Water Quality in the Middle Rio Grande

Rio Grande Seminar, May 2nd, 2008

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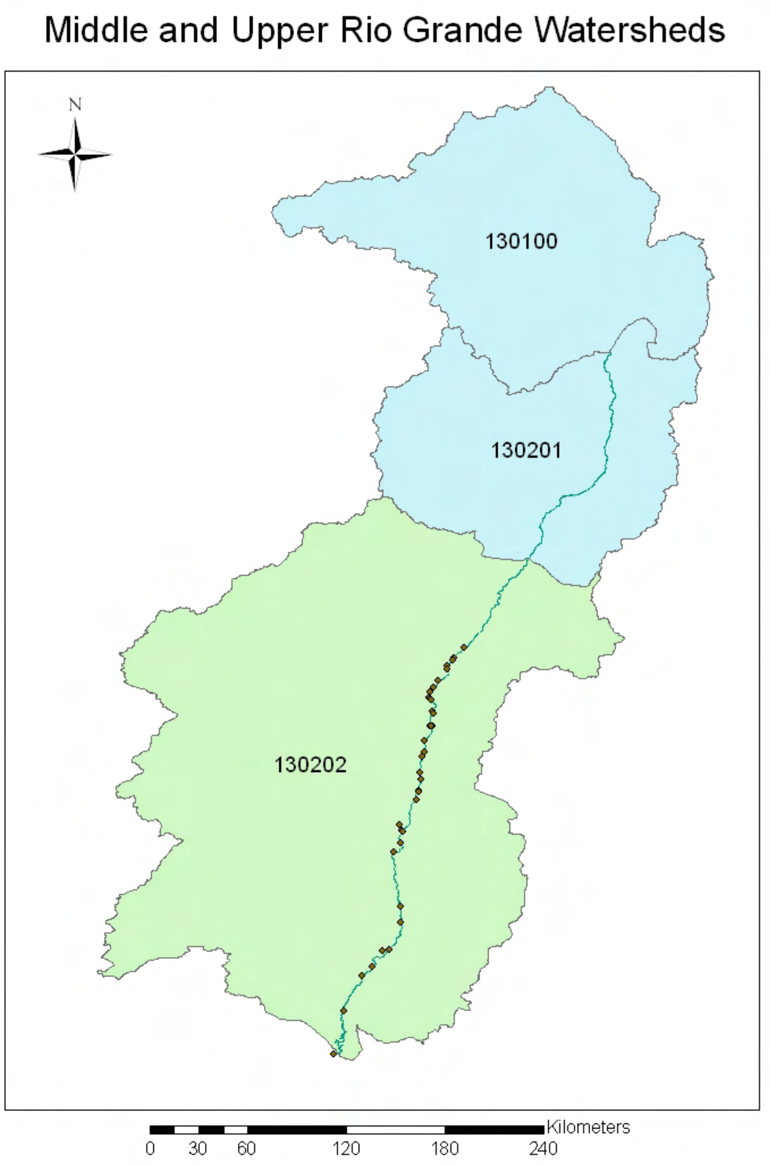
Outline

- Introduction – who wants this data
- Monthly Synoptic Sampling:
  - Methods
  - Nutrients in the Middle Rio Grande (MRG)
  - Salts in the MRG
- Continuous Monitoring:
  - Methods / site selection
  - Results

URGWOM Program Interests

- Upper Rio Grande Water Operations Model
- Based on RiverWare modeling software
- This software can be used to model:
    - Water balance budgeting for reservoirs
    - River Reach Routing
    - Diversions
    - Water Quality



Collaborative Program Interests

- How does water quality in the MRG impact the RGS Minnow ?

- Parameters of Interest Include: temperature, dissolved oxygen, conductivity, turbidity, dissolved salts, nutrients, pesticides and toxic chemicals.

- How do these parameters vary spatially and temporally?

- Relative contribution of point versus non-point sources?

U.S. Fish & Wildlife Service

Rio Grande Silvery Minnow

(Hybognathus amarus)

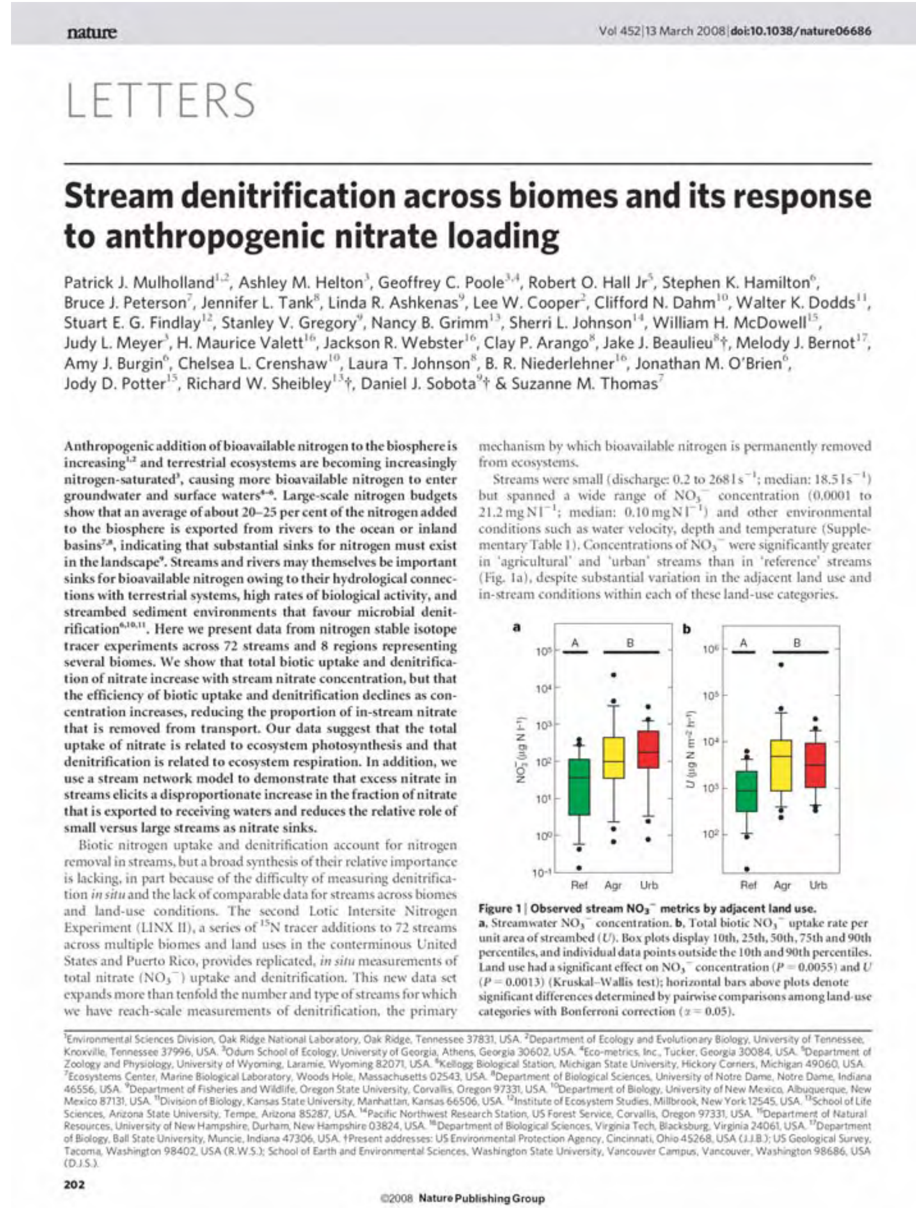
Draft Revised Recovery Plan

January 2007

Academic Interests

- LINX I and LINX II identified the MRG river network as unique – it violated all of the assumptions of a nitrogen removal model based on the river network.

- How does this unique network structure impact nutrient cycling?



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LETTERS

Stream denitrification across biomes and its response to anthropogenic nitrate loading

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Anthropogenic addition of bioavailable nitrogen to the biosphere is increasing[1,2] and terrestrial ecosystems are becoming increasingly nitrogen-saturated[3], causing more bioavailable nitrogen to enter groundwater and surface waters[4–6]. Large-scale nitrogen budgets show that an average of about 20–25 per cent of the nitrogen added to the biosphere is exported from rivers to the ocean or inland basins[7,8], indicating that substantial sinks for nitrogen must exist in the landscape[9]. Streams and rivers may themselves be important sinks for bioavailable nitrogen owing to their hydrological connections with terrestrial systems, high rates of biological activity, and streambed sediment environments that favour microbial denitrification[6,10,11]. Here we present data from nitrogen stable isotope tracer experiments across 72 streams and 8 regions representing several biomes. We show that total biotic uptake and denitrification of nitrate increase with stream nitrate concentration, but that the efficiency of biotic uptake and denitrification declines as concentration increases, reducing the proportion of in-stream nitrate that is removed from transport. Our data suggest that the total uptake of nitrate is related to ecosystem photosynthesis and that denitrification is related to ecosystem respiration. In addition, we use a stream network model to demonstrate that excess nitrate in streams elicits a disproportionate increase in the fraction of nitrate that is exported to receiving waters and reduces the relative role of small versus large streams as nitrate sinks.

Biotic nitrogen uptake and denitrification account for nitrogen removal in streams, but a broad synthesis of their relative importance is lacking, in part because of the difficulty of measuring denitrification *in situ* and the lack of comparable data for streams across biomes and land-use conditions. The second Lotic Intersite Nitrogen Experiment (LINX II), a series of ^{15}N tracer additions to 72 streams across multiple biomes and land uses in the conterminous United States and Puerto Rico, provides replicated, *in situ* measurements of total nitrate (NO_3^-) uptake and denitrification. This new data set expands more than tenfold the number and type of streams for which we have reach-scale measurements of denitrification, the primary mechanism by which bioavailable nitrogen is permanently removed from ecosystems.

Streams were small (discharge: 0.2 to 268 l s^{-1}; median: 18.5 l s^{-1}) but spanned a wide range of NO_3^- concentration (0.0001 to 21.2 mg N l^{-1}; median: 0.10 mg N l^{-1}) and other environmental conditions such as water velocity, depth and temperature (Supplementary Table 1). Concentrations of NO_3^- were significantly greater in 'agricultural' and 'urban' streams than in 'reference' streams (Fig. 1a), despite substantial variation in the adjacent land use and in-stream conditions within each of these land-use categories.

Figure 1 | Observed stream NO_3^- metrics by adjacent land use. **a**, Streamwater NO_3^- concentration. **b**, Total biotic NO_3^- uptake rate per unit area of streambed (U). Box plots display 10th, 25th, 50th, 75th and 90th percentiles, and individual data points outside the 10th and 90th percentiles. Land use had a significant effect on NO_3^- concentration ($P = 0.0055$) and U ($P = 0.0013$) (Kruskal–Wallis test); horizontal bars above plots denote significant differences determined by pairwise comparisons among land-use categories with Bonferroni correction ($\alpha = 0.05$).

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Research Questions

- What are the sources and sinks of nutrients to the MRG and how do these vary spatially and temporally?

- Are these nutrient sources/sinks similar to those found in other systems?

- What are the major sources of dissolved salts to the MRG and how do these sources vary spatially and temporally?

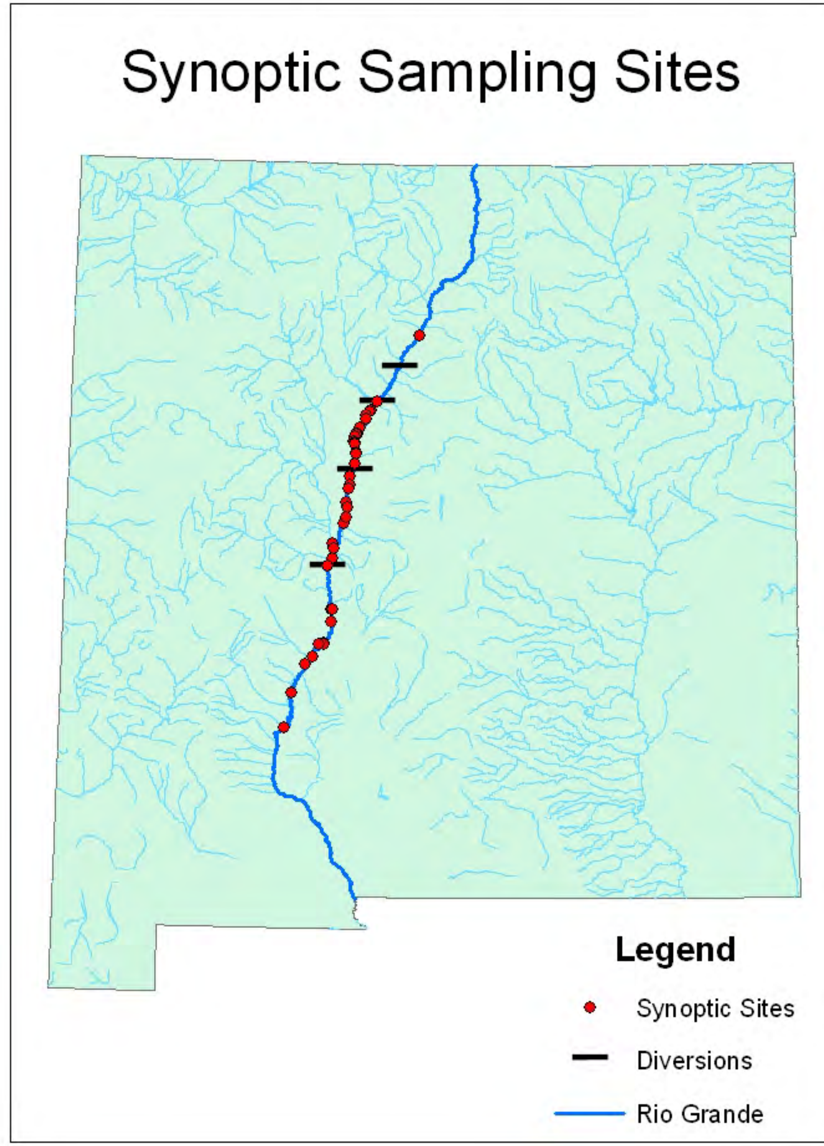
- How do episodic events impact water quality in the MRG?

RG – Buckman Wells

RG – Bosque del Apache

Synoptic Sampling Methods

- Collect water samples from approx. 30 sites from above Cochiti to Elephant Butte.
- Samples collected 29 times approximately monthly starting September 2005 during periods of stable flow.
- Mainstem samples on all dates.
- Tributary inputs on 15 dates.
- Samples analyzed for: pH, temp., cond, major nutrients, anions, cations, DOC, DIC.



