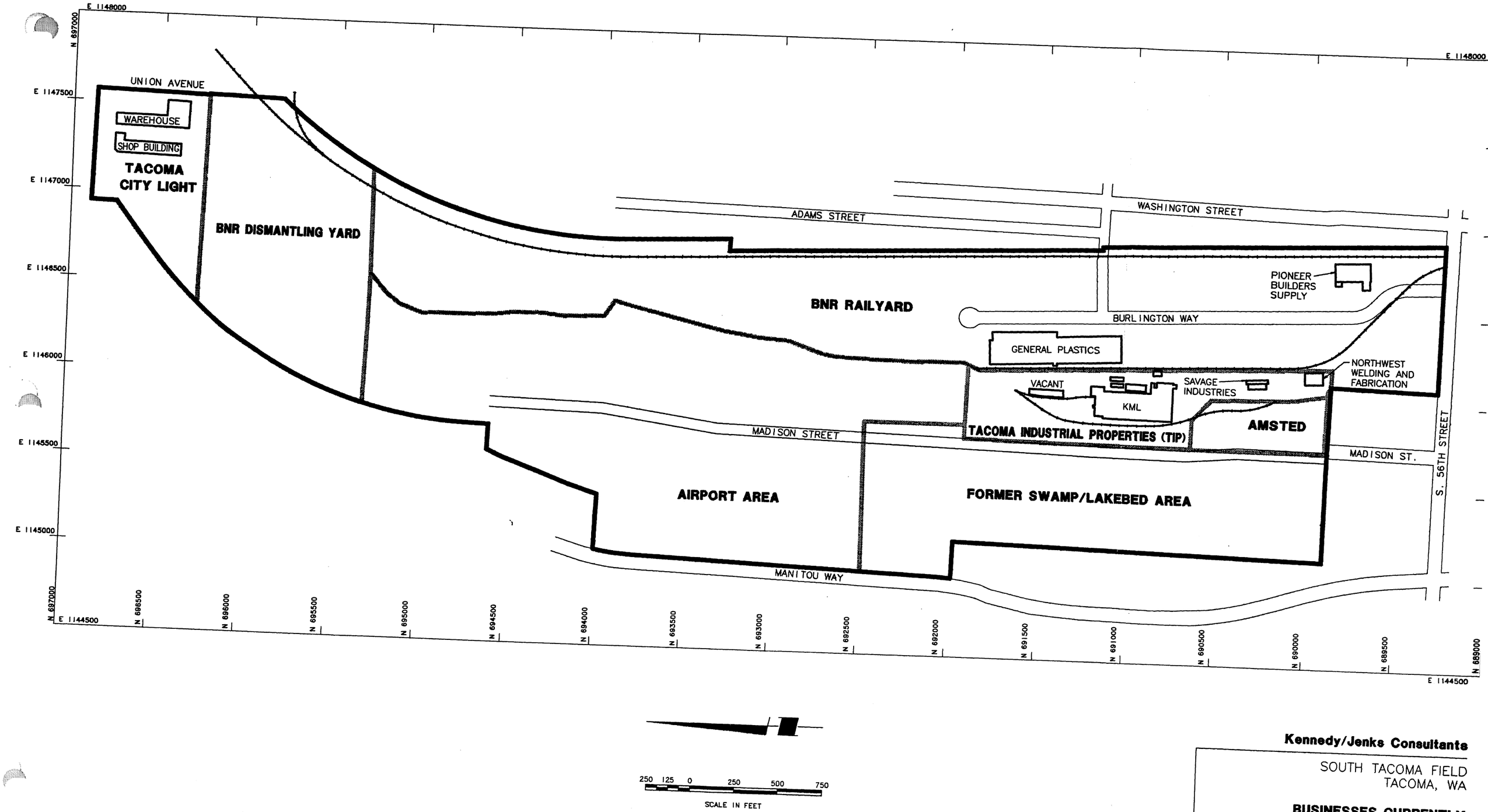
Tacoma City Light operations are located at the north end of the site. Repair, maintenance, and distribution of electric and water service equipment have occurred at the Tacoma City Light site since 1953.

1.4 CURRENT SITE USE

Much of the STF site is currently undeveloped and is covered with field grass, blackberries, shrubs, and a few trees. Concrete rubble, old foundations, and trash are apparent in some areas. A portion of the STF site is used for light industrial and commercial operations. Some businesses have operated from facilities previously used in association with the iron foundry and the railyards, while other manufacturers have constructed new facilities. Information in this section has been prepared using the Site Background Summary Report (ICF 1990a). A map of businesses currently operating at the STF site is shown in Figure GW-2.

Tacoma Public Utilities (Tacoma City Light) provides electrical service and drinking water to Tacoma residents and businesses, and has operated from the northernmost end of the STF site since 1953. Tacoma Public Utilities uses its facility for maintenance and repair of equipment, as a storage and distribution center for electrical and water supply system components, and as an administration center. The Tacoma City Light property is covered with asphalt pavement and buildings. Stormwater runoff drains to modified dry wells that have soil bottoms and interconnecting piping leading to the City of Tacoma's storm drainage system. Some of the dry wells have been plugged with bentonite to prevent surface water infiltration.

The Tacoma City Light property has four underground tanks and three aboveground tanks that are used to store automotive fuel, waste oil, and new, used, and waste mineral oil. Three of the underground tanks, which had contained leaded and unleaded gasoline, and diesel fuel, are empty and are under temporary closure. The tanks are scheduled for removal in August or September 1992. The other underground tank, which had contained waste oil, is empty and is also scheduled for removal in August or September 1992 (Post, R., 20 February and 4 June 1992, personal communication). The gasoline and diesel tanks reportedly are constructed of bare steel and are not equipped with cathodic protection or containment systems. The waste oil tank is constructed of concrete. The three aboveground



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SOUTH TACOMA FIELD
TACOMA, WA

BUSINESSES CURRENTLY OPERATING AT THE STF SITE

916055.08/P1SK141

FIGURE GW-2

2.0 INVESTIGATIVE METHODS

This section describes the field activities conducted during the Phase I Groundwater Investigation, including the drilling of soil borings, well installation, well development, well abandonment, four quarters of groundwater sampling, monthly water level monitoring, and surveying of the onsite monitoring wells. A discussion of the selection of background and upgradient wells is also included in this section. Analytical methods for groundwater samples and analyses of geotechnical parameters for aquifer soil are summarized at the end of this section.

2.1 FIELD ACTIVITIES

Field procedures that were used during the Phase I Groundwater Investigation field activities are described in the Standard Operating Guidelines (SOGs) of the STF FSAP (Kennedy/Jenks/Chilton 1991b).

2.1.1 Geological Investigations

Eleven (11) soil borings were completed as monitoring wells on the STF site during the Phase I Groundwater Investigation, in accordance with the Final Work Plan (ICF 1990b) and the FSAP (Kennedy/Jenks/Chilton 1991b). These 11 wells were designated NMW-1A, NMW-2A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5A, NMW-5B, NMW-5C, NMW-6A, and NMW-7A. Information gathered from soil collected from the well borings was used to assist in interpretation of the stratigraphy at the site. The locations of these newly installed monitoring wells and existing monitoring wells installed during previous investigations are shown in Figure GW-3.

tanks, which contain mineral oil, are located in enclosed areas with complete secondary containment.

In addition to the tanks, Tacoma City Light stores electrical equipment, including approximately 3,500 new and used transformers. Some of the transformers contained or have previously contained polychlorinated biphenyls (PCBs). PCB contamination of Tacoma City Light soil has been documented by Black & Veatch (1983) and by Hart-Crowser (1989).

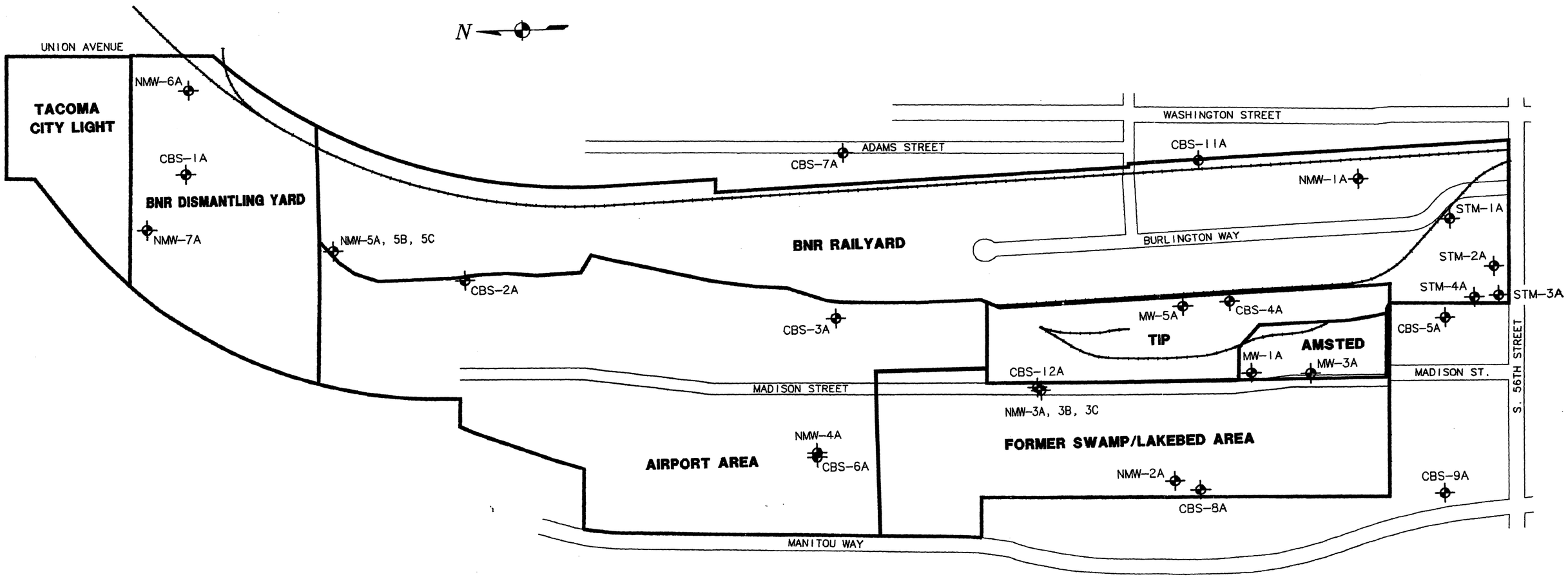
Tacoma Industrial Properties (TIP) Management Inc. owns property in the central portion of the STF site, which is the site of a former iron foundry. TIP uses the area for a variety of industrial purposes. Three businesses operate on TIP property: KML Corporation, Savage Industries, and Northwest Welding and Fabrication. KML Corporation has operated in the old iron foundry building since 1986. KML laminates films onto particle board for the construction of cabinets and interior partitions. Savage Industries has used a former wood patterns and vaults building since the early 1970s to manufacture wood picture frames. Northwest Welding and Fabrication has operated at TIP since 1986. Northwest Welding and Fabrication activities include repair of boats, motors, and boat trailers, as well as steel product fabrication and repair.

Other businesses have used TIP facilities; however, little information is available about their operations. These businesses reportedly included steel tubing, bending, and fabrication; lamination of plastic overlays on particle boards; railroad wheel journal bearing manufacturing; soil stabilization materials manufacturing; warehousing; and steel fabrication.

Facilities recently constructed on STF site property include the General Plastics and Pioneer Builders Supply complexes. General Plastics built a manufacturing plant in 1981 on a portion of the former Northern Pacific Car Shops area. General Plastics manufactures high-density rigid and flexible polyurethane foams and high-density rigid polyisocyanurate foams for the aviation, construction, marine, nuclear,

architectural, and sports equipment industries. General Plastics uses and/or stores onsite several chemical products including chlorofluorocarbons, methylene chloride, and isocyanates. One underground storage tank, formerly available for spill containment purposes, was removed in the summer of 1990 and properly disposed (Schatz, H., 25 February 1992, personal communication).

Pioneer Builders Supply purchased land in the southeast portion of the STF site for a warehouse and office building that were constructed in 1988. Pioneer Builders Supply operates a distribution center for asphalt and cedar roofing materials. Pioneer Builders Supply used two underground tanks for approximately 5 years to store gasoline and diesel fuel. Pioneer Builders Supply excavated the tanks in December 1991 and determined that the surrounding soil was contaminated with petroleum products (Saltbush Environmental Services 1992). In addition, three underground tanks were discovered in the northeast corner of the Pioneer Builders Supply property in early 1990 and were excavated and disposed of in June 1990 (Hildenbrand, J., 12 February 1991, personal communication).



LEGEND

NMW-1A — ONSITE MONITORING WELL LOCATION

0 500
SCALE IN FEET

NOTES:

1. ALL WELLS SHOWN WERE SAMPLED EXCEPT WELLS CBS-2A, CBS-6A, AND CBS-12A. THESE THREE WELLS WERE FORMERLY VANDALIZED AND WERE CONSIDERED UNSUITABLE FOR GROUNDWATER SAMPLING (ICF 1990B).
2. WELLS WITH "NMW" PREFIX WERE INSTALLED DURING THE PHASE I GROUNDWATER INVESTIGATION. ALL OTHER MONITORING WELLS WERE INSTALLED DURING PREVIOUS INVESTIGATIONS.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

ONSITE MONITORING WELL LOCATIONS

916055.08/P1SK349

FIGURE GW-3

To enable identification of the aquifer in which each well was installed, a letter designation was added to each of the previously existing and newly constructed monitoring wells. For example, the letter "A" was added to the monitoring well designation NMW-1 to indicate the well was installed in the upper aquifer. The letter "B" was used to indicate installation in the water-bearing zone beneath the next confining layer encountered during drilling, or at an approximate depth of 125 feet below ground surface (BGS) if no confining layer was encountered. The letter "C" was used to indicate installation in the third water-bearing zone, or at an approximate depth of 200 feet BGS if no confining layer was encountered.

Seven of the 11 new wells were installed in the upper aquifer. The four remaining wells were installed as well clusters at two of the new well locations (NMW-3 and NMW-5). At these two locations, wells were installed in the B and C zones, in addition to the A zone, as described in the preceding paragraph. These A, B, and C aquifer designations relate only to the relative positions of the aquifers encountered and not to existing hydrostratigraphic letter designations as proposed by Brown and Caldwell (1985). Further descriptions of these hydrostratigraphic designations are presented in Section 4.1.2.

Six of the well borings were drilled using a hollow-stem auger drill rig. The remaining five well borings were completed using a dual-tube air percussion hammer rig. Initially, the auger rig was to be used for drilling the seven shallow well borings and the hammer rig for drilling the four deeper well borings. However, because heaving sands were encountered while using the auger rig at the location of NMW-4A, this first boring was abandoned. A new well boring for NMW-4A was then drilled and installed using the hammer rig near the location of the abandoned auger boring. The hammer rig was used for the deeper borings because abundant gravel was anticipated in the borings and because the hammer rig method is effective to greater depths than the auger method. Drilling and subsurface soil sampling were conducted in accordance with SOG-11 (Kennedy/Jenks/Chilton 1991b). Borehole logging was completed in accordance with SOG-15 (Kennedy/Jenks/Chilton 1991b).

Attempts were made to collect soil samples at 5-foot intervals to a depth of 50 feet, and at 20-foot intervals from 50 feet to the bottom of the boring, as specified in the Final Work Plan (ICF 1990b). Soil samples were collected, where possible, using a split-spoon sampler equipped with stainless steel liners in accordance with SOG-11 (Kennedy/Jenks/Chilton 1991b). Depths from which the split-spoon samples were collected are shown in the boring and well construction logs (Appendix GW-A). At each of the well cluster locations (NMW-3 and NMW-5), the deepest (C) well was installed first. Samples were usually collected only from the C well borings, and lithologic information gathered from the deep borings was used to determine the placement of the B and A well screens at each location.

When field conditions such as the presence of gravels prohibited the collection of undisturbed split-spoon samples, disturbed samples were collected from soil that was discharged through the discharge hose into the cyclone separator on the hammer rig. Attempts were made to collect disturbed soil samples at approximately 5-foot intervals in all well borings where undisturbed samples were not collected. These soil samples were collected for lithologic logging purposes, although not specifically required by the Final Work Plan (ICF 1990b). All samples that were collected were archived in the onsite field office for possible future analysis in accordance with the Final Work Plan (ICF 1990b).

Soils were logged using the Unified Soil Classification System (USCS) Visual-Manual Procedure as described in SOG-15 (Kennedy/Jenks/Chilton 1991b). Soil descriptions and classifications are described in the boring and well construction logs (Appendix GW-A).

2.1.2 Groundwater Investigations

The Phase I Groundwater Investigation consisted of the installation and development of 11 new monitoring wells, abandonment of one existing monitoring well, sampling of 26 new and existing monitoring wells during four quarterly sampling

events, monthly monitoring of water levels in 30 monitoring wells, sampling of five background wells during the dry (July/August 1991) and wet (January 1992) seasons, and sampling of five upgradient wells during the dry and wet seasons. Field activities associated with this investigation are described in the following subsections.

2.1.2.1 Well Installation. Eleven (11) monitoring wells were installed during this investigation as described in Section 2.1.1. The wells were installed in accordance with SOG-17 (Kennedy/Jenks/Chilton 1991b) and in accordance with the State of Washington Minimum Standards for Construction and Maintenance of Wells (WAC 173-160). Well construction details are shown in the boring and well construction logs (Appendix GW-A) and in the well installation database (Data Appendix), and are summarized in Table GW-1.

Soil samples of the intervals to be screened were dried and analyzed for particle size distribution in approximate accordance with ASTM Method D422-63. (Hydrometer analyses were not performed.) Filter pack and well screen sizes were selected in accordance with SOG-16 (Kennedy/Jenks/Chilton 1991b) using the California Department of Health Services (DHS 1986) Decision Tree Method. Results of the sieve analyses are presented in Appendix GW-B. Due to the preponderance of large grain sizes (cobbles and boulders) in the soil to be screened in NMW-3C, a sieve analysis was not completed for this well. Instead, the largest available filter pack and screen slot sizes were used for completion of this well.

2.1.2.2 Well Development. The purpose of well development was to remove the fine material from pore spaces near the well borings and create a graded zone of sediment around the screen to stabilize the formation. The objective was to obtain groundwater with a minimal amount of sediment for chemical analyses. Well development activities were performed in accordance with SOG-17 (Kennedy/Jenks/Chilton 1991b). Summaries of well development activities for the 11 new wells are presented in Tables GW-2 and GW-3.

TABLE GW-1
MONITORING WELL CONSTRUCTION DATA

WELL ID	DATE INSTALLED (MM/DD/YY)	CASING DIAMETER (in)	TOTAL DEPTH (ft)	BLANK INTERVAL (ft)	BLANK TYPE	SCREENED INTERVAL (ft)	SCREEN TYPE	SLOT SIZE (in)	FILTER PACK	SURFACE SEAL (ft)	FILTER SEAL (ft)
CBS-1A	10/11/82	2	30	0-20	PVC	20-30	PVC	0.010	Coarse Sand	0-8 BG	8-13 BS
CBS-2A	10/13/82	2	33	0-28	PVC	28-33	PVC	0.010	Coarse Sand	0-20 BG	20-16 BS
CBS-3A	10/10/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-30 BG	30-36 BS
CBS-4A	10/11/82	2	43.5	0-38	PVC	38-43	PVC	0.010	Coarse Sand	0-28 BG	28-33 BS
CBS-5A	10/11/82	2	29	0-23	PVC	23-28	PVC	0.010	Coarse Sand	0-15 BG	15-20 BS
CBS-6A	10/12/82	2	28	0-23	PVC	23-28	PVC	0.010	Coarse Sand	0-12 BG	12-17 BS
CBS-7A	10/12/82	2	48	0-43	PVC	43-48	PVC	0.010	Coarse Sand	0-35 BG	35-41 BS
CBS-8A	10/13/82	2	18	0-13	PVC	13-18	PVC	0.010	Coarse Sand	0-5 BG	5-11 BS
CBS-9A	10/11/82	2	34	0-28	PVC	29-34	PVC	0.010	Coarse Sand	0-20.5 BG	20.5-25.5 BS
CBS-10A(a)	10/12/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-30 BG	30-35 BS
CBS-11A	10/14/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-31 BG	31-36 BS
CBS-12A	10/13/82	2	33	0-28	PVC	28-33	PVC	0.010	Coarse Sand	0-19 BG	19-25 BS
STM-1A	08/13/86	2	38	0-28	GALV	28-38	SS	0.010	10-20 Silica	0-3 RM 3-24.5 GB	24.5-26 BP
STM-2A	08/13/86	2	42.5	0-32.5	GALV	32.5-42.5	SS	0.010	10-20 Silica	0-3 RM 3-28.5 GB	28.5-31 BP
STM-3A	08/13/86	2	23	0-13	GALV	13-23	SS	0.010	10-20 Silica	0-3 RM 3-9.5 GB	9.5-11.5 BP
STM-4A	08/13/86	2	26.5	0-16.5	GALV	16.5-22.5	SS	0.010	10-20 Silica	0-3 RM 3-12.5 GB	12.5-14.5 BP
MW-1A	09/15/86	2	30.5	0-15	PVC	15-30.5	PVC	0.020	Med. Silica	0-12 BG	NA
MW-3A	09/17/86	2	29.5	0-14	PVC	14-29.5	PVC	0.020	Med. Silica	0-14 BG	NA
MW-5A	11/02/87	2	40.0	0-19.5	PVC	19.5-39.5	PVC	0.020	10-20 Silica	7-15.5 B	NA
NMW-1A	03/06/91	4	48.0	0-21	PVC	21-46	PVC	0.020	10-20 Silica	2-15 VC	15-18 BP
NMW-2A	03/04/91	4	40.0	0-13	PVC	13-38	PVC	0.010	10-20 Silica	2-8 VC	8-10 BP
NMW-3A	03/14/91	4	38.0	0-13	PVC	13-38	PVC	0.020	10-20 Silica	0-9 BG	9-11 BP
NMW-3B	03/11/91	4	127.5	0-110	PVC	110-125	PVC	0.010	20-40 Silica	0-104 VC	104-107 BS
NMW-3C	03/04/91	4	195.5	0-180	PVC	180-195	PVC	0.030	8-12 Silica	0-175 VC	175-177 FS
NMW-4A	03/13/91	4	35.5	0-10	PVC	10-35	PVC	0.020	10-20 Silica	0-4 CB	4-6.5 BP
NMW-5A	03/11/91	4	47.0	0-20	PVC	20-45	PVC	0.020	8-12 Silica	2-14 BG	14-17 BP
NMW-5B	03/05/91	4	127.5	0-110	PVC	110-125	PVC	0.020	10-20 Silica	0-105 VC	105-107 FS
NMW-5C	02/27/91	4	200.5	0-185	PVC	185-200	PVC	0.030	8-12 Silica	0-178 VC	178-180 FS
NMW-6A	03/01/91	4	42.0	0-15	PVC	15-40	PVC	0.020	10-20 Silica	2-9 VC	9-12 BP
NMW-7A	02/28/91	4	40.0	0-15	PVC	15-40	PVC	0.020	8-12 Silica	2-9 VC	9-12 BP

GALV - Galvanized Steel
B - Bentonite
SS - Stainless Steel
PVC - Schedule 40 PVC
NA - Not Applicable
BP - Bentonite Pellets
BS - Bentonite Slurry
GB - Granular Bentonite
RM - Ready-Mix Concrete
VC - Volclay Grout
FS - Fine Sand
CB - Cement/Bentonite Mix
BG - Bentonite Grout

(a) CBS-10A is located offsite and upgradient of the STF site. All other wells listed in this table are considered to be onsite for the purposes of this investigation.

TABLE GW-2

SUMMARY OF WELL DEVELOPMENT ACTIVITIES
BEGINNING OF DEVELOPMENT

Well Number	Development Method[a]	Date	Time	Depth to Water (ft)	Temperature (°C)	pH	Specific Conductivity (μmhos)	Turbidity[b]/Color
NMW-1A	Bail, surge, pump	03/19/91	1115	31.0	13.6	6.7	210	Strong turbidity/gray-brown
NMW-2A	Bail, surge, pump	03/19/91	0832	18.0	9.6	6.6	638	Strong turbidity/gray-brown
NMW-3A	Bail, surge, pump	03/18/91	1140	17.0	15.8	7.4	317	Strong turbidity/orange-brown
NMW-3B	Bail, surge, pump	03/18/91	0849	18.0	9.4	8.3	243	Very turbid/gray brown
NMW-3C	Bail, surge, pump	03/15/91	1308	22.0	12.5	11.6[c]	593	Very turbid/gray
NMW-4A	Bail, surge, pump	03/18/91	1339	14.0	11.4	6.6	370	Strong turbidity/medium-brown
NMW-5A	Bail, surge, pump	03/14/91	0828	22.3	9.0	7.1	195	Strong turbidity/orange brown
NMW-5B	Bail, surge, pump	03/14/91	1309	25.3	9.7	7.0	224	Strong turbidity/gray
NMW-5C	Bail, surge, pump	03/15/91	0819	39.5	9.3	6.5	349	Turbid/gray
NMW-6A	Bail, surge, pump	03/12/91	1455	23.0	12.9	7.5	205	Murky/light brown
NMW-7A	Bail, surge, pump	03/12/91	0827	23.5	10.0	7.7	287	Turbid/medium brown

(a) Pumping was completed using a 4-inch submersible pump.
(b) Relative turbidity was based on visual observations.
(c) High initial pH reading was a result of cement in well during installation.

TABLE GW-3

SUMMARY OF WELL DEVELOPMENT ACTIVITIES
ENDING OF DEVELOPMENT

Well Number	Time	Volume of Water Removed (gal)	Casing Volumes Removed	Temperature (°C)	pH	Specific Conductivity (μmhos)	Turbidity[a]/ Color	Purge Rate (gpm)	Depth to Water During Purge (ft)
NMW-1A	1224	440	36.1	13.0	6.7	482	Clear/pale yellow	10	35.0
NMW-2A	1017	990	71.7	10.6	6.5	600	Clear/yellow	10	19.0
NMW-3A	1239	330	27.3	13.4	6.4	342	Clear/pale brown	10	18.0
NMW-3B	1034	660	10.3	10.2	8.2	230	Clear	10	62.0
NMW-3C	1525	1080	9.7	9.0	9.0	196	Clear/light gray	20	24.0
NMW-4A	1436	550	39.9	10.4	6.0	1200	Clear	20	16.0
NMW-5A	1143	840	47.5	11.1	7.1	166	Clear/light brown	10	23.0
NMW-5B	1501	700	10.7	10.2	7.8	224	Clear	12	105.0
NMW-5C	1133	1250	12.1	10.2	8.0	315	Clear	20	60.0
NMW-6A	1602	385	31.6	11.3	7.1	225	Clear/pale yellow	10	33.0
NMW-7A	1357	490	41.5	12.5	6.9	254	Clear	20	24.5

(a) Relative turbidity was based on visual observations.

The 11 new onsite wells were developed using a combination of bailing, mechanical surging, and pumping techniques. A bailer was used initially to remove silt accumulations from the bottom of each well. A surge block was then inserted into the well, and surging was performed by slowly moving the surge block up and down in the well throughout the vertical extent of the screened interval. The wells were then pumped using a 1.5-horsepower submersible pump. The pump inlet was suspended at a given vertical location in the screened interval until the discharge water appeared to be relatively sediment-free. At that time, the pump inlet was relocated to a different portion of the screened interval and again pumped until sediment-free. This process was continued until the entire screened interval was pumped.

In addition to the 11 new wells, 10 existing onsite wells were redeveloped in an effort to obtain relatively sediment-free water for groundwater sampling. The existing wells that were redeveloped were CBS-1A, CBS-3A, CBS-4A, CBS-5A, CBS-9A, MW-1, MW-3, MW-5, STM-1A, and STM-2A. Background well 89.7-P1 (see Section 2.2) was also developed using bailing techniques prior to the second quarter of groundwater sampling. This well had been in use by the City of Tacoma as a piezometer and had not been previously developed.

All existing wells were developed in accordance with SOG-17 (Kennedy/Jenks/Chilton 1991b). The existing wells were redeveloped using a combination of bailing and pumping techniques. A bailer was first used to remove the sediment deposits from the bottom of the well. Next, a hand pump or centrifugal pump was used to pump the water until approximately 10 well volumes of water were removed or until the water appeared relatively sediment-free.

2.1.2.3 Well Abandonment. One monitoring well, CBS-13A, was abandoned during the Phase I Groundwater Investigation as specified in the Final Work Plan (ICF 1990b) and in accordance with WAC 173-160 (Abandonment of Resource Protection Wells, WAC 173-160-560). Descriptions of the original well

construction and soil characteristics for CBS-13A are based on information obtained from Black & Veatch (1983).

Well CBS-13A was constructed in November 1982 using an air-rotary drill rig. The well boring was advanced to a depth of 82 feet BGS through deposits consisting mainly of sand and gravel with minor silt. Clayey silt and silty sand deposits were encountered in the boring from 82 feet BGS to a total depth of 99 feet BGS, where the well boring was terminated. CBS-13A was constructed using 4-inch Schedule 40 PVC casing. The well was screened from a depth of approximately 76.4 feet to a depth of approximately 96.4 feet BGS with 0.010-inch slotted PVC casing. Natural cave-in of formation materials surrounded the screened interval and filter pack was not used. The natural filter pack was sealed with 10 feet of bentonite slurry. Cement-bentonite grout was used to fill the annulus from the bentonite slurry upward to ground surface.

An auger rig was used to abandon CBS-13A during the Phase I Groundwater Investigation. First, the steel surface housing was removed from the well. Then the 6.25-inch outside diameter (O.D.) auger was placed over the PVC well casing and overdrilling of the well casing was initiated. A continuous section consisting of approximately 50 feet of PVC well casing was then removed from the boring after drilling to 45 feet BGS. This casing was found to be plugged with several large cobbles and a broken bottle. Due to the underconsolidation of soil at this location, surface caving was apparent. The boring was reentered with an 8-inch O.D. auger equipped with a center bit in an attempt to grind up the casing still in place. Drilling was completed to a depth of 100 feet BGS, approximately 1 foot below the base of CBS-13A.

A mixture of cement and bentonite was prepared for grouting the boring. A tremie pipe was inserted to the bottom of the boring. Grouting commenced by pumping the cement/bentonite mix through the tremie pipe. Upper sections of tremie pipe were periodically removed as the grout filled the void space in the boring. Grouting continued until the boring was filled to the ground surface. After the grout settled

overnight, additional grout was added to the boring to fill the boring to ground surface.

Volume calculations were completed to verify that sufficient quantities of grout were placed in the boring to fill the void. Overdrilling of the well produced an 8-inch diameter borehole to a depth of 100 feet. The borehole was filled with approximately 260 gallons of cement/bentonite grout, which is almost equal to the calculated volume of the borehole (261 gallons).

2.1.2.4 Quarterly Groundwater Sampling. Twenty-six (26) onsite monitoring wells (including two background wells), three additional background monitoring wells, and five upgradient monitoring wells were sampled during this investigation. Dedicated bladder pumps and discharge hoses were installed in the 26 onsite wells prior to the first quarter of groundwater sampling. These pumps and hoses were used for purging and sampling the 26 onsite wells during all four quarters of groundwater sampling.

The Final Work Plan (ICF 1990b) identified two additional wells that were to be sampled during this RI. These wells were MW-2A and MW-4A, located on the Amsted property. During the initial field investigation, the presence of heavy oil was identified in MW-2A. MW-4A had apparently been vandalized, only a shard of PVC casing was evident at the surface. MW-4A was subsequently abandoned by Amsted under a separate Consent Order, and investigation of MW-2A is currently in progress under that Consent Order.

Three background wells and five upgradient wells were purged and sampled using various techniques. Background well 89.7-P1 was purged using a PVC bailer and sampled using a teflon bailer. Background well TL-16A was purged and sampled using a dedicated PVC bailer that was housed in the well. Background well WCC-2 was purged and sampled using a stainless steel and teflon 2-inch submersible sampling pump. Upgradient well CBS-10A was purged and sampled using a teflon bailer. Upgradient wells TL-12A, TL-13A, TL-14A, and TL-23A were purged and

sampled using their existing dedicated pumps equipped with an air motor attachment. A purge hose (provided by Tacoma Landfill personnel) was used to purge these four upgradient wells. A teflon sampling hose (also provided by Tacoma Landfill personnel) was used to sample these four upgradient wells. All groundwater sampling was conducted in accordance with SOG-12 (Kennedy/Jenks/Chilton 1991b). Samples were packaged and shipped in accordance with SOG-3 (Kennedy/Jenks/Chilton 1991b).

Field measurements were recorded on Groundwater Purge and Sample Forms during the monitoring well purging procedure and included temperature, pH, and specific conductivity. Measurement of these field parameters was completed in accordance with SOG-6 and SOG-8 (Kennedy/Jenks/Chilton 1991b). Visual observations of turbidity and color were also recorded on these forms. Results of these measurements and observations were entered into the appropriate database and are presented in Section 7.0 (Field Data) of the Data Appendix.

The 26 onsite wells (including two background wells) were sampled during four quarterly events. The three additional background wells and five upgradient wells were sampled only during the second and fourth quarters. Analytical methods for these samples are summarized in Section 2.3.

2.1.2.5 Monthly Water Level Monitoring. Monitoring of water levels in 30 wells (i.e., 29 onsite wells and 1 upgradient well) was conducted on a monthly basis beginning in April 1991. Wells included in the monthly water level monitoring events are identified in Table GW-4. Additional water level monitoring of the 30 wells was performed during August 1991, November 1991, and March 1992. Tacoma Landfill personnel provided water level data for May 1991, late August 1991, November 1991, and February 1992. These data were incorporated into the water level contour maps.

All water level measurements were completed in accordance with SOG-18 (Kennedy/Jenks/Chilton 1991b). Results of the monthly water level monitoring

TABLE GW-4

SURVEY DATA FOR MONITORING WELLS

Well No.	Location No.	Northing[a]	Easting[a]	Steel Casing Elevation[b,c] (ft MSL)	PVC Elevation[b,d] (ft MSL)	Ground Surface Elevation[b] (ft MSL)
NMW-1A	1760	690017.40	1146754.29	254.25	253.98	252.0
NMW-2A	1758	690979.42	1145215.34	240.91	240.33	238.8
NMW-3A	1756	691649.40	1145703.81	239.80	239.46[e]	237.3
NMW-3B	1755	691656.58	1145698.02	237.57	236.82[e]	237.5
NMW-3C	1757	691660.72	1145704.30	240.36	240.21	237.3
NMW-4A	1759	692795.40	1145408.83	236.10	235.98	233.4
NMW-5A	1754	695234.17	1146520.32	243.17	242.93	240.9
NMW-5B	1752	695239.96	1146515.50	243.28	243.14	240.6
NMW-5C	1753	695231.71	1146513.19	243.50	243.33	241.0
NMW-6A	1751	695951.03	1147366.74	243.21	243.15[e]	240.8
NMW-7A	1750	696177.86	1146651.70	243.65	243.53[e]	241.5
CBS-1A	1761	695976.02	1146934.36	240.85	240.35[e]	238.8
CBS-2A	1762	694571.22	1146352.26	241.78	241.39	240.8
CBS-3A	1763	692680.55	1146106.54	251.18	250.75	249.9
CBS-4A	1764	690682.06	1146139.68	252.49	251.96	251.5
CBS-5A	1765	689597.10	1146027.80	239.59	239.31	237.3
CBS-6A	1766	692795.99	1145387.03	234.43	234.33	233.3
CBS-7A	1767	692622.84	1146959.91	256.44	255.80	255.6
CBS-8A	1768	690653.60	1145164.68	227.46	226.72	224.9
CBS-9A	1769	689624.72	1145115.40	244.00	243.49	242.7
CBS-10A[f]	1770	689615.28	1147044.84	256.69	256.60	255.7
CBS-11A	1771	690820.19	1146871.71	255.63	255.44	254.9
CBS-12A	1772	691668.54	1145718.63	240.85	240.75	238.8
MW-1A	1773	690579.51	1145764.81	243.62	243.19	240.4
MW-3A	1775	690280.74	1145754.88	240.64	239.77	237.3
MW-5A	1777	690918.42	1146120.68	250.30	249.73	250.4
STM-1A	1778	689558.00	1146537.04	254.50	253.28	252.1
STM-2A	1779	689342.64	1146287.34	255.57	255.20	252.8
STM-3A	1780	689322.39	1146135.51	239.13	238.47	235.6
STM-4A	1781	689446.08	1146127.90	240.61	239.92	237.7

(a) City of Tacoma NAD 83 horizontal datum.
(b) City of Tacoma NGVD 29 vertical datum.
(c) The top of the steel casing was used as the water level measurement reference point during this investigation due to the movement of poorly fitting PVC caps during measurement.
(d) Measuring point for wells with dedicated pumps was a hole inside the PVC cap.
(e) PVC caps were poorly fitting.
(f) CBS-10A is located offsite and upgradient of the STF site. All other wells listed in this table are considered to be onsite for the purposes of this investigation.

events were entered into the appropriate database and are presented in Section 7.0 (Field Data) of the Data Appendix. Water level contour maps of the upper aquifer are presented in Section 4.1.4.2.

2.1.3 Surveying of Monitoring Wells

Surveying of the 26 onsite wells was completed by PEI/Barrett Consulting Group. Well locations were surveyed for horizontal (northing and easting) coordinates in reference to the City of Tacoma NAD 83 horizontal datum. Vertical elevations were surveyed in reference to the City of Tacoma NGVD 29 vertical datum. Vertical elevations that were measured for the monitoring wells included ground surface elevations, tops of the steel surface housings, and tops of PVC or steel well casings. Monitoring well survey data are presented in Table GW-4.

2.2 BACKGROUND AND UPGRADIENT WELL SELECTION

The Final Work Plan (ICF 1990b) called for the collection of 10 background and 10 upgradient groundwater samples. The background and upgradient groundwater samples were to be collected from wells that were screened in the same aquifer immediately underlying the STF site. Analytical results for the background samples were to be used to evaluate the concentrations of chemicals in the groundwater that might be naturally occurring in groundwater in the region. The upgradient samples were to be collected from wells upgradient of the site to characterize the quality of the groundwater at the STF site that may have originated from offsite sources.

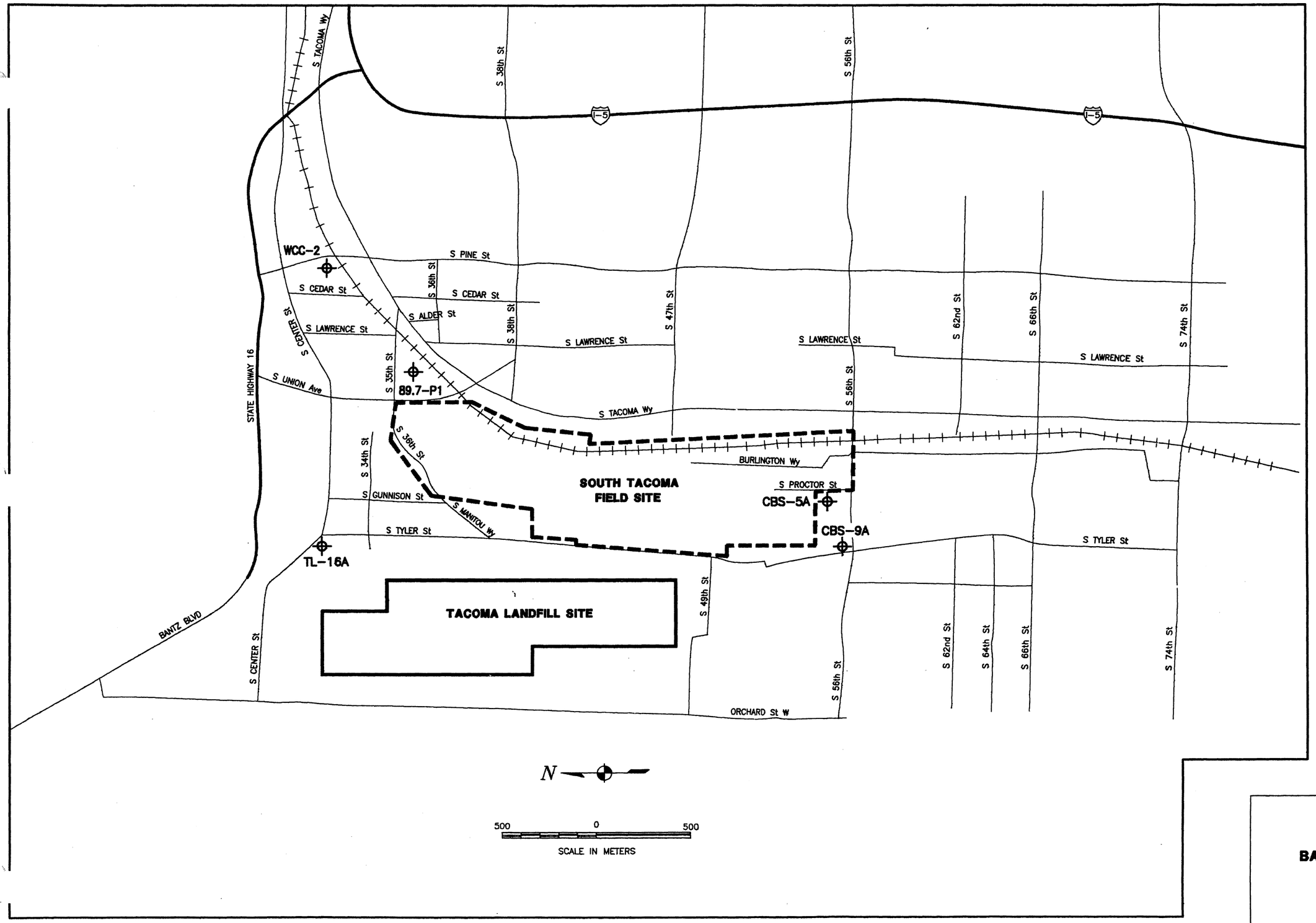
As stated in the FSAP (Kennedy/Jenks/Chilton 1991b), the background samples were to be collected within the South Tacoma Channel in close proximity to the site. Available well databases obtained from EPA and the U.S. Geological Survey (USGS) were searched to identify suitable wells for background groundwater

sampling. Because an insufficient number of wells suitable for use as background wells was identified, an alternate background groundwater sampling plan was used during this investigation. The plan requires two sampling events for the five background wells (i.e., once during the dry season and once during the wet season). These seasons correspond with the second and fourth quarters of groundwater sampling during this investigation. Locations of the background wells that were selected for groundwater sampling are shown in Figure GW-4.

Upgradient wells were selected after several months of monthly water level monitoring was completed. Using the same rationale as in the selection of background wells, five upgradient wells were selected to be sampled during the dry and wet seasons. Locations of the upgradient wells that were selected for groundwater sampling are shown in Figure GW-5.

The 26 monitoring wells that were scheduled for quarterly sampling are considered onsite wells for the purposes of this investigation. However, three of these wells (CBS-5A, CBS-7A, and CBS-9A) are located outside the STF site boundary. Two of these onsite wells, CBS-5A and CBS-9A, were also used as background monitoring wells during this investigation.

One of the background wells (TL-16A) and four of the upgradient wells (TL-12A, TL-13A, TL-14A, and TL-23A) are not located within the geomorphic feature known as the South Tacoma Channel (described in Section 4.1.1). However, hydrogeologic information gathered during this investigation suggests that all the background and upgradient wells appear to be screened in the upper aquifer in a laterally continuous hydrostratigraphic unit.



LEGEND

TL-16A — BACKGROUND WELL SAMPLING LOCATION

SOUTH TACOMA FIELD SITE BOUNDARY

TACOMA LANDFILL SITE BOUNDARY

NOTES:

1. ALL LOCATIONS ARE APPROXIMATE.

BASE MAP REFERENCE

AMERICAN DIGITAL CARTOGRAPHY SOUTH TACOMA, WA QUAD AND STEILACOOM, WA QUAD

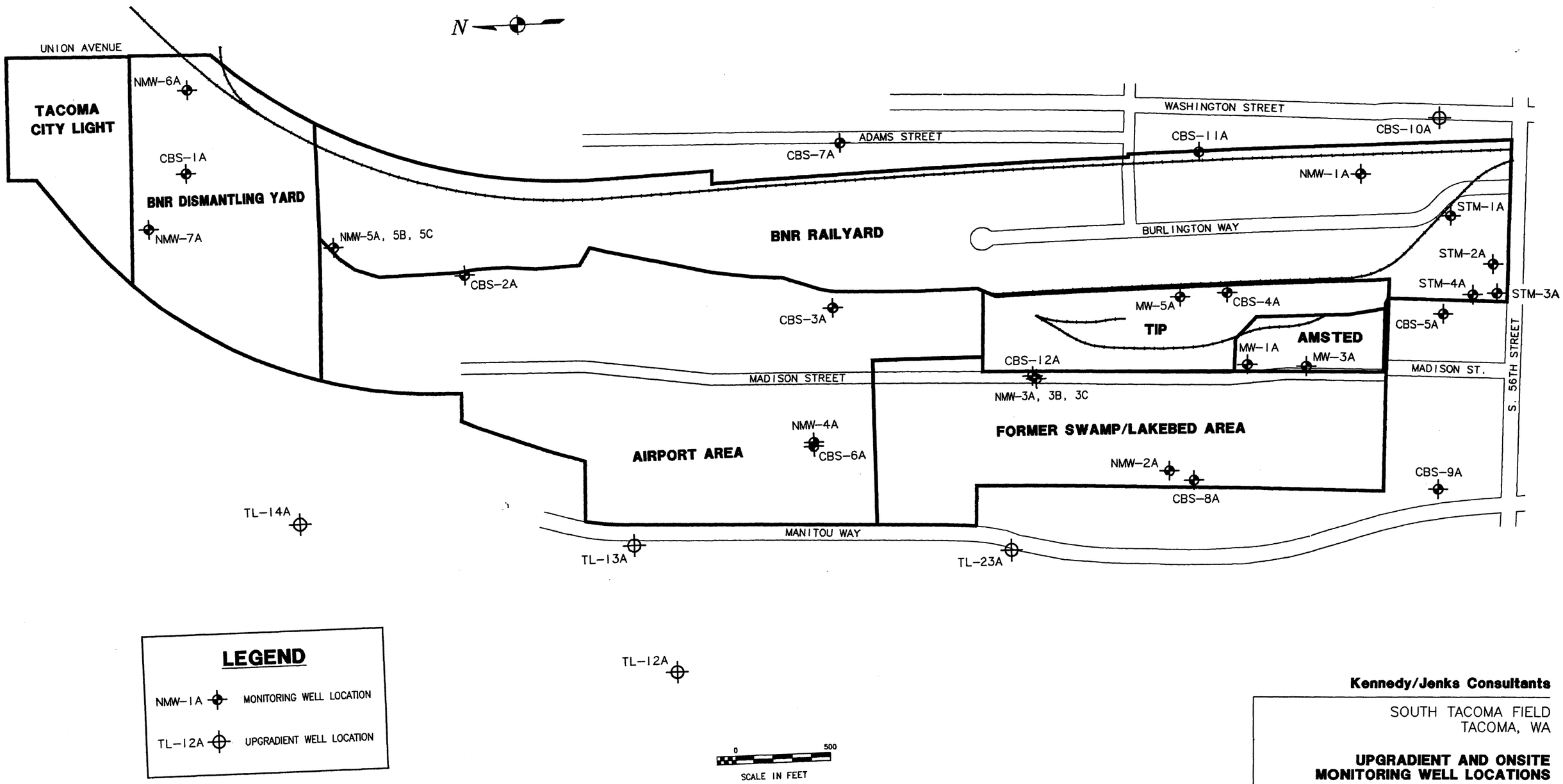
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

BACKGROUND WELL LOCATIONS

916055.08/P1SK348

FIGURE GW-4



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

UPGRADIENT AND ONSITE MONITORING WELL LOCATIONS

916055.08/P1SK347

FIGURE GW-5

2.3 ANALYTICAL METHODS

Analytical methods for soil and groundwater samples collected during the Phase I Groundwater Investigation are summarized in Table GW-5. Analytical results for these samples are presented in Section 5.0.

TABLE GW-5

SAMPLE ANALYSES, MATRICES, METHOD NUMBERS, CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES FOR THE GROUNDWATER INVESTIGATION

Analysis	Matrix	Method Referenced[a]	Container	Preservation	Holding Time
Volatile organic compounds (VOC)	Water	SOW OLM01.0	• Three 40-mL amber glass vials[b] w/PTFE - septum	HCl to pH<2 and Refrigerate 4°C	• 14 days
Base/neutral/acid (BNA) extractable	Water	SOW OLM01.0	• Three 1-L amber glass w/PTFE- lined lid	Refrigerate 4°C	• 7 days extraction/ 40 days analyzed
Polynuclear aromatic hydrocarbons (PAH)	Water	SOW OLM01.0 and/or EPA Method 8310	• Three 1-L amber glass w/PTFE-lined lid	Refrigerate 4°C	• 7 days extraction/ 40 days analyzed
Chlorinated pesticides/PCBs	Water	SOW No. 2/88 (EPA1988e)	• Three 1-L amber glass w/PTFE-lined lid	Refrigerate 4°C	• 7 days extraction/ 40 days analyzed
Metals	Water	SOW ILM01.0	• 500-mL plastic container	HNO_3[c] to pH<2 and Refrigerate 4°C	6 months, except Hg=28 days
Copper[d]	Water	SOW ILM01.0 and EPA Method 7211	• Included with metal analysis	HNO_3 to pH<2	6 months
Cyanide (total)	Water	SOW ILM01.0	• 250-mL plastic or glass container	NaOH[e] to pH>12 and Refrigerate 4°C	14 days
Boron	Water	EPA Method 6010	• Included with metal analysis	Refrigerate 4°C	6 months
Total dissolved solids (TDS)	Water	EPA Method 160.1	• 500-mL plastic container	Refrigerate 4°C	7 days
Total suspended solids (TSS)	Water	EPA Method 160.2	• 500-mL plastic container	Refrigerate 4°C	7 days
Total organic carbon (TOC)	Water	EPA Method 9060	• 250-mL glass jar	H_3PO_4[f] to pH<2 and refrigerate 4°C	28 days
pH Specific conductance Temperature	Water Water Water	EPA Method 150.1 EPA Method 120.1 EPA Method 170.1	NA[g] NA NA	NA NA NA	Field reading Field reading Field reading

TABLE GW-5

SAMPLE ANALYSES, MATRICES, METHOD NUMBERS, CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES FOR THE GROUNDWATER INVESTIGATION

Analysis	Matrix	Method Referenced[a]	Container	Preservation	Holding Time
GEOTECHNICAL PARAMETERS					
• Permeability/hydraulic conductivity (permeable soil)	Soil	ASTM[h] D-2434	Shelby tube or equivalent	NA	NA
• Particle size distribution	Soil	ASTM C-117, C-136 ASTM D-422	NA	NA	NA
• Porosity/specific gravity	Soil	ASTM D-854	Shelby tube or equivalent	NA	NA

(a) Methods are referenced in the following documents: SOW OLM01.0 (EPA 1990a); SOW ILM01.0 (EPA 1990b); SOW No. 2/88 (EPA 1988e); Test Methods for Evaluating Solid Waste, SW-846 (EPA 1986); Methods for Chemical Analysis of Water and Wastes (EPA 1983); and Standard Methods for the Examination of Water and Wastewater [American Public Health Association (APHA) 1985].
(b) Triplicate volumes of water samples were collected in order for laboratories to perform QA/QC analyses (matrix spike, matrix spike duplicates).
(c) HNO_3 = Nitric acid.
(d) When copper was detected at concentrations less than or equal to 50 ug/L using SOW ILM01.0 methods, the water sample was reanalyzed using Method 7211.
(e) NaOH = Sodium hydroxide.
(f) H_3PO_4 = Phosphoric acid.
(g) NA = Not applicable.
(h) ASTM = American Society for Testing Materials.

3.0 QUALITY ASSURANCE, DATA VALIDATION, AND STATISTICAL ANALYSES

3.1 FIELD QA/QC PROCEDURES

During field operations, quality control (QC) samples were collected to monitor both field and laboratory operations to evaluate the precision and accuracy of analytical data throughout the project. QC samples consisted of field duplicates and blank samples (rinsate, trip, and transfer blanks).

At a minimum, field duplicate groundwater samples were collected for every 20 samples (i.e., two duplicates were collected during each quarterly sampling event). Duplicate samples were collected from different wells for each quarterly event. Each field duplicate was assigned a unique sample number and treated as a separate sample. These samples were not identified to the analytical laboratory as duplicates. Duplicate samples were collected in accordance with SOG-14 (Kennedy/Jenks/Chilton 1991b).

One blank sample was submitted for laboratory analysis for each day of groundwater sampling. Rinsate blank samples were collected when decontamination of sampling equipment was performed (e.g., when nondedicated bailers and/or pumps were used for sampling). At a minimum, one trip blank sample was submitted for each 20 samples (i.e., two trip blanks were submitted during each quarterly sampling event). On the remaining days of sampling, transfer blank samples were submitted for analysis.

Rinsate blanks were collected when reusing sampling equipment to monitor the effectiveness of decontamination procedures and to identify the potential for cross-contamination between sampling locations. Rinsate blanks were collected by rinsing decontaminated sampling equipment with deionized water and placing the

collected rinsate water in appropriate containers with required preservatives. Rinsate blanks were analyzed for the same constituents as groundwater samples.

Trip blanks were carried during sampling and submitted for analyses to monitor for possible volatile organic contamination caused by diffusion of organic contaminants through the polytetrafluoroethylene-faced silicone rubber septum of the sample vials during transport to and from the laboratory, as well as to monitor the quality of the laboratory water. Trip blanks were prepared by the laboratory by filling volatile organic analysis (VOA) vials with deionized water and shipping the blanks with the sample containers. Whenever a sample within a batch was to be analyzed for volatile organic compounds (VOCs), a trip blank would accompany the sample containers through collection and shipment to the laboratory. Trip blanks were analyzed for VOCs only.

Transfer blanks were collected to evaluate the possibility of sample contamination from ambient conditions during the sampling event. Transfer blanks were prepared at the well location by placing high-purity deionized water in sample containers with appropriate preservatives. Transfer blanks were numbered using the location numbers of the wells at which the blanks were prepared.

Analytical results for QC samples collected during groundwater sampling are presented in Section 7.0 of the Data Appendix. These results were evaluated by EcoChem, Inc. (EcoChem) as part of the data validation requirements (see Section 3.4) and discussions of this evaluation are presented in the Data Validation Reports (Section 8.0 of the Data Appendix).

3.2 LABORATORY QA/QC REVIEW

Analytical methods outlined in EPA's Contract Laboratory Program (CLP) Statements of Work (EPA 1988b; 1990a,b) were used to measure organic and inorganic constituents. EPA's CLP methods specify QC procedures that the laboratory is

expected to meet or exceed. These procedures include analysis frequency and QC limits for laboratory method blanks, spiked samples, duplicates, and laboratory control samples. Analytical results and QC criteria were evaluated by the laboratory as part of their data reduction and documentation procedures, and in accordance with those procedures outlined in the STF QAPjP (Kennedy/Jenks/ Chilton 1991c). Laboratory qualifiers were assigned to data during this review as outlined in the CLP Statements of Work (EPA 1988b; 1990a,b). Descriptions of laboratory-assigned data qualifiers are presented in Section 6.0 (Tables 6-1, 6-2, and 6-3) of the Data Appendix.

3.3 INDEPENDENT QA/QC REVIEW OF LABORATORY DATA

Analytical data were received from the laboratory in hard copy or magnetic format, or both. A QA review of magnetic data was performed prior to its input into the STF database. This independent review included, at the minimum, the following activities:

- Verification of sample location numbers and laboratory accession numbers
- General review to check completeness of data packages
- Comparison of a minimum of 10 percent of magnetic data with hard copy data.

Data received in hard copy format only were manually entered into the STF database using a dual-entry or single-entry method, which was dependent on the quantity of data received. When data packages were dual-entered, a comparison program was used to check the dual-entered data for accuracy and was repeated until no discrepancies were reported (i.e., in a report of differences) between the dual-entered databases. Smaller data sets were entered into the STF database by

one person and reviewed by another for errors. Once data were input into the database, a final QA review was performed.

3.4 DATA VALIDATION

Data validation of analytical results was performed to evaluate procedural compliance with QA objectives as outlined in the STF QAPjP (Kennedy/Jenks/Chilton 1991c) and to assess the laboratory's performance in meeting the QC specifications for detection limits, accuracy, precision, and completeness as outlined in the CLP Statements of Work (EPA 1988b; 1990a,b). Data validation was performed by Ecochem.

Data validation was based on the criteria described in the functional guidelines for evaluating inorganic and organic analyses (EPA 1988c,d,e). Data that did not meet required criteria were flagged with validation qualifiers. Descriptions of data validation qualifiers are presented in Section 6.0 (Tables 6-4 and 6-5) of the Data Appendix.

A 100-percent data validation was completed for all groundwater analytical results. EcoChem prepared a separate Data Validation Report to summarize findings for each quarterly sampling event. These reports are presented in Section 8.0 of the Data Appendix.

3.5 STATISTICAL ANALYSES

A statistics program was written to analyze laboratory data contained in the STF project database files. The program allows the user to select any of the finalized STF database files on the network drive and to then calculate statistics as needed.

Statistics were calculated based on the following criteria:

- No QA/QC duplicate or blank analytical results were used to calculate statistics.

- Any analyte field that contained zero was not used in the statistical calculations because no data were entered in that field for that analyte.

- Any analytical result (analyte) value that contained an "R" in the data validation qualifier field was not used in the statistical calculation because the analysis produced a value that was rejected during data validation.

- All other analyte values (those without zeros or R's) were used to calculate statistics.

- All analyte values that contain "U" in either the laboratory qualifier field or data validation qualifier field were undetected values and were used in the program calculations at one-half the reported analyte value.

- All other analyte values (those without U's) were used at the reported analyte value. Where the laboratory reran an analysis because the quality control criteria were not met, both results were printed in the database. Reruns and dilutions were identified with an "R" or "D," respectively, after the laboratory-assigned sample number. For statistical purposes, only the R (rerun) or D (dilution) records were used to calculate statistics.

Statistics were calculated for groundwater samples collected from the five background wells sampled during the second and fourth quarters. Statistics were calculated for inorganics, excluding cyanide. Statistical calculations were limited to inorganic elements that occur naturally in groundwater in background wells. The objective was to estimate the concentrations of naturally occurring inorganic

elements to be expected in groundwater samples unaffected by anthropogenic sources. Statistical calculations are outlined below:

- The number of analyte values meeting the foregoing criteria was counted.

- The sum of selected analyte values was computed using one-half of the value where appropriate (i.e., analyte values qualified with U). In addition, the sum of the squares of the analyte values was computed for variance and standard deviation calculations.

- The maximum and minimum values were determined by a replacement algorithm. The maximum value was set to 0 and the minimum value was set to 1,000,000 at initiation of the analyte calculation pass.

- The number of values contained in various user selected class intervals (i.e., concentration ranges) was determined with a series of "IF" statements.

- The mean was calculated by dividing the sum of the analyte values by the number of values.

- The range was calculated by subtracting the minimum value from the maximum value.

- The variance, s^2, was calculated by dividing the sum of the squared deviations of the values about this mean $\bar{x}$ by the number of values (n) minus 1:

$$s^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n - 1}$$

- The standard deviation was calculated by taking the square root of the variance.

- The 95-percent upper confidence limit on the mean (95% UCL) was calculated by using a two-tail T-test of the data. The T-test table for 2.5 percent values was included in the program. The T-test value was obtained by subtracting one from the number of values and indexing into the T-test array to obtain the number. For data sets greater than 31, a T-test value of 1.96 was used. The 95-percent confidence limit on the mean was calculated by adding and subtracting the T-test value times the standard deviation divided by the square root of the number of values from the mean:

$$\bar{x} \pm [t_t * s] / \sqrt{n}$$

3.6 DATABASE REPORT PRINTOUTS

Database files were formatted and printed as database reports on 14.5x11-inch paper. This size was selected because it allowed a 75-percent reduction to fit 8.5x11-inch paper. The format and reduction maintains data that are easily readable, allows printing 53 lines of data per sheet, and significantly reduces the size of the Data Appendices. The database report printouts (analytical results) are presented in Section 7.0 of the Data Appendix.

Two lines of data from the report header are printed at the bottom of all database reports to make paging through the reports easier. This footer indicates the database filename, date and time that file was last revised, file size, date printed, and page number.

The database report has a separate but complementary location number report (see Section 3.0 of the Data Appendix) that includes all location, survey, and sampling information [i.e., EPA Storet code, STF location number, laboratory number, NAD coordinate (northing and easting) data, and elevation].

Special report printing programs were also written to print nonstandard reports that contain ancillary information (separate from analytical data) and retain a format comparable to the database reports. These reports contain groundwater monitoring well field data (e.g., field observations during sample collection), installation data, and monthly water levels for the monitoring wells.

4.0 GEOLOGICAL INVESTIGATIVE RESULTS

The initial findings of the Phase I Groundwater Investigation are based on field data collected during installation of monitoring wells, field data collected during development of the wells, and field data collected during nine monthly water level monitoring events. Results and interpretations of these geological field data are presented in this section. Database reports of the field database files are presented in Section 7.0 (Field Data) of the Data Appendix.

4.1 GEOLOGY AND HYDROGEOLOGY

The following sections describe the surface features of the STF site relative to its geologic setting and stratigraphy, surface water hydrology and its relationships to observed groundwater hydrology, and regional and local characteristics of the groundwater hydrology.

4.1.1 Geomorphology

The STF site lies within the central part of the Puget Lowland physiographic province of western Washington. The Lowland is bounded on the east by the Cascade Mountains and on the west by the Olympic Mountains and Willapa Hills. The portion of the Lowland in which the STF site lies is characterized by rolling hills and depressions that are occupied by lakes, rivers, and Puget Sound (Brown and Caldwell 1985).

The site is located on a drift plain that regionally ranges in elevation from sea level to approximately 600 feet. The present topography is the result of glacial and glaciofluvial processes of the most recent glaciation, the Vashon glaciation, which

occurred between 13,000 and 20,000 years before present. Numerous drumlins and kettles are scattered across the plain. The kettles are usually evident as lakes and swamps.

The STF site lies within the South Tacoma Channel, a geomorphic feature produced during the Vashon Glaciation. The South Tacoma Channel is an outwash channel that was cut into the drift plain by high-velocity glacial meltwater streams. The Channel acted as a spillway for meltwater from glacial Lake Puyallup during the northward retreat of the Puget lobe of the glacier (Thorson 1980).

4.1.2 Geologic History and Stratigraphy

During the Pleistocene epoch, several Cordilleran glaciers advanced into the Puget Lowland. The most recent of these (Vashon) was approximately 5,000 feet thick at the latitude of Seattle, approximately 1,500 feet thick over the STF vicinity, and had a terminus about 12 miles south of Olympia (USGS 1978).

The surficial deposits in the Puget Lowland are largely composed of glacial and interglacial unconsolidated sediments of Pleistocene age. In the Tacoma area, the thickness of these deposits is estimated to be approximately 2,000 feet (Noble 1990). The sediments were deposited during advances and retreats of glaciers throughout the Pleistocene epoch. Based on our interpretations of stratigraphy, three glacial and two interglacial climatic episodes are represented by the units encountered during this investigation.

Lithologic facies common to these deposits include glacial till, advance outwash deposits, recessional outwash deposits, and fine-grained interglacial deposits. Sediments deposited during the glacial periods are typically coarse-grained and represent high energy environments. Sediments deposited during the interglacial periods are typically finer grained with abundant organic matter and represent low

energy environments. Both glacial and interglacial deposits were encountered in the subsurface during this investigation.

The following stratigraphic correlations are based on information gathered from installation of monitoring wells during this investigation and on previously published information on the regional geology. Unit names and corresponding climatic episodes are based on the revised nomenclature proposed by Noble (1990). The units are described beginning with the youngest (i.e., shallowest) unit and ending with the oldest (i.e., deepest) subsurface unit encountered during this investigation. The uppermost unit encountered at the site was the Colvos Sand. Descriptions of this unit are based on boring logs from the new and existing monitoring wells at the STF site. Descriptions of units beneath the Colvos Sand are based on lithologic information from the installation of borings for monitoring wells NMW-3C and NMW-5C.

Table GW-6 is summary of the subsurface geologic units that were encountered during this investigation using the stratigraphic nomenclature proposed by Noble (1990). The table also correlates units that were encountered at the STF site with regional hydrostratigraphic layers as defined by Brown and Caldwell (1985) and with units encountered in the subsurface at the Tacoma Landfill to the west. Descriptions of these units are presented in the following sections and are detailed in the boring and well construction logs (Appendix GW-A).

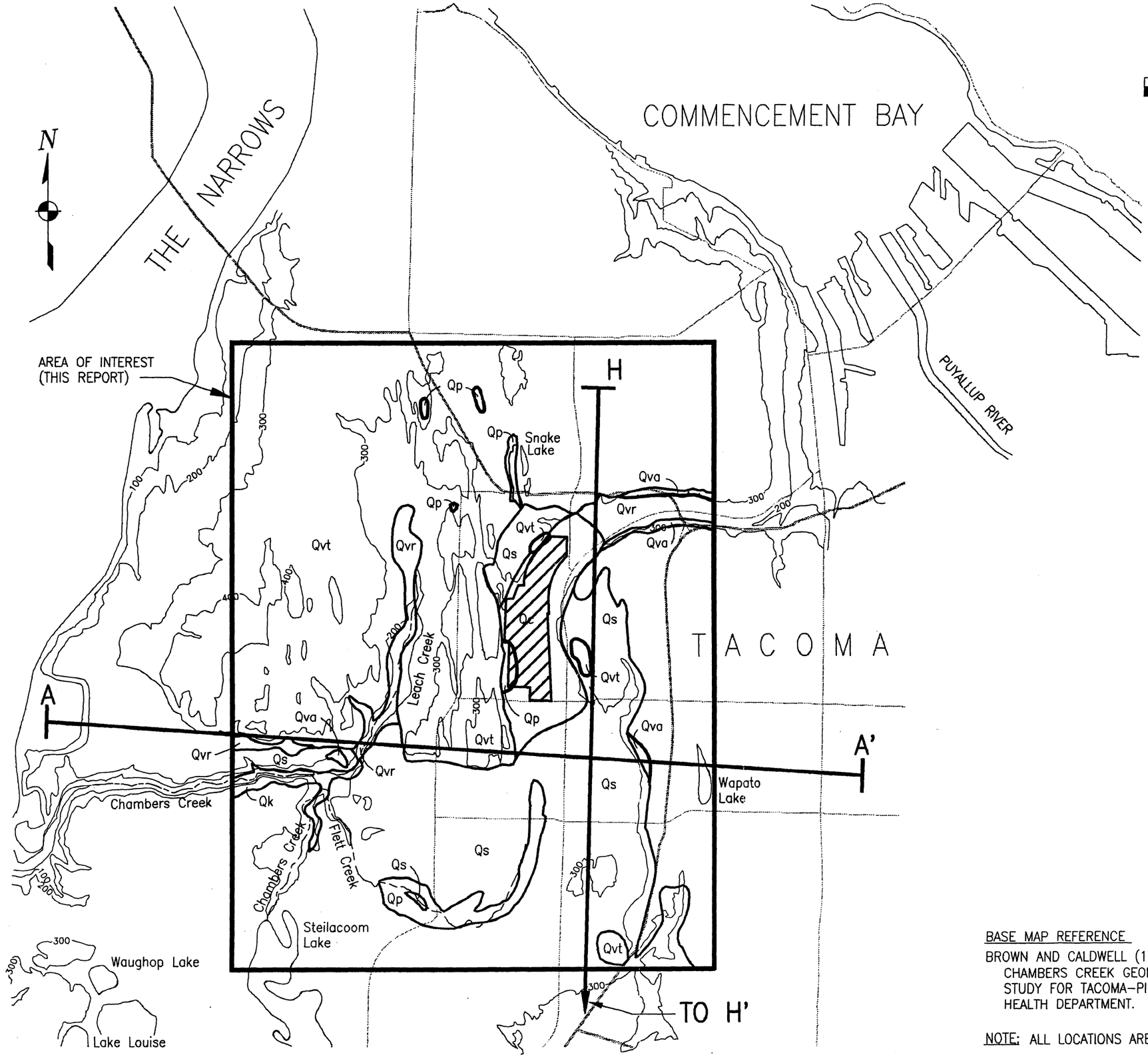
Figure GW-6 is a geologic map modified after Brown and Caldwell (1985) showing the regional geology in the vicinity of the STF site. Modifications were made based on information gathered during the Phase I Groundwater Investigation. Figures GW-7 and GW-8 are cross sections of the stratigraphy as correlated with Brown and Caldwell's (1985) regional cross sections. Figure GW-9 is a cross section through the STF site that shows in more detail the units encountered in the subsurface during this investigation.

TABLE GW-6

STRATIGRAPHIC CORRELATION IN THE VICINITY OF THE SOUTH TACOMA FIELD SITE

Climatic Episode[a]	Unit Name[a]	Hydrostratigraphic Layer[b]	Tacoma Landfill Subsurface Units[c]
Vashon Glaciation	Vashon Drift (Qv)	A	Vashon Till (Qvt) Vashon Advance (Qva) Colvos Sand (Qc) Older Gravel (Qog)
Olympia Interglaciation	Discovery nonglacial unit (Qd)	A_1	Older Sand (Qos) Older Lacustrine (Qol)
Narrows Glaciation	Narrows glacial unit (Qn)	A_1 A	Older Till (Qot) Older Advance (Qoa)
Kitsap Interglaciation	Kitsap Formation (Qk)	B	Kitsap Formation (Qk)
Flett Creek Glaciation	Flett Creek glacial unit (Qfc)	C	Not recognized

(a) Based on interpretations presented in Noble (1990).
(b) Based on correlations presented in Brown and Caldwell (1985).
(c) Based on correlations presented in Black & Veatch (1990).



APPROXIMATE SCALE IN MILES

0 1 2

CONTOUR INTERVAL 100 FEET

LEGEND

	EPOCH	MAP SYMBOL	FORMATION/ MATERIAL TYPE	APPROXIMATE HYDROSTRATIGRAPHIC EQUIVALENT
RECENT		Qa = ALLUVIUM – GRAVEL, SAND, SILT, CLAY		
		Qp = PEAT AND ORGANIC SILT		
		Qs = STEILACOOM GRAVEL – PEBBLE TO COBBLE GRAVEL		
PLEISTOCENE		Qvr = VASHON RECESSIONAL OUTWASH – STRATIFIED SAND AND GRAVEL	VASHON DRIFT	A
		Qvt = VASHON TILL – UNSTRATIFIED CLAY, SILT, SAND, GRAVEL		
		Qva = VASHON ADVANCE OUTWASH – STRATIFIED SAND AND GRAVEL		
		Qc = COLVOS SAND (USGS) – THINLY-BEDDED SAND, CONTAINS SOME GRAVEL		
		Qk = KITSAP FORMATION (USGS) – INTERBEDDED SAND AND GRAVEL TO SILT AND CLAY	KITSAP FORMATION	B

SOUTH TACOMA FIELD SITE

CROSS-SECTION LOCATION

A A'

BASE MAP REFERENCE

BROWN AND CALDWELL (1985). CLOVER/ CHAMBERS CREEK GEOHYDROLOGIC STUDY FOR TACOMA-PIERCE COUNTY HEALTH DEPARTMENT.

NOTE: ALL LOCATIONS ARE APPROXIMATE.

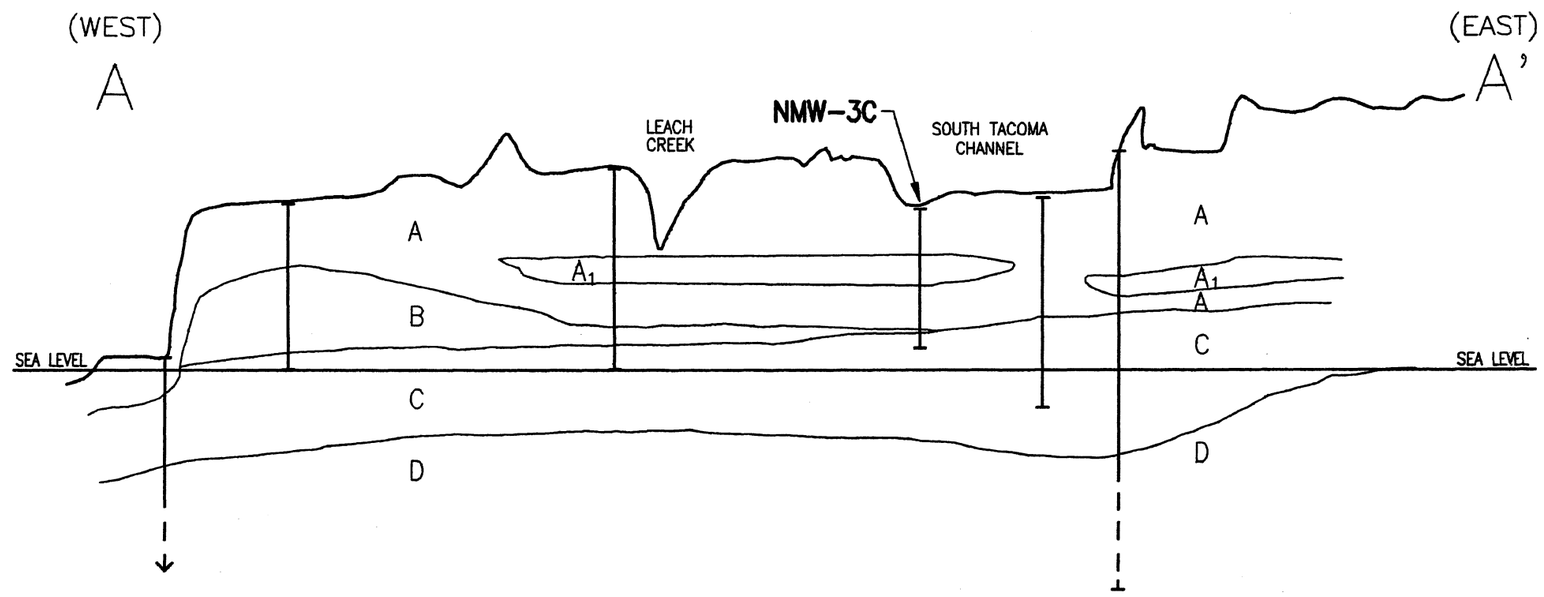
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

GEOLOGIC MAP

916055.08/P1SK103

FIGURE GW-6



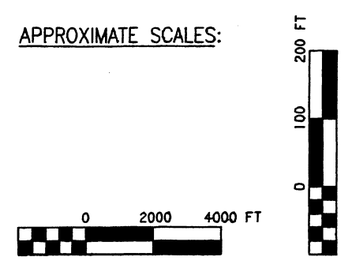
BASE MAP REFERENCE

BROWN AND CALDWELL (1985). CLOVER/ CHAMBERS CREEK GEOHYDROLOGIC STUDY FOR TACOMA–PIERCE COUNTY HEALTH DEPARTMENT.

NOTES

1. ALL LOCATIONS ARE APPROXIMATE.
2. A, A_1, B, AND C DESIGNATIONS ARE BASED ON HYDROSTRATIGRAPHIC UNITS PROPOSED BY BROWN AND CALDWELL (1985).
3. DASHED WELL INTERVALS INDICATE HYDROSTRATIGRAPHY WAS NOT PLOTTED.

APPROXIMATE SCALES:



VERTICAL EXAGGERATION: 20X

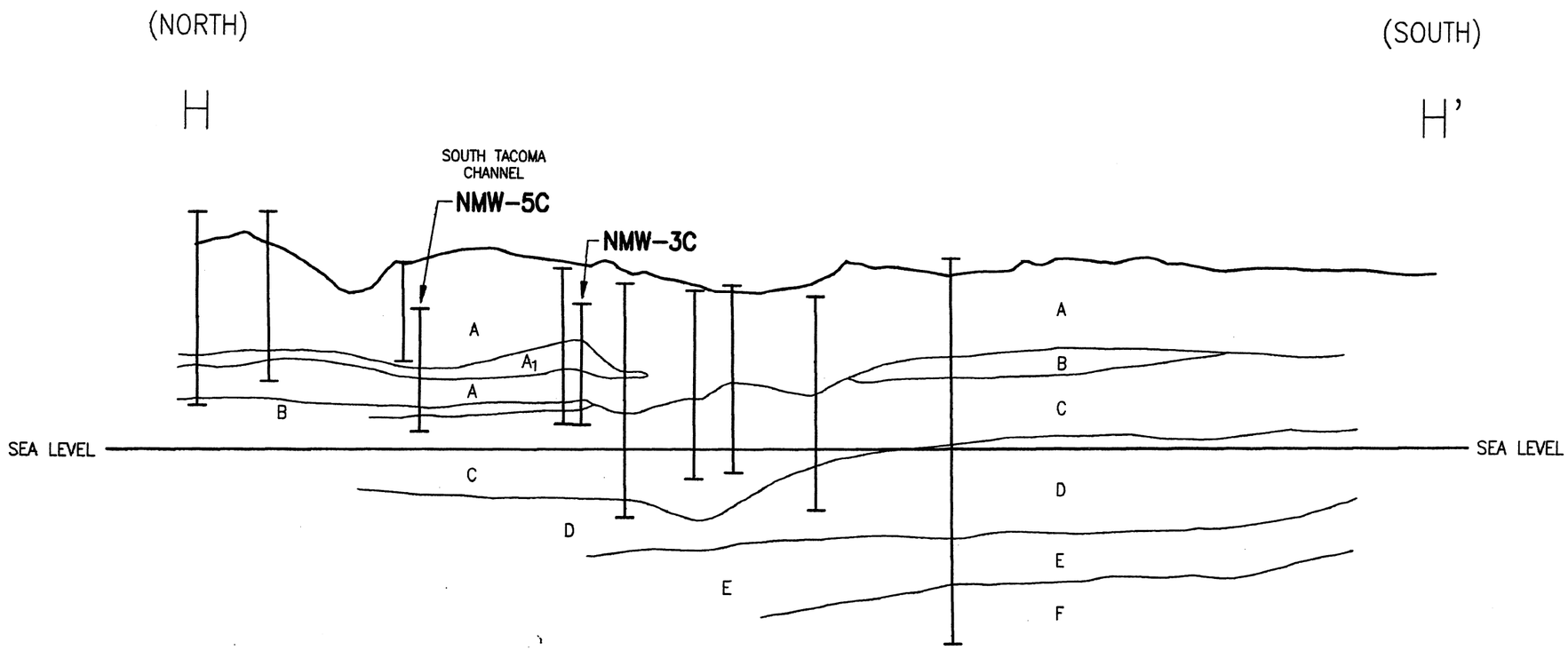
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

GEOLOGIC CROSS SECTION A-A'

916055.08/P1SK106

FIGURE GW-7



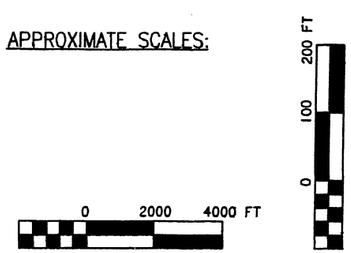
BASE MAP REFERENCE

BROWN AND CALDWELL (1985). CLOVER/ CHAMBERS CREEK GEOHYDROLOGIC STUDY FOR TACOMA–PIERCE COUNTY HEALTH DEPARTMENT.

NOTES

1. ALL LOCATIONS ARE APPROXIMATE.
2. A, A_1, B, AND C DESIGNATIONS ARE BASED ON HYDROSTRATIGRAPHIC UNITS PROPOSED BY BROWN AND CALDWELL (1985).

APPROXIMATE SCALES:



VERTICAL EXAGGERATION: 20X

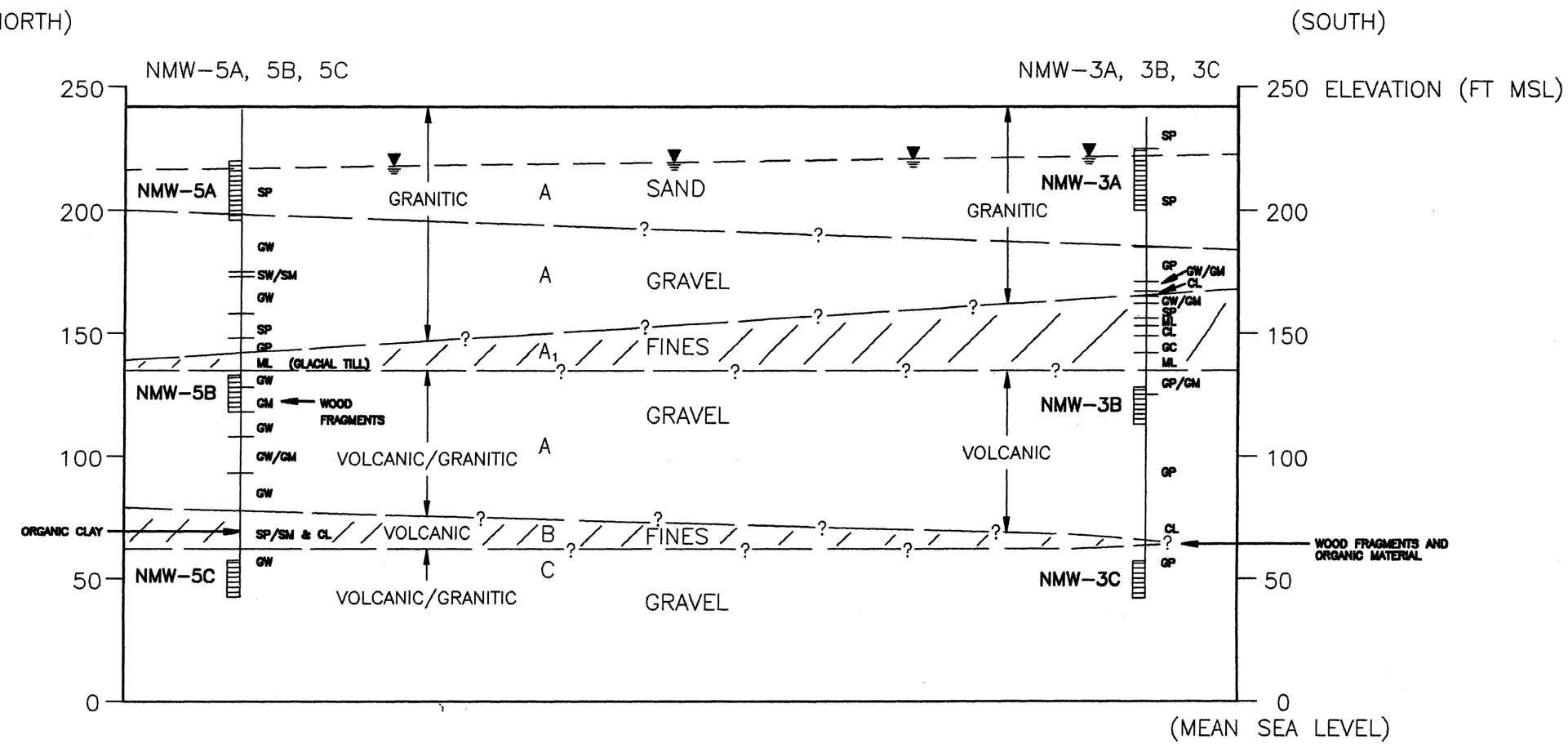
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

GEOLOGIC CROSS SECTION H-H'

916055.08/P1SK104

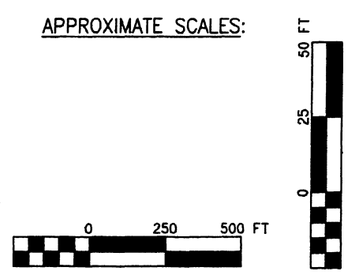
FIGURE GW-8



NOTES:

1. ALL LOCATIONS ARE APPROXIMATE.
2. ELEVATIONS ARE BASED ON CITY OF TACOMA NGVD 29 VERTICAL DATUM.
3. "GRANITIC" AND "VOLCANIC" DESIGNATIONS INDICATE THE THE MAJOR SOURCE ROCK COMPOSITION FROM WHICH THE FORMATION SEDIMENTS WERE DERIVED. THESE DESIGNATIONS WERE BASED ON FIELD OBSERVATIONS DURING WELL INSTALLATION.
4. A, A_1, B, AND C DESIGNATIONS ARE BASED UPON HYDROSTRATIGRAPHIC UNITS PROPOSED BY BROWN AND CALDWELL (1985).

APPROXIMATE SCALES:



VERTICAL EXAGGERATION 10X

LEGEND

? — INFERRED LITHOLOGIC CONTACT BETWEEN HYDROSTRATIGRAPHIC UNITS.

ESTIMATED WATER TABLE SURFACE AT THE TIME OF WELL INSTALLATION.

SCREENED INTERVALS OF MONITORING WELLS. UPPERMOST IS DESIGNATED A, INTERMEDIATE IS DESIGNATED B, AND DEEP IS DESIGNATED C.

GP — USCS CLASSIFICATION FOR SOILS BASED ON FIELD OBSERVATIONS.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

GEOLOGIC CROSS SECTION NMW-5C TO NMW-3C

916055.08/P1SK105

FIGURE GW-9

4.1.2.1 Vashon Drift. The Vashon Drift is the youngest formation that was encountered at the STF site. Regionally, the Vashon Drift consists of members deposited during the Vashon Glaciation, including the Steilacoom gravel, a till unit, and the Esperance or Colvos Sand (Noble 1990). The Vashon Drift is widely exposed throughout the Puget Lowland.

Investigators of previous studies in the STF area [Brown and Caldwell 1985, Remediation Technologies (ReTec) 1987, and ICF 1990a] concluded that the uppermost exposed unit in the South Tacoma Channel was the Steilacoom gravel member of the Vashon Drift. The Steilacoom gravel is a deposit formed from or reworked by the discharge of Lake Puyallup during the retreat of the glacier (Walters and Kimmel 1968). Steilacoom gravel is consistently coarse grained, with gravels approximately 1 inch in diameter (Walters and Kimmel 1968). The Steilacoom gravel, if present, should be the uppermost unit encountered at the STF site. However, most of the boring logs from monitoring wells installed at the STF site record finer grained deposits at the surface or beneath the fill material. This information suggests that the Steilacoom gravels are mostly absent in the South Tacoma Channel (i.e., the Colvos Sand member of the Vashon Drift is the uppermost unit encountered at the STF site).

The Colvos Sand represents advance outwash sands and gravels that were deposited from meltwater streams along the leading edge of the glacier during its southward advance. At the STF site, the Colvos Sand consists mainly of poorly graded (well sorted) sand with minor gravel and silt. The sand is mostly fine- to medium-grained and yellowish brown in color. Grains of quartz, feldspar, and mica are usually identifiable. The presence of these grains often imparts a salt-and-pepper coloration to the unit, which can be a diagnostic feature of glacially deposited sands from northern sources (Noble 1990). The Colvos Sand is approximately 50 feet thick where observed at the STF site.

The uppermost aquifer beneath the STF site is in the Colvos Sand. The uppermost aquifer beneath the Tacoma Landfill to the west also is in the Colvos Sand

(Black & Veatch 1987, 1990). The unit is correlative with the hydrostratigraphic layer A (Brown and Caldwell 1985) and the shallow aquifer of the City of Tacoma water supply wells (Carr/Associates 1991). The upper aquifer wells at the STF site are screened in the Colvos Sand.

Beneath the Colvos Sand is a layer of gravel that varies in thickness from approximately 17 feet to approximately 59 feet where observed in the well borings for NMW-3C and NMW-5C (see Figure GW-9). This gravel appears to be correlative with the gravel layer beneath the Tacoma Landfill known as the Older Gravel. The gravel layer is also correlative with hydrostratigraphic layer A.

4.1.2.2 Discovery Nonglacial Unit. The Discovery nonglacial unit was proposed by Noble (1990) for nonglacial sediments deposited during the Olympia Interglaciation. The unit is correlative with the hydrostratigraphic layer A_1 of Brown and Caldwell (1985) and with the Older Sand and Older Lacustrine units at the Tacoma Landfill. At the south end of the STF site (NMW-3B and NMW-3C), the Discovery unit is characterized by interbedded clay, silt, sand, and gravel deposits. In the northern portion of the site (NMW-5B and NMW-5C), the Discovery unit is absent or is represented by gravel and sand deposits that are similar in appearance to the overlying Vashon units. The Discovery nonglacial unit is approximately 37-46 feet thick where intersected in NMW-3B and NMW-3C.

4.1.2.3 Narrows Glacial Unit. The Narrows glacial unit was proposed by Noble (1990) for a drift unit below the Discovery nonglacial unit and above the Kitsap Formation. At the STF site in the well borings for NMW-5B and NMW-5C, the Narrows glacial unit is represented by an indurated silt that appeared to be glacial till based on field observations. Silt was also observed at the base of the Discovery nonglacial unit in NMW-3B and NMW-3C (see Figure GW-9) at elevations between approximately 130 and 143 feet above mean sea level (MSL). This silt unit occurs at approximately the same elevation and stratigraphic position in the well borings for NMW-5B and NMW-5C and may also be glacial till. The silt unit that makes up

the Narrows glacial unit at the STF site is approximately 6-13 feet in thickness where observed in the well borings for NMW-5C and NMW-3C, respectively.

The glacial till was also recognized beneath the Tacoma Landfill and was designated as the Older Till. The glacial deposit (glacial till) and the overlying nonglacial deposits (fine-grained units) form a continuous fine-grained unit that is correlative with hydrostratigraphic layer A_1. Black and Veatch (1990) recognized that the two deposits were closely associated with each other and suggested that the two deposits form a single aquitard beneath the Tacoma Landfill, separating the unconfined hydrostratigraphic layer A from lower-lying water bearing zones.

A gravel layer that is approximately 65 feet thick lies beneath the glacial till at the STF site. In the south portion of the site at NMW-3B and NMW-3C, the gravel contains sand, but finer-grained materials are rare. In the northern part of the site at NMW-5B and NMW-5C, silt and clay were more common in this part of the section and wood fragments were observed near the upper part of the section. The gravel unit appears to be correlative with the lower part of hydrostratigraphic layer A and with the Older Advance unit at the Tacoma Landfill. Wells NMW-3B and NMW-5C are screened in the upper portion of this gravel layer.

4.1.2.4 Kitsap Formation. The Kitsap Formation is the nonglacial unit below the Narrows glacial unit and was deposited during the Kitsap Interglaciation. The Kitsap Formation is correlative with hydrostratigraphic layer B and has been identified beneath the Tacoma Landfill. The unit has been recognized as an important regional aquitard that ranges in thickness to as much as 150 feet (Walters and Kimmel 1968), but it is typically 50 feet thick (Brown and Caldwell 1985). In previous regional studies in the vicinity of the STF site, Brown and Caldwell (1985) have postulated the absence of the Kitsap Formation in the South Tacoma Channel. This theory appears to be based on information gathered from a driller's log for a deep well in the South Tacoma Channel (Walters and Kimmel 1968, Well 20/2-24A2), and on the observed thinning of the Kitsap Formation approaching the South Tacoma Channel (see Figure GW-7).

Information gathered during this investigation suggests that the Kitsap Formation is thin but present beneath the STF site. Fine-grained organic-rich deposits were intersected in the well borings for NMW-3C and NMW-5C at approximate elevations of 60-80 feet above MSL. Based on information gathered during this investigation, the thickness of the Kitsap Formation beneath the South Tacoma Channel varies from approximately 2 feet in the south (NMW-3C) to approximately 15 feet in the north (NMW-5C) (see Figure GW-9).

In the southern portion of the site (NMW-3C), the Kitsap Formation consists of olive-gray lean clay with wood fragments and organic material. In the north (NMW-5C), the Kitsap Formation is represented by a 15-foot section of lean clay that is interbedded with sand and silt. The clay is olive gray and contains fibrous brown organic matter. A brownish-black organic-rich clay was observed near the base of the formation in the well boring for NMW-5C. The interbedded sand and silt is greenish black in color and the particles are volcanic in composition. Individual beds are on the order of 6 inches in thickness.

4.1.2.5 Flett Creek Glacial Unit. The lowermost subsurface unit encountered at the STF site was the Flett Creek glacial unit. The Flett Creek glacial unit is the informal term introduced by Noble (1990) for drift deposits stratigraphically below the Kitsap Formation that were deposited during the Flett Creek Glaciation. This term includes all drift that is near sea level and stratigraphically below the Kitsap Formation (Noble 1990). The Flett Creek glacial unit is also correlative with hydrostratigraphic layer C (Brown and Caldwell 1985) and the "sea level aquifer" (Carr/Associates 1991). Brown and Caldwell (1985) report that the top of this unit ranges from 100 feet above sea level to 100 feet below sea level. The top of this unit at the STF site occurs at approximately 65 feet above MSL.

Approximately the upper 23 feet of the Flett Creek glacial unit was intersected during this investigation. The unit consisted of gravel, cobbles, and boulders to at least 1 foot in diameter. Wells NMW-3C and NMW-5C were screened in the upper portion of this unit.

4.1.2.6 Conclusions. Based on the installation of monitoring wells for this investigation, the following geologic interpretations are revisions of theories proposed by previous investigations regarding the South Tacoma Channel and the STF site:

- The uppermost unit in the South Tacoma Channel within the boundary of the STF site is the Colvos Sand member of the Vashon Drift. This lower portion of this unit is saturated and forms the uppermost aquifer at the site. This unit appears to be continuous with the uppermost aquifer beneath the Tacoma Landfill to the west.

- The Steilacoom gravels are absent or very thin in the vicinity of the STF site. Past interpretations by other investigators have suggested that the site was mantled with a layer of Steilacoom gravels. The groundwater recharge characteristics in the vicinity of the STF site were partially attributed in the past to the highly transmissive nature of the Steilacoom gravels (ReTec 1987).

- The regional confining layers that were found beneath the Tacoma Landfill were also found beneath the STF site. These layers were identified as hydrostratigraphic layers A_1 and B of Brown and Caldwell (1985). At the STF site, layer A_1 varies in thickness from approximately 6 to 37 feet where encountered during subsurface drilling. Layer B, the Kitsap Formation, varies from approximately 2 to 15 feet where encountered during drilling.

4.1.3 Surface Water Hydrology

This section presents a brief summary of surface water hydrology as reported in the STF Surface Water and Sediment Investigation Report (Kennedy/Jenks Consultants 1992b; prepared as Appendix SW of the RI Report). The discussion of surface

water hydrology is presented here to provide a background for interpretation of the interaction of surface water and groundwater at the STF site.

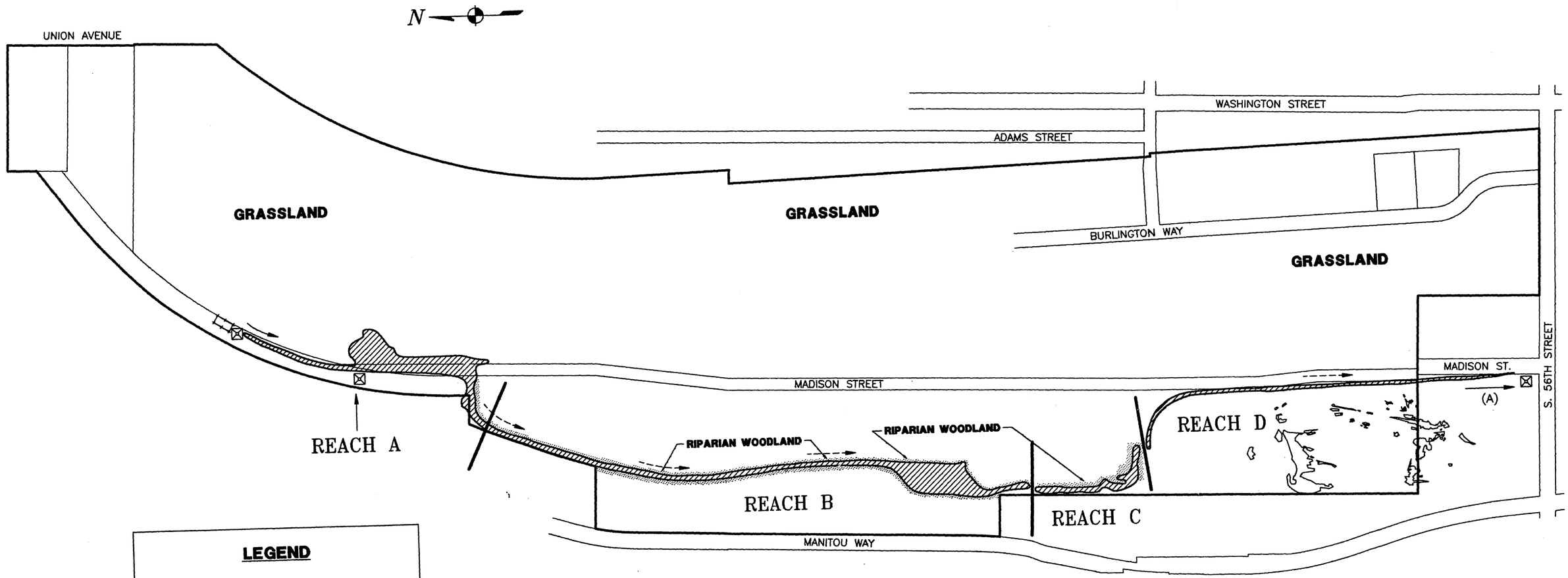
The information presented in the following paragraphs includes observations made during the transitional, dry, and wet seasons. Figure GW-10 shows surface water features as described in the STF Surface Water and Sediment Investigation Report (Kennedy/Jenks Consultants 1992b).

The STF site is located within the Clover/Chambers Creek surface water drainage basin. An open channel is situated along most of the western boundary of the site (see Figure GW-10). The channel begins at the northwest corner of the site where a 60-inch storm drain outfall opens into a 6-foot wide channel. Surface water from two upgradient sub-basins discharges onto the northwest portion of the channel at the 60-inch storm drain outfall and a 24-inch storm drain outfall located in the center of Reach A (see Figure GW-10). These upgradient sub-basins drain surface water from a mix of land uses: residential, commercial, industrial, and open space (e.g., Snake Lake).

Throughout the period of the STF Surface Water and Sediment Investigation, low flows were observed continuously discharging onto the site during non-storm periods through the 60-inch outfall. Low flows were observed on a sporadic basis at the 24-inch outfall. Substantial flows discharged from both outfalls during storm events.

For the STF Surface Water and Sediment Investigation, the onsite surface water channel was divided into four reaches based on observed hydrologic characteristics. These reaches were identified using alphabetic designators A through D, with Reach A being the farthest upstream and Reach D being the farthest downstream. A description of these reaches is provided below:

- Reach A is a 1,400-foot long portion of the surface water channel and is located in the northwest corner of the STF site. Both storm drains dis-



LEGEND

- RIPARIAN WOODLAND
- PERENNIAL WETLAND
- SEASONAL WETLAND
- STORM DRAINS (APPROXIMATE LOCATION)
- OBSERVED SURFACE WATER FLOW DIRECTION
- INFERRED SURFACE WATER FLOW DIRECTION
- (A) OBSERVED OFFSITE FLOW ON ONLY TWO OCCASIONS

0 500
SCALE IN FEET

BASE MAP REFERENCE:
KENNEDY/JENKS CONSULTANTS AND LSA ASSOCIATES (1991).

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

SURFACE WATER FEATURES

916055.08/P2SK112

FIGURE GW-10

charge to this reach. Surface water was observed to be present in Reach A throughout the year of this investigation (April 1991 to April 1992).

- Reach B continues downstream (south) from Reach A for a distance of approximately 2,750 feet along the western boundary in the Airport area into the Former Swamp/Lakebed area. Reach B begins in the north as a clearly defined channel and merges in its southern portion into the south swamp remnant area consisting of marshes and bogs. During most of the investigative period, surface water was only present in appreciable quantities in the south swamp remnant area, although some "ponding" along the channel comprising the northern portion of the reach was periodically observed. Under these conditions, water throughout the reach appeared to be stagnant (i.e., did not exhibit flow conditions). During periods of heavy or extended precipitation, surface water was present throughout the reach and flow conditions were evident.

- Reach C consists of a 690-foot long segment of the channel that parallels the western STF site boundary and then turns to the east in the north end of the Former Swamp/Lakebed area. Relatively stagnant surface water was generally present throughout Reach C during this investigation, except during the dry season when water was absent from much of the reach. During periods of heavy precipitation (including those occurring in the dry season), the channel through Reach C would fill and overflow.

- Reach D consists of the southernmost 2,100 feet of the onsite channel that runs east then south (parallel with Madison Street) to the site boundary. With the exception of a small area adjoining Reach C, this reach was generally dry during non-storm periods. During this investigation, surface water was observed to flow offsite on only four occasions following extended periods of precipitation (i.e., storms of approximately 1 week in duration consisting of 2 or more inches of precipitation). The

accumulation of a large volume of surface water in Reach D was necessary to produce offsite flow.

Channel flow of offsite surface water was only observed in the transitional and wet seasons during and after high-intensity storm events. Offsite flows were measured at the southern site boundary where continuous monitoring was conducted. Offsite flow was observed on only four occasions during this investigation. In April 1991 during a storm event that produced 2.82 inches of rain in a 48-hour period (data from McChord Air Force Base, approximately 5 miles south of the STF site). The total precipitation produced by the same storm system was 6.85 inches in 9 days, which created channel flow offsite for a 2-week period. Channel flow of surface water also flowed offsite during 2 days in late November 1991 after 6 days of rain. The third (3 February 1992) and fourth (19 February 1992) offsite flow events occurred after several weeks of rain. No offsite channel flow was observed in the dry months during this investigation.

Based on observations of surface water conditions and existing subsurface conditions observed in the Former Swamp/Lakebed area, it appears that channel flow of surface water offsite does not occur, except during major rainfall events. During the dry and transitional seasons, surface water is dissipated due to evaporation, transpiration, and infiltration through the unsaturated zone soil to recharge the upper aquifer at the site.

4.1.4 Hydrogeology

The following sections summarize the regional and local groundwater characteristics as related to the STF site. Further characterization of the hydraulic properties of aquifer zones at the STF site is being conducted as part of the Hydraulic Characterization Investigation. The results of the Hydraulic Characterization Investigation are presented in Appendix HC of the RI Report.

4.1.4.1 Regional Groundwater System. In general, the regional groundwater system in the uppermost unconfined aquifer is characterized by recharge in the Fircrest/Tacoma upland with shallow groundwater flow east and west to the Puyallup River Valley and to Puget Sound, respectively. The divide between east and west flow occurs in the vicinity of the South Tacoma Channel (Black & Veatch 1990). The STF site and surrounding vicinity are located within a recharge area. Groundwater is presumed to flow from the recharge areas in the central portion of the Fircrest/Tacoma upland toward the discharge areas to the west, north, northeast, and south (Black & Veatch 1987). Puget Sound and Commencement Bay form sea level discharge areas to the west and north. The discharge area for the groundwater that flows beneath the Tacoma Landfill to the west of the site is Leach Creek (Black & Veatch 1990) (see Figure GW-6).

The STF site is located within the Clover/Chambers Creek surface water drainage basin. The general direction of the groundwater hydraulic gradient in this basin is southeast to northwest (Brown and Caldwell 1985). This hydraulic gradient direction coincides with the hydraulic gradient direction observed in the upper aquifer at the STF site when the City of Tacoma is not pumping from the wellfield to the east of the site. The character of, and seasonal changes in, the shallow groundwater hydraulic gradient direction are described in Section 4.1.4.2.

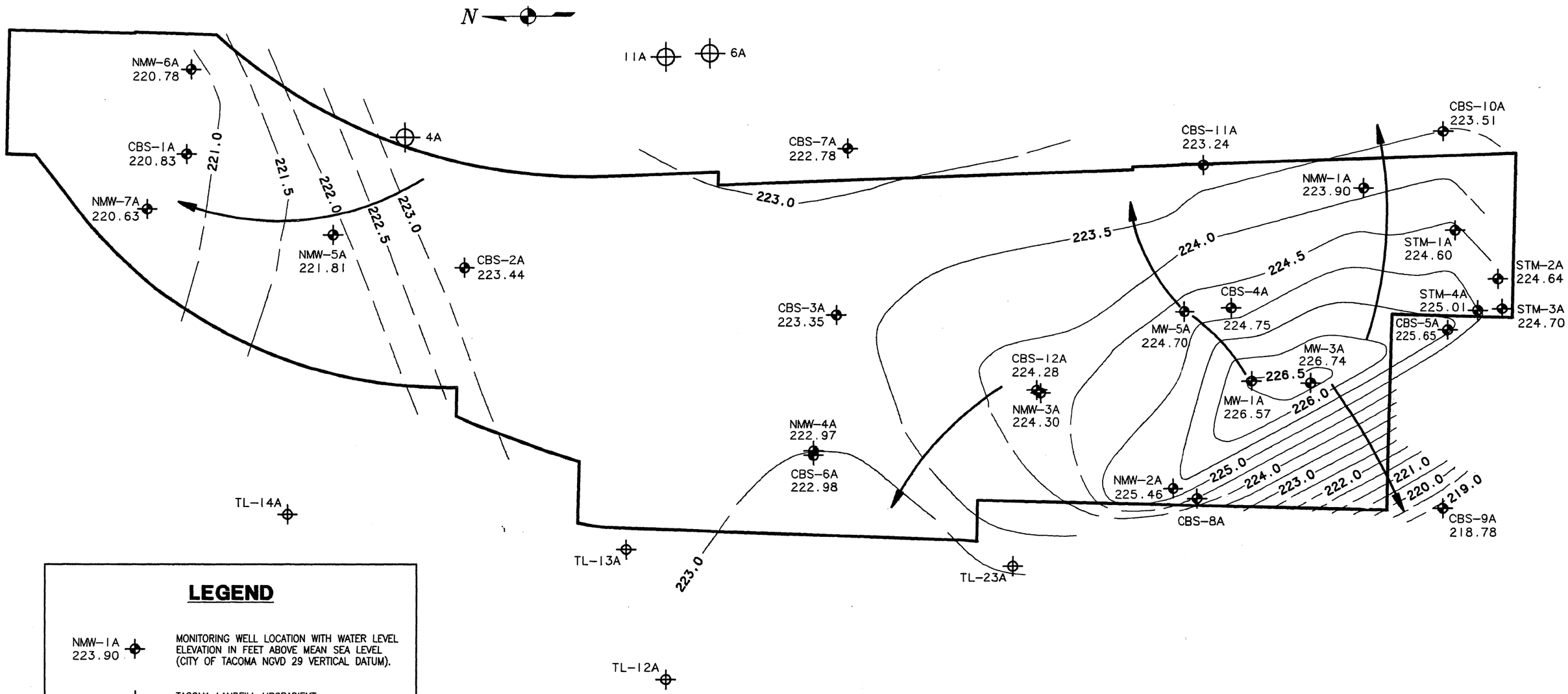
4.1.4.2 Local Groundwater System. Based on available potentiometric surface data, the STF site appears to lie within a groundwater recharge area. Based on preliminary information gathered during the Surface Water and Sediment Investigation of the STF RI, it appears that precipitation and surface water from the open channel in the northwestern portion of the site does not flow offsite as surface water, except during major rainfall events. Surface water is believed to dissipate by evaporation, transpiration, and infiltration downward through the unsaturated zone as recharge to the saturated zone.

The unsaturated zone at the STF site is composed mainly of the upper portion of the Colvos Sand unit. Other local deposits comprising the uppermost unsaturated

zone include fine-grained sediment and organic material in the Former Swamp/ Lakebed area and areas of fill material. The uppermost portion of the saturated zone, or upper aquifer, at the STF site is within the Colvos Sand unit, as described in Section 4.1.2. Most of the wells at the STF site are screened in the uppermost part of the Colvos Sand in poorly graded to well graded, fine- to medium-grained sand. Where observed, the lower portion of the upper aquifer consists mainly of gravel.

The top of the saturated zone was encountered at depths ranging from near ground surface in the Former Swamp/Lakebed area to approximately 35 feet BGS in the southeastern portion of the site. However, maximum potentiometric head differences in each uppermost aquifer well were on the order of 6 feet throughout the year. The surface housing above monitoring well CBS-8A, in a low portion of the Former Swamp/Lakebed area, was observed to be submerged under approximately 1.5 feet of surface water during the April monthly water level monitoring event. The depth to the uppermost saturated zone varies seasonally, a difference on the order of 10 feet over much of the site. These seasonal variations in depth to the unsaturated zone are dependent on climatic conditions and pumping of the City of Tacoma wellfield to the east of the site.

Figures GW-11 through GW-24 are contour maps of the potentiometric surface of the upper aquifer for the months of April 1991 through March 1992. The locations of the City of Tacoma production wells 4A, 6A, and 11A are also shown in Figures GW-11 through GW-24. (The letter designation "A" for the City of Tacoma wells bears no relation to the "A" designation used for monitoring wells during this investigation). The contour maps show the estimated hydraulic gradient directions for the days the groundwater levels were measured. The maps illustrate the seasonal variations in groundwater levels and seasonal reversals in hydraulic gradient due to pumping of the City of Tacoma production wells. The hydraulic gradient directions are used in this report as approximations of the groundwater flow directions in the upper aquifer under isotropic conditions. Most field conditions are anisotropic, however, and actual flow directions vary accordingly. The



LEGEND

NMW-1A 223.90	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
—— 223.0 ——	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-8A WAS SUBMERGED IN SURFACE WATER DURING THIS MONITORING EVENT.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

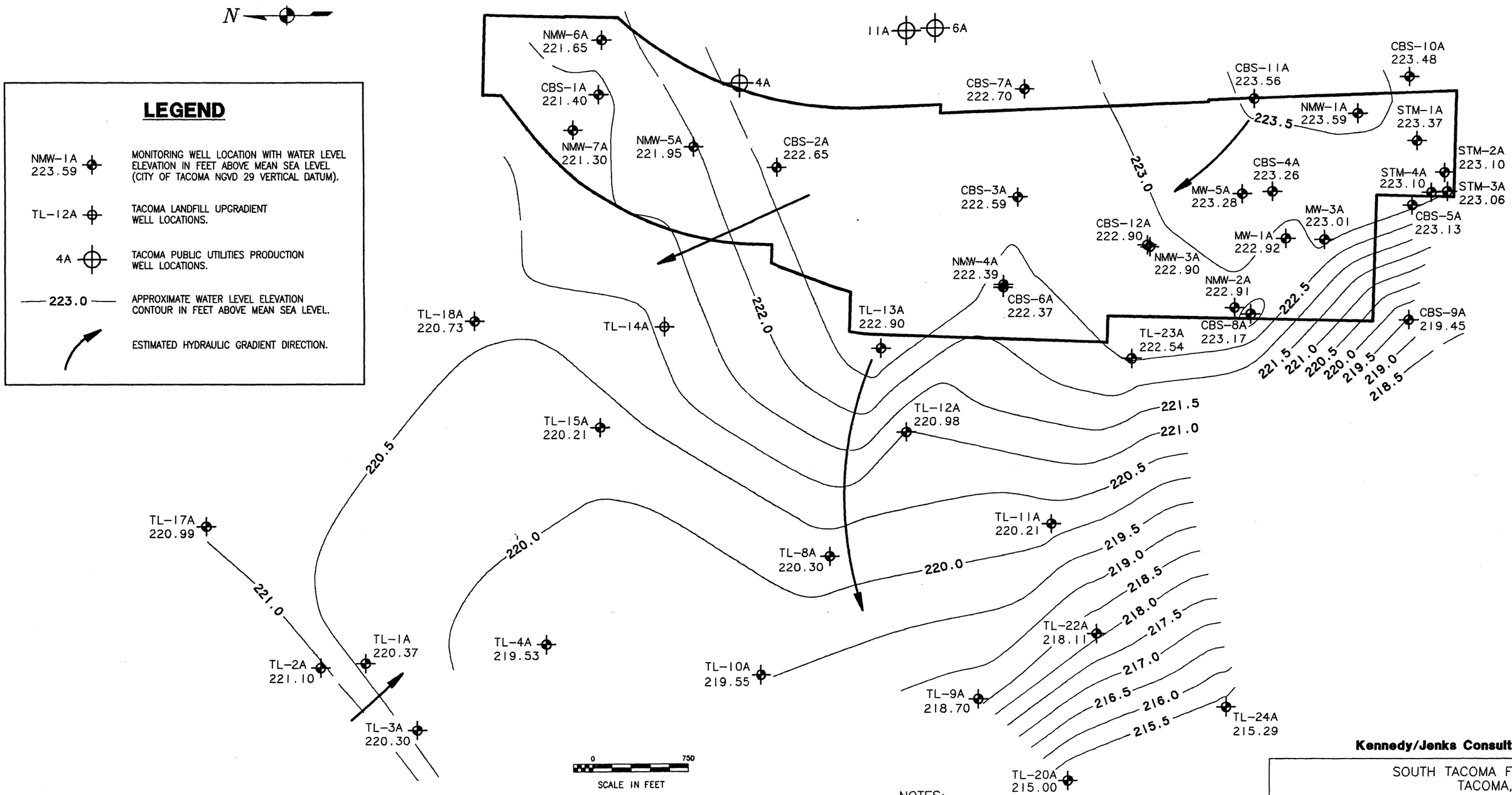
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 11 APRIL 1991

916055.08/P1SK329

FIGURE GW-11



NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

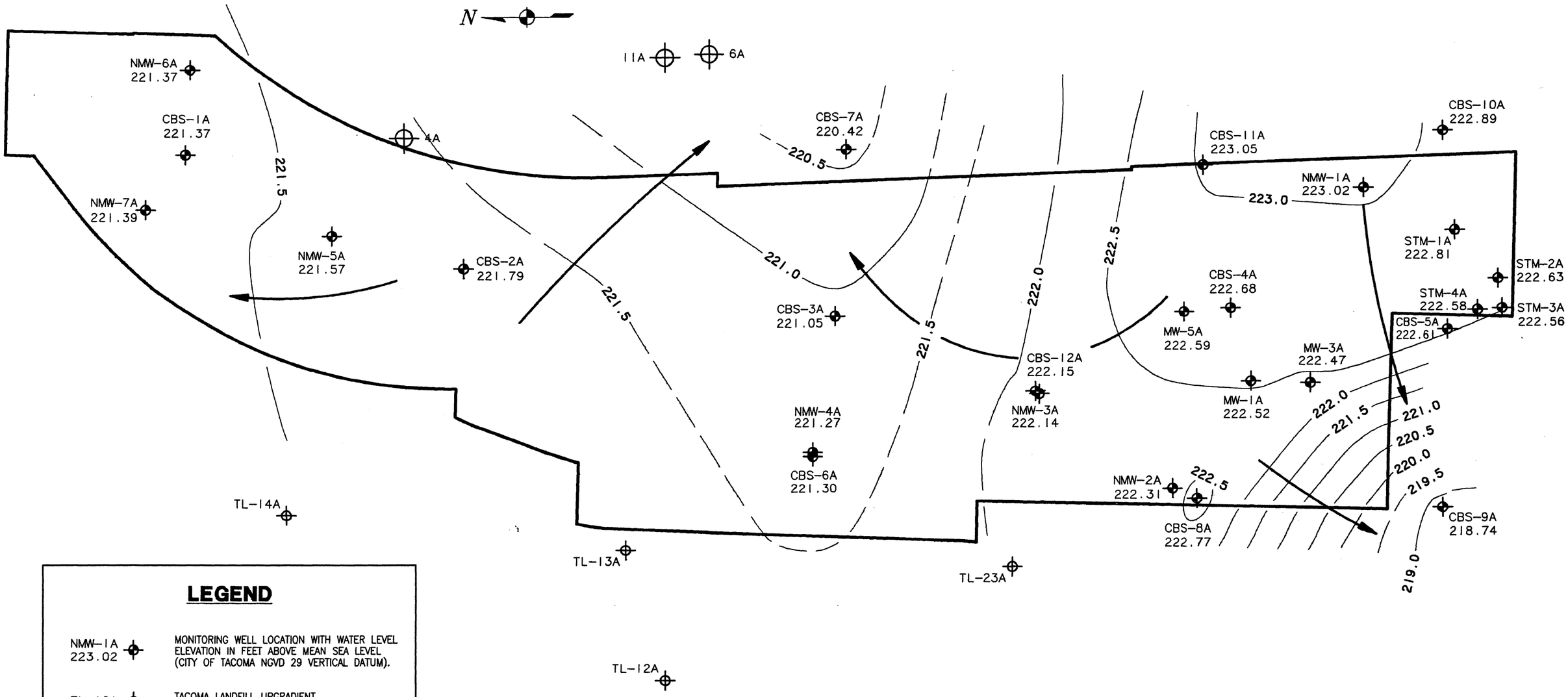
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 9 & 11 MAY 1991

916055.08/P1SK330

FIGURE GW-12



LEGEND

NMW-1A 223.02	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

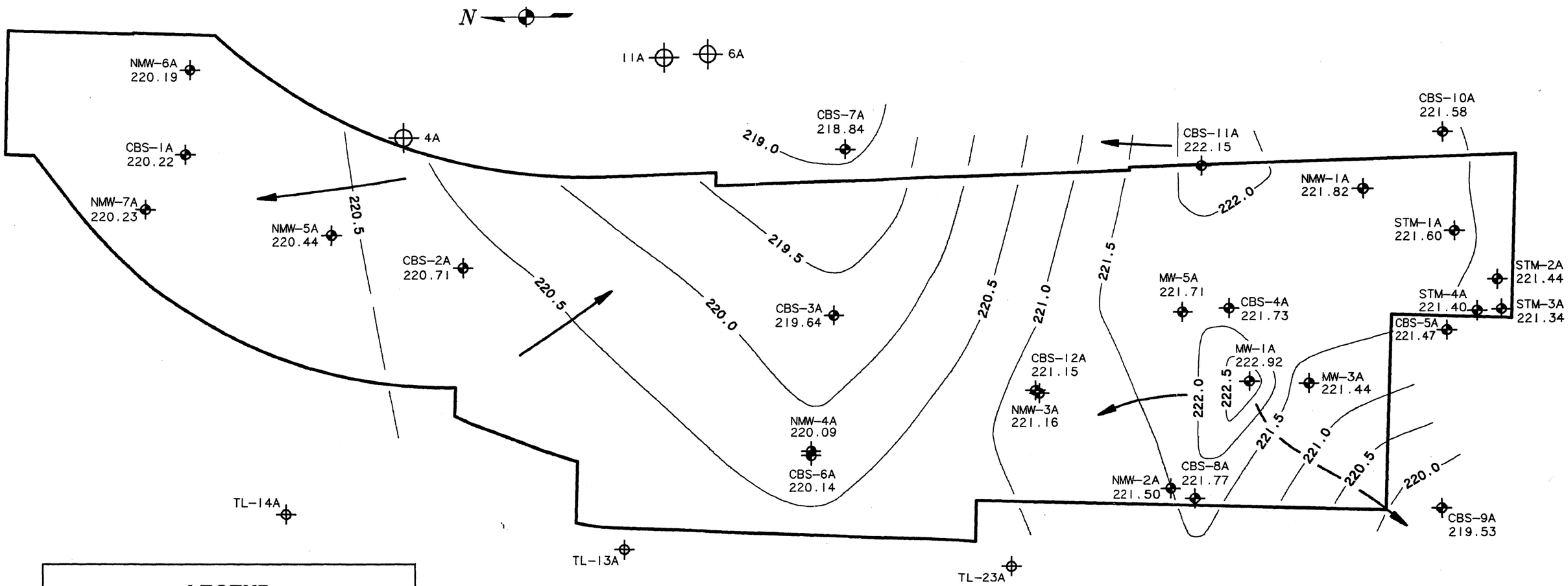
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 7 JUNE 1991

916055.08/P1SK331

FIGURE GW-13



LEGEND

NMW-1A 221.82	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

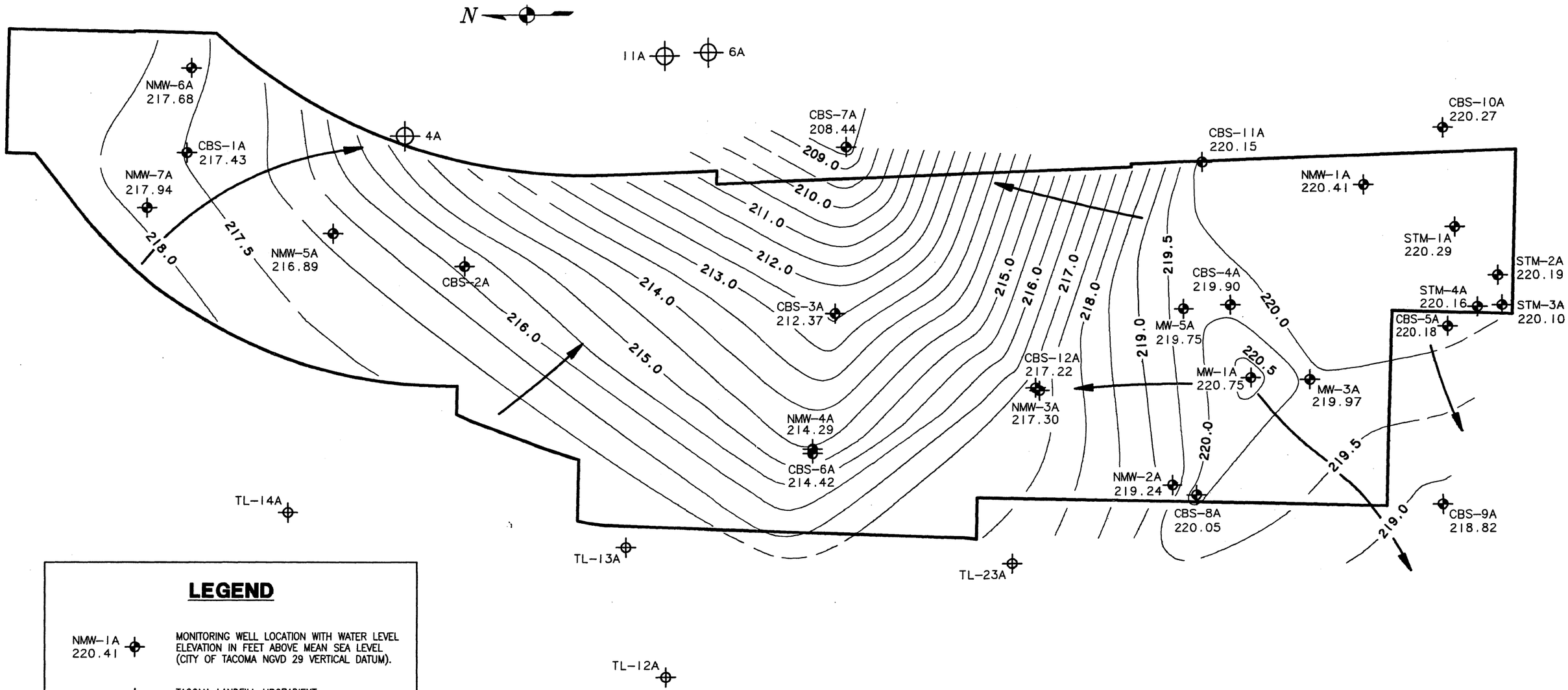
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 11 JULY 1991

916055.08/P1SK332

FIGURE GW-14



LEGEND

NMW-1A 220.41	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
—— 223.0 ——	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-7A WAS DRY DURING THIS MONITORING EVENT. THE ELEVATION OF THE WELL BOTTOM WAS USED AS THE WATER LEVEL ELEVATION.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

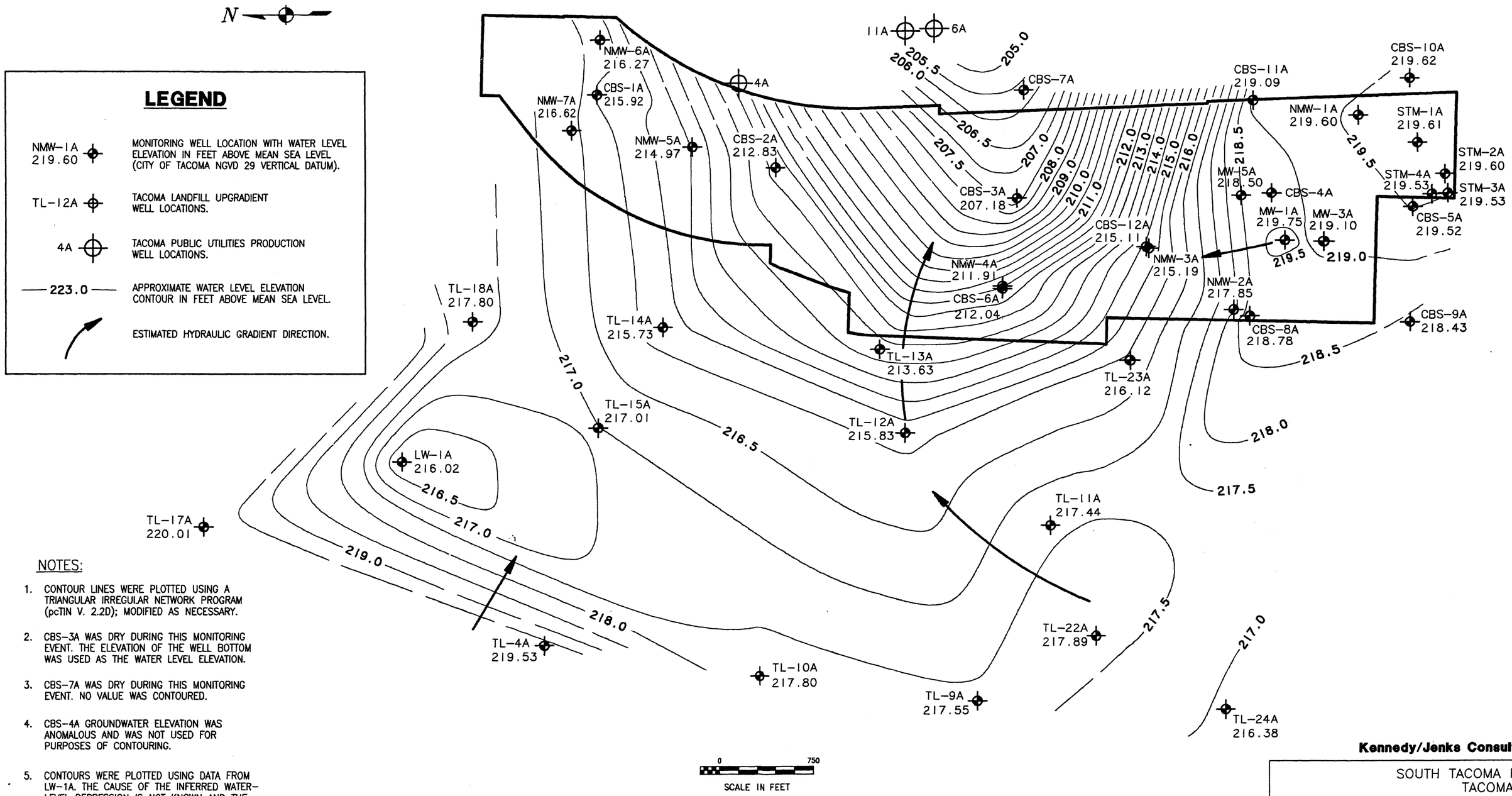
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 8 AUGUST 1991

916055.08/P1SK333

FIGURE GW-15



NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-3A WAS DRY DURING THIS MONITORING EVENT. THE ELEVATION OF THE WELL BOTTOM WAS USED AS THE WATER LEVEL ELEVATION.
3. CBS-7A WAS DRY DURING THIS MONITORING EVENT. NO VALUE WAS CONTOURED.
4. CBS-4A GROUNDWATER ELEVATION WAS ANOMALOUS AND WAS NOT USED FOR PURPOSES OF CONTOURING.
5. CONTOURS WERE PLOTTED USING DATA FROM LW-1A. THE CAUSE OF THE INFERRED WATER-LEVEL DEPRESSION IS NOT KNOWN AND THE DATA MAY BE IN ERROR.
6. ALL LOCATIONS ARE APPROXIMATE.
7. ALL CONTOURS ARE INFERRED.

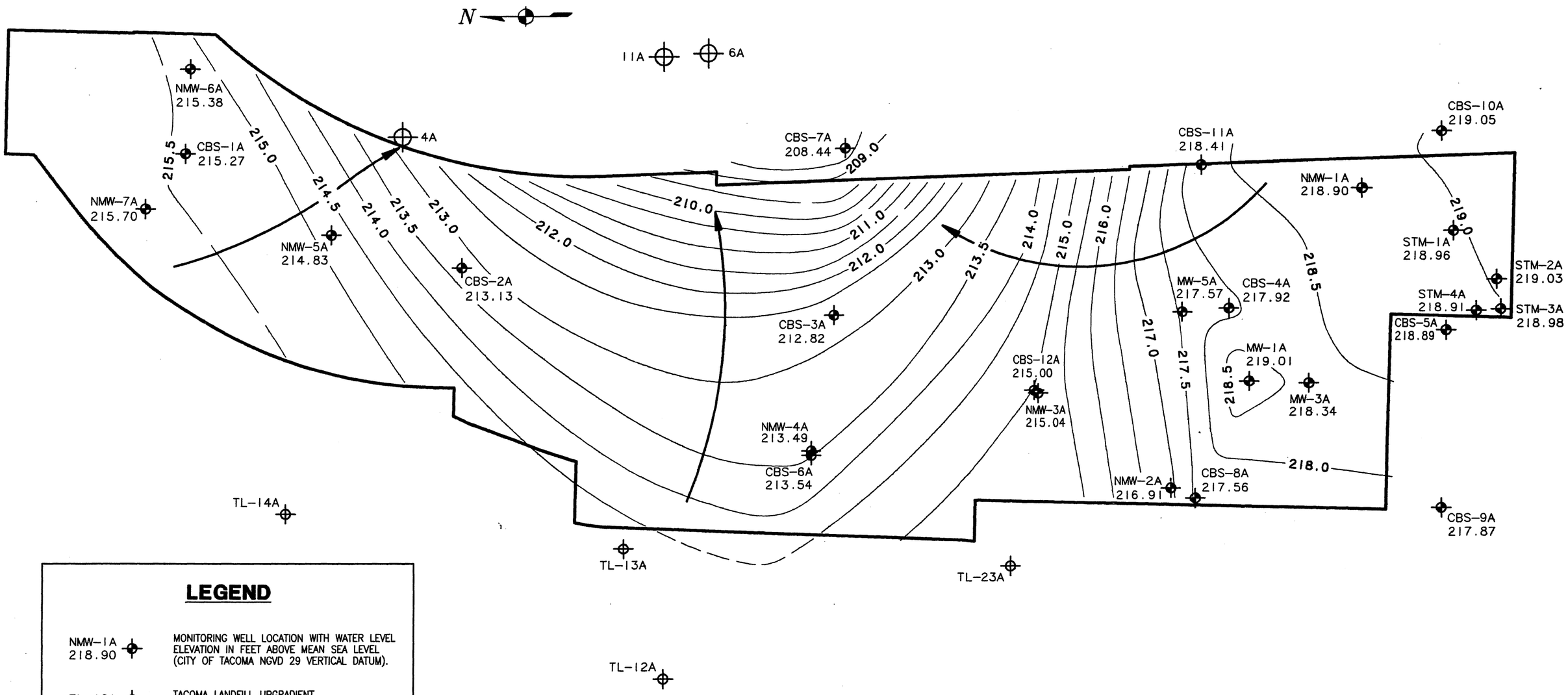
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 21 & 23 AUGUST 1991

916055.08/P1SK334

FIGURE GW-16



LEGEND

NMW-1A 218.90	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
—— 223.0 ——	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-7A WAS DRY DURING THIS MONITORING EVENT. THE ELEVATION OF THE WELL BOTTOM WAS USED AS THE WATER LEVEL ELEVATION.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

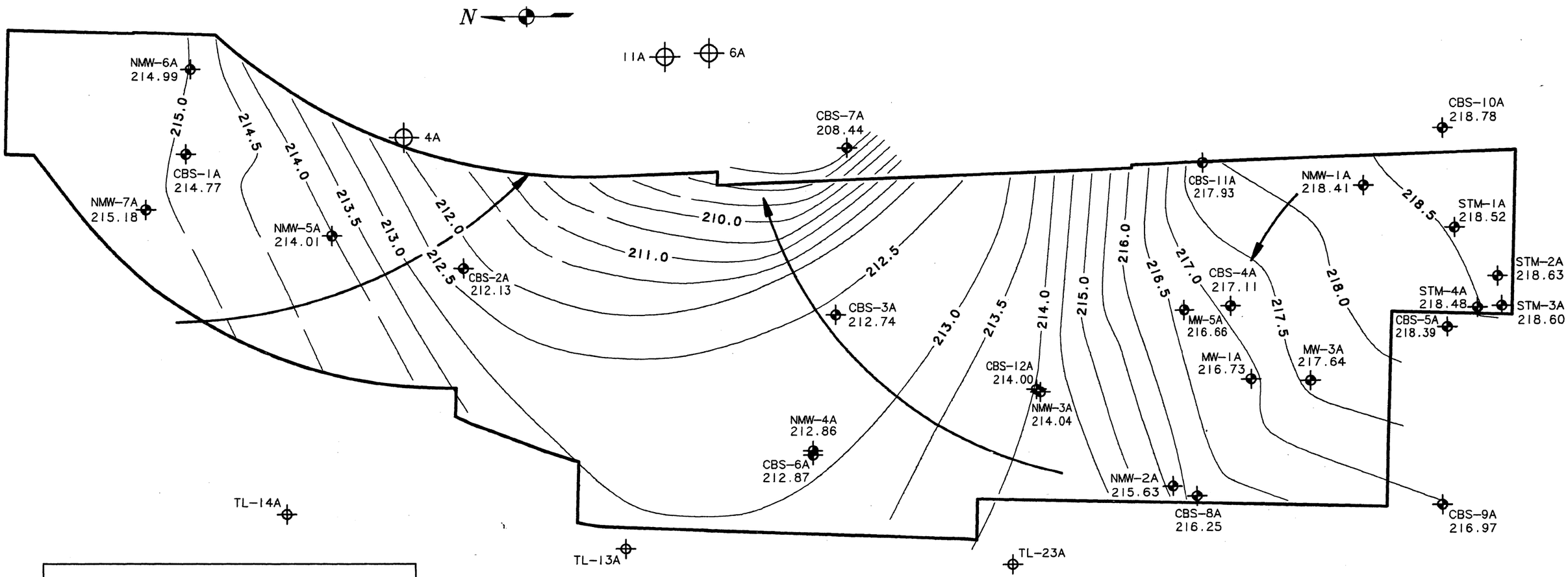
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 9 SEPTEMBER 1991

916055.08/P1SK335

FIGURE GW-17



LEGEND

NMW-1A 218.41	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-7A WAS DRY DURING THIS MONITORING EVENT. THE ELEVATION OF THE WELL BOTTOM WAS USED AS THE WATER LEVEL ELEVATION.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

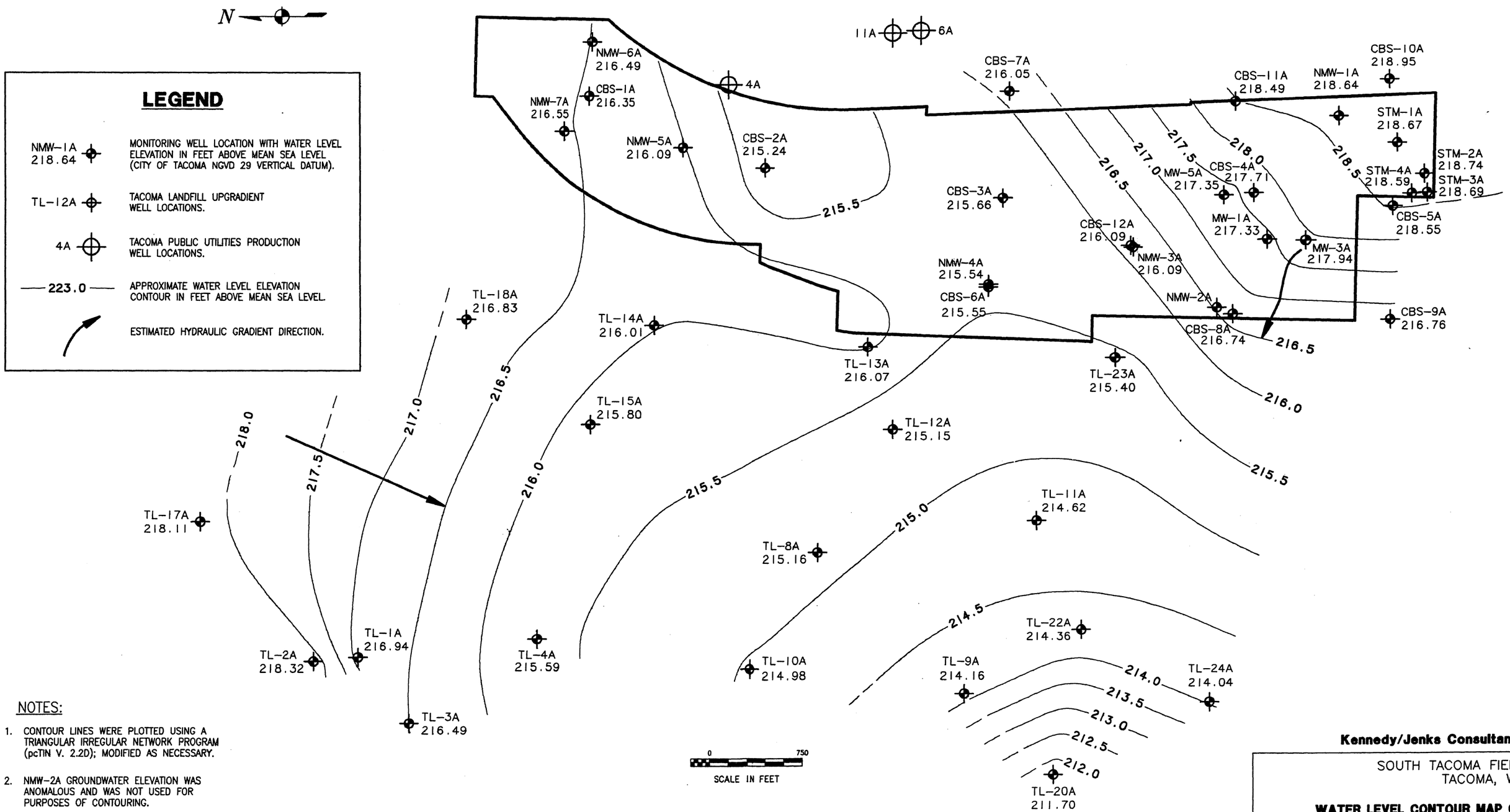
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 17 OCTOBER 1991

916055.08/P1SK336

FIGURE GW-18



NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. NMW-2A GROUNDWATER ELEVATION WAS ANOMALOUS AND WAS NOT USED FOR PURPOSES OF CONTOURING.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

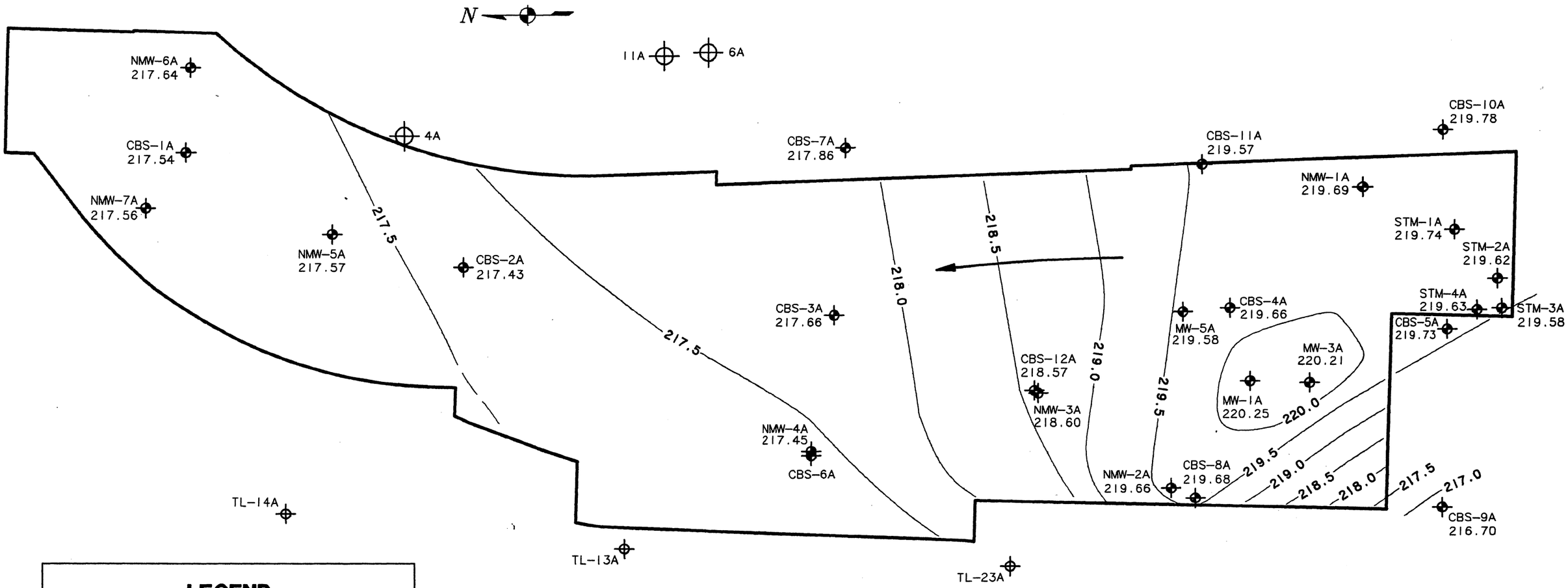
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 5-13 NOVEMBER 1991

916055.08/P2SK081

FIGURE GW-19



LEGEND

NMW-1A 219.69	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. CBS-6A GROUNDWATER ELEVATION WAS ANOMALOUS AND WAS NOT USED FOR PURPOSES OF CONTOURING.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

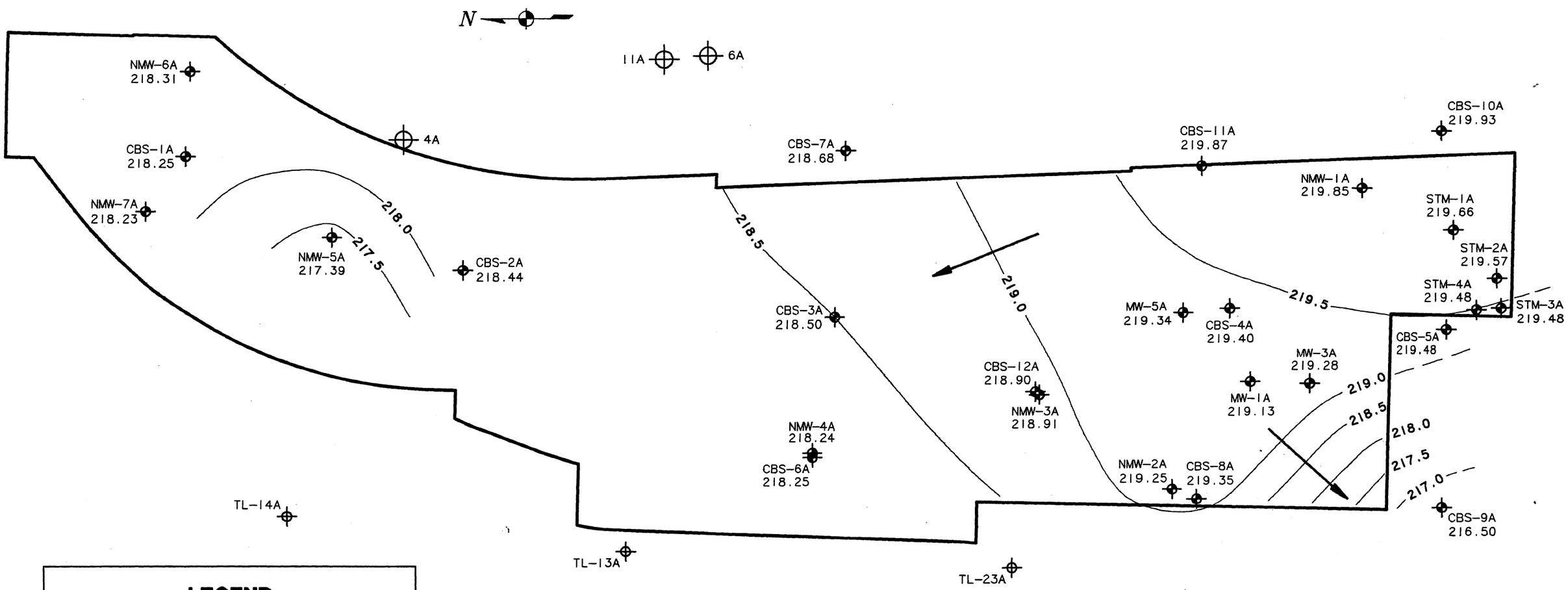
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 9 DECEMBER 1991

916055.08/P2SK082

FIGURE GW-20



LEGEND

NMW-1A 219.85	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

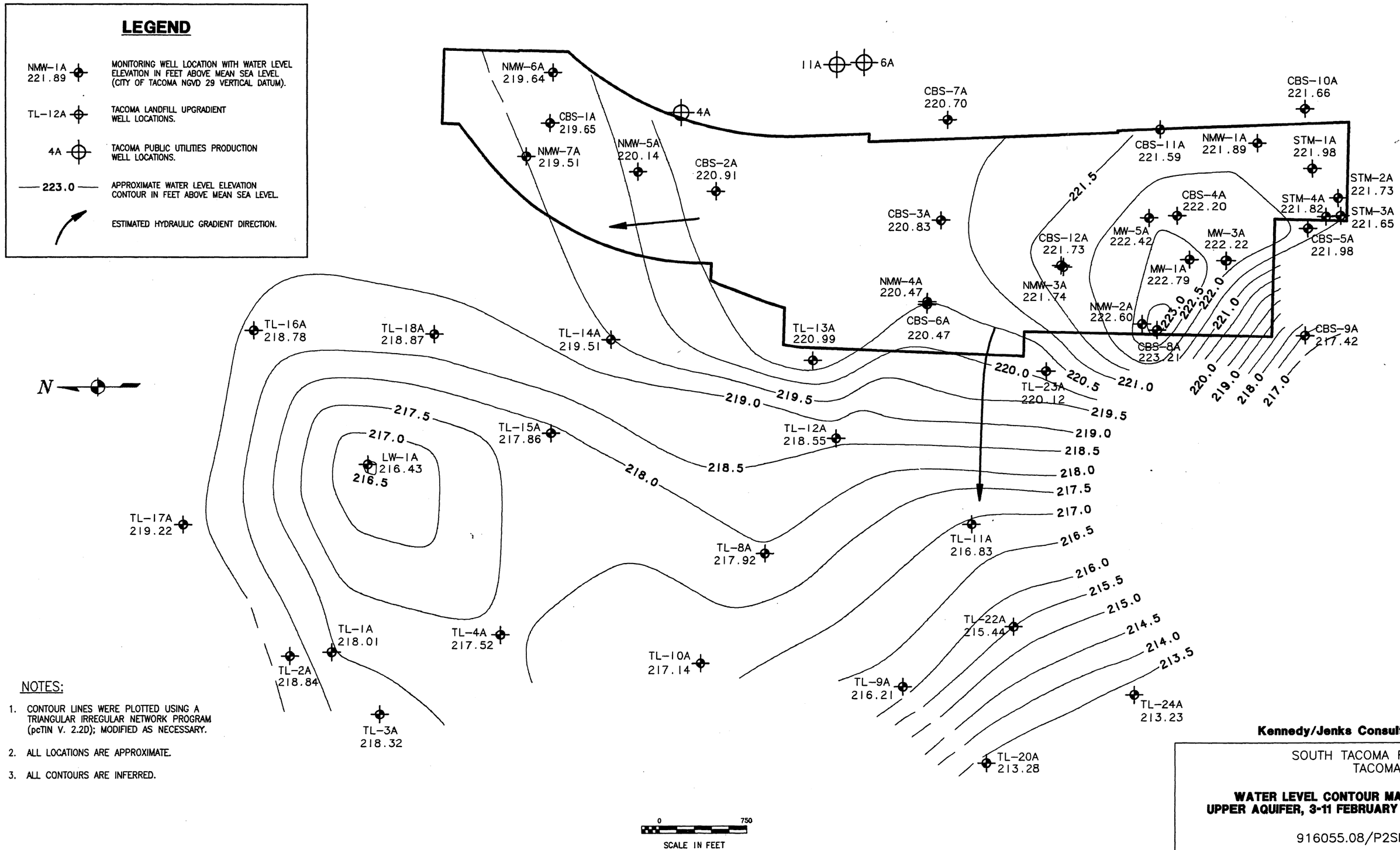
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 7 JANUARY 1992

916055.08/P2SK083

FIGURE GW-21



NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

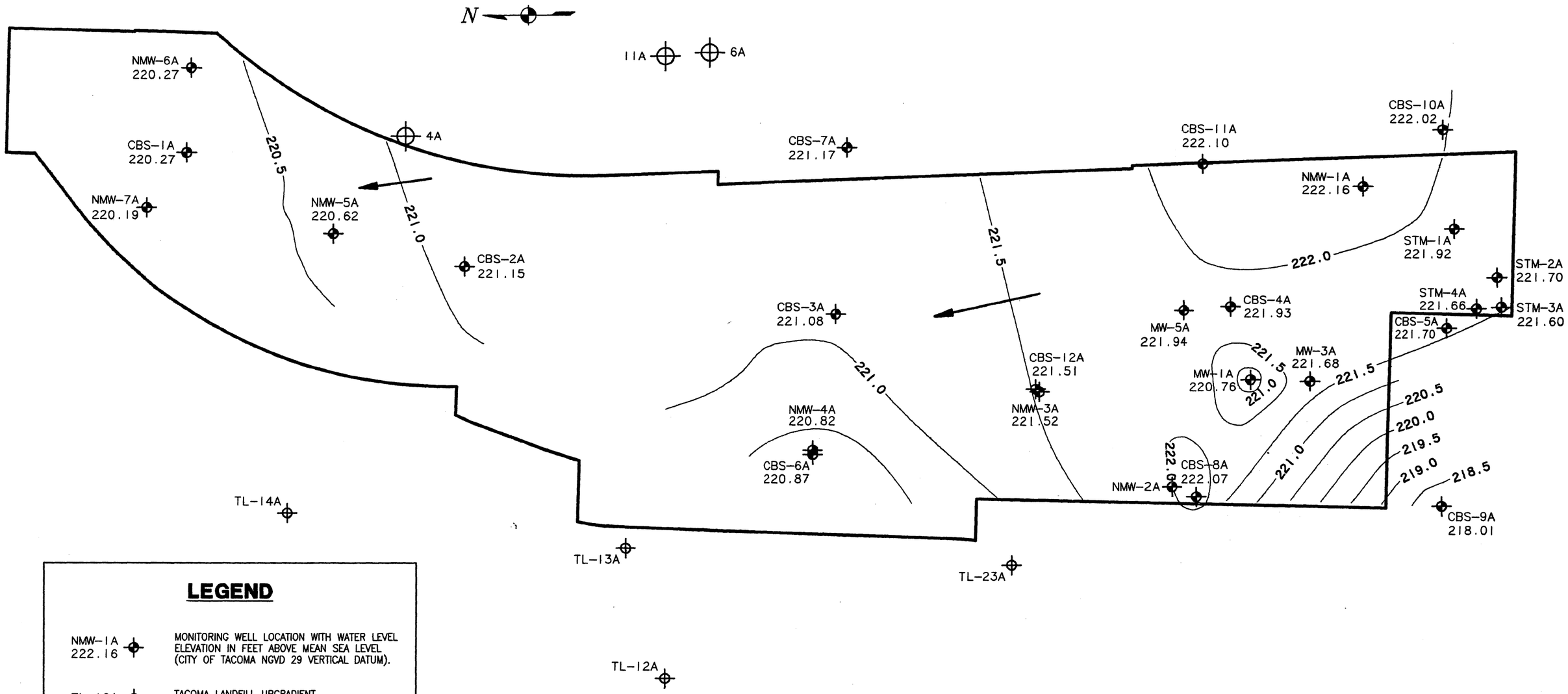
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 3-11 FEBRUARY 1992

916055.08/P2SK084

FIGURE GW-22



LEGEND

NMW-1A 222.16	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. NMW-2A GROUNDWATER ELEVATION WAS ANOMALOUS AND WAS NOT USED FOR PURPOSES OF CONTOURING.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ALL CONTOURS ARE INFERRED.

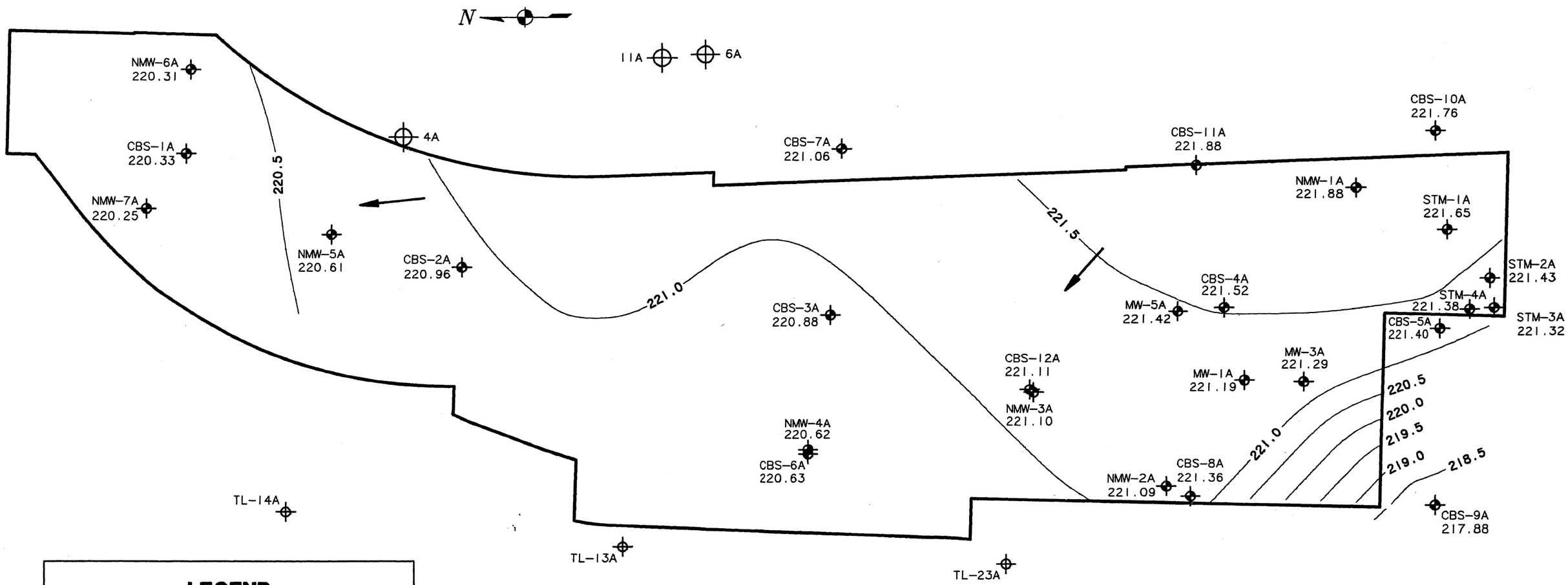
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 13 MARCH 1992

916055.08/P2SK085

FIGURE GW-23



LEGEND

NMW-1A 221.88	MONITORING WELL LOCATION WITH WATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CITY OF TACOMA NGVD 29 VERTICAL DATUM).
TL-12A	TACOMA LANDFILL UPGRADIENT WELL LOCATIONS.
4A	TACOMA PUBLIC UTILITIES PRODUCTION WELL LOCATIONS.
223.0	APPROXIMATE WATER LEVEL ELEVATION CONTOUR IN FEET ABOVE MEAN SEA LEVEL.
	ESTIMATED HYDRAULIC GRADIENT DIRECTION.

0 500
SCALE IN FEET

NOTES:

1. CONTOUR LINES WERE PLOTTED USING A TRIANGULAR IRREGULAR NETWORK PROGRAM (pcTIN V. 2.2D); MODIFIED AS NECESSARY.
2. ALL LOCATIONS ARE APPROXIMATE.
3. ALL CONTOURS ARE INFERRED.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

WATER LEVEL CONTOUR MAP OF UPPER AQUIFER, 30 MARCH 1992

916055.08/P2SK086

FIGURE GW-24

water level elevations in upper aquifer wells were initially contoured using the triangular network program pcTIN Version 2.20. Modifications were manually made to the computer-generated contour lines based on observations of field conditions. Because water level data were not available for the City of Tacoma pumping wells, contours were estimated based on known information.

The South Tacoma Channel in the vicinity of the STF site appears to act as a local recharge area for groundwater. The natural hydraulic gradient (when not influenced by regional pumping) in the upper aquifer appears to be from the southeast to the northwest across the site, following the regional pattern of hydraulic gradient directions described in Section 4.1.4.1. The natural hydraulic gradient direction in the west central portion of the site appears to be to the west, toward the Tacoma Landfill (see Figure GW-12). A steep hydraulic gradient exists throughout the year in the southwestern portion of the site, where the assumed groundwater flow direction observed during this investigation was always from the east to the west. The hydraulic gradient direction was observed to vary from the northwest to the southwest in the southwestern portion of the site.

Based on available potentiometric surface data for the upper aquifer, a natural groundwater divide appears to be located in the vicinity of the South Tacoma Channel. This divide shifts to the west toward or in the vicinity of the Tacoma Landfill when the City of Tacoma production wells are pumping (Black & Veatch 1987). The presence of this divide in the vicinity of the South Tacoma Channel appears to be due in part to the absence of the poorly transmissive glacial till unit that typically overlies the Colvos Sand in the region. The more highly transmissive Colvos Sand is exposed in the South Tacoma Channel and should promote more rapid infiltration of precipitation and surface water through the unsaturated zone into the saturated zone. Other subsurface features, such as aquifer grain size variations and aquifer thickness variations, also may have an impact on recharge characteristics of the aquifer.

During times when the City of Tacoma was not pumping from the wellfield to the east of the STF site (April, early May, and November through March), groundwater in the upper aquifer appears to have mounded in the southern portion of the site. A recharge mound centered in the vicinity of Amsted during the 11 April 1991 monitoring event may have been due to precipitation events that occurred in March and early April. More than 6 inches of rain fell on McChord Air Force Base to the south of the STF site during the first week in April. The actual location of the center of the mound may have been to the west of the Amsted property in the area of the open channel or Former Swamp/Lakebed area.

Hydraulic gradient reversals have been documented in the past for the STF site and the Tacoma Landfill to the west (Black & Veatch 1987, 1990). These reversals occurred in the upper aquifer and were caused by pumping of the City of Tacoma production wells to the east. Pumping of these wells began in early May 1991 and continued until early October 1991. Most of the pumping of nearby production wells during these months was conducted from wells 6A and 11A. Well 4A was pumped only during the months of July and August 1991 (Gibson, C., 4 December 1991, personal communication). Production wells 4A, 6A, and 11A are screened at various intervals, beginning at an uppermost elevation of approximately 190 feet above MSL to a lowermost elevation of approximately 75 feet above MSL in well 4A. The upper elevation of 190 feet above MSL roughly corresponds with the elevation of the lower part of the upper aquifer at the STF site. Most of the groundwater production this year was from well 11A (Gibson, C., 4 December 1991, personal communication), which is screened entirely in the interval designated by Carr/Associates (1991) as the shallow aquifer. The shallow aquifer appears to be correlative with part of the upper aquifer at the STF site.

The potentiometric surface in the upper aquifer at the STF site was affected throughout most of the site by pumping of the City of Tacoma production wells during the monthly monitoring events of June through October 1991 (see Figures GW-13 through GW-18). The Tacoma Landfill wells that were used as upgradient wells during this investigation (TL-12A, TL-13A, TL-14A, and TL-23A) are located

in the area affected by gradient reversals during pumping (see Figures GW-11 through GW-18). These wells were actually hydraulically upgradient of the STF site only during times of gradient reversals (approximately half of the year) and were hydraulically downgradient of the STF site during other times of the year.

The hydraulic gradient reversals are characterized by a cone of depression that usually appears to be centered on the City of Tacoma production wells 6A and 11A. During the monthly monitoring events of June and July, only the central section of the STF site appeared to be affected by gradient reversals (see Figures GW-13 and GW-14). During the monthly monitoring events of August, September, and October, gradient reversals were also observed in upper aquifer at the northern end of the site (see Figures GW-15 through GW-18). The extreme southwest corner of the STF site is the only area apparently unaffected by these gradient reversals, with the estimated hydraulic gradient direction always toward the southwest, west, or northwest when observed during this investigation. The hydraulic gradient appears to be less steep, however, during the months of pumping the City of Tacoma production wells.

Two well clusters were installed during this investigation. These well clusters were numbered NMW-3 and NMW-5. Three wells were installed in each cluster, and the wells were designated with the letters A, B, and C indicating screening of the upper, intermediate, and deep aquifers, respectively. Figure GW-9 is a cross section through the two well clusters that shows the locations of the screened intervals of the well clusters with respect to the site stratigraphy. Measured differences in hydraulic heads for the well clusters during the monthly water level monitoring events showed a vertical downward gradient at both well clusters. This downward gradient indicates a net downward flow of groundwater over time from the upper aquifer to the intermediate and deep aquifers.

Laboratory measurements of vertical hydraulic conductivity were performed on soil samples collected from the upper aquifer. Porosity was also calculated for these samples. Results of these measurements are presented in Section 5.4. Further characterization of the upper, intermediate, and deep aquifer and possible intercommunication among the aquifer zones is described in the Hydraulic Characterization Investigation Report (see Appendix HC of the RI Report).

5.0 LABORATORY ANALYTICAL RESULTS

Analytical results for groundwater sampling are summarized in this section. Database printouts of these analytical results, including laboratory and data validation qualifiers, are provided in Section 7.0 of the Data Appendix.

Soil samples were collected from the upper aquifer during the drilling of well borings. Groundwater samples were collected from 26 wells during all four quarters of groundwater sampling. Groundwater samples from these 26 wells plus three background wells were collected during the second and fourth quarter sampling events. Two additional background wells, CBS-5A and CBS-9A, were included in the 26 wells sampled for all four quarters. Groundwater samples from five upgradient wells were also collected during the second and fourth quarter sampling events. Table GW-7 lists the laboratory analyses and field measurements that were performed on soil samples from the upper aquifer and on groundwater samples collected during all four quarters.

The presentation of analytical results is organized into the following subsections: inorganics, organics (PAHs, VOCs, and semivolatiles), ancillary parameters, geotechnical parameters, and field measurements. The inorganic and organic discussions contain a summary of occurrences for each analyte detected in samples collected from background and upgradient wells, followed by a summary of occurrences for each analyte detected in samples collected from onsite wells. Analytes that were detected in transfer, trip, or rinsate blanks are also discussed, where applicable. Duplicate analytical results are discussed in the Data Validation Reports (Section 8.0 of the Data Appendix) and are not discussed in this report. Summary tables for the detected analyte concentrations for each well sampled are presented in Appendix GW-C (Tables GW-C1 through GW-C36).

TABLE GW-7

ANALYTICAL PARAMETERS FOR SAMPLES COLLECTED DURING THE GROUNDWATER INVESTIGATION

Soil Analysis	Subsurface Soil[a] Upper Aquifer			
Geotechnical Parameters				
• Particle size distribution	X			
• Porosity	X			
• Vertical hydraulic conductivity	X			
Water Analysis	**First Quarter (April 1991)**	**Second Quarter (July/August 1991)**	**Third Quarter (October/November 1991)**	**Fourth Quarter (January 1992)**
Target Compound List				
• PAHs[b]	X	X	X	X
• Volatile organic compounds	X	X	X	X
• Semivolatiles (BNAs)[c]		X	X	X
• PCBs[d]/pesticides		X		X
• Metals (excludes CrVI)				
- Total	X	X	X	X
- Dissolved[e]			X	X
• Cyanide (Total)[e]		X	X[f]	X
Additional Analysis				
• Boron		X	X	X
• Total dissolved solids (TDS)		X		X
• Total suspended solids (TSS)		X		X
• Total organic carbon (TOC)		X		X
• pH[g]	X	X	X	X
• Specific conductance[g]	X	X	X	X
• Temperature[g]	X	X	X	X

(a) Collected during drilling of soil borings.
(b) PAHs = Polynuclear aromatic hydrocarbons.
(c) BNAs = Base/neutral/acid extractables; only selected wells were sampled for BNAs during the third quarter.
(d) PCBs = Polychlorinated biphenyls.
(e) Only selected wells were sampled for dissolved metals.
(f) Only selected wells were sampled for cyanide during the third quarter.
(g) Field measurements.

5.1 INORGANICS

The following sections contain discussions of the occurrences of inorganics detected in groundwater samples during all four quarters of groundwater sampling. Twelve of the groundwater samples collected during the third and fourth quarters were filtered and analyzed for metals. Those results are discussed in Section 5.1.26. Table GW-8 provides a summary of the number of onsite wells in which inorganic analytes exceeded the Federal Safe Drinking Water Act (SDWA) existing and proposed Maximum Contaminant Levels (MCLs), Action Levels (ALs), Maximum Contaminant Level Goals (MCLGs), and Secondary Maximum Contaminant Levels (SMCLs).

Table GW-9 provides a comparison of inorganic analyte concentrations detected in samples collected from onsite wells to naturally occurring groundwater concentrations and concentrations detected in samples collected from background wells.

Table GW-10 is a preliminary statistical summary of inorganic analyte concentrations detected in samples collected from background wells during the second and fourth quarters. Statistics were calculated using the methods described in Section 3.5.

Concentrations of inorganics detected in samples collected from background wells are assumed, for the purposes of this investigation, to represent naturally occurring groundwater conditions in the upper aquifer in the vicinity of the STF site. Based on the complex groundwater flow regime that is characterized by seasonal gradient reversals, the shallow occurrence of groundwater in a highly transmissive formation, and the potential for contamination from multiple sources in an industrial area, it is possible that the concentrations of some of the inorganic analytes detected in samples collected from background wells do not reflect naturally occurring groundwater conditions.

TABLE GW-8

SUMMARY OF THE NUMBER OF ONSITE WELLS IN WHICH INORGANIC ANALYTES EXCEEDED FEDERAL EXISTING AND PROPOSED MCLs, ALs, MCLGs, AND SMCLs[a]

Analyte	Existing MCL or AL (μg/L)	No. of Wells Exceeding MCL[b]	Existing MCLG (μg/L)	No. of Wells Exceeding MCLG[b]	Proposed MCL (μg/L)	No. of Wells Exceeding Proposed MCL[b]	Proposed MCLG (μg/L)	No. of Wells Exceeding Proposed MCLG[b]	Existing SMCL (μg/L)	No. of Wells Exceeding SMCL[b]	Proposed SMCL (μg/L)	No. of Wells Exceeding Proposed SMCL[b]
Al	---[c]	---	---	---	---	---	---	---	---	---	50	11/11/10/4
Sb	---	---	---	---	5 or 10	*/*/2*/1*[d]	3	*/*/2*/1*[d]	---	---	---	---
As	50	1/0/0/0	---	---	---	---	---	---	---	---	---	---
Ba	1,000	0/0/0/0	---	---	2,000	0/0/0/0	2,000	0/0/0/0	---	---	---	---
Be	---	---	---	---	1	*/0/0/2[d]	0	*/*/*/3*[d]	---	---	---	---
B[e]	---	---	---	---	---	---	---	---	---	---	---	---
Cd	5	0/0/0/0	5	0/0/0/0	---	---	---	---	---	---	---	---
Ca[e]	---	---	---	---	---	---	---	---	---	---	---	---
Cr	100	0/0/0/0	100	0/0/0/0	---	---	---	---	---	---	---	---
Co[e]	---	---	---	---	---	---	---	---	---	---	---	---
Cu	1,300[f]	0/0/0/0	1,300	0/0/0/0	---	---	---	---	1,000	0/0/0/0	---	---
CN	---	---	---	---	200	NS[g]/0/0/0	200	NS[g]/0/0/0	---	---	---	---
Fe	---	---	---	---	---	---	---	---	300	16/10/14/9	---	---
Pb	15[f]	1/1/0/1	0	1*/11*/1*/12*[d]	---	---	---	---	---	---	---	---
Mg[e]	---	---	---	---	---	---	---	---	---	---	---	---
Mn	---	---	---	---	---	---	---	---	50	13/12/14/10	---	---
Hg	2	0/0/0/0	2	0/0/0/0	---	---	---	---	---	---	---	---
Ni	---	---	---	---	100	1/1/0/1	100	1/1/0/1	---	---	---	---
K[e]	---	---	---	---	---	---	---	---	---	---	---	---
Se	50	0/0/0/0	50	0/0/0/0	---	---	---	---	---	---	---	---
Ag	50[h]	---	---	---	---	---	---	---	---	---	100	0/0/0/0
Na[e]	---	---	---	---	---	---	---	---	---	---	---	---
Tl	---	---	---	---	2 or 1	*/0/0/0[d]	0.5	*/*/*/*[d]	---	---	---	---
V[e]	---	---	---	---	---	---	---	---	---	---	---	---
Zn	---	---	---	---	---	---	---	---	5,000	0/0/0/0	---	---

TABLE GW-8

SUMMARY OF THE NUMBER OF ONSITE WELLS IN WHICH INORGANIC ANALYTES EXCEEDED FEDERAL EXISTING AND PROPOSED MCLs, ALs, MCLGs, AND SMCLs[a]

(a) Drinking Water Regulations under the Safe Drinking Water Act, as amended (MCL = Maximum Contaminant Level; AL = Action Level; MCLG = Maximum Contaminant Level Goal; SMCL = Secondary Maximum Contaminant Level).
(b) The format of the four numbers shown in this column refers to the four quarters of groundwater sampling (i.e., 1st quarter/2nd quarter/3rd quarter/4th quarter).
(c) "---" indicates the MCL, AL, MCLG, or SMCL, existing or proposed, was not applicable.
(d) The symbol "*" indicates the laboratory detection limit exceeded the MCL or MCLG. If a number is also present, that number indicates the number of wells in which the concentration exceeded the detection limit.
(e) MCLs, ALs, MCLGs, and SMCLs (existing or proposed) do not exist for these analytes.
(f) Concentrations indicate ALs that, if exceeded in drinking water supplies, would require source treatment.
(g) NS = Not sampled for that analyte.
(h) Effective until 30 July 1992.

TABLE GW-9

COMPARISON OF INORGANIC ANALYTE CONCENTRATIONS DETECTED IN ONSITE WELLS TO NATURALLY OCCURRING CONCENTRATIONS IN GROUNDWATER AND CONCENTRATIONS DETECTED IN BACKGROUND WELLS

Analyte	Range of Concentrations in Onsite Wells (μg/L)	Naturally Occurring Concentrations in Groundwater (μg/L)[a]	Range of Concentrations in Background Wells (μg/L)[b]
Al	<16.0 - 5,940	<5.0 - 1,000	<16.0 - 10,500
Sb	<11.0 - 50.7	<100[c]	<11.0 - <20.0
As	<1.0 - 50.9	<1.0 - 30 (4,000)	<1.0 - 9.0
Ba	<2.0 - 500	10 - 500	<2.0 - 159
Be	<1.0 - <2.3[d]	<10	<1.0
B	20.2 - 1,940	20 - 1,000 (5,000)	<19.0 - 184
Cd	<1.0 - <3.0	<1.0	<1.0 - <4.6
Ca	3,470 - 109,000	1,000 - 150,000	9,490 - 78,300
Cr	<3.3 - 9.9	<1.0 - 5.0	<5.0 - 41.1
Co	<3.0 - 218	<10	<3.0 - 16.1
Cu	<1.0 - 19.7[d]	<1.0 - 30	<1.0 - 112
Fe	<11.0 - 31,000	10 - 10,000	13.6 - 28,800
Pb	<0.7 - 58.9	<15 .015	<1.0 - 33.4
Mg	1,300 - 93,800	1,000 - 50,000	6,440 - 48,300
Mn	<1.0 - 5,200 .03	<1.0 - 1,000	<1.0 - 896
Hg	<0.1 - <0.4	<1.0	<0.2
Ni	<6.7 - 1,950 3	<10 - 50	<8.0 - <44.0
K	<643 - 6,940	1,000 - 10,000	1,080 - 8,280
Se	<1.0 - 26.8[d]	<1.0 - 10	<1.0 - <30.0
Ag	<3.0 - 10.6	<5.0	<4.0 - <6.0
Na	3,500 - 234,000	500 - 120,000	5,190 - 514,000
Tl	<1.0 - <7.5	<100[c]	<1.0 - 2.2
V	<3.3 - 30.5	<1.0 - 10	<4.0 - 36.5
Zn	<2.0 - 726	<10 - 2,000	<2.0 - 170

(a) Dragun (1988). Numbers in parentheses are extreme values of naturally occurring elements.
(b) Includes second and fourth quarters of background well sampling.
(c) Freeze and Cherry (1979).
(d) For some analytical results, U qualifier indicates that U value exceeded maximum value shown. Upper limit of Be values was <2.6. Upper limit of Cr values was <41.1 for background and <21.5 for onsite. Upper limit of Cu values was <21.0. Upper limit of Se values was <30.0.

TABLE GW-10

STATISTICAL SUMMARY OF 2ND AND 4TH QUARTER INORGANIC RESULTS FOR BACKGROUND WELLS[a,b]

Analyte	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Mean Concentration (µg/L)	Standard Deviation (µg/L)	95% UCL (µg/L)	Number of Detects
Al	<16.0	10,500	1,490	3,280	3,840	6
Sb	<11.0	<20.0	7.75	2.40	9.45	0
As	<1.0	9.0	3.0	3.5	5.5	3
Ba	<2.0	159	38	49	74	6
Be	<1.0	<1.0	0.5	0	0.5	0
B	<19.0	184	64.3	65.5	111	8
Cd	<1.0	<4.6	0.93	0.54	1.3	0
Ca	9,490	78,300	29,100	21,300	44,300	10
Cr	<5.0	<41.1	5.4	5.7	9.5	1
Co	<3.0	16.1	4.2	4.6	7.4	3
Cu	<1.0	112	17.4	36	43	3
Fe	13.6	28,800	9,190	12,500	18,100	9
Pb	<1.0	33.4	5.2	10	13	5
Mg	6,440	48,300	16,300	14,300	26,500	10
Mn	<1.0	896	390	390	660	8
Hg	<0.2	<0.2	0.1	0	0.1	0
Ni	<8.0	<44.0	7.8	5.4	12	0
K	1,080	8,280	2,980	2,110	4,490	10
Se	<1.0	<30.0	2.4	4.5	5.6	0
Ag	<4.0	<6.0	2.5	0.53	2.9	0
Na	5,190	514,000	66,000	159,00	179,000	10
Tl	<1.0	2.2	0.67	0.54	1.0	1
V	<4.0	36.5	7.6	11	15	4
Zn	<2.0	170	30	55	69	3

(a) The five background wells are CBS-5A, CBS-9A, WCC-2, TL-16, and 89.7-P1. Each well was sampled twice for a total of 10 samples.

(b) Methods of calculation are described in text. Rounding of numbers was not completed until the final calculation of the 95-percent upper confidence limit (95% UCL) using the student's t-test. However, numbers reported in this table include the appropriate number of significant figures. If an analyte was report as undetected, the concentration was assumed to be one-half the reported detected limit for purposes of statistical calculations.

