Chapter 4 Water Quality Monitoring 2008 and 2009

TJ Kopshy[1]
Lee Xiong[1]
Victoria Bowles[1]
Central Valley Regional Water Quality Control Board

Introduction

The monitoring program for the Grassland Bypass Project (GBP), including water quality monitoring, is described in detail in Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project, Phase II (USBR et al., 2002). This chapter provides a summary of the water quality monitoring program, modifications to the plan for the seventh and eighth years of operation of Phase II of the GBP (January 1, 2008 to December 31, 2009), and water quality trends observed during this period. Detailed water quality data of individual monitoring stations will not be provided in this summary, as the San Francisco Estuary Institute (SFEI) has presented this information in annual narrative and graphical summary reports (SFEI, 2008 and 2009).

Monitoring Program

The Central Valley Regional Water Quality Control Board (CVRWQCB) has an on-going water quality monitoring program related to regulatory activities for agricultural subsurface drainage from the Grassland watershed. The water quality monitoring program for the GBP is an adaptation of the CVRWQCB monitoring program. The CVRWQCB conducts most of the water quality sampling. The Panoche Water District (under contract with the San Luis & Delta-Mendota Water Authority; SL&D-MWA) assists the CVRWQCB by collecting samples at Stations A, J, K, L2, and M2. Samples are transferred to and processed by the CVRWQCB and analyzed by its contract laboratories. The CVRWQCB conducts quality assurance (QA) reviews of the data before submitting them to the SFEI for reporting.

Monitoring Objectives

The water quality monitoring program was designed to provide data for evaluating compliance with commitments in the Project Waste Discharge Requirements, the Use Agreement, and associated documents. The commitments include:

- Monthly and annual selenium load limits on discharges
- No degradation of the San Joaquin River water quality relative to the pre-Project-condition
- Cessation of discharge of agricultural subsurface drainage to the wetland channels

- Management of flows in the San Luis Drain (SLD) so as to not mobilize channel sediments

The Monitoring Program was also designed to verify the validity of assumptions expressed in documents associated with the GBP. The assumptions include:

- The GBP is expected to result in selenium concentrations less than 2 µg/L in approximately 93 miles of wetland water supply channels.
- The increased frequency of exceeding selenium water quality objectives in Mud Slough (north) will be offset by a reduction of exceedances in Salt Slough.

In addition, the Monitoring Program was intended to provide data to be used to assess spatial and temporal trends in water quality parameters of concern and to characterize habitats in which biological samples were collected.

Sampling Locations

Monitoring was conducted in four areas; the SLD, Mud Slough (north), the San Joaquin River, and the Grassland wetland water supply channels, including Salt Slough. Table 1 summarizes the Monitoring Program, and sampling locations are depicted in Figure 2 in Chapter 1.

Frequency of Sampling

The frequency of sampling is outlined in Table 1. Weekly composite samples were collected at Station A (inflow to the SLD). Daily composite samples were collected at Station B (discharge from the SLD), and at Station N (San Joaquin River at Crows Landing). At Station A, daily samples were composited into a weekly sample to be used along with continuous flow data to calculate weekly selenium load inflow to the SLD. At Station B, daily composite samples along with continuous flow data were used to calculate daily selenium load discharge to Mud Slough (north). At Station N, daily composite samples were collected to allow the CVRWQCB to calculate loads and evaluate progress toward compliance with Basin Plan water quality objectives. The compliance date at Station N for the selenium water quality objective (5 µg/L 4-day average) during normal and wet years was October 1, 2005, and during critical, dry, and below normal years is October 1, 2010 (CVRWQCB, 1998a) (Table 2). Since the objective is based on a 4-day average concentration, consecutive daily samples are required at this station. The remaining stations were sampled on a weekly basis.

Sampling Methodology

Three types of sampling techniques were utilized, depending on the frequency of sampling and data needs: auto-sampler, mid-channel depth-integrated, and grab sample from channel bank. Auto-samplers were used to collect daily and weekly composite samples because of the remoteness of the station and frequency of sampling. At Stations A, B, and D, structures such as a bridge or platform over the channel permitted the

collection of mid-channel, depth-integrated samples. At other stations, a grab sample was collected from the stream bank. With respect to stream hydrology, lateral and vertical homogeneity was assumed for dissolved constituents at all sampling stations.

Modifications to the Water Quality Monitoring Program

During the Phase I of the GBP a number of issues were resolved with respect to the water quality monitoring program. These modifications and clarifications to the monitoring program are discussed in the previous Annual Reports (USBR, 1998 and SFEI, 1999, 2000, 2001, 2003, 2004b and 2005).

No other changes to the water quality monitoring program occurred during 2008 or 2009.

Water Quality Trends

Detailed water quality data for each monitoring station are presented in the Grassland Bypass Project Annual Narrative and Graphical Summary Reports, January 2008 to December 2009 (SFEI, 2009 and 2010). Thus, this presentation will be limited to major water quality trends and findings for the seventh year of operation of Phase II of the GBP. Of primary interest are selenium concentrations in the San Joaquin River and water quality trends in Mud Slough (north). Also of interest are sporadic exceedances in the wetland channels of selenium water quality objectives established in the Water Quality Control Plan for the Sacramento/San Joaquin River Basins.

