Overview of the Development and Implementation of Montana's Numeric Nutrient Standards

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April 28, 2015
U.S. EPA Numeric Nutrient Criteria Webinar Series
EPA Region VIII

2017-010046-0000278

Nutrient Standards Development in Montana

- 1980s: P-detergent bans in Flathead, Clark Fork basins
- 1990s: Clark Fork River criteria derived; voluntary compliance
- 2001: DEQ starts working on criteria for all surface waters
- 2002: Clark Fork River criteria adopted as standards by BER
- 2003-2008: Statewide criteria for wadeable streams largely identified. DEQ IDs geographic zones for different criteria. Large-river criteria work begun.
- 2009, 2011: Legislature adopts SB-95, SB-367: allow variances from nutrient standards. Nutrient Work Group (NWG) created.
- 2011-2013: DEQ & NWG address implementation details
- 2014: Rule adoption by BER, DEQ
- 2015: Montana's nutrient standards & variances approved by EPA

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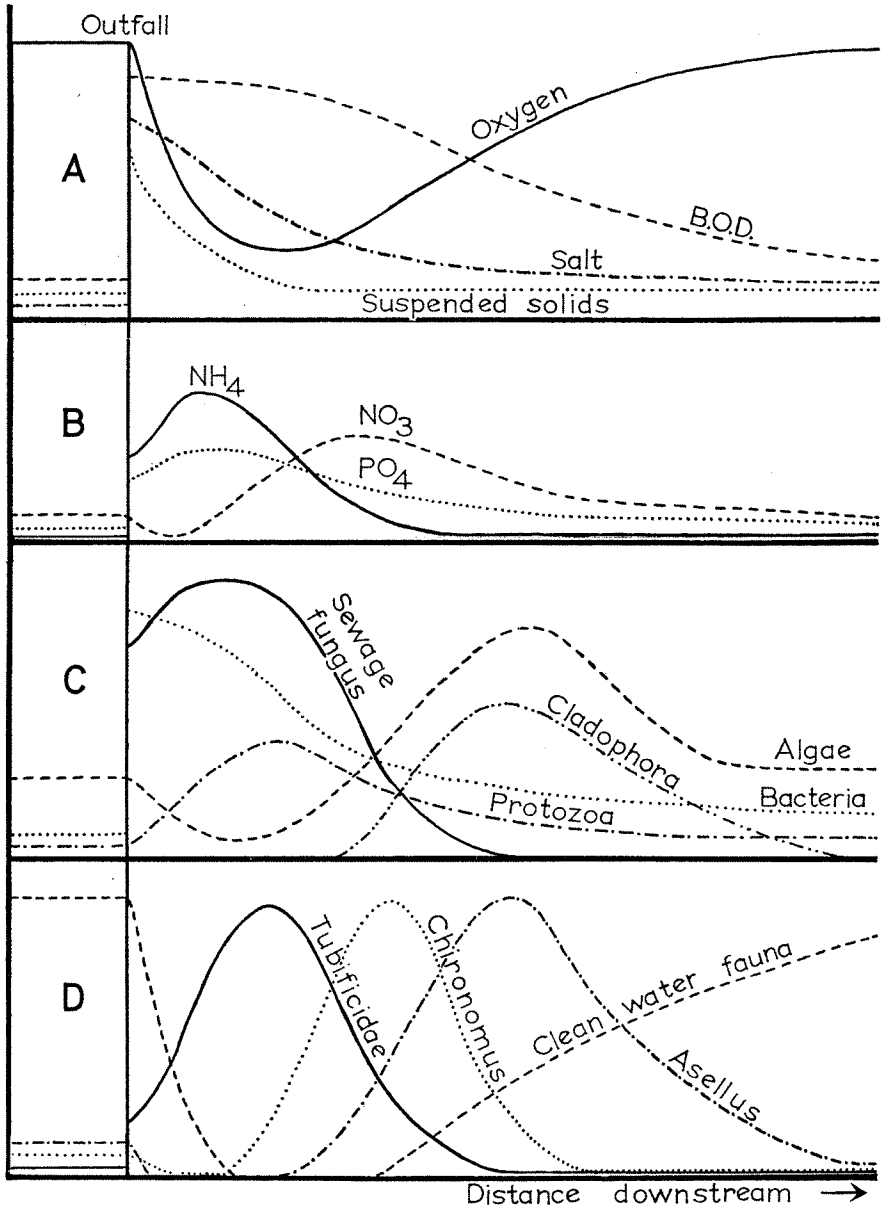


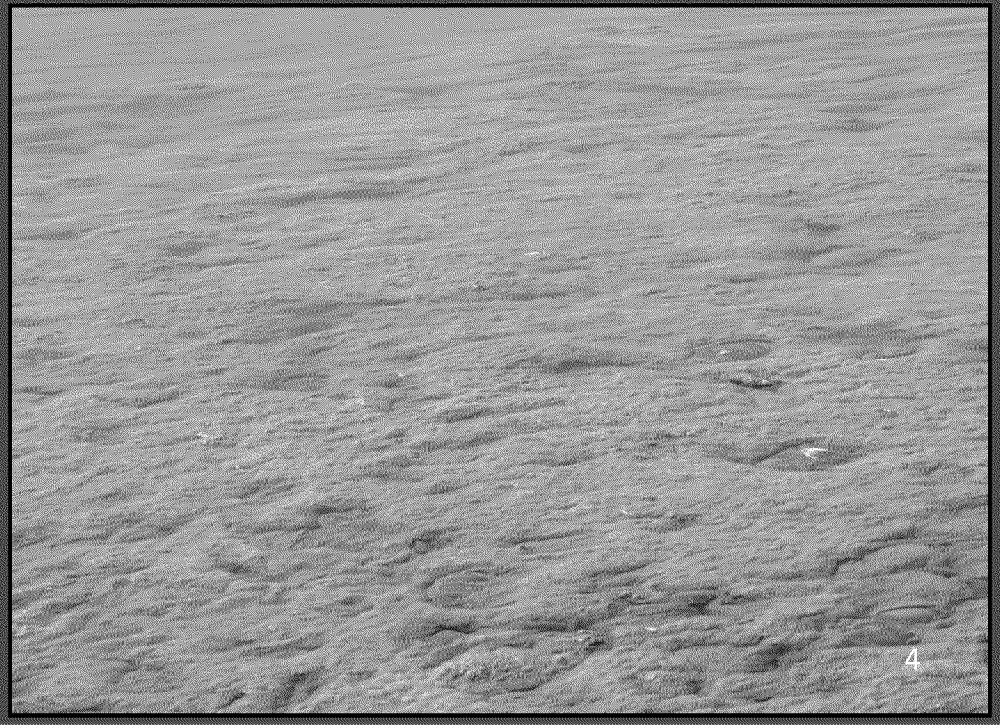
FIG. 16. Diagrammatic presentation of the effects of an organic effluent on a river and the changes as one passes downstream from the outfall. A & B physical and chemical changes, C Changes in micro-organisms, D Changes in larger animals.

Modern 2nd treatment eliminates the sewage fungus and high BOD/low DO zone

Un-removed mineralized nutrients salts still cause excessive algal growth and other biological changes

From Hynes (1966), after Bartsch (1948)

Nuisance algal growth, rivers & streams



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Attached algae growth commonly quantified as chlorophyll *a* per square meter of stream bottom