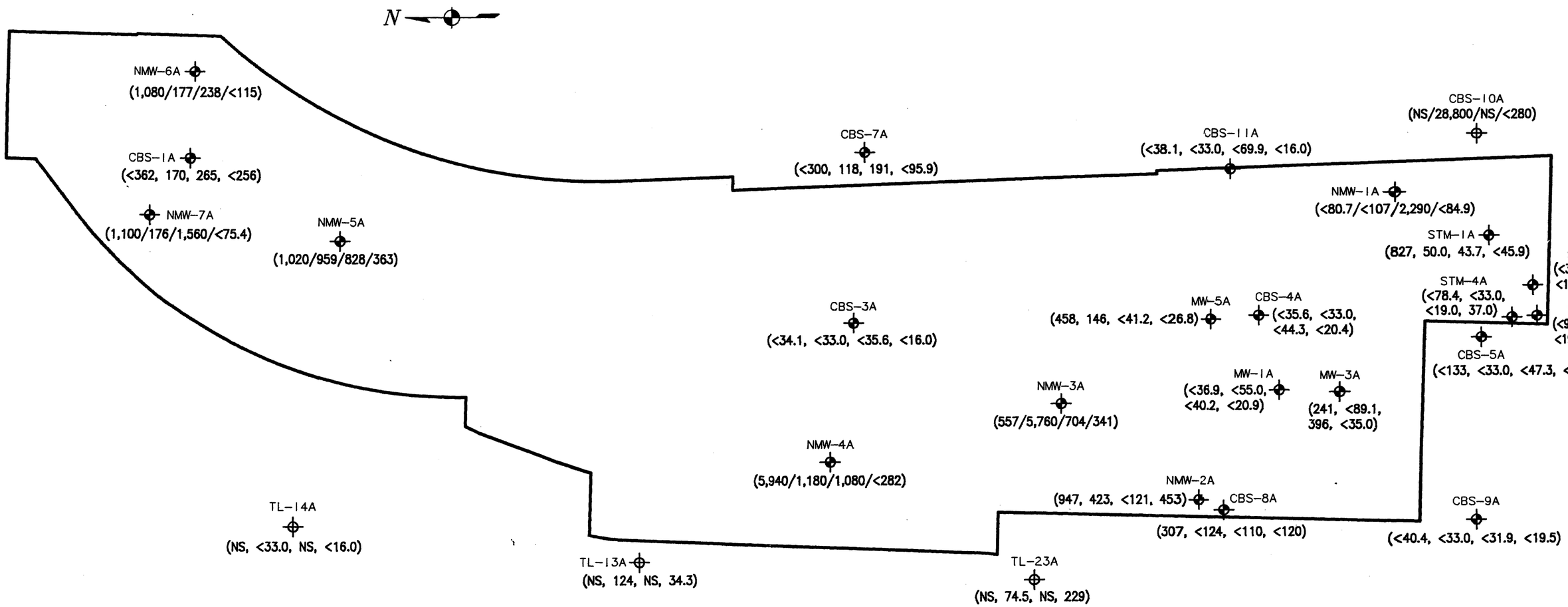
5.1.1 Aluminum

Aluminum was detected in samples collected from two background and three upgradient wells during the first quarter. During the fourth quarter, aluminum was detected in samples collected from three background and three upgradient wells. The highest concentration of aluminum (28,800 µg/L) for all wells sampled during this investigation was detected in a sample collected during the second quarter from offsite and upgradient well CBS-10A.

Aluminum was detected in samples collected from 11 onsite wells during the first quarter, 11 onsite wells during the second quarter, 11 onsite wells during the third quarter, and 5 onsite wells during the fourth quarter. Concentrations exceeded the proposed SMCL of 50 µg/L (see Table GW-8) for aluminum in all the wells in which aluminum was detected during the first, second, and fourth quarters. Ten of the 11 samples from the third quarter exceeded the proposed SMCL. The highest onsite concentrations of aluminum were detected in groundwater samples collected from NMW-4A (5,940 µg/L during the first quarter), NMW-3A (5,760 µg/L during the second quarter), NMW-1A (2,290 µg/L during the third quarter), and NMW-2A (453 µg/L during the fourth quarter). Concentrations of aluminum detected in onsite and upgradient wells are shown in Figure GW-25.

Aluminum was detected in samples collected from wells at locations throughout the site and in background and upgradient wells. Concentrations of aluminum detected in onsite wells were within the range of concentrations detected in background wells and mostly within the range of concentrations naturally occurring in groundwater (see Table GW-9). No wells exceeded the range of background well concentrations.

Aluminum is a metal that is a major constituent of the clay minerals. Naturally occurring concentrations of dissolved aluminum in groundwater typically range from <5.0 to 1,000 µg/L (Dragun 1988). Higher concentrations of aluminum are likely to be detected in wells for which total metals analyses results are obtained rather



LEGEND

NMW-3A (557/5,760/704/341) — TOTAL ALUMINUM DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.

TL-12A (NS, <33.0, NS, 21.7) — TOTAL ALUMINUM DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL ALUMINUM CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK070

FIGURE GW-25

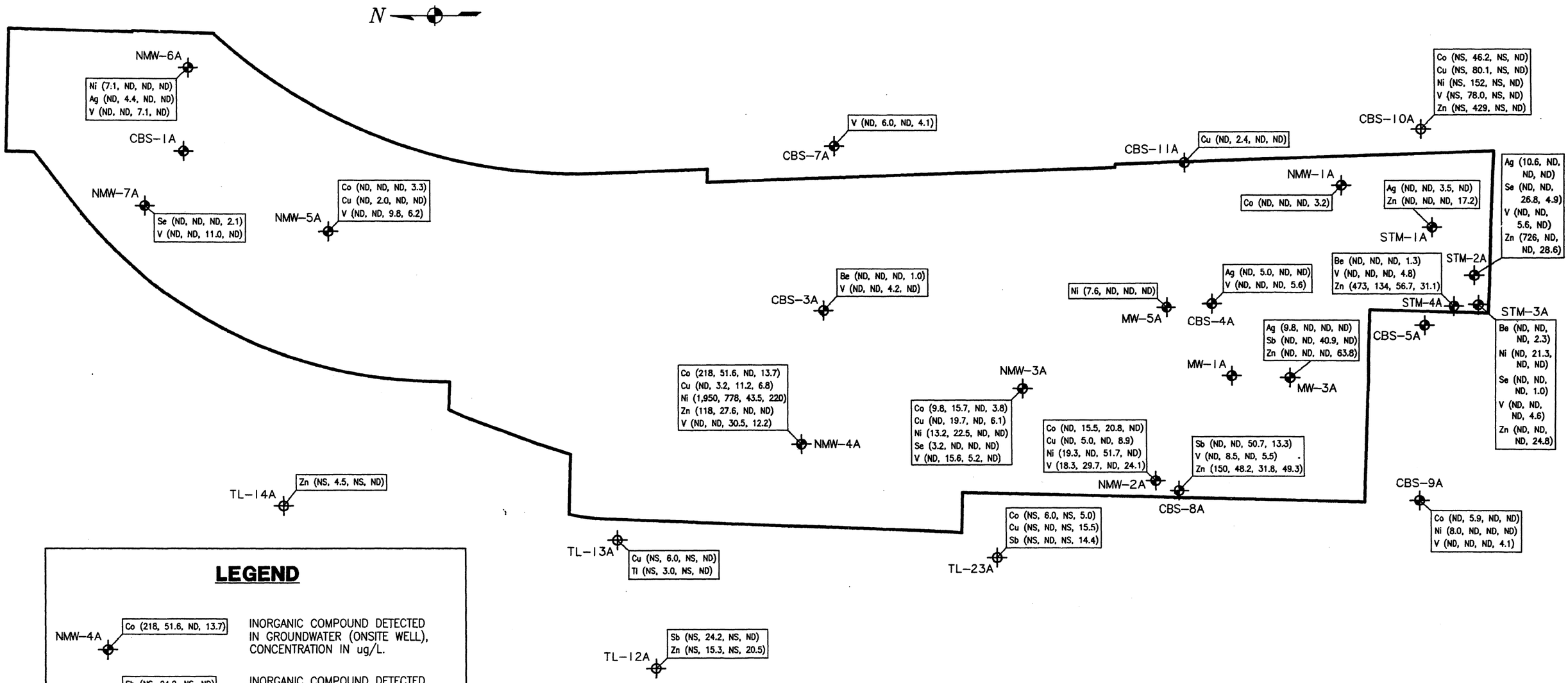
than dissolved metals. These higher aluminum concentrations would be expected due to the abundance of aluminum in clay minerals and other naturally occurring mineral species that are likely to be present as suspended solids in groundwater.

Based on the widespread distribution of aluminum in samples collected from onsite, background, and upgradient wells, the presence of suspended solids that likely were composed of clay minerals, and the analysis for total metals (vs dissolved metals), it appears likely that much of the aluminum detected in groundwater collected from onsite wells is naturally occurring in suspended sediment. Section 5.1.26 describes the filtered vs unfiltered results that are the basis for this conclusion.

5.1.2 Antimony

Antimony was not detected in samples collected from background wells during the second and fourth quarters. Antimony was detected in two upgradient wells: TL-12A at a concentration of 24.2 μg/L during the second quarter, and TL-23A at a concentration of 14.4 μg/L during the fourth quarter. Antimony was not detected in samples collected from onsite wells during the first and second quarters. Antimony was detected in onsite wells CBS-8A and MW-3A at concentrations of 50.7 and 40.9 μg/L, respectively, during the third quarter. Antimony was also detected in CBS-8A during the fourth quarter at a concentration of 13.3 μg/L. The proposed MCL for antimony of 5 or 10 μg/L was exceeded for all wells in which antimony was detected. The detection limits for antimony exceeded the proposed MCL for all groundwater samples collected during all quarters. Concentrations of total antimony detected in samples collected from onsite and upgradient wells are shown in Figure GW-26.

Antimony is a semi-metal or metalloid that occurs as a trace element in groundwater. Naturally occurring concentrations of antimony in groundwater are expected to be <100 μg/L (Freeze and Cherry 1979).



LEGEND

NMW-4A — Co (218, 51.6, ND, 13.7) — INORGANIC COMPOUND DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.

TL-12A — Sb (NS, 24.2, NS, ND) — INORGANIC COMPOUND DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

ND = NOT DETECTED.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

NOTES:

1. ONLY THOSE ONSITE AND UPGRADIENT WELLS THAT WERE SAMPLED ARE SHOWN.
2. ALL WELLS SHOWN ARE SCREENED IN THE UPPER AQUIFER.
3. WELLS NMW-3B, NMW-3C, NMW-5B, AND NMW-5C ARE NOT SHOWN.
4. INORGANICS PLOTTED ON THIS MAP INCLUDE Ag, Co, Cu, Ni, Sb, Se, Tl, V, AND Zn. THESE ELEMENTS WERE GROUPED ON ONE MAP BECAUSE DETECTION OF EACH ELEMENT OCCURRED IN FOUR OR LESS ONSITE WELLS.

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SOUTH TACOMA FIELD
TACOMA, WA

TOTAL CONCENTRATIONS OF OTHER INORGANICS DETECTED IN GROUNDWATER

916055.08/P2SK079

FIGURE GW-26

5.1.3 Arsenic

Arsenic was detected at a concentration of 9.0 μg/L in one background well, CBS-9A, sampled during the second quarter. During the fourth quarter, arsenic was detected in background wells CBS-9A and TL-16A at concentrations of 8.7 and 6.1 μg/L, respectively. Arsenic was detected at a concentration of 7.8 μg/L in one offsite and upgradient well, CBS-10A, sampled during the second quarter, and in one upgradient well, TL-23A, at a concentration of 16.7 μg/L during the fourth quarter.

Arsenic was detected in 1 onsite well (NMW-2A) sampled during the first quarter, 10 wells sampled during the second quarter, 10 wells sampled during the third quarter, and 11 wells sampled during the fourth quarter. Only one onsite well (NMW-2A) sample exceeded (50.9 μg/L) the MCL for arsenic (50 μg/L) during the first quarter. Concentrations of arsenic detected in samples collected from all onsite wells during the second, third, and fourth quarters were below the MCL for arsenic. Concentrations of total arsenic detected in groundwater samples collected from onsite and upgradient wells are shown in Figure GW-27.

Arsenic is a semi-metal or metalloid that occurs as a trace element in groundwater at concentrations typically <100 μg/L (Freeze and Cherry 1979). Concentrations of arsenic are usually expected to range from <1.0 to 30 μg/L, but extreme values of naturally occurring arsenic could be as much as 4,000 μg/L (Dragun 1988).

5.1.4 Barium

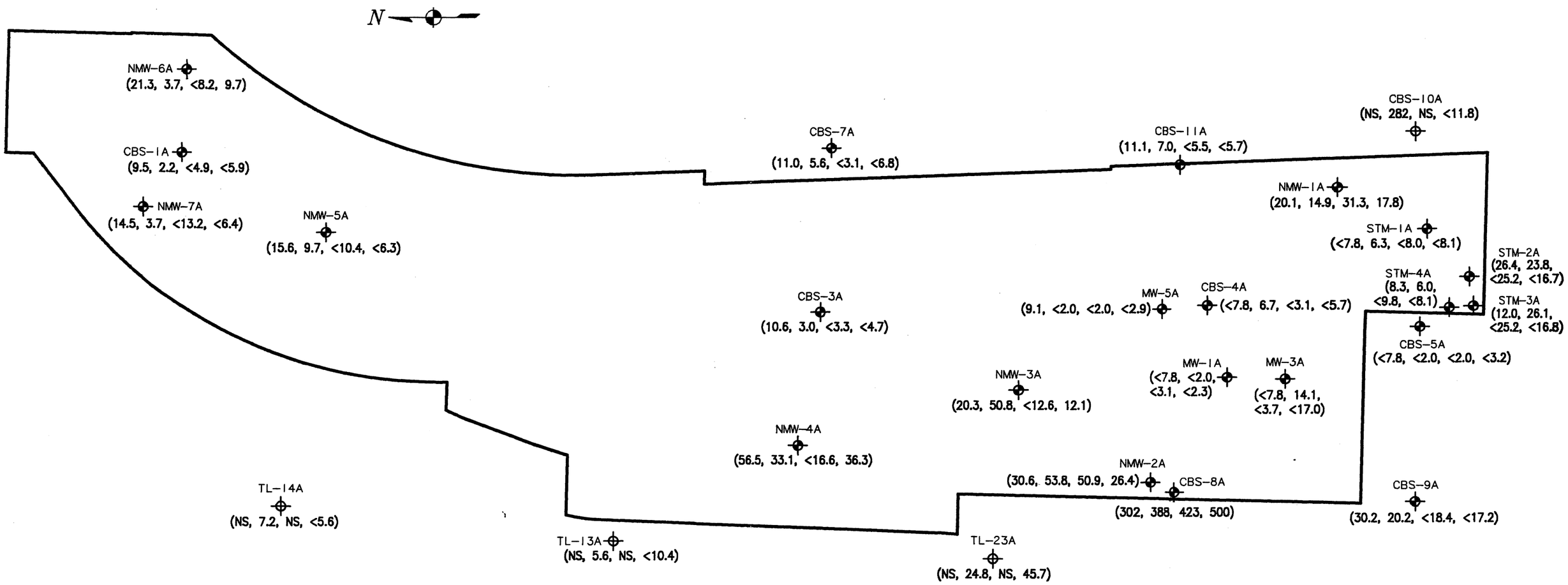
Barium was detected in samples collected from four background wells and five upgradient wells during the second quarter, and from two background wells and one upgradient well during the fourth quarter. Barium was detected in samples collected from 21 onsite wells during the first quarter, 23 onsite wells during the second quarter, 3 onsite wells during the third quarter, and 10 onsite wells during

the fourth quarter. Barium did not exceed the current MCL of 1,000 μg/L, the proposed MCL of 2,000 μg/L, or the proposed MCLG of 2,000 μg/L in any of the samples collected from onsite wells during the four quarters of sampling (see Table GW-8). Concentrations of total barium detected in groundwater samples collected from onsite and upgradient wells are shown in Figure GW-28.

Barium is an alkaline earth metal that is naturally occurring in groundwater. Concentrations of barium detected in samples collected from onsite wells were within the range of naturally occurring barium concentrations in groundwater (see Table GW-9). Barium concentrations in one onsite well, CBS-8A, exceeded the upper limit of the range of concentrations detected in samples collected from background wells. Barium was detected at a concentration of 282 μg/L in a sample collected during the second quarter from upgradient well CBS-10A. This concentration exceeded the upper limit of the background well concentration range (i.e., 58.5 μg/L).

5.1.5 Beryllium

Beryllium was not detected in samples collected from background or upgradient wells. However, the detection limit for beryllium (1.1 μg/L) exceeded the proposed MCL of 1 μg/L for samples collected during the first quarter; therefore, comparison of groundwater quality with that criteria is not possible. Beryllium was not detected at a detection limit of 1.0 μg/L in samples collected from onsite wells during the second and third quarters. Beryllium was detected in three onsite wells, CBS-3A, STM-3A, and STM-4A, at concentrations of 1.0, 2.3, and 1.3 μg/L, respectively, during the fourth quarter. These concentrations exceeded the proposed MCL. Detection limits for beryllium during all four quarters exceeded the proposed MCLG (0 μg/L) for beryllium (see Table GW-8). Concentrations of beryllium detected in samples collected from onsite wells are shown in Figure GW-26.



LEGEND

NMW-3A (20.3, 50.8, <12.6, 12.1)	TOTAL BARIUM DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS, 16.8, NS, <10.9)	TOTAL BARIUM DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.
	NS = NOT SAMPLED.
	NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

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SOUTH TACOMA FIELD
TACOMA, WA

TOTAL BARIUM CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK072

FIGURE GW-28

Beryllium is an alkaline earth metal that is naturally occurring in groundwater. Naturally occurring beryllium typically is present in groundwater at concentrations <10 μg/L (Dragun 1988).

5.1.6 Boron

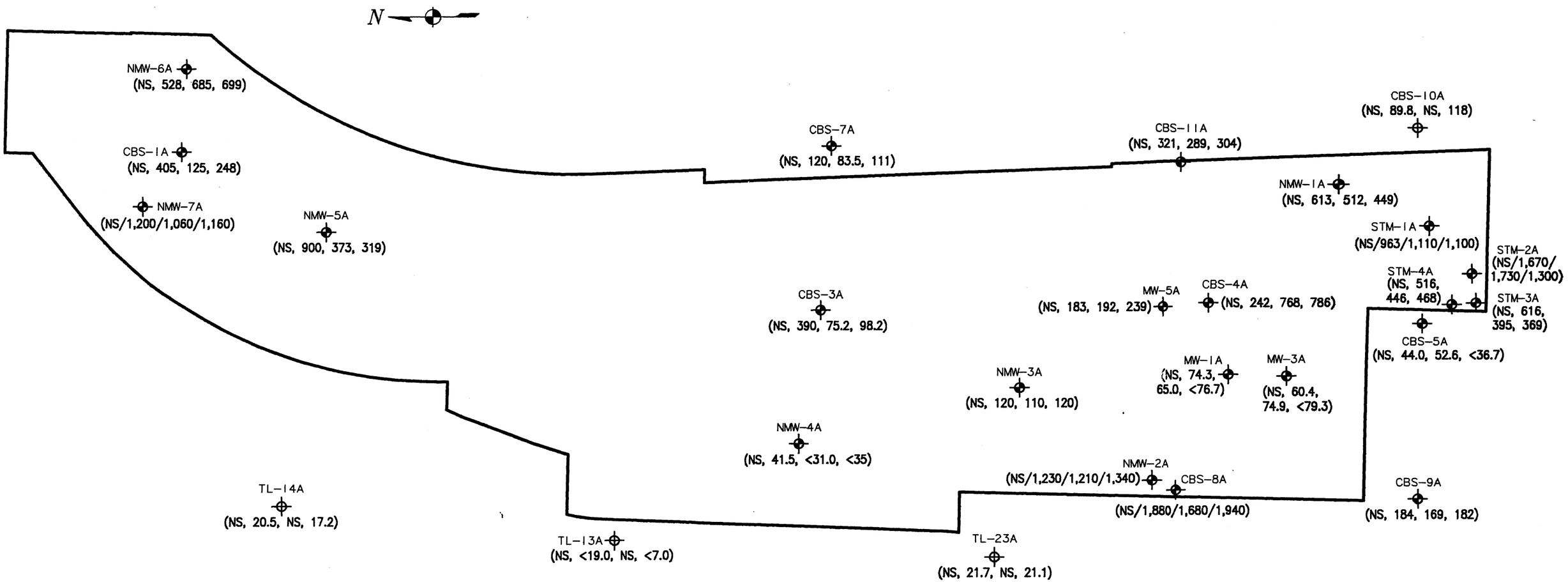
Boron was detected in samples collected from four background wells and three upgradient wells during both the second and fourth quarters. Concentrations of boron detected in samples collected from background wells during the second quarter ranged from undetected at <19.0 to 184 μg/L.

Boron was detected in samples collected from all 26 onsite wells during the second quarter. During the third quarter, boron was detected in 22 onsite wells. Boron was detected in samples collected from 18 onsite wells during the fourth quarter. Boron analyses were not performed on samples collected from onsite wells during the first quarter. The highest concentration of boron (1,940 μg/L) was detected in a sample collected during the fourth quarter from onsite well CBS-8A. MCLs, ALs, MCLGs, and SMCLs do not exist and have not been proposed for boron. Concentrations of boron detected in samples collected from onsite and upgradient wells are shown in Figure GW-29.

Boron is a semi-metal or metalloid that occurs naturally in groundwater. Typical concentrations of boron in groundwater commonly range from 20 to 1,000 μg/L, although extreme concentrations of as much as 5,000 μg/L of naturally occurring boron have been reported (Dragun 1988).

5.1.7 Cadmium

Cadmium was not detected in samples collected from background, upgradient, or onsite wells during the groundwater investigation. Cadmium is a metallic element



LEGEND

NMW-3A (NS, 120, 110, 120)	TOTAL BORON DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS, <19.0, NS, <7.0)	TOTAL BORON DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.
	NS = NOT SAMPLED.
	NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

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SOUTH TACOMA FIELD
TACOMA, WA

TOTAL BORON CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK073

FIGURE GW-29

that is naturally occurring in groundwater. Typical concentrations of cadmium in groundwater are expected to be <1.0 μg/L (Dragun 1988).

5.1.8 Calcium

Calcium was detected in samples collected from all background and upgradient wells during the second and fourth quarters, and all onsite wells during all four quarters. MCLs, ALs, MCLGs, and SMCLs do not exist and have not been proposed for calcium. The range of calcium concentrations detected in samples collected from background and onsite wells is provided in Table GW-9.

Calcium is an alkaline earth metal and is a major component of the solutes that are naturally occurring in groundwater. Naturally occurring concentrations of calcium are expected to range from 1,000 to 150,000 μg/L (Dragun 1988). Concentrations of calcium detected in samples collected from onsite wells were well within the range of naturally occurring concentrations expected to be detected in groundwater.

5.1.9 Chromium (Total)

Chromium was detected in samples collected from one background well and two upgradient wells during the second quarter. Concentrations of chromium in background wells ranged from <5.0 to 9.2 μg/L in well TL-16A. Chromium was detected at a concentration of 48.5 μg/L in offsite and upgradient well CBS-10 during the second quarter. This concentration is significantly higher than concentrations detected in samples collected from onsite and background wells and naturally occurring concentrations in groundwater. Chromium was not detected in samples collected from background or upgradient wells during the fourth quarter.

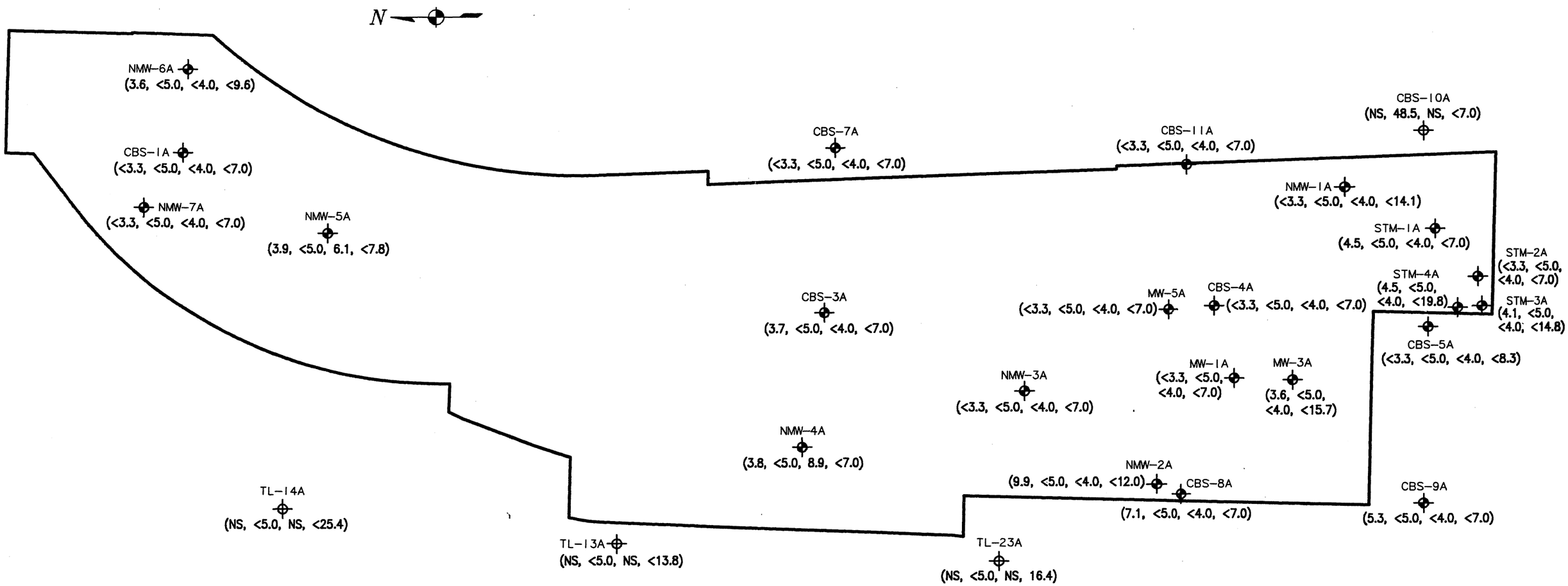
Chromium was detected in samples collected from 12 onsite wells during the first quarter, and from 2 onsite wells during the third quarter. Chromium was not detected in samples collected from onsite wells during the second and fourth quarters. The highest concentration of chromium (9.9 μg/L) was detected in a sample collected during the first quarter from onsite well NMW-2A. Chromium concentrations detected in samples collected from onsite wells did not exceed the MCL of 100 μg/L or the MCLG of 100 μg/L during any quarter. Concentrations of total chromium detected in groundwater samples collected from onsite and upgradient wells are shown in Figure GW-30.

Chromium is a transition metal that occurs naturally in groundwater at concentrations ranging from <1.0 μg/L to approximately 5.0 μg/L (Dragun 1988). Hem (1989) reports that concentrations of chromium are commonly <10 μg/L in natural waters that have not been affected by waste disposal.

5.1.10 Cobalt

Cobalt was detected in samples collected from two background wells and two upgradient wells during the second quarter. During the fourth quarter, cobalt was detected in samples collected from one background well and from one upgradient well. Concentrations of cobalt in background wells ranged from <3 μg/L to 16.1 μg/L. Cobalt was detected at a concentration of 46.2 μg/L in a sample collected from offsite and upgradient well CBS-10A during the second quarter. This concentration is higher than naturally occurring concentrations and concentrations detected in samples collected from background wells.

Cobalt was detected in samples collected from two onsite wells during the first quarter, five onsite wells during the second quarter, one onsite well during the third quarter, and four onsite wells during the fourth quarter. The highest concentrations of cobalt detected in the first, second, and fourth quarters were in onsite well NMW-4A (i.e., 218 μg/L in the first quarter, 51.6 μg/L in the second quarter, and



LEGEND

NMW-3A (<3.3, <5.0, <4.0, <7.0) — TOTAL CHROMIUM DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.

TL-12A (NS, 5.6, NS, <10.8) — TOTAL CHROMIUM DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL CHROMIUM CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK074

FIGURE GW-30

13.7 μg/L in the fourth quarter). During the third quarter, cobalt was detected in onsite well NMW-2A at a concentration of 20.8 μg/L. MCLs, ALs, MCLGs, and SMCLs do not exist and have not been proposed for cobalt. Concentrations of total cobalt detected in samples collected from onsite and upgradient wells are shown in Figure GW-26.

Cobalt is a transition metal that occurs naturally in groundwater at concentrations usually <10 μg/L (Dragun 1988).

5.1.11 Copper

Copper was detected in samples collected from two background wells and two upgradient wells during the second quarter, and from one background well and one upgradient well during the fourth quarter. Concentrations of copper detected in background wells during the second quarter ranged from <1.0 to 44.7 μg/L. During the fourth quarter, copper was detected at a concentration of 112 μg/L in background well TL-16. The highest detected concentration (80.1 μg/L) of copper was in the sample collected from offsite, upgradient well CBS-10A during the second quarter.

Copper was not detected in samples collected from onsite wells during the first quarter, but copper was detected in six onsite wells during the second quarter. Copper was detected in one onsite well during the third quarter and in three onsite wells during the fourth quarter. Copper did not exceed the AL of 1,300 μg/L, the MCLG of 1,300 μg/L, or the SMCL of 1,000 μg/L in samples collected from onsite wells during any quarter. Concentrations of total copper detected in samples collected from onsite and upgradient wells are shown in Figure GW-26.

Copper is a metallic element that commonly occurs in groundwater at concentrations ranging from <1.0 to 30 μg/L (Dragun 1988). Concentrations of copper

detected in onsite wells did not exceed the upper limits detected in samples collected from background wells or naturally occurring in groundwater.

5.1.12 Cyanide

Cyanide was not detected in samples collected from the background or upgradient wells during the second and fourth quarters. Cyanide was detected in samples collected from three onsite wells (NMW-1A, NMW-5A, and STM-1A) during the second, third, and fourth quarters. Cyanide was also detected in onsite well CBS-4A during the third and fourth quarters. Cyanide was also detected in onsite well NMW-2A during the fourth quarter. Detected concentrations ranged from 11.2 to 80 μg/L (less than the proposed MCL and MCLG of 200 μg/L).

5.1.13 Iron

Iron was detected in samples collected from five background wells and four upgradient wells during the second quarter, and from four background wells and five upgradient wells during the fourth quarter. Detected concentrations of iron in background well samples ranged from 13.6 to 28,800 μg/L. Iron was detected at a concentration of 45,900 μg/L in a sample collected from offsite and upgradient well CBS-10A during the second quarter. This concentration was the highest iron concentration detected among all the wells sampled during this investigation. A sample collected from CBS-10A during the second quarter contained $<$10,000 μg/L total suspended solids.

Iron was detected in 17 onsite wells during the first quarter, 17 wells during the second quarter, 14 wells during the third quarter, and 14 wells during the fourth quarter. Concentrations of iron exceeded the SMCL of 300 μg/L in 16 onsite wells during the first quarter, 10 onsite wells during the second quarter, 14 onsite wells during the third quarter, and 9 onsite wells during the fourth quarter.

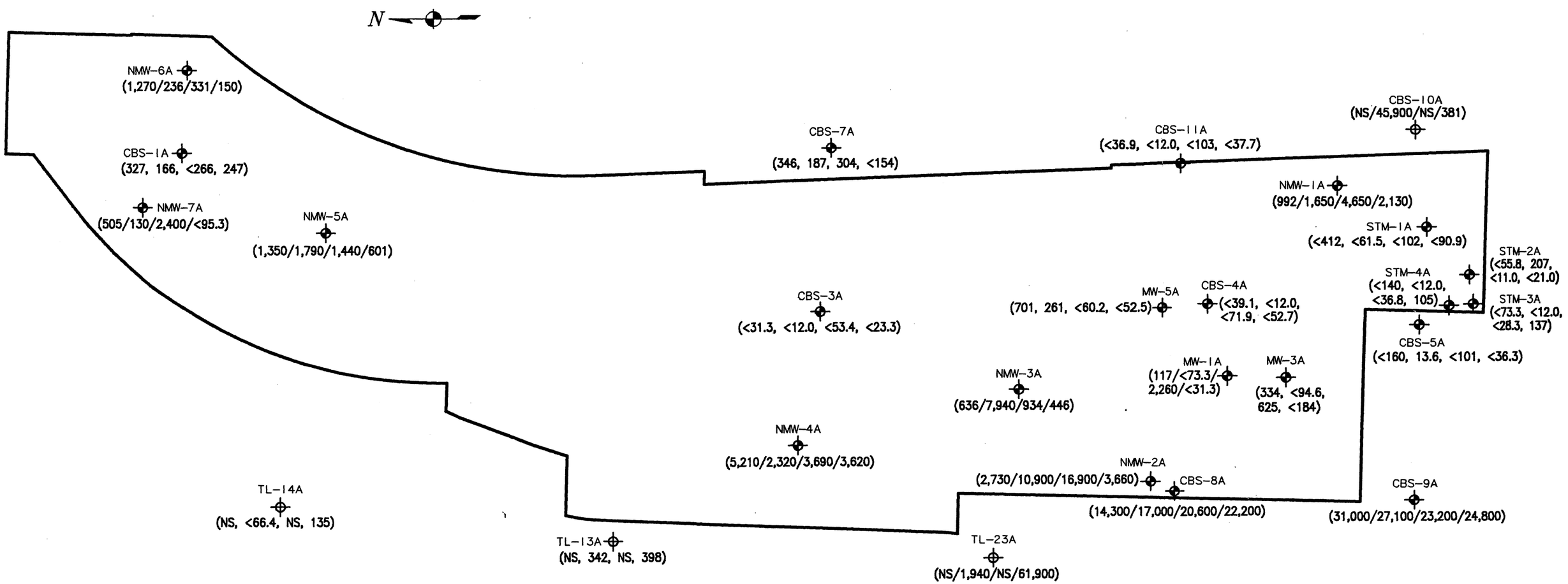
Concentrations of total iron detected in samples collected from onsite and upgradient wells are shown in Figure GW-31.

Iron is a transition metal that occurs naturally in groundwater at concentrations ranging from 10 to 10,000 μg/L (Dragun 1988). Samples collected from onsite wells CBS-8A and CBS-9A during the second, third, and fourth quarters exceeded the upper limit of expected naturally occurring concentrations of iron. In addition to CBS-8A and CBS-9A, samples collected from NMW-2A during the second and third quarters also exceeded the naturally occurring concentrations of iron. Samples collected from wells CBS-8A and CBS-9A contained 43,000 μg/L and 13,000 μg/L total suspended solids, respectively, during the second quarter and 15,000 μg/L and 62,000 μg/L of total suspended solids, respectively, during the fourth quarter. It is likely that some of the higher iron concentrations can be attributed to the presence of suspended solids in groundwater (see Section 5.1.26).

In a study of groundwater quality conducted for more than 100 wells in the Puget Sound region (Turney 1986), the USGS found that approximately 14 percent of the samples analyzed exceeded the SMCL for iron. In the USGS study, high iron concentrations in the Puget Sound region are attributed to naturally occurring iron concentrations in groundwater (Turney 1986).

5.1.14 Lead

Lead was detected in samples collected from two background wells and three upgradient wells during the second quarter, and from three background wells and one upgradient well during the fourth quarter. Concentrations of lead in background wells ranged from <4.4 to 33.4 μg/L. The highest concentration (42.0 μg/L) of lead was detected in a sample collected from offsite and upgradient well CBS-10A during the second quarter.



LEGEND

NMW-3A (636/7,940/934/446)	TOTAL IRON DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS, 162, NS, 134)	TOTAL IRON DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.
	NS = NOT SAMPLED.
	NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL IRON CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK075

FIGURE GW-21

Lead was detected in 1 onsite well during the first quarter, 11 onsite wells during the second quarter, 1 onsite well during the third quarter, and 12 onsite wells during the fourth quarter. Concentrations of lead detected in onsite wells exceeded the AL of 15 μg/L in one well, CBS-8A, during the first, second, and fourth quarters. Lead concentrations in CBS-8A for the first, second, and fourth quarters were 58.9, 25.2, and 16.5 μg/L, respectively. The detection limit for samples from all wells exceeded the MCLG of 0 μg/L for lead during all sampling events. Concentrations of total lead detected in samples collected from onsite and upgradient wells are shown in Figure GW-32.

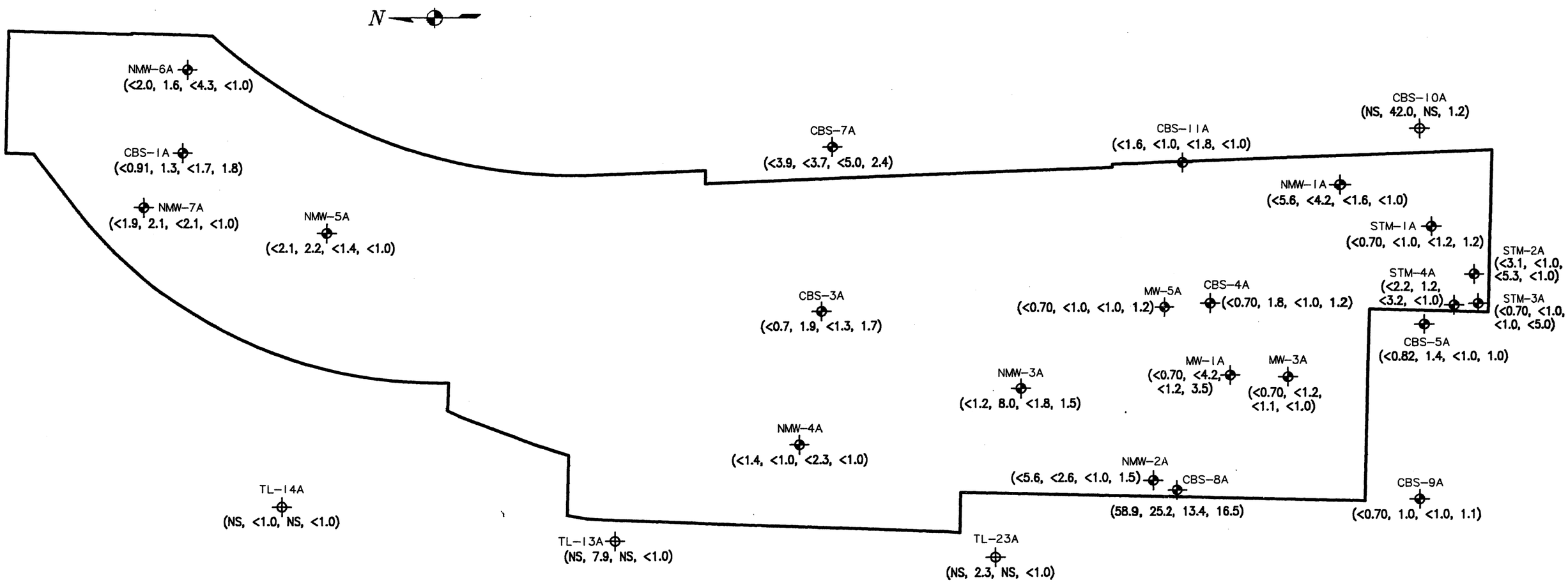
Lead is a heavy metal that occurs naturally in groundwater at concentrations usually <15 μg/L (Dragun 1988).

5.1.15 Magnesium

Magnesium was detected in samples collected from all background and upgradient wells during the second and fourth quarters. Concentrations of magnesium in background wells ranged from 6,440 to 35,100 μg/L. Concentrations of magnesium detected in upgradient wells were within the range of naturally occurring concentrations.

Magnesium was detected in all onsite wells during all four sampling events. MCLs, ALs, MCLGs, and SMCLs do not exist for magnesium. The highest concentrations of magnesium detected in onsite wells during the first, second, third, and fourth quarters were 70,800 μg/L in STM-2A, 76,500 μg/L in CBS-8A, 81,800 μg/L in CBS-8A, and 93,800 μg/L in CBS-8A, respectively.

Magnesium is an alkaline earth metal and is one of the major dissolved constituents that occurs naturally in groundwater. Naturally occurring concentrations of dissolved magnesium in groundwater are expected to range from 1,000 to 50,000 μg/L (Dragun 1988).



LEGEND

NMW-3A (<1.2, 8.0, <1.8, 1.5)	TOTAL LEAD DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS, <1.0, NS, <1.0)	TOTAL LEAD DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL LEAD CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK076

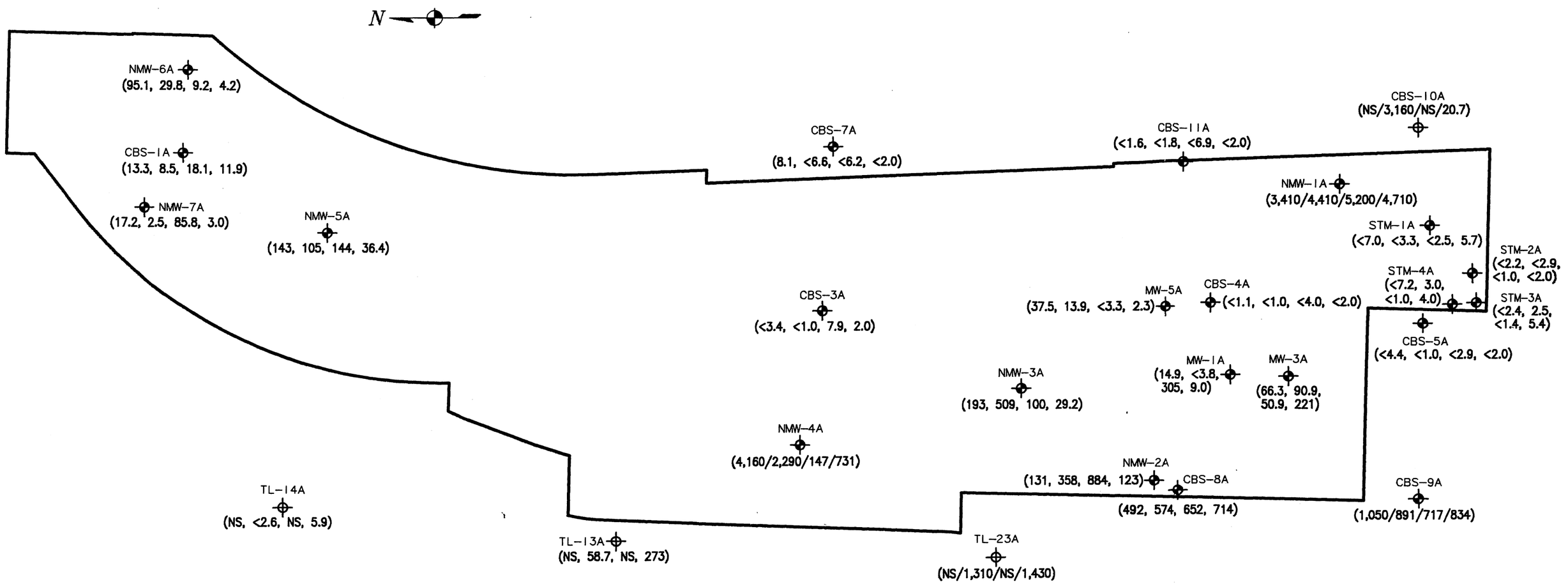
FIGURE GW-32

5.1.16 Manganese

Manganese was detected in samples collected from four background wells and four upgradient wells during the second quarter, and from four background and five upgradient wells during the fourth quarter. Concentrations in background wells ranged from <1.0 μg/L to 896 μg/L. Concentrations of manganese detected in samples collected from two upgradient wells, CBS-10A and TL-23A, exceeded the naturally occurring concentration range during the second quarter. Concentrations of manganese detected in samples collected from CBS-10A and TL-23A were 3,160 μg/L and 1,310 μg/L, respectively. During the fourth quarter, a concentration of manganese (1,430 μg/L) in upgradient well TL-23A exceeded the naturally occurring concentration range.

Manganese was detected in samples collected from 18 onsite wells during the first quarter, 18 onsite wells during the second quarter, 17 onsite wells during the third quarter, and 21 onsite wells during the fourth quarter. The SMCL for manganese of 50 μg/L was exceeded in 13 wells during the first quarter, 12 wells during the second quarter, 14 wells during the third quarter, and 10 wells during the fourth quarter. The highest concentrations of manganese detected in onsite wells during the first, second, third, and fourth quarters were 4,160 μg/L in NMW-4A, 4,410 μg/L in NMW-1A, 5,200 μg/L in NMW-1A, and 4,710 μg/L in NMW-1A, respectively. Concentrations of total manganese detected in samples collected from onsite and upgradient wells are shown in Figure GW-33.

Manganese is a transition metal that occurs naturally in groundwater at concentrations typically ranging from <1 to 1,000 μg/L (Dragun 1988). In a study of groundwater quality in more than 100 wells in the Puget Sound region (Turney 1981), the USGS found that approximately 40 percent of the samples analyzed exceeded the SMCL for manganese. The USGS study also stated that high manganese concentrations in the Puget Sound region are probably naturally occurring.



LEGEND

NMW-3A (193, 509, 100, 29.2)	TOTAL MANGANESE DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS, 151, NS, 190)	TOTAL MANGANESE DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.
	NS = NOT SAMPLED.
	NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL MANGANESE CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK078

FIGURE GW-33

5.1.17 Mercury

Mercury was not detected in samples collected from background or upgradient wells during the second and fourth quarters, or onsite wells during any quarter. The detection limits for mercury did not exceed the current MCL and MCLG of 2 μg/L in any samples collected from onsite wells.

Mercury is a heavy metal that occurs naturally in groundwater at concentrations typically <1.0 μg/L (Dragun 1988).

5.1.18 Nickel

Nickel was not detected in samples collected from background wells during the second and fourth quarters. Nickel was detected in one offsite and upgradient well sampled during the second quarter (i.e., 152 μg/L at CBS-10A).

Nickel was detected in samples collected from six onsite wells during the first quarter, three onsite wells during the second quarter, two onsite wells during the third quarter, and one onsite well during the fourth quarter. Concentrations of nickel exceeded the proposed MCL and MCLG of 100 μg/L in one onsite well, NMW-4A, during the first, second, and fourth quarters. Concentrations of nickel detected in samples collected from NMW-4A during the first, second, and fourth quarters were 1,950 μg/L, 778 μg/L, and 220 μg/L, respectively. Concentrations of total nickel detected in samples collected from onsite and upgradient wells are shown in Figure GW-26.

Nickel is a transition metal that occurs naturally in groundwater, typically in concentrations ranging from <10 to 50 μg/L (Dragun 1988). NMW-4A was the only onsite well in which nickel concentrations exceeded the naturally occurring concentration range. The sample collected from offsite and upgradient well

CBS-10A during the second quarter also exceeded (152 μg/L) the naturally occurring concentration range (<15.0-<19.9 μg/L) for nickel.

5.1.19 Potassium

Potassium was detected in samples collected from five background wells and three upgradient wells during the second quarter. During the fourth quarter, potassium was detected in five background wells and two upgradient wells. Concentrations of potassium detected in samples collected from background wells ranged from 1,080 to 8,280 μg/L.

Potassium was detected in samples collected from 13 onsite wells during the first quarter, 21 onsite wells during the second quarter, 15 onsite wells during the third quarter, and 23 onsite wells during the fourth quarter. MCLs, ALs, MCLGs, and SMCLs do not exist for potassium. The highest concentrations of potassium detected in onsite wells were 5,280 μg/L in STM-1A during the first quarter, 6,860 μg/L in CBS-8A during the second quarter, 6,570 μg/L in CBS-8A during the third quarter, and 6,940 μg/L in CBS-8A during the fourth quarter.

Potassium is an alkali metal that occurs naturally in groundwater at concentrations ranging from 1,000 to 10,000 μg/L (Dragun 1988). Concentrations of potassium detected in samples collected from onsite wells were well within the range of naturally occurring potassium concentrations in groundwater.

5.1.20 Selenium

Selenium was not detected in background or upgradient wells during the second and fourth quarters. Selenium was detected in one onsite well, NMW-3A, during the first quarter at a concentration of 3.2 μg/L (see Figure GW-26). Selenium was

not detected in onsite wells during the second quarter. During the third quarter, selenium was detected in one onsite well, STM-2A, at a concentration of 26.8 μg/L. Selenium was detected in three onsite wells, NMW-7A, STM-2A, and STM-3A at concentrations of 2.1, 4.9, and 1.0 μg/L, respectively. Selenium concentrations did not exceed the MCL and MCLG of 50 μg/L during any quarter.

Selenium is a nonmetallic element that occurs naturally in groundwater at concentrations typically ranging from <1.0 to 10 μg/L. The selenium concentration detected in a sample collected from onsite well STM-2A during the third quarter exceeded the range of naturally occurring concentrations.

5.1.21 Silver

Silver was not detected in samples collected from background or upgradient wells during the second and fourth quarters.

Silver was detected in samples collected from two onsite wells (MW-3A and STM-2A) during the first quarter, two onsite wells (NMW-6A and CBS-4A) during the second quarter, and one onsite well (STM-1A) during the third quarter. Silver was not detected in samples collected from onsite wells during the fourth quarter. The highest concentrations of silver detected in onsite wells were 10.6 μg/L in STM-2A during the first quarter and 5.0 μg/L in CBS-4A during the second quarter. The concentration in STM-1A was 3.5 μg/L during the third quarter. Concentrations of silver detected in samples collected from onsite wells did not exceed the proposed SMCL of 100 μg/L during any quarter. Concentrations of total silver detected in samples collected from onsite wells are shown in Figure GW-26.

Silver is a metal that occurs naturally in groundwater. Naturally occurring concentrations of silver in groundwater are usually expected to be <5.0 μg/L (Dragun 1988).

5.1.22 Sodium

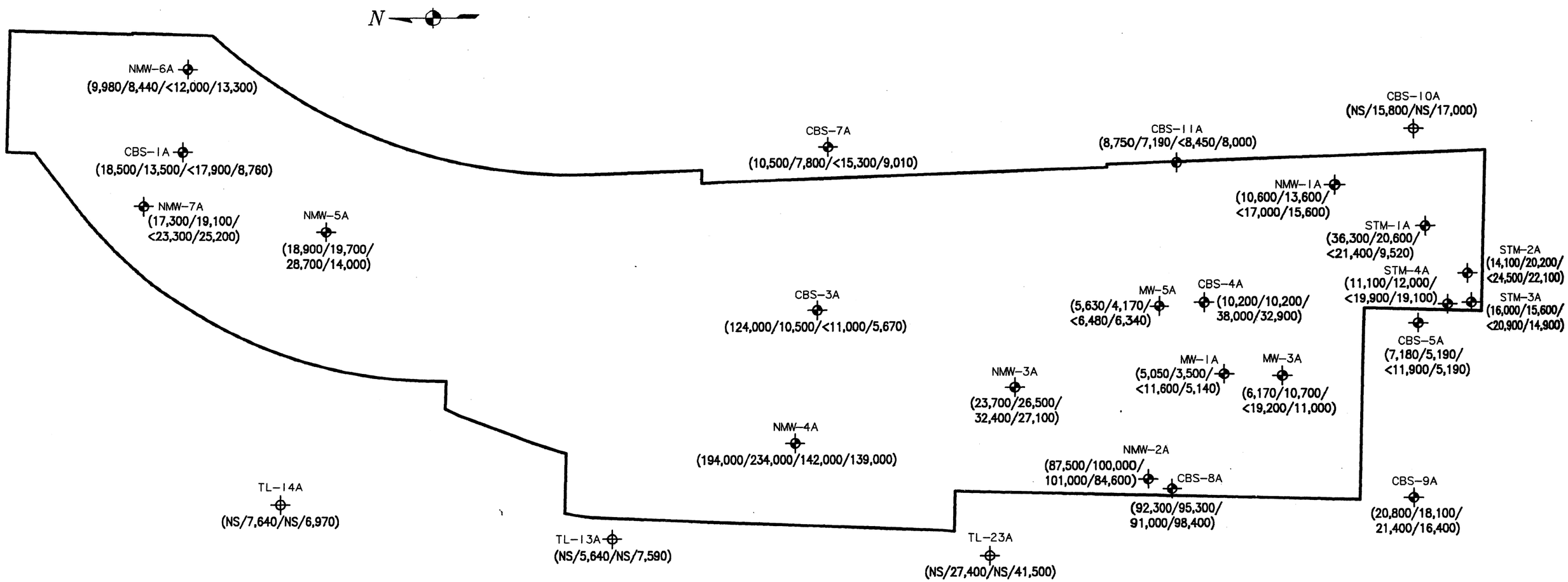
Sodium was detected in samples collected from all background and upgradient wells during the second and fourth quarters, and all onsite wells during the first, second, and fourth quarters. Sodium was detected in samples collected from seven onsite wells during the third quarter. Concentrations of sodium detected in background wells during the second and fourth quarters ranged from 5,190 to 514,000 µg/L. Concentrations of sodium in upgradient wells during the second quarter were within the concentration range of naturally occurring sodium in groundwater (see Table GW-9).

MCLs, ALs, MCLGs, and SMCLs do not exist and have not been proposed for sodium. The highest concentrations of sodium were detected in samples collected from onsite well NMW-4A (i.e., 194,000 µg/L during the first quarter, 234,000 µg/L during the second quarter, 142,000 µg/L during the third quarter, and 139,000 µg/L during the fourth quarter). Concentrations of total sodium detected in samples collected from onsite and upgradient wells are shown in Figure GW-34.

Sodium is an alkali metal that is one of the major dissolved constituents in naturally occurring groundwater. Sodium concentrations in groundwater typically range from 500 to 120,000 µg/L (Dragun 1988). In addition to onsite well NMW-4A, CBS-3A was the only other onsite well with a concentration greater than the typical range of naturally occurring sodium in groundwater. A concentration of 124,000 µg/L of sodium was detected in the sample collected from CBS-3A during the first quarter.

5.1.23 Thallium

Thallium was detected in samples collected from one background well and one upgradient well during the second quarter. During the fourth quarter, thallium was not detected in samples collected from background or upgradient wells. Background concentrations of thallium ranged from <1.0 to 2.2 µg/L during the second



LEGEND

NMW-3A (23,700/26,500/32,400/27,100)	TOTAL SODIUM DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.
TL-12A (NS/10,500/NS/9,110)	TOTAL SODIUM DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.
	NS = NOT SAMPLED.
	NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TOTAL SODIUM CONCENTRATIONS DETECTED IN GROUNDWATER

916055.08/P2SK080

FIGURE GW-34

quarter. Thallium was detected at a concentration of 3.0 μg/L in a sample collected from upgradient well TL-13A during the second quarter (see Figure GW-26).

Thallium was not detected in any samples collected from onsite wells during the four quarters of groundwater sampling. Because the detection limit for thallium exceeded both of the proposed MCLs of 2 μg/L and 1 μg/L during the first quarter, comparisons of water quality with these criteria are not possible. The detection limit did not exceed the proposed MCLs during the second, third, and fourth quarters. The detection limit exceeded the proposed MCLG of 0.5 μg/L for thallium during all four quarters.

Thallium is a metal that occurs naturally in groundwater at concentrations typically <100 μg/L (Freeze and Cherry 1979).

5.1.24 Vanadium

Vanadium was detected in samples collected from two background wells and one upgradient well during the second quarter. During the fourth quarter, vanadium was detected in two background wells, but was not detected in the upgradient wells. Concentrations of vanadium in background wells ranged from undetected at <6.0 to 36.5 μg/L. The highest concentration of vanadium (78.0 μg/L) was detected in a sample collected from offsite and upgradient well CBS-10A during the second quarter.

Vanadium was detected in samples collected from one onsite well during the first quarter, five onsite wells during the second quarter, eight onsite wells during the third quarter, and nine onsite wells during the fourth quarter. The highest concentrations of vanadium in onsite wells were detected in NMW-2A (i.e., 18.3 μg/L during the first quarter, 29.7 μg/L during the second quarter, and

24.1 μg/L during the fourth quarter). During the third quarter, the highest concentration of vanadium was detected in NMW-4A at 30.5 μg/L. MCLs, ALs, MCLGs, and SMCLs do not exist and have not been proposed for vanadium. Concentrations of vanadium detected in samples collected from onsite and upgradient wells are shown in Figure GW-26.

Vanadium is a transition metal that is naturally occurring in groundwater. Typical concentrations for naturally occurring vanadium in groundwater range from <1.0 to 10 μg/L (Dragun 1988).

5.1.25 Zinc

Zinc was detected in samples collected from two background wells and three upgradient wells during the second quarter. During the fourth quarter, zinc was detected in samples collected from one background and one upgradient well. Concentrations of zinc in samples collected from background wells ranged from undetected at <2.0 to 170 μg/L. The highest concentration of zinc detected in upgradient wells was 429 μg/L in CBS-10A during the second quarter.

Zinc was detected in samples collected from four onsite wells during the first quarter, four onsite wells during the second quarter, two onsite wells during the third quarter, and six onsite wells during the fourth quarter. The highest concentrations of zinc detected in onsite wells were 726 μg/L in STM-2A during the first quarter, 134 μg/L in STM-4A during the second quarter, 56.7 μg/L in STM-4A during the third quarter, and 63.8 μg/L in MW-3A during the fourth quarter. The relatively high concentrations of zinc in samples from STM-2A and STM-4A may be attributed to the use of galvanized steel as the blank casing material. Concentrations of zinc in onsite wells did not exceed the SMCL of 5,000 μg/L for zinc during any quarter. Concentrations of zinc detected in onsite and upgradient wells are shown in Figure GW-26.

Zinc is a metal that occurs naturally in groundwater at typical concentrations ranging from <10 to 2,000 μg/L (Dragun 1988).

5.1.26 Filtered vs Unfiltered Metals

Field-filtered groundwater samples were collected from 12 wells during the third and fourth quarters. The filtered samples were collected in addition to unfiltered samples required by EPA's Work Plan (ICF 1990b). The filtered samples were analyzed for total metals so that comparisons could be made with unfiltered samples. These comparisons could then be used to assess whether metals were present as dissolved constituents in groundwater or as suspended solids. Although groundwater samples were analyzed for total suspended solids (TSS) during the second and fourth quarters, the high detection limit for TSS (10 mg/L) prevented a direct comparison of TSS with metal concentrations.

Field-filtered samples were collected for metals analyses from 12 wells in which relatively high metal concentrations were detected in first and second quarter samples. The trend of results from the 12 wells selected would then be considered representative of other wells at the site. Analytical results from the filtered analyses are presented in Section 7.0 of the Data Appendix (Kennedy/Jenks Consultants 1991).

Tables GW-11 and GW-12 list filtered and unfiltered results for aluminum, iron, and manganese for the third and fourth quarters. These metals were listed because they were expected to be detected at higher concentrations as suspended solids than the other metals. Tables GW-13 and GW-14 contain the same results as Tables GW-11 and GW-12, but the results are arranged to evaluate consistency of the results from the third quarter to the fourth quarter of sampling. Table GW-13 compares filtered samples from the third quarter to filtered samples from the fourth quarter. Table GW-14 compares unfiltered samples from the third quarter to unfiltered samples from the fourth quarter.

TABLE GW-11

COMPARISON OF FILTERED VS UNFILTERED METALS RESULTS (THIRD QUARTER)

Location No.	Well No.	Al (F) (µg/L)	Al (U) (µg/L)	Fe (F)	Fe (U)	Mn (F)	Mn (U)
1754	NMW-5A	<19.0	828	<13.7	1,440	2.8	144
1755	NMW-3B	<19.0	271	<14.5	<279	103	108
1756	NMW-3A	<19.0	704	<34.3	934	62.3	100
1757	NMW-3C	<19.0	<59.3	677	766	210	213
1758	NMW-2A	<75.5	<121	17,200	16,900	916	884
1759	NMW-4A	<177	1,080	2,580	3,690	143	147
1760	NMW-1A	<25.7	2,290	2,270	4,650	5,170	5,200
1764	CBS-4A	<20.6	<44.3	<15.4	<71.9	<1.0	<4.0
1768	CBS-8A	<75.2	<110	20,700	20,600	660	652
1769	CBS-9A	<27.9	<31.9	22,800	23,200	712	717
1775	MW-3A	<19.0	396	<32.4	625	19	50.9
1777	MW-5A	<19.0	<41.2	<26.8	<60.2	<1.0	<3.3

< denotes that analyte was not detected at the detection limit indicated following the less than sign.

TABLE GW-12

COMPARISON OF FILTERED VS UNFILTERED METALS RESULTS (FOURTH QUARTER)

Location No.	Well No.	Al (F)	Al (U)	Fe (F)	Fe (U)	Mn (F)	Mn (U)
1754	NMW-5A	<16.0	363	<14.0	601	5.7	36.4
1755	NMW-3B	<16.0	<217	<45.9	218	113	116
1756	NMW-3A	<16.0	341	<38.7	446	11.4	29.2
1757	NMW-3C	<16.0	<35.6	796	833	222	223
1758	NMW-2A	<133	453	2,050	3,660	117	123
1759	NMW-4A	<86.4	<282	3,130	3,620	708	731
1760	NMW-1A	<16.0	<84.9	2,010	2,130	4,640	4,710
1764	CBS-4A	<16.0	<20.4	<12.1	<52.7	<2.0	<2.0
1768	CBS-8A	<61.4	<120	22,200	22,200	716	714
1769	CBS-9A	<16.0	<19.5	24,600	24,800	838	834
1775	MW-3A	<16.0	<35.0	<126	<184	212	221
1777	MW-5A	<16.0	<26.8	<6.8	<52.5	<2.0	2.3

< denotes that analyte was not detected at the detection limit indicated following the less than sign.

TABLE GW-13

COMPARISON OF FILTERED RESULTS FOR ALUMINUM, IRON, AND MANGANESE (THIRD AND FOURTH QUARTERS)

Location No.	Well No.	Al (F) (3rd)	Al (F)(4th)	Fe (F) (3rd)	Fe (F) (4th)	Mn (F) (3rd)	Mn (F) (4th)
1754	NMW-5A	<19.0	<16.0	<13.7	<14.0	2.8	5.7
1755	NMW-3B	<19.0	<16.0	<14.5	<45.9	103	113
1756	NMW-3A	<19.0	<16.0	<34.3	<38.7	62.3	11.4
1757	NMW-3C	<19.0	<16.0	677	796	210	222
1758	NMW-2A	<75.5	<133	17,200	2,050	916	117
1759	NMW-4A	<177	<86.4	2,580	3,130	143	708
1760	NMW-1A	<25.7	<16.0	2,270	2,010	5,170	4,640
1764	CBS-4A	<20.6	<16.0	<15.4	<12.1	<1.0	<2.0
1768	CBS-8A	<75.2	<61.4	20,700	22,200	660	716
1769	CBS-9A	<27.9	<16.0	22,800	24,600	712	838
1775	MW-3A	<19.0	<16.0	<32.4	<126	19	212
1777	MW-5A	<19.0	<16.0	<26.8	<6.8	<1.0	<2.0

< denotes that analyte was not detected at the detection limit indicated following the less than sign.

TABLE GW-14

COMPARISON OF UNFILTERED RESULTS FOR ALUMINUM, IRON, AND MANGANESE (THIRD AND FOURTH QUARTERS)

Location No.	Well No.	Al (U) (3rd)	Al (U) (4th)	Fe (U) (3rd)	Fe (U) (4th)	Mn (U) (3rd)	Mn (U) (4th)
1754	NMW-5A	828	363	1,440	601	144	36.4
1755	NMW-3B	271	<217	<279	218	108	116
1756	NMW-3A	704	341	934	446	100	29.2
1757	NMW-3C	<59.3	<35.6	766	833	213	223
1758	NMW-2A	<121	453	16,900	3,660	884	123
1759	NMW-4A	1,080	<282	3,690	3,620	147	731
1760	NMW-1A	2,290	<84.9	4,650	2,130	5,200	4,710
1764	CBS-4A	<44.3	<20.4	<71.9	<52.7	<4.0	<2.0
1768	CBS-8A	<110	<120	20,600	22,200	652	714
1769	CBS-9A	<31.9	<19.5	23,200	24,800	717	834
1775	MW-3A	396	<35.0	625	<184	50.9	221
1777	MW-5A	<41.2	<26.8	<60.2	<52.5	<3.3	2.3

< denotes that analyte was not detected at the detection limit indicated following the less than sign.

5.1.26.1 Filtered vs Unfiltered Conclusions. Aluminum was the only metal detected at consistently lower concentrations in filtered samples than in unfiltered samples. This is attributed to the presence of clay minerals as suspended solids in the groundwater samples. Aluminum was not detected in filtered groundwater samples from any of the 12 wells during the third and fourth quarters (Tables GW-11 and GW-12).

Iron showed varying results (Tables GW-11 and GW-12). In NMW-1A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5B, CBS-9A, and MW-3A, iron generally was detected at lower concentrations in filtered than in unfiltered samples. The relative concentrations of iron detected in NMW-2A and CBS-8A varied from the third quarter to the fourth quarter. Iron was not detected in samples from MW-5A during the third or fourth quarter.

Manganese also showed varying results (Tables GW-11 and GW-12). Manganese concentrations were generally lower in filtered than in unfiltered samples in NMW-1A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5A, MW-3A, and MW-5A. However, the differences were usually insignificant.

The following metals showed a difference in filtered vs. unfiltered concentrations:

- Lead. Consistently lower concentrations in filtered vs unfiltered samples from CBS-8A.

- Vanadium. Consistently lower concentrations in filtered vs unfiltered samples from NMW-4A and NMW-5A; varying results in NMW-2A, NMW-3A, NMW-3C, CBS-4A, CBS-8A, and CBS-9A.

- Zinc. Consistently lower concentrations in filtered vs unfiltered samples from CBS-8A; varying results in MW-3A.

Other metals such as boron and calcium were present at nearly the same concentrations in filtered vs unfiltered samples during the third and fourth quarters.

5.1.26.2 Consistency of Results. Aluminum concentrations in unfiltered samples varied inconsistently from the third quarter to the fourth quarter (Table GW-14). These results suggests that varying quantities of suspended solids may have been present in groundwater samples collected during each quarter. Iron and manganese generally showed more consistent results for each well from the third quarter to the fourth quarter (Tables GW-13 and GW-14).

5.1.27 Summary of Inorganics Occurrences

Concentrations of the naturally occurring inorganics were generally within the 95 percent upper confidence limit (95% UCL) of background concentrations in upper aquifer groundwater samples collected from wells in the northern and eastern portions of the site (NMW-7A, CBS-1A, NMW-6A, NMW-5A, CBS-2A, CBS-3A, CBS-7A, MW-5A, MW-1A, CBS-4A, CBS-11A, and CBS-5A).

Upper aquifer groundwater samples collected from onsite wells in several areas contained concentrations of naturally occurring inorganics that were greater than the 95% UCL of background concentrations. These areas include the Airport and Former Swamp/Lakebed areas (NMW-4A, NMW-3A, NMW-2A, CBS-8A, MW-3A, and CBS-9A), the railcar cleanout area (STM-1A, STM-2A, STM-3A, STM-4A), and Pioneer Builders Supply (NMW-1A). The railcar cleanout area is located in the southern end of the BNR Railyard (see legend number 54, Figure GW-1). Upgradient wells TL-12A, TL-13A, and TL-23A contained inorganics that also were greater than the 95% UCL of background concentrations. Some of the highest concentrations of inorganics (including aluminum, chromium, cobalt, copper, iron, lead, vanadium, and zinc) were detected in samples collected from offsite and upgradient well CBS-10A outside the southeast corner of the site.

Concentrations of inorganics were compared to existing and proposed Federal MCLs, ALs, MCLGs, and SMCLs. Inorganic concentrations for samples collected from onsite wells exceeded the regulatory levels as follows:

- Aluminum concentrations exceeded the proposed SMCL of 50 μg/L in 11 wells during the first quarter, 11 wells during the second quarter, 10 wells during the third quarter, and 5 wells during the fourth quarter. Most of the aluminum concentrations are likely caused by suspended solids, especially clay particles, in the groundwater.

- Antimony concentrations detected in samples collected from onsite wells CBS-8A and MW-3A during the third quarter and onsite well CBS-8A during the fourth quarter exceeded the proposed MCL of 5 or 10 μg/L.

- Arsenic concentrations detected in samples collected from onsite well NMW-2A during the first quarter exceeded the current MCL of 50 μg/L.

- Beryllium concentrations detected in samples collected from onsite wells STM-3A and STM-4A during the fourth quarter exceeded the proposed MCL of 1 μg/L.

- Iron concentrations exceeded the current SMCL of 300 μg/L in 16 wells during the first quarter, 10 wells during the second quarter, 14 wells during the third quarter, and 9 wells during the fourth quarter. Manganese concentrations exceeded the current SMCL of 50 μg/L in 13 wells during the first quarter, 12 wells during the second quarter, 14 wells during the third quarter, and 10 wells during the fourth quarter. High concentrations of iron and manganese were detected at other locations in the Puget Sound region and may be attributed to naturally occurring concentrations in groundwater (Turney 1986).

- Lead concentrations detected in samples collected from onsite well CBS-8A exceeded the current AL of 15 μg/L and the current MCL of 50 μg/L during the first, second, and fourth quarters.

- Nickel concentrations detected in samples collected from onsite well NMW-4A exceeded the proposed MCL of 100 μg/L during the first, second, and fourth quarters.

Potential anthropogenic sources for the inorganics that were detected in the Airport and Former Swamp/Lakebed areas include leaching of fill material deposited in the Former Swamp/Lakebed area, infiltration of stormwater from onsite and offsite sources, and offsite sources including the Tacoma Landfill. Possible sources for some of the constituents in CBS-8A include infiltration of surface water into the groundwater through the surface housing and/or surface seal of the well casing. Potential anthropogenic sources for the inorganics detected in samples collected from the railcar cleanout area include calcium and magnesium from lime deposits from cleaning of railcars, and zinc from galvanized well casing material. Possible sources for inorganics detected in samples collected from Pioneer Builders Supply include local unknown sources and transport of offsite groundwater from the vicinity of offsite and upgradient well CBS-10A.

5.2 ORGANICS

The following sections contain discussions of the occurrences of organic constituents detected in groundwater samples collected during this investigation. PAHs, VOCs, and semivolatile organic compounds were detected in samples collected from several of the onsite, background, and upgradient wells. Pesticides and PCBs were not detected in any of the onsite, background, or upgradient wells. Table GW-15 provides a summary of the number of onsite wells in which organic analytes exceeded the Federal SDWA existing and proposed MCLs, MCLGs, and SMCLs.

TABLE GW-15

SUMMARY OF THE NUMBER OF ONSITE WELLS IN WHICH ORGANIC ANALYTES EXCEEDED FEDERAL EXISTING AND PROPOSED MCLs, MCLGs, AND SMCLs[a]

Analyte	Concentration[b] or Range of Concentrations Detected (ug/L)	Existing MCL (ug/L)	No. of Wells Exceeding Existing MCL[c]	Proposed MCL (ug/L)	No. of Wells Exceeding Proposed MCL[c]	Existing MCLG (ug/L)	No. of Wells Exceeding MCLG[c]	Proposed MCLG (ug/L)	No. of Wells Exceeding Proposed MCLG[c]	Existing SMCL (ug/L)	No. of Wells Exceeding SMCL[c]	Proposed SMCL (ug/L)	No. of Wells Exceeding Proposed SMCL[c]
PAHs													
Naphthalene[d]	2.3 - 190	—[e]	—	—	—	—	—	—	—	—	—	—	—
Acenaphthylene[d]	2.9	—	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene[d]	2.6 - 5.8	—	—	—	—	—	—	—	—	—	—	—	—
Fluorene[d]	0.25 - 4.5	—	—	—	—	—	—	—	—	—	—	—	—
Phenanthrene[d]	0.14 - 1.1	—	—	—	—	—	—	—	—	—	—	—	—
Anthracene[d]	0.027 - 0.65	—	—	—	—	—	—	—	—	—	—	—	—
Fluoranthene[d]	0.21 - 0.73	—	—	—	—	—	—	—	—	—	—	—	—
Pyrene[d]	0.23 - 0.49	—	—	—	—	—	—	—	—	—	—	—	—
VOCs													
Chloromethane[d]	3	—	—	—	—	—	—	—	—	—	—	—	—
Methylene Chloride	3-6	5	*/*/1*/*[f]	—	—	0	*/*/2*/*[f]	—	—	—	—	—	—
Vinyl Chloride	2	2	*/*/*/*[f]	—	—	0	*/1*/*/*[f]	—	—	—	—	—	—
Acetone[d]	2 - 78	—	—		—	—	—	—	—	—	—	—	—
Carbon Disulfide	1 - 3	—	—	—	—	—	—	—	—	—	—	—	—
1,2—Dichloroethene (total)	5 - 7	70/100[g]	0/0/0/0	—	—	70/100	0/0/0/0	—	—	—	—	—	—
Chloroform	1 -20	100	0/0/0/0	—	—	—	—	—	—	—	—	—	—
1,1,1—Trichloroethane	1 - 10	200	0/0/0/0	—	—	200	0/0/0/0	—	—	—	—	—	—
Bromodichloromethane	2	100	0/0/0/0	—	—	—	—	—	—	—	—	—	—
Trichloroethene	1 - 6	5	*/*/1/1*[f]	—	—	0	2*/1*/2*/2*[f]	—	—	—	—	—	—
1,1,2—Trichloroethane	51	—	—	5	*/1*/*/*[f]	—	—	3	*/1*/*/*[f]	—	—	—	—
Benzene	86 - 480	5	1*/1*/1*/1*[f]	—	—	0	1*/1*/1*/1*[f]	—	—	—	—	—	—
Tetrachloroethene	3 - 4	5	*/*/*/*[f]	—	—	0	2*/2*/1*/1*[f]	—	—	—	—	—	—
Toluene	1 - 770	1,000	0/0/0/0	—	—	1,000	0/0/0/0	—	—	—	—	40	1/1/1/1
Ethyl Benzene	150 - 1,000	700	0/1/0/0	—	—	700	0/1/0/0	—	—	—	—	30	1/1/1/1
Styrene	3	100	0/0/0/0	—	—	100	0/0/0/0	—	—	—	—	—	—
Xylenes (total)	141 - 2,300	10,000	0/0/0/0	—	—	10,000	0/0/0/0	—	—	—	—	20	1/1/1/1

TABLE GW-15

SUMMARY OF THE NUMBER OF ONSITE WELLS IN WHICH ORGANIC ANALYTES EXCEEDED FEDERAL EXISTING AND PROPOSED MCLs, MCLGs, AND SMCLs[a]

Analyte	Concentration[b] or Range of Concentrations Detected (ug/L)	Existing MCL (ug/L)	No. of Wells Exceeding Existing MCL[c]	Proposed MCL (ug/L)	No. of Wells Exceeding Proposed MCL[c]	Existing MCLG (ug/L)	No. of Wells Exceeding MCLG[c]	Proposed MCLG (ug/L)	No. of Wells Exceeding Proposed MCLG[c]	Existing SMCL (ug/L)	No. of Wells Exceeding SMCL[c]	Proposed SMCL (ug/L)	No. of Wells Exceeding Proposed SMCL[c]
SEMIVOLATILES													
4—Methylphenol[d]	17	—	—	—	—	—	—	—	—	—	—	—	—
2,4—Dimethylphenol[d]	61	—	—	—	—	—	—	—	—	—	—	—	—
2—Methylnaphthalene[d]	1 - 47	—	—	—	—	—	—	—	—	—	—	—	—
Dibenzofuran[d]	3 - 4	—	—	—	—	—	—	—	—	—	—	—	—
Carbazole[d]	2 - 4	—	—	—	—	—	—	—	—	—	—	—	—
Diethylphthalate	2	—	—	—	—	—	—	—	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	0.7 - 7	—	—	4	NS[h]/*/NS/0*[f]	—	—	0	NS[h]/*/1*/3*[f]	—	—	—	—

(a) Drinking Water Regulations under the Safe Drinking Water Act, as amended (MCL = Maximum Contaminant Level; MCLG = Maximum Contaminant Level Goal; SMCL = Secondary Maximum Contaminant Level).
(b) The presence of only one value indicates that analyte was detected in one well during one sampling event.
(c) The format of the four numbers shown in this column refers to the four quarters of groundwater sampling (i.e., 1st quarter/2nd quarter/3rd quarter/4th quarter).
(d) MCLs, MCLGs, and SMCLs (existing or proposed) do not exist for these analytes.
(e) "—" indicates the MCL, MCLG, or SMCL, existing or proposed, was not applicable.
(f) The symbol "*" indicates the laboratory detection limit exceeded the MCL or MCLG. If a number is also shown with *, that number indicates the number of wells in which the analyte was detected.
(g) For 1,2-dichloroethene, the current MCLs and MCLGs are 70 μg/L for the cis-isomer and 100 μg/L for the trans-isomer.
(h) NS = Not sampled.

5.2.1 PAHs

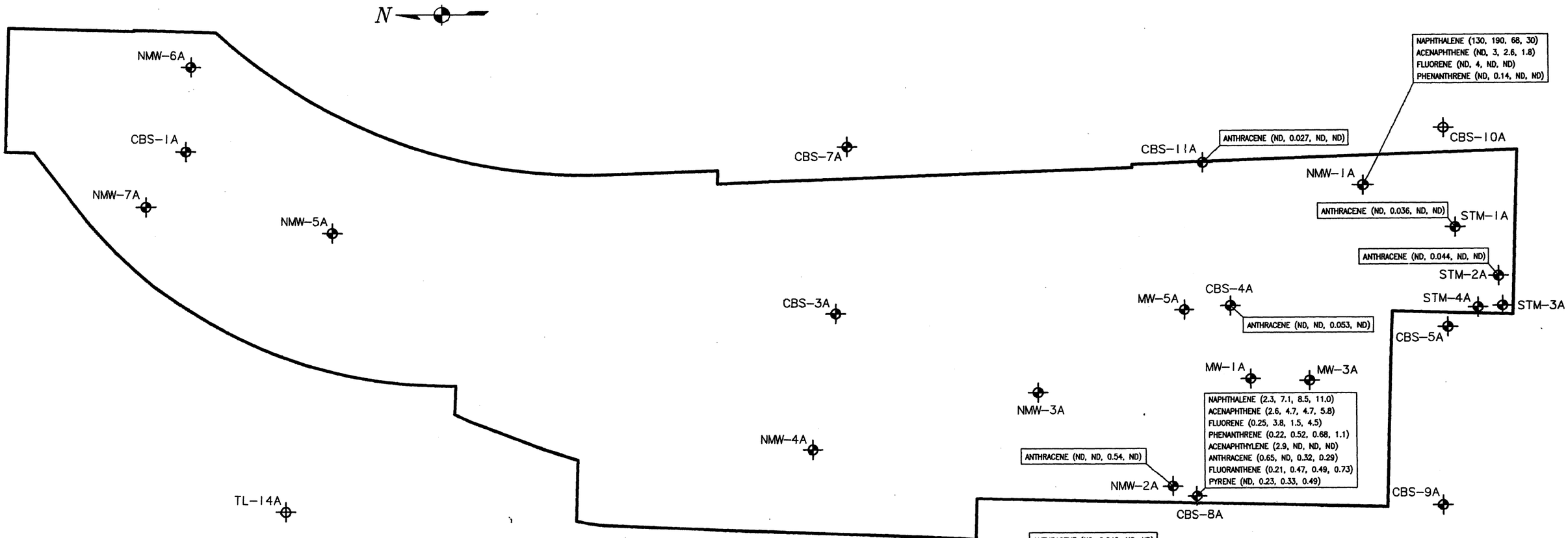
PAH analyses were performed on all groundwater samples collected during this investigation. Laboratory PAH results were obtained using both EPA Methods 8310 and CLP Method OLMO1.0. Because EPA Method 8310 is capable of achieving lower detection limits for PAHs, only those analyses are discussed in this report. Laboratory PAH results using the EPA CLP method are presented in Section 7.0 of the Data Appendix, but are not discussed in this report.

Figure GW-35 shows the occurrences of PAHs in onsite and upgradient wells.

Naphthalene was detected in one background well, TL-16A, during the second quarter at an estimated concentration of 0.12 μg/L. Anthracene was detected in one upgradient well, TL-23A, at an estimated concentration of 0.048 μg/L during the second quarter.

PAHs were detected in samples collected from two onsite wells, NMW-1A and CBS-8A, during all four quarters. PAHs detected in samples collected from onsite wells include naphthalene, acenaphthene, fluorene, phenanthrene, acenaphthylene, anthracene, fluoranthene, and pyrene.

Anthracene was detected at low concentrations in samples collected from three additional onsite upper aquifer wells during the second quarter (see Figure GW-35) and from NMW-5B and NMW-5C. In addition, anthracene was detected in samples collected from onsite wells NMW-2A and CBS-4A during the third quarter event. Anthracene was detected in many of the groundwater samples collected during the second and third quarters. Anthracene was also detected in laboratory method blanks and rinsate blanks. Many of the laboratory-detected anthracene concentrations were determined to be undetected during the data validation procedures (see Section 8.0 of the Data Appendix). It is likely that all anthracene concentrations detected in samples collected from onsite wells can be attributed to laboratory contamination.



LEGEND

NMW-1A — NAPHTHALENE (130, 190, 68, 30): POLYNUCLEAR AROMATIC HYDROCARBON COMPOUND DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.

TL-23A — ANTHRACENE (NS, 0.048, NS, ND): POLYNUCLEAR AROMATIC HYDROCARBON COMPOUND DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

ND = NOT DETECTED.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

0 500
SCALE IN FEET

NOTES:

1. ONLY THOSE ONSITE AND UPGRADIENT WELLS THAT WERE SAMPLED ARE SHOWN.
2. ALL WELLS SHOWN ARE SCREENED IN THE UPPER AQUIFER.
3. WELLS NMW-3B, NMW-3C, NMW-5B, AND NMW-5C ARE NOT SHOWN.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

POLYNUCLEAR AROMATIC HYDROCARBONS DETECTED IN GROUNDWATER

916055.08/P2SK067

FIGURE GW-35

Carcinogenic PAHs [benzo(a)anthracene, benzo(b)fluroanthene, benzo(k)-fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene] were not detected in any groundwater samples. MCLs, MCLGs, and SMCLs do not exist and are not proposed for PAHs that were detected in groundwater samples collected during this investigation.

5.2.1.1 Summary of PAH Occurrences. Possible sources for PAHs detected in samples collected from NMW-1A include underground storage tanks (see the Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992) and/or other potential local sources. Possible sources for PAHs detected in samples collected from CBS-8A include fill material in the Former Swamp/Lakebed area, infiltration of stormwater from onsite and/or offsite sources, and infiltration of surface water through the surface housing and/or surface seal of the well.

5.2.2 VOCs

VOC analyses were performed on samples collected during all four quarters of sampling. VOCs that were detected in samples collected from background, upgradient, and onsite wells are individually discussed in the following subsections. VOCs detected in samples collected from onsite and upgradient wells are shown in Figure GW-36.

5.2.2.1 Chloromethane. Chloromethane was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Chloromethane was detected in one onsite well, CBS-3A, during the second quarter at an estimated concentration of 3 μg/L. MCLs, MCLGs, and SMCLs do not exist and have not been proposed for chloromethane.

5.2.2.2 Methylene Chloride. Methylene chloride was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Methylene chloride was detected in onsite wells STM-3 and STM-4 at

estimated concentrations of 3 μg/L and 6 μg/L, respectively. The detected concentration of methylene chloride in STM-4 exceeded the current MCL of 5 μg/L. The detected concentrations of methylene chloride in STM-3 and STM-4 exceeded the current MCLG of 0 μg/L. The detection limit of 10 μg/L for methylene chloride exceeded both the MCL and the MCLG during all quarters.

5.2.2.3 Vinyl Chloride. Vinyl chloride was not detected in samples collected from background wells during the second and fourth quarters. Vinyl chloride was detected in one upgradient well, TL-12A, at an estimated concentration of 2 μg/L during the second quarter. Vinyl chloride was detected in one onsite well, CBS-8A, during the second quarter at an estimated concentration of 2 μg/L. The detected concentration of vinyl chloride in onsite well CBS-8A does not exceed the current MCL of 2 μg/L. The detection limit of 10 μg/L for vinyl chloride exceeded both the MCL and MCLG (0 μg/L) during all quarters.

5.2.2.4 Acetone. Acetone was detected in one background well WCC-2 at an estimated concentration of 3 μg/L during the second quarter. Acetone was detected in onsite well NMW-1A at an estimated concentration of 78 μg/L during the second quarter. MCLs, MCLGs, and SMCLs do not exist and have not been proposed for acetone.

5.2.2.5 Carbon Disulfide. Carbon disulfide was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Carbon disulfide was detected in one onsite well, NMW-5C, during the third quarter at an estimated concentration of 1.0 μg/L. During the fourth quarter, carbon disulfide was detected in onsite well MW-3 at an estimated concentration of 3.0 μg/L. MCLs, MCLGs, and SMCLs do not exist and have not been proposed for carbon disulfide.

5.2.2.6 1,1-Dichloroethane. 1,1-Dichloroethane (1,1-DCA) was not detected in samples collected from background wells during the second and fourth quarters. 1,1-DCA was detected in upgradient well TL-12A during the second and fourth

quarters at a concentration of 28 μg/L and 27 μg/L, respectively. 1,1-DCA was also detected in upgradient well TL-13A at an estimated concentration of 3.0 μg/L during the fourth quarter. 1,1-DCA was not detected in the onsite wells during this investigation.

5.2.2.7 1,2-Dichloroethene. 1,2-Dichloroethene (1,2-DCE) was not detected in samples collected from background wells during the second and fourth quarters. 1,2-DCE was detected in upgradient well TL-12A at a concentration of 26 μg/L during the fourth quarter. 1,2-DCE was detected in onsite well CBS-8A during the first quarter at an estimated concentration of 6 μg/L. 1,2-DCE was also detected in onsite well NMW-2A during the third and fourth quarters at estimated concentrations of 5 μg/L and 7 μg/L, respectively. The detected concentrations of total 1,2-DCE in onsite wells CBS-8A and NMW-2A did not exceed the current MCLs and MCLGs of 70 μg/L or 100 μg/L (for the cis- and trans-isomers, respectively).

5.2.2.8 Chloroform. Chloroform was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Chloroform was detected in onsite well NMW-3A during all four quarters at estimated concentrations ranging from 1 μg/L to 3 μg/L. During the second quarter, chloroform was detected at a concentration of 20 μg/L in a sample collected from onsite well MW-1A. During the third quarter, chloroform was also detected in onsite well MW-1A at an estimated concentration of 4 μg/L. Chloroform concentrations detected in onsite wells did not exceed the current MCL of 100 μg/L.

5.2.2.9 1,2-Dichloroethane. 1,2-Dichloroethane (1,2-DCA) was not detected in samples collected from background wells during the second and fourth quarters. 1,2-DCA was detected in upgradient well TL-12A during the second and fourth quarters at concentrations of 13 and 12 μg/L, respectively. 1,2-DCA was not detected in samples collected from onsite wells during this investigation.

5.2.2.10 1,1,1-Trichloroethane. 1,1,1-Trichloroethane (1,1,1-TCA) was not detected in samples collected from background wells during the second and fourth quarters. 1,1,1-TCA was detected at an estimated concentration of 3 μg/L in one upgradient well, TL-12A, during the second and fourth quarters. 1,1,1-TCA was detected at an estimated concentration of 1 μg/L in one onsite well, MW-5A, during the first quarter. 1,1,1-TCA was detected in two onsite wells, NMW-3A and MW-5A, during the second quarter. The detected concentrations of 1,1,1-TCA in these two wells were estimated at 2 μg/L in NMW-3A and estimated at 3 μg/L in MW-5A. 1,1,1-TCA was also detected in onsite well MW-5A at 10 μg/L and estimated 9 μg/L, respectively, during the third and fourth quarters. 1,1,1-TCA concentrations detected in onsite wells did not exceed the current MCL and MCLG of 200 μg/L.

5.2.2.11 Bromodichloromethane. Bromodichloromethane was not detected in samples collected from the background or upgradient wells during the second and fourth quarters. Bromodichloromethane was not detected in onsite wells during the first, third, and fourth quarters. Bromodichloromethane was detected at an estimated concentration of 2 μg/L in one onsite well, MW-1A, during the second quarter. Bromodichloromethane concentrations detected in onsite well MW-1A did not exceed the current MCL of 100 μg/L.

5.2.2.12 1,2-Dichloropropane. 1,2-Dichloropropane was not detected in samples collected from the background wells during the second and fourth quarters. 1,2-Dichloropropane was detected at an estimated concentration of 1 μg/L in one upgradient well, TL-12A, during the second quarter. 1,2-Dichloropropane was not detected in samples collected from onsite wells during this investigation.

5.2.2.13 Trichloroethene. Trichloroethene (TCE) was detected at estimated concentrations of 5 μg/L in one background well, WCC-2, during the second and fourth quarters. TCE was detected at estimated concentration of 7 μg/L in one upgradient well, TL-12A, during the second and fourth quarters.

TCE was detected in samples collected from two onsite wells, CBS-3A and CBS-8A, during the first quarter. Concentrations detected in samples collected from these two wells were estimated at 3 μg/L in CBS-3A and estimated at 1 μg/L in CBS-8A. Based on second quarter results, TCE was detected in CBS-3A at an estimated concentration of 2 μg/L, but was not detected in CBS-8A. In addition to CBS-3A, TCE was detected at an estimated concentration of 1 μg/L in a sample collected from one onsite well, NMW-2A, during the second quarter. During the third quarter, TCE was detected in onsite wells CBS-4A and CBS-3A at estimated concentrations of 2 μg/L and 6 μg/L, respectively. TCE was also detected in CBS-3A at an estimated concentration of 5 μg/L during the fourth quarter. In addition to CBS-3A, TCE was also detected in onsite well NMW-2A at an estimated concentration of 2 μg/L during the fourth quarter.

Estimated concentrations of TCE detected in onsite wells did not exceed the current MCL of 5 μg/L. TCE concentrations detected in onsite wells CBS-3A, CBS-8A, NMW-2A, and CBS-4A exceeded the current MCLG of 0 μg/L. The detection limit of 10 μg/L for TCE exceeded both the MCL and MCLG during all quarters.

5.2.2.14 <u>1,1,2-Trichloroethane</u>. 1,1,2-Trichloroethane (1,1,2-TCA) was not detected in samples collected from background or upgradient wells during the second and fourth quarters. 1,1,2-TCA was not detected in onsite wells during the first, third, and fourth quarters. 1,1,2-TCA was detected in onsite well NMW-1A during the second quarter at an estimated concentration of 51 μg/L. This estimated concentration exceeded the proposed MCL of 5 μg/L and the proposed MCLG of 3 μg/L. The detection limit of 10 μg/L for 1,1,2-TCA exceeded both the proposed MCL and the proposed MCLG for the remainder of the samples.

5.2.2.15 <u>Benzene</u>. Benzene was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Benzene was detected in onsite well NMW-1A at concentrations of 350 μg/L during the first quarter, 480 μg/L during the second quarter, 230 μg/L during the third quarter, and 86 μg/L during the fourth quarter. Benzene concentrations detected in NMW-1A

exceeded the current MCL of 5 μg/L and the MCLG of 0 μg/L during all quarters. The detection limit of 10 μg/L for benzene exceeded both the MCL and the MCLG for the remainder of the samples.

5.2.2.16 Tetrachloroethene. Tetrachloroethene (PCE) was not detected in samples collected from background wells during the second and fourth quarters. PCE was detected in upgradient well TL-12A during the second quarter at an estimated concentration of 1 μg/L. PCE was detected in two onsite wells, MW-5A and NMW-3A. PCE was detected in MW-5A during the first and second quarters at estimated concentrations of 3 μg/L and 4 μg/L, respectively. PCE was detected in NMW-3A during all four quarters at estimated concentrations of 3 μg/L during the first quarter, and 4 μg/L during the second, third, and fourth quarters.

Estimated PCE concentrations that were detected in samples collected from wells MW-5A and NMW-3A did not exceed the current MCL of 5 μg/L, but did exceed the current MCLG of 0 μg/L. The detection limit of 10 μg/L for PCE exceeded both the MCL and the MCLG for the remainder of the samples.

5.2.2.17 Toluene. Toluene was detected in background well TL-16A during the second quarter at an estimated concentration of 2 μg/L. Toluene was detected in offsite and upgradient well CBS-10A during the second quarter at an estimated concentration of 2 μg/L.

Toluene was detected in samples collected from two onsite wells, NMW-1A and NMW-5A. Toluene was detected in NMW-1A during all four quarters at concentrations of 610, 770, 170, and 51 μg/L, respectively. Toluene was detected in NMW-5A during the first quarter at an estimated concentration of 1 μg/L. Toluene concentrations detected in onsite wells did not exceed the current MCL and MCLG of 1,000 μg/L. Toluene concentrations detected in onsite well NMW-1A exceeded the proposed SMCL of 40 μg/L during all quarters.

5.2.2.18 Ethyl Benzene. Ethyl benzene was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Ethyl benzene was detected in samples collected from onsite well NMW-1A during all four quarters at concentrations of 600, 1,000, 600, and 150 µg/L, respectively. Ethyl benzene concentrations detected in onsite well NMW-1A exceeded the current MCL and MCLG of 700 µg/L during the second quarter only. Ethyl benzene concentrations detected in NMW-1A exceeded the proposed SMCL of 30 µg/L during all quarters.

5.2.2.19 Styrene. Styrene was not detected in samples collected from background or upgradient wells during the second and fourth quarters. Styrene was detected in onsite well NMW-1A at an estimated concentration of 3 µg/L during the fourth quarter. The concentration of styrene detected in the sample collected from NMW-1A did not exceed the current MCL and MCLG of 100 µg/L.

5.2.2.20 Xylenes (total). Xylenes were not detected in samples collected from background or upgradient wells during the second and fourth quarters. Xylenes were detected in onsite well NMW-1A during all four quarters at estimated concentrations of 1,800, 2,300, 644, and 141 µg/L, respectively. Concentrations of total xylenes detected in samples collected from NMW-1A did not exceed the current MCL and MCLG of 10,000 µg/L. Total xylene concentrations detected in samples collected from NMW-1A exceeded the proposed SMCL of 20 µg/L during all quarters.

5.2.2.21 Tentatively Identified Volatile Organic Compounds. Tentatively identified compounds (TICs) were reported by the laboratory for several VOCs in samples collected from several wells. A brief discussion of some of these TICs is presented herein. Database printouts (analytical results) for VOC TICs detected in groundwater samples are provided in Section 7.0 of the Data Appendix.

Dichlorofluoromethane was tentatively identified in upgradient wells TL-12A and TL-13A at estimated concentrations of 37 and 5 µg/L, respectively, during the

second quarter, and at estimated concentrations of 29 and 19 μg/L, respectively, during the fourth quarter. Hexane was tentatively identified in wells TL-13A and TL-23A during the second quarter and may be attributed to laboratory contamination. 1-Methylnaphthalene was tentatively identified in upgradient well CBS-10A at an estimated concentration of 6 μg/L during the fourth quarter. VOC TICs were not reported for groundwater samples collected from the background wells during the second quarter. During the fourth quarter, pentadecane was tentatively identified in background well CBS-9A at an estimated concentration of 10 μg/L.

During the first quarter, TICs were identified in samples collected from three onsite wells. Approximately 4,370 μg/L of benzene isomers and other related compounds were tentatively identified in a groundwater sample from NMW-1A. Trichlorofluoromethane was tentatively identified in MW-5A and STM-1A at estimated concentrations of 92 μg/L and 4 μg/L, respectively.

During the second quarter, approximately 6,300 μg/L of TICs with unknown identities were detected in a sample collected from NMW-1A. Trichloro-fluoromethane was again tentatively identified in MW-5A at an estimated concentration of 43 μg/L. Trichlorofluoromethane was also tentatively identified in NMW-3B, NMW-3C, and NMW-4A at estimated concentrations of 12 μg/L, 11 μg/L, and 18 μg/L respectively. Hexane was tentatively identified in samples collected from five wells during the second quarter. Hexane was also tentatively identified in three field blanks collected during the second quarter and is likely attributed to laboratory contamination. Other TICs of unknown identity were reported in samples collected from NMW-2A, NMW-3C, NMW-4A, NMW-5B, NMW-5C, CBS-7A, CBS-8A, CBS-11A, STM-1A, and STM-2A. Unknown TICs were also reported in six field blank samples collected during the second quarter.

During the third quarter, approximately 2,570 μg/L of benzene isomers and other related compounds were tentatively identified in a sample collected from NMW-1A.

Trichlorofluoromethane was tentatively identified in samples collected from NMW-2A and MW-5A at estimated concentrations of 14 and 64 μg/L, respectively.

Approximately 1,289 μg/L of tentatively identified compounds were detected in a sample collected from NMW-1A. Again, trichlorofluoromethane was tentatively identified in NMW-2A and MW-5A at estimated concentrations of 18 and 68 μg/L. Tetradecane was tentatively identified in samples collected from wells NMW-5C and NMW-5A at estimated concentrations of 10 and 38 μg/L, respectively. Pentadecane was tentatively identified in samples collected from NMW-3C, CBS-3A, and CBS-9A at estimated concentrations of 6, 9, and 10 μg/L, respectively.

5.2.2.22 Summary of VOC Occurrences. VOCs were generally undetected in upper aquifer groundwater samples collected from wells in the northern and extreme southern portions of the STF site (see Figure GW-36). Samples collected from onsite well NMW-1A at Pioneer Builders Supply contained the highest concentrations of VOCs detected during this investigation. Samples collected from some onsite wells in the south-central portion of the site contained low concentrations of VOCs (usually <10 μg/L). Samples collected from offsite and upgradient wells TL-12A, TL-13A, and CBS-10A, and background wells TL-16A and WCC-2 also contained low concentrations of VOCs.

Possible sources for VOCs detected in NMW-1A include underground storage tanks (see Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992) and/or other potential local sources. Based on the occurrence of VOCs detected in groundwater samples collected from the southern part of the site, the variety of chemical compounds that were detected, and the low concentrations of detected compounds, it is possible that several unknown sources for VOCs are present. Possible sources for VOCs detected in samples collected from CBS-8A include infiltration of surface water through the surface housing and/or surface seal of the well.

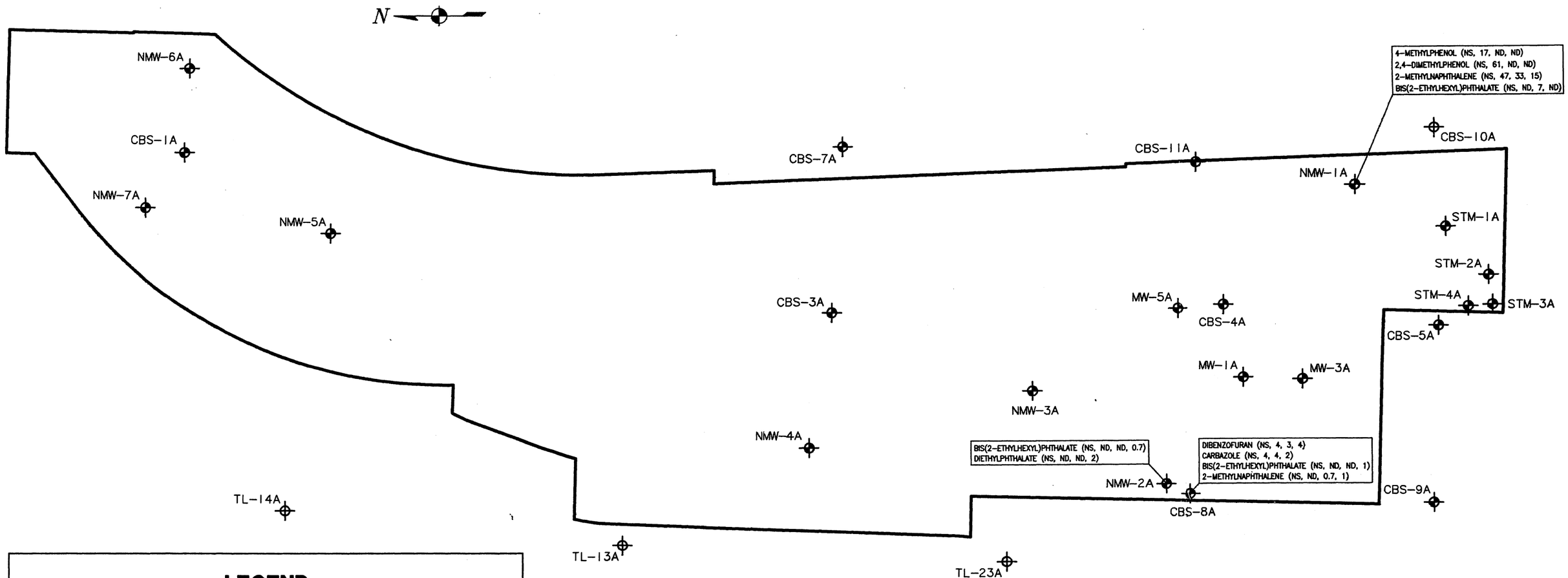
5.2.3 Semivolatiles (excluding PAHs)

Semivolatile analyses were performed on samples collected during the second quarter. PAHs that were detected using the EPA CLP method for semivolatile analysis are presented in Section 7.0 of the Data Appendix, but not discussed in this report. PAHs detected using EPA Method 8310 are discussed in Section 5.2.1.

Semivolatiles were not detected in samples collected from background wells during the second quarter. Bis(2-ethylhexyl)phthalate was detected in well TL-16A at an estimated concentration of 5 μg/L during the fourth quarter. Bis(2-ethylhexyl)-phthalate was detected in samples collected during the second and fourth quarters from upgradient well TL-12A at a concentration of 20 μg/L. Di-n-butyl-phthalate was detected in the sample collected from TL-12A during the fourth quarter at an estimated concentration of 0.6 μg/L.

Semivolatiles were detected in two onsite wells, NMW-1A and CBS-8A, during the second, third, and fourth quarters. Semivolatiles detected in NMW-1A included 4-methylphenol, 2,4-dimethylphenol, and 2-methylnaphthalene. 2-Methylnaphthalene, dibenzofuran, bis(2-ethylhexyl)phthalate, and carbazole were detected in CBS-8A. In addition, diethylphthalate and bis(2-ethylhexyl)phthalate were detected in onsite well NMW-2A during the fourth quarter. Bis(2-ethylhexyl)phthalate was also detected in onsite well NMW-5C during the fourth quarter. Semivolatiles (excluding PAHs) detected in samples collected from onsite and upgradient wells are shown in Figure GW-37.

The concentration of bis(2-ethylhexyl)phthalate detected in the sample collected from NMW-1A during the third quarter exceeded the proposed MCL of 4 μg/L. Bis(2-ethylhexyl)phthalate concentrations detected in samples collected from onsite wells during the third and fourth quarters exceeded the proposed MCLG of 0 μg/L. The detection limit of 10 μg/L for bis(2-ethylhexyl)phthalate exceeded both the proposed MCL and proposed MCLG for the remainder of the samples.



LEGEND

NMW-1A — 4-METHYLPHENOL (NS, 17, ND, ND)

SEMIVOLATILE ORGANIC COMPOUND DETECTED IN GROUNDWATER (ONSITE WELL), CONCENTRATION IN ug/L.

TL-12A — BIS(2-ETHYLHEXYL)PHTHALATE (NS, 20, NS, 20); DI-N-BUTYLPHTHALATE (NS, ND, NS, 0.6)

SEMIVOLATILE ORGANIC COMPOUND DETECTED IN GROUNDWATER (UPGRADIENT WELL), CONCENTRATION IN ug/L.

ND = NOT DETECTED.

NS = NOT SAMPLED.

NUMBERS IN PARENTHESES INDICATE 1st, 2nd, 3rd, AND 4th QUARTER RESULTS, RESPECTIVELY.

0 500
SCALE IN FEET

NOTES:

1. ONLY THOSE ONSITE AND UPGRADIENT WELLS THAT WERE SAMPLED ARE SHOWN.
2. ALL WELLS SHOWN ARE SCREENED IN THE UPPER AQUIFER.
3. WELLS NMW-3B, NMW-3C, NMW-5B, AND NMW-5C ARE NOT SHOWN.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER (EXCLUDING PAHs)

916055.08/P2SK069

FIGURE GW-37

MCLs, MCLGs, and SMCLs do not exist and have not been proposed for the other semivolatiles that were detected in groundwater during this investigation.

5.2.3.1 Tentatively Identified Semivolatile Compounds. Numerous TICs were reported by the laboratory for semivolatiles in samples collected from several wells and in field blanks. A discussion of these TICs is not presented in this report. Database printouts (analytical results) for semivolatile TICs detected in quarter groundwater samples are presented in Section 7.0 of the Data Appendix.

5.2.3.2 Summary of Semivolatile Compound Occurrences. Possible sources for semivolatile compounds detected in NMW-1A include underground storage tanks (see the Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992) and/or other potential local sources. Possible sources for semivolatile compounds detected in CBS-8A include fill material in the Former Swamp/Lakebed area, infiltration of stormwater from onsite and/or offsite sources, and infiltration of surface water through the surface housing and/or surface seal of the well.

5.3 ANCILLARY PARAMETERS

Other parameters analyzed during the Phase I Groundwater Investigation include total suspended solids (TSS), total dissolved solids (TDS), and total organic carbon (TOC). Results of these analyses are summarized in Table GW-16.

TSS measurements indicate the quantities of solids that are present in the sample at sizes >0.45 microns. Detectable suspended solids were detected in samples collected from onsite wells NMW-1A, NMW-2A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5A, NMW-5C, CBS-5A, CBS-8A, CBS-9A, and STM-4A. The presence of suspended solids in groundwater samples could increase the concentrations of chemical constituents detected by analytical methods. Inorganic analyses are especially affected because the methods used for the first and second quarter samples analyzed for total rather than dissolved concentrations of constituents.

TABLE GW-16

TSS, TDS, and TOC[a] DETECTED IN ONSITE, BACKGROUND, AND UPGRADIENT WELLS DURING SECOND QUARTER (JULY/AUGUST 1991) AND FOURTH QUARTER (JANUARY 1992)

Well No.	TSS (mg/L)		TDS (mg/L)		TOC (µg/L)	
	Second Quarter	Fourth Quarter	Second Quarter	Fourth Quarter	Second Quarter	Fourth Quarter
ONSITE						
NMW-1A	U 10	31	280	230	12,300	5,600
NMW-2A	U 10	16	420	390	21,300	22,600
NMW-3A	13	26	180	200	2,500 J4	1,700
NMW-3B	U 10	34	120	97	1,000 J4	U 1,000
NMW-3C	U 10	26	100	63	1,300 J4	U 1,000
NMW-4A	U 10	19	1,000	470	4,400 J4	9,400
NMW-5A	10	U 10	86	95	1,200 J4	U 1,000
NMW-5B	U 10	U 10	160	110	U 1,000	U 1,000
NMW-5C	U 10	79	240	220	U 1,000	U 1,000
NMW-6A	U 10	U 10	82	175	1,200 J4	1,000
NMW-7A	U 10	U 10	130	143	1,400 J4	1,000
CBS-1A	U 10	U 10	100	62	U 1,000	5,900
CBS-3A	U 10	U 10	140	105	1,000	U 1,000
CBS-4A	U 10	U 10	130	73	U 1,000	1,000
CBS-5A	U 10	31	130	110	U 1,000	U 1,000
CBS-7A	U 10	U 10	120	140	7,300 J4	U 1,000
CBS-8A	43	15	720	800	18,700	25,700
CBS-9A	13	62	320	200	19,100	14,100
CBS-11A	U 10	U 10	180	140	1,100 J4	U 1,000
MW-1A	U 10	U 10	30	37	1,300 J4	1,700
MW-3A	U 10	U 10	77	52	2,000 J4	U 1,000
MW-5A	U 10	U 10	34	79	U 1,000	U 1,000
STM-1A	U 10	U 10	140	U 10	U 1,000	1,200
STM-2A	U 10	U 10	550	470	2,900 J4	2,400
STM-3A	U 10	U 10	690	410	4,800 J4	1,900
STM-4A	U 10	U 48	240	170	2,300 J4	1,600

TABLE GW-16

TSS, TDS, and TOC[a] DETECTED IN ONSITE, BACKGROUND, AND UPGRADIENT WELLS DURING SECOND QUARTER (JULY/AUGUST 1991) AND FOURTH QUARTER (JANUARY 1992)

Well No.	TSS (mg/L)		TDS (mg/L)		TOC (µg/L)	
	Second Quarter	Fourth Quarter	Second Quarter	Fourth Quarter	Second Quarter	Fourth Quarter
BACKGROUND						
CBS-5A	U 10	31	130	110	U 1,000	U 1,000
CBS-9A	13	62	320	200	19,100	14,100
89.7-P1	56	U 10	540	1,800	U 1,000	1,000
TL-16A	130	490	120	160	4,800 J4	3,300
WCC-2	U 10	48	130	110	2,300 J4	14,200
UPGRADIENT						
CBS-10A	U 10	31	320	200	1,200 J4	U 1,000
TL-12A	19	45	350	210	1,900 J4	U 1,000
TL-13A	19	61	81	140	1,800 J4	U 1,000
TL-14A	22	U 10	150	140	U 1,000 J4	U 1,000
TL-23A	18	150	240	300	1,300 J4	6,400

(a) TSS = Total suspended solids.
TDS = Total dissolved solids.
TOC = Total organic carbon.

(b) Letters preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

Suspended solids in groundwater are likely to consist of naturally occurring mineral species composed of inorganic constituents.

The concentration of TDS in groundwater is determined by weighing the solid residue obtained by evaporating a measured volume of filtered sample to dryness. Concentrations of TDS in onsite wells ranged from 30 to 1,000 mg/L during the second quarter, and from 37 to 800 mg/L during the fourth quarter. Concentrations of TDS exceeded the SMCL of 500 mg/L during the second quarter in four onsite wells: NMW-4A, CBS-8A, STM-2A, and STM-3A. The SMCL was exceeded in only one onsite well, CBS-8A, during the fourth quarter.

TOC is a measurement of both naturally occurring and anthropogenic organic carbon in groundwater. TOC concentrations in onsite wells ranged from undetected at <1,000 to 21,300 μg/L in NMW-2A during the second quarter. TOC concentrations ranged from undetected at <1,000 to 22,600 μg/L in NMW-2A during the fourth quarter. NMW-2A and CBS-9A were the only wells sampled that exceeded the highest background concentration of TOC. Samples collected from NMW-1A, NMW-4A, CBS-1A, CBS-8A, and CBS-9A also contained TOC concentrations that were much greater than most concentrations detected in samples collected from most background and onsite wells. High concentrations of other analytes were also detected in samples collected from these wells, suggesting that TOC in these wells may be attributed to anthropogenic sources. Concentrations of TOC in upgradient well samples were uniformly low, ranging from <1,000 μg/L to 1,900 μg/L in TL-12A during second quarter and from <1,000 μg/L to 6,400 μg/L in TL-23A during the fourth quarter.

5.4 GEOTECHNICAL PARAMETERS

One soil sample was collected from the saturated zone in each of the seven wells that were installed in the upper aquifer during this investigation. Vertical hydraulic conductivity measurements were conducted in the laboratory by Golder Associates

using a flexible wall permeameter with back-pressure saturation in accordance with ASTM 854. Porosity values were calculated using the dry density and specific gravity values that were provided for each of the samples. Results of these measurements are shown in Table GW-17.

5.5 FIELD MEASUREMENTS

Purging of the wells was completed prior to groundwater sampling during each of the quarterly sampling events. Field measurements recorded for groundwater during the purging process included temperature, specific conductance, and pH.

The last of these measurements taken prior to sampling was considered to be the value of that parameter for the groundwater sample. Table GW-18 is a list of the field measurements for temperature, specific conductance, and pH of groundwater samples for all four quarters of this investigation.

TABLE GW-17

GEOTECHNICAL SOIL PARAMETERS
UPPER AQUIFER

Well Number	Depth[a] (ft)	Dry Density (pcf)	Specific Gravity[b]	Vertical K(cm/sec)[c]	n (%)[d]	USCS[e]	USCS[f]
NMW-1A	25.5	115.1	2.75	$2X10^{-4}$	32.9	SP	SW
NMW-2A	26.5	113.3	2.75	$6X10^{-5}$	34.0	SP	SM/SW
NMW-3A	27.5	93.9	2.70	$5X10^{-5}$	44.3	SP	SP
NMW-4A	23.5	115.9	2.70	$2X10^{-4}$	31.2	SP	SP
NMW-5A	29.0	103.2	2.68	$1X10^{-4}$	38.3	SP	SP
NMW-6A	27.0	107.9	2.70	$1X10^{-4}$	36.4	SW/SM	SP
NMW-7A	28.5	105.4	2.75	$6X10^{-5}$	38.6	SP	SW

(a) Depth refers to depth at the bottom of the sampled interval.
(b) Evaluated using ASTM 854.
(c) K = Hydraulic conductivity evaluated by constant-head computations using flexible wall permeameter with back-pressure saturation (ASTM 2434). Tests performed by Golder Associates.
(d) n = Porosity, calculated using this equation:

$$n = \left(1 - \frac{\rho_d}{62.4G}\right) x\ 100\%$$

where:

ρ_d = Dry density
G = Specific gravity.

(e) Unified Soil Classification System; field designation (visual-manual procedure) for soil type by Kennedy/Jenks Consultants field geologist.
(f) Unified Soil Classification System; laboratory designation (visual-manual) for soil type by Golder Associates.

TABLE GW-18

FIELD MEASUREMENTS OF GROUNDWATER PARAMETERS
UPPER AQUIFER

Well No.	pH				Temperature (°C)				Conductivity (μmhos/cm)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
NMW-1A	6.94	6.60	6.90	7.00	13.5	13.9	13.4	12.6	327.0	297.0	542.0	-[b]
NMW-2A	6.98	6.10	6.50	7.30	10.7	13.0	12.0	10.7	526.0	4,970.0	877.0	-
NMW-3A	7.09	6.70	6.80	6.50	13.0	14.0	12.3	12.9	202.0	179.0	282.0	-
NMW-3B	8.50	6.40	7.70	8.00	11.7	14.2	9.4	9.7	196.5	141.0	209.0	210.0
NMW-3C	8.86	7.20	7.20	7.50	10.4	13.9	9.8	9.8	144.3	110.0	173.4	198.5
NMW-4A	4.50	5.80	6.70	6.50	11.1	12.9	11.6	10.0	2,020	1,110.0	741.0	-
NMW-5A	5.00	6.70	7.60	7.60	10.0	12.3	11.2	10.6	155.2	105.0	221.0	128.6
NMW-5B	7.80[a]	7.20	8.20	8.10	10.2[a]	14.4	11.2	9.2	224.0	142.0	237.0	242.0
NMW-5C	7.50	7.30	7.70	7.40	13.3	14.0	11.3	11.0	289.0	201.0	325.0	355.0
NMW-6A	6.70	5.80	6.30	7.10	13.3	12.1	10.9	11.3	144.6	61.7	224.0	283.0
NMW-7A	7.03	6.50	6.70	7.30	11.6	12.7	11.5	12.5	196.0	19.8	195.9	249.0
CBS-1A	7.42	5.90	6.40	7.10	13.1	13.9	11.9	11.8	135.2	80.0	119.8	104.3
CBS-3A	5.50	6.10	7.20	6.90	10.5	13.1	11.6	11.4	188.6	130.0	162.6	170.1
CBS-4A	5.00	6.50	7.00	7.50	10.1	13.8	13.1	12.8	267.0	175.0	251.0	-
CBS-5A	5.00	6.40	6.60	7.40	11.7	12.5	11.2	11.8	158.0	97.0	150.4	-
CBS-7A	6.80	6.90	7.90	7.50	19.1	14.1	12.2	13.0	184.6	115.0	181.1	-
CBS-8A	8.22	6.60	6.70	6.80	9.4	12.5	12.3	10.8	1,055	820.0	1,298	-
CBS-9A	7.30	6.20	6.40	6.50	10.0	12.0	9.7	10.1	505.0	262.0	369.0	439.0
CBS-11A	6.91	6.80	7.50	7.20	14.8	13.4	10.3	12.1	244.0	172.0	263.0	-
MW-1A	6.36	6.70	6.60	7.20	10.3	15.4	13.1	13.4	130.6	42.0	157.3	-
MW-3A	6.42	6.20	6.70	6.80	8.5	11.3	8.9	9.6	125.5	79.0	112.1	-
MW-5A	5.00	6.40	6.60	7.30	13.7	13.8	11.5	13.2	133.0	62.0	134.2	-
STM-1A	8.25	8.50	9.40	8.50	11.7	13.4	10.4	11.2	221.0	120.0	197.0	-
STM-2A	7.27	6.80	7.60	7.60	14.1	13.2	10.8	10.7	1,032	500.0	896.0	-
STM-3A	7.13	6.40	7.00	7.80	13.4	12.2	10.6	10.5	487.0	520.0	748.0	-
STM-4A	6.71	6.60	6.90	8.30	14.1	12.5	11.0	11.2	299.0	211.0	364	-

(a) Measurement was not recorded. Data provided are from well development field measurement taken at the end of development.
(b) Measurement was not recorded.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Based on the results of the Phase I Groundwater Investigation, the following conclusions are presented for the hydrogeologic conditions and chemical characterization of groundwater at the STF site.

6.1.1 Hydrogeology

- Geologic units that were encountered beneath the STF site are correlative with the regional stratigraphy. Units appear to be laterally continuous with the subsurface units beneath the Tacoma Landfill to the west.

- The upper aquifer at the STF site is in the Colvos Sand unit of the Vashon Drift. This unit is composed of fine to medium, poorly graded to well-graded sand overlying a gravel unit. This aquifer is laterally continuous with the upper aquifer at the Tacoma Landfill.

- The regional confining layers identified as hydrostratigraphic layers A_1 and B by Brown and Caldwell (1985) were encountered beneath the STF site. At the STF site, layer A_1 varies in thickness from approximately 6 to 37 feet where encountered during drilling. Layer B, the Kitsap Formation, varies from approximately 2 to 15 feet where encountered at the STF site during drilling.

- The presence of a groundwater divide/recharge area in the vicinity of the STF site appears related to the absence of the glacial till unit that usually overlies the Colvos Sand throughout the region. The till is absent in the South Tacoma Channel due to nondeposition and/or erosion, leaving the more highly

transmissive Colvos Sand and possibly the Steilacoom gravels exposed at the surface. This feature should promote more rapid infiltration of precipitation and surface water through the unsaturated zone into the saturated zone.

- Hydraulic gradient reversals occur at the STF site during pumping of City of Tacoma production wells 4A, 6A, and 11A. A cone of depression is created in the upper aquifer across the STF site, and the hydraulic gradient reverses to a direction toward the production wells. The hydraulic gradient direction in the extreme southwest portion of the STF site does not appear to be affected by this gradient reversal, although the gradient appears to become less steep during the pumping events.

6.1.2 Groundwater Analytical Results

6.1.2.1 Inorganics. Concentrations of the naturally occurring inorganic elements were generally within the 95% UCL of background concentrations in upper aquifer groundwater samples collected from wells in the northern and eastern portions of the site (NMW-7A, CBS-1A, NMW-6A, NMW-5A, CBS-2A, CBS-3A, CBS-7A, MW-5A, MW-1A, CBS-4A, CBS-11A, and CBS-5A).

Upper aquifer groundwater samples collected from onsite wells in the Airport and Former Swamp/Lakebed areas (NMW-4A, NMW-3A, NMW-2A, CBS-8A, MW-3A, and CBS-9A), the railcar cleanout area (STM-1A, STM-2A, STM-3A, and STM-4A), and at Pioneer Builders Supply (NMW-1A) contained concentrations of naturally occurring inorganics that were greater than the 95% UCL of background concentrations. Upgradient wells TL-12A, TL-13A, and TL-23A contained inorganics that also were greater than the 95% UCL of background concentrations. Some of the highest concentrations of inorganics (including aluminum, chromium, cobalt, copper, iron, lead, vanadium, and zinc) were detected in samples collected from offsite and upgradient well CBS-10A, located outside the southeast corner of the site.

Concentrations of detected inorganics were compared to existing and proposed Federal MCLs, ALs, MCLGs, and SMCLs. Inorganic concentrations for samples collected from onsite wells exceeded the regulatory criteria as follows:

- Aluminum concentrations exceeded the proposed SMCL of 50 μg/L in 11 wells during the first quarter, 11 wells during the second quarter, 10 wells during the third quarter, and 4 wells during the fourth quarter. Most of the high aluminum concentrations are likely caused by suspended solids, especially clay particles, in the groundwater.

- Antimony concentrations detected in samples collected from onsite wells CBS-8A and MW-3A during the third quarter and onsite well CBS-8A during the fourth quarter exceeded the proposed MCL of 5 or 10 μg/L.

- Arsenic concentrations detected in samples collected from onsite well NMW-2A during the first quarter exceeded the current MCL of 50 μg/L.

- Beryllium concentrations detected in samples collected from onsite wells STM-3A and STM-4A during the fourth quarter exceeded the proposed MCL of 1 μg/L.

- Iron concentrations exceeded the current SMCL of 300 μg/L in 16 wells during the first quarter, 10 wells during the second quarter, 14 wells during the third quarter, and 9 wells during the fourth quarter. Manganese concentrations exceeded the current SMCL of 50 μg/L in 13 wells during the first quarter, 12 wells during the second quarter, 14 wells during the third quarter, and 10 wells during the fourth quarter. High iron and manganese concentrations were detected at other locations in the Puget Sound region and may be attributed to naturally occurring constituents (Turney 1986).

- Lead concentrations detected in samples collected from onsite well CBS-8A exceeded the current AL of 15 μg/L and the current MCL of 50 μg/L during the first, second, and fourth quarters.

- Nickel concentrations detected in samples collected from onsite well NMW-4A exceeded the proposed MCL of 100 μg/L during the first, second, and fourth quarters.

Potential anthropogenic sources for the inorganic constituents that were detected in samples collected from the Airport and Former Swamp/Lakebed areas include leaching of fill material deposited in the Former Swamp/Lakebed area, infiltration of stormwater from onsite and offsite sources, and offsite sources including the Tacoma Landfill. Possible additional sources for some of the constituents detected in CBS-8A include infiltration of surface water into the groundwater through the surface housing and/or surface seal of the well casing. Potential anthropogenic sources for the inorganics detected in samples collected from the railcar cleanout area include calcium and magnesium from lime deposits from cleaning of railcars, and zinc from galvanized well casing material. Possible sources for inorganics detected in samples collected from Pioneer Builders Supply (NMW-1A) include local unknown sources and transport of offsite groundwater from the vicinity of offsite and upgradient well CBS-10A. Summary tables for inorganic chemical constituents detected in each of these wells are provided in Appendix GW-C.

6.1.2.2 VOCs. VOCs were generally undetected in upper aquifer groundwater samples collected from wells in the northern and extreme southern portions of the STF site (see Figure GW-36). Onsite well NMW-1A at Pioneer Builders Supply contained the highest concentrations of VOCs detected during this investigation. Some onsite wells in the south-central portion of the site contained low concentrations of VOCs (usually less than 10 μg/L). Samples collected from offsite and upgradient wells TL-12A and CBS-10A, and background wells TL-16A and WCC-2 also contained low concentrations of VOCs.

Possible sources for VOCs detected in NMW-1A include underground storage tanks (see the Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992a) and/or other potential local sources. Based on the occurrence of VOCs detected in groundwater samples collected from the southern part of the site, the variety of chemical compounds that were detected, and the low concentrations of detected compounds, it is possible that several unknown sources for VOCs are present. Possible sources for VOCs detected in samples collected from CBS-8A include infiltration of surface water through the surface housing and/or surface seal of the well.

6.1.2.3 PAHs and Semivolatile Compounds. PAHs and semivolatile compounds were generally detected in only two onsite wells, NMW-1A and CBS-8A, during this investigation. Possible sources for PAHs and semivolatile compounds detected in samples collected from NMW-1A include underground storage tanks (see the Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992a) and/or other potential local sources. Possible sources for PAHs and semivolatile compounds detected in samples collected from CBS-8A include fill material in the Former Swamp/Lakebed area, infiltration of stormwater from onsite and/or offsite sources, and infiltration of surface water through the surface housing and/or surface seal of the well.

6.2 RECOMMENDATION

Based on information collected during this Phase I Groundwater Investigation and presented in this report, the conclusions summarized above, and results of preliminary subsurface drilling at the Tacoma City Light property (see Phase I Soil Investigation Report; Kennedy/Jenks Consultants 1992a), the following recommendation is proposed for further groundwater investigations at the STF site.

- Abandon CBS-8A in accordance with the Final Work Plan (ICF 1990b) and WAC 173-160. Based on the age of the well, the near-surface occurrence

of groundwater, and the observed submergence of the well during heavy precipitation storm events, the well is considered to be unsuitable for groundwater sampling purposes and could be acting as a conduit for infiltration of surface water to the saturated zone.

7.0 REFERENCES

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Appendix GW-A

Boring and Well Construction Logs

MAJOR DIVISIONS			GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS GREATER THAN 50% IS LARGER THAN NO. 200 SIEVE	GRAVELS MORE THAN 50% COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW		WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURE.
		GRAVELS WITH OVER 15% FINES	GM		CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND CLAY MIXTURE
			GC		SILTY GRAVELS, POORLY GRADED GRAVEL-SAND CLAY MIXTURES
	SANDS MORE THAN 50% COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW		WELL-GRADED SANDS, GRAVELLY SANDS
			SP		POORLY-GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 15% FINES	SM		SILTY GRAVELS, POORLY GRADED SAND-SILT MIXTURES
			SC		CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE-GRAINED SOILS GREATER THAN 50% IS SMALLER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50% OR LESS		ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAY
			OL		ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH		ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS

NOTES:

1. LITHOLOGIC CONDITIONS WERE LOGGED USING THE UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) IN APPROXIMATE ACCORDANCE WITH ASTM METHOD 2488D.

2. SUBSURFACE INFORMATION FROM BORING AND TEST PIT LOGS DEPICT CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS AT THESE LOCATIONS. ALSO THE CONDITIONS AT THESE LOCATIONS MAY CHANGE WITH TIME.

3. BLOW COUNTS INDICATE THE NUMBER OF BLOWS TO DRIVE THE SAMPLER 6 INCHES WITH A 140 POUND HAMMER FALLING 30 INCHES.

U	RELATIVELY UNDISTURBED SAMPLE
G	GRAB SAMPLE (DISTURBED)
O	OTHER TYPE OF SAMPLE
▽	GROUNDWATER FIRST ENCOUNTERED
▼ 10/31/90	WATER LEVEL AND DATE MEASURED

KENNEDY/JENKS CONSULTANTS

SOUTH TACOMA FIELD
TACOMA, WA

BORING LOG LEGEND

916055.08\P1SK117

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION	PIONEER BUILDERS SUPPLY
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER
DRILL BIT(S) SIZE:	10" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.0 TO 21.0 FT.
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC — FROM 21.0 TO 46.0 FT.
SIZE AND TYPE OF FILTER PACK	10-20 COLORADO SILICA SAND — FROM 18.0 TO 48.5 FT.
SEAL	1/4" BENTONITE PELLETS — FROM 15.0 TO 18.0 FT.
GROUT	CEMENT/BENTONITE MIX — FROM 2.0 TO 15.0 FT.

Boring/Well Name	NMW-1A
Project Name	SOUTH TACOMA FIELD
Project Number	916055.08
ELEVATION AND DATUM	252.0 FT MSL
TOTAL DEPTH	48.5 FT
DATE STARTED	03/05/1991
DATE COMPLETED	03/06/1991
INITIAL WATER DEPTH (FT)	31.0
LOGGED BY	T.C. MORIN
SAMPLING METHODS	2.5" DRIVE SAMPLES
WELL COMPLETION	☐ SURFACE HOUSING ■ STAND PIPE 2.0 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
						SP/SM	**Poorly graded SAND with silt and gravel** Tannish gray, moist. (tank excavation backfill material)
			5				
			10				Changes in drilling pressure indicate presence of debris or large cobbles.
			15				
U	1.2	3 3 5		NMW-1A-18.5	850	SP	**Poorly graded SAND** Greenish gray, wet, loose, 85% medium sand, 10% fine sand, 5% fines. Probably discolored, strong hydrocarbon odor.
			20				
U	1.5	16 34 37		NMW-1A-23.5	250		Discoloration lessens.
O	1.7		25	NMW-1A-25.5			
U	1.0	27 50		NMW-1A-28.5	>1000		Moist, no free water.
			30				

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-1A

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
									Continued strong odor.
U	1.3	17 32 42		NMW-1A-33.5		>1000			
			35						
U	1.2	3 6 7		NMW-1A-38.5		>1000			Increasing coarse sand. Few to little fine gravels present.
								SP	
O	2.0		40	NMW-1A-41.0		870			Occasional cobbles.
G	0.2	20 50/3		NMW-1A-43.5		960			
			45						
G	1.3	20 34 26		NMW-1A-47.5		>1000			Heave in borehole.

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	SWAMP/LAKEBED AREA
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER
DRILL BIT(S) SIZE	10" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -1.5 TO 13.0 FT.
PERFORATED CASING	4" 0.010"-SLOT SCHEDULE 40 PVC — FROM 13.0 TO 38.0 FT.
SIZE AND TYPE OF FILTER PACK	10/20 COLORADO SILICA SAND — FROM 10.0 TO 40.0 FT.
SEAL	1/4" BENTONITE PELLETS — FROM 8.0 TO 10.0 FT.
GROUT	CEMENT/BENTONITE MIX — FROM 0.0 TO 8.0 FT.

Boring/Well Name NMW-2A
Project Name SOUTH TACOMA FIELD
Project Number 916055.08

ELEVATION AND DATUM	238.8 FT MSL
TOTAL DEPTH	40.5 FT
DATE STARTED	03/01/1991
DATE COMPLETED	03/04/1991
INITIAL WATER DEPTH (FT)	18.0
LOGGED BY	T.C. MORIN
SAMPLING METHODS	2.5" DRIVE SAMPLES
WELL COMPLETION	☐ SURFACE HOUSING ■ STAND PIPE 1.5 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					570	GW	**Well-graded GRAVEL with sand** Gray, wet, 55% fine gravel, 25% medium gravel, 20% medium to coarse sand. Gravels are well rounded.
					>1000		
			5				**Poorly graded SAND**
U	1.4	10 5 5		NMW-2A-6.5	200	SP	Reddish gray, damp, loose, 40% medium sand, 10% gravel. Distinct green discoloration. Distinct hydrocarbon odor.
			10				Strong odor. Discoloration absent.
U	1.3	7 8 7		NMW-2A-11.5	460		
					270	ML	**Sandy SILT** Black, damp, stiff, 60% silt, 30% fine sand. Trace gravel, yellow discolored patches. Slight odor. Possible laustrine sediment.
			15				
U	1.1	3 34 50/5		NMW-2A-16.5	150	CL	
					230	SP	**Lean CLAY** Gray, moist, soft; 80% clay, 20% silt and fine sand.
			20				**Poorly graded SAND**
O	2.0	3 2 2 1		NMW-2A-22.0			Grayish brown, moist dense; 70% fine sand, 20% silt, 10% gravel and cobbles. Becomes wet at about 18 feet.
			25				
U	1.2	6 17 43		NMW-2A-26.5			6"-12" clay lens.
			30			SP/SM	**Poorly-graded SAND with silt** Light gray, wet, dense, 70% medium to fine sand, 30% fines.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-2A

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
U	1.3	4 14 27		NMW-2A-31.5		70			Light gray, wet, dense, 70% medium to fine sand, 30% silt.
			35						
O	0.1	9 14 19				2.4		SP/ SM	
			40						
G	1.2	3 6 4		NMW-2A-41.5					

Notes:

1. OVA reading of >1000 ppm was measured in the drill stem at a depth of 3 feet.

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	MADISON STREET
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER
DRILL BIT(S) SIZE	10" O.D.
ISOLATION CASING	NONE (FROM TO FT.)
BLANK CASING	4" SCHEDULE 40 PVC (FROM -2.2 TO 13.0 FT.)
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC (FROM 13.0 TO 38.0 FT.)
SIZE AND TYPE OF FILTER PACK	10-20 COLORADO SILICA SAND (FROM 11.0 TO 38.0 FT.)
SEAL	1/4" BENTONITE PELLETS (FROM 9.0 TO 11.0 FT.)
GROUT	CEMENT / BENTONITE MIX (FROM 0.0 TO 9.0 FT.)

Boring/Well Name NMW-3A

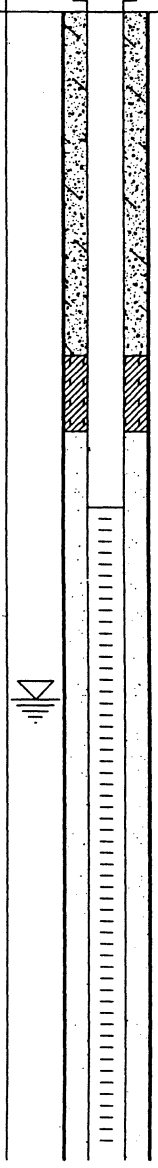
Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 237.3 FT MSL	TOTAL DEPTH: 40.5 FT
DATE STARTED: 03/13/1991	DATE COMPLETED: 03/14/1991
INITIAL WATER DEPTH (FT): 18.0	
LOGGED BY: T.C. MORIN	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.2 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					10.2	SP	**Poorly graded SAND with gravel** Reddish gray, moist, 65% medium sand, 30% fine gravel.
			5				Gravels decrease (less than or equal to 15%).
U	0.9	4 6 12		NMW-3A-6.5	4.1		
						SP	**Poorly graded SAND** Greenish gray, moist, dense; 90% medium sand, 10% fine sand.
			10				
U	1.3	11 20 28		NMW-3A-11.5	2.0		
			15				
			20				
			25				
o	2.5			NMW-3A-28.5			
							Occasional cobbles to 2".
			30				

WELL CONSTRUCTION



Boring & Well Construction Log

Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3A

SAMPLES TYPE	SAMPLES RECOVERY (FEET)	SAMPLES PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			35					SP	
			40						

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	MADISON STREET
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	RICHARD JIMENEZ
DRILLING METHOD	DUAL-TUBE AIR PERCUSSION HAMMER
DRILL BIT(S) SIZE:	9" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM 0.7 TO 110.0 FT.
PERFORATED CASING	4" 0.010"-SLOT SCHEDULE 40 PVC — FROM 110.0 TO 125.0 FT.
SIZE AND TYPE OF FILTER PACK	20-40 COLORADO SILICA SAND — FROM 104.0 TO 125.0 FT.
SEAL	BENTONITE SLURRY — FROM 102.0 TO 104.0 FT.
GROUT	VOLCLAY AND CEMENT/BENTONITE MIX — FROM 0.7 TO 102.0 FT.

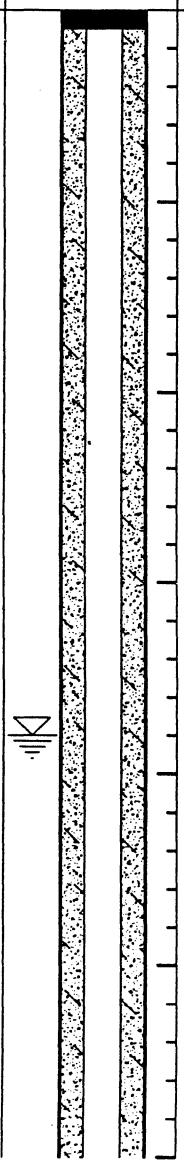
Boring/Well Name NMW-3B

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 237.5 FT MSL	TOTAL DEPTH: 127.5 FT
DATE STARTED: 03/06/1991	DATE COMPLETED: 03/11/1991
INITIAL WATER DEPTH (FT): 19.0	
LOGGED BY: S.J. ROTH	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ■ SURFACE HOUSING; ▭ STAND PIPE _____ FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			0–10				SP	**Poorly graded SAND with gravel** Mostly fine to medium sand, little subrounded gravel, trace clay; olive gray; moist.
			10–30				SP	**Poorly graded SAND** Mostly medium sand, trace gravel; dusky yellowish brown; moist. Quartz, feldspar, and mica grains.



Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			35					
			40				SP	
			45					
			50					Increasing gravel.
			55				GP	**Poorly graded Gravel** Mostly coarse, few fine subrounded to rounded gravel to 2 inches, few medium sand; gray; wet. Gravels are metamorphic, plutonic, and volcanic clasts.
			60					Mostly cobbles. Increasing silt and clay.
			65				GW/ GM	**Well-graded GRAVEL with silt and sand** Mostly fine to coarse subrounded to rounded gravel to 3 inches, little sand, few silt, few clay; dark yellowish brown; wet.
			70					

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
							CL	**Lean CLAY** Olive gray, moist to wet.
							GW/GM	**Well-graded GRAVEL with silt and sand** Mostly fine to coarse subrounded to rounded gravel to 3 inches, little sand, few silt, few clay; dark yellowish brown; wet.
			75				SP	**Poorly graded SAND** Mostly fine to medium sand, trace silt; moderate brown; wet. Increasing silt at 78 feet.
			80				ML	**Gravelly SILT** Mostly silt and clay, some gravel, few sand; olive gray; wet.
			85				CL	**Lean CLAY** Trace gravel; olive gray; moist.
			90				GC	**Clayey GRAVEL** Mostly coarse subrounded gravel, some clay, trace silt; olive gray; moist. Wet at 90 feet.
			95				ML	**SILT** Olive gray; wet. Decreasing moisture content at 98 feet.
			100					
			105					
			110				GP/GM	**Poorly graded GRAVEL with silt and sand** Mostly coarse rounded gravel, few fine gravel, little sand, few silt; olive gray; wet.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
							GP/ GM	
			115				GP	**Poorly graded GRAVEL with sand** Mostly coarse rounded gravel, little sand, trace silt; olive gray; wet. Mostly volcanic clasts.
			120					
			125					

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	MADISON STREET
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	RICHARD JIMENEZ
DRILLING METHOD	DUAL-TUBE AIR PERCUSSION HAMMER
DRILL BIT(S) SIZE:	9" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.9 TO 180.0 FT.
PERFORATED CASING	4" 0.030"-SLOT SCHEDULE 40 PVC — FROM 180.0 TO 195.0 FT.
SIZE AND TYPE OF FILTER PACK	8-12 COLORADO SILICA SAND — FROM 177.0 TO 195.0 FT.
SEAL	FINE SAND — FROM 175.0 TO 177.0 FT.
GROUT	VOLCLAY AND CEMENT/BENTONITE MIX — FROM 0.0 TO 175.0 FT.

Boring/Well Name NMW-3C

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 237.3 FT MSL	TOTAL DEPTH: 196.5 FT
DATE STARTED: 02/28/1991	DATE COMPLETED: 03/04/1991
INITIAL WATER DEPTH (FT): 19.0	
LOGGED BY: S.J. ROTH	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.9 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
O	0.0		5					SP	**Poorly graded SAND with gravel** Mostly fine to medium sand, little subrounded gravel, trace clay; olive gray; moist.
O	0.0	50	10						
U	1.5	9 26 24	15	NMW-3C-15.0		N.D.		SP	**Poorly graded SAND** Mostly medium sand, trace gravel; dusky yellowish brown; moist. Grains are quartz, feldspar, and mica.
U	1.5	11 23 50	20	NMW-3C-20.0	▽	N.D.			
U	1.2		25	NMW-3C-25.0					
U	1.1		30	NMW-3C-30.0					

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
U	0.9	17 28 30	35	NMW-3C-35.0				SP	
			40						
			45						
			50						Increasing gravel.
			55					GP	**Poorly graded GRAVEL** Mostly coarse, few fine subrounded to rounded gravel to 2 inches, few medium sand; gray; wet. Gravel is metamorphic, plutonic, and volcanic clasts.
			60						Mostly cobbles. Increasing silt and clay.
			65					GW/GM	**Well-graded GRAVEL with silt and sand** Mostly fine to coarse subrounded to rounded gravel to 3 inches, little sand, few silt, few clay; dark yellowish brown; wet.
			70						
O		17 50							

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
O	0.0	17 50						CL	**Lean CLAY** Olive gray; moist to wet.
								GW/GM	**Well-graded GRAVEL with silt and sand** Mostly fine to coarse subrounded to rounded gravel, little sand, few silt, few clay; dark yellowish brown; wet.
			75					SP	**Poorly graded SAND** Mostly fine to medium sand, trace silt; moderate brown; wet. Increasing silt at 78 feet.
			80					ML	**Gravelly SILT** Mostly silt and clay, some gravel, few sand; olive gray; wet.
G	0.5	25 50	85	NMW-3C-85.5				CL	**Lean CLAY** Trace gravel; olive gray; wet.
G	0.5	10 27 50		NMW-3C-88.5				GC	**Clayey GRAVEL** Mostly coarse subrounded gravel, some clay, trace silt; olive gray; moist. Wet at 91 feet.
O	0.0		90						
			95					ML	**SILT** Mostly silt; olive gray; wet. Decreasing moisture content at 98 feet.
U	1.4	18 32 36		NMW-3C-99.5					
			100						
			105						
			110					GP/GM	**Poorly graded GRAVEL with silt and sand** Mostly coarse rounded gravel, few fine gravel, little sand, few silt; olive gray; wet.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3C

SAMPLES TYPE	SAMPLES RECOVERY (FEET)	SAMPLES PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
									Poorly graded GRAVEL with sand Mostly coarse rounded gravel, little sand, trace silt; olive gray; wet. Mostly volcanic clasts.
			115						
			120					GP	
			125						
			130						**Poorly graded GRAVEL** Mostly coarse subrounded to rounded gravel, few medium sand, trace silt; olive gray; wet. Mostly volcanic clasts.
			135						Increasing sand at 135 feet.
			140					GP	Decreasing sand at 140 feet.
			145						Trace cobbles at 145 feet.
			150						

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			155						Increasing fine gravel at 155 feet.
			160					GP	Increasing sand, mostly coarse gravel at 160 feet.
			165						
			170						Increasing cobbles at 170 feet.
								CL	**Lean CLAY** Olive gray; moist; wood fragments and organic material.
G	0.2	28 50	175	NMW-3C-176.5					
								GP	**Poorly graded GRAVEL** Mostly coarse gravel and cobbles, few medium sand; olive gray; wet.
			180						Boulder, approximately 1 ft in diameter, at 181 feet.
									Increasing cobbles, commonly to 6 inches in diameter, at 183 feet.
			185						
			190						

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-3C

SAMPLES TYPE	SAMPLES RECOVERY (FEET)	SAMPLES PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			195					GP	
			200						
			205						
			210						

Notes:

1. N.D. = not detected.

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION	AIRPORT AREA		
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES	DRILLER	RICHARD JIMENEZ
DRILLING METHOD	DUAL-TUBE AIR PERCUSSION HAMMER	DRILL BIT(S) SIZE:	9" O.D.

		FROM	TO	FT.
ISOLATION CASING	NONE			
BLANK CASING	4" SCHEDULE 40 PVC	-2.6	10.0	
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC	10.0	35.0	
SIZE AND TYPE OF FILTER PACK	10-20 COLORADO SILICA SAND	6.5	35.0	
SEAL	1/4" BENTONITE PELLETS	4.0	6.5	
GROUT	CEMENT/BENTONITE MIX	0.0	4.0	

Boring/Well Name NMW-4A

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 233.4 FT MSL	TOTAL DEPTH: 50.0 FT
DATE STARTED: 03/13/1991	DATE COMPLETED: 03/13/1991
INITIAL WATER DEPTH (FT): 12.0	
LOGGED BY: S.J. ROTH	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.6 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					4.2	GP	**Poorly graded GRAVEL** Mostly fine to coarse rounded gravel, trace sand, trace silt; moderate brown; moist.
U	0.4	1 2 3	5	NMW-4A-5.5			
						PT	**PEAT** Moderate brown to dusky brown, organic odor, moist to wet.
U	1.1	4 8 8	10	NMW-4A-10.5	0.2		
						GM	**Silty GRAVEL** Mostly subrounded coarse gravel, few silt; moderate brown; wet.
U	1.3	3 27 30	15	NMW-4A-15.5	N.D.		
						SP	**Poorly graded SAND with gravel** Mostly medium sand, some subrounded to rounded fine to coarse gravel and cobbles, few silt and clay; moderate brown; wet.
G	0.3	1 2 10	20	NMW-4A-20.5	N.D.		
O	2.5			NMW-4A-23.5			
G	1.2	2 2 2	25	NMW-4A-25.5			
						SP	**Poorly graded SAND** Mostly medium sand, trace gravel; moderate brown; wet. Olive gray, salt-and-pepper color.
			30				

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-4A

SAMPLES TYPE	SAMPLES RECOVERY (FEET)	SAMPLES PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			35					SP	
			40					SP	**Poorly graded SAND with gravel** Mostly medium to coarse sand, some fine rounded gravel; salt-and-pepper color; wet.
			45					GP	**Poorly-graded GRAVEL with sand** Mostly coarse subrounded to rounded gravel, some medium sand; salt-and-pepper color; wet.
			50						

Notes:

1. N.D.=not detected.

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	BURLINGTON NORTHERN RAILYARD
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES, INC — DRILLER DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER — DRILL BIT(S) SIZE: 10" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.0 TO 20.0 FT.
PERFORATED CASING	4" 0.020"- SLOT SCHEDULE 40 PVC — FROM 20.0 TO 45.0 FT.
SIZE AND TYPE OF FILTER PACK	8-12 COLORADO SILICA SAND — FROM 17.0 TO 47.0 FT.
SEAL	3/8" BENTONITE PELLETS — FROM 14.0 TO 17.0 FT.
GROUT	CEMENT/BENTONITE MIX — FROM 0.0 TO 14.0 FT.

Boring/Well Name NMW-5A
Project Name SOUTH TACOMA FIELD
Project Number 916055.08

ELEVATION AND DATUM: 240.9 FT MSL	TOTAL DEPTH: 47.5 FT
DATE STARTED: 03/11/1991	DATE COMPLETED: 03/11/1991
INITIAL WATER DEPTH (FT): 22.0	
LOGGED BY: T.C. MORIN	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.0 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					10.2	GP/GM	**Poorly graded GRAVEL with silt and sand** Grayish black, moist, 70% rounded gravel, 20% medium sand, 10% fines. Possible fill and debris encountered (wood, steel, brick).
			5		0.4		
			10			SP	**Poorly graded SAND** Mottled light brown, moist; 90% fine sand, 10% fines.
			15			SP/SM	**Poorly graded SAND with silt** Reddish brown; moist; 75% medium to fine sand, 25% silt.
			20			SP	**Poorly graded SAND** Gray brown, moist; 80% coarse to medium sand, 15% rounded gravel, 5% fines; wet.
U	1.5	3 20 43	25	NMW-5A-26.5	0.3		Gravels absent (disturbed sample collected).
U	2.5			NMW-5A-28.0	0.2		
			30				Sand heaving in augers.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5A

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
G	1.5	3 3 4		NMW-5A-31.5		0.4			
			35					SP	
			40						
			45					GP	**Poorly graded GRAVEL with sand** Gray; wet; 65% coarse to medium gravel, 35% medium sand.

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	BURLINGTON NORTHERN RAILYARD
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES.
DRILLER	RICHARD JIMENEZ
DRILLING METHOD	DUAL-TUBE AIR PERCUSSION HAMMER
DRILL BIT(S) SIZE:	9" O.D.
ISOLATION CASING	NONE
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.5 TO 110.0 FT.
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC — FROM 110.0 TO 125.0 FT.
SIZE AND TYPE OF FILTER PACK	10-20 COLORADO SILICA SAND — FROM 107.0 TO 125.0 FT.
SEAL	FINE SAND — FROM 105.0 TO 107.0 FT.
GROUT	VOLCLAY AND CEMENT/BENTONITE MIX — FROM 0.0 TO 105.0 FT.

Boring/Well Name	NMW-5B
Project Name	SOUTH TACOMA FIELD
Project Number	916055.08
ELEVATION AND DATUM	240.6 FT MSL
TOTAL DEPTH	128.0 FT
DATE STARTED	03/05/1991
DATE COMPLETED	03/05/1991
INITIAL WATER DEPTH (FT)	23.0
LOGGED BY	S.J. ROTH
SAMPLING METHODS	2.5" DRIVE SAMPLES
WELL COMPLETION	☐ SURFACE HOUSING ■ STAND PIPE 2.5 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
							SP	**Poorly graded SAND** Mostly fine to medium sand, trace silt; moderate brown; moist. Grains are quartz, feldspar, and mica.
			5					
			10				SP	Dark yellowish brown.
			15					
			20					
			25				SP	**Poorly graded SAND with gravel** Mostly fine to medium sand, little subrounded cobbles, few silt; moderate brown; wet.
			30				SP	**Poorly graded SAND** Mostly medium sand, some fine sand; dusky yellowish brown; wet. Detritus from weathered granitic rocks.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			35				SP	Greenish black at 38 feet.
			40					
			45				GW	**Well-graded GRAVEL** Mostly rounded gravel and cobbles, few fine to medium sand; greenish black; wet. Cobbles include brecciated quartzite.
			50					Varying amounts of sand at 52 feet.
			55					
			60					
			65				GW	**Well-graded GRAVEL with sand** Mostly subangular to rounded fine to coarse gravel, some fine to medium sand; greenish black; wet. Gravel includes metavolcanic and granodiorite clasts.
			70				SW/SM	**Well-graded SAND with silt** Mostly medium sand, few silt; olive gray; wet.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			75, 80				GW	**Well-graded GRAVEL** Mostly subrounded to rounded fine to coarse gravel, few fine to medium sand, few silt; olive gray; wet.
			85, 90				SP	**Poorly graded SAND** Mostly fine sand, few silt; olive gray; wet.
			95, 100				GP	**Poorly graded GRAVEL with sand** Mostly subrounded to rounded coarse gravel, little fine to medium sand, trace silt; olive gray; wet. Increasing silt at 100 feet.
			105				ML	**Sandy SILT** Mostly silt, some fine to medium sand, few gravel; olive gray; moist. Locally indurated, possibly glacial till.
			110				GW	**Well-graded GRAVEL** Mostly coarse, few fine subrounded to rounded gravel, few medium to coarse sand; olive gray; wet. Clasts are chert, quartzite, and granitic rocks.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5B

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
							GW	
			115				GM	**Silty GRAVEL with sand** Mostly fine subrounded to rounded gravel, little fine to medium sand, little silt; olive gray; wet. Clasts are volcanic and granitic rocks. Wood chips at 118 feet.
			120					
			125				GP/GC	**Poorly graded GRAVEL with clay** Mostly fine subrounded gravel, few clay; greenish black; wet. Clasts are volcanic and sedimentary rocks and quartz vein material.
			130					
			135					
			140					
			145					
			150					

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	BURLINGTON NORTHERN RAILYARD
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES — DRILLER RICHARD JIMENEZ
DRILLING METHOD	DUAL-TUBE AIR PERCUSSION HAMMER — DRILL BIT(S) SIZE: 9" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.3 TO 185.0 FT.
PERFORATED CASING	4" 0.030-INCH SLOT SCHEDULE 40 PVC — FROM 185.0 TO 200.0 FT.
SIZE AND TYPE OF FILTER PACK	8-12 COLORADO SILICA SAND — FROM 180.0 TO 202.0 FT.
SEAL	FINE SAND — FROM 178.0 TO 180.0 FT.
GROUT	VOLCLAY AND CEMENT/BENTONITE MIX — FROM 0.0 TO 178.0 FT.

Boring/Well Name NMW-5C
Project Name SOUTH TACOMA FIELD
Project Number 916055.08

ELEVATION AND DATUM: 241.0 FT MSL	TOTAL DEPTH: 202.0 FT
DATE STARTED: 02/25/1991	DATE COMPLETED: 02/27/1991
INITIAL WATER DEPTH (FT): 23.0	
LOGGED BY: S.J. ROTH	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.3 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
						SP	**Poorly graded SAND** Fine to medium sand, trace silt; moderate brown; moist. Grains are quartz, feldspar, and mica.
U	1.0	20 20 11	5	NMW-5C-5.0	<10		
U	1.5	18 37 31	10	NMW-5C-10.0	<10		
							Dark yellowish brown.
U	1.5	10 18 26	15	NMW-5C-15.0	<10		
U	1.1	32 20 27	20	NMW-5C-20.0	<10		
U	1.1	27 44 21	25	NMW-5C-25.0	1.2	SP	**Poorly graded SAND with gravel** Mostly fine to medium sand, subrounded cobbles, few silt; moderate brown; wet.
O	0.0		30			SP	**Poorly graded SAND** Mostly medium sand, some fine sand; dusky yellowish brown; wet. Detritus from weathered granitic rocks.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
U	1.1		35	NMW-5C-35.0	<10	SP	
U	1.0	5 5 12	40	NMW-5C-40.0	<10	SP	Greenish black at 39 feet.
G	0.0	26 50	45	NMW-5C-45.0	<10	GW	**Well-graded GRAVEL** Rounded gravel and cobbles, few fine to medium sand; greenish black; wet. Cobbles include brecciated quartzite.
O	0.0		50		<10	GW	
			55			GW	
			60			GW	
			65			GW	**Well-graded GRAVEL with sand** Subangular to rounded fine to coarse gravel, up to 25% fine to medium sand; greenish black; wet. Gravel includes metavolcanic and granodiorite rock clasts.
U	0.8	8 7 18	70	NMW-5C-70.0	<10	SW/SM	**Well-graded SAND with silt** Mostly medium sand, trace fine to coarse sand, few silt; olive gray; wet.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			75			GW	**Well-graded GRAVEL** Subrounded to rounded fine to coarse gravel, few fine to medium sand, few silt; olive gray; wet.
			80				
			85			SP	**Poorly graded SAND** Mostly fine sand, few silt; olive gray; wet.
O	0.0	6 6 9	90				
			95			GP	**Poorly graded GRAVEL with sand** Mostly subrounded to rounded coarse gravel, little fine to medium sand, trace silt; olive gray; wet. Increasing silt at 100 feet.
U	1.0	50	100	NMW-5C-101.5	<10		
G	0.1	15 50		NMW-5C-103.0	3	ML	**Sandy SILT** Mostly silt, some fine to medium sand, few gravel; olive gray; moist. Locally indurated, possibly glacial till.
G	0.4	50		NMW-5C-104.5	<1		
			105			GW	**Well-graded GRAVEL** Mostly coarse, few fine subrounded to rounded gravel, few medium to coarse sand; olive gray; wet. Clasts are chert, quartzite, and granitic rocks.
			110				

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
								GW	
			115					GM	**Silty GRAVEL with sand** Mostly fine subrounded to rounded gravel, little fine to medium sand, little silt; olive gray; wet. Clasts are volcanic and granitic rocks. Wood chips at 118 feet.
G	0.3	50	120	NMW-5C-120.0					
			125					GP/GC	**Poorly graded GRAVEL with clay** Mostly fine subrounded gravel, few clay; greenish black; wet. Clasts are volcanic, sedimentary, and quartz vein material.
			130					GW	**Well-graded GRAVEL** Mostly coarse subrounded to rounded gravel, little cobbles, trace clay; olive gray; wet. Clasts are granitic and volcanic rocks.
			135					GW/GM	**Well-graded GRAVEL with silt and sand** Mostly fine to coarse subrounded gravel, little sand, little silt, little clay; olive gray; bluish clay; wet. Fragments of volcanic and granitic rocks.
			140						
			145						Decreasing sand, silt, and clay at 145 feet.
			150						

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5C

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			155			GW	**Well-graded GRAVEL** Mostly fine to coarse, subrounded to rounded flat gravel, few cobbles, little sand; greenish black; wet. Mostly volcanic, trace granitic fragments.
			160				
U	1.4	18 28 30	165	NMW-5C-165.5	<10	SP/SM & CL	**Interbedded Poorly graded SAND with silt and Lean CLAY** Greenish-black wet sand, volcanic-derived particles, and olive-gray moist to wet lean clay; approximately 6-inch interbeds. Fibrous brown organic matter in clay beds; minor brownish-black organic-rich clay at 175 feet.
O	0.0						
			170				
U	1.5	18 50	175	NMW-5C-176.5			
			180			GW	**Well-graded GRAVEL** Mostly fine to coarse subrounded to rounded gravel, few flat, trace cobbles, little medium to coarse sand; olive gray, wet. Mostly volcanic clasts, few granitic clasts. Decreasing sand, increasing coarse gravel and cobbles at 187 feet.
			185				
			190				

Boring & Well Construction Log

Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-5C

SAMPLES TYPE	SAMPLES RECOVERY (FEET)	SAMPLES PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
			195					GW	
			200						

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	BN DISMANTLING YARD
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES
DRILLER	DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER
DRILL BIT(S) SIZE	10" O.D.
ISOLATION CASING	NONE — FROM TO FT.
BLANK CASING	4" SCHEDULE 40 PVC — FROM -2.4 TO 15.0 FT.
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC — FROM 15.0 TO 40.0 FT.
SIZE AND TYPE OF FILTER PACK	10/20 COLORADO SILICA SAND — FROM 12.0 TO 42.0 FT.
SEAL	1/4" BENTONITE PELLETS — FROM 9.0 TO 12.0 FT.
GROUT	CEMENT/BENTONITE MIX — FROM 0.0 TO 9.0 FT.

Boring/Well Name NMW-6A

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 240.8 FT MSL	TOTAL DEPTH: 42.5 FT
DATE STARTED: 02/28/1991	DATE COMPLETED: 03/01/1991
INITIAL WATER DEPTH (FT): 22.1	
LOGGED BY: T.C. MORIN	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.4 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					50	GP/GM	**Poorly graded GRAVEL with silt and sand** Black, moist, 60% rounded cobbles, 30% sand, 10% silt, large amounts of debris (nails, bolts, slag, scrap steel, and wood).
U	0.5	11 25 29	5	NMW-6A-5.0	17	SW	**Well-graded SAND with gravel** Moist, dense, 70% medium sand, 30% well-rounded gravels, very dense layer at 5 feet (drill was hopping).
U	1.3	16 22 41	10	NMW-6A-10.0	6.0	SP	**Poorly graded SAND** Grayish, moist, dense, 90% medium sand, 10% fine sand and silt.
U	1.5	15 40 32	15	NMW-6A-15.0	9.1	SW/SM	**Well-graded SAND with silt and gravel** Light brown, moist, dense, 60% fine to medium sand, 30% fine gravel (rounded), 10% fines.
U	1.3	23 29 30	20	NMW-6A-20.0	11		Slightly fewer gravels.
							Wet.
U	1.5	6 13 36	25	NMW-6A-25.0	7.0		Gravels absent.
U	2.5			NMW-6A-28.0	5.2	SW	**Well-graded SAND** Light olive brown, dense, 90% fine to coarse sand, 10% fines.
U	1.4	2 4 10	30	NMW-6A-30.0			

WELL CONSTRUCTION

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-6A

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
U	0.9	1 4 15	35	NMW-6A-35.0				SW	
U	1.2	2 33 50/3	40	NMW-6A-41.5				SP	**Poorly-graded SAND with gravel** Dark gray, wet, dense, 60% medium sand, 40% fine gravel (well-rounded).

Boring & Well Construction Log — Kennedy/Jenks Consultants

BORING LOCATION	BN DISMANTLING YARD		
DRILLING COMPANY	LAYNE ENVIRONMENTAL SERVICES	DRILLER	DEAN PLAUTZ
DRILLING METHOD	HOLLOW-STEM AUGER	DRILL BIT(S) SIZE:	10" O.D.

		FROM	TO	FT.
ISOLATION CASING	NONE			
BLANK CASING	4" SCHEDULE 40 PVC	-2.0	15.0	
PERFORATED CASING	4" 0.020"-SLOT SCHEDULE 40 PVC	15.0	40.0	
SIZE AND TYPE OF FILTER PACK	8/12 COLORADO SILICA SAND	12.0	40.0	
SEAL	1/4" BENTONITE PELLETS	9.0	12.0	
GROUT	CEMENT/BENTONITE MIX	0.0	9.0	

Boring/Well Name NMW-7A

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

ELEVATION AND DATUM: 241.5 FT MSL	TOTAL DEPTH: 40.5 FT
DATE STARTED: 02/27/1991	DATE COMPLETED: 02/28/1991
INITIAL WATER DEPTH (FT): 22.2	
LOGGED BY: T.C. MORIN	
SAMPLING METHODS: 2.5" DRIVE SAMPLES	WELL COMPLETION: ☐ SURFACE HOUSING ■ STAND PIPE 2.0 FT.

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	OVA (ppm)	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
					3.9	SP/SC	**Poorly graded SAND with clay and gravel** Grayish black, very moist, 70% medium sand, 15% rounded gravel, 15% clay.
U	1.3	14 26 50	5	NMW-7A-5.0	1.1	SW	**Well-graded SAND** Tannish brown, moist, 70% sand, 30% well-rounded gravel. Debris encountered (steel, brick, slag).
U	1.5	11 24 28	10	NMW-7A-10.0	3.0	SP	**Poorly graded SAND** Tan, damp, 95% medium to fine sand, 5% silt. Sand is subrounded to round.
U	1.5	17 35 40	15	NMW-7A-15.0	6.0		Rounded to well-rounded cobbles encountered (3" diameter).
U	0.9	25 50/5	20	NMW-7A-20.0	3.5		Sand fraction coarsens (50% coarse sand, fine gravel). Granitic and gabbroic cobbles. Wet.
U	1.5	10 30 40	25	NMW-7A-25.0	11		Sand fraction becomes finer.
O	2.5			NMW-7A-28.5			
G	1.1	8 12 24	30	NMW-7A-30.0			Sample collected was heaving (disturbed) in augers.

Boring & Well Construction Log — Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD **Project Number** 916055.08 **Boring/Well Name** NMW-7A

SAMPLES TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)	DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
U	1.0	22 50/5		NMW-7A-34.0		4.0		SP	Gray; sand fraction is fine to medium: trace little silt.
			35					SP	**Poorly graded SAND** Gray, wet, very dense, 99% fine to medium sand, trace silt.
U	1.4	3 6 7		NMW-7A-40.0					
			40						

Appendix GW-B

Results of Sieve Analyses

SIEVE ANALYSIS DATA

WELL: NMW-1A

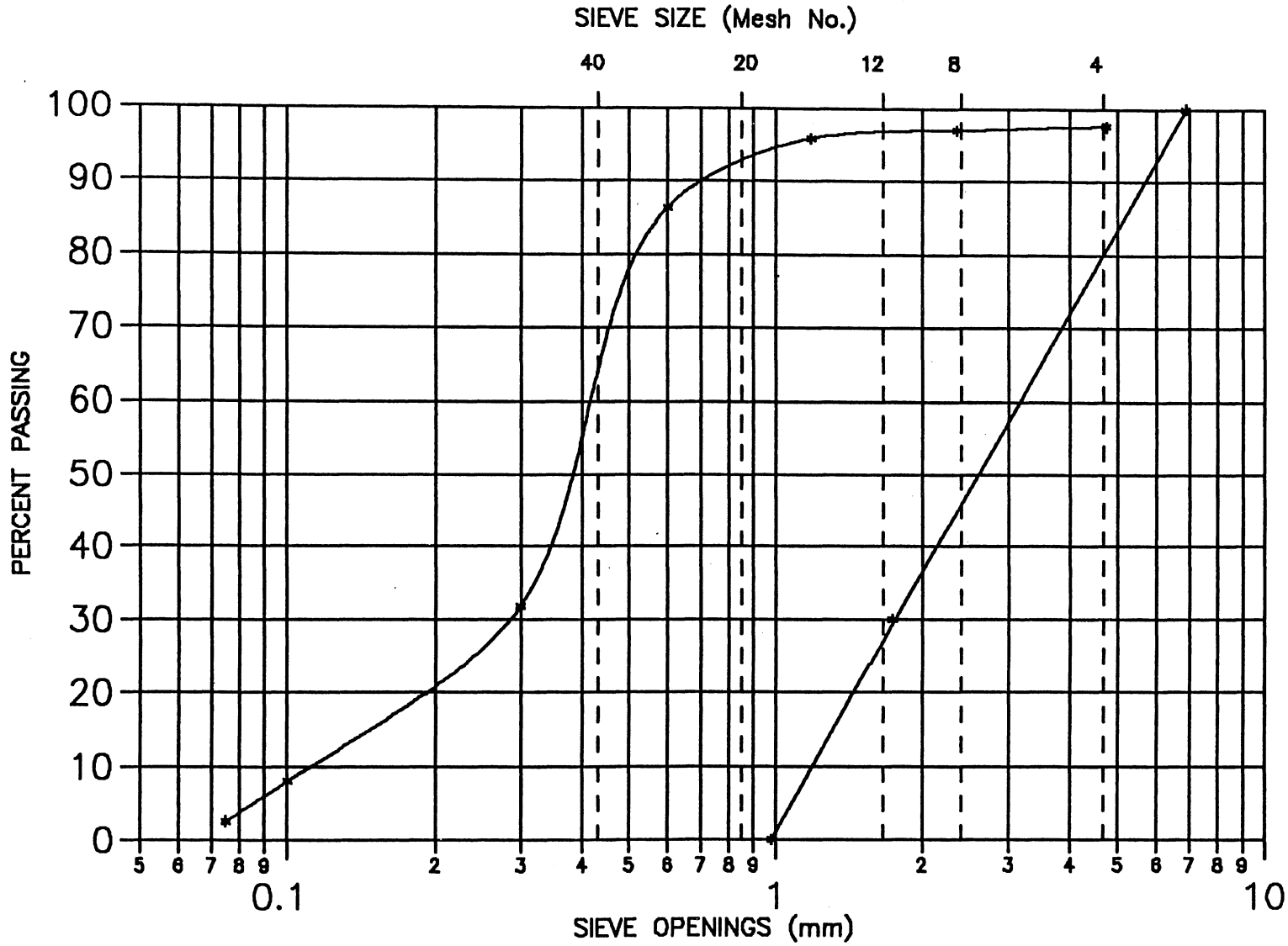
Depth collected (ft BGS) = 30.5-32.0

Weight of sample (g) = 100.3

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	2.45	2.4	97.6
8	0.093	2.36	0.55	0.5	97.0
16	0.046	1.18	1.20	1.2	95.8
30	0.024	0.600	9.45	9.4	86.4
50	0.012	0.300	54.80	54.6	31.8
100	0.006	0.150	23.85	23.8	8.0
200	0.003	0.075	5.40	5.4	2.6
Passed 200-Mesh Sieve			2.60	2.6	-
Total			100.30	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–1A



D_{60} = 0.41
D_{30} = 0.29
D_{10} = 0.12
$Cu_g = D_{60}/D_{10} = 3.4$
$Cu_{(fp)}$ = 2.5
F_{30} = 6
$D_{30(fp)}$ = 1.74

SIEVE ANALYSIS DATA

WELL: NMW-2A

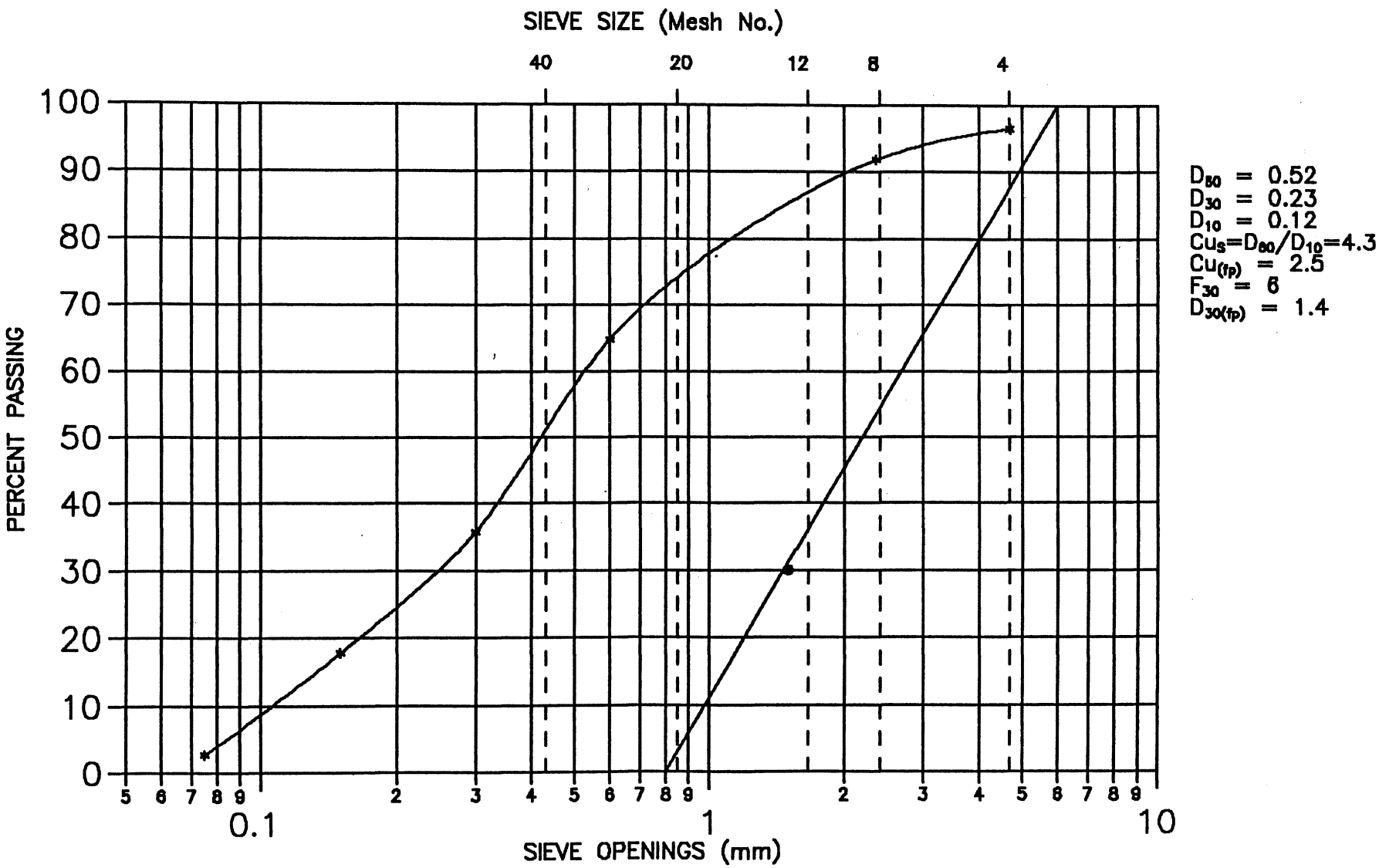
Depth collected (ft BGS) = 23.5-25

Weight of sample (g) = 100.7

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	3.5	3.5	96.5
8	0.093	2.36	4.8	4.8	91.8
30	0.024	0.600	27.2	27.0	64.7
50	0.012	0.300	29.1	28.9	35.8
100	0.006	0.150	18.2	18.1	17.8
200	0.003	0.075	15.2	15.1	2.7
Passed 200-Mesh Sieve			2.7	2.7	0.0
Total			100.7	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–2A


SIEVE SIZE (Mesh No.)
40
20
12
8
4
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
5 6 7 8 9
0.1
2 3 4 5 6 7 8 9
1
2 3 4 5 6 7 8 9
10
SIEVE OPENINGS (mm)
D_{60} = 0.52
D_{30} = 0.23
D_{10} = 0.12
$Cu_S = D_{60}/D_{10} = 4.3$
$Cu_{(fp)}$ = 2.5
F_{30} = 6
$D_{30(fp)}$ = 1.4

SIEVE ANALYSIS DATA

WELL: NMW-3A

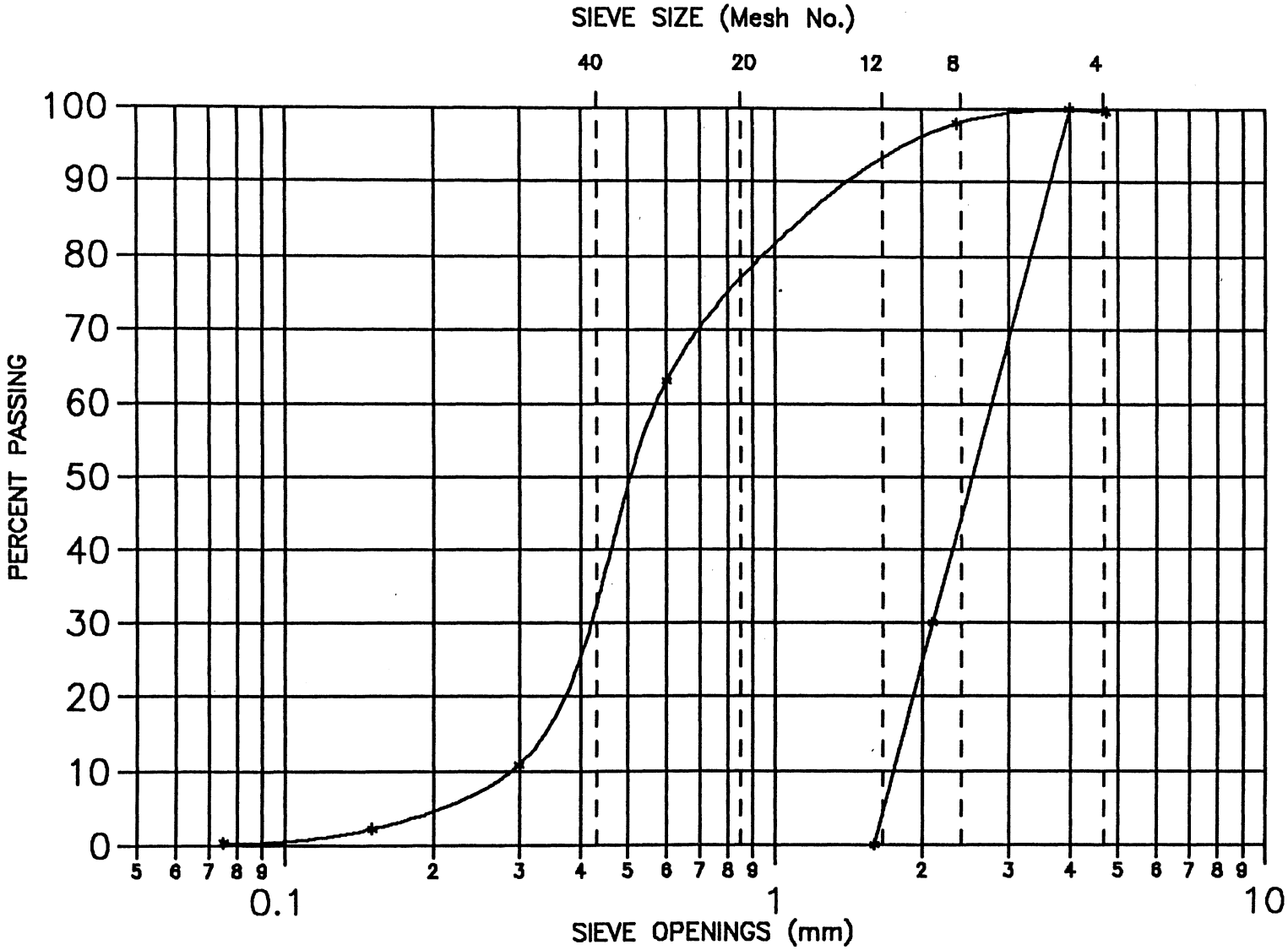
Depth collected (ft BGS) = 26.5-28

Weight of sample (g) = 100

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	0.4	0.4	99.6
8	0.093	2.36	1.6	1.6	98.0
30	0.024	0.600	34.8	34.9	63.1
50	0.012	0.300	52.1	52.2	10.9
100	0.006	0.150	8.6	8.6	2.3
200	0.003	0.075	1.9	1.9	0.4
Passed 200-Mesh Sieve			0.4	0.4	0.0
Total			99.8	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–3A



D_{60} = 0.58
D_{30} = 0.42
D_{10} = 0.29
$Cu_s = D_{60}/D_{10} = 2$
$Cu_{(fp)}$ = 2.5
F_{30} = 5
$D_{30(fp)}$ = 2.10

SIEVE ANALYSIS DATA

WELL: NMW-3B

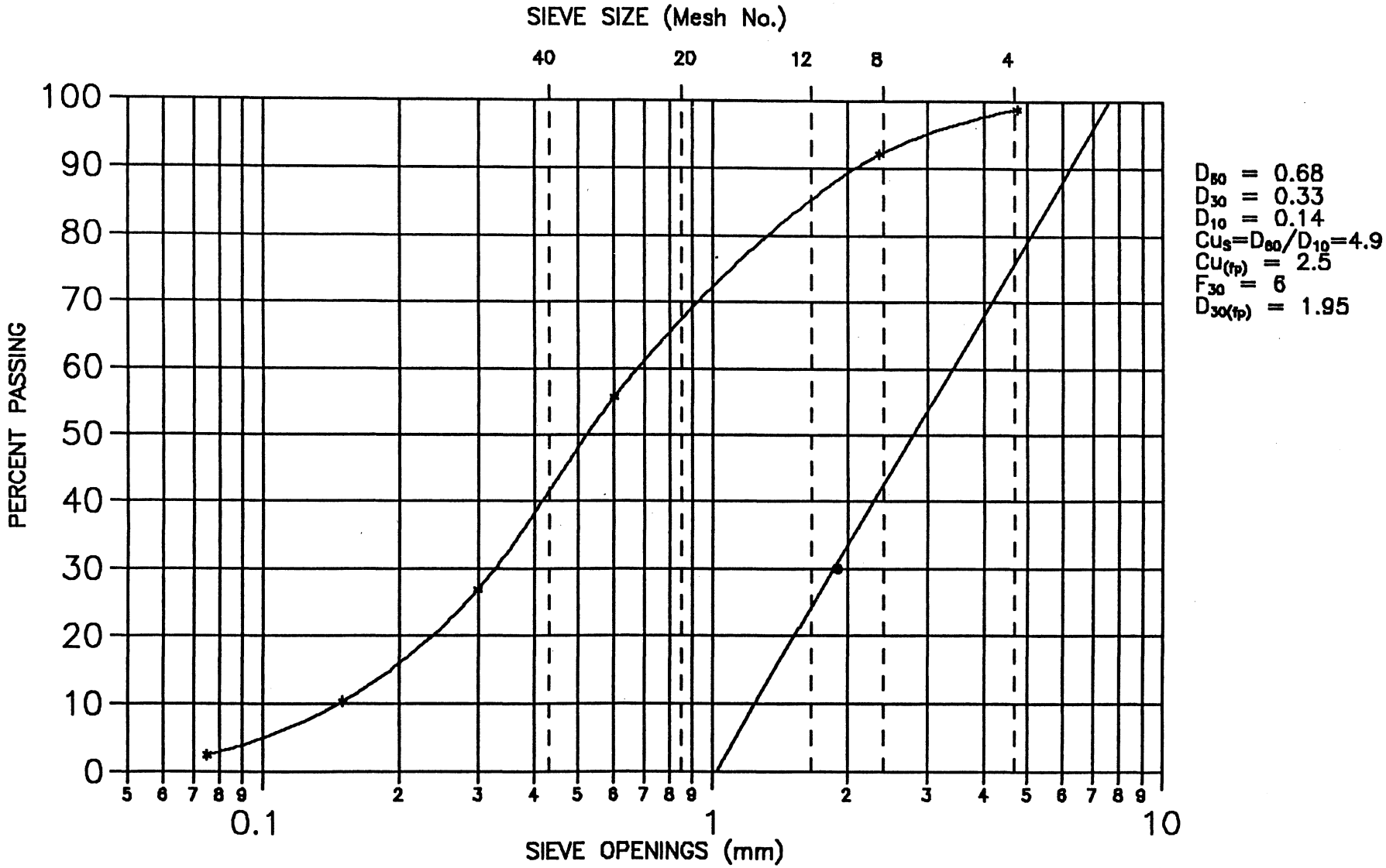
Depth collected (ft BGS) = 113.5-115

Weight of sample (g) = 57.5

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	0.6	1.1	98.9
8	0.093	2.36	3.5	6.7	92.2
30	0.024	0.600	19.1	36.5	55.6
50	0.012	0.300	15.0	28.7	27.0
100	0.006	0.150	8.7	16.6	10.3
200	0.003	0.075	4.1	7.8	2.5
Passed 200-Mesh Sieve			1.3	2.5	-
Total			52.3	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW-3B


SIEVE SIZE (Mesh No.)
40
20
12
8
4
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
5 6 7 8 9
0.1
2 3 4 5 6 7 8 9
1
2 3 4 5 6 7 8 9
10
SIEVE OPENINGS (mm)
D_{60} = 0.68
D_{30} = 0.33
D_{10} = 0.14
$Cu_s = D_{60}/D_{10} = 4.9$
$Cu_{(fp)}$ = 2.5
F_{30} = 6
$D_{30(fp)}$ = 1.95

Sieve analyses were not performed on soil samples collected from NMW-3C due to the preponderance of cobbles and boulders in the screened interval. The largest available filter pack and screen slot sizes were used for completion of NMW-3C.