San Joaquin River

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) contains a schedule for compliance with the 5 µg/L (4-day average) selenium water quality objective and performance goals. The compliance date was October 1, 2005 for above normal and wet water year types and is October 1, 2010 for critical, dry, and below normal water year types (Table 2). A 5 µg/L performance goal became effective October 1, 2005 for critical, dry, and below normal water year types. Compliance with selenium water quality objectives and performance goals specified in the Basin Plan is measured at Station N.

Figure 1 depicts selenium concentrations in the San Joaquin River at monitoring Stations G (weekly grab), and N (4-day average) for 2008. Figure 2 depicts selenium concentrations in the San Joaquin River at monitoring Stations G (weekly grab), and N (4-day average) for 2009. Station G is located at Fremont Ford, upstream of the Mud Slough (north) inflow to the San Joaquin River. Because this station is located upstream of drainage discharges from the GBP service area (except during flood events when drainage is occasionally routed to Salt Slough), selenium concentrations are generally low. Station N is located downstream of the GBP discharges conveyed by Mud Slough (north) and the Merced River inflow to the San Joaquin River. Merced River inflows dilute the upstream selenium contributions (CVRWQCB, 2002).

For the months of January through December 2008, the applicable performance goal for critical water years, such as Water Year 2008 and Water Year 2009 (DWR, 2009), are 5 µg/L monthly mean. Selenium concentrations remained below this performance goal for the 2008 calendar year at both Site N and Site G. Figure 3 depicts monthly mean selenium concentrations at Station N for 2008. The water quality objective was met continuously during the January through December 2008 timeframe. For the months of January through December 2009, the applicable performance goal for dry years, such as Water Year 2009 (DWR, 2010), are 5 µg/L monthly mean. Selenium concentrations remained below this performance goal for the 2009 calendar year at both Site N and Site G. Figure 4 depicts monthly mean selenium concentrations at Station N for 2009. The water quality objective was met continuously during the January through December 2009 timeframe.

The Basin Plan and the GBP Waste Discharge Requirements (WDRs) prohibit discharge of selenium from agricultural subsurface drainage systems in the Grassland Watershed to the San Joaquin River in amounts exceeding 8,000-pounds per water year. Compliance is measured at Station N. Calculations using daily selenium data, preliminary USGS flow data, and the load calculation methods found in CVRWQCB (1998b) indicate that the annual selenium loads measured at Station N during Water Year 2008 was 2,130 pounds and 1,574 pounds for Water Year 2009; both well below the 8,000-pound annual load limit for the Grassland Watershed.

Wetland Channels

Monthly mean selenium concentrations in the wetland channels during 2008 are depicted in Figure 5. The monthly mean 2 µg/L selenium objective was met during all months of 2008 in Salt Slough (Site F), San Luis Canal (Site L2), and Santa Fe Canal (Site M2). Selenium concentrations slightly in excess of the monthly mean 2 µg/L objective were observed at Station J in February 2008. At Station K selenium concentrations were in excess of the monthly mean 2 µg/L objective in August 2008. Monthly mean selenium concentrations in the wetland channels during 2009 are depicted in Figure 6. The monthly mean 2 µg/L selenium objective was met during all months of 2009 in Salt Slough (Site F), and Santa Fe Canal (Site M2). Selenium concentrations slightly in excess of the monthly mean 2 µg/L objective were observed at San Luis Canal (Site L2) and Camp 13 (Site J) in March 2009. At Site K, selenium concentrations were in excess of the monthly mean 2 µg/L objective in August 2009.

Regional Board staff conducted preliminary investigations on the potential sources of selenium, which are detailed in two separate reports (CVRWQCB, 2000 and CVRWQCB, 2002). In summary, primary sources of selenium to the channels were determined to be diversions from the 94,000-acre Drainage Project Area (DPA) (both stormwater flows and seepage from control gates), supply water, subsurface agricultural drainage from areas outside of the DPA, tailwater and local groundwater. To address the first source, diversions from the DPA, the Grassland Area Farmers (GAF) developed a stormwater management plan, and internal control gates were sealed. These actions

appear to have controlled peaks of selenium previously observed during storm events.

Despite the stormwater management plan and control gate modifications made by the GAF, selenium concentrations have continued to sporadically exceed the 2 µg/l monthly mean selenium objective in the wetland channels, particularly from the pre-irrigation season through the early irrigation season (February and March).

Mud Slough (North)

Selenium concentrations observed at Station D (Mud Slough (north) downstream of the SLD), during 2008 are depicted in Figure 7. Selenium concentrations observed at Station D (Mud Slough (north) downstream of the SLD), during 2009 are depicted in Figure 8. Water quality at Station D is dominated by the GBP drainage discharge. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation period, which commences in mid winter (pre-plant irrigation) and lasts through the summer. During 2008, selenium concentrations at Station D ranged from 1.2 µg/L in October to 51.1 µg/L in May. For comparison purposes, the 5 µg/L (4-day average) selenium water quality objective, which applies October 1, 2010 for Mud Slough (north), is noted on Figure 7. During 2009, selenium concentrations at Station D ranged from 1.93 µg/L in October to 24.6 µg/L in August. For comparison purposes, the 5 µg/L (4-day average) selenium water quality objective, which applies October 1, 2010 for Mud Slough (north), is noted on Figure 8. Selenium concentrations regularly exceeded 5 µg/L at Station D. During 2008, the observed concentration of selenium at Station C (Mud Slough (north) upstream of the drainage discharge) was always below 5 µg/L, as depicted in Figure 9. The maximum observed selenium concentration of 2.51 µg/L was noted for 2008 in September in Mud Slough upstream of SLD. During 2009, the observed concentration of selenium at Station C (Mud Slough (north) upstream of the drainage discharge) remained below 5 µg/L, as depicted in Figure 10. The maximum observed selenium concentration of 1.13 µg/L was noted for 2009 in March in Mud Slough upstream of SLD.