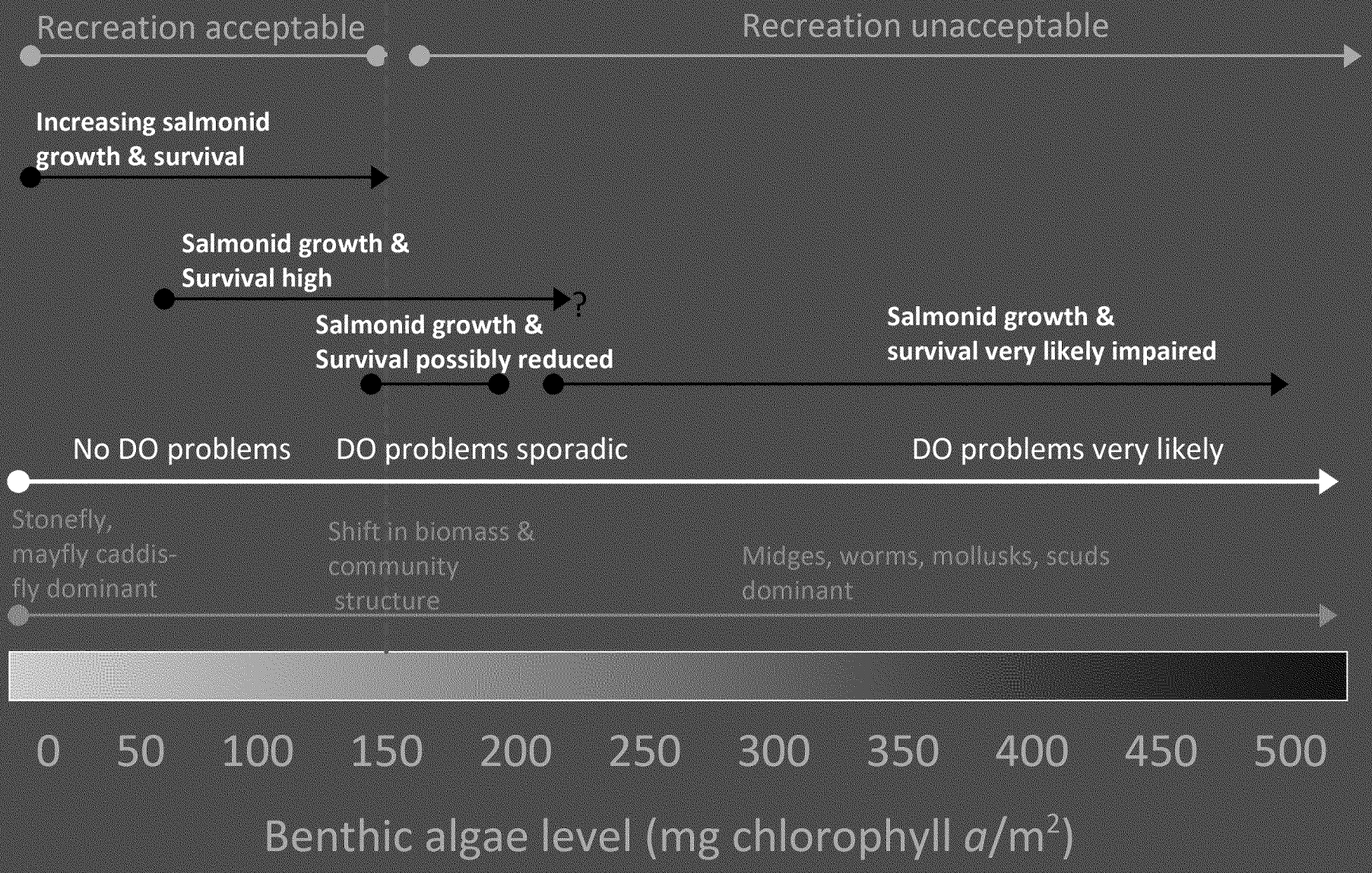
40 mg Chl*a*/m^2

120 mg Chl*a*/m^2

≤ 150 mg Chla/m^2 preferred by MT public for recreation per Suplee et al. (2009)

300 mg Chl*a*/m^2

Known/likely effects on wadeable-streams at different algae levels (western MT)



Eastern Montana Wadeable Streams

Low gradient, warm, often turbid, macrophytes, warm-water fishes

✓ Fish and DO concentrations key drivers

Deriving Numeric Nutrient Criteria: Wadeable Streams

Three Major Needs:

1) Identify geographic zones for specific criteria

2) Understand cause-effect relationships between nutrients and beneficial uses
   - Requires determining "harm to use"
   - Different expectations for different regions

3) Characterize water quality of reference sites

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Nutrient Criteria for Wadeable Streams: Geospatial Frame

- Nutrient concentrations vary naturally — geology, soils, climate, vegetation
- DEQ tested these frames:
  - Ecoregions (Omernik 1987)
  - Lithology (Montana surface geology)
  - Strahler Stream Order (~watershed area)
- Best frame maximizes variance between zones, minimizes variance within zones
- Focused on <u>reference</u> stream data from the zones

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Nutrient Criteria for Wadeable Streams: Geospatial Frame

- Ecoregions worked better than surface geology and stream order
  - Significantly explained nutrient concentration variation (typically, 60-78% of variation in reference data)
  - Practical to apply

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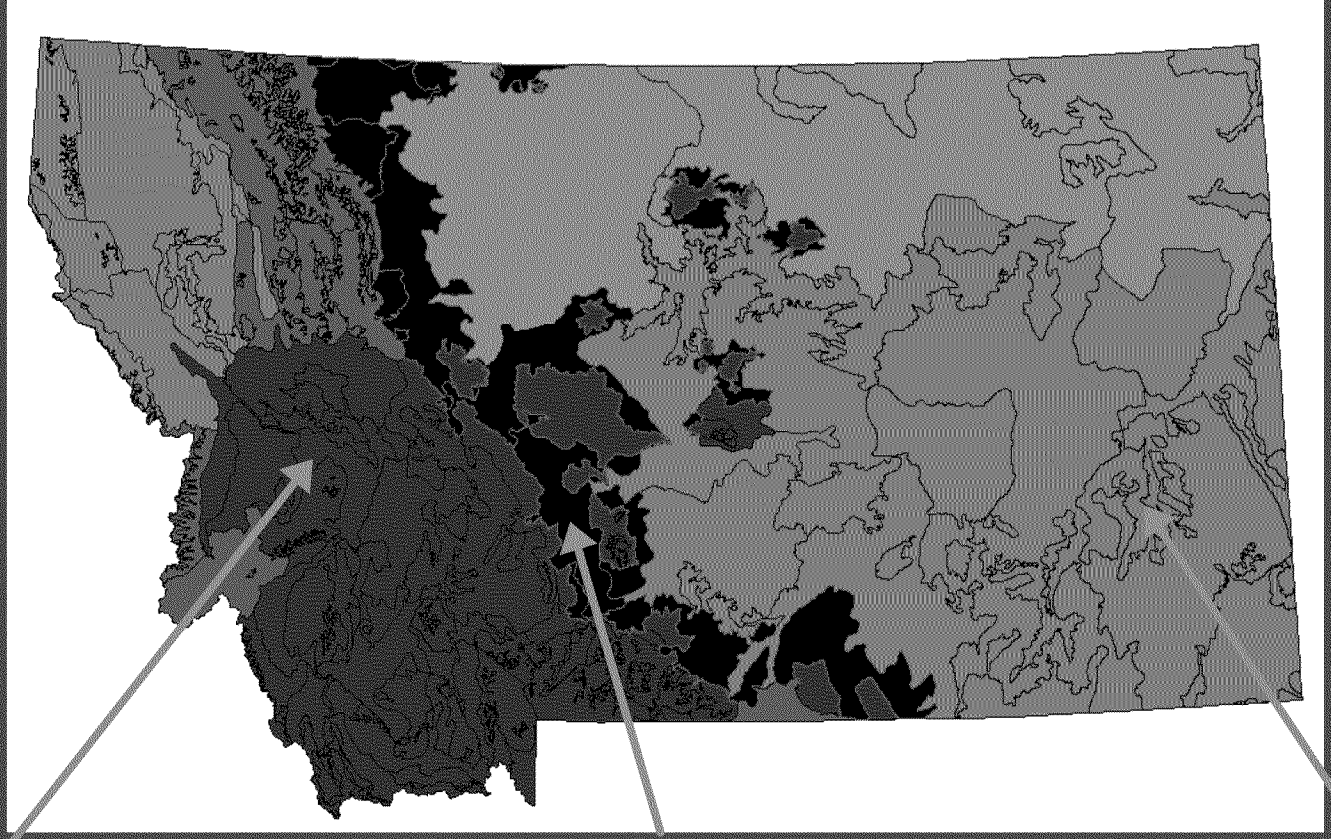
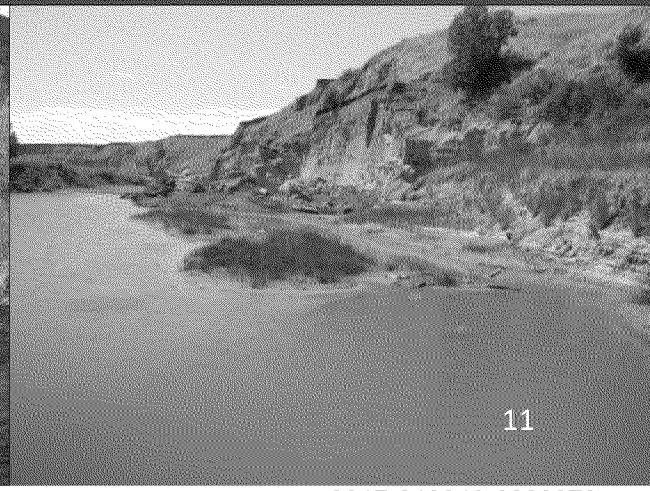