Nutrients in the MRG

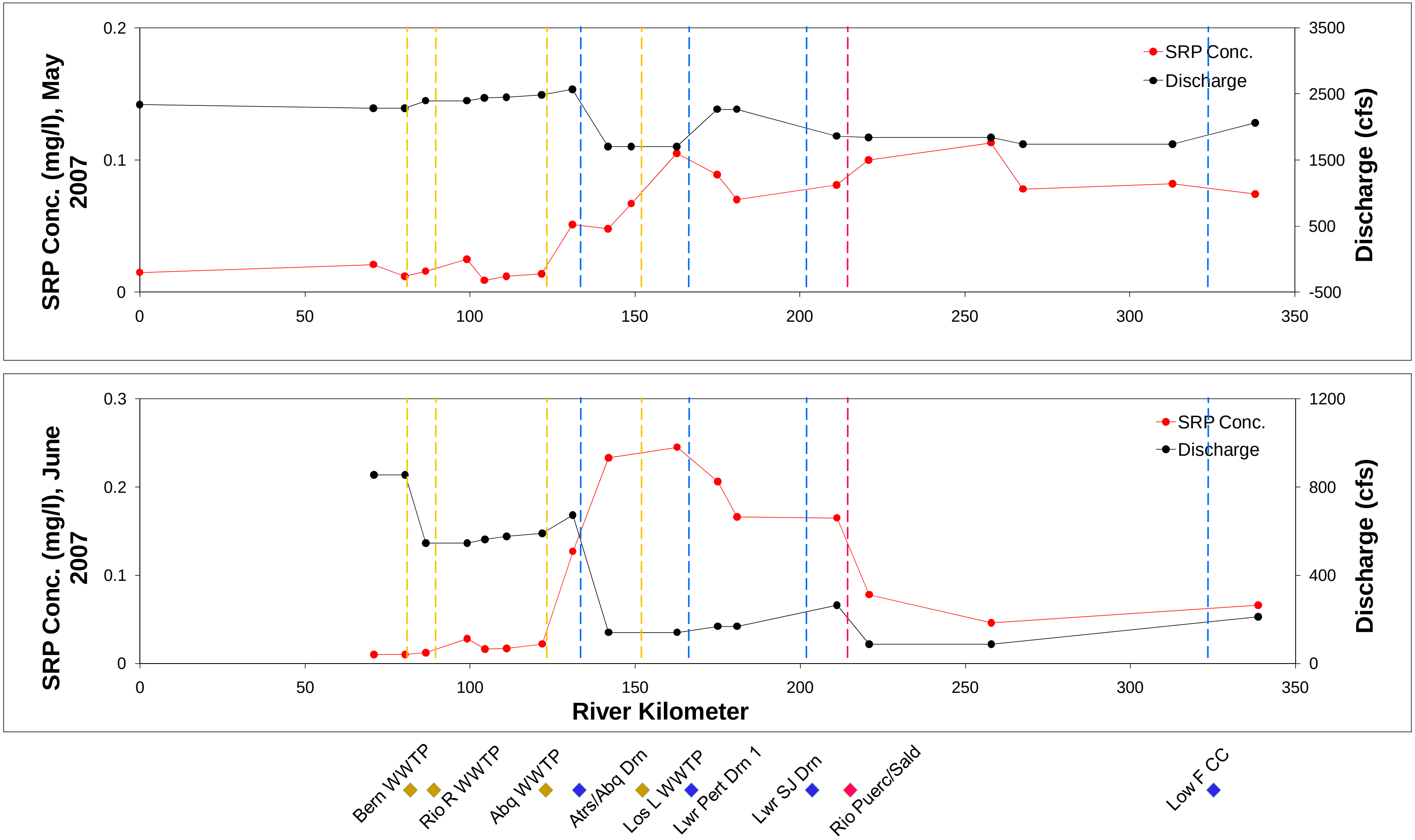
- Excess nutrients in river ecosystems affect in-stream conditions and downstream aquatic ecosystems in a variety of ways including:
  - Algal blooms – some of which are toxic
  - Simplification of aquatic communities
  - Oxygen sags and semi – permanent zones of hypoxia

Nutrients in the MRG:

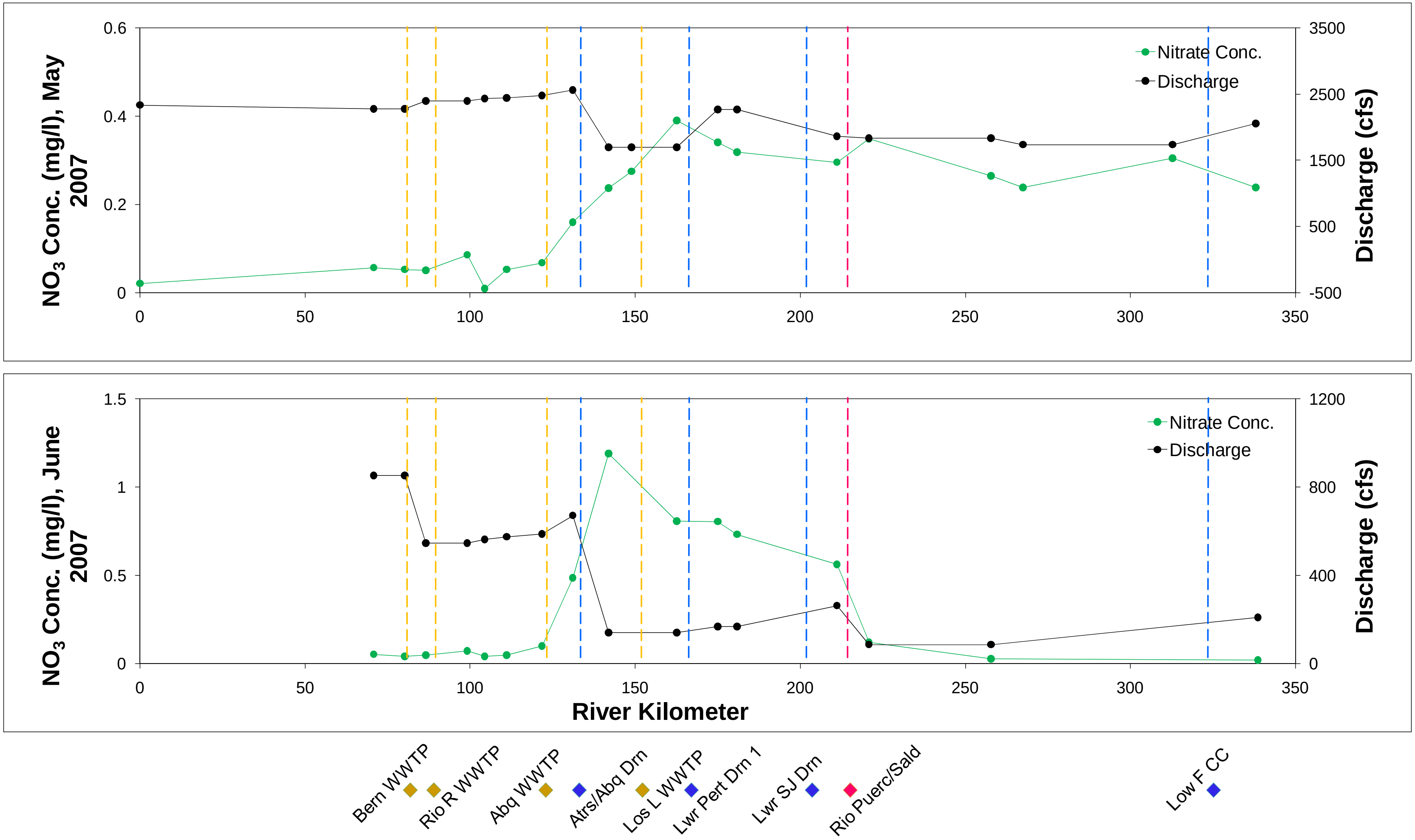
Site	NO_3 Load	NO_3 Conc.	PO_4 Load	PO_4 Conc.	NH_4 Load	NH_4 Conc.
Water Entering MRG	60.3	0.02	28.7	0.01	7.6	0.00
Bernalillo WWTP	1.7	0.71	2.7	1.00	29.2	10.65
Albuquerque WWTP	915.6	4.49	601.5	2.95	73.6	0.36
Rio Rancho WWTP	126.6	10.23	37.9	3.09	2.2	0.16
Los Lunas WWTP	53.4	13.89	14.3	3.67	7.3	1.81

Units: Loads – kg solute day $^{-1}$, Concentrations – mg l^{-1}

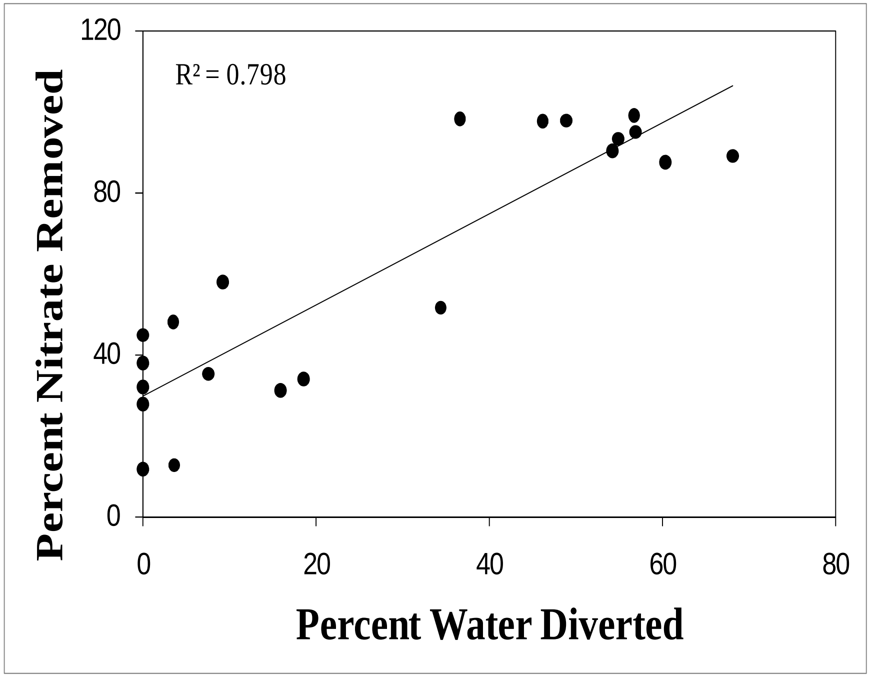
Nutrients in the MRG: Spatial and Temporal Variability - SRP

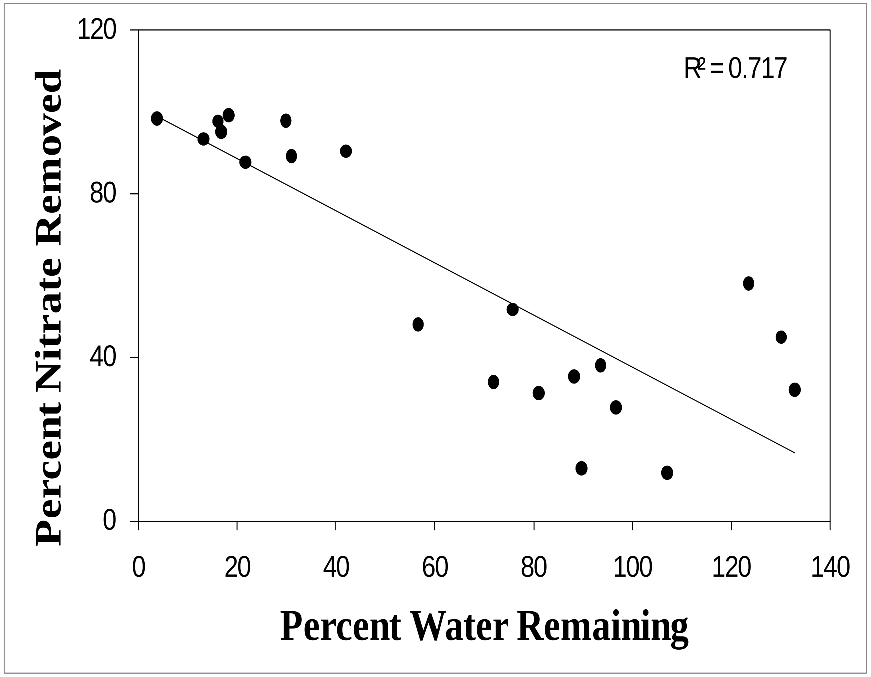


Nutrients in the MRG: Spatial and Temporal Variability – Nitrate



Nutrients in the MRG:





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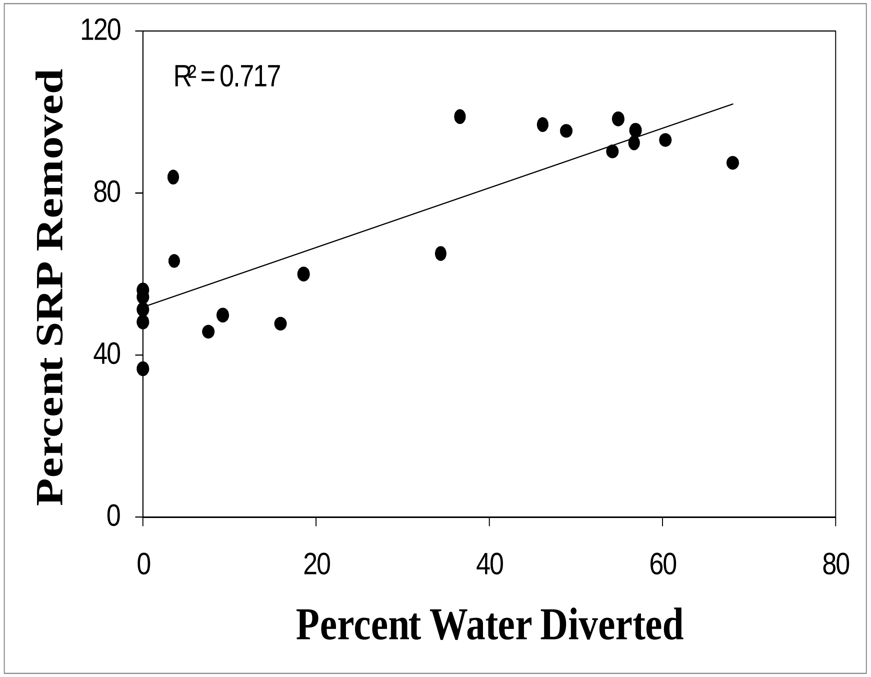