Boron Water Quality Objectives

Boron water quality objectives and monthly mean boron concentrations for Mud Slough, Salt Slough, and the San Joaquin River for 2008 are presented in Table 3 and for 2009 are presented in Table 4.

During 2008, exceedances of the 2.0 mg/L objective occurred at Station D from March 16 through September 15. Exceedances also occurred at Station C in March, April, June, July and August. The 1.3 mg/L objectives were met continuously at Station N throughout 2008. During 2009, exceedances of the 2.0 mg/L objective occurred at Station D from March 16 through September 15. Exceedances also occurred at Station C in March, April, and July. The 1.3 mg/L objectives were met continuously at Station N throughout 2009.

Sources of boron occur throughout the San Joaquin Basin and are not confined to the

GBP service area (CVRWQCB, 2002). The CVRWQCB is currently conducting a separate effort to control salt and boron loading to the lower San Joaquin Basin.

Molybdenum Water Quality Objectives

Molybdenum water quality objectives and monthly mean molybdenum concentrations for Mud Slough, Salt Slough, and the San Joaquin River for 2008 are presented in Table 5 and for 2009 are presented in Table 6. The data indicate that molybdenum concentrations were below the water quality objectives in Mud Slough, Salt Slough, and the San Joaquin River throughout 2008 at Stations C, F, G, and N. The 19 µg/L water quality objective was not met at Station D during April, June, and August 2008. The data indicate that molybdenum concentrations were below the 19 µg/L water quality objectives in Mud Slough, Salt Slough, and the San Joaquin River throughout 2009 at Stations C, D, F, G, and N.

Nutrient Data

CVRWQCB staff collected nutrient samples at Stations B, C, D, G, and N. Available nutrient data for the San Luis Drain, Mud Slough (north), and the San Joaquin River are presented in Tables 7 through 16.

For comparison purposes, the Primary Maximum Contaminant Level (MCL) for nitrate in drinking water is 10 mg/L nitrate expressed as nitrogen (CVRWQCB, 2003).

During 2008, nitrate levels in samples collected at Station B were above the MCL during January, February, March, one of the sampling events in April, two of the three sampling events in May, and one of the sampling events in June, with a maximum recorded value of 25 mg/L. During 2009, nitrate levels in samples collected at Station B were above the MCL during January, February, March, and one of the sampling events in June, with a maximum recorded value of 17 mg/L. Nitrate levels in samples collected at Stations D, C, G, and N were below the MCL in all samples collected during 2008 and 2009.

Freshwater aquatic life criteria for ammonia are found in CVRWQCB (2003). The threshold value for ammonia toxicity is a function of both the temperature and pH of the ambient water from which the nutrient sample is collected. Temperature and pH field measurements were used to determine the ammonia toxicity threshold for each sample. Ammonia levels exceeded the Ammonia Toxicity Threshold on July 2 during 2008 at Stations B and D. Ammonia levels were below the toxicity threshold at Stations B and D in all samples during 2008. Ammonia levels did not exceed the Ammonia Toxicity Thresholds throughout 2008 at Stations C, G, and N. Ammonia levels did not exceed the Ammonia Toxicity Thresholds throughout 2009 at Stations B, C, D, G, and N.

Additional constituents (total Kjeldhal nitrogen, total phosphorus, and orthophosphate) continue to be collected to aid in the development of a TMDL for oxygen demanding substances in the San Joaquin River and future nutrient criteria.

Conclusions

Monitoring has shown that selenium concentrations in the San Joaquin River are a function of location in the River with respect to discharge points and tributary inflows, and of the assimilative capacity of the River. The lowest selenium concentrations in the San Joaquin River are upstream of Mud Slough (north) inflows. Mud Slough (north) inflow contains relatively high concentrations of selenium. The Merced River dilutes the San Joaquin River with respect to selenium. Selenium concentrations in the San Joaquin River at Station N, however, remain elevated relative to the background condition in the San Joaquin River at Station G.

The 2 µg/L monthly mean selenium water quality objective was exceeded in two of the wetland supply channels during 2008 and in three of the wetland supply channels in 2009. Selenium concentrations were substantially lower than pre-project conditions for all sites.

A number of sources may contribute to the exceedances of selenium water quality objectives in the wetland channels, including agricultural subsurface drainage from areas outside the GBP being discharged to the channels upstream of the wetlands.

For most of the year, the water quality of Mud Slough (north) downstream of the SLD inflow is governed by the GBP drainage discharge and fluctuates widely. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation season, which commences in mid winter (pre-plant irrigation) and lasts through the summer. Selenium concentrations regularly exceeded 5 µg/L in Mud Slough (north) downstream of the SLD inflow. Upstream of the drainage discharge, the concentration of selenium was below 2 µg/L in all samples.