Mountainous

Transitional

Prairie



Montana's Wadeable Stream Nutrient Criteria Derivation Process

CRITERION

N:P Resource Ratio (Redfield Ratio)

Comparison to Regional Reference-site Data

Regional Dose-response studies

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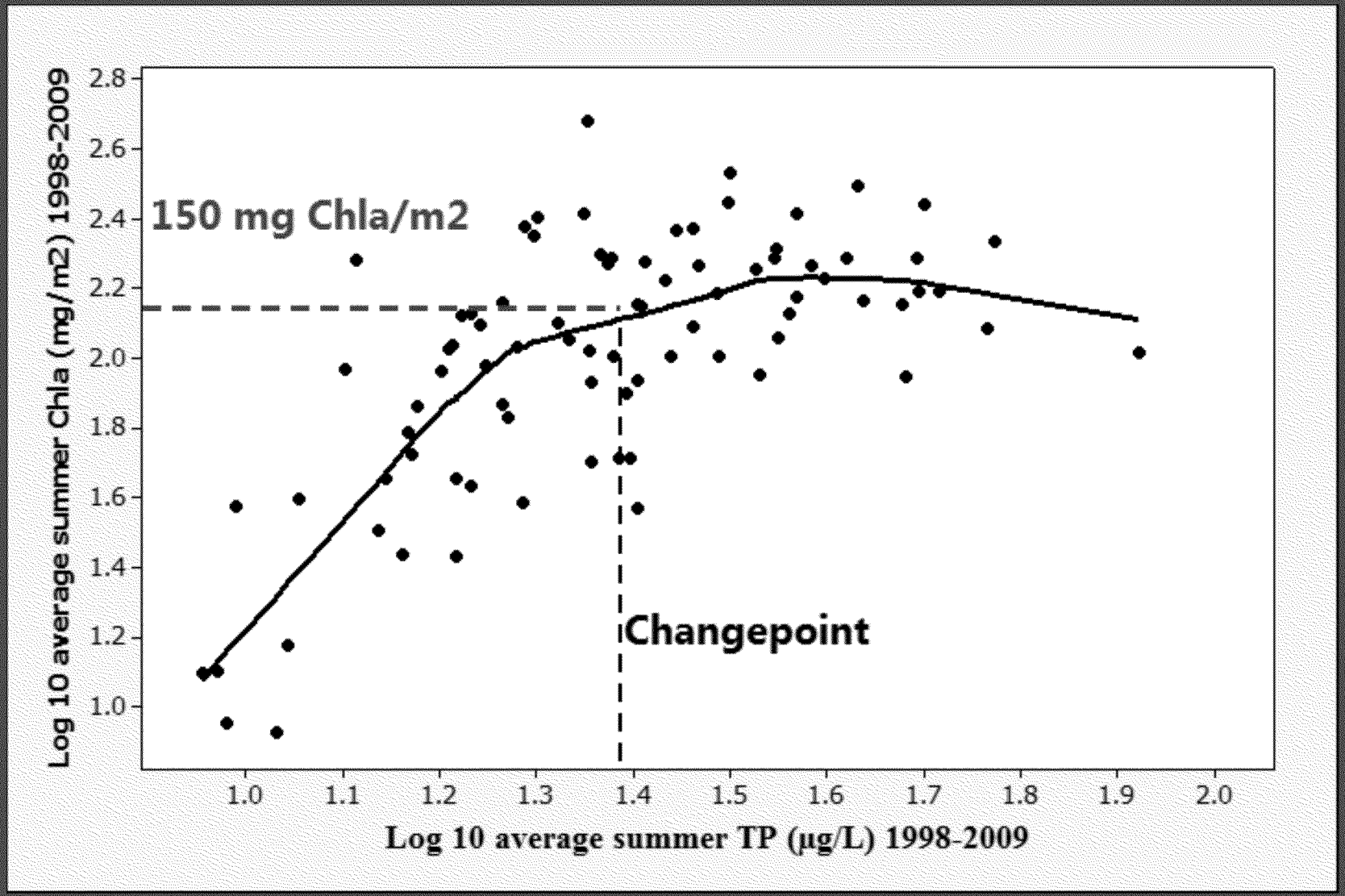
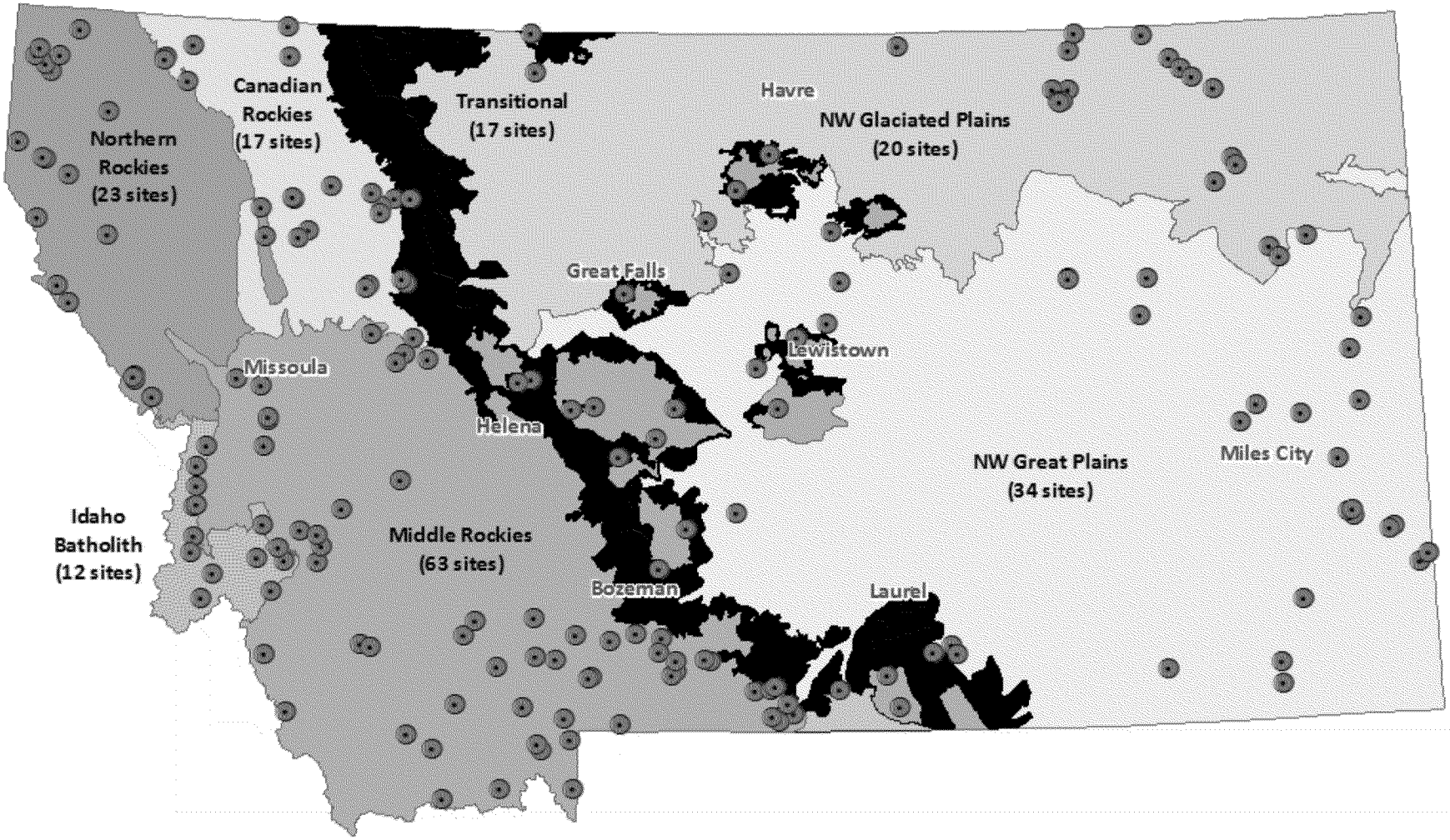
Example Dose-Response Relationship: Clark Fork River, 1998-2009