SIEVE ANALYSIS DATA

WELL: NMW-4A

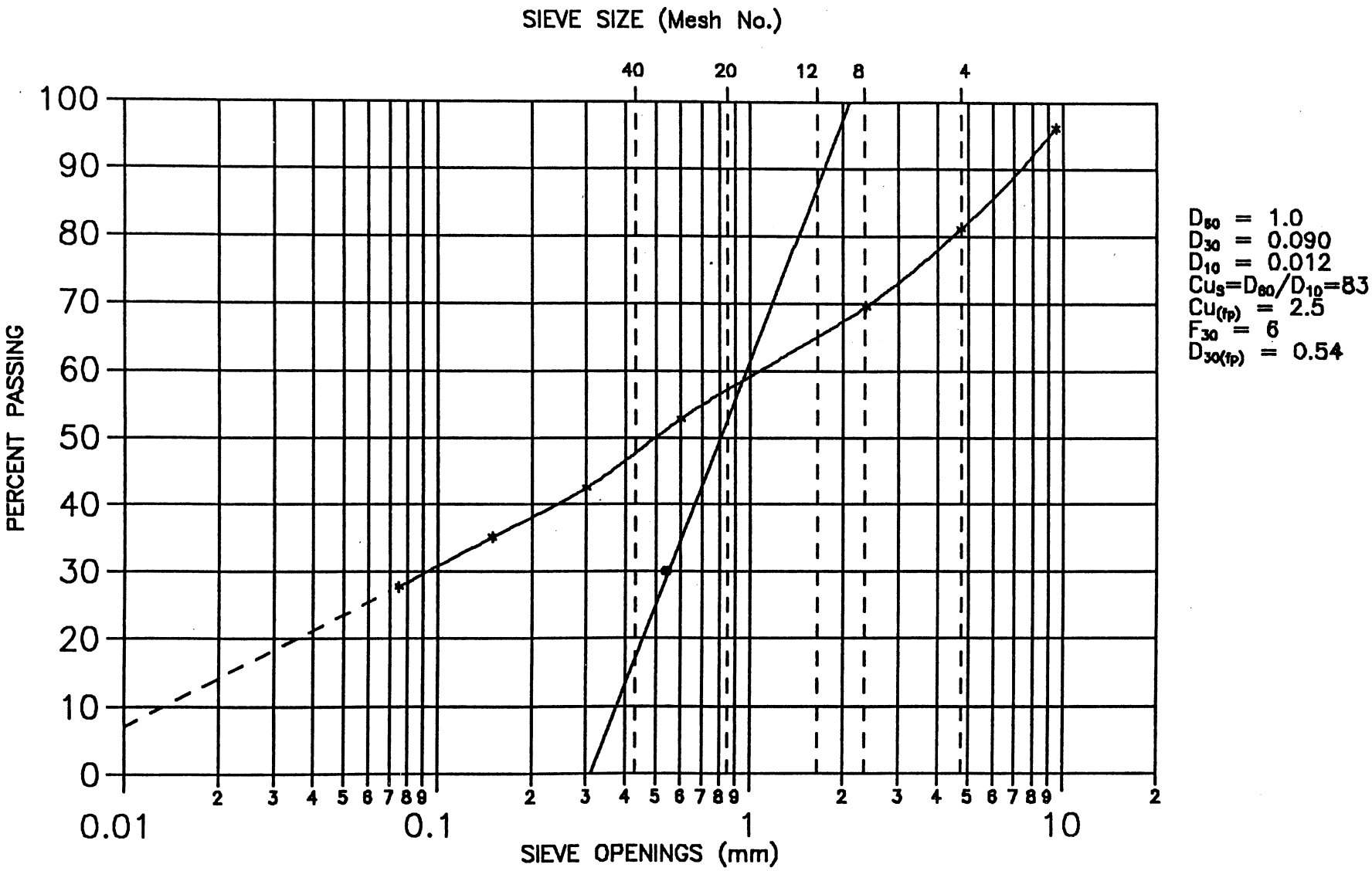
Depth collected (ft BGS) = 20.5-22.0

Weight of sample (g) = 100

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	3.7	3.8	96.2
4	0.187	4.75	14.9	15.1	81.1
8	0.093	2.36	11.3	11.5	69.6
30	0.024	0.600	16.6	16.9	52.8
50	0.012	0.300	10.0	10.2	42.6
100	0.006	0.150	7.4	7.5	35.1
200	0.003	0.075	7.3	7.4	27.7
Passed 200-Mesh Sieve			27.3	27.7	-
Total			98.5	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–4A



— — EXTRAPOLATION OF DATA

SIEVE ANALYSIS DATA

WELL: NMW-5A

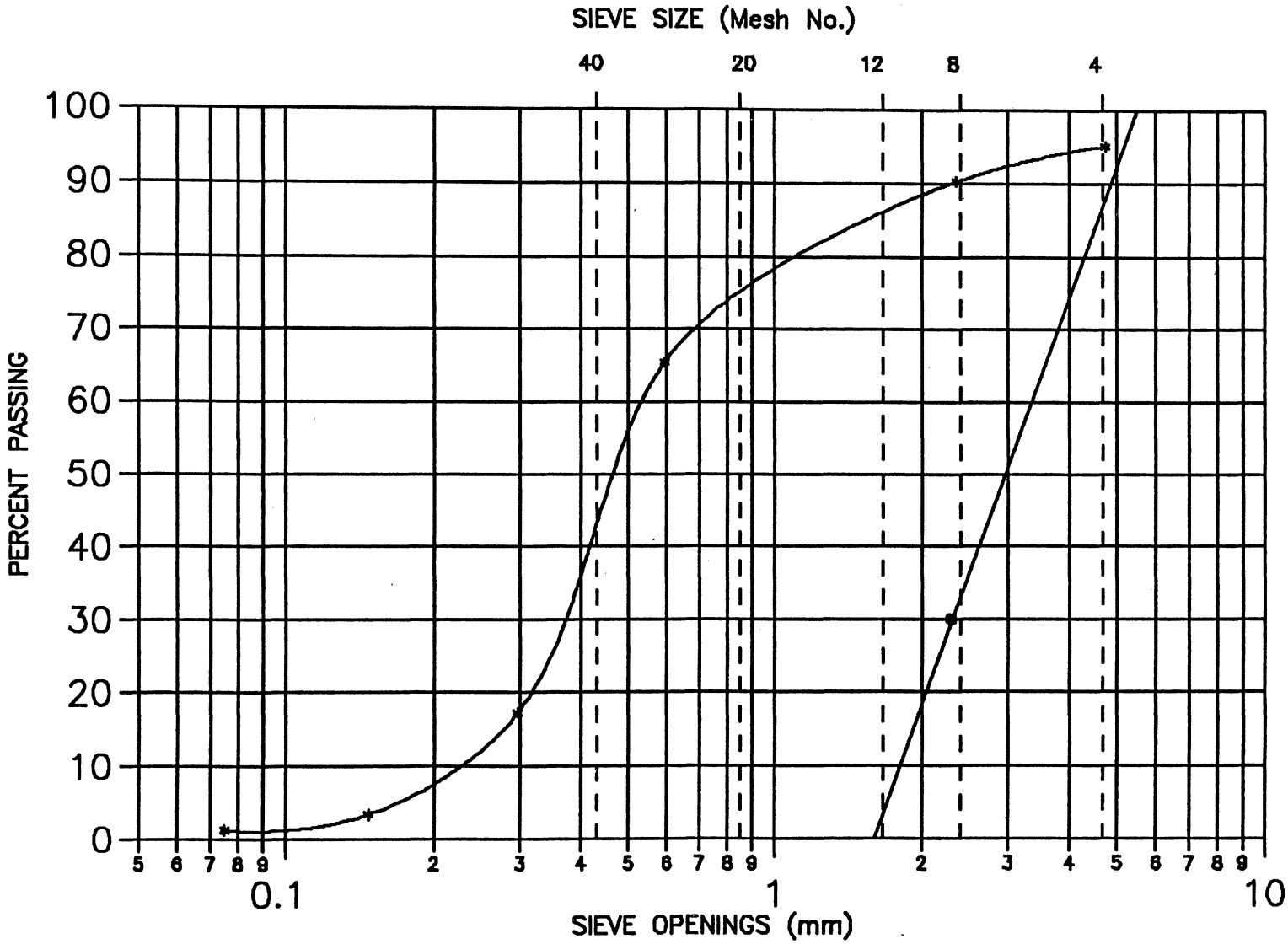
Depth collected (ft BGS) = 25-30 (Composite)

Weight of sample (g) = 100

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	5.0	4.9	95.1
8	0.093	2.36	5.0	4.9	90.3
30	0.024	0.600	25.6	24.9	65.4
50	0.012	0.300	49.5	48.2	17.2
100	0.006	0.150	14.2	13.8	3.4
200	0.003	0.075	2.2	2.1	1.3
Passed 200-Mesh Sieve			1.3	1.3	-
Total			102.8	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW-5A



D_{60} = 0.53
D_{30} = 0.38
D_{10} = 0.22
$Cu_s = D_{60}/D_{10} = 2.65$
$Cu_{(fp)}$ = 2.5
F_{30} = 6
$D_{30(fp)}$ = 2.3

Appendix GW-C

Summary Tables of Analytes Detected Per Monitoring Well

APPENDIX GW-C
LIST OF TABLES

Table No.	Table Title (Sampling Location Number)
GW-C1	Analytes Detected in Groundwater Samples from Onsite Well NMW-1A (1760)
GW-C2	Analytes Detected in Groundwater Samples from Onsite Well NMW-2A (1758)
GW-C3	Analytes Detected in Groundwater Samples from Onsite Well NMW-3A (1756)
GW-C4	Analytes Detected in Groundwater Samples from Onsite Well NMW-3B (1755)
GW-C5	Analytes Detected in Groundwater Samples from Onsite Well NMW-3C (1757)
GW-C6	Analytes Detected in Groundwater Samples from Onsite Well NMW-4A (1759)
GW-C7	Analytes Detected in Groundwater Samples from Onsite Well NMW-5A (1754)
GW-C8	Analytes Detected in Groundwater Samples from Onsite Well NMW-5B (1752)
GW-C9	Analytes Detected in Groundwater Samples from Onsite Well NMW-5C (1753)
GW-C10	Analytes Detected in Groundwater Samples from Onsite Well NMW-6A (1751)
GW-C11	Analytes Detected in Groundwater Samples from Onsite Well NMW-7A (1750)
GW-C12	Analytes Detected in Groundwater Samples from Onsite Well CBS-1A (1761)
GW-C13	Analytes Detected in Groundwater Samples from Onsite Well CBS-3A (1763)

APPENDIX GW-C
LIST OF TABLES

Table No.	Table Title (Sampling Location Number)
GW-C14	Analytes Detected in Groundwater Samples from Onsite Well CBS-4A (1764)
GW-C15	Analytes Detected in Groundwater Samples from Onsite Well CBS-5A (1765)
GW-C16	Analytes Detected in Groundwater Samples from Onsite Well CBS-7A (1767)
GW-C17	Analytes Detected in Groundwater Samples from Onsite Well CBS-8A (1768)
GW-C18	Analytes Detected in Groundwater Samples from Onsite Well CBS-9A (1769)
GW-C19	Analytes Detected in Groundwater Samples from Onsite Well CBS-11A (1771)
GW-C20	Analytes Detected in Groundwater Samples from Onsite Well MW-1A (1773)
GW-C21	Analytes Detected in Groundwater Samples from Onsite Well MW-3A (1775)
GW-C22	Analytes Detected in Groundwater Samples from Onsite Well MW-5A (1777)
GW-C23	Analytes Detected in Groundwater Samples from Onsite Well STM-1A (1778)
GW-C24	Analytes Detected in Groundwater Samples from Onsite Well STM-2A (1779)
GW-C25	Analytes Detected in Groundwater Samples from Onsite Well STM-3A (1780)
GW-C26	Analytes Detected in Groundwater Samples from Onsite Well STM-4A (1781)

APPENDIX GW-C
LIST OF TABLES

Table No.	Table Title (Sampling Location Number)
GW-C27	Analytes Detected in Groundwater Samples from Background Well CBS-5A (1765)
GW-C28	Analytes Detected in Groundwater Samples from Background Well CBS-9A (1769)
GW-C29	Analytes Detected in Groundwater Samples from Background Well 89.7-P1 (1782)
GW-C30	Analytes Detected in Groundwater Samples from Background Well TL-16A (1783)
GW-C31	Analytes Detected in Groundwater Samples from Background Well WCC-2 (1784)
GW-C32	Analytes Detected in Groundwater Samples from Upgradient Well CBS-10A (1770)
GW-C33	Analytes Detected in Groundwater Samples from Upgradient Well TL-12A (1785)
GW-C34	Analytes Detected in Groundwater Samples from Upgradient Well TL-13A (1786)
GW-C35	Analytes Detected in Groundwater Samples from Upgradient Well TL-14A (1787)
GW-C36	Analytes Detected in Groundwater Samples from Upgradient Well TL-23A (1788)

TABLE GW-C1

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-1A (1760)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum	B	80.7	UJ	B	107	UJ		2,290		B	84.9	UJ
Arsenic		12.4	UJ		13.8			11		B	8.8	
Barium	B	20.1		B	14.9		B	31.3		B	17.8	
Boron		Not Analyzed			613			512			449	
Calcium		37,700			46,600			57,000			48,800	
Cobalt	U	6.7		U	5		U	5		B	3.2	
Cyanide		Not Analyzed			60			38.7			29.3	
Iron		992			1,650			4,650			2,130	
Magnesium		13,600			19,000			24,500			20,500	
Manganese		3,410	J4		4,410			5,200			4,710	
Potassium	B	1,840	UJ	B	2,070		B	1,570	UJ	B	2,040	
Sodium		10,600	J4		13,600			17,000	UJ		15,600	
PAHs												
Naphthalene		130	J2		190			68			30	
Acenaphthene	U	0.5			3			2.6			1.8	
Fluorene	U	0.1			4		U	0.1		U	0.1	
Phenanthrene	U	0.05			0.14		U	0.05		U	0.05	
VOCs												
Acetone	E	410	R	J	78		U	50		U	10	
1,1,2-Trichloroethane	U	10		J	51		U	50		U	10	
Benzene	E	300	R		480		D	230			86	
Toluene	E	470	R		770		D	170			51	
Ethyl Benzene	E	570	R		1,000		D	600			150	
Styrene	U	10		U	100		U	50		J	3	
Xylenes (total)	E	1,100	R		2,300		DJ	644			141	

TABLE GW-C1

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-1A (1760)

Analyte	Concentration (μg/L)[a,b]								
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)	
Semivolatiles									
2-Methylphenol	Not Analyzed		34		U	10	R	U	10
2,2'-oxybis (1-Chloropropane)	Not Analyzed	J	1		U	10	R	U	10
4-Methylphenol	Not Analyzed		23		U	10	R	U	10
2,4-Dimethylphenol	Not Analyzed	E	120		U	10	R	U	10
2-Methylnaphthalene	Not Analyzed	E	85			27	J4		15
bis(2-Ethylhexyl)phthalate	Not Analyzed	U	10		BJ	6	J4	U	10

(a) Letters preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.
(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration indicated.

TABLE GW-C2

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-2A (1758)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		947			423		B	121	UJ		453	
Arsenic		50.9			39.1		B	8.3			45.6	
Barium	B	30.6		B	53.8		B	50.9		B	26.4	
Boron		Not Analyzed			1,230			1,210			1,340	
Calcium		6,760			9,240			58,100			9,530	
Total Chromium	B	9.9		B	5	UJ	U	4			12	UJ
Cobalt	U	6.7		B	15.5		B	20.8		U	3	
Copper	B	13	UJ	B	5	J4	B	1	UJ	B	8.9	
Cyanide		Not Analyzed		U	20		U	10			11.2	
Iron		2,730			10,900			16,900			3,660	
Lead		5.6	UJ	B	2.6	UJ	U	1		B	1.5	J4
Magnesium		21,600			19,000			22,400			43,500	
Manganese		131	J4		358			884			123	
Nickel	B	19.3		B	30.1	UJ		51.7		U	8	UJ
Potassium	B	2,720	J4	B	3,750		B	4,430		B	4,220	
Sodium		87,500	J4		100,000			101,000			84,600	
Vanadium	B	18.3		B	29.7		B	16.3	UJ	B	24.1	
PAHs												
Anthracene	U	0.05		B	0.053	UJ		0.054		U	0.05	
VOCs												
1,2-Dichloroethene (total)	U	10		U	13		J	5		J	7	
Trichloroethene	U	10		J	1		U	10		J	2	

TABLE GW-C2

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-2A (1758)

Analyte	Concentration (μg/L)[a,b]								
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)	4th Quarter (January 1992)			
Semivolatiles									
Diethylphthalate	Not Analyzed	U	10		Not Analyzed	J	2		
bis(2-Ethylhexyl) phthalate	Not Analyzed	U	10		Not Analyzed	J	0.7	J4	

(a) Letters preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration indicated.

TABLE GW-C3

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-3A (1756)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		557	J4		5,760			704			341	
Arsenic	U	3.2		B	3		U	2		U	2	
Barium	B	20.3		B	50.8		B	12.6	UJ	B	12.1	
Boron	Not Analyzed				120			110			120	
Calcium		10,500			13,500			13,700			12,500	
Cobalt	B	9.8		B	15.7		U	5		B	3.8	
Copper	B	14	UJ	B	19.7	J4	B	2.5	UJ	B	6.1	
Iron		636	J4		7,940			934			446	
Lead	B	1.2	UJ		8	J4	B	1.8	UJ	B	1.5	J4
Magnesium	B	4,630	J4		6,910			6,470			5,760	
Manganese		193			509			100			29.2	
Nickel	B	13.2		B	22.5	J4	U	14		U	8	UJ
Potassium	B	2,470		B	3,250		B	2,660		B	2,880	
Selenium	B	3.2		U	30	UJ	U	1		U	2	UJ
Sodium		23,700	J4		26,500			32,400			27,100	
Vanadium	U	3.3		B	15.6		B	5.2		U	4	
VOCs												
Chloroform	J	3		J	1		J	2		J	2	
1,1,1-Trichloroethane	U	10		J	2		U	10		U	10	
Tetrachloroethene	J	3		J	4		J	4		J	4	

(a) Letters preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration indicated.

TABLE GW-C4

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-3B (1755)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		724	J4	B	63	UJ		271			217	UJ
Arsenic		25.2	UJ	B	4.7			22.5			27.3	
Barium	B	25.3		B	10.8		B	13.7	UJ	B	15.3	
Boron	Not Analyzed				85.6		U	31		B	29.9	UJ
Calcium		15,500			7,840			18,400			17,600	
Total Chromium	B	3.6		U	5		U	4		U	7	
Cobalt	U	6.7		B	5.1		U	5		U	3	
Copper	B	4	UJ	B	1.4	J4	U	1		U	1	
Iron		441	J4		997			279	UJ		218	
Magnesium	B	4,680	J4	B	3,420			5,520			5,370	
Manganese		95.6			347			108			116	
Potassium	B	4,430		B	1,590		B	4,550		B	4,780	
Sodium		11,700	J4		7,960			17,100	UJ		12,000	
Zinc	B	5.7	UJ		23.2		B	3.1	UJ	B	4	UJ

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C5

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-3C (1757)

Analyte	Concentration (μg/L)[a,b]			
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)	3rd Quarter (Oct/Nov 1991)	4th Quarter (January 1992)
Inorganics				
Arsenic	B 5.7 UJ	B 7	10	B 8.1
Barium	B 11.5	B 6.6	B 6 UJ	B 6.8 UJ
Boron	Not Analyzed	66.9	U 31	B 25.5 UJ
Calcium	8,600	11,300	12,000	11,900
Iron	302 J4	723	766	833
Magnesium	B 5,460 J4	6,000	6,510	6,690
Manganese	122	205	213	223
Potassium	B 2,590	B 3,220	B 2,680	B 2,890
Sodium	8,380 J4	9,270	15,100 UJ	10,200

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C6

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-4A (1759)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		5,940	J4		1,180			1,080			282	UJ
Arsenic	B	7.2	UJ	B	3.3		B	4.4		B	4.2	
Barium	B	56.5		B	33.1		B	16.6	UJ	B	36.3	
Boron	Not Analyzed				41.5		U	31		B	35	UJ
Calcium		99,100			61,400			8,370			22,600	
Total Chromium	B	3.8		U	5		B	8.9		U	7	
Cobalt		218			51.6		U	5		B	13.7	
Copper	B	8	UJ	B	3.2	J4	B	11.2		B	6.8	
Iron		5,210	J4		2,320			3,690			3,620	
Magnesium		53,300	J4		32,300		B	2,290			10,400	
Manganese		4,160			2,290			147			731	
Nickel		1,950			778			43.5			220	
Potassium	B	4,500		B	3,830		B	1,060	UJ	B	2,180	
Sodium		194,000	J4		234,000			142,000			139,000	
Vanadium	U	3.3		U	6		B	30.5		B	12.2	
Zinc		118			27.6		B	7.7	UJ	B	10.3	UJ

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C7

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-5A (1754)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		1,020	J4		959			828			363	
Barium	B	15.6		B	9.7	J4	B	10.4	UJ	B	6.3	UJ
Boron	Not Analyzed				900			373			319	
Calcium	B	4,560		B	4,220			5,690		B	3,470	
Total Chromium	B	3.9		U	5		B	6.1		B	7.8	UJ
Cobalt	U	6.7		U	5		U	5		B	3.3	
Copper	B	5	UJ	B	2	J4	B	1.6	UJ	U	1	
Cyanide	Not Analyzed				80			13.1			15.7	J3
Iron		1,350	J4		1,790			1,440			601	
Lead	B	2.1	UJ	B	2.2		B	1.4	UJ	U	1	UJ
Magnesium	B	3,380	J4	B	3,800			5,670		B	3,460	
Manganese		143			105			144			36.4	
Potassium	B	1,500	UJ	B	1,160		B	1,980		B	1,270	
Sodium		18,900	J4		19,700			28,700			14,000	
Vanadium	U	3.3		U	6		B	9.8		B	6.2	
VOCs												
Toluene	J	1		J	3	UJ	U	10	UJ	U	10	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.2

TABLE GW-C8

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-5B (1752)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum	B	38.2	UJ	B	76.1		U	19		B	20.4	UJ
Arsenic		10.7	UJ	B	7.8	UJ	B	7.4		B	8.2	
Barium	B	9.1		B	9.1		B	7.7	UJ	B	8.6	
Boron	Not Analyzed				20.2		U	31		B	25.5	UJ
Calcium		17,800			17,200			18,800			18,400	
Magnesium		8,040			8,640			9,640			9,400	
Manganese		64.6	J4		63.8			67.3			69.4	
Potassium	B	2,630	J4	B	2,330		B	3,800		B	3,320	
Sodium		6,890	J4		6,420			13,200	UJ		7,210	
Vanadium	U	3.3		U	6		B	5.2		U	4	
PAHs												
Anthracene	U	0.05			0.054		B	0.061	UJ	U	0.05	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C9

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-5C (1753)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Arsenic	B	6.1	UJ	B	8.5			10.2		B	8.6	
Barium	B	12.9		B	8.4		B	7.1	UJ	B	8.3	
Boron	Not Analyzed			B	99.5			102		B	91.3	UJ
Calcium		28,000			29,700			30,500			31,200	
Iron		341	J4		407			367			408	
Magnesium		9,320	J4		10,700			11,000			11,300	
Manganese		196			203			202			212	
Potassium	B	3,590		B	3,710		B	3,410		B	3,660	
Sodium		8,970	J4		8,260			11,500	UJ		8,930	
Vanadium	U	3.3		B	6		U	4		U	4	
PAHs												
Anthracene	U	0.05		J	0.044		B	0.055	UJ	U	0.05	
VOCs												
Carbon Disulfide	U	10		U	10		J	1	J3	U	10	
Semivolatiles												
bis(2-Ethylhexyl)phthalate	Not Analyzed			U	10		Not Analyzed			J	1	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C10

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-6A (1751)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		1,080	J4	B	177			238		B	115	UJ
Barium	B	21.3		B	3.7	J4	B	8.2	UJ	B	9.7	
Boron	Not Analyzed				528			685			699	
Calcium		11,000			9,150			17,600			20,100	
Total Chromium	B	3.6		U	5		U	4		B	9.6	UJ
Iron		1,270	J4		236			331			150	
Lead	B	2	UJ	B	1.6			4.3	UJ	U	1	UJ
Magnesium	B	3,980	J4	B	3,430			6,950			7,910	
Manganese		95.1			29.8		B	9.2		B	4.2	
Nickel	B	7.1		U	15	UJ	U	14		U	8	UJ
Potassium	B	1,490	UJ	U	973		B	1,530		B	1,320	
Silver	U	6.7	R	B	4.4		U	3		U	6	
Sodium		9,980	J4		8,440			12,000	UJ		13,300	
Vanadium	U	3.3		U	6		B	7.1		U	4	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C11

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL NMW-7A (1750)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		1,100	J4	B	176			1,560		B	75.4	UJ
Barium	B	14.5		B	3.7	J4	B	13.2	UJ	B	6.4	UJ
Boron	Not Analyzed				1,200			1,060			1,160	
Calcium		12,800			12,100			10,500			13,500	
Iron		505	J4		130	J4		2,400		B	95.3	UJ
Lead	B	1.9	UJ	B	2.1		B	2.1	UJ	U	1	UJ
Magnesium		6,240	J4		5,550		B	4,920			5,920	
Manganese		17.2		B	2.5	J4		85.8		B	3	
Potassium	B	1,620	UJ	B	1,470		B	1,430		B	1,790	
Selenium	U	1.4		U	3	UJ	U	1		B	2.1	J4
Sodium		17,300	J4		19,100			23,300	UJ		25,200	
Vanadium	U	3.3		U	6		B	11		U	4	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C12

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-1A (1761)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		362	UJ	B	170			265			256	UJ
Barium	B	9.5		B	2.2	J4	B	4.9	UJ	B	5.9	UJ
Boron	Not Analyzed				405			125			248	
Calcium		5,920			6,220			8,520			6,380	
Iron		327	J4		166			266	UJ		247	
Lead	B	0.91	UJ	B	1.3		B	1.7	UJ	B	1.8	J4
Magnesium	B	1,450	J4	B	1,500		B	2,100		B	1,640	
Manganese	B	13.3		B	8.5			18.1		B	11.9	
Sodium		18,500	J4		13,500			17,900	UJ		8,760	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C13

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-3A (1763)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Barium	B	10.6		B	3	J4	B	3.3	UJ	B	4.7	UJ
Beryllium	U	1.1		U	1		U	1		B	1	
Boron	Not Analyzed				390			75.2		B	98.2	
Calcium		14,300			13,400			13,500			12,800	
Total Chromium	B	3.7		U	5		U	4		U	7	
Lead	U	0.7	UJ	B	1.9		B	1.3	UJ	B	1.7	J4
Magnesium		6,500	J4		6,760			6,640			6,330	
Manganese	B	3.4	UJ	U	1	UJ	B	7.9		B	2	
Potassium	B	2,240		B	2,320		B	1,480		B	1,620	
Sodium		124,000	J4		10,500			11,000	UJ		5,670	
Vanadium	U	3.3		U	6		B	4.2		U	4	
VOCs												
Chloromethane	U	10		J	3		U	10	UJ	U	10	
Trichloroethene	J	3		J	2		J	6	J3	J	5	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C14

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-4A (1764)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Arsenic	B	4.3	UJ	U	2		B	1.1		B	3	
Barium	U	7.8		B	6.7	J4	B	3.1	UJ	B	5.7	UJ
Boron	Not Analyzed				242			768			786	
Calcium		19,000			20,700			6,780			7,700	
Cyanide	Not Analyzed			U	10			11.4			11.9	
Lead	U	0.7		B	1.8		U	1		B	1.2	J4
Magnesium		11,800			13,400		B	4,440			5,130	
Potassium	B	1,830	UJ	B	2,480		B	2,080	UJ	B	1,870	
Silver	U	6.7		B	5		U	3		U	6	
Sodium		10,200	J4		10,200			38,000			32,900	
Vanadium	U	3.3		U	6		B	10.3	UJ	B	5.6	
PAHs												
Anthracene	U	0.05		U	0.05			0.053		U	0.05	
VOCs												
Trichloroethene	U	10		U	10		J	2		U	10	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C15

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-5A (1765)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Boron	Not Analyzed				44		B	52.6		B	36.7	UJ
Calcium		10,500			10,200			9,910			9,490	
Iron		160	UJ	B	13.6	J4		101	UJ	B	36.3	UJ
Lead	B	0.82	UJ	B	1.4		U	1		B	1	J4
Magnesium		6,640	J4		6,440			7,360			6,630	
Potassium	B	1,640	UJ	B	1,080		B	992	UJ	B	1,140	
Sodium		7,180	J4		5,190			11,900	UJ		5,190	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C16

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-7A (1767)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		300	UJ	B	118		B	191		B	95.9	UJ
Arsenic	B	6.4	UJ	U	2	UJ	U	1		B	1.1	
Barium	B	11		B	5.6		B	3.1	UJ	B	6.8	UJ
Boron	Not Analyzed				120		B	83.5			111	
Calcium		13,400			10,700			12,700			15,800	
Iron		346	J4		187			304			154	UJ
Lead		3.9	UJ		3.7	UJ		5	UJ	B	2.4	J4
Magnesium		7,270	J4		6,680			7,810			10,200	
Manganese	B	8.1		B	6.6	UJ	B	6.2	UJ	U	2	
Potassium	B	2,010		B	1,470		B	2,000	UJ	B	1,740	
Sodium		10,500	J4		7,800			15,300	UJ		9,010	
Vanadium	U	3.3		B	6		B	5.5	UJ	B	4.1	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C17

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-8A (1768)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		307		B	124	UJ	B	110	UJ	B	120	UJ
Antimony	U	43.3		U	20		B	50.7		B	13.3	
Arsenic	B	6.4	UJ	B	2.3		U	1		B	1.6	
Barium		302			388			423			500	
Boron		Not Analyzed			1,880			1,680			1,940	
Calcium		63,700			74,100			80,300			87,200	
Total Chromium	B	7.1		U	5		U	4		U	7	
Iron		14,300			17,000			20,600			22,200	
Lead		58.9			25.2			13.4	J4		16.5	J4
Magnesium		59,400			76,500			81,800			93,800	
Manganese		492	J4		574			652			714	
Potassium	B	5,140	J4		6,860			6,570			6,940	
Sodium		92,300	J4		95,300			91,000			98,400	
Vanadium	U	3.3		B	8.5		B	7.6	UJ	B	5.5	
Zinc		150			48.2			31.8			49.3	
PAHs												
Naphthalene		2.3			7.1			8.5			11	
Acenaphthylene		2.9		U	1		U	1		U	1	
Acenaphthene		2.6			4.7			4.7			5.8	
Fluorene		0.25			3.8			1.5			4.5	
Phenanthrene		0.22			0.52			0.68			1.1	
Anthracene		0.65			0.28	UJ		0.32			0.29	
Fluoranthene		0.21			0.47			0.49			0.73	
Pyrene	U	0.1			0.23			0.33			0.49	

TABLE GW-C17

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-8A (1768)

Analyte	Concentration (µg/L)[a,b]									
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)		4th Quarter (January 1992)		
VOCs											
Vinyl Chloride	U	1		J	2		U	10	U	10	
1,2-Dichloroethene (total)	J	6		U	13		U	10	U	10	
Trichloroethene	J	1		U	10		U	10	U	10	
2-Methylnaphthalene	Not Analyzed			U	10		J	0.7	J	1	
Semivolatiles											
Dibenzofuran	Not Analyzed			J	4		J	3	J	4	
Carbazole	Not Analyzed			J	3		J	4	J	2	
bis(2-Ethylhexyl)phthalate	Not Analyzed			U	10		U	10	J	1	J4

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C18

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-9A (1769)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Arsenic		13.9	UJ	B	9		B	7.6		B	8.7	
Barium	B	30.2		B	20.2		B	18.4	UJ	B	17.2	UJ
Boron	Not Analyzed				184			169			182	
Calcium		44,200			39,100			33,100			36,500	
Total Chromium	B	5.3		U	5		U	4		U	7	
Cobalt	U	6.7		B	5.9		U	5		U	3	
Iron		31,000			27,100			23,200			24,800	
Lead	U	0.7		B	1		U	1		B	1.1	J4
Magnesium		10,400			9,490			8,230			9,130	
Manganese		1,050	J4		891			717			834	
Nickel	B	8		U	15	UJ	U	14		U	8	
Potassium	B	2,270	J4	B	2,650		B	2,110	UJ	B	2,320	
Sodium		20,800	J4		18,100			21,400			16,400	
Vanadium	U	3.3		U	6		B	10.6	UJ	B	4.1	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C19

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL CBS-11A (1771)

Analyte	Concentration (µg/L)[a,b]			
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)	3rd Quarter (Oct/Nov 1991)	4th Quarter (January 1992)
Inorganics				
Barium	B 11.1	B 7	B 5.5 UJ	B 5.7 UJ
Boron	Not Analyzed	321	289	304
Calcium	27,000	30,800	28,800	26,800
Copper	B 3 UJ	B 2.4	B 2.7 UJ	U 1
Magnesium	6,840 J4	7,230	7,540	7,390
Potassium	B 1,650 UJ	U 973	B 1,490 UJ	B 1,160
Sodium	8,750 J4	7,190	8,450 UJ	8,000
PAHs				
Anthracene	U 0.05	J 0.027	U 0.05	U 0.05

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C20

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL MW-1A (1773)

Analyte	Concentration (μg/L)[a,b]			
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)	3rd Quarter (Oct/Nov 1991)	4th Quarter (January 1992)
Inorganics				
Arsenic	U 3.2	U 2	B 1.5	U 1
Boron	Not Analyzed	74.3	65	B 76.7 UJ
Calcium	11,200	5,160	14,300	6,990
Iron	117	B 73.3 UJ	2,260	B 31.3 UJ
Lead	U 0.7	4.2 UJ	B 1.2 UJ	3.5 J4
Magnesium	B 3,000	B 1,300	B 3,680	B 2,060
Manganese	B 14.9 J4	B 3.8 UJ	305	B 9
Potassium	B 643 UJ	U 973	B 1,790 UJ	B 652
Sodium	B 5,050 J4	B 3,500	11,600 UJ	5,140
VOCs				
Chloroform	U 10	20	J 4	U 10
Bromodichloromethane	U 10	J 2	U 10	U 10

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C21

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL MW-3A (1775)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		241		B	89.1	UJ		396		B	35	UJ
Antimony	U	43.3		B	28	UJ	B	40.9		U	11	
Arsenic	U	3.2			26.8		U	1		U	1	
Barium	U	7.8		B	14.1		B	3.7	UJ	B	17	UJ
Boron		Not Analyzed			60.4		B	74.9		B	79.3	UJ
Calcium		9,350			17,900		B	4,970			7,190	
Total Chromium	B	3.6		U	5		U	4			15.7	UJ
Iron		334		B	94.6	UJ		625			184	UJ
Magnesium	B	4,080			5,290		B	2,350		B	3,200	
Manganese		66.3	J4		90.9			50.9			221	
Potassium	B	1,140	UJ	B	4,930		B	1,660	UJ	B	1,490	
Silver	B	9.8	J4	U	4		B	4	UJ	U	6	
Sodium		6,170	J4		10,700			19,200	UJ		11,000	
Zinc	B	13.6	UJ	B	2	UJ	B	4.4	UJ		63.8	
VOCs												
Carbon Disulfide	U	10		U	10		U	10		J	3	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C22

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL MW-5A (1777)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		458		B	146		B	41.2	UJ	B	26.8	UJ
Barium	B	9.1		U	2	UJ	U	2		B	2.9	UJ
Boron		Not Analyzed			183			192			239	
Calcium		10,500			8,300			11,800			12,300	
Iron		701			261		B	60.2	UJ	B	52.5	UJ
Lead	U	0.7		U	1		U	1		B	1.2	J4
Magnesium	B	3,650		B	3,110		B	4,600		B	4,750	
Manganese		37.5	J4	B	13.9		B	3.3	UJ	B	2.3	
Nickel	B	7.6		U	15	UJ	U	14		U	8	
Potassium	B	863	UJ	U	973		B	1,580	UJ	B	883	
Sodium		5,630	J4	B	4,170			6,480	UJ		6,340	
VOCs												
1,1,1-Trichloroethane	J	1		J	3			10		J	9	
Tetrachloroethene	J	3		J	4		U	10		U	10	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C23

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL STM-1A (1778)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum		827		B	50		B	43.7		B	45.9	UJ
Barium	U	7.8		B	6.3		B	8	UJ	B	8.1	UJ
Boron	Not Analyzed				963			1,110			1,100	
Calcium	B	5,440			8,780			11,700			17,000	
Total Chromium	B	4.5		U	5		U	4		U	7	
Cyanide	Not Analyzed				20			33.3			29.8	
Lead	U	0.7		U	1		B	1.2	UJ	B	1.2	J4
Magnesium	B	1,600		B	2,820			5,010			6,910	
Manganese	B	7	UJ	B	3.3	UJ	B	2.5	UJ	B	5.7	
Potassium	B	5,280	J4	B	1,300		B	3,420		B	3,370	
Silver	U	6.7		U	4		B	3.5		U	6	
Sodium		36,300	J4		20,600			21,400	UJ		9,520	
Zinc	B	17	UJ	B	5.8	UJ	B	9.3	UJ	B	17.2	
PAHs												
Anthracene	U	0.05		J	0.036		U	0.05		U	0.05	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C24

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL STM-2A (1779)

Analyte	Concentration (μg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Barium	B	26.4		B	23.8		B	25.2	UJ	B	16.7	UJ
Boron	Not Analyzed				1,670			1,730			1,300	
Calcium		109,000			87,800			88,700			69,000	
Iron	B	55.8	UJ		207		U	11		B	21	UJ
Magnesium		70,800			43,500			51,500			36,100	
Potassium	B	2,550	J4	B	2,930		B	3,200		B	3,050	
Selenium	B	4	UJ		13.4	UJ		26.8	J4	B	4.9	J4
Silver	B	10.6	J4	U	4		U	3		U	6	
Sodium		14,100	J4		20,200			24,500	UJ		22,100	
Vanadium	U	3.3		U	6		B	5.6		U	4	
Zinc		726			54	UJ		22.2	UJ		28.6	
PAHs												
Anthracene	U	0.05		J	0.044		U	0.05		U	0.05	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C25

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL STM-3A (1780)

Analyte	Concentration (µg/L)[a,b]			
	1st Quarter (April 1991)	2nd Quarter (July/August 1991)	3rd Quarter (Oct/Nov 1991)	4th Quarter (January 1992)
Inorganics				
Aluminum	B 91.3 UJ	U 33	U 19	B 88.4
Barium	B 12	B 26.1	B 25.2 UJ	B 16.8
Beryllium	U 1.1	U 1	U 1	B 2.3
Boron	Not Analyzed	616	B 395	369
Calcium	37,600	79,600	61,700	45,200
Total Chromium	B 4.1	U 5	U 4	14.8 UJ

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C26

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM ONSITE WELL STM-4A (1781)

Analyte	Concentration (µg/L)[a,b]											
	1st Quarter (April 1991)			2nd Quarter (July/August 1991)			3rd Quarter (Oct/Nov 1991)			4th Quarter (January 1992)		
Inorganics												
Aluminum	B	78.4	UJ	U	33		U	19		B	37	
Barium	B	8.3		B	6	J4	B	9.8	UJ	B	8.1	UJ
Beryllium	U	1.1		U	1		U	1		B	1.3	
Boron	Not Analyzed				516		B	446			468	
Calcium		22,600			25,500			26,100			24,100	
Total Chromium	B	4.5		U	5		U	4			19.8	UJ
Iron		140	UJ	U	12	UJ	B	36.8	UJ		105	
Lead	B	2.2	UJ	B	1.2			3.2	UJ	U	1	UJ
Magnesium		15,400			17,000			17,800			16,500	
Manganese	B	7.2	UJ	B	3	J4	U	1		B	4	
Potassium	B	1,780	UJ	B	1,950		B	1,880		B	2,320	UJ
Sodium		11,100	J4		12,000			19,900	UJ		19,100	
Vanadium	U	3.3		U	6		U	4		B	4.8	
Zinc		473			134			56.7			31.1	
VOCs												
Methylene Chloride	B	5	UJ	J	4	UJ	J	6		U	10	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for all four quarters are listed if analyte was detected during one or more quarters. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C27

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL CBS-5A (1765)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Boron		44		B	36.7	UJ
Calcium		10,200			9,490	
Iron	B	13.6	J4	B	36.3	UJ
Lead	B	1.4		B	1	J4
Magnesium		6,440			6,630	
Potassium	B	1,080		B	1,140	
Sodium		5,190			5,190	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C28

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL CBS-9A (1769)

Analyte	Concentration (µg/L)[a,b]				
	2nd Quarter (July/August 1991)		4th Quarter (January 1992)		
Inorganics					
Arsenic	B	9	B	8.7	
Barium	B	20.2	B	17.2	UJ
Boron		184		182	
Calcium		39,100		36,500	
Cobalt	B	5.9	U	3	
Iron		27,100		24,800	
Lead	B	1	B	1.1	J4
Magnesium		9,490		9,130	
Manganese		891		834	
Potassium	B	2,650	B	2,320	
Sodium		18,100		16,400	
Vanadium	U	6	B	4.1	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C29

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL 89.7-P1 (1782)

Analyte	Concentration (µg/L)[a,b]				
	2nd Quarter (July/August 1991)		4th Quarter (January 1992)		
Inorganics					
Aluminum		1,820	B	34.3	
Barium	B	58.5	B	159	
Boron	B	29.8	B	75.4	
Calcium		45,000		78,300	
Copper		13.8	B	1.8	UJ
Iron		3,560	B	84.2	
Magnesium		35,100		48,300	
Manganese		541		896	
Potassium	B	4,680		8,280	
Sodium		70,700		514,000	
Thallium	B	2.2	U	1	
Vanadium	B	8.2	U	4	
Zinc		29.1	B	8.5	UJ

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C30

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL TL-16A (1783)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Aluminum		2,400			10,500	
Arsenic	B	3.2	UJ	B	6.1	
Barium	B	34.5		B	75.6	
Boron	U	19		B	13	
Calcium		17,900			22,600	
Total Chromium	B	9.2	J4		41.1	UJ
Cobalt	B	6.4		B	16.1	
Copper		44.7			112	
Iron		7,240			28,800	
Lead		16.9	UJ		33.4	J4
Magnesium		13,600			19,200	
Manganese		137			491	
Potassium	B	2,230		B	2,660	
Sodium		6,600			9,170	
Vanadium	B	12.1		B	36.5	
Zinc		78.3			170	
PAHs						
Naphthalene	J	0.12		U	0.5	
VOCs						
Toluene	J	2		U	10	
Semivolatiles						
bis(2-Ethylhexyl)phthalate	U	10		J	5	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C31

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM BACKGROUND WELL WCC-2 (1784)

Analyte	Concentration (µg/L)[a,b]				
	2nd Quarter (July/August 1991)		4th Quarter (January 1992)		
Inorganics					
Aluminum	B	94	B	31.6	
Barium	B	18.4	B	11.8	UJ
Boron	B	35.7	B	51.7	
Calcium		16,400		15,500	
Iron		180	B	79.9	
Magnesium		7,730		6,900	
Manganese		70.4	B	4.1	
Potassium	B	2,300	B	2,470	
Sodium		7,340		7,300	
VOCs					
Acetone	J	3	U	10	
Trichloroethene	J	5	J	5	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C32

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM UPGRADIENT WELL CBS-10A (1770)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Aluminum		28,800			280	UJ
Arsenic	B	7.8		U	1	
Barium		282		B	11.8	UJ
Boron		89.8			118	
Calcium		56,100			30,300	
Total Chromium		48.5		U	7	
Cobalt	B	46.2		U	3	
Copper		80.1	J4	B	1.2	UJ
Iron		45,900			381	
Lead		42		B	1.2	J4
Magnesium		24,300			10,500	
Manganese		3,160			20.7	
Nickel		152		B	9.8	UJ
Potassium	B	4,340		B	1,480	
Sodium		15,800			17,000	
Vanadium		78		U	4	
Zinc		429		B	11.5	UJ
VOCs						
Toluene	J	2		U	10	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C33

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM UPGRADIENT WELL TL-12A (1785)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Aluminum	U	33		B	21.7	
Antimony	B	24.2	J4	U	11	
Barium	B	16.8		B	10.9	UJ
Calcium		47,300			31,900	
Total Chromium	B	5.6	J4		10.8	UJ
Iron		162			134	
Magnesium		32,500			22,800	
Manganese		151			190	
Potassium	B	1,750		B	1,530	UJ
Sodium		10,500			9,110	
Zinc	B	15.3			20.5	
VOCs						
Vinyl Chloride	J	2		U	10	
1,1-Dichloroethane		28			27	
1,2-Dichloroethene (total)	U	37			26	
1,2-Dichloroethane		13			12	
1,1,1-Trichloroethane	J	3		J	3	
1,2-Dichloropropane	J	1		U	10	
Trichloroethene	J	7		J	7	
Tetrachloroethene	J	1		U	10	
Semivolatiles						
Di-n-butylphthalate	U	10		J	0.6	
bis(2-Ethylhexyl)phthalate		20			20	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C34

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM UPGRADIENT WELL TL-13A (1786)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Aluminum	B	124		B	34.3	
Barium	B	5.6		B	10.4	UJ
Calcium		8,910			18,500	
Copper		6		B	5.6	UJ
Iron		342			398	
Lead		7.9	J4	U	1	UJ
Magnesium		5,780			11,900	
Manganese		58.7			273	
Sodium		5,640			7,590	
Thallium	B	3		U	1	
VOCs						
1,1-Dichloroethane	U	10		J	3	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C35

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM UPGRADIENT WELL TL-14A (1787)

Analyte	Concentration (µg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Barium	B	7.2		B	5.6	UJ
Boron	B	20.5		B	17.2	
Calcium		24,300			19,700	
Iron	B	66.4	UJ		135	
Magnesium		9,900			7,990	
Manganese	B	2.6	UJ	B	5.9	
Sodium		7,640			6,970	
Zinc	B	4.5		B	5.4	UJ

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

TABLE GW-C36

ANALYTES DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM UPGRADIENT WELL TL-23A (1788)

Analyte	Concentration (μg/L)[a,b]					
	2nd Quarter (July/August 1991)			4th Quarter (January 1992)		
Inorganics						
Aluminum	B	74.5			229	
Antimony	U	20	UJ	B	14.4	
Arsenic	U	2			16.7	
Barium	B	24.8		B	45.7	
Boron	B	21.7		B	21.1	
Calcium		34,700			32,200	
Cobalt	B	6		B	5	
Copper	U	1		B	15.5	
Iron		1,940			61,900	
Lead	B	2.3	J4	U	1	UJ
Magnesium		15,000			13,900	
Manganese		1,310			1,430	
Potassium	B	2,440		B	2,770	
Sodium		27,400			41,500	
PAHs						
Anthracene	J	0.048		U	0.05	

(a) Letter preceding the concentration value are laboratory qualifiers. Letters following the concentration value are data validation qualifiers.

(b) Concentrations for second and fourth quarters are listed if analyte was detected during at least one quarter. A "U" qualifier indicates the analyte was not detected at the concentration.

SIEVE ANALYSIS DATA

WELL: NMW-5B

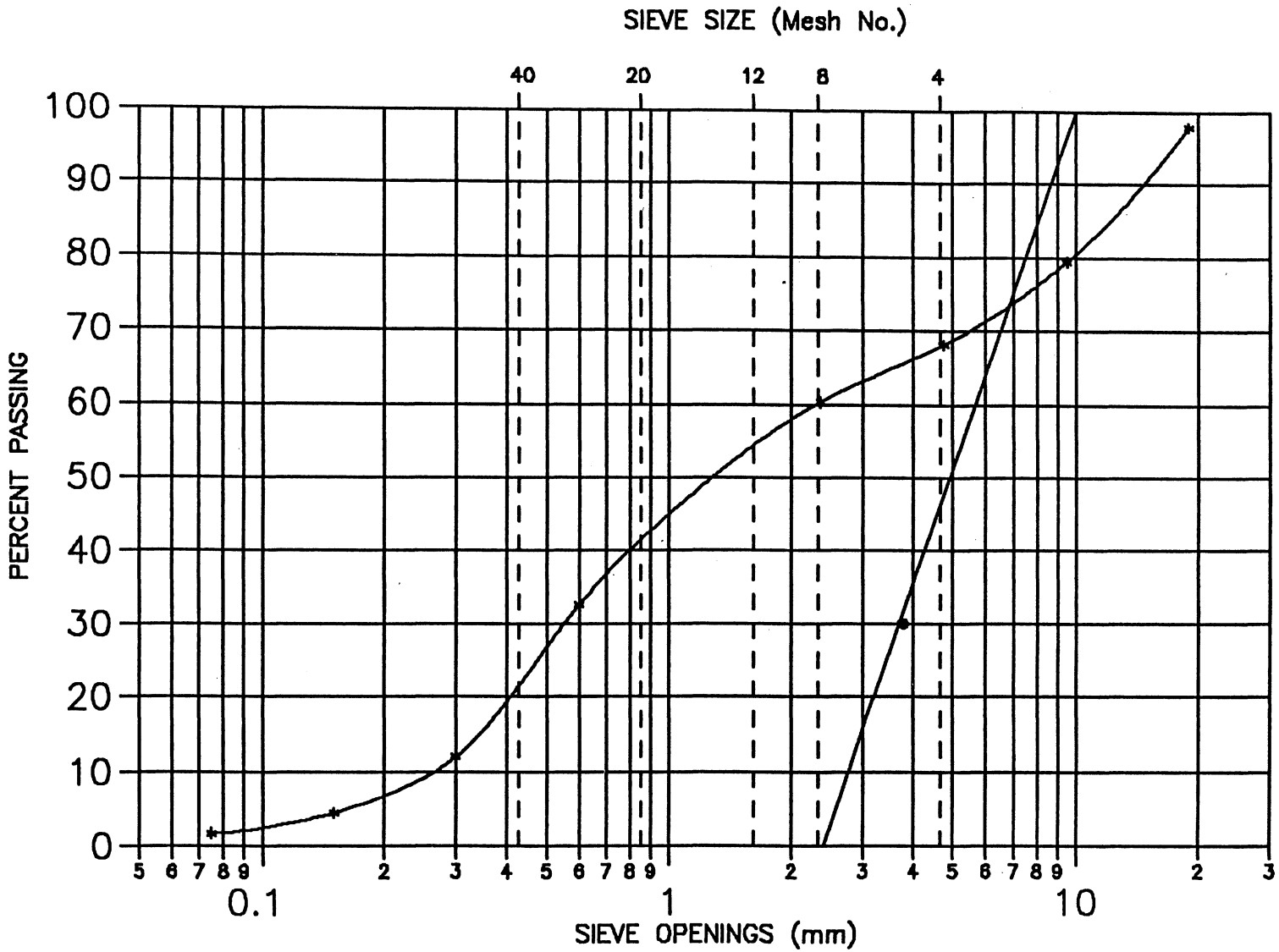
Depth collected (ft BGS) = 113.5-115

Weight of sample (g) = 617.2

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	12.5	2.1	97.9
	0.374	9.50	110.3	18.5	79.4
4	0.187	4.75	67.3	11.3	68.1
8	0.093	2.36	46.5	7.8	60.3
30	0.024	0.600	165.3	27.7	32.6
50	0.012	0.300	123.2	20.6	12.0
100	0.006	0.150	44.8	7.5	4.5
200	0.003	0.075	16.7	2.8	1.7
Passed 200-Mesh Sieve			10.1	1.7	-
Total			596.7	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–5B



D_{60} = 2.3
D_{30} = 0.54
D_{10} = 0.25
$Cu_s = D_{60}/D_{10} = 9.2$
$Cu_{(fp)}$ = 2.5
F_{30} = 7
$D_{30(fp)}$ = 3.78

SIEVE ANALYSIS DATA

WELL: NMW-5C

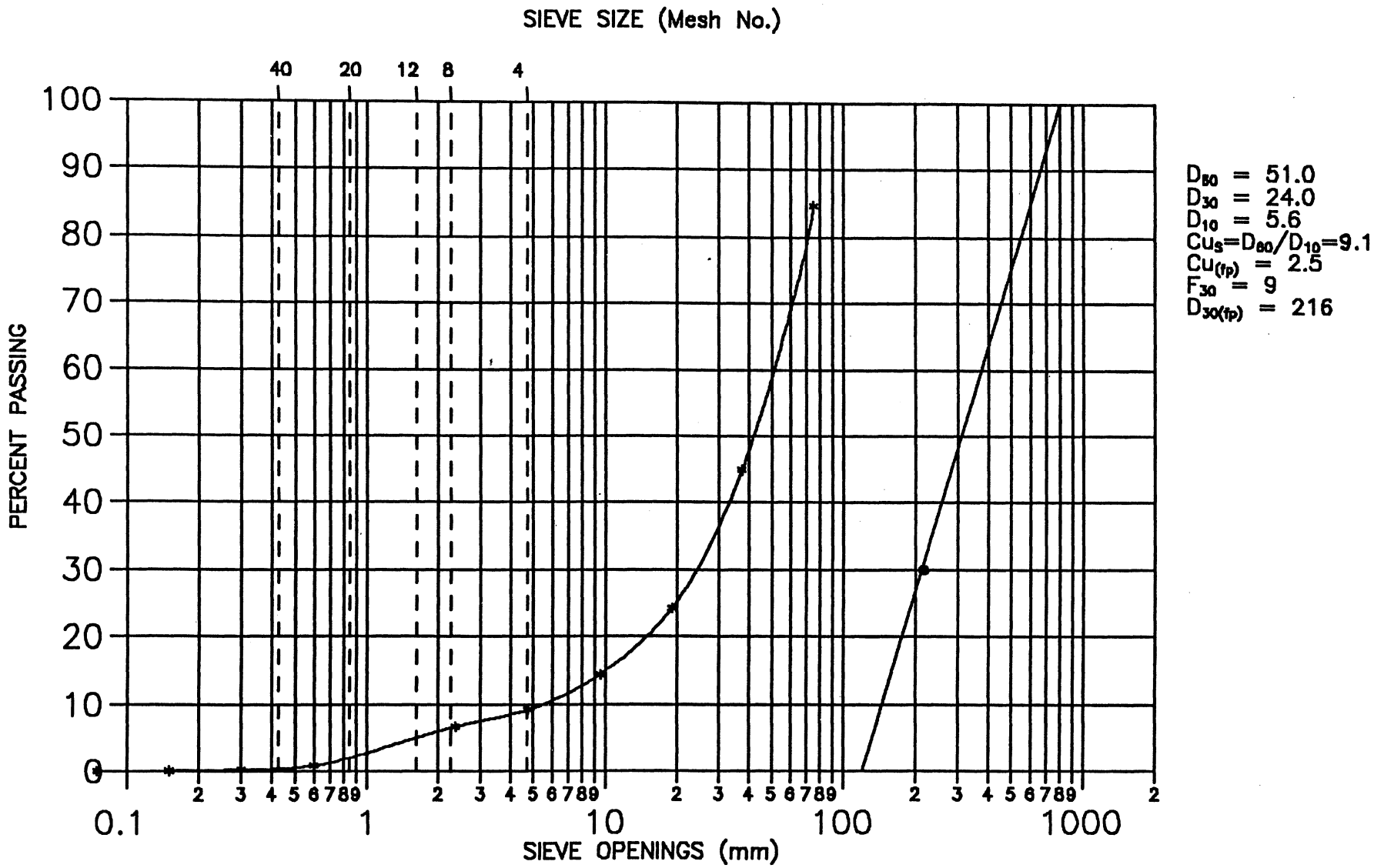
Depth collected (ft BGS) = 180-200 (Composite)

Weight of sample (g) = 2,103

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	322.5	15.3	84.7
	1.48	37.5	836.0	39.8	44.9
	0.748	19.00	434.1	20.7	24.2
	0.374	9.50	205.5	9.8	14.4
4	0.187	4.75	109.2	5.2	9.2
8	0.093	2.36	53.2	2.5	6.7
30	0.024	0.600	123.0	5.9	0.9
50	0.012	0.300	12.4	0.6	0.3
100	0.006	0.150	3.6	0.2	0.1
200	0.003	0.075	1.8	0.1	0.0
Passed 200-Mesh Sieve			0.2	0.0	-
Total			2,101.5	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW-5C


SIEVE SIZE (Mesh No.)
40
20
12
8
4
PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
SIEVE OPENINGS (mm)
D_{60} = 51.0
D_{30} = 24.0
D_{10} = 5.6
$Cu_s = D_{60}/D_{10} = 9.1$
$Cu_{(fp)}$ = 2.5
F_{30} = 9
$D_{30(fp)}$ = 216

SIEVE ANALYSIS DATA

WELL: NMW-6A

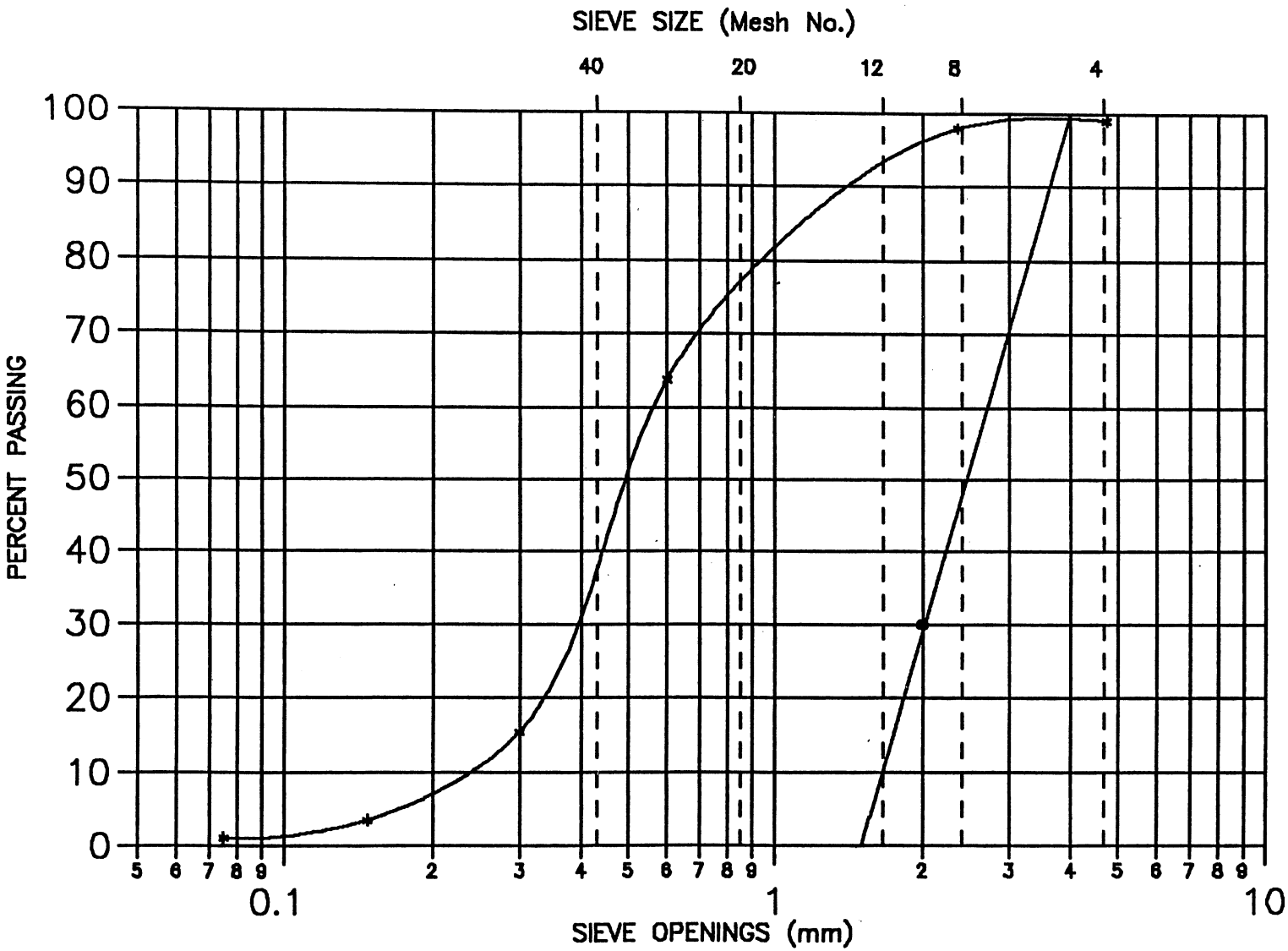
Depth collected (ft BGS) = 25-30 (Composite)

Weight of sample (g) = 100

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	1.0	1.0	99.0
8	0.093	2.36	1.1	1.1	97.9
30	0.024	0.600	34.9	34.2	63.7
50	0.012	0.300	49.2	48.2	15.5
100	0.006	0.150	12.2	12.0	3.5
200	0.003	0.075	2.5	2.5	1.1
Passed 200-Mesh Sieve			1.1	1.1	-
Total			102.0	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW-6A



D_{60} = 0.56
D_{30} = 0.4
D_{10} = 0.23
$Cu_S = D_{60}/D_{10} = 2.43$
$Cu_{(fp)}$ = 2.43
F_{30} = 5
$D_{30(fp)}$ = 2

SIEVE ANALYSIS DATA

WELL: NMW-7A

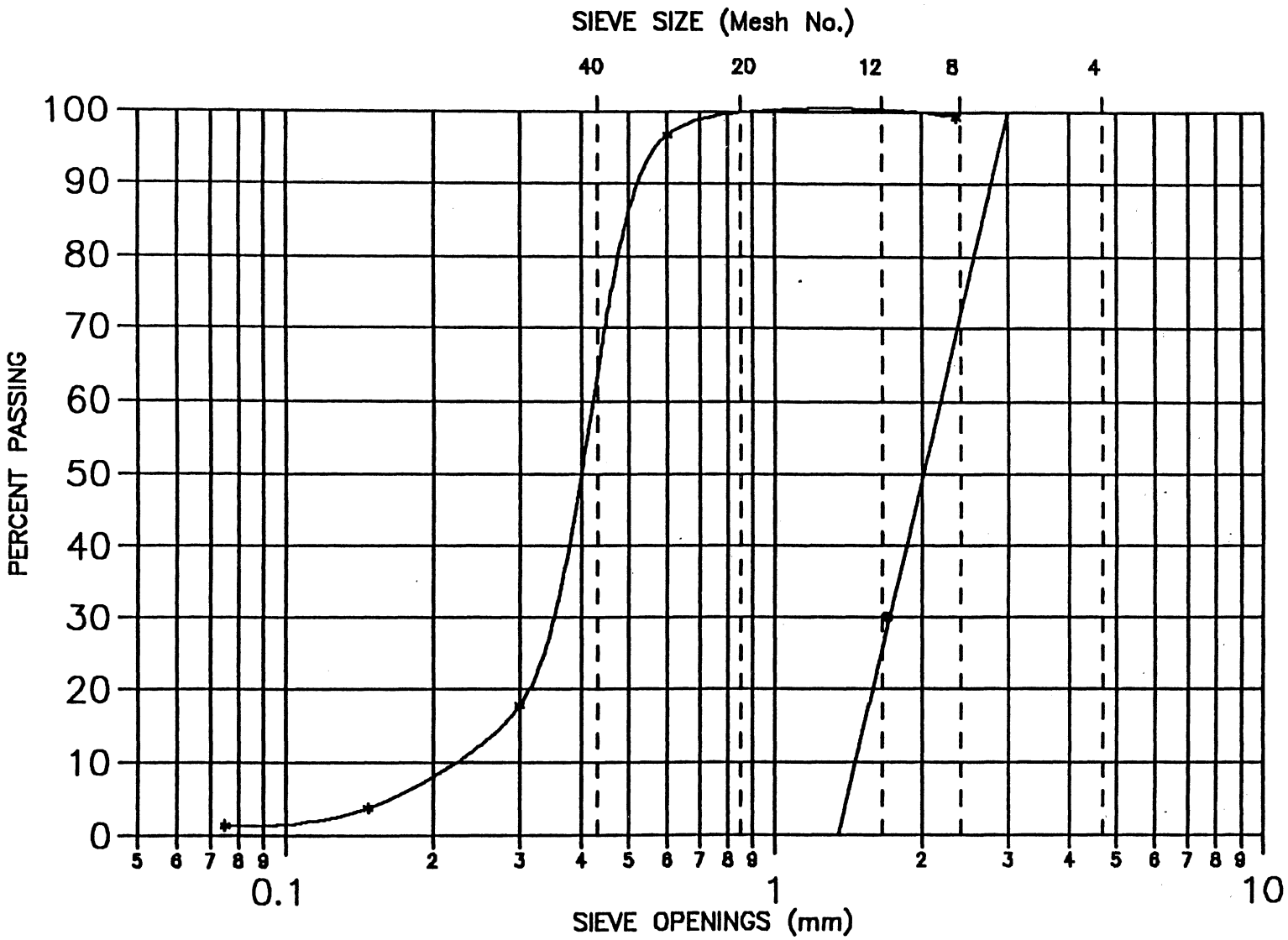
Depth collected (ft BGS) = 30-35 (Composite)

Weight of sample (g) = 100

Sieve Mesh No.[a]	Sieve Openings (in)	Sieve Openings (mm)	Weight Retained (grams)	Percent Retained (%)	Cumulative Percent Passing (%)
	2.95	75.0	0.0	0.0	100.0
	1.48	37.5	0.0	0.0	100.0
	0.748	19.00	0.0	0.0	100.0
	0.374	9.50	0.0	0.0	100.0
4	0.187	4.75	0.0	0.0	100.0
8	0.093	2.36	0.7	0.7	99.3
30	0.024	0.600	2.7	2.6	96.7
50	0.012	0.300	80.4	78.9	17.8
100	0.006	0.150	14.3	14.0	3.7
200	0.003	0.075	2.4	2.4	1.4
Passed 200-Mesh Sieve			1.4	1.4	0.0
Total			101.9	100.0	NA[b]

(a) U.S. standard sieve sizes.
(b) NA - Not applicable.

NMW–7A



D_{60} = 0.42
D_{30} = 0.34
D_{10} = 0.22
$Cu_S = D_{60}/D_{10} = 1.90$
$Cu_{(fp)}$ = 1.5
F_{30} = 5
$D_{30(fp)}$ = 1.7

Kennedy/Jenks Consultants

Remedial Investigation/Feasibility Study
South Tacoma Field Superfund Site
Tacoma, WA

Remedial Investigation Report
Appendix HC

HYDRAULIC CHARACTERIZATION REPORT

K/J Project No. 916055.09

Final Report

APPENDIX HC

HYDRAULIC CHARACTERIZATION INVESTIGATION

SOUTH TACOMA FIELD
SUPERFUND SITE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

FINAL

Prepared for

SOUTH TACOMA FIELD SITE GROUP

Prepared by

KENNEDY/JENKS CONSULTANTS
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K/J 916055.09

1 February 1993

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EXECUTIVE SUMMARY

This report addresses the objectives, investigative activities, findings, and conclusions of the Hydraulic Characterization Investigation performed at the South Tacoma Field (STF) site. The Hydraulic Characterization Investigation was performed as a part of an ongoing remedial investigation and feasibility study (RI/FS) at the STF site. Activities described herein were performed in accordance with the Final Work Plan (ICF 1990b), which established the level of effort required by the U.S. Environmental Protection Agency (EPA) to complete the RI/FS.

PURPOSE AND INVESTIGATIVE ACTIONS

The purpose of the Hydraulic Characterization Investigation was to evaluate selected hydraulic characteristics of subsurface water producing units at the STF site. The primary objectives for this investigation were to:

- Evaluate the range of aquifer parameters (transmissivity, hydraulic conductivity, storativity) within three separate aquifer zones at the site through performance of aquifer tests and slug tests

- Evaluate potential inter-aquifer communication between the shallow (uppermost) groundwater zone and the lower-lying zones of saturation through performance of an aquifer test at an offsite production well

- Evaluate seasonal fluctuations in the hydraulic gradient within the uppermost zone, Layer A, at the site through monthly water level monitoring.

The following task were completed during this investigation:

- Monitored monthly water level in 30 monitoring wells for 12 consecutive months
- Conducted two aquifer pumping tests in shallow onsite wells
- Conducted slug tests at 16 wells across the site
- Monitored water levels in onsite wells during the performance of an aquifer test at an adjacent offsite production well.

SUMMARY OF STRATIGRAPHIC UNITS

Three glacial and two interglacial climatic episodes are represented by units underlying the site. The episodes represented are the Vashon Glaciation, Olympia Interglaciation, Narrows Glaciation, Kitsap Interglaciation, and Flett Creek Glaciation. The units representing these episodes from youngest (i.e., shallowest) to oldest (i.e., deepest) are the Vashon Drift, Discovery nonglacial unit, Narrows glacial unit, Kitsap Formation, and Flett Creek glacial unit. The following four hydrostratigraphic layers identified at the STF site are composed of members of the five units (Brown and Caldwell 1985):

- Layer A
- Layer A_1
- Layer B
- Layer C.

Groundwater was encountered in two zones of saturation (Layer A and Layer C) in the first 200 feet of subsurface material encountered as part of the STF Phase I Groundwater Investigation (Kennedy/Jenks Consultants 1992a). The hydrostratigraphic layers, the sequence in which they were encountered, and their correlation to lithologic units identified in central Pierce County are summarized in Table HC-ES1.

TABLE HC-ES1

SUMMARY OF HYDROSTRATIGRAPHIC LAYERS

Hydrostratigraphic Layer	Unit Designation	Unit Thickness (ft)[a]	Soil Description
Layer A (Upper)	Vashon Drift (Colvos Sand Member)	62-101	Poorly graded sand with silt and gravel.
Layer A_1	Discovery Nonglacial Unit Narrows Glacial Unit	0-33 6-12.5	Clay, silt and sand. Silt.
Layer A (Lower)	Narrows Glacial Unit	59-67.5	Gravel.
Layer B	Kitsap Formation	2-15	Silt and clay.
Layer C	Fleet Creek Glacial Unit	100[b]	Cobbles and gravel.

(a) Unit thicknesses are based on field observations made during the STF Phase I Groundwater Investigation (Kennedy/Jenks Consultants 1992a).
(b) Layer C was penetrated approximately 25 feet during the STF Phase I Groundwater Investigation.

These hydrostratigraphic layers appear to be laterally continuous in the vicinity of the investigation area, with the exception of Layer A_1. According to Brown and Caldwell (1985), Layer A_1 appears to pinch out east of the site. Based on the STF Phase I Groundwater Investigation, Layer A_1 appears to thin out in the northern portion of the site at well NMW-5C. Layer B appears to be laterally continuous in the vicinity of the site. However, it is much thinner in the South Tacoma Channel than observed elsewhere. Layer B typically ranges in thickness from 50 to 150 feet in the Chambers/Clover Creek drainage area (Brown and Caldwell 1985). At the

STF site, Layer B was observed to range in thickness from 2 feet at Well NMW-3C to approximately 15 feet at Well NMW-5C. Layer C is also laterally continuous in the vicinity of the site and reportedly ranges in thickness from 50 to 180 feet (Brown and Caldwell 1985).

Layer A has been divided into an upper portion (Upper Layer A, which is unconfined) and a lower portion (Lower Layer A, which is likely semi-confined to confined). The two portions of Layer A are separated by Layer A_1. Layer B is a confining layer and separates Lower Layer A from the underlying Layer C, which forms the next water-bearing zone. Groundwater in Layer C occurs under confined conditions.

INVESTIGATION RESULTS

Results are presented for each task of the Hydraulic Characterization Investigation.

Water Level Monitoring

Available information indicates that the STF site lies in the vicinity of a regional groundwater mound of the uppermost aquifer, which is oblong in shape and oriented north-south (Griffin et al. 1962; Brown and Caldwell 1985). The axis of the mound forms a regional groundwater divide and the presumed direction of groundwater flow is east on the east side of the mound and west on the west side of the mound. The mound is likely caused by convergence of groundwater flow from north and south of the South Tacoma Channel and significant recharge of surface water. In the central portions of the mound, the direction of the hydraulic gradient is toward the north to northeast.

Results of monthly water level monitoring at the STF site (over a 1-year period) indicate that the predominant direction of the hydraulic gradient in Upper Layer A,

and presumed direction of shallow groundwater flow, is toward the north to northwest. The magnitude of the hydraulic gradient fluctuated both spatially and seasonally from 0.0004 to 0.001 ft/ft. Observed spatial variations included a steep dip in the hydraulic gradient in the southwestern portion of the site that trends to the southwest and a small groundwater mound in the vicinity of the Amsted property. The source of the mound is unknown. Water level monitoring indicates that the hydraulic gradient in Layer C is also toward the north at the STF site.

Pumping of shallow groundwater (Upper Layer A) by municipal wells to the east of the site has a significant impact on the direction of groundwater flow at the STF site. During the summer months, a cone of depression extended from the pumping wells to beyond the western property boundary of the site. As a result of pumping, the hydraulic gradient on the eastern side of the Tacoma Landfill investigation area (west of the STF site) is reversed.

There is a net downward vertical gradient from Upper Layer A to Lower Layer A. The head differential between these two zones of saturation ranged from a minimum of 0.51 feet at Well Cluster NMW-3 in the wet season to maximum of 39.39 feet in Well Cluster NMW-5 during the dry season. A net downward vertical gradient exists between Lower Layer A and Layer C. This head differential ranged from 0.27 feet in Well Cluster NMW-3 during the wet season to 27.87 feet in Well Cluster NMW-5 during the dry season. The exaggerated head differences during the summer months is a result of pumping of municipal wells installed in Layer C in the vicinity of the site.

Aquifer Pumping Tests and Slug Tests

Based on the results of the two aquifer pumping tests performed in Upper Layer A, transmissivity values ranged from 67,000 gpd/ft to 71,000 gpd/ft at Wells NMW-4A and NMW-3A, respectively. The specific yield for the Upper Layer A

ranged from 0.001 to 0.03. The estimated seepage velocity ranged from 60 feet/year to 150 feet/year.

Based on slug test results, transmissivity values were one to two orders of magnitude less than those values calculated through performance of aquifer tests. The anomalously low transmissivity values calculated through slug tests may be attributed to the high hydraulic conductivity of the formation and that slug tests may only test the filter pack of the well.

Inter-Aquifer Communication

Statistical analysis of monthly groundwater level monitoring data was inconclusive in identifying areas of enhanced leakage from Upper Layer A to the lower-lying zones. Based on visual examination of water level monitoring hydrographs, significant head fluctuations occurred in Lower Layer A (Wells NMW-3B and NMW-5B) during seasonal groundwater removal in Layer C. This observation indicates communication between the two zones of saturation (i.e., Lower Layer A and Layer C). Based on visual examination, it appears that communication between the two zones (Lower Layer A and Layer C) was greater in the south at Well NMW-3C, and less in the northern portion of the site at Well NMW-5C. This observation corresponds with lithologic conditions that indicate Layer B is approximately 2 feet thick at Well NMW-3C and 15 feet thick at Well NMW-5C. Hydrographs also indicate minimal head fluctuation between Upper Layer A and Lower Layer A, indicating limited, if any, communication between the two zones of saturation. Lithologic information indicates that Layer A_1 is approximately 37 feet thick at Well Cluster NMW-3 and 6 feet thick at Well Cluster NMW-5. Although quantification of the vertical conductivity of Layer A_1 is not possible with available information, lithologic information and the water level monitoring data indicate that this unit is an effective confining layer between Upper Layer A and the lower-lying zones.

Analysis of aquifer test data from Well TAC 1A indicate leakage from Lower Layer A to Layer C in the vicinity of Well Clusters NMW-3 and TAC 89.5. Estimates of vertical conductivity for Layer B at these two locations ranged from 1.34 E-03 feet/day to 4.44 E-04 feet/day, respectively. These conductivity values are approximately six to seven orders of magnitude lower than conductivity values calculated for Layer C. Test results for Well Cluster NMW-5 were influenced from operation of heat pump wells at Tacoma Public Utilities and cannot be used to estimate possible leakage in the northern portion of the STF site.

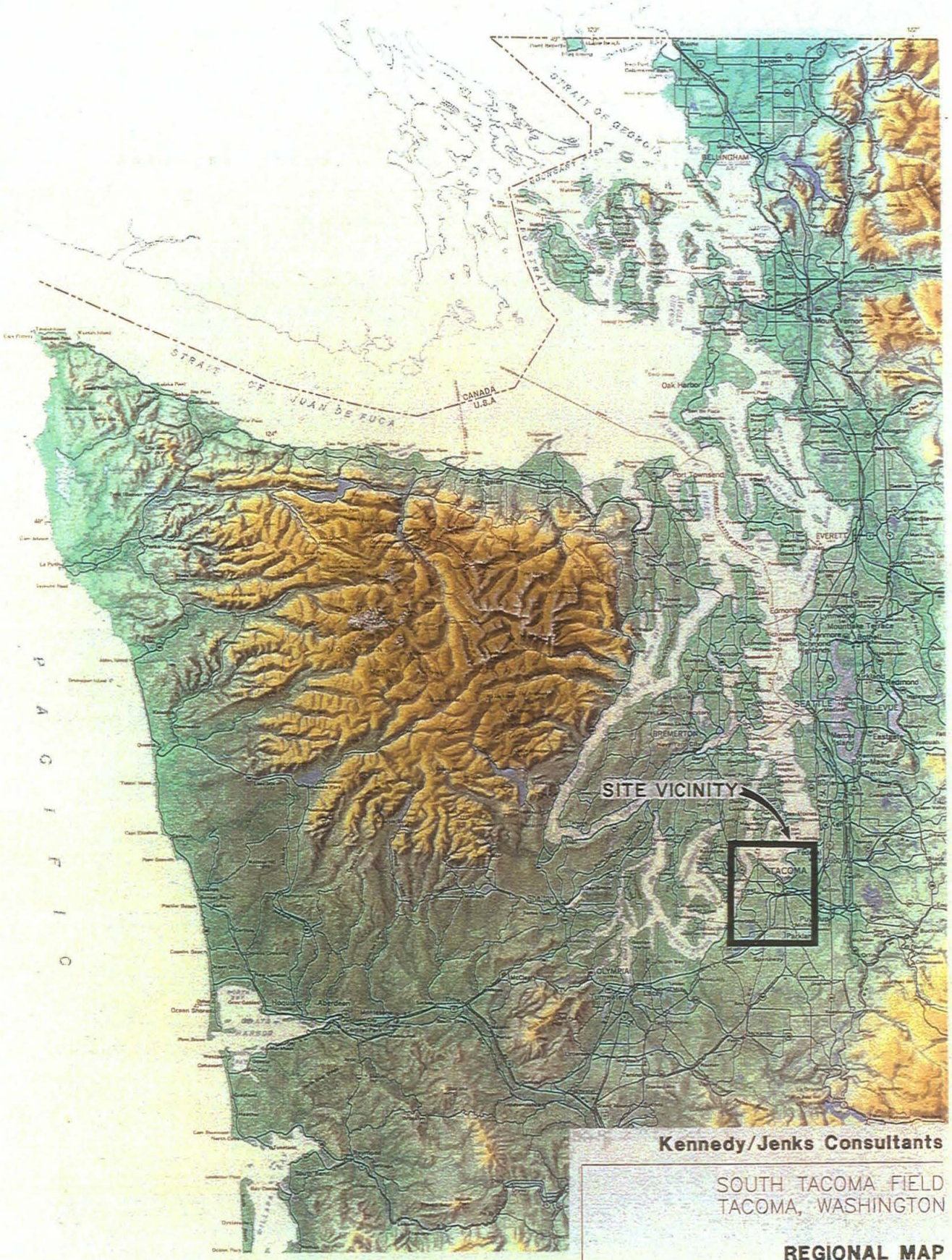
1.0 INTRODUCTION

This report presents findings of the South Tacoma Field (STF) Remedial Investigation (RI). The STF Superfund site is located within a physiographic subprovince of the northwestern United States known as the Puget Sound Lowland (Figure G-1). More specifically, the STF site is located in the southwestern portion of the City of Tacoma, Washington, on an industrial property approximately 260 acres in size (Figure G-2). Currently, the STF site is largely vacant with some remnant structures and recently constructed industrial and commercial buildings.

On 23 November 1981, the U.S. Environmental Protection Agency (EPA) published an "interim priority list" of 115 hazardous waste sites targeted for action under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This list included the Commencement Bay site in Tacoma. When the final list of the nation's top 418 sites was published [the National Priorities List (NPL)], the Commencement Bay site was listed as two separate sites: 1) Commencement Bay - Nearshore/Tideflats and 2) Commencement Bay - South Tacoma Channel. In 1983, the Commencement Bay - South Tacoma Channel site was divided into three Operable Units; South Tacoma Field (STF), Tacoma, Landfill, and Tacoma Well 12A.

On 12 October 1990, EPA and the potentially responsible parties (PRPs) signed an Administrative Order on Consent (Consent Order) for the STF site. The Consent Order, among other requirements, directed that a remedial investigation be conducted to determine the nature and extent of environmental contamination at the STF site.

The Consent Order cites the Final Work Plan, which establishes the level of effort required by EPA to complete a Remedial Investigation/Feasibility Study (RI/FS) at the STF site. The Final Work Plan was prepared for EPA by ICF Technology, Inc.



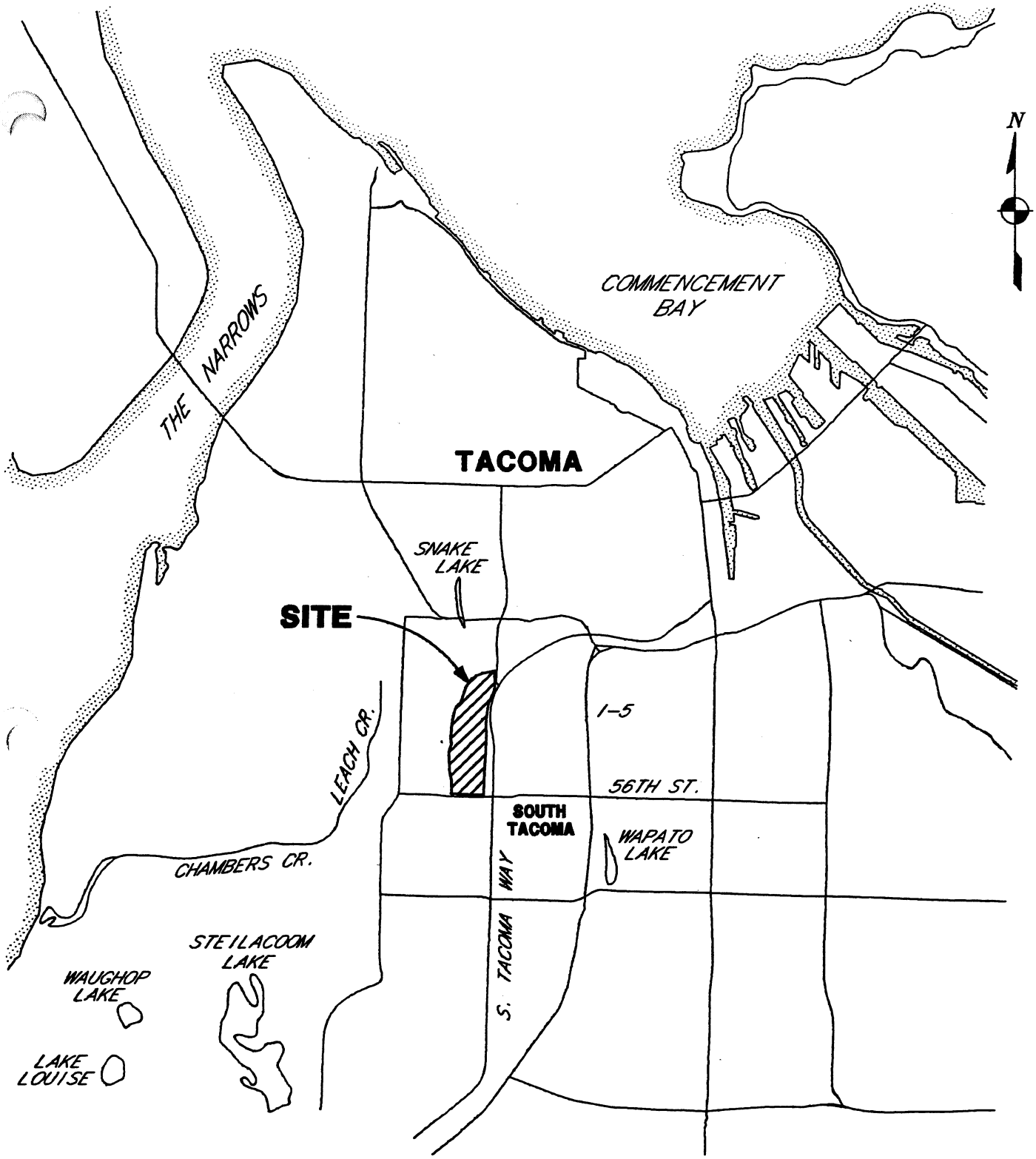
Kennedy/Jenks Consultants

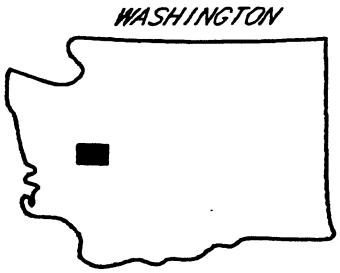
SOUTH TACOMA FIELD
TACOMA, WASHINGTON

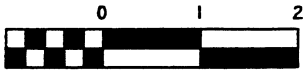
REGIONAL MAP

916055.02/P1SK092

FIGURE G-1







APPROXIMATE SCALE IN MILES

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

SITE LOCATION MAP

916055.19/P2SK191

FIGURE G-2

(ICF 1990b). Kennedy/Jenks Consultants was retained by the PRPs to conduct the RI/FS in accordance with the Final Work Plan, Revision 1, dated September 1990 (ICF 1990b).

The RI is composed of discrete investigations of surface soil, subsurface soil, groundwater, surface water, sediment, and blackberries. A wetland delineation and endangered plant species survey, dispersion air modeling, soil gas survey, geophysical survey, and hydraulic characterization were also discrete components of the STF RI. Results of each of these investigations are presented separately as appendices (Volumes 2-6) to this RI Report. This RI Report (Volume 1) presents a synthesis of the findings of these investigations. In addition, a Subsurface Target Confirmation Investigation was conducted based on the results of the Geophysical Survey. Results of this subsurface target investigation will be prepared as an addendum to the RI Report and submitted in January 1993.

1.1 PURPOSE OF INVESTIGATION

The purpose of the Hydraulic Characterization Investigation was to evaluate selected hydraulic characteristics of subsurface water producing units at the STF site. The primary objectives for this investigation were to:

- Evaluate the range of aquifer parameters (transmissivity, hydraulic conductivity, storativity) within three separate aquifer zones at the site through performance of aquifer tests and slug tests

- Evaluate potential inter-aquifer communication between the shallow (uppermost) groundwater zone and the lower-lying zones of saturation through performance of an aquifer test at an offsite production well

- Evaluate seasonal fluctuations in the hydraulic gradient within the uppermost zone, Layer A, at the site through monthly water level monitoring.

The following task were completed during this investigation:

- Monitored monthly water level in 30 monitoring wells for 12 consecutive months

- Conducted two aquifer pumping tests in shallow onsite wells

- Conducted slug tests at 16 wells across the site

- Monitored water levels in onsite wells during the performance of an aquifer test at an adjacent offsite production well.

The information obtained during this investigation was used to estimate the rate and direction of groundwater movement and may be used to help evaluate potential remedial alternatives.

1.2 REPORT ORGANIZATION

This report has been prepared in accordance with the EPA's (1988) Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. The remaining sections of this report are summarized below:

- Section 1.0 concludes with a summary of the site background, current land use, climate, and a discussion of geology and hydrostratigraphy.

- Section 2.0 summarizes the hydraulic investigative methods used during this investigation, including a description of the aquifer pumping tests, slug tests, and monthly water level monitoring.

- Section 3.0 summarizes the investigative results.

- Section 4.0 summarizes the findings and provides conclusions regarding the hydraulic characteristics of the aquifers that underlie the STF site and their interrelationships.

- Section 5.0 includes references for documents cited and used in the preparation of this report.

In addition, the Hydraulic Characterization Investigation Report includes the following appendices:

- Appendix HC-A — Quarterly Water Level Monitoring Data for the Tacoma Landfill

- Appendix HC-B — Well NMW-3A and Well NMW-4A Pump Test Barometric Pressure and Precipitation Data

- Appendix HC-C — Hydrographs of Monthly Water Levels in Monitoring Wells

- Appendix HC-D — Aquifer Pumping Test Data Analysis for Wells NMW-3A and NMW-4A

- Appendix HC-E — Slug Tests Data Analysis

- Appendix HC-F — Hydrographs of Water Levels in Wells Monitored During TAC 1A Aquifer Pumping Test

- Appendix HC-G TAC 1A Aquifer Pumping Test Data Analysis of Wells NMW-3C, NMW-5C, and TAC 89.5.

1.3 SITE BACKGROUND

This section presents a brief site description and history. More detailed information is provided in the Site Background Summary (ICF 1990a) and in the Final Work Plan prepared for the STF site (ICF 1990b).

1.3.1 Site Description

The STF site is located on the floor of a topographic lowland area referred to as the South Tacoma Channel, which is as much as 150 feet lower than the surrounding uplands. The site, once covered with industrial structures, is now mostly open fields of grass with six industrial and commercial facilities. Surface water is sometimes present in the western portion of the site, but no creeks, streams, or rivers currently pass through the site. The source of surface water is rainfall, overland flow, and storm drain runon. In general, this water does not leave the site but infiltrates or dissipates through evapotranspiration. However, runoff has been observed during high intensity, long duration storm events. Runoff, if any, leaves the site through a drainage ditch at the southern end of the site. Water in this ditch then flows into the 56th Street storm drain.

1.3.2 Site History

This discussion of historical activities at the STF site is based on material contained in the Site Background Summary Report (ICF 1990a). A more complete description of STF site history is available in the Site Background Summary Report (ICF 1990a),

along with references to other documents that provide additional information on historical site use.

The STF site has been used for a variety of industrial purposes for approximately 100 years. Locations where various activities have taken place at the site are shown in Figure HC-1. Areas where industrial activities occurred are briefly discussed in the following paragraphs.

The South Tacoma Car Shops area operated as a manufacturing and repair facility from 1892 until 1974. The area was used for manufacturing, repair, and maintenance of railroad equipment.

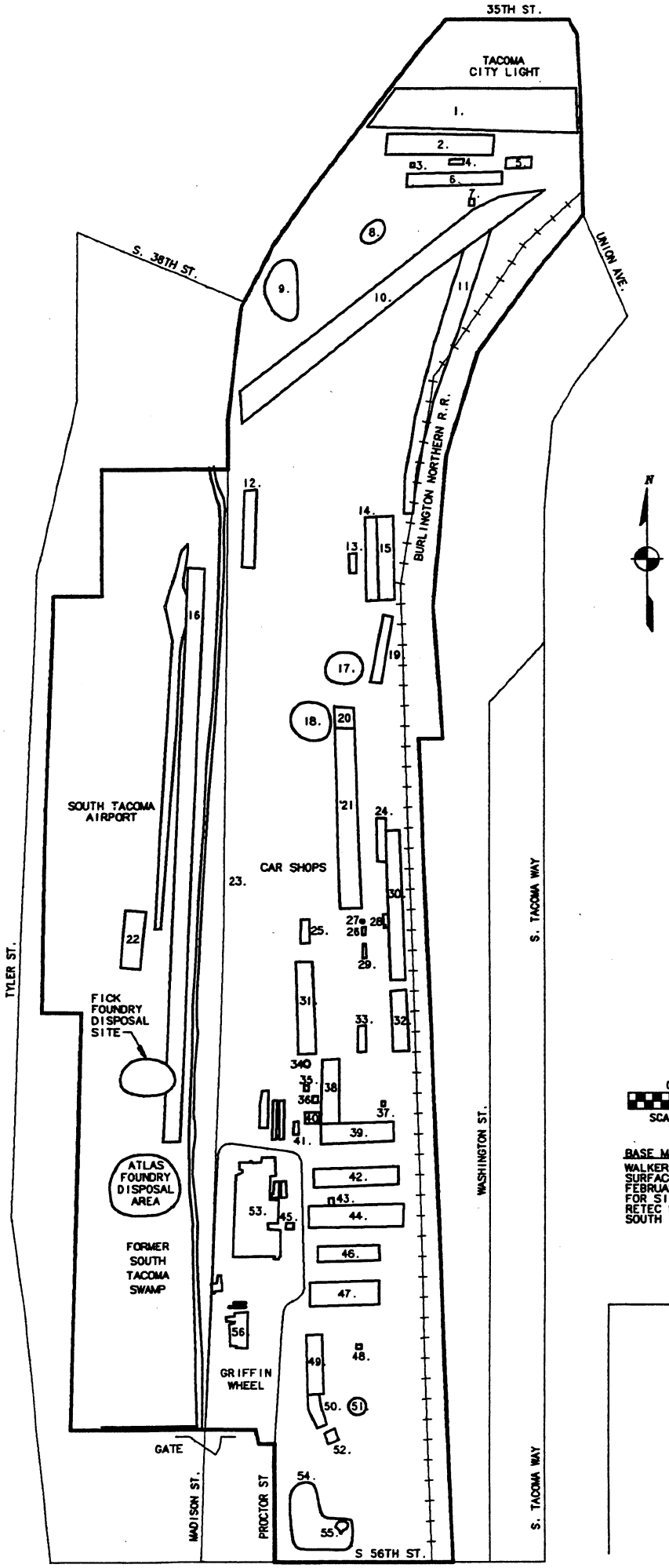
The BNR Dismantling Yard was located in the northern portion of the Car Shops area. Cars were cleaned out in this area.

Foundry facilities operated onsite from 1890 through 1980. An iron foundry produced iron wheels until 1957. A brass foundry produced journal bearings composed primarily of lead, tin, copper, zinc, and antimony until 1980.

The South Tacoma Airport operated from 1936 to 1973. Aircraft maintenance and refueling operations were performed at this location during those years. A lake was located beyond the south end of the former runway and, in the late 1940s, was used by seaplanes.

Reportedly, a variety of filling activities has occurred during the history of the site. Foundry, construction, and domestic wastes reportedly were disposed of as fill material in the Former Swamp/Lakebed area (ICF 1990a). Actual records of fill materials and volumes could not be obtained.

Tacoma City Light operations are located at the north end of the site. Repair, maintenance, and distribution of electric and water service equipment have occurred at the Tacoma City Light site since 1953.



LEGEND

STF-NPL SITE BOUNDARY

1. TCL YARD AREA
2. GANTRY CRANE AREA
3. FUEL TANK
4. SHED
5. LANTERN SHED
6. STOREHOUSE, BELTHOUSE ROLLING MILL, STORAGE BLDG
7. FUEL CELLAR
8. BURN PIT
9. TRASH DUMP
10. STORAGE YARD
11. RUBBISH TRACK CORRIDOR
12. CONCRETE CASTING PLANT
13. SANDBLAST SHED
14. BLACKSMITH SHOP
15. CONCRETE FLOOR
16. LANDING STRIP
17. TRASH BURNING AREA
18. TRASH PIT (PAINT SHOP)
19. CAR CASTINGS PLATFORM
20. PAINT SHOP
21. CAR SHOP
22. AIRPORT BLDG
23. MADISON STREET
24. OPEN SHED
25. DRY KILN
26. WASTE SOAKING VAT
27. UST (OIL)
28. PAINT SHOP
29. PAINT HOUSE
30. FREIGHT REPAIR SHED
31. FINISHED LUMBER SHED
32. WHEEL SHOP
33. GENERATOR HOUSE
34. UST (OIL)
35. PUMPS
36. DIP TANK
37. DROP PIT
38. WOODWORKING SHOP
39. COACH SHOP
40. BOILER HOUSE
41. OIL TANKS
42. PAINT SHOP
43. BRASS
44. MACHINE SHOP
45. SOLVENT SHED
46. BOILER, TIN TANK, AND COPPER SHOP
47. SOUTH MACHINE SHOP
48. TRASH BURNER
49. BLACKSMITH SHOP
50. IRON & STEEL STORAGE
51. TURNTABLE
52. COKE & COAL
53. FORMER IRON FOUNDRY
54. RAILCAR CLEANOUT AREA
55. BURIED DRUMS (REMOVED)
56. FORMER BRASS FOUNDRY SITE

0 200 400
SCALE IN FEET

BASE MAP REFERENCE
WALKER & ASSOC. 10-22-86
SURFACE DEBRIS SAMPLING PLAN
FEBRUARY 1987
FOR SITTS & HILL ENGINEERS, INC
RETEC REMEDIATION TECHNOLOGIES, INC.
SOUTH TACOMA SWAMP

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

MAJOR HISTORICAL USES OF THE STF SITE

916055.09/P2SK128

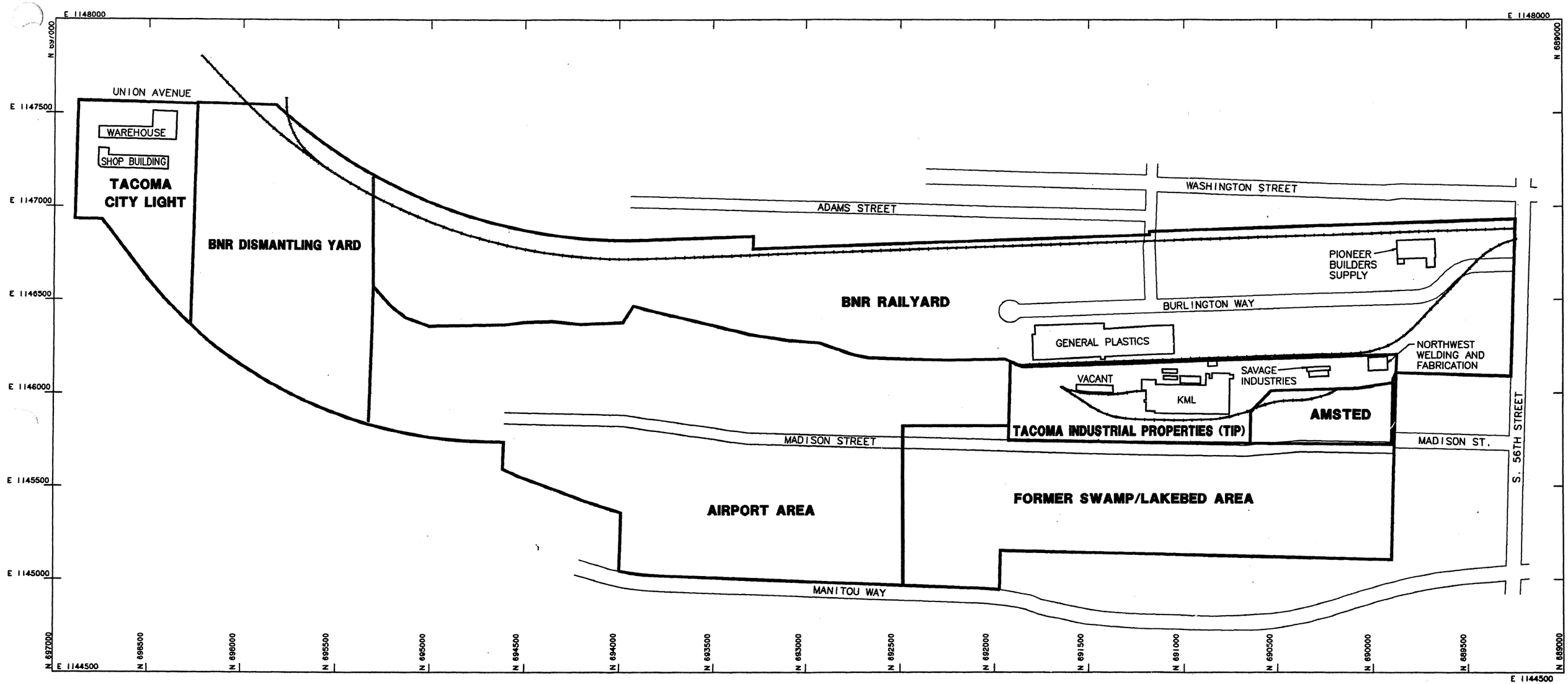
FIGURE HC-1

1.4 CURRENT SITE USE

Much of the STF site is currently undeveloped and is covered with field grass, blackberry bushes, shrubs, and a few trees. Concrete rubble, old foundations, and trash are apparent in some areas. A portion of the STF site is currently used for light industrial and commercial operations. Some businesses operate from facilities previously used in association with the foundries and the railyards, while other manufacturers have constructed new facilities. Information in this section has been prepared using the Site Background Summary Report (ICF 1990a). A map of businesses currently operating on the STF site is presented in Figure HC-2.

Tacoma Public Utilities (Tacoma City Light) provides electrical service and drinking water to Tacoma residents and businesses, and has operated from the northernmost end of the STF site since 1953. Tacoma Public Utilities uses its facility for maintenance and repair of equipment, as a storage and distribution center for electrical and water supply system components, and as an administration center. The Tacoma City Light property is covered with asphalt pavement and buildings. Stormwater runoff drains to modified dry wells that have soil bottoms and interconnecting piping leading to the City of Tacoma's storm drainage system. Some of the dry wells have been plugged with bentonite to prevent surface water infiltration.

The Tacoma City Light property has used four underground tanks and three aboveground tanks that are used to store automotive fuel, waste oil, and new, used, and waste mineral oil. Three of the underground tanks, which had contained leaded and unleaded gasoline, and diesel fuel, were removed in September 1992. The other underground tank, which had contained waste oil, were removed in September 1992 (Post, R., 20 February and 4 June 1992, and 10 January 1993 personal communication). Clean closures were achieved for all four of the removed underground tanks. The three aboveground tanks, which contain mineral oil, are located in enclosed areas with complete secondary containment.



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

BUSINESSES CURRENTLY OPERATING AT THE STF SITE

916055.09/P2SK129

FIGURE HC-2

Tacoma City Light stores electrical equipment, including approximately 3,500 new and used transformers. Some of the transformers contained or have previously contained polychlorinated biphenyls (PCBs). PCB contamination of Tacoma City Light soil has been documented by Black & Veatch (1983) and by Hart-Crowser (1989).

Tacoma Industrial Properties (TIP) Management Inc. owns property in the central portion of the STF site, which is the site of a former iron foundry. TIP uses the area for a variety of industrial purposes. Three businesses operate on TIP property: KML Corporation, Savage Industries, and Northwest Welding and Fabrication. KML Corporation has operated in the old iron foundry building since 1986. KML laminates films onto particle board for the construction of cabinets and interior partitions. Savage Industries has used a former wood patterns and vaults building since the early 1970s to manufacture wood picture frames. Northwest Welding and Fabrication has operated at TIP since 1986. Northwest Welding and Fabrication activities include repair of boats, motors, and boat trailers, as well as steel product fabrication and repair.

Other businesses have used TIP facilities; however, little information is available about their operations. These businesses reportedly included steel tubing, bending, and fabrication; lamination of plastic overlays on particle boards; railroad wheel journal bearing manufacturing; soil stabilization materials manufacturing; warehousing; and steel fabrication.

Facilities recently constructed on STF site property include the General Plastics and Pioneer Builders Supply complexes. General Plastics built a manufacturing plant in 1981 on a portion of the former Car Shops area. General Plastics manufactures high-density rigid and flexible polyurethane foams and high-density rigid polyisocyanurate foams for the aviation, construction, marine, nuclear, architectural, and sports equipment industries. General Plastics uses and/or stores onsite several chemical products including chlorofluorocarbons, methylene chloride, and isocyanates. One underground storage tank, formerly available for spill

containment purposes, was removed in the summer of 1990 and properly disposed (Schatz, H., 25 February 1992, personal communication).

Pioneer Builders Supply purchased land in the southeast portion of the STF site for a warehouse and office building that were constructed in 1988. Pioneer Builders Supply operates a distribution center for asphalt and cedar roofing materials. Pioneer Builders Supply used two underground tanks for approximately 5 years to store gasoline and diesel fuel. Pioneer Builders Supply excavated the tanks in December 1991 and determined that the surrounding soil was contaminated with petroleum products (Saltbush Environmental Services 1992). In addition, three underground tanks were discovered in the northeast corner of the Pioneer Builders Supply property in early 1990 and were excavated and disposed of in June 1990 (Hildenbrand, J., 12 February 1991, personal communication).

1.5 CLIMATE

The Tacoma region is characterized by mild temperatures and cloudiness during the rainy season (October through May). The U.S. Weather Bureau station at Tacoma reports an average annual precipitation of 37.06 inches. Approximately 76 percent of the annual precipitation falls during the months of October through March (Entranco Engineers 1989).

Rainfall data collected during the investigative period from April 1991 to March 1992 are summarized in Appendix SW-A of the STF Surface Water and Sediment Investigation Report (Kennedy/ Jenks Consultants 1992c). The maximum daily rainfall measured by McChord Air Force Base (AFB) was 4.08 inches on 9 January 1990. McChord AFB is located approximately 5 miles south of the STF site. The total amount of precipitation recorded at McChord AFB from April 1991 to April 1992 (investigative period) was 38.76 inches. Approximately 60 percent of the total precipitation fell during the period from October 1991 through February 1992.

1.6 GEOLOGY AND HYDROSTRATIGRAPHY

This section describes the geology and hydrostratigraphy of the STF and surrounding area. The information presented in this section is based primarily on the STF Phase I Groundwater Investigation (Kennedy/Jenks Consultants 1992a). However, available information from previous studies of the area has also been incorporated.

1.6.1 Geology

The STF site lies within the central part of the Puget Lowland physiographic province (Lowland) of western Washington. The Lowland is bounded on the east by the Cascade Mountains and on the west by the Olympic Mountains and Willapa Hills. The portion of the Lowland in which the STF site lies is characterized by rolling hills and depressions occupied by lakes, rivers, and Puget Sound (Brown and Caldwell 1985).

The site is located on a drift plain that regionally ranges in elevation from sea level to approximately 600 feet. The present regional topography is the result of glacial and glaciofluvial processes of the most recent glaciation, the Vashon glaciation.

The STF site lies within the South Tacoma Channel, which is 4 miles long. It is an outwash channel that was cut by high-velocity glacial meltwater streams. The Channel acted as a spillway for meltwater from glacial Lake Puyallup during the northward retreat of the Puget lobe of the Vashon Glacier (Thorson 1980).

Surficial deposits in the Lowland are largely composed of glacial and interglacial unconsolidated sediments of Pleistocene age. In the Tacoma area, the thickness of these deposits is estimated to be approximately 2,000 feet (Noble 1990). The sediments were deposited during advances and retreats of glaciers throughout the Pleistocene epoch.

Sediments deposited during glacial periods are typically coarse-grained and represent high energy environments. Sediments deposited during interglacial periods are typically finer grained with abundant organic matter and represent low energy environments.

1.6.2 Stratigraphic Units

Three glacial and two interglacial climatic episodes are represented by units underlying the site. The episodes represented are the Vashon Glaciation, Olympia Interglaciation, Narrows Glaciation, Kitsap Interglaciation, and Flett Creek Glaciation. The units representing these episodes from youngest (i.e., shallowest) to oldest (i.e., deepest) are the Vashon Drift, Discovery nonglacial unit, Narrows glacial unit, Kitsap Formation, and Flett Creek glacial unit. The following six hydrostratigraphic layers identified at the STF site are composed of members of the five units (Brown and Caldwell 1985):

- Layer A (Upper)
- Layer A_1
- Layer A (Lower)
- Layer B
- Layer C.

These layers are shown in Figures GW-6 through GW-9 of the STF Phase I Groundwater Investigation Report (Kennedy/Jenks Consultants 1992a). Table HC-1 summarizes the correlation of these zones with locally identified stratigraphic units.

TABLE HC-1

STRATIGRAPHIC CORRELATION IN THE VICINITY OF THE STF SITE

Climatic Episode[a]	Unit Name[a]	Hydrostratigraphic Layer[b]	Tacoma Landfill Subsurface Units[c]
Vashon Glaciation	Vashon Drift (Qv)	A (Upper)	Vashon Till (Qvt) Vashon Advance (Qva) Colvos Sand (Qc) Older Gravel (Qog)
Olympia Interglaciation	Discovery nonglacial unit (Qd)	A_1	Older Sand (Qos) Older Lacustrine (Qol)
Narrows Glaciation	Narrows glacial unit (Qn)	A_1 A (Lower)	Older Till (Qot) Older Advance (Qoa)
Kitsap Interglaciation	Kitsap Formation (Qk)	B	Kitsap Formation (Qk)
Flett Creek Glaciation	Flett Creek glacial unit (Qfc)	C	Not recognized

(a) Based on interpretations presented in Noble (1990).
(b) Based on correlations presented in Brown and Caldwell (1985).
(c) Based on correlations presented in Black & Veatch (1990).

1.6.2.1 Vashon Drift. The upper most aquifer beneath the STF site is composed of Colvos Sand. Colvos Sand is a member of the Vashon Drift and is correlative with the upper portion of hydrostratigraphic Layer A (Upper Layer A). Colvos Sand represents advanced outwash sand and gravels that were deposited from meltwater streams along the leading edge of the Vashon Glacier during its southward advance. At the STF site, the Colvos Sand consists mainly of poorly graded (well-sorted) sand with minor gravel and silt. The Colvos Sand is approximately 50 feet thick where observed at the STF site. The upper aquifer (Layer A) wells at the STF site are screened in the Colvos Sand.

Beneath the Colvos Sand is a gravel layer that varies in thickness from approximately 17 feet to approximately 59 feet where observed. This gravel layer is also correlative with hydrostratigraphic Upper Layer A.

1.6.2.2 Discovery Nonglacial Unit. The Discovery nonglacial unit underlies the Vashon Drift gravel layer. The Discovery nonglacial sediments deposited during the Olympia Interglaciation are correlative with portions of hydrostratigraphic Layer A_1 and are characterized by interbedded clay, silt, sand, and gravel deposits. In the northern portion of the site, the Discovery unit is absent or is represented by gravel and sand deposits similar in appearance to the overlying Vashon units. The unit is approximately 40 feet thick where intersected in the southern portion of the site at Well NMW-3C.

1.6.3.3 Narrows Glacial Unit. Immediately underlying the Discovery nonglacial unit regionally is a layer of glacial till. At the STF site, this layer was recognized as indurated silt in the northern portion of the site and as a silt in the southern portion. This glacial till/silt layer and the overlying nonglacial Discovery sediments together form a continuous fine-grained unit across the site that is correlative with hydrostratigraphic Layer A_1. Black & Veatch (1990) recognized that the two deposits are closely associated and suggested the two deposits form a single aquitard beneath the Tacoma Landfill, separating the unconfined hydrostratigraphic Layer A from lower-lying water-bearing zones. The approximate thickness of this unit where observed at the STF site is approximately 65-75 feet.

A gravel layer approximately 65 feet thick lies beneath this silty layer of the glacial till at the STF site. In the south portion of the site, the gravel contains sand, but finer-grained materials are rare. In the northern part of the site, the gravel contains silt and clay; wood fragments were also observed. The gravel unit is correlative with lower portion of hydrostratigraphic Layer A (Lower Layer A). Wells NMW-5B and NMW-3B are completed in this layer.

1.6.2.4 Kitsap Formation. The Kitsap Formation is a nonglacial unit below the Narrows glacial unit and was deposited during the Kitsap Interglaciation. At the STF site, this unit consists of fine-grained organic rich sediment. The Kitsap Formation is correlative with hydrostratigraphic Layer B. The unit has been recognized as an important regional aquitard that ranges in thickness to as much as

150 feet (Walters and Kimmel 1968), but is typically 50 feet thick (Brown and Caldwell 1985). In previous regional studies in the vicinity of the STF site, Brown and Caldwell (1985) have postulated the absence of the Kitsap Formation in the South Tacoma Channel. This theory appears to be based on information gathered from a driller's log for a deep well (Well 20/2-24A2) in the South Tacoma Channel (Walters and Kimmel 1968), and on the observed thinning of the Kitsap Formation approaching the South Tacoma Channel (see Figure GW-7 of the STF Phase I Groundwater Report; Kennedy/Jenks Consultants 1992a).

Information gathered during the STF Phase I Groundwater Investigation suggests the Kitsap Formation is thin but present beneath the STF site. Based on information gathered during the Groundwater Investigation the thickness of the Kitsap Formation varies from approximately 2 feet in the south to 15 feet in the north.

1.6.2.5 Flett Creek Glacial Unit. The lowermost unit (Layer C) is the Flett Creek glacial unit. This drift unit consist of gravel, cobbles, and boulders to at least 1 foot in diameter. Wells NMW-3C and NMW-5C are screened in the upper portion of this unit. At the STF site, the Flett Creek glacial unit was penetrated approximately 25 feet. Offsite this unit has been observed to thicknesses of 100 feet or more.

1.6.3 Hydrogeologic Conditions

This section provides an outline of the hydrogeologic conditions that have been encountered both regionally and at the STF site based on available information gathered prior to this Hydraulic Characterization Investigation. Local hydrogeologic conditions encountered onsite are detailed in Section 4.0, Discussion and Conclusions, based on the results of this investigation.

1.6.3.1 Occurrence of Groundwater. Both locally and regionally, groundwater is encountered in two stratigraphic zones (Layer A and Layer C) in the upper 200-350 feet of sediment. Regionally deeper saturated zones have also been encountered.

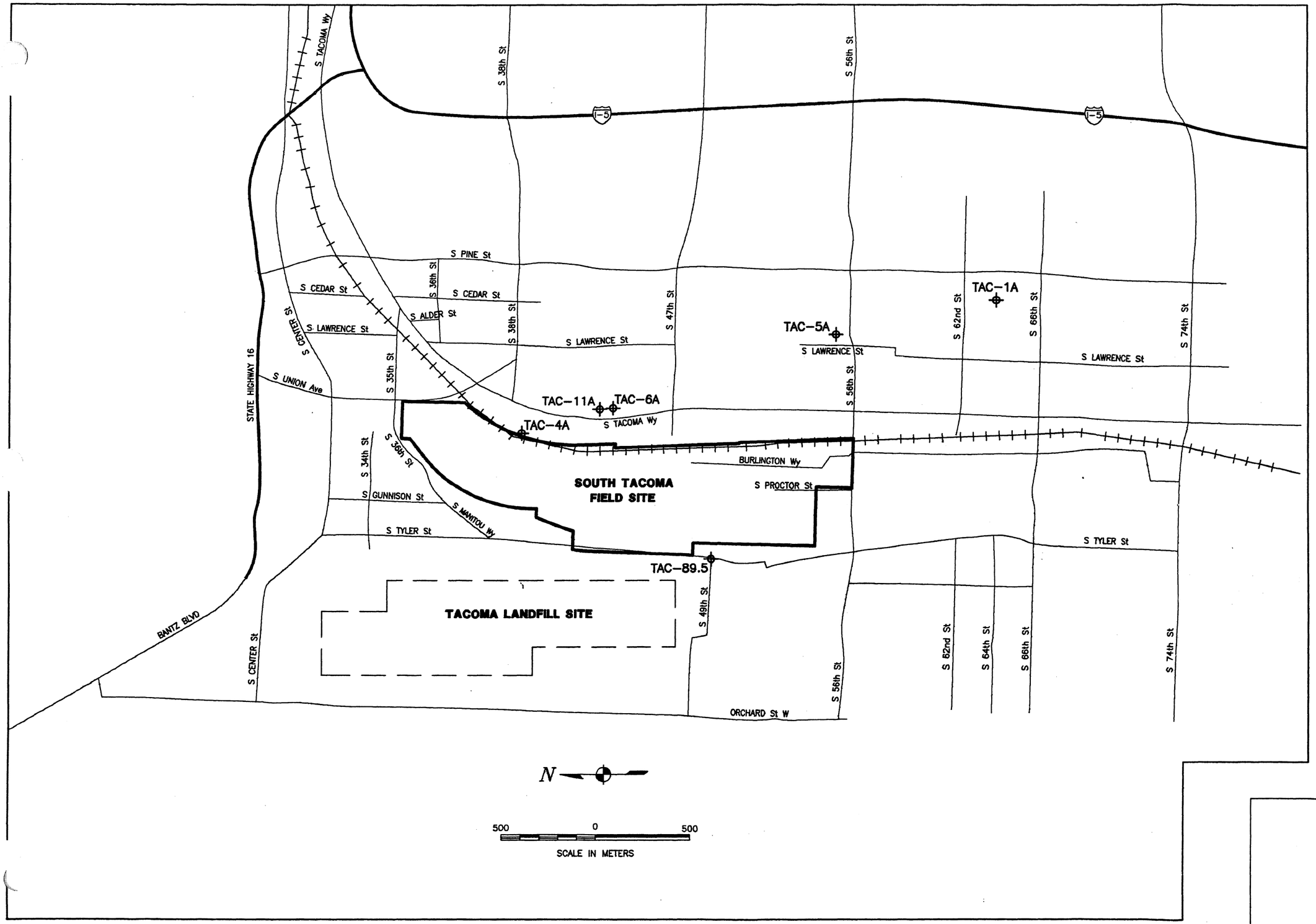
Layer A_1 and Layer B are regional confining layers. Layer A_1 is a confining or semi-confining layer between the upper portion of Layer A (Colvos Sand) and the lower portion of Layer A (Narrows Glacial Unit). The upper portion of Layer A and the lower portion of Layer A are referred to in this report as Upper Layer A and Lower Layer A, respectively. Layer B minimizes hydraulic communication between the unconfined to semi-confined Layer A and the confined Layer C. Available background information suggests that Layer B is missing in the South Tacoma Channel (Brown and Caldwell 1985). However, as discussed above, Layer B was identified during the installation of deep monitoring wells at the STF site. The thickness of this layer is less at the STF site than it is elsewhere in the Channel.

1.6.3.2 Hydraulic Gradients. Based on potentiometric surface maps for the Clover Creek/Chambers Creek drainage area (the regional drainage area), the hydraulic gradient in Layer A is in a northwestern direction (Brown and Caldwell 1985). This generalized regional direction of the hydraulic gradient is consistent with observations made at the STF site. However, the hydraulic gradient in several areas of this site have been observed to trend to the east, west, or southwest during different times of the year. Variations in the direction of the hydraulic gradient observed at the site are typically a result of:

- Groundwater extraction from large municipal production wells owned by Tacoma Public Utilities (i.e., Wells TAC 4A, TAC 6A, TAC 11A, and TAC 5A) (see Figure HC-3)

- Seasonal variations in recharge

- Lithologic and structural influences, including variations in aquifer thickness and transmissivity.



LEGEND

TAC-1A — MUNICIPAL PUMPING WELL

SOUTH TACOMA FIELD SITE BOUNDARY

TACOMA LANDFILL SITE BOUNDARY

NOTES:

1. ALL LOCATIONS ARE APPROXIMATE.

BASE MAP REFERENCE

AMERICAN DIGITAL CARTOGRAPHY SOUTH TACOMA, WA QUAD AND STEILACOOM, WA QUAD

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TACOMA PUBLIC UTILITIES MUNICIPAL PUMPING WELLS

916055.09/P2SK126

FIGURE HC-3

Available information suggests that the hydraulic gradient in Layer C is also toward the northwest (Brown and Caldwell 1985). However, there are few monitoring locations to confirm this presumed hydraulic gradient in the vicinity of the STF site.

Vertical gradients between Layers A and C are reported to be in a net downward direction throughout the Clover Creek/Chambers Creek drainage area (Brown and Caldwell 1985). The same information source also indicates a net upward vertical gradient in the South Tacoma Channel. This contradicts findings in the STF Phase I Groundwater Investigation Report, which indicates a net downward vertical gradient between the two zones of saturation.

During the summer months, when the regional potentiometric surface in Layer C is depressed due to pumping by Tacoma Public Utilities, the head differential between Lower Layer A and Layer C was observed to be as great as 27 feet or more (Kennedy/Jenks Consultants 1992a). During times when groundwater extraction is not in progress, head differentials between Lower Layer A and Layer C are 0.27 feet at Wells NMW-3B and NMW-3C, and 10.95 feet at Wells NMW-5B and NMW-5C. These results indicate that Layer B is more effective at preventing inter-aquifer communication in the vicinity of Well Cluster NMW-5 than in the vicinity of Well Cluster NMW-3.

1.6.3.3 Aquifer Properties. Layer A contains advance outwash sand and gravels deposited during the Vashon Glaciation (see Section 1.6.2). As a result, these materials typically have very high hydraulic conductivity values. Hydraulic conductivity values for Layer A in the vicinity of the South Tacoma Channel reportedly (Brown and Caldwell 1985) ranged from 1,000 to 3,000 gallons per day per square-foot (gpd/ft^2) assuming an average saturated thickness of 60 feet (based on observations of Upper Layer A at the STF site). Hydraulic conductivity values for Layer C in the vicinity of the STF site reportedly ranged from 300 gpd/ft^2 to 3,000 gpd/ft^2 using an average saturated thickness of 100 feet (Carr/Associates 1991).

2.0 INVESTIGATIVE METHODS

The investigative methods used to evaluate the hydraulic characteristics of the hydrostratigraphic layers that underlie STF are presented in this section. Field activities associated with water level monitoring, aquifer pumping tests, slug tests, and investigation of inter-aquifer communication at the site are also presented. Investigative activities were performed in accordance with the standard operating guidelines (SOGs) presented in the STF Field Sampling and Analysis Plan (FSAP) (Kennedy/Jenks/Chilton 1991). Deviation from these procedures are discussed herein.

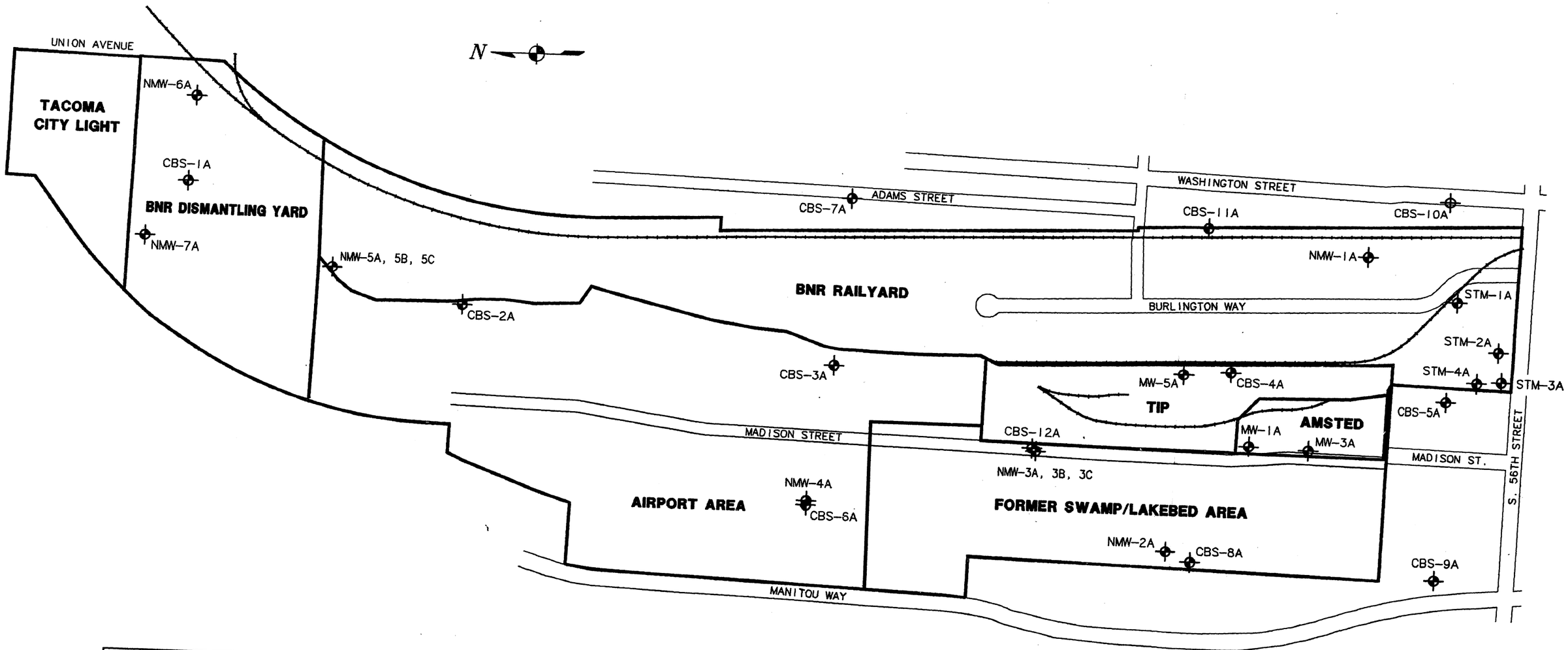
2.1 WATER LEVEL MONITORING

Water level monitoring was conducted to observe seasonal water level variations, and to estimate the direction and magnitude of the hydraulic gradient in Layer A.

Water level monitoring was performed on a monthly basis beginning in April 1991 and ending in March 1992. All water level measurements were completed in accordance with SOG-18 (Kennedy/Jenks/Chilton 1991). Monthly water level monitoring data were entered into a database and are presented in Section 3.1 of this report.

2.1.1 Monitoring Wells

During the STF RI, water levels were monitored in 27 onsite wells and three offsite wells. Well construction details of these 30 monitoring wells are presented in Table HC-2. The locations of these monitoring wells are shown in Figure HC-4. Boring



LEGEND

NMW-1A ONSITE MONITORING WELL LOCATION

0 500
SCALE IN FEET

NOTES:

1. WELLS WITH "NMW" PREFIX WERE INSTALLED DURING THE PHASE I GROUNDWATER INVESTIGATION. ALL OTHER MONITORING WELLS WERE INSTALLED DURING PREVIOUS INVESTIGATIONS.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

MONITORING WELL LOCATIO

916055.09/P2SK130

FIGURE HC-4

TABLE HC-2

MONITORING WELL CONSTRUCTION DATA

WELL ID	DATE INSTALLED (MM/DD/YY)	CASING DIAMETER (in)	TOTAL DEPTH (ft)	BLANK INTERVAL (ft)	BLANK TYPE	SCREENED INTERVAL (ft)	SCREEN TYPE	SLOT SIZE (in)	FILTER PACK	SURFACE SEAL (ft)	FILTER SEAL (ft)
CBS-1A	10/11/82	2	30	0-20	PVC	20-30	PVC	0.010	Coarse Sand	0-8 BG	8-13 BS
CBS-2A	10/13/82	2	33	0-28	PVC	28-33	PVC	0.010	Coarse Sand	0-20 BG	20-16 BS
CBS-3A	10/10/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-30 BG	30-36 BS
CBS-4A	10/11/82	2	43.5	0-38	PVC	38-43	PVC	0.010	Coarse Sand	0-28 BG	28-33 BS
CBS-5A	10/11/82	2	29	0-23	PVC	23-28	PVC	0.010	Coarse Sand	0-15 BG	15-20 BS
CBS-6A	10/12/82	2	28	0-23	PVC	23-28	PVC	0.010	Coarse Sand	0-12 BG	12-17 BS
CBS-7A	10/12/82	2	48	0-43	PVC	43-48	PVC	0.010	Coarse Sand	0-35 BG	35-41 BS
CBS-8A	10/13/82	2	18	0-13	PVC	13-18	PVC	0.010	Coarse Sand	0-5 BG	5-11 BS
CBS-9A	10/11/82	2	34	0-28	PVC	29-34	PVC	0.010	Coarse Sand	0-20.5 BG	20.5-25.5 BS
CBS-10A(a)	10/12/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-30 BG	30-35 BS
CBS-11A	10/14/82	2	44	0-39	PVC	39-44	PVC	0.010	Coarse Sand	0-31 BG	31-36 BS
CBS-12A	10/13/82	2	33	0-28	PVC	28-33	PVC	0.010	Coarse Sand	0-19 BG	19-25 BS
STM-1A	08/13/86	2	38	0-28	GALV	28-38	SS	0.010	10-20 Silica	0-3 RM 3-24.5 GB	24.5-26 BP
STM-2A	08/13/86	2	42.5	0-32.5	GALV	32.5-42.5	SS	0.010	10-20 Silica	0-3 RM 3-28.5 GB	28.5-31 BP
STM-3A	08/13/86	2	23	0-13	GALV	13-23	SS	0.010	10-20 Silica	0-3 RM 3-9.5 GB	9.5-11.5 BP
STM-4A	08/13/86	2	26.5	0-16.5	GALV	16.5-22.5	SS	0.010	10-20 Silica	0-3 RM 3-12.5 GB	12.5-14.5 BP
MW-1A	09/15/86	2	30.5	0-15	PVC	15-30.5	PVC	0.020	Med. Silica	0-12 BG	NA
MW-3A	09/17/86	2	29.5	0-14	PVC	14-29.5	PVC	0.020	Med. Silica	0-14 BG	NA
MW-5A	11/02/87	2	40.0	0-19.5	PVC	19.5-39.5	PVC	0.020	10-20 Silica	7-15.5 B	NA
NMW-1A	03/06/91	4	48.0	0-21	PVC	21-46	PVC	0.020	10-20 Silica	2-15 VC	15-18 BP
NMW-2A	03/04/91	4	40.0	0-13	PVC	13-38	PVC	0.010	10-20 Silica	2-8 VC	8-10 BP
NMW-3A	03/14/91	4	38.0	0-13	PVC	13-38	PVC	0.020	10-20 Silica	0-9 BG	9-11 BP
NMW-3B	03/11/91	4	127.5	0-110	PVC	110-125	PVC	0.010	20-40 Silica	0-104 VC	104-107 BS
NMW-3C	03/04/91	4	195.5	0-180	PVC	180-195	PVC	0.030	8-12 Silica	0-175 VC	175-177 FS
NMW-4A	03/13/91	4	35.5	0-10	PVC	10-35	PVC	0.020	10-20 Silica	0-4 CB	4-6.5 BP
NMW-5A	03/11/91	4	47.0	0-20	PVC	20-45	PVC	0.020	8-12 Silica	2-14 BG	14-17 BP
NMW-5B	03/05/91	4	127.5	0-110	PVC	110-125	PVC	0.020	10-20 Silica	0-105 VC	105-107 FS
NMW-5C	02/27/91	4	200.5	0-185	PVC	185-200	PVC	0.030	8-12 Silica	0-178 VC	178-180 FS
NMW-6A	03/01/91	4	42.0	0-15	PVC	15-40	PVC	0.020	10-20 Silica	2-9 VC	9-12 BP
NMW-7A	02/28/91	4	40.0	0-15	PVC	15-40	PVC	0.020	8-12 Silica	2-9 VC	9-12 BP

GALV - Galvanized Steel
B - Bentonite
SS - Stainless Steel
PVC - Schedule 40 PVC
NA - Not Applicable
BP - Bentonite Pellets
BS - Bentonite Slurry
GB - Granular Bentonite
RM - Ready-Mix Concrete
VC - Volclay Grout
FS - Fine Sand
CB - Cement/Bentonite Mix
BG - Bentonite Grout

(a) CBS-10A is located offsite and upgradient of the STF site. All other wells listed in this table were considered to be onsite for the purposes of this investigation.

and well construction logs for these wells are presented in Appendix GW-A of the STF Phase I Groundwater Investigation Report (Kennedy/Jenks Consultants 1992a). Monitoring wells installed in Upper Layer A were given a well designation ending in "A." Wells installed in the lower portion of Layer A have been given a designation ending in "B." Wells installed in Layer C were given a designation ending in "C."

When appropriate, monitoring of STF wells corresponded with quarterly monitoring of Tacoma Landfill wells. These data were used to develop a regional understanding of the hydraulic gradient in Layer A and are summarized in Appendix HC-A.

2.1.2 Surveying of Monitoring Wells

Surveying of monitoring wells was completed by PEI/Barrett Consulting Group. Well locations were surveyed for horizontal (northing and easting) coordinates in reference to the City of Tacoma NAD 83 horizontal datum. Vertical elevations were surveyed to the nearest 0.01 foot in reference to the City of Tacoma NGVD 29 vertical datum. Vertical elevations that were measured for the monitoring wells included ground surface elevations, tops of the steel surface housings, and tops of PVC or steel well casings (Table HC-3).

2.2 AQUIFER PUMPING TESTS

As outlined in the STF Final Work Plan (ICF 1990b), the following aquifer tests were planned for the STF site:

- Two aquifer tests in Layer A at Wells NMW-3A and NMW-4A to estimate transmissivity, hydraulic conductivity, and specific yield of Upper Layer A

TABLE HC–3

COORDINATES AND ELEVATIONS OF MONITORING WELLS AND WATER LEVEL ELEVATION DATA

Well Designation	Northing (ft)[a]	Easting (ft)[a]	Elevation of Top of Monument (ft above MLW)[b]	Water Level Elevation (feet, MLW)[b]		
				04/11/91	05/09/91	06/07/91
CBS–1A	695976.02	1146934.36	240.85	220.83	221.40	221.37
CBS–2A	694571.22	1146352.26	241.78	223.44	222.65	221.79
CBS–3A	692680.55	1146106.55	251.18	223.35	222.59	221.05
CBS–4A	690682.06	1146139.68	252.49	224.75	223.26	222.68
CBS–5A	689597.10	1146027.80	239.59	225.65	223.13	222.61
CBS–6A	692795.99	1145387.03	234.43	222.98	222.37	221.30
CBS–7A	692622.84	1146959.91	256.44	222.78	222.70	220.42
CBS–8A	690853.60	1145164.68	227.46	NM (c)	223.17	222.77
CBS–9A	689624.72	1145115.40	244.00	218.78	219.45	218.74
CBS–10A	689615.28	1147044.84	256.69	223.51	223.48	222.89
CBS–11A	690820.19	1146871.71	255.63	223.24	223.56	223.05
CBS–12A	691668.54	1145718.63	240.85	224.28	222.90	222.15
MW–1A	690579.51	1145764.81	243.62	226.57	222.92	222.52
MW–3A	690280.74	1145754.88	240.64	226.74	223.01	222.47
MW–5A	690918.42	1146120.68	250.30	224.70	223.28	222.59
NMW–1A	690017.40	1146754.29	254.25	223.90	223.59	223.02
NMW–2A	690979.42	1145215.34	240.91	225.46	222.91	222.31
NMW–3A	691649.40	1145703.81	239.80	224.30	222.90	222.14
NMW–3B	691656.58	1145698.02	237.57	220.09	220.17	199.95
NMW–3C	691660.72	1145704.30	240.36	218.29	218.55	183.97
NMW–4A	692795.40	1145408.83	236.10	222.97	222.39	221.27
NMW–5A	695234.17	1146520.32	243.17	221.81	221.95	221.57
NMW–5B	695239.96	1146515.50	243.28	218.63	219.08	216.45
NMW–5C	695231.71	1146513.19	243.50	204.11	203.29	194.68
NMW–6A	695951.03	1147366.74	243.21	220.78	221.65	221.37
NMW–7A	696177.86	1146651.70	243.65	220.63	221.30	221.39
STM–1A	689558.00	1146537.04	254.50	224.60	223.37	222.81
STM–2A	689342.64	1146287.34	255.57	224.64	223.10	222.63
STM–3A	689322.39	1146135.51	239.13	224.70	223.06	222.56
STM–4A	689446.08	1146127.90	240.61	225.01	223.10	222.58

TABLE HC-3

COORDINATES AND ELEVATIONS OF MONITORING WELLS AND WATER LEVEL ELEVATION DATA

Well Designation	Water Level Elevation (feet, MLW)[b]			Water Level Elevation (feet, MLW)[b]		
	07/11/91	08/08/91	08/23/91	09/09/91	10/17/91	11/11/91
CBS-1A	220.22	217.43	215.92	215.27	214.77	216.35
CBS-2A	220.71	"Dry"	212.83	213.13	212.13	215.24
CBS-3A	219.64	212.37	"Dry" (d)	212.82	212.74	215.66
CBS-4A	221.73	219.90	212.74	217.92	217.11	217.71
CBS-5A	221.47	220.18	219.52	218.89	218.39	218.55
CBS-6A	220.14	214.42	212.04	213.54	212.87	215.55
CBS-7A	218.84	"Dry"	"Dry"	"Dry"	"Dry"	216.05
CBS-8A	221.77	220.05	218.78	217.56	216.25	216.74
CBS-9A	219.53	218.82	218.43	217.87	216.97	216.76
CBS-10A	221.58	220.27	219.62	219.05	218.78	218.95
CBS-11A	222.15	220.15	219.09	218.41	217.93	218.49
CBS-12A	221.15	217.22	215.11	215.00	214.00	216.09
MW-1A	222.92	220.75	219.75	219.01	216.73	217.33
MW-3A	221.44	219.97	219.10	218.34	217.64	217.94
MW-5A	221.71	219.75	218.50	217.57	216.66	217.35
NMW-1A	221.82	220.41	219.60	218.90	218.41	218.64
NMW-2A	221.50	219.24	217.85	216.91	215.63	214.67
NMW-3A	221.16	217.30	215.19	215.04	214.04	216.09
NMW-3B	191.41	192.88	188.36	206.60	213.53	214.75
NMW-3C	176.41	181.19	178.88	205.63	213.26	213.96
NMW-4A	220.09	214.29	211.91	213.49	212.86	215.54
NMW-5A	220.44	216.89	214.97	214.83	214.01	216.09
NMW-5B	181.05	178.76	197.98	209.86	210.92	213.14
NMW-5C	170.10	167.43	170.11	189.71	194.81	196.86
NMW-6A	220.19	217.68	216.27	215.38	214.99	216.49
NMW-7A	220.23	217.94	216.62	215.70	215.18	216.55
STM-1A	221.60	220.29	219.61	218.96	218.52	218.67
STM-2A	221.44	220.19	219.60	219.03	218.63	218.74
STM-3A	221.34	220.10	219.53	218.98	218.60	218.69
STM-4A	221.40	220.16	219.53	218.91	218.48	218.59

TABLE HC-3

COORDINATES AND ELEVATIONS OF MONITORING WELLS AND WATER LEVEL ELEVATION DATA

Well Designation	Water Level Elevation (feet, MLW)[b]			Water Level Elevation (feet, MLW)[b]		
	12/09/91	01/07/92	01/31/92	02/11/92	03/13/92	03/30/92
CBS-1A	217.54	218.25	219.10	219.65	220.27	220.33
CBS-2A	217.43	218.44	219.88	220.91	221.15	220.96
CBS-3A	217.66	218.50	220.56	220.83	221.08	220.88
CBS-4A	219.66	219.40	221.53	222.20	221.93	221.52
CBS-5A	219.73	219.48	223.46	221.98	221.70	221.40
CBS-6A	216.46	218.25	NM	220.47	220.87	220.63
CBS-7A	217.86	218.68	219.85	220.70	221.17	221.06
CBS-8A	219.68	219.35	223.15	223.21	222.07	221.36
CBS-9A	216.70	216.50	217.06	217.42	218.01	217.88
CBS-10A	219.78	219.93	220.88	221.66	222.02	221.76
CBS-11A	219.57	219.87	220.74	221.59	222.10	221.88
CBS-12A	218.57	218.90	221.24	221.73	221.51	221.11
MW-1A	220.25	219.13	223.75	222.79	220.76	221.19
MW-3A	220.21	219:28	224.21	222.22	221.68	221.29
MW-5A	219.58	219.34	221.29	222.42	221.94	221.42
NMW-1A	219.69	219.85	221.03	221.89	222.16	221.88
NMW-2A	219.66	219.25	222.85	222.60	223.89	221.09
NMW-3A	218.60	218.91	221.26	221.74	221.52	221.10
NMW-3B	204.03	216.99	218.14	218.45	218.49	212.73
NMW-3C	187.37	216.00	216.80	217.03	217.00	208.32
NMW-4A	217.45	218.24	222.21	220.47	220.82	220.62
NMW-5A	217.57	217.39	219.42	220.14	220.62	220.61
NMW-5B	214.17	215.63	216.53	216.98	217.08	217.04
NMW-5C	197.16	202.26	199.55	201.64	197.60	198.25
NMW-6A	217.64	218.31	219.17	219.64	220.27	220.31
NMW-7A	217.56	218.23	219.06	219.51	220.19	220.25
STM-1A	219.74	219.66	221.52	221.98	221.92	221.65
STM-2A	219.62	219.57	221.75	221.73	221.70	221.43
STM-3A	219.58	219.48	222.14	221.65	221.60	221.32
STM-4A	219.63	219.48	222.50	221.82	221.66	221.38

Notes:

(a) Horizontal survey based on State Plane Coordinates (STPCO, Northing and Easting). City of Tacoma 1983 NAD.

(b) Vertical datum based on City of Tacoma NGVD 29.

(c) NM = Water level not measured.
"Dry" denotes well was dry at time of monitoring.

- Two aquifer tests in Lower Layer A or Layer C at Well Clusters NMW-3 and NMW-5 to evaluate potential inter-aquifer communication between Upper Layer A and Layer C.

Based on a review of information regarding hydraulic conductivity in Layer C, the expected drawdown from the proposed tests was estimated. Based on this estimate, it was concluded that aquifer tests at onsite wells installed in Layer C may not provide sufficient drawdown to evaluate potential inter-aquifer communication. This conclusion was provided to EPA (Kennedy/Jenks Consultants, 3 October 1991, personal communication) along with suggested alternative methods for evaluating inter-aquifer communication. This proposed alternative approach included:

- Analysis of the mean water level fluctuation in Upper Layer A monitoring wells during summer groundwater extraction by Tacoma Public Utilities in Layer C

- Performance of an aquifer test at a nearby (offsite) groundwater extraction well used by Tacoma Public Utilities

- Monitoring the recovery of water levels in both Layers A and C following completion of seasonal groundwater extraction by Tacoma Public Utilities.

EPA agreed with this proposed approach (EPA, 30 October 1991, personal communication) in lieu of aquifer tests at Wells NMW-3C and NMW-5C. Kennedy/Jenks Consultants (3 March 1991, personal communication) provided EPA with additional details for the proposed activities. Kennedy/Jenks Consultants identified the procedures and schedule for performance of an aquifer test at Well TAC 1A (see Figure HC-3) operated by Tacoma Public Utilities. Kennedy/Jenks Consultants also indicated that monitoring the recovery of water levels following regional pumping would not be feasible due to the intermittent nature of pumping by Tacoma Public Utilities.

Upper Layer A aquifer tests were conducted at Wells NMW-3A and NMW-4A. These wells were selected because they are located within 25 feet of additional monitoring wells and could be used to observe the effects of pumping during the aquifer tests. Well NMW-3A is located in the southern portion of the site and Well NMW-4A is located in the west-central portion of the site (see Figure HC-4). The results of these activities are discussed in Section 3.4.

2.2.1 Construction of Wells NMW-3A and NMW-4A and Observation Wells

Wells NMW-3A and NMW-4A are screened in the unconfined upper aquifer (Upper Layer A). Wells CBS-12A, NMW-3B, and NMW-3C were selected as observation wells for the aquifer pumping test at NMW-3A. These observation wells are screened in Upper Layer A, Lower Layer A and Layer C. Well CBS-6A was selected as the observation well for the aquifer pumping test at NMW-4A. Well CBS-6A is screened in Upper Layer A. Well construction details for these wells are summarized in Table HC-2. Boring logs for these wells are presented in Appendix GW-A of the STF Phase I Groundwater Investigation Report (Kennedy/ Jenks Consultants 1992a).

2.2.2 Aquifer Pumping Test Methods

An overview of the methods and procedures used during performance of aquifer pumping tests at the STF site is presented in this section. For additional details regarding procedures used during the tests, refer to SOG-19 in Appendix A of the STF FSAP (Kennedy/Jenks/Chilton 1991).

Prior to performing the constant rate aquifer tests, a step test was conducted at the pumping well to evaluate the magnitude of drawdown induced by various pumping rates. The step tests were done in three 1-hour steps of approximately 30 gpm,

45 gpm, and 60 gpm. These data indicated that the 60-gpm discharge rate (the maximum discharge rate of the pump) would result in adequate drawdown in the observation well, while not causing excessive drawdown (i.e., head loss) in the pumping well. After completion of the step test, all pumping was stopped and the aquifer was allowed to recover for 24 hours prior to starting the constant-rate test.

Aquifer pumping tests were conducted at a constant rate of 60 gpm. The tests were conducted by pumping the well with a 5-horsepower submersible pump. Flow rate was monitored with a in-line flow meter and controlled by a flow control (gate) valve located on the downstream side of the flow meter. The flow control valve was monitored at 15-minute intervals and adjusted manually, as required to maintain the 60-gpm flow rate. Groundwater was discharged from the well, through a flexible hose, to a series of holding tanks located approximately 500 feet from the pumping well. During the aquifer test, flow rate variations were typically in the range of plus or minus 5 percent (i.e., less than 3 gpm).

Drawdown of the water table was recorded using analog data loggers and pressure transducers at logarithmically spaced time increments and manually at 1-hour intervals. Data were plotted in the field to assess the progress of the aquifer tests and to help identify possible steady-state conditions. Manual drawdown readings of barometric pressure and rain gauge readings were also measured. Barometric pressure monitoring was performed to identify possible water level fluctuations induced by barometric pressure changes. Precipitation was monitored to evaluate potential water level fluctuations as a result of surface water infiltration. Barometric pressure and precipitation readings for each aquifer test are summarized in Appendix HC-B.

At the completion of the drawdown portion of the test, the data loggers were reset, the pump was shut off, and recovery monitoring was started. Results of the drawdown and recovery tests are presented in Section 3.2.

2.2.3 Aquifer Pumping Test Duration

The aquifer pumping test performed at Well NMW-3A started on 4 December 1991. Although originally planned for a maximum of 72 hours, the test was stopped after 48 hours because steady-state conditions (no apparent enlargement of cone of depression) were reached after 11 hours of constant discharge at 60 gpm.

The aquifer pumping test performed at Well NMW-4A started on 11 December 1991. This test was also planned for 72 hours, however, steady-state conditions were reached after approximately 4 hours of constant discharge and the test was stopped after 50 hours. Antecedent monitoring was conducted for 14 days at the completion of both tests to identify possible trends in water level fluctuation unrelated to the aquifer test.

During performance of the pumping test at Well NMW-4A, power was lost to the pump after approximately 18 hours of discharge. Power to the pump was restored approximately 3 minutes later. The effects of this power failure on the pumping test are discussed in Section 3.2.

2.3 SLUG TESTS

In accordance with the Final Work Plan (ICF 1990b), slug tests were performed at 16 onsite wells to provide a reasonable estimate of the hydraulic conductivity of water-producing zones across the site. Slug tests were performed at all new monitoring wells installed as part of the RI (Wells NMW-1A, NMW-2A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5A, NMW-5B, NMW-5C, NMW-6A, and NMW-7A). Slug tests were also performed at several of the existing wells installed during previous investigations at the site (Wells STM-1A, MW-5A, CBS-3A, CBS-11A, and CBS-7A). A slug test planned for Well MW-2A, located on the Amsted property, could not be performed because floating-phase hydrocarbons were found in the well.

2.3.1 Slug Test Method

Slug tests were performed in accordance with procedures outlined in SOG-20. Water level fluctuations were induced by submergence and removal of a 5-foot length of PVC pipe filled with sand (slug). Water level fluctuations were monitored using data loggers and pressure transducer. Because the water table recovered at a fast rate, depths measurements were typically collected at 1-second intervals to provide the maximum amount of data.

Three rising head tests were typically conducted at wells installed in the unconfined Upper Layer A. Two rising head and two falling head test were typically conducted at wells installed in Lower Layer A and Layer C (Wells NMW-3B, NMW-3C, NMW-5B, and NMW-5C). The three most reproducible data sets from each well were typically analyzed to develop an estimate of the average hydraulic conductivity for the well location. Results of slug test data analysis are summarized in Section 3.3.

In general, slug test results are limited in usefulness by the extent to which the aquifer meets the assumptions established for the equation. Factors such as well construction, aquifer heterogeneity and anisotropy, and the degree of well development may have significant effects on the analysis of results. The assumptions from which slug test analyses are based are rarely met by the aquifer and well being tested. Therefore, for the purposes of this investigation, slug test results are used to provide an estimate of the subsurface hydraulic properties. It is generally accepted that slug tests are accurate to within one or two orders of magnitude. More accurate estimates of hydraulic conductivity and transmissivity are obtained through performance of aquifer tests as discussed above.

2.4 INTER-AQUIFER COMMUNICATION

Available information gathered prior to the RI indicated that a regional confining layer (Layer B), which separates the Layers A and C, was absent in the South

Tacoma Channel (see Section 1.6). Activities discussed below were performed to evaluate possible communication between the Layers A and C, and to provide a quantitative estimate of the amount of leakage, if any.

An aquifer test was performed in cooperation with Tacoma Public Utilities at Well TAC 1A in lieu of tests originally proposed at Wells NMW-3C and NMW-5C (see Section 2.2). In addition, an evaluation of seasonal water level fluctuations was performed to provide a qualitative evaluation of possible inter-aquifer communication between Layers A and C across the site.

2.4.1 Water Level Monitoring

During the spring and summer months, groundwater in the South Tacoma Channel is pumped by Tacoma Public Utilities to meet additional water demands. Groundwater is removed predominately from Layer C. However, several Layer A wells are also pumped. During this seasonal groundwater removal, the potentiometric surface of the Layer C is significantly lower than at times when pumping does not occur.

A statistical analysis of monthly water level monitoring data was performed to identify the maximum water level fluctuations for wells installed in Layer A at the site. The activities were performed on the assumption that well locations with the greatest seasonal water level fluctuation (when Layer C is being pumped) may be representative of areas with proportionally higher leakage to the lower-lying Layer C. Results of this analysis were evaluated to provide a site-wide and qualitative understanding of possible inter-aquifer communication and are discussed in Section 3.4.

2.4.2 Aquifer Pumping Test at Well TAC 1A

Well TAC 1A, a water supply well used by Tacoma Public Utilities, is screened in Layer C. The well is located approximately 6,000 feet southeast of Well Cluster NMW-3 at the site (see Figure HC-3). The objective of the aquifer pumping test was to induce sufficient regional drawdown in the potentiometric surface of Layer C and evaluate possible effects, if any, to the potentiometric surface of Layer A. Results of this test were evaluated to provide a qualitative estimate of leakage at locations where paired monitoring wells exist (i.e., well locations with a discrete well installed in both Layers A and C).

The test at Well TAC 1A was started on 24 March 1992 and was performed at a constant discharge rate of 3,000 gpm over a 7-day period. The discharge rate was held constant through periodic adjustment of a flow valve at the well head. Water levels were electronically and manually monitored at selected onsite and offsite wells (see Table HC-4 for the monitoring schedule). Antecedent monitoring was performed 2 days prior to the test and recovery monitoring was performed for 4 days following pump shutoff.

TABLE HC-4

TAC 1A AQUIFER PUMPING TEST
SUMMARY OF MONITORING WELLS AND SCHEDULE

Well Number	Owner	Aquifer (Layer)	Monitoring Schedule
NMW-1A	STF[a]	A	1[b]
NMW-2A	STF	A	1
NMW-3A	STF	A	2[c]
NMW-3B	STF	B	2
NMW-3C	STF	C	2
NMW-4A	STF	A	2
NMW-5A	STF	A	1
NMW-5B	STF	B	2
NMW-5C	STF	C	1
NMW-6A	STF	A	2
NMW-7A	STF	A	1
CBS-1A	STF	A	1
CBS-2A	STF	A	1
CBS-3A	STF	A	1
CBS-4A	STF	A	1
CBS-5A	STF	A	1
CBS-6A	STF	A	1
CBS-7A	STF	A	1
CBS-8A	STF	A	1
CBS-9A	STF	A	1
CBS-10A	STF	A	1
CBS-11A	STF	A	1
CBS-12A	STF	A	1
TAC 1A	TPU[d]	C	3[e], 4[f]
TAC AL11	TPU	A and C	4
TAC AL5	TPU	C	3, 4
TAC 8A	TPU	A and C	4
TAC 8B	TPU	C	3, 4
TAC 89.1	TPU	A and C	4

TABLE HC-4

TAC 1A AQUIFER PUMPING TEST
SUMMARY OF MONITORING WELLS AND SCHEDULE

Well Number	Owner	Aquifer (Layer)	Monitoring Schedule
TAC AL7	TPU	A	3, 4
TAC AL13	TPU	C	4
TAC 7B	TPU	C	3, 4
TAC 7A	TPU	A and C	4
TAC 10C	TPU	A	4
TAC 87.3	TPU	C	4
TAC 10B	TPU	A	4
TAC 3A	TPU	A and C	4
TAC 14A	TPU	C	4
TAC 6A	TPU	A	3, 4
TAC 11A	TPU	A	3, 4
TAC 9A	TPU	A	3, 4
TAC 12A	TPU	A	3, 4
TAC 89.7	TPU	A and C	3, 4
TAC 2B	TPU	A	3, 4
TAC 4A	TPU	A	3, 4

(a) "STF" denotes well is owned by members of the South Tacoma Field Site Group.
(b) The number 1 indicates that water level measurements was recorded manually by Kennedy/Jenks Consultants once per day before, during, and after the test, except during the first day of pumping when measurements were recorded twice.
(c) The number 2 indicates that water level measurements were recorded once every half-hour using a data logger and pressure transducer installed by Kennedy/Jenks Consultants.
(d) "TPU" denotes well is owned by Tacoma Public Utilities.
(e) The number 3 indicates water level measurements were recorded 4 times during the first day and twice thereafter using equipment installed by Tacoma Public Utilities or Carr/Associates.
(f) The number 4 indicates water level measurements were manually recorded by Carr/Associates once per day during and after the test, except during the first day of pumping when measurements were recorded twice.

3.0 INVESTIGATIVE RESULTS

The investigative results of this Hydraulic Characterization Investigation are presented in this section. A summary of monthly water level monitoring results are provided in Section 3.1. Methods for data analysis and the results of the aquifer tests and slug tests are summarized in Sections 3.2 and 3.3, respectively. Results of activities performed to assess possible inter-aquifer communication between Layers A and C are summarized in Section 3.4.

3.1 WATER LEVEL MONITORING

Monthly water level monitoring performed during the RI has enabled:

- Evaluation of seasonal water level fluctuations in Upper Layer A, Lower Layer A, and Layer C
- Estimation of the hydraulic gradient direction and magnitude in Upper Layer A
- Identification of vertical hydraulic gradients and evaluation of possible inter-aquifer communication between Layers A and C.

The use of water level monitoring data to assess inter-aquifer communication is discussed in Section 3.4. The following discussions of water level monitoring results focus primarily on data collected from Upper Layer A wells.

3.1.1 Seasonal Fluctuations in Upper Layer A

Monthly water level monitoring was performed from April 1991 to March 1992. Potentiometric surface contour maps for these months are presented in Figures GW-11 through GW-24 of the STF Phase I Groundwater Investigation Report (Kennedy/Jenks Consultants 1992a). These maps were generated by contouring monthly water level elevation data for Layer A wells using the triangular network program pcTIN Version 2.20. Modifications were manually made to the computer-generated contour lines based on professional judgement.

The potentiometric surface for Layer A and Layer C at the STF site are influenced by lithologic and stratigraphic properties of the aquifer, seasonal variations in recharge, and by pumping from nearby water production wells owned by Tacoma Public Utilities (see Section 1.6.3). Although lithologic and stratigraphic influences are difficult to assess, the effects of seasonal recharge and groundwater pumping are more readily apparent.

Water levels in Layer A are strongly influenced from groundwater pumping of Wells TAC 4A, TAC 5A, TAC 6A, and TAC 11A, which are owned and operated by Tacoma Public Utilities. Three of these wells are screened in Layer A, except TAC 5A which is reportedly screened in both Layers A and C. Each of these wells are pumped intermittently at discharge rates ranging from 3,000 to 11,500 gallons per minute (Larson, T., 29 July 1992, personal communication). Since the wells are pumped on a on-demand basis there are no schedules from which to estimate annual groundwater removal volumes.

Tacoma Public Utilities pumps groundwater in the summer months (typically May through September) to supplement surface water obtained from the Green River. As the summer progresses, pumping of these wells has an increasing effect on the potentiometric surface of Upper Layer A. Toward the end of the pumping season (August and September), a large cone of depression has developed around these wells that extends beyond the western edge of the STF site and apparently into the

eastern margins of the Tacoma Landfill study area located to the west of the STF site. As is indicated in the potentiometric surface contour maps, the strongest effect of seasonal pumping is apparent from wells in the east-central portion of the site.

The potentiometric surface maps also indicate a groundwater mound in the vicinity of the Amsted property in the southern portion of the site. In September 1991, a leaking water line on the Amsted property was identified and subsequently repaired in October 1991. The leaking water line was thought to be the source of the groundwater mound centered around the Amsted property. However, during subsequent months of groundwater level monitoring, the mound did not dissipate entirely. Although, the reason the groundwater mound has not dissipated is not understood, it may be attributed to additional water line leaks in the area.

The fluctuation of the potentiometric surface in onsite wells are depicted graphically in Appendix HC-C. As indicated, water levels across the site are noticeably lower during the summer pumping months. This may be attributed to a reduced recharge or regional drawdown due to pumping of Layer A wells by Tacoma Public Utilities. Annual water level fluctuations in Upper Layer A ranged from a minimum of 3.03 feet in Well CBS-9A to a maximum of 12.01 feet in Well NMW-4A.

In Upper Layer A, the highest water levels were recorded in April 1991 and the lowest water levels were recorded in October and November 1991. In Lower Layer A (Wells NMW-3B and NMW-5B) and Layer C, the highest potentiometric heads were recorded in April 1991 and the lowest potentiometric heads were recorded in August 1991.

3.1.2 Horizontal Hydraulic Gradients

As indicated above, the potentiometric surface of Upper Layer A is affected by variations in recharge and groundwater extraction from Tacoma Public Utilities'

water supply wells. These influences have a significant effect on the direction and magnitude of the hydraulic gradient at the STF site. During extraction months (May through September), hydraulic gradients changed and were observed to reverse completely. As the cones of depression centered around the Tacoma Public Utilities wells deepen, their influence dominates the site flow regime. During non-extraction months (November through May), the predominant direction of the hydraulic gradient is from the south-southeast to the north-northwest. This gradient is generally consistent across the site, except in the southwest portion of the site where the gradient is toward the west to southwest.

The magnitude of the hydraulic gradient in Upper Layer A also varies across the site. These variations are summarized below:

- During non-extraction periods, the hydraulic gradient in the central portion of the site ranged from 0.0004 ft/ft to 0.001 ft/ft

- During non-extraction periods, the hydraulic gradient in the southwest portion of the site ranged from 0.0005 ft/ft to 0.0088 ft/ft

- During seasonal groundwater pumping, the hydraulic gradient within the cone of depression reached 0.0052 ft/ft in the east-central portion of the site where drawdown was observed to be the greatest.

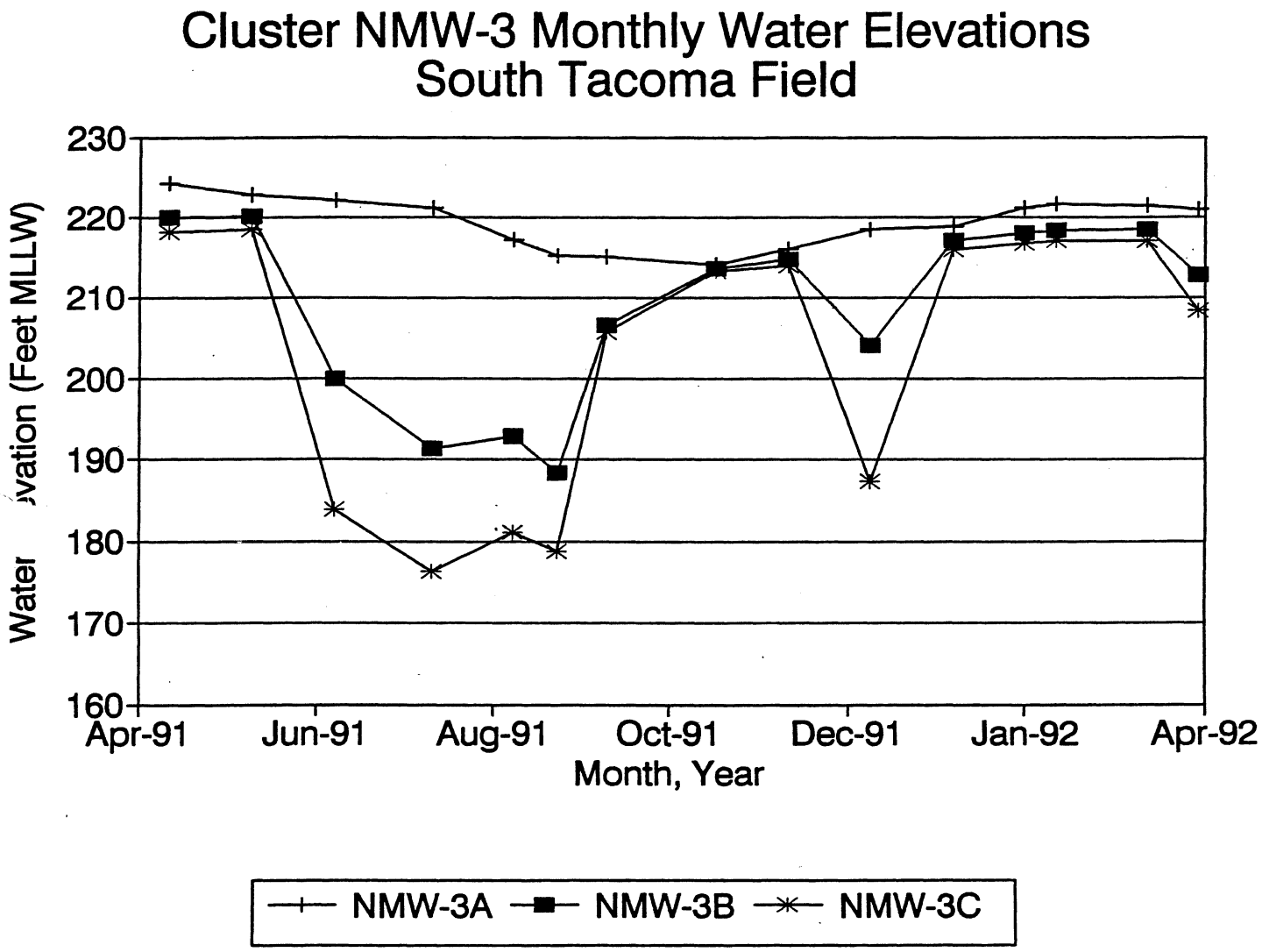
The direction of the hydraulic gradient in Layer C was estimated through triangulation using water level monitoring data from onsite Wells NMW-3C and NMW-5C, and Tacoma Public Utilities offsite Well TAC 89.5. Based on this calculation, it appears that the direction of the hydraulic gradient in Layer C generally also to the north as reported by Brown and Caldwell (1985). The magnitude of the hydraulic gradient, estimated based on water level monitoring data from these three wells, is approximately 0.004 ft/ft.

3.1.3 Vertical Hydraulic Gradients

There are two onsite well clusters (NMW-3 and NMW-5) and a third offsite well cluster (TAC 89.5) located west of the STF property to measure vertical gradients between Layers A and C (Figures HC-3 and HC-4). Water level measurements from these well clusters indicate that the vertical gradient is in a net downward direction. Hydrographs depicting water level elevations in Layers A and C wells for the onsite Well Clusters NMW-3 and NMW-5 are presented in Figures HC-5 and HC-6. Head fluctuations in Well TAC 89.5 are shown in Figure HC-7. The maximum head differentials between Upper Layer A and Layer C occurred during the summer months when the potentiometric surface was depressed due to seasonal pumping. Heads in Lower Layer A wells (NMW-3B and NMW-5B) dropped between 31.8 and 40.3 feet, whereas heads in Layer C wells dropped between 36.7 and 42.1 feet during summer pumping periods.

3.2 AQUIFER PUMPING TESTS

Results of the two aquifer tests performed in Upper Layer A are discussed below. Pumping test data were evaluated to determine aquifer hydraulic parameters such as hydraulic conductivity, transmissivity, and storativity. Hydraulic conductivity is defined as the capacity of an aquifer to conduct water at the prevailing viscosity and is affected by fluid temperature, fluid density, and porosity and packing structure of the porous media. Transmissivity is defined as aquifer hydraulic conductivity multiplied by aquifer thickness. Storativity is a dimensionless coefficient that refers to the volume of water that an confirmed aquifer releases from or takes into storage per unit horizontal area of aquifer per unit change in head.



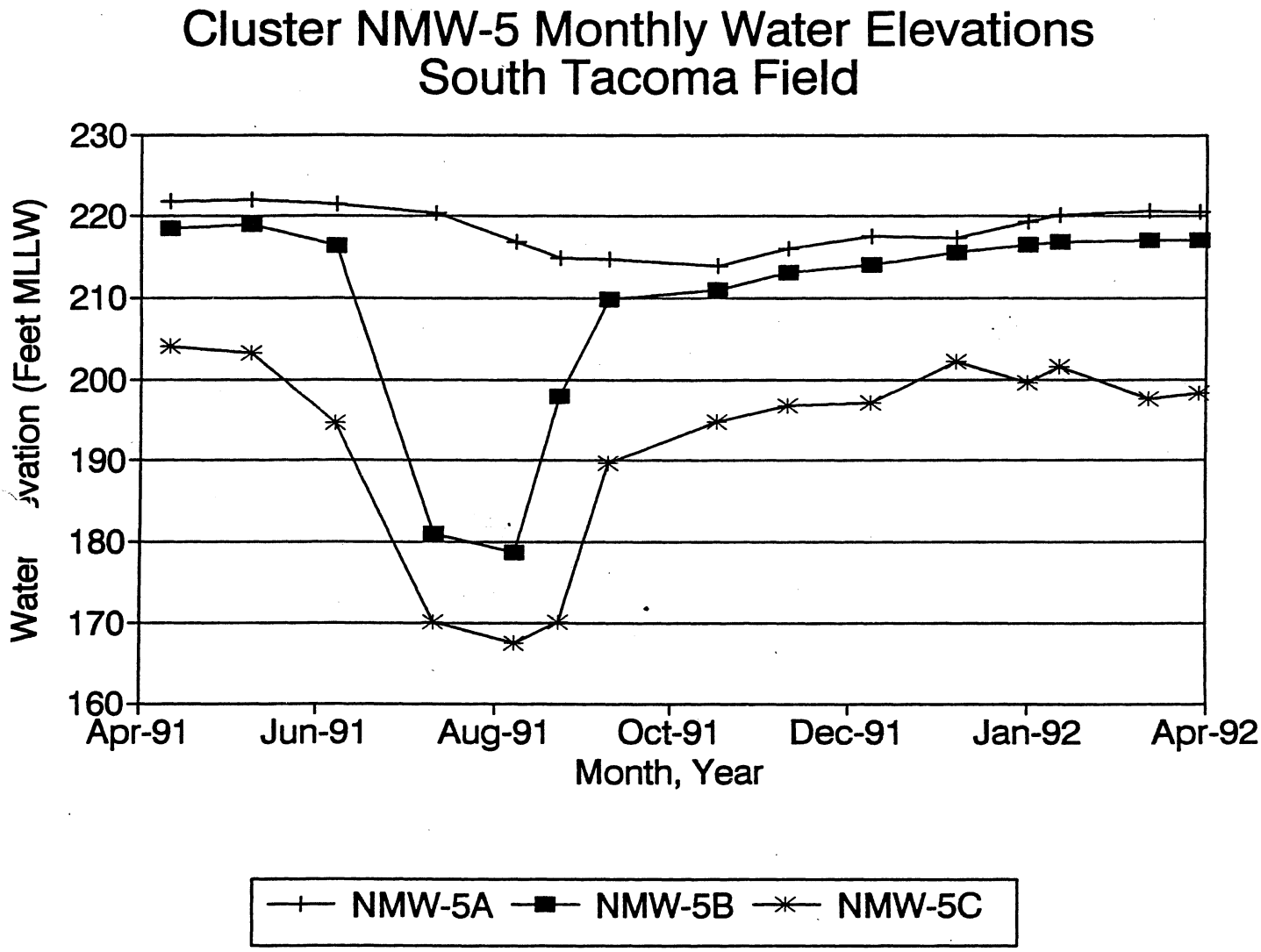
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

HYDROGRAPH OF WELLS AT WELL CLUSTER NMW-3

916055.09/P2SK139

FIGURE HC-5



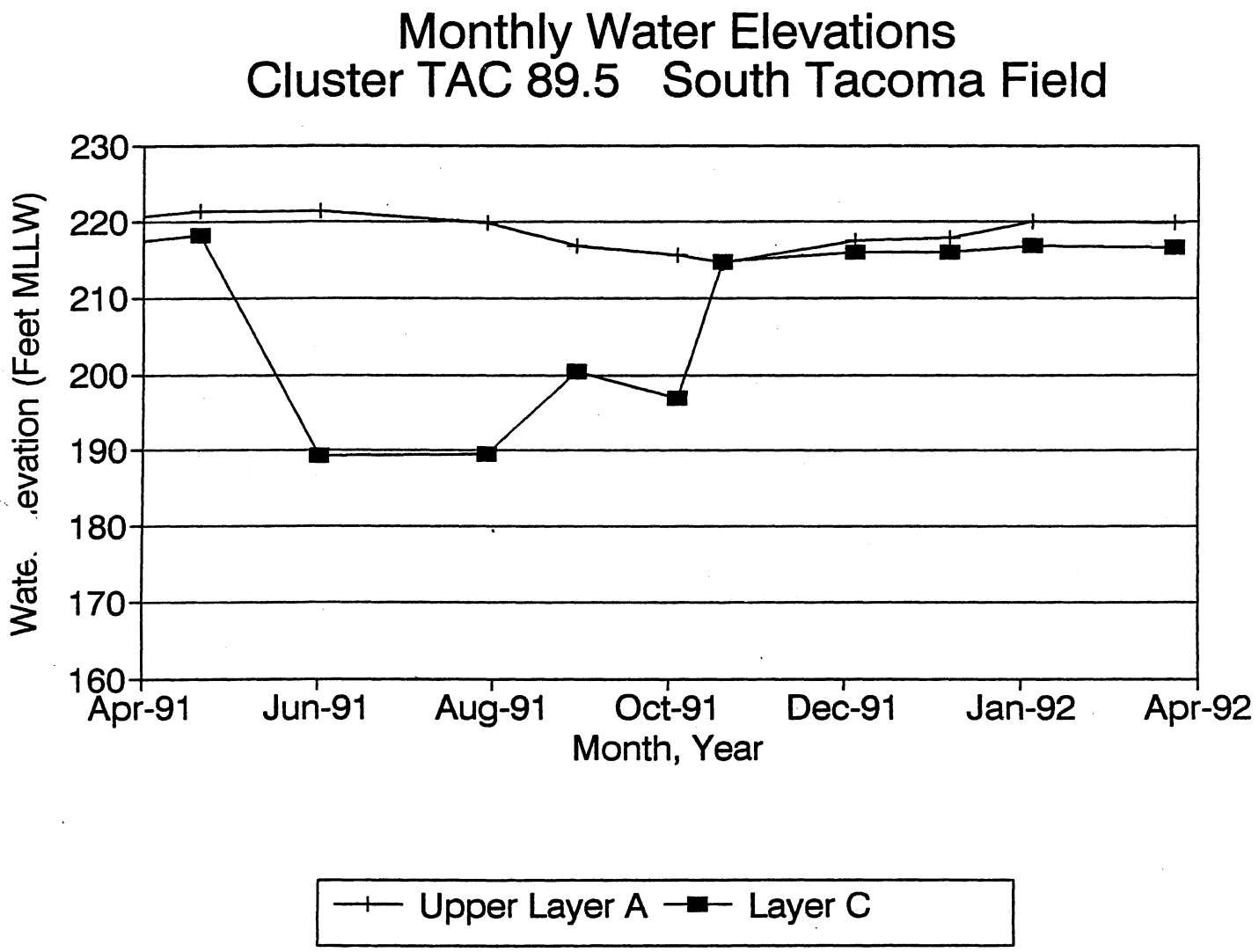
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

HYDROGRAPH OF WELLS AT WELL CLUSTER NMW-5

916055.09/P2SK140

FIGURE HC-6



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

HYDROGRAPH OF WELLS AT WELL CLUSTER TAC-89.5

916055.09/P2SK141

FIGURE HC-7

3.2.1 Methods of Evaluating Pumping Test Data

A number of methods and equations have been developed for calculating hydraulic parameters from time-drawdown and time-recovery data. The most common method is curve matching. Curve matching is accomplished by one of two methods: 1) visual-manual curve matching or 2) analytical curve matching. For this investigation, data were analyzed using AQTESOLV, a Geraghty & Miller (1989) computer program. AQTESOLV allows the user to evaluate aquifer pumping test and slug test data either manually or analytically. To manually evaluate data, the user interactively moves a type curve in relation to a plot of the drawdown data until a visual "best fit" with the data set is achieved. If the analytical option is selected the program automatically finds the best fit between the type curve and data set.