Boron water quality data from Mud Slough (north), Salt Slough, and the San Joaquin River were compared to applicable water quality objectives and there were no exceedances in the San Joaquin River or in Salt Slough. Boron water quality objectives were exceeded during the irrigation season in Mud Slough (north). Sources of boron occur throughout the San Joaquin Basin and are not confined to the GBP. The CVRWQCB is concurrently conducting a separate effort to control salt and boron loading to the lower San Joaquin Basin.

Molybdenum water quality objectives were met in Mud Slough (north) upstream of San Luis Drain, Salt Slough, and the San Joaquin River throughout 2008. Molybedenum concentrations in Mud slough downstream of San Luis Drain exceeded the water quality objective in April, June, and August of 2008. Molybdenum water quality objectives were met in Mud Slough (north) upstream and down stream of San Luis Drain, Salt Slough, and the San Joaquin River throughout 2009.

Nitrate concentrations were frequently observed above the MCL in samples collected at Station B, and were the lowest during the summer months for both 2008 and 2009. Nitrate concentrations were below the MCL at Stations C, D, G, and N in all samples

collected during 2008 and 2009. Ammonia levels were observed above the ammonia toxicity threshold for one sample at Station B and one sample at Station D during 2008 but were below the toxicity threshold at all other stations during 2008. Ammonia levels were observed below the toxicity threshold at all stations during 2009.

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Table 1. Summary of Water Quality Monitoring Plan

Location	Site	Description	Purpose	Analytical Parameter	Frequency	Sampling Methodology
San Luis Drain	A	inflow to SLD	water quality of inflow	Se, B, SC	weekly composite	auto-sampler
				SC, TSS	weekly	mid-channel, depth integrated
	B	discharge from SLD	water quality of discharge (for Se load calculation)	Se, B, SC	daily composite	auto-sampler
				pH, SC, Temp, Se, B, TSS[1], Mo[2], Nutrients[3]	weekly	mid-channel, depth integrated
Mud Slough (north)	C	upstream of SLD discharge	Mud Slough (north) base water quality prior to receiving drainage discharges	pH, SC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	D	downstream of discharge	Mud Slough (north) water quality as impacted by drainage discharge	pH, SC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	mid-channel, depth integrated
	I/I2	back water	water quality impact of Mud Slough (north) flooding in Kesterson Refuge	Se, B, SC	annually	N/A
Wetland Channels	F	Salt Slough	water quality of habitat and to track improvements in former drainage conveyance channel	pH, SC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	J	Camp 13	verify no discharge of drainage provision, water quality of wetland water supply channel	Se, B, SC	weekly	grab
	K	Agatha Canal	verify no discharge of drainage provision, water quality of wetland water supply channel	Se, B, SC	weekly	grab
	L2	San Luis Canal	water quality of wetland water supply channel	Se, B, SC	weekly	grab
	M2	Santa Fe Canal	water quality of wetland water supply channel	Se, B, SC	weekly	grab
San Joaquin River	G	at Fremont Ford (upstream of drainage inflow)	track improvements in former drainage conveyance channel and characterize water quality of habitat	pH, SC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab
	N	at Crows Landing (downstream of Merced River confluence)	characterize water quality of habitat	Se, B, SC	daily composite	auto-sampler
				pH, SC, Temp, Se, B, Mo[2], Nutrients[3]	weekly	grab

Notes:

1 TSS required daily during storm events

2 Molybdenum required monthly

3 Nutrients required monthly September through February and every other week March through August

Table 2. Summary of Selenium Water Quality Objectives and Compliance Time Schedule

[Selenium Water Quality Objectives (in bold) and Performance Goals (in italics)]

Water Body/Water Year Type[1]	1 October, 1996	1 October, 2002	1 October, 2005	1 October, 2010
Salt Slough and Wetland Channels listed in Appendix 40 of Basin Plan	**2 µg/L monthly mean**			
San Joaquin River below the Merced River; Above Normal, and Wet Water Year Types		*5 µg/L monthly mean*	**5 µg/L 4-day average**	
San Joaquin River below the Merced River; Critical, Dry, and Below Normal Water Year Types		*8 µg/L monthly mean*	*5 µg/L monthly mean*	**5 µg/L 4-day average**
Mud Slough (north) and the San Joaquin River from Sack Dam to the Merced River				**5 µg/L 4-day average**

[1] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley water year hydrologic classification (as defined in Footnote17 for Table 3 in the State Water Resources Control Board's *Water Quality*

Table 3. Boron Concentrations in the Grassland Watershed and San Joaquin River: October 2007 - September 2008

Station		Mean Monthly Concentration (mg/L)														Monthly
ID	Description	Jan-08	Feb-08	Mar-08		Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08		Oct-08	Nov-08	Dec-08	WQO
C	Mud Slu (N) upstrm of SLD Discharge	a	a	a	2.2	2.5	1.8	2.3	2.06	2.3	0.6	a	a	a	a	2.0
D	Mud Slu (N) dwnstrm of SLD Discharge	a	a	a	3.1	4.8	5.8	6.1	5.7	5.4	4.2	a	a	a	a	2.0
F	Salt Slough at Lander Avenue	a	a	a	1.0	0.8	0.7	0.6	0.5	0.5	0.5	a	a	a	a	2.0
G	SJR at Fremont Ford	a	a	a	1.0	0.8	0.7	0.7	0.5	0.5	0.6	a	a	a	a	2.0
N	SJR at Crows Landing Weekly Grab Samples	0.7	0.7	1.1		1.0	0.5	0.9	0.8	0.4	0.5		0.5	0.6	0.9	1.3
N	SJR at Crows Landing Daily Autosamples	0.7	0.7	1.0		1.1	0.5	0.9	0.8	0.5	0.5		0.5	0.6	0.8	1.3