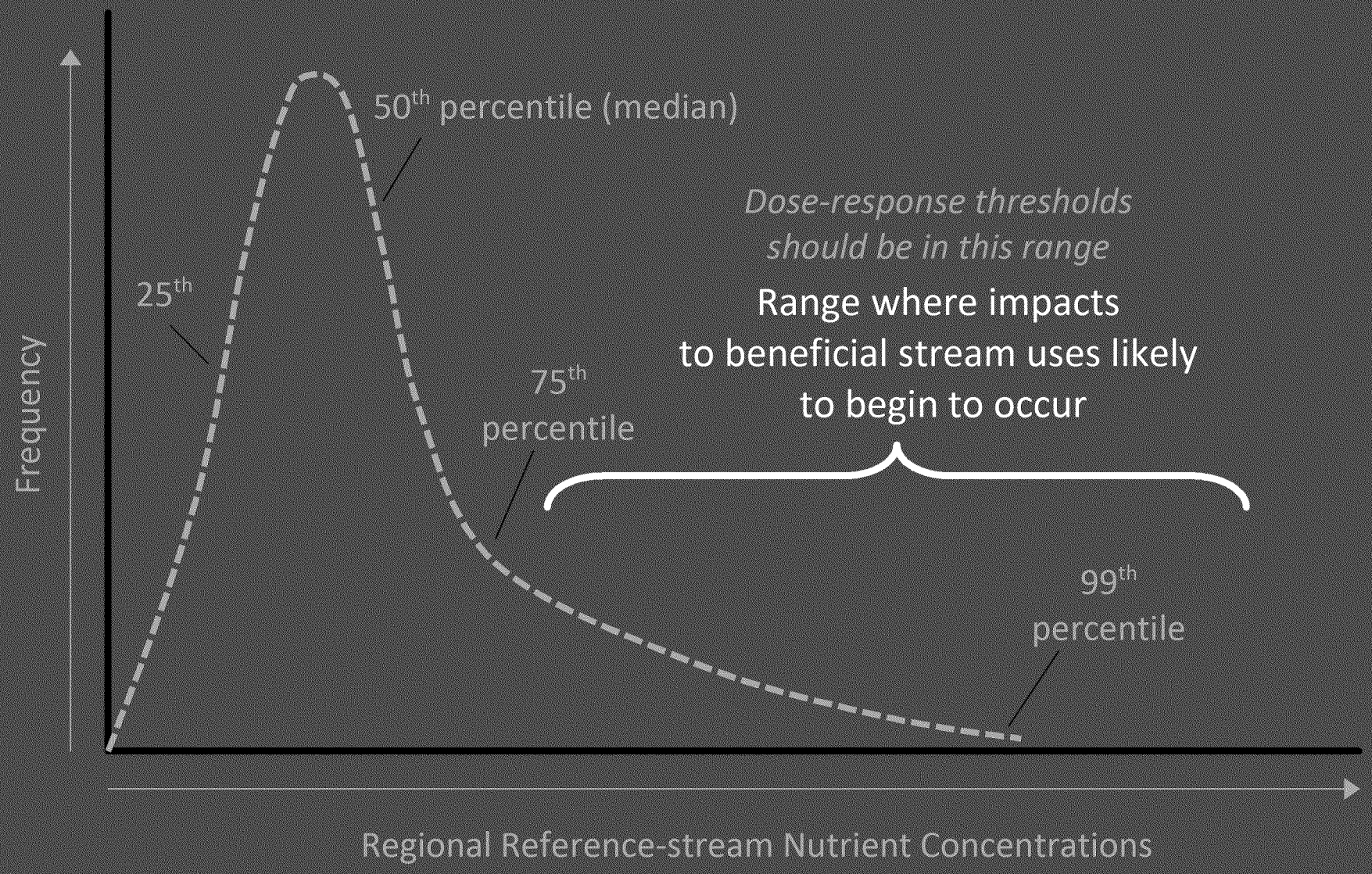


Stream Reference Sites

n=186



Linking Reference Data and Dose-response Studies



N:P Ratios Considered

Nuisance growths of *Didymosphenia* in streams with very low P & high N:P ratios (N:P 34:1)

Nuisance growths of *Cladophora* noted in high P streams with low N:P ratios

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Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers: Update 1

May 2013

Prepared by:
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Helena, MT 59620-0901

WQPBWQSTR-002

- ✓ Descriptive statistics of the reference site data, by ecoregion
- ✓ Compilation of dose-response studies applicable to each ecoregion
- ✓ N:P ratio of reference sites, criteria

http://deq.mt.gov/wqinfo/standards/NumericNutrientCriteria.mcpx

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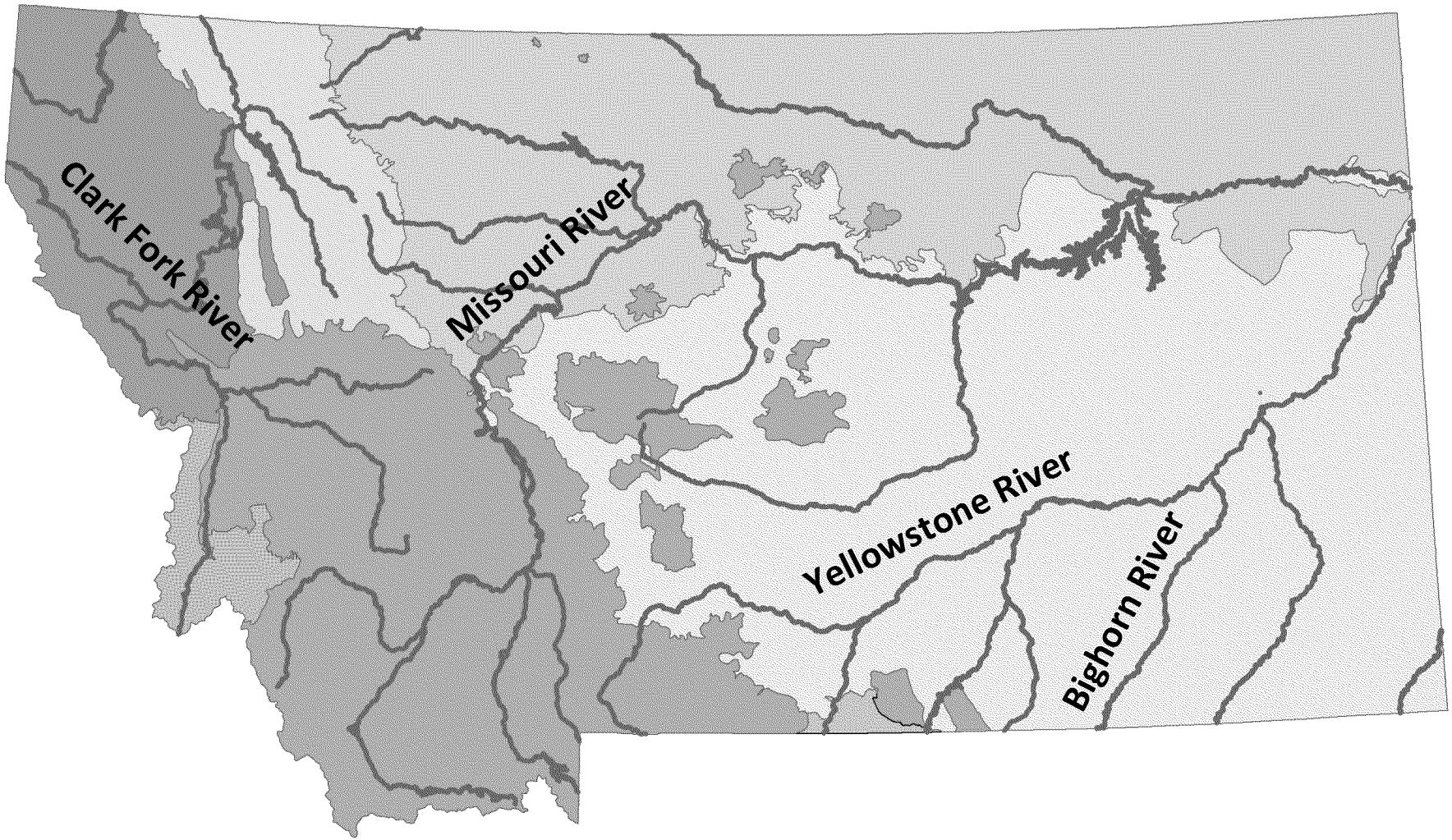
Nutrient Criteria for Large Rivers



The Case for Mechanistic Models in Large Rivers

- No comparable reference sites available
- Large rivers traverse multiple coarse-scale ecoregions
- Wadeable-stream empirical relationships likely poorly transferable
- Predictive benefits
  - Define endpoints upfront based on other water-quality standards (DO, pH, benthic algae biomass, TDG, TOC)
  - Forecast <u>or</u> hind-cast water quality conditions