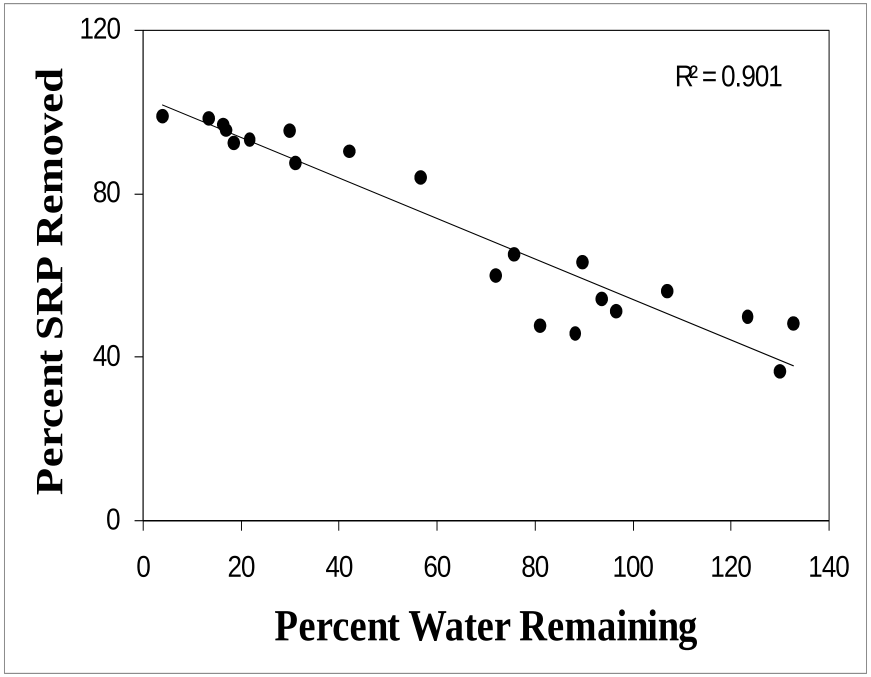

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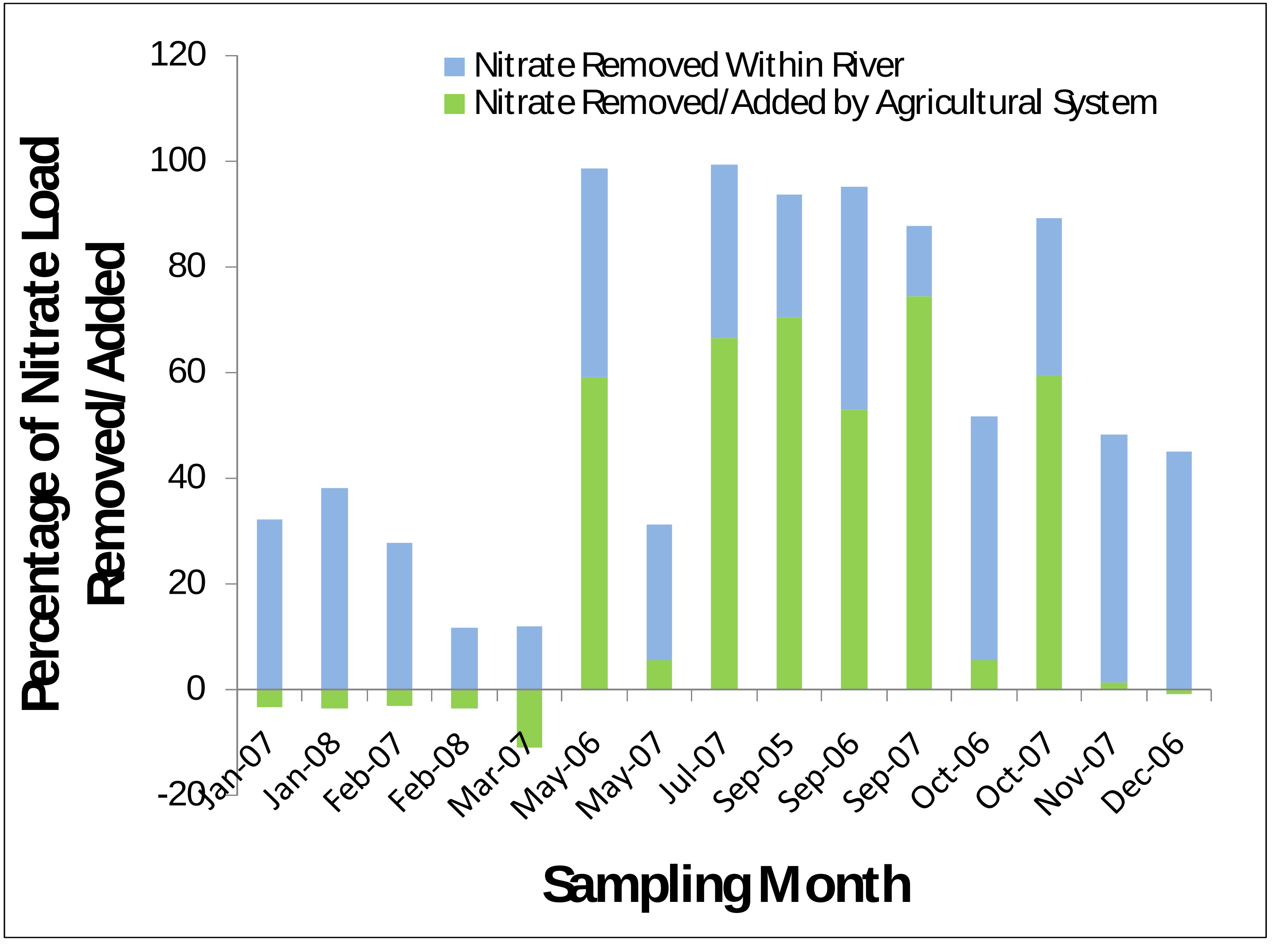

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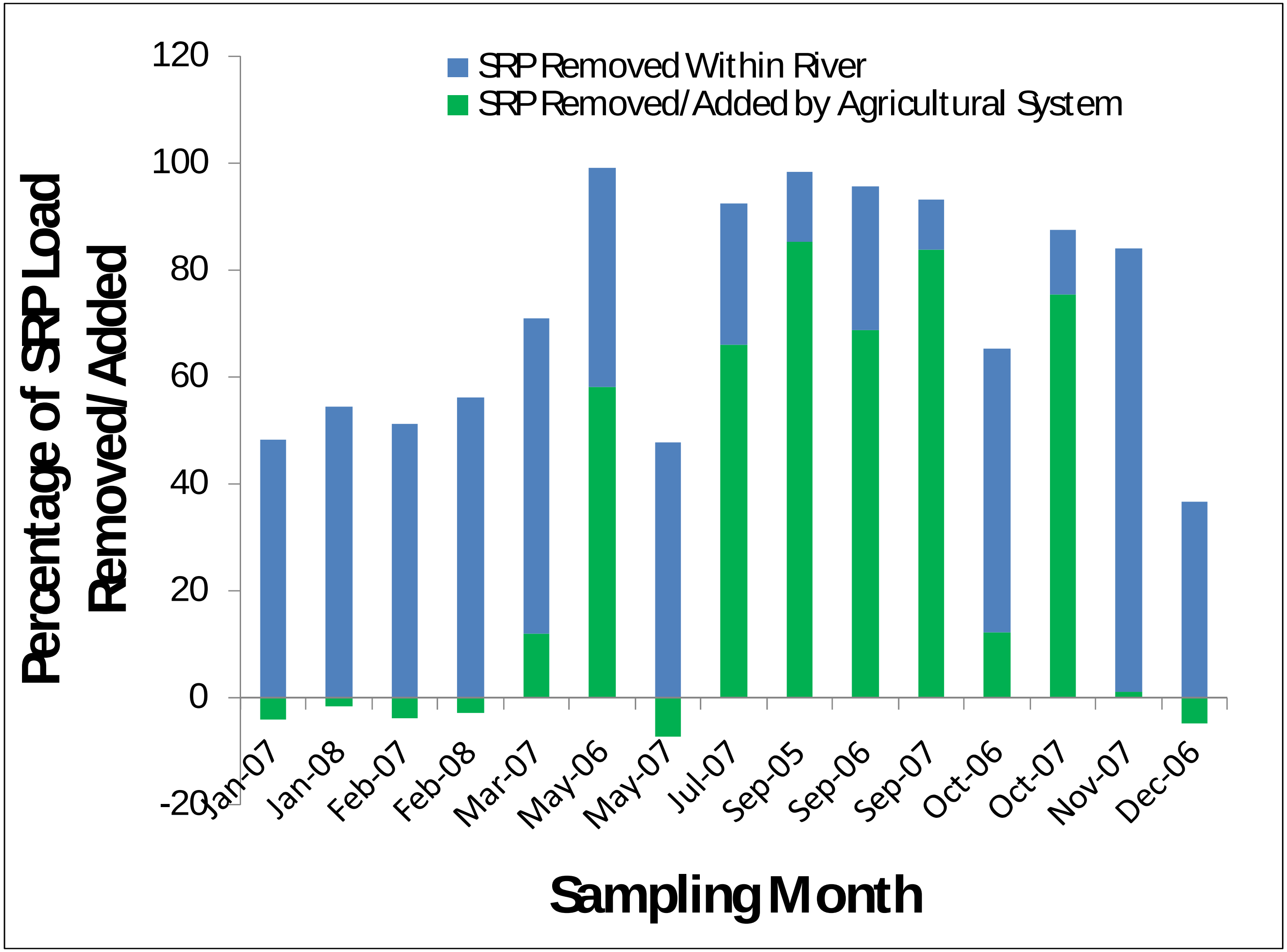
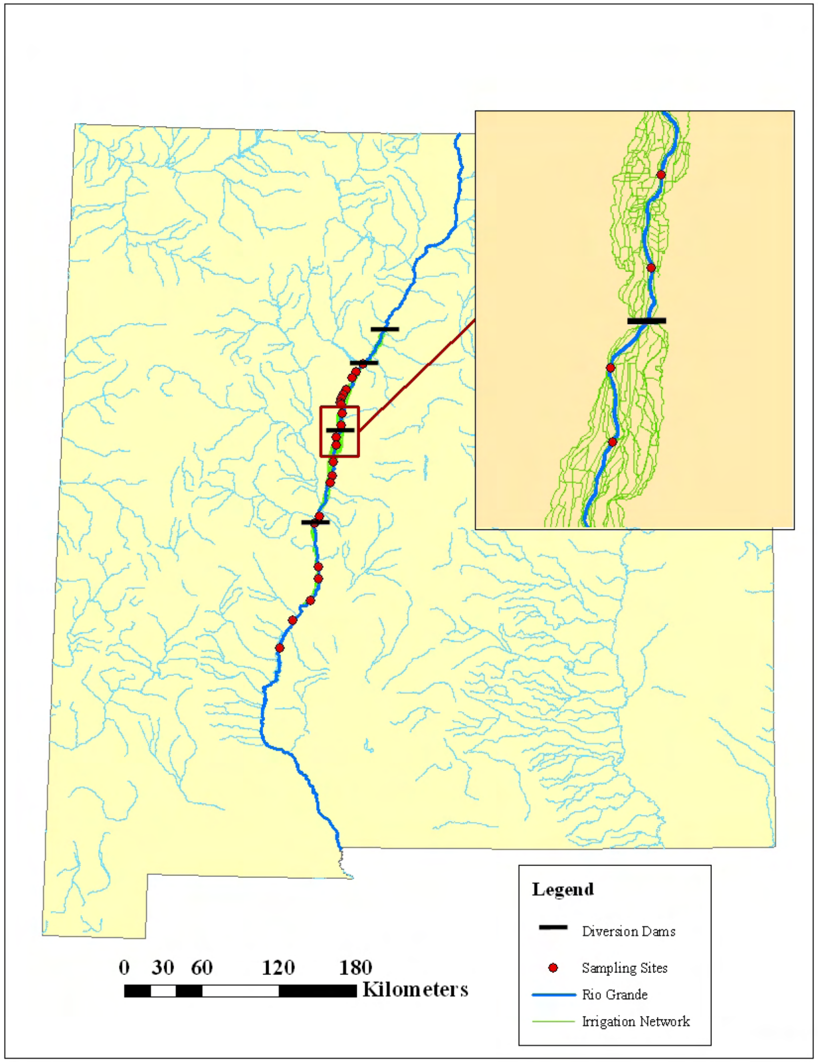


Nutrients in the MRG:

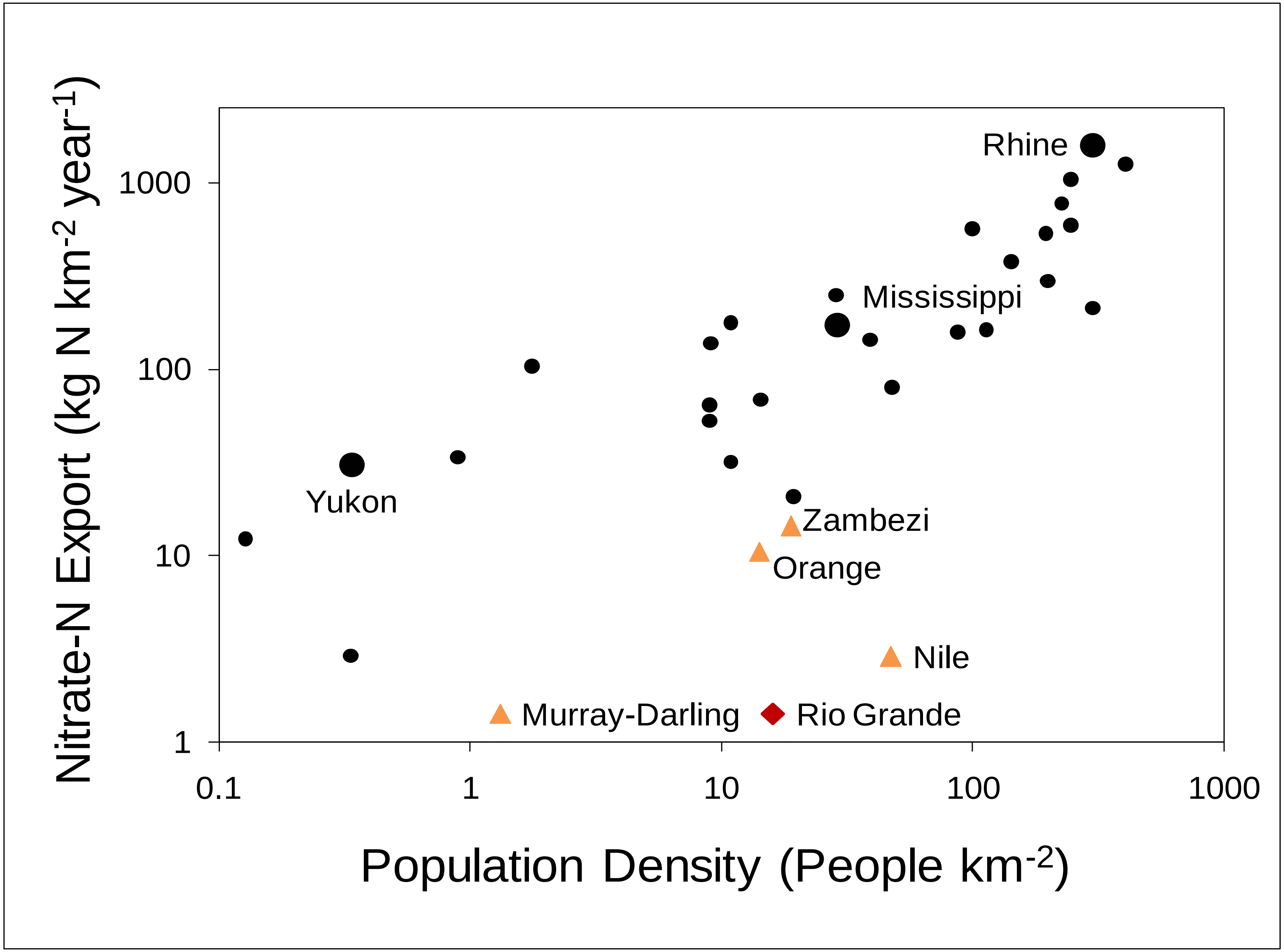
• 250 km^2 of cropland are irrigated in the MRG each month during the irrigation season – most of which do not require intensive fertilization.