Notes:

= water quality objective exceedance

a = objective only applies 15 March through 15 September

WQO = water quality objective in mg/L

na = no data available

Table 4. Boron Concentrations in the Grassland Watershed and San Joaquin River: January 2009 - December 2009

Station		Mean Monthly Concentration (mg/L)														Monthly
ID	Description	Jan-09	Feb-09	Mar-09		Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09		Oct-09	Nov-09	Dec-09	WQO
C	Mud Slu (N) upstrm of SLD Discharge	a	a	a	2.2	2.4	1.9	1.7	2.2	1.3	0.5	a	a	a	a	2.0
D	Mud Slu (N) dwnstrm of SLD Discharge	a	a	a	2.9	4.9	4.7	4.8	5.5	5.6	3.3	a	a	a	a	2.0
F	Salt Slough at Lander Avenue	a	a	a	1.2	0.8	0.6	0.5	0.4	0.4	0.4	a	a	a	a	2.0
G	SJR at Fremont Ford	a	a	a	1.1	0.8	0.6	0.5	0.4	0.4	0.4	a	a	a	a	2.0
N	SJR at Crows Landing Weekly Grab Samples	0.8	0.9	1.0	1.2	0.9	0.7	0.8	0.9	0.7	0.6	0.7	0.5	0.7	0.9	1.3
N	SJR at Crows Landing Daily Autosamples	0.9	1.0	0.9	1.2	1.0	0.6	0.7	0.8	0.7	0.6	0.8	0.5	0.7	0.9	1.3

Notes:

= water quality objective exceedance

a = objective only applies 15 March through 15 September

WQO = water quality objective in mg/L

na = no data available

Table 5. Molybdenum Concentrations in the Grassland Watershed and San Joaquin River: October 2007 - September 2008

Station ID	Description	Mean Monthly Concentration (ug/L) Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Monthly WQO
C	Mud Slu (N) upstrm of SLD Discharge	6.1	10.1	7.1	9.8	11.3	14.3	9.7	15.9	4.4	8.5	8.2	7.5	19.0
D	Mud Slu (N) dwnstrm of SLD Discharge	9.9	12.3	10.1	21.9	18.4	22.8	18.9	20.4	10.6	11.1	13.0	11.1	19.0
F	Salt Slough at Lander Avenue	9.3	3.2	7.8	7.6	5.4	7.7	4.9	5.5	6.6	8.3	6.0	9.8	19.0
G	SJR at Fremont Ford	8.2	6.8	8.3	10.6	7.1	9.3	7.0	6.6	8.0	10.2	9.1	11.0	19.0
N	SJR at Crows Landing Grab Samples	5.1	5.1	6.3	5.0	3.2	6.4	5.6	2.9	1.9	3.7	3.4	5.6	10.0

Notes:

= water quality objective exceedance

WQO = water quality objective in ug/L

na = no data available

Table 6. Molybdenum Concentrations in the Grassland Watershed and San Joaquin River: January 2009 - December 2009

Station ID	Description	Mean Monthly Concentration (ug/L) Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Monthly WQO
C	Mud Slu (N) upstrm of SLD Discharge	10.6	12.3	9.6	17.7	11.2	16.5	9.8	1.1	10.8	8.1	14.9	15.2	19.0
D	Mud Slu (N) dwnstrm of SLD Discharge	10.5	8.1	6.6	11.3	12.8	13.8	7.7	6.1	4.0	7.0	10.3	11.6	19.0
F	Salt Slough at Lander Avenue	10.1	5.8	9.5	7.8	5.7	5.1	5.2	3.1	3.8	5.8	6.4	8.5	19.0
G	SJR at Fremont Ford	11	5.3	6.9	8.3	6.8	7.0	4.7	4.8	6.6	8.4	7.6	13.5	19.0
N	SJR at Crows Landing Grab Samples	5.1	5.1	5.5	5.9	3.4	4.2	4.6	3.8	5.4	5.7	4.7	6.1	10.0

Notes:

= water quality objective exceedance

WQO = water quality objective in ug/L

na = no data available

Table 7. Nutrient Series Data, Site B, SLD at terminus (MER535)

January 2008 - December 2008

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
17/Jan/2008	25.00	NA	0.06	<0.15	NA	1.79
21/Feb/2008	16.00	NA	0.06	<0.15	<0.10	2.10
06/Mar/2008	13.00	0.95	0.13	<0.15	NA	1.29
20/Mar/2008	12.00	NA	0.13	<0.15	NA	0.72
03/Apr/2008	10.00	1.00	0.10	<0.15	NA	0.49
17/Apr/2008	13.00	NA	0.08	<0.15	NA	0.66
01/May/2008	13.00	2.30	0.27	<0.15	NA	0.67
08/May/2008	16.00	NA	0.10	<0.15	NA	0.92
22/May/2008	7.00	2.30	NA	<0.15	0.56	1.36
05/Jun/2008	19.00	NA	0.05	<0.15	NA	0.92
19/Jun/2008	4.30	1.80	0.15	<0.15	NA	1.19
02/Jul/2008	4.10	2.70	0.21	<0.15	0.56	0.55
17/Jul/2008	1.10	3.00	0.18	<0.15	0.85	2.76
14/Aug/2008	2.70	1.48	0.09	<0.15	0.23	1.26
28/Aug/2008	3.40	3.10	0.10	<0.15	1.40	2.55
11/Sep/2008	1.40	NA	0.09	<0.15	NA	0.76
16/Oct/2008	8.10	1	0.08	<0.15	<0.10	5.25
20/Nov/2008	7.80	NA	0.10	NA	<0.10	4.50
18/Dec/2008	16.00	NA	NA	0.02	NA	4.36