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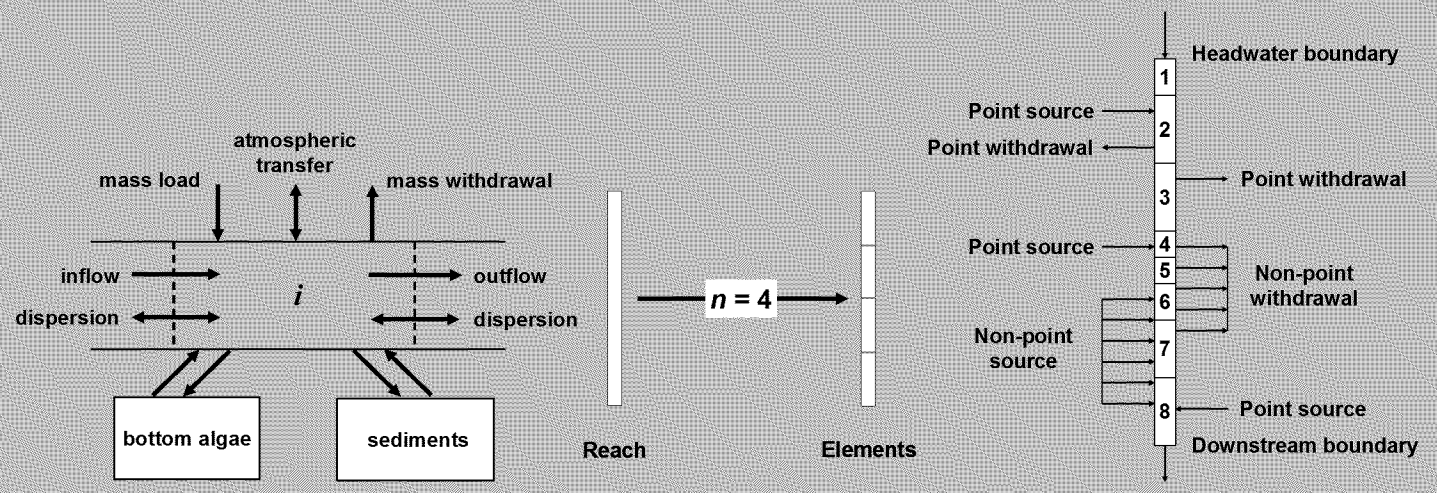
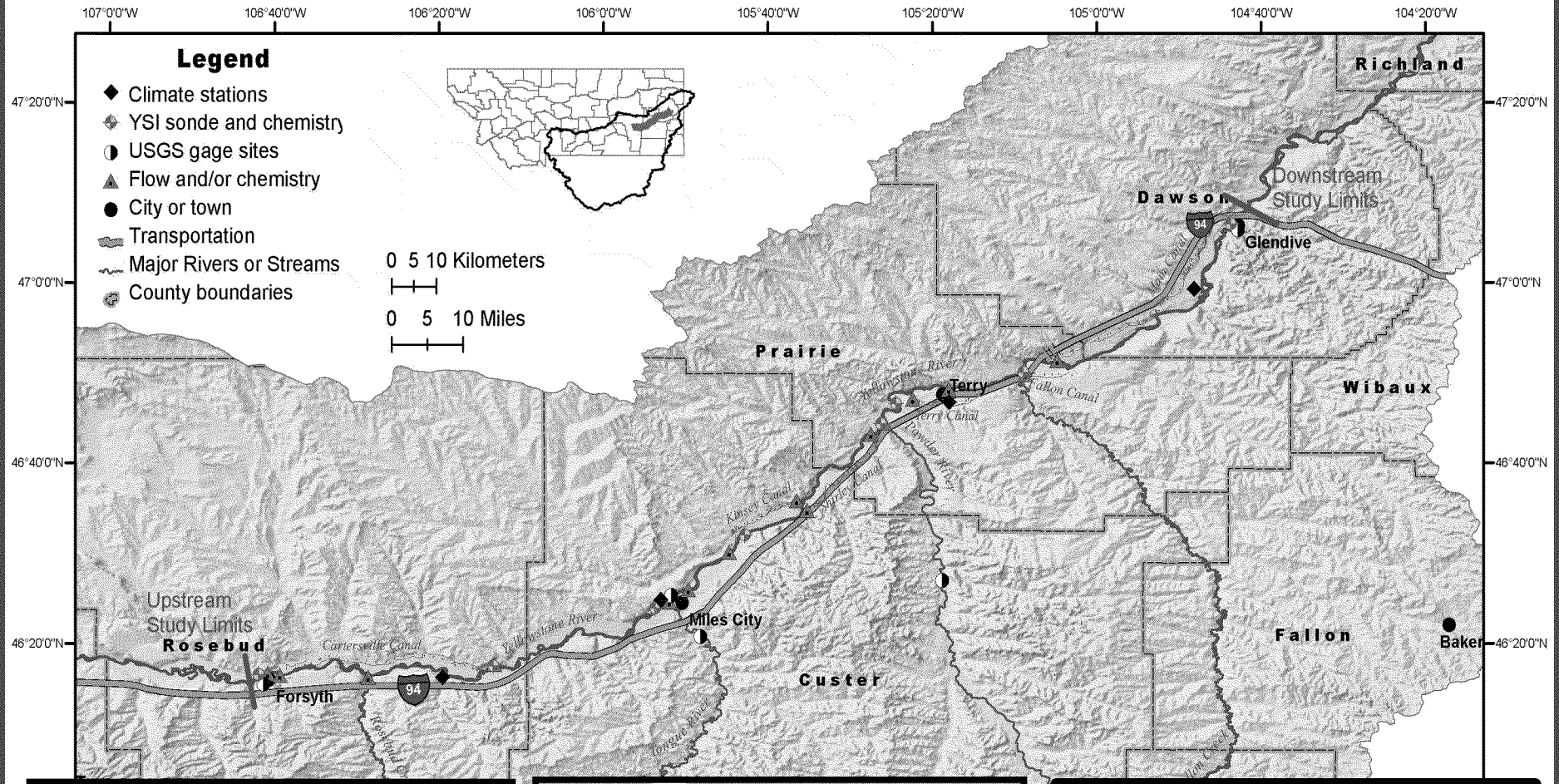
QUAL2K Model Conceptual Basis



elements reaches domain

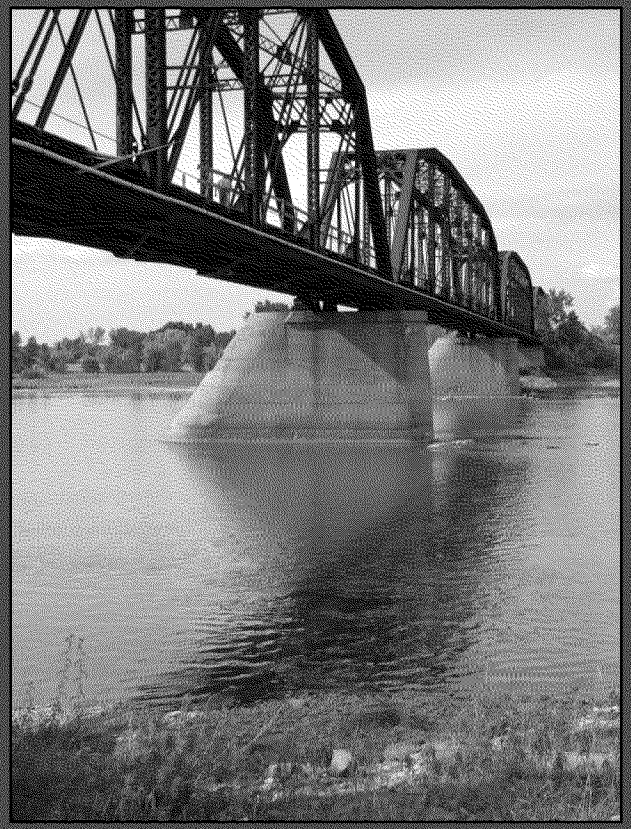

Legend
Climate stations
YSI sonde and chemistry
USGS gage sites
Flow and/or chemistry
City or town
Transportation
Major Rivers or Streams
County boundaries
0 5 10 Kilometers
0 5 10 Miles
107°0'0"W
106°40'0"W
106°20'0"W
106°0'0"W
105°40'0"W
105°20'0"W
105°0'0"W
104°40'0"W
104°20'0"W
47°20'0"N
47°0'0"N
46°40'0"N
46°20'0"N
Richland
Downstream Study Limits
Dawson
Glendive
Prairie
Terry
Wibaux
Fallon
Baker
Custer
Miles City
Upstream Study Limits
Rosebud
Forsyth
94
Yellowstone River
Powder River
Tongue River
Cartersville Canal
Kinsey Canal
Terry Canal
Fallon Canal
Main Canal

Temporal Considerations

Nutrient criteria for the lower Yellowstone River were developed for the time when use-impact potential was maximal

JUNE

FEBRUARY



AUGUST

Decisions Prior to Initiating Model Runs

- Selection of critical low flow ("design flow")
  - Montana using seasonal 14Q5
- Selection of weather pattern ("design climate") to accompany the low flow
- Boundary conditions for tributaries, groundwater, model headwaters
- Longitudinal extent of criteria reaches: lump or split?