• Flood irrigation conditions may promote nutrient removal.

• The network of irrigation ditches and drains contains ~ 2,100 km of channel, approximately 7 times the length of the MRG – small streams effectively process nutrients.



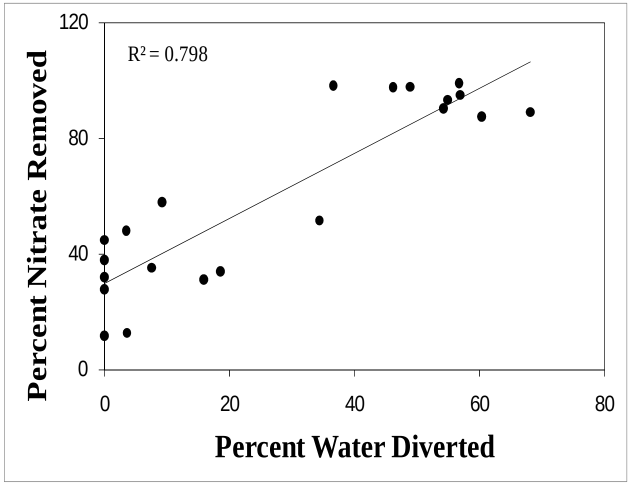
Nutrients in the MRG:

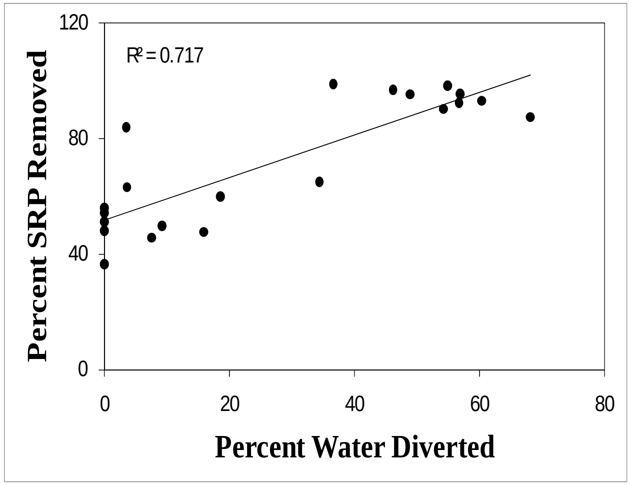


Model of Nutrient Retention in the MRG:

- Model Includes:
  - Mean monthly diversions
  - Mean river Q for historically wet, dry, and average flow years
  - Nutrient loading data

- Model was run under several scenarios including:
  - Present conditions
  - Albuquerque metropolitan area uses ~ 4.25 m^3/sec of treated river water
  - A 25% population increase
  - A minimum river flow requirement of 8.5 m^3/sec





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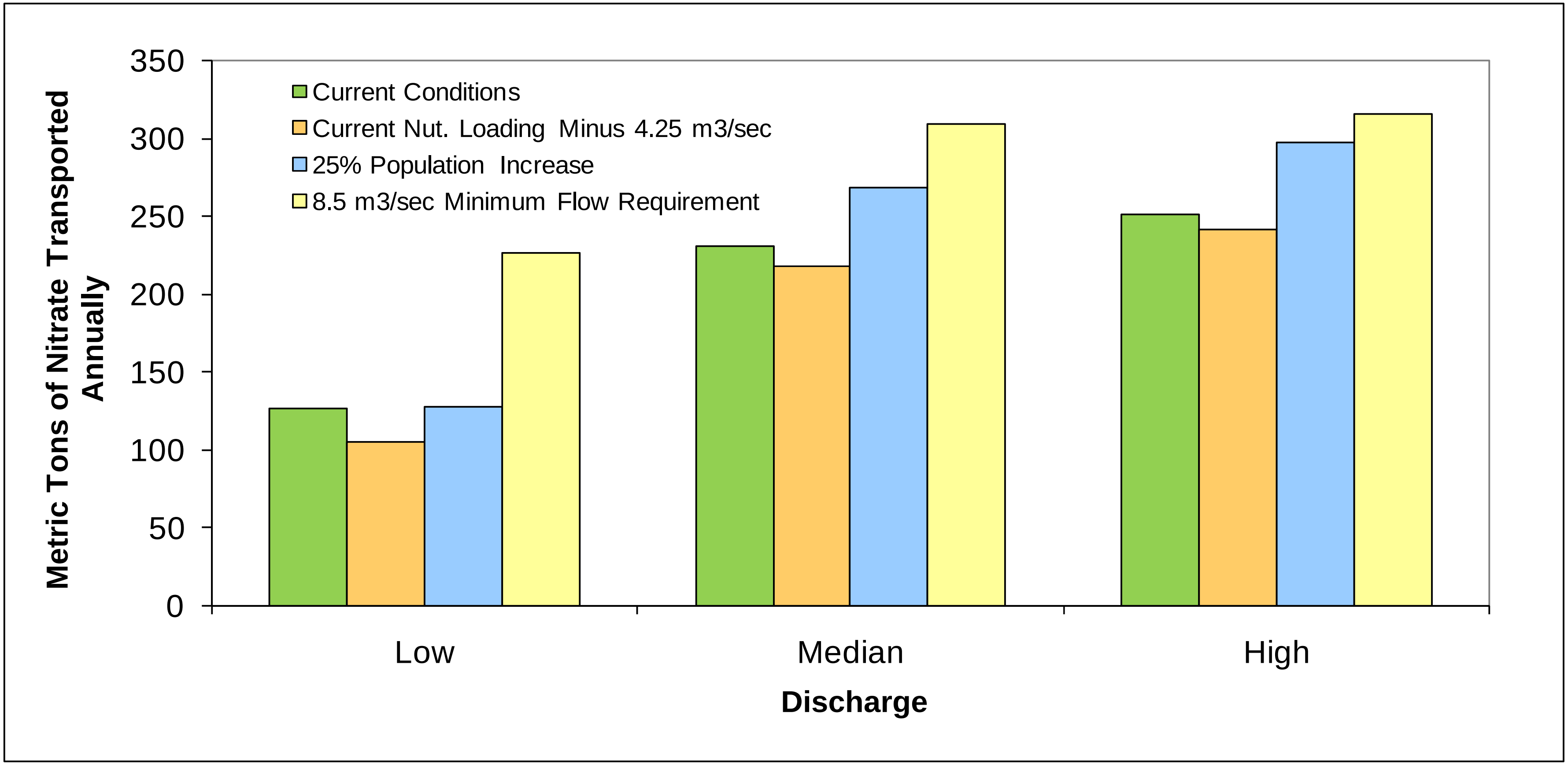
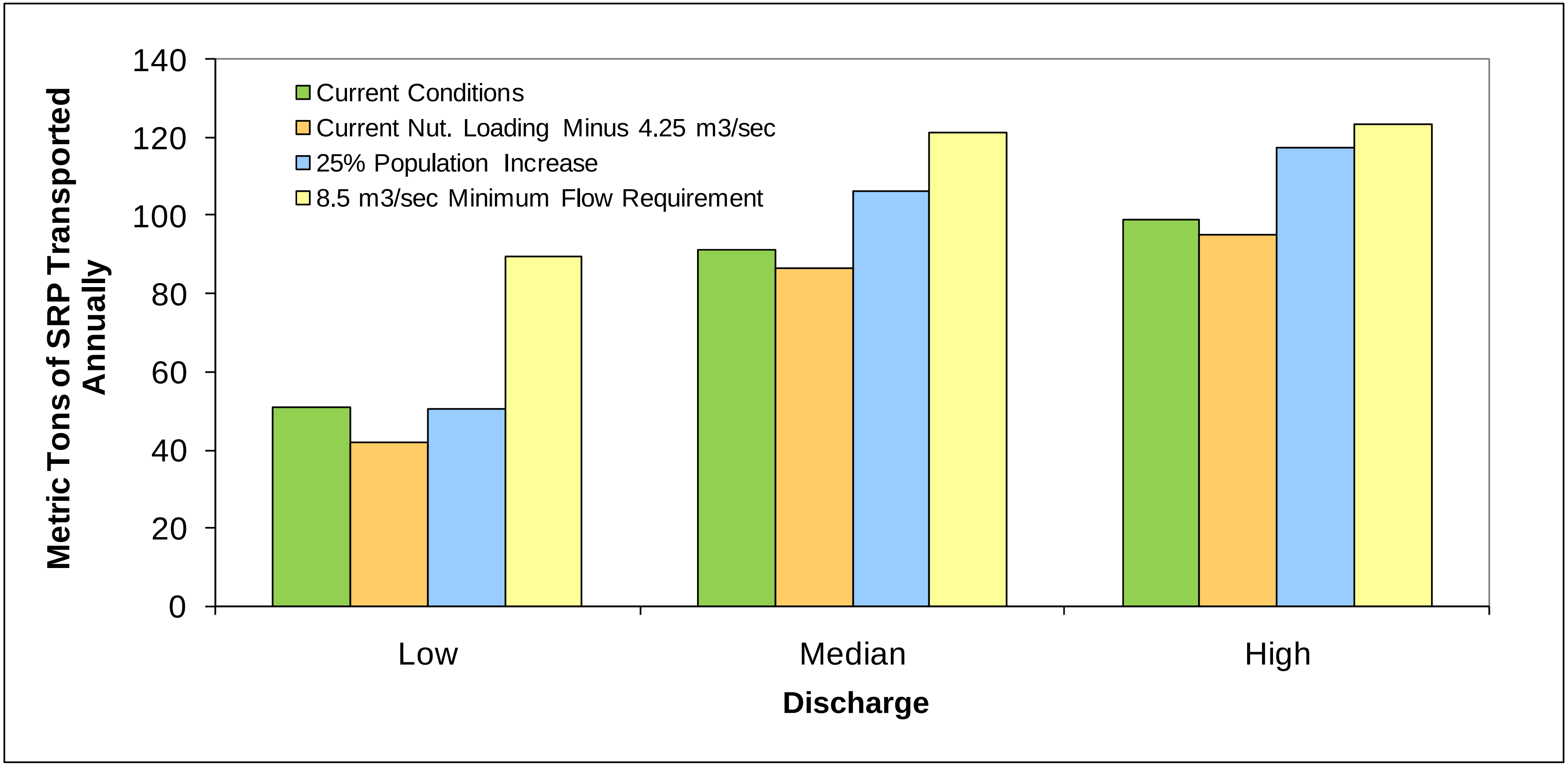


Model of Nutrient Retention in the MRG:



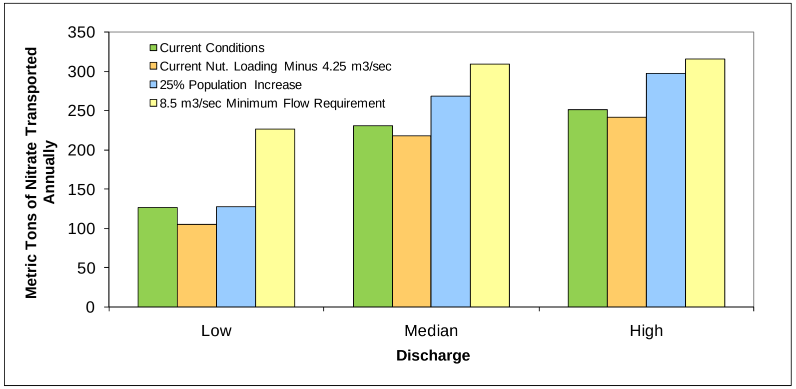
Nutrients in the MRG: Model Summary

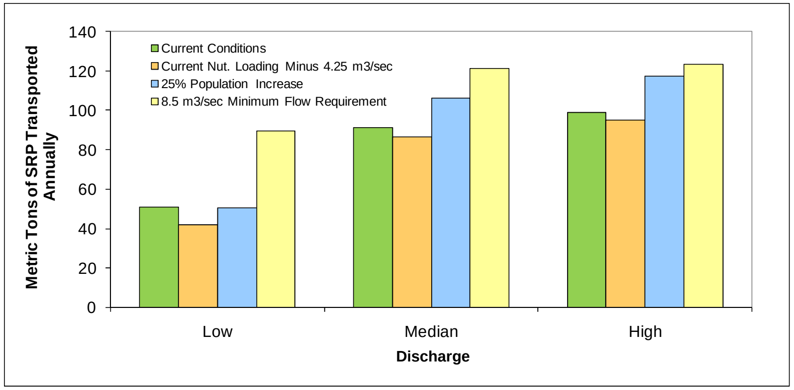
• Under current conditions ~ 125 and 50 metric tons or nitrate and SRP respectively are exported from the MRG.

• If the Abq Metro area drew all of it's water from the MRG, export of nitrate and SRP from the MRG would decline.

• A 25% population increase in the Abq Metro area that depended entirely on MRG water for municipal use would return export levels to current conditions.

• A minimum instream flow requirement of 8.5 m^3/sec would dramatically increase downstream delivery of nitrate and SRP.





Nutrients in the MRG: Summary

- NO_3, NH_4, and SRP are added to the MRG primarily by WWTPs.

- During months with minimal diversion the flux of NO_3 and SRP from the MRG to downstream systems is ~ 50% of inputs.

- During months with significant diversions the delivery of NO3 and SRP from the MRG to downstream systems is ~ 5% of inputs.

- There is a strong positive relationship between the water removed from the system for irrigation and the nitrate and SRP removed from the system.