The equations developed for analysis of time-drawdown data sets include Theis, Jacob, Copper-Jacob, Neuman, and many others. The assumptions from which these equations are based include aquifer conditions and the manner in which an aquifer test is conducted. Ideally the geologic and hydrogeologic conditions that exist at a site are completely defined and the equation for analysis is selected based on this understanding. However, geologic and hydrogeologic conditions at a site are never completely understood or as simple as the assumptions upon which the equations are based. As a result, several equations can appear consistent with the available geological data. Typically, a data set is evaluated using all the equations that appear consistent and scientific judgment is used to evaluate the results.

Based on the available geologic and hydrogeologic data, both Wells NMW-3A and NMW-4A can be described as a partially penetrating pumping well in an unconfined aquifer with a partially penetrating observation well. The Neuman, Theis, and Cooper-Jacob equations were selected to evaluate the aquifer pumping test data. A summary of each of these methods, advantages and disadvantages, and rationale for using them is provided below.

3.2.1.1 Neuman (1975). The Neuman equation was developed for conditions of unsteady flow to a well in an unconfined aquifer. The Neuman equation was developed for evaluation of aquifer pumping test data obtained by pumping a partially penetrating well and collecting drawdown data from either a piezometer or a partially penetrating observation well. The primary advantage of this equation is that it is one of the few methods available to evaluate data obtained from aquifer pumping tests conducted in partially penetrating wells in unconfined aquifers. A disadvantage of the Neuman equation is its computational complexity. The Neuman equation was selected because the underlying assumptions of this equation and the field conditions closely match.

3.2.1.2 Theis (1935). The Theis equation was developed for conditions of unsteady flow to a well in a confined aquifer. The Theis equation was developed for analysis of both time-drawdown and time-recovery data. However, Kruseman and DeRidder (1979) developed a method for correcting unconfined drawdown data for evaluation using the Theis equation. Advantages of using the Theis equation include that it is relatively simple to use, evaluation can be done both manually and analytically, it is common method of aquifer pump test data evaluation, and can be used to evaluate time-recovery data recorded in the pumped well and observation well. A disadvantage of the Theis equation is it was developed assuming a fully penetrating pumping and observation well. The Theis equation was selected for evaluation of the aquifer pumping test data because (with correction for unconfined conditions) the equation is suitable for evaluation of unconfined aquifer data, the equation is relatively simple to use, and hydraulic parameters calculated using the Theis equation provided a comparison with parameters calculated using the Neuman equation.

3.2.1.3 Cooper-Jacob (1946). The Cooper-Jacob equation is a modification of the Theis method. The Cooper-Jacob equation is used for conditions of unsteady flow to a well in a confined aquifer. The Cooper-Jacob equation can be used to evaluate unconfined aquifer pump test data if data are corrected using the Kruseman and DeRidder (1979) method (as with the Theis equation). The advantages and dis-

advantages of using the Cooper-Jacob equation are the same as those for the Theis equation. However, the Cooper-Jacob equation is simpler than the Theis equation. The Cooper-Jacob equation was used for the same reasons the Theis equation was used.

3.2.2 Well NMW-3A Aquifer Pumping Test

Both drawdown and recovery aquifer pumping test data were evaluated using the previously described methods of analysis. Results of these analyses are presented in Table HC-5. Hydrographs of the drawdown and recovery data, and the data plots for the various methods are presented in Appendix HC-D.

Drawdown and recovery data obtained from pumping well NMW-3A and observation well CBS-12A were evaluated using the previously described methods of analysis. The transmissivity estimates calculated using these methods ranged from 23,000 gpd/ft to 97,000 gpd/ft.

Transmissivity estimates based on observation well CBS-12A data and the unconfined methods ranged from 51,000 gpd/ft to 72,000 gpd/ft. These transmissivity estimates are considered more accurate than those calculated using the confined methods because they include correction for the unconfined conditions that exist at the STF site.

Transmissivity estimates based on drawdown data from NMW-3A are not considered as accurate as those calculated using the data from Well CBS-12A because the drawdown observed in NMW-3A was most likely greater than drawdown in the formation just outside of the well. The additional drawdown was a result of filter pack and well screen headlosses. The aquifer appears less conductive (transmissive) than it actually is as a result of these non-formation headlosses.

TABLE HC-5

WELL NMW-3A AQUIFER PUMP TEST DATA ANALYSIS RESULTS

Data Analysis Method	Upper Layer A Hydraulic Properties					
	T[a] NMW-3A (gpd/ft)	T CBS-12A (gpd/ft)	K[b] NMW-3A (ft/day)	K CBS-12A (ft/day)	SY[c] NMW-3A	SY CBS-12A
AQTESOLV Neuman (unconfined)	NA[d]	71,000	NA	160	NA	0.001
Theis Drawdown (unconfined)	31,000	72,000	70	170	2.70E-05	0.010
Cooper Jacob Drawdown (unconfined)	28,000	51,000	60	120	4.68E-04	0.036
Theis Recovery (confined)	23,000	23,000	50	50	NA	NA
MANUAL Cooper Jacob Drawdown (confined)	NA	55,000	NA	120	NA	0.029
Theis Drawdown (confined)	NA	97,000	NA	220	NA	0.003

(a) T = Transmissivity (gpd/ft).
(b) K = Hydraulic conductivity (ft/day) based on a saturated thickness of 60 feet.
(c) SY = Specific yield (unitless).
(d) NA = Not applicable.

The specific yield calculated using the unconfined methods and CBS-12A data ranged from 0.001 to 0.036. Because the assumptions of the Neuman equation provide the best approximation of actual field conditions, they appear to provide the most credible estimates of transmissivity. Using Neuman's equation, transmissivity was calculated at 71,000 gpd/ft.

During pumping and recovery, no clearly visible effects of pumping were noted in the water levels of Wells NMW-3B or NMW-3C which could be attributed to drawdown in these formations (see Appendix HC-D). This result indicates that the confining layers (Layer A_1 and Layer B) appear to have been effective in preventing inter-aquifer communication between Upper Layer A and the lower-lying saturated zones during the duration of this aquifer test.

Barometric pressure and precipitation data were recorded during the test, but the drawdown data were not normalized for pressure changes prior to analysis because Upper Layer A is unconfined. Barometric pressure data are presented in Appendix HC-B.

3.2.3 Well NMW-4A Aquifer Pumping Test

The aquifer pumping test data for NMW-4A were evaluated using the same methods as described for the test at NMW-3A. Results of these analyses are presented in Table HC-6. Hydrographs of the drawdown and recovery data, and the data plots for the various methods are presented in Appendix HC-D.

As shown in the hydrographs of the drawdown data, brief recovery of the water table is noted at an elapsed time of 1,000 minutes. This deflection in the cone of depression was caused by a loss of power to the pumping well. Because the duration of pump failure was less than 3 minutes and equilibrium had already been achieved, no adverse effects were expected in the analysis of results.

TABLE HC-6

WELL NMW-4A AQUIFER PUMP TEST DATA ANALYSIS RESULTS

Data Analysis Method	Upper Layer A Hydraulic Properties					
	T[a] NMW-4A (gpd/ft)	T CBS-6A (gpd/ft)	K[b] NMW-4A (ft/day)	K CBS-6A (ft/day)	SY[c] NMW-4A	SY CBS-6A
AQTESOLV Neuman (unconfined)	NA[d]	67,000	NA	150	NA	0.028
Theis Drawdown (unconfined)	17,000	60,000	40	130	0.366	0.034
Cooper Jacob Drawdown (unconfined)	42,000	78,000	90	170	5.52E-07	0.005
Theis Recovery (confined)	43,000	39,000	90	90	NA	NA
MANUAL Cooper Jacob Drawdown (confined)	NA	72,000	NA	120	NA	0.007
Theis Drawdown (confined)	NA	48,000	NA	80	NA	0.040

(a) T = Transmissivity (gpd/ft).
(b) K = Hydraulic conductivity (ft/day).
(c) SY = Specific yield (unitless).
(d) NA = Not applicable.

Drawdown and recovery data obtained from pumping well NMW-4A and observation well CBS-6A were evaluated using the previously described methods of analysis. The transmissivity estimates calculated using these methods ranged from 17,000 gpd/ft to 78,000 gpd/ft.

Transmissivity estimates based on observation well CBS-6A data and the unconfined methods ranged from 60,000 gpd/ft to 78,000 gpd/ft. These transmissivity estimates are considered more accurate than those calculated using the confined methods because they include correction for the unconfined conditions that exist at the STF site.

Transmissivity estimates based on drawdown data from NMW-4A are not considered as accurate as those calculated using data from Well CBS-6A because the drawdown observed in NMW-4A was most likely greater than drawdown in the formation just outside of the well. The additional drawdown was a result of filter pack and well screen headlosses. The aquifer appears less conductive (transmissive) than it actually is as a result of these non-formation headlosses.

The specific yield calculated using the unconfined methods and CBS-6A data ranged from 0.005 to 0.034. As discussed in Section 3.2.2, the Neuman equation appears to be the most appropriate for the conditions encountered at the STF site. Using Neuman's equation, transmissivity was calculated at 67,000 gpd/ft.

During pumping and recovery, no observable effects were noted in the water levels of Wells NMW-5B or NMW-5C.

Barometric pressure and precipitation data were recorded during the test but the drawdown data were not normalized for pressure changes prior to analysis because Layer A is unconfined. Barometric pressure data are presented in Appendix HC-B.

3.2.4 Antecedent Monitoring of Wells NMW-3A and NMW-4A

Figures HC-8 and HC-9 are plots of antecedent monitoring data recorded at Wells NMW-3A and NMW-4A during a 14 day-period from 13 January 1992 to 27 January 1992. Two patterns were apparent: 1) the water level rose approximately 1 foot or less at both locations during the monitoring period, and 2) there were notable short-term fluctuations at both locations during the monitoring period.

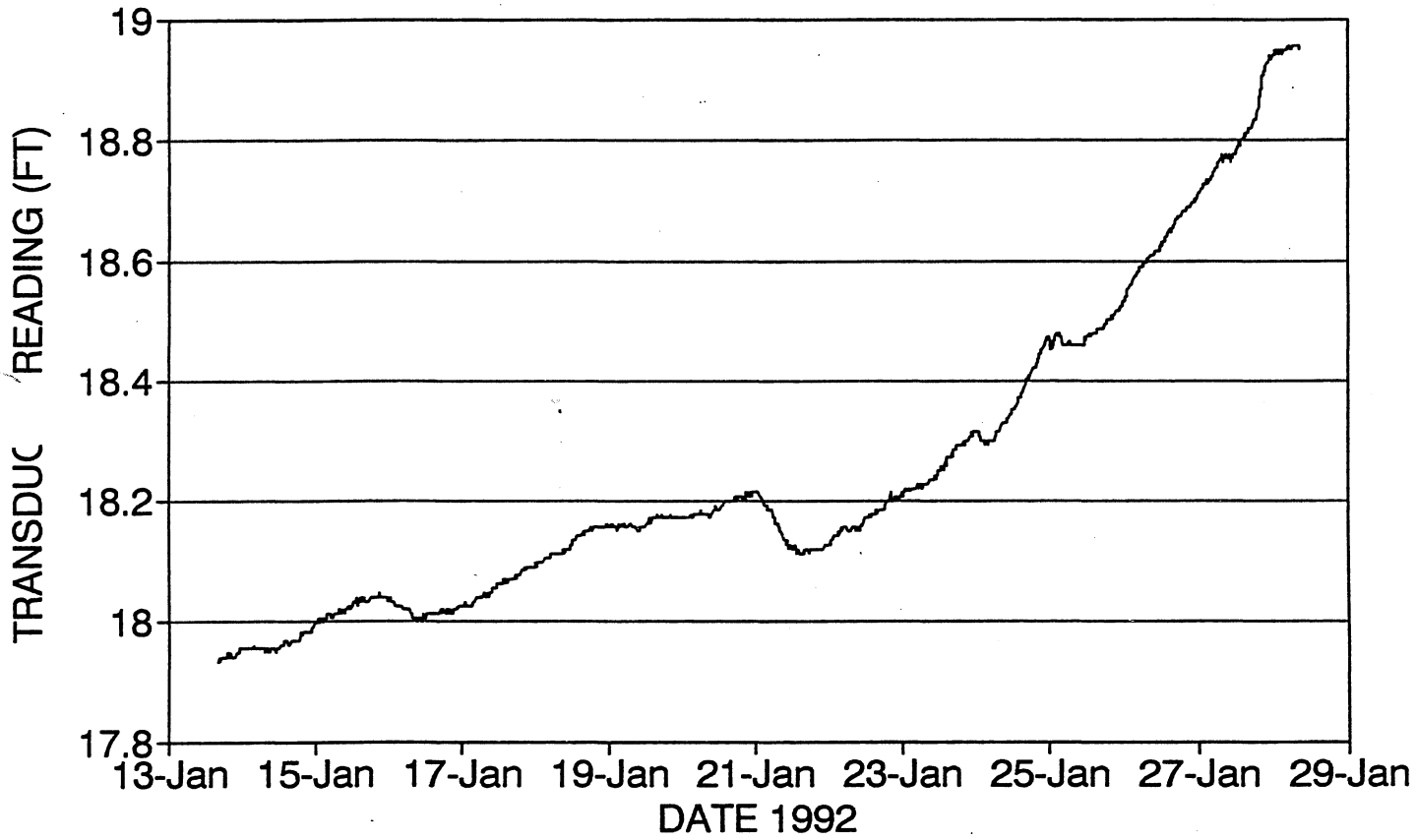
The rise in water level during the period is likely a result of infiltration. During the monitoring period, 5.97 inches of rainfall was recorded at nearby McChord Air Force Base [see Appendix SW-A of the Surface Water and Sediment Investigation Report (Kennedy/Jenks Consultants 1992c)]. The short-term fluctuations are believed to be a result of the cycling of Tacoma Public Utilities heat pump wells. These wells are located on the Tacoma Public Utilities property in the northwestern portion of the site. The heat pump wells are used for heating and cooling of Tacoma Public Utilities buildings. The influence of these wells was greater at NMW-4A than at NMW-3A.

3.2.5 Estimated Seepage Velocity

Minimum and maximum seepage velocities were estimated for Upper Layer A using the hydraulic conductivity values calculated for aquifer tests at NMW-3A and NMW-4A, and using average porosity. Seepage velocities were estimated to help evaluate the approximate (bulk movement) rate of groundwater movement across the site. Average porosity was calculated based on the porosity of soil samples collected during drilling of wells NMW-1A, NMW-2A, NMW-3A, NMW-4A, NMW-5A, NMW-6A, and NMW-7A. Seepage velocity was estimated using the following equation (Fetter 1980):

$$V = \frac{K * i}{n}$$

STF-AQUIFER TEST
NMW-3A ANTECEDENT MONITORING



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SOUTH TACOMA FIELD
TACOMA, WA

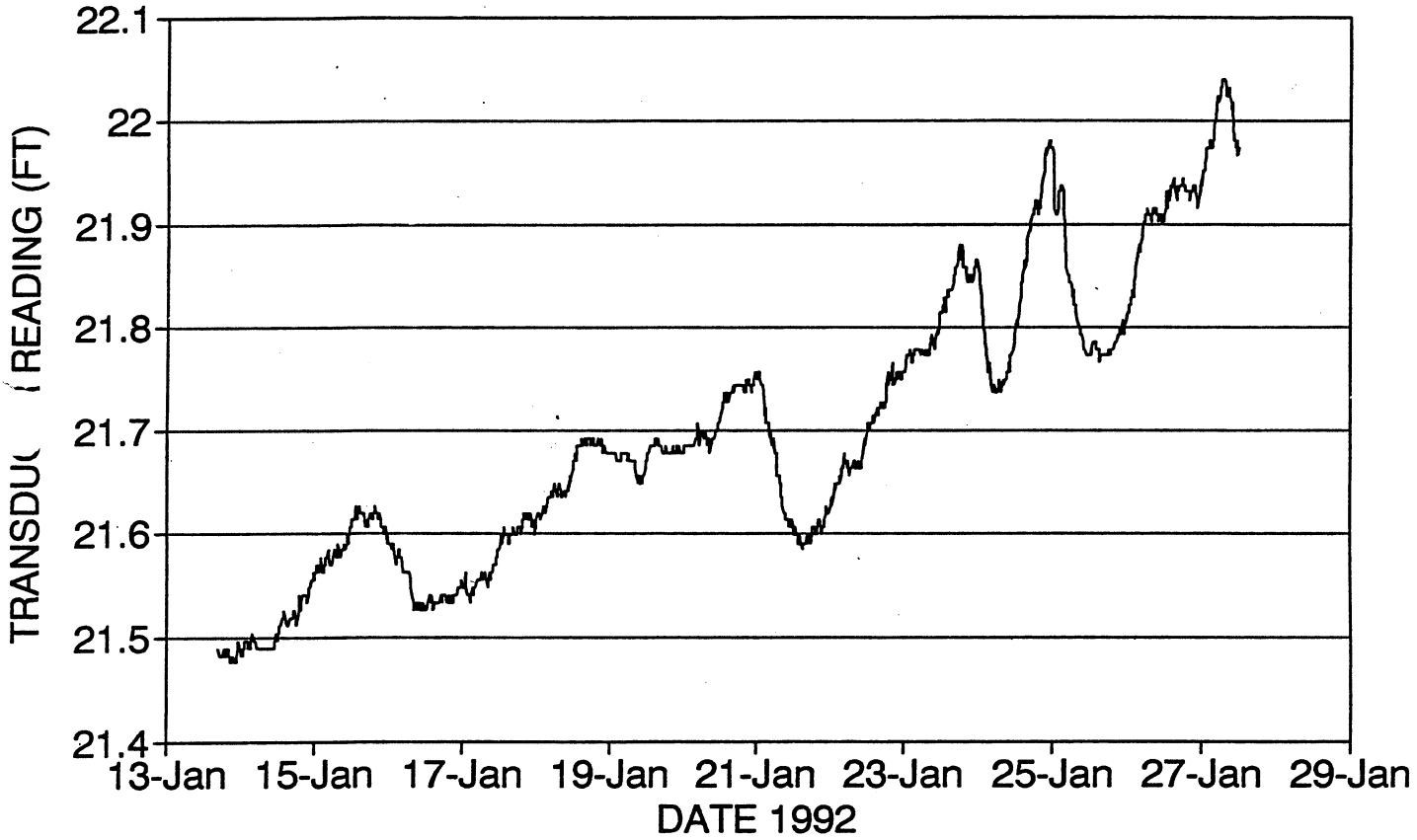
WELL NMW-3A ANTECEDENT MONITORING DATA

916055.09/P2SK133

FIGURE HC-8

STF - AQUIFER TEST

NMW-4A ANTECEDENT MONITORING



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WELL NMW-4A ANTECEDENT MONITORING DATA

916055.09/P2SK134

FIGURE HC-9

Where: V = Seepage velocity (ft/yr).

K = Horizontal conductivity (ft/yr).

i = Minimum and maximum hydraulic gradient estimated based on monthly potentiometric surface maps during non-pumping periods (i.e., 0.0004 and 0.001 ft/ft) (refer to Section 3.1.2).

n = Average porosity (36.5 percent).

Based on this equation, minimum and maximum seepage velocities were estimated and are presented in Table HC-7.

TABLE HC-7

MAXIMUM AND MINIMUM SEEPAGE VELOCITIES BASED ON AQUIFER PUMPING TEST RESULTS

Well Designation	Average Hydraulic Conductivity K (ft/day)	Maximum Seepage Velocity V (ft/yr)	Minimum Seepage Velocity V (ft/yr)
NMW-3A	150	150	60
NMW-4A	150	150	60

3.3 SLUG TESTS

Results of the slug tests performed at selected wells at the STF site are presented in this section. Slug tests were performed at all new monitoring wells installed as part of the RI (Wells NMW-1A, NMW-2A, NMW-3A, NMW-3B, NMW-3C, NMW-4A, NMW-5A, NMW-5B, NMW-5C, NMW-6A, and NMW-7A) and several of the existing wells installed during previous investigations at the site (Wells STM-1A, MW-5A, CBS-3A, CBS-11A, and CBS-7A).

3.3.1 Methods of Evaluating Slug Test Data

Methods used to evaluate slug test data include the Bouwer and Rice (1976) method and the Cooper, Bredehoeft, and Papadopulos (1967) method. The Bouwer and Rice method is applicable to unconfined aquifers with completely or partially penetrating wells. The Cooper, Bredehoeft, and Papadopulos method is applicable to confined aquifers with completely penetrating wells. Slug test data were analyzed using the AQTESOLV software package distributed by Geraghty & Miller (1989). As with pumping test data, the solution of these equations can be accomplished by either a visual-manual or analytical method. Both of these equations are based on a number of assumptions and their applicability to a given slug test depends on the degree to which these assumptions fit actual field conditions.

3.3.2 Results of Slug Test Data Analyses

Results of slug test data analysis are summarized in Table HC-8. Transmissivity for Upper Layer A ranged from 88.2 gpd/ft to 2,310 gpd/ft. Wells NMW-3B and NMW-5B are installed in Lower Layer A. Transmissivity for these wells ranged from 1,670 gpd/ft to 5,000 gpd/ft. Based on slug tests performed at NMW-5C, transmissivity ranged from 600 gpd/ft to 1,200 gpd/ft for this well.

Five rising and falling head tests were performed at NMW-3C. However, none of these tests resulted in data sets appropriate for analysis. The data sets obtained did not have a pattern "typical" of slug tests. The reason(s) for the non-typical pattern of drawdown and recovery could not be discerned. A representative plot of those data and the slug test data plots are presented in Appendix HC-E.

The values of transmissivity for Upper Layer A and Layer C (as estimated by slug test methods) were consistently one to two orders of magnitude less than transmissivity estimates based on aquifer test data. It is unclear why the slug test

TABLE HC-8

SUMMARY OF SLUG TEST RESULTS

WELL DESIGNATION	SATURATED THICKNESS b (ft)	TRANSMISSIVITY T (ft^2/minute)	HYDRAULIC CONDUCTIVITY K (ft/minute)	AVERAGE CONDUCTIVITY K (ft/minute)
CBS-11A	46.90	0.59375	0.01266	
	46.90	0.68662	0.01464	0.01298
	46.90	0.54592	0.01164	
CBS-3A	51.00	0.90474	0.01774	
	51.00	1.00623	0.01973	0.01880
	51.00	0.96594	0.01894	
CBS-7A	45.40	0.70325	0.01549	
	45.40	0.67328	0.01483	0.01407
	45.40	0.53981	0.01189	
NMW-1A	49.90	0.51447	0.01031	
	49.90	0.60179	0.01206	0.01148
	49.90	0.60179	0.01206	
NMW-2A	62.20	1.18615	0.01907	
	62.20	1.27883	0.02056	0.01839
	62.20	0.96721	0.01555	
NMW-3A	55.50	0.98679	0.01778	
	55.50	0.66045	0.01190	0.01484
NMW-3B	35.00	0.04624	0.00132	
	35.00	0.02980	0.00085	0.00098
	35.00	0.02661	0.00076	
NMW-4A	59.50	2.14081	0.03598	
	59.50	1.44764	0.02433	0.02890
	59.50	1.57080	0.02640	
NMW-5A	54.00	0.34992	0.00648	
	54.00	0.73872	0.01368	0.01112
	54.00	0.71280	0.01320	
NMW-5B	35.00	0.03667	0.00105	
	35.00	0.01549	0.00044	0.00093
	35.00	0.04532	0.00129	
NMW-5C	100.00	0.05527	0.00055	
	100.00	0.06327	0.00063	0.00077
	100.00	0.11170	0.00112	
NMW-6A	54.00	0.93906	0.01739	
	54.00	0.74898	0.01387	0.01205
	54.00	0.26401	0.00489	
NMW-7A	54.00	0.13932	0.00258	
	54.00	0.08186	0.00152	0.00194
	54.00	0.09304	0.00172	
STM-1A	49.50	0.32368	0.00654	
	49.50	0.33655	0.00680	0.00626
	49.50	0.26864	0.00543	

NOTES:

T = K*M
K = T/M
V = K*I/P

I = 0.001 (maximum)
I = 0.0004 (minimum)
P (porosity) = 0.365

transmissivity estimates were consistently lower than estimates based on aquifer tests. Possible reasons for the disparity are discussed below.

- Lohman (1979) and Ferris and Knowles (1954) report the Cooper, Bredehoeft, and Papadopulos method is strictly applicable in aquifers of rather low transmissivity (less than about 50,000 gpd/ft). Based on the aquifer tests, transmissivity estimates of Upper Layer A are greater than 50,000 gpd/ft. Therefore, the slug test may be an inappropriate test for the highly transmissive aquifer formations at the STF site.

- Slug tests estimate the hydraulic properties of the aquifer immediately surrounding a well. In contrast, aquifer pumping tests influence a much larger area. As a result, the slug test results may indicate the transmissivity of the filter pack installed around the well casing, rather than the transmissivity of aquifer.

3.4 INTER-AQUIFER COMMUNICATION

This section describes results and activities that have been performed at the STF site to evaluate possible inter-aquifer communication between Layer A and Layer C. The potential for inter-aquifer communication was determined by:

- Evaluating of monthly water level monitoring data obtained from April 1991 to March 1992

- Performing an aquifer test at Well TAC 1A in cooperation with Tacoma Public Utilities.

Results of these activities are presented in the following sections.

3.4.1 Water Level Monitoring

Visual examination and statistical analysis were used to evaluate the monthly water level monitoring data for inter-aquifer communication (leakage). Monthly water level monitoring data were used to evaluate the mean seasonal water level fluctuations of Upper Layer A across the site. These activities were performed on the assumption that the lowering of Layer C potentiometric surface, as a result of seasonal pumping, may result in enhanced leakage through the confining layer (Layer B). Enhanced leakage may be perceptible through exaggerated water level fluctuations in Upper Layer A.

3.4.1.1 Examination. The fluctuation of the potentiometric surface of Layers A and C at Well Clusters NMW-3 and NMW-5 from April 1991 to March 1992 are illustrated in Figures HC-5 and HC-6 (see Section 3.1.3). By inspecting these figures, inter-aquifer communication between Lower Layer A (NMW-3B and NMW-5B) and the underlying Layer C (NMW-3C and NMW-5C) is apparent. However, head fluctuations in Upper Layer A (NMW-3A and NMW-5A) do not correspond with head fluctuations in Layer C (NMW-3C and NMW-5C). Head fluctuations observed in Upper Layer A wells appear to be consistent with reduced seasonal recharge to the formation during the summer months. Based on interpretation, enhanced inter-aquifer communication between Upper Layer A and the underlying layers is not apparent at well cluster NMW-3C and NMW-5C.

Figure HC-7 shows the fluctuation of the water level in Upper Layer A and the potentiometric surface of Layer C at offsite Well TAC 89.5 during the monitoring period (April 1991 through March 1992). Based on visual examination, inter-aquifer communication between Upper Layer A and Layer C at Well TAC 89.5 is not apparent.

3.4.1.2 Statistics. In addition to a visual examination of the water level monitoring data, these data were statistically analyzed. The analysis was based on the assumption that either statistical patterns or statistical abnormalities would develop

that could point to local areas of inter-aquifer communication (leakage) in the confining layer underlying Upper Layer A.

The analysis consisted of calculating the maximum water level fluctuation at each well, average maximum water level fluctuation for wells in a selected group, and standard deviation of the maximum water level fluctuations for wells in that group. For this statistical analysis, wells at the site were grouped by sub-areas: North, Central, Southeast, and Southwest. The sub-areas are shown in Figure HC-10 and were selected based on the areal distribution of wells across the site and observed water level fluctuations during the monitoring period.

Statistical results are summarized in Table HC-9 and illustrated in Figures HC-11 through HC-14. Water level fluctuations were greatest in the central area and least in the southeast area. Water levels throughout the site were influenced by pumping of municipal wells installed in Layer A (TAC 4A, TAC 6A, and TAC 11A) during the summer months. The greatest influence was observed in the central area. Site-wide water level fluctuations ranged from 3.03 feet at Well CBS-9A to 12.01 feet at Well CBS-4A. Area-by-area fluctuations were generally uniform and statistical analysis did not indicate large fluctuations that may be indicative of enhanced leakage resulting from a local window in the confining layer (Layer A_1). As a result, the statistical analysis of water level monitoring results were inconclusive in identifying possible inter-aquifer communication.

3.4.2 Well TAC 1A Aquifer Pumping Test

Tacoma Public Utilities' Well TAC 1A is located approximately 6,000 feet southeast of Well Cluster NMW-3 at the STF site (see Figure HC-3) and is completed in Layer C. Onsite Well Clusters NMW-3 and NMW-5 also contain wells completed in Layer C. These clusters also have shallow wells installed in both Upper Layer A and Lower Layer A. Offsite Well Cluster TAC 89.5 contains a well installed in Upper

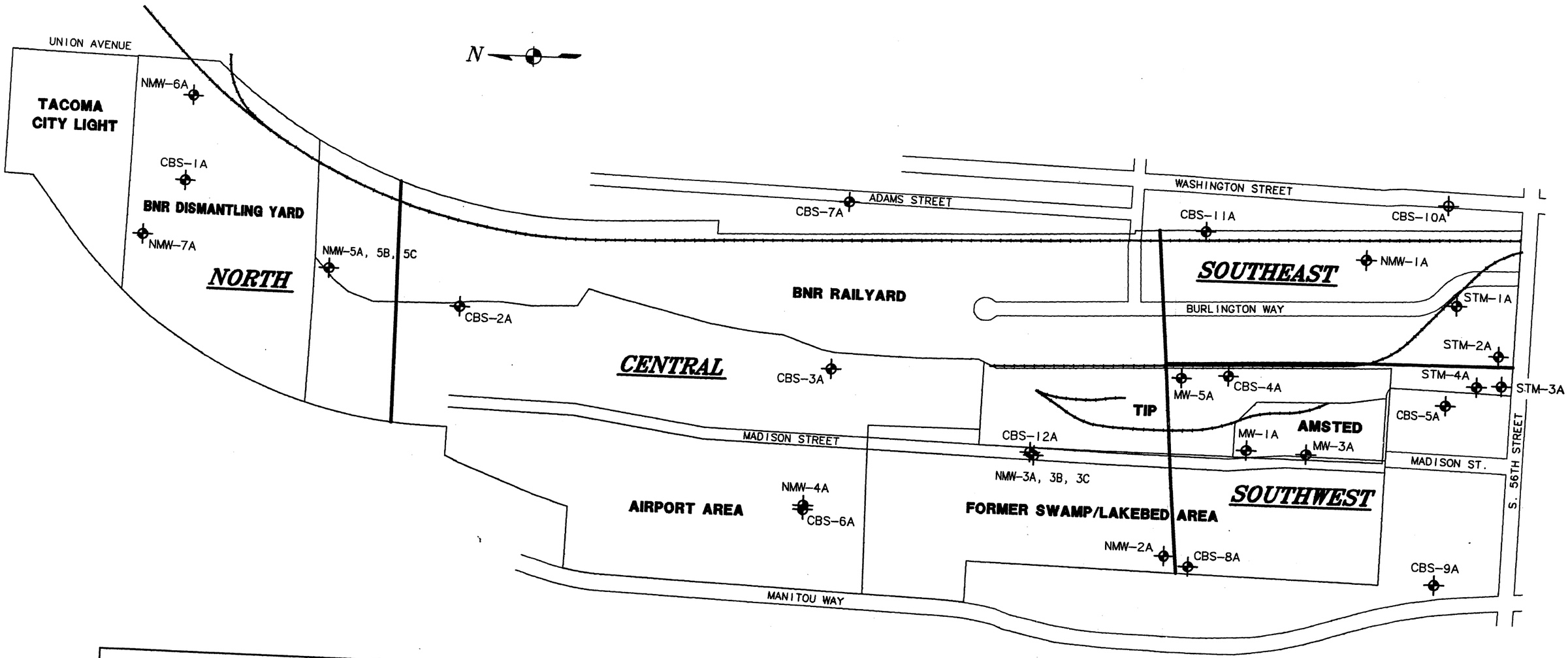
TABLE HC-9

STATISTICAL ANALYSIS OF UPPER LAYER A WATER LEVEL MONITORING DATA BY SUB-AREA

WELL DESIGNATION	TOTAL WATER LEVEL FLUCTUATION (ft)	WELL DESIGNATION	TOTAL WATER LEVEL FLUCTUATION (ft)
North		Southeast	
CBS-1A	6.63	CBS-10A	4.73
NMW-5A	7.94	CBS-11A	5.63
NMW-6A	6.66	NMW-1A	5.49
NMW-7A	6.21	STM-1A	6.08
		STM-2A	6.01
AVERAGE	6.86	AVERAGE	5.59
STANDARD DEVIATION	0.75	STANDARD DEVIATION	0.54

Central		Southwest	
CBS-2A	11.31	CBS-5A	7.26
CBS-3A	10.98	CBS-8A	6.96
CBS-4A	12.01	MW-1A	9.84
CBS-6A	10.94	MW-3A	9.10
CBS-12A	10.28	MW-5A	8.04
NMW-2A	10.79	STM-3A	6.10
NMW-3A	10.26	STM-4A	6.53
NMW-4A	11.06	CBS-09A(b)	3.03
CBS-7A(a)	6.73		
AVERAGE	10.95	AVERAGE	7.69
STANDARD DEVIATION	0.56	STANDARD DEVIATION	1.37

(a) Not used in calculations. Well was dry at times during monitoring period.
(b) Not used in calculations. Offsite well.



LEGEND

NMW-1A — ONSITE MONITORING WELL LOCATION

0 500
SCALE IN FEET

NOTES:

1. WELLS WITH "NMW" PREFIX WERE INSTALLED DURING THE PHASE I GROUNDWATER INVESTIGATION. ALL OTHER MONITORING WELLS WERE INSTALLED DURING PREVIOUS INVESTIGATIONS.

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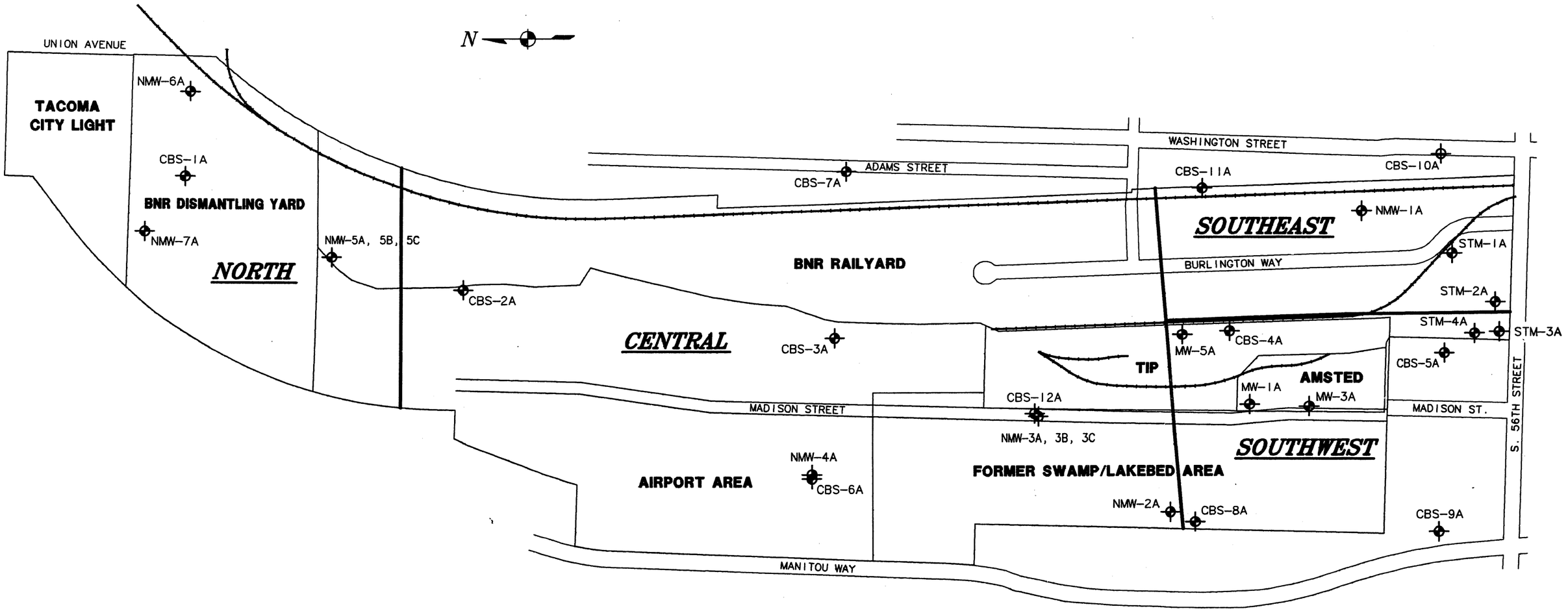
SOUTH TACOMA FIELD
TACOMA, WA

DESIGNATION OF SUB-AREAS USED IN STATISTICAL ANALYSES

916055.09/P2SK131

FIGURE HC-10



LEGEND

NMW-1A ONSITE MONITORING WELL LOCATION

0 500
SCALE IN FEET

NOTES:

1. WELLS WITH "NMW" PREFIX WERE INSTALLED DURING THE PHASE I GROUNDWATER INVESTIGATION. ALL OTHER MONITORING WELLS WERE INSTALLED DURING PREVIOUS INVESTIGATIONS.

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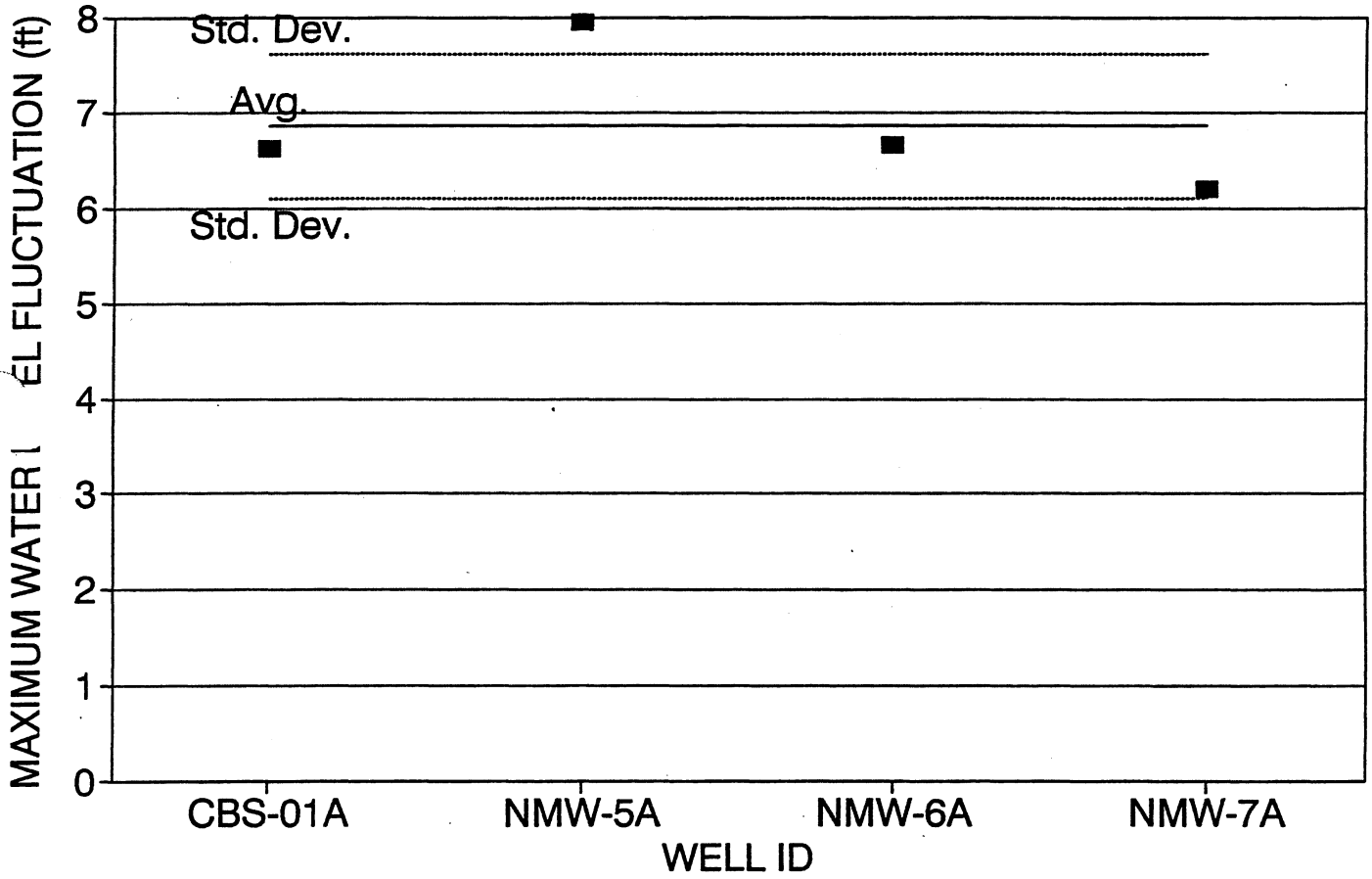
SOUTH TACOMA FIELD
TACOMA, WA

DESIGNATION OF SUB-AREA USED IN STATISTICAL ANALYS

916055.09/P2SK131

FIGURE HC-10

STF - NORTH AREA
MAXIMUM WATER LEVEL FLUCTUATIONS



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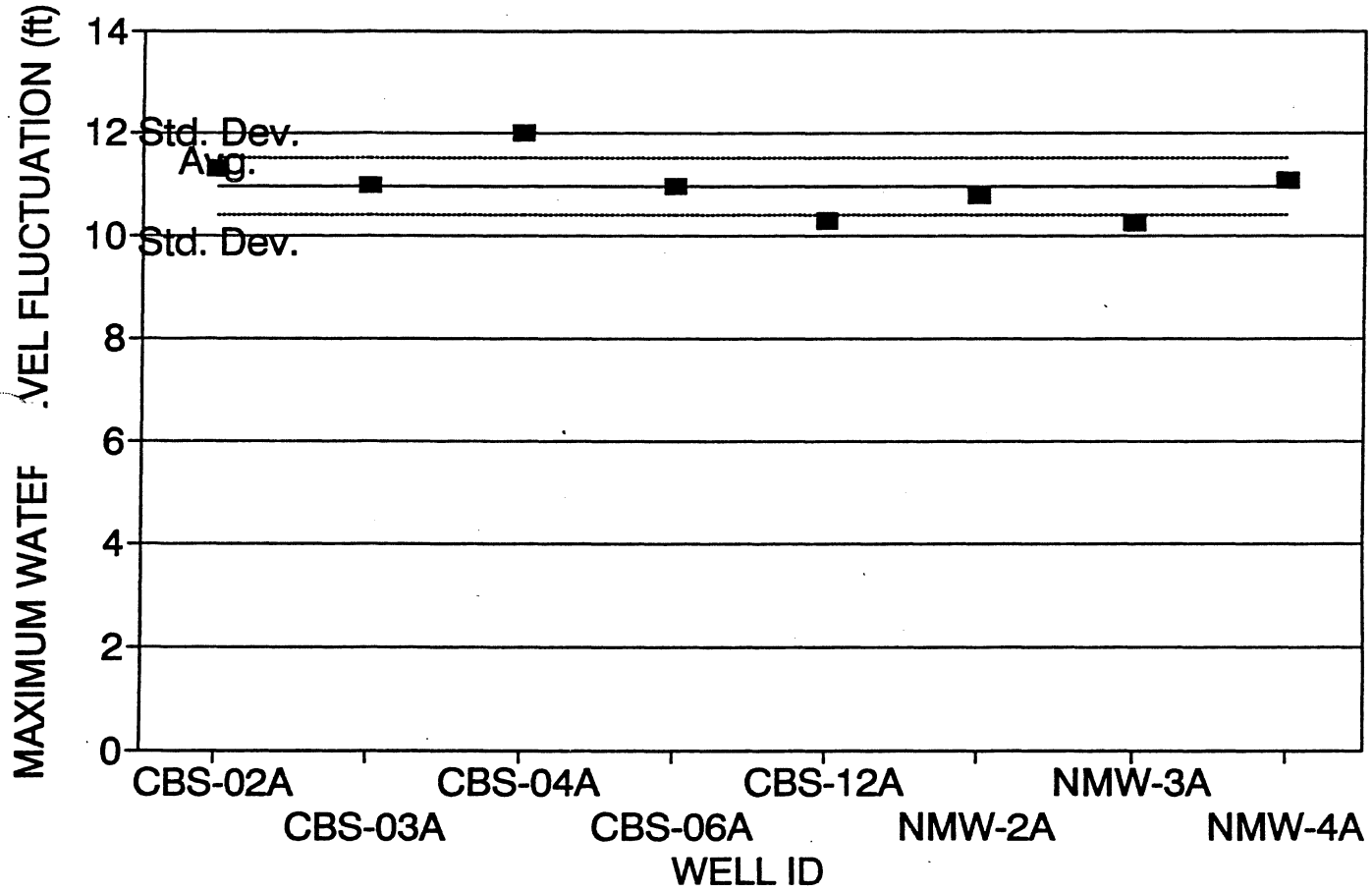
SOUTH TACOMA FIELD
TACOMA, WA

NORTH AREA MAXIMUM WATER LEVEL FLUCTUATIONS AND STATISTICAL ANALYSIS

916055.09/P2SK135

FIGURE HC-11

STF - CENTRAL AREA
MAXIMUM WATER LEVEL FLUCTUATIONS



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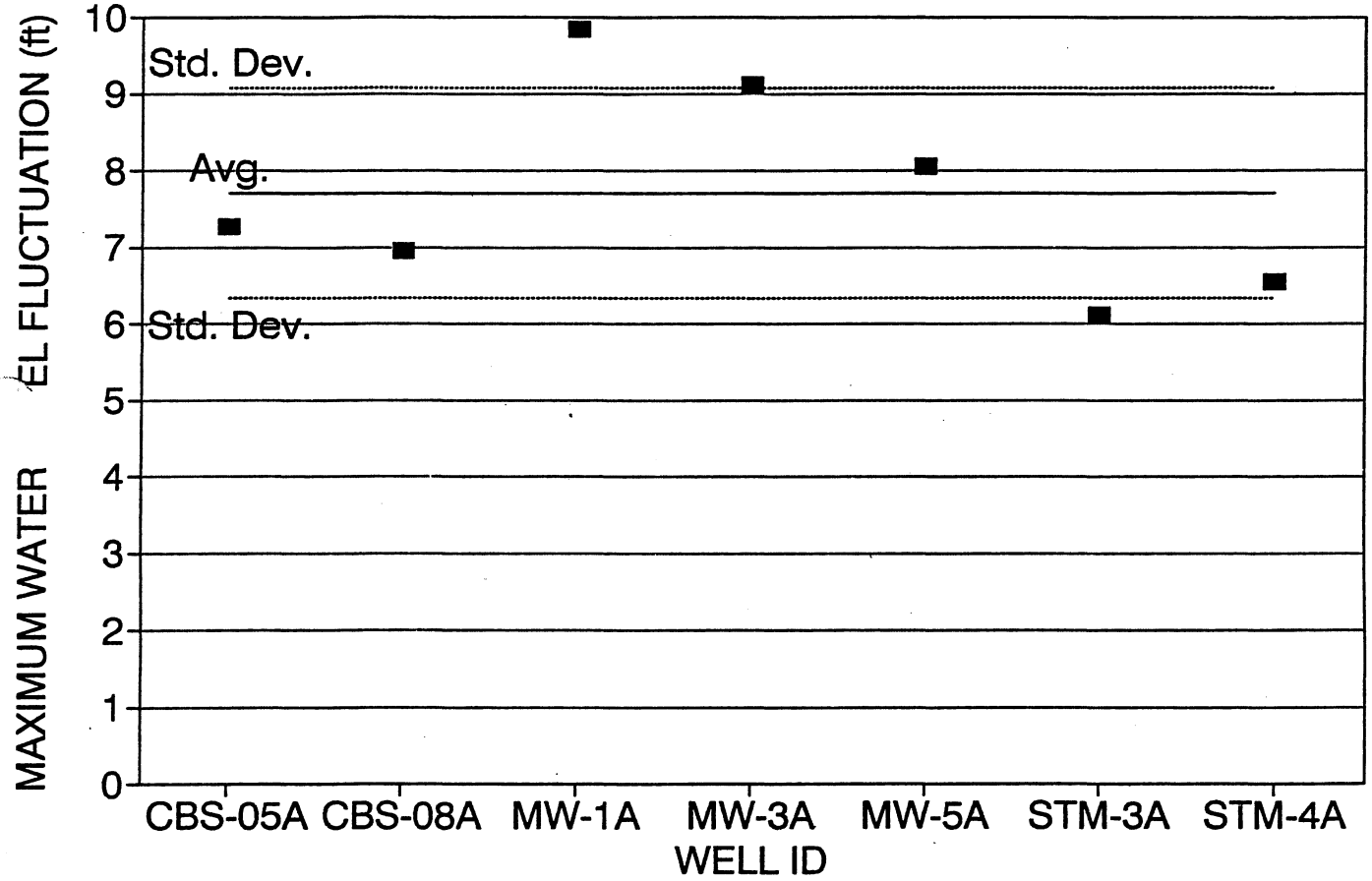
SOUTH TACOMA FIELD
TACOMA, WA

CENTRAL AREA MAXIMUM WATER LEVEL FLUCTUATIONS AND STATISTICAL ANALYSIS

916055.09/P2SK136

FIGURE HC-12

STF - SOUTH WEST AREA
MAXIMUM WATER LEVEL FLUCTUATIONS



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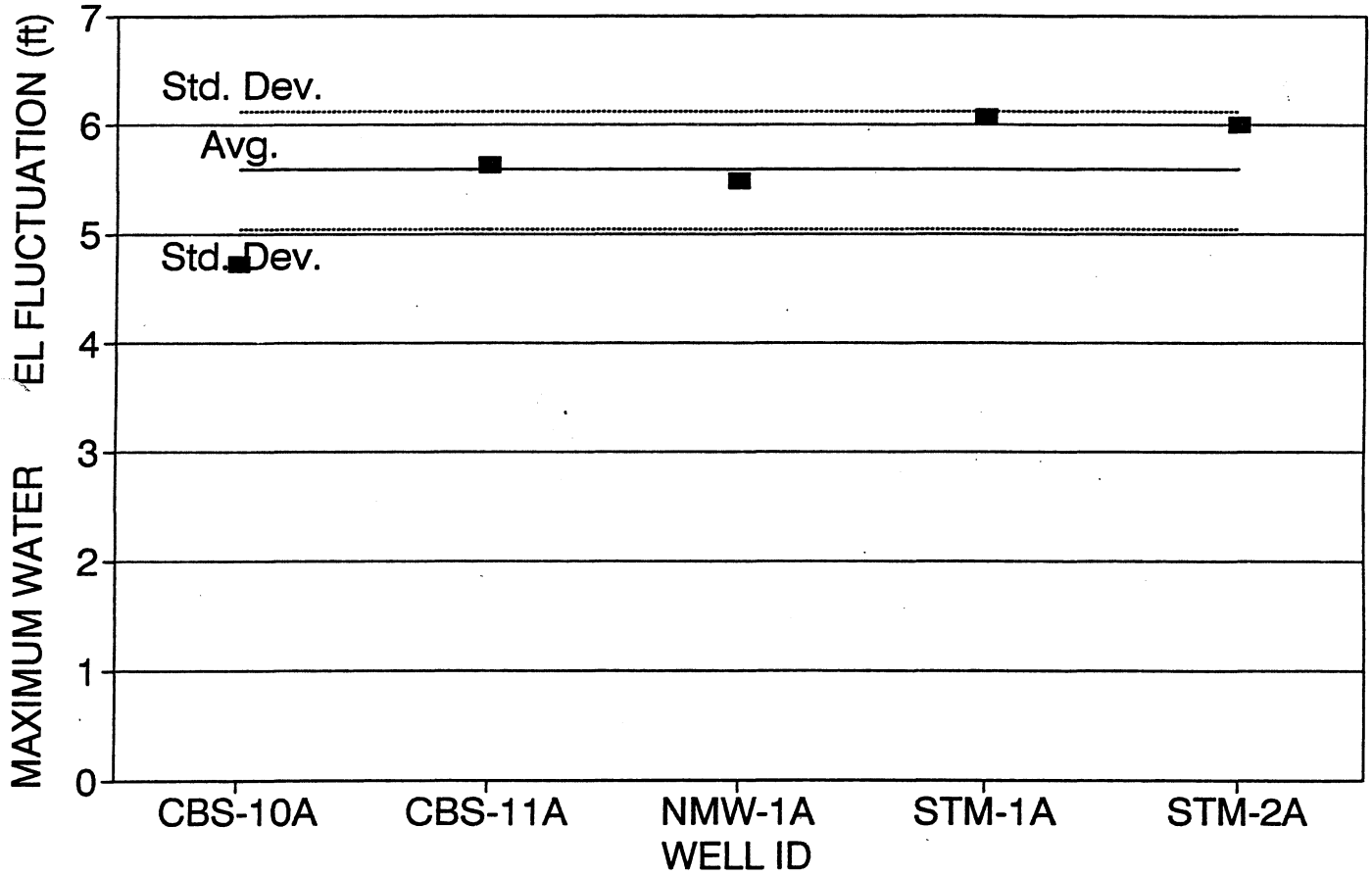
SOUTH TACOMA FIELD
TACOMA, WA

SOUTHWEST AREA MAXIMUM WATER LEVEL FLUCTUATIONS AND STATISTICAL ANALYSIS

916055.09/P2SK137

FIGURE HC-13

STF - SOUTH EAST AREA
MAXIMUM WATER LEVEL FLUCTUATIONS



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

SOUTHEAST AREA MAXIMUM WATER LEVEL FLUCTUATIONS AND STATISTICAL ANALYSIS

916055.09/P2SK138

FIGURE HC-14

Layer A and Layer C. Drawdown and recovery were monitored in these wells during the 7-day aquifer test (see Table HC-4).

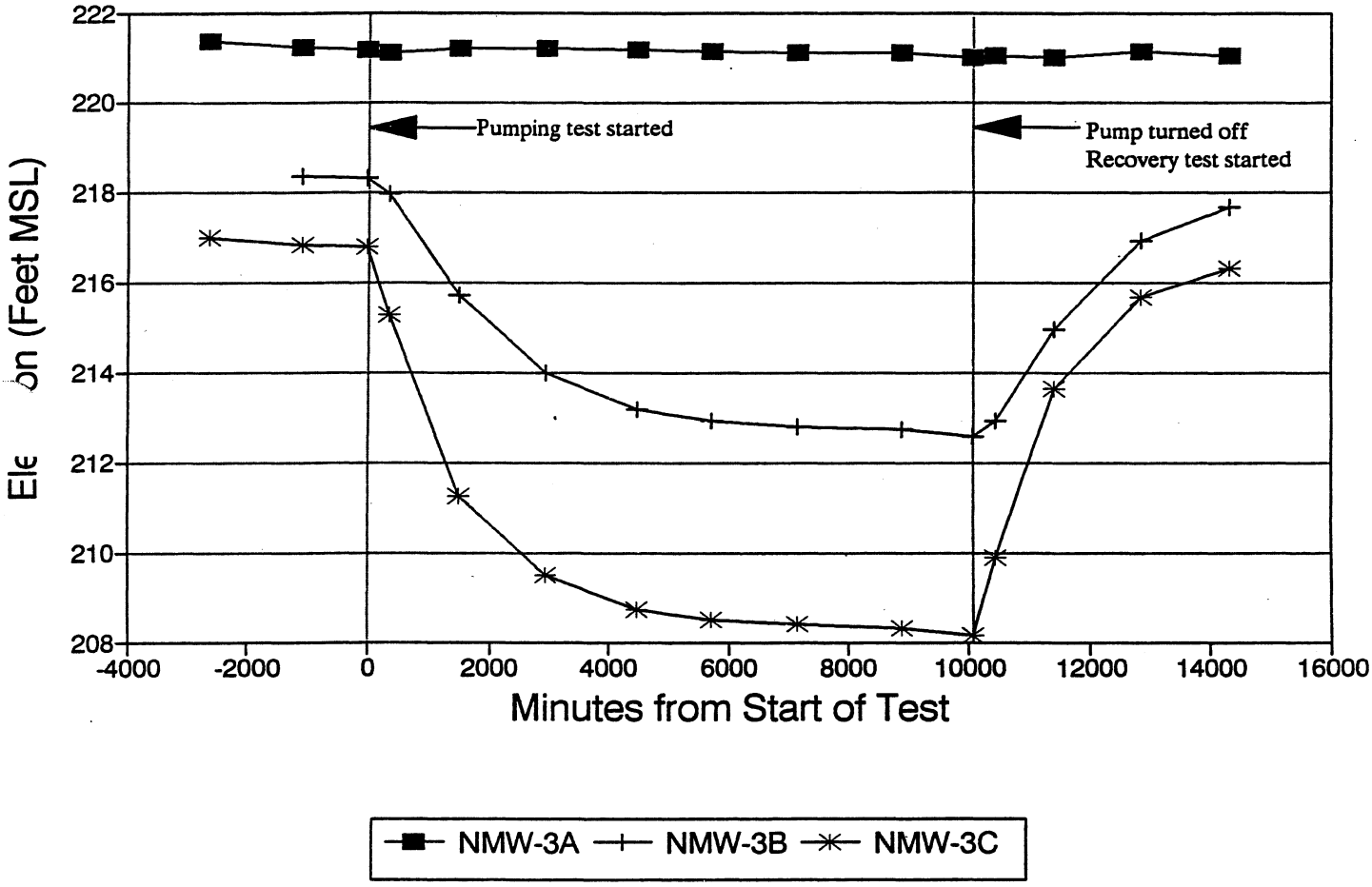
Figures HC-15 through HC-17 are hydrographs for Well Clusters NMW-3, NMW-5, and TAC 89.5, respectively. The same pattern of drawdown in Layer C that was observed in the monthly monitoring data hydrographs of well clusters NMW-3 and NMW-5 was also observed in the hydrographs of well cluster TAC 89.5. The drawdown in Layer C was also paralleled by drawdown in Lower Layer A. This similar pattern of drawdown indicates inter-aquifer communication between Lower Layer A and Layer C. As observed in the monthly monitoring data hydrographs, water levels in Upper Layer A did not appear influenced by drawdown in Lower Layer A, indicating the intervening layer is an effective confining layer.

Drawdown and recovery data obtained from monitoring Layer C wells was evaluated using the Theis (see Section 3.2.1) and Hantush methods. The Hantush methods are described below.

- Hantush and Jacob (1955) and Hantush (1960). The Hantush-Jacob and Hantush equations were developed for unsteady flow to a well in a semi-confined aquifer. Hantush and Jacob developed an equation for no storage in aquitards and Hantush developed an equation for storage in aquitards. An advantage of these equations is that they are used to evaluate data collected from a semi-confined aquifer, with or without storage in the aquitard. A disadvantage of the Hantush equations is that they were developed assuming the pumping and observation well are fully penetrating.

The objective of analyzing drawdown and recovery data was to provide additional information regarding possible inter-aquifer communication between Layer C and the overlying zones of saturation and to calculate the vertical hydraulic conductivity of the overlying leaky confining layer and transmissivity of Layer C.

NMW-3 Observation Well Cluster
TAC-1A Aquifer Test/South Tacoma Field



Kennedy/Jenks Consultants

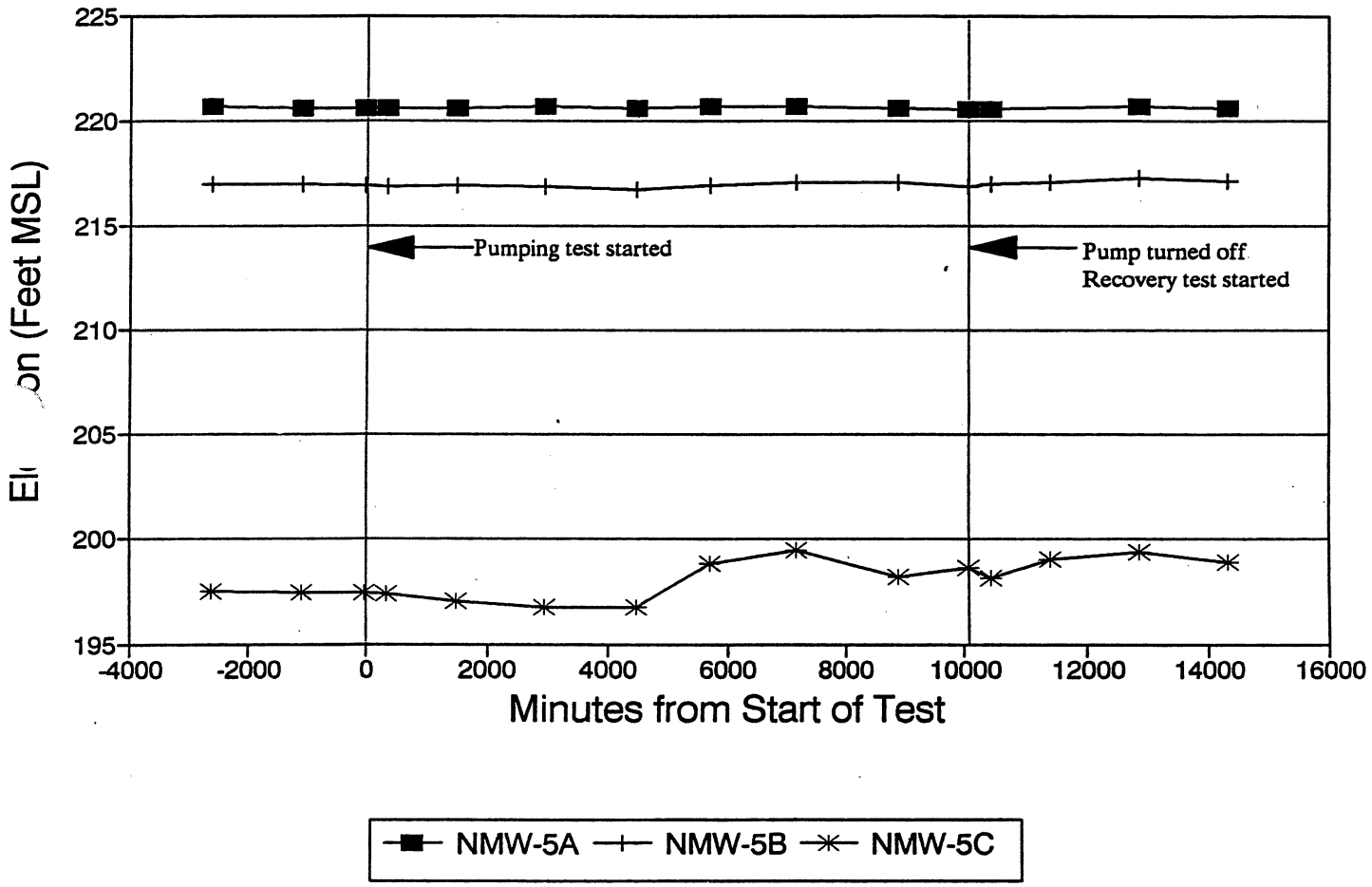
SOUTH TACOMA FIELD
TACOMA, WA

TAC-1A AQUIFER TEST
HYDROGRAPH OF WELLS
AT WELL CLUSTER NMW-3

916055.09/P2SK146

FIGURE HC-15

NMW-5 Observation Well Cluster
TAC-1A Aquifer Test/South Tacoma Field



Kennedy/Jenks Consultants

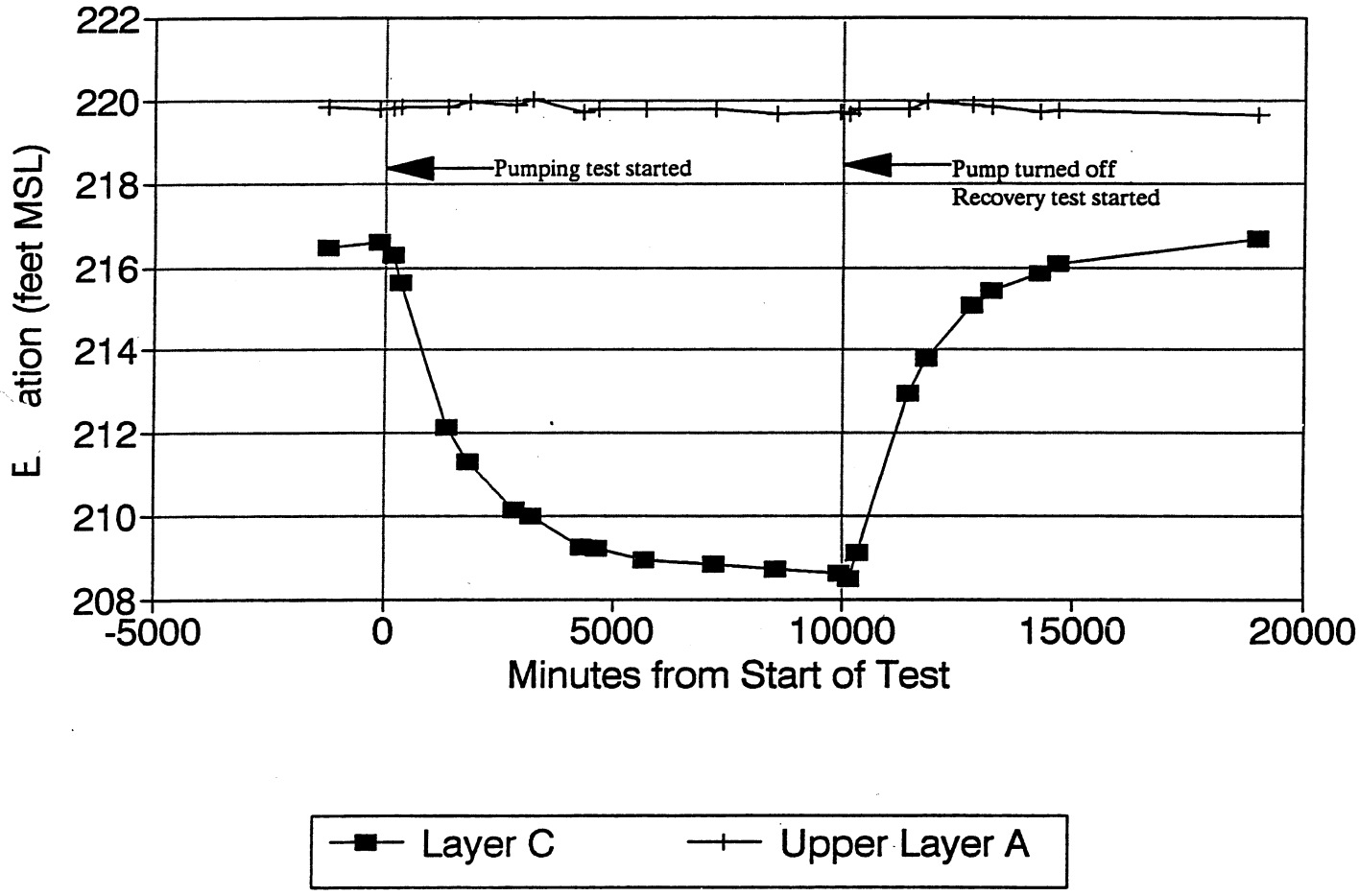
SOUTH TACOMA FIELD
TACOMA, WA

TAC-1A AQUIFER TEST
HYDROGRAPH OF WELLS
AT WELL CLUSTER NMW-5

916055.09/P2SK147

FIGURE HC-16

TAC 89.5 Observation Well Cluster
TAC-1A Aquifer Test/South Tacoma Field



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

TAC-1A AQUIFER TEST
HYDROGRAPH OF WELLS
AT WELL CLUSTER TAC 89.5

916055.09/P2SK148

FIGURE HC-17

Water level monitoring was also performed in selected onsite wells installed in Upper Layer A during the Well TAC 1A pumping test. Plots of monitoring data from these wells are presented in Appendix HC-F.

3.4.2.1 Well NMW-3C Results. Drawdown and recovery data recorded in NMW-3C during the TAC 1A test was evaluated using the Theis drawdown and recovery equations, and the Hantush no storage in aquitard and storage in aquitard equations. The Hantush (no storage in aquitard) type curve fit the data set best, indicating possible leakage from Layer B (the aquitard) to Layer C. The fit of the drawdown and recovery data sets with the type curves of the Theis and Hantush (storage in aquitard) equations were not as closely matched. Horizontal transmissivity values calculated for Layer C using the latter two equations were one order of magnitude greater than the transmissivity calculated using the Hantush (no storage in the aquitard) equation.

An estimate of the vertical transmissivity was also calculated using the Hantush (no storage in the aquitard) equation. Based on this calculation, the vertical hydraulic conductivity of Layer B was estimated at 1.34 E-4 ft/day (4.72 E-8 cm/sec) at this location.

3.4.2.2 Well NMW-5C Results. Drawdown and recovery was monitored in NMW-5C throughout the TAC 1A pumping test. However, the data set was of limited value for analysis because of the influence of nearby heat pump wells located at Tacoma Public Utilities property north of the STF site. According to Tacoma Public Utilities, there are five heat pump wells used for discharge and subsequent recharge of groundwater. These wells had a significant effect on drawdown of the potentiometric surface of Layers A and C and appear to have distorted the data set for Well NMW-5C during the pumping test.

The effects of the heat pump wells is evident in the data set after approximately 3 days (4,300 minutes) of pumping. The drawdown data obtained from this well prior to operation of the heat pump wells was evaluated using the Theis equation

and the Hantush equation. The aquifer properties calculated are similar in magnitude to those calculated using data from Well NMW-3C. Data collected after 3 days (4,300 minutes) were not evaluated due to influence from the heat pump wells. It is acknowledged that the information gained from this well cluster may be of limited value as a result of these interferences.

3.4.2.3 Well TAC 89.5 Results. Drawdown and recovery data recorded in TAC 89.5 during the TAC 1A pumping test was evaluated using the Theis drawdown and recovery equation, and the Hantush (no storage in aquitard and storage in aquitard) equation. As with data collected from NMW-3C, the type curve for the Hantush (no storage in aquitard) equation provided the best fit for the data set. This fit may indicate leakage from Layer B to Layer C. Vertical hydraulic conductivity of Layer B was estimated at 4.44 E-3 ft/day (1.57 E-6 cm/sec) using the Hantush equation.

Estimates of the vertical hydraulic conductivity of the aquitard (Layer B) ranged from 1.34 E-4 ft/day to 4.44 E-3 ft/day. Well TAC 1A aquifer test results also indicated the horizontal transmissivity of Layer C is approximately 70,000 gpd/ft. The analyses of the NMW-3C, NMW-5C, and TAC 89.5 data are presented in Appendix HC-G.

4.0 DISCUSSION AND CONCLUSIONS

A discussion of the results of the Hydraulic Characterization Investigation are presented in this section. In addition, conclusions based on these results and the results of previous investigations performed at and in the vicinity of the STF site are presented.

4.1 HYDROGEOLOGIC CONDITIONS

Hydrogeologic conditions encountered at the STF site are summarized below. The following discussions focus on the occurrence of groundwater, horizontal and vertical gradients observed in Upper Layer A, and a conceptual model of the regional groundwater flow system.

4.1.1 Occurrence of Groundwater

Groundwater is encountered in two zones of saturation (Layer A and Layer C) in the first 200 feet of subsurface material encountered as part of the STF Phase I Groundwater Investigation (see Section 1.6.2). The hydrostratigraphic layers, the sequence in which they were encountered, and their correlation to lithologic units identified in central Pierce County are summarized in Table HC-10.

TABLE HC-10

SUMMARY OF HYDROSTRATIGRAPHIC LAYERS

Hydrostratigraphic Layer	Unit Designation	Unit Thickness[a]	Soil Description
Layer A (Upper)	Vashon Drift (Colvos Sand Member)	62-101	Poorly graded sand with silt and gravel.
Layer A_1	Discovery Nonglacial Unit Narrows Glacial Unit	0-33 6-12.5	Clay, silt and sand. Silt.
Layer A (Lower)	Narrows Glacial Unit	59-67.5	Gravel.
Layer B	Kitsap Formation	2-15	Silt and clay.
Layer C	Fleet Creek Glacial Unit	100[b]	Cobbles and gravel.

(a) Unit thicknesses are based on field observations made during the STF Phase I Groundwater Investigation, Kennedy/Jenks Consultants (1992a).
(b) Layer C was penetrated approximately 25 feet during the STF Phase I Groundwater Investigation.

In the vicinity of the South Tacoma Channel, aquifer units appear to be laterally continuous in the vicinity of the investigation area, with the exception of Layer A_1. Information collected during the RI is insufficient to confirm the lateral continuity of the confining layer (Layers A, and B) across the site. According to Brown and Caldwell (1985), Layer A_1 appears to pinch out east of the site. Based on the Phase I Groundwater Investigation, Layer A_1 appears to thin out in the northern portion of the site at well NMW-5C. However, it is much thinner in the South Tacoma Channel than observed elsewhere. Layer B typically ranges in thickness from 50 to 150 feet in the Chambers/Clover Creek drainage area (Brown and Caldwell 1985). At the STF site, Layer B was observed to range in thickness from two feet at Well NMW-3C to approximately 15 feet at Well NMW-5C. Layer C is also laterally continuous in the vicinity of the site and reportedly ranges in thickness from 50 to 180 feet (Brown and Caldwell 1985).

Layer A has been divided into an upper portion (Upper Layer A, which is unconfined), and a lower portion (Lower Layer A, which is likely semi-confined to confined). Wells NMW-3B and NMW-5B are installed in this zone. The two portions of Layer A are separated by Layer A_1. Based on the results of monthly groundwater monitoring and aquifer testing, Layer A_1 is effective at limiting hydraulic communication between Upper and Lower Layers A at the site. Groundwater in Layer C occurs under confined conditions.

4.1.2 Groundwater Recharge

Onsite recharge to Layer A is from infiltration of precipitation and stormwater runon. Using a reported annual precipitation of 37.06 inches and an evapotranspiration rate of 21 inches per year (Brown and Caldwell 1985), approximately 114,000,000 gallons of water might percolate to groundwater from precipitation. Based on the estimated size of the drainage basin, net stormwater runon (i.e., runon entering from drainage culverts in the northern portion of the site minus stormwater that discharges at the southern end of the site) from offsite sources is estimated at approximately 85,000,000 gallons per year (Kennedy/Jenks Consultants 1992c). Using a rough estimate rate of 60 percent evapotranspiration, an estimated 34,000,000 gallons of stormwater runon might percolate through the vadose zone and eventually recharge groundwater. Therefore, total recharge to shallow groundwater (Upper Layer A) from surface water runon and precipitation is estimated at approximately 150,000,000 gallons annually. This estimate is likely accurate to approximately one order of magnitude.

Approximately 2.02 billion gallons of water are held in storage in interstitial spaces of the porous media of the upper portion of Layer A. This calculation was based on the following assumptions:

- Site area is approximately 261 acres

- Upper Layer A has a saturated thickness of 65 feet

- Average porosity is 36.5 percent.

Using these approximate runon and evapotranspiration values, the estimated volume of annual recharge through onsite percolation (approximately 150 million gallons) amounts to less than 7 percent of the volume of water held in storage in Upper Layer A.

4.1.3 Estimated Groundwater Flow

To the south of the STF site, the direction of the hydraulic gradient is towards the north to northwest (Griffin et al. 1962). The same gradient is observed in Upper Layer A at the site. To the north of the site, a broad groundwater mound has been identified which corresponds to a topographic high. The hydraulic gradient of the southern portion of the mound is to the south. As a result, the mound reportedly serves as a recharge source to the South Tacoma Channel (Brown and Caldwell 1985).

Potentiometric surface maps from previous investigations (Brown and Caldwell 1985) indicate that the South Tacoma Channel is the vicinity of a groundwater mound. The mound is generally oblong in shape and may be caused by convergence of groundwater flow from the north and south as well as significant onsite recharge of surface water. Available information indicates that the hydraulic gradient to the west of the channel is toward the west and on the east side of the channel the hydraulic gradient is toward the east. Therefore, it appears that a groundwater divide occurs in the vicinity of the site. The axis of the divide is oriented north-south and appears to shift either east or west seasonally.

Based on this conceptual model, during static (non-pumping) conditions the predominant direction of groundwater flow at the site is toward the north to

northwest in the direction of the hydraulic gradient. Along the eastern and western margins of the mound (which are typically offsite), groundwater is expected to flow to the east and to the west, respectively.

The STF site is located adjacent to (west of) a municipal wellfield operated by Tacoma Public Utilities. Wells in the wellfield are installed in both Layer A and Layer C. Groundwater is pumped primarily in the spring and summer months (May through September). When seasonal groundwater pumping is conducted in Layer A wells, a large cone of depression forms around Wells TAC 4A, TAC 11A, and TAC 6A. The size of the cone of depression increases as the summer progresses and by August and September it appears that cone of depression may extend to the eastern boundary of the Tacoma Landfill investigation area. As a result, groundwater below the Tacoma Landfill, which typically flows to the west toward Puget Sound, may be reversed and flow toward the STF site.

Pumping of water supply wells in Layer C also results in a regional lowering of the potentiometric surface of this layer. The vertical conductivity of Layer B (the confining layer) was estimated at approximately 1.4 E-4 ft/day at Well NMW-3C (see Section 3.4). This estimate was based on the results of the TAC 1A aquifer test. Based on this vertical conductivity, a leakage velocity from Lower Layer A to Layer C was developed. Because Layer B varies in thickness across the site from 2 feet at Well NMW-3C to 15 feet at Well NMW-5C, calculating a leakage volume for the entire site is impractical given the limited data. Therefore, Table HC-11 presents minimum and maximum leakage velocities (ft/day) for the different site conditions encountered.

TABLE HC-11

ESTIMATED MAXIMUM AND MINIMUM LEAKAGE VELOCITY THROUGH LAYER B

Well Location	Head Differential[a] (feet)	Estimated Leakage Velocity[b] (ft/day)
NMW-3C (Minimum)	0.27	1.8 E-5
NMW-3C (Maximum)	16.66	1.1 E-3
NMW-5C (Minimum)	10.95	9.8 E-5
NMW-5C (Maximum)	27.87	2.4 E-4

(a) The head differential is between Lower Layer A and Layer C.
(b) Estimated velocity was calculated using a Layer B thickness of 2 feet at Well NMW-3C and 15 feet at Well NMW-5C.

As indicated in Table HC-11, these leakage velocities are over six orders of magnitude less than the seepage velocities used to estimate horizontal flow. As a result, there is a much greater tendency for groundwater to flow laterally than to pass through the confining layer.

4.2 CONCLUSIONS

The following conclusions have been developed based on the findings of this investigation. Conclusions are divided into the investigative task from which data were developed.

4.2.1 Water Level Monitoring

- The predominant direction of the hydraulic gradient in Layer A, and presumed direction of shallow groundwater flow, is toward the north to northwest. The magnitude of the hydraulic gradient fluctuates both spatially and seasonally from 0.0004 to 0.001 ft/ft.

- The STF site lies in the vicinity of a groundwater mound that is oblong in shape and oriented north-south. The axis of the mound forms a regional

groundwater divide and the presumed direction of groundwater flow is east on the east side of the mound and west on the west side of the mound. The mound is likely caused by convergence of groundwater flow from north and south of the South Tacoma Channel.

- Shallow groundwater flow is significantly impacted by pumping of groundwater by municipal wells to the east of the site. During the summer months, a cone of depression extends from the pumping wells to beyond the western property boundary of the site. As a result of pumping, the hydraulic gradient on the western side of the Tacoma Landfill is reversed.

- There is a net downward vertical gradient from Upper Layer A to Lower Layer A. The head differential between these two zones of saturation ranged from a minimum of 0.51 feet at Well Cluster NMW-3 in the wet season to maximum of 39.39 feet in Well Cluster NMW-5 during the dry season. A net downward vertical gradient exists between Lower Layer A and Layer C. This head differential ranged from 0.27 feet in Well Cluster NMW-3 during the wet season to 27.87 feet in Well Cluster NMW-5 during the dry season.

4.2.2 Aquifer Pumping Tests

- Based on aquifer tests performed in Upper Layer A, the estimated transmissivity values for Layer A ranged from 67,000 gpd/ft and 71,000 gpd/ft at Wells NMW-4A and NMW-3A, respectively.

- The estimated seepage velocity ranged from 60 ft/yr to 150 ft/yr.

4.2.3 Slug Tests

- Based on slug test results, transmissivity values were one to two orders of magnitude less than those values calculated through performance of aquifer tests. The anomalously low transmissivity values calculated through slug tests may be attributed to the high hydraulic conductivity of the formation and that slug tests may only test the filter pack of the wall.

4.2.4 Inter-Aquifer Communication

- Statistical analysis of monthly groundwater level monitoring data was inconclusive in identifying areas of enhanced leakage from Upper Layer A to the lower-lying saturated zones.

- Visual examination of water level monitoring hydrographs show significant head fluctuations in Lower Layer A (Wells NMW-3B and NMW-5B) during seasonal groundwater removal in Layer C, indicating communication between the two zones of saturation (i.e., Lower Layer A and Layer C). Based on visible examination, it appears that communication between the two zones (Lower Layer A and Layer C) is greater in the south at Well NMW-3C, and less in the northern portion of the site at Well NMW-5C. This corresponds with lithologic conditions that indicate Layer B is approximately 2 feet thick at Well NMW-3C and 15 feet thick at Well NMW-5C.

- Hydrographs also indicate little head fluctuation between Upper Layer A and Lower Layer A, indicating limited, if any, communication between the two zones of saturation. Lithologic information indicates that Layer A_1 is approximately 37 feet thick at Well Cluster NMW-3 and 6 feet thick at Well Cluster NMW-5. Although, quantification of the vertical conductivity of Layer A_1 is not possible with available information, lithologic information and the water

level monitoring data indicate that this unit is an effective confining layer between Upper Layer A and the lower-lying zones.

- Analysis of aquifer test data from Well TAC 1A indicate leakage from Lower Layer A to Layer C in the vicinity of Well Clusters NMW-3 and TAC 89.5. Estimates of vertical conductivity for Layer B at these two locations ranged from 1.34 E-03 ft/day to 4.44 E-04 ft/day, respectively. These conductivity values are approximately six to seven orders of magnitude lower than horizontal conductivity values calculated for Layer C. Test results for Well Cluster NMW-5 were influenced from operation of heat pump wells at Tacoma Public Utilities and cannot be used to estimate possible leakage in the northern portion of the STF site.

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Appendix HC-A

Quarterly Water Level Monitoring Data for the Tacoma Landfill

TACOMA LANDFILL
QUARTERLY WATER LEVEL MONITORING DATA
10 MAY 1991

WELL ID	EASTING (ft)[a]	NORTHING (ft)[a]	W.S.E (ft)[b]
TL-1A	1142422.00	697824.50	220.37
TL-2A	1142387.84	698175.51	221.10
TL-3A	1141887.81	697417.50	220.30
TL-4A	1142566.81	696402.49	219.53
TL-5A	1141899.79	696149.48	201.78
TL-7A	1141235.76	694678.46	191.90
TL-8A	1143255.79	694157.47	220.30
TL-9A	1142115.75	693001.45	218.70
TL-10A	1142319.78	694707.47	219.55
TL-11A	1143505.77	692421.46	220.21
TL-12A	1144243.80	693554.48	220.98
TL-13A	1144909.82	693753.48	222.90
TL-15A	1144291.85	695971.51	220.21
TL-17A	1143512.88	699075.53	220.99
TL-18A	1145139.88	696961.53	220.73
TL-19A	1141607.74	693110.45	206.89
TL-20A	1141462.73	692292.44	215.00
TL-21A	1141073.69	690772.42	200.86
TL-22A	1142627.74	692065.44	218.11
TL-23A	1144816.78	691791.46	222.54
TL-24A	1142043.72	691051.43	215.29

[a] Horizontal survey based on State Plane Coordinates
[b] Vertical datum based on New City of Tacoma 1990.

TACOMA LANDFILL
QUARTERLY WATER LEVEL MONITORING DATA
21 AUGUST 1991

WELL ID	EASTING (ft)[a]	NORTHING (ft)[a]	W.S.E (ft)[b]
TL-7A	1141235.76	694678.46	190.13
TL-9A	1142115.75	693001.45	217.55
TL-10A	1142319.78	694707.47	217.80
TL-11A	1143505.77	692421.46	217.44
TL-12A	1144243.80	693554.48	215.83
TL-13A	1144909.82	693753.48	213.63
TL-14A	1145090.85	695468.51	215.73
TL-15A	1144291.85	695971.51	217.01
TL-17A	1143512.88	699075.53	220.01
TL-18A	1145139.88	696961.53	217.80
TL-19A	1141607.74	693110.45	205.27
TL-21A	1141073.69	690772.42	199.47
TL-22A	1142627.74	692065.44	217.89
TL-23A	1144816.78	691791.46	216.12
TL-24A	1142043.72	691051.43	216.38
LW-1	1144026.87	697517.52	216.02

[a] Horizontal survey based on State Plane Coordinates.
[b] Vertical datum based on New City of Tacoma 1990.

TACOMA LANDFILL
QUARTERLY WATER LEVEL MONITORING DATA
5-13 NOVEMBER 1991

WELL ID	EASTING (ft)[a]	NORTHING (ft)[a]	W.S.E (ft)[b]
TL-1A	1142421.83	697824.51	216.94
TL-2A	1142387.84	698175.51	218.32
TL-3A	1141887.81	697417.50	216.49
TL-4A	1142566.81	696402.49	215.59
TL-7A	1141235.76	694678.46	191.94
TL-8A	1143255.79	694157.47	215.16
TL-9A	1142115.75	693001.45	214.16
TL-10A	1142319.78	694707.47	214.96
TL-11A	1143505.77	692421.46	214.62
TL-12A	1144243.80	693554.48	215.15
TL-13A	1144909.82	693753.48	216.07
TL-14A	1145090.85	695468.51	216.01
TL-15A	1144291.85	695971.51	215.80
TL-17A	1143512.88	699075.53	218.11
TL-18A	1145139.88	696961.53	216.83
TL-19A	1141607.74	693110.45	203.31
TL-20A	1141462.73	692292.44	211.70
TL-21A	1141073.69	690772.42	199.18
TL-22A	1142627.74	692065.44	214.36
TL-23A	1144816.78	691791.46	215.40
TL-24A	1142043.72	691051.43	214.04

[a] Horizontal survey based on State Plane Coordinates.
[b] Vertical datum based on New City of Tacoma 1990.

TACOMA LANDFILL
QUARTERLY WATER LEVEL MONITORING DATA
3-10 FEBRUARY 1992

WELL ID	EASTING (ft)[a]	NORTHING (ft)[a]	W.S.E (ft)[b]
TL-1A	1142421.83	697824.51	218.01
TL-2A	1142387.84	698175.51	218.84
TL-3A	1141887.81	697417.50	218.32
TL-4A	1142566.81	696402.49	217.52
TL-7A	1141235.76	694678.46	192.40
TL-8A	1143255.79	694157.47	217.92
TL-9A	1142115.75	693001.45	216.21
TL-10A	1142319.78	694707.47	217.14
TL-11A	1143505.77	692421.46	216.83
TL-12A	1144243.80	693554.48	218.55
TL-13A	1144909.82	693753.48	220.99
TL-14A	1145090.85	695468.51	219.51
TL-15A	1144291.85	695971.51	217.86
TL-16A	1145170.91	698482.54	218.78
TL-17A	1143512.88	699075.53	219.22
TL-18A	1145139.88	696961.53	218.87
TL-19A	1141607.74	693110.45	209.29
TL-20A	1141462.73	692292.44	213.28
TL-21A	1141073.69	690772.42	200.03
TL-22A	1142627.74	692065.44	215.44
TL-23A	1144816.78	691791.46	220.12
TL-24A	1142043.72	691051.43	213.23
LW-1	1144026.87	697517.52	216.43

[a] Horizontal survey based on State Plane Coordinates.
[b] Vertical datum based on New City of Tacoma 1990.

Appendix HC-B

Well NMW-3A and Well NMW-4A Pump Test Barometric Pressure and Precipitation Data

NMW-3A PUMP TEST

PRECIPITATION AND BAROMETRIC PRESSURE

Start Date: 12/04/91
Stop Date: 12/06/91

Start Time: 10:45 a.m.
Stop Time: 10:30 a.m.

Date	Time	Precipitation (inches)	Barometric Pressure (In. Hg.)
12/04/91	10:45	Start Test	
	11:10	0	29.95
	11:41	0	29.95
	12:10	0	29.95
	12:42	0	29.96
	13:55	0	29.95
	14:35	0	29.95
	15:30	0	29.95
	16:30	0	29.95
	17:32	0	29.95
	18:30	0	29.89
	19:30	0	29.89
	20:30	0	29.88
	21:30	0	29.87
	22:30	0	29.85
	23:30	0	29.84
12/05/92	00:30	0	29.84
	1:30	0.11	29.83
	2:30	0.21	29.78
	3:30	0.27	29.73
	4:30	0.30	29.70
	5:30	0.31	29.65
	6:30	0.34	29.63
	7:30	0.36	29.61
	8:30	0.38	29.59
	9:30	0.41	29.58
	10:30	0.44	29.57
	11:30	0.50	29.57
	12:30	0.53	29.51
	13:30	0.56	29.51
	14:30	0.60	29.48
	15:30	0.69	29.49
	16:30	0.70	29.50

NMW-3A PUMP TEST

PRECIPITATION AND BAROMETRIC PRESSURE

Date	Time	Precipitation (inches)	Barometric Pressure (In. Hg.)
12/05/92	17:30	0.70	29.52
	18:30	0.70	29.53
	19:30	0.74	29.55
	20:30	0.74	29.56
	21:30	0.74	29.56
	22:30	0.74	29.56
	23:30	0.74	29.63
12/06/92	00:30	0.74	29.66
	1:30	0.74	29.67
	2:30	0.74	29.67
	3:30	0.74	29.67
	4:30	0.74	29.64
	5:30	0.74	29.62
	6:30	0.74	29.60
	7:30	0.74	29.58
	8:30	0.72	29.58
	9:30	0.72	29.57
	10:30	0.72	29.57

NMW-4A PUMP TEST

PRECIPITATION AND BAROMETRIC PRESSURE

Start Date: 12/11/91
Stop Date: 12/13/91

Start Time: 10:20 a.m.
Stop Time: 1:15 p.m.

Date	Time	Precipitation (inches)	Barometric Pressure (In. Hg.)
12/11/91	10:20	Start Test	
	10:22	0	29.5
	10:26	0	29.5
	10:28	0	29.5
	10:30	0	29.5
	10:32	0	29.5
	10:39	0	29.5
	10:46	0	29.5
	10:52	0	29.5
	10:57	0	29.5
	11:05	0	29.5
	11:17	0	29.5
	11:30	0	29.5
	11:55	0	29.5
	12:55	0	29.8
	13:55	0	29.8
	14:55	0	29.8
	15:55	0	29.9
	16:55	0	30.0
	17:55	0	30.1
	18:55	0	30.3
	19:55	0	30.05
	20:55	0	30.04
	21:55	0	30.02
	22:55	0	29.98
	23:55	0.015	29.94
12/12/91	00:55	0.020	29.89
	1:55	0.020	29.86
	2:55	0.020	29.80
	3:55	0.025	29.76
	4:55	0.038	29.76
	5:55	0.050	29.79
	6:55	0.059	29.80
	7:55	0.075	29.83
	8:55	0.075	29.86
	9:55	0.075	29.85
	10:55	0.100	29.86
	11:55	0.100	29.89

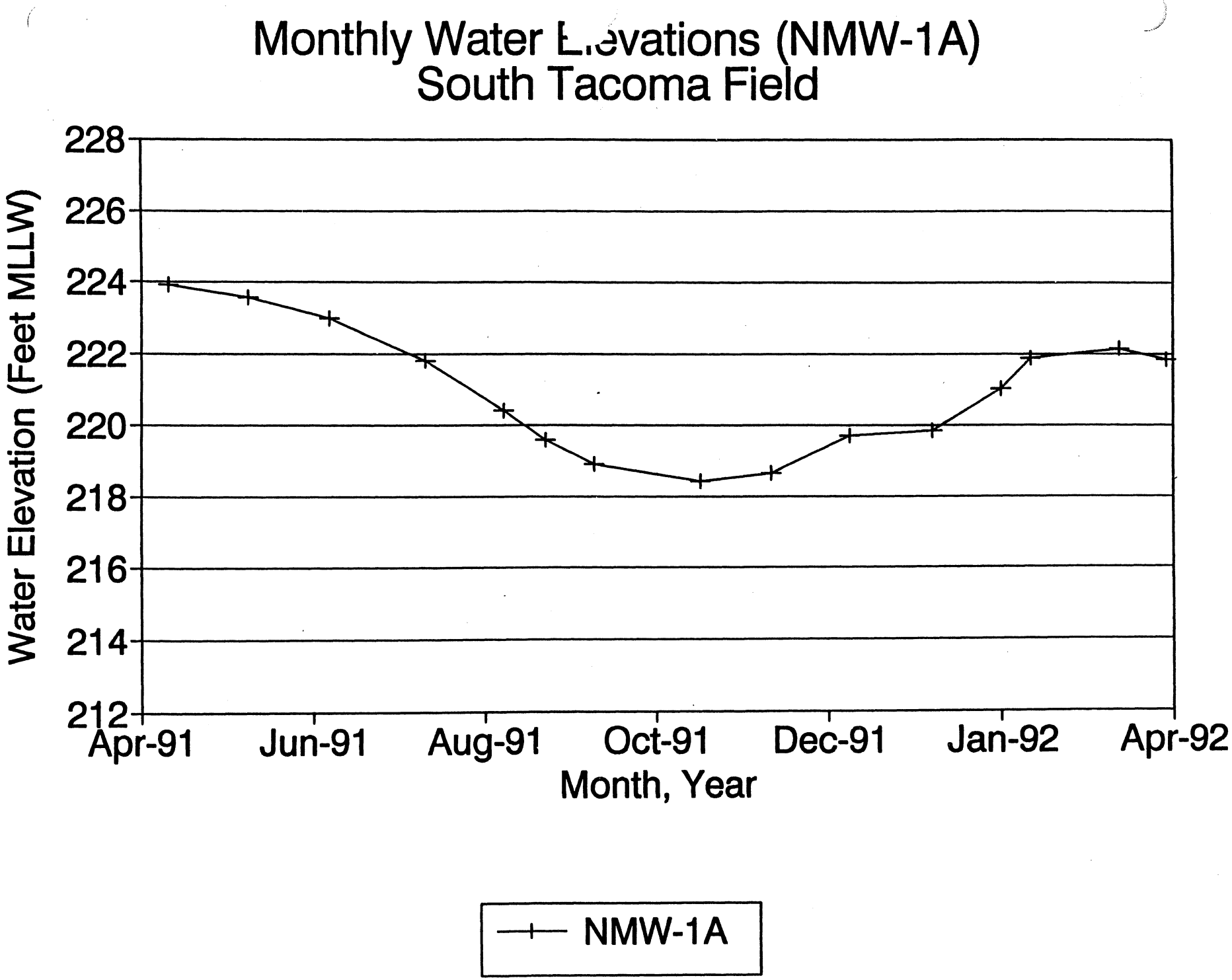
NMW-4A PUMP TEST

PRECIPITATION AND BAROMETRIC PRESSURE

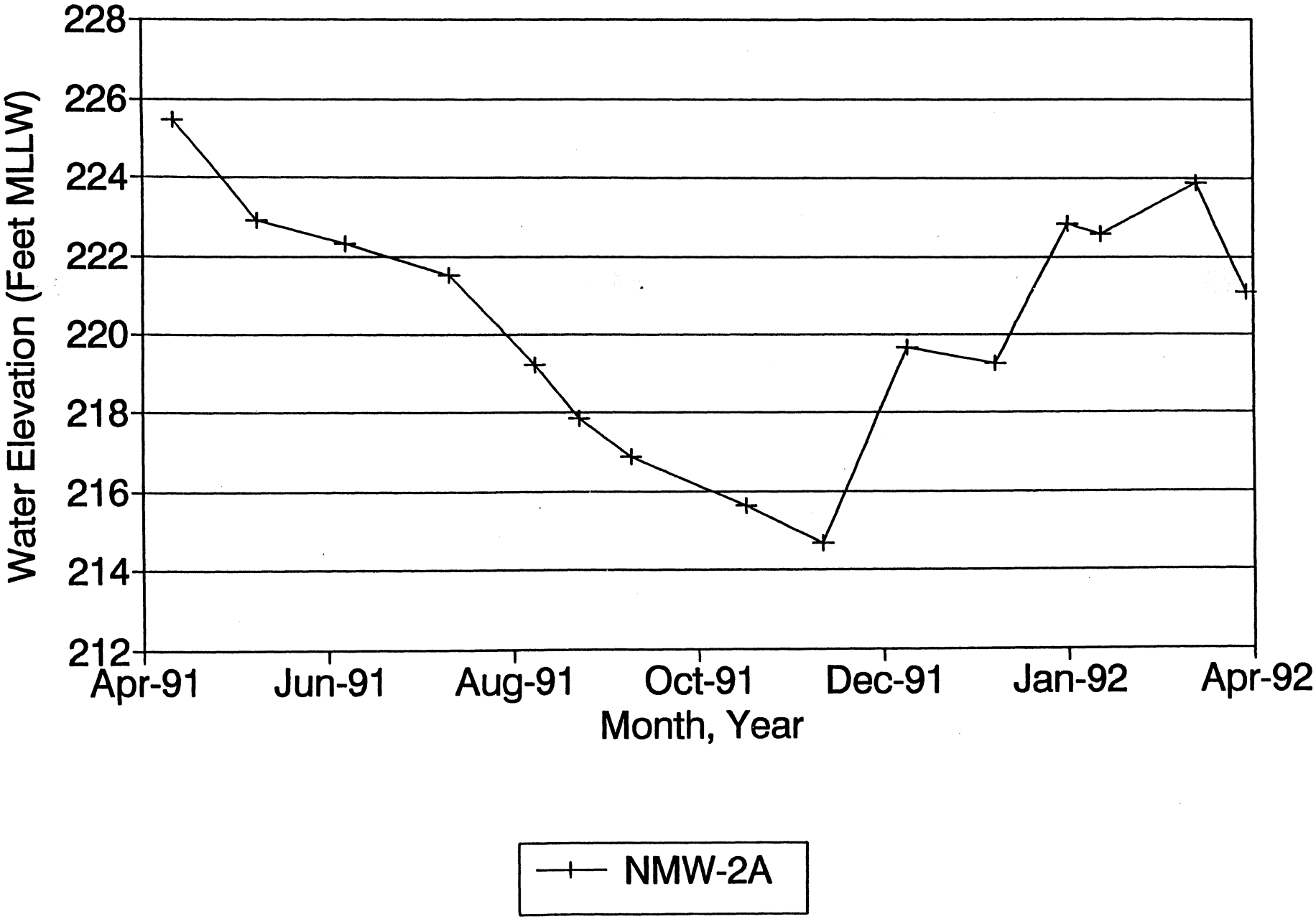
Date	Time	Precipitation (inches)	Barometric Pressure (In. Hg.)
12/12/91	12:55	0.100	29.93
	13:55	0.100	29.98
	14:55	0.100	30.03
	15:55	0.100	30.09
	16:55	0.100	30.15
	17:55	0.100	30.18
	18:55	0.100	30.23
	19:55	0.100	30.30
	20:55	0.100	30.34
	21:55	0.100	30.38
	22:55	0.100	30.42
	23:55	0.100	30.46
12/13/91	00:55	0.100	30.47
	1:55	0.100	30.49
	2:55	0.100	30.51
	3:55	0.100	30.53
	4:55	0.100	30.53
	5:55	0.100	30.55
	6:55	0.100	30.57
	7:55	0.100	30.58
	8:55	0.100	30.58
	9:55	0.100	30.58
	11:02	0.10	30.58
	11:58	0.01	30.56
	12:53	0.01	30.56
	13:15	Pumping Stopped	

Appendix HC-C

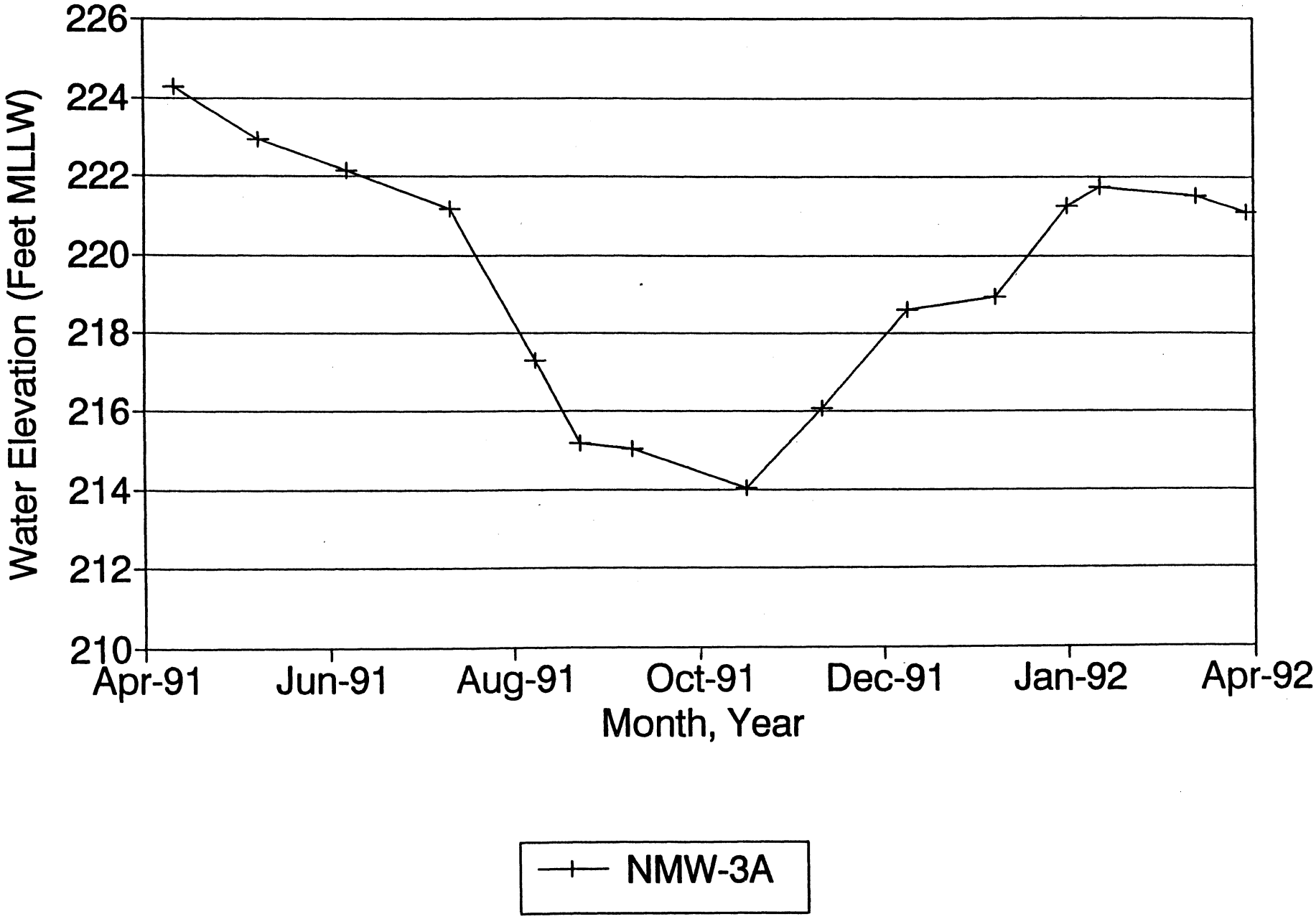
Hydrographs of Monthly Water Levels in Monitoring Wells


Monthly Water Elevations (NMW-1A)
South Tacoma Field
Water Elevation (Feet MLLW)
228
226
224
222
220
218
216
214
212
Apr-91
Jun-91
Aug-91
Oct-91
Dec-91
Jan-92
Apr-92
Month, Year
NMW-1A

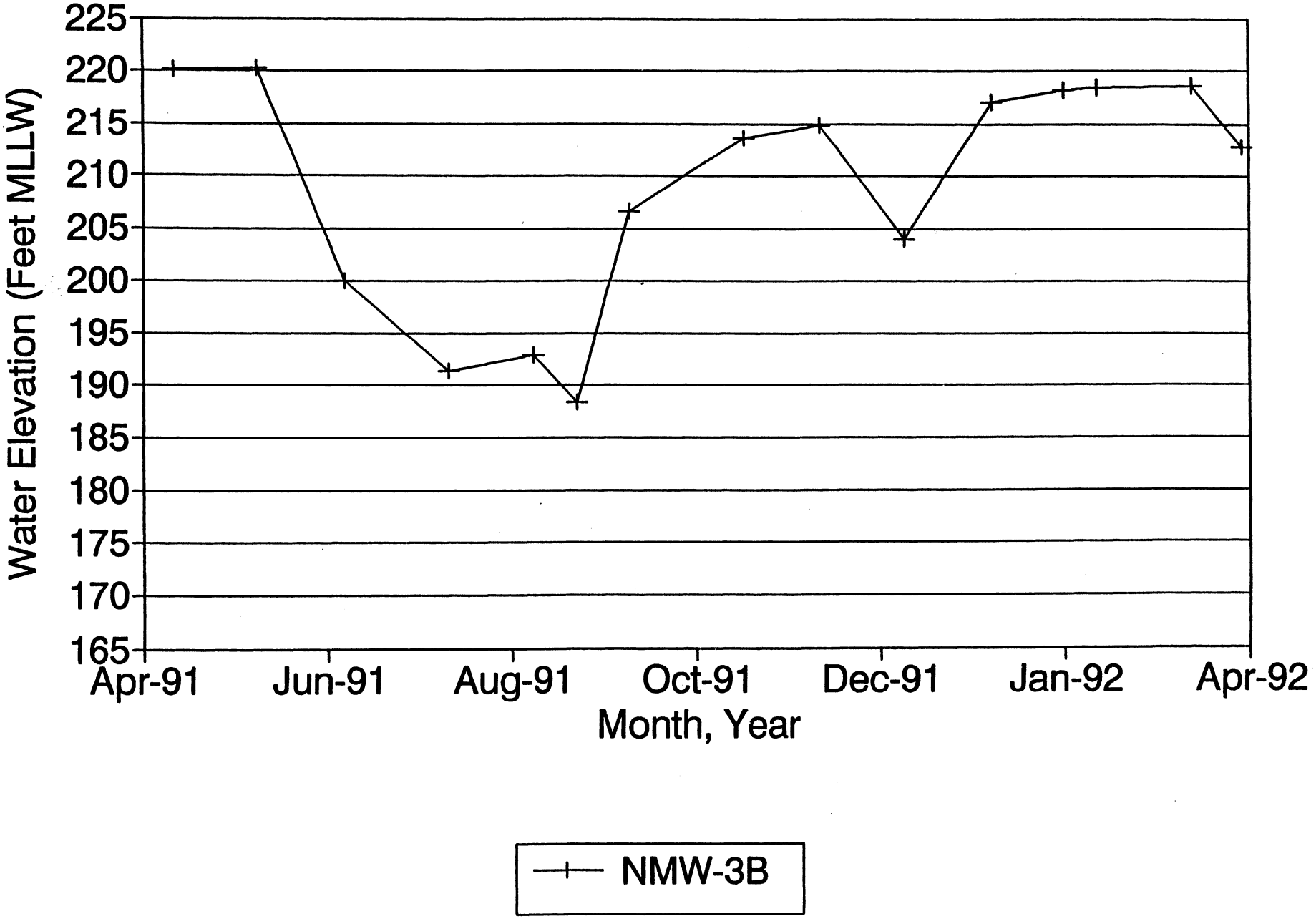
Monthly Water Elevations (NMW-2A)
South Tacoma Field



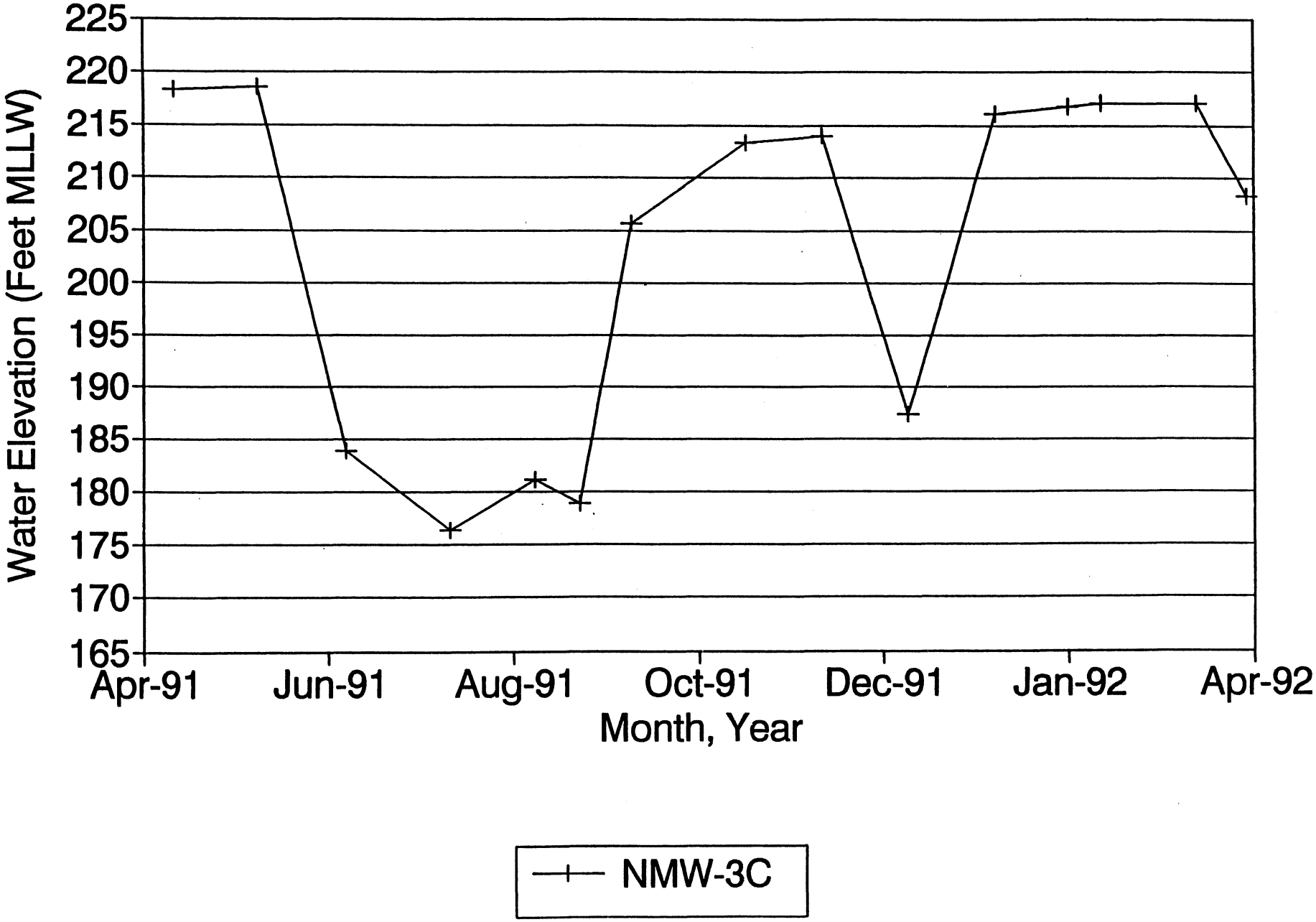
Monthly Water Elevations (NMW-3A)
South Tacoma Field



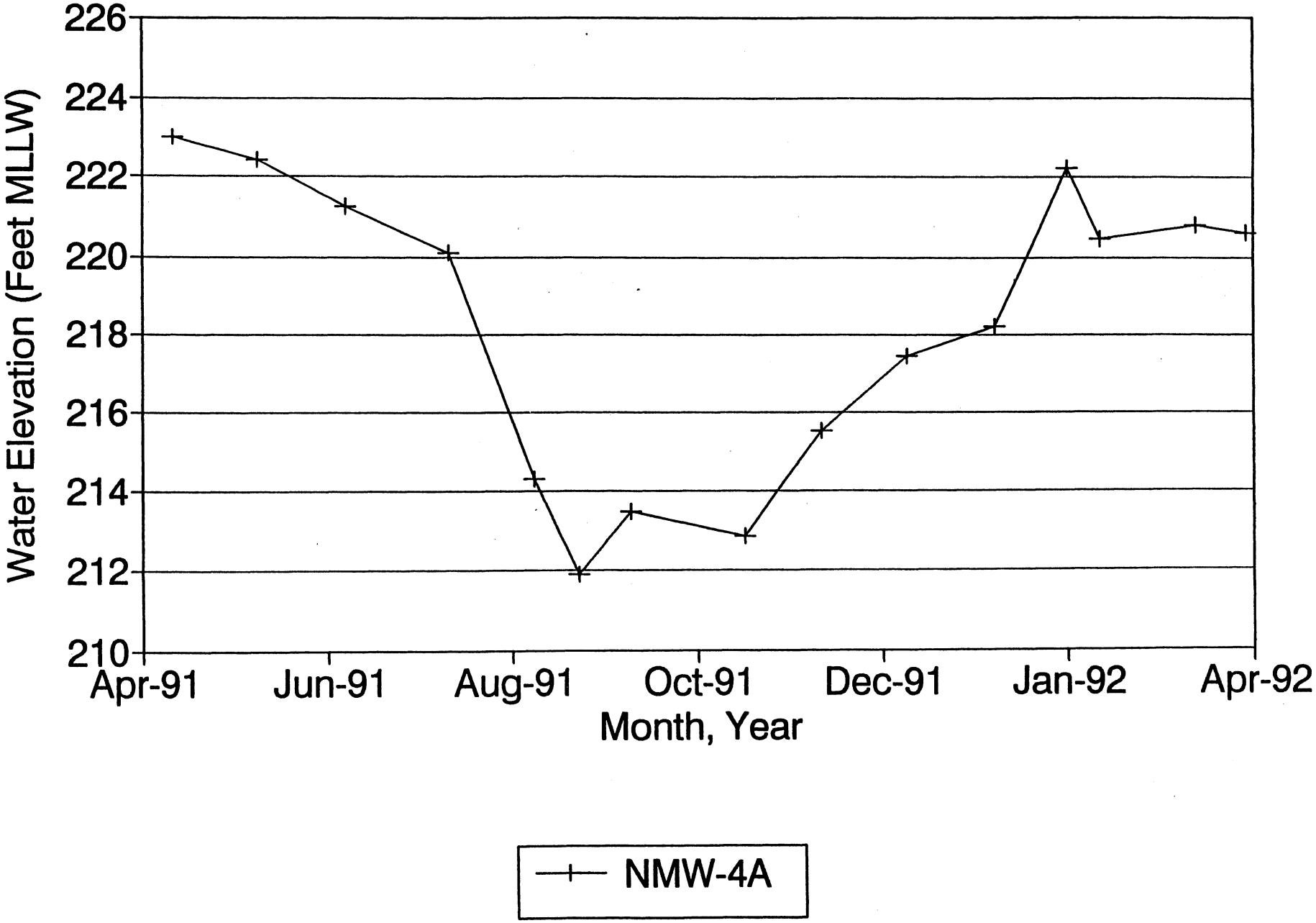
Monthly Water Elevations (NMW-3B)
South Tacoma Field

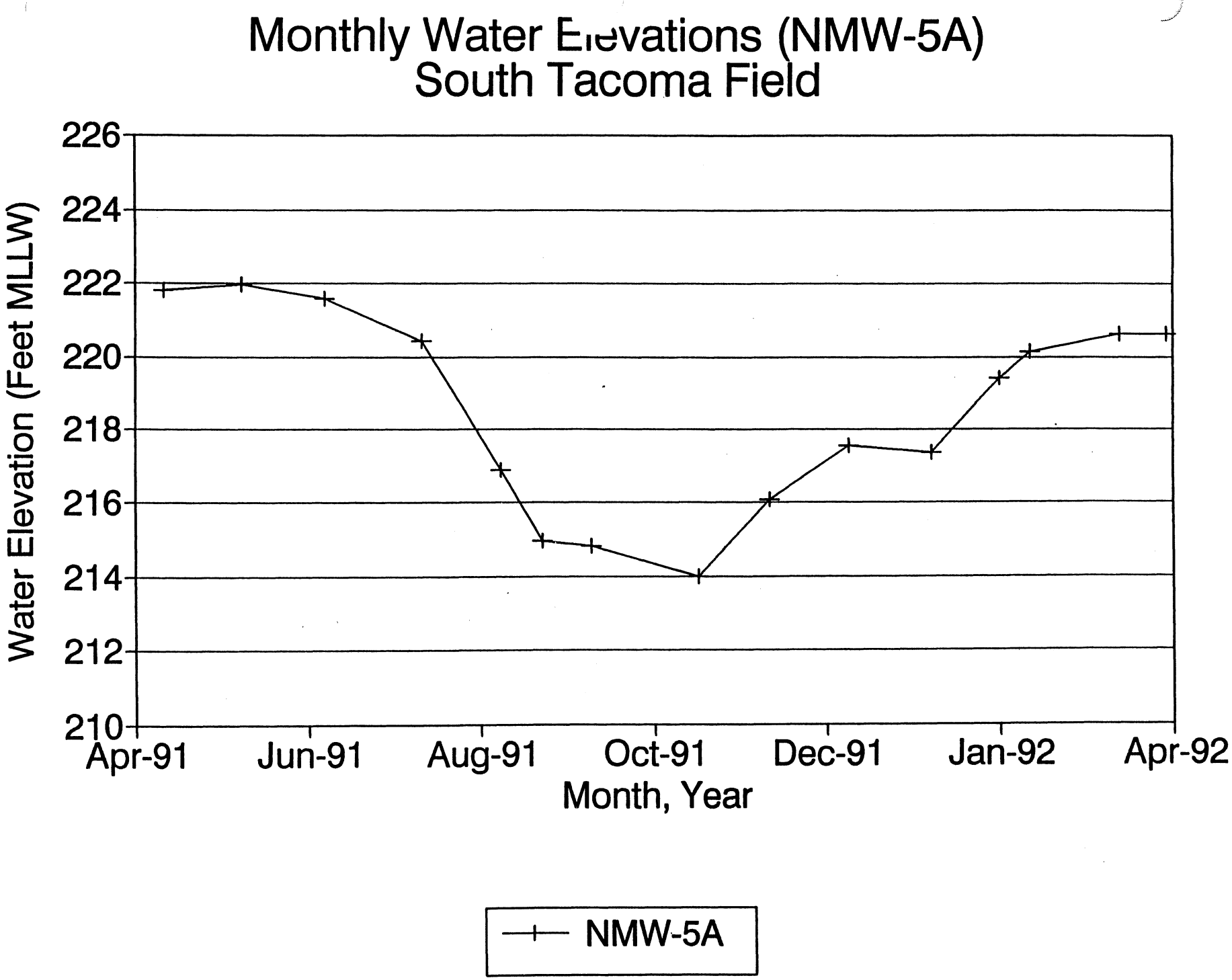


Monthly Water Elevations (NMW-3C)
South Tacoma Field

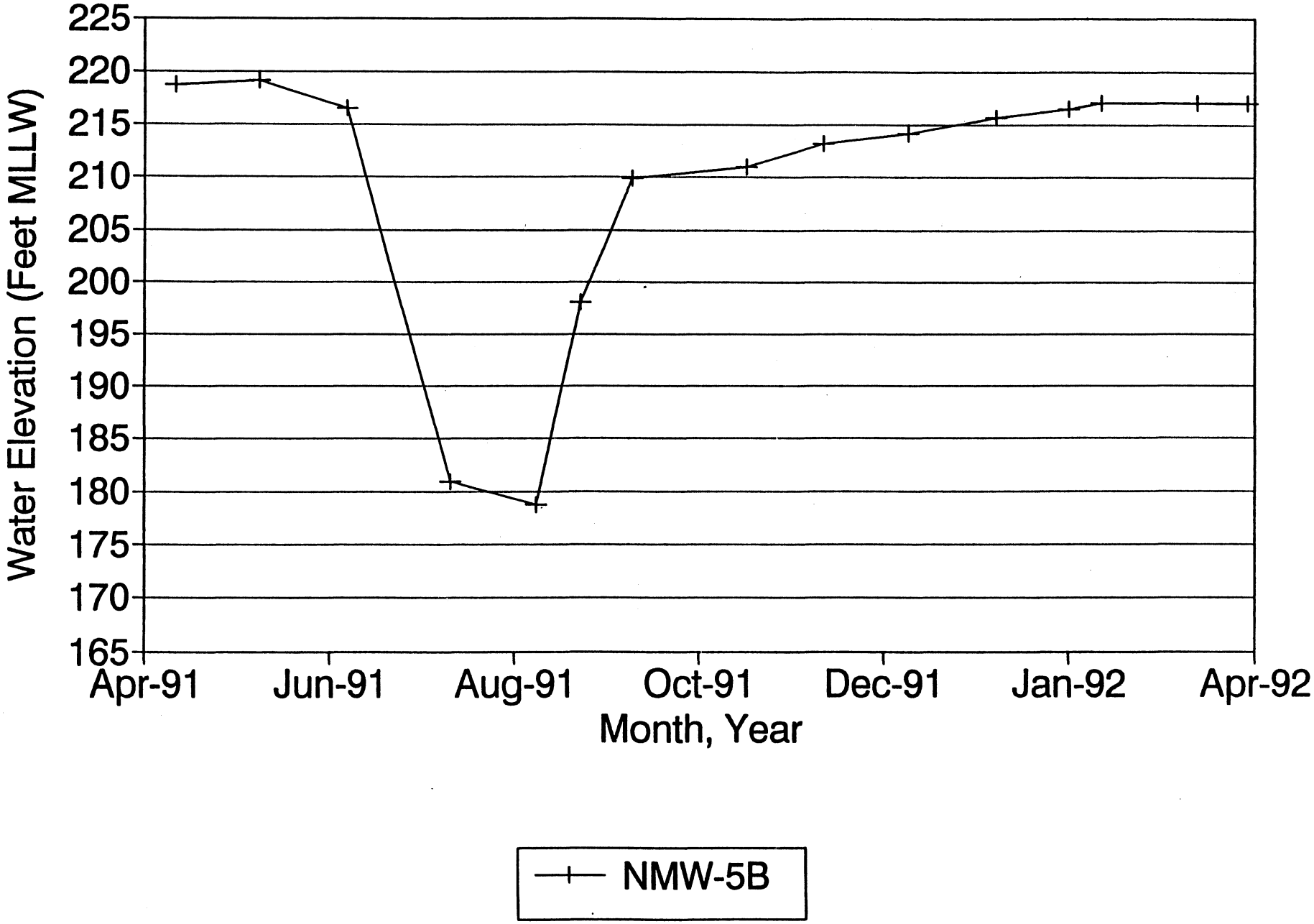


Monthly Water Elevations (NMW-4A)
South Tacoma Field

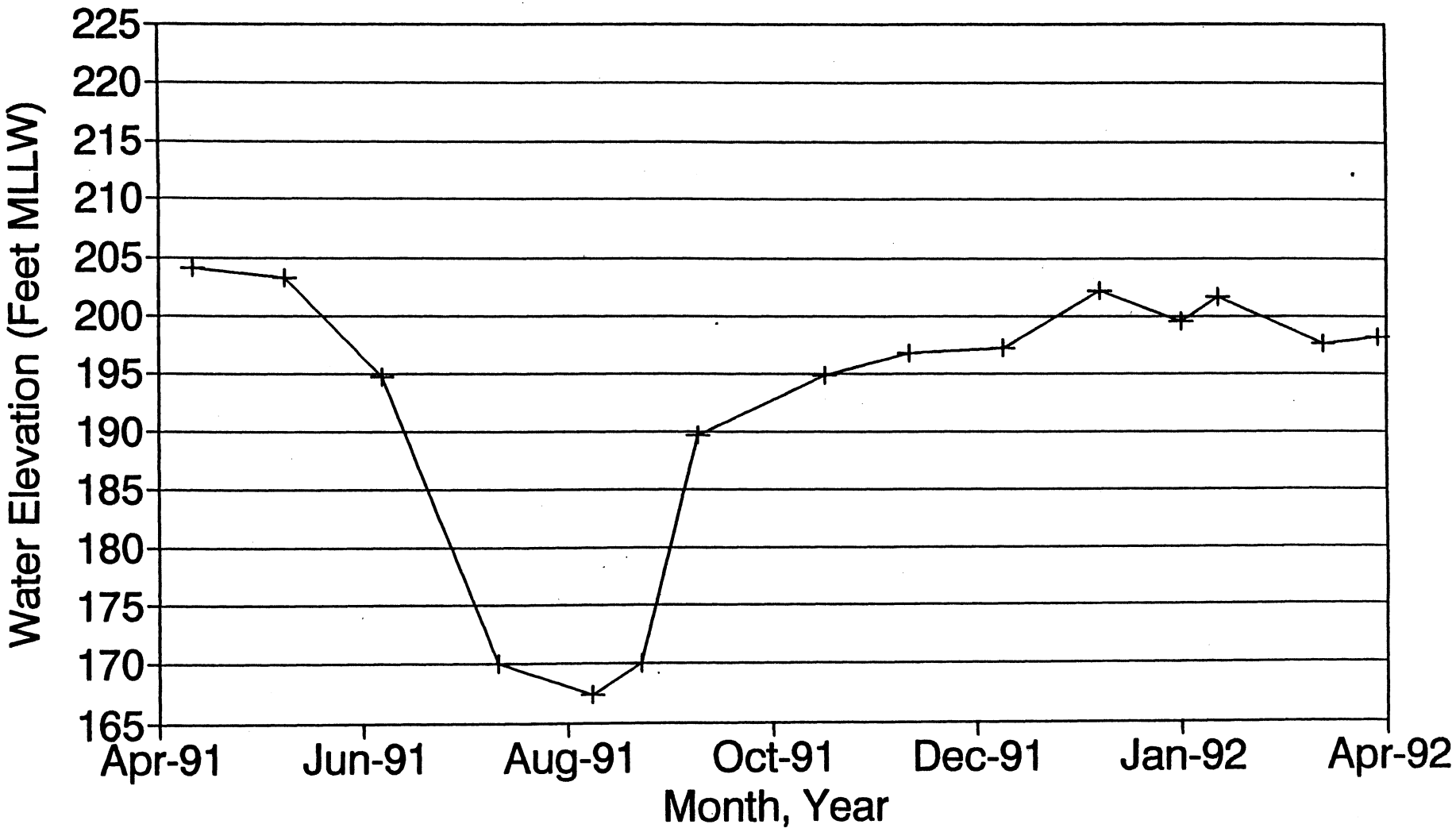



Monthly Water Elevations (NMW-5A)
South Tacoma Field
Water Elevation (Feet MLLW)
226
224
222
220
218
216
214
212
210
Apr-91
Jun-91
Aug-91
Oct-91
Dec-91
Jan-92
Apr-92
Month, Year
NMW-5A

Monthly Water Elevations (NMW-5B)
South Tacoma Field

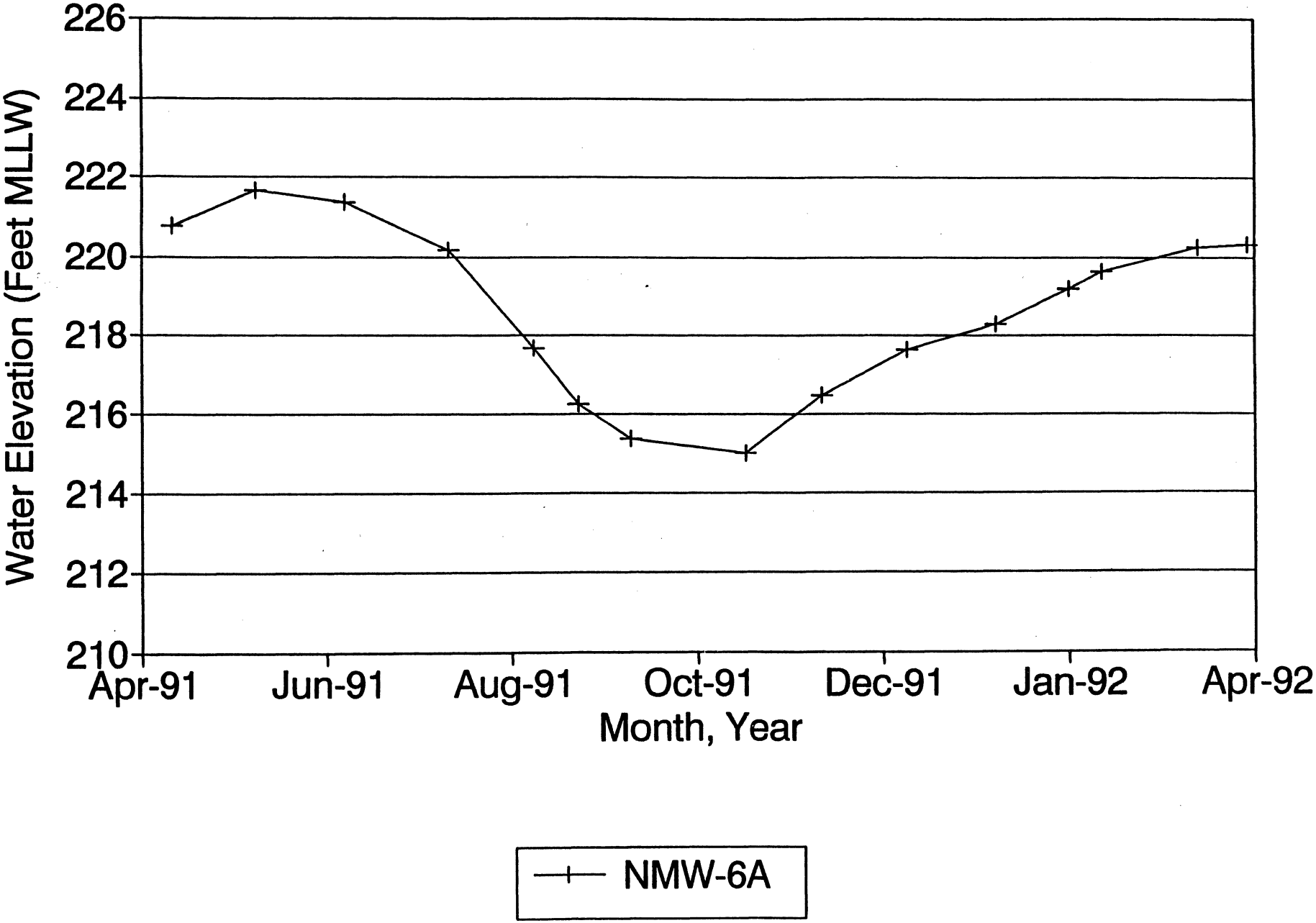


Monthly Water Elevations (NMW-5C)
South Tacoma Field

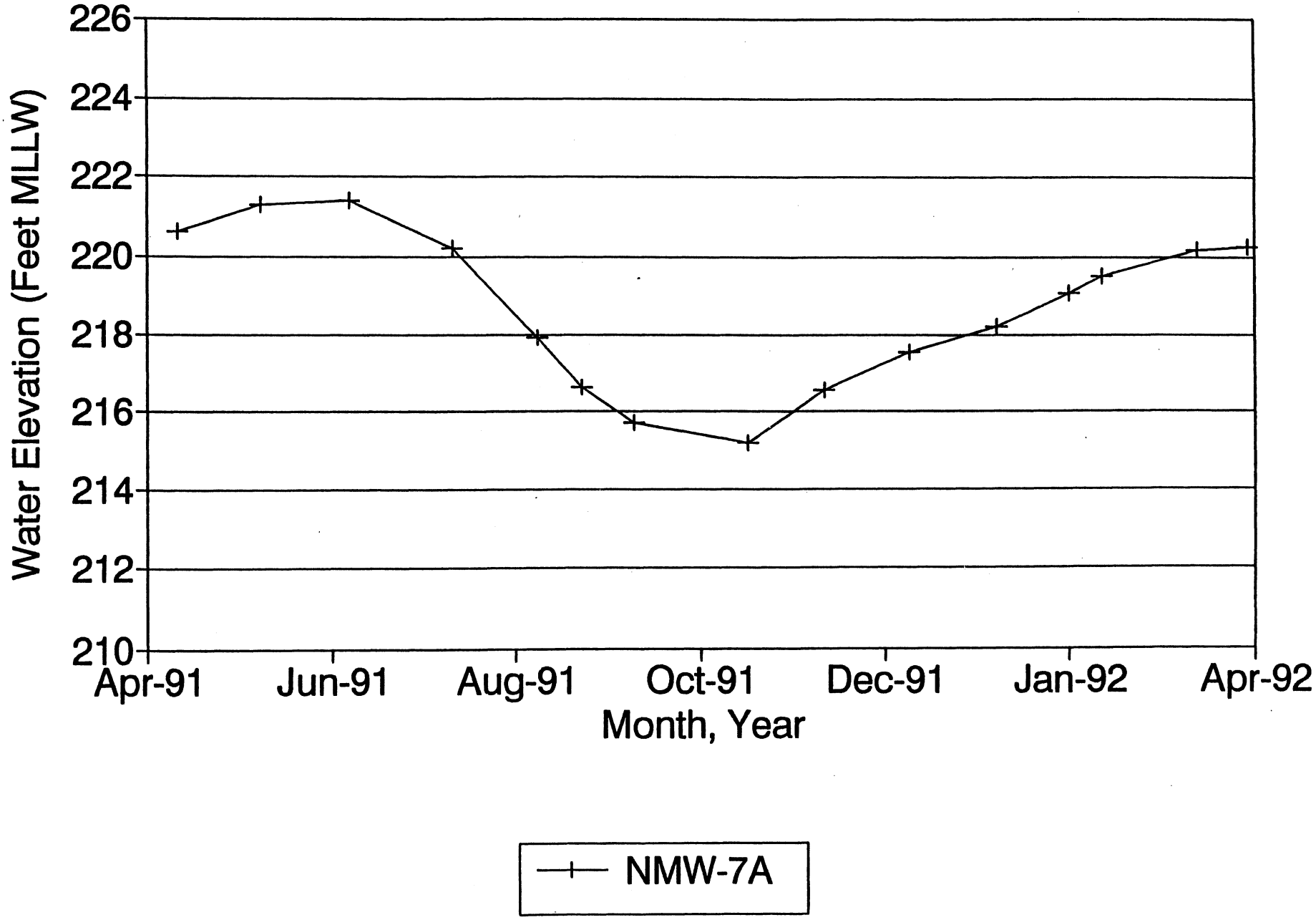


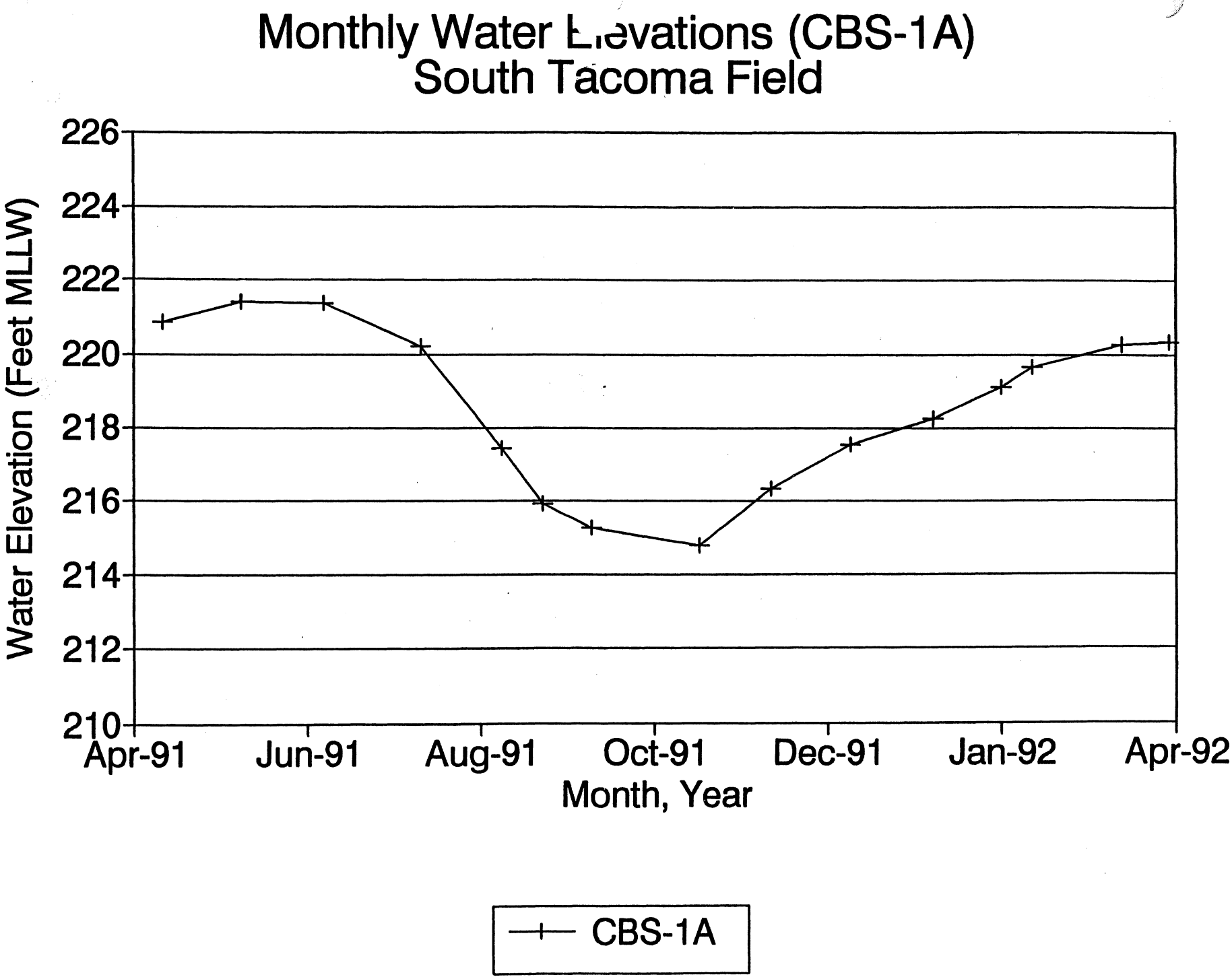
NMW-5C

Monthly Water Elevations (NMW-6A)
South Tacoma Field

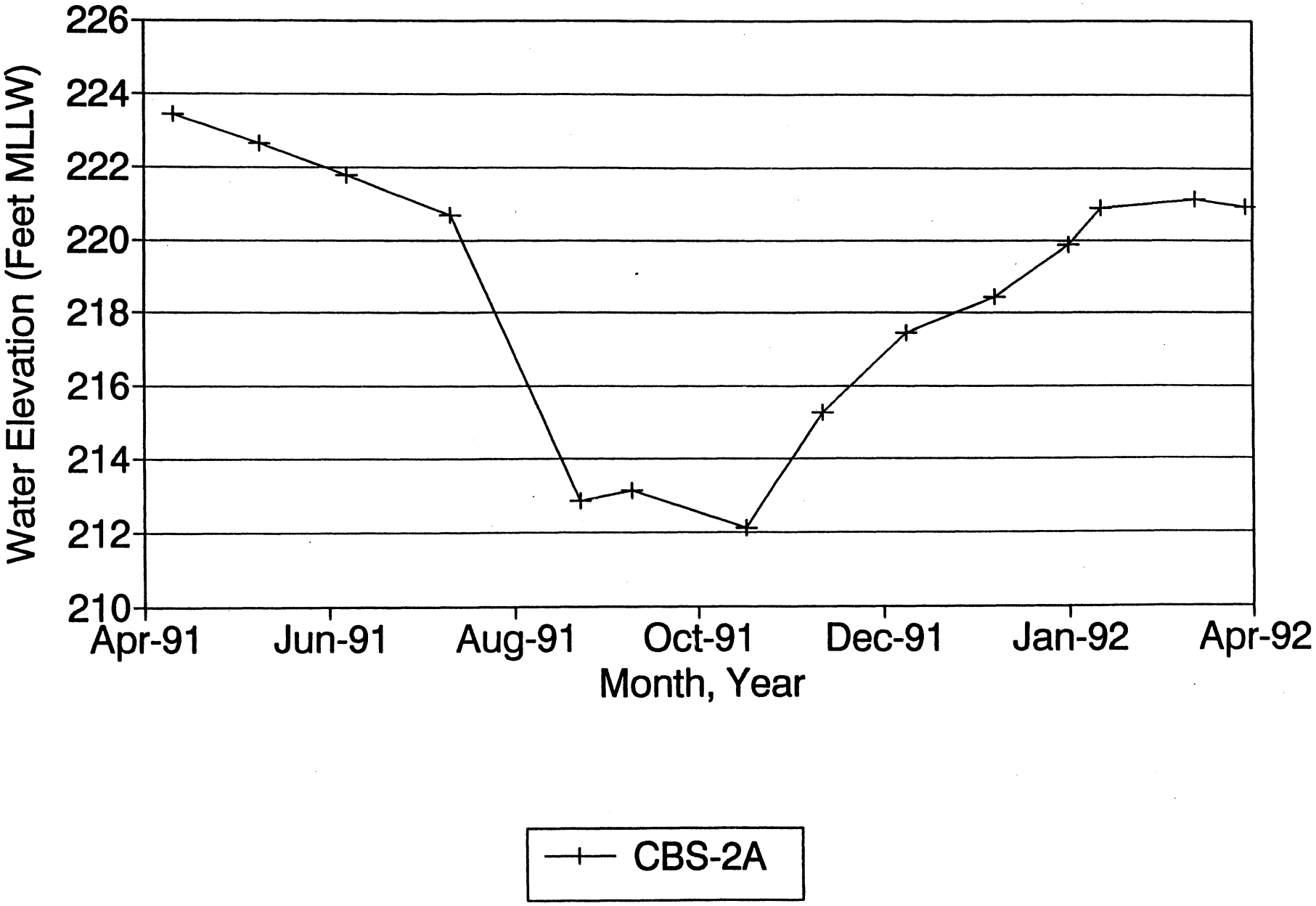


Monthly Water Elevations (NMW-7A)
South Tacoma Field

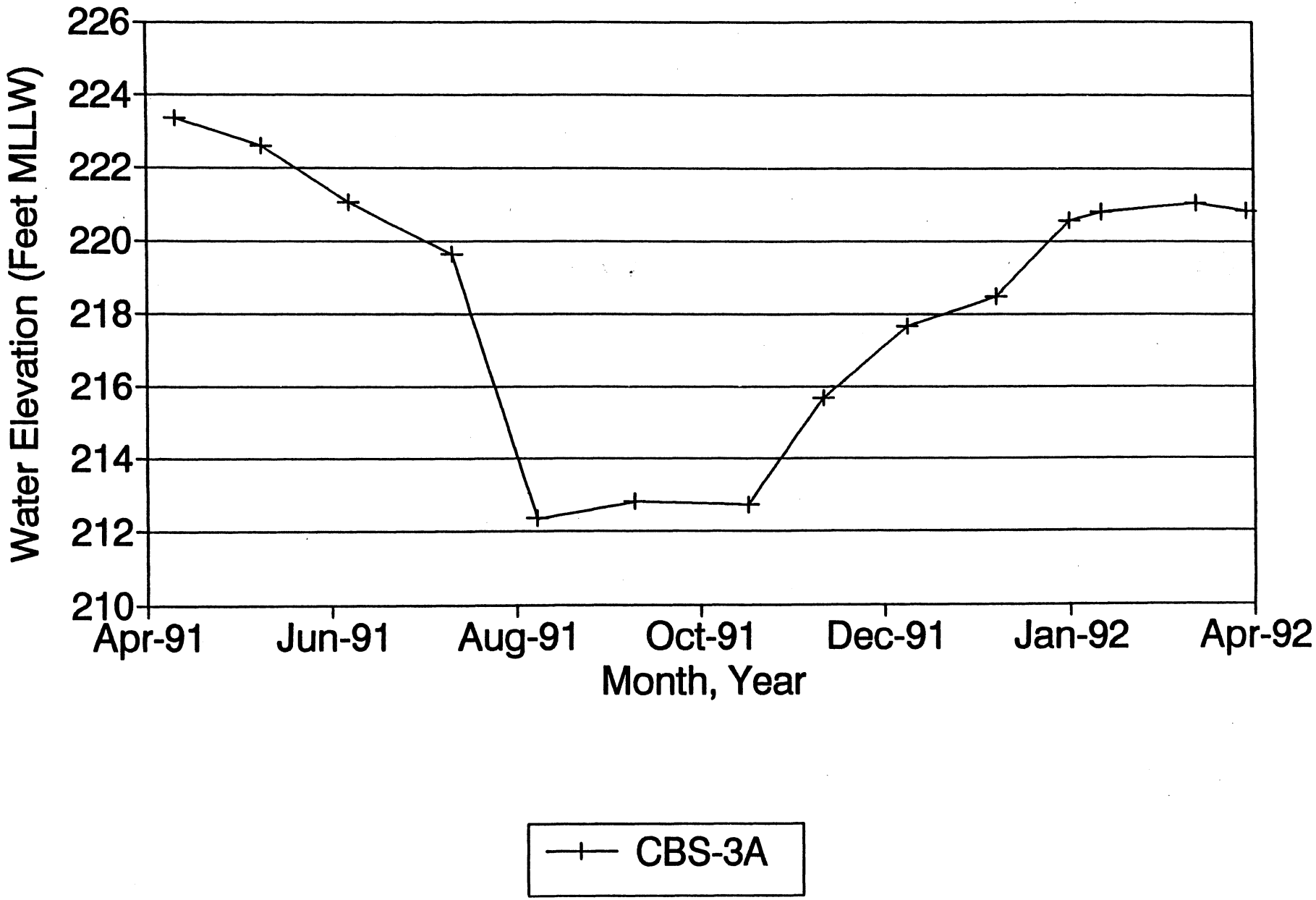



Monthly Water Elevations (CBS-1A)
South Tacoma Field
Water Elevation (Feet MLLW)
226
224
222
220
218
216
214
212
210
Apr-91
Jun-91
Aug-91
Oct-91
Dec-91
Jan-92
Apr-92
Month, Year
CBS-1A

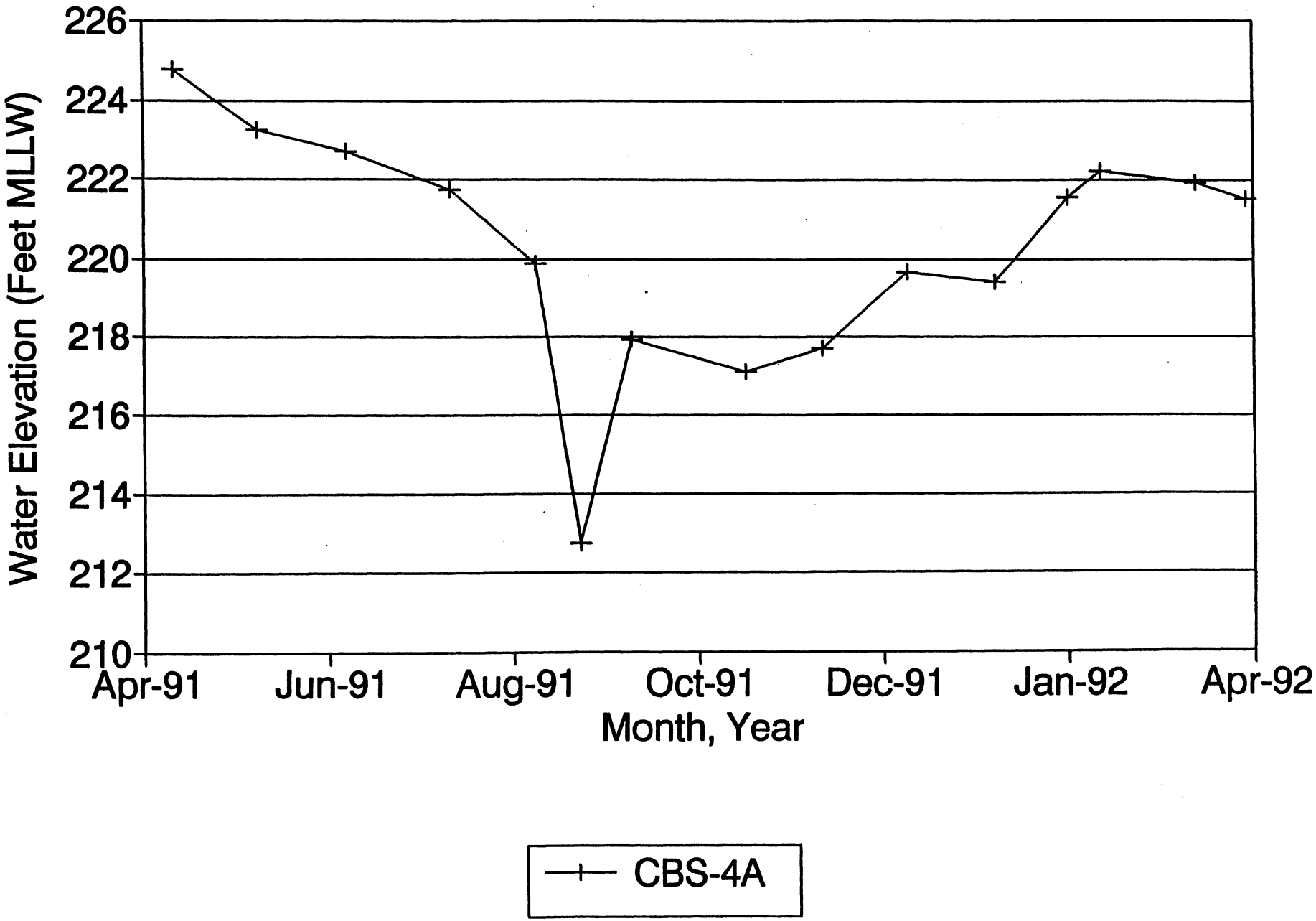
Monthly Water Elevations (CBS-2A)
South Tacoma Field

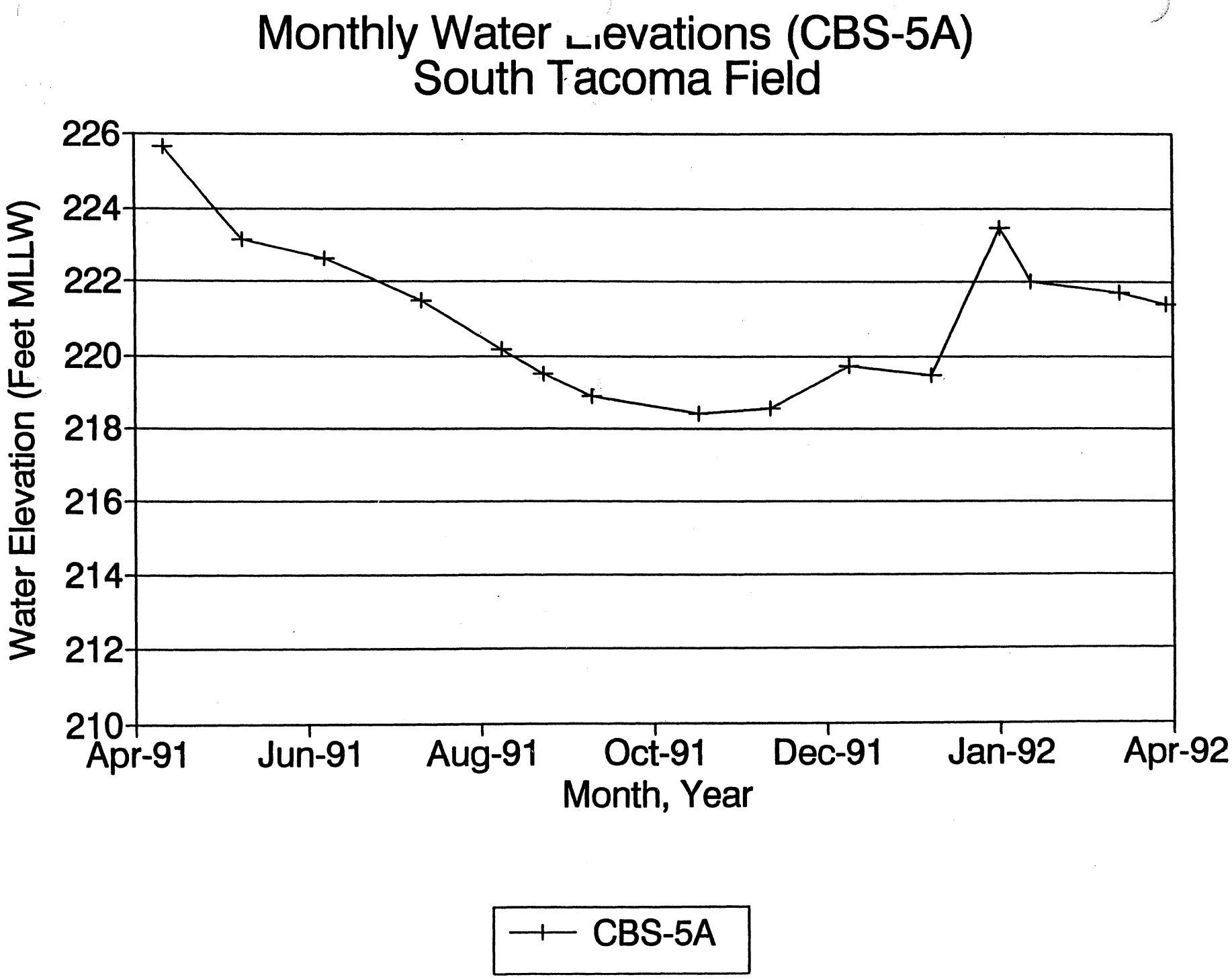


Monthly Water Elevations (CBS-3A)
South Tacoma Field

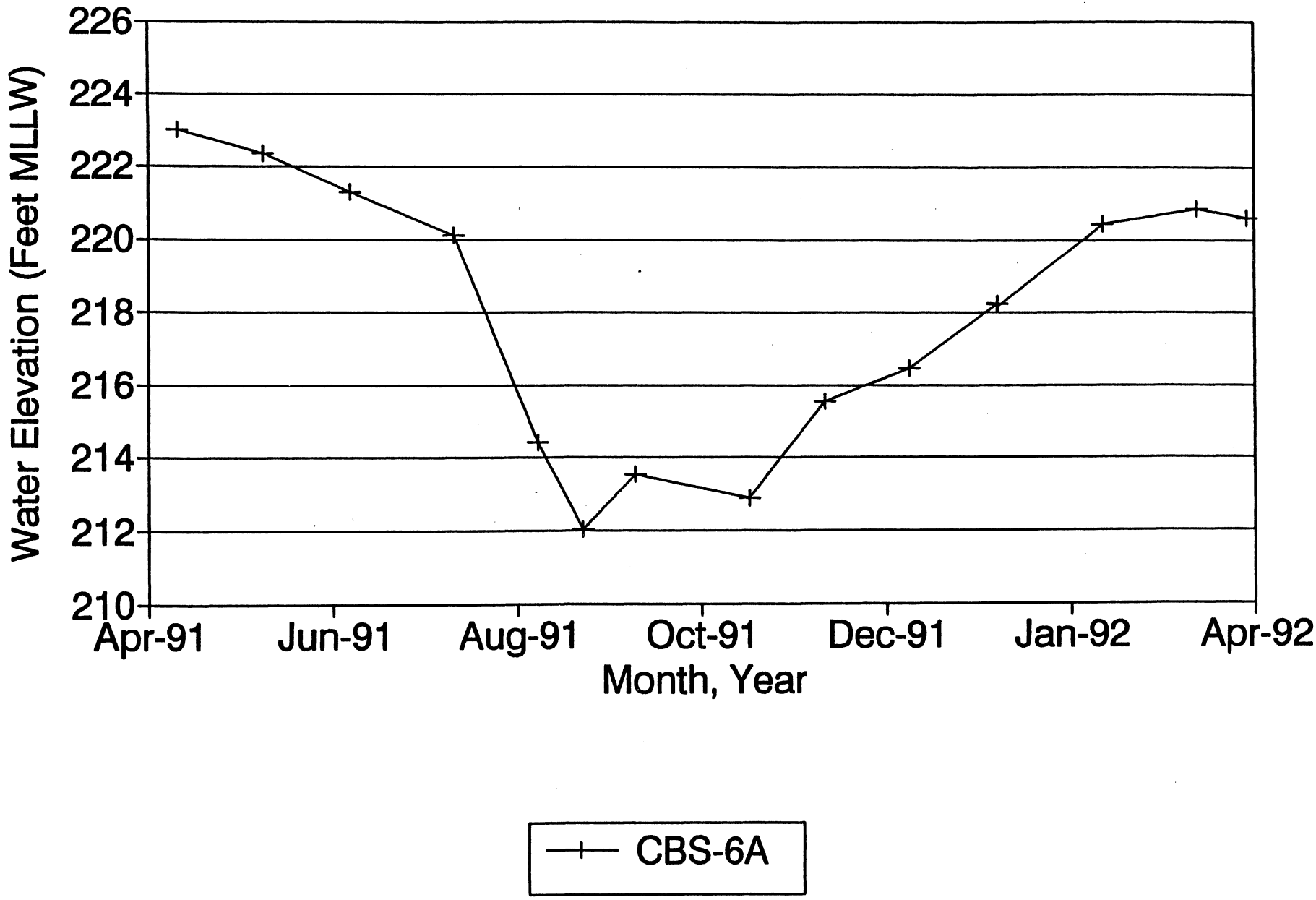


Monthly Water Elevations (CBS-4A)
South Tacoma Field

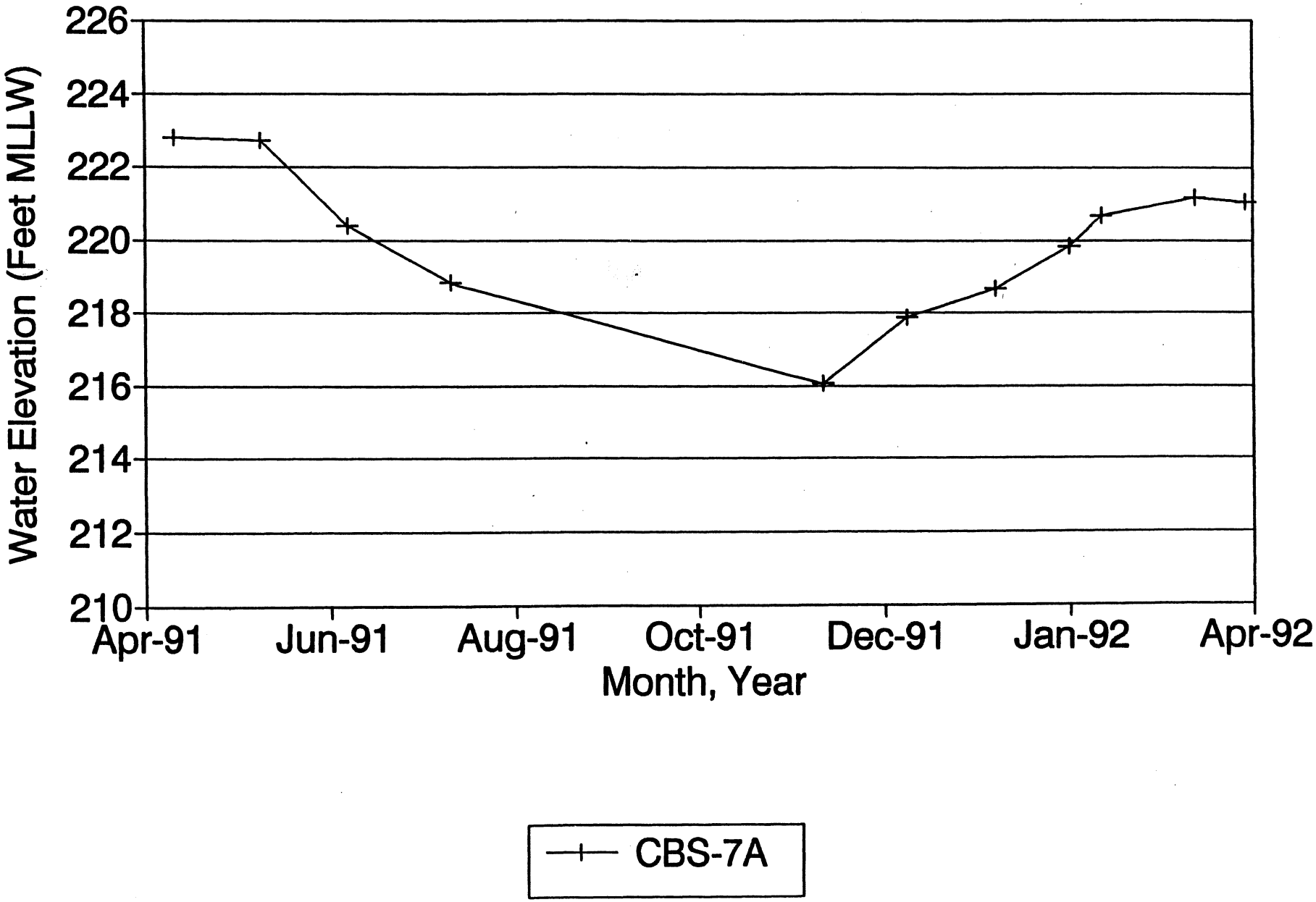


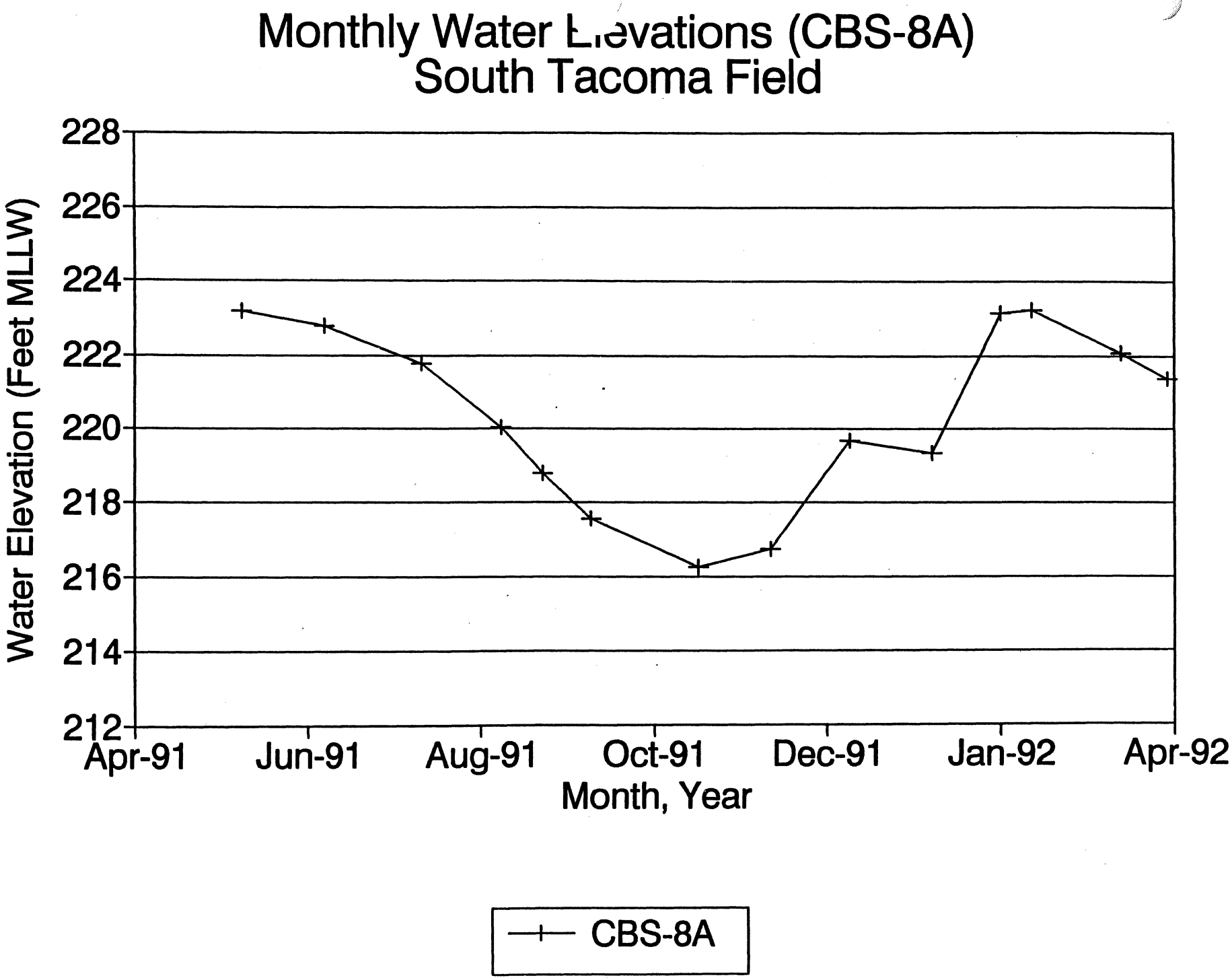

Monthly Water Elevations (CBS-5A)
South Tacoma Field
Water Elevation (Feet MLLW)
226
224
222
220
218
216
214
212
210
Apr-91
Jun-91
Aug-91
Oct-91
Dec-91
Jan-92
Apr-92
Month, Year
CBS-5A

Monthly Water Elevations (CBS-6A)
South Tacoma Field

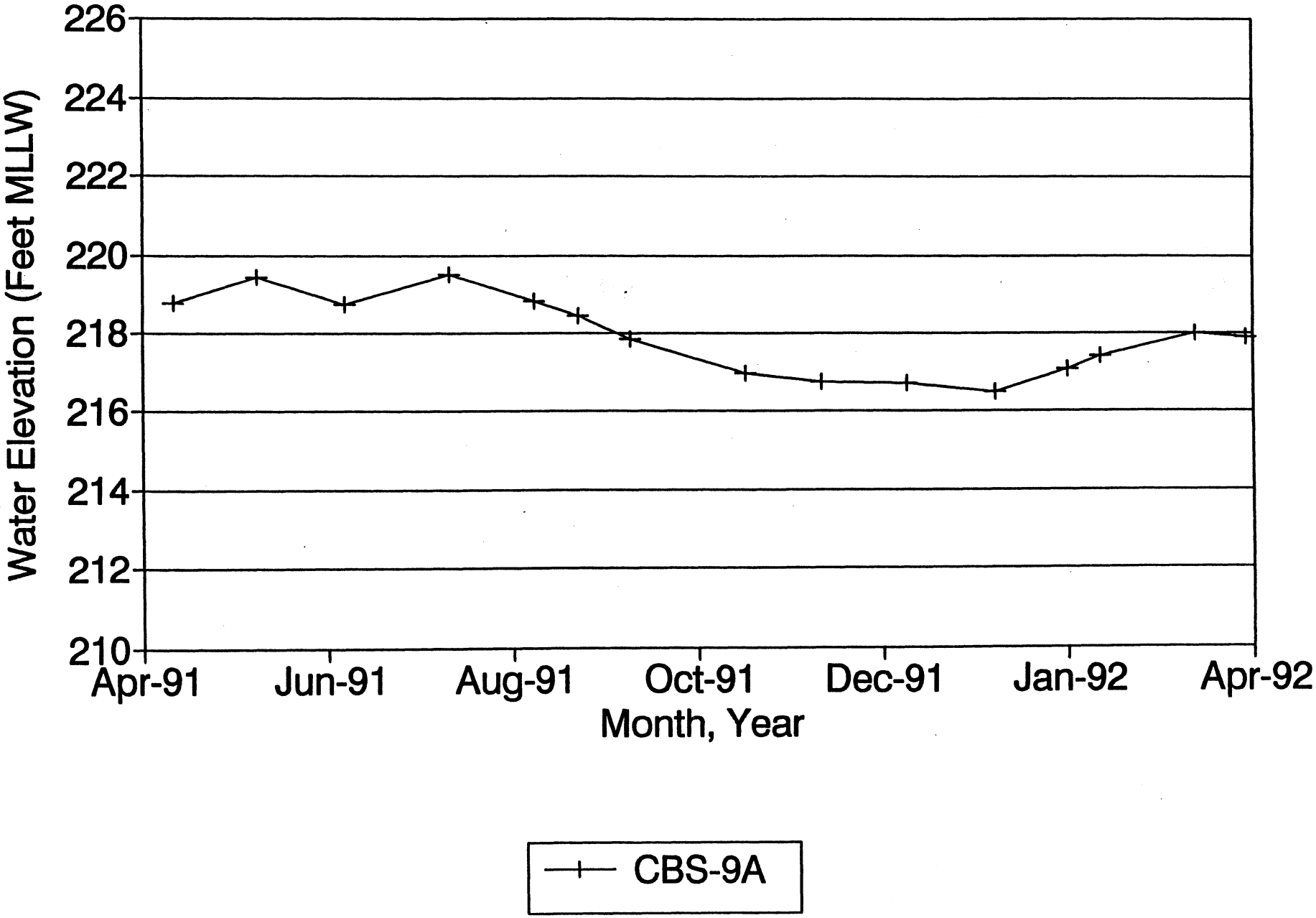


Monthly Water Elevations (CBS-7A)
South Tacoma Field

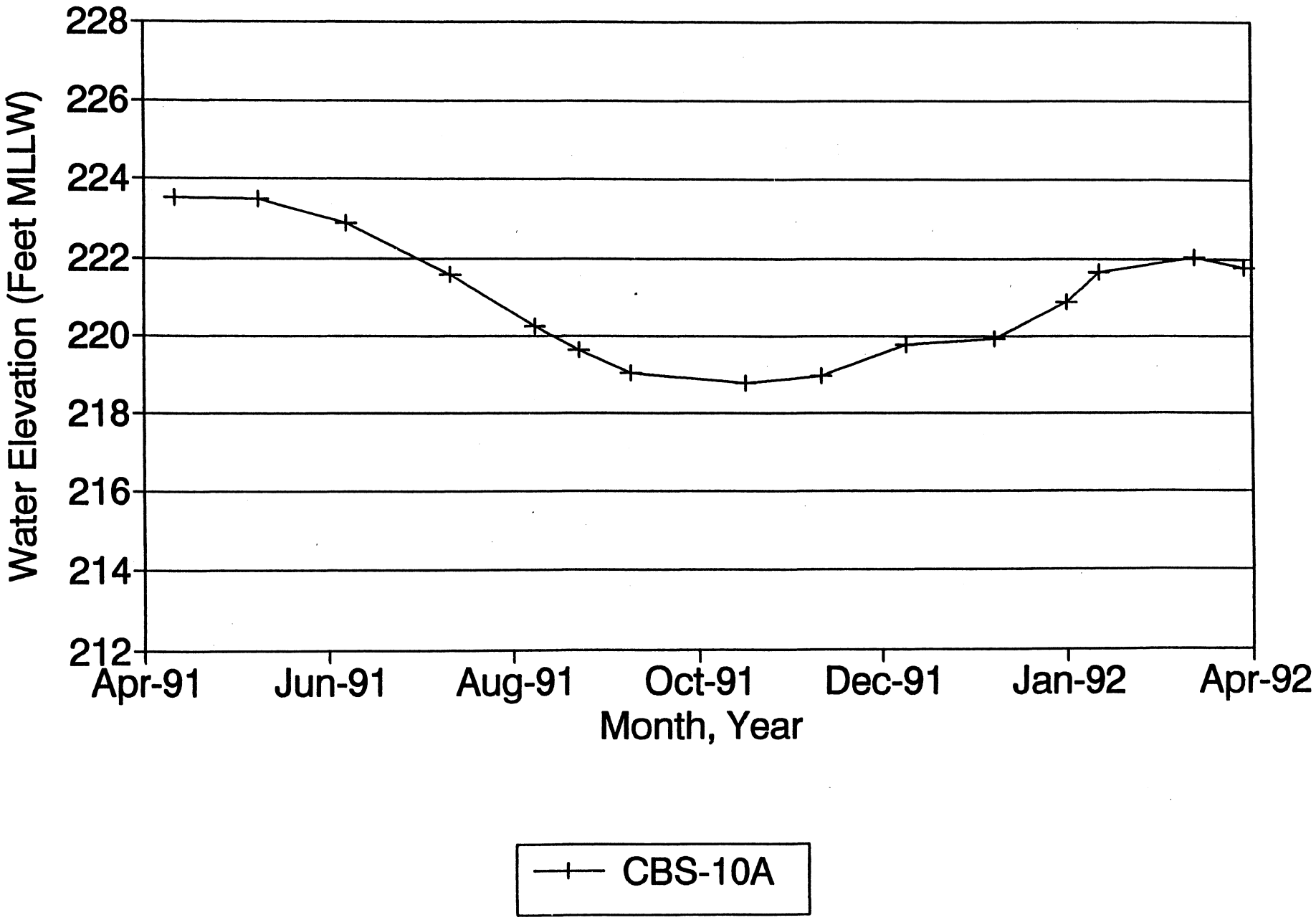



Monthly Water Elevations (CBS-8A)
South Tacoma Field
Water Elevation (Feet MLLW)
228
226
224
222
220
218
216
214
212
Apr-91
Jun-91
Aug-91
Oct-91
Dec-91
Jan-92
Apr-92
Month, Year
CBS-8A

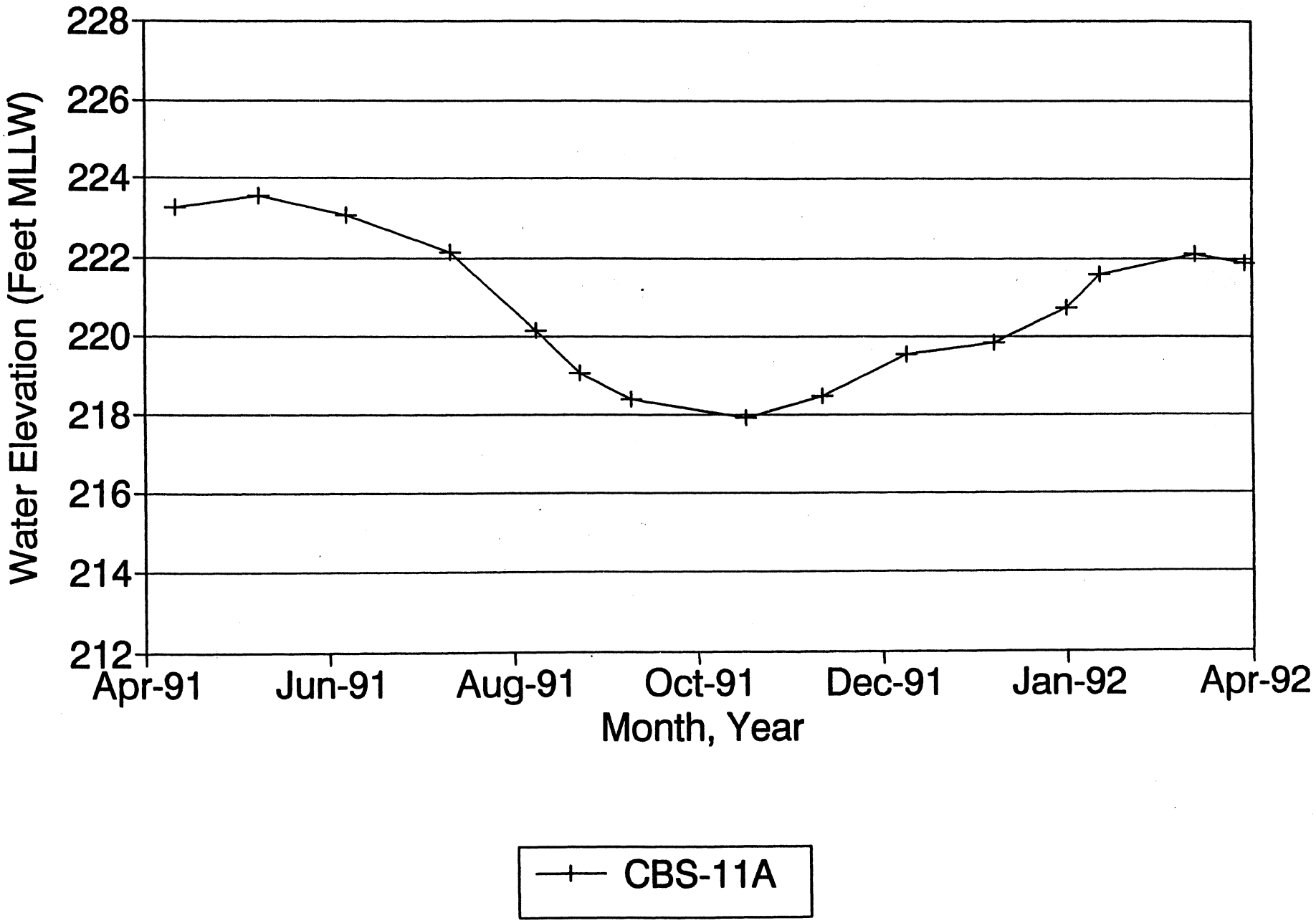
Monthly Water Elevations (CBS-9A)
South Tacoma Field