Data Source: California Regional Water Quality Control Board, Central Valley Region

Notes: = water quality objective exceedance

Table 8. Nutrient Series Data, Site B, SLD at terminus (MER535)

January 2009 - December 2009

	Total Kjeldhal	Total	Ortho	Dissolved	Ammonia

Parameter	Nitrate	Nitrogen	Phosphorus	Phosphate	Ammonia	Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
22-Jan-09	13.0	0.7	0.06	0.02	<.2	5.17
10-Feb-09	17.0	<.5	0.07	<.01	<.2	5.64
12-Mar-09	17.0	0.6	0.08	0.01	<.2	5.77
26-Mar-09	16.0	1.0	0.12	0.02	<.2	1.68
2-Apr-09	8.0	1.6	0.11	<.01	<.2	4.87
16-Apr-09	6.8	1.4	0.12	0.01	<.2	4.66
7-May-09	5.6	2.0	0.15	<.01	<.2	2.21
21-May-09	8.6	1.7	0.12	<.01	<.2	0.95
4-Jun-09	12.0	2.4	0.20	0.02	<.2	0.98
18-Jun-09	7.4	2.0	0.15	0.02	0.56	2.62
7-Jul-09	4.6	<.5	0.17	<.01	<.2	0.28
21-Jul-09	1.4	2.5	0.12	<.01	<.2	0.68
4-Aug-09	1.1	<.5	0.12	<.01	<.2	0.31
18-Aug-09	5.0	1.8	0.13	<.01	<.2	0.47
1-Sep-09	3.1	2.4	0.11	<.01	0.34	0.46
20-Oct-09	2.6	<.5	0.09	<.01	<.2	1.33
3-Nov-09	6.6	1.3	0.08	<.01	<.2	1.78
1-Dec-09	10.0	0.7	0.04	<.01	0.22	3.46

Data Source: California Regional Water Quality Control Board, Central Valley Region

Notes: = water quality objective exceedance

Table 9. Nutrient Series Data, Site C, Mud Slough (North) Upstream of SLD (MER536)

January 2008 - December 2008

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N

17/Jan/2008	<0.50	NA	0.22	0.39	NA	2.80
21/Feb/2008	<0.50	NA	0.37	0.65	0.57	3.58
06/Mar/2008	<0.50	1.2	0.43	0.7	NA	2.10
20/Mar/2008	0.8	NA	0.46	0.54	NA	1.94
03/Apr/2008	<0.50	1.4	0.41	0.42	NA	1.44
17/Apr/2008	<0.50	NA	0.29	<0.15	NA	1.11
01/May/2008	<0.50	0.48	0.24	0.24	NA	1.67
08/May/2008	<0.50	NA	0.26	<0.15	NA	1.36
22/May/2008	<0.50	1	-88	0.54	0.61	1.79
05/Jun/2008	<0.50	NA	0.18	0.32	NA	1.82
19/Jun/2008	<0.50	0.54	0.26	0.28	NA	1.61
02/Jul/2008	<0.50	0.64	0.34	0.73	0.11	0.92
17/Jul/2008	<0.50	1	0.39	NA	<0.10	1.83
14/Aug/2008	<0.50	0.91	0.38	0.38	<0.10	0.65
28/Aug/2008	<0.50	1.1	0.2	0.02	<0.10	0.59
11/Sep/2008	0.11	NA	0.097	0.08	NA	1.27
16/Oct/2008	0.09	1	0.33	0.21	<0.10	3.25
20/Nov/2008	<0.50	NA	0.41	NA	<0.10	3.18
18/Dec/2008	0.16	NA	NA	0.18	NA	3.18

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 10. Nutrient Series Data, Site C, Mud Slough (North) Upstream of SLD (MER536)
January 2009 - December 2009

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
22-Jan-09	0.15	0.90	0.19	0.13	<.2	3.54
10-Feb-09	0.14	1.10	0.27	0.19	<.2	3.14
12-Mar-09	0.43	1.60	0.44	0.20	<.2	2.80
26-Mar-09	0.40	1.80	0.44	0.22	<.2	1.78
2-Apr-09	0.07	2.10	0.52	0.20	<.2	2.12
16-Apr-09	0.09	1.30	0.30	0.19	<.2	2.50
7-May-09	<.05	1.10	0.34	0.24	<.2	1.68
21-May-09	0.05	1.10	0.37	0.30	<.2	1.47
4-Jun-09	<.05	0.78	0.25	0.18	<.2	1.42
18-Jun-09	<.05	0.67	0.18	0.14	<.2	1.59
7-Jul-09	<.05	<.5	0.20	0.11	<.2	0.82
21-Jul-09	<.05	1.60	0.34	0.24	<.2	0.84
4-Aug-09	<.05	<.5	0.21	<.01	<.2	0.50
18-Aug-09	<.05	0.67	0.17	<.01	<.2	1.21
1-Sep-09	0.44	1.30	0.13	0.03	0.34	0.61
20-Oct-09	<.05	<.5	0.90	0.70	<.2	3.66
3-Nov-09	<.05	2.10	0.54	0.40	<.2	2.65
1-Dec-09	<.05	1.30	0.30	0.28	<.2	2.95