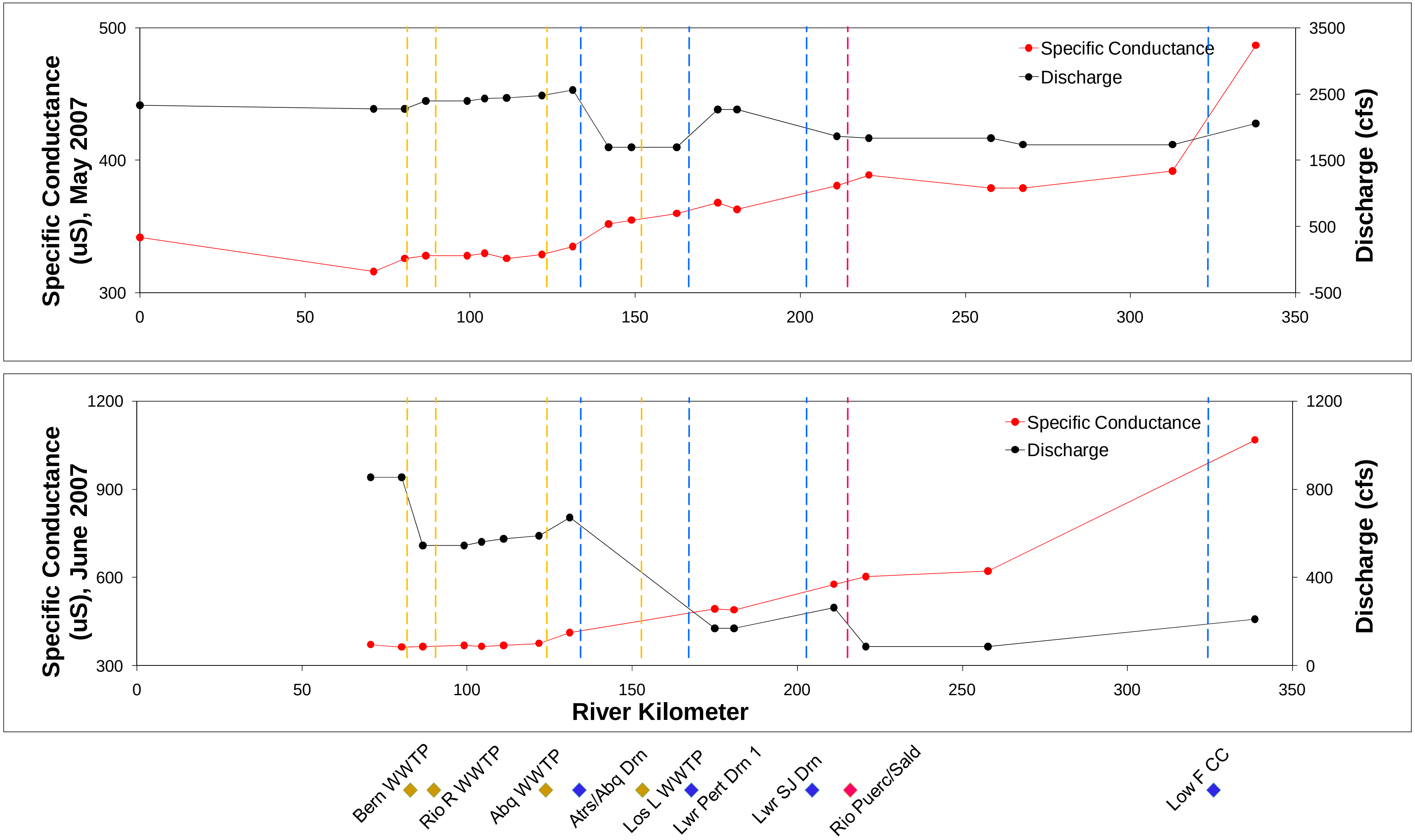
- In stream removal of nitrate and SRP is relatively constant while removal by the agricultural system varies.

- Similar patterns are seen in other arid land rivers where significant portions of flow are diverted for irrigation.

Dissolved Salts in the MRG

- Salinization can impact aquatic ecosystems and the humans that depend on them in several ways including:
  - Direct toxicity for aquatic organisms
  - Shifts in community structure
  - Water potability for human consumption and use for irrigation

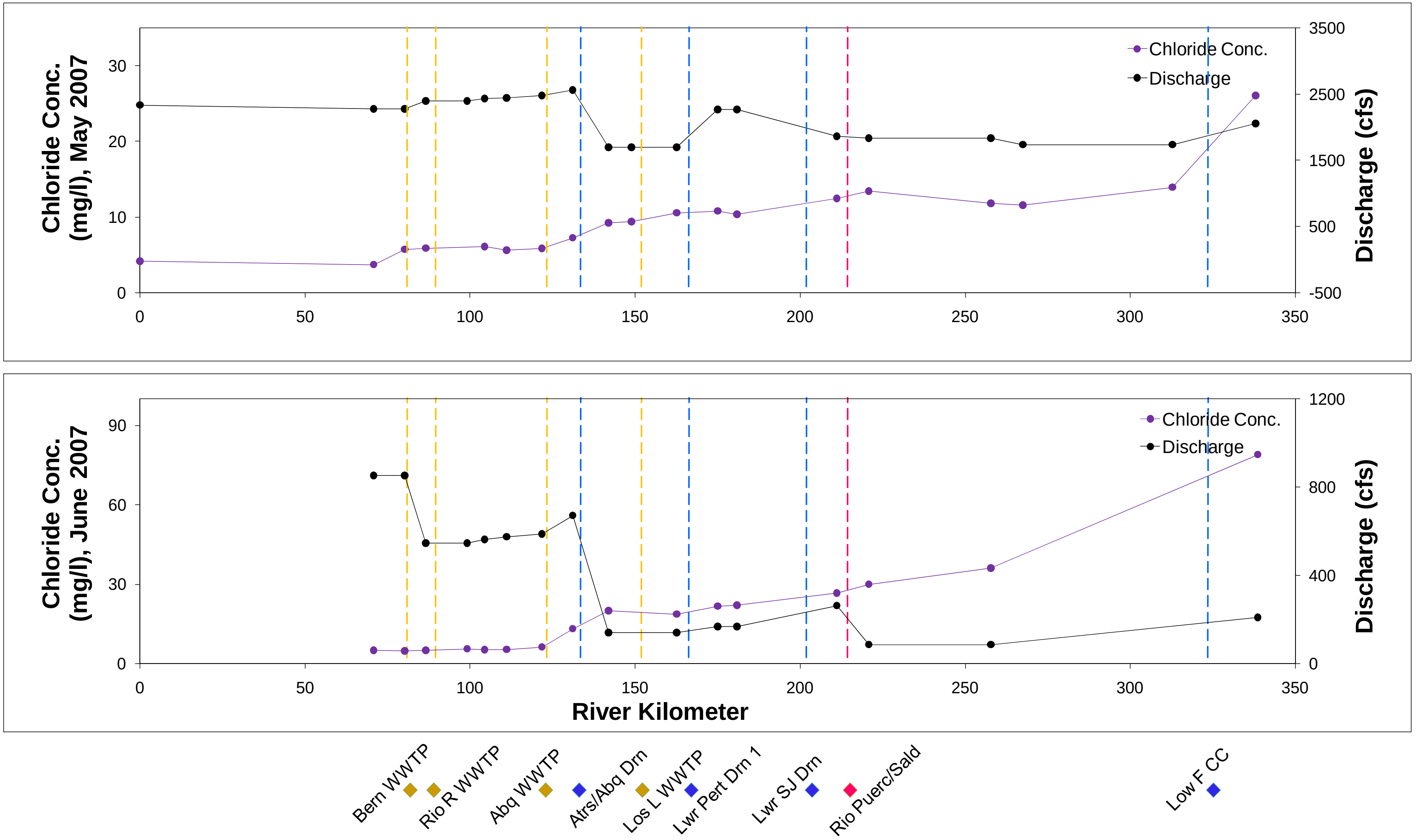
Salts in the MRG: Spatial and Temporal Variability – Specific Conductance



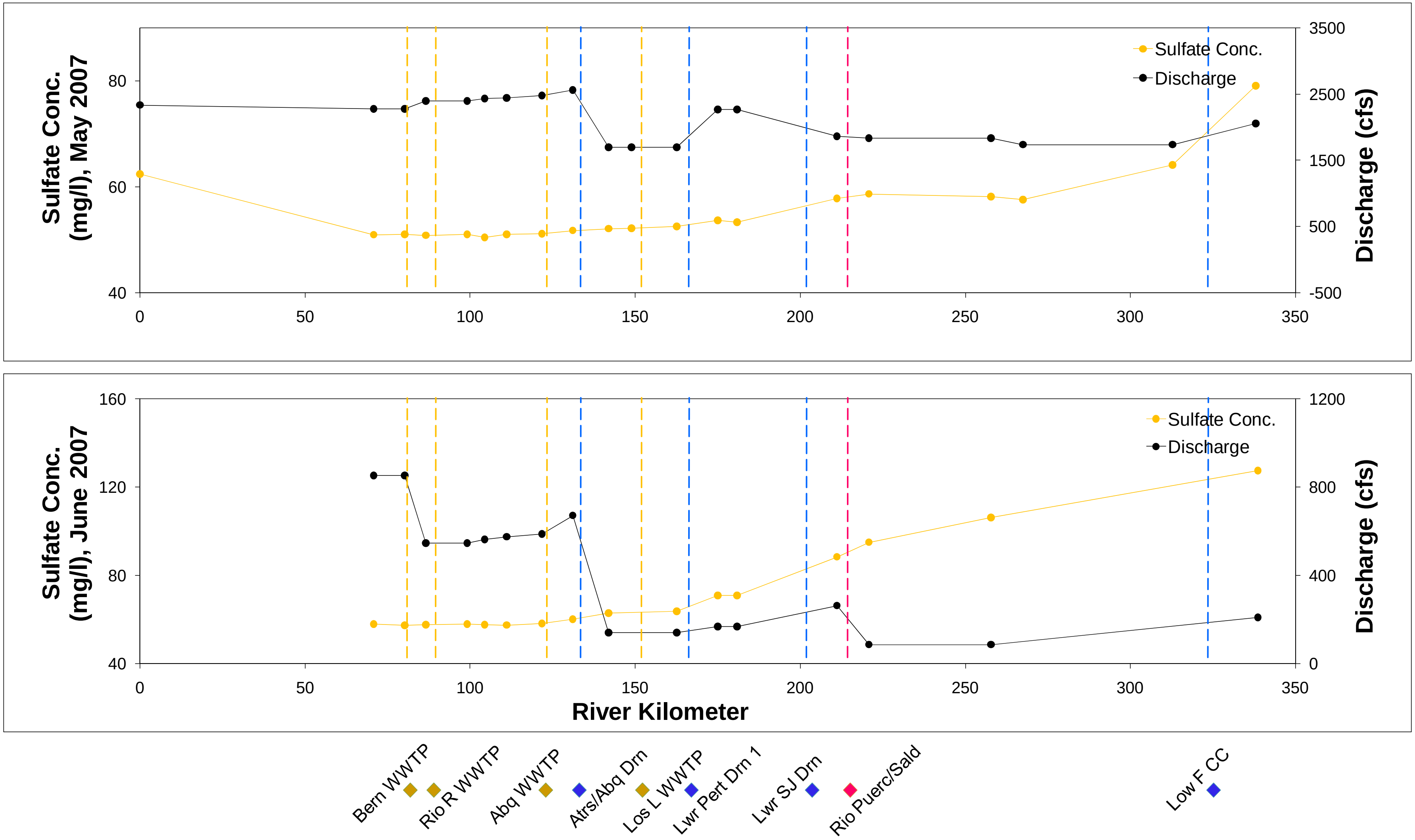
Salts in the MRG

Site	Na Ratio	K Ratio	Mg Ratio	Ca Ratio	SO_4 Ratio	Br Ratio	Cl Ratio	Cl/Br
RG Angostura	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rio Rancho WWTP	**9.0**	**9.3**	0.7	1.0	2.2	**7.0**	**21.3**	**3.1**
Albuquerque WWTP	**5.4**	**7.0**	1.1	1.1	2.0	**11.1**	**14.0**	**1.3**
Abq Rvsd Drn	1.8	1.7	1.2	1.4	1.6	**3.2**	**3.5**	1.1
Atrisco Drn	1.6	1.4	1.2	1.3	1.6	**2.4**	**2.8**	1.1
Lower SJ Drn	3.0	2.0	1.8	1.7	2.6	**4.9**	**5.9**	1.2
Rio Puerco	**24.7**	**3.2**	**7.6**	**5.3**	**20.7**	**28.7**	**57.7**	2.0
Elmendorf Drn	**6.7**	2.5	2.8	2.2	**3.3**	**6.9**	**13.7**	2.0
LFCC at State Park	**6.7**	2.4	2.4	2.1	**3.0**	**7.2**	**12.0**	1.7
RG at Rock House	4.7	2.1	1.9	1.8	2.8	5.4	8.9	1.7

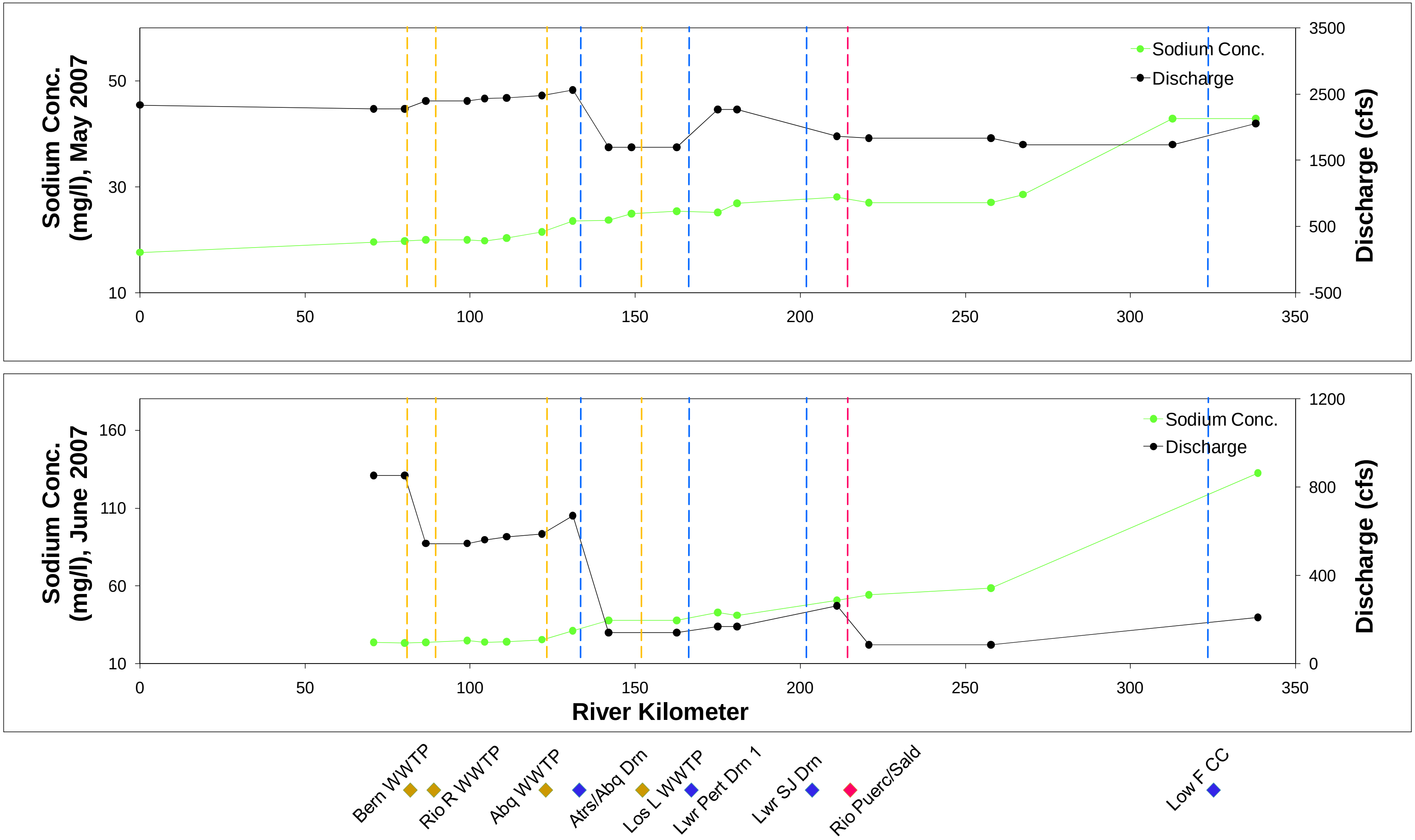
Salts in the MRG: Spatial and Temporal Variability - Chloride