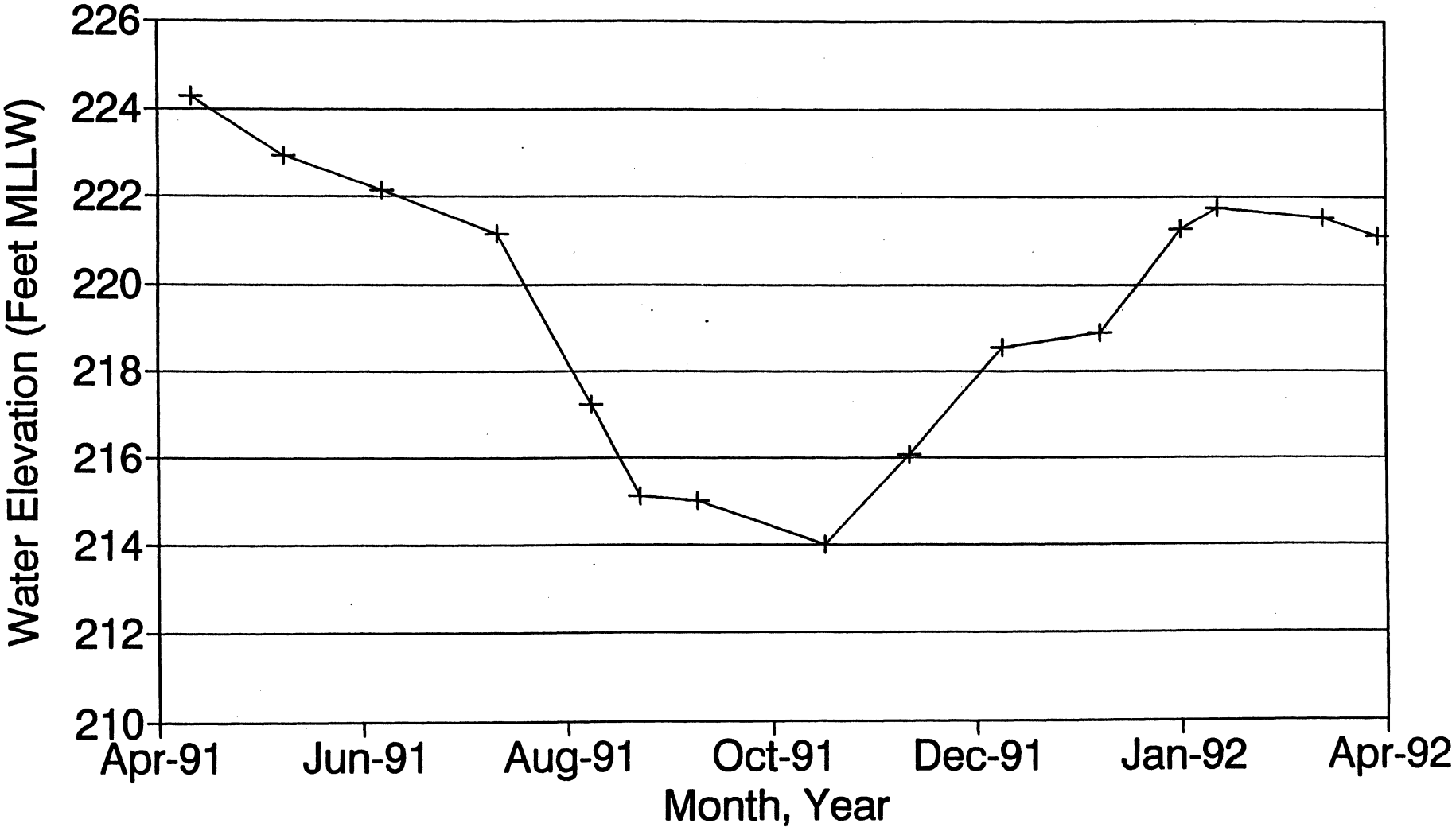
Monthly Water Elevations (CBS-10A)
South Tacoma Field



Monthly Water Elevations (CBS-11A)
South Tacoma Field

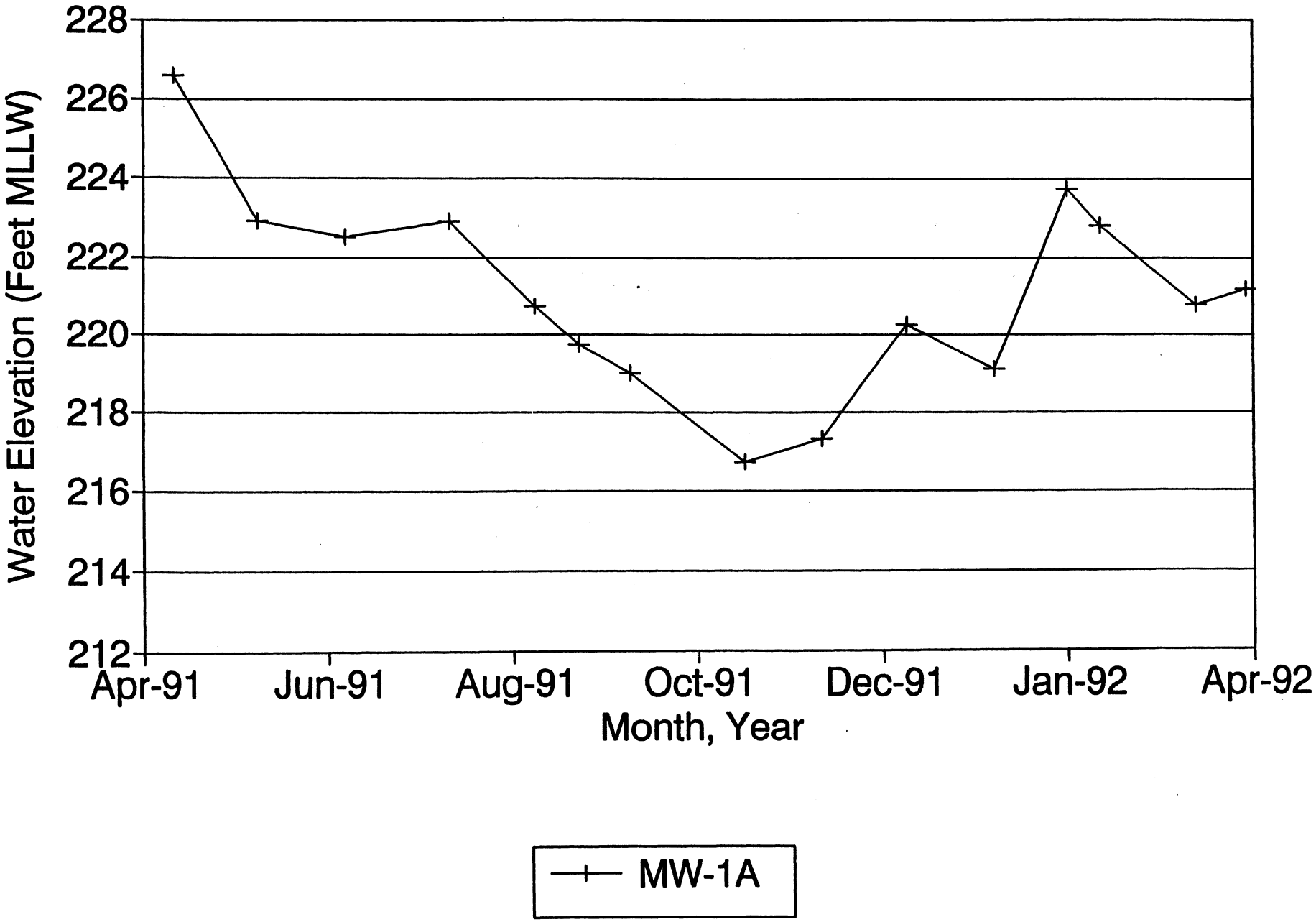


Monthly Water Elevations (CBS-12A)
South Tacoma Field

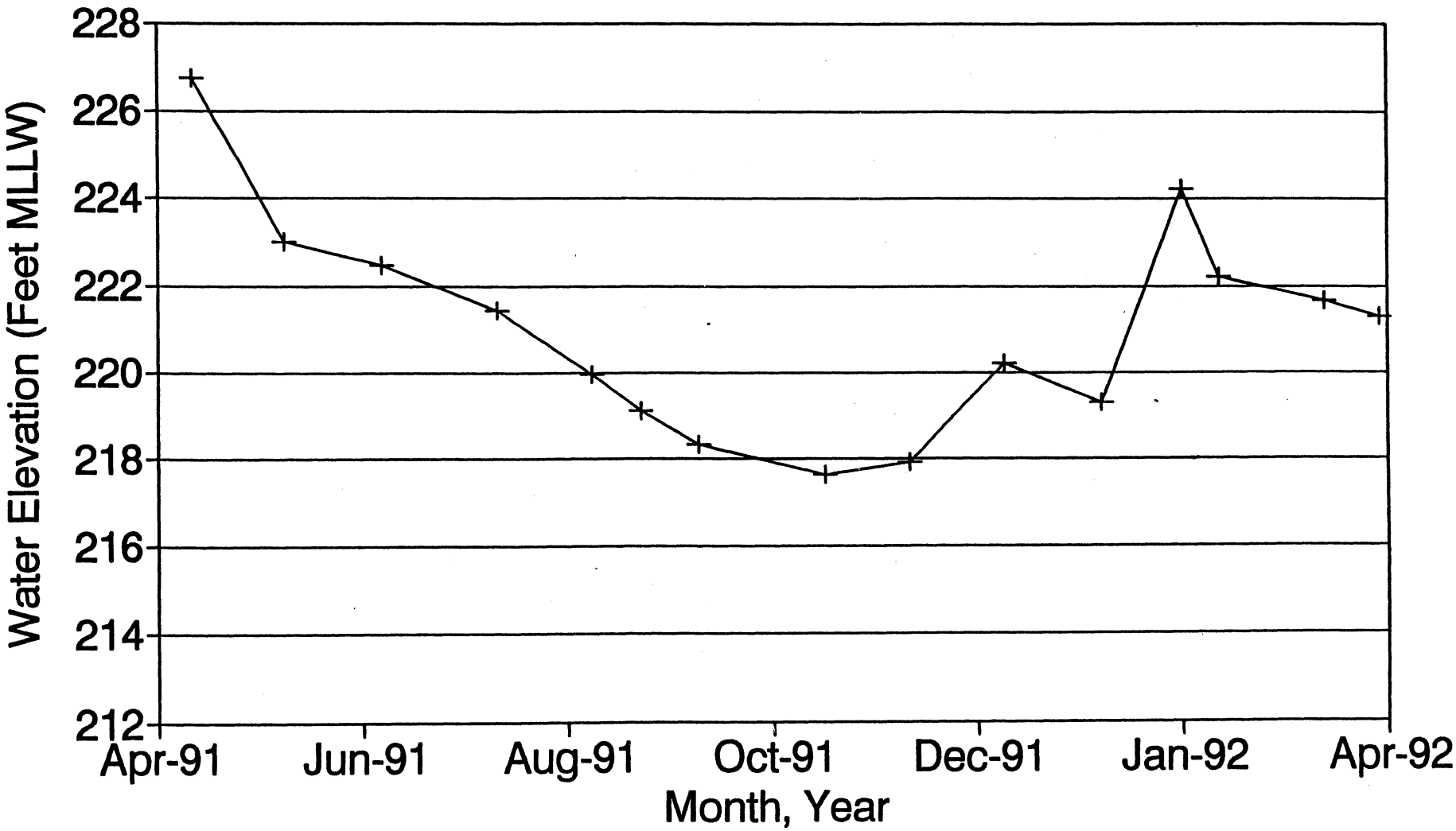


CBS-12A

Monthly Water Elevations (MW-1A)
South Tacoma Field

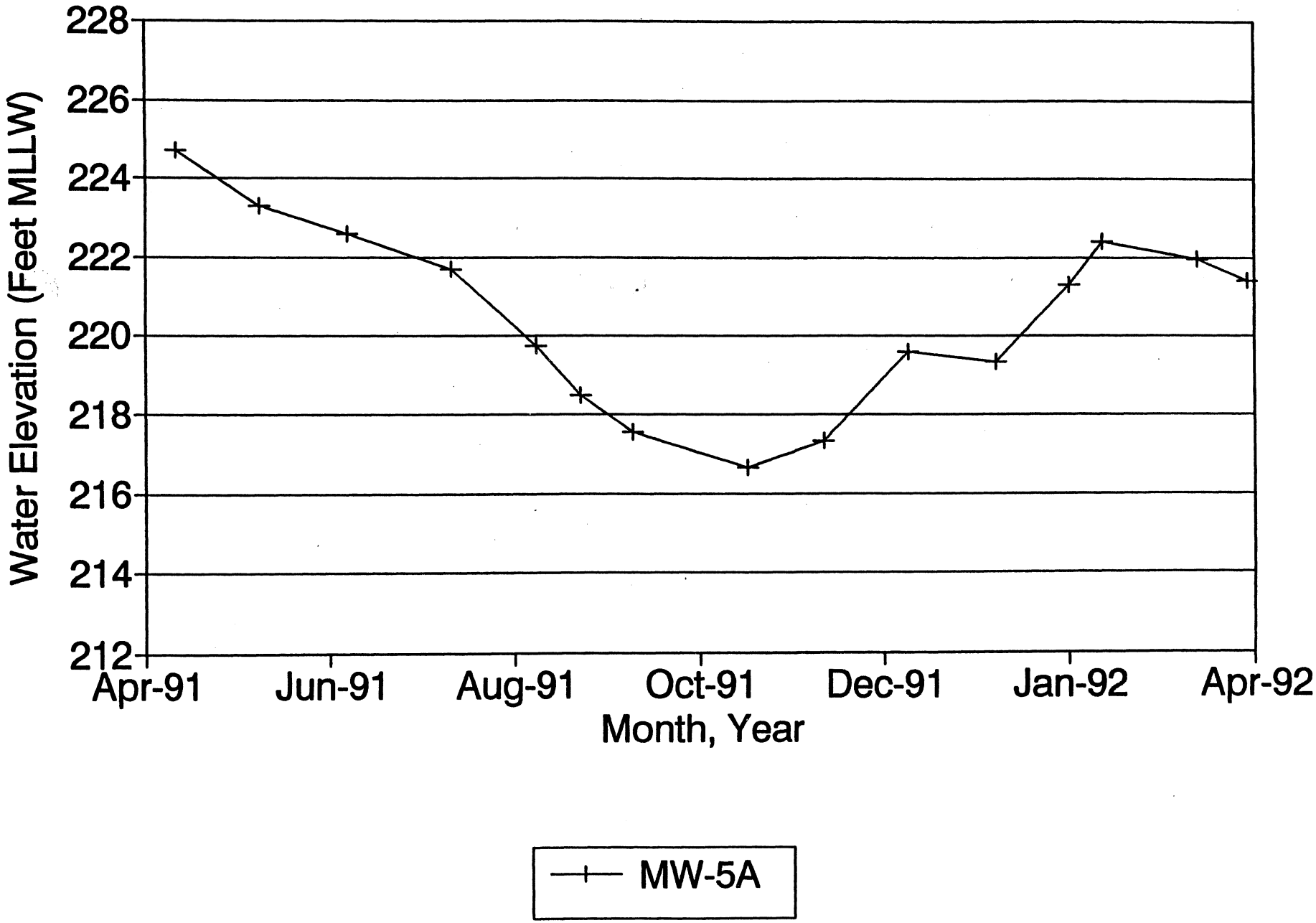


Monthly Water Elevations (MW-3A)
South Tacoma Field

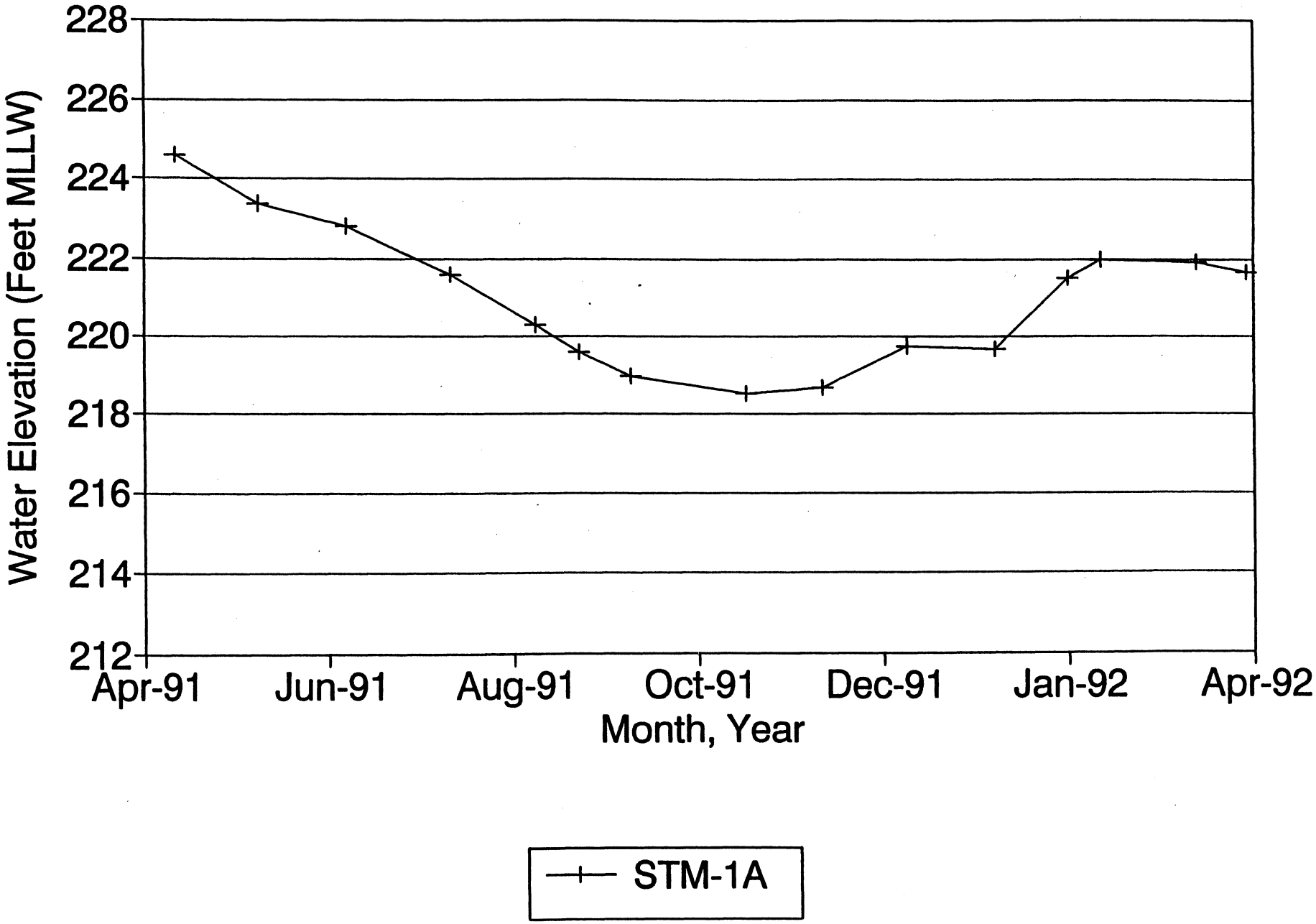


MW-3A

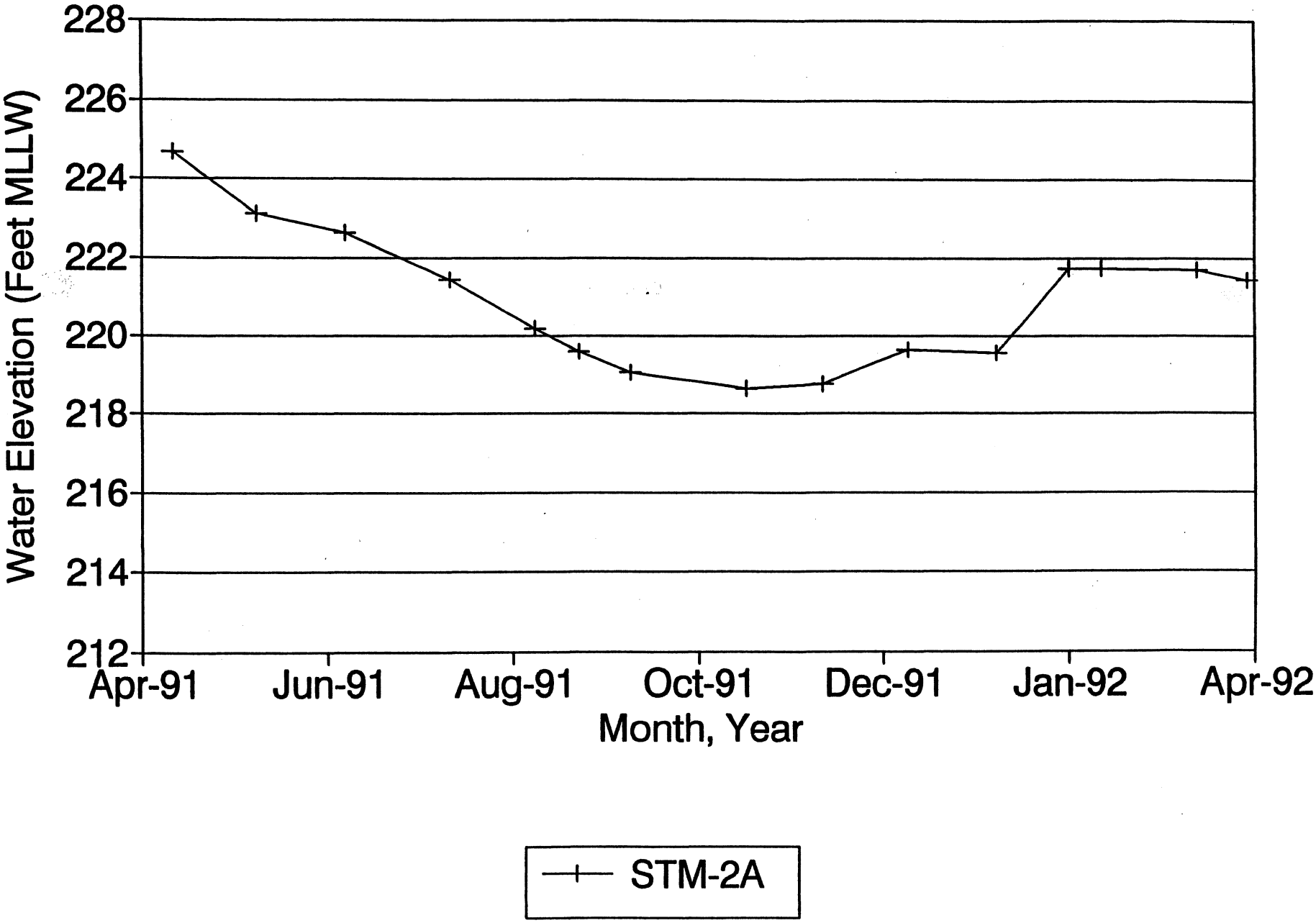
Monthly Water Elevations (MW-5A)
South Tacoma Field



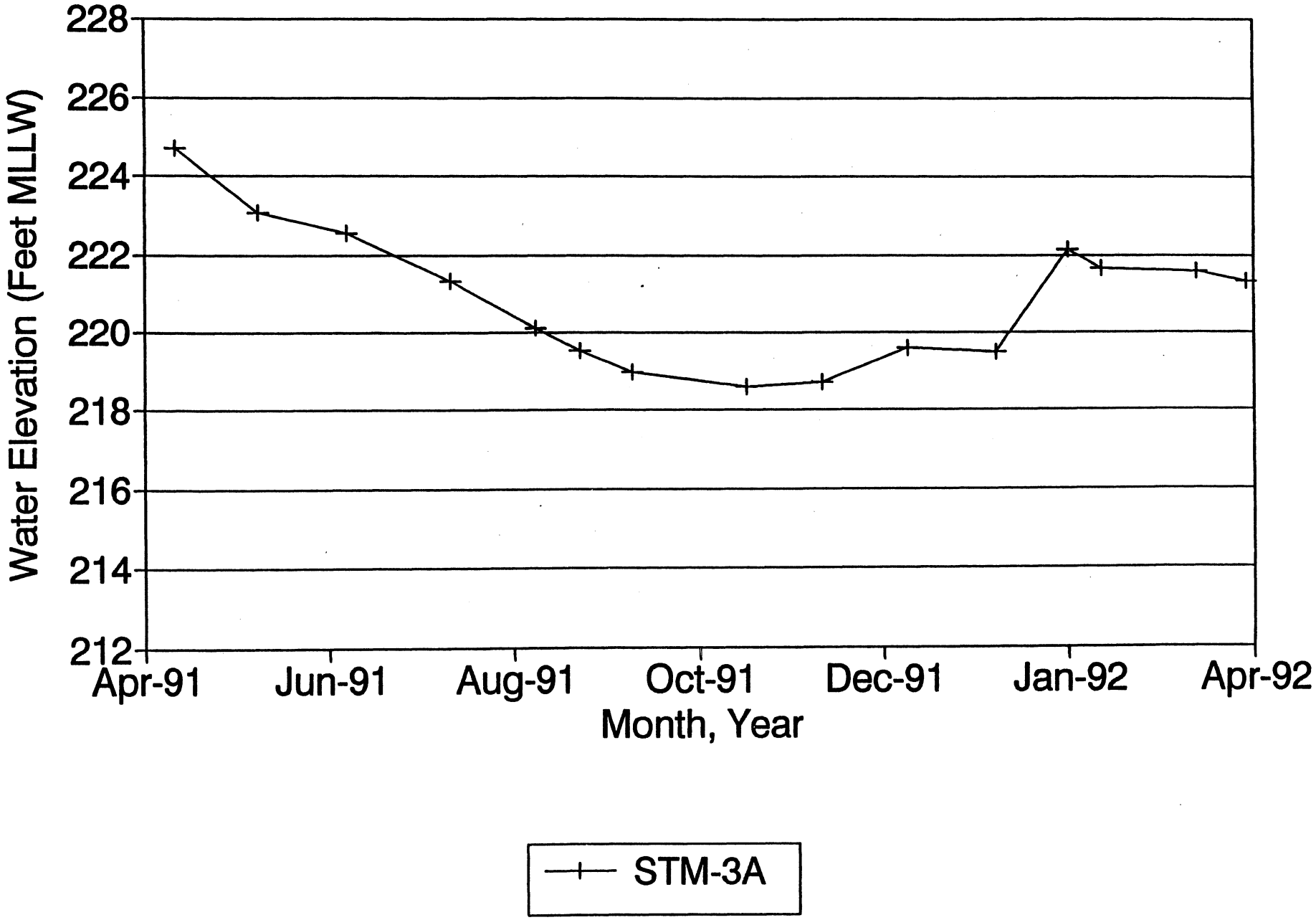
Monthly Water Elevations (STM-1A)
South Tacoma Field



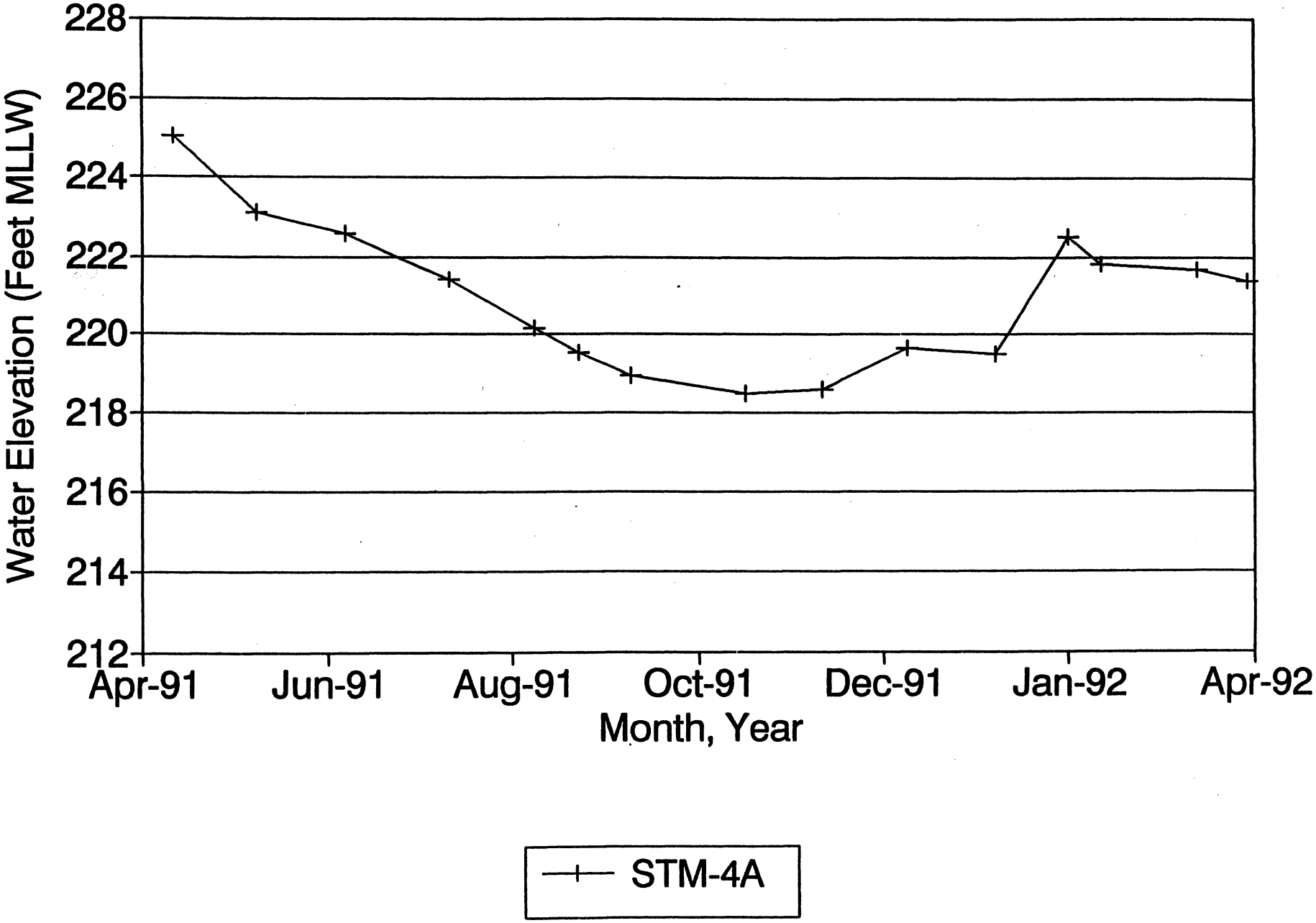
Monthly Water Elevations (STM-2A)
South Tacoma Field



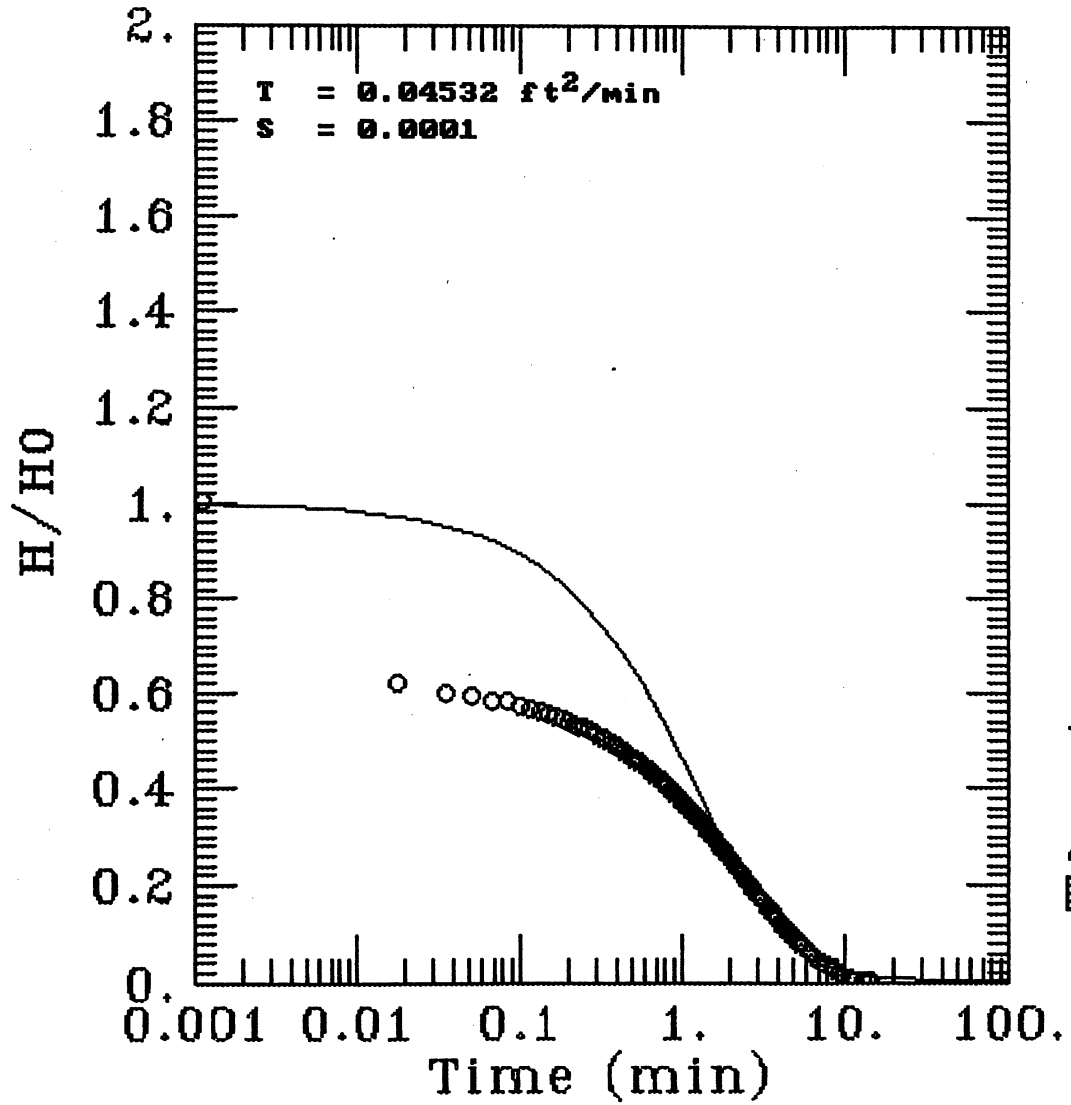
Monthly Water Elevations (STM-3A)
South Tacoma Field



Monthly Water Elevations (STM-4A)
South Tacoma Field



WELL NMW-5B



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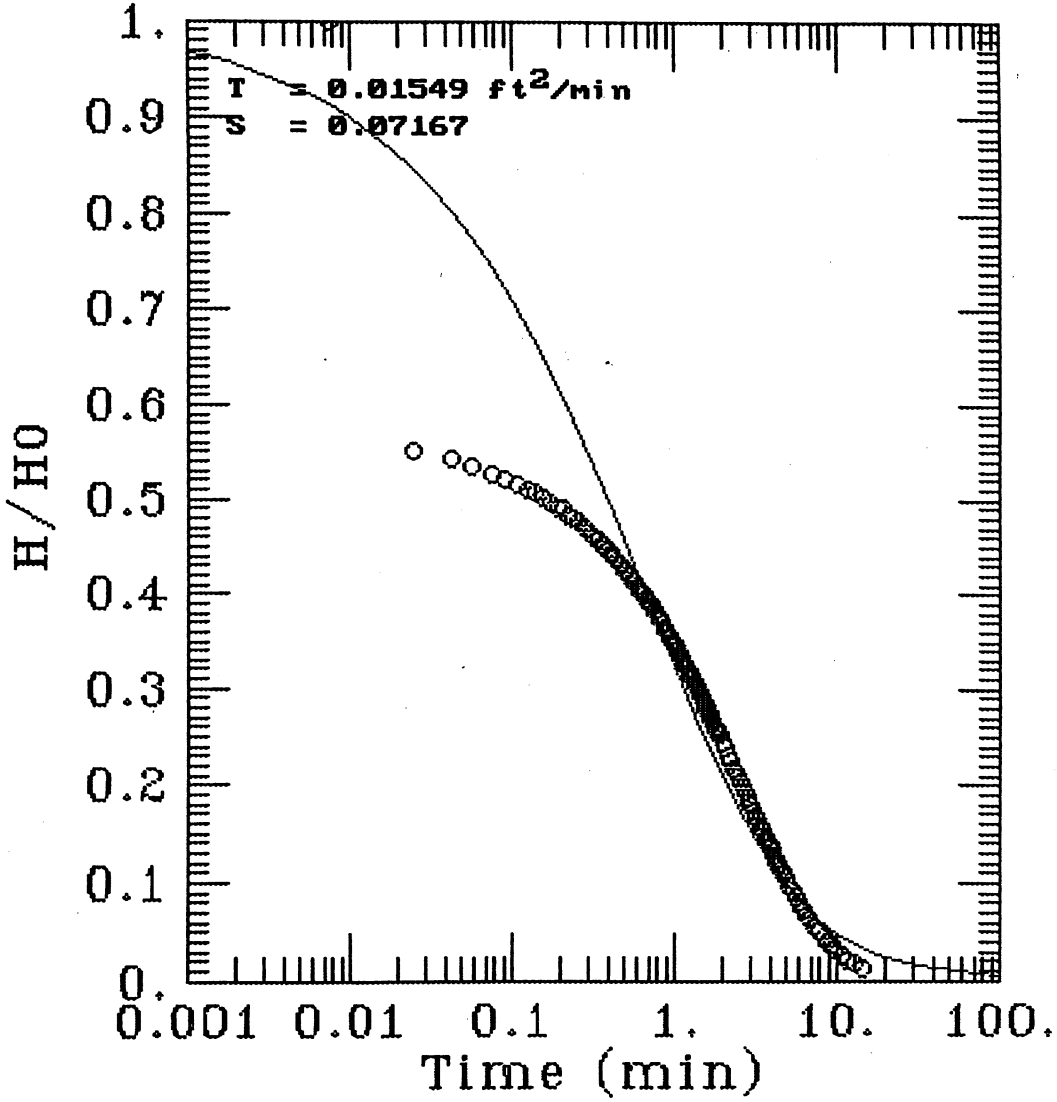
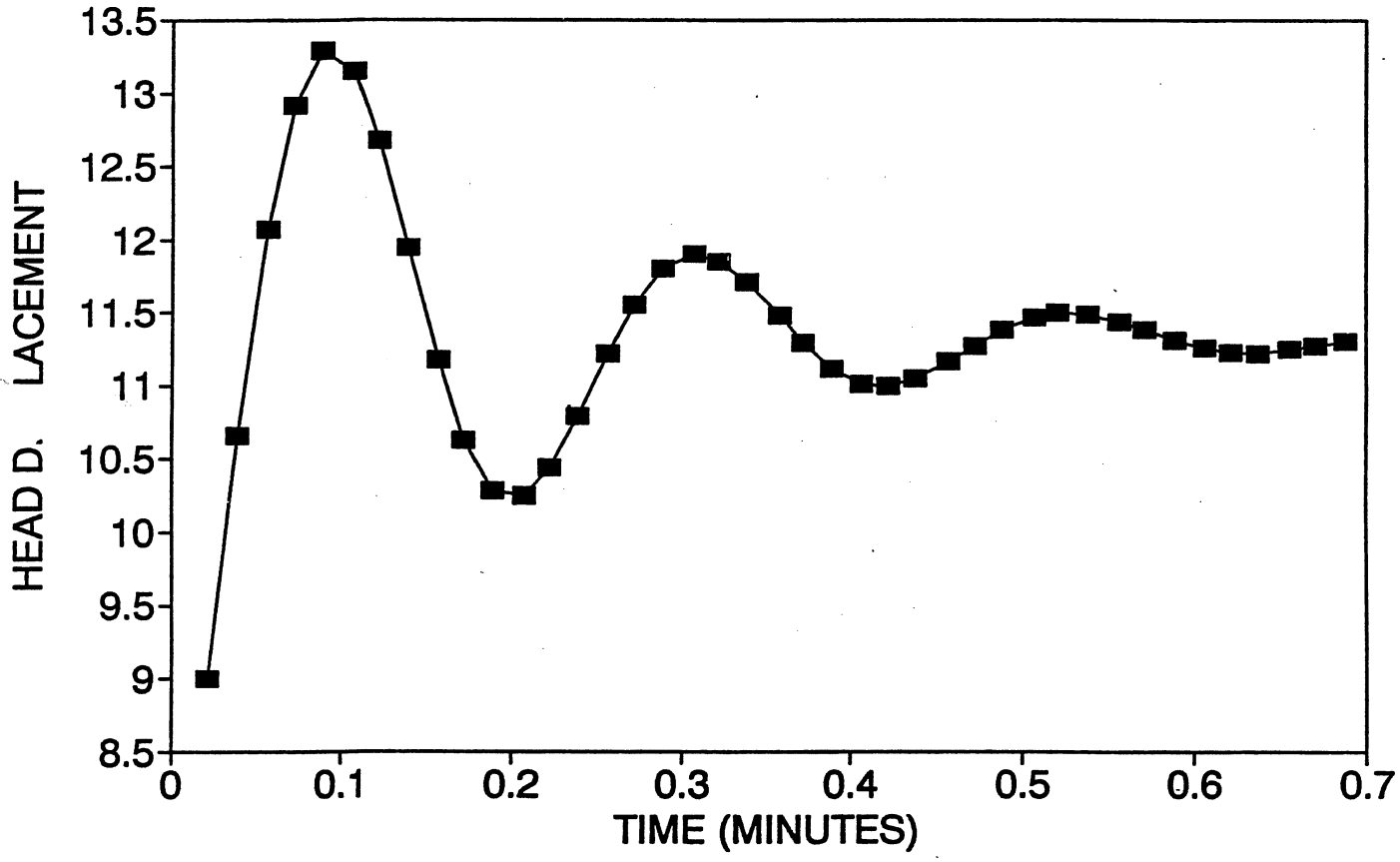
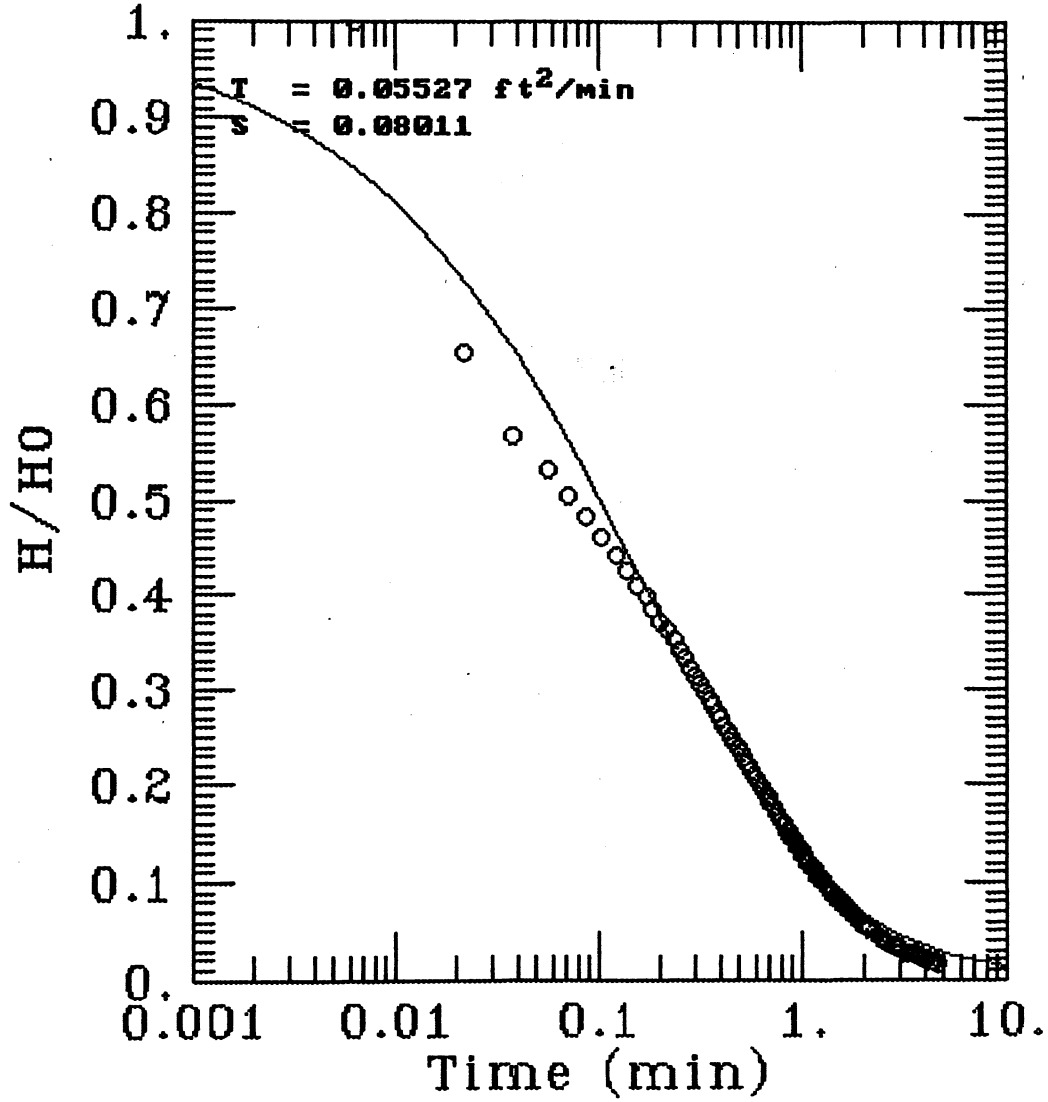
WELL NMW-5B


T = 0.01549 ft²/min
S = 0.07167
H/H0
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.001
0.01
0.1
1.
10.
100.
Time (min)

WELL NMW-3C
SLUG TEST DATA PLOT



WELL NMW-5C



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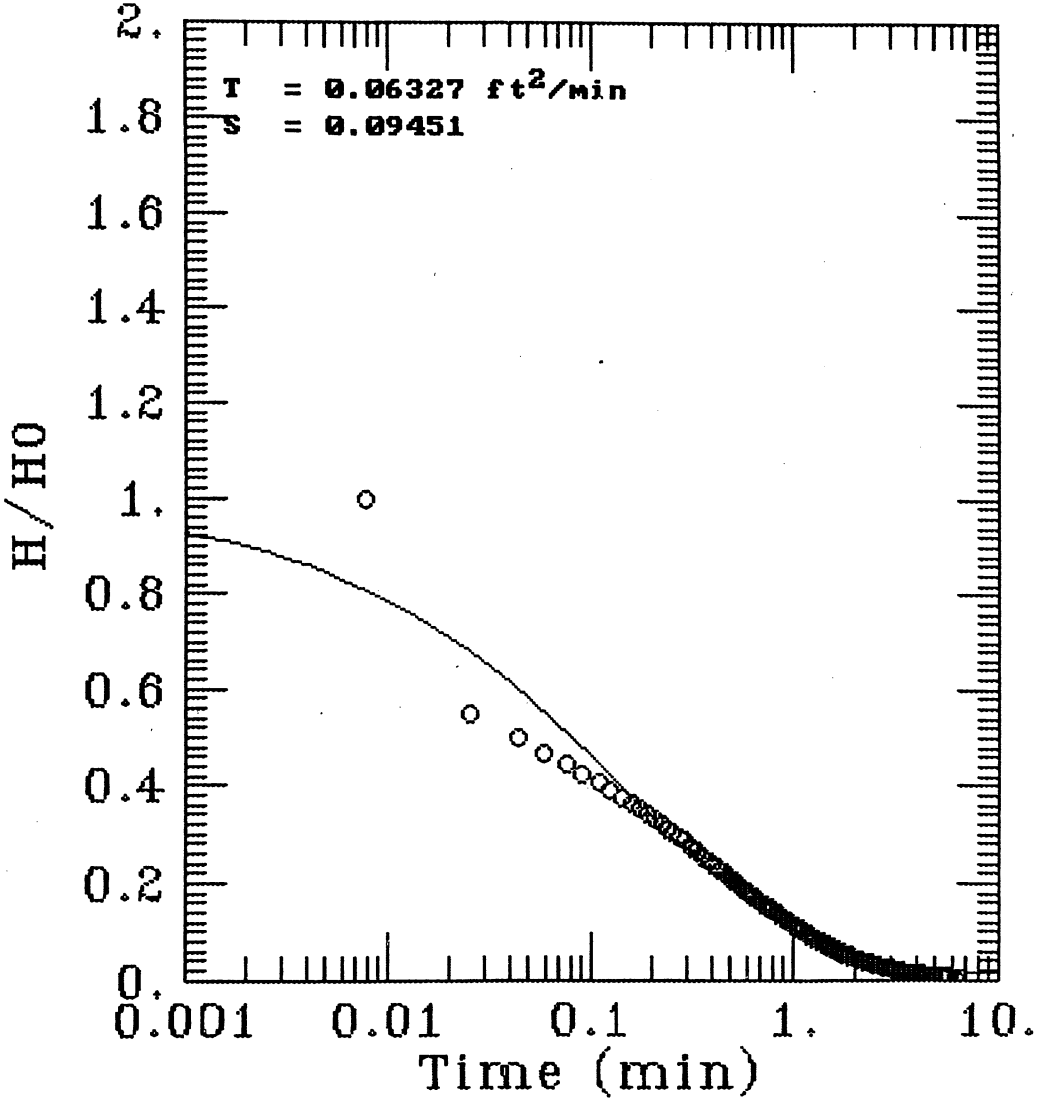
WELL NMW-5C



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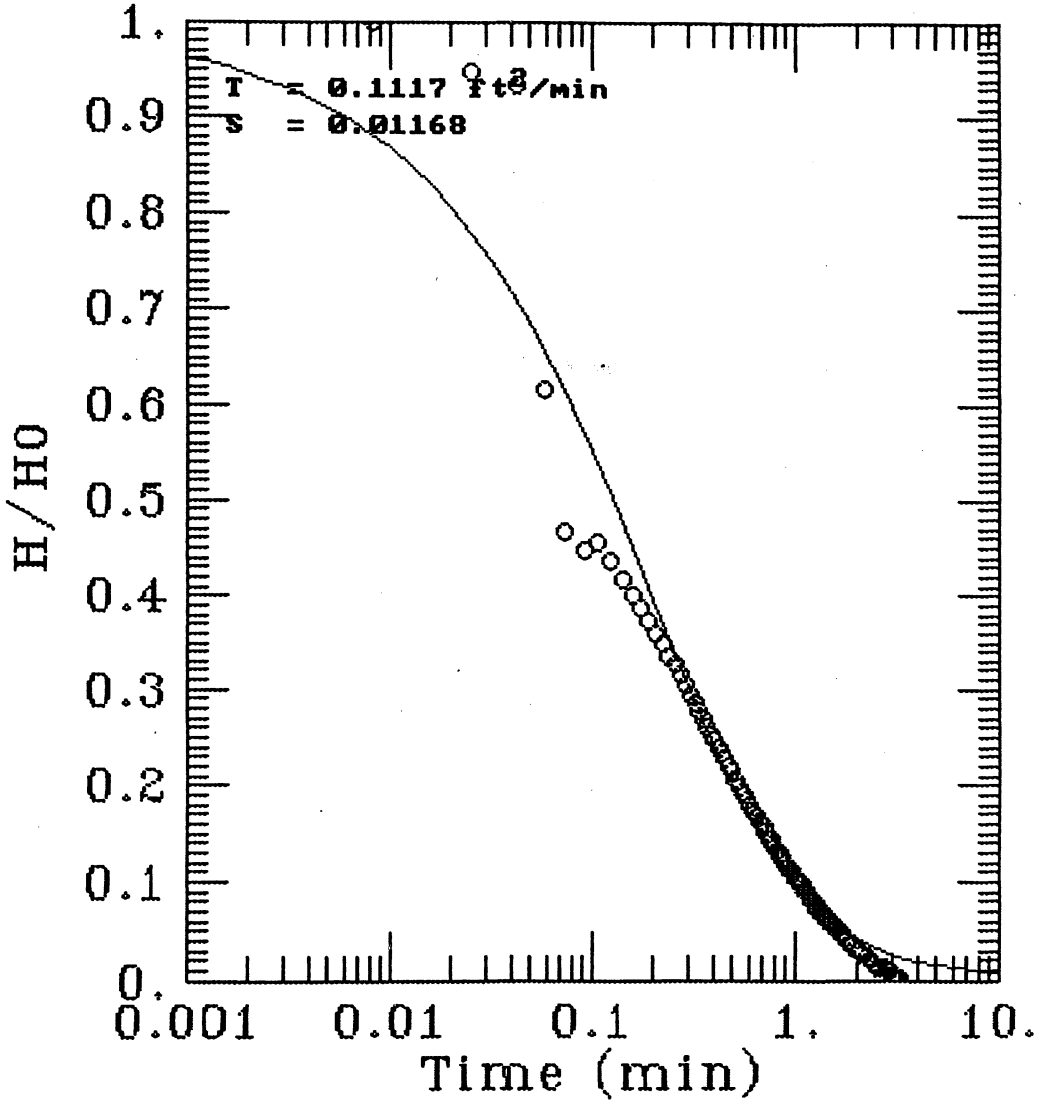
WELL NMW-5C



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Appendix HC-D

Aquifer Pumping Test Data Analysis for Wells NMW-3A and NMW-4A

DATA ANALYSIS
OF AQUIFER PUMPING TEST
FOR NMW-3A

4 x 4 Grid Sheet **Kennedy/Jenks/Chilton**

By TCE Date 9 MAR 92 Subject STF - NMW - 3A Job No. _____
Checked By _____ Date _____ Pump TEST Sheet 1 of 2

WELL NMW-3A

BLANK INTERVAL	0-13 ft	
Screened Interval	13-38 ft	
Top Casing Elv.	215.19 ft	
DEPTH TO WATER	21.53 ft	(193.66')

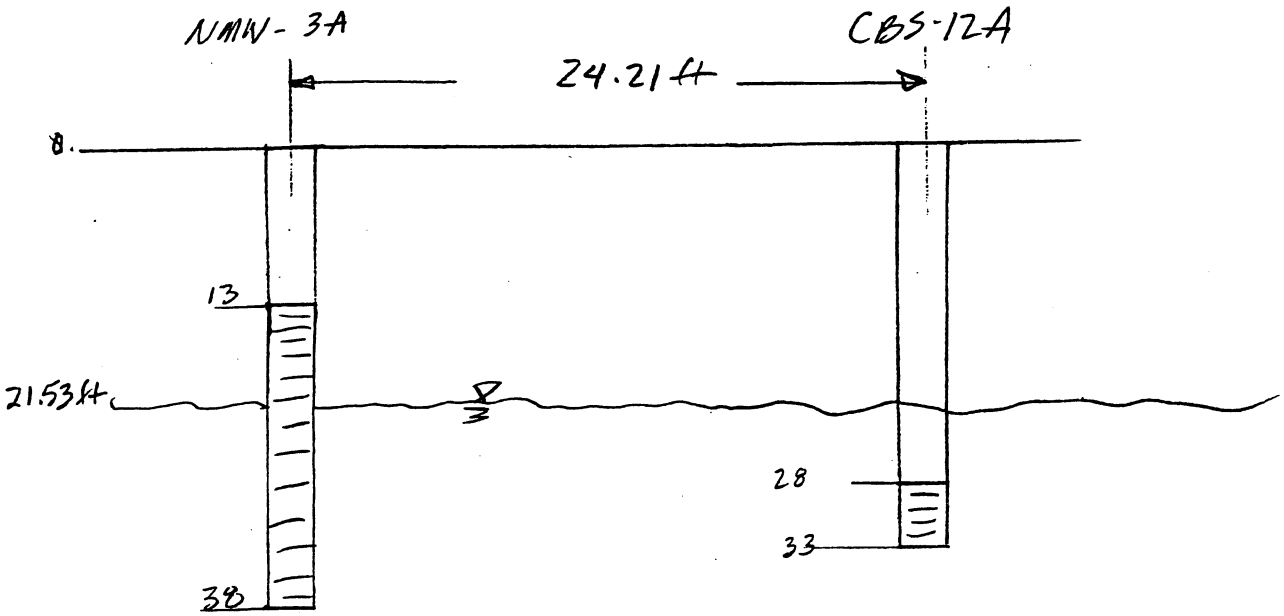
WELL CBS-12A

BLANK INTERVAL	0-28 ft	
SCreened INTERVAL	28-33 ft	
TOP CASING ELEV.	215.11 ft	
Depth to WATER	22.64 ft	(192.47')

4 x 4 Grid Sheet **Kennedy/Jenks/Chilton**

By TCE Date 3/9/92 Subject STF - NMW - 3A Job No. _____

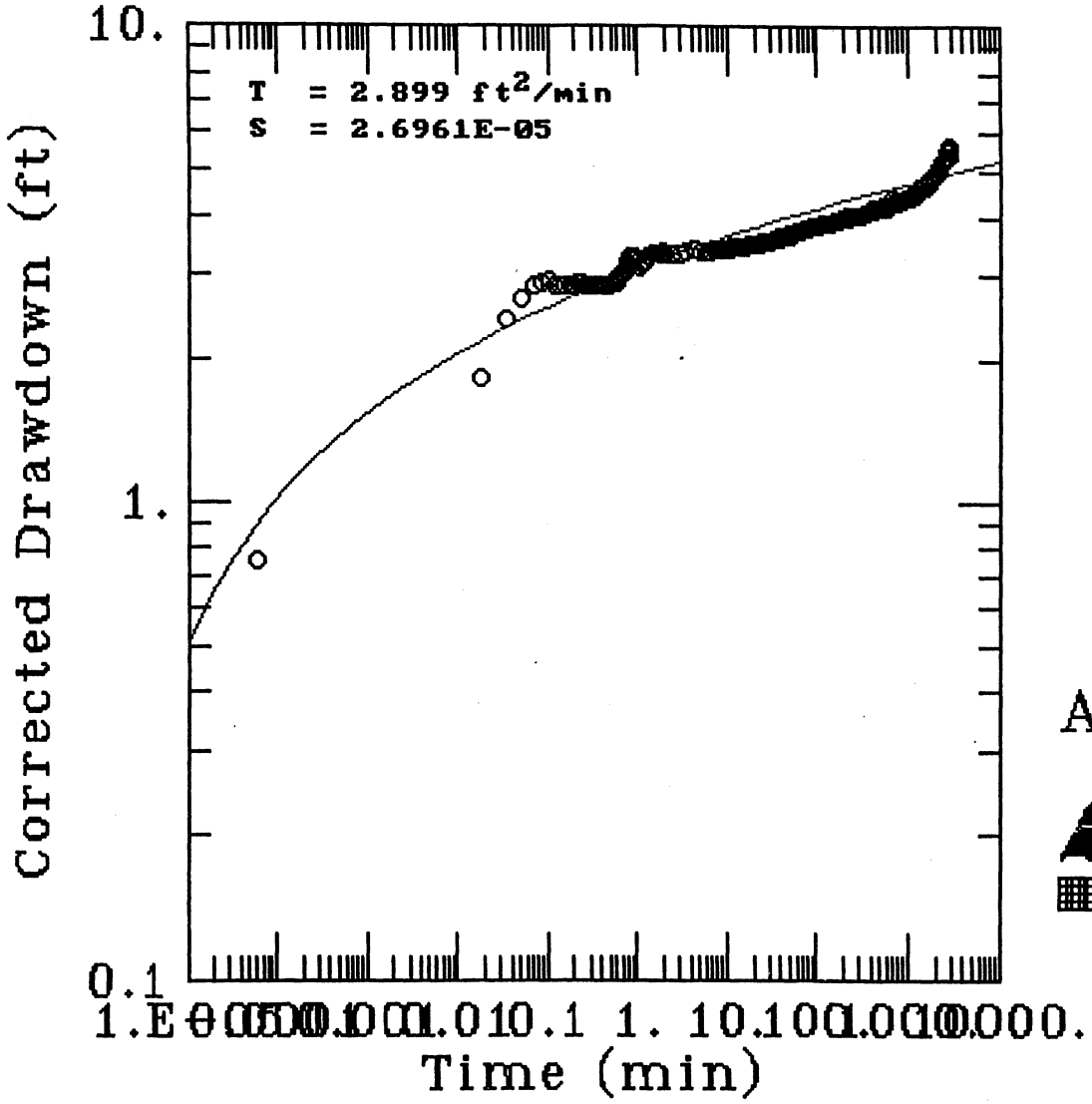
Checked By _____ Date _____ PUMP TEST Sheet 2 of 2



SATURATED THICKNESS = 80' - 21.53' = 58.47'

80'

STF AQUIFER TEST, 3A DATA, 3A DRAWDOWN



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<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V   R E S U L T S
Version 1.10

7/27/92 09:25:06

==

TEST DESCRIPTION

ata set........... b:\3a_dd.aqt
ata set title..... STF AQUIFER TEST, 3A DATA, 3A DRAWDOWN

nowns and Constants:
  No. of data points.................. 281
  Pumping rate........................ 8.02
  Radius (distance) to obs. well...... 0.5
  Aquifer saturated thickness......... 58.47

==

ANALYTICAL METHOD

heis (Unconfined Aquifer)

==

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	2.8989E+000	+/-	6.2220E-002
S =	2.6961E-005	+/-	9.7267E-006

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
  Number of residuals................ 281
  Number of estimated parameters.... 2
  Degrees of freedom................ 279
  Residual mean..................... -1.987E-005
  Residual standard deviation....... 0.2712
  Residual variance................. 0.07355

odel Residuals:

Time	Observed	Calculated	Residual	Weight
6E-005	0.758	0.90285	-0.14485	1
0.01734	1.8408	2.1819	-0.34115	1
0.03462	2.4761	2.3403	0.13581	1

0.05046	2.772	2.4268	0.34525	1
0.06774	2.9236	2.4944	0.42917	1
0.08358	2.9958	2.5428	0.45302	1
0.10086	3.003	2.586	0.41695	1
0.1167	2.9597	2.6197	0.34004	1
0.13398	2.9597	2.6515	0.30821	1
0.15126	2.9525	2.6795	0.27303	1
0.18726	2.9597	2.7288	0.23095	1
0.19878	2.9308	2.7425	0.18826	1
0.21174	2.9742	2.7571	0.21707	1
0.2247	2.9742	2.7709	0.20334	1
0.23766	2.9742	2.7838	0.19038	1
0.24918	2.9453	2.7948	0.15054	1
0.2679	2.9525	2.8115	0.14098	1
0.28374	2.9453	2.8248	0.1205	1
0.30102	2.9381	2.8385	0.09962	1
0.31686	2.9381	2.8503	0.087753	1
0.33414	2.9381	2.8626	0.075462	1
0.35142	2.9381	2.8743	0.063789	1
0.36726	2.9453	2.8845	0.06078	1
0.38454	2.9453	2.8952	0.050132	1
0.40038	2.9453	2.9045	0.040782	1
0.41766	2.9381	2.9143	0.023792	1
0.4335	2.9381	2.9229	0.015167	1
0.45078	2.9525	2.932	0.020508	1
0.46806	2.9597	2.9407	0.018988	1
0.4839	2.9597	2.9484	0.011273	1
0.50118	2.9742	2.9566	0.017638	1
0.51702	2.9742	2.9638	0.010422	1
0.5343	2.9814	2.9714	0.0099972	1
0.55014	2.9886	2.9782	0.010421	1
0.56742	2.9886	2.9854	0.0032461	1
0.5847	3.0175	2.9923	0.025186	1
0.60054	3.0319	2.9985	0.033383	1
0.61782	3.068	3.0051	0.0629	1
0.63366	3.0897	3.011	0.078725	1
0.65094	3.1041	3.0172	0.08688	1
0.66678	3.1185	3.0228	0.095698	1
0.68406	3.1402	3.0287	0.11146	1
0.70134	3.133	3.0345	0.098466	1
0.71718	3.1691	3.0397	0.12938	1
0.73446	3.2196	3.0453	0.17435	1
0.7503	3.2557	3.0502	0.20549	1
0.76758	3.299	3.0555	0.24351	1
0.78342	3.3351	3.0602	0.27486	1
0.8007	3.3784	3.0653	0.31309	1
0.8367	3.3928	3.0755	0.31727	1
0.84966	3.3928	3.0791	0.3137	1
0.86262	3.4001	3.0826	0.31748	1
0.87414	3.3856	3.0857	0.2999	1
0.8871	3.3928	3.0891	0.30368	1
0.89862	3.3712	3.0921	0.27908	1
0.91734	3.3712	3.0969	0.27429	1
0.93462	3.364	3.1013	0.26275	1
0.95046	3.3568	3.1052	0.25164	1
0.96774	3.3062	3.1093	0.19685	1
1.0513	3.234	3.1286	0.1054	1
1.1333	3.2557	3.1461	0.10961	1
1.2169	3.299	3.1626	0.13636	1
1.3004	3.3784	3.1781	0.20031	1

1.3839	3.4073	3.1926	0.21472	1
1.4674	3.4289	3.2062	0.22267	1
1.5509	3.4506	3.2191	0.23148	1
1.6345	3.4434	3.2313	0.21205	1
1.718	3.4506	3.243	0.20764	1
1.8001	3.4578	3.2538	0.20396	1
1.8836	3.465	3.2644	0.20059	1
1.9685	3.4362	3.2747	0.1615	1
2.4668	3.4506	3.3273	0.12325	1
2.9679	3.4578	3.3705	0.087266	1
3.4676	3.4867	3.4069	0.079802	1
3.9673	3.5156	3.4384	0.077223	1
4.4669	3.5156	3.4661	0.049468	1
4.9681	3.4795	3.491	-0.011521	1
5.4677	3.4939	3.5135	-0.019564	1
5.9674	3.5011	3.534	-0.032851	1
6.4671	3.5011	3.5528	-0.051696	1
6.9668	3.5156	3.5702	-0.054644	1
7.4679	3.5156	3.5865	-0.070932	1
7.9676	3.5156	3.6017	-0.086125	1
8.4673	3.5228	3.616	-0.093197	1
8.9669	3.5372	3.6295	-0.092254	1
9.4681	3.5372	3.6422	-0.10502	1
9.9677	3.5228	3.6543	-0.1315	1
10.467	3.5444	3.6658	-0.12138	1
10.967	3.5589	3.6767	-0.11784	1
11.467	3.5589	3.6872	-0.12831	1
11.968	3.5661	3.6973	-0.13116	1
12.468	3.5661	3.7069	-0.14077	1
12.967	3.5661	3.7161	-0.15001	1
13.467	3.5661	3.725	-0.1589	1
13.968	3.5733	3.7336	-0.16029	1
14.468	3.5805	3.7419	-0.16135	1
14.967	3.5805	3.7498	-0.16934	1
15.467	3.5878	3.7576	-0.16977	1
15.967	3.595	3.765	-0.17005	1
16.468	3.6022	3.7723	-0.17012	1
16.968	3.6022	3.7794	-0.17716	1
17.467	3.6094	3.7862	-0.17679	1
17.967	3.6094	3.7928	-0.18343	1
18.468	3.6094	3.7993	-0.1899	1
18.968	3.6166	3.8056	-0.18899	1
19.467	3.6166	3.8117	-0.19511	1
19.967	3.6238	3.8177	-0.19388	1
20.467	3.6238	3.8235	-0.1997	1
20.969	3.6311	3.8292	-0.19812	1
21.967	3.6383	3.8402	-0.20187	1
22.968	3.6383	3.8507	-0.21237	1
23.967	3.6599	3.8607	-0.20081	1
24.967	3.6672	3.8703	-0.20314	1
25.968	3.6816	3.8796	-0.19801	1
26.967	3.6672	3.8885	-0.22131	1
27.968	3.6816	3.8971	-0.21551	1
28.967	3.6888	3.9054	-0.21659	1
29.968	3.6816	3.9134	-0.2318	1
30.967	3.6816	3.9211	-0.23954	1
31.968	3.696	3.9286	-0.23265	1
32.967	3.7105	3.9359	-0.22541	1
33.967	3.7105	3.943	-0.23246	1
34.968	3.7105	3.9498	-0.23932	1

35.967	3.7321	3.9565	-0.22437	1
36.968	3.7393	3.963	-0.22365	1
37.967	3.761	3.9693	-0.20825	1
38.968	3.7321	3.9754	-0.2433	1
39.967	3.7321	3.9814	-0.24928	1
40.968	3.7393	3.9872	-0.24792	1
41.967	3.7393	3.9929	-0.25362	1
42.967	3.7393	3.9985	-0.25918	1
43.968	3.7538	4.0039	-0.25012	1
44.967	3.7393	4.0092	-0.26993	1
45.968	3.7682	4.0144	-0.24623	1
46.967	3.7899	4.0195	-0.22962	1
47.968	3.7827	4.0245	-0.2418	1
48.967	3.7682	4.0294	-0.26118	1
49.968	3.7827	4.0342	-0.25146	1
50.967	3.7899	4.0388	-0.24895	1
51.967	3.7827	4.0434	-0.26074	1
52.968	3.7971	4.048	-0.25085	1
53.967	3.7971	4.0524	-0.25527	1
54.968	3.8043	4.0567	-0.25242	1
55.967	3.8043	4.061	-0.25668	1
56.968	3.8404	4.0652	-0.22477	1
57.967	3.8548	4.0693	-0.21449	1
58.968	3.8621	4.0733	-0.21124	1
59.967	3.8621	4.0773	-0.21522	1
60.97	3.8765	4.0812	-0.20474	1
65.968	3.8837	4.0999	-0.21619	1
70.968	3.8909	4.1172	-0.22629	1
75.967	3.9126	4.1333	-0.22071	1
80.967	3.927	4.1484	-0.22142	1
85.968	3.9415	4.1626	-0.22112	1
90.968	3.9487	4.176	-0.22732	1
95.967	3.9559	4.1887	-0.23281	1
100.97	3.9776	4.2008	-0.22315	1
105.97	3.9848	4.2122	-0.22742	1
110.97	3.9992	4.2232	-0.22396	1
115.97	4.0137	4.2336	-0.21992	1
120.97	4.0137	4.2436	-0.22994	1
125.97	4.0209	4.2533	-0.23235	1
130.97	4.0281	4.2625	-0.2344	1
135.97	4.0353	4.2714	-0.23609	1
140.97	4.0353	4.28	-0.24467	1
145.97	4.0425	4.2882	-0.24575	1
150.97	4.057	4.2963	-0.23925	1
155.97	4.0642	4.304	-0.2398	1
160.97	4.0714	4.3115	-0.2401	1
165.97	4.0714	4.3188	-0.24736	1
170.97	4.0858	4.3258	-0.24002	1
175.97	4.0786	4.3327	-0.25408	1
180.97	4.1075	4.3393	-0.23184	1
195.97	4.1292	4.3583	-0.22908	1
210.97	4.1508	4.3758	-0.22502	1
225.97	4.1147	4.3922	-0.27747	1
240.97	4.1725	4.4075	-0.23497	1
255.97	4.1797	4.4219	-0.24215	1
270.97	4.1725	4.4354	-0.26292	1
285.97	4.1941	4.4483	-0.25416	1
300.97	4.2013	4.4604	-0.25914	1
315.97	4.1653	4.472	-0.30673	1
330.97	4.2374	4.4831	-0.24569	1

345.97	4.2302	4.4937	-0.26346	1
360.97	4.2447	4.5038	-0.25908	1
375.97	4.288	4.5135	-0.22549	1
390.97	4.288	4.5228	-0.23483	1
405.97	4.3168	4.5318	-0.21501	1
420.97	4.2808	4.5405	-0.25967	1
435.97	4.2952	4.5488	-0.25363	1
450.97	4.3241	4.5569	-0.23281	1
465.97	4.3241	4.5647	-0.24062	1
480.97	4.3385	4.5723	-0.23378	1
495.97	4.3385	4.5796	-0.24112	1
510.97	4.3313	4.5867	-0.25544	1
525.97	4.3529	4.5936	-0.24075	1
540.97	4.389	4.6004	-0.21137	1
555.97	4.3818	4.6069	-0.2251	1
570.97	4.3746	4.6133	-0.23867	1
585.97	4.3529	4.6195	-0.26657	1
600.97	4.3529	4.6255	-0.27261	1
615.97	4.4107	4.6314	-0.2207	1
630.97	4.4035	4.6372	-0.23366	1
645.97	4.4107	4.6428	-0.23207	1
660.97	4.4323	4.6483	-0.21596	1
675.97	4.5623	4.6536	-0.091331	1
690.97	4.4829	4.6589	-0.17598	1
705.97	4.454	4.664	-0.21002	1
720.97	4.5118	4.669	-0.15725	1
750.97	4.4829	4.6788	-0.1959	1
780.97	4.4901	4.6882	-0.19808	1
826.97	4.4901	4.7019	-0.21178	1
856.97	4.5406	4.7104	-0.16981	1
886.97	4.5406	4.7187	-0.17805	1
916.97	4.5623	4.7266	-0.16432	1
946.97	4.5623	4.7343	-0.17203	1
976.97	4.5984	4.7418	-0.1434	1
1007	4.5912	4.749	-0.15785	1
1037	4.5839	4.7561	-0.17218	1
1067	4.6128	4.7629	-0.15012	1
1097	4.6273	4.7696	-0.14226	1
1127	4.6417	4.776	-0.13433	1
1157	4.6417	4.7823	-0.14063	1
1187	4.6633	4.7885	-0.12517	1
1217	4.7716	4.7945	-0.022853	1
1247	4.7067	4.8003	-0.093593	1
1277	4.8149	4.806	0.0089046	1
1307	4.7428	4.8116	-0.068766	1
1337	4.7861	4.817	-0.03091	1
1367	4.8005	4.8223	-0.021835	1
1397	4.8222	4.8275	-0.0053437	1
1427	4.8222	4.8326	-0.010443	1
1457	4.8149	4.8376	-0.022736	1
1487	4.8294	4.8425	-0.013128	1
1517	4.8727	4.8473	0.025377	1
1547	4.8438	4.852	-0.008224	1
1577	4.851	4.8566	-0.0056353	1
1607	4.8943	4.8612	0.03314	1
1637	4.9016	4.8656	0.035998	1
1667	4.9304	4.87	0.060437	1
1697	5.0387	4.8742	0.16445	1
1727	4.9738	4.8785	0.095344	1
1757	5.0026	4.8826	0.12001	1

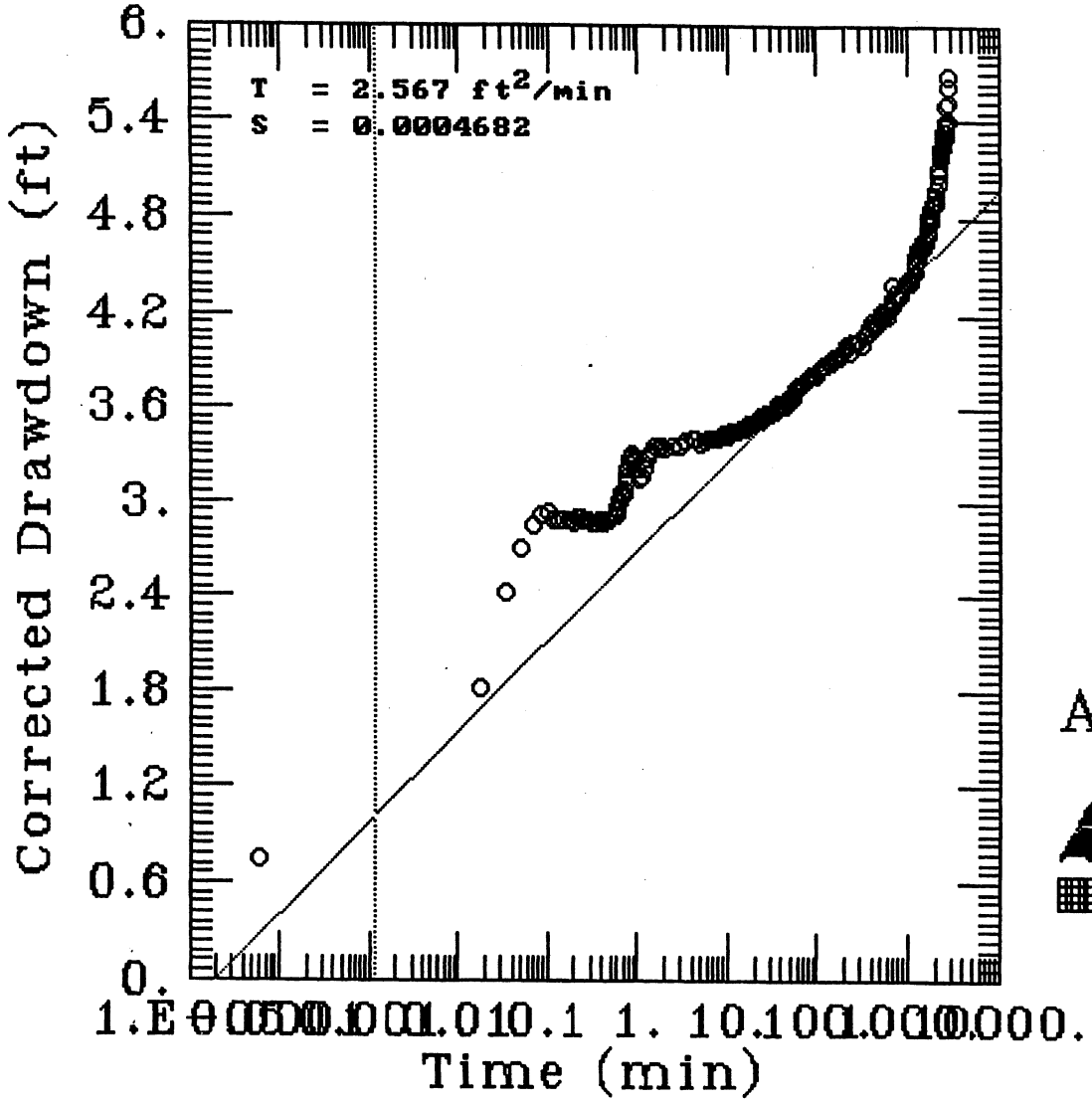
1787	5.0243	4.8867	0.13764	1
1817	5.0893	4.8907	0.19864	1
1847	5.0532	4.8946	0.15861	1
1877	5.0965	4.8985	0.19803	1
1907	5.1037	4.9023	0.20142	1
1937	5.1181	4.906	0.21207	1
1967	5.1181	4.9097	0.20838	1
1997	5.1253	4.9134	0.21194	1
2027	5.1759	4.9169	0.25896	1
2057	5.2048	4.9205	0.28433	1
2087	5.212	4.924	0.28805	1
2117	5.2553	4.9274	0.32791	1
2147	5.2408	4.9308	0.31003	1
2177	5.2697	4.9341	0.33559	1
2207	5.313	4.9374	0.3756	1
2223	5.3563	4.9391	0.41717	1
2253	5.3636	4.9424	0.42124	1
2283	5.443	4.9455	0.49746	1
2313	5.4358	4.9487	0.48712	1
2343	5.4646	4.9518	0.51282	1
2373	5.4863	4.9548	0.53146	1
2403	5.5079	4.9579	0.55004	1
2433	5.5079	4.9608	0.54706	1
2463	5.5296	4.9638	0.56581	1
2493	5.5152	4.9667	0.5485	1
2523	5.5513	4.9696	0.58172	1
2553	5.6018	4.9724	0.62937	1
2583	5.6595	4.9752	0.68426	1
2613	5.5801	4.978	0.60208	1
2643	5.6162	4.9808	0.63544	1
2673	5.674	4.9835	0.69052	1
2703	5.7823	4.9862	0.79613	1
2733	5.6451	4.9888	0.65628	1
2763	5.6884	4.9915	0.69695	1
2793	5.9194	4.9941	0.92535	1
2823	5.9988	4.9966	1.0022	1
2853	5.8111	4.9992	0.81193	1
2883	5.8111	5.0017	0.80941	1

==========

RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATC

STF AQUIFER TEST, 3A DATA, 3A DRAWDOWN



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V   R E S U L T S

Version 1.10

7/27/92 11:12:2,

TEST DESCRIPTION

ata set........... B:\3A_DD.AQT
ata set title..... STF AQUIFER TEST, 3A DATA, 3A DRAWDOWN

nowns and Constants:
  No. of data points.................. 281
  Pumping rate........................ 8.02
  Radius (distance) to obs. well...... 0.5
  Aquifer saturated thickness......... 58.47

ANALYTICAL METHOD

ooper-Jacob (Unconfined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	2.8995E+000	+/-	6.2185E-002
S =	2.6964E-005	+/-	9.7200E-006

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
  Number of residuals................ 281
  Number of estimated parameters.... 2
  Degrees of freedom................ 279
  Residual mean..................... -1.487E-005
  Residual standard deviation....... 0.2712
  Residual variance................. 0.07355

odel Residuals:

Time	Observed	Calculated	Residual	Weight
6E-005	0.758	0.90071	-0.14271	1
0.01734	1.8408	2.182	-0.34115	1
0.03462	2.4761	2.3403	0.13581	1

0.05046	2.772	2.4268	0.34524	1
0.06774	2.9236	2.4944	0.42916	1
0.08358	2.9958	2.5428	0.45302	1
0.10086	3.003	2.5861	0.41695	1
0.1167	2.9597	2.6197	0.34003	1
0.13398	2.9597	2.6515	0.3082	1
0.15126	2.9525	2.6795	0.27302	1
0.18726	2.9597	2.7288	0.23094	1
0.19878	2.9308	2.7426	0.18825	1
0.21174	2.9742	2.7571	0.21706	1
0.2247	2.9742	2.7709	0.20333	1
0.23766	2.9742	2.7838	0.19037	1
0.24918	2.9453	2.7948	0.15053	1
0.2679	2.9525	2.8115	0.14098	1
0.28374	2.9453	2.8248	0.12049	1
0.30102	2.9381	2.8385	0.099612	1
0.31686	2.9381	2.8504	0.087745	1
0.33414	2.9381	2.8626	0.075454	1
0.35142	2.9381	2.8743	0.063781	1
0.36726	2.9453	2.8845	0.060772	1
0.38454	2.9453	2.8952	0.050124	1
0.40038	2.9453	2.9045	0.040773	1
0.41766	2.9381	2.9143	0.023784	1
0.4335	2.9381	2.9229	0.015159	1
0.45078	2.9525	2.932	0.0205	1
0.46806	2.9597	2.9407	0.01898	1
0.4839	2.9597	2.9484	0.011265	1
0.50118	2.9742	2.9566	0.01763	1
0.51702	2.9742	2.9638	0.010414	1
0.5343	2.9814	2.9714	0.0099893	1
0.55014	2.9886	2.9782	0.010413	1
0.56742	2.9886	2.9854	0.0032382	1
0.5847	3.0175	2.9923	0.025178	1
0.60054	3.0319	2.9985	0.033376	1
0.61782	3.068	3.0051	0.062892	1
0.63366	3.0897	3.011	0.078717	1
0.65094	3.1041	3.0172	0.086872	1
0.66678	3.1185	3.0228	0.09569	1
0.68406	3.1402	3.0287	0.11145	1
0.70134	3.133	3.0345	0.098458	1
0.71718	3.1691	3.0397	0.12937	1
0.73446	3.2196	3.0453	0.17434	1
0.7503	3.2557	3.0502	0.20549	1
0.76758	3.299	3.0555	0.2435	1
0.78342	3.3351	3.0602	0.27485	1
0.8007	3.3784	3.0653	0.31308	1
0.8367	3.3928	3.0755	0.31727	1
0.84966	3.3928	3.0791	0.31369	1
0.86262	3.4001	3.0826	0.31748	1
0.87414	3.3856	3.0857	0.29989	1
0.8871	3.3928	3.0891	0.30367	1
0.89862	3.3712	3.0921	0.27907	1
0.91734	3.3712	3.0969	0.27428	1
0.93462	3.364	3.1013	0.26274	1
0.95046	3.3568	3.1052	0.25163	1
0.96774	3.3062	3.1094	0.19684	1
1.0513	3.234	3.1286	0.10539	1
1.1333	3.2557	3.1461	0.1096	1
1.2169	3.299	3.1626	0.13636	1
1.3004	3.3784	3.1781	0.20031	1

1.3839	3.4073	3.1926	0.21471	1
1.4674	3.4289	3.2062	0.22266	1
1.5509	3.4506	3.2191	0.23147	1
1.6345	3.4434	3.2314	0.21205	1
1.718	3.4506	3.243	0.20763	1
1.8001	3.4578	3.2538	0.20395	1
1.8836	3.465	3.2644	0.20058	1
1.9685	3.4362	3.2747	0.16149	1
2.4668	3.4506	3.3274	0.12325	1
2.9679	3.4578	3.3705	0.08726	1
3.4676	3.4867	3.4069	0.079796	1
3.9673	3.5156	3.4384	0.077217	1
4.4669	3.5156	3.4661	0.049462	1
4.9681	3.4795	3.491	-0.011526	1
5.4677	3.4939	3.5135	-0.019569	1
5.9674	3.5011	3.534	-0.032856	1
6.4671	3.5011	3.5528	-0.051701	1
6.9668	3.5156	3.5702	-0.054649	1
7.4679	3.5156	3.5865	-0.070937	1
7.9676	3.5156	3.6017	-0.08613	1
8.4673	3.5228	3.616	-0.093202	1
8.9669	3.5372	3.6295	-0.092258	1
9.4681	3.5372	3.6422	-0.10502	1
9.9677	3.5228	3.6543	-0.1315	1
10.467	3.5444	3.6658	-0.12139	1
10.967	3.5589	3.6767	-0.11784	1
11.467	3.5589	3.6872	-0.12831	1
11.968	3.5661	3.6973	-0.13116	1
12.468	3.5661	3.7069	-0.14077	1
12.967	3.5661	3.7161	-0.15001	1
13.467	3.5661	3.725	-0.1589	1
13.968	3.5733	3.7336	-0.16029	1
14.468	3.5805	3.7419	-0.16136	1
14.967	3.5805	3.7498	-0.16935	1
15.467	3.5878	3.7576	-0.16977	1
15.967	3.595	3.7651	-0.17005	1
16.468	3.6022	3.7723	-0.17012	1
16.968	3.6022	3.7794	-0.17716	1
17.467	3.6094	3.7862	-0.17679	1
17.967	3.6094	3.7928	-0.18343	1
18.468	3.6094	3.7993	-0.18991	1
18.968	3.6166	3.8056	-0.18899	1
19.467	3.6166	3.8117	-0.19512	1
19.967	3.6238	3.8177	-0.19389	1
20.467	3.6238	3.8235	-0.19971	1
20.969	3.6311	3.8292	-0.19812	1
21.967	3.6383	3.8402	-0.20188	1
22.968	3.6383	3.8507	-0.21237	1
23.967	3.6599	3.8607	-0.20081	1
24.967	3.6672	3.8703	-0.20314	1
25.968	3.6816	3.8796	-0.19801	1
26.967	3.6672	3.8885	-0.22131	1
27.968	3.6816	3.8971	-0.21551	1
28.967	3.6888	3.9054	-0.21659	1
29.968	3.6816	3.9134	-0.2318	1
30.967	3.6816	3.9211	-0.23955	1
31.968	3.696	3.9287	-0.23265	1
32.967	3.7105	3.9359	-0.22542	1
33.967	3.7105	3.943	-0.23247	1
34.968	3.7105	3.9498	-0.23932	1

35.967	3.7321	3.9565	-0.22437	1
36.968	3.7393	3.963	-0.22366	1
37.967	3.761	3.9693	-0.20826	1
38.968	3.7321	3.9754	-0.2433	1
39.967	3.7321	3.9814	-0.24928	1
40.968	3.7393	3.9872	-0.24793	1
41.967	3.7393	3.9929	-0.25362	1
42.967	3.7393	3.9985	-0.25918	1
43.968	3.7538	4.0039	-0.25012	1
44.967	3.7393	4.0092	-0.26993	1
45.968	3.7682	4.0144	-0.24624	1
46.967	3.7899	4.0195	-0.22962	1
47.968	3.7827	4.0245	-0.24181	1
48.967	3.7682	4.0294	-0.26118	1
49.968	3.7827	4.0342	-0.25147	1
50.967	3.7899	4.0388	-0.24895	1
51.967	3.7827	4.0434	-0.26074	1
52.968	3.7971	4.048	-0.25085	1
53.967	3.7971	4.0524	-0.25527	1
54.968	3.8043	4.0567	-0.25242	1
55.967	3.8043	4.061	-0.25668	1
56.968	3.8404	4.0652	-0.22478	1
57.967	3.8548	4.0693	-0.21449	1
58.968	3.8621	4.0733	-0.21124	1
59.967	3.8621	4.0773	-0.21522	1
60.97	3.8765	4.0812	-0.20474	1
65.968	3.8837	4.0999	-0.21619	1
70.968	3.8909	4.1172	-0.22629	1
75.967	3.9126	4.1333	-0.22072	1
80.967	3.927	4.1484	-0.22142	1
85.968	3.9415	4.1626	-0.22112	1
90.968	3.9487	4.176	-0.22732	1
95.967	3.9559	4.1887	-0.23281	1
100.97	3.9776	4.2008	-0.22315	1
105.97	3.9848	4.2122	-0.22742	1
110.97	3.9992	4.2232	-0.22396	1
115.97	4.0137	4.2336	-0.21992	1
120.97	4.0137	4.2436	-0.22994	1
125.97	4.0209	4.2533	-0.23235	1
130.97	4.0281	4.2625	-0.2344	1
135.97	4.0353	4.2714	-0.23609	1
140.97	4.0353	4.28	-0.24467	1
145.97	4.0425	4.2883	-0.24575	1
150.97	4.057	4.2963	-0.23925	1
155.97	4.0642	4.304	-0.2398	1
160.97	4.0714	4.3115	-0.2401	1
165.97	4.0714	4.3188	-0.24737	1
170.97	4.0858	4.3258	-0.24002	1
175.97	4.0786	4.3327	-0.25408	1
180.97	4.1075	4.3393	-0.23184	1
195.97	4.1292	4.3583	-0.22908	1
210.97	4.1508	4.3758	-0.22503	1
225.97	4.1147	4.3922	-0.27747	1
240.97	4.1725	4.4075	-0.23497	1
255.97	4.1797	4.4219	-0.24215	1
270.97	4.1725	4.4354	-0.26292	1
285.97	4.1941	4.4483	-0.25416	1
300.97	4.2013	4.4604	-0.25914	1
315.97	4.1653	4.472	-0.30673	1
330.97	4.2374	4.4831	-0.24569	1

345.97	4.2302	4.4937	-0.26346	1
360.97	4.2447	4.5038	-0.25908	1
375.97	4.288	4.5135	-0.22549	1
390.97	4.288	4.5228	-0.23483	1
405.97	4.3168	4.5318	-0.21501	1
420.97	4.2808	4.5405	-0.25967	1
435.97	4.2952	4.5488	-0.25363	1
450.97	4.3241	4.5569	-0.23281	1
465.97	4.3241	4.5647	-0.24062	1
480.97	4.3385	4.5723	-0.23378	1
495.97	4.3385	4.5796	-0.24112	1
510.97	4.3313	4.5867	-0.25544	1
525.97	4.3529	4.5936	-0.24075	1
540.97	4.389	4.6004	-0.21137	1
555.97	4.3818	4.6069	-0.2251	1
570.97	4.3746	4.6133	-0.23867	1
585.97	4.3529	4.6195	-0.26657	1
600.97	4.3529	4.6255	-0.27261	1
615.97	4.4107	4.6314	-0.2207	1
630.97	4.4035	4.6372	-0.23366	1
645.97	4.4107	4.6428	-0.23207	1
660.97	4.4323	4.6483	-0.21596	1
675.97	4.5623	4.6536	-0.09133	1
690.97	4.4829	4.6589	-0.17598	1
705.97	4.454	4.664	-0.21002	1
720.97	4.5118	4.669	-0.15725	1
750.97	4.4829	4.6788	-0.1959	1
780.97	4.4901	4.6882	-0.19808	1
826.97	4.4901	4.7019	-0.21178	1
856.97	4.5406	4.7104	-0.16981	1
886.97	4.5406	4.7187	-0.17805	1
916.97	4.5623	4.7266	-0.16432	1
946.97	4.5623	4.7343	-0.17203	1
976.97	4.5984	4.7418	-0.1434	1
1007	4.5912	4.749	-0.15784	1
1037	4.5839	4.7561	-0.17218	1
1067	4.6128	4.7629	-0.15011	1
1097	4.6273	4.7696	-0.14226	1
1127	4.6417	4.776	-0.13433	1
1157	4.6417	4.7823	-0.14063	1
1187	4.6633	4.7885	-0.12517	1
1217	4.7716	4.7945	-0.022851	1
1247	4.7067	4.8003	-0.093592	1
1277	4.8149	4.806	0.0089061	1
1307	4.7428	4.8116	-0.068764	1
1337	4.7861	4.817	-0.030909	1
1367	4.8005	4.8223	-0.021833	1
1397	4.8222	4.8275	-0.0053421	1
1427	4.8222	4.8326	-0.010441	1
1457	4.8149	4.8376	-0.022734	1
1487	4.8294	4.8425	-0.013126	1
1517	4.8727	4.8473	0.025379	1
1547	4.8438	4.852	-0.0082222	1
1577	4.851	4.8566	-0.0056335	1
1607	4.8943	4.8612	0.033142	1
1637	4.9016	4.8656	0.036	1
1667	4.9304	4.87	0.060439	1
1697	5.0387	4.8742	0.16446	1
1727	4.9738	4.8785	0.095346	1
1757	5.0026	4.8826	0.12001	1

1787	5.0243	4.8867	0.13764	1
1817	5.0893	4.8907	0.19864	1
1847	5.0532	4.8946	0.15861	1
1877	5.0965	4.8985	0.19804	1
1907	5.1037	4.9023	0.20143	1
1937	5.1181	4.906	0.21208	1
1967	5.1181	4.9097	0.20838	1
1997	5.1253	4.9134	0.21194	1
2027	5.1759	4.9169	0.25896	1
2057	5.2048	4.9205	0.28433	1
2087	5.212	4.924	0.28805	1
2117	5.2553	4.9274	0.32792	1
2147	5.2408	4.9308	0.31003	1
2177	5.2697	4.9341	0.3356	1
2207	5.313	4.9374	0.37561	1
2223	5.3563	4.9391	0.41717	1
2253	5.3636	4.9424	0.42125	1
2283	5.443	4.9455	0.49746	1
2313	5.4358	4.9487	0.48712	1
2343	5.4646	4.9518	0.51283	1
2373	5.4863	4.9548	0.53147	1
2403	5.5079	4.9579	0.55004	1
2433	5.5079	4.9608	0.54706	1
2463	5.5296	4.9638	0.56581	1
2493	5.5152	4.9667	0.5485	1
2523	5.5513	4.9696	0.58172	1
2553	5.6018	4.9724	0.62938	1
2583	5.6595	4.9752	0.68426	1
2613	5.5801	4.978	0.60209	1
2643	5.6162	4.9808	0.63544	1
2673	5.674	4.9835	0.69052	1
2703	5.7823	4.9862	0.79614	1
2733	5.6451	4.9888	0.65628	1
2763	5.6884	4.9914	0.69695	1
2793	5.9194	4.994	0.92535	1
2823	5.9988	4.9966	1.0022	1
2853	5.8111	4.9992	0.81194	1
2883	5.8111	5.0017	0.80942	1

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RESULTS FROM VISUAL CURVE MATCHING

[SUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	2.5672E+000
S =	4.6819E-004

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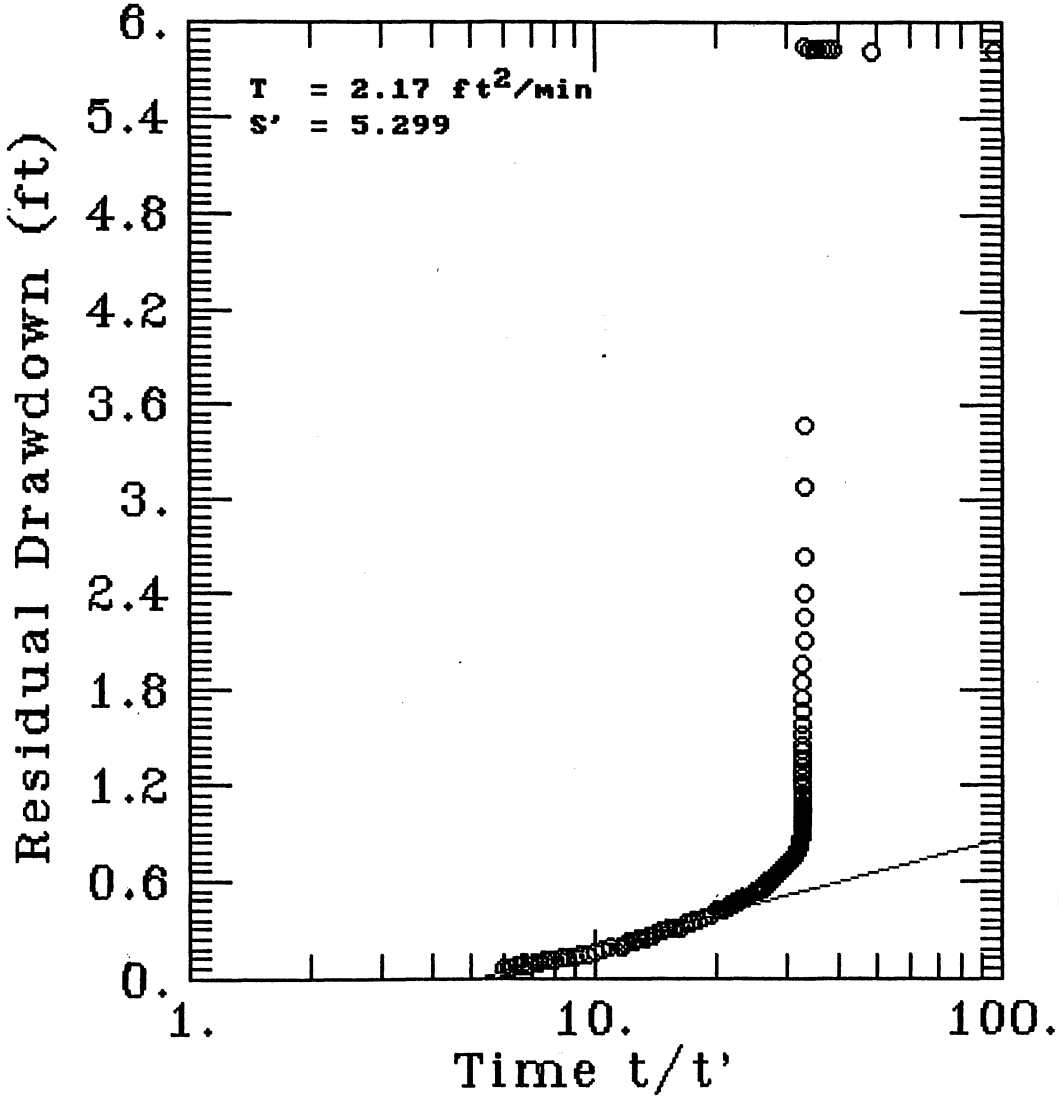
STF, AQUIFER TEST, 3A DATA, 3A RECOVERY



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

7/21/92 11:29:24

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TEST DESCRIPTION

ata set........... B:\3a_t&rec.aqt
ata set title..... STF, AQUIFER TEST, 3A DATA, 3A RECOVERY

nowns and Constants:
No. of data points.................. 204
Pumping rate........................ 8.02
Total pumping time.................. 2852

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ANALYTICAL METHOD

heis Recovery (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

...STICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	5.1039E-001	+/-	6.2003E-002
S' =	1.1174E+001	+/-	1.2077E+000

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 204
Number of estimated parameters.... 2
Degrees of freedom................ 202
Residual mean..................... -1.077E-011
Residual standard deviation....... 1.008
Residual variance................. 1.017

odel Residuals:

Time	Observed	Calculated	Residual	Weight
30	5.8183	2.6909	3.1274	1
60	5.8183	1.837	3.9813	1
75.55	5.84	1.5554	4.2846	1
77.55	5.84	1.5236	4.3164	1

79.86	5.8328	1.4879	4.3449	1
81.87	5.8328	1.4576	4.3752	1
83.87	5.8328	1.4283	4.4045	1
85.87	5.8255	1.3997	4.4258	1
87.87	5.8472	1.3717	4.4755	1
89	3.465	1.3562	2.1088	1
89.02	3.068	1.3559	1.7121	1
89.03	2.6349	1.3558	1.2791	1
89.05	2.4111	1.3555	1.0556	1
89.07	2.2595	1.3553	0.90423	1
89.08	2.1007	1.3551	0.74557	1
89.1	1.9635	1.3549	0.60864	1
89.12	1.8408	1.3546	0.48621	1
89.13	1.747	1.3545	0.39255	1
89.15	1.6675	1.3542	0.31332	1
89.17	1.5809	1.3539	0.22699	1
89.18	1.5232	1.3538	0.16943	1
89.2	1.4582	1.3535	0.1047	1
89.22	1.4149	1.3532	0.061672	1
89.23	1.3644	1.3531	0.011308	1
89.25	1.3283	1.3528	-0.02452	1
89.27	1.285	1.3525	-0.067549	1
89.28	1.2561	1.3524	-0.096313	1
89.3	1.2272	1.3521	-0.12494	1
89.32	1.2055	1.3519	-0.14637	1
89.33	1.1839	1.3517	-0.16783	1
89.35	1.1622	1.3515	-0.18926	1
89.37	1.1406	1.3512	-0.21059	1
89.38	1.1189	1.3511	-0.23216	1
89.4	1.1189	1.3508	-0.23188	1
89.42	1.0973	1.3505	-0.25321	1
89.43	1.0828	1.3504	-0.26758	1
89.45	1.0684	1.3501	-0.28171	1
89.47	1.0612	1.3498	-0.28863	1
89.48	1.0467	1.3497	-0.303	1
89.5	1.0395	1.3494	-0.30993	1
89.52	1.0323	1.3492	-0.31686	1
89.53	1.0179	1.349	-0.33112	1
89.55	1.0179	1.3488	-0.33085	1
89.57	1.0034	1.3485	-0.34508	1
89.58	0.9962	1.3483	-0.35214	1
89.6	0.9962	1.3481	-0.35187	1
89.62	0.9818	1.3478	-0.366	1
89.65	0.9818	1.3474	-0.3656	1
89.67	0.9745	1.3471	-0.37263	1
89.68	0.9745	1.347	-0.37249	1
89.69	0.9745	1.3469	-0.37236	1
89.7	0.9673	1.3467	-0.37942	1
89.71	0.9673	1.3466	-0.37929	1
89.73	0.9601	1.3463	-0.38622	1
89.75	0.9529	1.346	-0.39315	1
89.77	0.9457	1.3458	-0.40008	1
89.78	0.9385	1.3456	-0.40714	1
89.8	0.9312	1.3454	-0.41417	1
89.82	0.9385	1.3451	-0.4066	1
89.83	0.9312	1.345	-0.41377	1
89.85	0.9312	1.3447	-0.4135	1
89.87	0.9312	1.3444	-0.41323	1
89.88	0.9168	1.3443	-0.42749	1
89.9	0.9168	1.344	-0.42722	1

89.92	0.924	1.3438	-0.41975	1
89.93	0.9168	1.3436	-0.42682	1
89.95	0.9096	1.3433	-0.43375	1
89.97	0.9096	1.3431	-0.43348	1
89.98	0.9096	1.3429	-0.43334	1
90	0.9096	1.3427	-0.43307	1
90.08	0.8951	1.3416	-0.4465	1
90.17	0.8879	1.3404	-0.45249	1
90.25	0.8807	1.3393	-0.45861	1
90.33	0.8735	1.3382	-0.46474	1
90.42	0.8663	1.337	-0.47073	1
90.5	0.8663	1.336	-0.46966	1
90.58	0.859	1.3349	-0.47589	1
90.67	0.8518	1.3337	-0.48188	1
90.75	0.8518	1.3326	-0.48081	1
90.83	0.8518	1.3315	-0.47975	1
90.92	0.8374	1.3303	-0.49294	1
91	0.8374	1.3293	-0.49188	1
91.5	0.8085	1.3226	-0.51414	1
92	0.8013	1.316	-0.51474	1
92.5	0.7941	1.3095	-0.51537	1
93	0.7796	1.3029	-0.52334	1
93.5	0.7652	1.2964	-0.53125	1
94	0.758	1.29	-0.53199	1
94.5	0.7508	1.2836	-0.53277	1
95	0.7435	1.2772	-0.53368	1
95.5	0.7435	1.2708	-0.52732	1
96	0.7291	1.2645	-0.53541	1
96.5	0.7219	1.2582	-0.53632	1
97	0.7147	1.252	-0.53727	1
97.5	0.7075	1.2458	-0.53825	1
98	0.7002	1.2396	-0.53937	1
98.5	0.693	1.2334	-0.54041	1
99	0.6858	1.2273	-0.54149	1
99.5	0.6786	1.2212	-0.5426	1
100	0.6858	1.2151	-0.52935	1
100.5	0.6714	1.2091	-0.53772	1
101	0.6641	1.2031	-0.53903	1
101.5	0.6569	1.1972	-0.54026	1
102	0.6569	1.1912	-0.53433	1
102.5	0.6497	1.1853	-0.53562	1
103	0.6425	1.1794	-0.53695	1
103.5	0.6425	1.1736	-0.5311	1
104	0.628	1.1678	-0.53979	1
104.5	0.6353	1.162	-0.5267	1
105	0.6208	1.1562	-0.53544	1
105.5	0.628	1.1505	-0.52251	1
106	0.6208	1.1448	-0.52401	1
106.5	0.6136	1.1391	-0.52554	1
107	0.6136	1.1335	-0.51989	1
107.5	0.6064	1.1279	-0.52147	1
108	0.592	1.1223	-0.53028	1
108.5	0.5992	1.1167	-0.51751	1
109	0.5847	1.1112	-0.52648	1
109.5	0.592	1.1057	-0.51366	1
110	0.592	1.1002	-0.50818	1
111	0.5847	1.0893	-0.50458	1
112	0.5631	1.0785	-0.51539	1
113	0.5559	1.0678	-0.51189	1
114	0.5559	1.0572	-0.50129	1

115	0.5559	1.0467	-0.49079	1
116	0.5342	1.0363	-0.50208	1
117	0.5342	1.026	-0.49177	1
118	0.5342	1.0157	-0.48155	1
119	0.527	1.0056	-0.47861	1
120	0.5342	0.99557	-0.46137	1
121	0.5198	0.98561	-0.46581	1
122	0.5053	0.97574	-0.47044	1
123	0.5053	0.96595	-0.46065	1
124	0.5053	0.95624	-0.45094	1
125	0.4981	0.94662	-0.44852	1
126	0.4981	0.93707	-0.43897	1
127	0.4837	0.92761	-0.44391	1
128	0.4837	0.91822	-0.43452	1
129	0.4837	0.9089	-0.4252	1
130	0.4765	0.89966	-0.42316	1
131	0.462	0.8905	-0.4285	1
132	0.4692	0.88141	-0.41221	1
133	0.462	0.87239	-0.41039	1
134	0.462	0.86344	-0.40144	1
135	0.4476	0.85456	-0.40696	1
136	0.4476	0.84575	-0.39815	1
137	0.4476	0.837	-0.3894	1
138	0.4476	0.82833	-0.38073	1
139	0.4331	0.81972	-0.38662	1
140	0.4404	0.81117	-0.37077	1
141	0.4404	0.80268	-0.36228	1
142	0.4259	0.79426	-0.36836	1
143	0.4187	0.7859	-0.3672	1
144	0.4187	0.77761	-0.35891	1
145	0.4187	0.76937	-0.35067	1
146	0.4187	0.76119	-0.34249	1
147	0.4187	0.75307	-0.33437	1
148	0.4187	0.74501	-0.32631	1
149	0.4115	0.737	-0.3255	1
150	0.4115	0.72905	-0.31755	1
155	0.3898	0.69013	-0.30033	1
160	0.3754	0.6525	-0.2771	1
165	0.3537	0.61609	-0.26239	1
170	0.3537	0.58082	-0.22712	1
175	0.3393	0.54664	-0.20734	1
180	0.3393	0.51347	-0.17417	1
185	0.3104	0.48126	-0.17086	1
190	0.3104	0.44997	-0.13957	1
195	0.3032	0.41953	-0.11633	1
200	0.296	0.38992	-0.09392	1
205	0.2815	0.36109	-0.079585	1
210	0.2815	0.33299	-0.051491	1
215	0.2671	0.3056	-0.038503	1
220	0.2527	0.27889	-0.026188	1
225	0.2599	0.25282	0.0070839	1
230	0.2382	0.22736	0.010842	1
235	0.2382	0.20249	0.035711	1
240	0.231	0.17818	0.052818	1
245	0.2238	0.15441	0.069385	1
250	0.2238	0.13117	0.092634	1
255	0.2166	0.10841	0.10819	1
260	0.2094	0.086139	0.12326	1
265	0.1949	0.064324	0.13058	1
270	0.1949	0.042951	0.15195	1

285	0.1877	-0.018675	0.20637	1
300	0.1733	-0.07686	0.25016	1
315	0.1588	-0.13194	0.29074	1
330	0.1444	-0.18421	0.32861	1
345	0.1372	-0.23393	0.37113	1
360	0.13	-0.2813	0.4113	1
375	0.1227	-0.32653	0.44923	1
390	0.1155	-0.36978	0.48528	1
405	0.1011	-0.41121	0.51231	1
420	0.1011	-0.45095	0.55205	1
435	0.1011	-0.48911	0.59021	1
450	0.0866	-0.52582	0.61242	1
465	0.0866	-0.56116	0.64776	1
480	0.0794	-0.59522	0.67462	1
495	0.0866	-0.62809	0.71469	1
510	0.0722	-0.65984	0.73204	1
525	0.0722	-0.69052	0.76272	1
540	0.065	-0.72021	0.78521	1
555	0.0578	-0.74896	0.80676	1
570	0.0578	-0.77682	0.83462	1

===

RESULTS FROM VISUAL CURVE MATCHING

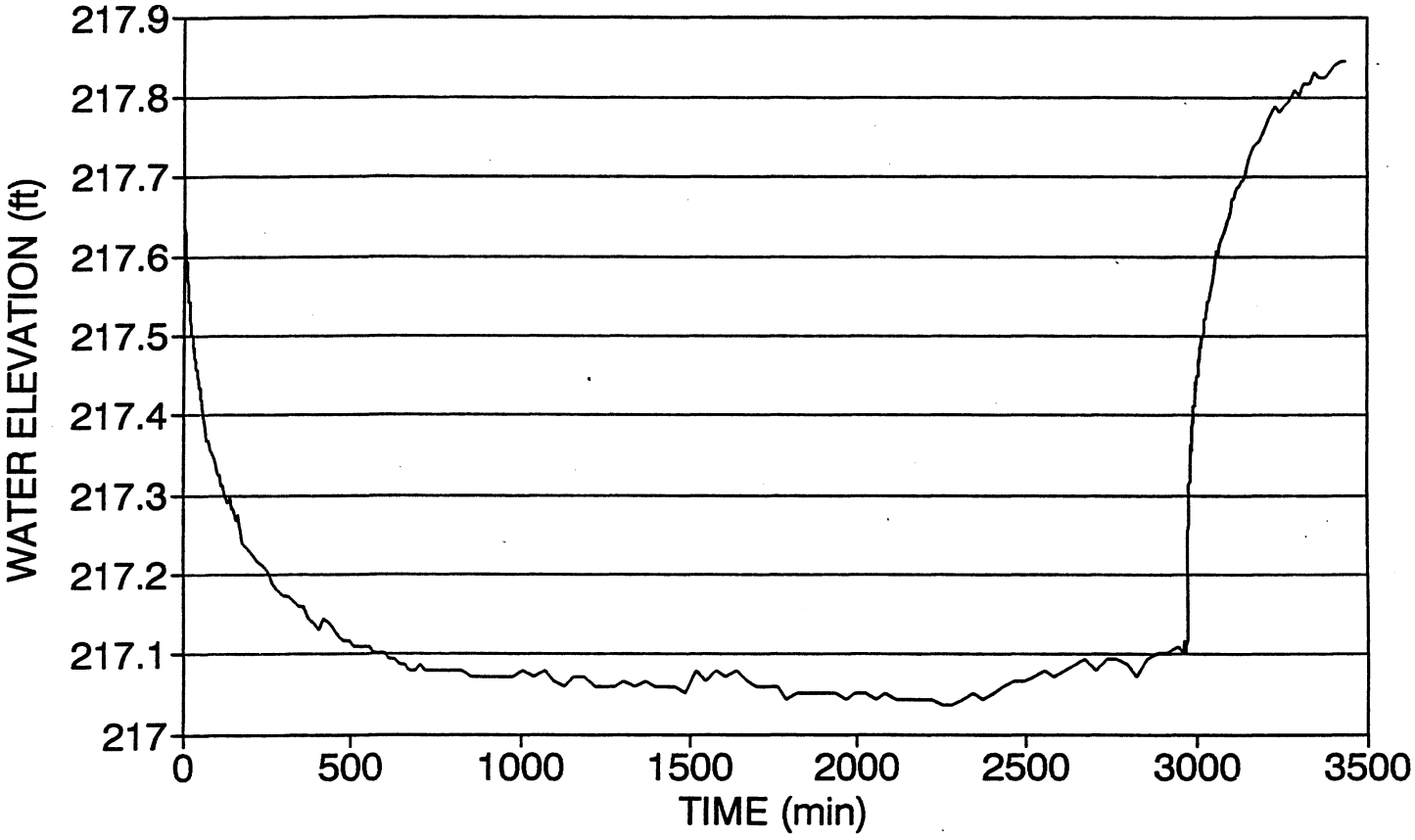
:SUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	2.1697E+000
	=	5.2993E+000

:<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

STF - NMW-3A PUMP TEST

WELL CBS-12A HYDROGRAPH



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A Q T E S O L V   R E S U L T S
Version 1.10

L/08/93 13:51:31

TEST DESCRIPTION

ata set........... 12a_neum.aqt
ata set title..... STF, AQUIFER TEST, 12A DATA, 3A PUMPED

nowns and Constants:
No. of data points.................. 281
Pumping rate........................ 8.02
Radius (distance) to obs. well...... 24.21
Aquifer saturated thickness......... 58.47

artial Penetration Data:
Depth of top of well screen......... 0
Depth of bottom of well screen...... 16.47
Depth of top of obs. well screen..... ~~0~~ 6.47
Depth of bottom of obs. well screen.. ~~16.47~~ 11.47
Hyd. conductivity ratio (Kz/Kr)..... 1

} output file is not correctly Echoing input data

ANALYTICAL METHOD

euman (Unconfined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	6.5775E+000	+/-	8.5335E-002
S =	2.6627E-005	+/-	3.2606E-003
Sy =	1.1146E-002	+/-	2.9228E-003
β =	1.0000E+000	+/-	2.1693E-001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
umber of residuals............... 281
ber of estimated parameters.... 4
grees of freedom................ 277
Residual mean..................... 0.002965
Residual standard deviation....... 0.03928
Residual variance................. 0.001543

[odel Residuals:

Time	Observed	Calculated	Residual	Weight
6E-005	0.0072	0	0.0072	1
0.01734	0.0145	0.0051024	0.0093976	1
0.03462	0.0217	0.0058534	0.015847	1
0.05046	0.0217	0.0067197	0.01498	1
0.06774	0.0361	0.0077863	0.028314	1
0.08358	0.0361	0.0088385	0.027262	1
0.10086	0.0433	0.0096319	0.033668	1
0.1167	0.0578	0.010793	0.047007	1
0.13398	0.0506	0.012094	0.038506	1
0.15126	0.0578	0.013445	0.044355	1
0.18726	0.0578	0.016332	0.041468	1
0.19878	0.0578	0.017294	0.040506	1
0.21174	0.0578	0.018377	0.039423	1
0.2247	0.0722	0.019458	0.052742	1
0.23766	0.0722	0.020564	0.051636	1
0.24918	0.0722	0.021557	0.050643	1
0.2679	0.0722	0.023203	0.048997	1
0.28374	0.0722	0.024596	0.047604	1
0.30102	0.0722	0.026129	0.046071	1
0.31686	0.0794	0.027524	0.051876	1
0.33414	0.0794	0.02908	0.05032	1
0.35142	0.0794	0.030646	0.048754	1
0.36726	0.0794	0.032089	0.047311	1
0.38454	0.0867	0.033697	0.053003	1
0.40038	0.0794	0.03515	0.04425	1
0.41766	0.0867	0.03674	0.04996	1
0.4335	0.0867	0.038201	0.048499	1
0.45078	0.0867	0.039796	0.046904	1
0.46806	0.0867	0.041393	0.045307	1
0.4839	0.0939	0.042856	0.051044	1
0.50118	0.0939	0.044453	0.049447	1
0.51702	0.1011	0.045914	0.055186	1
0.5343	0.0939	0.047507	0.046393	1
0.55014	0.0939	0.048964	0.044936	1
0.56742	0.1011	0.050549	0.050551	1
0.5847	0.0939	0.05213	0.04177	1
0.60054	0.1011	0.054006	0.047094	1
0.61782	0.0939	0.055577	0.038323	1
0.63366	0.1083	0.057011	0.051289	1
0.65094	0.1011	0.058569	0.042531	1
0.66678	0.1083	0.05999	0.04831	1
0.68406	0.1083	0.061534	0.046766	1
0.70134	0.1083	0.064453	0.043847	1
0.71718	0.1083	0.065853	0.042447	1
0.73446	0.1155	0.067372	0.048128	1
0.7503	0.1155	0.068756	0.046744	1
0.76758	0.1155	0.070256	0.045244	1
0.78342	0.1155	0.071624	0.043876	1
0.8007	0.1227	0.073106	0.049594	1
0.8367	0.1227	0.07616	0.04654	1
0.84966	0.1227	0.077249	0.045451	1
0.86262	0.1227	0.078331	0.044369	1
0.87414	0.13	0.079288	0.050712	1
0.8871	0.1227	0.080359	0.042341	1

0.89862	0.1227	0.081306	0.041394	1
0.91734	0.13	0.082835	0.047165	1
0.93462	0.13	0.084335	0.045665	1
0.95046	0.13	0.085608	0.044392	1
0.96774	0.13	0.086986	0.043014	1
1.0513	0.1372	0.093489	0.043711	1
1.1333	0.1372	0.099626	0.037574	1
1.2169	0.1444	0.10562	0.038783	1
1.3004	0.1372	0.11136	0.02584	1
1.3839	0.1516	0.11671	0.034888	1
1.4674	0.1516	0.12199	0.02961	1
1.5509	0.1516	0.12705	0.024548	1
1.6345	0.1588	0.13191	0.02689	1
1.718	0.1588	0.13658	0.022223	1
1.8001	0.1588	0.14099	0.017814	1
1.8836	0.1661	0.1453	0.020796	1
1.9685	0.1805	0.14953	0.030968	1
2.4668	0.1877	0.17172	0.015978	1
2.9679	0.2022	0.18996	0.012243	1
3.4676	0.2094	0.20538	0.0040241	1
3.9673	0.2166	0.21874	-0.0021357	1
4.4669	0.2238	0.23051	-0.0067082	1
4.9681	0.231	0.24105	-0.010053	1
5.4677	0.2382	0.25011	-0.011913	1
5.9674	0.2382	0.25877	-0.020568	1
6.4671	0.2382	0.26672	-0.028519	1
6.9668	0.2455	0.27407	-0.028571	1
7.4679	0.2527	0.28093	-0.028226	1
7.9676	0.2599	0.28731	-0.027413	1
8.4673	0.2527	0.29331	-0.040606	1
8.9669	0.2671	0.29895	-0.031852	1
9.4681	0.2671	0.3043	-0.037203	1
9.9677	0.2743	0.30936	-0.035061	1
10.467	0.2743	0.31417	-0.039868	1
10.967	0.2816	0.31875	-0.037149	1
11.467	0.2743	0.32312	-0.048823	1
11.968	0.2816	0.32732	-0.045721	1
12.468	0.2888	0.33133	-0.042534	1
12.967	0.2888	0.33519	-0.046388	1
13.467	0.2888	0.33889	-0.050094	1
13.968	0.296	0.34247	-0.046474	1
14.468	0.3032	0.34592	-0.042717	1
14.967	0.3104	0.34924	-0.038842	1
15.467	0.3104	0.35246	-0.042058	1
15.967	0.3104	0.35557	-0.04517	1
16.468	0.3104	0.35859	-0.048194	1
16.968	0.3177	0.36152	-0.043818	1
17.467	0.3104	0.36436	-0.053957	1
17.967	0.3177	0.36712	-0.049415	1
18.468	0.3177	0.36981	-0.052105	1
18.968	0.3177	0.37241	-0.054714	1
19.467	0.3321	0.37496	-0.042856	1
19.967	0.3321	0.37743	-0.045333	1
20.467	0.3321	0.37985	-0.047748	1
20.969	0.3393	0.38222	-0.042917	1
21.967	0.3393	0.38676	-0.047458	1
22.968	0.3465	0.39111	-0.044608	1
23.967	0.3537	0.39526	-0.041565	1
24.967	0.3537	0.39925	-0.045552	1
25.968	0.361	0.40309	-0.042086	1

26.967	0.361	0.40677	-0.04577	1
27.968	0.361	0.41032	-0.049324	1
28.967	0.361	0.41375	-0.052748	1
29.968	0.3682	0.41706	-0.048859	1
30.967	0.3754	0.42026	-0.044857	1
31.968	0.3826	0.42421	-0.041612	1
32.967	0.3754	0.42721	-0.051811	1
33.967	0.3826	0.43012	-0.047521	1
34.968	0.3898	0.43295	-0.043151	1
35.967	0.3898	0.4357	-0.045896	1
36.968	0.3898	0.43837	-0.048569	1
37.967	0.3971	0.44097	-0.043867	1
38.968	0.3971	0.4435	-0.046401	1
39.967	0.4043	0.44597	-0.041667	1
40.968	0.4043	0.44837	-0.044075	1
41.967	0.4043	0.45072	-0.046421	1
42.967	0.4115	0.45301	-0.041513	1
43.968	0.4115	0.45525	-0.043754	1
44.967	0.4115	0.45744	-0.045942	1
45.968	0.4187	0.45958	-0.040884	1
46.967	0.4259	0.46168	-0.035778	1
47.968	0.4259	0.46373	-0.03783	1
48.967	0.4259	0.46574	-0.039837	1
49.968	0.4259	0.46771	-0.041805	1
50.967	0.4332	0.46963	-0.036432	1
51.967	0.4332	0.47152	-0.038322	1
52.968	0.4404	0.47338	-0.032978	1
53.967	0.4404	0.4752	-0.034796	1
54.968	0.4404	0.47698	-0.036584	1
55.967	0.4476	0.47874	-0.031137	1
56.968	0.4548	0.48046	-0.025661	1
57.967	0.4548	0.48215	-0.027352	1
58.968	0.4548	0.48382	-0.029017	1
59.967	0.4548	0.48545	-0.030652	1
60.97	0.462	0.48706	-0.025064	1
65.968	0.4765	0.49473	-0.018226	1
70.968	0.4909	0.50183	-0.010929	1
75.967	0.4909	0.50845	-0.017547	1
80.967	0.4981	0.51464	-0.016543	1
85.968	0.5053	0.52047	-0.015168	1
90.968	0.5126	0.52596	-0.013361	1
95.967	0.5198	0.53116	-0.011361	1
100.97	0.527	0.5361	-0.0090964	1
105.97	0.5342	0.54079	-0.0065938	1
110.97	0.5342	0.54528	-0.011076	1
115.97	0.5487	0.54956	-0.00085854	1
120.97	0.5487	0.55366	-0.0049612	1
125.97	0.5559	0.5576	-0.0016987	1
130.97	0.5631	0.56138	0.0017162	1
135.97	0.5703	0.56503	0.0052736	1
140.97	0.5631	0.56854	-0.0054366	1
145.97	0.5775	0.57192	0.0055751	1
150.97	0.5775	0.5752	0.0023013	1
155.97	0.5847	0.57837	0.006334	1
160.97	0.592	0.58143	0.010568	1
165.97	0.5847	0.5844	0.00029722	1
170.97	0.5992	0.58729	0.011915	1
175.97	0.6064	0.59008	0.016316	1
180.97	0.6208	0.5928	0.027997	1
195.97	0.6281	0.60052	0.027577	1

210.97	0.6353	0.60767	0.027635	1
225.97	0.6425	0.61431	0.028193	1
240.97	0.6497	0.62052	0.029185	1
255.97	0.6569	0.62634	0.030556	1
270.97	0.6714	0.63184	0.039561	1
285.97	0.6786	0.63703	0.041567	1
300.97	0.6858	0.64197	0.043831	1
315.97	0.6858	0.64667	0.03913	1
330.97	0.693	0.65116	0.041842	1
345.97	0.7002	0.65546	0.044745	1
360.97	0.7002	0.65958	0.04062	1
375.97	0.7147	0.66355	0.051155	1
390.97	0.7219	0.66737	0.054534	1
405.97	0.7291	0.67105	0.058047	1
420.97	0.7147	0.67461	0.040085	1
435.97	0.7219	0.67806	0.043837	1
450.97	0.7291	0.6814	0.047696	1
465.97	0.7363	0.68464	0.051656	1
480.97	0.7436	0.68779	0.055811	1
495.97	0.7436	0.69085	0.052754	1
510.97	0.7508	0.69382	0.056983	1
525.97	0.7508	0.69671	0.054091	1
540.97	0.7508	0.69952	0.051284	1
555.97	0.7508	0.70226	0.048542	1
570.97	0.758	0.70493	0.053069	1
585.97	0.758	0.70754	0.050463	1
600.97	0.758	0.71008	0.047921	1
615.97	0.7652	0.71256	0.052641	1
630.97	0.7652	0.71498	0.050219	1
645.97	0.7724	0.71734	0.055056	1
660.97	0.7724	0.71965	0.052747	1
675.97	0.7797	0.72191	0.057791	1
690.97	0.7797	0.72411	0.055586	1
705.97	0.7724	0.72627	0.046132	1
720.97	0.7797	0.72837	0.051325	1
750.97	0.7797	0.73245	0.047251	1
780.97	0.7797	0.73635	0.043352	1
826.97	0.7797	0.742	0.037704	1
856.97	0.7869	0.7455	0.041404	1
886.97	0.7869	0.74885	0.038047	1
916.97	0.7869	0.75208	0.034824	1
946.97	0.7869	0.75517	0.031727	1
976.97	0.7869	0.75815	0.028751	1
1007	0.7797	0.76101	0.018687	1
1037	0.7869	0.76377	0.023131	1
1067	0.7797	0.76642	0.013275	1
1097	0.7941	0.76898	0.025115	1
1127	0.8013	0.77145	0.029846	1
1157	0.7869	0.77384	0.013062	1
1187	0.7869	0.77614	0.010759	1
1217	0.8013	0.77837	0.022933	1
1247	0.8013	0.78052	0.020779	1
1277	0.8013	0.78261	0.018694	1
1307	0.7941	0.78463	0.0094737	1
1337	0.8013	0.78658	0.014715	1
1367	0.7941	0.78849	0.0056145	1
1397	0.8013	0.79033	0.010969	1
1427	0.8013	0.79212	0.0091759	1
1457	0.8013	0.79387	0.007432	1
1487	0.8085	0.79557	0.012935	1

1517	0.7797	0.79722	-0.017518	1
1547	0.7941	0.79883	-0.0047285	1
1577	0.7797	0.8004	-0.020699	1
1607	0.7869	0.80193	-0.015033	1
1637	0.7797	0.80343	-0.02373	1
1667	0.7941	0.80489	-0.010794	1
1697	0.8013	0.80633	-0.0050254	1
1727	0.8013	0.80773	-0.0064265	1
1757	0.8013	0.8091	-0.0077988	1
1787	0.8157	0.81044	0.0052563	1
1817	0.8085	0.81176	-0.0032626	1
1847	0.8085	0.81306	-0.0045569	1
1877	0.8085	0.81433	-0.0058278	1
1907	0.8085	0.81558	-0.0070765	1
1937	0.8085	0.8168	-0.0083041	1
1967	0.8157	0.81801	-0.0023118	1
1997	0.8085	0.8192	-0.0107	1
2027	0.8085	0.82037	-0.011871	1
2057	0.8157	0.82152	-0.0058242	1
2087	0.8085	0.82266	-0.014161	1
2117	0.8157	0.82378	-0.0080828	1
2147	0.8157	0.82489	-0.0091895	1
2177	0.8157	0.82598	-0.010282	1
2207	0.8157	0.82706	-0.011362	1
2223	0.8157	0.82763	-0.011932	1
2253	0.823	0.82869	-0.005692	1
2283	0.823	0.82974	-0.0067402	1
2313	0.8157	0.83078	-0.015077	1
2343	0.8085	0.8318	-0.023303	1
2373	0.8157	0.83282	-0.017119	1
2403	0.8085	0.83383	-0.025325	1
2433	0.8013	0.83482	-0.033522	1
2463	0.7941	0.83581	-0.04171	1
2493	0.7941	0.83679	-0.04269	1
2523	0.7869	0.83776	-0.050861	1
2553	0.7797	0.83872	-0.059024	1
2583	0.7869	0.83968	-0.05278	1
2613	0.7797	0.84063	-0.060929	1
2643	0.7724	0.84157	-0.069171	1
2673	0.7652	0.84251	-0.077306	1
2703	0.7797	0.84344	-0.063736	1
2733	0.7652	0.84436	-0.079159	1
2763	0.7652	0.84528	-0.080076	1
2793	0.7724	0.84619	-0.073788	1
2823	0.7869	0.84709	-0.060194	1
2853	0.7652	0.848	-0.082795	1
2883	0.758	0.84889	-0.090891	1

==========

RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	6.5775E+000
S	=	2.6627E-005
Sy	=	1.1146E-002
β	=	1.0000E+000

Input file (6 JAN 93)

```
CF, AQUIFER TEST, 12A DATA, 3A PUMPED
vrate
.02
[illegible]s
[illegible]
[illegible]
3.47
arpn2
3.47
```

— Depth to top of well screen
5.47 — Depth to bottom of well screen
.47 — Depth to top of obs. well screen
1.47 — Depth to bottom of obs. well screen

```
sdata
e-005    0.0072    1
.01734    0.0145    1
.03462    0.0217    1
.05046    0.0217    1
.06774    0.0361    1
.08358    0.0361    1
.10086    0.0433    1
.1167    0.0578    1
.13398    0.0506    1
.15126    0.0578    1
.18726    0.0578    1
.19878    0.0578    1
.21174    0.0578    1
.2247    0.0722    1
[illegible]66    0.0722    1
[illegible]8    0.0722    1
.2879    0.0722    1
.28374    0.0722    1
.30102    0.0722    1
.31686    0.0794    1
.33414    0.0794    1
.35142    0.0794    1
.36726    0.0794    1
.38454    0.0867    1
.40038    0.0794    1
.41766    0.0867    1
.4335    0.0867    1
.45078    0.0867    1
.46806    0.0867    1
.4839    0.0939    1
.50118    0.0939    1
.51702    0.1011    1
.5343    0.0939    1
.55014    0.0939    1
.56742    0.1011    1
.5847    0.0939    1
.60054    0.1011    1
.61782    0.0939    1
.63366    0.1083    1
[illegible]094    0.1011    1
[illegible]78    0.1083    1
[illegible]06    0.1083    1
.70134    0.1083    1
.71718    0.1083    1
.73446    0.1155    1
```

.7503	0.1155	1
.76758	0.1155	1
.78342	0.1155	1
.8007	0.1227	1
.8367	0.1227	1
.84966	0.1227	1
.86262	0.1227	1
.87414	0.13	1
.8871	0.1227	1
.89862	0.1227	1
.91734	0.13	1
.93462	0.13	1
.95046	0.13	1
.96774	0.13	1
.05126	0.1372	1
.13334	0.1372	1
.21686	0.1444	1
.30038	0.1372	1
.3839	0.1516	1
.46742	0.1516	1
.55094	0.1516	1
.63446	0.1588	1
.71798	0.1588	1
.80006	0.1588	1
.88358	0.1661	1
.96854	0.1805	1
.46678	0.1877	1
.9679	0.2022	1
.46758	0.2094	1
.96726	0.2166	1
.46694	0.2238	1
.96806	0.231	1
.46774	0.2382	1
.96742	0.2382	1
.4671	0.2382	1
.96678	0.2455	1
.4679	0.2527	1
.96758	0.2599	1
.46726	0.2527	1
.96694	0.2671	1
.46806	0.2671	1
.96774	0.2743	1
0.4674	0.2743	1
0.9671	0.2816	1
1.4668	0.2743	1
1.9679	0.2816	1
2.4676	0.2888	1
2.9673	0.2888	1
3.4669	0.2888	1
3.9681	0.296	1
4.4677	0.3032	1
4.9674	0.3104	1
5.4671	0.3104	1
5.9668	0.3104	1
5.4679	0.3104	1
5.9676	0.3177	1
7.4673	0.3104	1
7.9669	0.3177	1
3.4681	0.3177	1
3.9677	0.3177	1

9.4674	0.3321	1
9.9671	0.3321	1
0.4668	0.3321	1
[illegible]93	0.3393	1
[illegible]73	0.3393	1
2.[illegible]31	0.3465	1
3.9674	0.3537	1
4.9668	0.3537	1
5.9676	0.361	1
5.9669	0.361	1
7.9677	0.361	1
8.9671	0.361	1
9.9679	0.3682	1
0.9673	0.3754	1
1.9681	0.3826	1
2.9674	0.3754	1
3.9668	0.3826	1
4.9676	0.3898	1
5.9669	0.3898	1
6.9677	0.3898	1
7.9671	0.3971	1
8.9679	0.3971	1
9.9673	0.4043	1
0.9681	0.4043	1
1.9674	0.4043	1
2.9668	0.4115	1
3.9676	0.4115	1
4.9669	0.4115	1
5.9677	0.4187	1
[illegible]71	0.4259	1
[illegible]79	0.4259	1
8.9673	0.4259	1
9.9681	0.4259	1
0.9674	0.4332	1
1.9668	0.4332	1
2.9676	0.4404	1
3.9669	0.4404	1
4.9677	0.4404	1
5.9671	0.4476	1
6.9679	0.4548	1
7.9673	0.4548	1
8.9681	0.4548	1
9.9674	0.4548	1
0.9697	0.462	1
5.9679	0.4765	1
0.9676	0.4909	1
5.9673	0.4909	1
0.9669	0.4981	1
5.9681	0.5053	1
0.9677	0.5126	1
5.9674	0.5198	1
00.967	0.527	1
05.967	0.5342	1
10.968	0.5342	1
[illegible]968	0.5487	1
[illegible]57	0.5487	1
25.967	0.5559	1
30.968	0.5631	1
35.968	0.5703	1
40.967	0.5631	1

45.967	0.5775	1
50.967	0.5775	1
55.968	0.5847	1
60.968	0.592	1
65.967	0.5847	1
70.967	0.5992	1
75.968	0.6064	1
80.969	0.6208	1
95.967	0.6281	1
10.967	0.6353	1
25.968	0.6425	1
40.967	0.6497	1
55.967	0.6569	1
70.968	0.6714	1
85.967	0.6786	1
00.967	0.6858	1
15.968	0.6858	1
30.967	0.693	1
45.967	0.7002	1
60.968	0.7002	1
75.967	0.7147	1
90.967	0.7219	1
05.968	0.7291	1
20.967	0.7147	1
35.967	0.7219	1
50.968	0.7291	1
65.967	0.7363	1
80.967	0.7436	1
95.968	0.7436	1
10.967	0.7508	1
25.967	0.7508	1
40.968	0.7508	1
55.967	0.7508	1
70.967	0.758	1
85.968	0.758	1
00.967	0.758	1
15.967	0.7652	1
30.968	0.7652	1
45.967	0.7724	1
60.967	0.7724	1
75.968	0.7797	1
90.967	0.7797	1
05.967	0.7724	1
20.969	0.7797	1
50.967	0.7797	1
80.967	0.7797	1
26.973	0.7797	1
56.973	0.7869	1
86.974	0.7869	1
16.973	0.7869	1
46.973	0.7869	1
76.974	0.7869	1
006.97	0.7797	1
036.97	0.7869	1
066.97	0.7797	1
096.97	0.7941	1
.26.97	0.8013	1
.56.97	0.7869	1
.86.97	0.7869	1
216.97	0.8013	1

246.97	0.8013	1
276.97	0.8013	1
306.97	0.7941	1
[illegible]97	0.8013	1
3[illegible]97	0.7941	1
3[illegible]97	0.8013	1
426.97	0.8013	1
456.97	0.8013	1
486.97	0.8085	1
516.97	0.7797	1
546.97	0.7941	1
576.97	0.7797	1
606.97	0.7869	1
636.97	0.7797	1
666.97	0.7941	1
696.97	0.8013	1
726.97	0.8013	1
756.97	0.8013	1
786.97	0.8157	1
816.97	0.8085	1
846.97	0.8085	1
876.97	0.8085	1
906.97	0.8085	1
936.97	0.8085	1
966.97	0.8157	1
996.97	0.8085	1
026.97	0.8085	1
056.97	0.8157	1
086.97	0.8085	1
[illegible]97	0.8157	1
1[illegible]97	0.8157	1
176.97	0.8157	1
206.97	0.8157	1
222.97	0.8157	1
252.97	0.823	1
282.97	0.823	1
312.97	0.8157	1
342.97	0.8085	1
372.97	0.8157	1
402.97	0.8085	1
432.97	0.8013	1
462.97	0.7941	1
492.97	0.7941	1
522.97	0.7869	1
552.97	0.7797	1
582.97	0.7869	1
612.97	0.7797	1
642.97	0.7724	1
672.97	0.7652	1
702.97	0.7797	1
732.97	0.7652	1
762.97	0.7652	1
792.97	0.7724	1
822.97	0.7869	1
[illegible]97	0.7652	1
[illegible]97	0.758	1

```
═╤═╡ Program Control ╞═══════════════════════╕STF, AQUIFER TEST, 12A DATA, 3A PUMPED═╕
 │Data Set Manager                            │Pumping rate..........         8.02   │
 │Confined solutions                          │Distance to obs. well..       24.21   │
 │Unconfined solutions                        │Number of data points..        281    │
 │Leaky solutions                             └───────────────────────────────────────┘
 │Slug test solutions                                      ╡ Estimation Data ╞
 │Fracture solutions                                        Max. iter. =  25
 │╔═╡ Unconfined Solutions ╞═══╗                          Parameter Estimates
 ││Theis me╔═╡ Parameter Estimation Control ╞═╗             T   =    7.650E+000
 └│Cooper-J║Maximum no. of iterations           ║           S   =    4.629E-003
  │Neuman m║Starting guesses                    ║           Sy  =    4.629E-003
  └────────║Upper and lower bounds              ║           β   =    1.000E+000
           ║Activate/deactivate parameters      ║          Parameter Bounds
           ║Partial penetration--on/off         ║         min. T  = 7.650E-003
           ║Graph data/match curve              ║         max. T  = 7.650E+003
           ║Estimate aquifer parameters         ║         min. S  = 1.000E-008
           ╚════════════════════════════════════╝         max. S  = 5.000E-001
                                                          min. Sy = 1.000E-008
                                                          max. Sy = 5.000E-001
                                                          min. β  = 1.000E-004
                                                          max. β  = 1.000E+000
                                                           No. of wells =  1

    Unconfined Aquifer:  NEUMAN                          P
═══ AQTESOLV ══════════ F1=HELP ═════════════ Fri Jan  8, 1993   1:55 PM ═══
```

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

A Q T E S O L V

A Program for

Automatic Estimation of Aquifer Coefficients

From Aquifer Test Data

By:

Glenn M. Duffield
and
James O. Rumbaugh, III

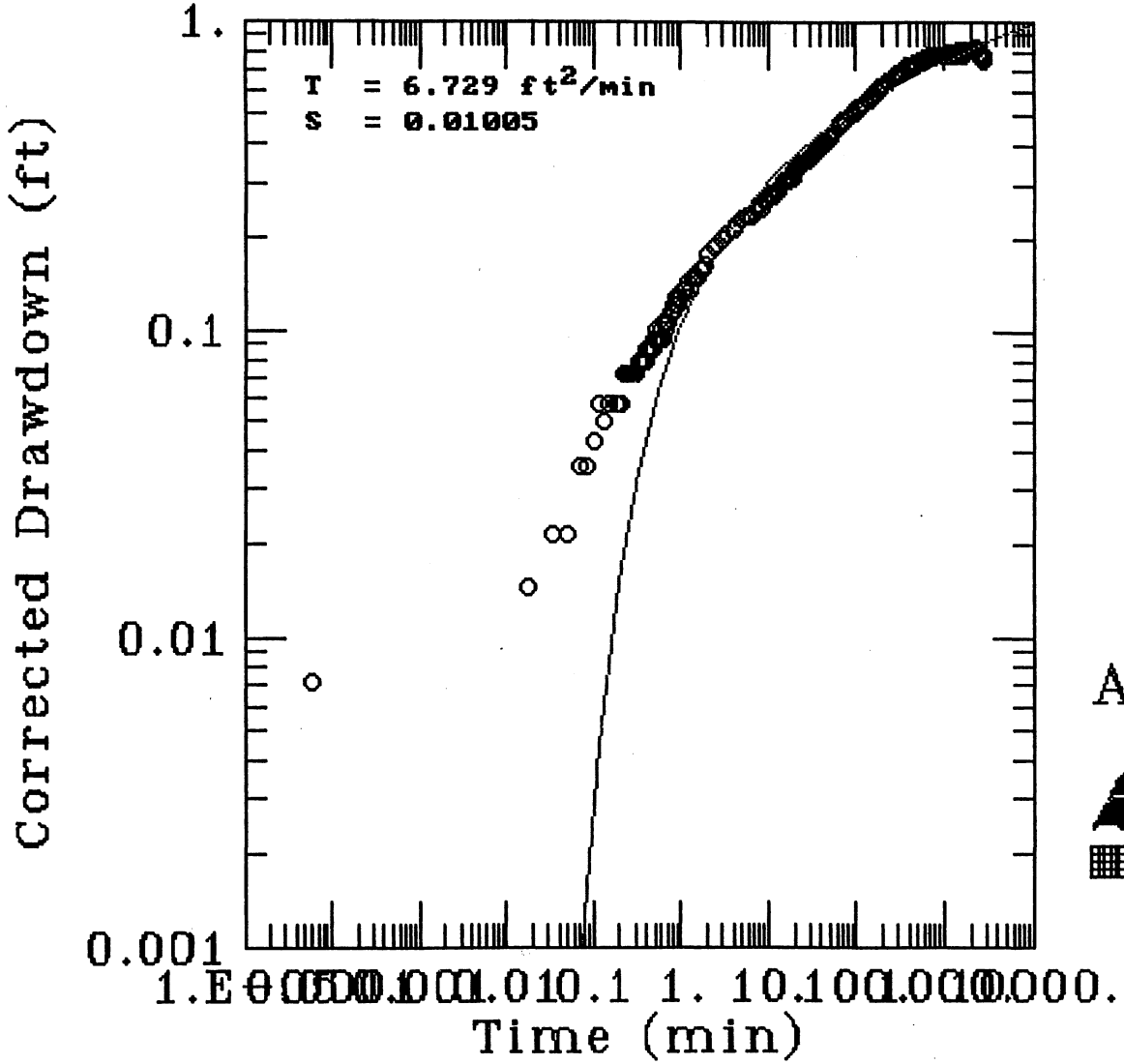
Geraghty & Miller Modeling Group
1895 Preston White Drive, Suite 301
Reston, VA 22091

(703) 476 - 0335

A Q T E S O L V is a user-friendly program designed to analyze data from aquifer tests automatically. Aquifer coefficients for a variety of aquifer test conditions can be estimated by A Q T E S O L V , including the following:

- o confined aquifers, unconfined aquifers, and leaky aquifers

STF, AQUIFER TEST, 12A DATA, 3A PUMPED



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

7/29/92 10:23:..

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TEST DESCRIPTION

ata set........... 12a_t&dd.aqt
ata set title..... STF, AQUIFER TEST, 12A DATA, 3A PUMPED

nowns and Constants:
No. of data points.................. 281
Pumping rate........................ 8.02
Radius (distance) to obs. well...... 24.21
Aquifer saturated thickness......... 58.47

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ANALYTICAL METHOD

heis (Unconfined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	6.7288E+000	+/-	7.1453E-002
S	=	1.0045E-002	+/-	5.5916E-004

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 281
Number of estimated parameters.... 2
Degrees of freedom................ 279
Residual mean..................... 0.003148
Residual standard deviation....... 0.03796
Residual variance................. 0.001441

odel Residuals:

Time	Observed	Calculated	Residual	Weight
6E-005	0.0072	0	0.0072	1
0.01734	0.0145	2.3243E-008	0.0145	1
0.03462	0.0217	2.3722E-005	0.021676	1

0.05046	0.0217	0.00023944	0.021461	1
0.06774	0.0361	0.00092642	0.035174	1
0.08358	0.0361	0.0020263	0.034074	1
0.10086	0.0433	0.0036799	0.03962	1
0.1167	0.0578	0.0055256	0.052274	1
0.13398	0.0506	0.0078054	0.042795	1
0.15126	0.0578	0.010282	0.047518	1
0.18726	0.0578	0.015807	0.041993	1
0.19878	0.0578	0.01763	0.04017	1
0.21174	0.0578	0.019693	0.038107	1
0.2247	0.0722	0.021761	0.050439	1
0.23766	0.0722	0.023826	0.048374	1
0.24918	0.0722	0.025654	0.046546	1
0.2679	0.0722	0.028602	0.043598	1
0.28374	0.0722	0.031067	0.041133	1
0.30102	0.0722	0.033721	0.038479	1
0.31686	0.0794	0.036118	0.043282	1
0.33414	0.0794	0.038691	0.040709	1
0.35142	0.0794	0.041219	0.038181	1
0.36726	0.0794	0.043495	0.035905	1
0.38454	0.0867	0.045933	0.040767	1
0.40038	0.0794	0.048127	0.031273	1
0.41766	0.0867	0.050477	0.036223	1
0.4335	0.0867	0.05259	0.03411	1
0.45078	0.0867	0.054852	0.031848	1
0.46806	0.0867	0.05707	0.02963	1
0.4839	0.0939	0.059066	0.034834	1
0.50118	0.0939	0.061202	0.032698	1
0.51702	0.1011	0.063125	0.037975	1
0.5343	0.0939	0.065184	0.028716	1
0.55014	0.0939	0.067037	0.026863	1
0.56742	0.1011	0.069022	0.032078	1
0.5847	0.0939	0.070971	0.022929	1
0.60054	0.1011	0.072726	0.028374	1
0.61782	0.0939	0.074607	0.019293	1
0.63366	0.1083	0.076302	0.031998	1
0.65094	0.1011	0.078119	0.022981	1
0.66678	0.1083	0.079758	0.028542	1
0.68406	0.1083	0.081515	0.026785	1
0.70134	0.1083	0.083243	0.025057	1
0.71718	0.1083	0.084802	0.023498	1
0.73446	0.1155	0.086475	0.029025	1
0.7503	0.1155	0.087984	0.027516	1
0.76758	0.1155	0.089605	0.025895	1
0.78342	0.1155	0.091069	0.024431	1
0.8007	0.1227	0.092641	0.030059	1
0.8367	0.1227	0.095839	0.026861	1
0.84966	0.1227	0.096966	0.025734	1
0.86262	0.1227	0.09808	0.02462	1
0.87414	0.13	0.09906	0.03094	1
0.8871	0.1227	0.10015	0.02255	1
0.89862	0.1227	0.10111	0.02159	1
0.91734	0.13	0.10265	0.027351	1
0.93462	0.13	0.10405	0.025951	1
0.95046	0.13	0.10532	0.024684	1
0.96774	0.13	0.10668	0.023322	1
1.0513	0.1372	0.11301	0.024189	1
1.1333	0.1372	0.11886	0.018342	1
1.2169	0.1444	0.12447	0.019933	1
1.3004	0.1372	0.12977	0.0074299	1

1.3839	0.1516	0.1348	0.016803	1
1.4674	0.1516	0.13958	0.012024	1
1.5509	0.1516	0.14413	0.0074718	1
1.6345	0.1588	0.14848	0.010325	1
1.718	0.1588	0.15263	0.0061656	1
1.8001	0.1588	0.15655	0.0022464	1
1.8836	0.1661	0.16038	0.0057162	1
1.9685	0.1805	0.16413	0.016371	1
2.4668	0.1877	0.18356	0.004139	1
2.9679	0.2022	0.19979	0.0024085	1
3.4676	0.2094	0.21363	-0.0042253	1
3.9673	0.2166	0.22571	-0.0091073	1
4.4669	0.2238	0.23643	-0.012631	1
4.9681	0.231	0.2461	-0.015098	1
5.4677	0.2382	0.25485	-0.016652	1
5.9674	0.2382	0.26287	-0.02467	1
6.4671	0.2382	0.27027	-0.032067	1
6.9668	0.2455	0.27713	-0.031632	1
7.4679	0.2527	0.28355	-0.030854	1
7.9676	0.2599	0.28955	-0.029655	1
8.4673	0.2527	0.2952	-0.0425	1
8.9669	0.2671	0.30053	-0.033431	1
9.4681	0.2671	0.30559	-0.038494	1
9.9677	0.2743	0.31039	-0.036089	1
10.467	0.2743	0.31495	-0.040654	1
10.967	0.2816	0.31931	-0.037712	1
11.467	0.2743	0.32348	-0.049179	1
11.968	0.2816	0.32748	-0.045883	1
12.468	0.2888	0.33132	-0.042515	1
12.967	0.2888	0.335	-0.0462	1
13.467	0.2888	0.33855	-0.049747	1
13.968	0.296	0.34198	-0.045978	1
14.468	0.3032	0.34528	-0.04208	1
14.967	0.3104	0.34847	-0.038072	1
15.467	0.3104	0.35156	-0.041161	1
15.967	0.3104	0.35455	-0.044153	1
16.468	0.3104	0.35746	-0.047063	1
16.968	0.3177	0.36028	-0.042578	1
17.467	0.3104	0.36301	-0.052614	1
17.967	0.3177	0.36567	-0.047972	1
18.468	0.3177	0.36827	-0.050567	1
18.968	0.3177	0.37079	-0.053085	1
19.467	0.3321	0.37324	-0.041139	1
19.967	0.3321	0.37563	-0.043532	1
20.467	0.3321	0.37797	-0.045866	1
20.969	0.3393	0.38026	-0.040957	1
21.967	0.3393	0.38465	-0.045351	1
22.968	0.3465	0.38886	-0.042364	1
23.967	0.3537	0.39289	-0.039193	1
24.967	0.3537	0.39676	-0.043059	1
25.968	0.361	0.40048	-0.039481	1
26.967	0.361	0.40406	-0.043057	1
27.968	0.361	0.40751	-0.04651	1
28.967	0.361	0.41084	-0.049838	1
29.968	0.3682	0.41406	-0.045858	1
30.967	0.3754	0.41717	-0.04177	1
31.968	0.3826	0.42019	-0.037587	1
32.967	0.3754	0.42311	-0.047708	1
33.967	0.3826	0.42594	-0.043343	1
34.968	0.3898	0.4287	-0.0389	1

35.967	0.3898	0.43138	-0.041576	1
36.968	0.3898	0.43398	-0.044183	1
37.967	0.3971	0.43652	-0.039417	1
38.968	0.3971	0.43899	-0.041889	1
39.967	0.4043	0.4414	-0.037096	1
40.968	0.4043	0.44375	-0.039447	1
41.967	0.4043	0.44604	-0.041738	1
42.967	0.4115	0.44828	-0.036776	1
43.968	0.4115	0.45047	-0.038966	1
44.967	0.4115	0.4526	-0.041103	1
45.968	0.4187	0.4547	-0.035997	1
46.967	0.4259	0.45674	-0.030844	1
47.968	0.4259	0.45875	-0.03285	1
48.967	0.4259	0.46071	-0.034813	1
49.968	0.4259	0.46264	-0.036738	1
50.967	0.4332	0.46452	-0.031323	1
51.967	0.4332	0.46637	-0.033172	1
52.968	0.4404	0.46819	-0.027788	1
53.967	0.4404	0.46997	-0.029568	1
54.968	0.4404	0.47172	-0.031318	1
55.967	0.4476	0.47343	-0.025834	1
56.968	0.4548	0.47512	-0.020322	1
57.967	0.4548	0.47678	-0.021979	1
58.968	0.4548	0.47841	-0.02361	1
59.967	0.4548	0.48001	-0.025211	1
60.97	0.462	0.48159	-0.019591	1
65.968	0.4765	0.4891	-0.012601	1
70.968	0.4909	0.49607	-0.0051662	1
75.967	0.4909	0.50256	-0.01166	1
80.967	0.4981	0.50864	-0.010541	1
85.968	0.5053	0.51436	-0.0090608	1
90.968	0.5126	0.51976	-0.0071569	1
95.967	0.5198	0.52487	-0.0050654	1
100.97	0.527	0.52972	-0.0027154	1
105.97	0.5342	0.53433	-0.0001321	1
110.97	0.5342	0.53874	-0.0045376	1
115.97	0.5487	0.54295	0.0057513	1
120.97	0.5487	0.54698	0.0017182	1
125.97	0.5559	0.55085	0.0050471	1
130.97	0.5631	0.55457	0.0085255	1
135.97	0.5703	0.55816	0.012144	1
140.97	0.5631	0.56161	0.0014913	1
145.97	0.5775	0.56494	0.012558	1
150.97	0.5775	0.56816	0.0093372	1
155.97	0.5847	0.57128	0.01342	1
160.97	0.592	0.5743	0.017702	1
165.97	0.5847	0.57722	0.0074761	1
170.97	0.5992	0.58006	0.019136	1
175.97	0.6064	0.58282	0.023578	1
180.97	0.6208	0.5855	0.035296	1
195.97	0.6281	0.59312	0.034976	1
210.97	0.6353	0.60018	0.035116	1
225.97	0.6425	0.60676	0.03574	1
240.97	0.6497	0.61291	0.036786	1
255.97	0.6569	0.6187	0.038202	1
270.97	0.6714	0.62415	0.047247	1
285.97	0.6786	0.62931	0.049285	1
300.97	0.6858	0.63421	0.051587	1
315.97	0.6858	0.63887	0.046926	1
330.97	0.693	0.64332	0.049681	1

345.97	0.7002	0.64757	0.052633	1
360.97	0.7002	0.65164	0.048564	1
375.97	0.7147	0.65554	0.059162	1
390.97	0.7219	0.65929	0.062611	1
405.97	0.7291	0.6629	0.066201	1
420.97	0.7147	0.66638	0.048322	1
435.97	0.7219	0.66974	0.052165	1
450.97	0.7291	0.67298	0.05612	1
465.97	0.7363	0.67612	0.060182	1
480.97	0.7436	0.67916	0.064443	1
495.97	0.7436	0.6821	0.061497	1
510.97	0.7508	0.68496	0.065839	1
525.97	0.7508	0.68774	0.063063	1
540.97	0.7508	0.69043	0.060365	1
555.97	0.7508	0.69306	0.057741	1
570.97	0.758	0.69561	0.062387	1
585.97	0.758	0.6981	0.059898	1
600.97	0.758	0.70053	0.057473	1
615.97	0.7652	0.70289	0.062307	1
630.97	0.7652	0.7052	0.059998	1
645.97	0.7724	0.70746	0.064943	1
660.97	0.7724	0.70966	0.06274	1
675.97	0.7797	0.71181	0.067886	1
690.97	0.7797	0.71392	0.065779	1
705.97	0.7724	0.71598	0.056418	1
720.97	0.7797	0.718	0.061699	1
750.97	0.7797	0.72191	0.057786	1
780.97	0.7797	0.72568	0.054025	1
826.97	0.7797	0.73117	0.048529	1
856.97	0.7869	0.73459	0.052307	1
886.97	0.7869	0.7379	0.049002	1
916.97	0.7869	0.74109	0.045808	1
946.97	0.7869	0.74418	0.042716	1
976.97	0.7869	0.74718	0.03972	1
1007	0.7797	0.75008	0.029615	1
1037	0.7869	0.7529	0.033995	1
1067	0.7797	0.75564	0.024055	1
1097	0.7941	0.75831	0.035791	1
1127	0.8013	0.7609	0.040399	1
1157	0.7869	0.76343	0.023475	1
1187	0.7869	0.76589	0.021015	1
1217	0.8013	0.76828	0.033016	1
1247	0.8013	0.77062	0.030676	1
1277	0.8013	0.77291	0.028392	1
1307	0.7941	0.77514	0.01896	1
1337	0.8013	0.77732	0.023979	1
1367	0.7941	0.77945	0.014646	1
1397	0.8013	0.78154	0.019759	1
1427	0.8013	0.78358	0.017717	1
1457	0.8013	0.78558	0.015717	1
1487	0.8085	0.78754	0.020958	1
1517	0.7797	0.78946	-0.0097622	1
1547	0.7941	0.79134	0.0027551	1
1577	0.7797	0.79319	-0.013491	1
1607	0.7869	0.795	-0.0081032	1
1637	0.7797	0.79678	-0.017082	1
1667	0.7941	0.79853	-0.0044276	1
1697	0.8013	0.80024	0.0010574	1
1727	0.8013	0.80193	-0.00062764	1
1757	0.8013	0.80358	-0.0022837	1

1787	0.8157	0.80521	0.010488	1
1817	0.8085	0.80681	0.0016873	1
1847	0.8085	0.80839	0.00011246	1
1877	0.8085	0.80994	-0.001437	1
1907	0.8085	0.81146	-0.002962	1
1937	0.8085	0.81296	-0.0044632	1
1967	0.8157	0.81444	0.0012586	1
1997	0.8085	0.8159	-0.0073972	1
2027	0.8085	0.81733	-0.0088314	1
2057	0.8157	0.81874	-0.0030445	1
2087	0.8085	0.82014	-0.011637	1
2117	0.8157	0.82151	-0.0058101	1
2147	0.8157	0.82286	-0.0071636	1
2177	0.8157	0.8242	-0.0084985	1
2207	0.8157	0.82552	-0.0098151	1
2223	0.8157	0.82621	-0.01051	1
2253	0.823	0.8275	-0.0044995	1
2283	0.823	0.82877	-0.0057721	1
2313	0.8157	0.83003	-0.014328	1
2343	0.8085	0.83127	-0.022768	1
2373	0.8157	0.83249	-0.016792	1
2403	0.8085	0.8337	-0.025201	1
2433	0.8013	0.83489	-0.033594	1
2463	0.7941	0.83607	-0.041973	1
2493	0.7941	0.83724	-0.043138	1
2523	0.7869	0.83839	-0.051489	1
2553	0.7797	0.83953	-0.059827	1
2583	0.7869	0.84065	-0.053751	1
2613	0.7797	0.84176	-0.062062	1
2643	0.7724	0.84286	-0.07046	1
2673	0.7652	0.84395	-0.078747	1
2703	0.7797	0.84502	-0.065321	1
2733	0.7652	0.84608	-0.080883	1
2763	0.7652	0.84713	-0.081933	1
2793	0.7724	0.84817	-0.075773	1
2823	0.7869	0.8492	-0.062301	1
2853	0.7652	0.85022	-0.085018	1
2883	0.758	0.85123	-0.093225	1

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RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	6.7288E+000
S =	1.0045E-002

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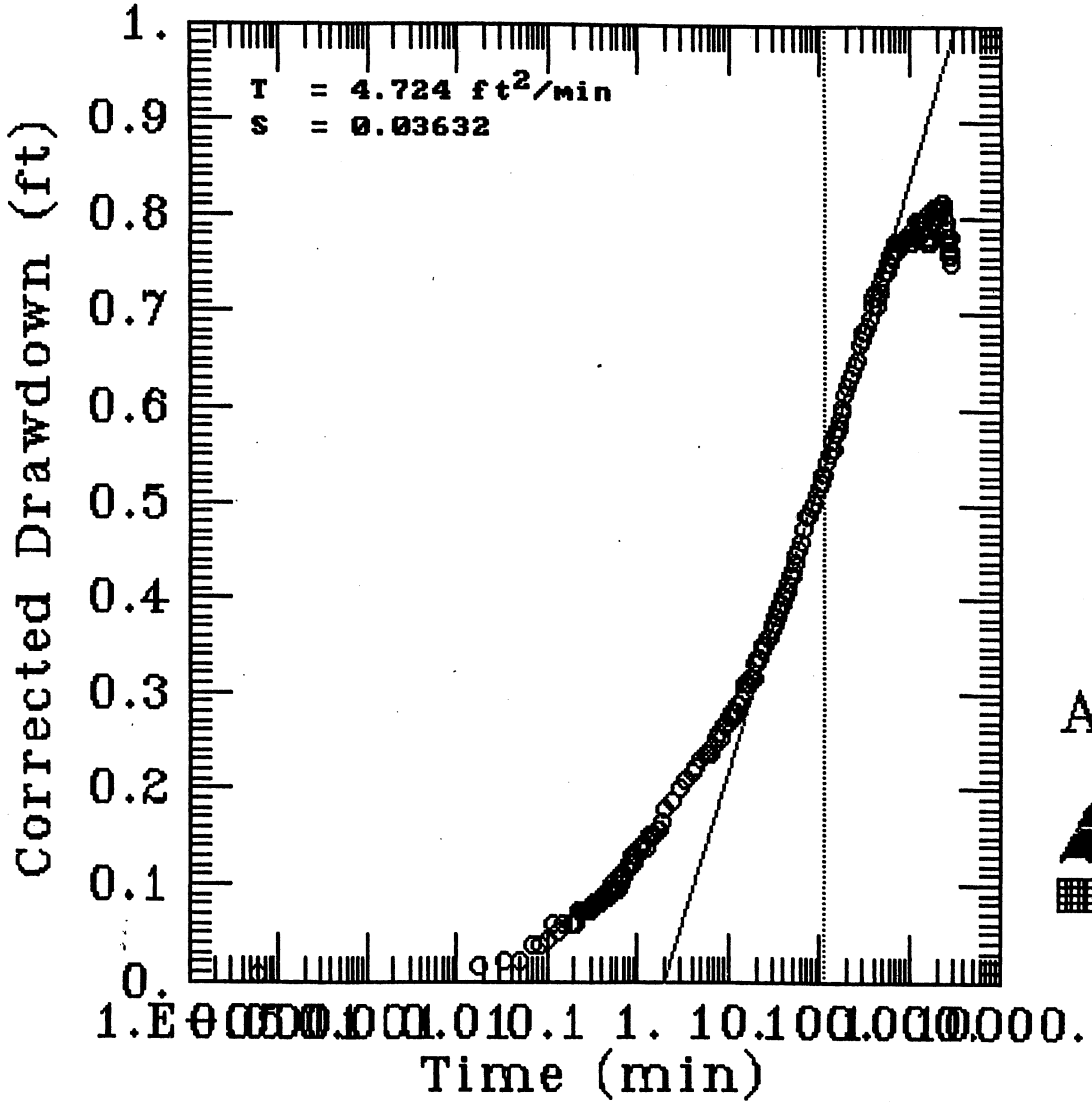
STF, AQUIFER TEST, 12A DATA, 3A PUMPED



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

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TEST DESCRIPTION

ıta set........... 12a_t&dd.aqt
ıta set title..... STF, AQUIFER TEST, 12A DATA, 3A PUMPED

ıowns and Constants:
- No. of data points.................. 281
- Pumping rate........................ 8.02
- Radius (distance) to obs. well...... 24.21
- Aquifer saturated thickness......... 58.47

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ANALYTICAL METHOD

ɔoper-Jacob (Unconfined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

'ATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	7.7035E+000	+/-	1.1066E-001
S =	4.6441E-003	+/-	3.7335E-004

IALYSIS OF MODEL RESIDUALS

ɜsidual = calculated - observed
ɜighted residual = residual * weight

ɜighted Residual Statistics:
- Number of residuals............... 281
- Number of estimated parameters.... 2
- Degrees of freedom................ 279
- Residual mean..................... -7.108E-007
- Residual standard deviation....... 0.06456
- Residual variance................. 0.004168

ɔdel Residuals:

Time	Observed	Calculated	Residual	Weight
6E-005	0.0072	-0.64868	0.65588	1
0.01734	0.0145	-0.18246	0.19696	1
0.03462	0.0217	-0.12531	0.14701	1

0.05046	0.0217	-0.094154	0.11585	1
0.06774	0.0361	-0.069786	0.10589	1
0.08358	0.0361	-0.052392	0.088492	1
0.10086	0.0433	-0.036832	0.080132	1
0.1167	0.0578	-0.024751	0.082551	1
0.13398	0.0506	-0.013313	0.063913	1
0.15126	0.0578	-0.0032622	0.061062	1
0.18726	0.0578	0.01443	0.04337	1
0.19878	0.0578	0.019379	0.038421	1
0.21174	0.0578	0.024614	0.033186	1
0.2247	0.0722	0.029539	0.042661	1
0.23766	0.0722	0.034188	0.038012	1
0.24918	0.0722	0.038113	0.034087	1
0.2679	0.0722	0.044119	0.028081	1
0.28374	0.0722	0.048883	0.023317	1
0.30102	0.0722	0.053786	0.018414	1
0.31686	0.0794	0.05804	0.02136	1
0.33414	0.0794	0.062444	0.016956	1
0.35142	0.0794	0.066627	0.012773	1
0.36726	0.0794	0.070285	0.0091155	1
0.38454	0.0867	0.074099	0.012601	1
0.40038	0.0794	0.077448	0.0019518	1
0.41766	0.0867	0.080954	0.0057458	1
0.4335	0.0867	0.084043	0.002657	1
0.45078	0.0867	0.087287	-0.00058666	1
0.46806	0.0867	0.090408	-0.0037084	1
0.4839	0.0939	0.093171	0.00072943	1
0.50118	0.0939	0.096083	-0.0021827	1
0.51702	0.1011	0.098665	0.0024347	1
0.5343	0.0939	0.10139	-0.0074942	1
0.55014	0.0939	0.10382	-0.0099193	1
0.56742	0.1011	0.10639	-0.0052866	1
0.5847	0.0939	0.10888	-0.014977	1
0.60054	0.1011	0.1111	-0.0099961	1
0.61782	0.0939	0.11345	-0.019551	1
0.63366	0.1083	0.11555	-0.007253	1
0.65094	0.1011	0.11779	-0.016687	1
0.66678	0.1083	0.11978	-0.011483	1
0.68406	0.1083	0.12191	-0.013608	1
0.70134	0.1083	0.12398	-0.015679	1
0.71718	0.1083	0.12583	-0.017534	1
0.73446	0.1155	0.12781	-0.012311	1
0.7503	0.1155	0.12958	-0.014083	1
0.76758	0.1155	0.13147	-0.015974	1
0.78342	0.1155	0.13317	-0.01767	1
0.8007	0.1227	0.13498	-0.012282	1
0.8367	0.1227	0.13863	-0.015935	1
0.84966	0.1227	0.13991	-0.017212	1
0.86262	0.1227	0.14117	-0.018469	1
0.87414	0.13	0.14227	-0.012271	1
0.8871	0.1227	0.14349	-0.020794	1
0.89862	0.1227	0.14457	-0.021865	1
0.91734	0.13	0.14628	-0.016278	1
0.93462	0.13	0.14783	-0.017828	1
0.95046	0.13	0.14922	-0.019224	1
0.96774	0.13	0.15072	-0.020721	1
1.0513	0.1372	0.1576	-0.020399	1
1.1333	0.1372	0.16385	-0.026645	1
1.2169	0.1444	0.16975	-0.025354	1
1.3004	0.1372	0.17527	-0.038071	1

1.3839	0.1516	0.18044	-0.028845	1
1.4674	0.1516	0.18532	-0.033716	1
1.5509	0.1516	0.18992	-0.038318	1
1.6345	0.1588	0.19428	-0.035478	1
1.718	0.1588	0.19842	-0.039622	1
1.8001	0.1588	0.2023	-0.043502	1
1.8836	0.1661	0.20607	-0.039973	1
1.9685	0.1805	0.20974	-0.029242	1
2.4668	0.1877	0.22851	-0.040808	1
2.9679	0.2022	0.24389	-0.041695	1
3.4676	0.2094	0.25684	-0.047444	1
3.9673	0.2166	0.26805	-0.051449	1
4.4669	0.2238	0.27792	-0.054125	1
4.9681	0.231	0.28678	-0.055778	1
5.4677	0.2382	0.29476	-0.056559	1
5.9674	0.2382	0.30204	-0.063842	1
6.4671	0.2382	0.30874	-0.07054	1
6.9668	0.2455	0.31494	-0.069441	1
7.4679	0.2527	0.32073	-0.068028	1
7.9676	0.2599	0.32612	-0.066224	1
8.4673	0.2527	0.33119	-0.078493	1
8.9669	0.2671	0.33597	-0.068871	1
9.4681	0.2671	0.3405	-0.073404	1
9.9677	0.2743	0.34479	-0.07049	1
10.467	0.2743	0.34887	-0.074567	1
10.967	0.2816	0.35275	-0.071155	1
11.467	0.2743	0.35647	-0.082169	1
11.968	0.2816	0.36004	-0.078436	1
12.468	0.2888	0.36345	-0.074646	1
12.967	0.2888	0.36672	-0.077923	1
13.467	0.2888	0.36988	-0.081075	1
13.968	0.296	0.37292	-0.076923	1
14.468	0.3032	0.37585	-0.072653	1
14.967	0.3104	0.37869	-0.068285	1
15.467	0.3104	0.38142	-0.071024	1
15.967	0.3104	0.38408	-0.073676	1
16.468	0.3104	0.38665	-0.076254	1
16.968	0.3177	0.38915	-0.071447	1
17.467	0.3104	0.39157	-0.081169	1
17.967	0.3177	0.39392	-0.076221	1
18.468	0.3177	0.39622	-0.078517	1
18.968	0.3177	0.39844	-0.080743	1
19.467	0.3321	0.40061	-0.068513	1
19.967	0.3321	0.40273	-0.070628	1
20.467	0.3321	0.40479	-0.07269	1
20.969	0.3393	0.40681	-0.067514	1
21.967	0.3393	0.41069	-0.071394	1
22.968	0.3465	0.41441	-0.067912	1
23.967	0.3537	0.41797	-0.064266	1
24.967	0.3537	0.42138	-0.067676	1
25.968	0.361	0.42466	-0.063656	1
26.967	0.361	0.42781	-0.066808	1
27.968	0.361	0.43085	-0.06985	1
28.967	0.361	0.43378	-0.072781	1
29.968	0.3682	0.43662	-0.068416	1
30.967	0.3754	0.43936	-0.063955	1
31.968	0.3826	0.44201	-0.059411	1
32.967	0.3754	0.44458	-0.069181	1
33.967	0.3826	0.44707	-0.064474	1
34.968	0.3898	0.4495	-0.059699	1

35.967	0.3898	0.45185	-0.062052	1
36.968	0.3898	0.45414	-0.064344	1
37.967	0.3971	0.45637	-0.059272	1
38.968	0.3971	0.45854	-0.061445	1
39.967	0.4043	0.46066	-0.05636	1
40.968	0.4043	0.46273	-0.058425	1
41.967	0.4043	0.46474	-0.060438	1
42.967	0.4115	0.4667	-0.055204	1
43.968	0.4115	0.46863	-0.057127	1
44.967	0.4115	0.4705	-0.059005	1
45.968	0.4187	0.47234	-0.053644	1
46.967	0.4259	0.47414	-0.04824	1
47.968	0.4259	0.4759	-0.050002	1
48.967	0.4259	0.47762	-0.051724	1
49.968	0.4259	0.47931	-0.053415	1
50.967	0.4332	0.48097	-0.047769	1
51.967	0.4332	0.48259	-0.049392	1
52.968	0.4404	0.48419	-0.043785	1
53.967	0.4404	0.48575	-0.045347	1
54.968	0.4404	0.48728	-0.046882	1
55.967	0.4476	0.48879	-0.041188	1
56.968	0.4548	0.49027	-0.035469	1
57.967	0.4548	0.49172	-0.036922	1
58.968	0.4548	0.49315	-0.038353	1
59.967	0.4548	0.49456	-0.039757	1
60.97	0.462	0.49594	-0.033942	1
65.968	0.4765	0.50253	-0.026027	1
70.968	0.4909	0.50863	-0.017734	1
75.967	0.4909	0.51432	-0.023425	1
80.967	0.4981	0.51965	-0.021553	1
85.968	0.5053	0.52466	-0.019364	1
90.968	0.5126	0.52939	-0.016791	1
95.967	0.5198	0.53387	-0.014065	1
100.97	0.527	0.53811	-0.011112	1
105.97	0.5342	0.54215	-0.0079548	1
110.97	0.5342	0.54601	-0.011812	1
115.97	0.5487	0.5497	-0.00099827	1
120.97	0.5487	0.55323	-0.0045286	1
125.97	0.5559	0.55662	-0.0007169	1
130.97	0.5631	0.55987	0.0032259	1
135.97	0.5703	0.56301	0.0072913	1
140.97	0.5631	0.56603	-0.0029298	1
145.97	0.5775	0.56895	0.0085538	1
150.97	0.5775	0.57176	0.0057355	1
155.97	0.5847	0.57449	0.010208	1
160.97	0.592	0.57713	0.014868	1
165.97	0.5847	0.57969	0.005008	1
170.97	0.5992	0.58218	0.017024	1
175.97	0.6064	0.58459	0.021811	1
180.97	0.6208	0.58693	0.033865	1
195.97	0.6281	0.5936	0.0345	1
210.97	0.6353	0.59977	0.035526	1
225.97	0.6425	0.60553	0.036975	1
240.97	0.6497	0.61091	0.038793	1
255.97	0.6569	0.61596	0.040936	1
270.97	0.6714	0.62073	0.050667	1
285.97	0.6786	0.62525	0.053354	1
300.97	0.6858	0.62953	0.056272	1
315.97	0.6858	0.6336	0.052198	1
330.97	0.693	0.63749	0.055513	1

345.97	0.7002	0.6412	0.058999	1
360.97	0.7002	0.64476	0.055443	1
375.97	0.7147	0.64817	0.066532	1
390.97	0.7219	0.65145	0.070453	1
405.97	0.7291	0.6546	0.074498	1
420.97	0.7147	0.65764	0.057058	1
435.97	0.7219	0.66058	0.061324	1
450.97	0.7291	0.66341	0.065688	1
465.97	0.7363	0.66615	0.070146	1
480.97	0.7436	0.66881	0.07479	1
495.97	0.7436	0.67138	0.072216	1
510.97	0.7508	0.67388	0.076918	1
525.97	0.7508	0.67631	0.074493	1
540.97	0.7508	0.67866	0.072135	1
555.97	0.7508	0.68096	0.069843	1
570.97	0.758	0.68319	0.074811	1
585.97	0.758	0.68536	0.072636	1
600.97	0.758	0.68748	0.070517	1
615.97	0.7652	0.68955	0.07565	1
630.97	0.7652	0.69157	0.073632	1
645.97	0.7724	0.69354	0.078862	1
660.97	0.7724	0.69546	0.076937	1
675.97	0.7797	0.69734	0.082355	1
690.97	0.7797	0.69919	0.080515	1
705.97	0.7724	0.70099	0.071413	1
720.97	0.7797	0.70275	0.07695	1
750.97	0.7797	0.70617	0.073531	1
780.97	0.7797	0.70945	0.070245	1
826.97	0.7797	0.71426	0.065444	1
856.97	0.7869	0.71725	0.069654	1
886.97	0.7869	0.72013	0.066768	1
916.97	0.7869	0.72292	0.063977	1
946.97	0.7869	0.72562	0.061276	1
976.97	0.7869	0.72824	0.058659	1
1007	0.7797	0.73078	0.048922	1
1037	0.7869	0.73324	0.053658	1
1067	0.7797	0.73564	0.044065	1
1097	0.7941	0.73796	0.056138	1
1127	0.8013	0.74023	0.061074	1
1157	0.7869	0.74243	0.044469	1
1187	0.7869	0.74458	0.04232	1
1217	0.8013	0.74667	0.054625	1
1247	0.8013	0.74872	0.052581	1
1277	0.8013	0.75071	0.050586	1
1307	0.7941	0.75266	0.041436	1
1337	0.8013	0.75457	0.046731	1
1367	0.7941	0.75643	0.037668	1
1397	0.8013	0.75825	0.043046	1
1427	0.8013	0.76004	0.041262	1
1457	0.8013	0.76178	0.039515	1
1487	0.8085	0.7635	0.045004	1
1517	0.7797	0.76517	0.014527	1
1547	0.7941	0.76682	0.027283	1
1577	0.7797	0.76843	0.01127	1
1607	0.7869	0.77001	0.016888	1
1637	0.7797	0.77157	0.0081348	1
1667	0.7941	0.77309	0.02101	1
1697	0.8013	0.77459	0.026712	1
1727	0.8013	0.77606	0.02524	1
1757	0.8013	0.77751	0.023794	1

1787	0.8157	0.77893	0.036772	1
1817	0.8085	0.78033	0.028174	1
1847	0.8085	0.7817	0.026799	1
1877	0.8085	0.78305	0.025445	1
1907	0.8085	0.78439	0.024114	1
1937	0.8085	0.7857	0.022803	1
1967	0.8157	0.78699	0.028712	1
1997	0.8085	0.78826	0.02024	1
2027	0.8085	0.78951	0.018988	1
2057	0.8157	0.79075	0.024954	1
2087	0.8085	0.79196	0.016538	1
2117	0.8157	0.79316	0.022539	1
2147	0.8157	0.79434	0.021357	1
2177	0.8157	0.79551	0.020191	1
2207	0.8157	0.79666	0.019041	1
2223	0.8157	0.79727	0.018434	1
2253	0.823	0.79839	0.024608	1
2283	0.823	0.7995	0.023497	1
2313	0.8157	0.8006	0.0151	1
2343	0.8085	0.80168	0.0068175	1
2373	0.8157	0.80275	0.012949	1
2403	0.8085	0.80381	0.0046931	1
2433	0.8013	0.80485	-0.0035494	1
2463	0.7941	0.80588	-0.011779	1
2493	0.7941	0.8069	-0.012796	1
2523	0.7869	0.8079	-0.021001	1
2553	0.7797	0.80889	-0.029195	1
2583	0.7869	0.80988	-0.022976	1
2613	0.7797	0.81085	-0.031147	1
2643	0.7724	0.81181	-0.039406	1
2673	0.7652	0.81275	-0.047554	1
2703	0.7797	0.81369	-0.033992	1
2733	0.7652	0.81462	-0.04942	1
2763	0.7652	0.81554	-0.050337	1
2793	0.7724	0.81644	-0.044045	1
2823	0.7869	0.81734	-0.030442	1
2853	0.7652	0.81823	-0.053031	1
2883	0.758	0.81911	-0.06111	1

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RESULTS FROM VISUAL CURVE MATCHING

[SUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	4.7244E+000
S =	3.6316E-002

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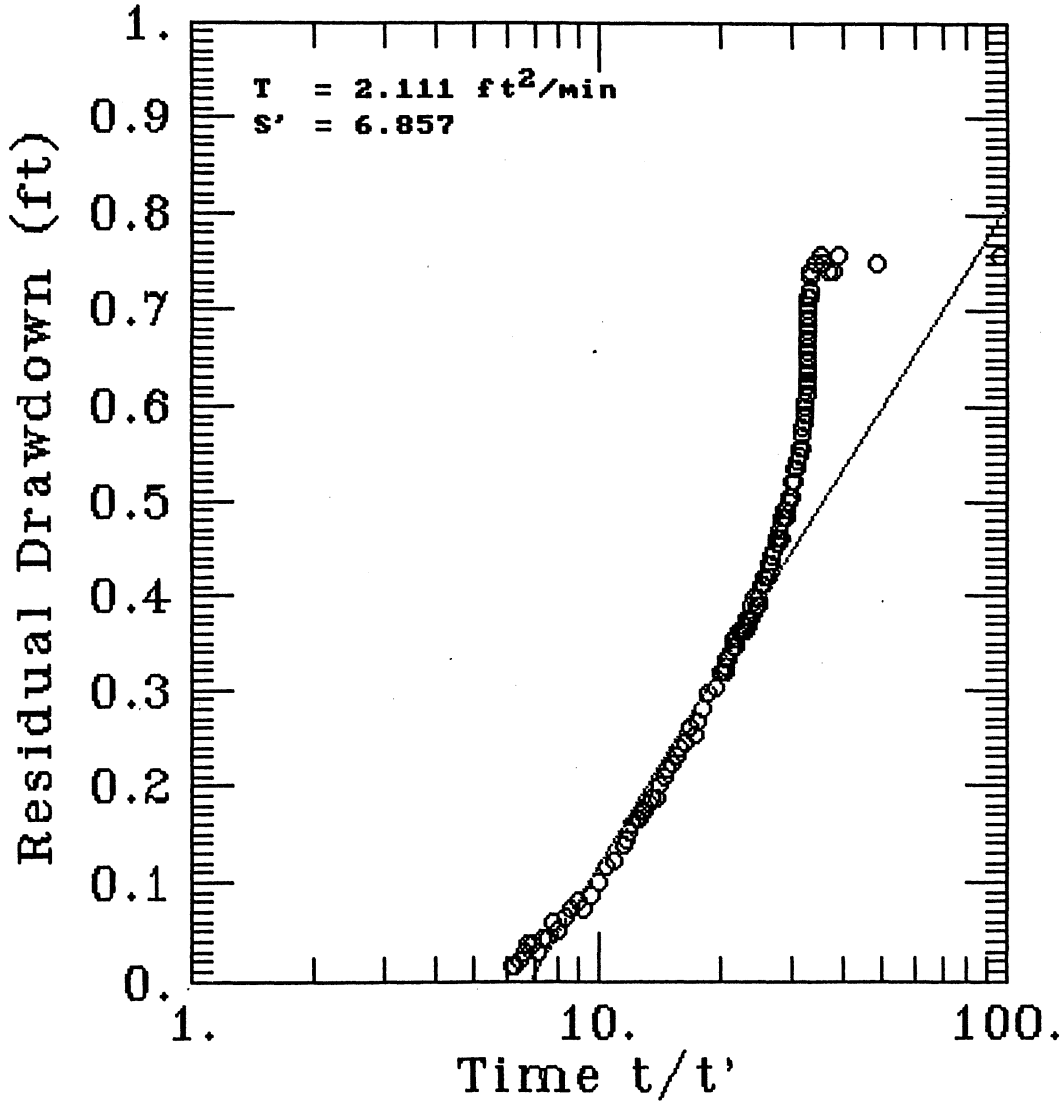
STF, AQUIFER TEST, 12A DATA, 3A RECOVERY



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

7/29/92 11:36:59

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TEST DESCRIPTION

ata set........... 12a_t&re.aqt
ata set title..... STF, AQUIFER TEST, 12A DATA, 3A RECOVERY

nowns and Constants:
No. of data points.................. 203
Pumping rate........................ 8.02
Total pumping time.................. 2852

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ANALYTICAL METHOD

ieis Recovery (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

..ISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.5019E+000	+/-	3.9068E-002
S' =	8.0574E+000	+/-	2.4771E-001

IALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals............... 203
Number of estimated parameters.... 2
Degrees of freedom................ 201
Residual mean..................... -5.262E-012
Residual standard deviation....... 0.07179
Residual variance................. 0.005154

odel Residuals:

Time	Observed	Calculated	Residual	Weight
30	0.758	1.0534	-0.29544	1
60	0.7508	0.76324	-0.012444	1
75.55	0.758	0.66756	0.090438	1
77.55	0.7436	0.65675	0.086853	1

79.86	0.7436	0.64461	0.098994	1
81.87	0.7508	0.63433	0.11647	1
83.87	0.758	0.62436	0.13364	1
85.87	0.7508	0.61464	0.13616	1
87.87	0.7436	0.60514	0.13846	1
89	0.7436	0.59987	0.14373	1
89.02	0.7364	0.59978	0.13662	1
89.03	0.7364	0.59973	0.13667	1
89.05	0.7219	0.59964	0.12226	1
89.07	0.7147	0.59955	0.11515	1
89.08	0.7219	0.5995	0.1224	1
89.1	0.7075	0.59941	0.10809	1
89.12	0.7147	0.59932	0.11538	1
89.13	0.7075	0.59927	0.10823	1
89.15	0.7003	0.59918	0.10112	1
89.17	0.7075	0.59909	0.10841	1
89.18	0.693	0.59904	0.093959	1
89.2	0.693	0.59895	0.094051	1
89.22	0.693	0.59886	0.094144	1
89.23	0.6858	0.59881	0.08699	1
89.25	0.6858	0.59872	0.087082	1
89.27	0.6858	0.59863	0.087175	1
89.28	0.6786	0.59858	0.080021	1
89.3	0.6858	0.59849	0.087313	1
89.32	0.6786	0.59839	0.080206	1
89.33	0.6786	0.59835	0.080252	1
89.35	0.6714	0.59826	0.073144	1
89.37	0.6714	0.59816	0.073236	1
89.38	0.6714	0.59812	0.073282	1
89.4	0.6714	0.59803	0.073374	1
89.42	0.6642	0.59793	0.066267	1
89.43	0.6642	0.59789	0.066313	1
89.45	0.6642	0.5978	0.066405	1
89.47	0.6642	0.5977	0.066497	1
89.48	0.657	0.59766	0.059343	1
89.5	0.657	0.59756	0.059435	1
89.52	0.657	0.59747	0.059527	1
89.53	0.6497	0.59743	0.052273	1
89.55	0.6497	0.59733	0.052365	1
89.57	0.6497	0.59724	0.052457	1
89.58	0.6497	0.5972	0.052503	1
89.6	0.6497	0.5971	0.052595	1
89.62	0.6497	0.59701	0.052687	1
89.65	0.6425	0.59687	0.045625	1
89.67	0.6425	0.59678	0.045717	1
89.68	0.6425	0.59674	0.045763	1
89.69	0.6425	0.59669	0.045809	1
89.7	0.6425	0.59665	0.045855	1
89.71	0.6425	0.5966	0.045901	1
89.73	0.6425	0.59651	0.045993	1
89.75	0.6425	0.59642	0.046085	1
89.77	0.6425	0.59632	0.046176	1
89.78	0.6425	0.59628	0.046222	1
89.8	0.6353	0.59619	0.039114	1
89.82	0.6353	0.59609	0.039206	1
89.83	0.6353	0.59605	0.039252	1
89.85	0.6353	0.59596	0.039343	1
89.87	0.6353	0.59586	0.039435	1
89.88	0.6353	0.59582	0.039481	1
89.9	0.6281	0.59573	0.032373	1

89.92	0.6281	0.59564	0.032464	1
89.93	0.6353	0.59559	0.03971	1
89.95	0.6281	0.5955	0.032602	1
89.97	0.6353	0.59541	0.039893	1
89.98	0.6281	0.59536	0.032739	1
90	0.6281	0.59527	0.032831	1
90.08	0.6209	0.5949	0.025997	1
90.17	0.6136	0.59449	0.019108	1
90.25	0.6136	0.59413	0.019474	1
90.33	0.6136	0.59376	0.019839	1
90.42	0.6064	0.59335	0.013049	1
90.5	0.5992	0.59299	0.0062132	1
90.58	0.5992	0.59262	0.0065772	1
90.67	0.5992	0.59221	0.0069863	1
90.75	0.5992	0.59185	0.0073496	1
90.83	0.592	0.59149	0.00051252	1
90.92	0.592	0.59108	0.00092045	1
91	0.592	0.59072	0.0012827	1
91.5	0.5848	0.58846	-0.0036606	1
92	0.5775	0.58622	-0.0087166	1
92.5	0.5703	0.58399	-0.013685	1
93	0.5559	0.58177	-0.025866	1
93.5	0.5487	0.57956	-0.030859	1
94	0.5559	0.57736	-0.021465	1
94.5	0.5487	0.57518	-0.026482	1
95	0.5415	0.57301	-0.031511	1
95.5	0.5342	0.57085	-0.036652	1
96	0.5342	0.5687	-0.034505	1
96.5	0.5198	0.56657	-0.046769	1
97	0.5198	0.56444	-0.044645	1
97.5	0.5054	0.56233	-0.056932	1
98	0.5198	0.56023	-0.04043	1
98.5	0.5054	0.55814	-0.052739	1
99	0.4981	0.55606	-0.057959	1
99.5	0.4981	0.55399	-0.05589	1
100	0.5054	0.55193	-0.046531	1
100.5	0.4909	0.54988	-0.058983	1
101	0.4909	0.54785	-0.056946	1
101.5	0.4837	0.54582	-0.062119	1
102	0.4909	0.5438	-0.052902	1
102.5	0.4837	0.5418	-0.058096	1
103	0.4837	0.5398	-0.0561	1
103.5	0.4837	0.53781	-0.054113	1
104	0.4765	0.53584	-0.059337	1
104.5	0.462	0.53387	-0.07187	1
105	0.4693	0.53191	-0.062614	1
105.5	0.462	0.52997	-0.067966	1
106	0.462	0.52803	-0.066029	1
106.5	0.4548	0.5261	-0.0713	1
107	0.4548	0.52418	-0.069381	1
107.5	0.462	0.52227	-0.060272	1
108	0.4548	0.52037	-0.065571	1
108.5	0.4476	0.51848	-0.07088	1
109	0.4476	0.5166	-0.068998	

STF - AQUIFER TEST
NMW-3A PUMPED, CBS-12A OBS (DATA)
JACOB STRAIGHT LINE METHOD

12 March 92
K/J 916055.09
12a_t&dd.mcd

Transmissivity

$$T := \frac{2.30}{\left[4 \cdot p \cdot \left[\frac{s_2 - s_1}{Q}\right]\right]}$$

(1)

Storage coefficient

$$S := \frac{\left[\frac{2.25 \cdot T \cdot t_2}{r^2}\right]}{10^{\left[\frac{\frac{s_2}{Q}}{\frac{s_2 - s_1}{Q}}\right]}}$$

flowrate $Q := 60 \cdot \frac{gal}{min}$

radius $r := 24.21 \cdot ft$

time $t_1 := 10 \cdot min$ $t_2 := 100 \cdot min$

drawdown $s_1 := 0.24 \cdot ft$ $s_2 := 0.53 \cdot ft$

$$T := \frac{2.30}{\left[4 \cdot p \cdot \left[\frac{s_2 - s_1}{Q}\right]\right]}$$

$$S := \frac{\left[\frac{2.25 \cdot T \cdot t_2}{r^2}\right]}{10^{\left[\frac{\frac{s_2}{Q}}{\frac{s_2 - s_1}{Q}}\right]}}$$

$T = 5.06 \frac{ft^2}{min}$ <------ **Transmissivity**

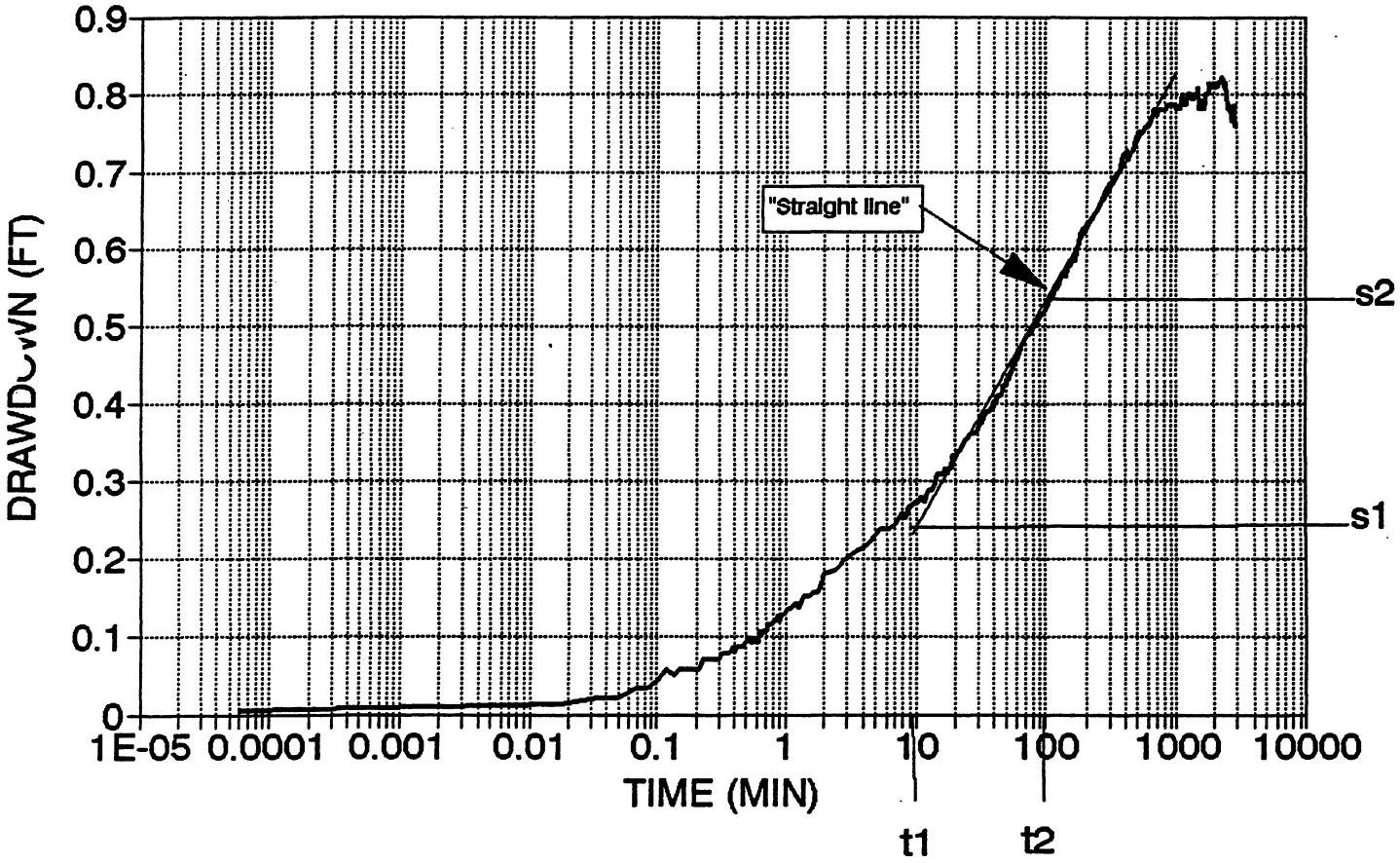
$T = 54529.78 \frac{gal}{(ft \cdot day)}$

$S = 0.029$ <------ **Storage coefficient**

NOTE: see attached graph for semi-log plot of data and straight line.