Many of these decisions will vary depending on applicable laws, rules, agency policies

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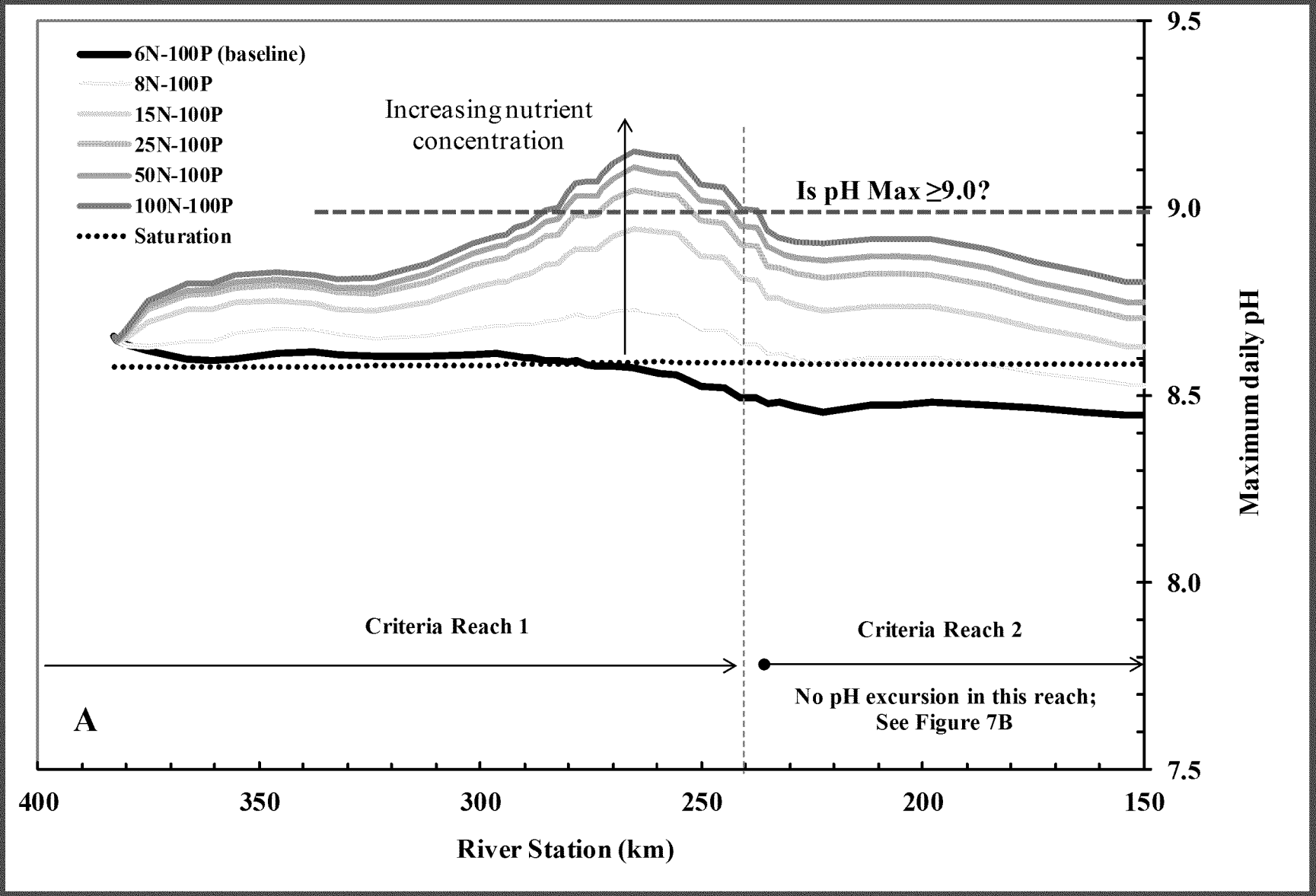
Incremental Nutrient Increases to ID Criteria



P is saturated, N is incremented up till endpoint reached

P saturated scenario: N incremented up till endpoint reached

NO_3- (µg/l)	TN (µg/l)	Minimum DO (mg/l)	DO delta (mg/l)	pH (max)	pH (max) delta	pH (min)	pH (min) delta	Benthic algae (mgChla/m^2)	Benthic algae wadeable zone per AT2K (mgChla/m^2)	TOC increase above background (mg/l)	TDG (% sat)
Yellowstone R. Criteria Reach 1-between Bighorn and Power River confluences (as represented by Forsyth to Power River in model)											
6	370	7.26	1.7	8.66	0.00	8.26	0.00	13.5	16.0	0	105
8	419	7.22	2.3	8.73	0.16	8.29	-0.04	24.9	16.0	1.05	105
10	490	7.23	2.9	8.84	0.27	8.31	-0.10	33.0	65.8	1.65	106
15	591	7.22	3.8	8.94	0.38	8.32	-0.17	43.5	88.8	2.42	108
20	659	7.18	4.3	*9.00	0.43	8.33	-0.20	49.2	103.5	2.82	109
25	745	7.16	4.7	9.05	0.48	8.36	-0.25	53.5	114.7	3.10	110
30	799	7.15	4.8	9.06	0.50	8.37	-0.27	55.0	120.7	3.27	110
50	921	7.10	5.3	9.11	0.54	8.37	-0.30	60.5	139.1	3.74	111
70	1090	7.07	5.6	9.13	0.57	8.38	-0.33	61.9	147.8	4.11	112
100	1241	7.06	5.7	9.15	0.58	8.39	-0.35	62.7	154.2	4.37	113
Yellowstone River Criteria Reach 2- Powder River to state-line (as represented by Powder River to Glendive in model)											
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20	696	7.22	3.0	8.80	0.00	8.60	0.00	23.3	106.7	0.00	106
25	713	7.22	3.2	8.80	0.02	8.53	-0.02	24.7	115.6	0.06	106
30	728	7.21	3.3	8.81	0.03	8.53	-0.03	26.2	121.8	0.09	106
50	780	7.20	3.6	8.84	0.07	8.55	-0.07	30.1	140.8	0.20	107
70	820	7.19	3.8	8.86	0.09	8.57	-0.09	32.4	*150.6	0.25	108
100	871	7.19	3.9	8.88	0.11	8.59	-0.11	34.3	159.9	0.31	108

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Using a Computer Water Quality Model to Derive Numeric Nutrient Criteria

LOWER YELLOWSTONE RIVER, MT

Photo: Montana DEQ; Mark Greytak, MontanaPictures.Net

MAY 2013

Prepared by:
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WQPBDMSTECH-22

Journal articles on this project are also available upon request
Flynn et al. (2015)
Suplee et al. (2015)

E-mail: msuplee@mt.gov

http://deq.mt.gov/wqinfo/standards/NumericNutrientCriteria.mcpx

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Selected MT Numeric Nutrient Standards: wadeable streams, large rivers

			Numeric Nutrient Standard	
Ecoregion (level III or IV) and Number	**Ecoregion Level**	**Period When Criteria Apply**	**Total Phosphorus (µg/L)**	**Total Nitrogen (µg/L)**
Northern Rockies (15)	III	July 1 to September 30	25	275
Canadian Rockies (41)	III	July 1 to September 30	25	325
Idaho Batholith (16)	III	July 1 to September 30	25	275
Middle Rockies (17)	III	July 1 to September 30	30	300
Absaroka-Gallatin Volcanic Mountains (17i)	IV	July 1 to September 30	105	250
Northwestern Glaciated Plains (42)	III	June 16 to September 30	110	1300
Sweetgrass Upland (42l), Milk River Pothole Upland (42n), Rocky Mountain Front Foothill Potholes (42q), and Foothill Grassland (42r)	IV	July 1 to September 30	80	560
Northwestern Great Plains (43) and Wyoming Basin (18)	III	July 1 to September 30	150	1300
River Breaks (43c)	IV	Narrative only	Narrative only	Narrative only
*Non-calcareous Foothill Grassland (43s), Shields-Smith Valleys (43t), Limy Foothill Grassland (43u), Pryor-Bighorn Foothills (43v), and Unglaciated Montana High Plains (43o)**	IV	July 1 to September 30	33	440
Large Rivers:				
Yellowstone River (Bighorn River confluence to Powder River confluence)	n/a	August 1 -October 31	55	655
Yellowstone River (Powder River confluence to stateline)	n/a	August 1 -October 31	95	815