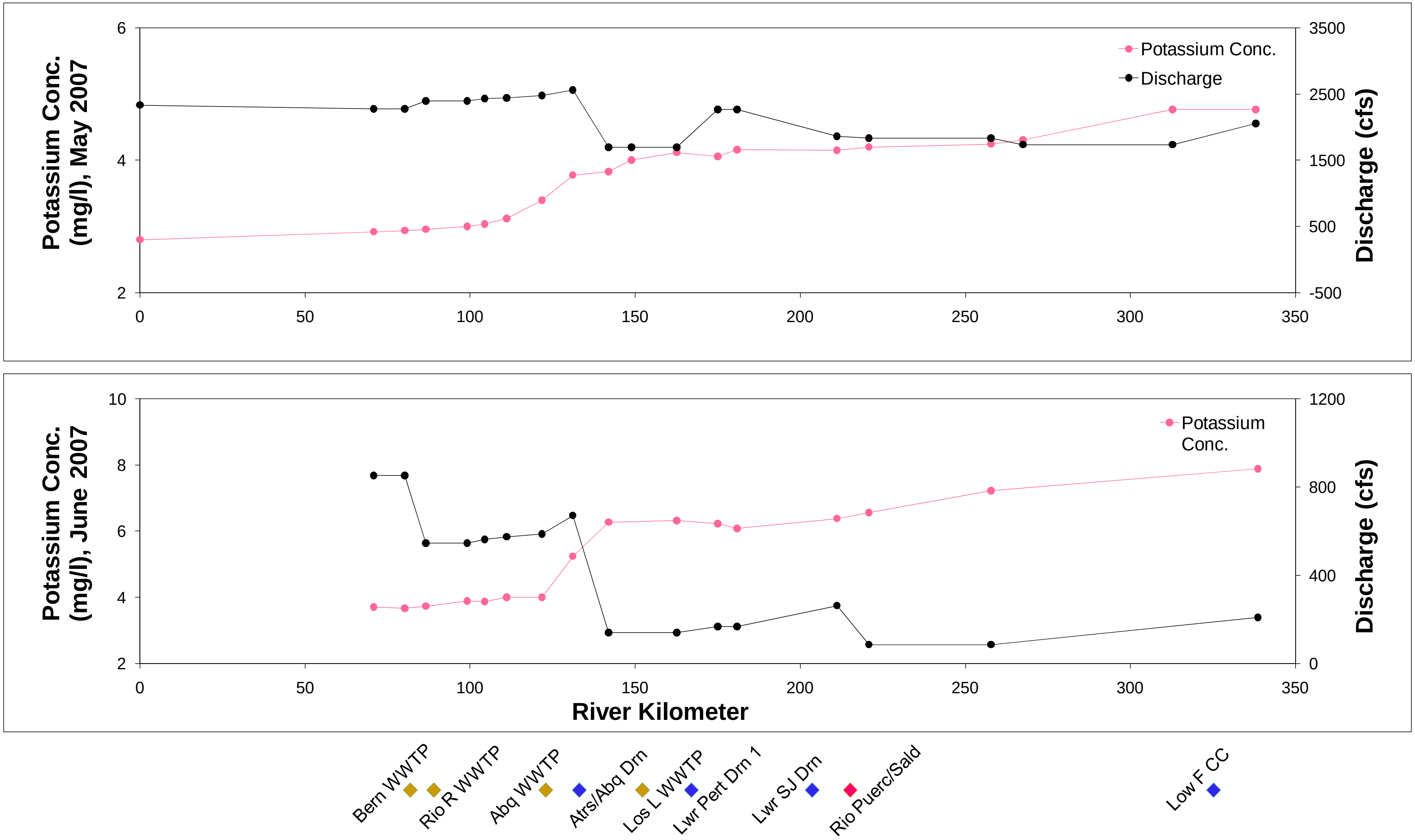
Salts in the MRG: Spatial and Temporal Variability - Sulfate



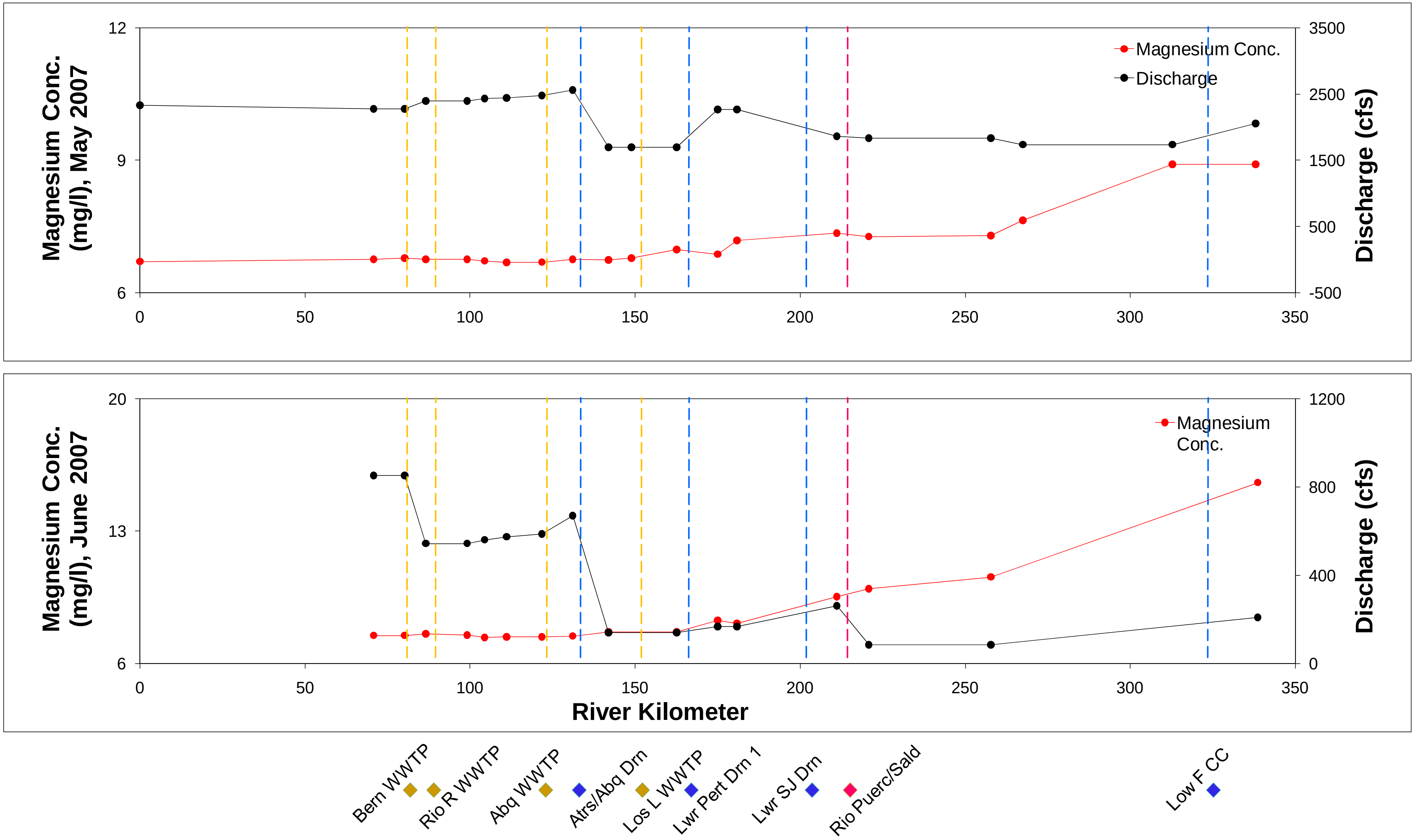
Salts in the MRG: Spatial and Temporal Variability - Sodium



Salts in the MRG: Spatial and Temporal Variability - Potassium



Salts in the MRG: Spatial and Temporal Variability - Magnesium



Salts in the MRG: Summary

- Salinity increases in the downstream direction during all months.
- The various types of inputs to the river have distinct ion signatures.
- WWTPs contain high concentrations of Na, K, Br and Cl.
- Irrigation return flows are elevated in Br and Cl.
- Saline tributary inputs contain high levels of all ions except K.

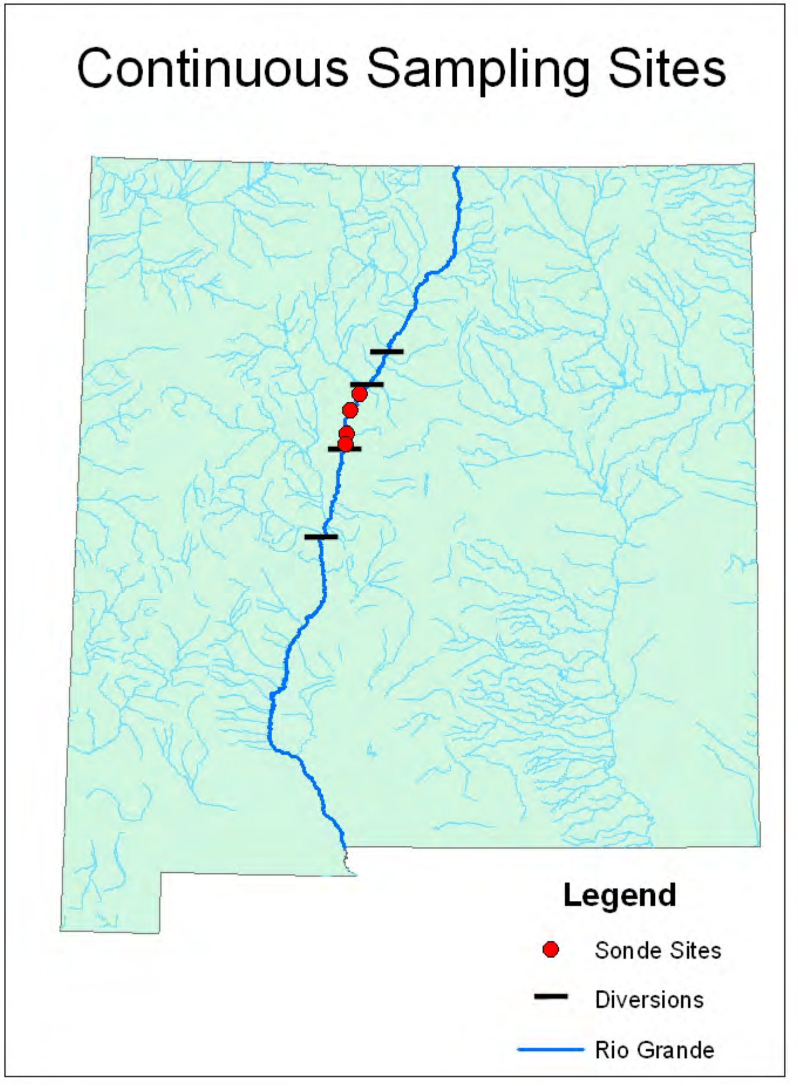
Continuous Monitoring in the MRG

- Four YSI 6920 sondes located in the Albuquerque reach of the MRG.

- Located at the Bernalillo 550, Alameda, Rio Bravo and I-25 bridges.

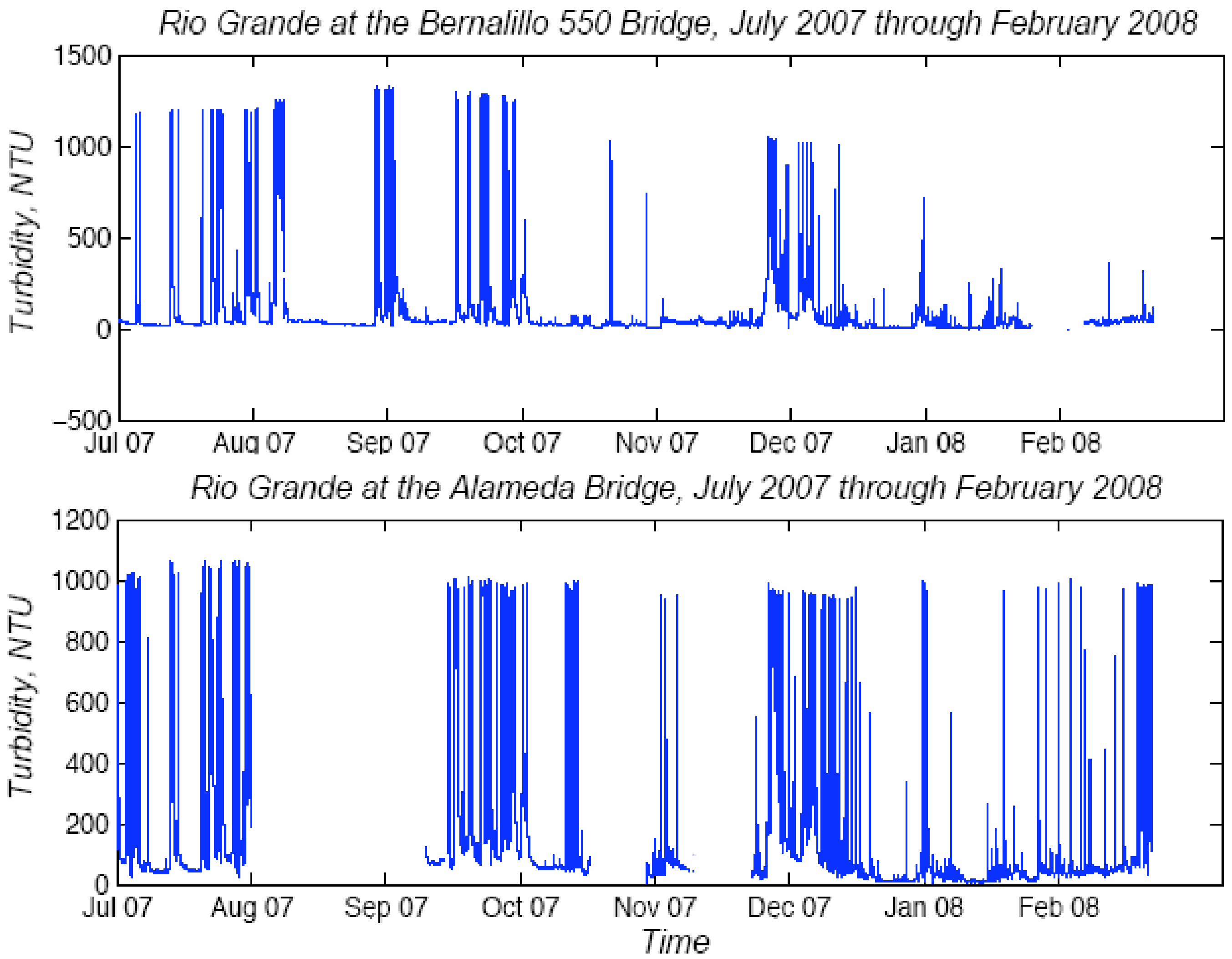
- Began collecting data in June 2006.

- Measure pH, conductivity, dissolved oxygen, temperature and turbidity at 15 minute intervals.