STF-AQUIFER TEST

NMW-3A PUMPED CBS-12A OBSERVATION(DATA)



STF - AQUIFER TEST
NMW-3A PUMPED, CBS-12A OBS (DATA)
THEIS METHOD

12 March 92
K/J 916055.09
12a_THES.mcd

DEVELOP STANDARD THEIS CURVE

$i := 0 .. 9$

$u_i := \frac{1}{10^i}$

$$w_i := -0.577216 - \ln\left[u_i\right] + u_i - \frac{\left[u_i\right]^2}{4} + \frac{\left[u_i\right]^3}{18} - \frac{\left[u_i\right]^4}{96} + \frac{\left[u_i\right]^5}{600} - \frac{\left[u_i\right]^6}{4320} + \frac{\left[u_i\right]^7}{35280} - \frac{\left[u_i\right]^8}{32256}$$

PLOT FIELD DATA SET IN THEIS FORM

$Q := 60 \cdot \frac{gal}{min}$ test pumping rate

$r := 24.21 \cdot ft$ radius between pumping and observation well

$t\_s := READPRN(data\_12a)$ read time-drawdown data file

$t := t\_s^{<0>} \cdot min$ time data

$s := t\_s^{<1>} \cdot ft$ drawdown data

$N := length(t)$

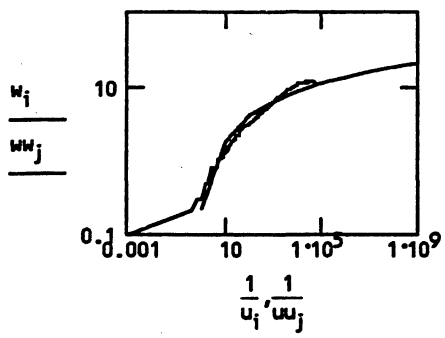
$N = 281$ number of observations, N

$j := 0 .. N - 1$

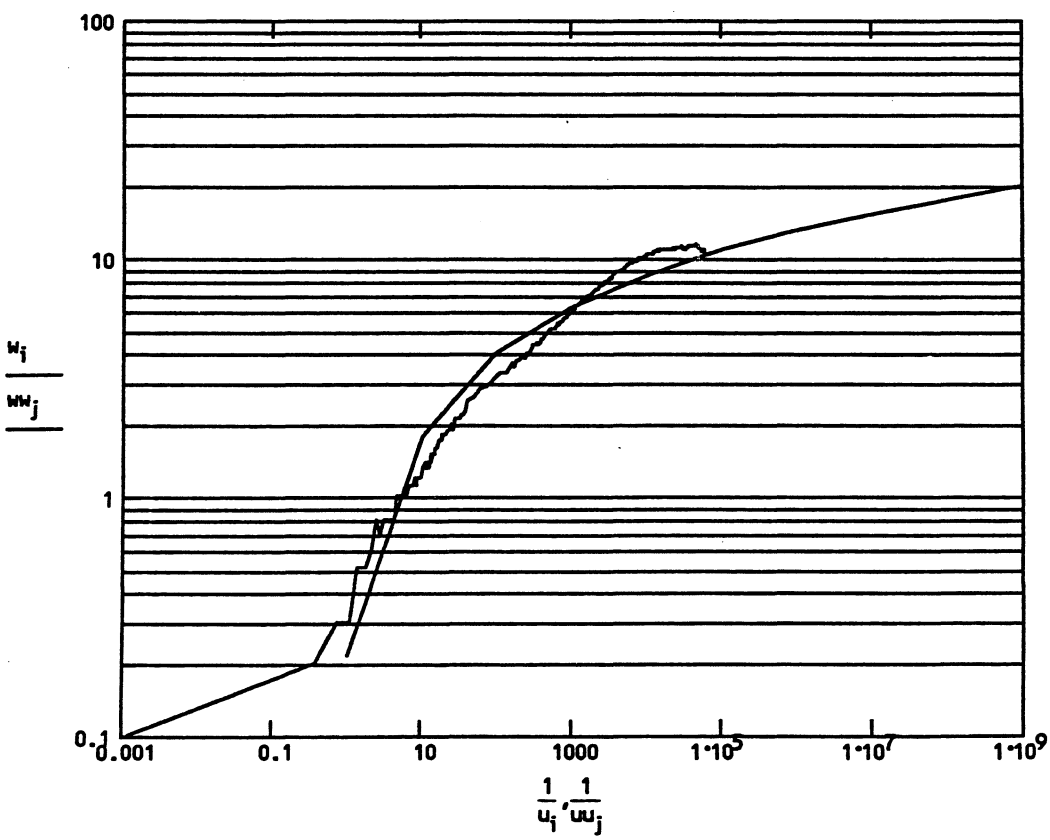
Estimates of Transmissivity, T, and Storage Coefficient, S

$$T := 9 \cdot \frac{ft^2}{min} \qquad S := 0.003$$

$$ww_j := \frac{\left[T \cdot 4 \cdot p \cdot s_j\right]}{Q} \qquad uu_j := \frac{\left[r^2 \cdot S\right]}{\left[4 \cdot T \cdot t_j\right]}$$



ENLARGED PLOT OF DATA AND STANDARD THEIS CURVES



$$T = 9 \cdot \frac{ft^2}{min} \qquad T = 9.695 \cdot 10^4 \frac{gal}{(ft \cdot day)} \qquad S = 0.003$$

AQUIFER TEST DATA SHEET

WATER LEVEL MEASUREMENTS DURING AQUIFER TEST AT WELL NMW-3A
South Tacoma Field

Elapsed Time (minutes)	Observation Well Water Level Depth - Feet	
	NMW-3B	NMW-3C
0	Start Test	
25	20.84	24.57
56	20.84	24.57
95	20.84	24.57
117	20.84	24.57
190	20.84	24.57
230	20.84	24.56
285	20.84	24.57
345	20.84	24.55
405	20.84	24.57
465	20.84	24.57
525	20.84	24.57
585	20.88	24.59
645	20.89	24.60
705	20.89	24.61
765	20.88	24.58
825	20.86	24.56
885	20.81	24.52
945	20.80	24.50
1,005	20.76	24.47
1,065	20.74	24.44
1,125	20.73	24.42
1,185	20.74	24.44
1,245	20.73	24.44
1,305	20.73	24.44
1,365	20.74	24.44

Elapsed Time (minutes)	Observation Well Water Level Depth - Feet	
	NMW-3B	NMW-3C
1,425	20.74	24.44
1,485	20.74	24.44
1,545	20.71	24.42
1,605	20.70	24.40
1,665	20.69	24.39
1,725	20.69	24.39
1,785	20.70	24.41
1,845	20.71	24.43
1,905	20.73	24.46
1,965	20.75	24.49
2,025	20.82	24.51
2,085	20.80	24.55
2,145	20.82	24.57
2,205	20.83	24.58
2,265	20.81	24.54
2,325	20.80	24.54
2,385	20.78	24.51
2,445	20.76	24.50
2,505	20.75	24.49
2,565	20.72	24.46
2,625	20.72	24.45
2,685	20.74	24.48
2,745	20.73	24.47
2,805	20.74	24.47
2,865	20.75	24.47

DATA ANALYSIS
OF AQUIFER PUMPING TEST
FOR NMW-4A

4 x 4 Grid Sheet **Kennedy/Jenks/Chilton**

By TW Date 3/10/92 Subject STF - NMW-4A Job No. _____

Checked By _____ Date _____ Sheet 1 of 2

WELL NMW-4A

BLANK INTERVAL	0-10 ft	
SCREENED INTERVAL	10-35 ft	
TOP CASING ELV.	211.91 ft	
DEPTH TO WATER	18.46	(193.45')

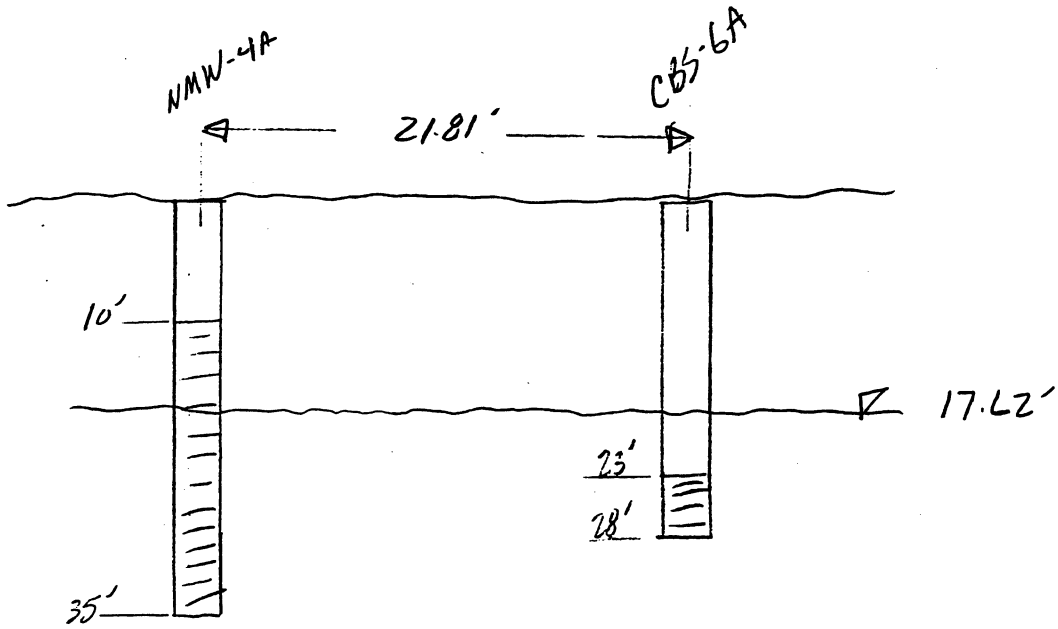
WELL CBS-6A

BLANK INTERVAL	0-23 ft	
SCREENED INTERVAL	23-28 ft	
TOP CASING ELV.	212.04	
DEPTH TO WATER	16.78	(195.26')

4 x 4 Grid Sheet **Kennedy/Jenks/Chilton**

By TCe Date 3/10/92 Subject STF - NMW-4A Job No. _____

Checked By _____ Date _____ Pumpkin Sheet 2 of 2



SATURATED THICKNESS $= 99'^{+} - \left[\left(\frac{211.91' + 212.04'}{2}\right) - \left(\frac{193.45' + 195.26'}{2}\right)\right]$

$= 81.38^{+}$

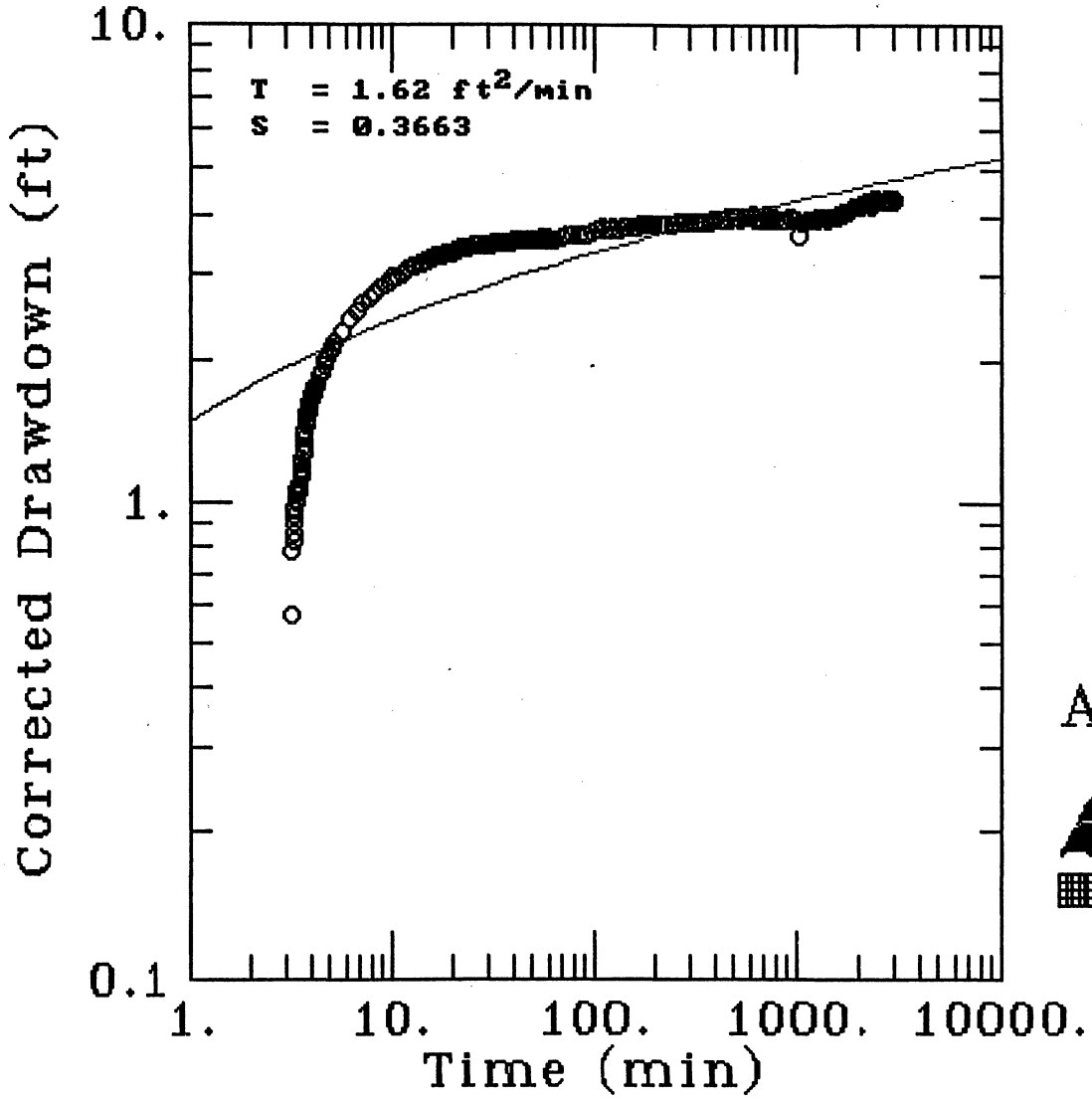
* Revised saturated thickness $= 80' - \left[\left(\frac{211.91 + 212.04}{2}\right) - \left(\frac{193.45 + 195.26}{2}\right)\right]$

$= 62.38'$

99'+ ~

* Revised to 80' because TY used 80ft throughout in the slug test calculations 7/15/92 TC

STF AQUIFER TEST, 4A DATA, 4A DRAWDOWN



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

A Q T E S O L V   R E S U L T S
Version 1.10

7/27/92 16:29:05

TEST DESCRIPTION

ata set........... b:\4a_dd.aqt
ata set title..... STF AQUIFER TEST, 4A DATA, 4A DRAWDOWN

nowns and Constants:
No. of data points.................. 288
Pumping rate........................ 8.02
Radius (distance) to obs. well...... 0.5
Aquifer saturated thickness......... 62.38

ANALYTICAL METHOD

heis (Unconfined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

'ATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.6199E+000	+/-	4.9847E-002
S =	3.6629E-001	+/-	8.4618E-002

'ALYSIS OF MODEL RESIDUALS

sidual = calculated - observed
ighted residual = residual * weight

ighted Residual Statistics:
Number of residuals............... 288
Number of estimated parameters.... 2
Degrees of freedom................ 286
Residual mean..................... -0.0004013
Residual standard deviation....... 0.5164
Residual variance................. 0.2667

del Residuals:

Time	Observed	Calculated	Residual	Weight
3.23	0.577	1.9447	-1.3677	1
3.24	0.786	1.9459	-1.1599	1
3.26	0.83	1.9484	-1.1184	1

3.28	0.866	1.9509	-1.0849	1
3.29	0.902	1.9521	-1.0501	1
3.31	0.938	1.9546	-1.0166	1
3.32	0.96	1.9558	-0.99581	1
3.34	0.981	1.9582	-0.97724	1
3.36	1.003	1.9607	-0.95766	1
3.38	1.017	1.9631	-0.94607	1
3.39	1.039	1.9643	-0.92526	1
3.41	1.054	1.9666	-0.91265	1
3.42	1.061	1.9678	-0.90683	1
3.44	1.075	1.9702	-0.89519	1
3.46	1.075	1.9725	-0.89754	1
3.48	1.061	1.9749	-0.91388	1
3.49	1.054	1.976	-0.92204	1
3.51	1.082	1.9784	-0.89636	1
3.52	1.09	1.9795	-0.88951	1
3.56	1.14	1.9841	-0.84409	1
3.58	1.14	1.9864	-0.84636	1
3.59	1.147	1.9875	-0.84049	1
3.61	1.162	1.9897	-0.82774	1
3.62	1.183	1.9909	-0.80787	1
3.64	1.22	1.9931	-0.7731	1
3.65	1.241	1.9942	-0.75321	1
3.67	1.277	1.9964	-0.71943	1
3.68	1.292	1.9975	-0.70553	1
3.69	1.328	1.9986	-0.67063	1
3.71	1.386	2.0008	-0.61482	1
3.73	1.422	2.003	-0.581	1
3.74	1.436	2.0041	-0.56809	1
3.76	1.465	2.0063	-0.54125	1
3.77	1.479	2.0073	-0.52833	1
3.79	1.494	2.0095	-0.51547	1
3.81	1.508	2.0116	-0.50361	1
3.83	1.501	2.0137	-0.51273	1
3.84	1.537	2.0148	-0.47779	1
3.86	1.559	2.0169	-0.4579	1
3.87	1.566	2.0179	-0.45195	1
3.89	1.588	2.02	-0.43204	1
3.91	1.602	2.0221	-0.42012	1
3.93	1.609	2.0242	-0.41519	1
3.94	1.631	2.0252	-0.39422	1
3.96	1.645	2.0273	-0.38228	1
3.97	1.653	2.0283	-0.3753	1
3.99	1.66	2.0303	-0.37034	1
4.01	1.667	2.0324	-0.36537	1
4.03	1.682	2.0344	-0.35239	1
4.04	1.682	2.0354	-0.35339	1
4.08	1.71	2.0394	-0.32939	1
4.09	1.71	2.0404	-0.33038	1
4.11	1.718	2.0424	-0.32436	1
4.12	1.725	2.0434	-0.31835	1
4.14	1.747	2.0453	-0.29832	1
4.15	1.739	2.0463	-0.3073	1
4.17	1.739	2.0482	-0.30925	1
4.18	1.761	2.0492	-0.28822	1
4.2	1.768	2.0512	-0.28316	1
4.21	1.775	2.0521	-0.27712	1
4.22	1.775	2.0531	-0.27809	1
4.31	1.811	2.0617	-0.25066	1
4.39	1.862	2.0691	-0.20713	1

4.48	1.898	2.0774	-0.17937	1
4.56	1.927	2.0846	-0.15756	1
4.64	1.978	2.0916	-0.11363	1
4.73	2.014	2.0994	-0.085439	1
4.81	2.042	2.1063	-0.064257	1
4.89	2.093	2.113	-0.019964	1
4.98	2.1075	2.1204	-0.01288	1
5.06	2.1291	2.1269	0.0022377	1
5.14	2.158	2.1332	0.024757	1
5.23	2.2013	2.1403	0.060994	1
5.73	2.3312	2.1775	0.15373	1
6.23	2.4756	2.2116	0.26404	1
6.73	2.5839	2.243	0.34087	1
7.23	2.6705	2.2723	0.39824	1
7.73	2.7572	2.2996	0.45764	1
8.23	2.8221	2.3252	0.49694	1
8.73	2.8799	2.3493	0.53064	1
9.23	2.9232	2.372	0.55117	1
9.73	2.9882	2.3936	0.59459	1
10.23	3.0387	2.4141	0.62458	1
10.73	3.0603	2.4337	0.62665	1
11.23	3.0964	2.4523	0.6441	1
11.73	3.1397	2.4701	0.66955	1
12.23	3.1686	2.4873	0.68134	1
12.73	3.1975	2.5037	0.69382	1
13.23	3.2264	2.5195	0.70692	1
13.73	3.248	2.5347	0.7133	1
14.23	3.2769	2.5494	0.72753	1
14.73	3.2913	2.5635	0.72775	1
15.23	3.313	2.5773	0.73575	1
15.73	3.3491	2.5905	0.75858	1
16.23	3.3563	2.6034	0.75293	1
16.73	3.3635	2.6158	0.74767	1
17.23	3.378	2.6279	0.75006	1
17.73	3.3852	2.6397	0.74551	1
18.23	3.3924	2.6511	0.74127	1
18.73	3.4141	2.6623	0.75185	1
19.23	3.4285	2.6731	0.75541	1
19.73	3.4357	2.6836	0.75205	1
20.23	3.4357	2.6939	0.74175	1
20.73	3.4646	2.704	0.76061	1
21.23	3.4718	2.7138	0.758	1
21.73	3.4862	2.7234	0.76281	1
22.23	3.5079	2.7328	0.77515	1
22.73	3.5223	2.7419	0.78039	1
23.23	3.5368	2.7509	0.78593	1
23.73	3.5368	2.7596	0.77715	1
24.23	3.5368	2.7682	0.76856	1
25.23	3.5512	2.7849	0.76629	1
26.23	3.5584	2.8009	0.75747	1
27.23	3.5584	2.8164	0.74204	1
28.23	3.5873	2.8312	0.75607	1
29.23	3.5512	2.8456	0.70561	1
30.23	3.5729	2.8595	0.71342	1
31.23	3.5801	2.8729	0.70719	1
32.23	3.5945	2.8859	0.70858	1
33.23	3.5945	2.8985	0.69596	1
34.23	3.5945	2.9108	0.68371	1
35.23	3.5945	2.9227	0.67181	1
36.23	3.6017	2.9343	0.66745	1

37.23	3.609	2.9455	0.66349	1
38.23	3.6234	2.9565	0.66694	1
39.23	3.6234	2.9671	0.65626	1
40.23	3.6378	2.9775	0.66025	1
41.23	3.6451	2.9877	0.65739	1
42.23	3.6378	2.9976	0.64018	1
43.23	3.6378	3.0073	0.6305	1
44.23	3.6378	3.0168	0.62103	1
45.23	3.6378	3.026	0.61178	1
46.23	3.6523	3.0351	0.61722	1
47.23	3.6523	3.0439	0.60836	1
48.23	3.6378	3.0526	0.58519	1
49.23	3.6523	3.0611	0.59119	1
50.23	3.6739	3.0694	0.60446	1
51.23	3.6667	3.0776	0.58909	1
52.23	3.6739	3.0856	0.58828	1
53.23	3.6595	3.0935	0.56602	1
54.23	3.6812	3.1012	0.58001	1
55.23	3.6812	3.1088	0.57243	1
56.23	3.6884	3.1162	0.57219	1
57.23	3.6812	3.1235	0.55768	1
58.23	3.6812	3.1307	0.5505	1
59.23	3.6884	3.1378	0.55064	1
60.23	3.6739	3.1447	0.52919	1
61.23	3.6812	3.1515	0.52966	1
62.23	3.6739	3.1583	0.51564	1
63.23	3.6739	3.1649	0.50903	1
64.23	3.6667	3.1714	0.49532	1
69.23	3.7245	3.2025	0.522	1
74.23	3.7317	3.2315	0.50023	1
79.23	3.7461	3.2586	0.48755	1
84.23	3.7461	3.284	0.46211	1
89.23	3.7461	3.308	0.43812	1
94.23	3.7461	3.3307	0.41544	1
99.23	3.7967	3.3522	0.44452	1
104.23	3.8544	3.3727	0.48175	1
109.23	3.8905	3.3922	0.49833	1
114.23	3.8616	3.4108	0.45078	1
119.23	3.8761	3.4287	0.44743	1
124.23	3.8905	3.4458	0.4447	1
129.23	3.8688	3.4623	0.40654	1
134.23	3.8688	3.4781	0.39071	1
139.23	3.8833	3.4934	0.38995	1
144.23	3.8977	3.5081	0.38962	1
149.23	3.9122	3.5223	0.38989	1
154.23	3.9122	3.5361	0.37613	1
159.23	3.9266	3.5494	0.37721	1
164.23	3.9194	3.5623	0.35709	1
169.23	3.9338	3.5748	0.35896	1
174.23	3.941	3.587	0.35399	1
179.23	3.9555	3.5988	0.35666	1
184.23	3.9555	3.6103	0.34516	1
199.23	3.9627	3.6431	0.31961	1
214.23	3.9771	3.6735	0.30363	1
229.23	3.9771	3.7018	0.2753	1
244.23	3.9699	3.7284	0.24154	1
259.23	3.9843	3.7533	0.23096	1
274.23	3.9988	3.7769	0.22188	1
289.23	4.006	3.7993	0.20674	1
304.23	4.006	3.8205	0.18553	1

319.23	4.006	3.8407	0.16532	1
334.23	4.0132	3.86	0.15324	1
349.23	4.006	3.8784	0.1276	1
364.23	4.0204	3.8961	0.12433	1
379.23	4.0204	3.913	0.10737	1
394.23	4.0565	3.9293	0.12716	1
409.23	4.0565	3.945	0.11146	1
424.23	4.0493	3.9602	0.089118	1
439.23	4.0637	3.9748	0.088899	1
454.23	4.071	3.9889	0.082067	1
469.23	4.0926	4.0026	0.089991	1
484.23	4.0854	4.0159	0.069542	1
499.23	4.0998	4.0287	0.071094	1
514.23	4.0998	4.0412	0.058624	1
529.23	4.0926	4.0533	0.03931	1
544.23	4.0565	4.0651	-0.0085675	1
559.23	4.0998	4.0765	0.023273	1
574.23	4.1071	4.0877	0.019414	1
589.23	4.1071	4.0986	0.0085411	1
604.23	4.1143	4.1092	0.0051396	1
619.23	4.1432	4.1195	0.023696	1
634.23	4.0926	4.1296	-0.037001	1
649.23	4.0782	4.1395	-0.061265	1
664.23	4.1143	4.1491	-0.034804	1
679.23	4.1143	4.1585	-0.04423	1
694.23	4.0493	4.1678	-0.11845	1
709.23	4.1576	4.1768	-0.019177	1
724.23	4.0998	4.1856	-0.085815	1
754.23	4.0854	4.2028	-0.11736	1
784.23	4.0926	4.2192	-0.12664	1
814.23	4.0854	4.2351	-0.1497	1
844.23	4.0782	4.2504	-0.1722	1
874.23	4.0421	4.2652	-0.22307	1
904.23	4.0493	4.2794	-0.23014	1
934.23	4.0998	4.2932	-0.19344	1
964.23	4.0998	4.3066	-0.20682	1
994.23	4.0565	4.3196	-0.26309	1
1024.2	4.0782	4.3322	-0.25397	1
1054.2	3.7678	4.3444	-0.5766	1
1084.2	3.9843	4.3563	-0.37198	1
1114.2	3.9843	4.3678	-0.38354	1
1144.2	4.0493	4.3791	-0.3298	1
1174.2	4.0637	4.3901	-0.32637	1
1204.2	4.0637	4.4008	-0.33706	1
1234.2	4.0565	4.4112	-0.35469	1
1264.2	4.0637	4.4214	-0.35767	1
1294.2	4.0926	4.4313	-0.33872	1
1324.2	4.0926	4.441	-0.34844	1
1354.2	4.0926	4.4505	-0.35794	1
1384.2	4.0926	4.4598	-0.36724	1
1414.2	4.0998	4.4689	-0.36914	1
1444.2	4.0854	4.4778	-0.39245	1
1474.2	4.0998	4.4866	-0.38677	1
1504.2	4.1143	4.4951	-0.38083	1
1534.2	4.1287	4.5035	-0.37481	1
1564.2	4.1359	4.5117	-0.37584	1
1594.2	4.1359	4.5198	-0.38391	1
1624.2	4.1792	4.5277	-0.34852	1
1654.2	4.172	4.5355	-0.3635	1
1684.2	4.1648	4.5431	-0.37834	1

1714.2	4.2226	4.5506	-0.32804	1
1744.2	4.2081	4.558	-0.34991	1
1774.2	4.2226	4.5653	-0.34266	1
1804.2	4.237	4.5724	-0.33539	1
1834.2	4.2875	4.5794	-0.2919	1
1864.2	4.302	4.5863	-0.2843	1
1894.2	4.3092	4.5931	-0.28389	1
1924.2	4.3236	4.5998	-0.27617	1
1954.2	4.3597	4.6064	-0.24665	1
1984.2	4.3164	4.6128	-0.29644	1
2014.2	4.3597	4.6192	-0.25952	1
2044.2	4.3453	4.6255	-0.28021	1
2074.2	4.3597	4.6317	-0.27201	1
2104.2	4.3814	4.6378	-0.25642	1
2134.2	4.4175	4.6438	-0.22635	1
2164.2	4.4175	4.6498	-0.23229	1
2194.2	4.3958	4.6557	-0.25985	1
2224.2	4.4608	4.6614	-0.20063	1
2254.2	4.4391	4.6671	-0.22804	1
2284.2	4.4319	4.6728	-0.24087	1
2314.2	4.4247	4.6783	-0.25363	1
2344.2	4.3597	4.6838	-0.32411	1
2374.2	4.3669	4.6892	-0.32233	1
2404.2	4.5113	4.6946	-0.18328	1
2434.2	4.3958	4.6999	-0.30406	1
2464.2	4.4897	4.7051	-0.21538	1
2494.2	4.4608	4.7102	-0.24944	1
2524.2	4.4319	4.7153	-0.28343	1
2554.2	4.4608	4.7204	-0.25957	1
2584.2	4.4536	4.7253	-0.27175	1
2614.2	4.4319	4.7303	-0.29837	1
2644.2	4.4247	4.7351	-0.31043	1
2674.2	4.4391	4.7399	-0.30084	1
2704.2	4.4391	4.7447	-0.3056	1
2734.2	4.4536	4.7494	-0.2958	1
2764.2	4.4536	4.7541	-0.30046	1
2794.2	4.4897	4.7587	-0.26896	1
2824.2	4.4608	4.7632	-0.30242	1
2854.2	4.4608	4.7677	-0.30693	1
2884.2	4.4752	4.7722	-0.29699	1
2914.2	4.4536	4.7766	-0.323	1
2944.2	4.468	4.781	-0.31297	1
2974.2	4.4608	4.7853	-0.3245	1
3004.2	4.4897	4.7896	-0.29988	1
3034.2	4.4608	4.7938	-0.33302	1

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RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

Estimate
T = 1.6199E+000
= 3.6629E-001

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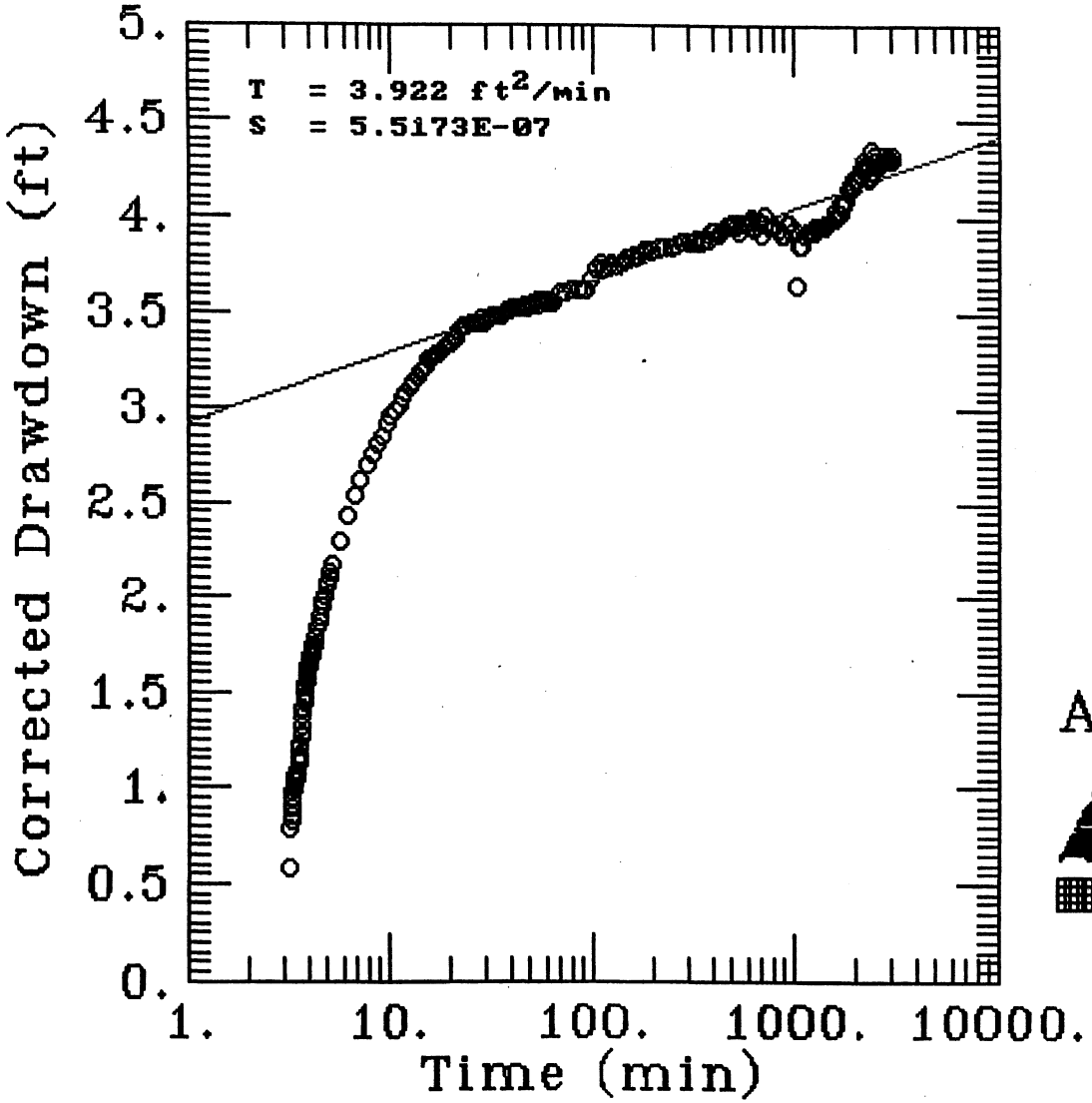
STF AQUIFER TEST, 4A DATA, 4A DRAWDOWN



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V R E S U L T S
Version 1.10

/21/92 16:32:30

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TEST DESCRIPTION

ta set........... b:\4a_dd.aqt
ta set title..... STF AQUIFER TEST, 4A DATA, 4A DRAWDOWN

owns and Constants:
No. of data points.................. 288
Pumping rate........................ 8.02
Radius (distance) to obs. well...... 0.5
Aquifer saturated thickness......... 62.38

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ANALYTICAL METHOD

oper-Jacob (Unconfined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

ATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.6184E+000	+/-	4.9479E-002
S =	3.6908E-001	+/-	8.4509E-002

ALYSIS OF MODEL RESIDUALS

sidual = calculated - observed
ighted residual = residual * weight

ighted Residual Statistics:
Number of residuals................ 288
Number of estimated parameters.... 2
Degrees of freedom................ 286
Residual mean..................... 4.489E-005
Residual standard deviation....... 0.5161
Residual variance................. 0.2663

del Residuals:

Time	Observed	Calculated	Residual	Weight
3.23	0.577	1.9415	-1.3645	1
3.24	0.786	1.9428	-1.1568	1
3.26	0.83	1.9453	-1.1153	1

3.28	0.866	1.9478	-1.0818	1
3.29	0.902	1.949	-1.047	1
3.31	0.938	1.9515	-1.0135	1
3.32	0.96	1.9527	-0.99273	1
3.34	0.981	1.9552	-0.97417	1
3.36	1.003	1.9576	-0.95461	1
3.38	1.017	1.96	-0.94302	1
3.39	1.039	1.9612	-0.92223	1
3.41	1.054	1.9636	-0.90962	1
3.42	1.061	1.9648	-0.90381	1
3.44	1.075	1.9672	-0.89219	1
3.46	1.075	1.9695	-0.89455	1
3.48	1.061	1.9719	-0.9109	1
3.49	1.054	1.9731	-0.91906	1
3.51	1.082	1.9754	-0.89339	1
3.52	1.09	1.9766	-0.88655	1
3.56	1.14	1.9812	-0.84115	1
3.58	1.14	1.9834	-0.84344	1
3.59	1.147	1.9846	-0.83757	1
3.61	1.162	1.9868	-0.82484	1
3.62	1.183	1.988	-0.80496	1
3.64	1.22	1.9902	-0.77021	1
3.65	1.241	1.9913	-0.75032	1
3.67	1.277	1.9936	-0.71655	1
3.68	1.292	1.9947	-0.70266	1
3.69	1.328	1.9958	-0.66777	1
3.71	1.386	1.998	-0.61197	1
3.73	1.422	2.0002	-0.57816	1
3.74	1.436	2.0012	-0.56525	1
3.76	1.465	2.0034	-0.53842	1
3.77	1.479	2.0045	-0.5255	1
3.79	1.494	2.0067	-0.51266	1
3.81	1.508	2.0088	-0.50081	1
3.83	1.501	2.0109	-0.50994	1
3.84	1.537	2.012	-0.475	1
3.86	1.559	2.0141	-0.45512	1
3.87	1.566	2.0152	-0.44917	1
3.89	1.588	2.0173	-0.42927	1
3.91	1.602	2.0194	-0.41737	1
3.93	1.609	2.0214	-0.41244	1
3.94	1.631	2.0225	-0.39148	1
3.96	1.645	2.0245	-0.37954	1
3.97	1.653	2.0256	-0.37257	1
3.99	1.66	2.0276	-0.36762	1
4.01	1.667	2.0297	-0.36266	1
4.03	1.682	2.0317	-0.34969	1
4.04	1.682	2.0327	-0.3507	1
4.08	1.71	2.0367	-0.32671	1
4.09	1.71	2.0377	-0.32771	1
4.11	1.718	2.0397	-0.3217	1
4.12	1.725	2.0407	-0.31569	1
4.14	1.747	2.0427	-0.29567	1
4.15	1.739	2.0437	-0.30465	1
4.17	1.739	2.0456	-0.30661	1
4.18	1.761	2.0466	-0.28559	1
4.2	1.768	2.0485	-0.28053	1
4.21	1.775	2.0495	-0.2745	1
4.22	1.775	2.0505	-0.27547	1
4.31	1.811	2.0591	-0.24808	1
4.39	1.862	2.0666	-0.20458	1

4.48	1.898	2.0749	-0.17686	1
4.56	1.927	2.0821	-0.15508	1
4.64	1.978	2.0892	-0.11118	1
4.73	2.014	2.097	-0.083017	1
4.81	2.042	2.1039	-0.061863	1
4.89	2.093	2.1106	-0.017596	1
4.98	2.1075	2.118	-0.010541	1
5.06	2.1291	2.1245	0.0045518	1
5.14	2.158	2.131	0.027046	1
5.23	2.2013	2.138	0.063258	1
5.73	2.3312	2.1753	0.15586	1
6.23	2.4756	2.2095	0.26606	1
6.73	2.5839	2.2411	0.34278	1
7.23	2.6705	2.2704	0.40006	1
7.73	2.7572	2.2978	0.45938	1
8.23	2.8221	2.3235	0.49861	1
8.73	2.8799	2.3477	0.53225	1
9.23	2.9232	2.3705	0.55272	1
9.73	2.9882	2.3921	0.59608	1
10.23	3.0387	2.4127	0.62603	1
10.73	3.0603	2.4323	0.62805	1
11.23	3.0964	2.4509	0.64545	1
11.73	3.1397	2.4688	0.67087	1
12.23	3.1686	2.486	0.68262	1
12.73	3.1975	2.5024	0.69506	1
13.23	3.2264	2.5183	0.70813	1
13.73	3.248	2.5335	0.71448	1
14.23	3.2769	2.5482	0.72867	1
14.73	3.2913	2.5624	0.72887	1
15.23	3.313	2.5762	0.73684	1
15.73	3.3491	2.5895	0.75965	1
16.23	3.3563	2.6023	0.75397	1
16.73	3.3635	2.6148	0.74868	1
17.23	3.378	2.6269	0.75106	1
17.73	3.3852	2.6387	0.74648	1
18.23	3.3924	2.6502	0.74222	1
18.73	3.4141	2.6613	0.75278	1
19.23	3.4285	2.6722	0.75632	1
19.73	3.4357	2.6828	0.75294	1
20.23	3.4357	2.6931	0.74263	1
20.73	3.4646	2.7031	0.76147	1
21.23	3.4718	2.713	0.75884	1
21.73	3.4862	2.7226	0.76364	1
22.23	3.5079	2.7319	0.77596	1
22.73	3.5223	2.7411	0.78118	1
23.23	3.5368	2.7501	0.7867	1
23.73	3.5368	2.7589	0.77792	1
24.23	3.5368	2.7675	0.76931	1
25.23	3.5512	2.7842	0.76702	1
26.23	3.5584	2.8002	0.75817	1
27.23	3.5584	2.8157	0.74272	1
28.23	3.5873	2.8306	0.75672	1
29.23	3.5512	2.845	0.70623	1
30.23	3.5729	2.8589	0.71403	1
31.23	3.5801	2.8723	0.70778	1
32.23	3.5945	2.8854	0.70914	1
33.23	3.5945	2.898	0.69651	1
34.23	3.5945	2.9103	0.68424	1
35.23	3.5945	2.9222	0.67233	1
36.23	3.6017	2.9338	0.66795	1

37.23	3.609	2.945	0.66398	1
38.23	3.6234	2.956	0.6674	1
39.23	3.6234	2.9667	0.65671	1
40.23	3.6378	2.9771	0.66069	1
41.23	3.6451	2.9873	0.65782	1
42.23	3.6378	2.9972	0.64059	1
43.23	3.6378	3.0069	0.63089	1
44.23	3.6378	3.0164	0.62141	1
45.23	3.6378	3.0257	0.61215	1
46.23	3.6523	3.0347	0.61758	1
47.23	3.6523	3.0436	0.60871	1
48.23	3.6378	3.0523	0.58552	1
49.23	3.6523	3.0608	0.59151	1
50.23	3.6739	3.0691	0.60477	1
51.23	3.6667	3.0773	0.58939	1
52.23	3.6739	3.0853	0.58857	1
53.23	3.6595	3.0932	0.5663	1
54.23	3.6812	3.1009	0.58028	1
55.23	3.6812	3.1085	0.57269	1
56.23	3.6884	3.116	0.57244	1
57.23	3.6812	3.1233	0.55793	1
58.23	3.6812	3.1305	0.55073	1
59.23	3.6884	3.1375	0.55086	1
60.23	3.6739	3.1445	0.52941	1
61.23	3.6812	3.1513	0.52987	1
62.23	3.6739	3.1581	0.51584	1
63.23	3.6739	3.1647	0.50922	1
64.23	3.6667	3.1712	0.4955	1
69.23	3.7245	3.2024	0.52214	1
74.23	3.7317	3.2314	0.50034	1
79.23	3.7461	3.2585	0.48762	1
84.23	3.7461	3.284	0.46215	1
89.23	3.7461	3.308	0.43813	1
94.23	3.7461	3.3307	0.41542	1
99.23	3.7967	3.3522	0.44448	1
104.23	3.8544	3.3727	0.48168	1
109.23	3.8905	3.3923	0.49824	1
114.23	3.8616	3.4109	0.45067	1
119.23	3.8761	3.4288	0.4473	1
124.23	3.8905	3.446	0.44455	1
129.23	3.8688	3.4624	0.40637	1
134.23	3.8688	3.4783	0.39052	1
139.23	3.8833	3.4936	0.38974	1
144.23	3.8977	3.5083	0.3894	1
149.23	3.9122	3.5225	0.38965	1
154.23	3.9122	3.5363	0.37588	1
159.23	3.9266	3.5497	0.37694	1
164.23	3.9194	3.5626	0.3568	1
169.23	3.9338	3.5751	0.35866	1
174.23	3.941	3.5873	0.35367	1
179.23	3.9555	3.5992	0.35633	1
184.23	3.9555	3.6107	0.34481	1
199.23	3.9627	3.6435	0.31924	1
214.23	3.9771	3.6739	0.30322	1
229.23	3.9771	3.7022	0.27485	1
244.23	3.9699	3.7288	0.24107	1
259.23	3.9843	3.7538	0.23046	1
274.23	3.9988	3.7774	0.22135	1
289.23	4.006	3.7998	0.20619	1
304.23	4.006	3.8211	0.18495	1

319.23	4.006	3.8413	0.16473	1
334.23	4.0132	3.8606	0.15262	1
349.23	4.006	3.879	0.12696	1
364.23	4.0204	3.8967	0.12367	1
379.23	4.0204	3.9137	0.10669	1
394.23	4.0565	3.93	0.12647	1
409.23	4.0565	3.9458	0.11075	1
424.23	4.0493	3.9609	0.088389	1
439.23	4.0637	3.9755	0.088154	1
454.23	4.071	3.9897	0.081306	1
469.23	4.0926	4.0034	0.089215	1
484.23	4.0854	4.0166	0.068751	1
499.23	4.0998	4.0295	0.07029	1
514.23	4.0998	4.042	0.057806	1
529.23	4.0926	4.0541	0.038479	1
544.23	4.0565	4.0659	-0.0094115	1
559.23	4.0998	4.0774	0.022416	1
574.23	4.1071	4.0886	0.018545	1
589.23	4.1071	4.0994	0.0076607	1
604.23	4.1143	4.1101	0.0042476	1
619.23	4.1432	4.1204	0.022793	1
634.23	4.0926	4.1305	-0.037916	1
649.23	4.0782	4.1404	-0.06219	1
664.23	4.1143	4.15	-0.03574	1
679.23	4.1143	4.1595	-0.045176	1
694.23	4.0493	4.1687	-0.11941	1
709.23	4.1576	4.1777	-0.020143	1
724.23	4.0998	4.1866	-0.086791	1
754.23	4.0854	4.2038	-0.11835	1
784.23	4.0926	4.2203	-0.12765	1
814.23	4.0854	4.2361	-0.15073	1
844.23	4.0782	4.2514	-0.17325	1
874.23	4.0421	4.2662	-0.22413	1
904.23	4.0493	4.2805	-0.23121	1
934.23	4.0998	4.2943	-0.19454	1
964.23	4.0998	4.3077	-0.20793	1
994.23	4.0565	4.3207	-0.26421	1
1024.2	4.0782	4.3333	-0.25511	1
1054.2	3.7678	4.3455	-0.57774	1
1084.2	3.9843	4.3574	-0.37314	1
1114.2	3.9843	4.369	-0.38471	1
1144.2	4.0493	4.3803	-0.33098	1
1174.2	4.0637	4.3913	-0.32756	1
1204.2	4.0637	4.402	-0.33827	1
1234.2	4.0565	4.4124	-0.35591	1
1264.2	4.0637	4.4226	-0.3589	1
1294.2	4.0926	4.4326	-0.33996	1
1324.2	4.0926	4.4423	-0.34969	1
1354.2	4.0926	4.4518	-0.3592	1
1384.2	4.0926	4.4611	-0.36851	1
1414.2	4.0998	4.4702	-0.37042	1
1444.2	4.0854	4.4791	-0.39374	1
1474.2	4.0998	4.4879	-0.38808	1
1504.2	4.1143	4.4964	-0.38214	1
1534.2	4.1287	4.5048	-0.37613	1
1564.2	4.1359	4.5131	-0.37716	1
1594.2	4.1359	4.5211	-0.38524	1
1624.2	4.1792	4.5291	-0.34987	1
1654.2	4.172	4.5369	-0.36485	1
1684.2	4.1648	4.5445	-0.3797	1

1714.2	4.2226	4.552	-0.32941	1
1744.2	4.2081	4.5594	-0.35129	1
1774.2	4.2226	4.5666	-0.34405	1
1804.2	4.237	4.5738	-0.33678	1
1834.2	4.2875	4.5808	-0.2933	1
1864.2	4.302	4.5877	-0.28571	1
1894.2	4.3092	4.5945	-0.28531	1
1924.2	4.3236	4.6012	-0.2776	1
1954.2	4.3597	4.6078	-0.24809	1
1984.2	4.3164	4.6143	-0.29787	1
2014.2	4.3597	4.6207	-0.26097	1
2044.2	4.3453	4.627	-0.28166	1
2074.2	4.3597	4.6332	-0.27347	1
2104.2	4.3814	4.6393	-0.25789	1
2134.2	4.4175	4.6453	-0.22782	1
2164.2	4.4175	4.6513	-0.23377	1
2194.2	4.3958	4.6571	-0.26134	1
2224.2	4.4608	4.6629	-0.20212	1
2254.2	4.4391	4.6686	-0.22954	1
2284.2	4.4319	4.6743	-0.24237	1
2314.2	4.4247	4.6798	-0.25514	1
2344.2	4.3597	4.6853	-0.32563	1
2374.2	4.3669	4.6908	-0.32385	1
2404.2	4.5113	4.6961	-0.18481	1
2434.2	4.3958	4.7014	-0.3056	1
2464.2	4.4897	4.7066	-0.21692	1
2494.2	4.4608	4.7118	-0.25098	1
2524.2	4.4319	4.7169	-0.28498	1
2554.2	4.4608	4.7219	-0.26112	1
2584.2	4.4536	4.7269	-0.27331	1
2614.2	4.4319	4.7318	-0.29993	1
2644.2	4.4247	4.7367	-0.312	1
2674.2	4.4391	4.7415	-0.30242	1
2704.2	4.4391	4.7463	-0.30718	1
2734.2	4.4536	4.751	-0.29739	1
2764.2	4.4536	4.7556	-0.30205	1
2794.2	4.4897	4.7603	-0.27056	1
2824.2	4.4608	4.7648	-0.30402	1
2854.2	4.4608	4.7693	-0.30853	1
2884.2	4.4752	4.7738	-0.2986	1
2914.2	4.4536	4.7782	-0.32462	1
2944.2	4.468	4.7826	-0.31459	1
2974.2	4.4608	4.7869	-0.32612	1
3004.2	4.4897	4.7912	-0.30151	1
3034.2	4.4608	4.7955	-0.33465	1

==

RESULTS FROM VISUAL CURVE MATCHING

SUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	3.9225E+000
	=	5.5173E-007

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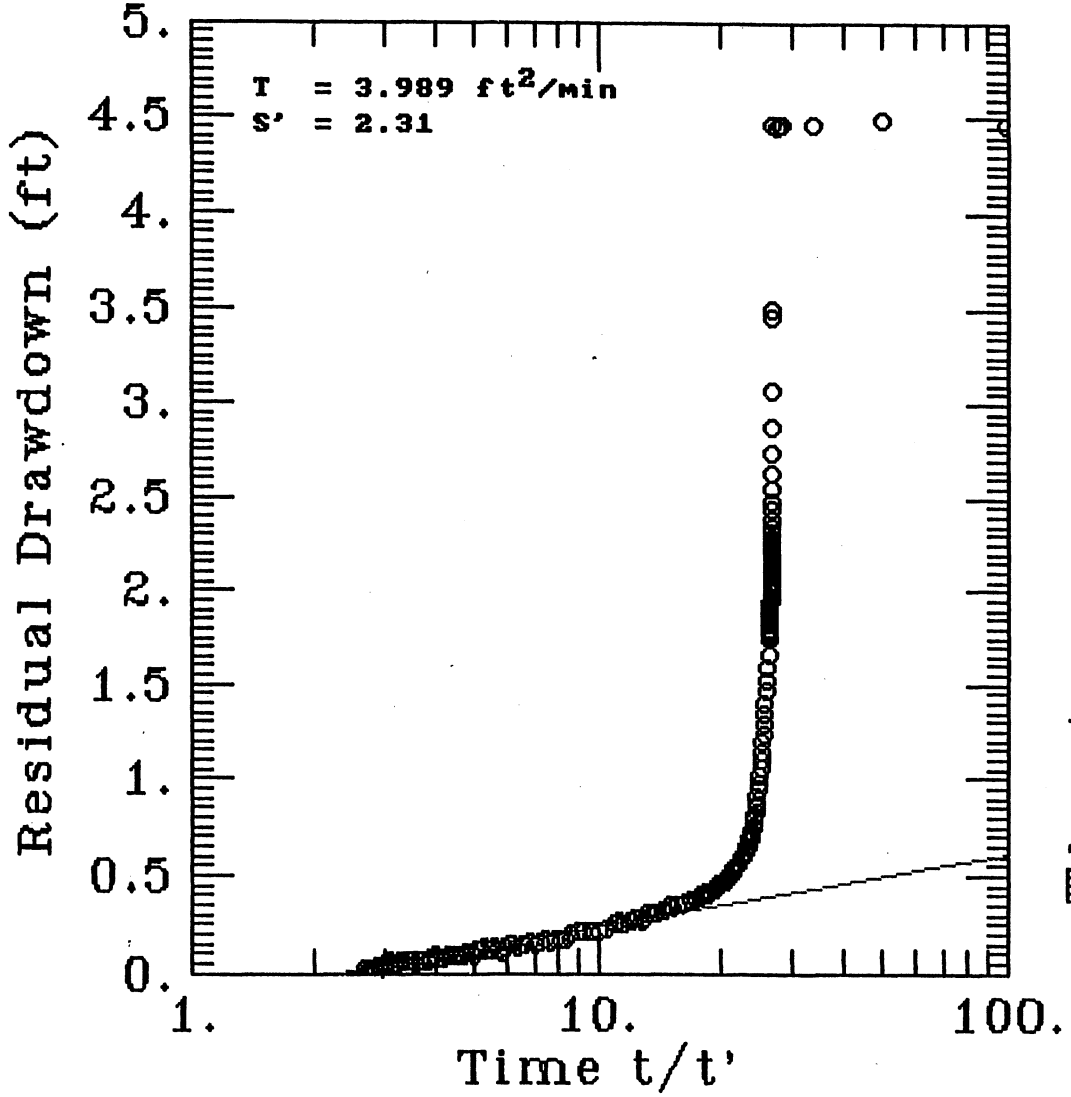
STF, AQUIFER TEST, 4A DATA, 4A RECOVERY



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

7/27/92 16:49:[illegible]

TEST DESCRIPTION

ata set........... 4A_T&REC.AQT
ata set title..... STF, AQUIFER TEST, 4A DATA, 4A RECOVERY

nowns and Constants:
 No. of data points.................. 248
 Pumping rate........................ 8.02
 Total pumping time.................. 2944

ANALYTICAL METHOD

heis Recovery (Confined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	6.7214E-001	+/-	4.5116E-002
S' =	5.0805E+000	+/-	4.4812E-001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
 Number of residuals............... 248
 Number of estimated parameters.... 2
 Degrees of freedom................ 246
 Residual mean..................... 1.164E-009
 Residual standard deviation....... 0.7515
 Residual variance................. 0.5647

odel Residuals:

Time	Observed	Calculated	Residual	Weight
30	4.4608	2.8216	1.6392	1
60	4.4897	2.1729	2.3168	1
90	4.4608	1.7973	2.6635	1
107.3	4.4608	1.6357	2.8251	1

109.3	4.4608	1.6188	2.842	1
111.3	4.4536	1.6022	2.8514	1
113.3	4.4608	1.5859	2.8749	1
114	3.4646	1.5803	1.8843	1
114.01	3.5007	1.5802	1.9205	1
114.03	3.0676	1.58	1.4876	1
114.05	2.8727	1.5799	1.2928	1
114.07	2.7355	1.5797	1.1558	1
114.08	2.6272	1.5796	1.0476	1
114.1	2.555	1.5795	0.97554	1
114.12	2.4828	1.5793	0.9035	1
114.13	2.4467	1.5792	0.86748	1
114.15	2.389	1.5791	0.80994	1
114.16	2.3457	1.579	0.76672	1
114.18	2.3168	1.5788	0.73798	1
114.2	2.2952	1.5787	0.71654	1
114.22	2.2735	1.5785	0.695	1
114.23	2.2518	1.5784	0.67338	1
114.25	2.2374	1.5783	0.65914	1
114.26	2.223	1.5782	0.64482	1
114.28	2.2013	1.578	0.62328	1
114.3	2.1941	1.5779	0.61624	1
114.32	2.1797	1.5777	0.602	1
114.33	2.1652	1.5776	0.58758	1
114.35	2.1508	1.5775	0.57334	1
114.36	2.1436	1.5774	0.56622	1
114.38	2.1291	1.5772	0.55188	1
114.4	2.1291	1.5771	0.55204	1
114.42	2.1147	1.5769	0.5378	1
114.45	2.1075	1.5767	0.53084	1
114.47	2.1002	1.5765	0.5237	1
114.48	2.086	1.5764	0.50958	1
114.5	2.086	1.5763	0.50974	1
114.51	2.071	1.5762	0.49482	1
114.53	2.071	1.576	0.49498	1
114.54	2.064	1.5759	0.48806	1
114.55	2.057	1.5759	0.48114	1
114.57	2.064	1.5757	0.4883	1
114.58	2.057	1.5756	0.48138	1
114.6	2.042	1.5755	0.46654	1
114.62	2.042	1.5753	0.4667	1
114.63	2.035	1.5752	0.45978	1
114.65	2.028	1.5751	0.45294	1
114.66	2.028	1.575	0.45302	1
114.68	2.014	1.5748	0.43918	1
114.7	2.021	1.5747	0.44634	1
114.72	2.006	1.5745	0.4315	1
114.73	1.999	1.5744	0.42458	1
114.75	2.006	1.5743	0.43174	1
114.76	1.992	1.5742	0.41781	1
114.78	1.992	1.574	0.41797	1
114.8	1.985	1.5739	0.41113	1
114.82	1.978	1.5737	0.40429	1
114.83	1.985	1.5736	0.41137	1
114.85	1.978	1.5735	0.40453	1
114.86	1.97	1.5734	0.39661	1
114.88	1.97	1.5732	0.39677	1
114.9	1.97	1.5731	0.39693	1
114.92	1.956	1.5729	0.38309	1
114.93	1.956	1.5728	0.38317	1

114.95	1.949	1.5727	0.37633	1
114.99	1.941	1.5724	0.36864	1
115	1.934	1.5723	0.36172	1
115.02	1.934	1.5721	0.36188	1
115.08	1.927	1.5716	0.35536	1
115.17	1.898	1.5709	0.32707	1
115.25	1.884	1.5703	0.31371	1
115.33	1.869	1.5697	0.29934	1
115.42	1.855	1.5689	0.28606	1
115.5	1.833	1.5683	0.26469	1
115.58	1.819	1.5677	0.25132	1
115.67	1.804	1.567	0.23703	1
115.75	1.79	1.5663	0.22366	1
115.83	1.768	1.5657	0.2023	1
115.92	1.754	1.565	0.18901	1
116	1.739	1.5644	0.17464	1
116.5	1.66	1.5604	0.099566	1
117	1.588	1.5565	0.031478	1
117.5	1.523	1.5526	-0.029627	1
118	1.465	1.5487	-0.08375	1
118.5	1.4	1.5449	-0.14489	1
119	1.342	1.541	-0.19905	1
119.5	1.292	1.5372	-0.24522	1
120	1.241	1.5334	-0.29241	1
120.5	1.191	1.5296	-0.33861	1
121	1.147	1.5258	-0.37884	1
121.5	1.097	1.5221	-0.42508	1
122	1.061	1.5183	-0.45733	1
122.5	1.017	1.5146	-0.4976	1
123	0.974	1.5109	-0.53689	1
123.5	0.945	1.5072	-0.56219	1
124	0.916	1.5035	-0.58751	1
124.5	0.873	1.4998	-0.62684	1
125	0.851	1.4962	-0.64519	1
125.5	0.83	1.4926	-0.66255	1
126	0.815	1.4889	-0.67393	1
126.5	0.794	1.4853	-0.69132	1
127	0.765	1.4817	-0.71673	1
127.5	0.75	1.4782	-0.72816	1
128	0.736	1.4746	-0.73859	1
128.5	0.721	1.471	-0.75005	1
129	0.707	1.4675	-0.76051	1
129.5	0.693	1.464	-0.77099	1
130	0.685	1.4605	-0.77549	1
130.5	0.671	1.457	-0.786	1
131	0.656	1.4535	-0.79752	1
131.5	0.649	1.4501	-0.80105	1
132	0.649	1.4466	-0.79761	1
132.5	0.628	1.4432	-0.81517	1
133	0.628	1.4397	-0.81175	1
133.5	0.628	1.4363	-0.80834	1
134	0.613	1.4329	-0.81994	1
134.5	0.599	1.4296	-0.83056	1
135	0.592	1.4262	-0.83419	1
136	0.592	1.4195	-0.82749	1
137	0.577	1.4128	-0.83584	1
138	0.563	1.4062	-0.84324	1
139	0.555	1.3997	-0.84469	1
140	0.548	1.3932	-0.84519	1
141	0.541	1.3867	-0.84574	1

142	0.534	1.3803	-0.84634	1
143	0.527	1.374	-0.84698	1
144	0.519	1.3677	-0.84867	1
145	0.505	1.3614	-0.8564	1
146	0.505	1.3552	-0.85018	1
147	0.505	1.349	-0.84401	1
148	0.49	1.3429	-0.85288	1
149	0.483	1.3368	-0.85379	1
150	0.476	1.3307	-0.85474	1
151	0.476	1.3247	-0.84874	1
152	0.469	1.3188	-0.84978	1
153	0.469	1.3129	-0.84386	1
154	0.454	1.307	-0.85298	1
155	0.454	1.3011	-0.84714	1
156	0.447	1.2953	-0.84834	1
157	0.454	1.2896	-0.83557	1
158	0.447	1.2839	-0.83685	1
159	0.433	1.2782	-0.84517	1
160	0.433	1.2725	-0.83952	1
161	0.425	1.2669	-0.84191	1
162	0.433	1.2613	-0.82833	1
163	0.418	1.2558	-0.83779	1
164	0.418	1.2503	-0.83229	1
165	0.418	1.2448	-0.82682	1
166	0.404	1.2394	-0.83539	1
167	0.411	1.234	-0.82299	1
168	0.411	1.2286	-0.81763	1
169	0.411	1.2233	-0.81229	1
170	0.397	1.218	-0.821	1
171	0.404	1.2127	-0.80873	1
172	0.397	1.2075	-0.8105	1
173	0.389	1.2023	-0.8133	1
174	0.397	1.1971	-0.80013	1
175	0.397	1.192	-0.79499	1
180	0.375	1.1668	-0.79176	1
185	0.382	1.1423	-0.76026	1
190	0.361	1.1184	-0.75745	1
195	0.353	1.0953	-0.74229	1
200	0.346	1.0728	-0.72676	1
205	0.339	1.0508	-0.71182	1
210	0.346	1.0294	-0.68344	1
215	0.317	1.0086	-0.6916	1
220	0.324	0.98827	-0.66427	1
225	0.303	0.96842	-0.66542	1
230	0.31	0.94905	-0.63905	1
235	0.303	0.93012	-0.62712	1
240	0.31	0.91162	-0.60162	1
245	0.281	0.89352	-0.61252	1
250	0.267	0.87583	-0.60883	1
255	0.281	0.8585	-0.5775	1
260	0.274	0.84155	-0.56755	1
265	0.267	0.82494	-0.55794	1
270	0.267	0.80866	-0.54166	1
275	0.252	0.79271	-0.54071	1
280	0.252	0.77708	-0.52508	1
285	0.267	0.76174	-0.49474	1
290	0.259	0.74669	-0.48769	1
295	0.259	0.73192	-0.47292	1
310	0.231	0.68921	-0.45821	1
325	0.209	0.6487	-0.4397	1

340	0.216	0.6102	-0.3942	1
355	0.216	0.57353	-0.35753	1
370	0.209	0.53853	-0.32953	1
385	0.194	0.50508	-0.31108	1
400	0.173	0.47305	-0.30005	1
415	0.166	0.44234	-0.27634	1
430	0.173	0.41285	-0.23985	1
445	0.151	0.3845	-0.2335	1
460	0.166	0.35721	-0.19121	1
475	0.151	0.33091	-0.17991	1
490	0.144	0.30554	-0.16154	1
505	0.151	0.28104	-0.13004	1
520	0.137	0.25737	-0.12037	1
535	0.137	0.23446	-0.097463	1
550	0.13	0.21229	-0.082288	1
565	0.137	0.1908	-0.053802	1
580	0.137	0.16997	-0.032969	1
595	0.13	0.14975	-0.019754	1
610	0.108	0.13013	-0.022125	1
625	0.122	0.11105	0.010946	1
640	0.13	0.092514	0.037486	1
655	0.122	0.074479	0.047521	1
670	0.122	0.056925	0.065075	1
685	0.13	0.039831	0.090169	1
700	0.115	0.023177	0.091823	1
715	0.115	0.0069421	0.10806	1
730	0.115	-0.0088903	0.12389	1
745	0.093	-0.024337	0.11734	1
760	0.108	-0.039415	0.14742	1
775	0.101	-0.054139	0.15514	1
790	0.093	-0.068522	0.16152	1
805	0.093	-0.082577	0.17558	1
820	0.086	-0.096319	0.18232	1
835	0.086	-0.10976	0.19576	1
865	0.086	-0.13577	0.22177	1
895	0.086	-0.1607	0.2467	1
925	0.079	-0.18462	0.26362	1
955	0.079	-0.20759	0.28659	1
985	0.086	-0.22969	0.31569	1
1015	0.079	-0.25096	0.32996	1
1045	0.065	-0.27145	0.33645	1
1075	0.057	-0.29122	0.34822	1
1105	0.057	-0.3103	0.3673	1
1135	0.05	-0.32873	0.37873	1
1165	0.065	-0.34654	0.41154	1
1195	0.057	-0.36378	0.42078	1
1225	0.057	-0.38047	0.43747	1
1255	0.057	-0.39664	0.45364	1
1285	0.057	-0.41231	0.46931	1
1315	0.05	-0.42752	0.47752	1
1345	0.05	-0.44227	0.49227	1
1375	0.05	-0.4566	0.5066	1
1405	0.057	-0.47053	0.52753	1
1435	0.043	-0.48406	0.52706	1
1465	0.043	-0.49723	0.54023	1
1495	0.028	-0.51004	0.53804	1
1525	0.036	-0.52251	0.55851	1
1555	0.036	-0.53466	0.57066	1
1585	0.021	-0.5465	0.5675	1
1615	0.021	-0.55803	0.57903	1

1645	0.014	-0.56928	0.58328	1
1675	0.007	-0.58026	0.58726	1
1705	0.007	-0.59097	0.59797	1
1735	0.014	-0.60143	0.61543	1

==

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	3.9895E+000
S' =	2.3103E+000

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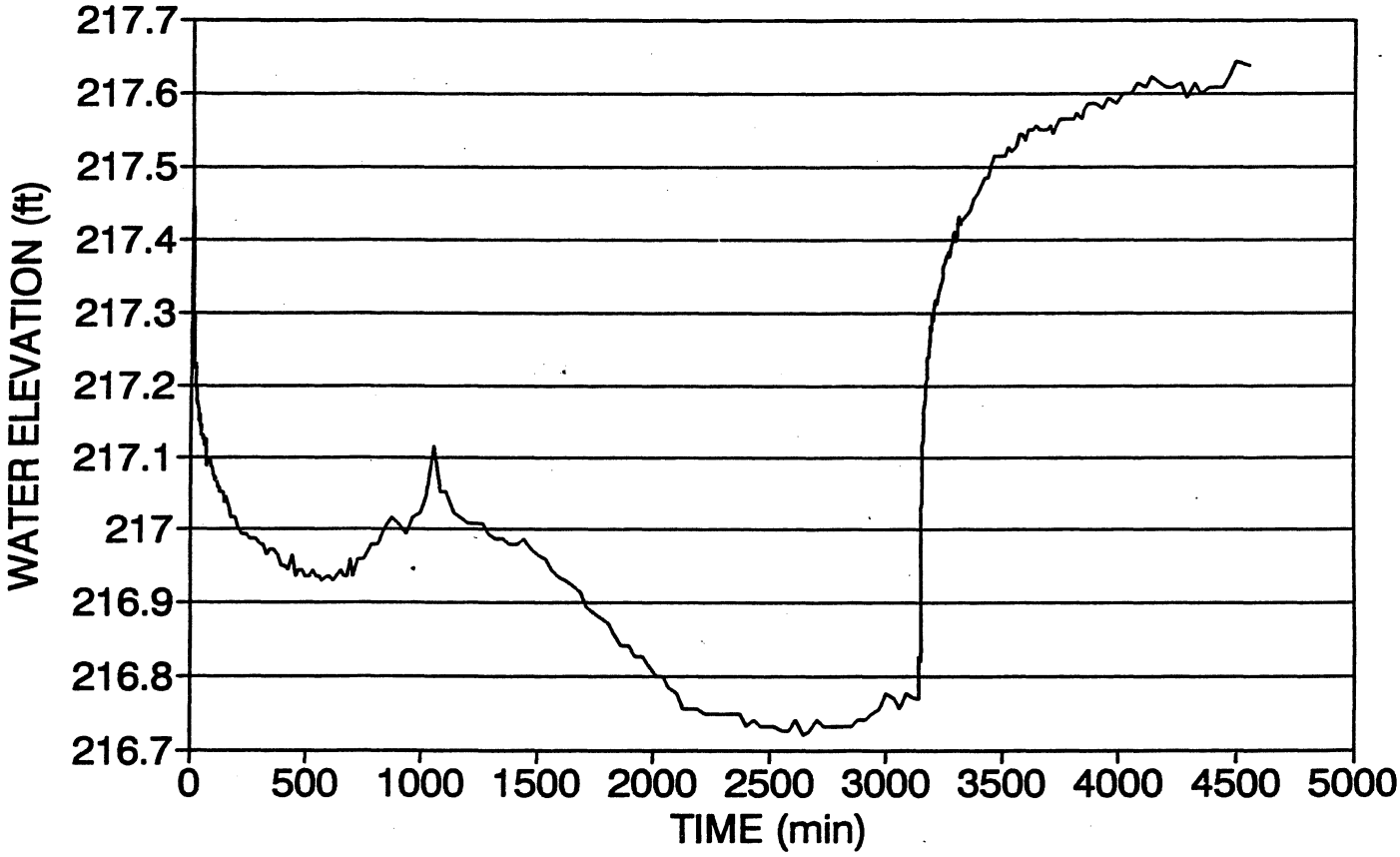
STF - NMW-4A PUMP TEST

WELL CBS-6A HYDROGRAPH



OUTPUT file

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A Q T E S O L V   R E S U L T S
Version 1.10

7/21/92 15:20:40

TEST DESCRIPTION

ata set........... b:\6a_neum.aqt
ata set title..... STF, AQUIFER TEST, 6A DATA, 4A PUMPED

nowns and Constants:
No. of data points.................. 289
Pumping rate........................ 8.02
Radius (distance) to obs. well...... 21.81
Aquifer saturated thickness......... 61.38

artial Penetration Data:
Depth of top of well screen......... 0
Depth of bottom of well screen...... 17.38
Depth of top of obs. well screen..... ~~0~~ 5.38
Depth of bottom of obs. well screen.. ~~17.38~~ 10.38
Hyd. conductivity ratio (Kz/Kr)..... 1

For some reason output file is not correctly echoing obs. well Partial Penetration data

ANALYTICAL METHOD

euman (Unconfined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	6.1810E+000	+/-	9.1220E-002
S	=	1.6087E-002	+/-	5.8642E-004
Sy	=	2.8173E-002	+/-	1.2332E-003
β	=	1.7210E-001	+/-	9.1680E-003

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 289
umber of estimated parameters.... 4
grees of freedom................ 285
Residual mean..................... -0.0004763
Residual standard deviation....... 0.06923
Residual variance................. 0.004793

odel Residuals:

Time	Observed	Calculated	Residual	Weight
2.01	0.007	0.074314	-0.067314	1
3.23	0.014	0.11016	-0.096156	1
3.24	0.029	0.11044	-0.081436	1
3.26	0.022	0.11099	-0.088995	1
3.28	0.029	0.11155	-0.082552	1
3.29	0.022	0.11183	-0.089831	1
3.31	0.029	0.11239	-0.083387	1
3.32	0.029	0.11267	-0.083665	1
3.34	0.029	0.11322	-0.08422	1
3.36	0.036	0.11377	-0.077774	1
3.38	0.029	0.11433	-0.085326	1
3.39	0.029	0.1146	-0.085602	1
3.41	0.036	0.11515	-0.079153	1
3.42	0.036	0.11543	-0.079428	1
3.44	0.036	0.11598	-0.079978	1
3.46	0.036	0.11653	-0.080526	1
3.48	0.043	0.11707	-0.074073	1
3.49	0.036	0.11735	-0.081346	1
3.51	0.051	0.11789	-0.066892	1
3.52	0.043	0.11816	-0.075164	1
3.56	0.051	0.11925	-0.068251	1
3.58	0.051	0.11979	-0.068793	1
3.59	0.058	0.12006	-0.062064	1
3.61	0.043	0.1206	-0.077604	1
3.62	0.051	0.12087	-0.069873	1
3.64	0.058	0.12141	-0.063412	1
3.65	0.058	0.12168	-0.063681	1
3.67	0.058	0.12222	-0.064218	1
3.68	0.051	0.12249	-0.071486	1
3.69	0.058	0.12275	-0.064754	1
3.71	0.058	0.12329	-0.065288	1
3.73	0.058	0.12382	-0.065822	1
3.74	0.065	0.12409	-0.059089	1
3.76	0.065	0.12462	-0.059621	1
3.77	0.065	0.12489	-0.059886	1
3.79	0.058	0.12542	-0.067416	1
3.81	0.072	0.12595	-0.053946	1
3.83	0.065	0.12647	-0.061474	1
3.84	0.065	0.12674	-0.061738	1
3.86	0.065	0.12726	-0.062264	1
3.87	0.065	0.12753	-0.062527	1
3.89	0.079	0.12805	-0.049052	1
3.91	0.072	0.12858	-0.056576	1
3.93	0.079	0.1291	-0.050098	1
3.94	0.072	0.12936	-0.057359	1
3.96	0.072	0.12988	-0.05788	1
3.97	0.072	0.13014	-0.058141	1
3.99	0.072	0.13066	-0.05866	1
4.01	0.079	0.13118	-0.052178	1
4.03	0.072	0.1317	-0.059696	1
4.04	0.079	0.13195	-0.052954	1
4.08	0.079	0.13298	-0.053984	1
4.09	0.087	0.13305	-0.046045	1
4.11	0.079	0.13356	-0.054558	1

4.12	0.079	0.13381	-0.054814	1
4.14	0.087	0.13433	-0.047325	1
4.15	0.087	0.13458	-0.04758	1
4.17	0.087	0.13509	-0.04809	1
4.18	0.087	0.13534	-0.048344	1
4.2	0.094	0.13585	-0.041852	1
4.21	0.087	0.13611	-0.049106	1
4.22	0.087	0.13636	-0.049359	1
4.31	0.094	0.13863	-0.044626	1
4.39	0.101	0.14062	-0.039623	1
4.48	0.101	0.14285	-0.041849	1
4.56	0.101	0.14481	-0.043809	1
4.64	0.116	0.14675	-0.030752	1
4.73	0.108	0.14892	-0.040917	1
4.81	0.116	0.15082	-0.034823	1
4.89	0.123	0.15271	-0.029712	1
4.98	0.13	0.15482	-0.024818	1
5.06	0.13	0.15667	-0.026672	1
5.14	0.137	0.15851	-0.021509	1
5.23	0.13	0.16056	-0.030556	1
5.73	0.166	0.17156	-0.0055559	1
6.23	0.173	0.18195	-0.0089488	1
6.73	0.202	0.19177	0.01023	1
7.23	0.217	0.1988	0.018202	1
7.73	0.231	0.20792	0.023085	1
8.23	0.245	0.21618	0.028822	1
8.73	0.26	0.22407	0.035931	1
9.23	0.267	0.23156	0.03544	1
9.73	0.282	0.23868	0.043319	1
10.23	0.303	0.24546	0.057542	1
10.73	0.31	0.25192	0.058083	1
11.23	0.318	0.25808	0.05992	1
11.73	0.325	0.26397	0.061033	1
12.23	0.325	0.2696	0.0554	1
12.73	0.339	0.27499	0.064006	1
13.23	0.347	0.28017	0.066833	1
13.73	0.354	0.28513	0.068868	1
14.23	0.361	0.2899	0.071095	1
14.73	0.375	0.2945	0.080503	1
15.23	0.368	0.29892	0.069081	1
15.73	0.375	0.30318	0.071817	1
16.23	0.39	0.3073	0.082702	1
16.73	0.39	0.31127	0.078728	1
17.23	0.404	0.31511	0.088885	1
17.73	0.412	0.31883	0.093167	1
18.23	0.404	0.32243	0.081566	1
18.73	0.404	0.32592	0.078076	1
19.23	0.412	0.32931	0.08269	1
19.73	0.412	0.3326	0.079404	1
20.23	0.426	0.33579	0.090211	1
20.73	0.426	0.33889	0.087108	1
21.23	0.433	0.34191	0.091089	1
21.73	0.426	0.34485	0.081151	1
22.23	0.433	0.34771	0.08529	1
22.73	0.419	0.3505	0.068501	1
23.23	0.44	0.35322	0.086783	1
23.73	0.426	0.35587	0.07013	1
24.23	0.44	0.35846	0.081541	1
25.23	0.44	0.36346	0.076542	1
26.23	0.448	0.36823	0.079765	1

27.23	0.462	0.37281	0.089193	1
28.23	0.455	0.37719	0.077808	1
29.23	0.462	0.3814	0.080598	1
30.23	0.469	0.38545	0.083548	1
31.23	0.469	0.38935	0.079648	1
32.23	0.476	0.39311	0.082887	1
33.23	0.469	0.39674	0.072256	1
34.23	0.484	0.40025	0.083747	1
35.23	0.484	0.40365	0.080351	1
36.23	0.484	0.40694	0.077062	1
37.23	0.491	0.41013	0.080873	1
38.23	0.491	0.41322	0.077779	1
39.23	0.491	0.41623	0.074773	1
40.23	0.498	0.41915	0.078853	1
41.23	0.498	0.42199	0.076012	1
42.23	0.491	0.42475	0.066246	1
43.23	0.498	0.42745	0.070552	1
44.23	0.505	0.43007	0.074926	1
45.23	0.498	0.43263	0.065365	1
46.23	0.505	0.43513	0.069866	1
47.23	0.505	0.43757	0.067425	1
48.23	0.513	0.43996	0.073041	1
49.23	0.513	0.44229	0.07071	1
50.23	0.505	0.44457	0.060431	1
51.23	0.513	0.4468	0.0662	1
52.23	0.513	0.44898	0.064017	1
53.23	0.52	0.45112	0.068879	1
54.23	0.52	0.45322	0.066784	1
55.23	0.527	0.45527	0.07173	1
56.23	0.52	0.45728	0.062717	1
57.23	0.52	0.45926	0.060742	1
58.23	0.52	0.4612	0.058804	1
59.23	0.52	0.4631	0.056902	1
60.23	0.52	0.46497	0.055034	1
61.23	0.527	0.4668	0.060199	1
62.23	0.527	0.4686	0.058396	1
63.23	0.534	0.47038	0.063624	1
64.23	0.527	0.47212	0.054882	1
69.23	0.527	0.48041	0.046587	1
74.23	0.563	0.48809	0.074909	1
79.23	0.556	0.49524	0.060762	1
84.23	0.556	0.50192	0.054078	1
89.23	0.556	0.5082	0.0478	1
94.23	0.563	0.51412	0.048882	1
99.23	0.563	0.51971	0.043286	1
104.23	0.578	0.52502	0.052977	1
109.23	0.585	0.53007	0.054927	1
114.23	0.578	0.53489	0.043114	1
119.23	0.585	0.53949	0.045514	1
124.23	0.592	0.54389	0.048111	1
129.23	0.592	0.54811	0.043888	1
134.23	0.599	0.55217	0.046831	1
139.23	0.599	0.55607	0.042928	1
144.23	0.599	0.55983	0.039167	1
149.23	0.606	0.56346	0.042537	1
154.23	0.614	0.56697	0.047032	1
159.23	0.606	0.57036	0.035641	1
164.23	0.614	0.57364	0.040358	1
169.23	0.621	0.57682	0.044176	1
174.23	0.621	0.57991	0.04109	1

179.23	0.635	0.58291	0.052093	1
184.23	0.635	0.58568	0.049323	1
199.23	0.635	0.59346	0.041543	1
214.23	0.65	0.59993	0.050075	1
229.23	0.657	0.60706	0.049944	1
244.23	0.657	0.61373	0.043274	1
259.23	0.664	0.61999	0.04401	1
274.23	0.664	0.6259	0.038104	1
289.23	0.664	0.63148	0.032517	1
304.23	0.671	0.63678	0.034217	1
319.23	0.671	0.64182	0.029176	1
334.23	0.686	0.64663	0.039369	1
349.23	0.679	0.65122	0.027776	1
364.23	0.679	0.65562	0.023377	1
379.23	0.686	0.65984	0.026159	1
394.23	0.7	0.6639	0.036105	1
409.23	0.7	0.6678	0.032204	1
424.23	0.707	0.67156	0.035444	1
439.23	0.686	0.67518	0.010817	1
454.23	0.715	0.67869	0.036312	1
469.23	0.707	0.68208	0.024922	1
484.23	0.707	0.68771	0.019288	1
499.23	0.715	0.69089	0.024107	1
514.23	0.715	0.69398	0.021021	1
529.23	0.707	0.69697	0.010025	1
544.23	0.715	0.69989	0.015114	1
559.23	0.715	0.70272	0.012283	1
574.23	0.722	0.70547	0.016529	1
589.23	0.715	0.70815	0.0068462	1
604.23	0.715	0.71077	0.0042323	1
619.23	0.722	0.71332	0.0086838	1
634.23	0.715	0.7158	-0.00080257	1
649.23	0.707	0.71823	-0.01123	1
664.23	0.715	0.7206	-0.0055999	1
679.23	0.715	0.72292	-0.0079162	1
694.23	0.693	0.72518	-0.032181	1
709.23	0.715	0.7274	-0.012396	1
724.23	0.693	0.72956	-0.036563	1
754.23	0.693	0.73376	-0.040764	1
784.23	0.671	0.7378	-0.066797	1
814.23	0.671	0.74168	-0.070676	1
844.23	0.65	0.74541	-0.095412	1
874.23	0.635	0.74902	-0.11402	1
904.23	0.643	0.7525	-0.1095	1
934.23	0.657	0.75586	-0.098862	1
964.23	0.635	0.75912	-0.12412	1
994.23	0.628	0.76228	-0.13428	1
1024.2	0.606	0.76535	-0.15935	1
1054.2	0.534	0.76833	-0.23433	1
1084.2	0.599	0.77123	-0.17223	1
1114.2	0.599	0.77405	-0.17505	1
1144.2	0.628	0.77679	-0.14879	1
1174.2	0.635	0.77947	-0.14447	1
1204.2	0.643	0.78209	-0.13909	1
1234.2	0.643	0.78464	-0.14164	1
1264.2	0.643	0.78714	-0.14414	1
1294.2	0.657	0.78958	-0.13258	1
1324.2	0.664	0.79197	-0.12797	1
1354.2	0.664	0.79431	-0.13031	1
1384.2	0.671	0.7966	-0.1256	1

1414.2	0.671	0.79884	-0.12784	1
1444.2	0.664	0.80104	-0.13704	1
1474.2	0.679	0.8032	-0.1242	1
1504.2	0.686	0.80532	-0.11932	1
1534.2	0.693	0.8074	-0.1144	1
1564.2	0.707	0.80944	-0.10244	1
1594.2	0.715	0.81145	-0.096451	1
1624.2	0.722	0.81342	-0.091424	1
1654.2	0.729	0.81536	-0.086363	1
1684.2	0.736	0.81727	-0.08127	1
1714.2	0.758	0.81915	-0.061146	1
1744.2	0.765	0.82099	-0.055992	1
1774.2	0.772	0.82281	-0.050808	1
1804.2	0.78	0.8246	-0.044595	1
1834.2	0.794	0.82635	-0.032355	1
1864.2	0.809	0.82809	-0.019088	1
1894.2	0.809	0.82979	-0.020794	1
1924.2	0.823	0.83147	-0.0084749	1
1954.2	0.823	0.83313	-0.010131	1
1984.2	0.837	0.83476	0.0022375	1
2014.2	0.852	0.83637	0.01563	1
2044.2	0.852	0.83795	0.014045	1
2074.2	0.866	0.83952	0.026483	1
2104.2	0.874	0.84106	0.032943	1
2134.2	0.895	0.84258	0.052425	1
2164.2	0.895	0.84407	0.050928	1
2194.2	0.895	0.84555	0.049452	1
2224.2	0.902	0.847	0.054996	1
2254.2	0.902	0.84844	0.05356	1
2284.2	0.902	0.84986	0.052143	1
2314.2	0.902	0.85125	0.050745	1
2344.2	0.902	0.85263	0.049367	1
2374.2	0.902	0.85399	0.048006	1
2404.2	0.917	0.85534	0.061664	1
2434.2	0.91	0.85666	0.053339	1
2464.2	0.917	0.85797	0.059032	1
2494.2	0.917	0.85926	0.057741	1
2524.2	0.917	0.86053	0.056467	1
2554.2	0.924	0.86179	0.06221	1
2584.2	0.924	0.86303	0.060969	1
2614.2	0.91	0.86426	0.045744	1
2644.2	0.931	0.86547	0.065534	1
2674.2	0.924	0.86666	0.057339	1
2704.2	0.91	0.86784	0.04216	1
2734.2	0.917	0.86901	0.047995	1
2764.2	0.917	0.87016	0.046844	1
2794.2	0.917	0.87129	0.045708	1
2824.2	0.917	0.87241	0.044586	1
2854.2	0.917	0.87352	0.043478	1
2884.2	0.91	0.87462	0.035383	1
2914.2	0.91	0.8757	0.034301	1
2944.2	0.902	0.87677	0.025233	1
2974.2	0.895	0.87782	0.017177	1
3004.2	0.874	0.87887	-0.0048662	1
3034.2	0.881	0.8799	0.0011031	1

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RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

Estimate

=

STF, AQUIFER TEST, 6A DATA, 4A PUMPED INPUT File b:\6A_nevm.ART

pwrate
8.02
radius
21.81
sthick
61.38
parpn2
61.38
0 — DEPTH TO TOP of well screen
17.38 — DEPTH TO Bottom of well screen
5.38 — Depth to top of obs. well screen
10.38 — Depth to bottom of obs well screen
1
tsdata

2.01	0.007	1
3.23	0.014	1
3.24	0.029	1
3.26	0.022	1
3.28	0.029	1
3.29	0.022	1
3.31	0.029	1
3.32	0.029	1
3.34	0.029	1
3.36	0.036	1
3.38	0.029	1
3.39	0.029	1
3.41	0.036	1
3.42	0.036	1
3.44	0.036	1
3.46	0.036	1
3.48	0.043	1
3.49	0.036	1
3.51	0.051	1
3.52	0.043	1
3.56	0.051	1
3.58	0.051	1
3.59	0.058	1
3.61	0.043	1
3.62	0.051	1
3.64	0.058	1
3.65	0.058	1
3.67	0.058	1
3.68	0.051	1
3.69	0.058	1
3.71	0.058	1
3.73	0.058	1
3.74	0.065	1
3.76	0.065	1
3.77	0.065	1
3.79	0.058	1
3.81	0.072	1
3.83	0.065	1
3.84	0.065	1
3.86	0.065	1
3.87	0.065	1
3.89	0.079	1
3.91	0.072	1
3.93	0.079	1
3.94	0.072	1
3.96	0.072	1
3.97	0.072	1

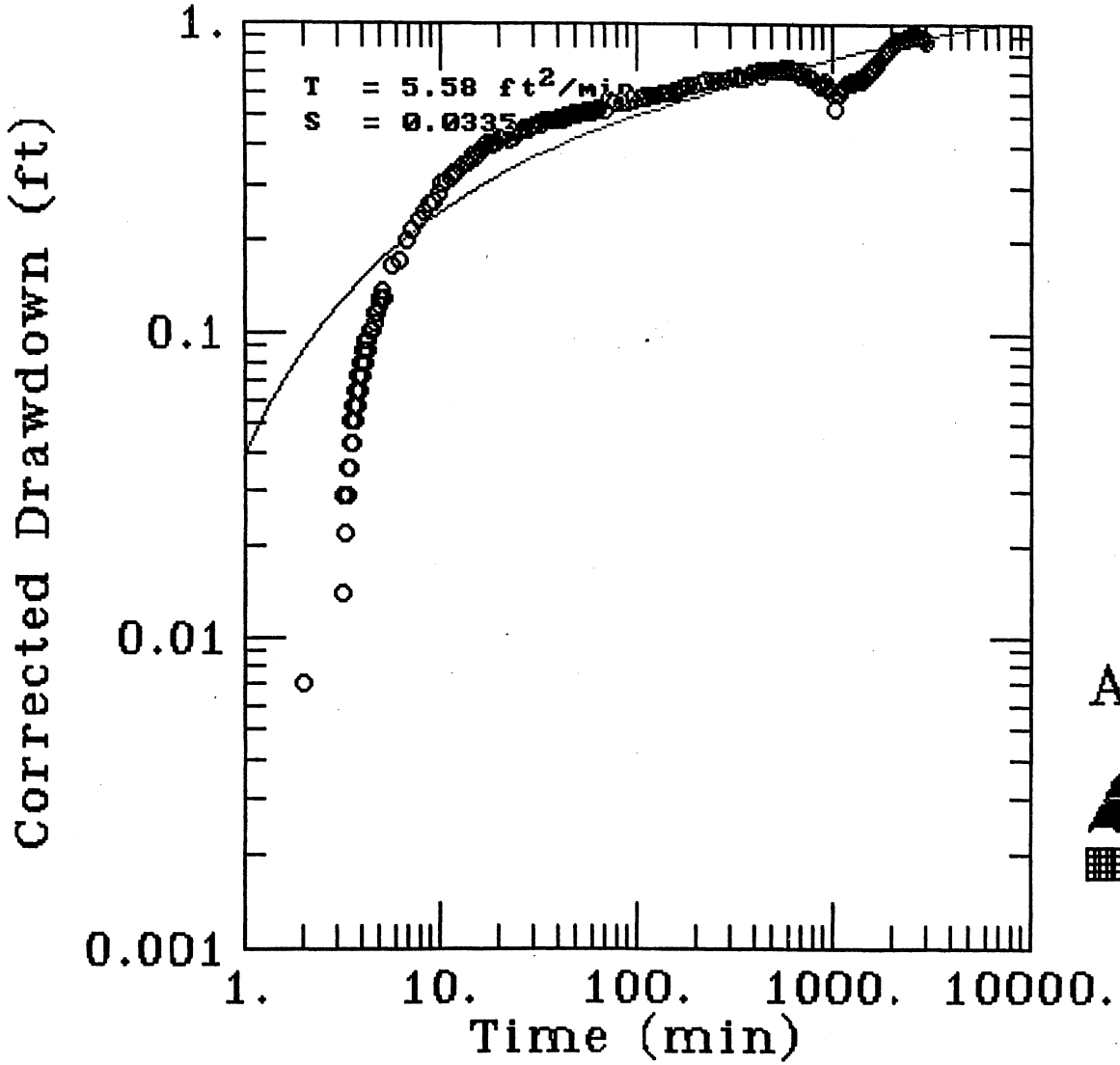
4.08	0.079	1
4.09	0.087	1
4.11	0.079	1
4.12	0.079	1
4.14	0.087	1
4.15	0.087	1
4.17	0.087	1
4.18	0.087	1
4.2	0.094	1
4.21	0.087	1
4.22	0.087	1
4.31	0.094	1
4.39	0.101	1
4.48	0.101	1
4.56	0.101	1
4.64	0.116	1
4.73	0.108	1
4.81	0.116	1
4.89	0.123	1
4.98	0.13	1
5.06	0.13	1
5.14	0.137	1
5.23	0.13	1
5.73	0.166	1
6.23	0.173	1
6.73	0.202	1
7.23	0.217	1
7.73	0.231	1
8.23	0.245	1
8.73	0.26	1
9.23	0.267	1
9.73	0.282	1
10.23	0.303	1
10.73	0.31	1
11.23	0.318	1
11.73	0.325	1
12.23	0.325	1
12.73	0.339	1
13.23	0.347	1
13.73	0.354	1
14.23	0.361	1
14.73	0.375	1
15.23	0.368	1
15.73	0.375	1
16.23	0.39	1
16.73	0.39	1
17.23	0.404	1
17.73	0.412	1
18.23	0.404	1
18.73	0.404	1
19.23	0.412	1
19.73	0.412	1
20.23	0.426	1
20.73	0.426	1
21.23	0.433	1
21.73	0.426	1
22.23	0.433	1
22.73	0.419	1
23.23	0.44	1
23.73	0.426	1
24.23	0.44	1
25.23	0.44	1

30.23	0.469	1
31.23	0.469	1
32.23	0.476	1
33.23	0.469	1
34.23	0.484	1
35.23	0.484	1
36.23	0.484	1
37.23	0.491	1
38.23	0.491	1
39.23	0.491	1
40.23	0.498	1
41.23	0.498	1
42.23	0.491	1
43.23	0.498	1
44.23	0.505	1
45.23	0.498	1
46.23	0.505	1
47.23	0.505	1
48.23	0.513	1
49.23	0.513	1
50.23	0.505	1
51.23	0.513	1
52.23	0.513	1
53.23	0.52	1
54.23	0.52	1
55.23	0.527	1
56.23	0.52	1
57.23	0.52	1
58.23	0.52	1
59.23	0.52	1
60.23	0.52	1
61.23	0.527	1
62.23	0.527	1
63.23	0.534	1
64.23	0.527	1
69.23	0.527	1
74.23	0.563	1
79.23	0.556	1
84.23	0.556	1
89.23	0.556	1
94.23	0.563	1
99.23	0.563	1
104.23	0.578	1
109.23	0.585	1
114.23	0.578	1
119.23	0.585	1
124.23	0.592	1
129.23	0.592	1
134.23	0.599	1
139.23	0.599	1
144.23	0.599	1
149.23	0.606	1
154.23	0.614	1
159.23	0.606	1
164.23	0.614	1
169.23	0.621	1
174.23	0.621	1
179.23	0.635	1
184.23	0.635	1
199.23	0.635	1
214.23	0.65	1
229.23	0.657	1

304.23	0.671	1
319.23	0.671	1
334.23	0.686	1
349.23	0.679	1
364.23	0.679	1
379.23	0.686	1
394.23	0.7	1
409.23	0.7	1
424.23	0.707	1
439.23	0.686	1
454.23	0.715	1
469.23	0.707	1
484.23	0.707	1
499.23	0.715	1
514.23	0.715	1
529.23	0.707	1
544.23	0.715	1
559.23	0.715	1
574.23	0.722	1
589.23	0.715	1
604.23	0.715	1
619.23	0.722	1
634.23	0.715	1
649.23	0.707	1
664.23	0.715	1
679.23	0.715	1
694.23	0.693	1
709.23	0.715	1
724.23	0.693	1
754.23	0.693	1
784.23	0.671	1
814.23	0.671	1
844.23	0.65	1
874.23	0.635	1
904.23	0.643	1
934.23	0.657	1
964.23	0.635	1
994.23	0.628	1
1024.23	0.606	1
1054.23	0.534	1
1084.23	0.599	1
1114.23	0.599	1
1144.23	0.628	1
1174.23	0.635	1
1204.23	0.643	1
1234.23	0.643	1
1264.23	0.643	1
1294.23	0.657	1
1324.23	0.664	1
1354.23	0.664	1
1384.23	0.671	1
1414.23	0.671	1
1444.23	0.664	1
1474.23	0.679	1
1504.23	0.686	1
1534.23	0.693	1
1564.23	0.707	1
1594.23	0.715	1
1624.23	0.722	1
1654.23	0.729	1
1684.23	0.736	1
1714.23	0.758	1

1864.23	0.809	1
1894.23	0.809	1
1924.23	0.823	1
1954.23	0.823	1
1984.23	0.837	1
2014.23	0.852	1
2044.23	0.852	1
2074.23	0.866	1
2104.23	0.874	1
2134.23	0.895	1
2164.23	0.895	1
2194.23	0.895	1
2224.23	0.902	1
2254.23	0.902	1
2284.23	0.902	1
2314.23	0.902	1
2344.23	0.902	1
2374.23	0.902	1
2404.23	0.917	1
2434.23	0.91	1
2464.23	0.917	1
2494.23	0.917	1
2524.23	0.917	1
2554.23	0.924	1
2584.23	0.924	1
2614.23	0.91	1
2644.23	0.931	1
2674.23	0.924	1
2704.23	0.91	1
2734.23	0.917	1
2764.23	0.917	1
2794.23	0.917	1
2824.23	0.917	1
2854.23	0.917	1
2884.23	0.91	1
2914.23	0.91	1
2944.23	0.902	1
2974.23	0.895	1
3004.23	0.874	1
3034.23	0.881	1

STF, AQUIFER TEST, 6A DATA, 4A PUMPED



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

A Q T E S O L V R E S U L T S
Version 1.10

)7 3/92 09:20:02

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TEST DESCRIPTION

)ata set..... b:\6a_t&dd.aqt
)ata set title..... STF, AQUIFER TEST, 6A DATA, 4A PUMPED

:nowns and Constants:
No. of data points..... 289
Pumping rate..... 8.02
Radius (distance) to obs. well..... 21.81
Aquifer saturated thickness..... 60.38

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ANALYTICAL METHOD

'heis (Unconfined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

T"ISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	5.5797E+000	+/-	1.1007E-001
S	=	3.3502E-002	+/-	2.7593E-003

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals..... 289
Number of estimated parameters.... 2
Degrees of freedom..... 287
Residual mean..... -0.002985
Residual standard deviation..... 0.08007
Residual variance..... 0.006411

odel Residuals:

Time	Observed	Calculated	Residual	Weight
2.01	0.007	0.089716	-0.082716	1
3.23	0.014	0.13071	-0.11671	1
3.24	0.029	0.13099	-0.10199	1
3.26	0.022	0.13156	-0.10956	1
3.28	0.029	0.13212	-0.10312	1
3.29	0.022	0.13241	-0.11041	1

3.34	0.029	0.1338	-0.1048	1
3.36	0.036	0.13435	-0.098352	1
3.38	0.029	0.1349	-0.1059	1
3.39	0.029	0.13518	-0.10618	1
3.41	0.036	0.13572	-0.099724	1
3.42	0.036	0.136	-0.099996	1
3.44	0.036	0.13654	-0.10054	1
3.46	0.036	0.13708	-0.10108	1
3.48	0.043	0.13762	-0.094617	1
3.49	0.036	0.13788	-0.10188	1
3.51	0.051	0.13842	-0.087419	1
3.52	0.043	0.13869	-0.095685	1
3.56	0.051	0.13974	-0.088744	1
3.58	0.051	0.14027	-0.08927	1
3.59	0.058	0.14053	-0.082532	1
3.61	0.043	0.14105	-0.098054	1
3.62	0.051	0.14131	-0.090315	1
3.64	0.058	0.14183	-0.083834	1
3.65	0.058	0.14209	-0.084092	1
3.67	0.058	0.14261	-0.084608	1
3.68	0.051	0.14286	-0.091865	1
3.69	0.058	0.14312	-0.085121	1
3.71	0.058	0.14363	-0.085632	1
3.73	0.058	0.14414	-0.086141	1
3.74	0.065	0.14439	-0.079394	1
3.76	0.065	0.1449	-0.0799	1
3.77	0.065	0.14515	-0.080152	1
3.79	0.058	0.14565	-0.087654	1
3.81	0.072	0.14615	-0.074154	1
3.83	0.065	0.14665	-0.081652	1
3.84	0.065	0.1469	-0.0819	1
3.86	0.065	0.14739	-0.082395	1
3.87	0.065	0.14764	-0.082642	1
3.89	0.079	0.14813	-0.069133	1
3.91	0.072	0.14862	-0.076623	1
3.93	0.079	0.14911	-0.07011	1
3.94	0.072	0.14935	-0.077354	1
3.96	0.072	0.14984	-0.077838	1
3.97	0.072	0.15008	-0.07808	1
3.99	0.072	0.15056	-0.078561	1
4.01	0.079	0.15104	-0.072041	1
4.03	0.072	0.15152	-0.079518	1
4.04	0.079	0.15176	-0.072757	1
4.08	0.079	0.1527	-0.073704	1
4.09	0.087	0.15294	-0.06594	1
4.11	0.079	0.15341	-0.07441	1
4.12	0.079	0.15364	-0.074644	1
4.14	0.087	0.15411	-0.067111	1
4.15	0.087	0.15434	-0.067344	1
4.17	0.087	0.15481	-0.067808	1
4.18	0.087	0.15504	-0.06804	1
4.2	0.094	0.1555	-0.061502	1
4.21	0.087	0.15573	-0.068732	1
4.22	0.087	0.15596	-0.068961	1
4.31	0.094	0.15801	-0.064008	1
4.39	0.101	0.1598	-0.058798	1
4.48	0.101	0.16178	-0.06078	1
4.56	0.101	0.16351	-0.062513	1
4.64	0.116	0.16522	-0.049221	1
4.73	0.108	0.16711	-0.059113	1
4.81	0.116	0.16877	-0.052769	1

5.06	0.13	0.1738	-0.043798	1
5.14	0.137	0.17536	-0.038362	1
5.23	0.13	0.1771	-0.047097	1
5.73	0.166	0.18629	-0.020291	1
6.23	0.173	0.19481	-0.021809	1
6.73	0.202	0.20274	-0.0007431	1
7.23	0.217	0.21017	0.0068322	1
7.73	0.231	0.21714	0.013856	1
8.23	0.245	0.22372	0.021277	1
8.73	0.26	0.22995	0.030052	1
9.23	0.267	0.23585	0.031146	1
9.73	0.282	0.24147	0.040528	1
10.23	0.303	0.24683	0.05617	1
10.73	0.31	0.25195	0.058051	1
11.23	0.318	0.25685	0.061149	1
11.73	0.325	0.26155	0.063446	1
12.23	0.325	0.26607	0.058928	1
12.73	0.339	0.27042	0.068581	1
13.23	0.347	0.27461	0.072391	1
13.73	0.354	0.27865	0.075348	1
14.23	0.361	0.28256	0.078443	1
14.73	0.375	0.28633	0.088665	1
15.23	0.368	0.28999	0.078007	1
15.73	0.375	0.29354	0.081462	1
16.23	0.39	0.29698	0.093022	1
16.73	0.39	0.30032	0.089682	1
17.23	0.404	0.30356	0.10044	1
17.73	0.412	0.30672	0.10528	1
18.23	0.404	0.30979	0.094207	1
18.73	0.404	0.31279	0.091214	1
19.23	0.412	0.3157	0.096296	1
19.73	0.412	0.31855	0.093451	1
20.23	0.426	0.32133	0.10467	1
20.73	0.426	0.32404	0.10196	1
21.23	0.433	0.32669	0.10631	1
21.73	0.426	0.32928	0.096724	1
22.23	0.433	0.33181	0.10119	1
22.73	0.419	0.33429	0.084713	1
23.23	0.44	0.33671	0.10329	1
23.73	0.426	0.33909	0.086911	1
24.23	0.44	0.34142	0.098583	1
25.23	0.44	0.34594	0.094063	1
26.23	0.448	0.35029	0.097713	1
27.23	0.462	0.35448	0.10752	1
28.23	0.455	0.35852	0.096478	1
29.23	0.462	0.36243	0.099571	1
30.23	0.469	0.36621	0.10279	1
31.23	0.469	0.36987	0.099132	1
32.23	0.476	0.37341	0.10259	1
33.23	0.469	0.37686	0.092144	1
34.23	0.484	0.3802	0.1038	1
35.23	0.484	0.38344	0.10056	1
36.23	0.484	0.3866	0.097398	1
37.23	0.491	0.38968	0.10132	1
38.23	0.491	0.39267	0.098329	1
39.23	0.491	0.39559	0.095411	1
40.23	0.498	0.39844	0.099564	1
41.23	0.498	0.40121	0.096786	1
42.23	0.491	0.40393	0.087074	1
43.23	0.498	0.40658	0.091423	1
44.23	0.505	0.40917	0.095832	1

47.23	0.505	0.41661	0.088391	1
48.23	0.513	0.41599	0.094014	1
49.23	0.513	0.42132	0.091685	1
50.23	0.505	0.4236	0.081401	1
51.23	0.513	0.42584	0.087162	1
52.23	0.513	0.42803	0.084966	1
53.23	0.52	0.43019	0.089811	1
54.23	0.52	0.43231	0.087695	1
55.23	0.527	0.43438	0.092617	1
56.23	0.52	0.43642	0.083576	1
57.23	0.52	0.43843	0.08157	1
58.23	0.52	0.4404	0.079599	1
59.23	0.52	0.44234	0.077661	1
60.23	0.52	0.44425	0.075754	1
61.23	0.527	0.44612	0.080879	1
62.23	0.527	0.44797	0.079034	1
63.23	0.534	0.44978	0.084217	1
64.23	0.527	0.45157	0.075429	1
69.23	0.527	0.46012	0.066882	1
74.23	0.563	0.46808	0.094923	1
79.23	0.556	0.47552	0.080478	1
84.23	0.556	0.48252	0.073484	1
89.23	0.556	0.48911	0.066889	1
94.23	0.563	0.49535	0.06765	1
99.23	0.563	0.50127	0.061731	1
104.23	0.578	0.5069	0.0711	1
109.23	0.585	0.51227	0.072731	1
114.23	0.578	0.5174	0.060601	1
119.23	0.585	0.52231	0.062688	1
124.23	0.592	0.52702	0.064976	1
129.23	0.592	0.53155	0.060448	1
134.23	0.599	0.53591	0.063091	1
139.23	0.599	0.54011	0.058892	1
144.23	0.599	0.54416	0.054841	1
149.23	0.606	0.54807	0.057926	1
154.23	0.614	0.55186	0.06214	1
159.23	0.606	0.55553	0.050473	1
164.23	0.614	0.55908	0.05492	1
169.23	0.621	0.56253	0.058472	1
174.23	0.621	0.56588	0.055124	1
179.23	0.635	0.56913	0.06587	1
184.23	0.635	0.57229	0.062705	1
199.23	0.635	0.5813	0.0537	1
214.23	0.65	0.58966	0.060344	1
229.23	0.657	0.59745	0.059552	1
244.23	0.657	0.60475	0.052251	1
259.23	0.664	0.61162	0.052383	1
274.23	0.664	0.6181	0.0459	1
289.23	0.664	0.62424	0.039761	1
304.23	0.671	0.63007	0.040931	1
319.23	0.671	0.63562	0.035381	1
334.23	0.686	0.64092	0.045084	1
349.23	0.679	0.64598	0.033019	1
364.23	0.679	0.65083	0.028166	1
379.23	0.686	0.65549	0.030509	1
394.23	0.7	0.65997	0.040031	1
409.23	0.7	0.66428	0.03572	1
424.23	0.707	0.66844	0.038564	1
439.23	0.686	0.67245	0.013551	1
454.23	0.715	0.67633	0.038673	1
469.23	0.707	0.68008	0.026921	1

514.23	0.715	0.69066	0.024341	1
529.23	0.707	0.69398	0.013019	1
544.23	0.715	0.69721	0.017789	1
559.23	0.715	0.70035	0.014646	1
574.23	0.722	0.70341	0.018587	1
589.23	0.715	0.70639	0.0086065	1
604.23	0.715	0.7093	0.0057005	1
619.23	0.722	0.71213	0.0098656	1
634.23	0.715	0.7149	9.8265E-005	1
649.23	0.707	0.7176	-0.010605	1
664.23	0.715	0.72025	-0.0052458	1
679.23	0.715	0.72283	-0.0078282	1
694.23	0.693	0.72535	-0.032354	1
709.23	0.715	0.72783	-0.012827	1
724.23	0.693	0.73025	-0.037247	1
754.23	0.693	0.73494	-0.041943	1
784.23	0.671	0.73945	-0.068455	1
814.23	0.671	0.7438	-0.072798	1
844.23	0.65	0.74799	-0.097985	1
874.23	0.635	0.75203	-0.11703	1
904.23	0.643	0.75593	-0.11293	1
934.23	0.657	0.75971	-0.10271	1
964.23	0.635	0.76337	-0.12837	1
994.23	0.628	0.76691	-0.13891	1
1024.2	0.606	0.77036	-0.16436	1
1054.2	0.534	0.7737	-0.2397	1
1084.2	0.599	0.77695	-0.17795	1
1114.2	0.599	0.78011	-0.18111	1
1144.2	0.628	0.78319	-0.15519	1
1174.2	0.635	0.78618	-0.15118	1
1204.2	0.643	0.7891	-0.1461	1
1234.2	0.643	0.79195	-0.14895	1
1264.2	0.643	0.79474	-0.15174	1
1294.2	0.657	0.79745	-0.14045	1
1324.2	0.664	0.80011	-0.13611	1
1354.2	0.664	0.8027	-0.1387	1
1384.2	0.671	0.80524	-0.13424	1
1414.2	0.671	0.80773	-0.13673	1
1444.2	0.664	0.81016	-0.14616	1
1474.2	0.679	0.81254	-0.13354	1
1504.2	0.686	0.81488	-0.12888	1
1534.2	0.693	0.81716	-0.12416	1
1564.2	0.707	0.81941	-0.11241	1
1594.2	0.715	0.82161	-0.10661	1
1624.2	0.722	0.82377	-0.10177	1
1654.2	0.729	0.82589	-0.096894	1
1684.2	0.736	0.82798	-0.091977	1
1714.2	0.758	0.83002	-0.072024	1
1744.2	0.765	0.83203	-0.067035	1
1774.2	0.772	0.83401	-0.062012	1
1804.2	0.78	0.83596	-0.055956	1
1834.2	0.794	0.83787	-0.043868	1
1864.2	0.809	0.83975	-0.030749	1
1894.2	0.809	0.8416	-0.0326	1
1924.2	0.823	0.84342	-0.020422	1
1954.2	0.823	0.84522	-0.022216	1
1984.2	0.837	0.84698	-0.0099829	1
2014.2	0.852	0.84872	0.0032768	1
2044.2	0.852	0.85044	0.0015623	1
2074.2	0.866	0.85213	0.013873	1
2104.2	0.874	0.85379	0.020207	1

2194.2	0.895	0.85865	0.036349	1
2224.2	0.902	0.86023	0.041774	1
2254.2	0.902	0.86178	0.04022	1
2284.2	0.902	0.86331	0.038687	1
2314.2	0.902	0.86483	0.037173	1
2344.2	0.902	0.86632	0.035679	1
2374.2	0.902	0.8678	0.034203	1
2404.2	0.917	0.86925	0.047747	1
2434.2	0.91	0.87069	0.039308	1
2464.2	0.917	0.87211	0.044887	1
2494.2	0.917	0.87352	0.043483	1
2524.2	0.917	0.8749	0.042096	1
2554.2	0.924	0.87628	0.047725	1
2584.2	0.924	0.87763	0.04637	1
2614.2	0.91	0.87897	0.03103	1
2644.2	0.931	0.88029	0.050706	1
2674.2	0.924	0.8816	0.042397	1
2704.2	0.91	0.8829	0.027103	1
2734.2	0.917	0.88418	0.032822	1
2764.2	0.917	0.88544	0.031556	1
2794.2	0.917	0.8867	0.030303	1
2824.2	0.917	0.88794	0.029064	1
2854.2	0.917	0.88916	0.027837	1
2884.2	0.91	0.89038	0.019624	1
2914.2	0.91	0.89158	0.018423	1
2944.2	0.902	0.89277	0.0092341	1
2974.2	0.895	0.89394	0.0010574	1
3004.2	0.874	0.89511	-0.021108	1
3034.2	0.881	0.89626	-0.015261	1

===

RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	5.5797E+000
S =	3.3502E-002

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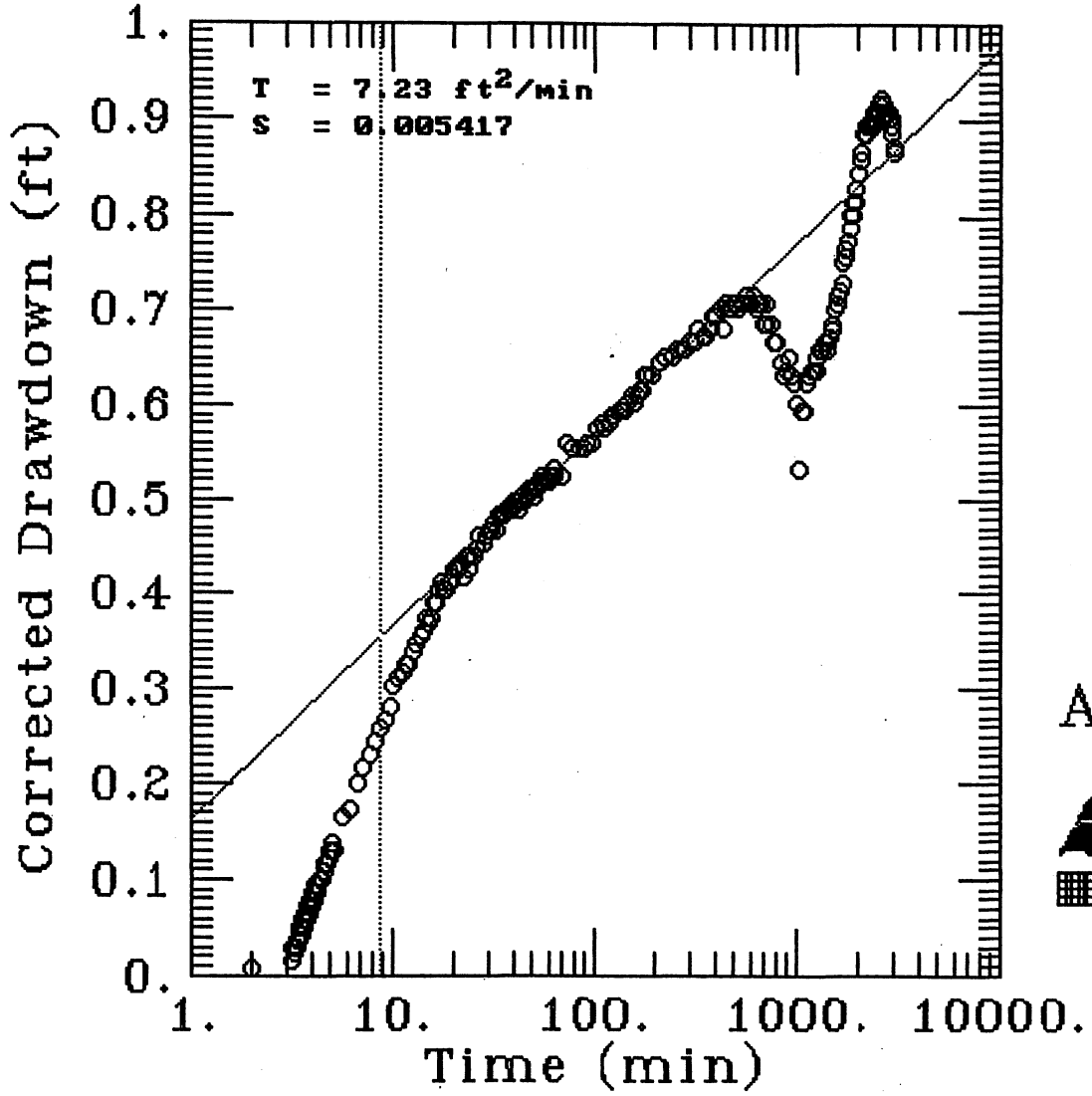
STF, AQUIFER TEST, 6A DATA, 4A PUMPED



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

A Q T E S O L V R E S U L T S
Version 1.10

/92 09:25:17

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TEST DESCRIPTION

ıta set..... b:\6a_t&dd.aqt
ıta set title..... STF, AQUIFER TEST, 6A DATA, 4A PUMPED

ıowns and Constants:
No. of data points..... 289
Pumping rate..... 8.02
Radius (distance) to obs. well..... 21.81
Aquifer saturated thickness..... 60.38

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ANALYTICAL METHOD

ɔoper-Jacob (Unconfined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	5.6002E+000	+/-	9.1163E-002
S =	3.2154E-002	+/-	2.0845E-003

NALYSIS OF MODEL RESIDUALS

ɜsidual = calculated - observed
ɜighted residual = residual * weight

ɜighted Residual Statistics:
Number of residuals..... 289
Number of estimated parameters.... 2
Degrees of freedom..... 287
Residual mean..... 3.78E-007
Residual standard deviation..... 0.0761
Residual variance..... 0.005792

ɔdel Residuals:

Time	Observed	Calculated	Residual	Weight
2.01	0.007	0.057306	-0.050306	1
3.23	0.014	0.11145	-0.097449	1
3.24	0.029	0.1118	-0.082802	1
3.26	0.022	0.1125	-0.090505	1
3.28	0.029	0.1132	-0.084203	1
3.29	0.022	0.11355	-0.091551	1

3.34	0.029	0.11527	-0.086273	1
3.36	0.036	0.11596	-0.079955	1
3.38	0.029	0.11663	-0.087633	1
3.39	0.029	0.11697	-0.08797	1
3.41	0.036	0.11764	-0.081642	1
3.42	0.036	0.11798	-0.081977	1
3.44	0.036	0.11864	-0.082643	1
3.46	0.036	0.1193	-0.083305	1
3.48	0.043	0.11996	-0.076963	1
3.49	0.036	0.12029	-0.084291	1
3.51	0.051	0.12094	-0.069943	1
3.52	0.043	0.12127	-0.078268	1
3.56	0.051	0.12256	-0.071559	1
3.58	0.051	0.1232	-0.072199	1
3.59	0.058	0.12352	-0.065517	1
3.61	0.043	0.12415	-0.081152	1
3.62	0.051	0.12447	-0.073468	1
3.64	0.058	0.1251	-0.067097	1
3.65	0.058	0.12541	-0.06741	1
3.67	0.058	0.12603	-0.068034	1
3.68	0.051	0.12635	-0.075345	1
3.69	0.058	0.12666	-0.068655	1
3.71	0.058	0.12727	-0.069273	1
3.73	0.058	0.12789	-0.069887	1
3.74	0.065	0.12819	-0.063193	1
3.76	0.065	0.1288	-0.063802	1
3.77	0.065	0.12911	-0.064105	1
3.79	0.058	0.12971	-0.07171	1
3.81	0.072	0.13031	-0.058311	1
3.83	0.065	0.13091	-0.065909	1
3.84	0.065	0.13121	-0.066207	1
3.86	0.065	0.1318	-0.0668	1
3.87	0.065	0.1321	-0.067096	1
3.89	0.079	0.13268	-0.053685	1
3.91	0.072	0.13327	-0.06127	1
3.93	0.079	0.13385	-0.054853	1
3.94	0.072	0.13414	-0.062143	1
3.96	0.072	0.13472	-0.062722	1
3.97	0.072	0.13501	-0.06301	1
3.99	0.072	0.13558	-0.063584	1
4.01	0.079	0.13616	-0.057155	1
4.03	0.072	0.13672	-0.064724	1
4.04	0.079	0.13701	-0.058007	1
4.08	0.079	0.13813	-0.059132	1
4.09	0.087	0.13841	-0.051412	1
4.11	0.079	0.13897	-0.059969	1
4.12	0.079	0.13925	-0.060247	1
4.14	0.087	0.1398	-0.0528	1
4.15	0.087	0.14008	-0.053076	1
4.17	0.087	0.14063	-0.053625	1
4.18	0.087	0.1409	-0.053899	1
4.2	0.094	0.14144	-0.047444	1
4.21	0.087	0.14172	-0.054716	1
4.22	0.087	0.14199	-0.054987	1
4.31	0.094	0.1444	-0.050398	1
4.39	0.101	0.1465	-0.045499	1
4.48	0.101	0.14882	-0.047818	1
4.56	0.101	0.15084	-0.049841	1
4.64	0.116	0.15283	-0.036828	1
4.73	0.108	0.15502	-0.047023	1
4.81	0.116	0.15694	-0.04094	1

5.06	0.13	0.16273	-0.032731	1
5.14	0.137	0.16452	-0.027524	1
5.23	0.13	0.16651	-0.036507	1
5.73	0.166	0.17694	-0.010944	1
6.23	0.173	0.18651	-0.013509	1
6.73	0.202	0.19534	0.0066638	1
7.23	0.217	0.20353	0.013468	1
7.73	0.231	0.21118	0.01982	1
8.23	0.245	0.21835	0.02665	1
8.73	0.26	0.2251	0.034903	1
9.23	0.267	0.23147	0.035531	1
9.73	0.282	0.23751	0.044494	1
10.23	0.303	0.24324	0.05976	1
10.73	0.31	0.2487	0.061298	1
11.23	0.318	0.25391	0.064085	1
11.73	0.325	0.2589	0.066099	1
12.23	0.325	0.26368	0.06132	1
12.73	0.339	0.26827	0.070733	1
13.23	0.347	0.27268	0.074322	1
13.73	0.354	0.27693	0.077074	1
14.23	0.361	0.28102	0.079978	1
14.73	0.375	0.28498	0.090023	1
15.23	0.368	0.2888	0.0792	1
15.73	0.375	0.2925	0.0825	1
16.23	0.39	0.29608	0.093916	1
16.73	0.39	0.29956	0.090441	1
17.23	0.404	0.30293	0.10107	1
17.73	0.412	0.30621	0.10579	1
18.23	0.404	0.3094	0.094604	1
18.73	0.404	0.3125	0.091504	1
19.23	0.412	0.31551	0.096485	1
19.73	0.412	0.31846	0.093544	1
20.23	0.426	0.32132	0.10468	1
20.73	0.426	0.32412	0.10188	1
21.23	0.433	0.32685	0.10615	1
21.73	0.426	0.32952	0.096479	1
22.23	0.433	0.33213	0.10087	1
22.73	0.419	0.33468	0.084322	1
23.23	0.44	0.33717	0.10283	1
23.73	0.426	0.33961	0.086387	1
24.23	0.44	0.342	0.097997	1
25.23	0.44	0.34664	0.093361	1
26.23	0.448	0.3511	0.096905	1
27.23	0.462	0.35539	0.10661	1
28.23	0.455	0.35952	0.09548	1
29.23	0.462	0.36351	0.098488	1
30.23	0.469	0.36737	0.10163	1
31.23	0.469	0.3711	0.097898	1
32.23	0.476	0.37472	0.10128	1
33.23	0.469	0.37822	0.090778	1
34.23	0.484	0.38162	0.10238	1
35.23	0.484	0.38493	0.099074	1
36.23	0.484	0.38814	0.095863	1
37.23	0.491	0.39126	0.09974	1
38.23	0.491	0.3943	0.096699	1
39.23	0.491	0.39726	0.093736	1
40.23	0.498	0.40015	0.097848	1
41.23	0.498	0.40297	0.095031	1
42.23	0.491	0.40572	0.085281	1
43.23	0.498	0.4084	0.089595	1
44.23	0.505	0.41103	0.093971	1

47.23	0.505	0.41856	0.086439	1
48.23	0.513	0.42097	0.092034	1
49.23	0.513	0.42332	0.089678	1
50.23	0.505	0.42563	0.07937	1
51.23	0.513	0.42789	0.085107	1
52.23	0.513	0.43011	0.082888	1
53.23	0.52	0.43229	0.08771	1
54.23	0.52	0.43443	0.085574	1
55.23	0.527	0.43652	0.090476	1
56.23	0.52	0.43858	0.081415	1
57.23	0.52	0.44061	0.079391	1
58.23	0.52	0.4426	0.077402	1
59.23	0.52	0.44455	0.075447	1
60.23	0.52	0.44648	0.073525	1
61.23	0.527	0.44837	0.078634	1
62.23	0.527	0.45023	0.076773	1
63.23	0.534	0.45206	0.081943	1
64.23	0.527	0.45386	0.073141	1
69.23	0.527	0.46247	0.064531	1
74.23	0.563	0.47048	0.09252	1
79.23	0.556	0.47797	0.078031	1
84.23	0.556	0.485	0.071	1
89.23	0.556	0.49163	0.064373	1
94.23	0.563	0.49789	0.065108	1
99.23	0.563	0.50383	0.059165	1
104.23	0.578	0.50949	0.068514	1
109.23	0.585	0.51487	0.070128	1
114.23	0.578	0.52002	0.057982	1
119.23	0.585	0.52494	0.060056	1
124.23	0.592	0.52967	0.062333	1
129.23	0.592	0.5342	0.057795	1
134.23	0.599	0.53857	0.060429	1
139.23	0.599	0.54278	0.056223	1
144.23	0.599	0.54684	0.052165	1
149.23	0.606	0.55076	0.055245	1
154.23	0.614	0.55455	0.059454	1
159.23	0.606	0.55822	0.047783	1
164.23	0.614	0.56177	0.052226	1
169.23	0.621	0.56522	0.055776	1
174.23	0.621	0.56857	0.052425	1
179.23	0.635	0.57183	0.063169	1
184.23	0.635	0.575	0.060003	1
199.23	0.635	0.58401	0.050995	1
214.23	0.65	0.59236	0.057639	1
229.23	0.657	0.60015	0.056848	1
244.23	0.657	0.60745	0.049551	1
259.23	0.664	0.61431	0.049687	1
274.23	0.664	0.62079	0.043209	1
289.23	0.664	0.62692	0.037076	1
304.23	0.671	0.63275	0.038252	1
319.23	0.671	0.63829	0.032708	1
334.23	0.686	0.64358	0.042418	1
349.23	0.679	0.64864	0.03036	1
364.23	0.679	0.65349	0.025514	1
379.23	0.686	0.65814	0.027863	1
394.23	0.7	0.66261	0.037393	1
409.23	0.7	0.66691	0.033089	1
424.23	0.707	0.67106	0.03594	1
439.23	0.686	0.67507	0.010935	1
454.23	0.715	0.67894	0.036064	1
469.23	0.707	0.68268	0.024318	1

514.23	0.715	0.69324	0.02176	1
529.23	0.707	0.69656	0.010444	1
544.23	0.715	0.69978	0.015221	1
559.23	0.715	0.70291	0.012086	1
574.23	0.722	0.70597	0.016033	1
589.23	0.715	0.70894	0.0060589	1
604.23	0.715	0.71184	0.0031595	1
619.23	0.722	0.71467	0.007331	1
634.23	0.715	0.71743	-0.0024299	1
649.23	0.707	0.72013	-0.013126	1
664.23	0.715	0.72276	-0.0077614	1
679.23	0.715	0.72534	-0.010338	1
694.23	0.693	0.72786	-0.034858	1
709.23	0.715	0.73032	-0.015324	1
724.23	0.693	0.73274	-0.039739	1
754.23	0.693	0.73742	-0.044422	1
784.23	0.671	0.74192	-0.070923	1
814.23	0.671	0.74626	-0.075256	1
844.23	0.65	0.75043	-0.10043	1
874.23	0.635	0.75446	-0.11946	1
904.23	0.643	0.75836	-0.11536	1
934.23	0.657	0.76212	-0.10512	1
964.23	0.635	0.76577	-0.13077	1
994.23	0.628	0.76931	-0.14131	1
1024.2	0.606	0.77274	-0.16674	1
1054.2	0.534	0.77608	-0.24208	1
1084.2	0.599	0.77932	-0.18032	1
1114.2	0.599	0.78247	-0.18347	1
1144.2	0.628	0.78554	-0.15754	1
1174.2	0.635	0.78852	-0.15352	1
1204.2	0.643	0.79144	-0.14844	1
1234.2	0.643	0.79428	-0.15128	1
1264.2	0.643	0.79705	-0.15405	1
1294.2	0.657	0.79976	-0.14276	1
1324.2	0.664	0.80241	-0.13841	1
1354.2	0.664	0.805	-0.141	1
1384.2	0.671	0.80753	-0.13653	1
1414.2	0.671	0.81001	-0.13901	1
1444.2	0.664	0.81243	-0.14843	1
1474.2	0.679	0.81481	-0.13581	1
1504.2	0.686	0.81714	-0.13114	1
1534.2	0.693	0.81942	-0.12642	1
1564.2	0.707	0.82165	-0.11465	1
1594.2	0.715	0.82385	-0.10885	1
1624.2	0.722	0.826	-0.104	1
1654.2	0.729	0.82812	-0.09912	1
1684.2	0.736	0.8302	-0.094197	1
1714.2	0.758	0.83224	-0.074237	1
1744.2	0.765	0.83424	-0.069242	1
1774.2	0.772	0.83621	-0.064213	1
1804.2	0.78	0.83815	-0.058152	1
1834.2	0.794	0.84006	-0.046058	1
1864.2	0.809	0.84193	-0.032933	1
1894.2	0.809	0.84378	-0.034778	1
1924.2	0.823	0.84559	-0.022595	1
1954.2	0.823	0.84738	-0.024383	1
1984.2	0.837	0.84914	-0.012145	1
2014.2	0.852	0.85088	0.0011206	1
2044.2	0.852	0.85259	-0.00058869	1
2074.2	0.866	0.85427	0.011727	1
2104.2	0.874	0.85593	0.018067	1

2194.2	0.895	0.86078	0.034224	1
2224.2	0.902	0.86235	0.039654	1
2254.2	0.902	0.8639	0.038105	1
2284.2	0.902	0.86542	0.036576	1
2314.2	0.902	0.86693	0.035067	1
2344.2	0.902	0.86842	0.033577	1
2374.2	0.902	0.86989	0.032107	1
2404.2	0.917	0.87135	0.045655	1
2434.2	0.91	0.87278	0.03722	1
2464.2	0.917	0.8742	0.042804	1
2494.2	0.917	0.8756	0.041404	1
2524.2	0.917	0.87698	0.040021	1
2554.2	0.924	0.87835	0.045655	1
2584.2	0.924	0.8797	0.044304	1
2614.2	0.91	0.88103	0.028969	1
2644.2	0.931	0.88235	0.048649	1
2674.2	0.924	0.88366	0.040344	1
2704.2	0.91	0.88495	0.025054	1
2734.2	0.917	0.88622	0.030778	1
2764.2	0.917	0.88748	0.029515	1
2794.2	0.917	0.88873	0.028266	1
2824.2	0.917	0.88997	0.027031	1
2854.2	0.917	0.89119	0.025809	1
2884.2	0.91	0.8924	0.017599	1
2914.2	0.91	0.8936	0.016402	1
2944.2	0.902	0.89478	0.0072168	1
2974.2	0.895	0.89596	-0.00095609	1
3004.2	0.874	0.89712	-0.023117	1
3034.2	0.881	0.89827	-0.017267	1

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RESULTS FROM VISUAL CURVE MATCHING

:SUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	7.2303E+000
S	=	5.4170E-003

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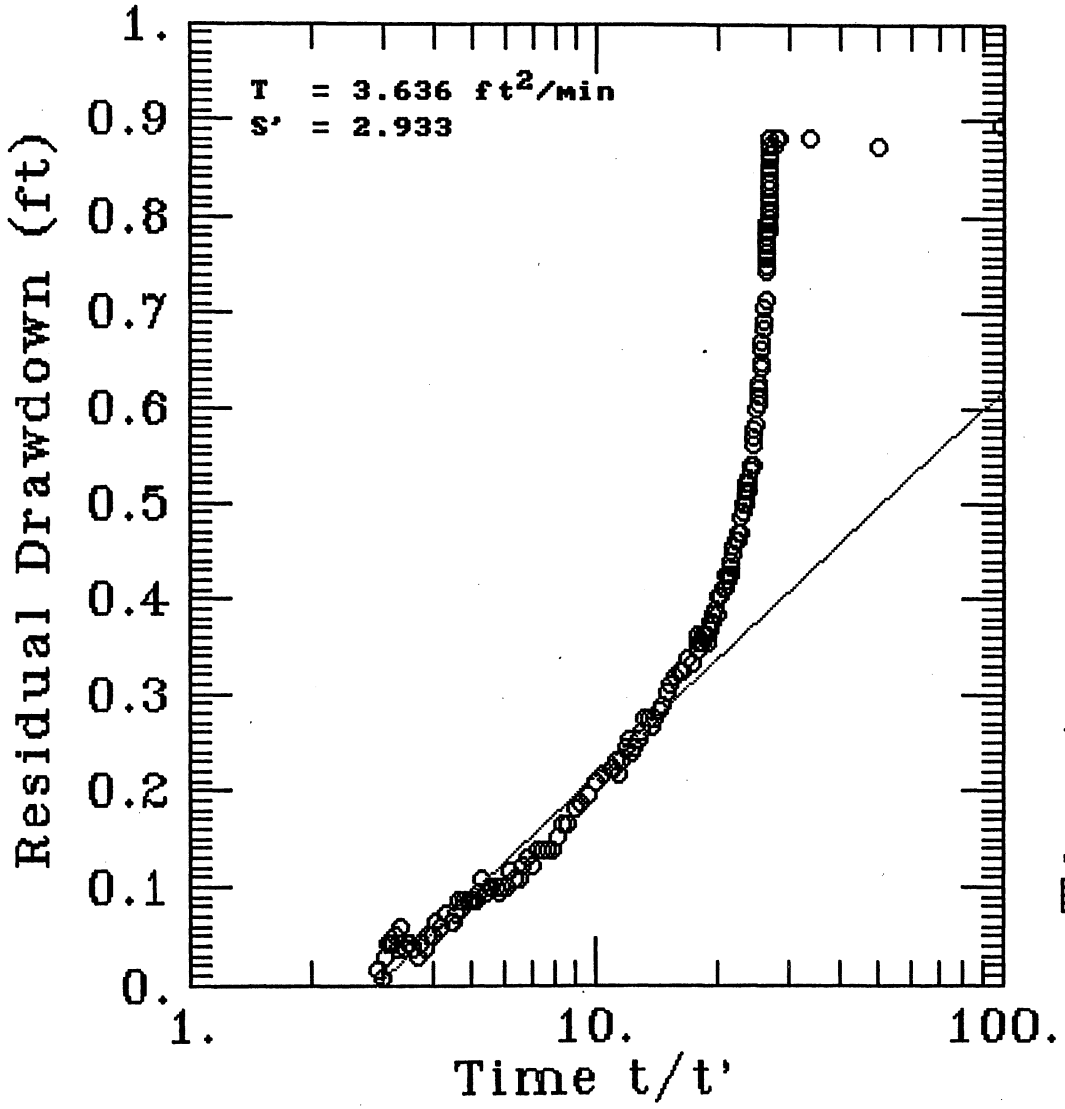
STF, AQUIFER TEST, 6A DATA, 4A RECOVERY



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

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TEST DESCRIPTION

ata set........... b:\6a_t&rec.aqt
ata set title..... STF, AQUIFER TEST, 6A DATA, 4A RECOVERY

nowns and Constants:
  No. of data points.................. 240
  Pumping rate........................ 8.02
  Total pumping time.................. 2944

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ANALYTICAL METHOD

heis Recovery (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.7408E+000	+/-	5.8788E-002
S' =	4.2933E+000	+/-	2.1409E-001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
  Number of residuals............... 240
  Number of estimated parameters.... 2
  Degrees of freedom................ 238
  Residual mean..................... -5.422E-012
  Residual standard deviation....... 0.1335
  Residual variance................. 0.01783

odel Residuals:

Time	Observed	Calculated	Residual	Weight
30	0.895	1.1512	-0.25619	1
60	0.874	0.90071	-0.026707	1
90	0.881	0.75567	0.12533	1
107.3	0.881	0.69329	0.18771	1

109.3	0.881	0.68676	0.19424	1
111.3	0.874	0.68035	0.19365	1
113.3	0.874	0.67406	0.19994	1
114	0.874	0.67188	0.20212	1
114.01	0.881	0.67185	0.20915	1
114.03	0.866	0.67179	0.19421	1
114.05	0.874	0.67173	0.20227	1
114.07	0.866	0.67167	0.19433	1
114.08	0.874	0.67164	0.20236	1
114.1	0.859	0.67157	0.18743	1
114.12	0.859	0.67151	0.18749	1
114.13	0.874	0.67148	0.20252	1
114.15	0.852	0.67142	0.18058	1
114.16	0.852	0.67139	0.18061	1
114.18	0.852	0.67133	0.18067	1
114.2	0.852	0.67127	0.18073	1
114.22	0.845	0.6712	0.1738	1
114.23	0.845	0.67117	0.17383	1
114.25	0.837	0.67111	0.16589	1
114.26	0.837	0.67108	0.16592	1
114.28	0.837	0.67102	0.16598	1
114.3	0.837	0.67096	0.16604	1
114.32	0.837	0.67089	0.16611	1
114.33	0.83	0.67086	0.15914	1
114.35	0.83	0.6708	0.1592	1
114.36	0.83	0.67077	0.15923	1
114.38	0.823	0.67071	0.15229	1
114.4	0.83	0.67065	0.15935	1
114.42	0.83	0.67059	0.15941	1
114.45	0.823	0.67049	0.15251	1
114.47	0.823	0.67043	0.15257	1
114.48	0.823	0.6704	0.1526	1
114.5	0.823	0.67034	0.15266	1
114.51	0.823	0.67031	0.15269	1
114.53	0.823	0.67025	0.15275	1
114.54	0.823	0.67022	0.15278	1
114.55	0.823	0.67019	0.15281	1
114.57	0.816	0.67012	0.14588	1
114.58	0.816	0.67009	0.14591	1
114.6	0.816	0.67003	0.14597	1
114.62	0.816	0.66997	0.14603	1
114.63	0.816	0.66994	0.14606	1
114.65	0.809	0.66988	0.13912	1
114.66	0.809	0.66985	0.13915	1
114.68	0.809	0.66978	0.13922	1
114.7	0.809	0.66972	0.13928	1
114.72	0.809	0.66966	0.13934	1
114.73	0.801	0.66963	0.13137	1
114.75	0.809	0.66957	0.13943	1
114.76	0.801	0.66954	0.13146	1
114.78	0.801	0.66948	0.13152	1
114.8	0.801	0.66942	0.13158	1
114.82	0.801	0.66935	0.13165	1
114.83	0.801	0.66932	0.13168	1
114.85	0.801	0.66926	0.13174	1
114.86	0.794	0.66923	0.12477	1
114.88	0.801	0.66917	0.13183	1
114.9	0.801	0.66911	0.13189	1
114.92	0.794	0.66905	0.12495	1
114.93	0.794	0.66902	0.12498	1

114.95	0.787	0.66895	0.11805	1
114.99	0.794	0.66883	0.12517	1
115	0.794	0.6688	0.1252	1
115.02	0.794	0.66874	0.12526	1
115.08	0.787	0.66856	0.11844	1
115.17	0.78	0.66828	0.11172	1
115.25	0.772	0.66803	0.10397	1
115.33	0.772	0.66779	0.10421	1
115.42	0.765	0.66751	0.097485	1
115.5	0.765	0.66727	0.09773	1
115.58	0.765	0.66703	0.097974	1
115.67	0.758	0.66675	0.091249	1
115.75	0.744	0.66651	0.077492	1
115.83	0.751	0.66626	0.084736	1
115.92	0.751	0.66599	0.08501	1
116	0.751	0.66575	0.085254	1
116.5	0.715	0.66423	0.050771	1
117	0.707	0.66272	0.044281	1
117.5	0.693	0.66121	0.031785	1
118	0.686	0.65972	0.026282	1
118.5	0.671	0.65823	0.012773	1
119	0.664	0.65674	0.0072569	1
119.5	0.65	0.65527	-0.0052655	1
120	0.643	0.65379	-0.010794	1
120.5	0.628	0.65233	-0.024329	1
121	0.621	0.65087	-0.029871	1
121.5	0.614	0.64942	-0.035419	1
122	0.606	0.64797	-0.041973	1
122.5	0.599	0.64653	-0.047533	1
123	0.585	0.6451	-0.060099	1
123.5	0.585	0.64367	-0.058671	1
124	0.578	0.64225	-0.064249	1
124.5	0.57	0.64083	-0.070833	1
125	0.563	0.63942	-0.076424	1
125.5	0.541	0.63802	-0.097019	1
126	0.541	0.63662	-0.095621	1
126.5	0.541	0.63523	-0.094229	1
127	0.541	0.63384	-0.092842	1
127.5	0.534	0.63246	-0.098461	1
128	0.527	0.63109	-0.10409	1
128.5	0.527	0.62972	-0.10272	1
129	0.52	0.62835	-0.10835	1
129.5	0.513	0.62699	-0.11399	1
130	0.513	0.62564	-0.11264	1
130.5	0.52	0.62429	-0.10429	1
131	0.505	0.62295	-0.11795	1
131.5	0.498	0.62161	-0.12361	1
132	0.498	0.62028	-0.12228	1
132.5	0.498	0.61895	-0.12095	1
133	0.491	0.61763	-0.12663	1
133.5	0.491	0.61631	-0.12531	1
134	0.484	0.615	-0.131	1
134.5	0.484	0.6137	-0.1297	1
135	0.469	0.6124	-0.1434	1
136	0.469	0.60981	-0.14081	1
137	0.462	0.60724	-0.14524	1
138	0.462	0.60469	-0.14269	1
139	0.462	0.60217	-0.14017	1
140	0.455	0.59966	-0.14466	1
141	0.448	0.59716	-0.14916	1

142	0.44	0.59469	0.15469	1
143	0.433	0.59224	-0.15924	1
144	0.426	0.5898	-0.1638	1
145	0.426	0.58738	-0.16138	1
146	0.419	0.58498	-0.16598	1
147	0.426	0.5826	-0.1566	1
148	0.412	0.58023	-0.16823	1
149	0.412	0.57788	-0.16588	1
150	0.412	0.57554	-0.16354	1
151	0.404	0.57323	-0.16923	1
152	0.404	0.57092	-0.16692	1
153	0.404	0.56864	-0.16464	1
154	0.404	0.56637	-0.16237	1
155	0.383	0.56411	-0.18111	1
156	0.39	0.56187	-0.17187	1
157	0.39	0.55965	-0.16965	1
158	0.383	0.55744	-0.17444	1
159	0.383	0.55524	-0.17224	1
160	0.375	0.55306	-0.17806	1
161	0.368	0.5509	-0.1829	1
162	0.375	0.54874	-0.17374	1
163	0.354	0.54661	-0.19261	1
164	0.361	0.54448	-0.18348	1
165	0.361	0.54237	-0.18137	1
166	0.361	0.54027	-0.17927	1
167	0.361	0.53819	-0.17719	1
168	0.361	0.53612	-0.17512	1
169	0.361	0.53406	-0.17306	1
170	0.354	0.53201	-0.17801	1
171	0.354	0.52998	-0.17598	1
172	0.354	0.52796	-0.17396	1
173	0.361	0.52595	-0.16495	1
174	0.354	0.52395	-0.16995	1
175	0.347	0.52197	-0.17497	1
180	0.332	0.51223	-0.18023	1
185	0.339	0.50277	-0.16377	1
190	0.325	0.49358	-0.16858	1
195	0.325	0.48463	-0.15963	1
200	0.318	0.47593	-0.15793	1
205	0.31	0.46746	-0.15746	1
210	0.303	0.45921	-0.15621	1
215	0.289	0.45116	-0.16216	1
220	0.282	0.44331	-0.16131	1
225	0.274	0.43565	-0.16165	1
230	0.267	0.42817	-0.16117	1
235	0.274	0.42086	-0.14686	1
240	0.274	0.41372	-0.13972	1
245	0.26	0.40673	-0.14673	1
250	0.253	0.3999	-0.1469	1
255	0.245	0.39321	-0.14821	1
260	0.238	0.38666	-0.14866	1
265	0.253	0.38025	-0.12725	1
270	0.245	0.37397	-0.12897	1
275	0.231	0.36781	-0.13681	1
280	0.217	0.36177	-0.14477	1
285	0.231	0.35585	-0.12485	1
290	0.224	0.35004	-0.12604	1
295	0.224	0.34434	-0.12034	1
310	0.217	0.32784	-0.11084	1
325	0.209	0.3122	-0.1032	1

340	0.195	0.29734	-0.10234	1
355	0.188	0.28318	-0.095178	1
370	0.181	0.26967	-0.088666	1
385	0.166	0.25675	-0.09075	1
400	0.166	0.24438	-0.078383	1
415	0.152	0.23253	-0.080525	1
430	0.137	0.22114	-0.08414	1
445	0.137	0.21019	-0.073193	1
460	0.137	0.19966	-0.062656	1
475	0.137	0.1895	-0.052502	1
490	0.123	0.17971	-0.056707	1
505	0.13	0.17025	-0.040248	1
520	0.123	0.16111	-0.038106	1
535	0.108	0.15226	-0.044263	1
550	0.108	0.1437	-0.035701	1
565	0.116	0.13541	-0.019406	1
580	0.101	0.12736	-0.026362	1
595	0.101	0.11956	-0.018557	1
610	0.094	0.11198	-0.017978	1
625	0.101	0.10461	-0.0036144	1
640	0.101	0.097456	0.0035442	1
655	0.101	0.090492	0.010508	1
670	0.094	0.083715	0.010285	1
685	0.108	0.077115	0.030885	1
700	0.094	0.070684	0.023316	1
715	0.087	0.064416	0.022584	1
730	0.087	0.058303	0.028697	1
745	0.087	0.052339	0.034661	1
760	0.087	0.046517	0.040483	1
775	0.087	0.040832	0.046168	1
790	0.079	0.035279	0.043721	1
805	0.087	0.029852	0.057148	1
820	0.072	0.024546	0.047454	1
835	0.065	0.019358	0.045642	1
865	0.065	0.0093139	0.055686	1
895	0.072	-0.00031126	0.072311	1
925	0.058	-0.0095466	0.067547	1
955	0.065	-0.018418	0.083418	1
985	0.051	-0.026949	0.077949	1
1015	0.051	-0.035161	0.086161	1
1045	0.036	-0.043074	0.079074	1
1075	0.043	-0.050706	0.093706	1
1105	0.029	-0.058072	0.087072	1
1135	0.036	-0.065187	0.10119	1
1165	0.043	-0.072067	0.11507	1
1195	0.043	-0.078722	0.12172	1
1225	0.036	-0.085166	0.12117	1
1255	0.058	-0.091409	0.14941	1
1285	0.036	-0.09746	0.13346	1
1315	0.051	-0.10333	0.15433	1
1345	0.043	-0.10903	0.15203	1
1375	0.043	-0.11456	0.15756	1
1405	0.043	-0.11994	0.16294	1
1435	0.029	-0.12516	0.15416	1
1465	0.007	-0.13025	0.13725	1
1525	0.014	-0.14001	0.15401	1

==========

RESULTS FROM VISUAL CURVE MATCHING

SUAL MATCH PARAMETER ESTIMATES

```
         Estimate
    =    3.6362E+000
 S' =    2.9328E+000
```

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

STF - AQUIFER TEST
NMW-4A PUMPED, CBS-6A OBS (DATA)
JACOB STRAIGHT LINE METHOD

12 March 92
K/J 916055.09
6a_t&dd.mcd

Transmissivity

$$T := \frac{2.30}{\left[4 \cdot p \cdot \left[\frac{s_2 - s_1}{Q}\right]\right]}$$

Storage coefficient

$$S := \frac{\left[\frac{2.25 \cdot T \cdot t_2}{r^2}\right]}{10^{\left[\frac{\frac{s_2}{Q}}{\frac{s_2 - s_1}{Q}}\right]}}$$

flowrate $Q := 60 \cdot \frac{gal}{min}$

radius $r := 21.81 \cdot ft$

time $t_1 := 10 \cdot min$ $t_2 := 100 \cdot min$

drawdown $s_1 := 0.36 \cdot ft$ $s_2 := 0.58 \cdot ft$

$$T := \frac{2.30}{\left[4 \cdot p \cdot \left[\frac{s_2 - s_1}{Q}\right]\right]}$$

$$S := \frac{\left[\frac{2.25 \cdot T \cdot t_2}{r^2}\right]}{10^{\left[\frac{\frac{s_2}{Q}}{\frac{s_2 - s_1}{Q}}\right]}}$$

$T = 6.67 \frac{ft^2}{min}$ <------ **Transmissivity**

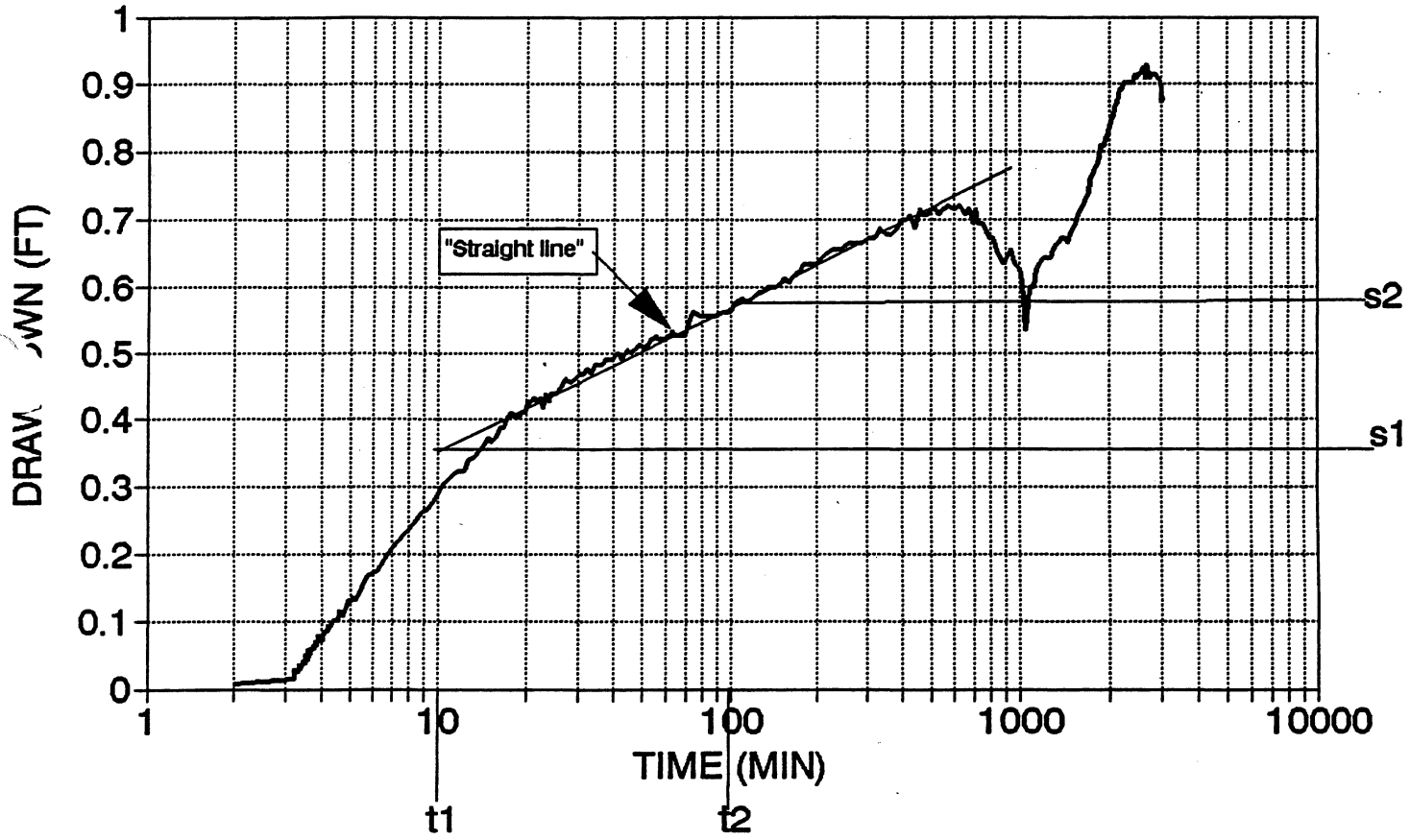
$T = 71880.16 \frac{gal}{(ft \cdot day)}$

$S = 0.007$ <------ **Storage coefficient**

NOTE: see attached graph for semi-log plot of data and straight line.