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 11. Nutrient Series Data, Site D, Mud Slough (North) Downstream of SLD (MER542)
January 2008 - December 2008

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
17/Jan/2008	4.5	NA	0.2	0.3	NA	2.80
21/Feb/2008	4.5	NA	0.3	0.48	0.21	2.80
06/Mar/2008	2.6	1.4	0.36	0.43	NA	1.79
20/Mar/2008	2.3	NA	0.43	0.32	NA	1.38
03/Apr/2008	1.9	1.8	0.37	0.16	NA	1.42
17/Apr/2008	5.6	NA	0.21	<0.15	NA	0.96
01/May/2008	10	1.3	0.17	<0.15	NA	0.83
08/May/2008	9	NA	0.16	<0.15	NA	1.14
22/May/2008	5.2	1.6	NA	<0.15	0.49	1.47
05/Jun/2008	9.7	NA	0.07	<0.15	NA	0.95
19/Jun/2008	5.6	1.4	0.14	<0.15	NA	1.11
02/Jul/2008	3.2	2.3	0.21	<0.15	0.86	0.39
17/Jul/2008	0.48	3.1	0.17	NA	<0.10	0.89
14/Aug/2008	2.8	1.93	0.12	0.012	0.23	1.14
28/Aug/2008	1.1	2.2	0.17	0.013	0.57	3.70
11/Sep/2008	0.8	NA	0.099	0.015	NA	1.34
16/Oct/2008	0.98	2	0.27	0.059	<0.10	3.27
20/Nov/2008	2.2	NA	0.32	NA	0.22	3.18
18/Dec/2008	3.2	NA	NA	0.14	NA	3.58

Data Source: California Regional Water Quality Control Board, Central Valley Region

Notes: = water quality objective exceedance

Table 12. Nutrient Series Data, Site D, Mud Slough (North) Downstream of SLD (MER542)

January 2009 - December 2009

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
22-Jan-09	2.70	1.30	0.18	0.11	<.2	4.17
10-Feb-09	3.70	1.10	0.22	0.14	<.2	3.94
12-Mar-09	2.30	1.80	0.38	0.18	<.2	3.42
26-Mar-09	3.00	1.70	0.38	0.12	<.2	1.89
2-Apr-09	2.30	2.10	0.38	0.06	<.2	2.17
16-Apr-09	2.20	1.10	0.20	0.02	<.2	2.54
7-May-09	3.60	1.90	0.22	<.01	<.2	1.68
21-May-09	3.00	1.40	0.28	0.14	<.2	1.84
4-Jun-09	5.00	1.70	0.26	0.03	<.2	1.29
18-Jun-09	3.50	1.60	0.15	0.02	<.2	1.68
7-Jul-09	1.90	<.5	0.26	<.01	<.2	0.73
21-Jul-09	1.50	2.20	0.16	0.02	0.22	0.44
4-Aug-09	0.52	<.5	0.14	<.01	<.2	0.47
18-Aug-09	2.80	1.80	0.13	<.01	<.2	0.63
1-Sep-09	1.60	1.80	0.11	0.01	0.56	0.64
20-Oct-09	0.20	<.5	0.83	0.56	<.2	3.55
3-Nov-09	2.00	2.00	0.39	0.09	0.22	3.14
1-Dec-09	2.80	1.10	0.21	0.11	<.2	3.22

Data Source: California Regional Water Quality Control Board, Central Valley Region

Notes: = water quality objective exceedance

Table 13. Nutrient Series Data, Site G, San Joaquin River at Fremont Ford (MER538)

January 2008 - December 2008

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
17/Jan/2008	0.55	NA	0.18	<0.15	NA	6.12
21/Feb/2008	2.8	NA	0.27	0.18	0.11	2.80
06/Mar/2008	2.7	0.98	0.31	0.29	NA	3.18
20/Mar/2008	2.5	NA	0.29	<0.15	NA	2.33
03/Apr/2008	1.2	1.3	0.29	<0.15	NA	3.25
17/Apr/2008	0.94	NA	0.29	0.24	NA	3.43
01/May/2008	<0.50	0.85	0.23	<0.15	NA	3.19
08/May/2008	1.1	NA	0.39	<0.15	NA	1.99
22/May/2008	0.85	0.88	NA	0.47	0.2	3.23
05/Jun/2008	1.6	NA	0.2	0.21	NA	2.03
19/Jun/2008	0.87	0.81	0.35	0.18	NA	3.24
02/Jul/2008	1.5	0.69	0.35	0.34	0.25	1.60
17/Jul/2008	1.1	1.4	0.3	NA	<0.10	2.96
14/Aug/2008	0.9	1.25	0.26	0.19	<0.10	1.32
28/Aug/2008	0.2	0.9	0.2	0.13	<0.10	2.32
11/Sep/2008	0.082	NA	0.2	0.14	NA	2.04
16/Oct/2008	<0.50	0.54	0.11	0.075	<0.10	5.12
20/Nov/2008	0.51	NA	0.13	NA	<0.10	5.67
18/Dec/2008	0.25	NA	NA	0.076	NA	2.80