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Most Montana Streams already Meet the Criteria

Based on probabilistic stream survey

- About 70-80% of stream miles statewide currently meet the TP criteria
- About 85-90% of stream miles statewide currently meet the TN criteria

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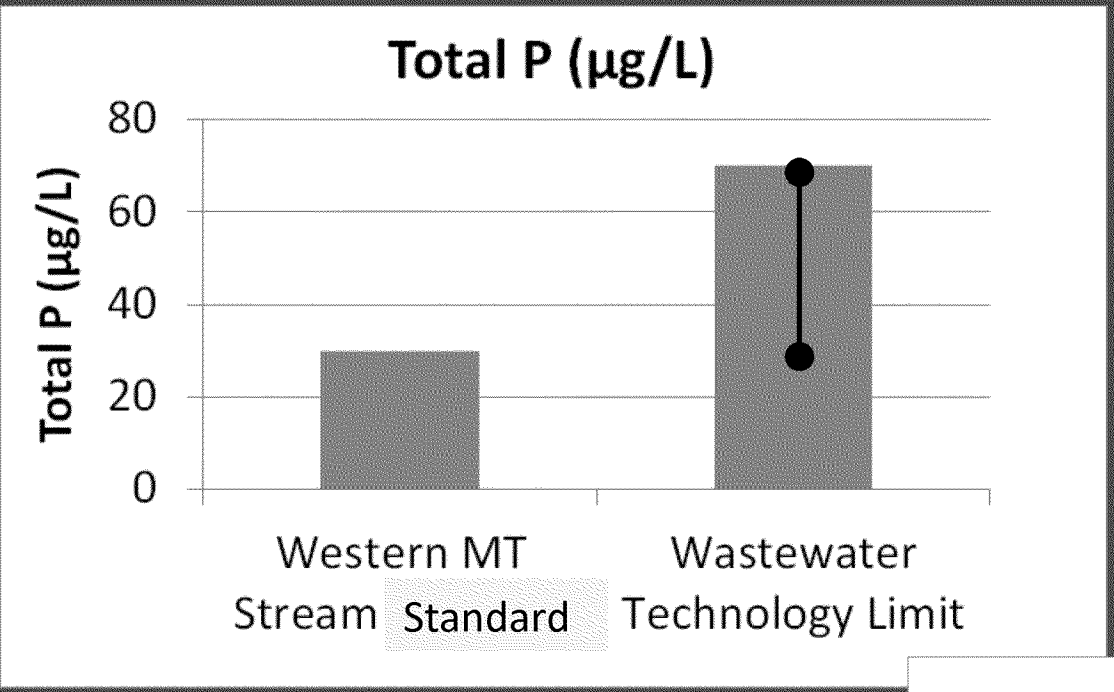
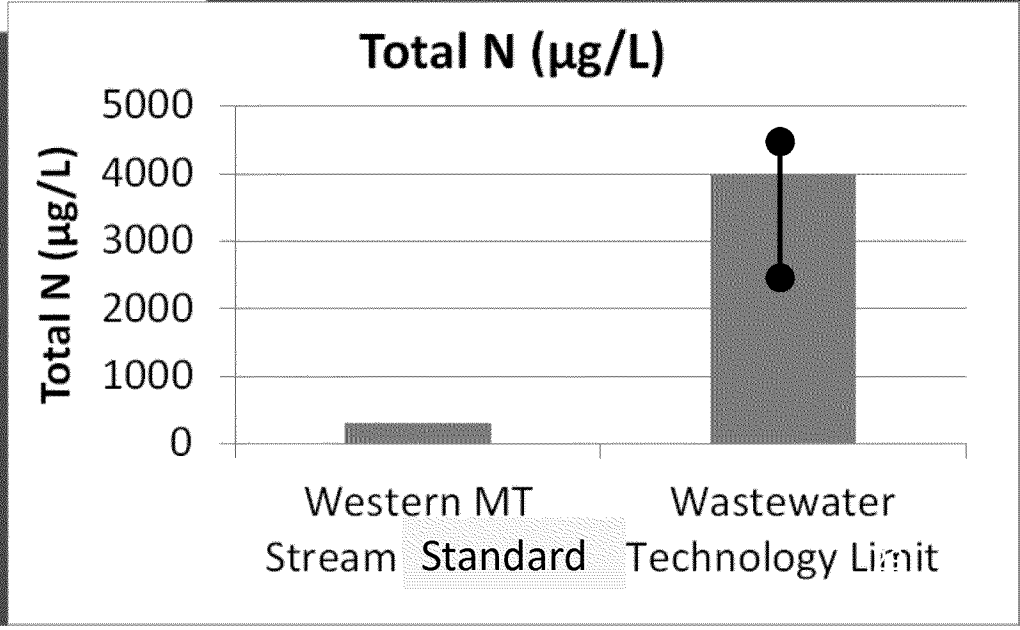
Implementation





Variances from Numeric Nutrient Standards: Economic Considerations

- Options available for communities to receive temporary relief from the standards based on:
  - Inability to pay for treatment/economics
  - Limits of technology

- General Variances
- Individual Variances

Senate bills 95 (2009 Legislature) and 367 (2011 Legislature) (now §75-5-313, MCA)

- Montana DEQ given authority to grant variances from nutrient criteria
- Based on economic harm that would have resulted from immediate implementation of the standards
  - Variances up to 20 years, subject to 3-year reviews

  - General Variance: Can be requested if criteria can't be met, but these can:
  - > 1 MGD: 1 mg TP/L, 10 mg TN/L
  - < 1 MGD: 2 mg TP/L, 15 mg TN/L
  - Lagoons: Maintain current performance

  Had to be adopted in Dept. rule by 5/31/2016 (DONE)

  - Individual Variance: Permittee may apply for these if meeting the general variance is difficult, or if treating beyond gen. levels does not make sense. Case-by-case analysis.

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Nutrient Trading

- 2013: Montana Board of Environmental Review adopted rules allowing dischargers to use nutrient trading to help comply with numeric nutrient standards <u>and</u> variances
  - Found in Department Circular DEQ-13

http://deq.mt.gov/wqinfo/circulars.mcpx

OVERALL: Law allows Montana to implement numeric nutrient criteria in a staged manner over ~ 20 years, allowing critical time to better address all sources of nutrient pollution (point and nonpoint) and for treatment technology to improve/come down in cost