Continuous Monitoring in the MRG

Continuous Monitoring in the MRG



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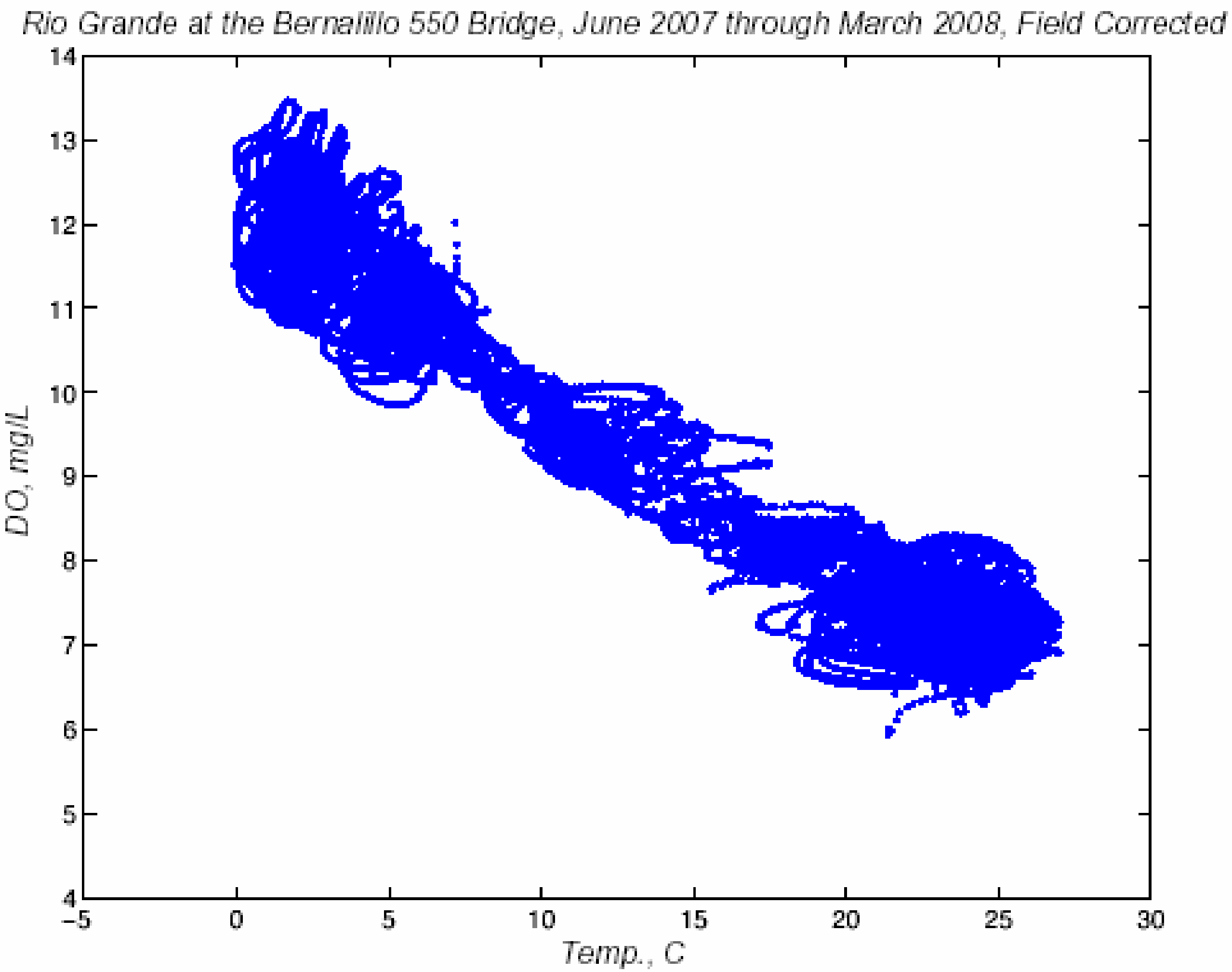

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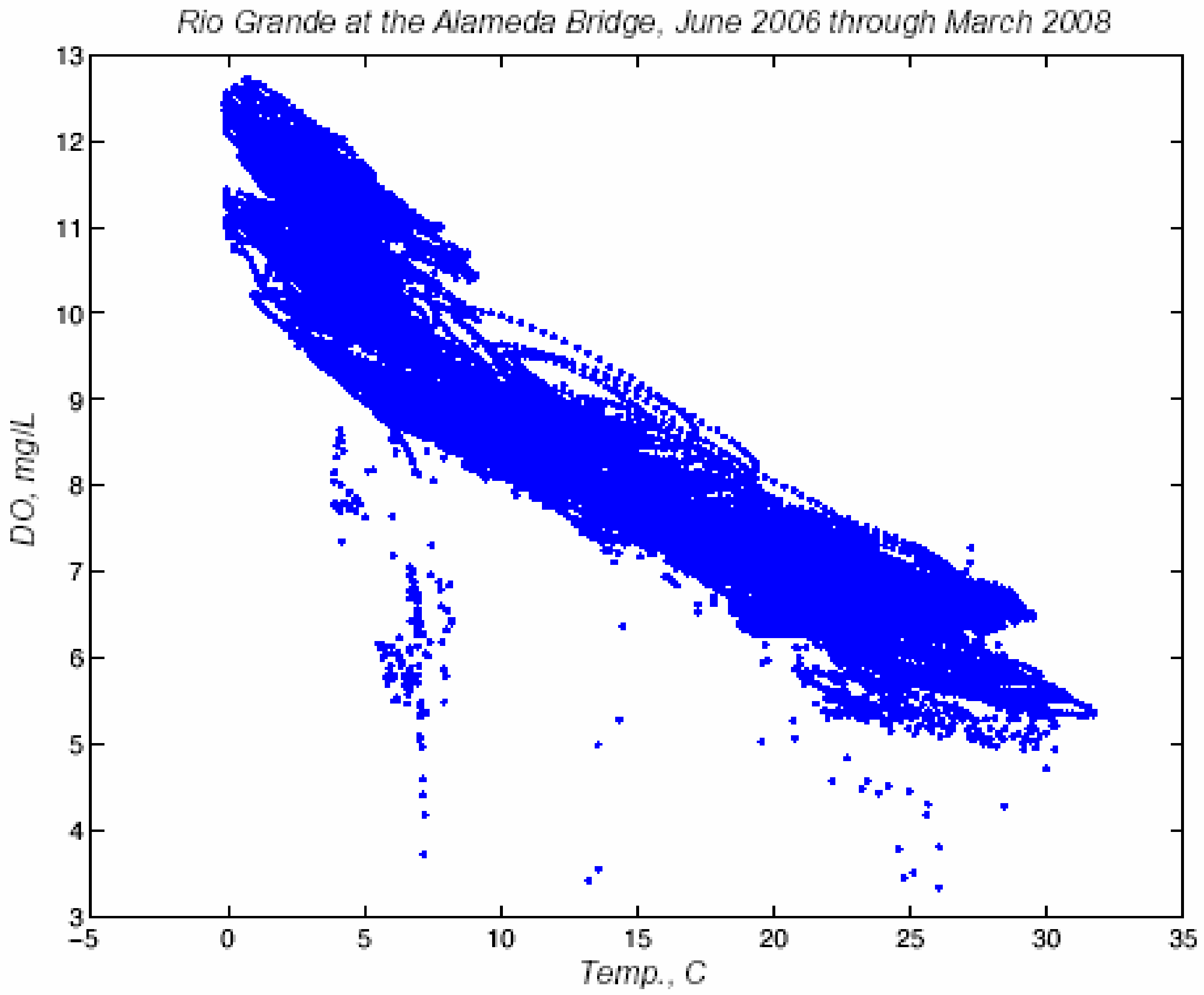
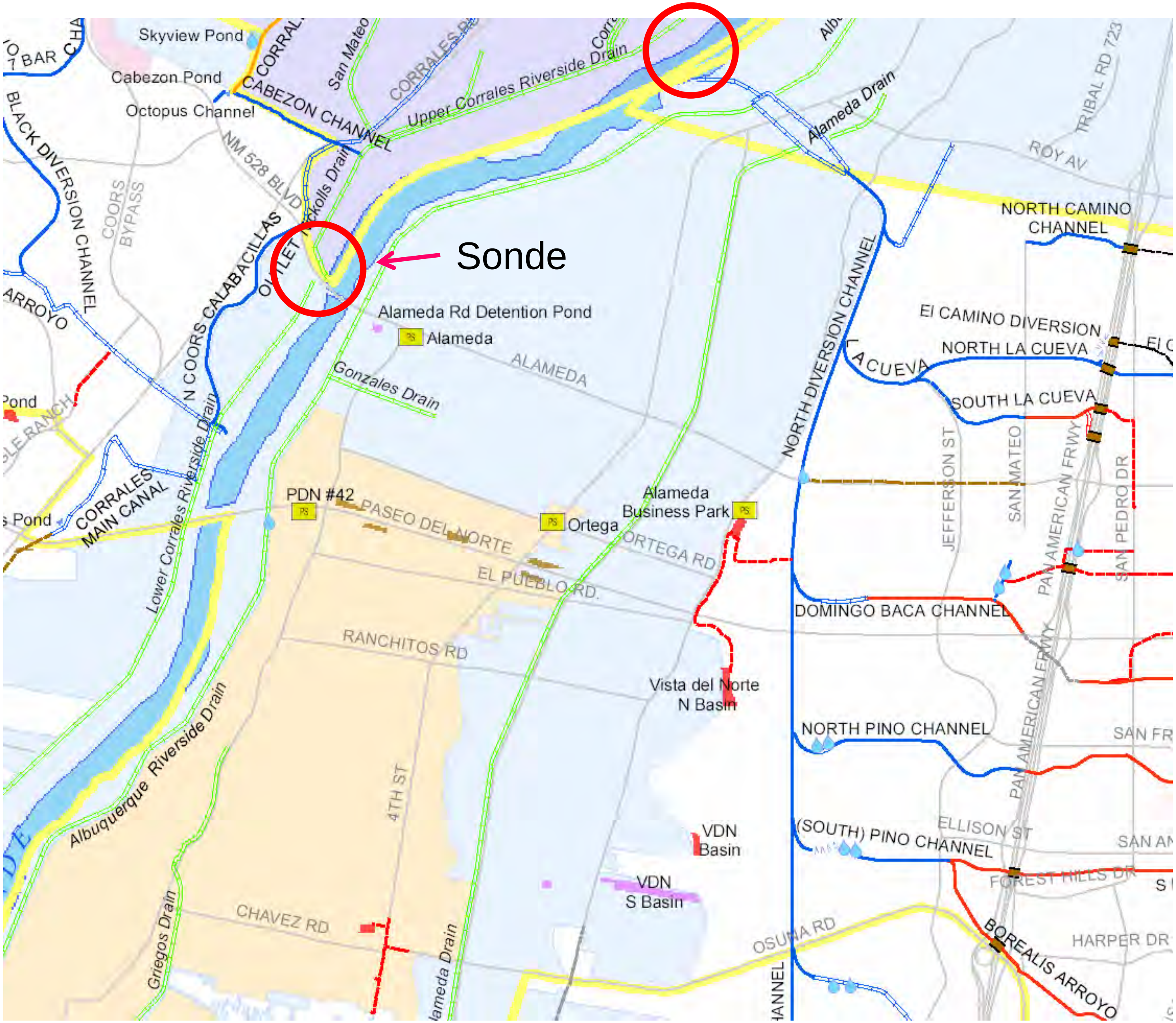
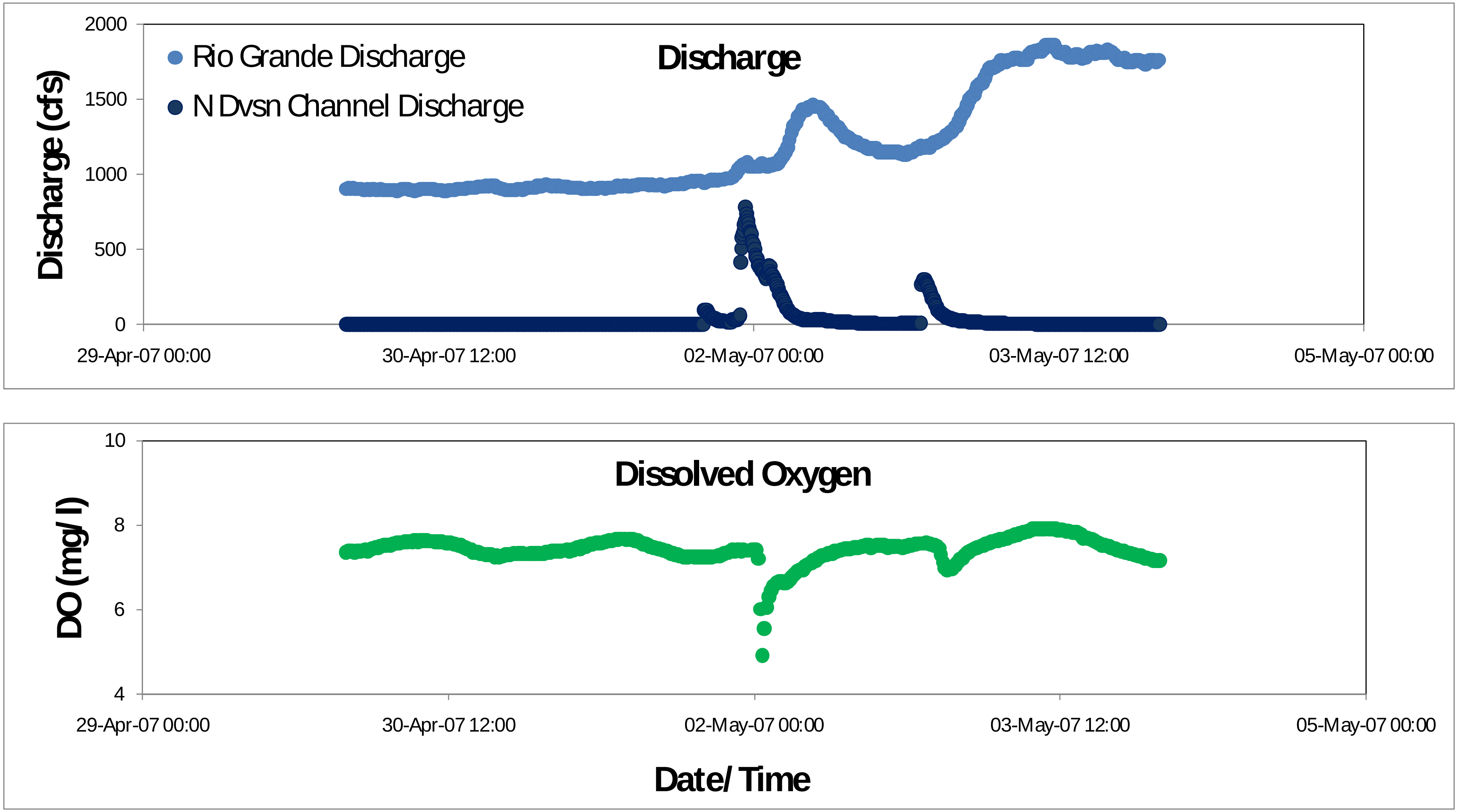
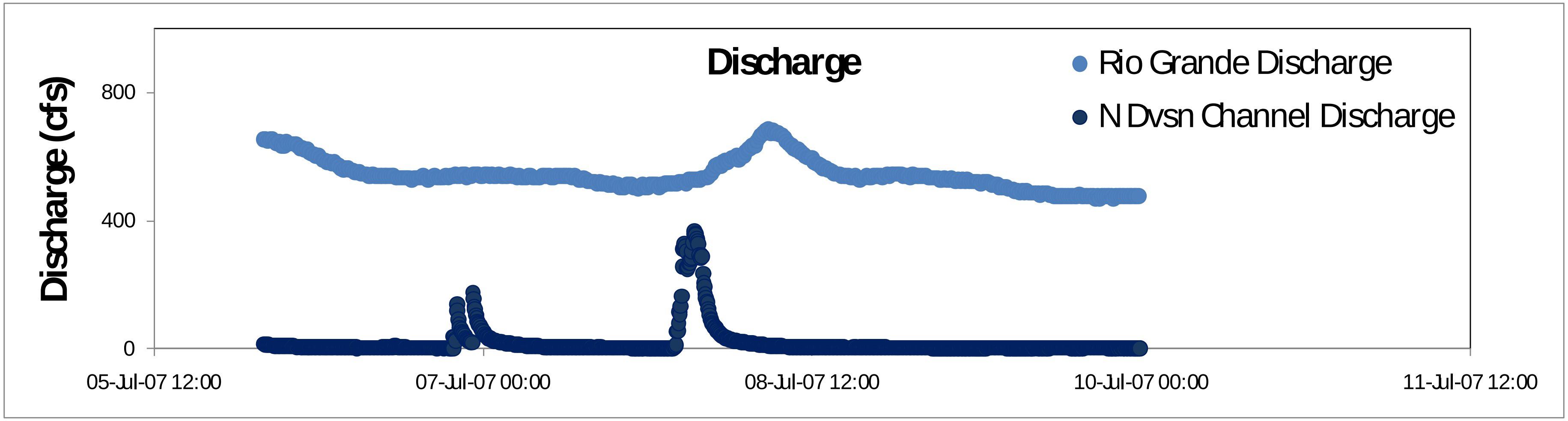