STF-AQUIFER TEST

NMW-4A PUMPED, CBS-6A OBSERVATION(DATA)



STF - AQUIFER TEST
NMW-4A PUMPED, CBS-6A OBS (DATA)
THEIS METHOD

12 March 92
K/J 916055.09
6a_THES.MCD

DEVELOP STANDARD THEIS CURVE

$i := 0 .. 9$

$u_i := \frac{1}{10^i}$

$$w_i := -0.577216 - \ln\left[u_i\right] + u_i - \frac{\left[u_i\right]^2}{4} + \frac{\left[u_i\right]^3}{18} - \frac{\left[u_i\right]^4}{96} + \frac{\left[u_i\right]^5}{600} - \frac{\left[u_i\right]^6}{4320} + \frac{\left[u_i\right]^7}{35280} - \frac{\left[u_i\right]^8}{32256}$$

PLOT FIELD DATA SET IN THEIS FORM

$Q := 60 \cdot \frac{gal}{min}$ test pumping rate

$r := 21.81 \cdot ft$ radius between pumping and observation well

$t\_s := READPRN(data\_6a)$ read time-drawdown data file

$t := t\_s^{<0>} \cdot min$ time data

$s := t\_s^{<1>} \cdot ft$ drawdown data

$N := length(t)$

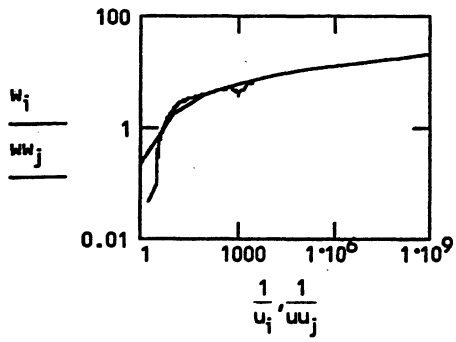
$N = 289$ number of observations, N

$j := 0 .. N - 1$

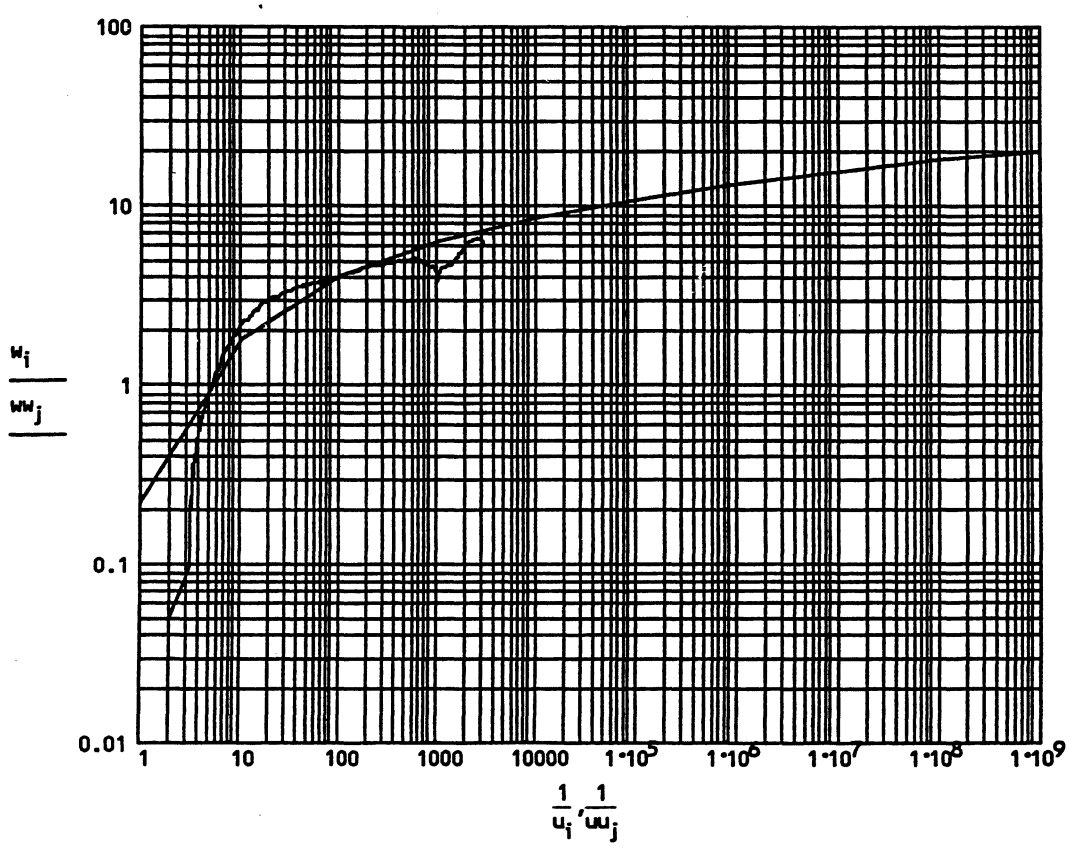
Estimates of Transmissivity, T, and Storage Coefficient, S

$$T := 4.5 \cdot \frac{ft^2}{min} \qquad S := 0.04$$

$$ww_j := \frac{\left[T \cdot 4 \cdot p \cdot s_j\right]}{Q} \qquad uu_j := \frac{\left[r^2 \cdot S\right]}{\left[4 \cdot T \cdot t_j\right]}$$



ENLARGED PLOT OF DATA AND STANDARD THEIS CURVES

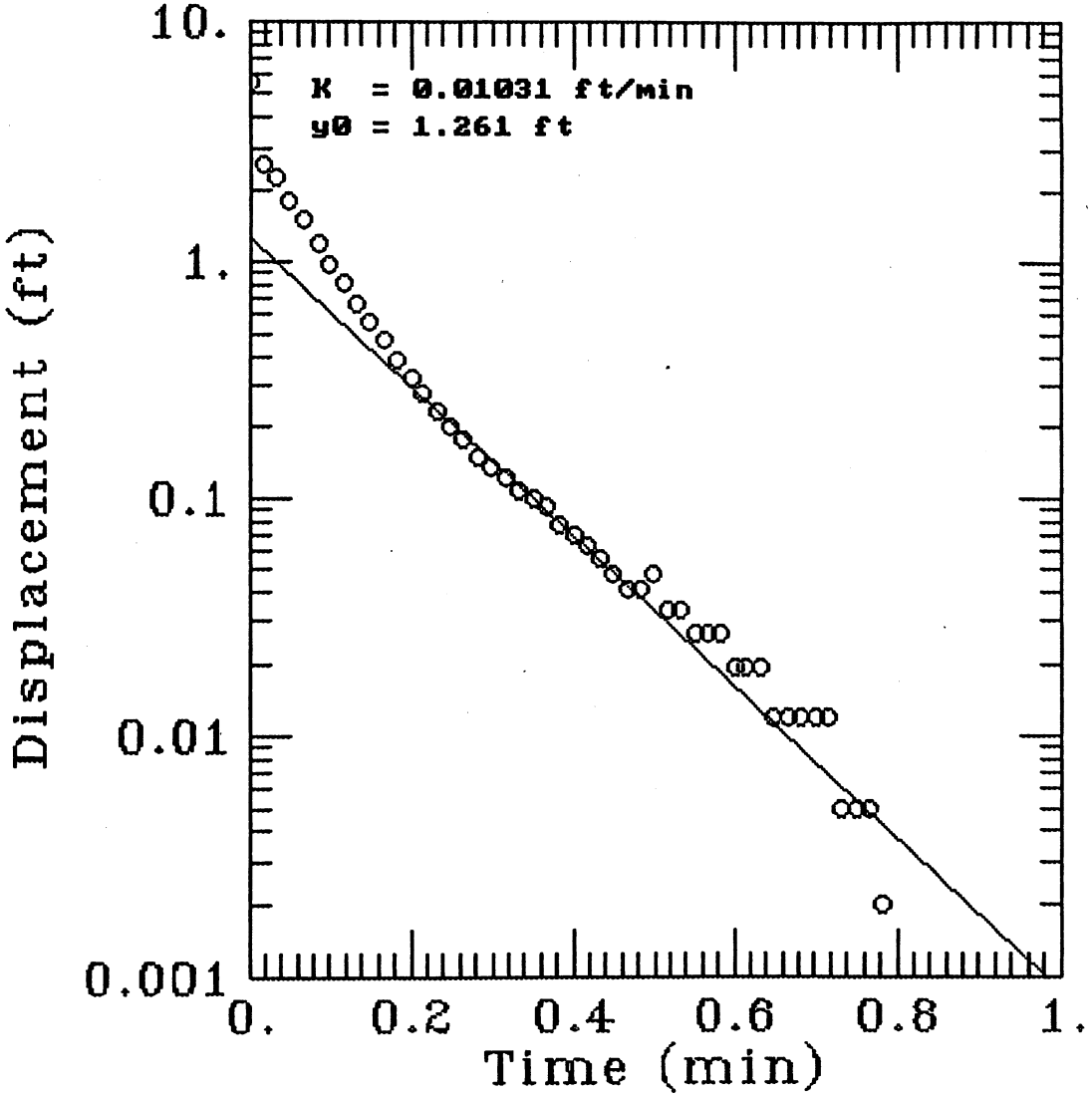


$$T = 4.5 \frac{ft^2}{min} \qquad T = 4.847 \cdot 10^4 \frac{gal}{(ft \cdot day)} \qquad S = 0.04$$

Appendix HC-E

Slug Test Data Analysis

WELL NMW-1A

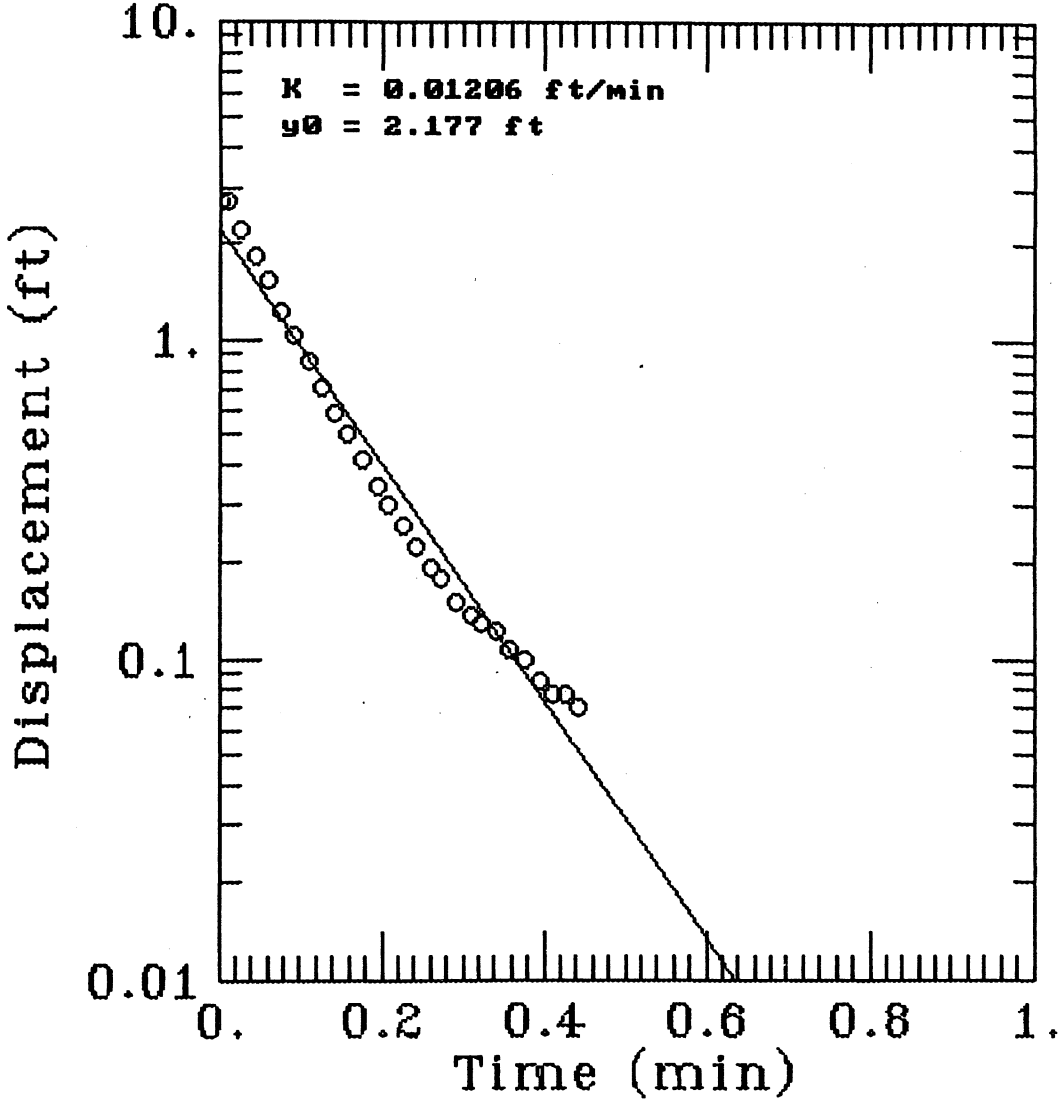


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL NMW-1A

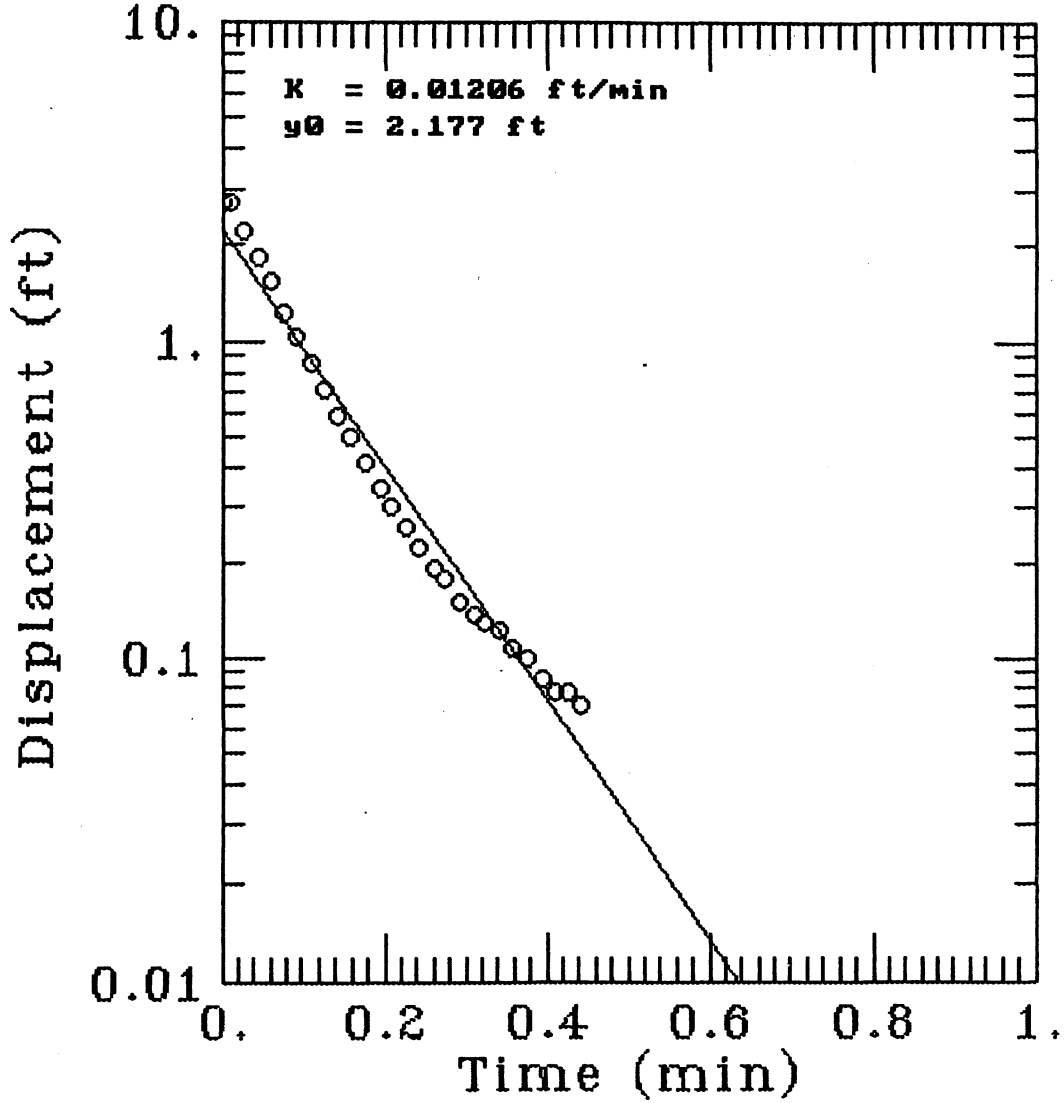


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL NMW-1A

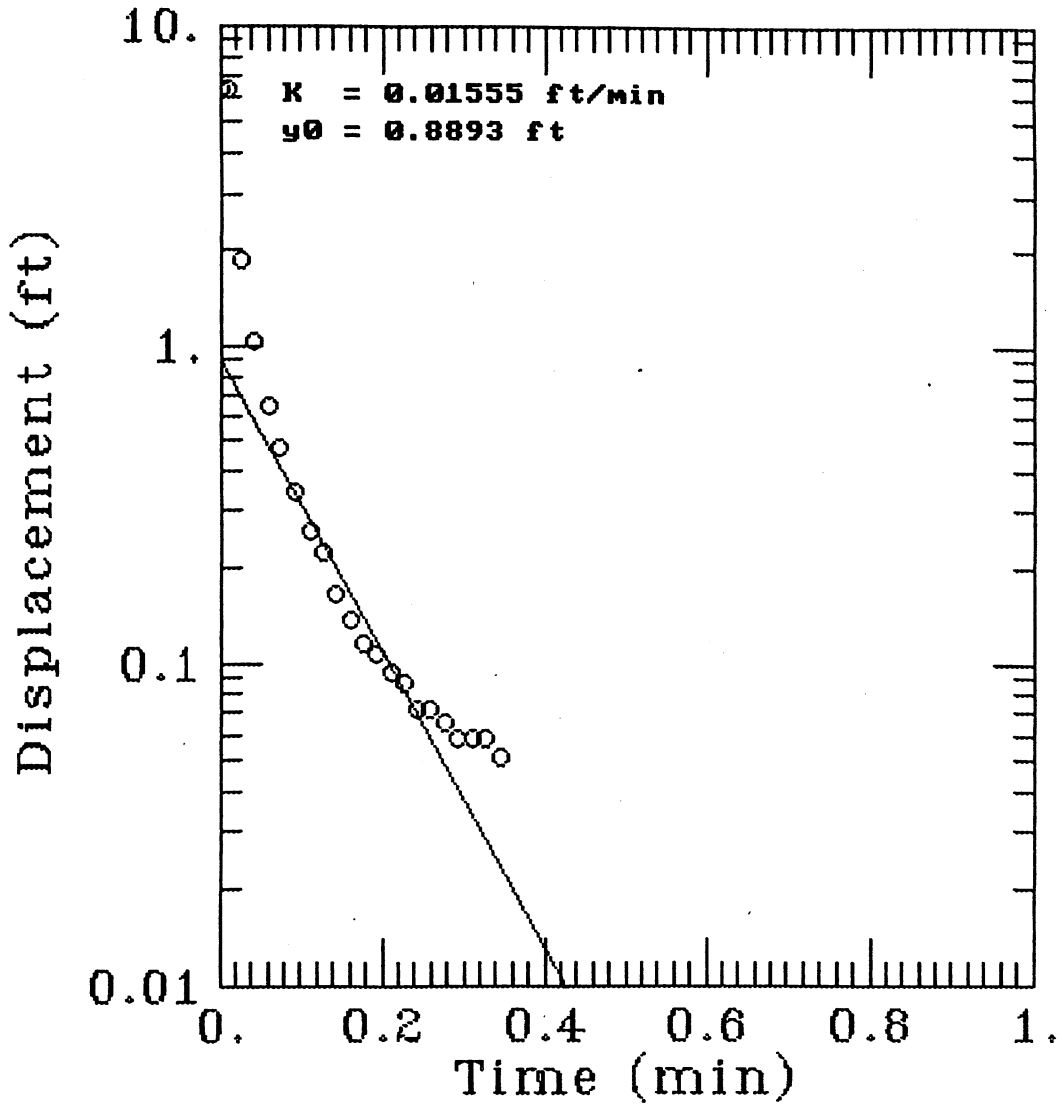


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL NMW-2A

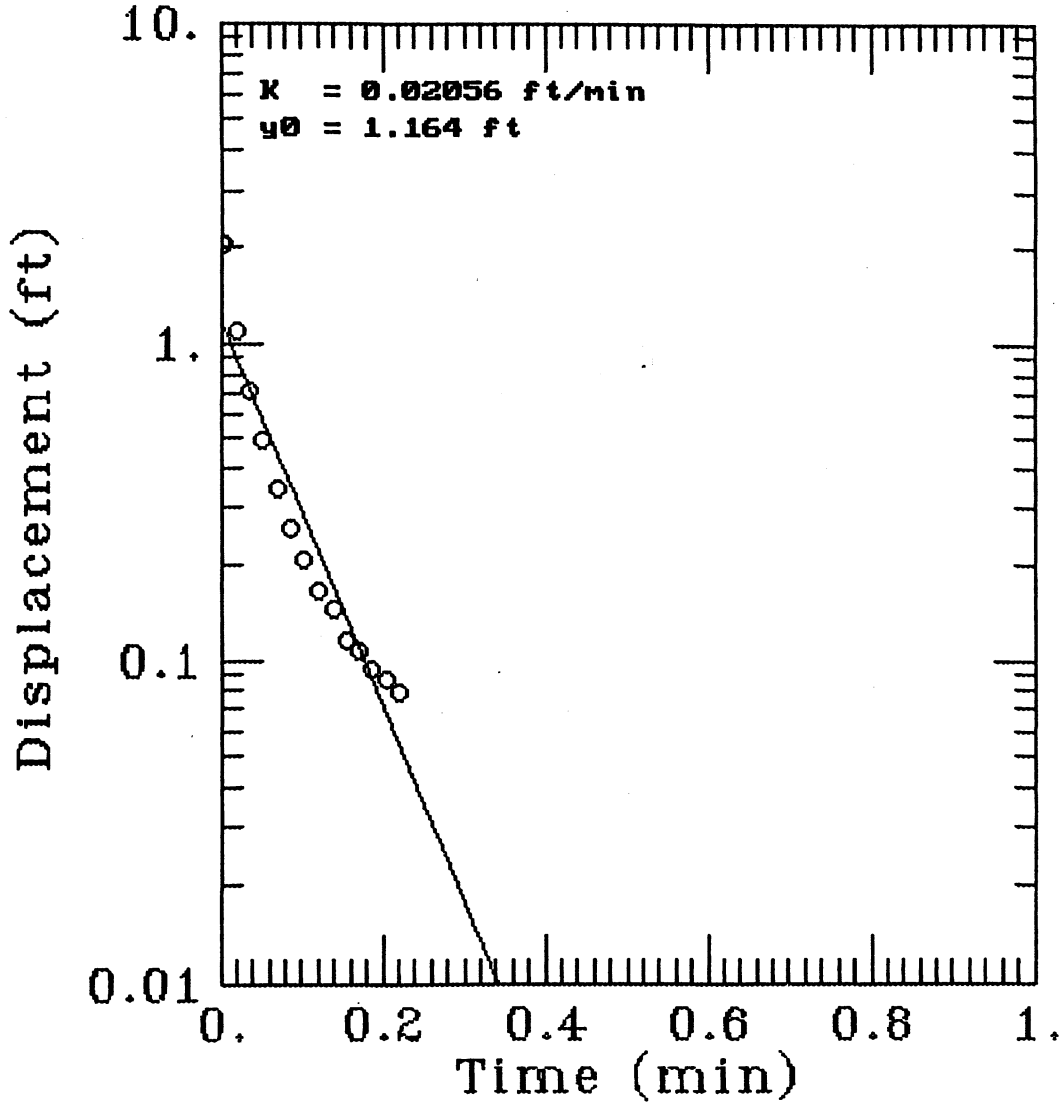


AQTESOLV

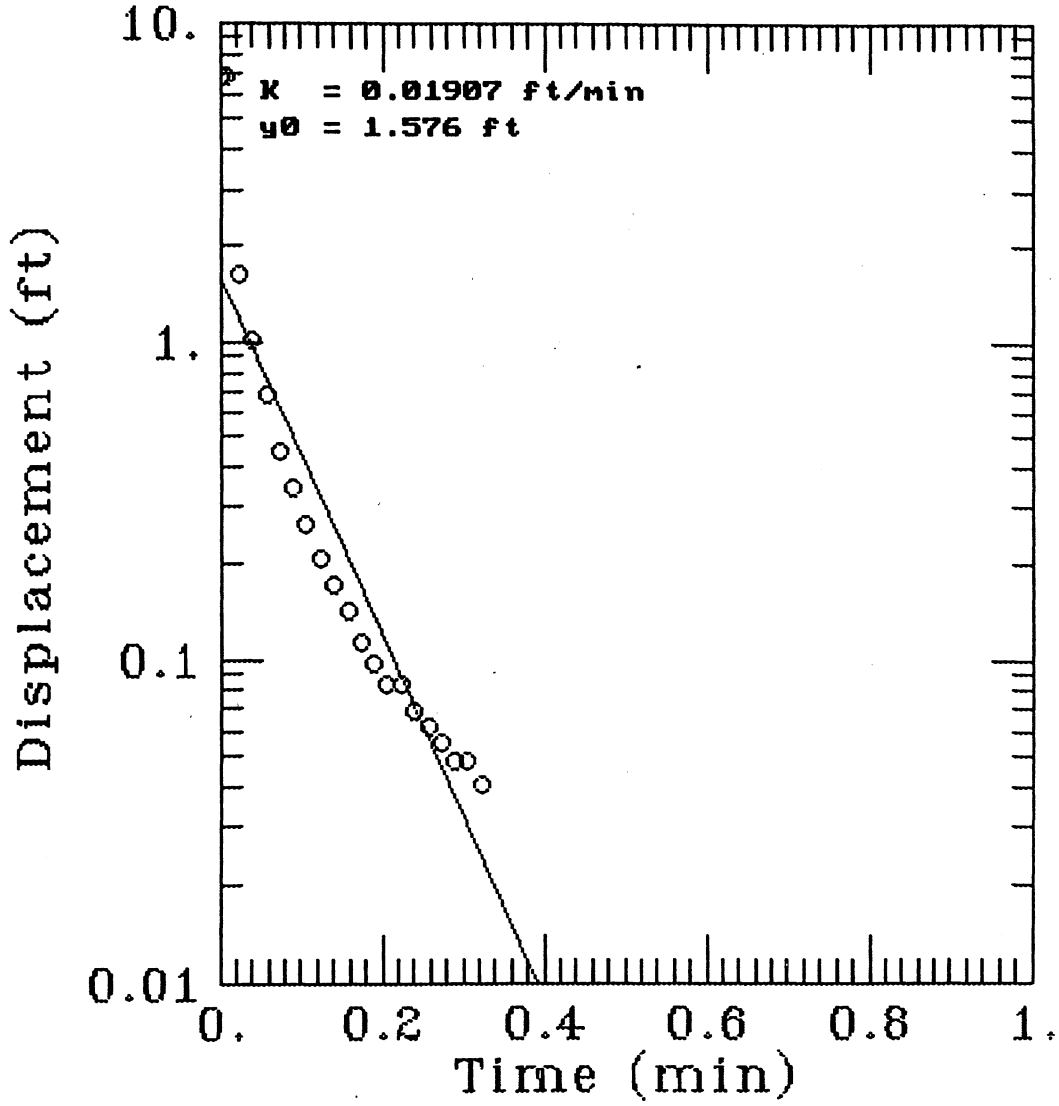
GERAGHTY & MILLER, INC.

Modeling Group

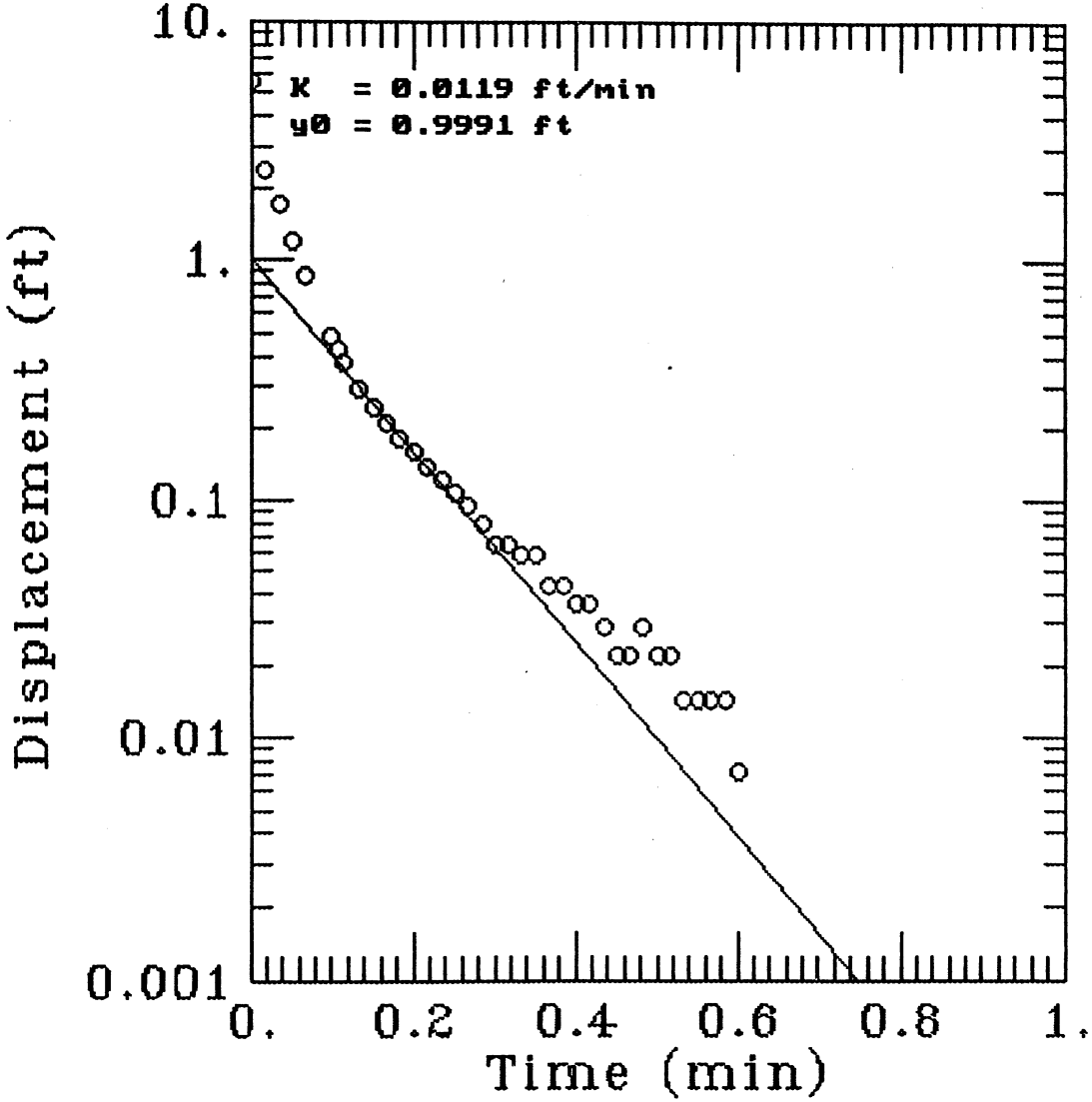
WELL NMW-2A


K = 0.02056 ft/min
y0 = 1.164 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

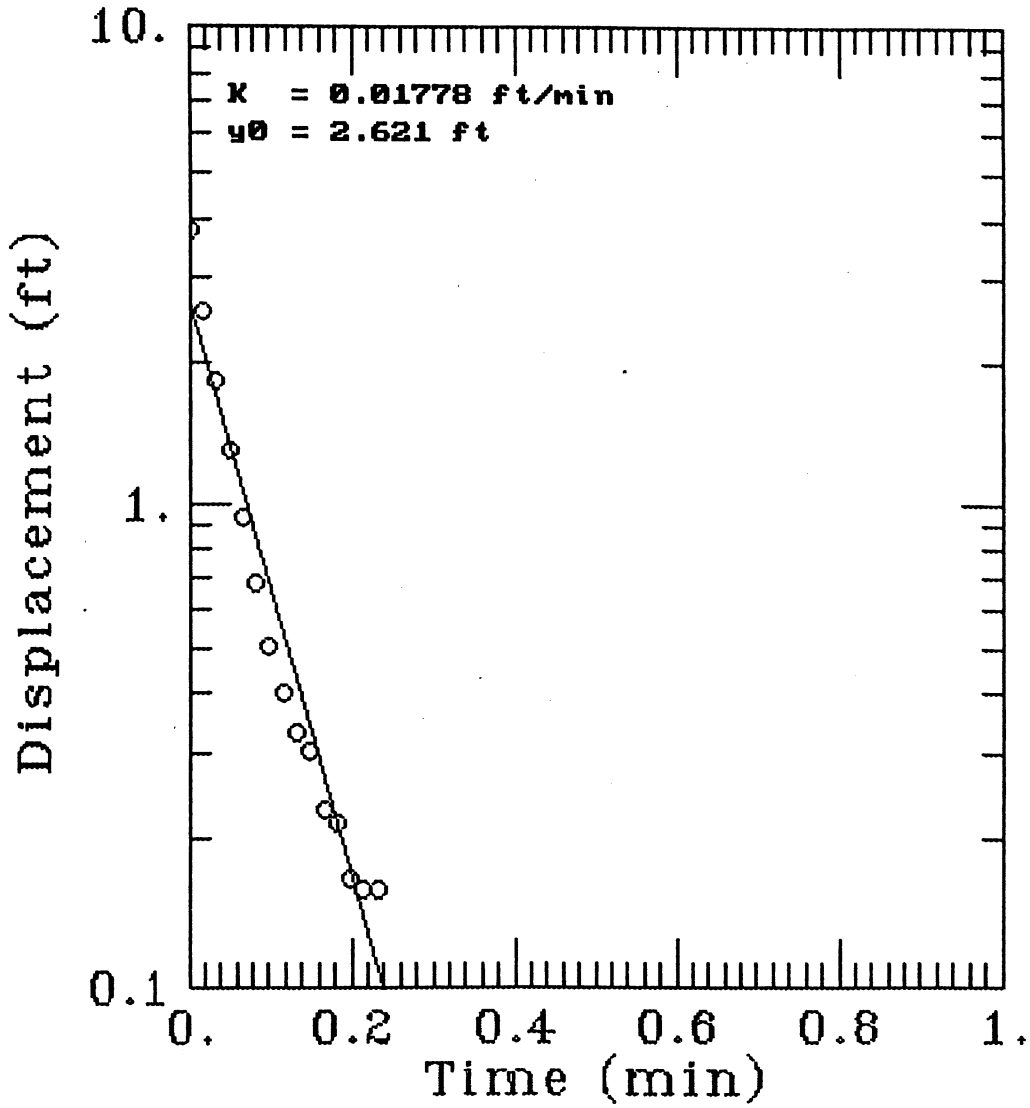
WELL NMW-2A


K = 0.01907 ft/min
y0 = 1.576 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

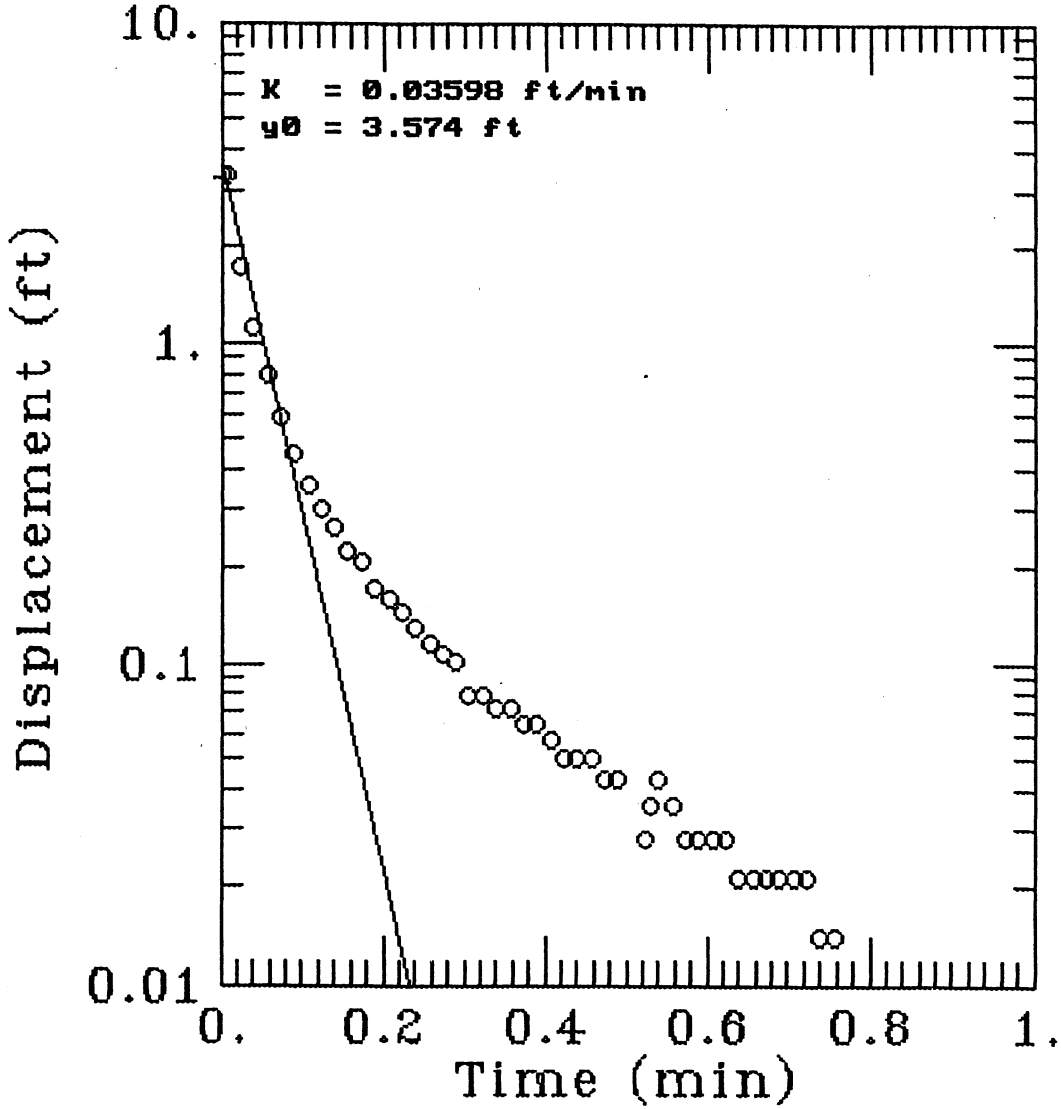
WELL NMW-3A


K = 0.0119 ft/min
y0 = 0.9991 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

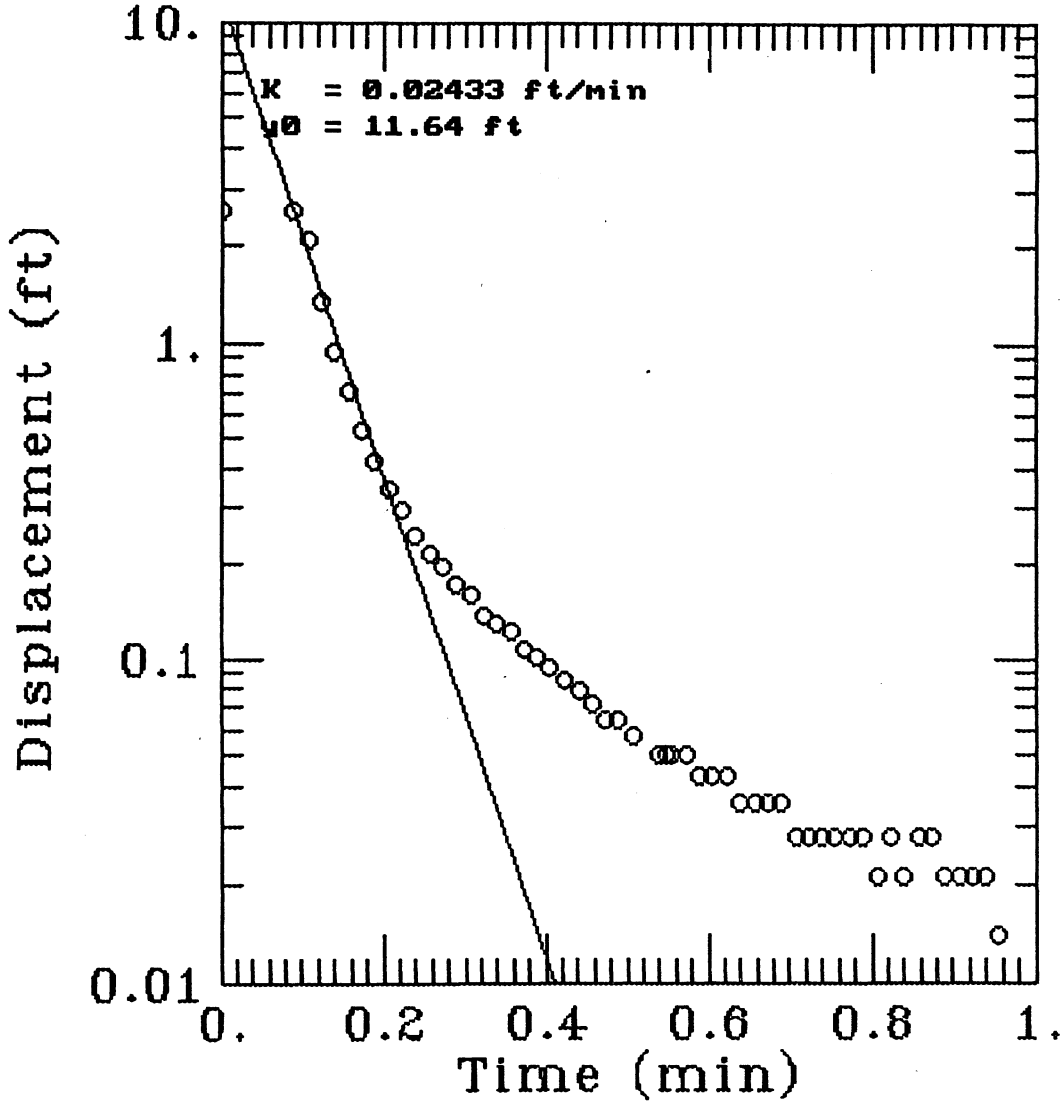
WELL NMW-3A


K = 0.01778 ft/min
y0 = 2.621 ft
10.
1.
0.1
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

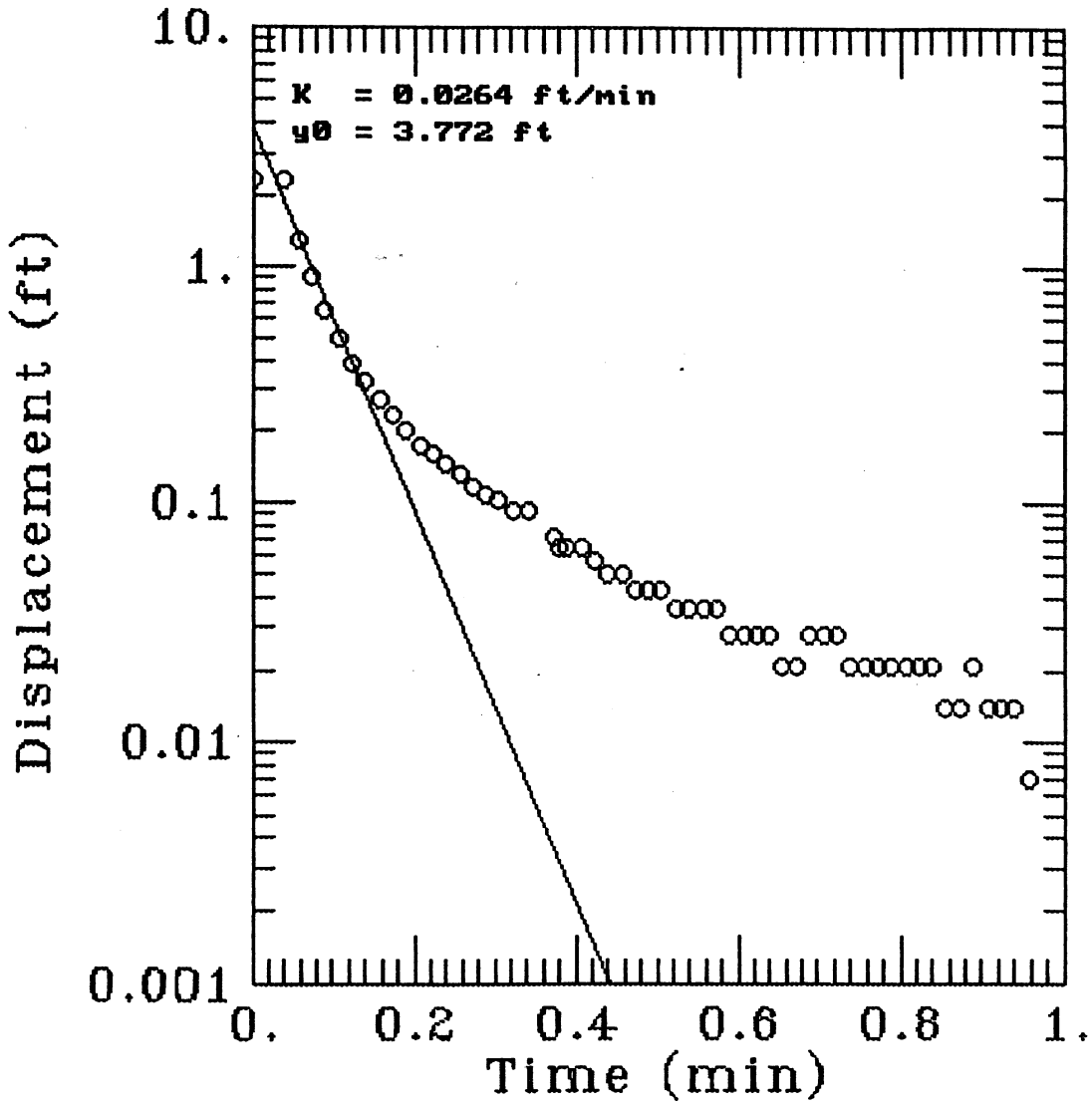
WELL NMW-4A


K = 0.03598 ft/min
y0 = 3.574 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

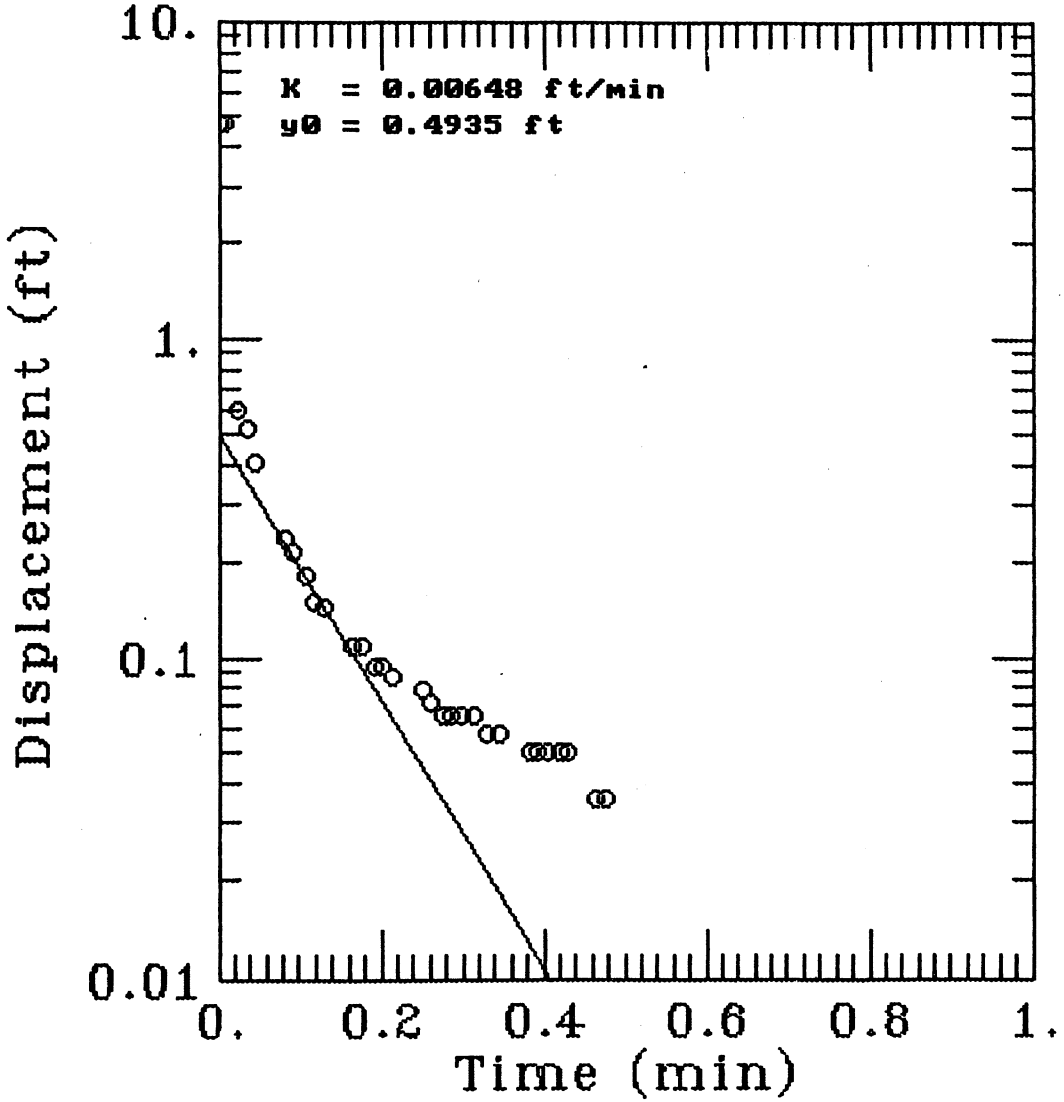
WELL NMW-4A


K = 0.02433 ft/min
y0 = 11.64 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

WELL NMW-4A


K = 0.0264 ft/min
y0 = 3.772 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

WELL MW-5A



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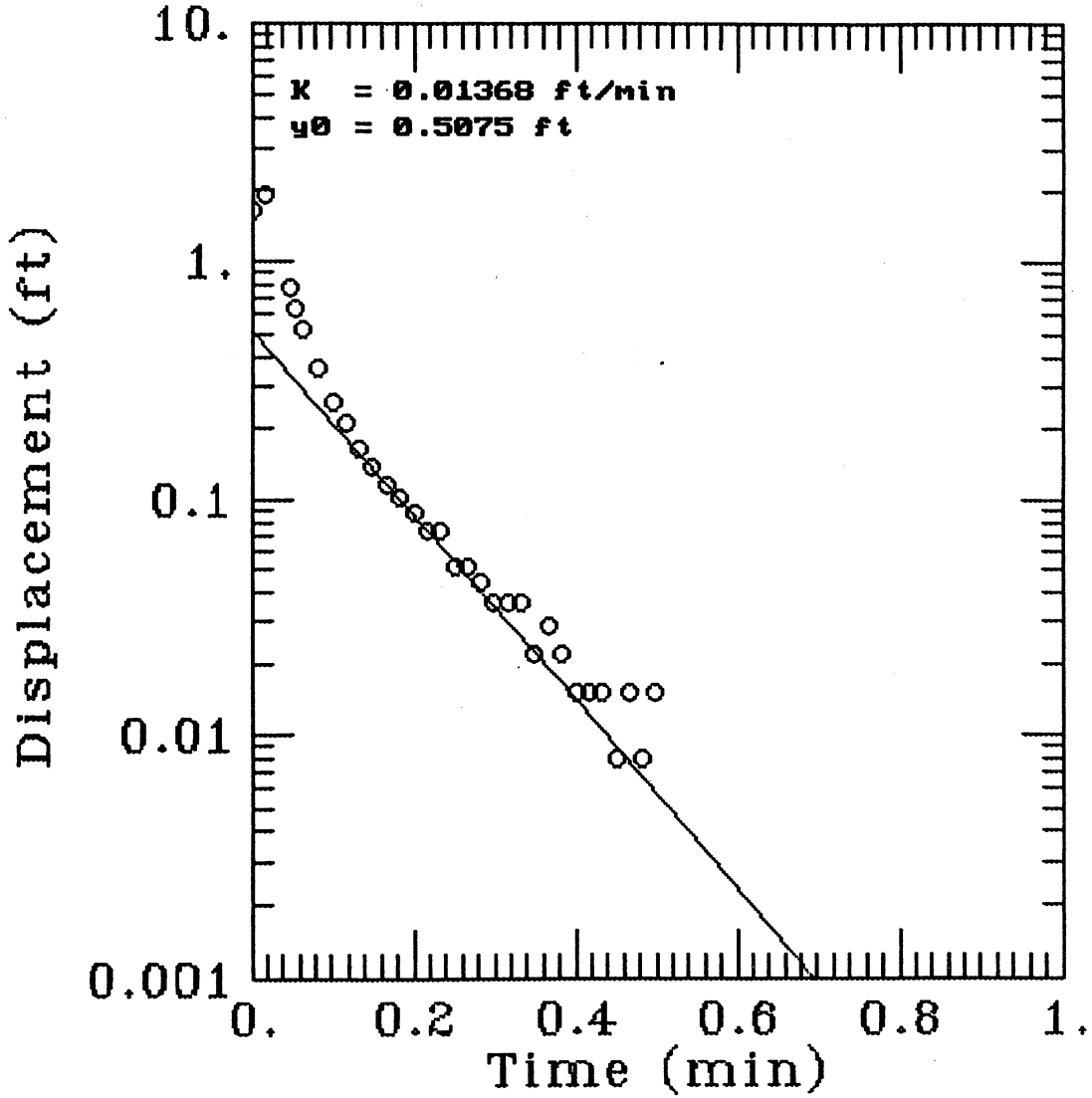
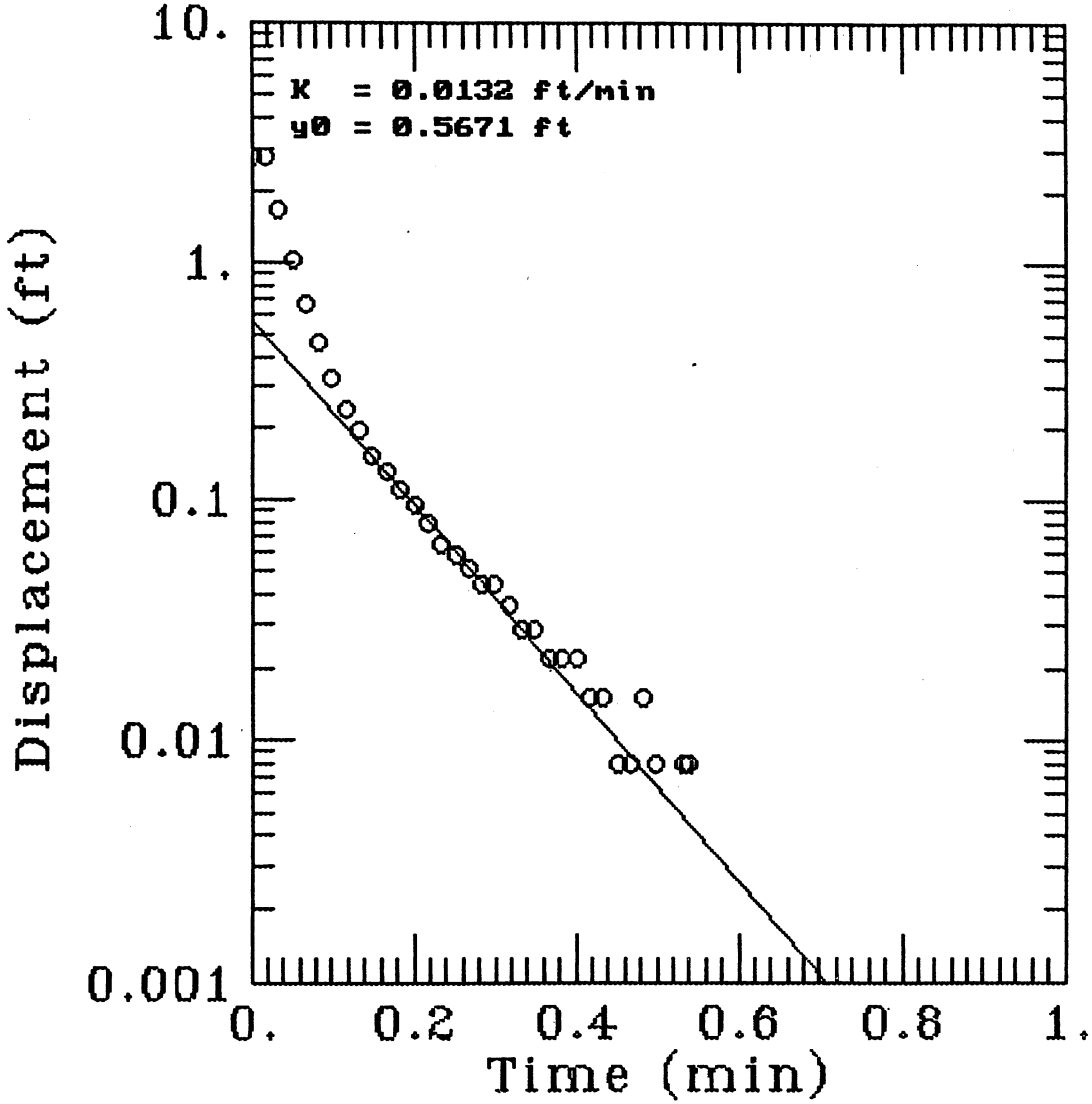
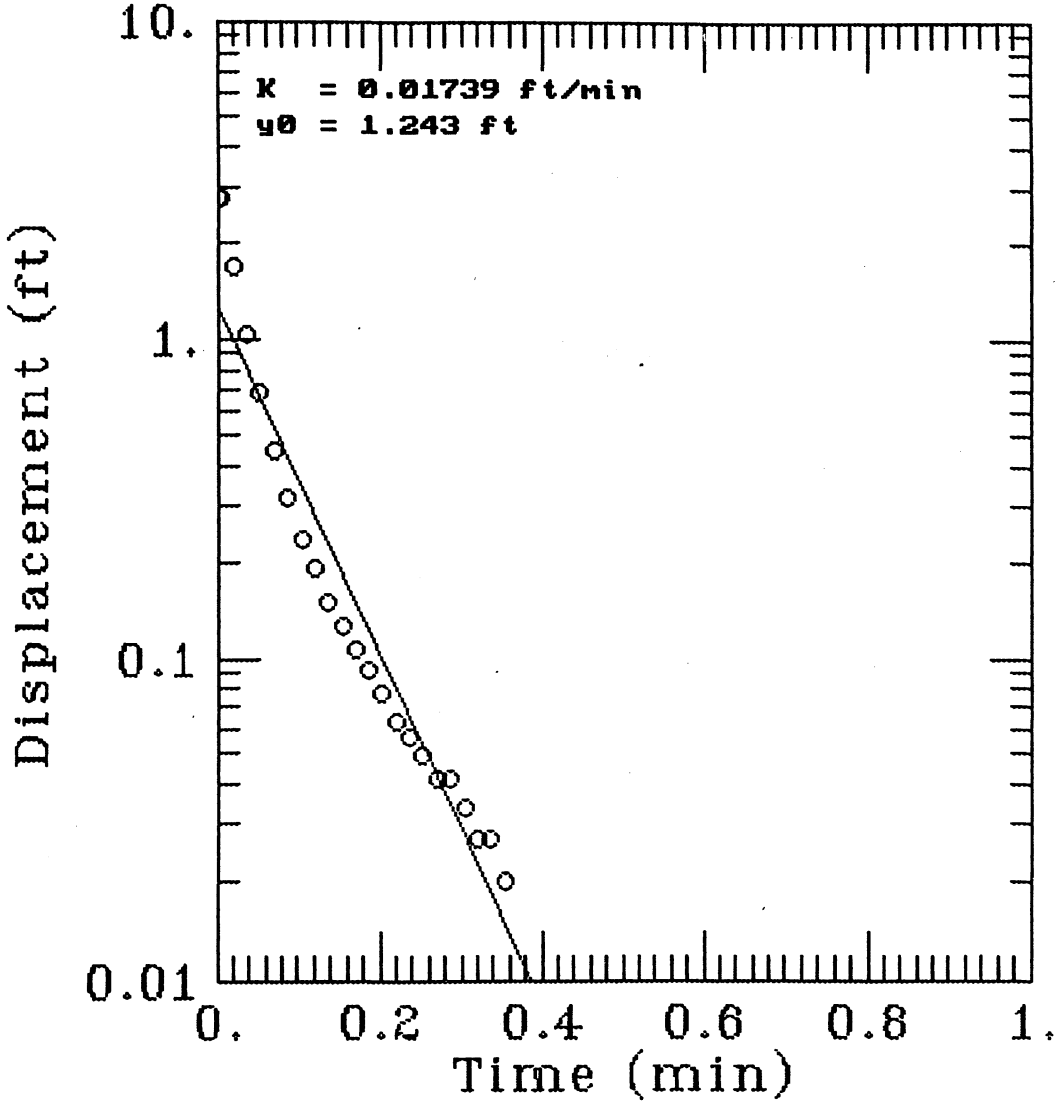
WELL NMW-5A


K = 0.01368 ft/min
y0 = 0.5075 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

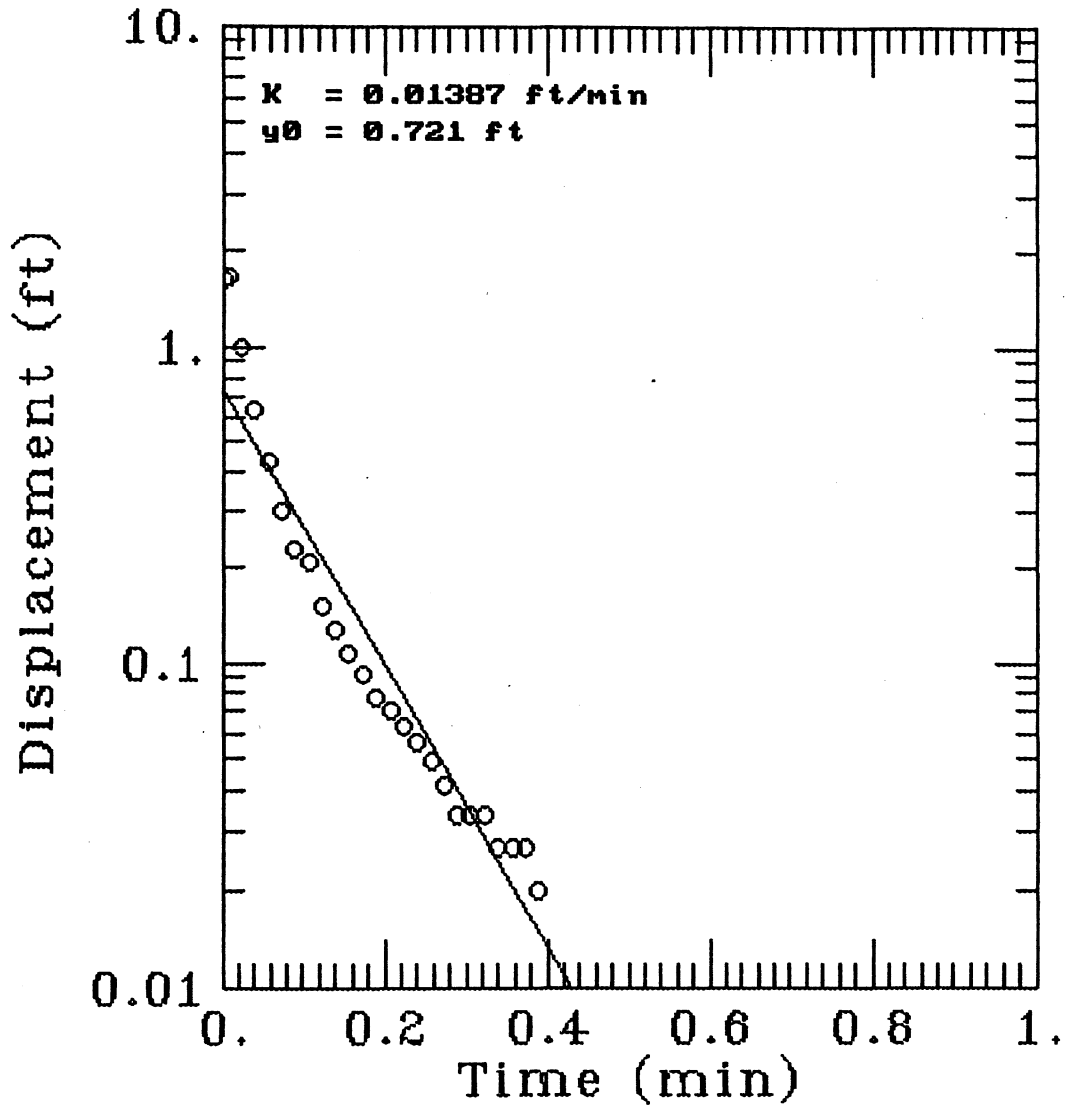
WELL NMW-5A


K = 0.0132 ft/min
y0 = 0.5671 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

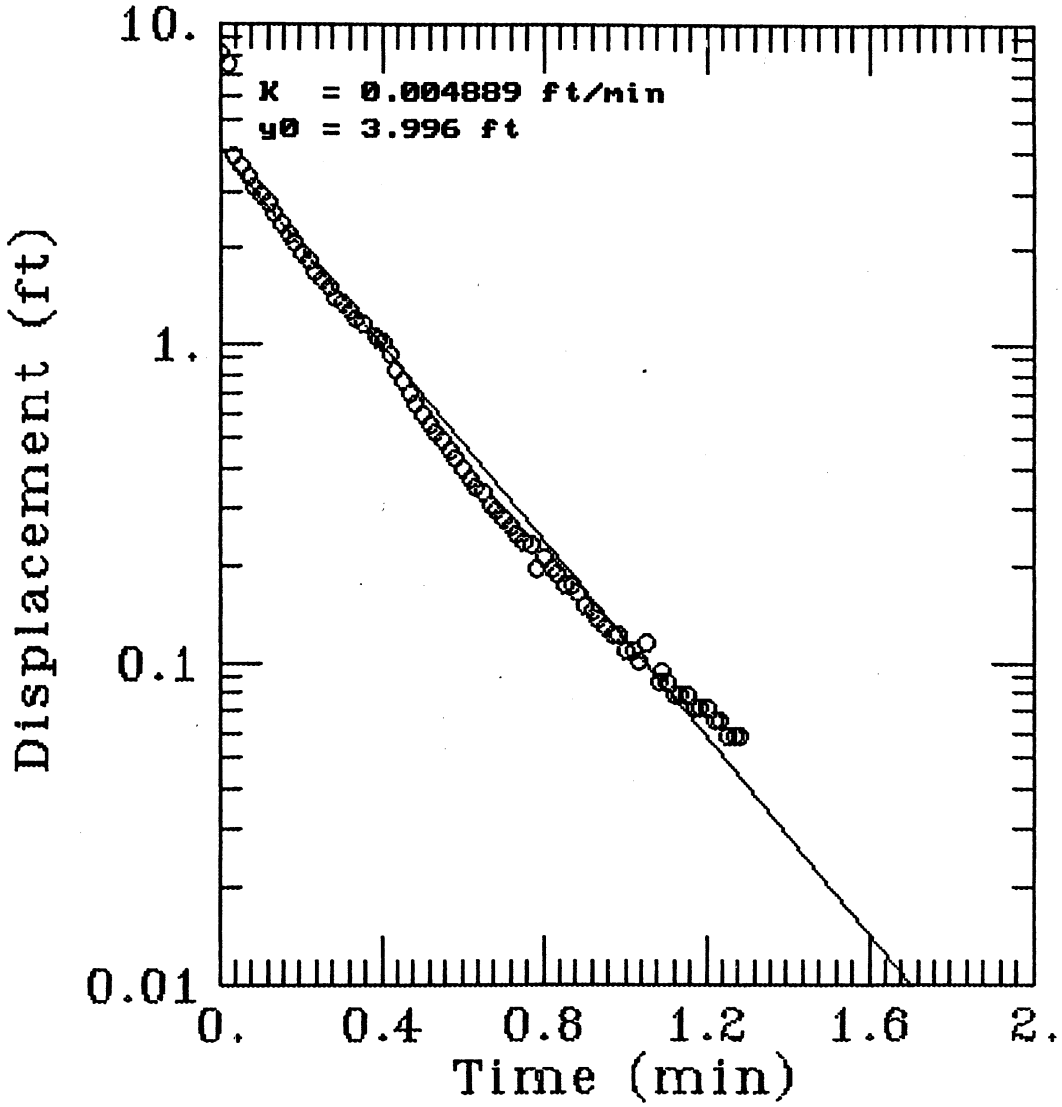
WELL NMW-6A


K = 0.01739 ft/min
y0 = 1.243 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

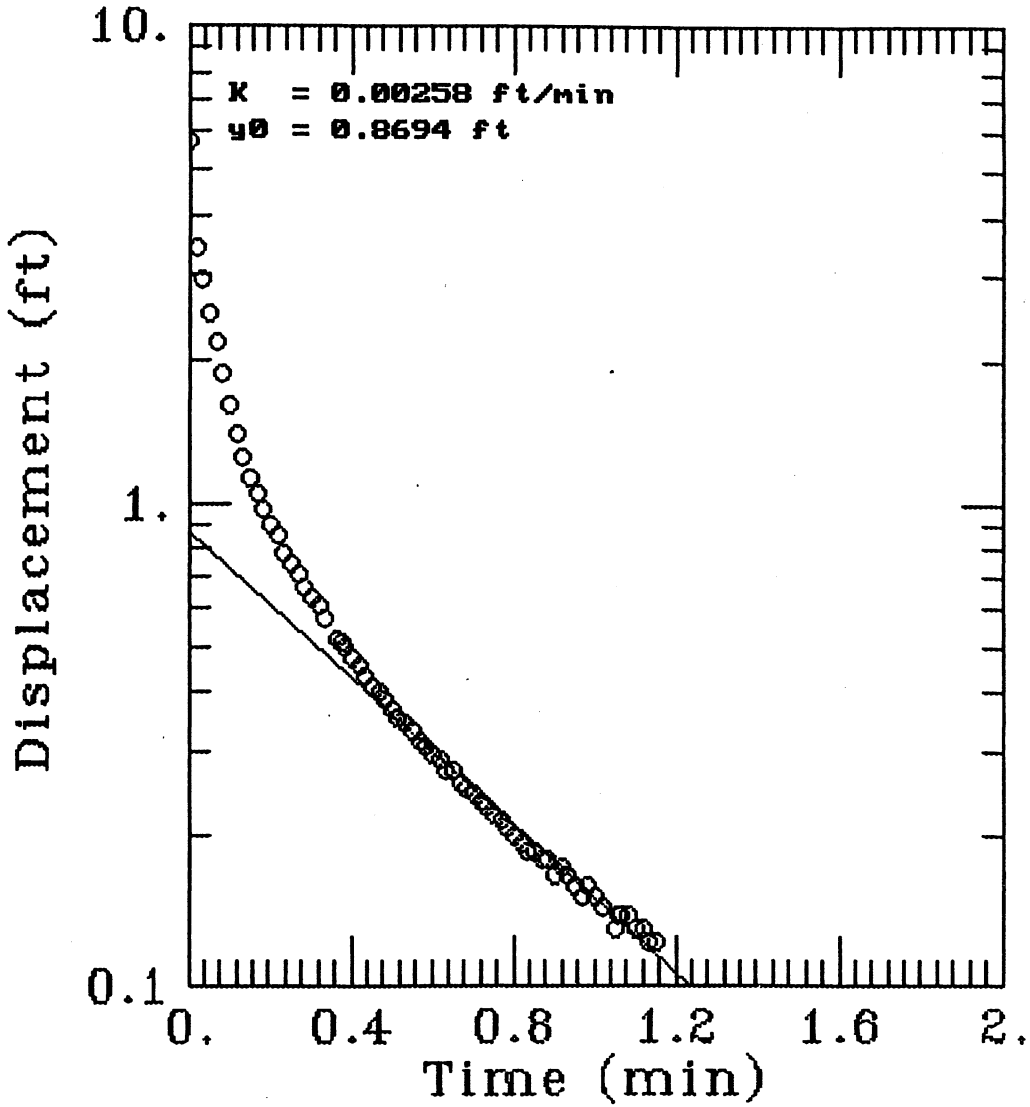
WELL NMW-6A


K = 0.01387 ft/min
y0 = 0.721 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

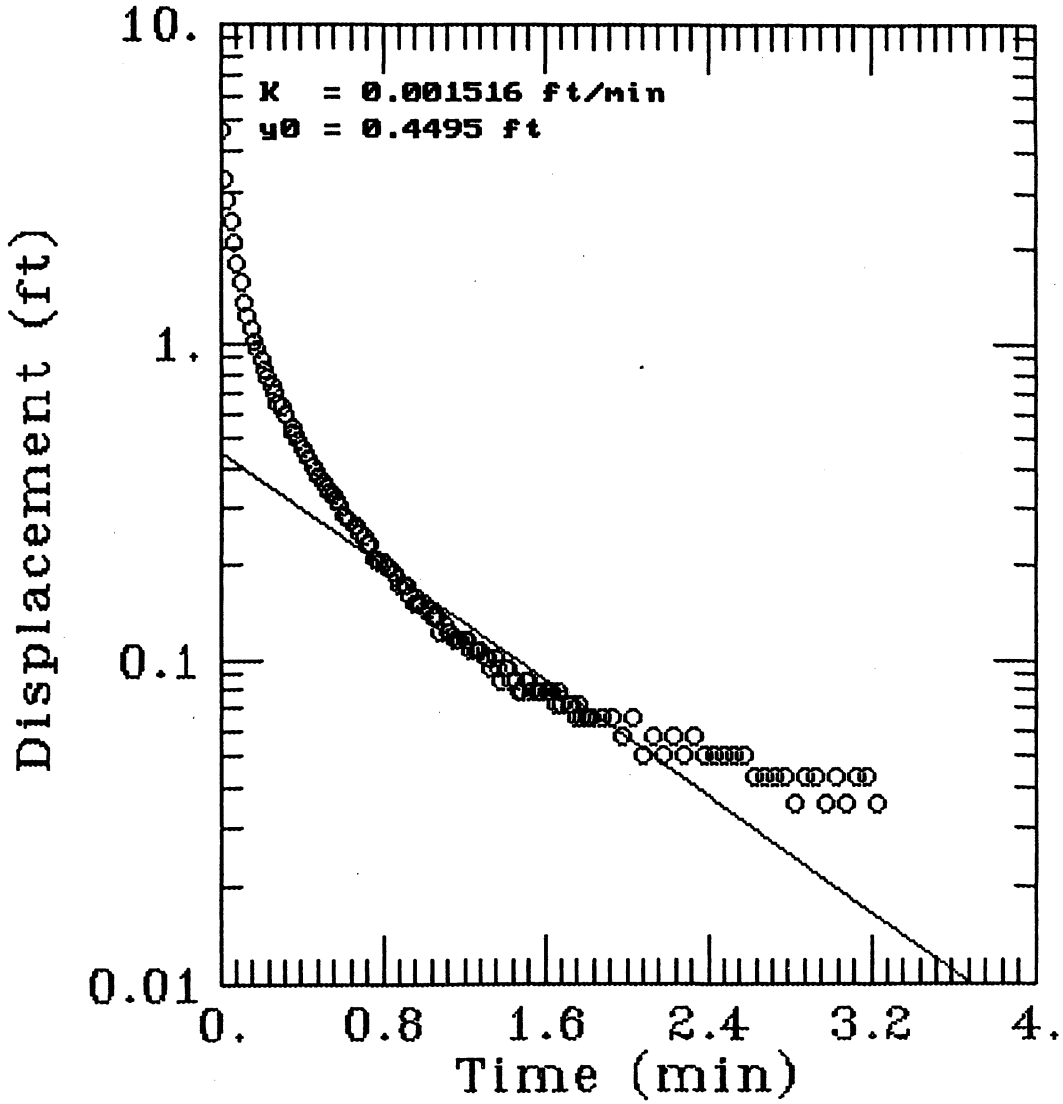
WELL NMW-6A


K = 0.004889 ft/min
y0 = 3.996 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.4
0.8
1.2
1.6
2.
Time (min)

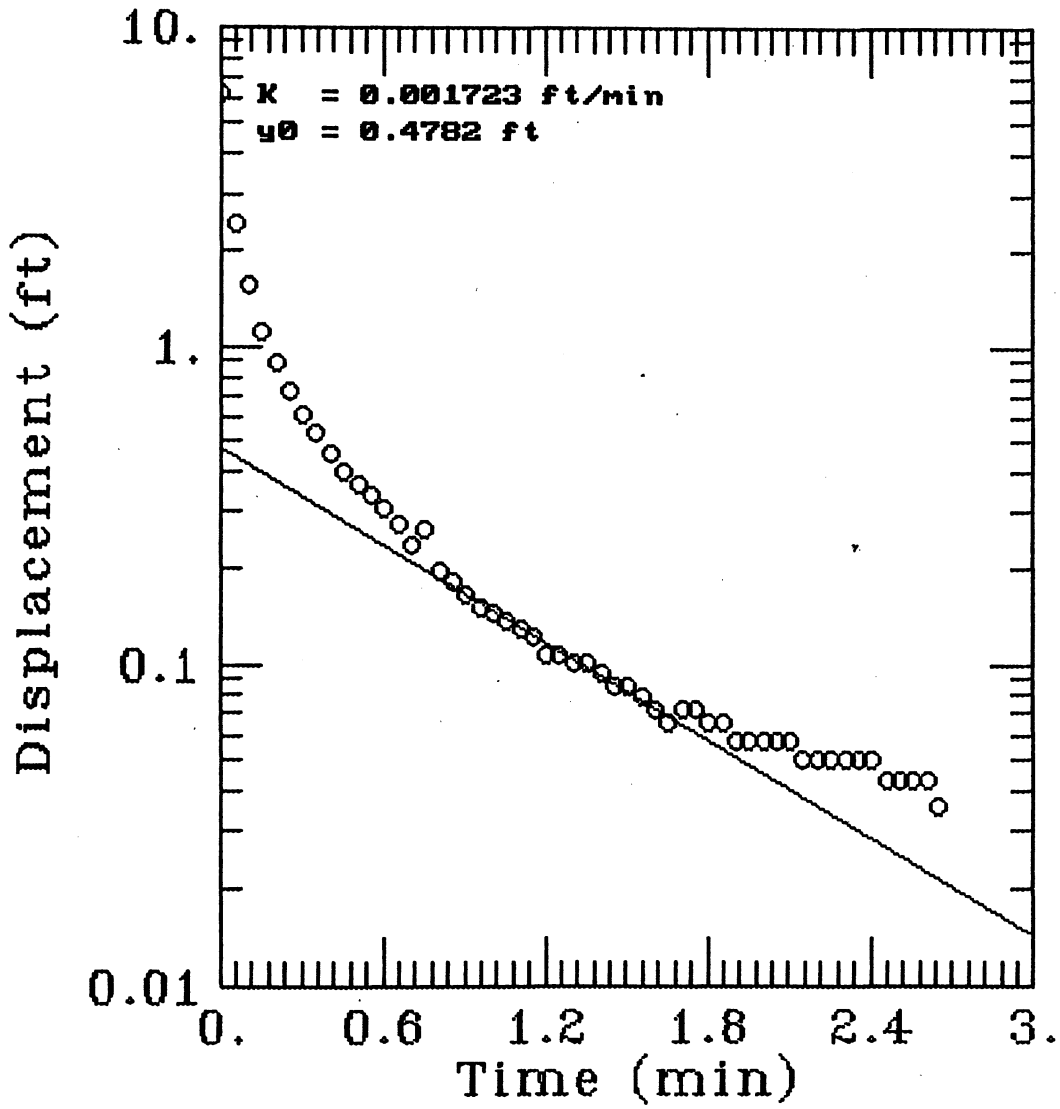
WELL NMW-7A


K = 0.00258 ft/min
y0 = 0.8694 ft
10.
1.
0.1
Displacement (ft)
0.
0.4
0.8
1.2
1.6
2.
Time (min)

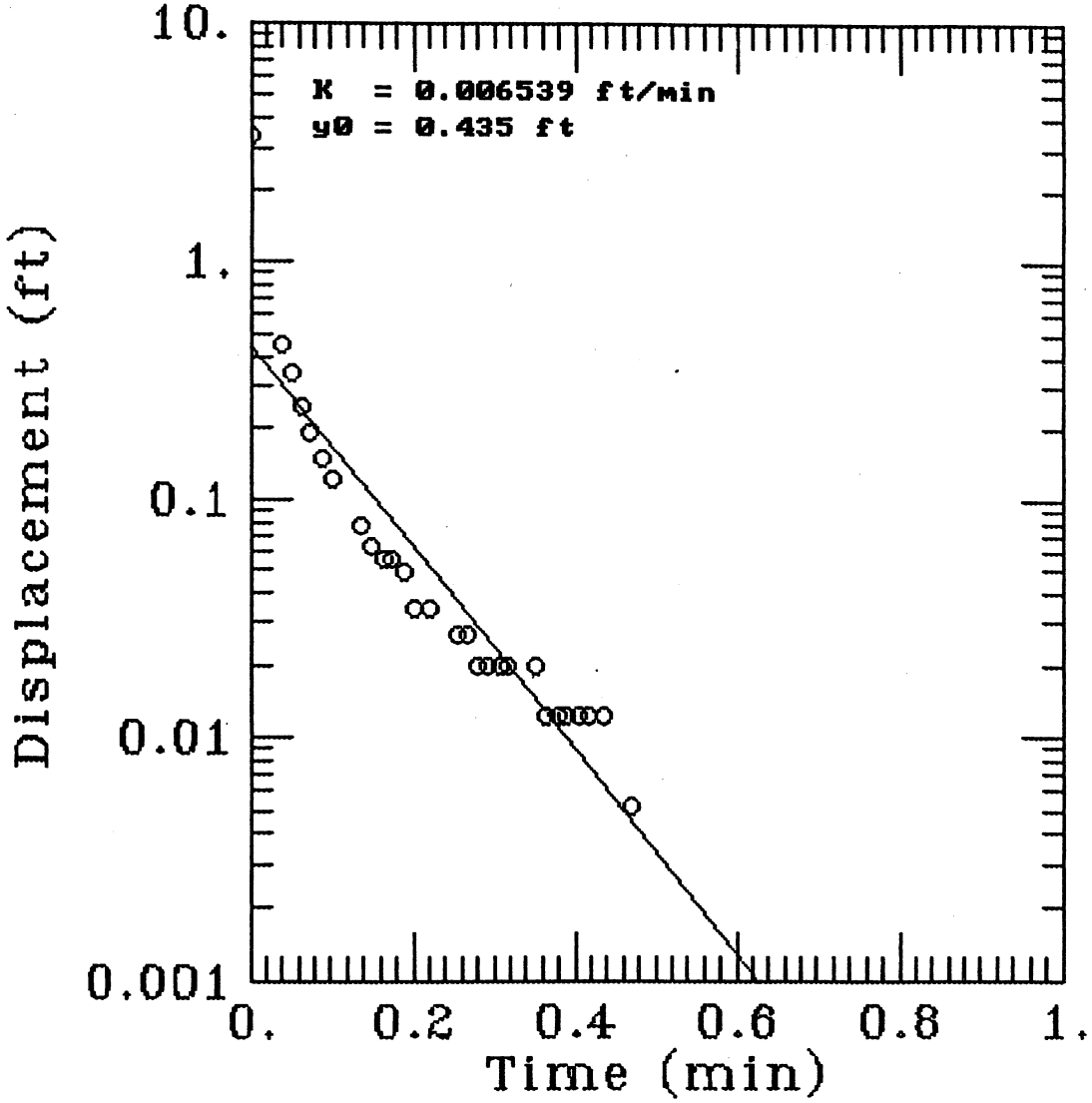
WELL NMW-7A


K = 0.001516 ft/min
y0 = 0.4495 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.8
1.6
2.4
3.2
4.
Time (min)

WELL NMW-7A


K = 0.001723 ft/min
y0 = 0.4782 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.6
1.2
1.8
2.4
3.
Time (min)

WELL STM-1A



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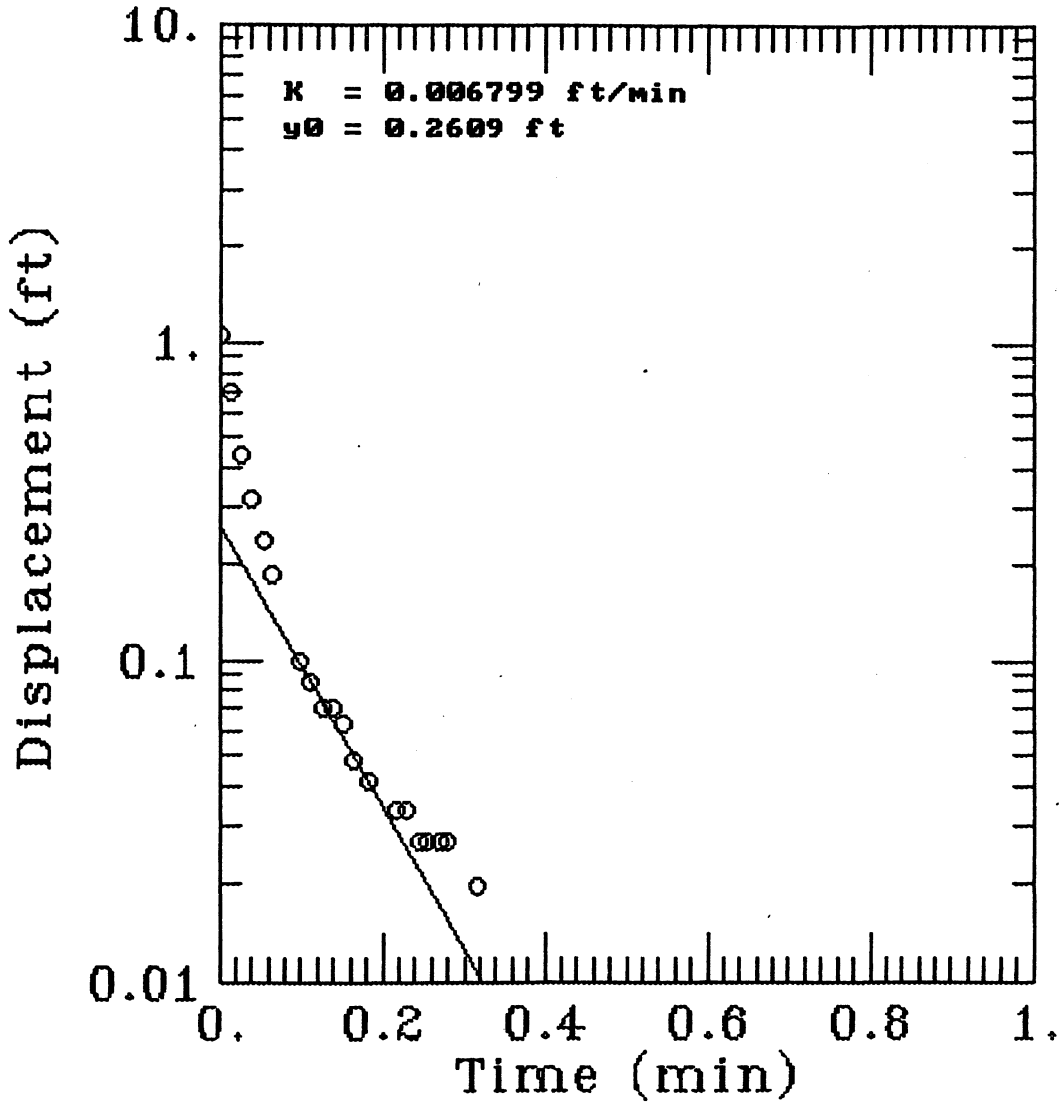
Modeling Group

WELL STM-1A

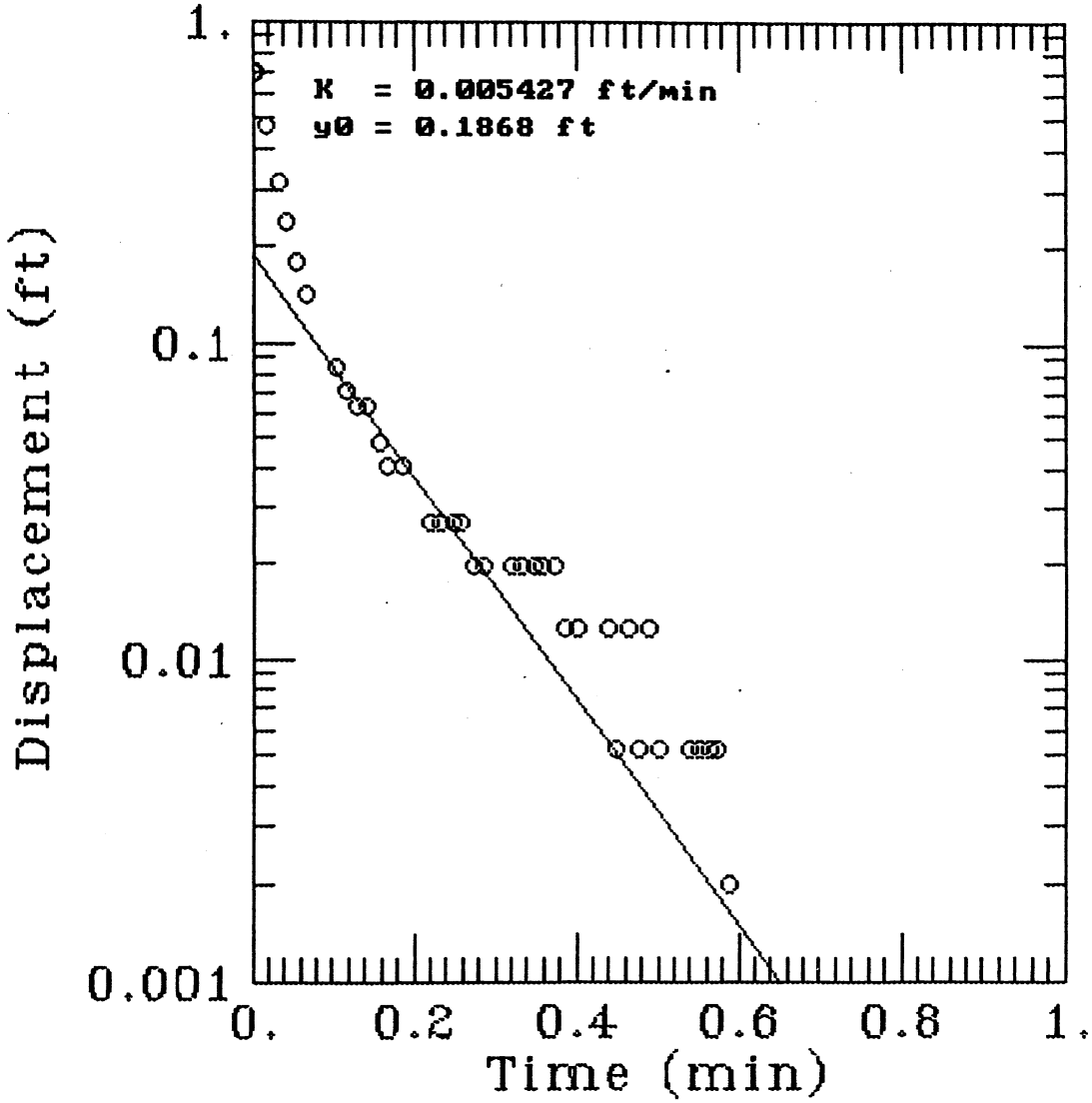


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL STM-1A

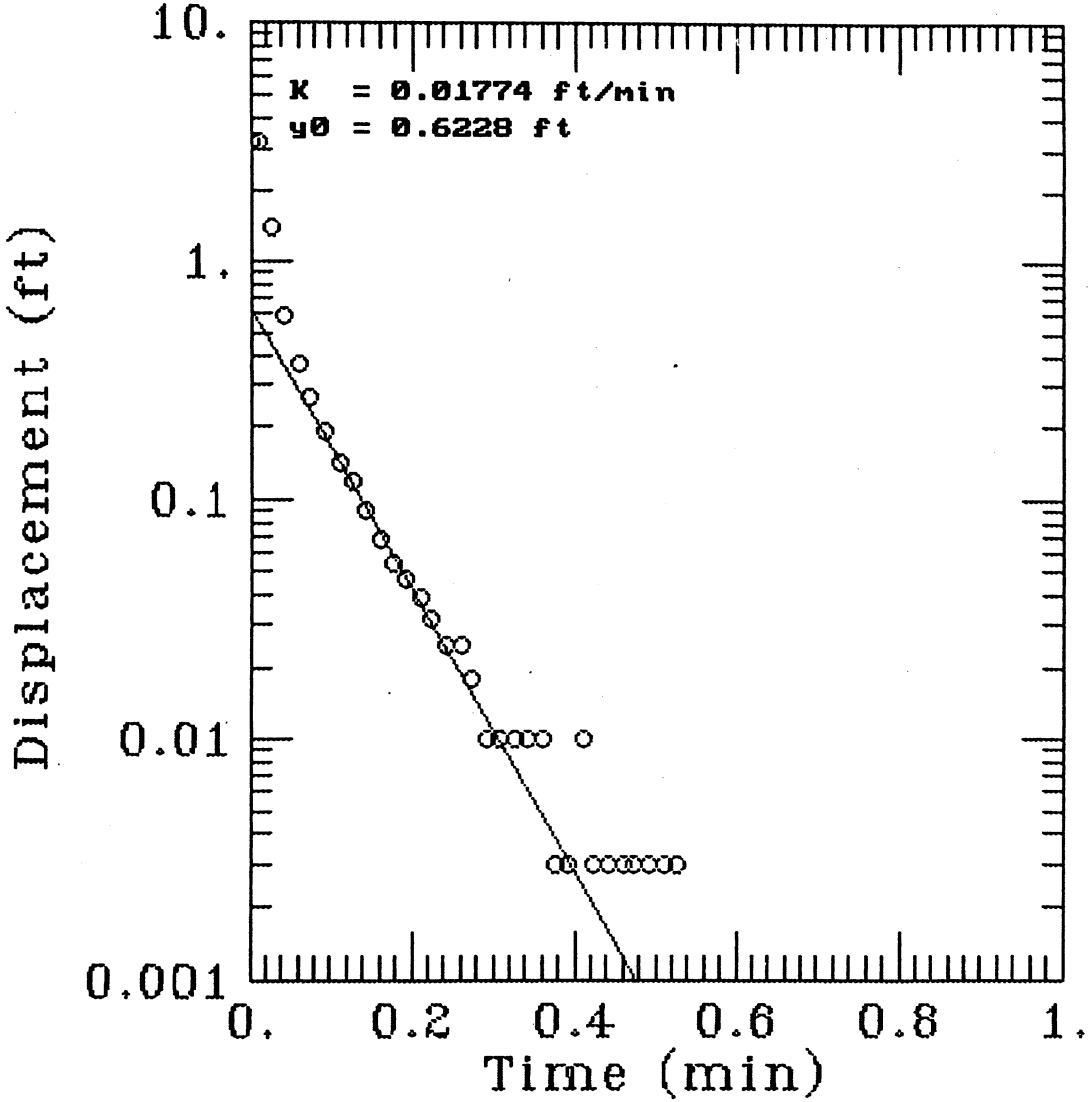


AQTESOLV

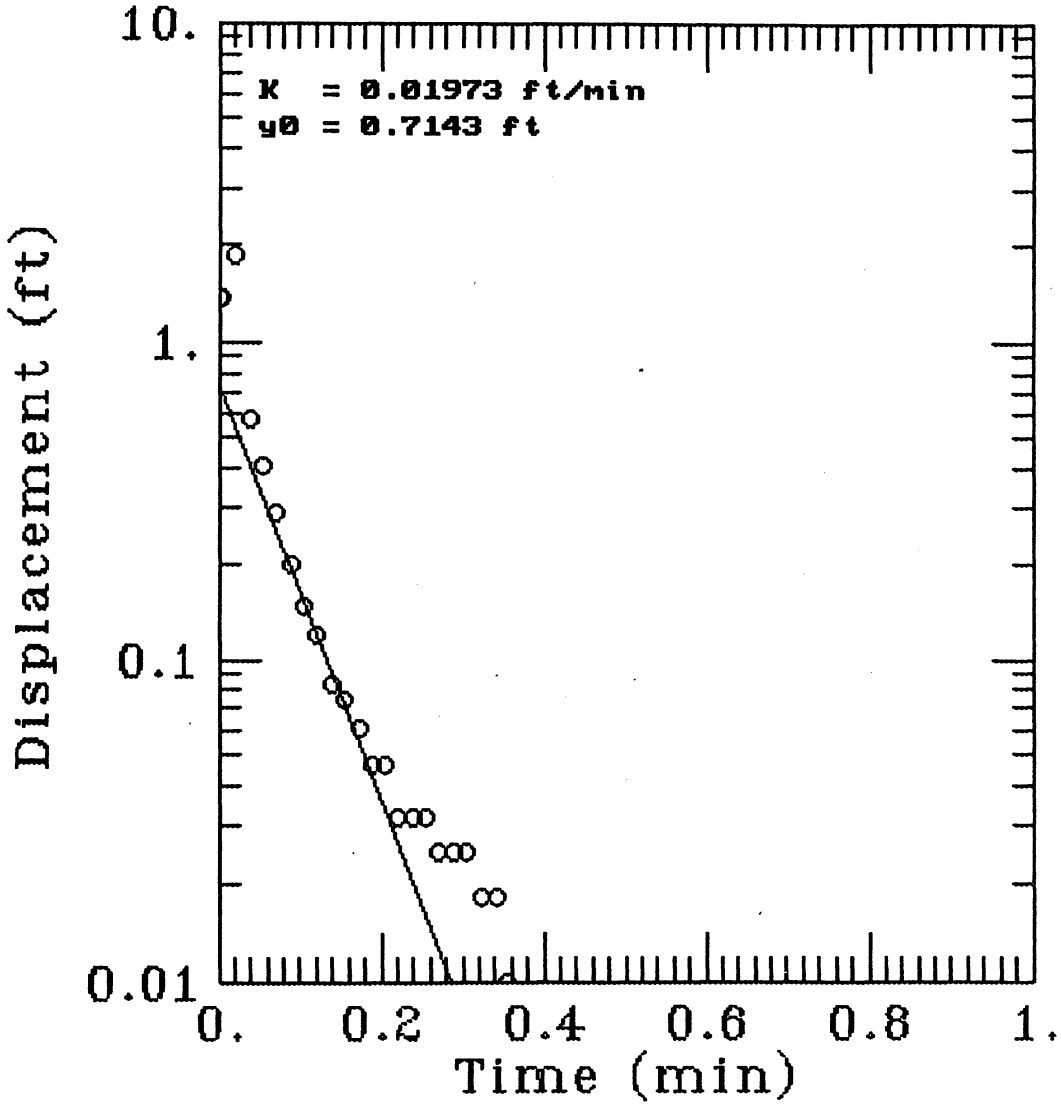
GERAGHTY & MILLER, INC.

Modeling Group

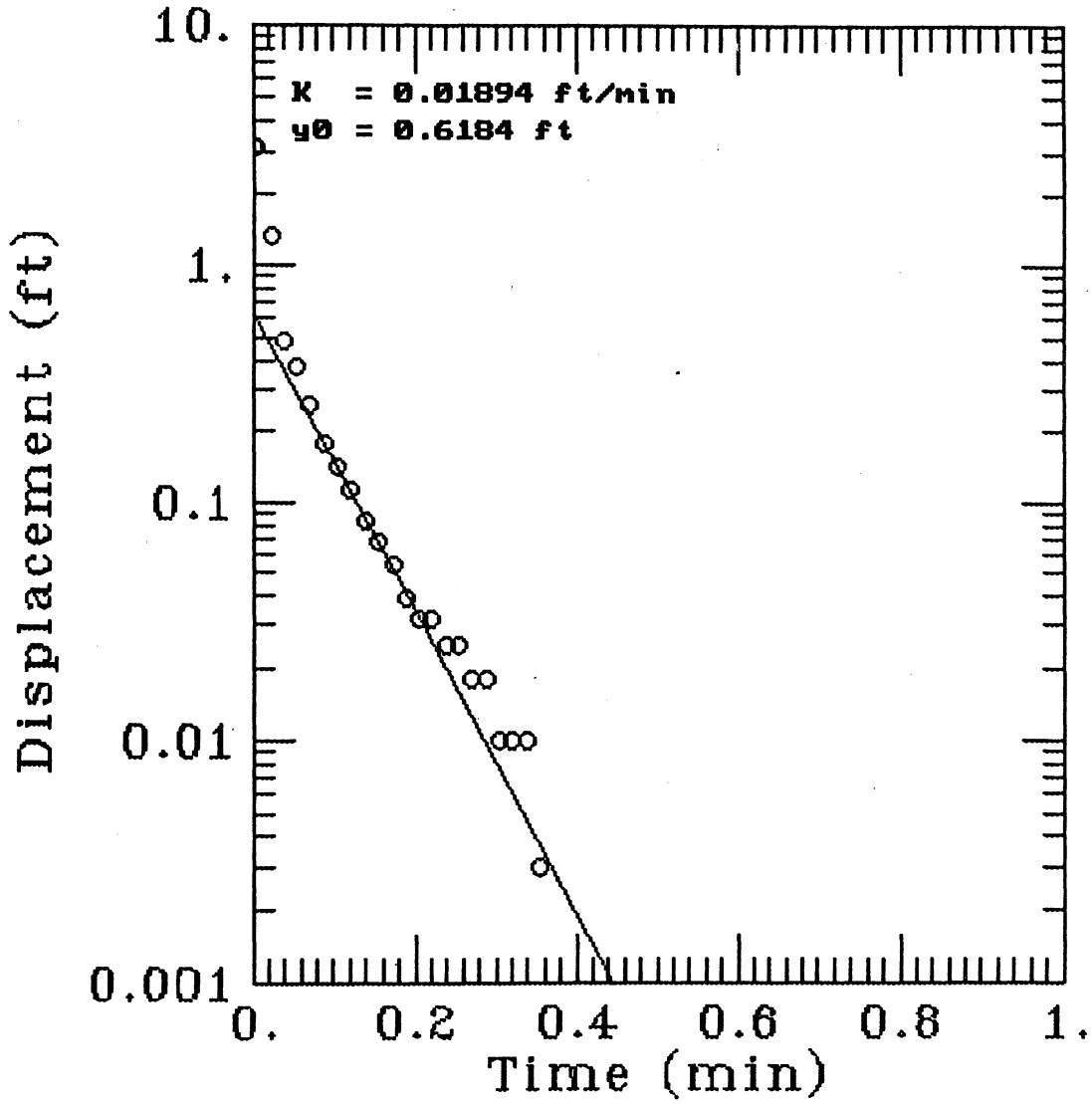
WELL CBS-3A


K = 0.01774 ft/min
y0 = 0.6228 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

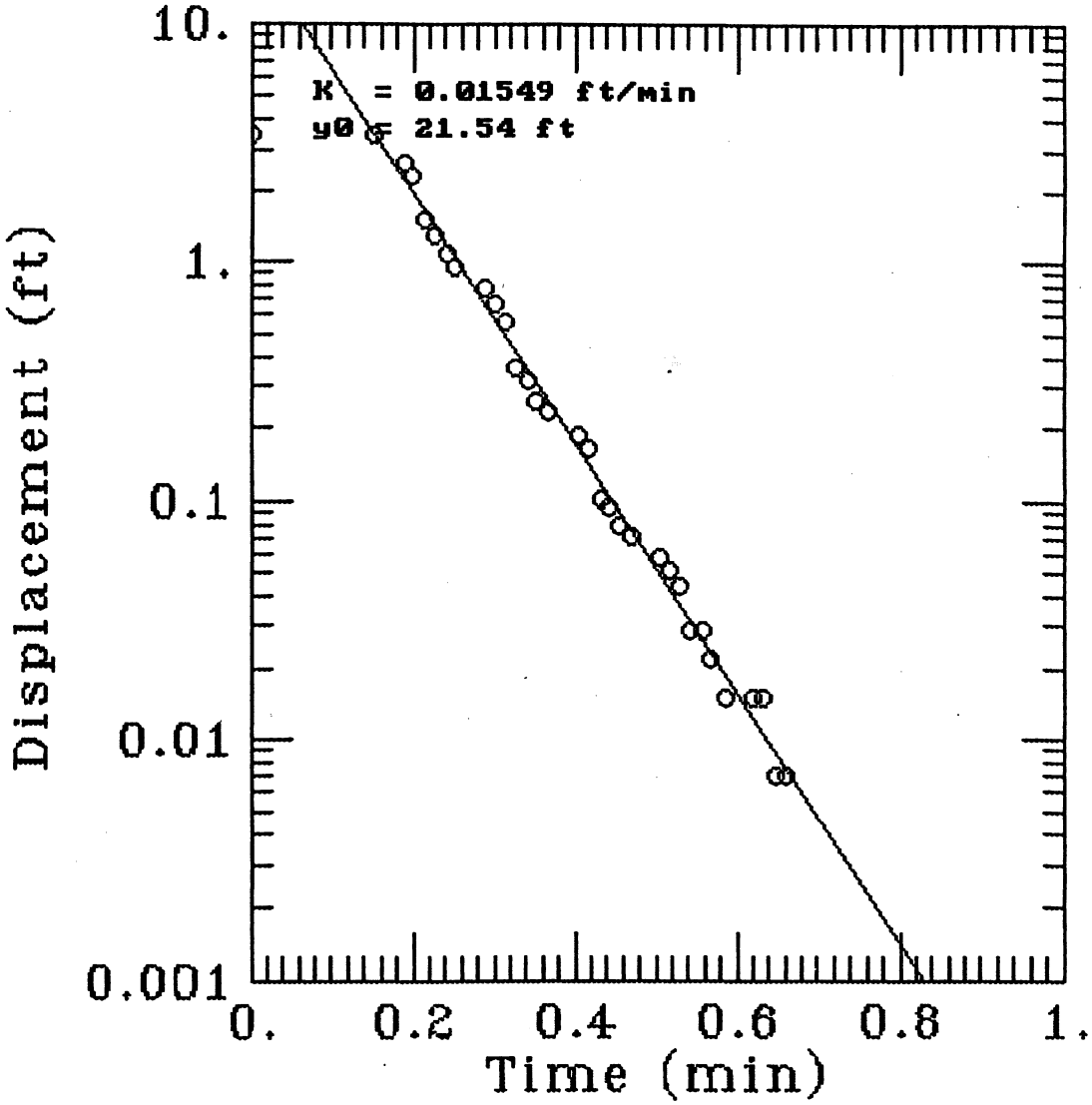
WELL CBS-3A


K = 0.01973 ft/min
y0 = 0.7143 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

WELL CBS-3A


K = 0.01894 ft/min
y0 = 0.6184 ft
10.
1.
0.1
0.01
0.001
Displacement (ft)
0.
0.2
0.4
0.6
0.8
1.
Time (min)

WELL CBS-7A



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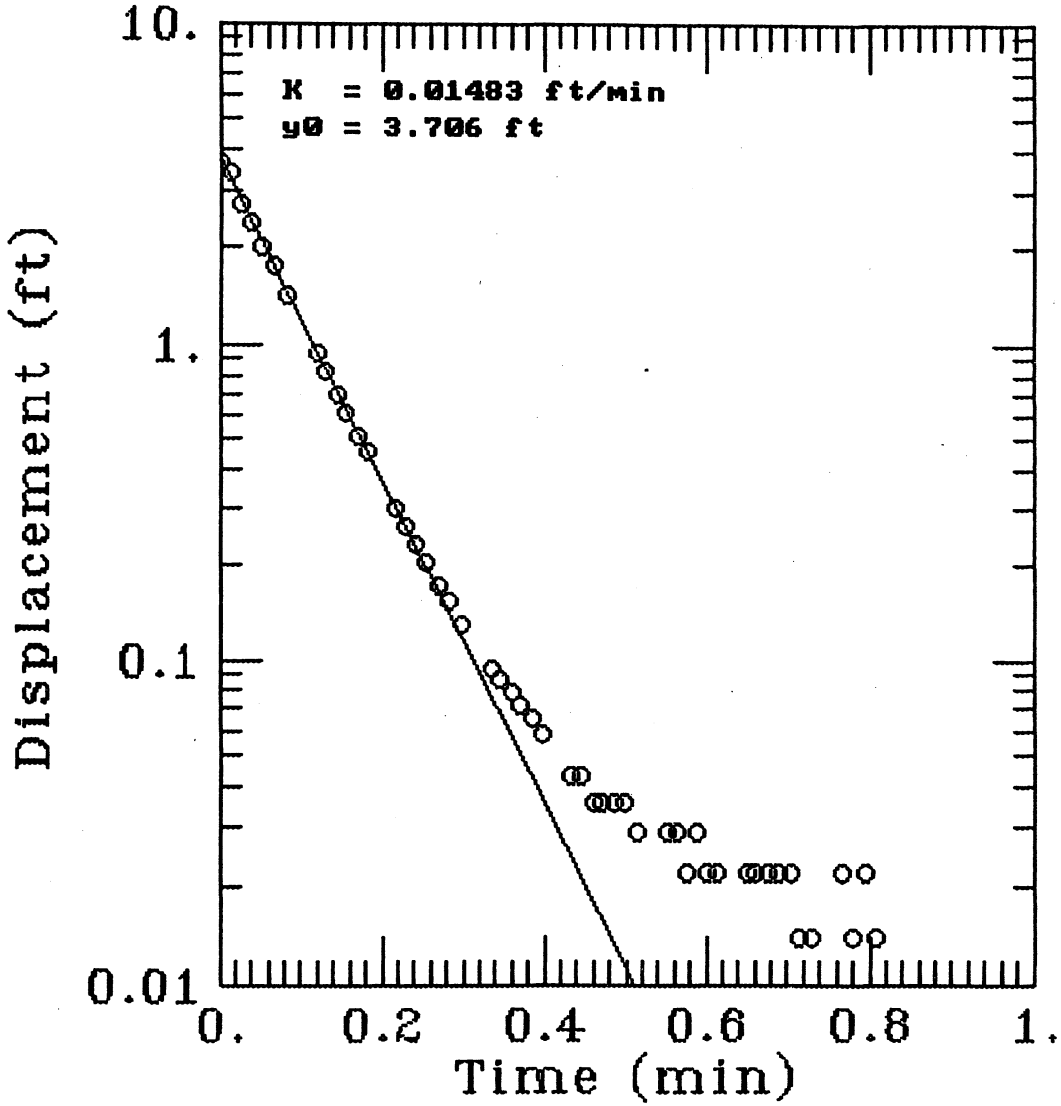
GERAGHTY & MILLER, INC.

Modeling Group

WELL CBS-7A

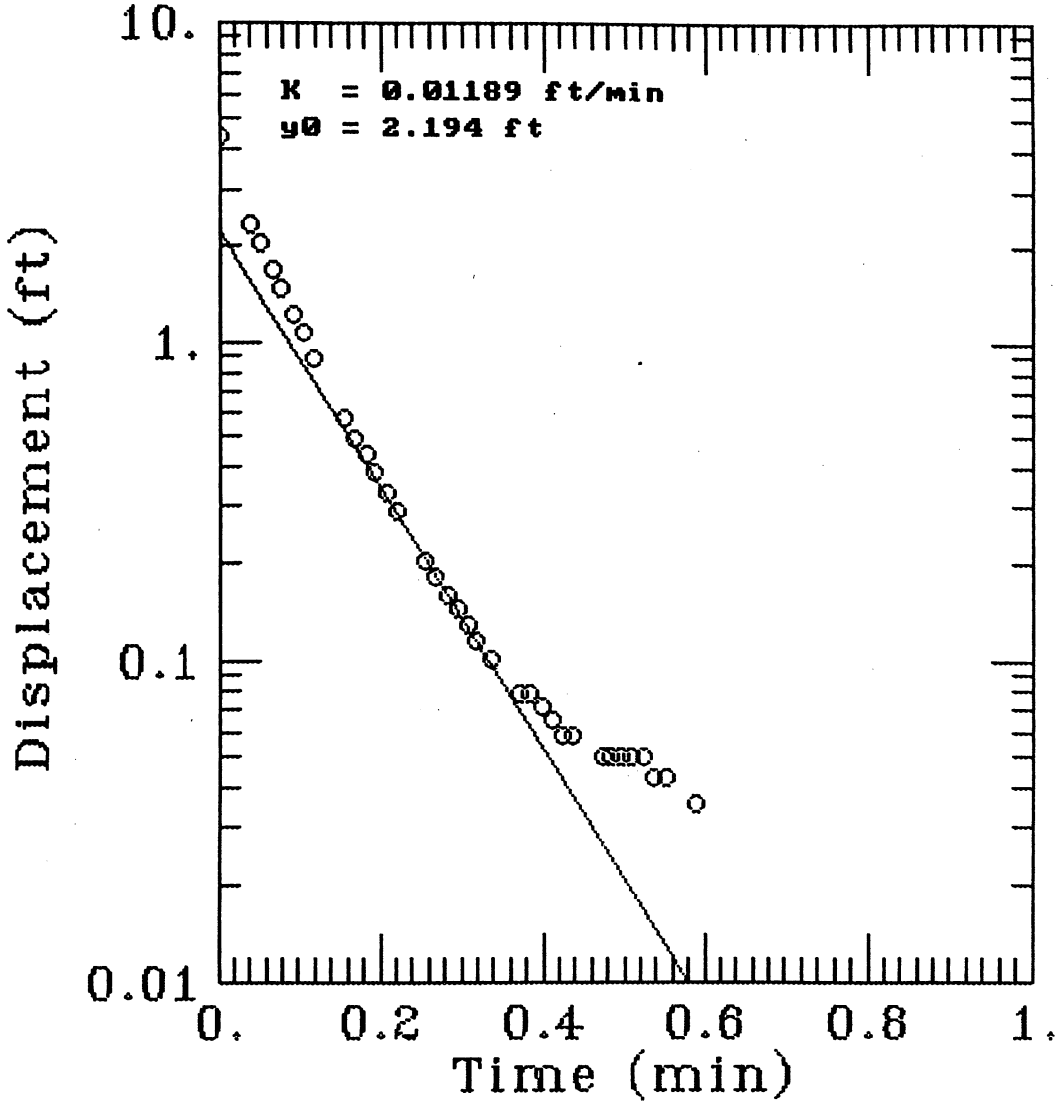


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL CBS-7A

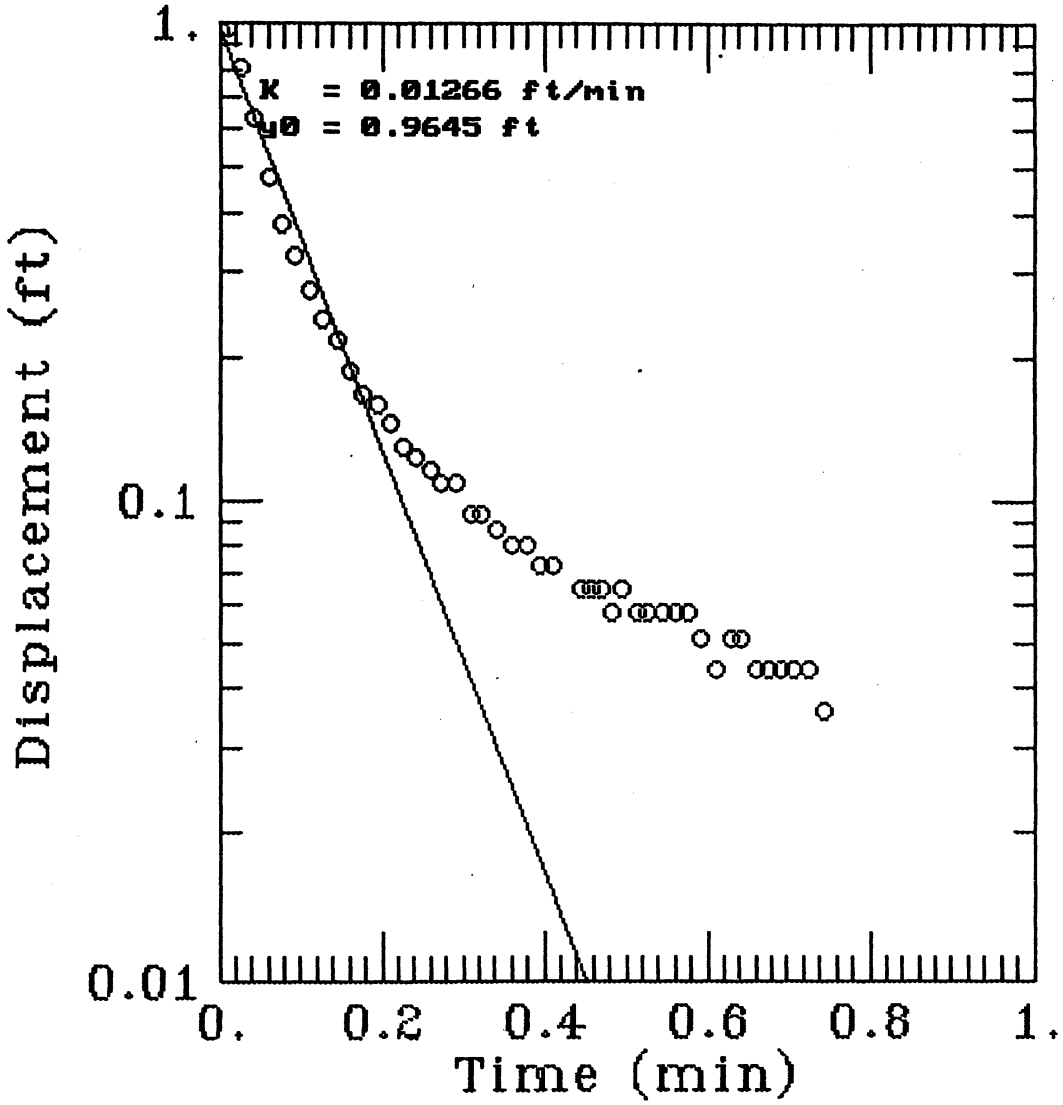


AQTESOLV

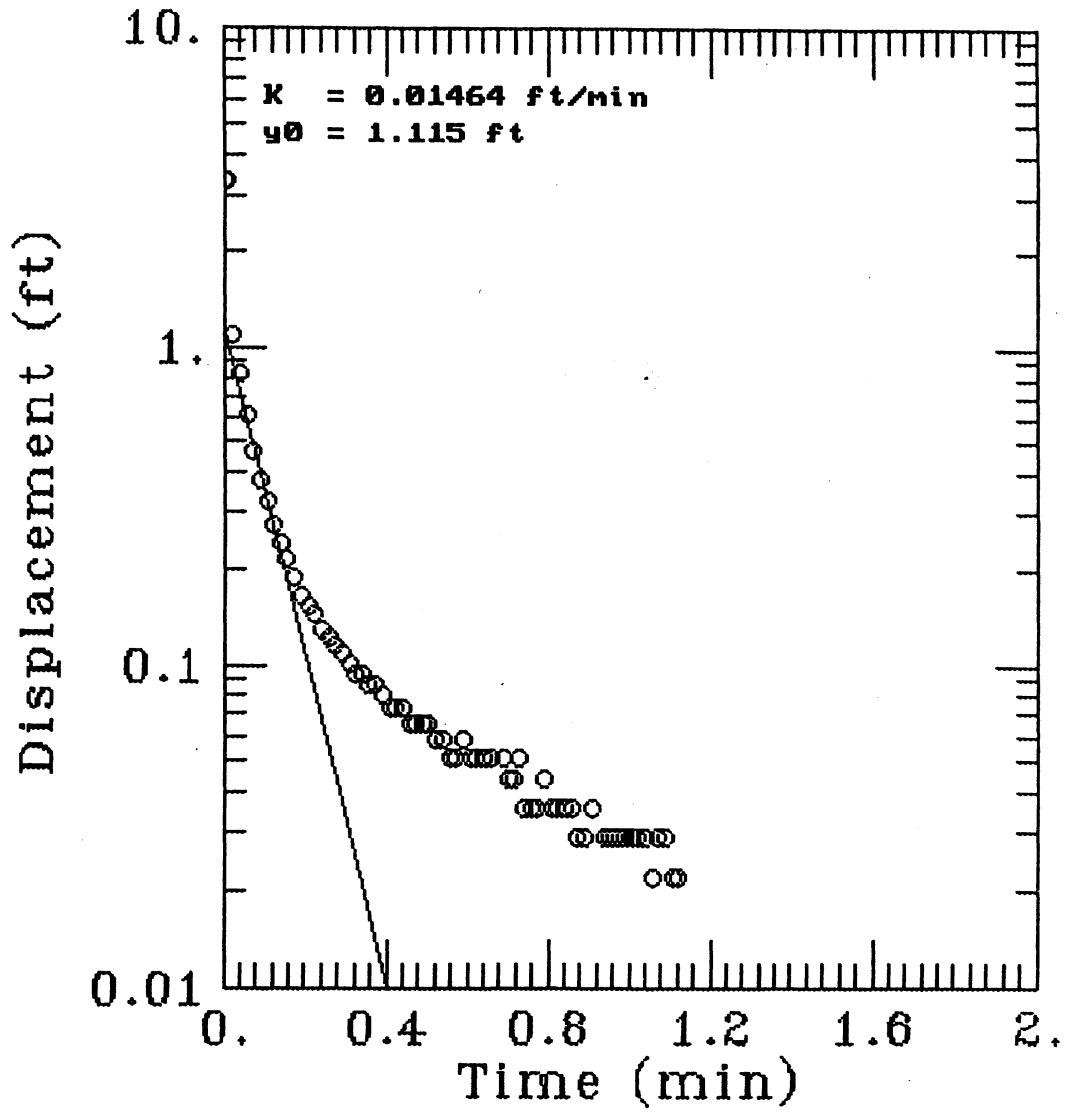
GERAGHTY & MILLER, INC.

Modeling Group

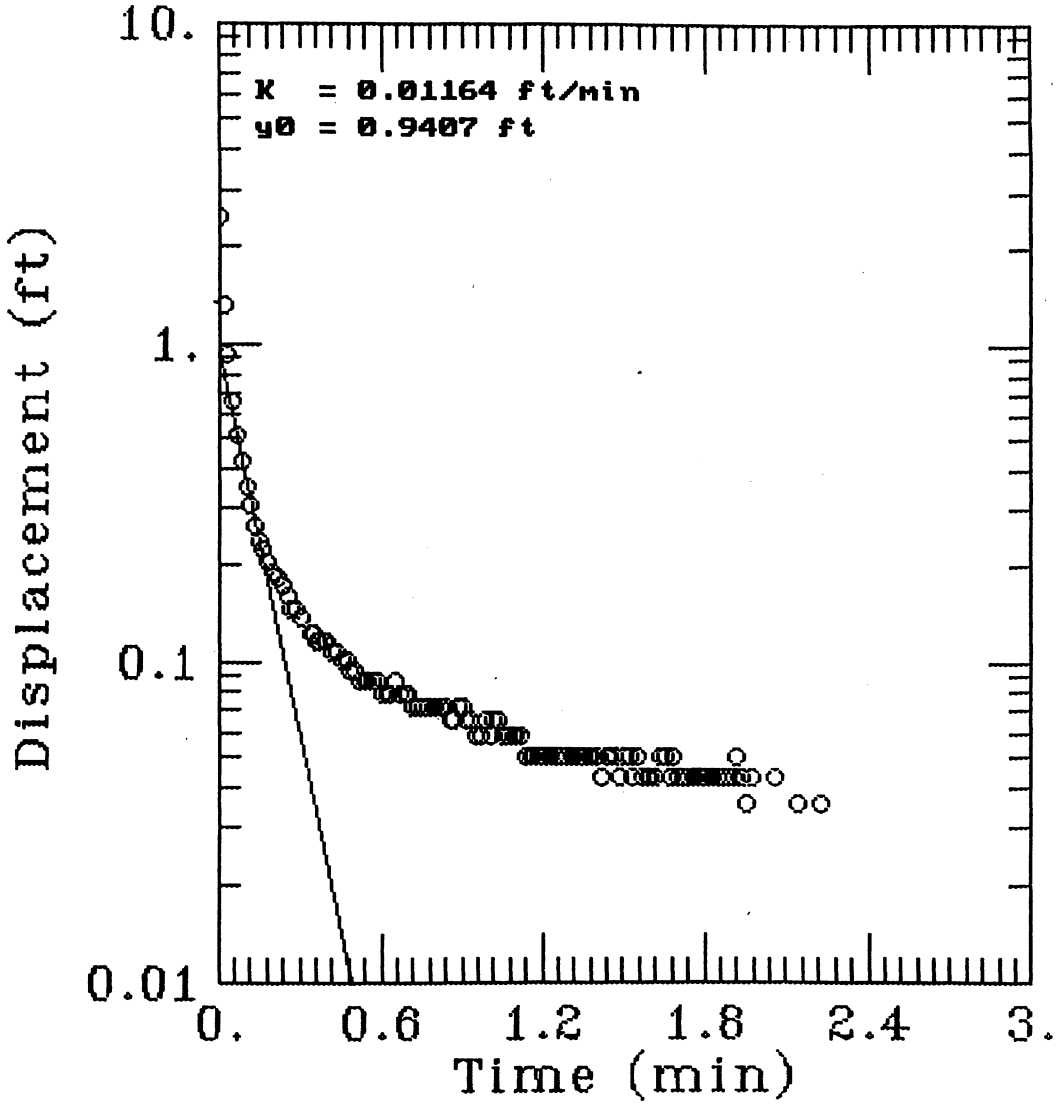
WELL CBS-11A


K = 0.01266 ft/min
y0 = 0.9645 ft
1.
0.1
0.01
0.
0.2
0.4
0.6
0.8
1.
Displacement (ft)
Time (min)

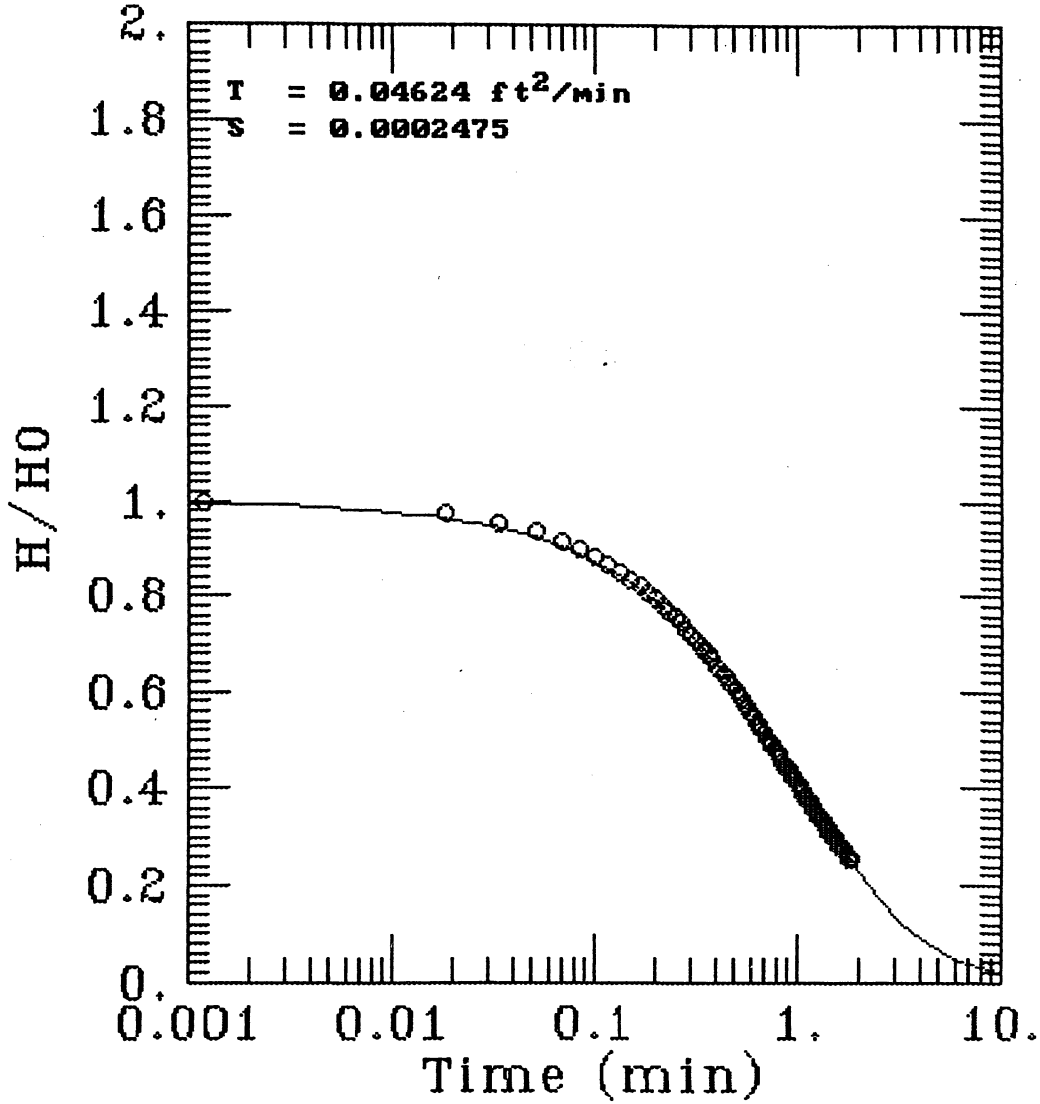
WELL CBS-11A


K = 0.01464 ft/min
y0 = 1.115 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.4
0.8
1.2
1.6
2.
Time (min)

WELL CBS-11A


K = 0.01164 ft/min
y0 = 0.9407 ft
10.
1.
0.1
0.01
Displacement (ft)
0.
0.6
1.2
1.8
2.4
3.
Time (min)

WELL NMW-3B



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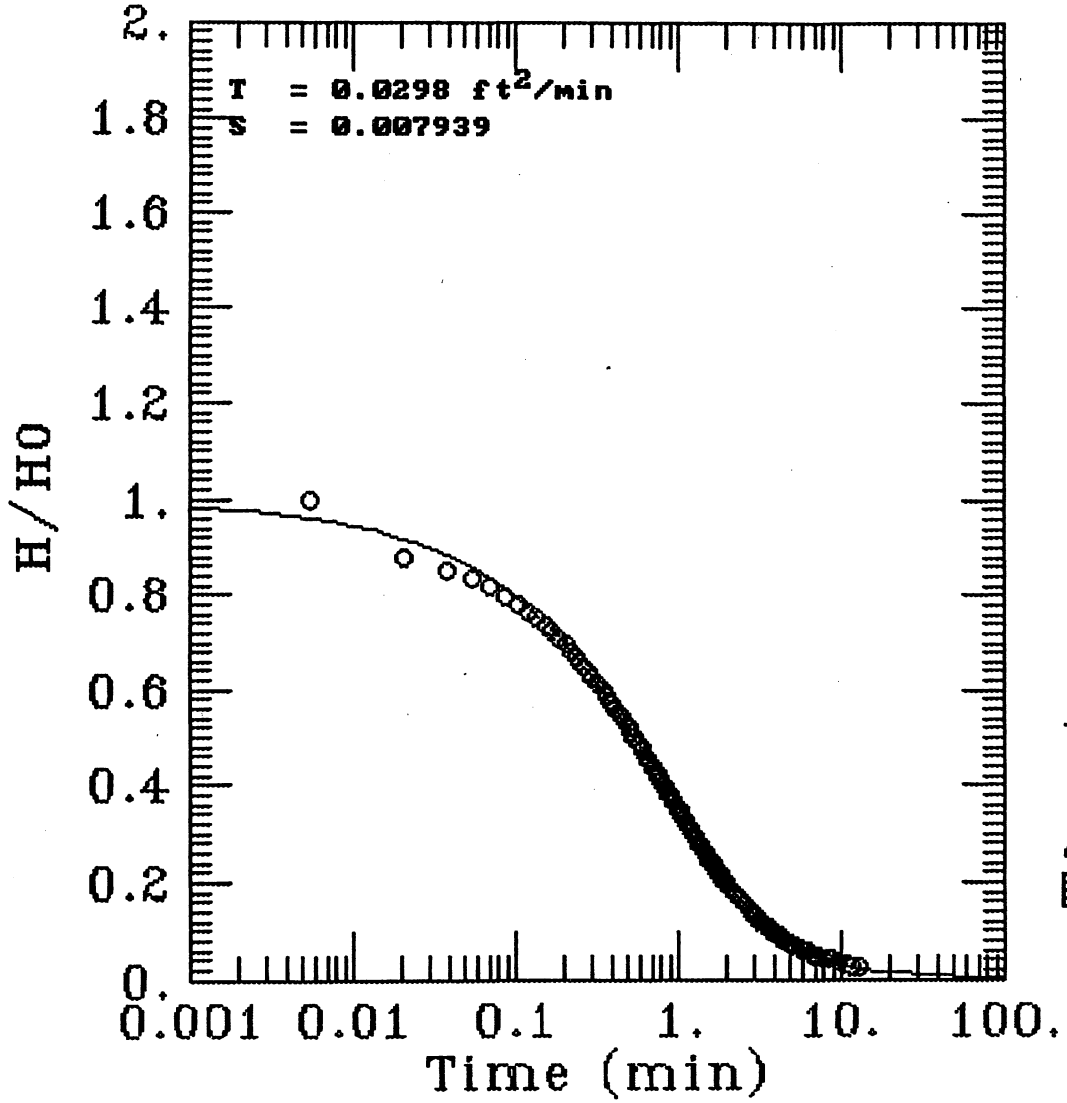
Modeling Group

WELL NMW-3B

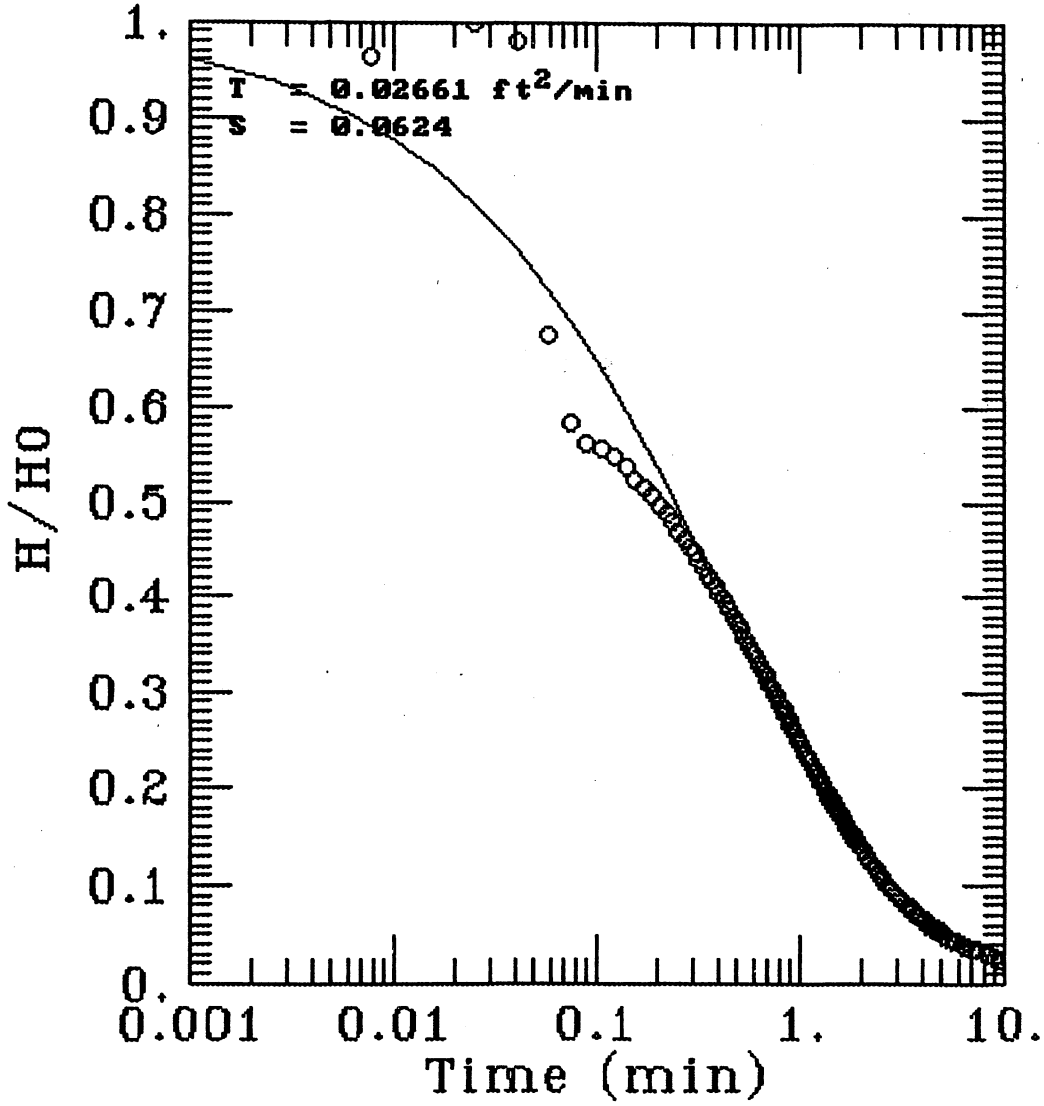


AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

WELL NMW-3B



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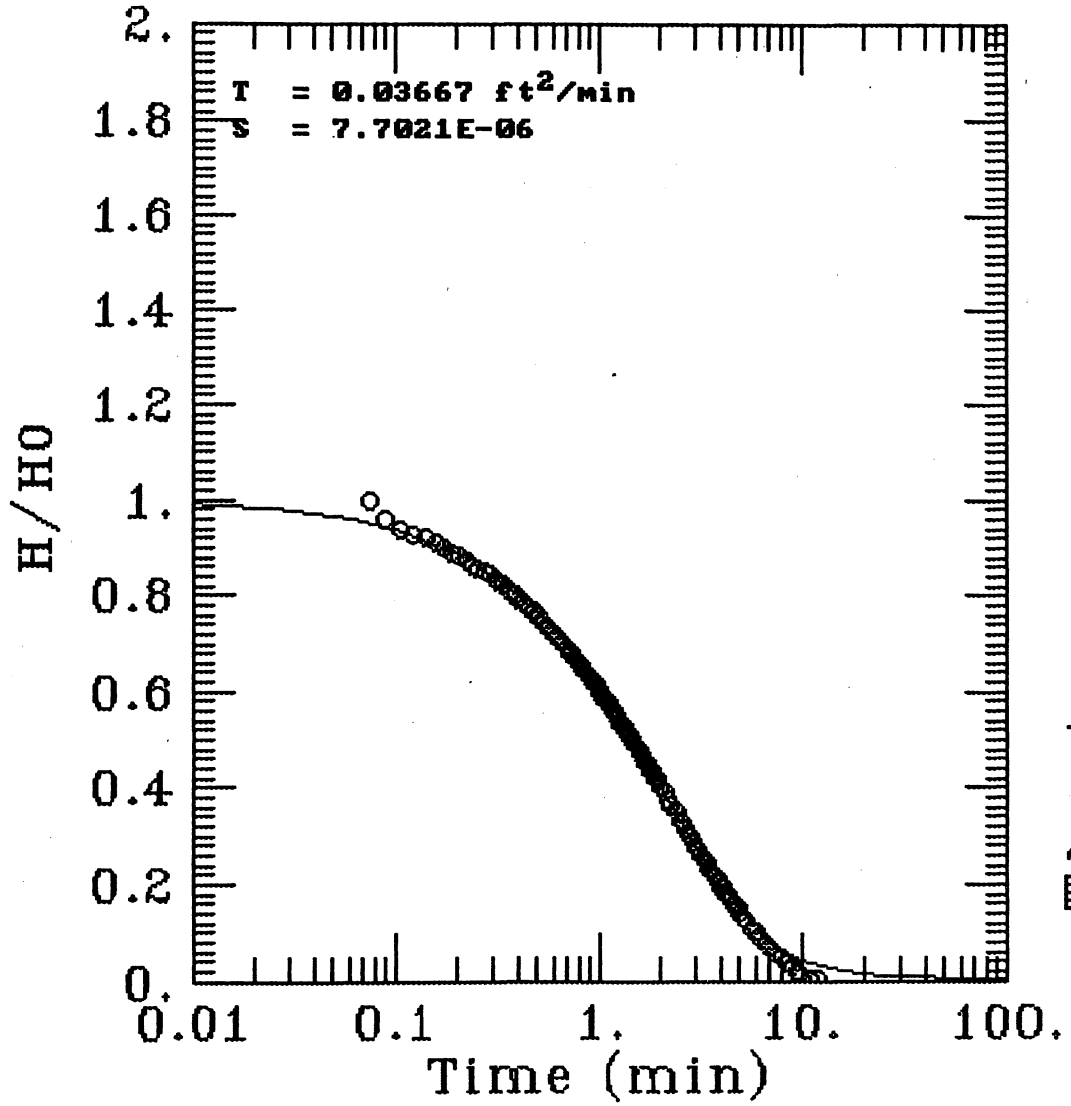
Modeling Group

WELL NMW-5B



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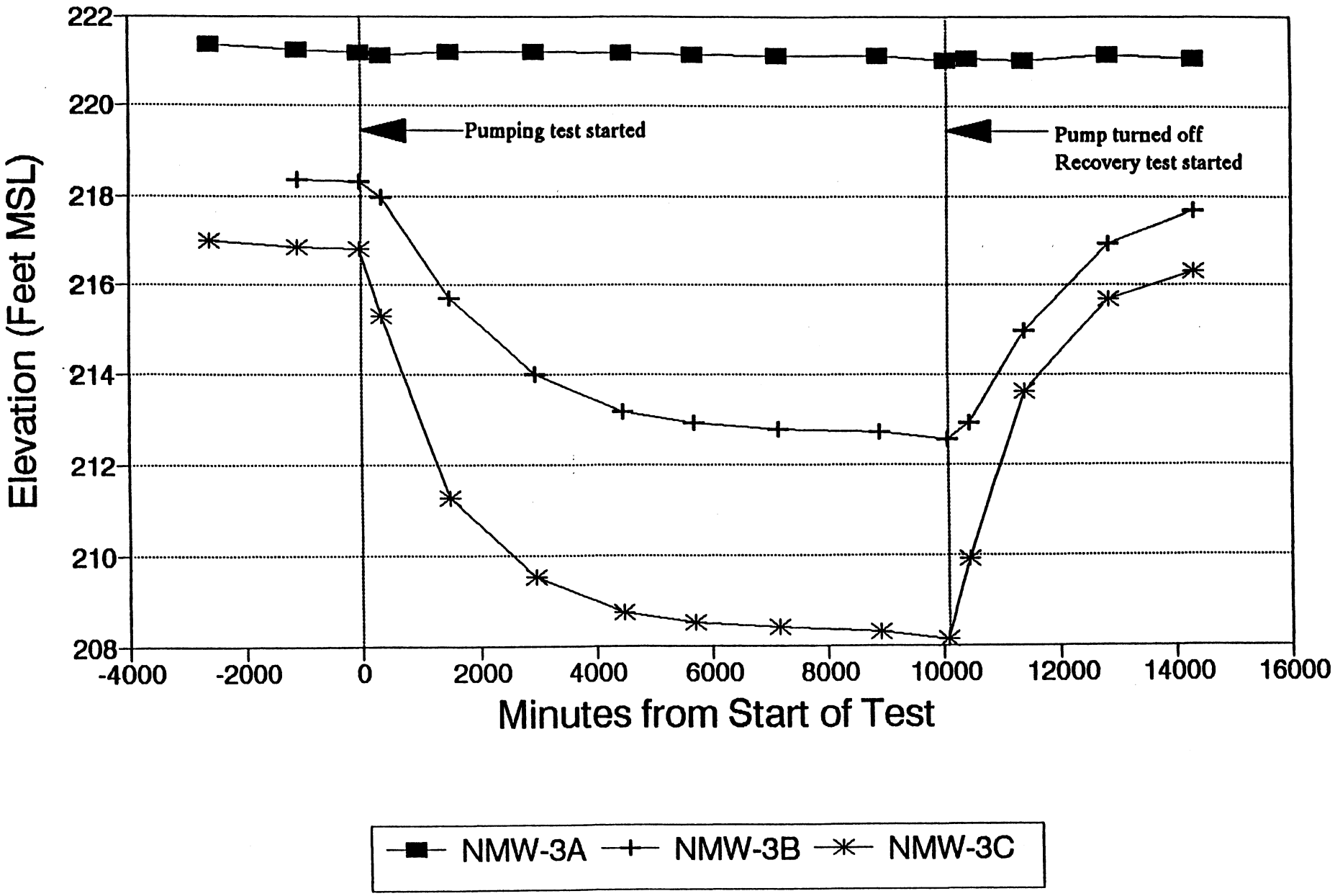
GERAGHTY & MILLER, INC.

Modeling Group

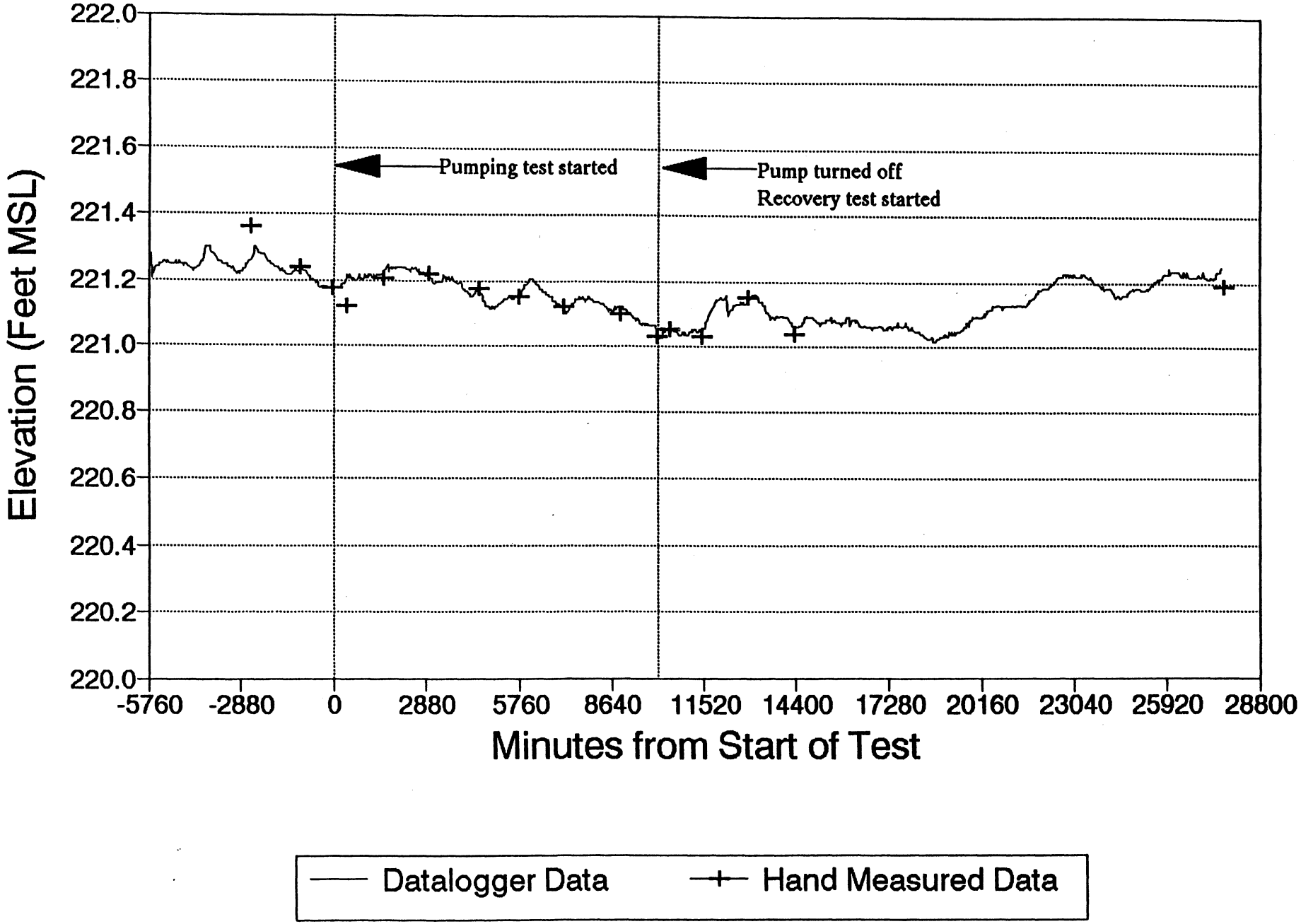
Appendix HC-F

Hydrographs of Water Levels in Wells Monitored During TAC 1A Aquifer Pumping Test

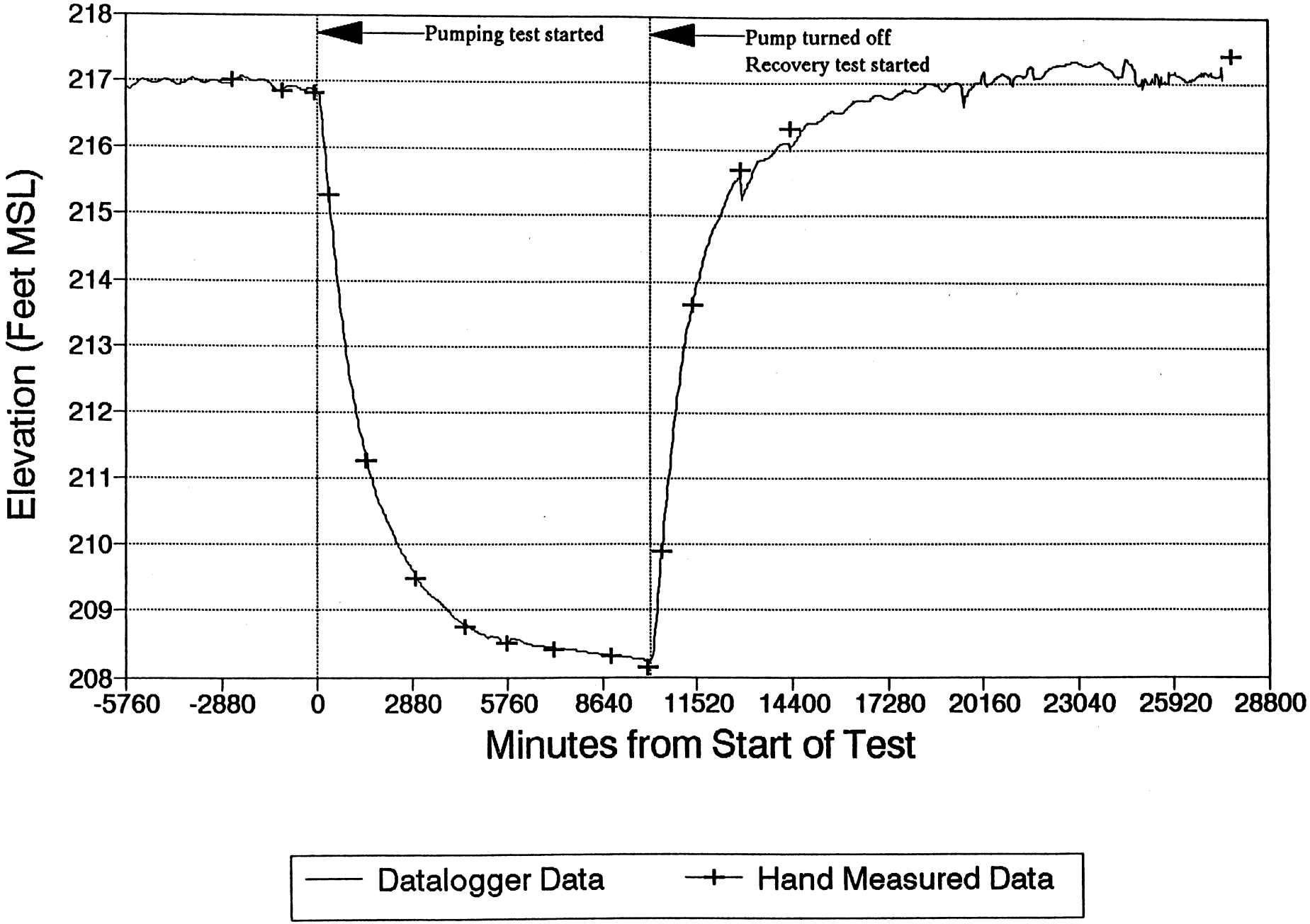
NMW-3 Observation Well Cluster
TAC-1A Aquifer Test/South Tacoma Field



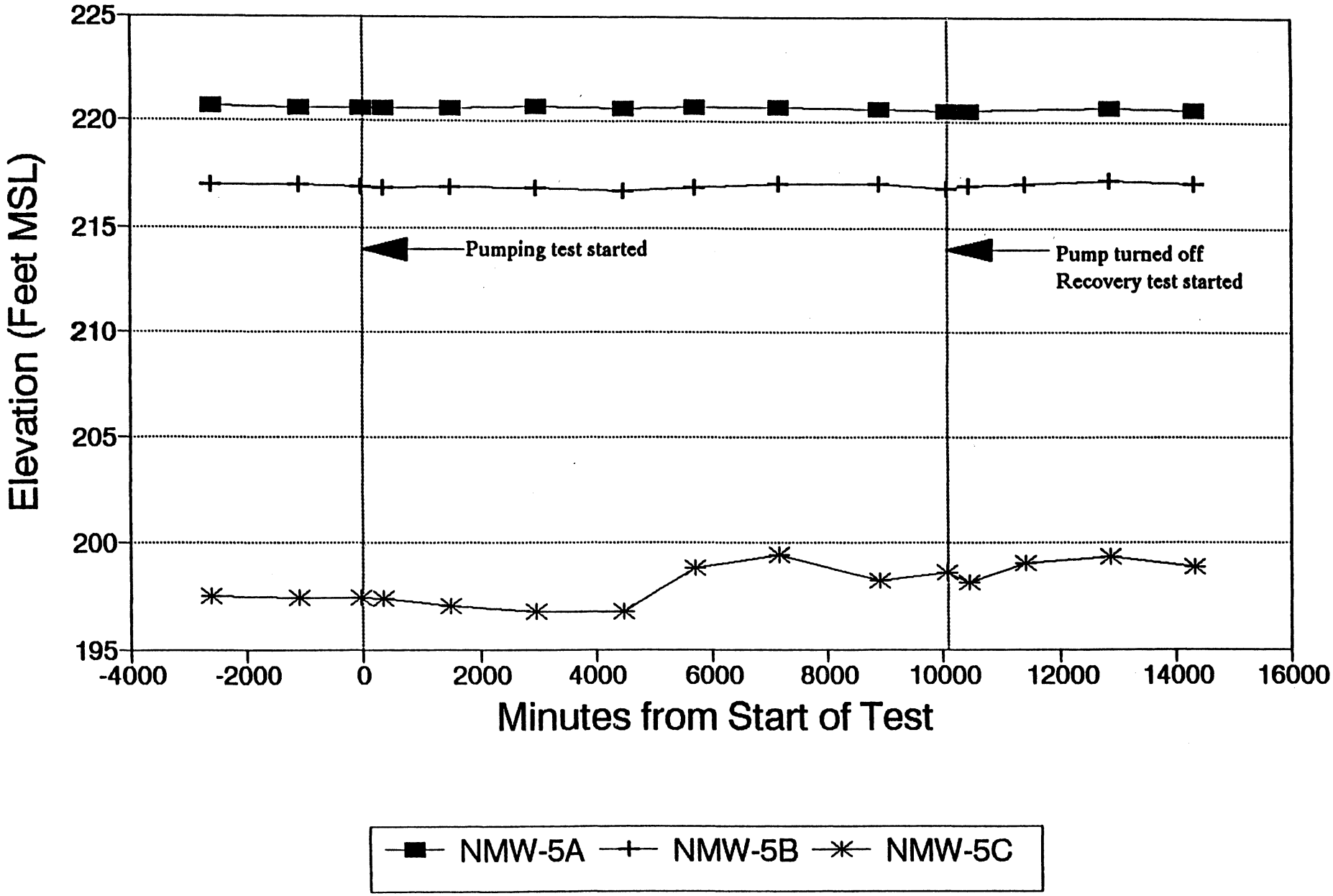
Observation Well NMW-3A Elevations
TAC-1A Aquifer Test/South Tacoma Field



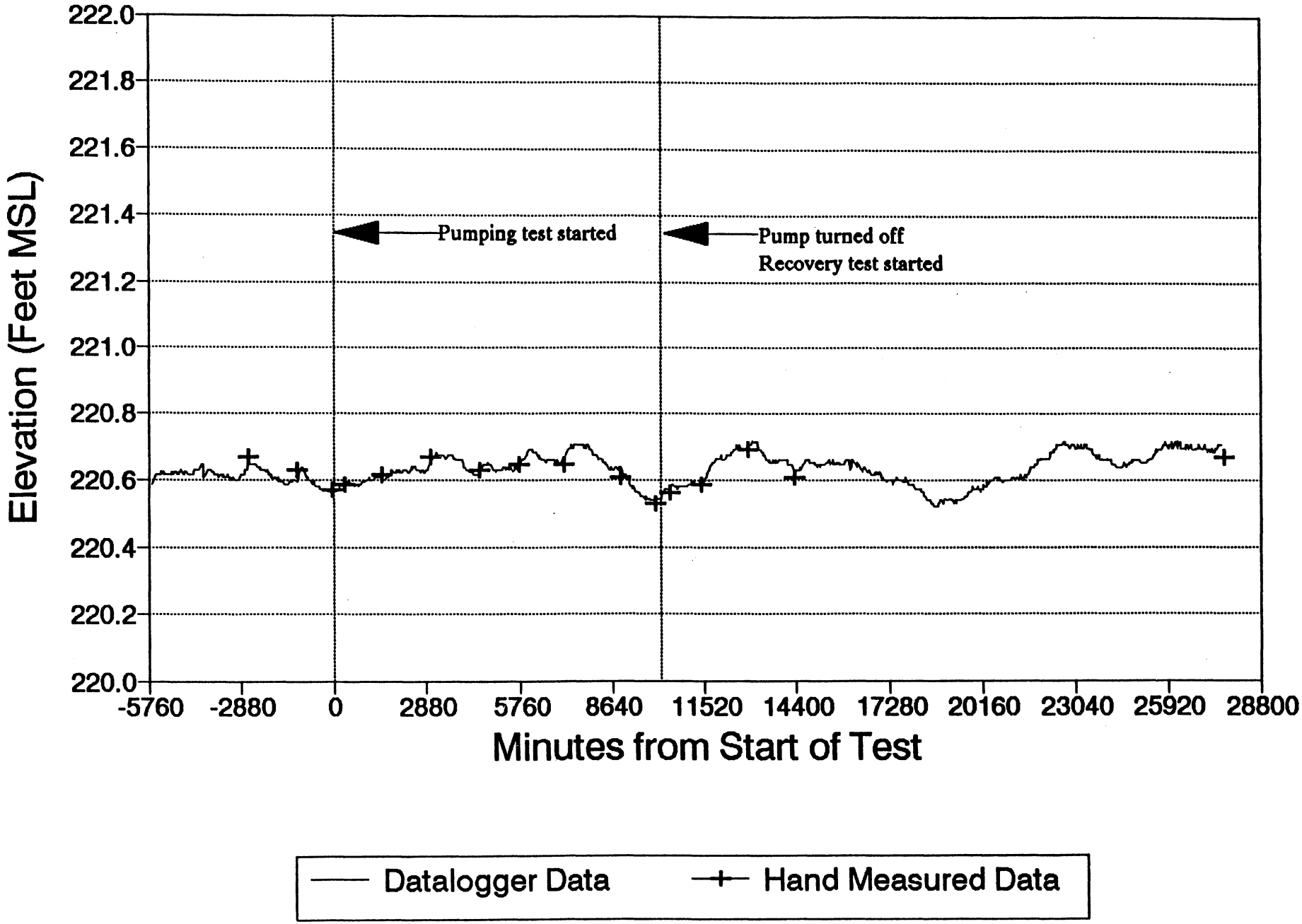
Observation Well NMW-3C Elevations
TAC-1A Aquifer Test/South Tacoma Field



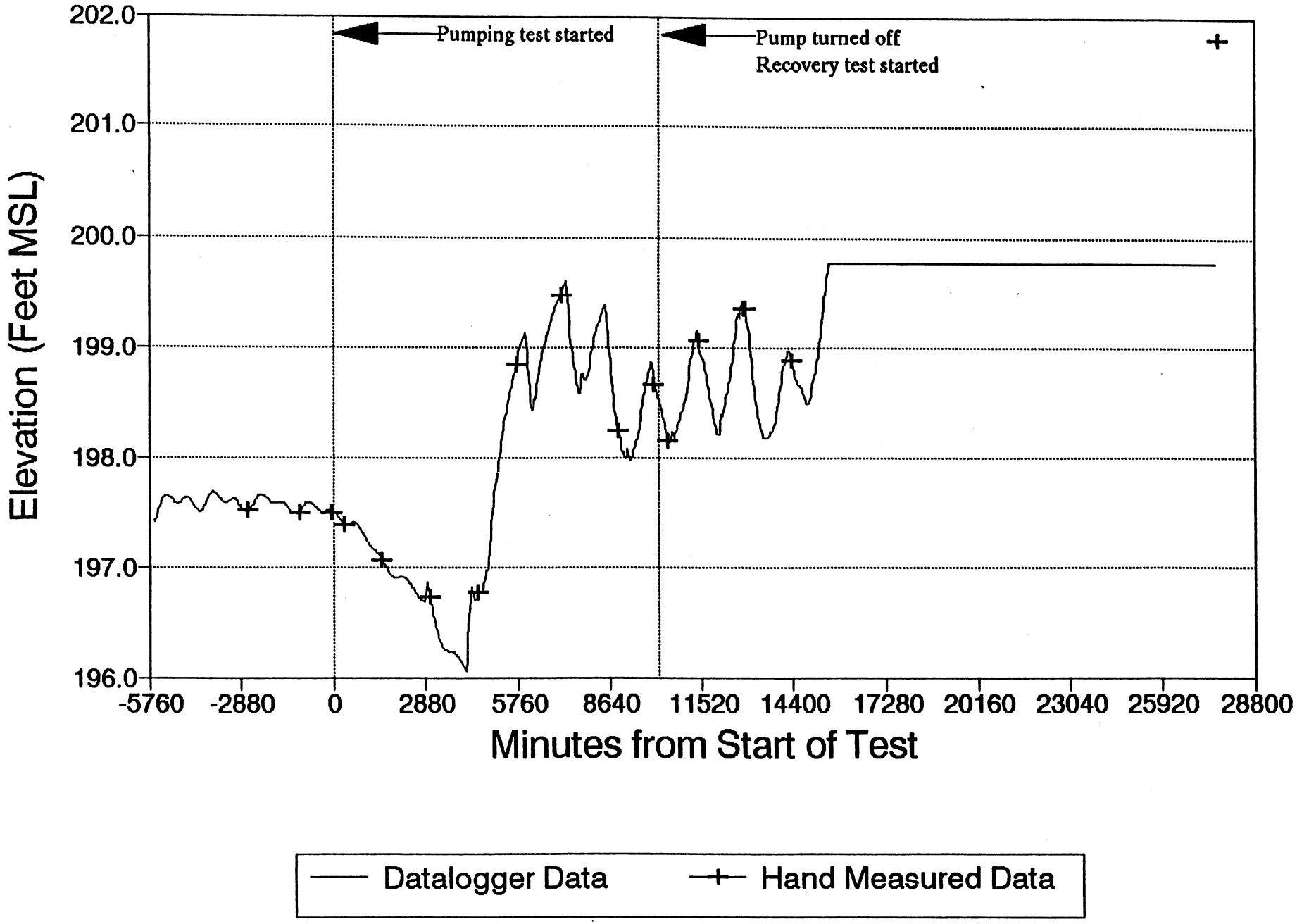
NMW-5 Observation Well Cluster
TAC-1A Aquifer Test/South Tacoma Field



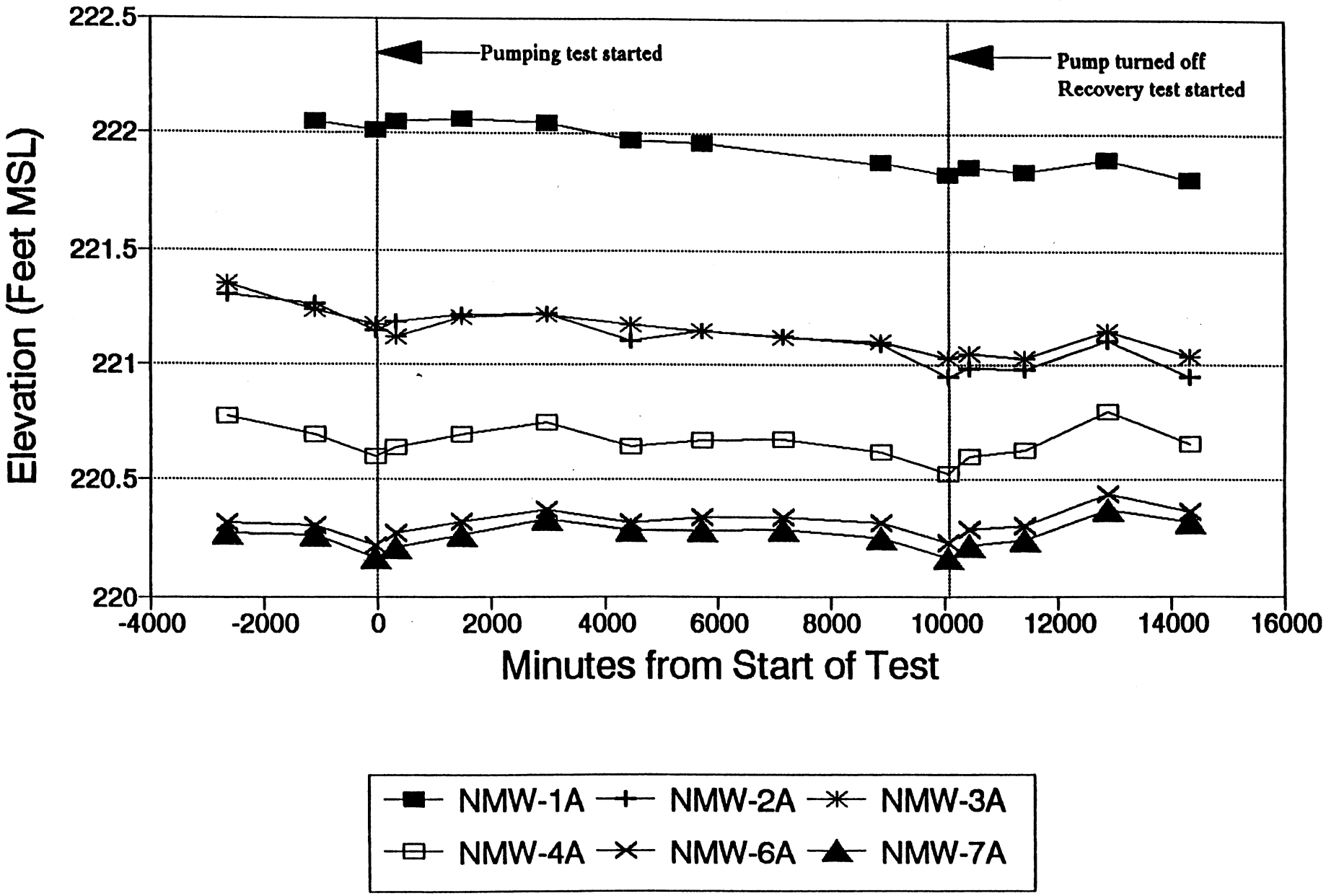
Observation Well NMW-5A Elevations
TAC-1A Aquifer Test/South Tacoma Field



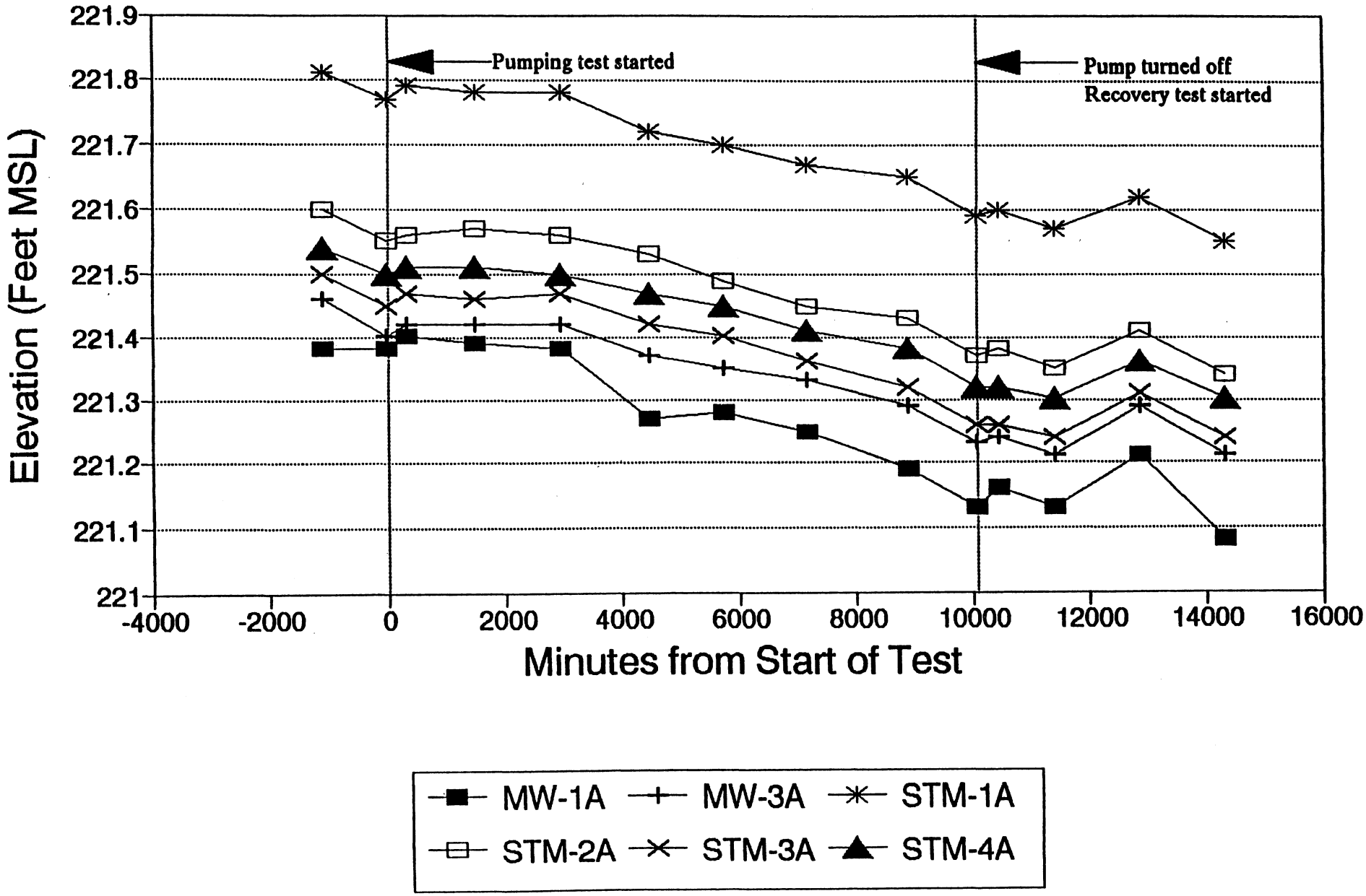
Observation Well NMW-5C Elevations
TAC-1A Aquifer Test/South Tacoma Field



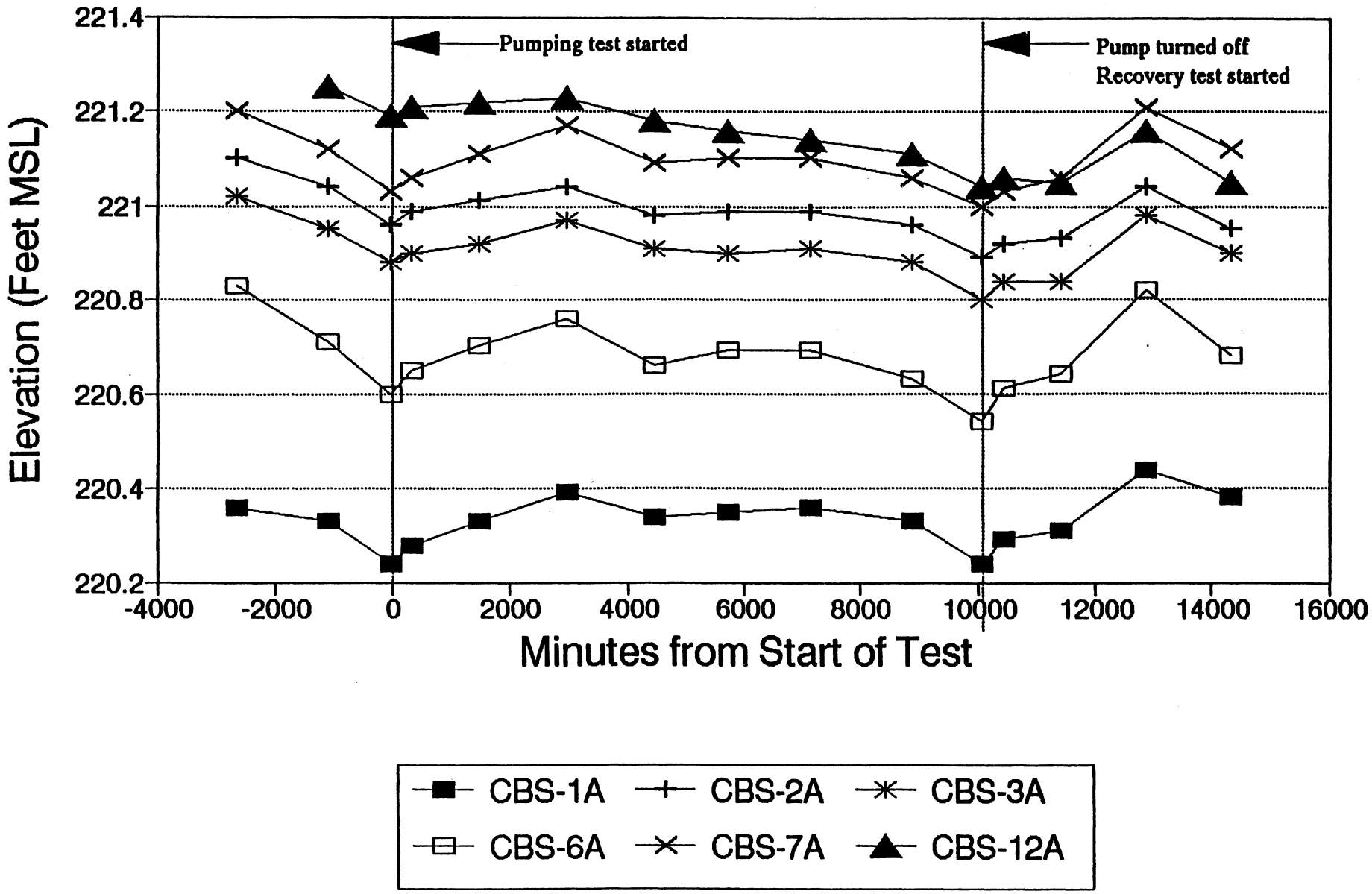
NMW Observation Wells (Upper Aquifer)
TAC-1A Aquifer Test/South Tacoma Field



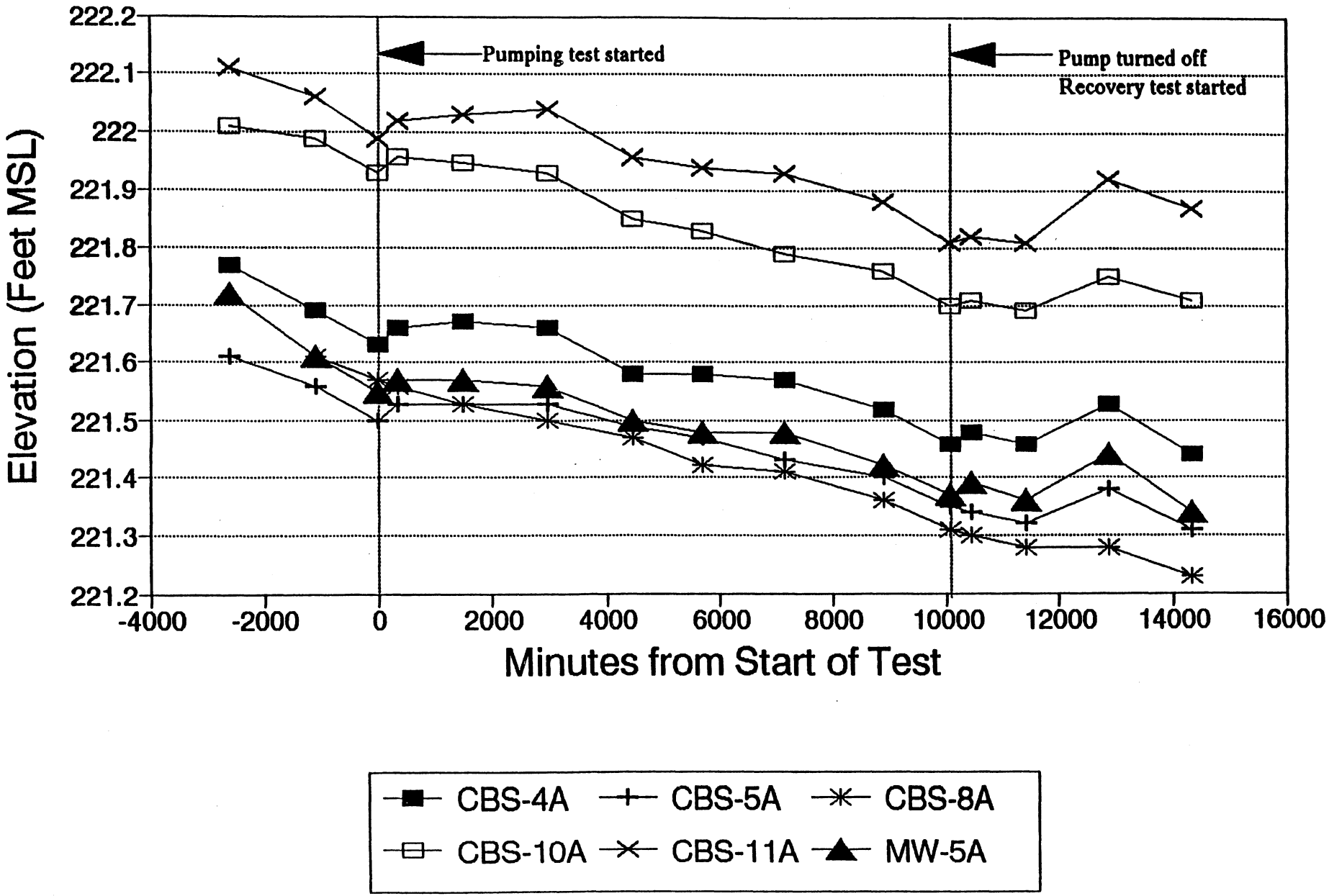
MW and STM Observation Wells
TAC-1A Aquifer Test/South Tacoma Field



Northern CBS Observation Wells
TAC-1A Aquifer Test/South Tacoma Field



Southern CBS Observation Wells
TAC-1A Aquifer Test/South Tacoma Field



Appendix HC-G

TAC 1A Aquifer Pumping Test
Data Analysis of Wells NMW-3C, NMW-5C, and TAC 89.5

Memo **Kennedy/Jenks/Chilton**

To File
From CHRIS EVENSEN
Project STF - Hydraulic Investigation
Subject Coordinates of TAC-1A

Sheet 1 of 1
Date 15 JUN 92
Job No. 916055

TIM LARSON, TACOMA public Utilities, (593-8204)

Said the Coordinates of TAC-1A are:

X 1,149,277

Y 686,844

$TAC1A_x := 1149277 \cdot ft$

$TAC1A_y := 686844 \cdot ft$

$NMW5C_x := 1146513.19 \cdot ft$

$NMW5C_y := 695231.71 \cdot ft$

$NMW3B_x := 1145698.02 \cdot ft$

$NMW3B_y := 691656.58 \cdot ft$

$NMW3C_x := 1145704.3 \cdot ft$

$NMW3C_y := 691660.72 \cdot ft$

$$d_{5c} := \sqrt{(TAC1A_x - NMW5C_x)^2 + (TAC1A_y - NMW5C_y)^2}$$

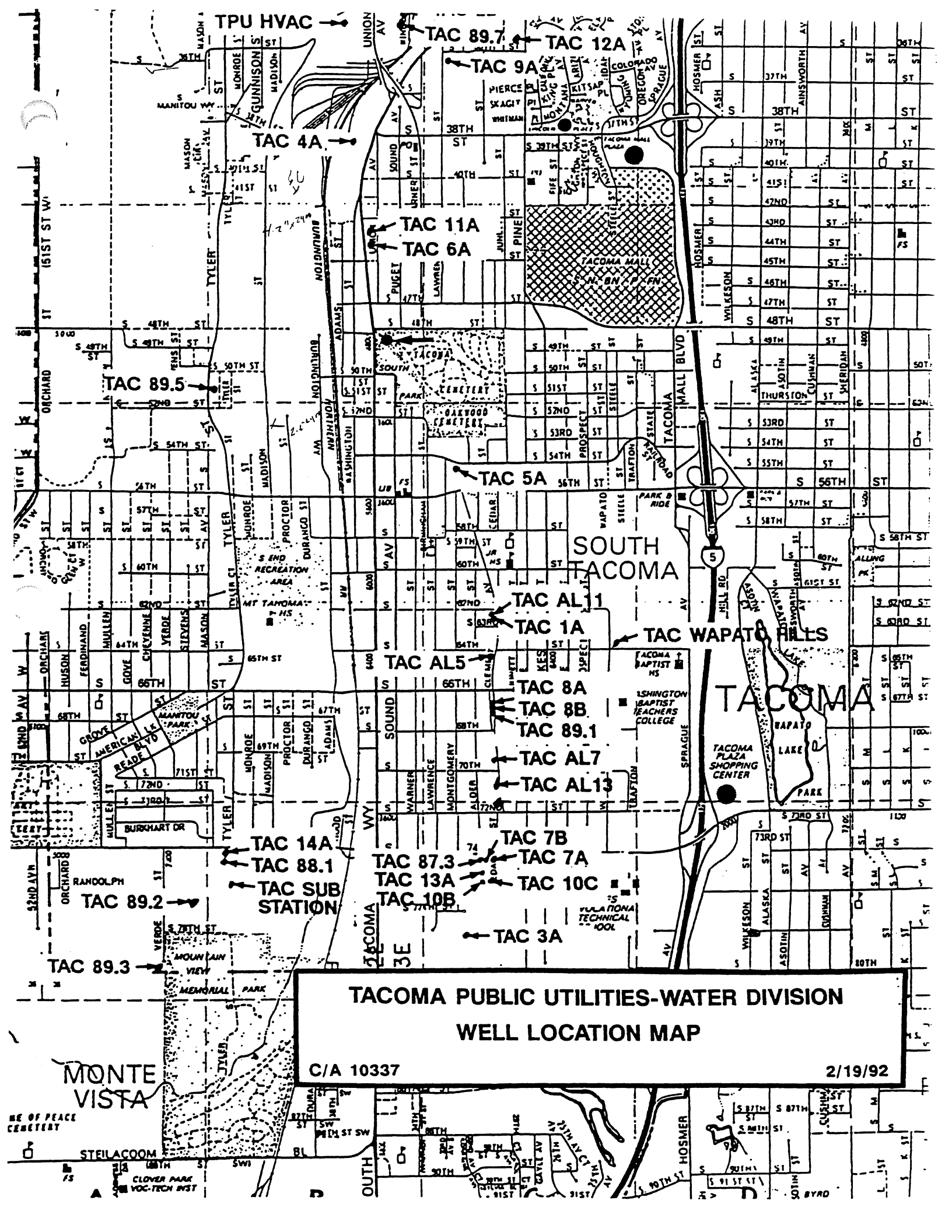
$d_{5c} = 8831.33 \cdot ft$

$$d_{3b} := \sqrt{(TAC1A_x - NMW3B_x)^2 + (TAC1A_y - NMW3B_y)^2}$$

$d_{3b} = 5997.5 \cdot ft$

$$d_{3c} := \sqrt{(TAC1A_x - NMW3C_x)^2 + (TAC1A_y - NMW3C_y)^2}$$

$d_{3c} = 5997.08 \cdot ft$


TPU HVAC
TAC 89.7
TAC 12A
TAC 9A
TAC 4A
TAC 11A
TAC 6A
TAC 89.5
TAC 5A
SOUTH TACOMA
TAC AL11
TAC 1A
TAC WAPATO HILLS
TAC AL5
TAC 8A
TAC 8B
TAC 89.1
TAC AL7
TAC AL13
TACOMA
TAC 14A
TAC 88.1
TAC SUB STATION
TAC 89.2
TAC 7B
TAC 87.3
TAC 7A
TAC 13A
TAC 10C
TAC 10B
TAC 3A
TAC 89.3
MONTE VISTA
TACOMA MALL
TACOMA PLAZA SHOPPING CENTER
WAPATO LAKE PARK
MT TAHOMA HS
S END RECREATION AREA
MANITOU PARK
MOUNTAIN VIEW MEMORIAL PARK
CLOVER PARK VOC-TECH INST
STEILACOOM
38TH ST
48TH ST
56TH ST
66TH ST
TACOMA MALL BLVD
HOSMER
TYLER
SOUND
PINE
PUGET
ADAMS
BURLINGTON
WASHINGTON
PROSPECT
STEELE
TRAFTON
SPRAGUE
WAPATO
ALASKA
ASOTIN
CUSHMAN
SHERIDAN
AINSWORTH
WILKESON
ORCHARD
MONROE
MADISON
PROCTOR
DURANGO
WARNER
LAWRENCE
MONTGOMERY
ALDER
CLEMENT
CEDAR
GUNNISON
MANITOU WY
BURKHART DR
RANDOLPH
HILL RD
PARK & RIDE
TACOMA BAPTIST HS
WASHINGTON BAPTIST TEACHERS COLLEGE
TACOMA TECHNICAL SCHOOL
TACOMA PUBLIC UTILITIES-WATER DIVISION
WELL LOCATION MAP
C/A 10337
2/19/92

Memo **Kennedy/Jenks/Chilton**

To File
From CHRIS Evensen
Project STF - HYDRAULIC INV.
Subject Coordinates of Tacoma Public Utility well TAC-1A + 89.5

Sheet 1 of 1
Date 13 July 92
Job No. 916055.09

TAC 1A

1149286.7
686845.8

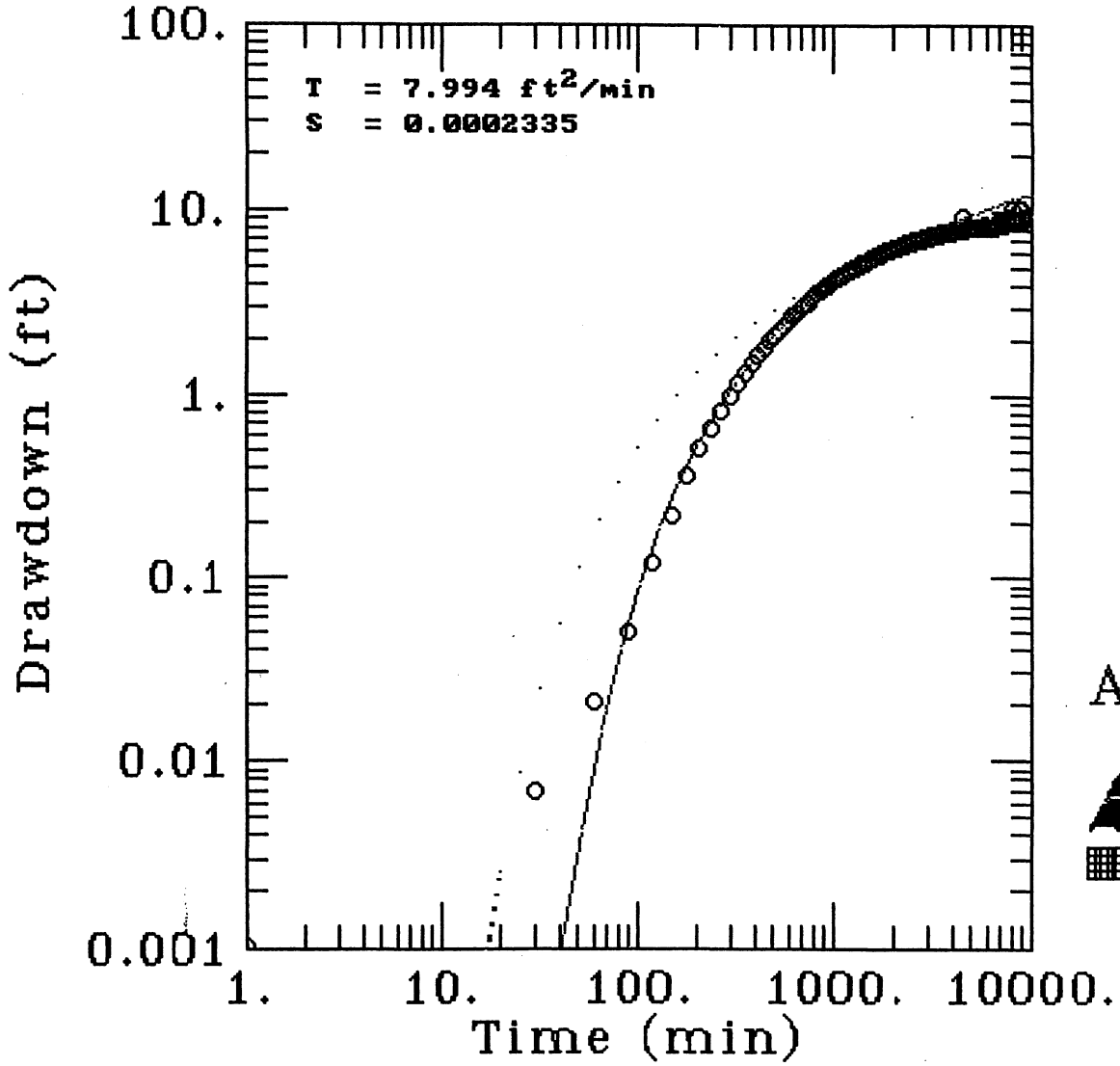
89.5 1144878.7
691667.3

$$d_{89.5} = \sqrt{(1149277ft - 1144878.7)^2 + (686844 - 691667.3)^2}$$

$$d_{89.5} = 6,527.58$$

DATA ANALYSIS
OF TAC 1A PUMPING TEST
FOR NMW-3C

TAC-1A TEST - DRAWDOWN NMW-3C



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

:<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V   R E S U L T S
Version 1.10

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TEST DESCRIPTION

ata set........... B:\NMW3C_DD.AQT
ata set title..... TAC-1A TEST - DRAWDOWN NMW-3C

nowns and Constants:
- No. of data points.................. 305
- Pumping rate........................ 401
- Radius (distance) to obs. well...... 5997
- Radius of pumped well casing........ 0.5
- Radius of pumped wellbore........... 0.5

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ANALYTICAL METHOD

heis (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.3229E+001	+/-	2.0070E-001
S =	1.4944E-004	+/-	5.1957E-006

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
- Number of residuals............... 305
- Number of estimated parameters.... 2
- Degrees of freedom................ 303
- Residual mean..................... -0.0129
- Residual standard deviation....... 0.4005
- Residual variance................. 0.1604

el Residuals:

Time	Observed	Calculated	Residual	Weight
1	0.001	0	0.001	1
29.998	0.007	0.019376	-0.012376	1

59.999	0.021	0.18197	-0.16097	1
89.997	0.05	0.42837	-0.37837	1
120	0.122	0.68951	-0.56751	1
150	0.223	0.9419	-0.7189	1
180	0.368	1.1789	-0.81085	1
210	0.512	1.3993	-0.88735	1
240	0.671	1.6042	-0.9332	1
270	0.837	1.7948	-0.95781	1
300	1.01	1.9727	-0.96267	1
330	1.183	2.1391	-0.95614	1
360	1.349	2.2954	-0.94645	1
390	1.515	2.4427	-0.92768	1
420	1.674	2.5818	-0.90776	1
450	1.833	2.7135	-0.88051	1
480	1.992	2.8386	-0.84663	1
510	2.151	2.9577	-0.80673	1
540	2.302	3.0713	-0.76934	1
570	2.447	3.1799	-0.73294	1
600	2.584	3.2839	-0.69995	1
630	2.728	3.3837	-0.65571	1
660	2.865	3.4796	-0.61458	1
690	2.995	3.5718	-0.57682	1
720	3.125	3.6607	-0.53571	1
750	3.248	3.7465	-0.49847	1
780	3.378	3.8293	-0.45131	1
810	3.493	3.9094	-0.41643	1
840	3.609	3.987	-0.37799	1
870	3.724	4.0622	-0.33816	1
900	3.84	4.1351	-0.29506	1
930	3.948	4.2059	-0.25785	1
960	4.049	4.2746	-0.22563	1
990	4.158	4.3415	-0.18352	1
1020	4.259	4.4066	-0.14761	1
1050	4.352	4.47	-0.11799	1
1080	4.439	4.5318	-0.09276	1
1110	4.533	4.592	-0.059003	1
1140	4.612	4.6508	-0.038777	1
1170	4.699	4.7082	-0.0091563	1
1200	4.771	4.7642	0.0067867	1
1230	4.858	4.819	0.039	1
1260	4.923	4.8726	0.050427	1
1290	4.995	4.925	0.070012	1
1320	5.067	4.9763	0.090709	1
1350	5.139	5.0265	0.11247	1
1380	5.204	5.0757	0.12825	1
1410	5.262	5.124	0.13802	1
1440	5.327	5.1713	0.15573	1
1470	5.399	5.2177	0.18134	1
1500	5.457	5.2632	0.19383	1
1530	5.515	5.3078	0.20716	1
1560	5.587	5.3517	0.2353	1
1590	5.645	5.3948	0.25022	1
1620	5.702	5.4371	0.2649	1
1650	5.767	5.4787	0.2883	1
1680	5.825	5.5196	0.30541	1
1710	5.876	5.5598	0.3162	1
1740	5.933	5.5994	0.33365	1
1770	5.984	5.6383	0.34573	1
1800	6.042	5.6766	0.36543	1
1830	6.085	5.7143	0.37073	1

1860	6.135	5.7514	0.3836	1
1890	6.179	5.788	0.39104	1
1920	6.222	5.824	0.39803	1
1950	6.258	5.8595	0.39854	1
1980	6.294	5.8944	0.39957	1
2010	6.33	5.9289	0.40109	1
2040	6.374	5.9629	0.4111	1
2070	6.403	5.9964	0.40659	1
2100	6.431	6.0295	0.40153	1
2130	6.46	6.0621	0.39792	1
2160	6.504	6.0943	0.40974	1
2190	6.533	6.126	0.40698	1
2220	6.561	6.1574	0.40364	1
2250	6.597	6.1883	0.4087	1
2280	6.634	6.2188	0.41515	1
2310	6.67	6.249	0.42098	1
2340	6.699	6.2788	0.42019	1
2370	6.735	6.3082	0.42676	1
2400	6.771	6.3373	0.43368	1
2430	6.8	6.3661	0.43395	1
2460	6.828	6.3944	0.43355	1
2490	6.865	6.4225	0.44249	1
2520	6.893	6.4502	0.44275	1
2550	6.922	6.4777	0.44432	1
2580	6.951	6.5048	0.44621	1
2610	6.987	6.5316	0.45539	1
2640	7.016	6.5581	0.45787	1
2670	7.038	6.5844	0.45363	1
2700	7.059	6.6103	0.44868	1
2730	7.088	6.636	0.45201	1
2760	7.117	6.6614	0.4556	1
2790	7.139	6.6865	0.45246	1
2820	7.161	6.7114	0.44958	1
2850	7.189	6.7361	0.45295	1
2880	7.211	6.7604	0.45057	1
2910	7.233	6.7846	0.44843	1
2940	7.254	6.8085	0.44554	1
2970	7.283	6.8321	0.45088	1
3000	7.305	6.8556	0.44944	1
3030	7.341	6.8788	0.46224	1
3060	7.363	6.9017	0.46125	1
3090	7.392	6.9245	0.46748	1
3120	7.413	6.9471	0.46592	1
3150	7.435	6.9694	0.46558	1
3180	7.457	6.9916	0.46543	1
3210	7.478	7.0135	0.46449	1
3240	7.5	7.0353	0.46475	1
3270	7.521	7.0568	0.4642	1
3300	7.543	7.0782	0.46484	1
3330	7.558	7.0993	0.45867	1
3360	7.572	7.1203	0.45168	1
3390	7.594	7.1411	0.45287	1
3420	7.608	7.1618	0.44625	1
3450	7.623	7.1822	0.44079	1
3480	7.637	7.2025	0.43451	1
3510	7.644	7.2226	0.4214	1
3540	7.659	7.2425	0.41645	1
3570	7.666	7.2623	0.40367	1
3600	7.673	7.282	0.39105	1
3630	7.688	7.3014	0.38658	1

3660	7.695	7.3207	0.37427	1
3690	7.702	7.3399	0.36212	1
3720	7.716	7.3589	0.35712	1
3750	7.731	7.3777	0.35326	1
3780	7.745	7.3964	0.34855	1
3810	7.76	7.415	0.34499	1
3840	7.767	7.4334	0.33356	1
3870	7.789	7.4517	0.33728	1
3900	7.803	7.4699	0.33313	1
3930	7.81	7.4879	0.32212	1
3960	7.825	7.5058	0.31924	1
3990	7.846	7.5235	0.3225	1
4020	7.868	7.5411	0.32688	1
4050	7.882	7.5586	0.32339	1
4080	7.897	7.576	0.32103	1
4110	7.919	7.5932	0.32579	1
4140	7.94	7.6103	0.32967	1
4170	7.947	7.6273	0.31968	1
4200	7.962	7.6442	0.3178	1
4230	7.976	7.661	0.31504	1
4260	7.991	7.6776	0.31339	1
4290	7.998	7.6941	0.30386	1
4320	8.005	7.7106	0.29444	1
4350	8.02	7.7269	0.29314	1
4380	8.027	7.7431	0.28394	1
4410	8.034	7.7591	0.27485	1
4440	8.056	7.7751	0.28087	1
4470	8.063	7.791	0.27199	1
4500	8.07	7.8068	0.26322	1
4530	9.225	7.8225	1.4025	1
4560	8.077	7.838	0.23897	1
4590	8.092	7.8535	0.2385	1
4620	8.099	7.8689	0.23013	1
4650	8.113	7.8841	0.22886	1
4680	8.128	7.8993	0.22868	1
4710	8.135	7.9144	0.2206	1
4740	8.15	7.9294	0.22061	1
4770	8.15	7.9443	0.20571	1
4800	8.164	7.9591	0.2049	1
4830	8.171	7.9738	0.19719	1
4860	8.178	7.9884	0.18956	1
4890	8.186	8.003	0.18302	1
4920	8.193	8.0174	0.17557	1
4950	8.2	8.0318	0.1682	1
4980	8.207	8.0461	0.16092	1
5010	8.214	8.0603	0.15373	1
5040	8.222	8.0744	0.14761	1
5070	8.222	8.0884	0.13358	1
5100	8.229	8.1024	0.12663	1
5130	8.243	8.1162	0.12676	1
5160	8.258	8.13	0.12797	1
5190	8.272	8.1437	0.12826	1
5220	8.279	8.1574	0.12163	1
5250	8.265	8.1709	0.094068	1
5280	8.258	8.1844	0.073587	1
5310	8.251	8.1978	0.053179	1
5340	8.251	8.2112	0.039846	1
5370	8.258	8.2244	0.033586	1
5400	8.272	8.2376	0.034398	1
5430	8.272	8.2507	0.021283	1

5460	8.265	8.2638	0.0012381	1
5490	8.258	8.2767	-0.018737	1
5520	8.265	8.2896	-0.024642	1
5550	8.287	8.3025	-0.015478	1
5580	8.316	8.3152	0.00075243	1
5610	8.337	8.3279	0.009051	1
5640	8.344	8.3406	0.0034164	1
5670	8.344	8.3532	-0.0091531	1
5700	8.352	8.3657	-0.013657	1
5730	8.359	8.3781	-0.019096	1
5760	8.337	8.3905	-0.053472	1
5790	8.626	8.4028	0.22322	1
5820	8.323	8.415	-0.092034	1
5850	8.337	8.4272	-0.090222	1
5880	8.308	8.4393	-0.13135	1
5910	8.301	8.4514	-0.15042	1
5940	8.294	8.4634	-0.16942	1
5970	8.294	8.4754	-0.18137	1
6000	8.294	8.4873	-0.19326	1
6030	8.294	8.4991	-0.20509	1
6060	8.301	8.5109	-0.20986	1
6090	8.301	8.5226	-0.22157	1
6120	8.308	8.5342	-0.22623	1
6150	8.316	8.5458	-0.22983	1
6180	8.323	8.5574	-0.23438	1
6210	8.337	8.5689	-0.23187	1
6240	8.337	8.5803	-0.24331	1
6270	8.352	8.5917	-0.23969	1
6300	8.352	8.603	-0.25102	1
6330	8.359	8.6143	-0.2553	1
6360	8.359	8.6255	-0.26652	1
6390	8.366	8.6367	-0.27069	1
6420	8.366	8.6478	-0.28181	1
6450	8.373	8.6589	-0.28588	1
6480	8.381	8.6699	-0.2889	1
6510	8.381	8.6809	-0.29987	1
6540	8.388	8.6918	-0.30379	1
6570	8.388	8.7027	-0.31466	1
6600	8.388	8.7135	-0.32548	1
6630	8.388	8.7243	-0.33626	1
6660	8.388	8.735	-0.34698	1
6690	8.395	8.7457	-0.35066	1
6720	8.438	8.7563	-0.31829	1
6750	8.496	8.7669	-0.27087	1
6780	8.684	8.7774	-0.093411	1
6810	8.749	8.7879	-0.038903	1
6840	8.64	8.7983	-0.15835	1
6870	8.619	8.8088	-0.18975	1
6900	8.59	8.8191	-0.22911	1
6930	8.547	8.8294	-0.28242	1
6960	8.51	8.8397	-0.32969	1
6990	8.496	8.8499	-0.35391	1
7020	8.482	8.8601	-0.3781	1
7050	8.482	8.8702	-0.38824	1
7080	8.474	8.8803	-0.40633	1
7110	8.482	8.8904	-0.40839	1
7140	8.482	8.9004	-0.4184	1
7170	8.482	8.9104	-0.42837	1
7200	8.46	8.9203	-0.4603	1
7230	8.409	8.9302	-0.52119	1

7260	8.409	8.94	-0.53104	1
7290	8.395	8.9498	-0.55485	1
7320	8.409	8.9596	-0.55062	1
7350	9.11	8.9693	0.14065	1
7380	9.146	8.979	0.16696	1
7410	8.864	8.9887	-0.12469	1
7440	8.727	8.9983	-0.27131	1
7470	8.698	9.0079	-0.30988	1
7500	8.691	9.0174	-0.32642	1
7530	8.698	9.0269	-0.32892	1
7560	8.727	9.0364	-0.30938	1
7590	8.749	9.0458	-0.29681	1
7620	8.734	9.0552	-0.3212	1
7650	8.727	9.0646	-0.33755	1
7680	8.713	9.0739	-0.36087	1
7710	8.691	9.0832	-0.39215	1
7740	8.785	9.0924	-0.3074	1
7770	8.879	9.1016	-0.22261	1
7800	8.864	9.1108	-0.24678	1
7830	9.333	9.1199	0.21308	1
7860	8.879	9.129	-0.25003	1
7890	8.944	9.1381	-0.1941	1
7920	8.864	9.1471	-0.28314	1
7950	8.871	9.1561	-0.28514	1
7980	8.944	9.1651	-0.22111	1
8010	8.958	9.174	-0.21605	1
8040	8.922	9.183	-0.26095	1
8070	9.023	9.1918	-0.16882	1
8100	10.192	9.2007	0.99134	1
8130	8.879	9.2095	-0.33047	1
8160	9.037	9.2182	-0.18124	1
8190	8.763	9.227	-0.46399	1
8220	8.828	9.2357	-0.4077	1
8250	8.857	9.2444	-0.38738	1
8280	8.871	9.253	-0.38203	1
8310	8.864	9.2616	-0.39765	1
8340	8.886	9.2702	-0.38423	1
8370	8.857	9.2788	-0.42179	1
8400	8.857	9.2873	-0.43032	1
8430	8.835	9.2958	-0.46081	1
8460	8.843	9.3043	-0.46128	1
8490	8.85	9.3127	-0.46272	1
8520	8.871	9.3211	-0.45012	1
8550	8.879	9.3295	-0.4505	1
8580	8.936	9.3379	-0.40185	1
8610	8.929	9.3462	-0.41717	1
8640	8.922	9.3545	-0.43246	1
8670	8.922	9.3627	-0.44073	1
8700	8.936	9.371	-0.43496	1
8730	8.972	9.3792	-0.40717	1
8760	9.052	9.3874	-0.33535	1
8790	10.142	9.3955	0.7465	1
8820	10.351	9.4036	0.94737	1
8850	8.929	9.4117	-0.48272	1
8880	8.98	9.4198	-0.43979	1
8910	9.095	9.4278	-0.33284	1
8940	10.358	9.4359	0.92215	1
8970	9.167	9.4438	-0.27684	1
9000	9.276	9.4518	-0.17581	1
9030	9.175	9.4597	-0.28475	1

9060	8.915	9.4677	-0.55266	1
9090	8.936	9.4755	-0.53954	1
9120	9.016	9.4834	-0.4674	1

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RESULTS FROM VISUAL CURVE MATCHING

'ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	7.9941E+000
S	=	2.3346E-004

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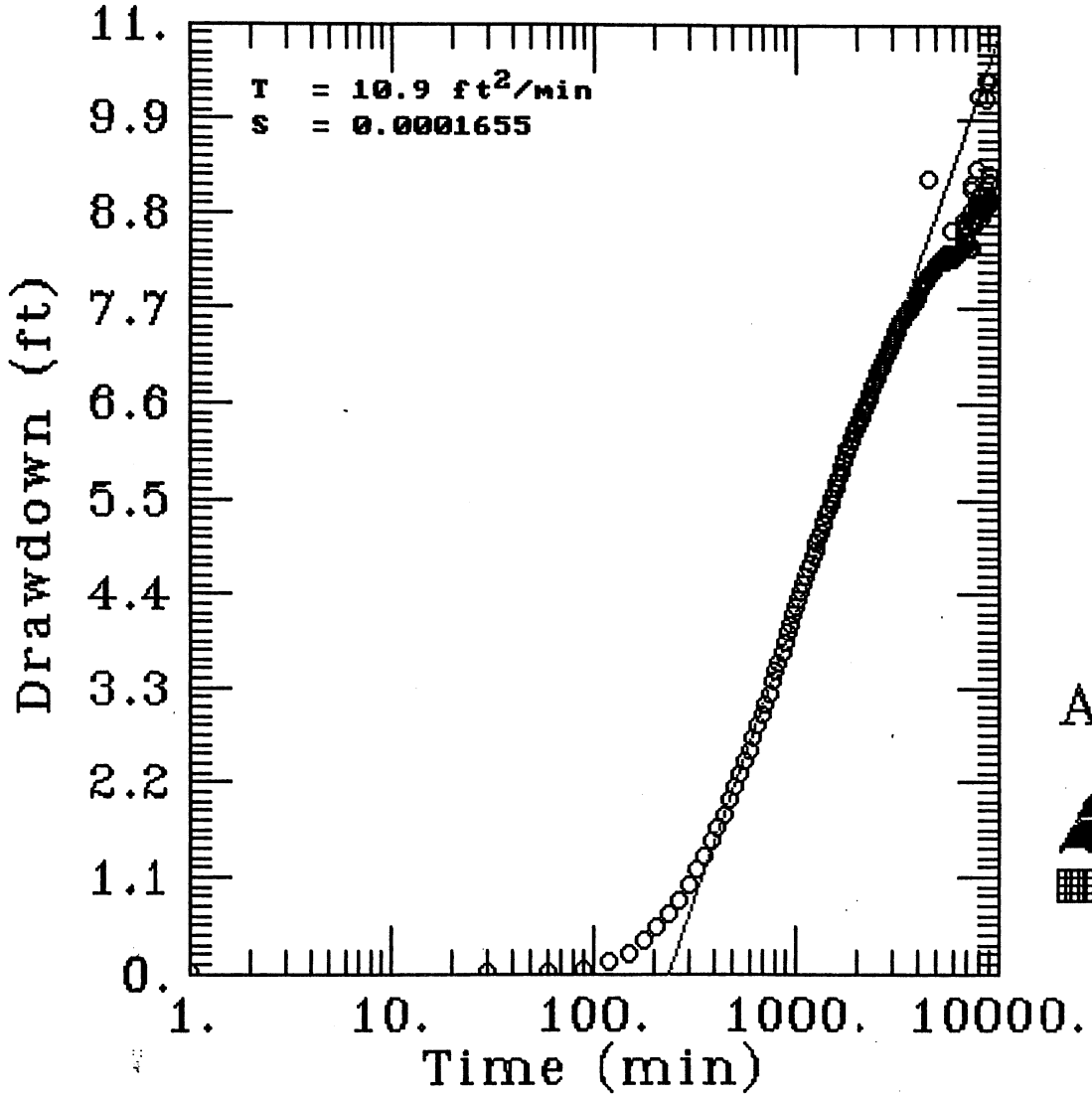
TAC-1A TEST - DRAWDOWN NMW-3C



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V R E S U L T S
Version 1.10

)7/29/92 15:57:07

TEST DESCRIPTION

)ata set........... B:\NMW3C_DD.AQT
)ata set title..... TAC-1A TEST - DRAWDOWN NMW-3C

:nowns and Constants:
- No. of data points.................. 305
- Pumping rate........................ 401
- Radius (distance) to obs. well...... 5997
- Radius of pumped well casing........ 0.5
- Radius of pumped wellbore........... 0.5

ANALYTICAL METHOD

:ooper-Jacob (Confined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	1.6466E+001	+/-	3.1608E-001
S	=	8.3616E-005	+/-	4.6536E-006

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
- Number of residuals............... 305
- Number of estimated parameters.... 2
- Degrees of freedom................ 303
- Residual mean..................... 3.917E-009
- Residual standard deviation....... 0.6877
- Residual variance................. 0.473

r ̄ ̄l Residuals:

Time	Observed	Calculated	Residual	Weight
1	0.001	-8.5251	8.5261	1
29.998	0.007	-1.9328	1.9398	1

59.999	0.021	-0.58924	0.61024	1
89.997	0.05	0.19663	-0.14663	1
120	0.122	0.75427	-0.63227	1
150	0.223	1.1868	-0.96378	1
180	0.368	1.5402	-1.1722	1
210	0.512	1.839	-1.327	1
240	0.671	2.0978	-1.4268	1
270	0.837	2.3261	-1.4891	1
300	1.01	2.5303	-1.5203	1
330	1.183	2.715	-1.532	1
360	1.349	2.8837	-1.5347	1
390	1.515	3.0388	-1.5238	1
420	1.674	3.1825	-1.5085	1
450	1.833	3.3162	-1.4832	1
480	1.992	3.4413	-1.4493	1
510	2.151	3.5588	-1.4078	1
540	2.302	3.6696	-1.3676	1
570	2.447	3.7744	-1.3274	1
600	2.584	3.8738	-1.2898	1
630	2.728	3.9684	-1.2404	1
660	2.865	4.0585	-1.1935	1
690	2.995	4.1447	-1.1497	1
720	3.125	4.2272	-1.1022	1
750	3.248	4.3063	-1.0583	1
780	3.378	4.3823	-1.0043	1
810	3.493	4.4555	-0.96249	1
840	3.609	4.526	-0.91698	1
870	3.724	4.594	-0.86999	1
900	3.84	4.6597	-0.8197	1
930	3.948	4.7233	-0.77526	1
960	4.049	4.7848	-0.7358	1
990	4.158	4.8444	-0.68644	1
1020	4.259	4.9023	-0.64331	1
1050	4.352	4.9585	-0.60649	1
1080	4.439	5.0131	-0.57409	1
1110	4.533	5.0662	-0.5332	1
1140	4.612	5.1179	-0.50589	1
1170	4.699	5.1682	-0.46923	1
1200	4.771	5.2173	-0.44631	1
1230	4.858	5.2652	-0.40717	1
1260	4.923	5.3119	-0.38888	1
1290	4.995	5.3575	-0.36249	1
1320	5.067	5.402	-0.33505	1
1350	5.139	5.4456	-0.3066	1
1380	5.204	5.4882	-0.2842	1
1410	5.262	5.5299	-0.26789	1
1440	5.327	5.5707	-0.2437	1
1470	5.399	5.6107	-0.21166	1
1500	5.457	5.6498	-0.19282	1
1530	5.515	5.6882	-0.1732	1
1560	5.587	5.7258	-0.13884	1
1590	5.645	5.7628	-0.11776	1
1620	5.702	5.799	-0.09699	1
1650	5.767	5.8346	-0.067557	1
1680	5.825	5.8695	-0.044481	1
1710	5.876	5.9038	-0.027787	1
1740	5.933	5.9375	-0.0044977	1
1770	5.984	5.9706	0.013369	1
1800	6.042	6.0032	0.038793	1
1830	6.085	6.0352	0.049754	1

1860	6.135	6.0668	0.068237	1
1890	6.179	6.0978	0.081225	1
1920	6.222	6.1283	0.093699	1
1950	6.258	6.1584	0.099648	1
1980	6.294	6.1879	0.10606	1
2010	6.33	6.2171	0.11291	1
2040	6.374	6.2458	0.12819	1
2070	6.403	6.2741	0.1289	1
2100	6.431	6.302	0.12901	1
2130	6.46	6.3295	0.13051	1
2160	6.504	6.3566	0.1474	1
2190	6.533	6.3833	0.14967	1
2220	6.561	6.4097	0.1513	1
2250	6.597	6.4357	0.16128	1
2280	6.634	6.4614	0.17261	1
2310	6.67	6.4867	0.18327	1
2340	6.699	6.5117	0.18726	1
2370	6.735	6.5364	0.19857	1
2400	6.771	6.5608	0.21019	1
2430	6.8	6.5849	0.21511	1
2460	6.828	6.6087	0.21933	1
2490	6.865	6.6322	0.23283	1
2520	6.893	6.6554	0.23762	1
2550	6.922	6.6783	0.24368	1
2580	6.951	6.701	0.25001	1
2610	6.987	6.7234	0.2636	1
2640	7.016	6.7455	0.27045	1
2670	7.038	6.7674	0.27055	1
2700	7.059	6.7891	0.26989	1
2730	7.088	6.8105	0.27748	1
2760	7.117	6.8317	0.28529	1
2790	7.139	6.8527	0.28634	1
2820	7.161	6.8734	0.28761	1
2850	7.189	6.8939	0.2951	1
2880	7.211	6.9142	0.2968	1
2910	7.233	6.9343	0.29871	1
2940	7.254	6.9542	0.29983	1
2970	7.283	6.9738	0.30916	1
3000	7.305	6.9933	0.31168	1
3030	7.341	7.0126	0.32839	1
3060	7.363	7.0317	0.33129	1
3090	7.392	7.0506	0.34138	1
3120	7.413	7.0693	0.34366	1
3150	7.435	7.0879	0.34711	1
3180	7.457	7.1063	0.35074	1
3210	7.478	7.1245	0.35354	1
3240	7.5	7.1425	0.35751	1
3270	7.521	7.1604	0.36064	1
3300	7.543	7.1781	0.36494	1
3330	7.558	7.1956	0.3624	1
3360	7.572	7.213	0.35902	1
3390	7.594	7.2302	0.36379	1
3420	7.608	7.2473	0.36071	1
3450	7.623	7.2642	0.35878	1
3480	7.637	7.281	0.356	1
3510	7.644	7.2976	0.34636	1
3540	7.659	7.3141	0.34487	1
3570	7.666	7.3305	0.33551	1
3600	7.673	7.3467	0.32629	1
3630	7.688	7.3628	0.3252	1

3660	7.695	7.3787	0.31625	1
3690	7.702	7.3946	0.30743	1
3720	7.716	7.4103	0.30573	1
3750	7.731	7.4258	0.30517	1
3780	7.745	7.4413	0.30372	1
3810	7.76	7.4566	0.3034	1
3840	7.767	7.4718	0.2952	1
3870	7.789	7.4869	0.30211	1
3900	7.803	7.5019	0.30115	1
3930	7.81	7.5167	0.29329	1
3960	7.825	7.5314	0.29355	1
3990	7.846	7.5461	0.29992	1
4020	7.868	7.5606	0.30741	1
4050	7.882	7.575	0.307	1
4080	7.897	7.5893	0.30769	1
4110	7.919	7.6035	0.31549	1
4140	7.94	7.6176	0.32239	1
4170	7.947	7.6316	0.3154	1
4200	7.962	7.6455	0.3165	1
4230	7.976	7.6593	0.31671	1
4260	7.991	7.673	0.31801	1
4290	7.998	7.6866	0.31141	1
4320	8.005	7.7001	0.3049	1
4350	8.02	7.7135	0.30649	1
4380	8.027	7.7268	0.30017	1
4410	8.034	7.7401	0.29394	1
4440	8.056	7.7532	0.3028	1
4470	8.063	7.7663	0.29674	1
4500	8.07	7.7792	0.29078	1
4530	9.225	7.7921	1.4329	1
4560	8.077	7.8049	0.27211	1
4590	8.092	7.8176	0.2744	1
4620	8.099	7.8302	0.26877	1
4650	8.113	7.8428	0.27022	1
4680	8.128	7.8552	0.27276	1
4710	8.135	7.8676	0.26737	1
4740	8.15	7.8799	0.27007	1
4770	8.15	7.8922	0.25784	1
4800	8.164	7.9043	0.25969	1
4830	8.171	7.9164	0.25461	1
4860	8.178	7.9284	0.24961	1
4890	8.186	7.9403	0.24568	1
4920	8.193	7.9522	0.24082	1
4950	8.2	7.964	0.23604	1
4980	8.207	7.9757	0.23133	1
5010	8.214	7.9873	0.22669	1
5040	8.222	7.9989	0.22312	1
5070	8.222	8.0104	0.21161	1
5100	8.229	8.0218	0.20718	1
5130	8.243	8.0332	0.20981	1
5160	8.258	8.0445	0.21351	1
5190	8.272	8.0557	0.21627	1
5220	8.279	8.0669	0.2121	1
5250	8.265	8.078	0.18699	1
5280	8.258	8.0891	0.16895	1
5310	8.251	8.1	0.15097	1
5340	8.251	8.111	0.14005	1
5370	8.258	8.1218	0.13619	1
5400	8.272	8.1326	0.13939	1
5430	8.272	8.1433	0.12865	1

5460	8.265	8.154	0.11097	1
5490	8.258	8.1646	0.093352	1
5520	8.265	8.1752	0.089789	1
5550	8.287	8.1857	0.10128	1
5580	8.316	8.1962	0.11983	1
5610	8.337	8.2066	0.13044	1
5640	8.344	8.2169	0.1271	1
5670	8.344	8.2272	0.11682	1
5700	8.352	8.2374	0.11459	1
5730	8.359	8.2476	0.11142	1
5760	8.337	8.2577	0.079297	1
5790	8.626	8.2678	0.35823	1
5820	8.323	8.2778	0.045212	1
5850	8.337	8.2878	0.049247	1
5880	8.308	8.2977	0.010333	1
5910	8.301	8.3075	-0.0065314	1
5940	8.294	8.3173	-0.023345	1
5970	8.294	8.3271	-0.03311	1
6000	8.294	8.3368	-0.042826	1
6030	8.294	8.3465	-0.052493	1
6060	8.301	8.3561	-0.055112	1
6090	8.301	8.3657	-0.064684	1
6120	8.308	8.3752	-0.067208	1
6150	8.316	8.3847	-0.068686	1
6180	8.323	8.3941	-0.071118	1
6210	8.337	8.4035	-0.066504	1
6240	8.337	8.4128	-0.075846	1
6270	8.352	8.4221	-0.070142	1
6300	8.352	8.4314	-0.079394	1
6330	8.359	8.4406	-0.081602	1
6360	8.359	8.4498	-0.090766	1
6390	8.366	8.4589	-0.092887	1
6420	8.366	8.468	-0.10197	1
6450	8.373	8.477	-0.104	1
6480	8.381	8.486	-0.105	1
6510	8.381	8.4949	-0.11395	1
6540	8.388	8.5039	-0.11586	1
6570	8.388	8.5127	-0.12473	1
6600	8.388	8.5216	-0.13356	1
6630	8.388	8.5304	-0.14235	1
6660	8.388	8.5391	-0.1511	1
6690	8.395	8.5478	-0.15281	1
6720	8.438	8.5565	-0.11849	1
6750	8.496	8.5651	-0.069121	1
6780	8.684	8.5737	0.11028	1
6810	8.749	8.5823	0.16673	1
6840	8.64	8.5908	0.049206	1
6870	8.619	8.5993	0.019724	1
6900	8.59	8.6077	-0.017721	1
6930	8.547	8.6161	-0.069131	1
6960	8.51	8.6245	-0.1145	1
6990	8.496	8.6328	-0.13684	1
7020	8.482	8.6411	-0.15914	1
7050	8.482	8.6494	-0.16741	1
7080	8.474	8.6576	-0.18364	1
7110	8.482	8.6658	-0.18383	1
7140	8.482	8.674	-0.19199	1
7170	8.482	8.6821	-0.20012	1
7200	8.46	8.6902	-0.23021	1
7230	8.409	8.6983	-0.28927	1

7260	8.409	8.7063	-0.2973	1
7290	8.395	8.7143	-0.31929	1
7320	8.409	8.7223	-0.31325	1
7350	9.11	8.7302	0.37982	1
7380	9.146	8.7381	0.40793	1
7410	8.864	8.7459	0.11806	1
7440	8.727	8.7538	-0.026768	1
7470	8.698	8.7616	-0.063568	1
7500	8.691	8.7693	-0.078337	1
7530	8.698	8.7771	-0.079074	1
7560	8.727	8.7848	-0.057781	1
7590	8.749	8.7925	-0.043457	1
7620	8.734	8.8001	-0.066103	1
7650	8.727	8.8077	-0.080719	1
7680	8.713	8.8153	-0.10231	1
7710	8.691	8.8229	-0.13186	1
7740	8.785	8.8304	-0.045389	1
7770	8.879	8.8379	0.041112	1
7800	8.864	8.8454	0.018643	1
7830	9.333	8.8528	0.4802	1
7860	8.879	8.8602	0.018791	1
7890	8.944	8.8676	0.076407	1
7920	8.864	8.8749	-0.010949	1
7950	8.871	8.8823	-0.011277	1
7980	8.944	8.8896	0.054422	1
8010	8.958	8.8969	0.06115	1
8040	8.922	8.9041	0.017903	1
8070	9.023	8.9113	0.11168	1
8100	10.192	8.9185	1.2735	1
8130	8.879	8.9257	-0.046673	1
8160	9.037	8.9328	0.10419	1
8190	8.763	8.9399	-0.17693	1
8220	8.828	8.947	-0.11901	1
8250	8.857	8.9541	-0.097073	1
8280	8.871	8.9611	-0.090109	1
8310	8.864	8.9681	-0.10412	1
8340	8.886	8.9751	-0.089103	1
8370	8.857	8.9821	-0.12506	1
8400	8.857	8.989	-0.132	1
8430	8.835	8.9959	-0.16091	1
8460	8.843	9.0028	-0.15979	1
8490	8.85	9.0097	-0.15965	1
8520	8.871	9.0165	-0.14549	1
8550	8.879	9.0233	-0.1443	1
8580	8.936	9.0301	-0.094093	1
8610	8.929	9.0369	-0.10786	1
8640	8.922	9.0436	-0.1216	1
8670	8.922	9.0503	-0.12832	1
8700	8.936	9.057	-0.12101	1
8730	8.972	9.0637	-0.091686	1
8760	9.052	9.0703	-0.018335	1
8790	10.142	9.077	1.065	1
8820	10.351	9.0836	1.2674	1
8850	8.929	9.0901	-0.16115	1
8880	8.98	9.0967	-0.11671	1
8910	9.095	9.1032	-0.0082436	1
8940	10.358	9.1098	1.2482	1
8970	9.167	9.1163	0.050748	1
9000	9.276	9.1227	0.15328	1
9030	9.175	9.1292	0.045826	1

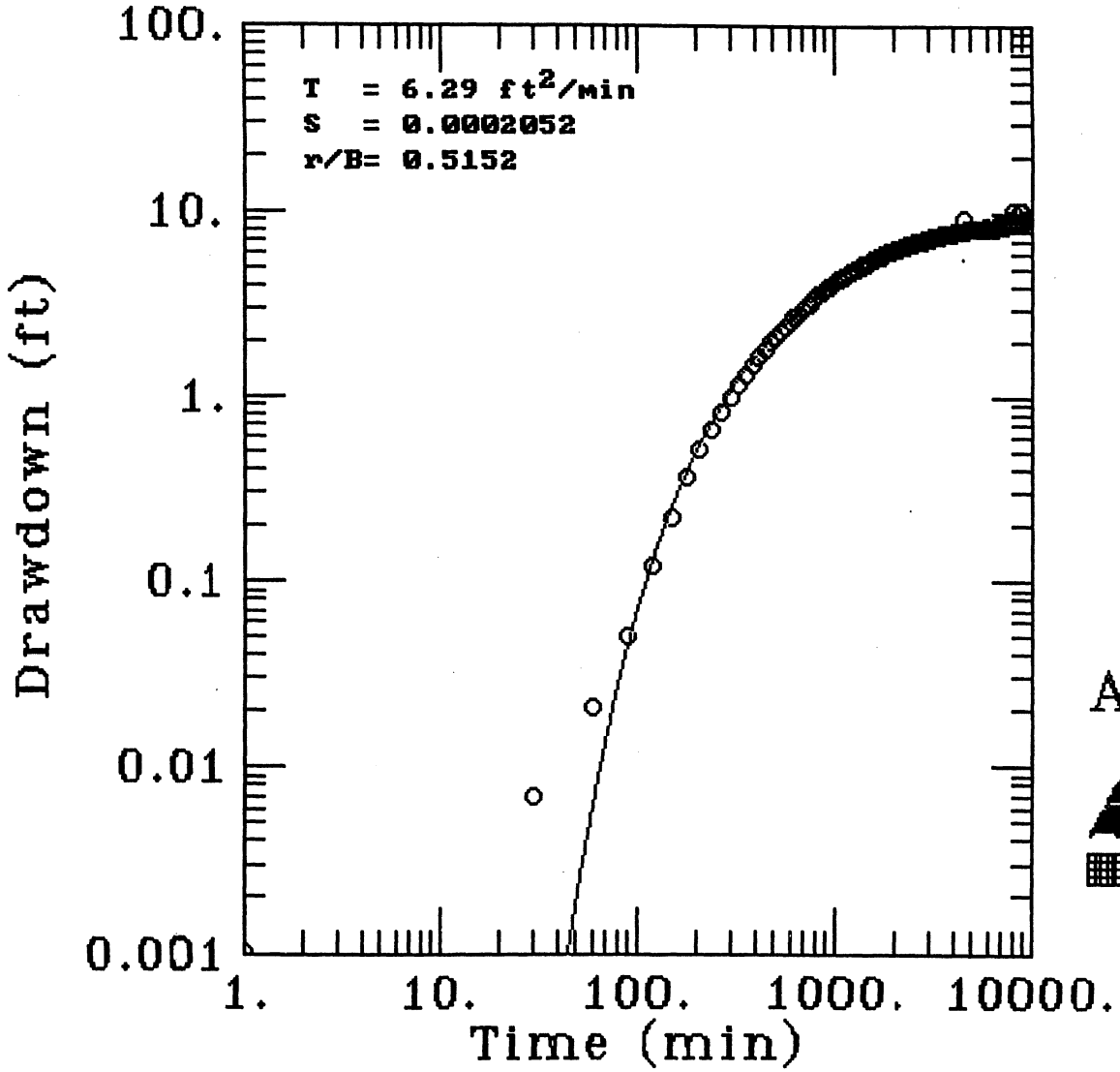
9060	8.915	9.1356	-0.2206	1
9090	8.936	9.142	-0.20601	1
9120	9.016	9.1484	-0.1324	1

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	1.0896E+001
S	=	1.6547E-004

TAC-1A TEST - DRAWDOWN NMW-3C



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

)7/29/92 16:15:36

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TEST DESCRIPTION

)ata set........... B:\NMW3C_DD.AQT
)ata set title..... TAC-1A TEST - DRAWDOWN NMW-3C

:nowns and Constants:
- No. of data points.................. 305
- Pumping rate........................ 401
- Radius (distance) to obs. well...... 5997
- Radius of pumped well casing........ 0.5
- Radius of pumped wellbore........... 0.5

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ANALYTICAL METHOD

[antush (Leaky Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	6.2903E+000	+/-	2.0979E-001
S =	2.0517E-004	+/-	2.0547E-006
r/B=	5.1517E-001	+/-	2.0816E-002

NALYSIS OF MODEL RESIDUALS

'esidual = calculated - observed
'eighted residual = residual * weight

'eighted Residual Statistics:
- Number of residuals............... 305
- Number of estimated parameters.... 3
- Degrees of freedom................ 302
- Residual mean..................... -0.001849
- Residual standard deviation....... 0.2124
- Residual variance................. 0.04511

Residuals:

Time	Observed	Calculated	Residual	Weight
1	0.001	0	0.001	1

29.998	0.007	2.6767E-005	0.0069732	1
59.999	0.021	0.0065685	0.014432	1
89.997	0.05	0.046964	0.0030363	1
120	0.122	0.13322	-0.011218	1
150	0.223	0.25724	-0.034245	1
180	0.368	0.40707	-0.039066	1
210	0.512	0.57275	-0.060752	1
240	0.671	0.74714	-0.076145	1
270	0.837	0.92538	-0.08838	1
300	1.01	1.1042	-0.094213	1
330	1.183	1.2815	-0.098489	1
360	1.349	1.4558	-0.10683	1
390	1.515	1.6264	-0.11137	1
420	1.674	1.7926	-0.11857	1
450	1.833	1.9541	-0.12113	1
480	1.992	2.1109	-0.11894	1
510	2.151	2.2629	-0.11194	1
540	2.302	2.4102	-0.10818	1
570	2.447	2.5528	-0.10578	1
600	2.584	2.6908	-0.10683	1
630	2.728	2.8245	-0.096494	1
660	2.865	2.9539	-0.088921	1
690	2.995	3.0793	-0.084261	1
720	3.125	3.2007	-0.07568	1
750	3.248	3.3183	-0.070342	1
780	3.378	3.4324	-0.054395	1
810	3.493	3.543	-0.04999	1
840	3.609	3.6503	-0.041267	1
870	3.724	3.7544	-0.030365	1
900	3.84	3.8554	-0.015427	1
930	3.948	3.9536	-0.0055801	1
960	4.049	4.0489	6.1142E-005	1
990	4.158	4.1416	0.016381	1
1020	4.259	4.2317	0.027273	1
1050	4.352	4.3194	0.032634	1
1080	4.439	4.4046	0.034364	1
1110	4.533	4.4876	0.045354	1
1140	4.612	4.5685	0.04354	1
1170	4.699	4.6472	0.051829	1
1200	4.771	4.7239	0.047131	1
1230	4.858	4.7986	0.059379	1
1260	4.923	4.8715	0.051503	1
1290	4.995	4.9426	0.052424	1
1320	5.067	5.0119	0.055086	1
1350	5.139	5.0796	0.059427	1
1380	5.204	5.1456	0.058379	1
1410	5.262	5.2101	0.051894	1
1440	5.327	5.2731	0.053918	1
1470	5.399	5.3346	0.064393	1
1500	5.457	5.3947	0.062276	1
1530	5.515	5.4535	0.061521	1
1560	5.587	5.5109	0.076077	1
1590	5.645	5.5671	0.077908	1
1620	5.702	5.622	0.079972	1
1650	5.767	5.6758	0.091226	1
1680	5.825	5.7284	0.096638	1
1710	5.876	5.7798	0.096171	1
1740	5.933	5.8302	0.10279	1
1770	5.984	5.8795	0.10446	1
1800	6.042	5.9278	0.11415	1

1830	6.085	5.9752	0.10983	1
1860	6.135	6.0215	0.11348	1
1890	6.179	6.0669	0.11206	1
1920	6.222	6.1115	0.11055	1
1950	6.258	6.1551	0.10292	1
1980	6.294	6.1978	0.096152	1
2010	6.33	6.2398	0.090214	1
2040	6.374	6.2809	0.093089	1
2070	6.403	6.3212	0.081755	1
2100	6.431	6.3608	0.070186	1
2130	6.46	6.3996	0.060367	1
2160	6.504	6.4377	0.066272	1
2190	6.533	6.4751	0.057892	1
2220	6.561	6.5118	0.049199	1
2250	6.597	6.5478	0.04918	1
2280	6.634	6.5832	0.050817	1
2310	6.67	6.6179	0.052096	1
2340	6.699	6.652	0.046998	1
2370	6.735	6.6855	0.049506	1
2400	6.771	6.7184	0.052608	1
2430	6.8	6.7507	0.049292	1
2460	6.828	6.7825	0.045538	1
2490	6.865	6.8137	0.051337	1
2520	6.893	6.8443	0.048675	1
2550	6.922	6.8745	0.047537	1
2580	6.951	6.9041	0.046915	1
2610	6.987	6.9332	0.053795	1
2640	7.016	6.9618	0.054165	1
2670	7.038	6.99	0.048014	1
2700	7.059	7.0177	0.041333	1
2730	7.088	7.0449	0.043109	1
2760	7.117	7.0717	0.045333	1
2790	7.139	7.098	0.040997	1
2820	7.161	7.1239	0.037088	1
2850	7.189	7.1494	0.039598	1
2880	7.211	7.1745	0.036518	1
2910	7.233	7.1992	0.033842	1
2940	7.254	7.2234	0.030557	1
2970	7.283	7.2473	0.03566	1
3000	7.305	7.2709	0.034136	1
3030	7.341	7.294	0.046983	1
3060	7.363	7.3168	0.046192	1
3090	7.392	7.3392	0.052753	1
3120	7.413	7.3613	0.051661	1
3150	7.435	7.3831	0.05191	1
3180	7.457	7.4045	0.052491	1
3210	7.478	7.4256	0.052398	1
3240	7.5	7.4464	0.053626	1
3270	7.521	7.4668	0.054167	1
3300	7.543	7.487	0.056015	1
3330	7.558	7.5068	0.051165	1
3360	7.572	7.5264	0.04561	1
3390	7.594	7.5457	0.048345	1
3420	7.608	7.5646	0.043366	1
3450	7.623	7.5833	0.039664	1
3480	7.637	7.6018	0.035236	1
3510	7.644	7.6199	0.024077	1
3540	7.659	7.6378	0.021181	1
3570	7.666	7.6555	0.010544	1
3600	7.673	7.6728	0.00016026	1

3630	7.688	7.69	-0.0019723	1
3660	7.695	7.7069	-0.011861	1
3690	7.702	7.7235	-0.02151	1
3720	7.716	7.7399	-0.023923	1
3750	7.731	7.7561	-0.025104	1
3780	7.745	7.7721	-0.027057	1
3810	7.76	7.7878	-0.027788	1
3840	7.767	7.8033	-0.036299	1
3870	7.789	7.8186	-0.029593	1
3900	7.803	7.8337	-0.030677	1
3930	7.81	7.8486	-0.038551	1
3960	7.825	7.8632	-0.038221	1
3990	7.846	7.8777	-0.031691	1
4020	7.868	7.892	-0.023963	1
4050	7.882	7.906	-0.024039	1
4080	7.897	7.9199	-0.022926	1
4110	7.919	7.9336	-0.014624	1
4140	7.94	7.9471	-0.0071375	1
4170	7.947	7.9605	-0.01347	1
4200	7.962	7.9736	-0.011625	1
4230	7.976	7.9866	-0.010602	1
4260	7.991	7.9994	-0.0084086	1
4290	7.998	8.012	-0.014045	1
4320	8.005	8.0245	-0.019515	1
4350	8.02	8.0368	-0.016819	1
4380	8.027	8.049	-0.021962	1
4410	8.034	8.0609	-0.026946	1
4440	8.056	8.0728	-0.016774	1
4470	8.063	8.0844	-0.021448	1
4500	8.07	8.096	-0.02597	1
4530	9.225	8.1073	1.1177	1
4560	8.077	8.1186	-0.041571	1
4590	8.092	8.1297	-0.037653	1
4620	8.099	8.1406	-0.041594	1
4650	8.113	8.1514	-0.038394	1
4680	8.128	8.1621	-0.034057	1
4710	8.135	8.1726	-0.037584	1
4740	8.15	8.183	-0.032978	1
4770	8.15	8.1932	-0.04324	1
4800	8.164	8.2034	-0.039373	1
4830	8.171	8.2134	-0.042378	1
4860	8.178	8.2233	-0.045258	1
4890	8.186	8.233	-0.047014	1
4920	8.193	8.2426	-0.049649	1
4950	8.2	8.2522	-0.052164	1
4980	8.207	8.2616	-0.05456	1
5010	8.214	8.2708	-0.056841	1
5040	8.222	8.28	-0.058007	1
5070	8.222	8.2891	-0.06706	1
5100	8.229	8.298	-0.069001	1
5130	8.243	8.3068	-0.063833	1
5160	8.258	8.3156	-0.057558	1
5190	8.272	8.3242	-0.052175	1
5220	8.279	8.3327	-0.053687	1
5250	8.265	8.3411	-0.076097	1
5280	8.258	8.3494	-0.091405	1
5310	8.251	8.3576	-0.10661	1
5340	8.251	8.3657	-0.11472	1
5370	8.258	8.3737	-0.11573	1
5400	8.272	8.3816	-0.10965	1

5430	8.272	8.3895	-0.11747	1
5460	8.265	8.3972	-0.13219	1
5490	8.258	8.4048	-0.14683	1
5520	8.265	8.4124	-0.14737	1
5550	8.287	8.4198	-0.13283	1
5580	8.316	8.4272	-0.11119	1
5610	8.337	8.4345	-0.097471	1
5640	8.344	8.4417	-0.097664	1
5670	8.344	8.4488	-0.10477	1
5700	8.352	8.4558	-0.1038	1
5730	8.359	8.4627	-0.10374	1
5760	8.337	8.4696	-0.1326	1
5790	8.626	8.4764	0.14961	1
5820	8.323	8.4831	-0.16009	1
5850	8.337	8.4897	-0.15271	1
5880	8.308	8.4963	-0.18826	1
5910	8.301	8.5027	-0.20173	1
5940	8.294	8.5091	-0.21513	1
5970	8.294	8.5155	-0.22146	1
6000	8.294	8.5217	-0.22771	1
6030	8.294	8.5279	-0.23389	1
6060	8.301	8.534	-0.233	1
6090	8.301	8.54	-0.23903	1
6120	8.308	8.546	-0.238	1
6150	8.316	8.5519	-0.23591	1
6180	8.323	8.5577	-0.23474	1
6210	8.337	8.5635	-0.22651	1
6240	8.337	8.5692	-0.23221	1
6270	8.352	8.5749	-0.22285	1
6300	8.352	8.5804	-0.22843	1
6330	8.359	8.5859	-0.22694	1
6360	8.359	8.5914	-0.23239	1
6390	8.366	8.5968	-0.23078	1
6420	8.366	8.6021	-0.23611	1
6450	8.373	8.6074	-0.23438	1
6480	8.381	8.6126	-0.23159	1
6510	8.381	8.6177	-0.23674	1
6540	8.388	8.6228	-0.23484	1
6570	8.388	8.6279	-0.23988	1
6600	8.388	8.6329	-0.24486	1
6630	8.388	8.6378	-0.24979	1
6660	8.388	8.6427	-0.25466	1
6690	8.395	8.6475	-0.25248	1
6720	8.438	8.6522	-0.21425	1
6750	8.496	8.657	-0.16096	1
6780	8.684	8.6616	0.022378	1
6810	8.749	8.6662	0.082767	1
6840	8.64	8.6708	-0.030794	1
6870	8.619	8.6753	-0.056305	1
6900	8.59	8.6798	-0.089766	1
6930	8.547	8.6842	-0.13718	1
6960	8.51	8.6885	-0.17854	1
6990	8.496	8.6929	-0.19686	1
7020	8.482	8.6971	-0.21513	1
7050	8.482	8.7014	-0.21936	1
7080	8.474	8.7055	-0.23154	1
7110	8.482	8.7097	-0.22767	1
7140	8.482	8.7138	-0.23176	1
7170	8.482	8.7178	-0.2358	1
7200	8.46	8.7218	-0.26181	1

7230	8.409	8.7258	-0.31676	1
7260	8.409	8.7297	-0.32068	1
7290	8.395	8.7336	-0.33856	1
7320	8.409	8.7374	-0.32839	1
7350	9.11	8.7412	0.36882	1
7380	9.146	8.7449	0.40107	1
7410	8.864	8.7486	0.11535	1
7440	8.727	8.7523	-0.025318	1
7470	8.698	8.756	-0.057952	1
7500	8.691	8.7595	-0.068547	1
7530	8.698	8.7631	-0.065105	1
7560	8.727	8.7666	-0.039624	1
7590	8.749	8.7701	-0.021107	1
7620	8.734	8.7736	-0.039553	1
7650	8.727	8.777	-0.049962	1
7680	8.713	8.7803	-0.067336	1
7710	8.691	8.7837	-0.092675	1
7740	8.785	8.787	-0.0019778	1
7770	8.879	8.7902	0.088753	1
7800	8.864	8.7935	0.070518	1
7830	9.333	8.7967	0.53632	1
7860	8.879	8.7999	0.07915	1
7890	8.944	8.803	0.14102	1
7920	8.864	8.8061	0.057913	1
7950	8.871	8.8092	0.061843	1
7980	8.944	8.8122	0.1318	1
8010	8.958	8.8152	0.1428	1
8040	8.922	8.8182	0.10382	1
8070	9.023	8.8211	0.20188	1
8100	10.192	8.824	1.368	1
8130	8.879	8.8269	0.052079	1
8160	9.037	8.8298	0.20722	1
8190	8.763	8.8326	-0.069601	1
8220	8.828	8.8354	-0.007397	1
8250	8.857	8.8382	0.018835	1
8280	8.871	8.8409	0.030096	1
8310	8.864	8.8436	0.020385	1
8340	8.886	8.8463	0.039701	1
8370	8.857	8.849	0.0080447	1
8400	8.857	8.8516	0.0054156	1
8430	8.835	8.8542	-0.019187	1
8460	8.843	8.8568	-0.013763	1
8490	8.85	8.8593	-0.0093124	1
8520	8.871	8.8618	0.0091639	1
8550	8.879	8.8643	0.014666	1
8580	8.936	8.8668	0.069193	1
8610	8.929	8.8693	0.059745	1
8640	8.922	8.8717	0.050322	1
8670	8.922	8.8741	0.047923	1
8700	8.936	8.8765	0.059548	1
8730	8.972	8.8788	0.093197	1
8760	9.052	8.8811	0.17087	1
8790	10.142	8.8834	1.2586	1
8820	10.351	8.8857	1.4653	1
8850	8.929	8.888	0.041028	1
8880	8.98	8.8902	0.089793	1
8910	9.095	8.8924	0.20258	1
8940	10.358	8.8946	1.4634	1
8970	9.167	8.8968	0.27022	1
9000	9.276	8.8989	0.37707	1

9030	9.175	8.9011	0.27395	1
9060	8.915	8.9032	0.011844	1
9090	8.936	8.9052	0.03076	1
9120	9.016	8.9073	0.1087	1

==

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	6.2903E+000
S =	2.0517E-004
r/B=	5.1517E-001

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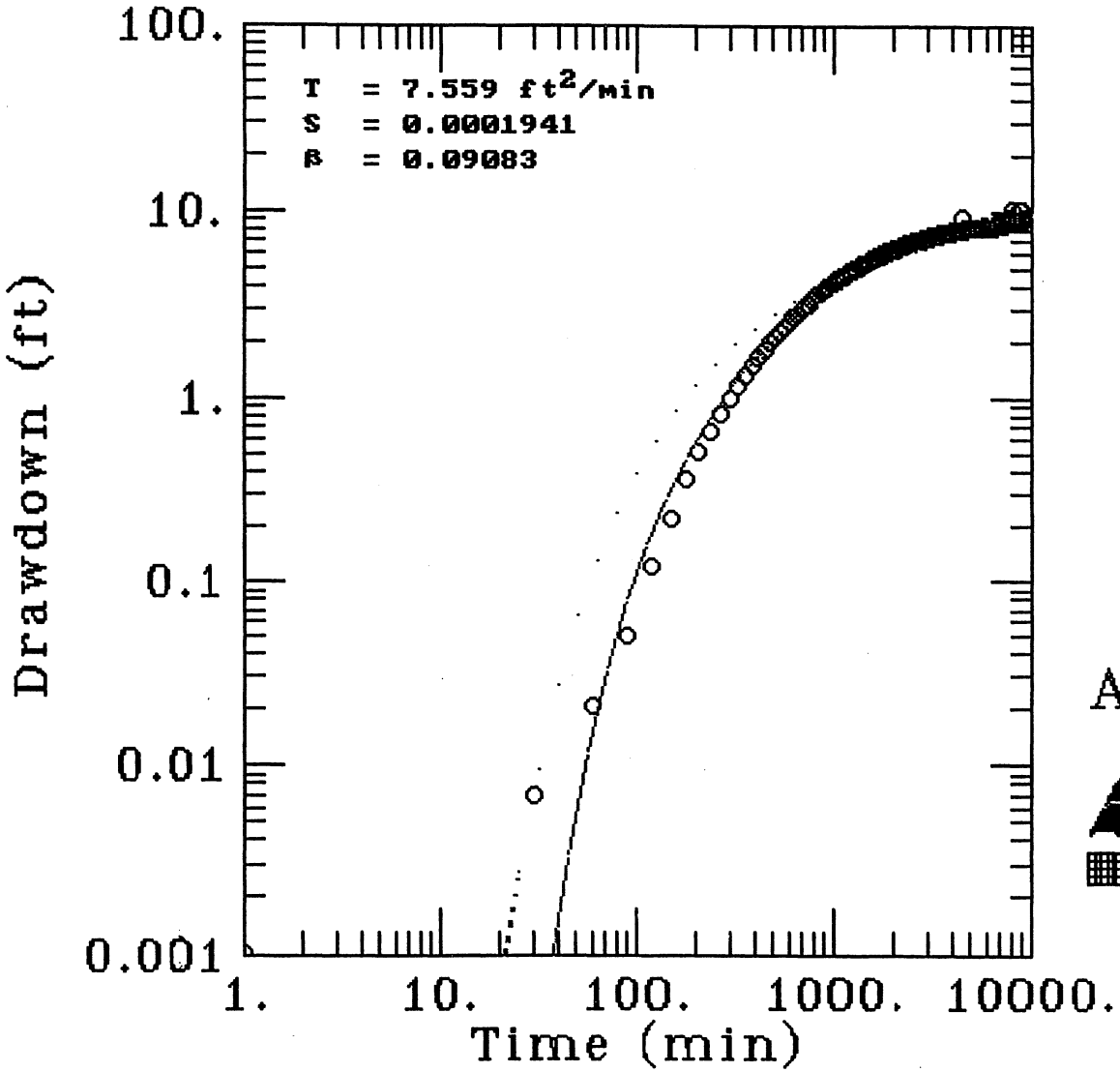
TAC-1A TEST - DRAWDOWN NMW-3C



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V   R E S U L T S
Version 1.10

7/30/92 11:00:00

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TEST DESCRIPTION

ata set........... nmw3c_dd.aqt
ata set title..... TAC-1A TEST - DRAWDOWN NMW-3C

nowns and Constants:
- No. of data points.................. 305
- Pumping rate........................ 401
- Radius (distance) to obs. well...... 5997
- Radius of pumped well casing........ 0.5
- Radius of pumped wellbore........... 0.5

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ANALYTICAL METHOD

antush (Leaky Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	9.1307E+000	+/-	9.9667E+000
S	=	1.3183E-004	+/-	1.1609E-004
β	=	9.0826E-002	+/-	4.0414E-001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
- Number of residuals............... 305
- Number of estimated parameters.... 3
- Degrees of freedom................ 302
- Residual mean..................... -0.01333
- Residual standard deviation....... 0.3599
- Residual variance................. 0.1296

. Residuals:

Time	Observed	Calculated	Residual	Weight
1	0.001	-1.3711E-010	0.001	1

29.998	0.007	0.007289	-0.00028899	1
59.999	0.021	0.1127	-0.091697	1
89.997	0.05	0.31293	-0.26293	1
120	0.122	0.54809	-0.42609	1
150	0.223	0.78816	-0.56516	1
180	0.368	1.0212	-0.65319	1
210	0.512	1.243	-0.73099	1
240	0.671	1.4522	-0.78122	1
270	0.837	1.649	-0.81203	1
300	1.01	1.8341	-0.82412	1
330	1.183	2.0084	-0.82537	1
360	1.349	2.1727	-0.82369	1
390	1.515	2.328	-0.81298	1
420	1.674	2.475	-0.80101	1
450	1.833	2.6145	-0.78153	1
480	1.992	2.7472	-0.75519	1
510	2.151	2.8736	-0.72256	1
540	2.302	2.9942	-0.69217	1
570	2.447	3.1095	-0.66249	1
600	2.584	3.2199	-0.63592	1
630	2.728	3.3258	-0.59784	1
660	2.865	3.4276	-0.56257	1
690	2.995	3.5254	-0.53042	1
720	3.125	3.6197	-0.49465	1
750	3.248	3.7105	-0.46251	1
780	3.378	3.7982	-0.42023	1
810	3.493	3.883	-0.38999	1
840	3.609	3.965	-0.35597	1
870	3.724	4.0443	-0.32035	1
900	3.84	4.1213	-0.28128	1
930	3.948	4.1959	-0.2479	1
960	4.049	4.2683	-0.21934	1
990	4.158	4.3387	-0.18071	1
1020	4.259	4.4071	-0.14812	1
1050	4.352	4.4737	-0.12168	1
1080	4.439	4.5385	-0.09948	1
1110	4.533	4.6016	-0.068601	1
1140	4.612	4.6631	-0.051128	1
1170	4.699	4.7231	-0.024135	1
1200	4.771	4.7817	-0.010693	1
1230	4.858	4.8389	0.019134	1
1260	4.923	4.8947	0.028285	1
1290	4.995	4.9493	0.045701	1
1320	5.067	5.0027	0.06433	1
1350	5.139	5.0549	0.084121	1
1380	5.204	5.106	0.098027	1
1410	5.262	5.156	0.106	1
1440	5.327	5.205	0.12201	1
1470	5.399	5.253	0.146	1
1500	5.457	5.3001	0.15694	1
1530	5.515	5.3462	0.1688	1
1560	5.587	5.3915	0.19555	1
1590	5.645	5.4359	0.20914	1
1620	5.702	5.4794	0.22255	1
1650	5.767	5.5222	0.24476	1
1680	5.825	5.5643	0.26073	1
1710	5.876	5.6056	0.27044	1
1740	5.933	5.6461	0.28687	1
1770	5.984	5.686	0.29798	1
1800	6.042	5.7252	0.31677	1

1830	6.085	5.7638	0.32121	1
1860	6.135	5.8017	0.33327	1
1890	6.179	5.8391	0.33994	1
1920	6.222	5.8758	0.3462	1
1950	6.258	5.912	0.34604	1
1980	6.294	5.9476	0.34643	1
2010	6.33	5.9826	0.34736	1
2040	6.374	6.0172	0.35681	1
2070	6.403	6.0512	0.35178	1
2100	6.431	6.0848	0.34624	1
2130	6.46	6.1178	0.34218	1
2160	6.504	6.1504	0.35359	1
2190	6.533	6.1825	0.35046	1
2220	6.561	6.2142	0.34677	1
2250	6.597	6.2455	0.35151	1
2280	6.634	6.2763	0.35768	1
2310	6.67	6.3067	0.36325	1
2340	6.699	6.3368	0.36223	1
2370	6.735	6.3664	0.36859	1
2400	6.771	6.3957	0.37534	1
2430	6.8	6.4245	0.37546	1
2460	6.828	6.4531	0.37494	1
2490	6.865	6.4812	0.38377	1
2520	6.893	6.509	0.38395	1
2550	6.922	6.5365	0.38547	1
2580	6.951	6.5637	0.38732	1
2610	6.987	6.5905	0.39649	1
2640	7.016	6.617	0.39897	1
2670	7.038	6.6432	0.39476	1
2700	7.059	6.6691	0.38986	1
2730	7.088	6.6948	0.39325	1
2760	7.117	6.7201	0.39692	1
2790	7.139	6.7451	0.39388	1
2820	7.161	6.7699	0.39112	1
2850	7.189	6.7944	0.39462	1
2880	7.211	6.8186	0.3924	1
2910	7.233	6.8426	0.39043	1
2940	7.254	6.8663	0.38771	1
2970	7.283	6.8898	0.39324	1
3000	7.305	6.913	0.39202	1
3030	7.341	6.936	0.40504	1
3060	7.363	6.9587	0.40429	1
3090	7.392	6.9812	0.41077	1
3120	7.413	7.0035	0.40948	1
3150	7.435	7.0256	0.40941	1
3180	7.457	7.0474	0.40955	1
3210	7.478	7.0691	0.40891	1
3240	7.5	7.0905	0.40948	1
3270	7.521	7.1118	0.40925	1
3300	7.543	7.1328	0.41022	1
3330	7.558	7.1536	0.4044	1
3360	7.572	7.1742	0.39776	1
3390	7.594	7.1947	0.39932	1
3420	7.608	7.2149	0.39307	1
3450	7.623	7.235	0.388	1
3480	7.637	7.2549	0.38211	1
3510	7.644	7.2746	0.36939	1
3540	7.659	7.2941	0.36486	1
3570	7.666	7.3135	0.35249	1
3600	7.673	7.3327	0.3403	1

3630	7.688	7.3517	0.33627	1
3660	7.695	7.3706	0.3244	1
3690	7.702	7.3893	0.3127	1
3720	7.716	7.4078	0.30815	1
3750	7.731	7.4262	0.30476	1
3780	7.745	7.4445	0.30053	1
3810	7.76	7.4626	0.29744	1
3840	7.767	7.4805	0.2865	1
3870	7.789	7.4983	0.29071	1
3900	7.803	7.5159	0.28706	1
3930	7.81	7.5334	0.27656	1
3960	7.825	7.5508	0.27419	1
3990	7.846	7.568	0.27796	1
4020	7.868	7.5851	0.28286	1
4050	7.882	7.6021	0.2799	1
4080	7.897	7.6189	0.27807	1
4110	7.919	7.6356	0.28337	1
4140	7.94	7.6522	0.2878	1
4170	7.947	7.6686	0.27835	1
4200	7.962	7.685	0.27703	1
4230	7.976	7.7012	0.27483	1
4260	7.991	7.7173	0.27375	1
4290	7.998	7.7332	0.26478	1
4320	8.005	7.7491	0.25594	1
4350	8.02	7.7648	0.25521	1
4380	8.027	7.7804	0.24659	1
4410	8.034	7.7959	0.23809	1
4440	8.056	7.8113	0.24469	1
4470	8.063	7.8266	0.23641	1
4500	8.07	7.8418	0.22823	1
4530	9.225	7.8568	1.3682	1
4560	8.077	7.8718	0.20519	1
4590	8.092	7.8867	0.20533	1
4620	8.099	7.9014	0.19757	1
4650	8.113	7.9161	0.1969	1
4680	8.128	7.9307	0.19734	1
4710	8.135	7.9451	0.18988	1
4740	8.15	7.9595	0.19051	1
4770	8.15	7.9738	0.17624	1
4800	8.164	7.9879	0.17607	1
4830	8.171	8.002	0.16898	1
4860	8.178	8.016	0.16199	1
4890	8.186	8.0299	0.15609	1
4920	8.193	8.0437	0.14928	1
4950	8.2	8.0574	0.14255	1
4980	8.207	8.0711	0.13592	1
5010	8.214	8.0846	0.12937	1
5040	8.222	8.0981	0.12391	1
5070	8.222	8.1115	0.11053	1
5100	8.229	8.1248	0.10423	1
5130	8.243	8.138	0.10502	1
5160	8.258	8.1511	0.10689	1
5190	8.272	8.1642	0.10784	1
5220	8.279	8.1771	0.10186	1
5250	8.265	8.19	0.074971	1
5280	8.258	8.2028	0.055155	1
5310	8.251	8.2156	0.035416	1
5340	8.251	8.2282	0.022753	1
5370	8.258	8.2408	0.017165	1
5400	8.272	8.2533	0.018651	1

5430	8.272	8.2658	0.0062105	1
5460	8.265	8.2782	-0.013158	1
5490	8.258	8.2905	-0.032454	1
5520	8.265	8.3027	-0.03768	1
5550	8.287	8.3148	-0.027835	1
5580	8.316	8.3269	-0.010921	1
5610	8.337	8.3389	-0.0019389	1
5640	8.344	8.3509	-0.0068886	1
5670	8.344	8.3628	-0.018771	1
5700	8.352	8.3746	-0.022587	1
5730	8.359	8.3863	-0.027338	1
5760	8.337	8.398	-0.061023	1
5790	8.626	8.4096	0.21636	1
5820	8.323	8.4212	-0.098202	1
5850	8.337	8.4327	-0.095697	1
5880	8.308	8.4441	-0.13613	1
5910	8.301	8.4555	-0.1545	1
5940	8.294	8.4668	-0.17281	1
5970	8.294	8.4781	-0.18406	1
6000	8.294	8.4892	-0.19525	1
6030	8.294	8.5004	-0.20638	1
6060	8.301	8.5115	-0.21045	1
6090	8.301	8.5225	-0.22147	1
6120	8.308	8.5334	-0.22542	1
6150	8.316	8.5443	-0.22832	1
6180	8.323	8.5552	-0.23217	1
6210	8.337	8.566	-0.22895	1
6240	8.337	8.5767	-0.23969	1
6270	8.352	8.5874	-0.23536	1
6300	8.352	8.598	-0.24599	1
6330	8.359	8.6086	-0.24956	1
6360	8.359	8.6191	-0.26008	1
6390	8.366	8.6295	-0.26354	1
6420	8.366	8.64	-0.27395	1
6450	8.373	8.6503	-0.27731	1
6480	8.381	8.6606	-0.27963	1
6510	8.381	8.6709	-0.28989	1
6540	8.388	8.6811	-0.29309	1
6570	8.388	8.6913	-0.30326	1
6600	8.388	8.7014	-0.31337	1
6630	8.388	8.7114	-0.32343	1
6660	8.388	8.7214	-0.33344	1
6690	8.395	8.7314	-0.33641	1
6720	8.438	8.7413	-0.30333	1
6750	8.496	8.7512	-0.2552	1
6780	8.684	8.761	-0.077025	1
6810	8.749	8.7708	-0.021805	1
6840	8.64	8.7805	-0.14054	1
6870	8.619	8.7902	-0.17123	1
6900	8.59	8.7999	-0.20987	1
6930	8.547	8.8095	-0.26247	1
6960	8.51	8.819	-0.30903	1
6990	8.496	8.8285	-0.33254	1
7020	8.482	8.838	-0.356	1
7050	8.482	8.8474	-0.36543	1
7080	8.474	8.8568	-0.38281	1
7110	8.482	8.8662	-0.38415	1
7140	8.482	8.8755	-0.39345	1
7170	8.482	8.8847	-0.40271	1
7200	8.46	8.8939	-0.43393	1

7230	8.409	8.9031	-0.4941	1
7260	8.409	8.9122	-0.50324	1
7290	8.395	8.9213	-0.52633	1
7320	8.409	8.9304	-0.52139	1
7350	9.11	8.9394	0.1706	1
7380	9.146	8.9484	0.19762	1
7410	8.864	8.9573	-0.093319	1
7440	8.727	8.9662	-0.23922	1
7470	8.698	8.9751	-0.27708	1
7500	8.691	8.9839	-0.2929	1
7530	8.698	8.9927	-0.29469	1
7560	8.727	9.0014	-0.27444	1
7590	8.749	9.0102	-0.26115	1
7620	8.734	9.0188	-0.28483	1
7650	8.727	9.0275	-0.30047	1
7680	8.713	9.0361	-0.32307	1
7710	8.691	9.0446	-0.35364	1
7740	8.785	9.0532	-0.26817	1
7770	8.879	9.0617	-0.18267	1
7800	8.864	9.0701	-0.20613	1
7830	9.333	9.0786	0.25444	1
7860	8.879	9.087	-0.20795	1
7890	8.944	9.0953	-0.15131	1
7920	8.864	9.1036	-0.23964	1
7950	8.871	9.1119	-0.24093	1
7980	8.944	9.1202	-0.17619	1
8010	8.958	9.1284	-0.17042	1
8040	8.922	9.1366	-0.21461	1
8070	9.023	9.1448	-0.12177	1
8100	10.192	9.1529	1.0391	1
8130	8.879	9.161	-0.282	1
8160	9.037	9.1691	-0.13206	1
8190	8.763	9.1771	-0.4141	1
8220	8.828	9.1851	-0.3571	1
8250	8.857	9.1931	-0.33607	1
8280	8.871	9.201	-0.33001	1
8310	8.864	9.2089	-0.34492	1
8340	8.886	9.2168	-0.3308	1
8370	8.857	9.2247	-0.36765	1
8400	8.857	9.2325	-0.37547	1
8430	8.835	9.2403	-0.40526	1
8460	8.843	9.248	-0.40502	1
8490	8.85	9.2558	-0.40575	1
8520	8.871	9.2635	-0.39245	1
8550	8.879	9.2711	-0.39213	1
8580	8.936	9.2788	-0.34277	1
8610	8.929	9.2864	-0.35739	1
8640	8.922	9.294	-0.37198	1
8670	8.922	9.3015	-0.37954	1
8700	8.936	9.3091	-0.37307	1
8730	8.972	9.3166	-0.34457	1
8760	9.052	9.324	-0.27205	1
8790	10.142	9.3315	0.8105	1
8820	10.351	9.3389	1.0121	1
8850	8.929	9.3463	-0.41732	1
8880	8.98	9.3537	-0.37369	1
8910	9.095	9.361	-0.26603	1
8940	10.358	9.3683	0.98965	1
8970	9.167	9.3756	-0.20864	1
9000	9.276	9.3829	-0.1069	1

9030	9.175	9.3901	-0.21514	1
9060	8.915	9.3974	-0.48235	1
9090	8.936	9.4045	-0.46854	1
9120	9.016	9.4117	-0.3957	1

===

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	7.5591E+000
S	=	1.9408E-004
β	=	9.0826E-002

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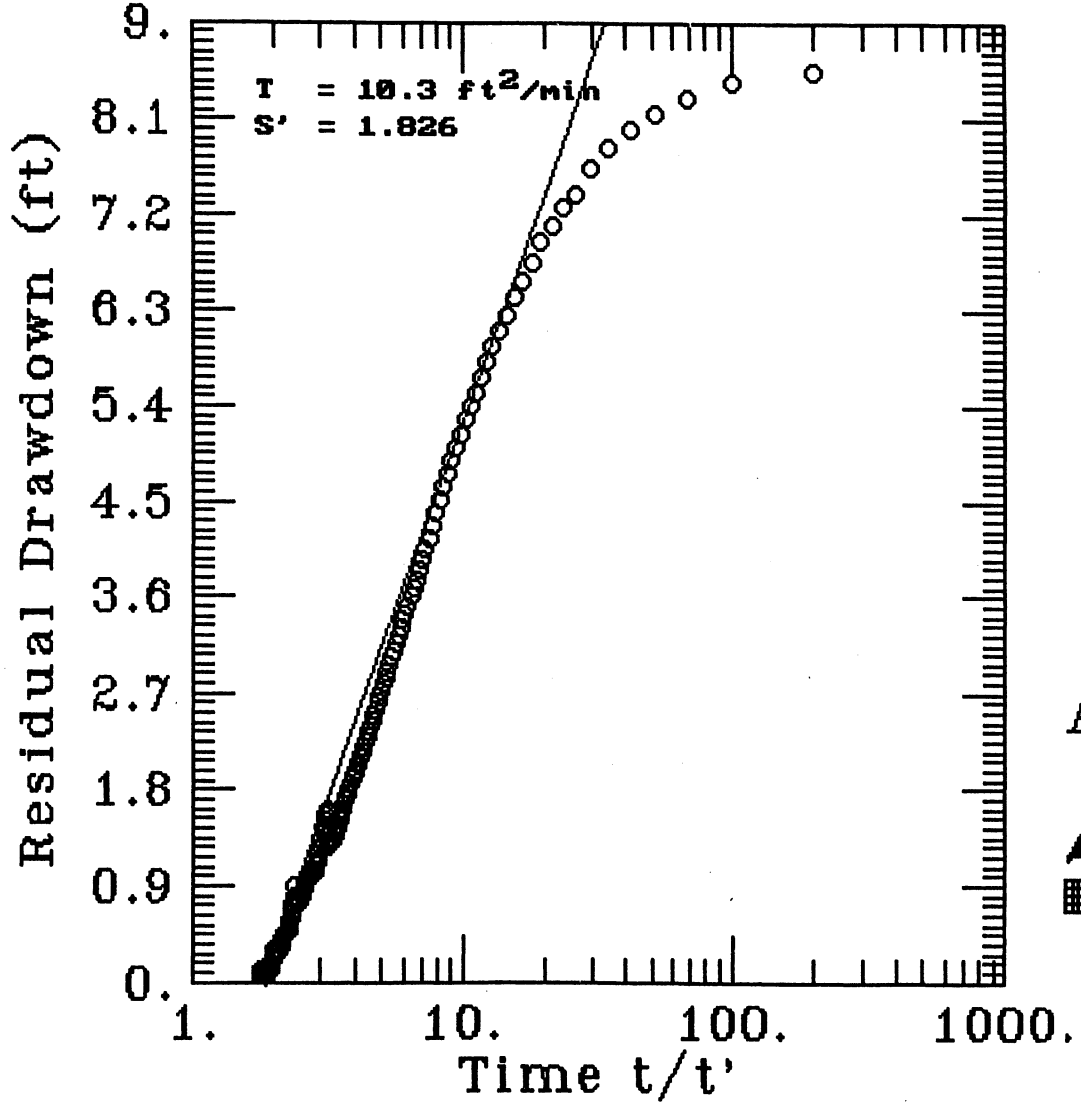
TAC-1A TEST - RECOVERY NMW-3C



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

A Q T E S O L V   R E S U L T S
Version 1.10

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TEST DESCRIPTION

ata set........... B:\RECNMW3C.AQT
ata set title..... TAC-1A TEST - RECOVERY NMW-3C

nowns and Constants:
  No. of data points.................. 251
  Pumping rate........................ 401
  Total pumping time.................. 5997

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ANALYTICAL METHOD

heis Recovery (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.2198E+001	+/-	1.4994E-001
S' =	1.8024E+000	+/-	2.1655E-002

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
  Number of residuals............... 251
  Number of estimated parameters.... 2
  Degrees of freedom................ 249
  Residual mean..................... -1.87E-011
  Residual standard deviation....... 0.3796
  Residual variance................. 0.1441

odel Residuals:

Time	Observed	Calculated	Residual	Weight
30.001	8.554	12.334	-3.7796	1
60.001	8.453	10.533	-2.08	1
90	8.316	9.485	-1.169	1
120	8.164	8.7451	-0.58114	1

150	8.005	8.1741	-0.16907	1
180	7.832	7.7098	0.12223	1
210	7.644	7.3191	0.32491	1
240	7.4	6.9823	0.41769	1
270	7.283	6.6867	0.59631	1
300	7.103	6.4235	0.67951	1
330	6.964	6.1865	0.77745	1
360	6.757	5.9713	0.78574	1
390	6.59	5.7741	0.81587	1
420	6.424	5.5925	0.83151	1
450	6.266	5.4242	0.84183	1
480	6.107	5.2674	0.83956	1
510	5.97	5.1209	0.84909	1
540	5.818	4.9834	0.83461	1
570	5.681	4.8539	0.82711	1
600	5.537	4.7316	0.80539	1
630	5.407	4.6158	0.79118	1
660	5.269	4.5059	0.76309	1
690	5.14	4.4014	0.73864	1
720	5.002	4.3017	0.70029	1
750	4.88	4.2066	0.67343	1
780	4.75	4.1156	0.63445	1
810	4.627	4.0284	0.59864	1
840	4.504	3.9447	0.55929	1
870	4.389	3.8643	0.52466	1
900	4.273	3.787	0.48595	1
930	4.158	3.7126	0.4454	1
960	4.057	3.6408	0.41616	1
990	3.956	3.5716	0.38442	1
1020	3.847	3.5047	0.34232	1
1050	3.761	3.44	0.321	1
1080	3.674	3.3774	0.2966	1
1110	3.595	3.3168	0.27822	1
1140	3.515	3.258	0.25698	1
1170	3.436	3.201	0.23497	1
1200	3.378	3.1457	0.23229	1
1230	3.306	3.092	0.21401	1
1260	3.234	3.0398	0.19423	1
1290	3.169	2.989	0.18	1
1320	3.097	2.9396	0.15741	1
1350	3.032	2.8915	0.1405	1
1380	2.967	2.8447	0.12235	1
1410	2.902	2.799	0.103	1
1440	2.844	2.7545	0.089513	1
1470	2.793	2.7111	0.081932	1
1500	2.728	2.6687	0.059302	1
1530	2.671	2.6273	0.043667	1
1560	2.627	2.5869	0.040068	1
1590	2.548	2.5475	0.00054247	1
1620	2.49	2.5089	-0.018874	1
1650	2.44	2.4711	-0.031147	1
1680	2.404	2.4342	-0.030246	1
1710	2.346	2.3981	-0.052139	1
1740	2.295	2.3628	-0.067797	1
1770	2.245	2.3282	-0.083194	1
1800	2.209	2.2943	-0.085304	1
1830	2.165	2.2611	-0.096103	1
1860	2.122	2.2286	-0.10657	1
1890	2.093	2.1967	-0.10367	1
1920	2.057	2.1654	-0.1084	1

1950	2.028	2.1347	-0.10673	1
1980	1.992	2.1046	-0.11264	1
2010	1.963	2.0751	-0.11211	1
2040	1.934	2.0461	-0.11213	1
2070	1.906	2.0177	-0.11168	1
2100	1.869	1.9897	-0.12075	1
2130	1.848	1.9623	-0.11431	1
2160	1.804	1.9354	-0.13135	1
2190	1.768	1.9089	-0.14087	1
2220	1.732	1.8828	-0.15084	1
2250	1.703	1.8572	-0.15425	1
2280	1.66	1.8321	-0.17209	1
2310	1.617	1.8074	-0.19036	1
2340	1.573	1.783	-0.21003	1
2370	1.545	1.7591	-0.21409	1
2400	1.508	1.7355	-0.22754	1
2430	1.472	1.7124	-0.24037	1
2460	1.436	1.6896	-0.25356	1
2490	1.415	1.6671	-0.25211	1
2520	1.386	1.645	-0.25901	1
2550	1.357	1.6232	-0.26624	1
2580	1.342	1.6018	-0.25981	1
2610	1.328	1.5807	-0.25269	1
2640	1.314	1.5599	-0.24589	1
2670	1.292	1.5394	-0.2474	1
2700	1.285	1.5192	-0.23421	1
2730	1.27	1.4993	-0.2293	1
2760	1.624	1.4797	0.14431	1
2790	1.588	1.4603	0.12765	1
2820	1.559	1.4413	0.11772	1
2850	1.516	1.4225	0.09352	1
2880	1.472	1.4039	0.068061	1
2910	1.444	1.3857	0.058348	1
2940	1.415	1.3676	0.047387	1
2970	1.386	1.3498	0.036182	1
3000	1.35	1.3323	0.01774	1
3030	1.306	1.3149	-0.0089341	1
3060	1.277	1.2978	-0.020836	1
3090	1.234	1.281	-0.046961	1
3120	1.191	1.2643	-0.073304	1
3150	1.14	1.2479	-0.10786	1
3180	1.126	1.2316	-0.10563	1
3210	1.083	1.2156	-0.1326	1
3240	1.054	1.1998	-0.14577	1
3270	1.032	1.1841	-0.15214	1
3300	1.025	1.1687	-0.1437	1
3330	1.018	1.1534	-0.13545	1
3360	1.01	1.1384	-0.12838	1
3390	1.01	1.1235	-0.1135	1
3420	1.01	1.1088	-0.098797	1
3450	1.003	1.0943	-0.091267	1
3480	0.996	1.0799	-0.083908	1
3510	0.996	1.0657	-0.069718	1
3540	0.996	1.0517	-0.055693	1
3570	0.982	1.0378	-0.05583	1
3600	0.974	1.0241	-0.050126	1
3630	0.953	1.0106	-0.057578	1
3660	0.953	0.99718	-0.044184	1
3690	0.931	0.98394	-0.05294	1
3720	0.909	0.97084	-0.061844	1

3750	0.888	0.95789	-0.069893	1
3780	0.873	0.94508	-0.072085	1
3810	0.844	0.93242	-0.088417	1
3840	0.83	0.91989	-0.089886	1
3870	0.808	0.90749	-0.099491	1
3900	0.794	0.89523	-0.10123	1
3930	0.779	0.8831	-0.1041	1
3960	0.772	0.8711	-0.099096	1
3990	0.765	0.85922	-0.09422	1
4020	0.758	0.84747	-0.089468	1
4050	0.758	0.83584	-0.077839	1
4080	0.758	0.82433	-0.066329	1
4110	0.758	0.81294	-0.054939	1
4140	0.758	0.80166	-0.043664	1
4170	0.758	0.7905	-0.032504	1
4200	0.758	0.77946	-0.021456	1
4230	0.888	0.76852	0.11948	1
4260	0.808	0.75769	0.050308	1
4290	0.787	0.74697	0.040028	1
4320	0.765	0.73636	0.028642	1
4350	0.758	0.72585	0.032153	1
4380	0.736	0.71544	0.020561	1
4410	0.714	0.70513	0.0088676	1
4440	0.693	0.69492	-0.0019247	1
4470	0.664	0.68481	-0.020815	1
4500	0.642	0.6748	-0.032801	1
4530	0.613	0.66488	-0.051883	1
4560	0.584	0.65506	-0.071058	1
4590	0.556	0.64532	-0.089325	1
4620	0.527	0.63568	-0.10868	1
4650	0.505	0.62613	-0.12113	1
4680	0.491	0.61667	-0.12567	1
4710	0.476	0.60729	-0.13129	1
4740	0.469	0.598	-0.129	1
4770	0.455	0.58879	-0.13379	1
4800	0.455	0.57966	-0.12466	1
4830	0.455	0.57062	-0.11562	1
4860	0.447	0.56166	-0.11466	1
4890	0.447	0.55278	-0.10578	1
4920	0.447	0.54397	-0.096974	1
4950	0.447	0.53525	-0.088248	1
4980	0.447	0.5266	-0.079599	1
5010	0.447	0.51803	-0.071025	1
5040	0.447	0.50953	-0.062526	1
5070	0.433	0.5011	-0.0681	1
5100	0.426	0.49275	-0.066746	1
5130	0.411	0.48446	-0.073464	1
5160	0.404	0.47625	-0.072252	1
5190	0.39	0.46811	-0.078109	1
5220	0.375	0.46004	-0.085036	1
5250	0.361	0.45203	-0.09103	1
5280	0.346	0.44409	-0.09809	1
5310	0.332	0.43622	-0.10422	1
5340	0.317	0.42841	-0.11141	1
5370	0.31	0.42067	-0.11067	1
5400	0.296	0.41298	-0.11698	1
5430	0.289	0.40537	-0.11637	1
5460	0.281	0.39781	-0.11681	1
5490	0.281	0.39032	-0.10932	1
5520	0.281	0.38288	-0.10188	1

5550	0.289	0.37551	-0.086506	1
5580	0.289	0.36819	-0.07919	1
5610	0.296	0.36093	-0.064932	1
5640	0.296	0.35373	-0.057731	1
5670	0.303	0.34659	-0.043587	1
5700	0.296	0.3395	-0.043498	1
5730	0.303	0.33247	-0.029465	1
5760	0.303	0.32549	-0.022487	1
5790	0.296	0.31856	-0.022562	1
5820	0.289	0.31169	-0.022691	1
5850	0.289	0.30487	-0.015873	1
5880	0.274	0.29811	-0.024106	1
5910	0.26	0.29139	-0.031391	1
5940	0.26	0.28473	-0.024727	1
5970	0.231	0.27811	-0.047113	1
6000	0.209	0.27155	-0.062548	1
6030	0.187	0.26503	-0.078033	1
6060	0.18	0.25857	-0.078566	1
6090	0.166	0.25215	-0.086147	1
6120	0.166	0.24578	-0.079775	1
6150	0.13	0.23945	-0.10945	1
6180	0.137	0.23317	-0.096172	1
6210	0.122	0.22694	-0.10494	1
6240	0.115	0.22075	-0.10575	1
6270	0.115	0.21461	-0.09961	1
6300	0.122	0.20851	-0.086511	1
6330	0.115	0.20246	-0.087457	1
6360	0.115	0.19645	-0.081445	1
6390	0.122	0.19048	-0.068477	1
6420	0.13	0.18455	-0.05455	1
6450	0.13	0.17867	-0.048666	1
6480	0.13	0.17282	-0.042823	1
6510	0.13	0.16702	-0.037021	1
6540	0.13	0.16126	-0.03126	1
6570	0.122	0.15554	-0.033538	1
6600	0.115	0.14986	-0.034856	1
6630	0.115	0.14421	-0.029214	1
6660	0.101	0.13861	-0.03761	1
6690	0.086	0.13304	-0.047045	1
6720	0.079	0.12752	-0.048517	1
6750	0.065	0.12203	-0.057028	1
6780	0.058	0.11657	-0.058575	1
6810	0.043	0.11116	-0.068159	1
6840	0.043	0.10578	-0.06278	1
6870	0.036	0.10044	-0.064436	1
6900	0.029	0.095129	-0.066129	1
6930	0.029	0.089856	-0.060856	1
6960	0.043	0.084619	-0.041619	1
6990	0.043	0.079416	-0.036416	1
7020	0.05	0.074248	-0.024248	1
7050	0.058	0.069113	-0.011113	1
7080	0.072	0.064012	0.0079881	1
7110	0.072	0.058944	0.013056	1
7140	0.079	0.053909	0.025091	1
7170	0.086	0.048906	0.037094	1
7200	0.094	0.043936	0.050064	1
7230	0.094	0.038998	0.055002	1
7260	0.101	0.034091	0.066909	1
7290	0.101	0.029215	0.071785	1
7320	0.094	0.024371	0.069629	1

7350	0.079	0.019557	0.059443	1
7380	0.072	0.014773	0.057227	1
7410	0.065	0.01002	0.05498	1
7440	0.05	0.0052965	0.044704	1
7470	0.036	0.00060232	0.035398	1
7500	0.021	-0.0040626	0.025063	1
7530	0.014	-0.0086986	0.022699	1

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RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	1.0296E+001
S'	=	1.8261E+000

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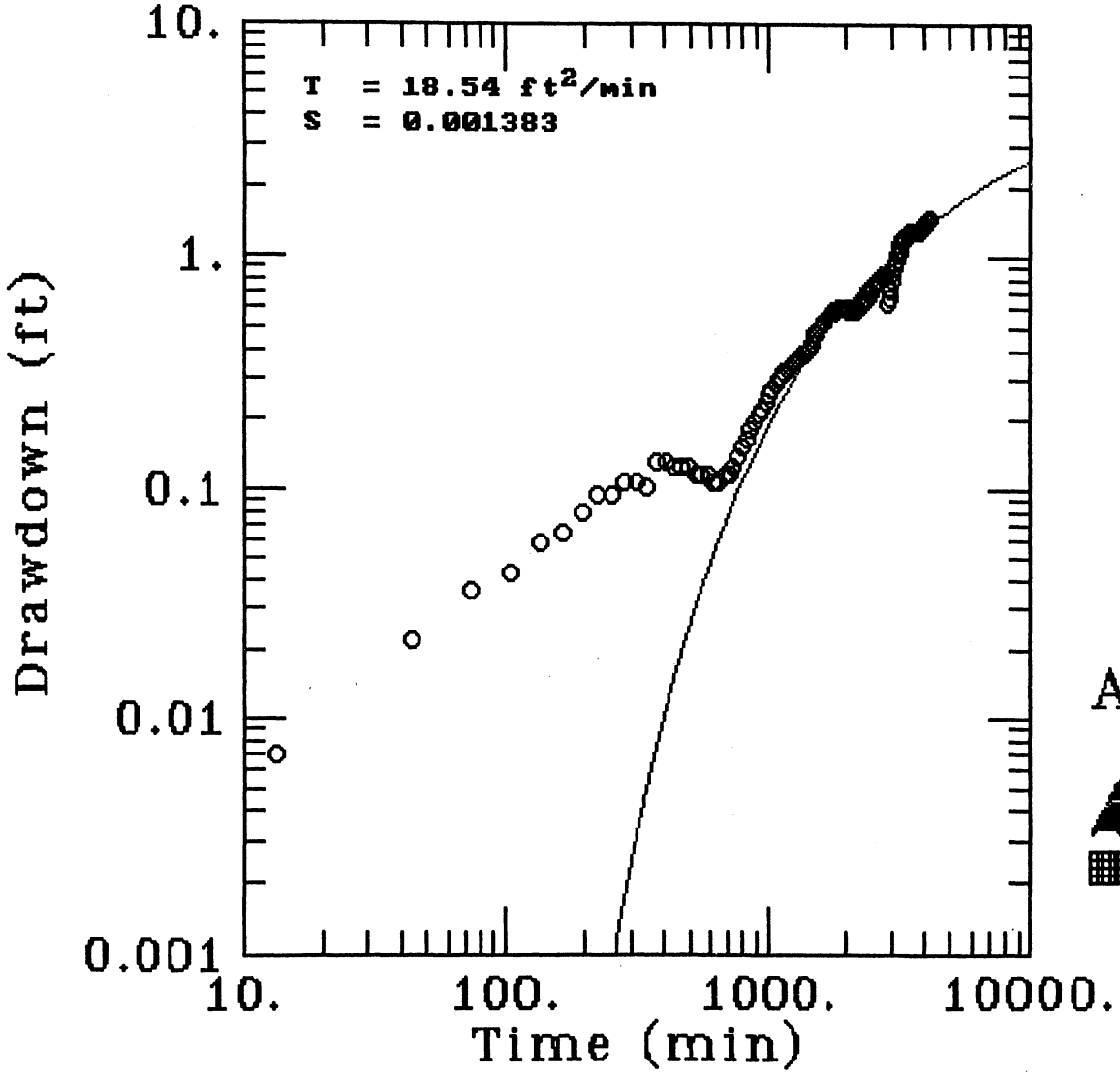
DATA ANALYSIS
OF TAC 1A PUMPING TEST
FOR NMW-5C

TAC-1A TEST - DRAWDOWN NMW-5C



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A Q T E S O L V   R E S U L T S
Version 1.10

7/30/92 12:38:

TEST DESCRIPTION

ata set........... b:\ddnmw-5c.aqt
ata set title..... TAC-1A TEST - DRAWDOWN NMW-5C

nowns and Constants:
No. of data points.................. 278
Pumping rate........................ 401
Radius (distance) to obs. well...... 8831
Radius of pumped well casing........ 0.5
Radius of pumped wellbore........... 0.5

ANALYTICAL METHOD

heis (Confined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.8542E+001	+/-	7.1710E-001
S =	1.3829E-003	+/-	1.0049E-005

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 278
Number of estimated parameters.... 2
Degrees of freedom................ 276
Residual mean..................... 0.01692
Residual standard deviation....... 0.08995
Residual variance................. 0.008092

odel Residuals:

Time	Observed	Calculated	Residual	Weight
13.476	0.007	0	0.007	1
43.477	0.022	1.4885E-016	0.022	1

73.476	0.036	2.1062E-010	0.036	1
103.48	0.043	9.0472E-008	0.043	1
133.48	0.058	2.7014E-006	0.057997	1
163.48	0.065	2.4037E-005	0.064976	1
193.47	0.079	0.00011125	0.078889	1
223.48	0.094	0.00034727	0.093653	1
253.48	0.094	0.0008386	0.093161	1
283.47	0.108	0.0016972	0.1063	1
313.48	0.108	0.0030253	0.10497	1
343.48	0.101	0.0049059	0.096094	1
373.47	0.13	0.0074002	0.1226	1
403.48	0.13	0.010547	0.11945	1
433.48	0.123	0.014368	0.10863	1
463.47	0.123	0.018864	0.10414	1
493.48	0.123	0.02403	0.09897	1
523.48	0.115	0.029844	0.085156	1
553.48	0.115	0.036282	0.078718	1
583.48	0.115	0.043316	0.071684	1
613.48	0.108	0.05091	0.05709	1
643.48	0.108	0.059032	0.048968	1
673.48	0.115	0.067645	0.047355	1
703.48	0.115	0.076716	0.038284	1
733.48	0.123	0.086209	0.036791	1
763.48	0.137	0.096092	0.040908	1
793.48	0.151	0.10633	0.044668	1
823.48	0.166	0.1169	0.049099	1
853.48	0.18	0.12777	0.052231	1
883.48	0.195	0.13891	0.056091	1
913.48	0.209	0.1503	0.058703	1
943.48	0.224	0.16191	0.062091	1
973.48	0.238	0.17372	0.064278	1
1003.5	0.26	0.18572	0.074281	1
1033.5	0.274	0.19788	0.076124	1
1063.5	0.289	0.21018	0.078823	1
1093.5	0.303	0.22261	0.080393	1
1123.5	0.31	0.23515	0.07485	1
1153.5	0.325	0.24779	0.077207	1
1183.5	0.332	0.26052	0.071479	1
1213.5	0.339	0.27332	0.065677	1
1243.5	0.346	0.28619	0.059811	1
1273.5	0.354	0.29911	0.054893	1
1303.5	0.368	0.31207	0.055932	1
1333.5	0.375	0.32506	0.049935	1
1363.5	0.382	0.33809	0.043913	1
1393.5	0.39	0.35113	0.038871	1
1423.5	0.397	0.36418	0.032817	1
1453.5	0.411	0.37724	0.033757	1
1483.5	0.426	0.3903	0.035697	1
1513.5	0.469	0.40336	0.065642	1
1543.5	0.476	0.4164	0.059597	1
1573.5	0.491	0.42943	0.061566	1
1603.5	0.505	0.44245	0.062555	1
1633.5	0.52	0.45543	0.06457	1
1663.5	0.534	0.4684	0.065603	1
1693.5	0.548	0.48133	0.066669	1
1723.5	0.57	0.49423	0.075768	1
1753.5	0.577	0.5071	0.069902	1
1783.5	0.585	0.51993	0.065074	1
1813.5	0.592	0.53272	0.059285	1
1843.5	0.599	0.54546	0.053538	1

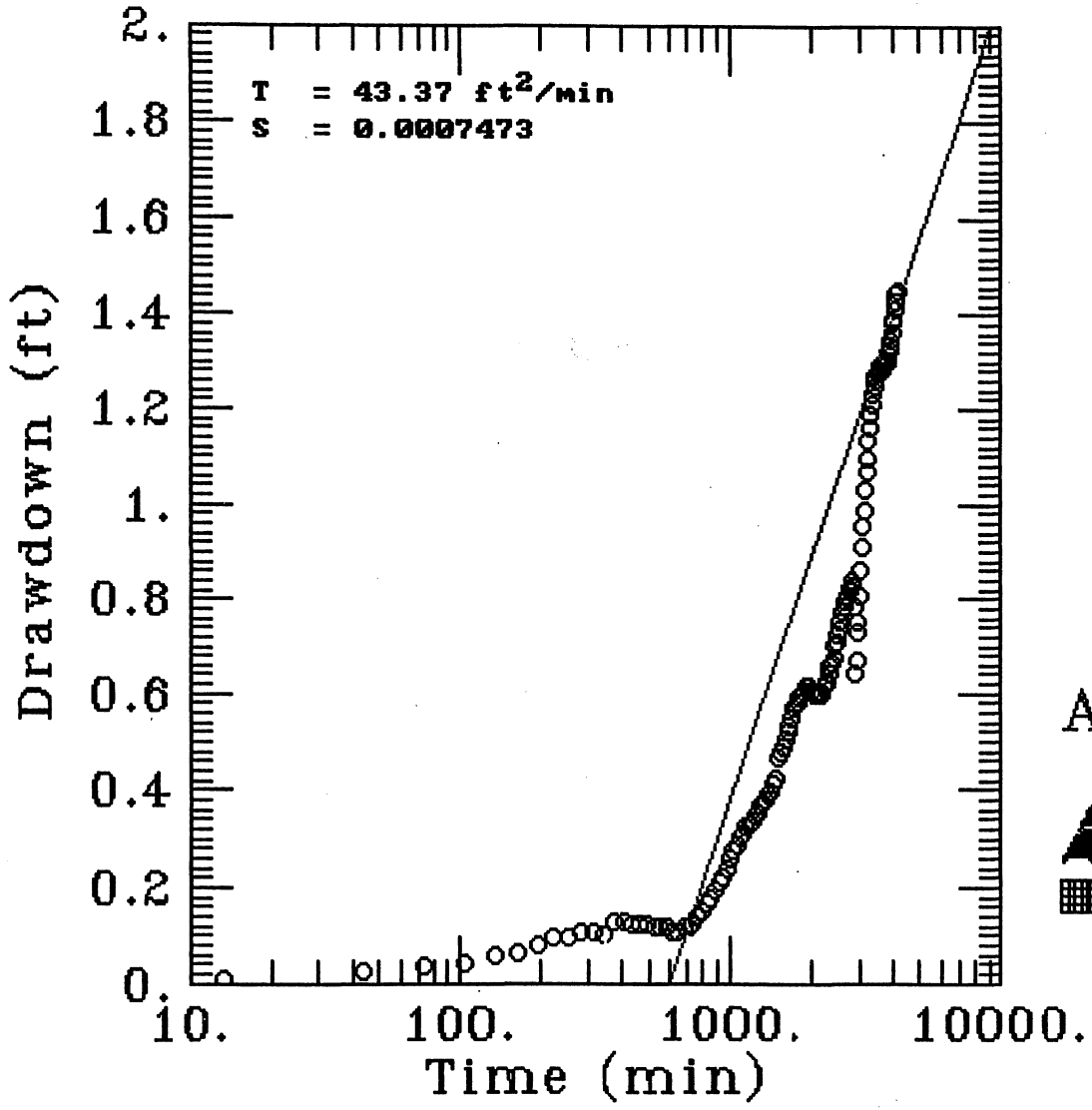
1873.5	0.606	0.55817	0.047835	1
1903.5	0.613	0.57082	0.042177	1
1933.5	0.613	0.58343	0.029566	1
1963.5	0.613	0.596	0.017003	1
1993.5	0.606	0.60851	-0.0025094	1
2023.5	0.606	0.62097	-0.014971	1
2053.5	0.599	0.63338	-0.034381	1
2083.5	0.599	0.64574	-0.046739	1
2113.5	0.599	0.65804	-0.059042	1
2143.5	0.599	0.67029	-0.071292	1
2173.5	0.599	0.68249	-0.083486	1
2203.5	0.606	0.69462	-0.088625	1
2233.5	0.613	0.70671	-0.093707	1
2263.5	0.621	0.71873	-0.097734	1
2293.5	0.628	0.7307	-0.1027	1
2323.5	0.642	0.74262	-0.10062	1
2353.5	0.657	0.75447	-0.09747	1
2383.5	0.664	0.76627	-0.10227	1
2413.5	0.678	0.77801	-0.10001	1
2443.5	0.7	0.78969	-0.089688	1
2473.5	0.707	0.80131	-0.094312	1
2503.5	0.722	0.81288	-0.090878	1
2533.5	0.736	0.82439	-0.088385	1
2563.5	0.751	0.83584	-0.084835	1
2593.5	0.772	0.84723	-0.075227	1
2623.5	0.787	0.85856	-0.071562	1
2653.5	0.794	0.86984	-0.075838	1
2683.5	0.801	0.88106	-0.080058	1
2713.5	0.808	0.89222	-0.084219	1
2743.5	0.816	0.90332	-0.087324	1
2773.5	0.823	0.91437	-0.091372	1
2803.5	0.83	0.92536	-0.095363	1
2833.5	0.837	0.9363	-0.099298	1
2863.5	0.787	0.94718	-0.16018	1
2893.5	0.642	0.958	-0.316	1
2923.5	0.671	0.96877	-0.29777	1
2953.5	0.729	0.97948	-0.25048	1
2983.5	0.751	0.99013	-0.23913	1
3013.5	0.808	1.0007	-0.19274	1
3043.5	0.859	1.0113	-0.15228	1
3073.5	0.909	1.0218	-0.11278	1
3103.5	0.953	1.0322	-0.079215	1
3133.5	0.989	1.0426	-0.053601	1
3163.5	1.032	1.0529	-0.020933	1
3193.5	1.068	1.0632	0.004787	1
3223.5	1.097	1.0734	0.02356	1
3253.5	1.133	1.0836	0.049385	1
3283.5	1.162	1.0937	0.068261	1
3313.5	1.191	1.1038	0.087189	1
3343.5	1.213	1.1138	0.099168	1
3373.5	1.234	1.1238	0.1102	1
3403.5	1.249	1.1337	0.11528	1
3433.5	1.263	1.1436	0.11941	1
3463.5	1.27	1.1534	0.11659	1
3493.5	1.278	1.1632	0.11482	1
3523.5	1.278	1.1729	0.10509	1
3553.5	1.285	1.1826	0.10242	1
3583.5	1.292	1.1922	0.099794	1
3613.5	1.292	1.2018	0.090216	1
3643.5	1.292	1.2113	0.080685	1

73.5	1.292	1.2208	0.07[illegible]	
03.5	1.285	1.2302	0.054765	
[illegible] 5	1.292	1.2396	0.052375	[illegible]
[illegible] 5	1.299	1.249	0.05003	1
793.5	1.299	1.2583	0.040731	1
823.5	1.306	1.2675	0.038477	1
3853.5	1.321	1.2767	0.044268	1
3883.5	1.328	1.2859	0.042104	1
3913.5	1.335	1.295	0.039984	1
3943.5	1.35	1.3041	0.045907	1
3973.5	1.364	1.3131	0.050874	1
4003.5	1.386	1.3221	0.063885	1
4033.5	1.393	1.3311	0.061938	1
4063.5	1.415	1.34	0.075033	1
4093.5	1.429	1.3488	0.080171	1
4123.5	1.444	1.3576	0.08635	1
4153.5	1.451	1.3664	0.084571	1
13.476	0.007	0	0.007	1
43.477	0.022	1.4885E-016	0.022	1
73.476	0.036	2.1062E-010	0.036	1
103.48	0.043	9.0472E-008	0.043	1
133.48	0.058	2.7014E-006	0.057997	1
163.48	0.065	2.4037E-005	0.064976	1
193.47	0.079	0.00011125	0.078889	1
223.48	0.094	0.00034727	0.093653	1
253.48	0.094	0.0008386	0.093161	1
283.47	0.108	0.0016972	0.1063	1
313.48	0.108	0.0030253	0.10497	1
343.48	0.101	0.0049059	0.096094	1
373.47	0.13	0.0074002	0.1226	1
403.48	0.13	0.010547	0.11945	1
433.48	0.123	0.014368	0.10863	1
463.47	0.123	0.018864	0.10414	1
493.48	0.123	0.02403	0.09897	1
523.48	0.115	0.029844	0.085156	1
553.48	0.115	0.036282	0.078718	1
583.48	0.115	0.043316	0.071684	1
613.48	0.108	0.05091	0.05709	1
643.48	0.108	0.059032	0.048968	1
673.48	0.115	0.067645	0.047355	1
703.48	0.115	0.076716	0.038284	1
733.48	0.123	0.086209	0.036791	1
763.48	0.137	0.096092	0.040908	1
793.48	0.151	0.10633	0.044668	1
823.48	0.166	0.1169	0.049099	1
853.48	0.18	0.12777	0.052231	1
883.48	0.195	0.13891	0.056091	1
913.48	0.209	0.1503	0.058703	1
943.48	0.224	0.16191	0.062091	1
973.48	0.238	0.17372	0.064278	1
1003.5	0.26	0.18572	0.074281	1
1033.5	0.274	0.19788	0.076124	1
1063.5	0.289	0.21018	0.078823	1
1093.5	0.303	0.22261	0.080393	1
1123.5	0.31	0.23515	0.07485	1
1153.5	0.325	0.24779	0.077207	1
1183.5	0.332	0.26052	0.071479	1
1213.5	0.339	0.27332	0.065677	1
1243.5	0.346	0.28619	0.059811	1
1273.5	0.354	0.29911	0.054893	1

1303.5	0.368	0.31207	0.055932	1
1333.5	0.375	0.32506	0.049935	1
1363.5	0.382	0.33809	0.043913	1
1393.5	0.39	0.35113	0.038871	1
1423.5	0.397	0.36418	0.032817	1
1453.5	0.411	0.37724	0.033757	1
1483.5	0.426	0.3903	0.035697	1
1513.5	0.469	0.40336	0.065642	1
1543.5	0.476	0.4164	0.059597	1
1573.5	0.491	0.42943	0.061566	1
1603.5	0.505	0.44245	0.062555	1
1633.5	0.52	0.45543	0.06457	1
1663.5	0.534	0.4684	0.065603	1
1693.5	0.548	0.48133	0.066669	1
1723.5	0.57	0.49423	0.075768	1
1753.5	0.577	0.5071	0.069902	1
1783.5	0.585	0.51993	0.065074	1
1813.5	0.592	0.53272	0.059285	1
1843.5	0.599	0.54546	0.053538	1
1873.5	0.606	0.55817	0.047835	1
1903.5	0.613	0.57082	0.042177	1
1933.5	0.613	0.58343	0.029566	1
1963.5	0.613	0.596	0.017003	1
1993.5	0.606	0.60851	-0.0025094	1
2023.5	0.606	0.62097	-0.014971	1
2053.5	0.599	0.63338	-0.034381	1
2083.5	0.599	0.64574	-0.046739	1
2113.5	0.599	0.65804	-0.059042	1
2143.5	0.599	0.67029	-0.071292	1
2173.5	0.599	0.68249	-0.083486	1
2203.5	0.606	0.69462	-0.088625	1
2233.5	0.613	0.70671	-0.093707	1
2263.5	0.621	0.71873	-0.097734	1
2293.5	0.628	0.7307	-0.1027	1
2323.5	0.642	0.74262	-0.10062	1
2353.5	0.657	0.75447	-0.09747	1
2383.5	0.664	0.76627	-0.10227	1
2413.5	0.678	0.77801	-0.10001	1
2443.5	0.7	0.78969	-0.089688	1
2473.5	0.707	0.80131	-0.094312	1
2503.5	0.722	0.81288	-0.090878	1
2533.5	0.736	0.82439	-0.088385	1
2563.5	0.751	0.83584	-0.084835	1
2593.5	0.772	0.84723	-0.075227	1
2623.5	0.787	0.85856	-0.071562	1
2653.5	0.794	0.86984	-0.075838	1
2683.5	0.801	0.88106	-0.080058	1
2713.5	0.808	0.89222	-0.084219	1
2743.5	0.816	0.90332	-0.087324	1
2773.5	0.823	0.91437	-0.091372	1
2803.5	0.83	0.92536	-0.095363	1
2833.5	0.837	0.9363	-0.099298	1
2863.5	0.787	0.94718	-0.16018	1
2893.5	0.642	0.958	-0.316	1
2923.5	0.671	0.96877	-0.29777	1
2953.5	0.729	0.97948	-0.25048	1
2983.5	0.751	0.99013	-0.23913	1
3013.5	0.808	1.0007	-0.19274	1
3043.5	0.859	1.0113	-0.15228	1
3073.5	0.909	1.0218	-0.11278	1

3103.5	0.953	1.0322	-0.079215	1
3133.5	0.989	1.0426	-0.053601	1
3163.5	1.032	1.0529	-0.020933	1
3193.5	1.068	1.0632	0.004787	1
3223.5	1.097	1.0734	0.02356	1
3253.5	1.133	1.0836	0.049385	1
3283.5	1.162	1.0937	0.068261	1
3313.5	1.191	1.1038	0.087189	1
3343.5	1.213	1.1138	0.099168	1
3373.5	1.234	1.1238	0.1102	1
3403.5	1.249	1.1337	0.11528	1
3433.5	1.263	1.1436	0.11941	1
3463.5	1.27	1.1534	0.11659	1
3493.5	1.278	1.1632	0.11482	1
3523.5	1.278	1.1729	0.10509	1
3553.5	1.285	1.1826	0.10242	1
3583.5	1.292	1.1922	0.099794	1
3613.5	1.292	1.2018	0.090216	1
3643.5	1.292	1.2113	0.080685	1
3673.5	1.292	1.2208	0.071202	1
3703.5	1.285	1.2302	0.054765	1
3733.5	1.292	1.2396	0.052375	1
3763.5	1.299	1.249	0.05003	1
3793.5	1.299	1.2583	0.040731	1
3823.5	1.306	1.2675	0.038477	1
3853.5	1.321	1.2767	0.044268	1
3883.5	1.328	1.2859	0.042104	1
3913.5	1.335	1.295	0.039984	1
3943.5	1.35	1.3041	0.045907	1
3973.5	1.364	1.3131	0.050874	1
4003.5	1.386	1.3221	0.063885	1
4033.5	1.393	1.3311	0.061938	1
4063.5	1.415	1.34	0.075033	1
4093.5	1.429	1.3488	0.080171	

TAC-1A TEST - DRAWDOWN NMW-5C



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Modeling Group

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A Q T E S O L V   R E S U L T S

Version 1.10

7/30/92 12:31:36

TEST DESCRIPTION

ata set........... b:\ddnmw-5c.aqt
ata set title..... TAC-1A TEST - DRAWDOWN NMW-5C

nowns and Constants:
No. of data points.................. 278
Pumping rate........................ 401
Radius (distance) to obs. well...... 8831
Radius of pumped well casing........ 0.5
Radius of pumped wellbore........... 0.5

ANALYTICAL METHOD

ooper-Jacob (Confined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	8.9547E+001	+/-	3.8172E+000
S =	6.3574E-004	+/-	3.4909E-005

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 278
Number of estimated parameters.... 2
Degrees of freedom................ 276
Residual mean..................... -3.817E-011
Residual standard deviation....... 0.2485
Residual variance................. 0.06178

l Residuals:

Time	Observed	Calculated	Residual	Weight
13.476	0.007	-1.036	1.043	1
43.477	0.022	-0.61851	0.64051	1

73.476	0.036	-0.43148	0.46748	1
103.48	0.043	-0.30945	0.35245	1
133.48	0.058	-0.21871	0.27671	1
163.48	0.065	-0.14645	0.21145	1
193.47	0.079	-0.086399	0.1654	1
223.48	0.094	-0.035016	0.12902	1
253.48	0.094	0.0098793	0.084121	1
283.47	0.108	0.049745	0.058255	1
313.48	0.108	0.085601	0.022399	1
343.48	0.101	0.11818	-0.017176	1
373.47	0.13	0.14802	-0.018021	1
403.48	0.13	0.17556	-0.04556	1
433.48	0.123	0.20112	-0.078123	1
463.47	0.123	0.22497	-0.10197	1
493.48	0.123	0.24733	-0.12433	1
523.48	0.115	0.26836	-0.15336	1
553.48	0.115	0.28823	-0.17323	1
583.48	0.115	0.30704	-0.19204	1
613.48	0.108	0.32491	-0.21691	1
643.48	0.108	0.34193	-0.23393	1
673.48	0.115	0.35817	-0.24317	1
703.48	0.115	0.3737	-0.2587	1
733.48	0.123	0.38859	-0.26559	1
763.48	0.137	0.40287	-0.26587	1
793.48	0.151	0.41661	-0.26561	1
823.48	0.166	0.42984	-0.26384	1
853.48	0.18	0.44259	-0.26259	1
883.48	0.195	0.45491	-0.25991	1
913.48	0.209	0.46681	-0.25781	1
943.48	0.224	0.47833	-0.25433	1
973.48	0.238	0.48948	-0.25148	1
1003.5	0.26	0.5003	-0.2403	1
1033.5	0.274	0.5108	-0.2368	1
1063.5	0.289	0.521	-0.232	1
1093.5	0.303	0.53091	-0.22791	1
1123.5	0.31	0.54056	-0.23056	1
1153.5	0.325	0.54995	-0.22495	1
1183.5	0.332	0.55911	-0.22711	1
1213.5	0.339	0.56803	-0.22903	1
1243.5	0.346	0.57673	-0.23073	1
1273.5	0.354	0.58523	-0.23123	1
1303.5	0.368	0.59353	-0.22553	1
1333.5	0.375	0.60164	-0.22664	1
1363.5	0.382	0.60957	-0.22757	1
1393.5	0.39	0.61733	-0.22733	1
1423.5	0.397	0.62492	-0.22792	1
1453.5	0.411	0.63235	-0.22135	1
1483.5	0.426	0.63963	-0.21363	1
1513.5	0.469	0.64677	-0.17777	1
1543.5	0.476	0.65376	-0.17776	1
1573.5	0.491	0.66063	-0.16963	1
1603.5	0.505	0.66736	-0.16236	1
1633.5	0.52	0.67396	-0.15396	1
1663.5	0.534	0.68045	-0.14645	1
1693.5	0.548	0.68682	-0.13882	1
1723.5	0.57	0.69308	-0.12308	1
1753.5	0.577	0.69923	-0.12223	1
1783.5	0.585	0.70528	-0.12028	1
1813.5	0.592	0.71122	-0.11922	1
1843.5	0.599	0.71707	-0.11807	1

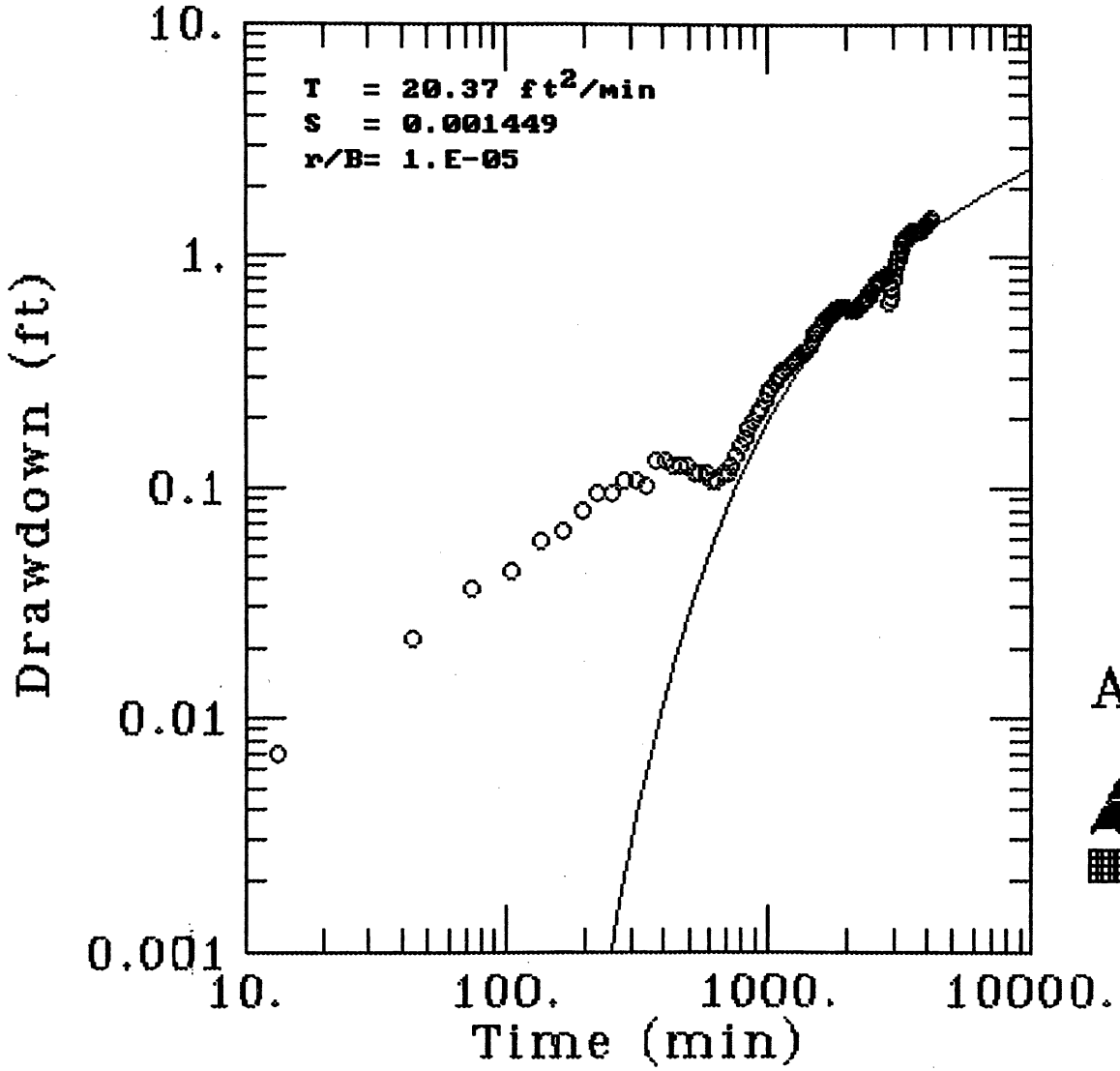
1873.5	0.606	0.72282	-0.11682	1
1903.5	0.613	0.72849	-0.11549	1
1933.5	0.613	0.73406	-0.12106	1
1963.5	0.613	0.73955	-0.12655	1
1993.5	0.606	0.74495	-0.13895	1
2023.5	0.606	0.75028	-0.14428	1
2053.5	0.599	0.75552	-0.15652	1
2083.5	0.599	0.76069	-0.16169	1
2113.5	0.599	0.76579	-0.16679	1
2143.5	0.599	0.77081	-0.17181	1
2173.5	0.599	0.77576	-0.17676	1
2203.5	0.606	0.78065	-0.17465	1
2233.5	0.613	0.78547	-0.17247	1
2263.5	0.621	0.79023	-0.16923	1
2293.5	0.628	0.79492	-0.16692	1
2323.5	0.642	0.79955	-0.15755	1
2353.5	0.657	0.80412	-0.14712	1
2383.5	0.664	0.80864	-0.14464	1
2413.5	0.678	0.8131	-0.1351	1
2443.5	0.7	0.8175	-0.1175	1
2473.5	0.707	0.82185	-0.11485	1
2503.5	0.722	0.82614	-0.10414	1
2533.5	0.736	0.83039	-0.09439	1
2563.5	0.751	0.83459	-0.083586	1
2593.5	0.772	0.83873	-0.066733	1
2623.5	0.787	0.84283	-0.055832	1
2653.5	0.794	0.84688	-0.052885	1
2683.5	0.801	0.85089	-0.049892	1
2713.5	0.808	0.85485	-0.046854	1
2743.5	0.816	0.85877	-0.042773	1
2773.5	0.823	0.86265	-0.03965	1
2803.5	0.83	0.86648	-0.036484	1
2833.5	0.837	0.87028	-0.033278	1
2863.5	0.787	0.87403	-0.087032	1
2893.5	0.642	0.87775	-0.23575	1
2923.5	0.671	0.88142	-0.21042	1
2953.5	0.729	0.88506	-0.15606	1
2983.5	0.751	0.88866	-0.13766	1
3013.5	0.808	0.89223	-0.08423	1
3043.5	0.859	0.89576	-0.036761	1
3073.5	0.909	0.89926	0.009743	1
3103.5	0.953	0.90272	0.050281	1
3133.5	0.989	0.90615	0.082852	1
3163.5	1.032	0.90954	0.12246	1
3193.5	1.068	0.91291	0.15509	1
3223.5	1.097	0.91624	0.18076	1
3253.5	1.133	0.91954	0.21346	1
3283.5	1.162	0.92281	0.23919	1
3313.5	1.191	0.92606	0.26494	1
3343.5	1.213	0.92927	0.28373	1
3373.5	1.234	0.93245	0.30155	1
3403.5	1.249	0.93561	0.31339	1
3433.5	1.263	0.93874	0.32426	1
3463.5	1.27	0.94184	0.32816	1
3493.5	1.278	0.94491	0.33309	1
3523.5	1.278	0.94796	0.33004	1
3553.5	1.285	0.95098	0.33402	1
3583.5	1.292	0.95398	0.33802	1
3613.5	1.292	0.95695	0.33505	1
3643.5	1.292	0.95989	0.33211	1

3673.5	1.292	0.96282	0.32918	1
3703.5	1.285	0.96572	0.31928	1
3733.5	1.292	0.96859	0.32341	1
3763.5	1.299	0.97144	0.32756	1
3793.5	1.299	0.97427	0.32473	1
3823.5	1.306	0.97708	0.32892	1
3853.5	1.321	0.97987	0.34113	1
3883.5	1.328	0.98263	0.34537	1
3913.5	1.335	0.98537	0.34963	1
3943.5	1.35	0.9881	0.3619	1
3973.5	1.364	0.9908	0.3732	1
4003.5	1.386	0.99348	0.39252	1
4033.5	1.393	0.99614	0.39686	1
4063.5	1.415	0.99878	0.41622	1
4093.5	1.429	1.0014	0.4276	1
4123.5	1.444	1.004	0.44	1
4153.5	1.451	1.0066	0.44441	1
13.476	0.007	-1.036	1.043	1
43.477	0.022	-0.61851	0.64051	1
73.476	0.036	-0.43148	0.46748	1
103.48	0.043	-0.30945	0.35245	1
133.48	0.058	-0.21871	0.27671	1
163.48	0.065	-0.14645	0.21145	1
193.47	0.079	-0.086399	0.1654	1
223.48	0.094	-0.035016	0.12902	1
253.48	0.094	0.0098793	0.084121	1
283.47	0.108	0.049745	0.058255	1
313.48	0.108	0.085601	0.022399	1
343.48	0.101	0.11818	-0.017176	1
373.47	0.13	0.14802	-0.018021	1
403.48	0.13	0.17556	-0.04556	1
433.48	0.123	0.20112	-0.078123	1
463.47	0.123	0.22497	-0.10197	1
493.48	0.123	0.24733	-0.12433	1
523.48	0.115	0.26836	-0.15336	1
553.48	0.115	0.28823	-0.17323	1
583.48	0.115	0.30704	-0.19204	1
613.48	0.108	0.32491	-0.21691	1
643.48	0.108	0.34193	-0.23393	1
673.48	0.115	0.35817	-0.24317	1
703.48	0.115	0.3737	-0.2587	1
733.48	0.123	0.38859	-0.26559	1
763.48	0.137	0.40287	-0.26587	1
793.48	0.151	0.41661	-0.26561	1
823.48	0.166	0.42984	-0.26384	1
853.48	0.18	0.44259	-0.26259	1
883.48	0.195	0.45491	-0.25991	1
913.48	0.209	0.46681	-0.25781	1
943.48	0.224	0.47833	-0.25433	1
973.48	0.238	0.48948	-0.25148	1
1003.5	0.26	0.5003	-0.2403	1
1033.5	0.274	0.5108	-0.2368	1
1063.5	0.289	0.521	-0.232	1
1093.5	0.303	0.53091	-0.22791	1
1123.5	0.31	0.54056	-0.23056	1
1153.5	0.325	0.54995	-0.22495	1
1183.5	0.332	0.55911	-0.22711	1
1213.5	0.339	0.56803	-0.22903	1
1243.5	0.346	0.57673	-0.23073	1
1273.5	0.354	0.58523	-0.23123	1

1303.5	0.368	0.59353	-0.22553	1
1333.5	0.375	0.60164	-0.22664	1
1363.5	0.382	0.60957	-0.22757	1
1393.5	0.39	0.61733	-0.22733	1
1423.5	0.397	0.62492	-0.22792	1
1453.5	0.411	0.63235	-0.22135	1
1483.5	0.426	0.63963	-0.21363	1
1513.5	0.469	0.64677	-0.17777	1
1543.5	0.476	0.65376	-0.17776	1
1573.5	0.491	0.66063	-0.16963	1
1603.5	0.505	0.66736	-0.16236	1
1633.5	0.52	0.67396	-0.15396	1
1663.5	0.534	0.68045	-0.14645	1
1693.5	0.548	0.68682	-0.13882	1
1723.5	0.57	0.69308	-0.12308	1
1753.5	0.577	0.69923	-0.12223	1
1783.5	0.585	0.70528	-0.12028	1
1813.5	0.592	0.71122	-0.11922	1
1843.5	0.599	0.71707	-0.11807	1
1873.5	0.606	0.72282	-0.11682	1
1903.5	0.613	0.72849	-0.11549	1
1933.5	0.613	0.73406	-0.12106	1
1963.5	0.613	0.73955	-0.12655	1
1993.5	0.606	0.74495	-0.13895	1
2023.5	0.606	0.75028	-0.14428	1
2053.5	0.599	0.75552	-0.15652	1
2083.5	0.599	0.76069	-0.16169	1
2113.5	0.599	0.76579	-0.16679	1
2143.5	0.599	0.77081	-0.17181	1
2173.5	0.599	0.77576	-0.17676	1
2203.5	0.606	0.78065	-0.17465	1
2233.5	0.613	0.78547	-0.17247	1
2263.5	0.621	0.79023	-0.16923	1
2293.5	0.628	0.79492	-0.16692	1
2323.5	0.642	0.79955	-0.15755	1
2353.5	0.657	0.80412	-0.14712	1
2383.5	0.664	0.80864	-0.14464	1
2413.5	0.678	0.8131	-0.1351	1
2443.5	0.7	0.8175	-0.1175	1
2473.5	0.707	0.82185	-0.11485	1
2503.5	0.722	0.82614	-0.10414	1
2533.5	0.736	0.83039	-0.09439	1
2563.5	0.751	0.83459	-0.083586	1
2593.5	0.772	0.83873	-0.066733	1
2623.5	0.787	0.84283	-0.055832	1
2653.5	0.794	0.84688	-0.052885	1
2683.5	0.801	0.85089	-0.049892	1
2713.5	0.808	0.85485	-0.046854	1
2743.5	0.816	0.85877	-0.042773	1
2773.5	0.823	0.86265	-0.03965	1
2803.5	0.83	0.86648	-0.036484	1
2833.5	0.837	0.87028	-0.033278	1
2863.5	0.787	0.87403	-0.087032	1
2893.5	0.642	0.87775	-0.23575	1
2923.5	0.671	0.88142	-0.21042	1
2953.5	0.729	0.88506	-0.15606	1
2983.5	0.751	0.88866	-0.13766	1
3013.5	0.808	0.89223	-0.08423	1
3043.5	0.859	0.89576	-0.036761	1
3073.5	0.909	0.89926	0.009743	1

3103.5	0.953	0.90272	0.050281	1
3133.5	0.989	0.90615	0.082852	1
3163.5	1.032	0.90954	0.12246	1
3193.5	1.068	0.91291	0.15509	1
3223.5	1.097	0.91624	0.18076	1
3253.5	1.133	0.91954	0.21346	1
3283.5	1.162	0.92281	0.23919	1
3313.5	1.191	0.92606	0.26494	1
3343.5	1.213	0.92927	0.28373	1
3373.5	1.234	0.93245	0.30155	1
3403.5	1.249	0.93561	0.31339	1
3433.5	1.263	0.93874	0.32426	1
3463.5	1.27	0.94184	0.32816	1
3493.5	1.278	0.94491	0.33309	1
3523.5	1.278	0.94796	0.33004	1
3553.5	1.285	0.95098	0.33402	1
3583.5	1.292	0.95398	0.33802	1
3613.5	1.292	0.95695	0.33505	1
3643.5	1.292	0.95989	0.33211	1
3673.5	1.292	0.96282	0.32918	1
3703.5	1.285	0.96572	0.31928	1
3733.5	1.292	0.96859	0.32341	1
3763.5	1.299	0.97144	0.32756	1
3793.5	1.299	0.97427	0.32473	1
3823.5	1.306	0.97708	0.32892	1
3853.5	1.321	0.97987	0.34113	1
3883.5	1.328	0.98263	0.34537	1
3913.5	1.335	0.98537	0.34963	1
3943.5	1.35	0.9881	0.3619	1
3973.5	1.364	0.9908	0.3732	1
4003.5	1.386	0.99348	0.39252	1
4033.5	1.393	0.99614	0.39686	1
4063.5	1.415	0.99878	0.41622	1
4093.5	1.429	1.0014	0.42	

TAC-1A TEST - DRAWDOWN NMW-5C



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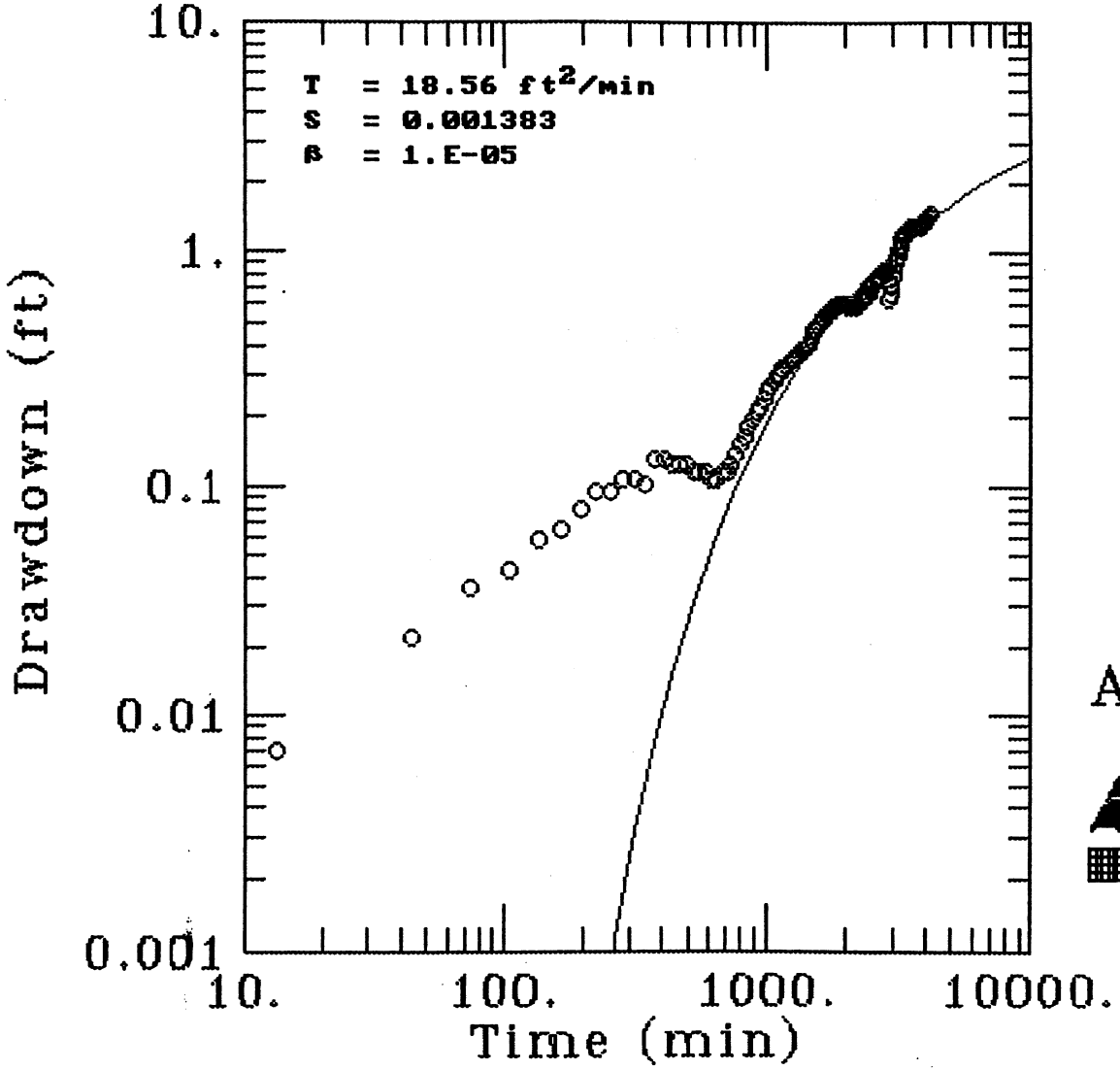
Modeling Group

TAC-1A TEST - DRAWDOWN NMW-5C



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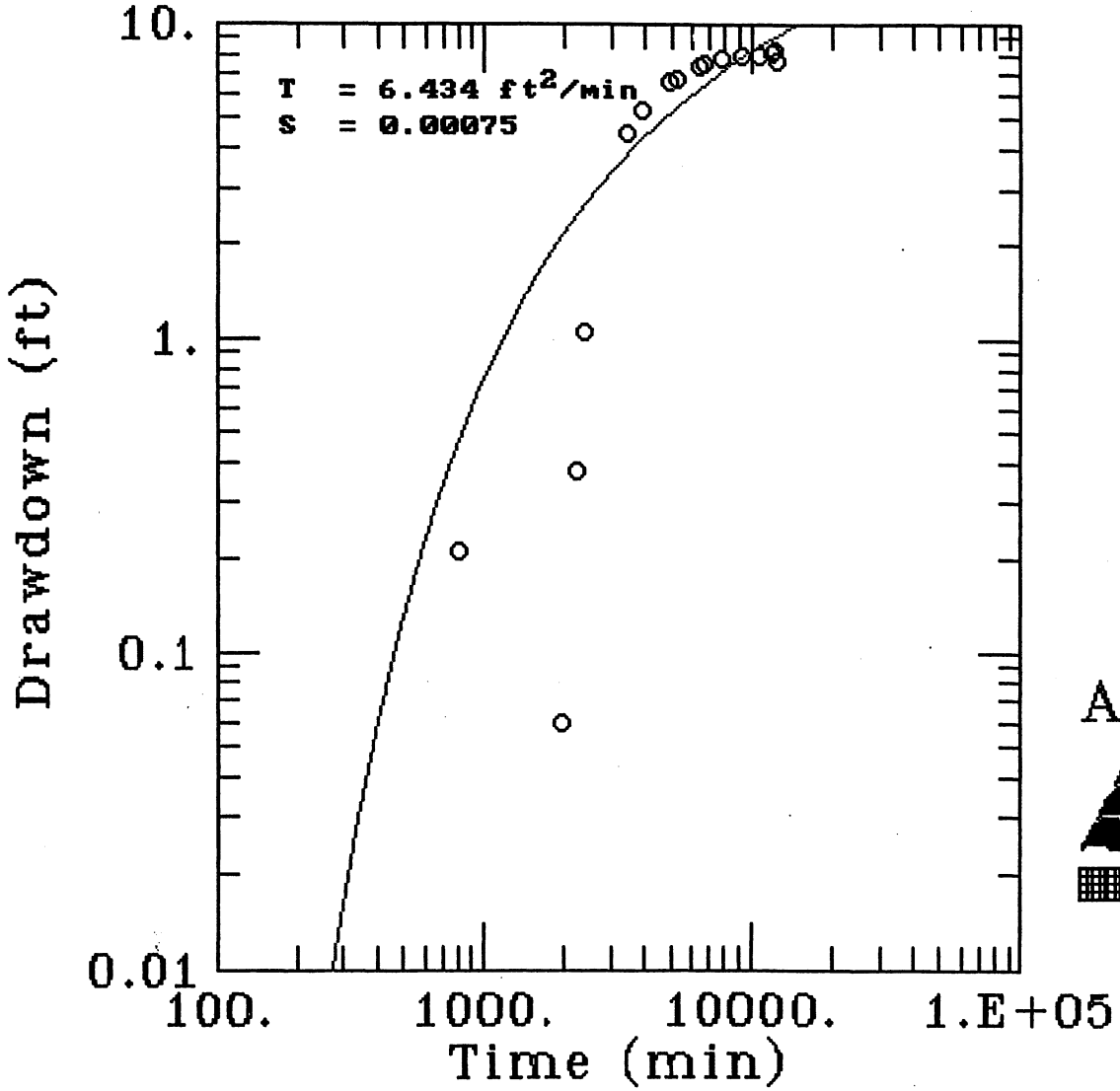
Modeling Group

DATA ANALYSIS
OF TAC 1A PUMPING TEST
FOR TAC 89.5

TAC-1A - 89.5 DRAWDOWN



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A Q T E S O L V   R E S U L T S
Version 1.10

7/30/92 11:07:05

TEST DESCRIPTION

ata set........... b:\89_5dd.aqt
ata set title..... TAC-1A - 89.5 DRAWDOWN

nowns and Constants:
No. of data points.................. 16
Pumping rate......................... 401
Radius (distance) to obs. well...... 6528
Radius of pumped well casing........ 0.25
Radius of pumped wellbore........... 0.25

ANALYTICAL METHOD

heis (Confined Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	6.4337E+000	+/-	1.4480E+000
S	=	7.4998E-004	+/-	1.1668E-004

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals................ 16
Number of estimated parameters.... 2
Degrees of freedom................ 14
Residual mean..................... -0.08252
Residual standard deviation....... 1.294
Residual variance................. 1.674

l Residuals:

Time	Observed	Calculated	Residual	Weight
805	0.21	0.46578	-0.25578	1
1925	0.06	2.0609	-2.0009	1

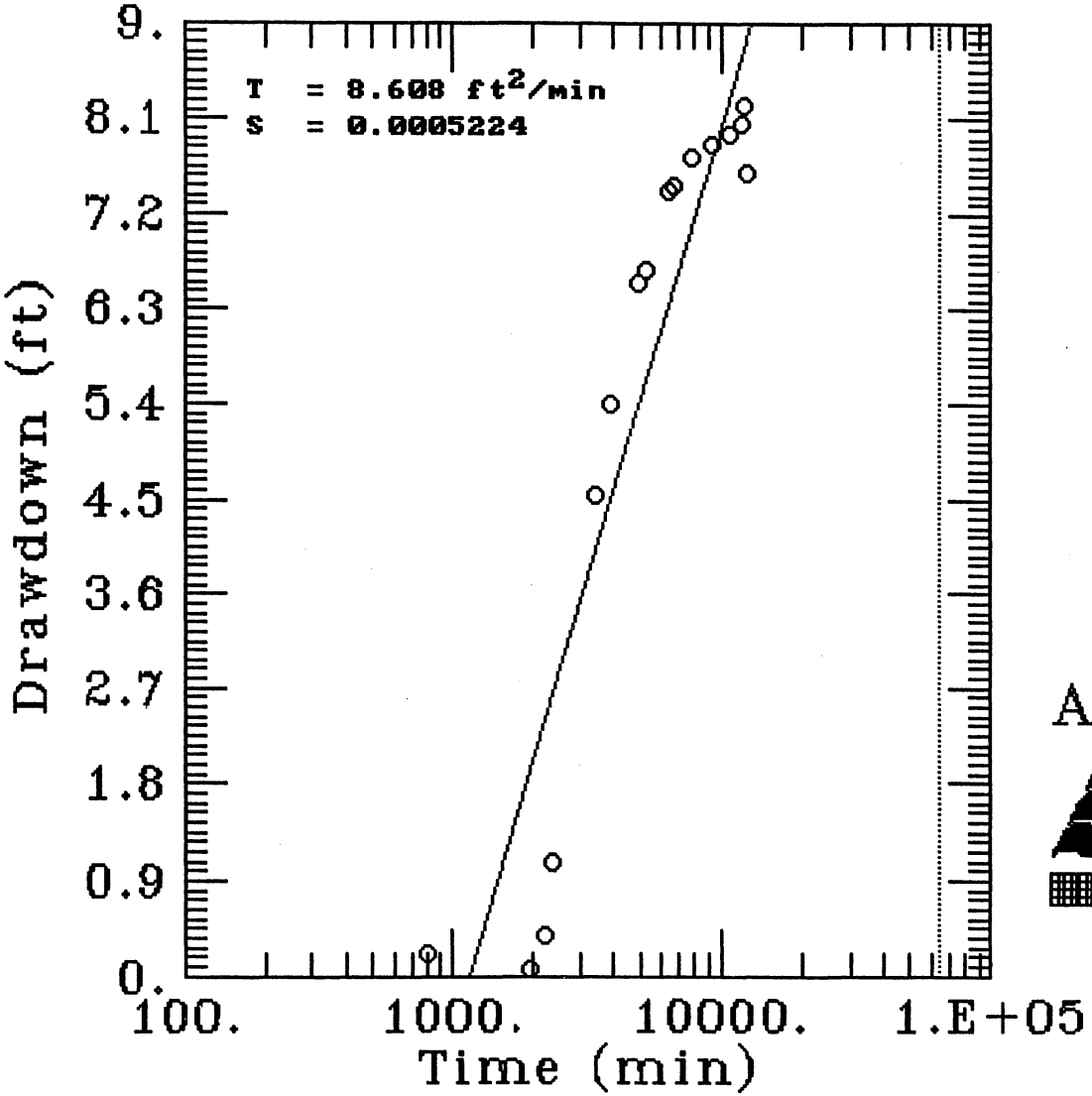
2195	0.38	2.4166	-2.0366	1
2386	1.06	2.6572	-1.5972	1
3398	4.53	3.7895	0.74046	1
3853	5.39	4.2317	1.1583	1
4875	6.57	5.1075	1.4625	1
5230	6.69	5.3801	1.3099	1
6354	7.43	6.1584	1.2716	1
6664	7.46	6.3536	1.1064	1
7734	7.75	6.9747	0.77525	1
9248	7.87	7.7403	0.12973	1
10610	7.96	8.3414	-0.38137	1
11995	8.06	8.8865	-0.82646	1
12175	8.23	8.9531	-0.72312	1
12394	7.58	9.033	-1.453	1

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	6.4337E+000
S	=	7.4998E-004

TAC-1A - 89.5 DRAWDOWN



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A Q T E S O L V   R E S U L T S
Version 1.10

7/30/92 11:10:48

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TEST DESCRIPTION

ata set........... b:\89_5dd.aqt
ata set title..... TAC-1A - 89.5 DRAWDOWN

nowns and Constants:
- No. of data points.................. 16
- Pumping rate........................ 401
- Radius (distance) to obs. well...... 6528
- Radius of pumped well casing........ 0.25
- Radius of pumped wellbore........... 0.25

==

ANALYTICAL METHOD

ooper-Jacob (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	8.6081E+000	+/-	9.4181E-001
S =	5.2244E-004	+/-	5.1196E-005

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
- Number of residuals............... 16
- Number of estimated parameters.... 2
- Degrees of freedom................ 14
- Residual mean..................... 2.046E-011
- Residual standard deviation....... 1.228
- Residual variance................. 1.508

r-l Residuals:

Time	Observed	Calculated	Residual	Weight
805	0.21	-1.3271	1.5371	1
1925	0.06	1.9054	-1.8454	1

2195	0.38	2.3921	-2.0121	1
2386	1.06	2.7014	-1.6414	1
3398	4.53	4.0123	0.51766	1
3853	5.39	4.4783	0.91174	1
4875	6.57	5.3506	1.2194	1
5230	6.69	5.6112	1.0788	1
6354	7.43	6.333	1.097	1
6664	7.46	6.5096	0.95041	1
7734	7.75	7.0617	0.68831	1
9248	7.87	7.7246	0.14544	1
10610	7.96	8.234	-0.27395	1
11995	8.06	8.6889	-0.62886	1
12175	8.23	8.7441	-0.51409	1
12394	7.58	8.8102	-1.2302	1

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RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

```
          Estimate
  T  =   8.6081E+000
  S  =   5.2244E-004
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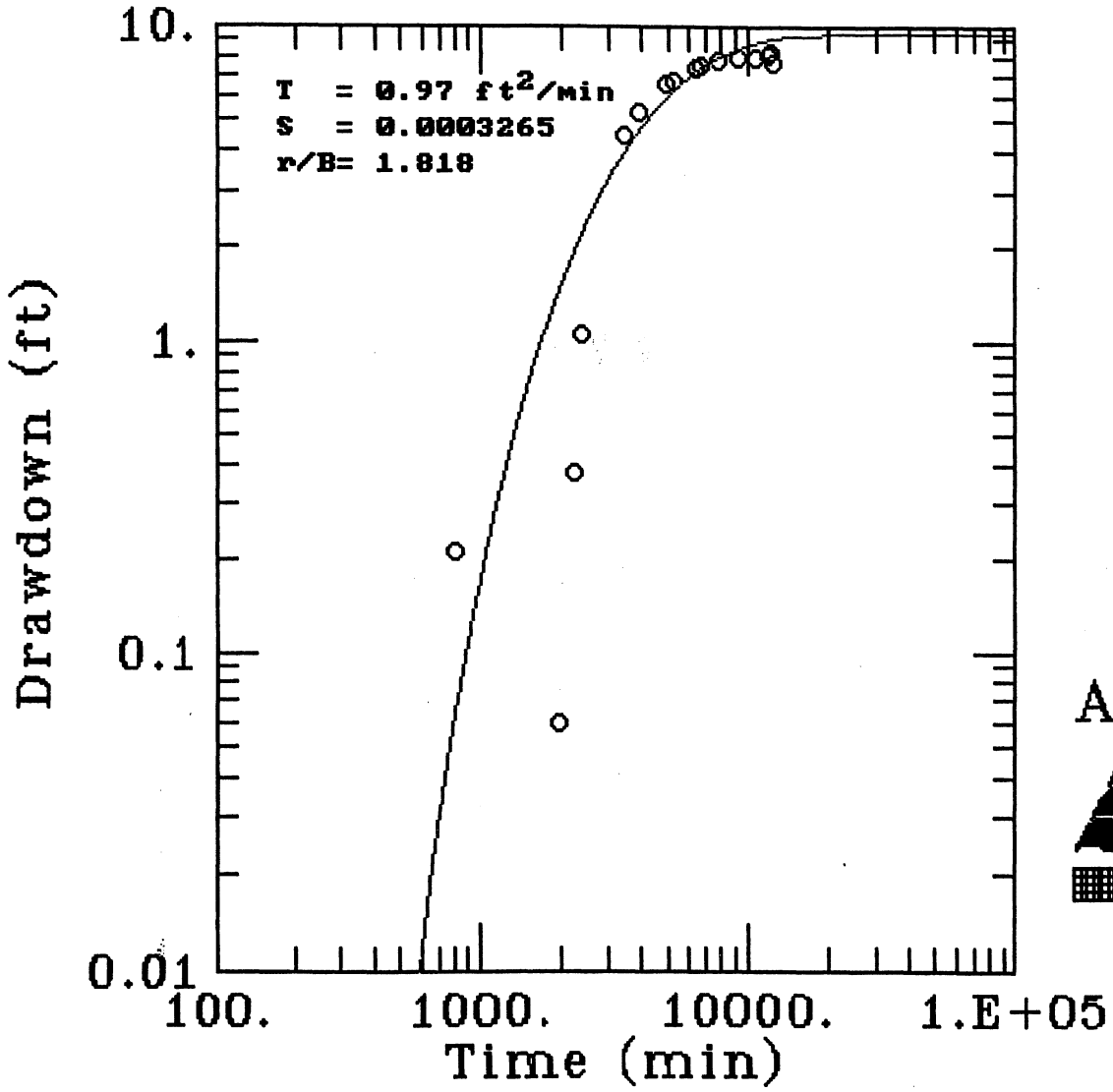
TAC-1A - 89.5 DRAWDOWN



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V   R E S U L T S
Version 1.10

7/30/92 11:14:01

TEST DESCRIPTION

ata set........... b:\89_5dd.aqt
ata set title..... TAC-1A - 89.5 DRAWDOWN

nowns and Constants:
- No. of data points................... 16
- Pumping rate......................... 401
- Radius (distance) to obs. well...... 6528
- Radius of pumped well casing........ 0.25
- Radius of pumped wellbore........... 0.25

ANALYTICAL METHOD

antush (Leaky Aquifer)

RESULTS FROM STATISTICAL CURVE MATCHING

TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	9.7000E-001	+/-	1.5662E+000
S =	3.2648E-004	+/-	2.3656E-004
r/B=	1.8177E+000	+/-	9.1158E-001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
- Number of residuals................ 16
- Number of estimated parameters.... 3
- Degrees of freedom................ 13
- Residual mean..................... -0.3084
- Residual standard deviation....... 0.9411
- Residual variance................. 0.8857

Residuals:

Time	Observed	Calculated	Residual	Weight
805	0.21	0.061495	0.1485	1

1925	0.06	1.3961	-1.3361	1
2195	0.38	1.8659	-1.4859	1
2386	1.06	2.204	-1.144	1
3398	4.53	3.9039	0.62613	1
3853	5.39	4.5699	0.82007	1
4875	6.57	5.8117	0.75831	1
5230	6.69	6.1668	0.52322	1
6354	7.43	7.0759	0.35414	1
6664	7.46	7.2776	0.18244	1
7734	7.75	7.8459	-0.095863	1
9248	7.87	8.3944	-0.52438	1
10610	7.96	8.7159	-0.75591	1
11995	8.06	8.9346	-0.87462	1
12175	8.23	8.9571	-0.72713	1
12394	7.58	8.983	-1.403	1

==

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	9.7000E-001
S =	3.2648E-004
r/B=	1.8177E+000

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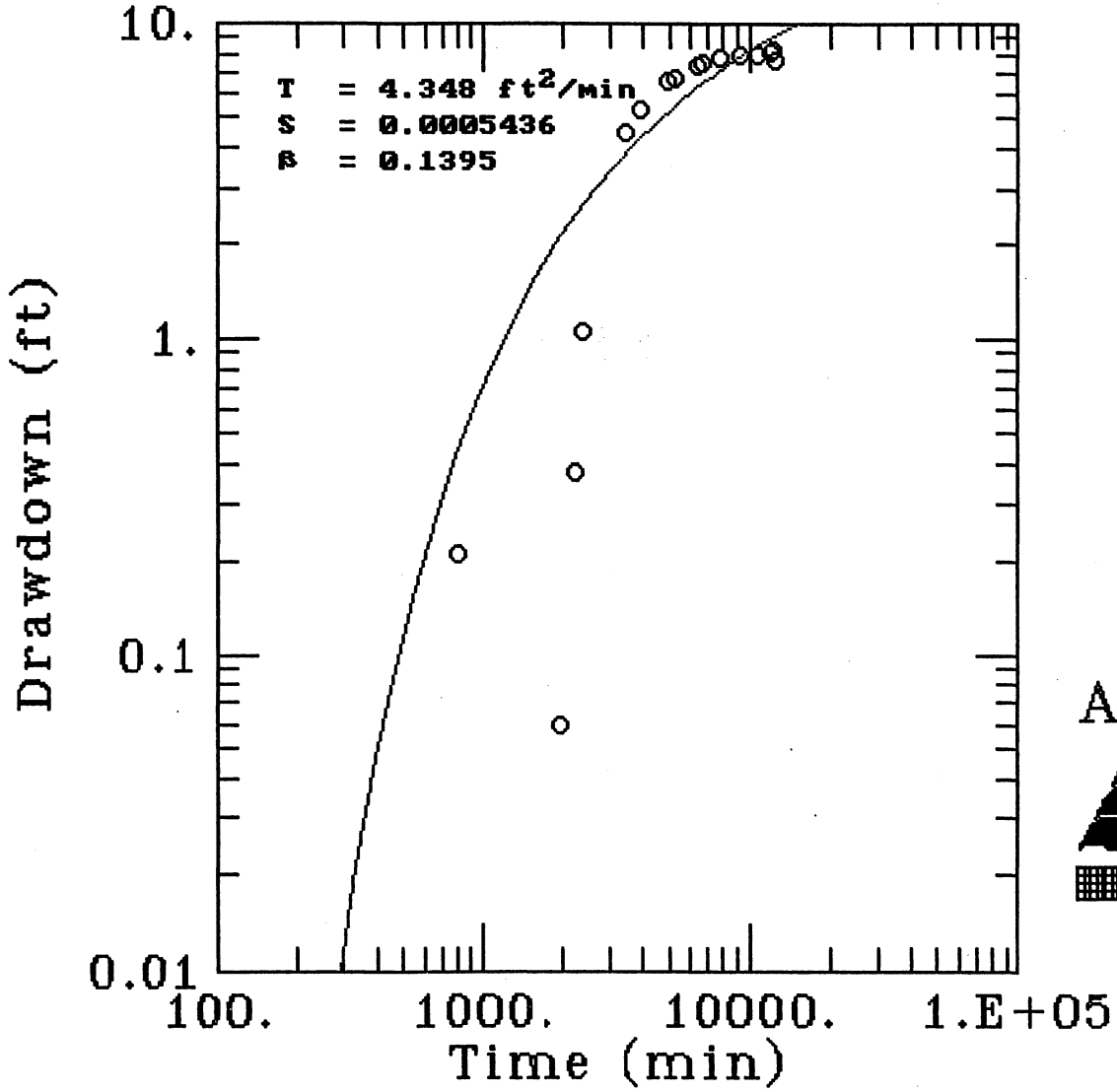
TAC-1A - 89.5 DRAWDOWN



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Modeling Group

A Q T E S O L V R E S U L T S
Version 1.10

0/92 12:01:20

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TEST DESCRIPTION

ata set..... b:\89_5dd.aqt
ata set title..... TAC-1A - 89.5 DRAWDOWN

nowns and Constants:
No. of data points..... 16
Pumping rate..... 401
Radius (distance) to obs. well..... 6528
Radius of pumped well casing..... 0.25
Radius of pumped wellbore..... 0.25

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ANALYTICAL METHOD

antush (Leaky Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

STICAL MATCH PARAMETER ESTIMATES

		Estimate		Std. Error
T	=	4.3477E+000	+/-	2.4240E+002
S	=	5.4363E-004	+/-	2.9093E-002
β	=	1.3946E-001	+/-	2.4955E+001

NALYSIS OF MODEL RESIDUALS

esidual = calculated - observed
eighted residual = residual * weight

eighted Residual Statistics:
Number of residuals..... 16
Number of estimated parameters.... 3
Degrees of freedom..... 13
Residual mean..... -0.08531
Residual standard deviation..... 1.321
Residual variance..... 1.746

odel Residuals:

Time	Observed	Calculated	Residual	Weight
805	0.21	0.43473	-0.22473	1
1925	0.06	2.0399	-1.9799	1
2195	0.38	2.4026	-2.0226	1
2386	1.06	2.648	-1.588	1

4875	6.57	5.1362	1.4338	1
5230	6.69	5.4105	1.2795	1
6354	7.43	6.1894	1.2406	1
6664	7.46	6.3838	1.0762	1
7734	7.75	6.9997	0.75035	1
9248	7.87	7.7526	0.11742	1
10610	7.96	8.3389	-0.37888	1
11995	8.06	8.8667	-0.80668	1
12175	8.23	8.931	-0.70097	1
12394	7.58	9.008	-1.428	1

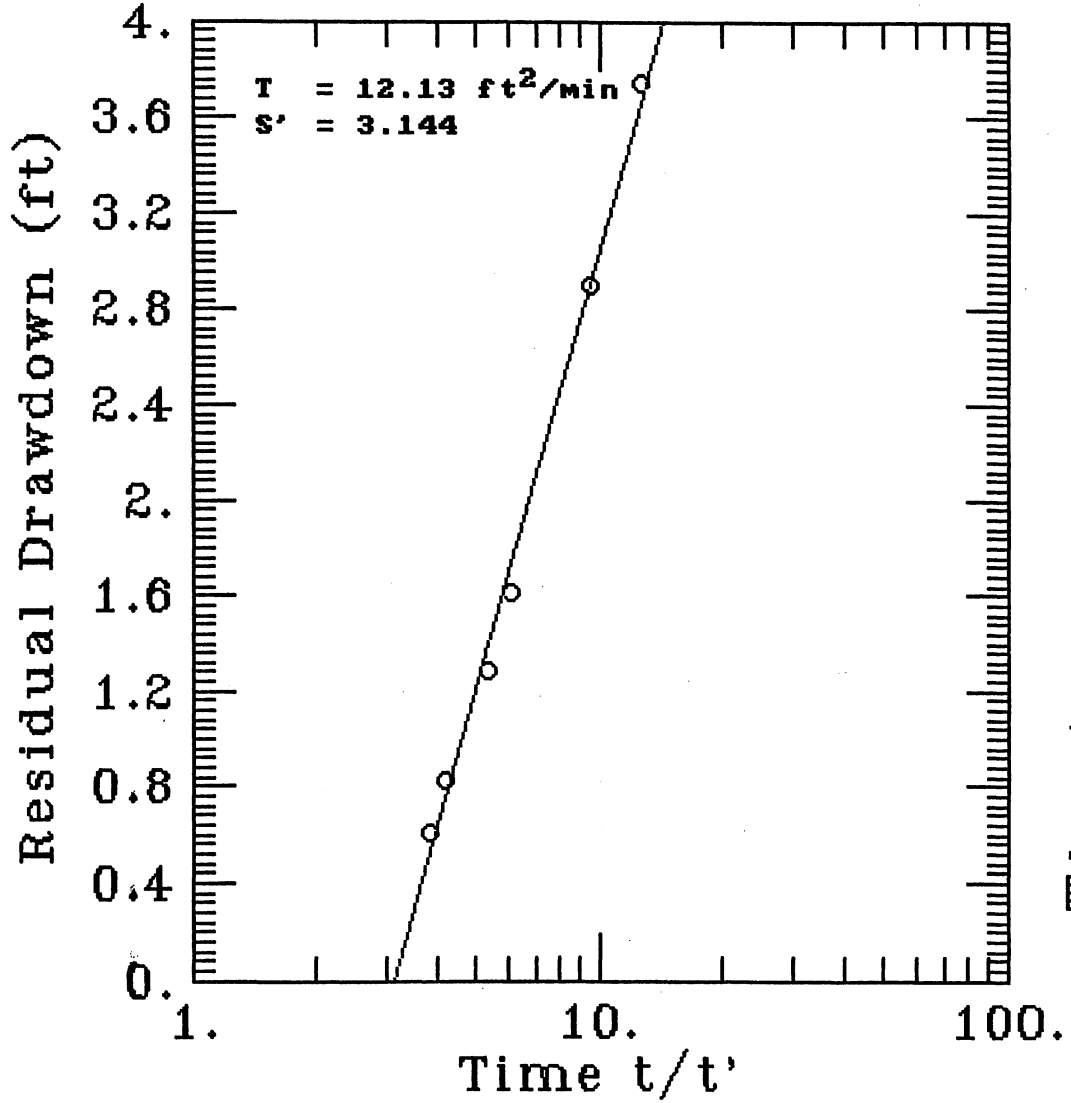
==========

RESULTS FROM VISUAL CURVE MATCHING

ISUAL MATCH PARAMETER ESTIMATES

		Estimate
T	=	4.3477E+000
S	=	5.4363

TAC-1A - 89.5 RECOVERY



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Modeling Group

A Q T E S O L V R E S U L T S
Version 1.10

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TEST DESCRIPTION

)ata set..... b:\89_5rec.aqt
)ata set title..... TAC-1A - 89.5 RECOVERY

:nowns and Constants:
No. of data points..... 6
Pumping rate..... 401
Total pumping time..... 12390

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ANALYTICAL METHOD

'heis Recovery (Confined Aquifer)

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RESULTS FROM STATISTICAL CURVE MATCHING

'TATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	1.2126E+001	+/-	4.4545E-001
S' =	3.1442E+000	+/-	9.3861E-002

.NALYSIS OF MODEL RESIDUALS

'esidual = calculated - observed
'eighted residual = residual * weight

'eighted Residual Statistics:
Number of residuals..... 6
Number of estimated parameters.... 2
Degrees of freedom..... 4
Residual mean..... -2.071E-011
Residual standard deviation..... 0.1005
Residual variance..... 0.01009

:odel Residuals:

Time	Observed	Calculated	Residual	Weight
1057	3.75	3.6799	0.070129	1
1460	2.9	2.9074	-0.0073906	1
2455	1.61	1.7221	-0.11206	1
2869	1.28	1.3843	-0.10426	1
3909	0.83	0.7436	0.086404	1
4327	0.61	0.54283	0.067174	1

HYDRAULIC INVESTIGATION
VERTICAL CONDUCTIVITY
OF AQUITARD OVERLYING LAYER C

SOUTH TACOMA FIELD
HYDRAULIC INVESTIGATION
VERTICAL CONDUCTIVITY
OF AQUITARD OVERLYING LAYER C

29 JULY 1992
K/J 916055.09
VERTCOND.MCD

PURPOSE

The purpose of these calculations is to determine the vertical hydraulic conductivity of the aquitard overlying aquifer Layer C at South Tacoma Field.

In March 1992 Tacoma Public Utilities pumped municipal well TAC-1A at a rate of 3,000 gpm for several days. During this time Kennedy/Jenks monitored onsite wells NMW-3C and NMW-5C and Carr/Associates monitored offsite well 89.5. These wells are completed in Layer C. The time-drawdown data obtained from monitoring of these wells was evaulated using the Theis, Hantush-no storage in aquitard, and Hantush-storage in aquitard methods. The NMW-3C, NMW-5C, and 89.5 time-drawdown data sets were to fit the Hantush-no storage in aquitard type curve. As part of the evaluation the variable B was calculated. B is one of the variables in the well function of Hantush, w(u,r/B). From B the vertical hydraulic conductivity of the aquitard can be calculated as follows:

$$B := \sqrt{\frac{T \cdot b_v}{K_v}}$$

where

T = horizontal transmissivity of aquifer.

b_v = thickness of aquitard.

K_v = vertical hydraulic conductivity of aquitard.

RADIUS, r, FORM WELL TAC-1A TO WELLS

The radius or distance from well TAC-1A to wells NMW-3C, NMW-5C, and 89.5 are as follows:

$$r_{3c} := 5997 \cdot ft$$

$$r_{5c} := 8831 \cdot ft$$

$$r_{89.5} := 6527.6 \cdot ft$$

AQUITARD THICKNESS, b_v

The thickness of the aquitard at wells NMW-3C, NMW-5C, and 89.5 is as follows:

$$b_{v3c} := 2 \cdot ft$$

$$b_{v5c} := 15 \cdot ft$$

$$b_{v89.5} := 41 \cdot ft$$

TRANSMISSIVITY, T

The transmissivity of Layer C at wells NMW-3C, NMW-5C, and 89.5 as calculated using the Hantush-no storage in aquitard method are as follows:

$$T_{3c} := 6.29 \cdot \frac{ft^2}{min}$$

$$T_{5c} := 20.37 \cdot \frac{ft^2}{min}$$

$$T_{89.5} := 0.97 \cdot \frac{ft^2}{min}$$

RATIO OF RADIUS TO B, r/B

The r/B ratio of Layer C at wells NMW-3C, NMW-5C, and 89.5 as calculated using the Hantush-no storage in aquitard method are as follows:

$$B_{3c} := \frac{r_{3c}}{0.5152}$$

$$B_{5c} := \frac{r_{5c}}{1 \cdot 10^{-5}}$$

$$B_{89.5} := \frac{r_{89.5}}{1.818}$$

VERTICAL HYDRAULIC CONDUCTIVITY, K_v

Vertical hydraulic conductivity calculated based on results of Hantush-no storage in aquitard results.

$$K_v := \frac{T \cdot b}{B^2}$$ K_v equation

$$K_{v3c} := \frac{T_{3c} \cdot b_{v3c}}{B_{3c}^2}$$

$$K_{v5c} := \frac{T_{5c} \cdot b_{v5c}}{B_{5c}^2}$$

$$K_{v89.5} := \frac{T_{89.5} \cdot b_{v89.5}}{B_{89.5}^2}$$

Vertical Hydraulic Conductivities

$K_{v3c} = 1.337 \cdot 10^{-4} \cdot \frac{ft}{day}$ or $K_{v3c} = 4.717 \cdot 10^{-8} \cdot \frac{cm}{sec}$

$K_{v5c} = 5.642 \cdot 10^{-13} \cdot \frac{ft}{day}$ $K_{v5c} = 0 \cdot \frac{cm}{sec}$

$K_{v89.5} = 4.442 \cdot 10^{-3} \cdot \frac{ft}{day}$ $K_{v89.5} = 1.567 \cdot 10^{-6} \cdot \frac{cm}{sec}$

NOTE ON WELL NMW-5C

It should be noted that the well NMW-5C data set was distorted by nearby recharge wells shortly after the start of TAC-1A pump test. The early un-distorted data was used for this analysis. Based on the vertical conductivity results it appears that un-distorted drawdown did not extend long enough to a establish a data set for calulation of leakance by the Hantush method.