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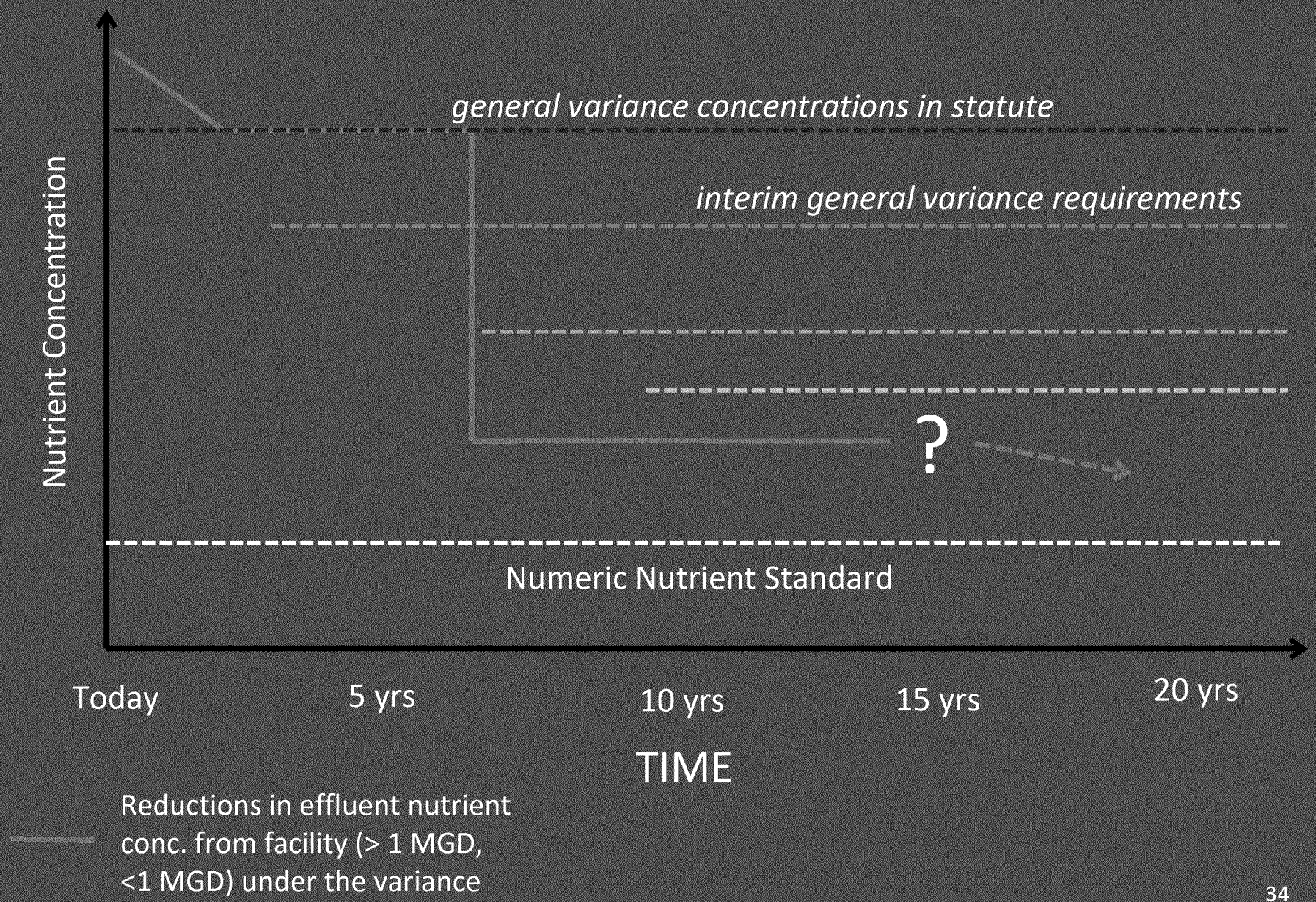
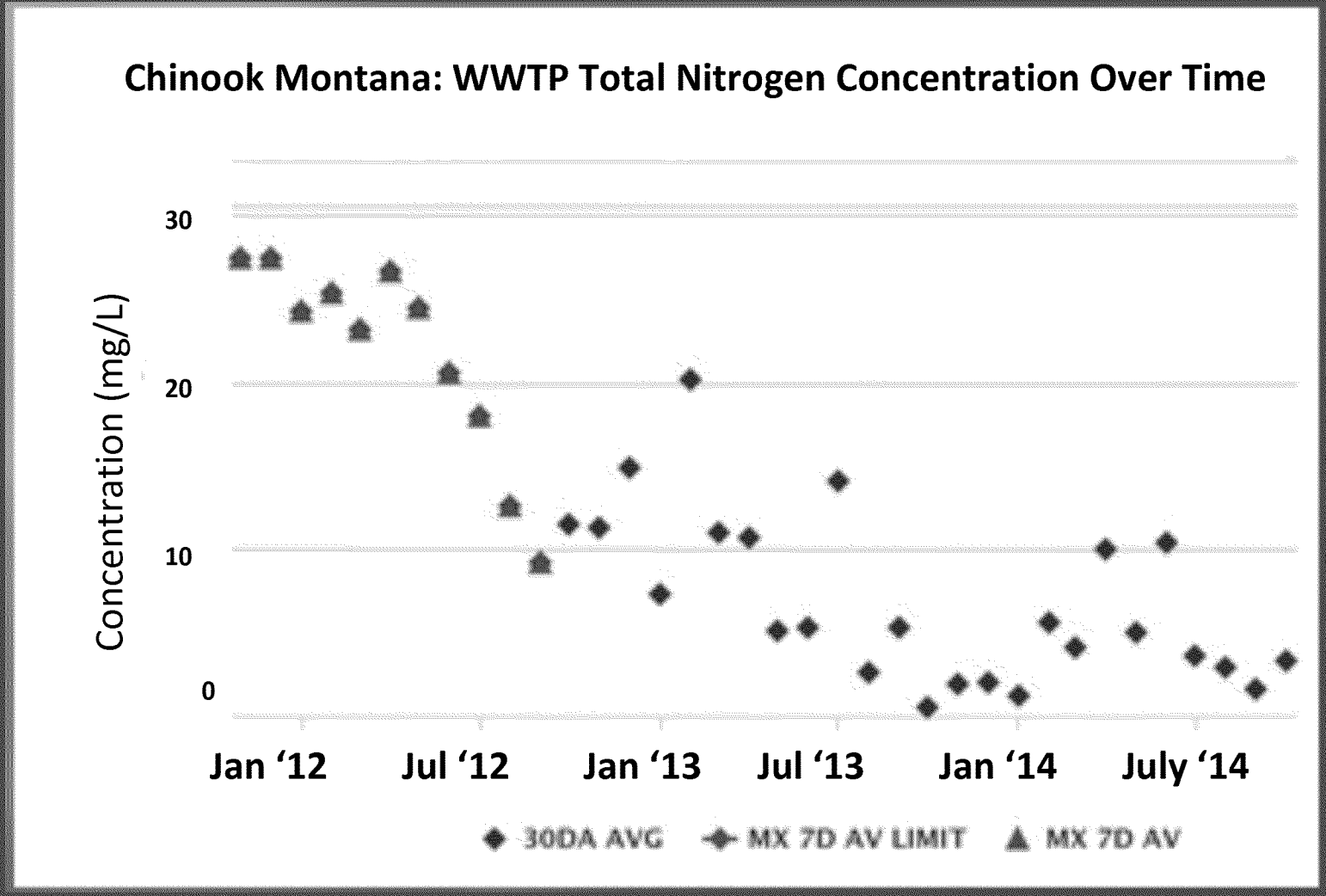
Example General Variance Reductions (per DEQ Guidance Document)



Optimization Requirement

- Permittees receiving a general variance must carry out an optimization study:
  - Address facility operations & maintenance of existing infrastructure
  - Not result in rate increases or major investment
  - Must include exploration of the potential for trading in the watershed

Benefits of Facility Optimization



Lagoon Optimization Study

- MT DEQ is compiling innovative, low-cost approaches to reduce ammonia and total nutrients from facultative lagoon discharges (2014-15)

- Intend to carry out trial tests of methods with a group of cooperating communities, starting 2016

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Permitting

- 14Q5 low-flow design flow for nutrients
  - Previously used 7Q10
- Using permitting methods in EPA's TSD (1991)
  - Well-established, consistent
- General variance administered in the permit
  - Permit writers determine if facility needs a general variance
  - If permittee believes they need an individual variance, standards will carry out evaluation

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Ambient Monitoring & Assessment

- Minimum number of nutrient samples per assessment reach (n = 12)
- Companion data required (e.g. diatom samples, benthic Chl*a*, macroinvertebrates, DO (sample mins for all)
  - Varies by regions
- Complete dataset evaluated, compared to decision matrix

Nutrient concentrations test 1	Nutrient concentrations test 2	Benthic algae density	Diatom metric score	RESULT
PASS	**FAIL**	**PASS**	**PASS**	**Not Impaired**

http://deq.mt.gov/wqinfo/Standards/default.mcpx

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Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels

DECEMBER 2011

Prepared by:
Water Quality Planning Bureau, Water Quality Standards Section
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WQPBMASTR-01

Montana Department of
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Base Numeric Nutrient Standards Implementation Guidance

Version 1.0

JULY 2014

Prepared by:
Water Quality Planning Bureau, Water Quality Standards Section
Montana Department of Environmental Quality
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Helena, MT 59620-0901

WQPBWQSTR-002

http://deq.mt.gov/wqinfo/qaprogram/sops.mcpx

Overview

- The N and P criteria are scientifically defensible, appropriate for different regions and lotic waterbody types
  - Provide clarity as to what the true water quality endpoints are
  - Ongoing work will lead to other large-river nutrient standards, additional site-specific wadeable stream standards
- Numeric nutrient standards and variances adopted in law
  - Two state legislative bills defined variance process (§75-5-313, MCA)
  - Standards, variance procedures adopted in rule August 2014
  - EPA approval February 2015
- Statute and rule allow the numeric nutrient standards to be met over a 20 year period
  - Reduction requirements occur in steps over this period
  - Critical time to evaluate all options: optimization, trading, nonpoint reductions, facility upgrades, technology changes
  - If more time needed, additional law-making likely needed

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Acknowledgments

- Rosie Sada, Dr. Kyle Flynn, many other MT Dept. of Environmental Quality staff
- Dr. Vicki Watson– University of Montana
  - and her students
- George Mathieus– Division Administrator, MT Dept. of Environmental Quality
- Members of the Nutrient Work Group

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Thank You

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