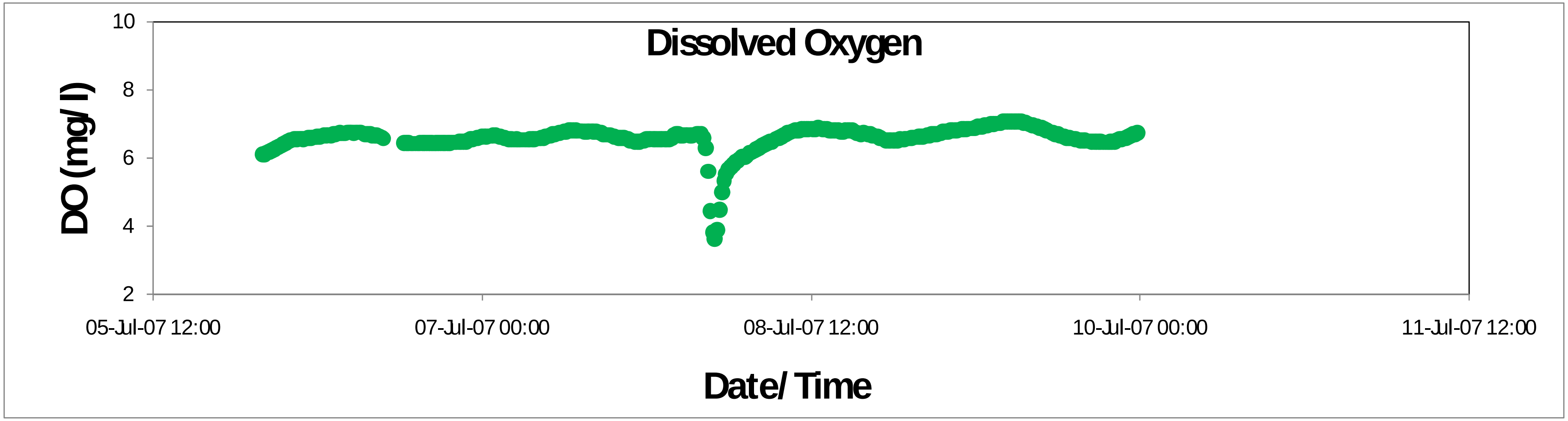

Sonde
Skyview Pond
Cabezon Pond
Octopus Channel
CABEZON CHANNEL
Upper Corrales Riverside Drain
Alameda Drain
ROY AV
TRIBAL RD 723
NORTH CAMINO CHANNEL
BLACK DIVERSION CHANNEL
COORS BYPASS
NM 528 BLVD
N COORS
CALABACILLAS
ARROYO
Alameda Rd Detention Pond
Alameda
ALAMEDA
Gonzales Drain
NORTH DIVERSION CHANNEL
El CAMINO DIVERSION
NORTH LA CUEVA
LA CUEVA
SOUTH LA CUEVA
JEFFERSON ST
SAN MATEO
PAN AMERICAN FRWY
SAN PEDRO DR
CORRALES MAIN CANAL
Lower Corrales Riverside Drain
PDN #42
PASEO DEL NORTE
Ortega
Alameda Business Park
ORTEGA RD
EL PUEBLO RD.
DOMINGO BACA CHANNEL
RANCHITOS RD
Vista del Norte N Basin
NORTH PINO CHANNEL
Albuquerque Riverside Drain
4TH ST
VDN Basin
(SOUTH) PINO CHANNEL
ELLISON ST
FOREST HILLS DR
VDN S Basin
CHAVEZ RD
Griegos Drain
Alameda Drain
OSUNA RD
BOREALIS ARROYO
HARPER DR

Episodic Events in the MRG

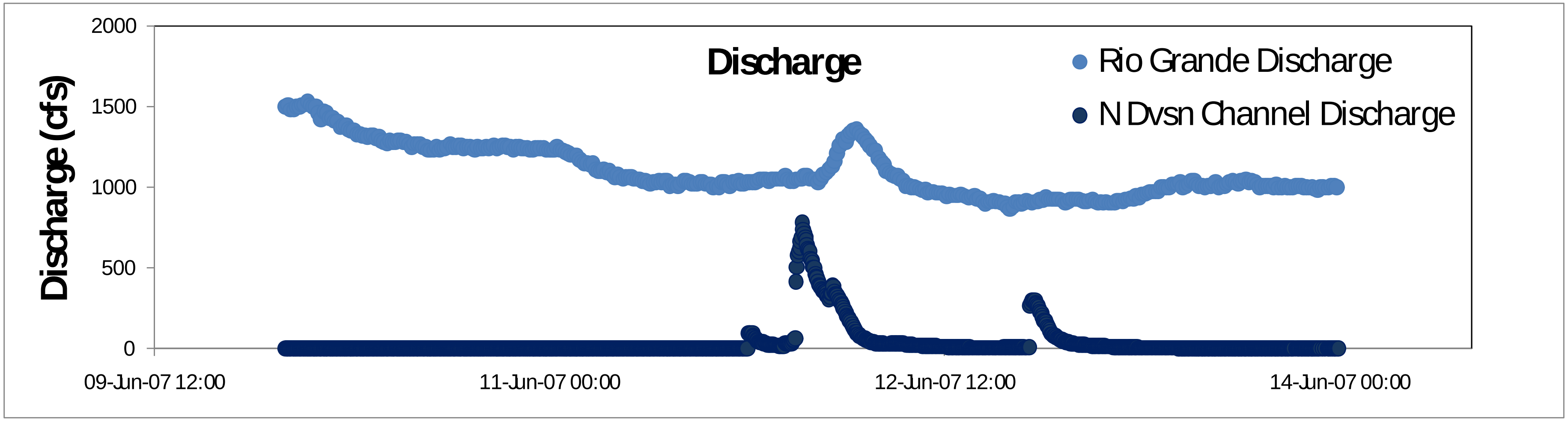


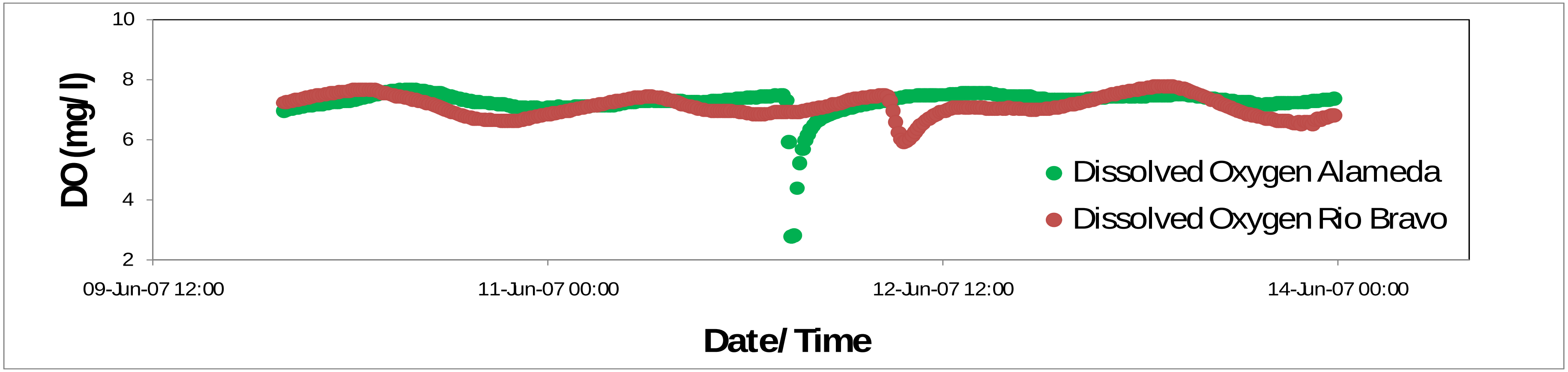
Episodic Events in the MRG

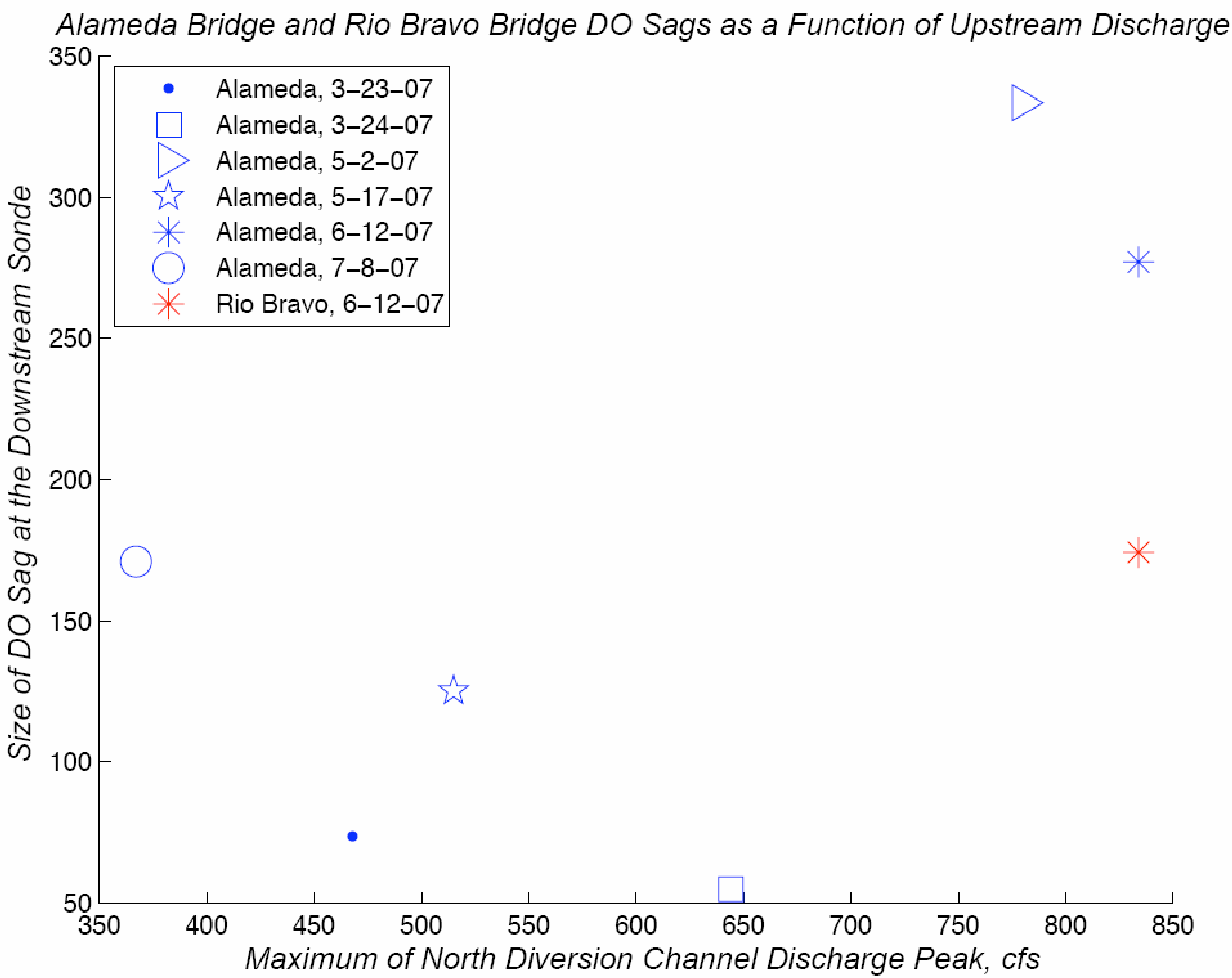




Episodic Events in the MRG







Alameda Bridge and Rio Bravo Bridge DO Sags as a Function of Upstream Discharge
Size of DO Sag at the Downstream Sonde
Maximum of North Diversion Channel Discharge Peak, cfs
Alameda, 3–23–07
Alameda, 3–24–07
Alameda, 5–2–07
Alameda, 5–17–07
Alameda, 6–12–07
Alameda, 7–8–07
Rio Bravo, 6–12–07
350
300
250
200
150
100
50
350
400
450
500
550
600
650
700
750
800
850


OCT 1952
JUL 1996
© 2008 Tele Atlas
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Pointer 35°12'32.07" N 106°36'25.89" W elev 1526 m
Streaming |||||||||| 100%
Eye alt 2.95 km

Episodic Events in the MRG: Summary

- Episodic events frequently increase turbidity in the MRG.

- Some events cause DO sags in the river – these events appear to be closely linked to discharge from the north diversion channel.

- A cursory investigation of the data shows a decreasing trend in primary production from the 550 bridge to the I-25 bridge.

Overall Summary

• Waste water treatment plants increase nutrient loads in the MRG by ~ 2000 %, however agricultural irrigation removes most of these inputs during some months.

• Salinity in the MRG increases substantially by the end of the reach as a result of waste water, irrigation returns and natural inputs.

• Episodic events, particularly those associated with Abq., negatively impact water quality.

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