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 14. Nutrient Series Data, Site G, San Joaquin River at Fremont Ford (MER538)
January 2009 - December 2009

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
22-Jan-09	0.37	0.90	0.14	0.09	0.22	2.54
10-Feb-09	1.50	0.90	0.31	0.21	<.2	3.54
12-Mar-09	0.78	1.00	0.22	0.11	<.2	5.53
26-Mar-09	0.76	1.10	0.27	0.10	<.2	2.06
2-Apr-09	0.45	1.20	0.36	0.08	<.2	4.65
16-Apr-09	1.80	1.10	0.38	0.15	<.2	5.17
7-May-09	0.73	1.70	0.42	0.09	<.2	1.78
21-May-09	1.00	1.10	0.31	0.23	<.2	3.39
4-Jun-09	1.10	0.78	0.26	0.16	<.2	2.21
18-Jun-09	0.62	0.78	0.23	0.17	<.2	3.24
7-Jul-09	1.90	<.5	0.26	0.17	<.2	2.55
21-Jul-09	1.50	0.90	0.29	0.20	<.2	2.37
4-Aug-09	<.05	<.5	0.25	<.01	<.2	1.21
18-Aug-09	1.40	0.90	0.22	<.01	<.2	1.69
1-Sep-09	0.51	0.67	0.24	0.17	0.22	1.75
20-Oct-09	0.13	<.5	0.26	0.17	<.2	2.59
3-Nov-09	0.27	0.78	0.17	0.11	<.2	2.51
1-Dec-09	0.28	0.90	0.16	0.10	<.2	4.84

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 15. Nutrient Series Data, Site N, San Joaquin River at Crows Landing (STC504)

January 2008 - December 2008

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
17/Jan/2008	2.4	NA	0.19	0.19	NA	5.67
21/Feb/2008	3.1	NA	0.19	0.22	<0.10	2.80
06/Mar/2008	1.7	0.75	0.26	0.25	NA	2.43
20/Mar/2008	2.9	NA	0.25	0.27	NA	2.27
03/Apr/2008	2.9	0.82	0.27	0.25	NA	2.14
17/Apr/2008	3	NA	0.23	0.19	NA	2.03
01/May/2008	<0.50	0.22	0.097	<0.15	NA	1.74
08/May/2008	0.94	NA	0.13	<0.15	NA	1.65
22/May/2008	1.5	0.4	-88	0.2	0.18	2.09
05/Jun/2008	3.3	NA	0.15	<0.15	NA	1.24
19/Jun/2008	4.1	1.1	0.29	0.2	NA	1.96
02/Jul/2008	2.3	1.3	0.3	<0.15	0.33	1.07
17/Jul/2008	2.7	NA	NA	NA	NA	1.49
14/Aug/2008	1.7	0.8	0.2	0.14	<0.10	1.55
28/Aug/2008	2.4	0.68	0.18	0.136	<0.10	1.32
11/Sep/2008	1.8	NA	0.16	0.12	NA	1.95
16/Oct/2008	2.6	0.65	0.16	0.12	<0.10	3.36
20/Nov/2008	1.3	NA	0.13	NA	<0.10	2.80
18/Dec/2008	1.4	NA	NA	0.07	NA	2.80

Data Source: California Regional Water Quality Control Board, Central Valley Region

Table 16. Nutrient Series Data, Site N, San Joaquin River at Crows Landing (STC504)

January 2009 - December 2009

Parameter	Nitrate	Total Kjeldhal Nitrogen	Total Phosphorus	Ortho Phosphate	Dissolved Ammonia	Ammonia Toxicity Threshold
Units	mg/L as N	mg/L	mg/L	mg/L as P	mg/L as N	mg/L as N
22-Jan-09	1.40	0.67	0.09	0.06	<.2	2.47
10-Feb-09	1.80	0.90	0.19	0.12	<.2	3.58
12-Mar-09	1.30	0.78	0.23	0.10	<.2	4.55
26-Mar-09	1.90	0.90	0.22	0.08	<.2	1.70
2-Apr-09	1.90	1.00	0.24	0.08	<.2	2.77
16-Apr-09	1.90	0.67	0.24	0.11	<.2	4.50
7-May-09	1.80	1.30	0.32	0.08	<.2	1.64
21-May-09	1.50	1.00	0.18	0.07	<.2	2.18
4-Jun-09	1.60	0.78	0.21	0.07	<.2	1.04
18-Jun-09	1.40	0.67	0.16	0.07	<.2	2.25
7-Jul-09	2.80	<.5	0.24	0.08	<.2	1.50
21-Jul-09	2.40	0.90	0.27	0.11	<.2	1.68
4-Aug-09	3.00	<.5	0.23	<.01	<.2	2.55
18-Aug-09	5.50	0.67	0.32	<.01	<.2	1.83
1-Sep-09	3.00	0.67	0.24	0.18	<.2	1.66
20-Oct-09	1.80	<.5	0.49	0.36	0.22	2.73
3-Nov-09	1.10	0.90	0.14	0.09	<.2	3.08
1-Dec-09	2.00	0.67	0.13	0.09	<.2	3.50

Data Source: California Regional Water Quality Control Board, Central Valley Region

Figure 1. Selenium Concentration in the San Joaquin River
January 2008 - December 2008

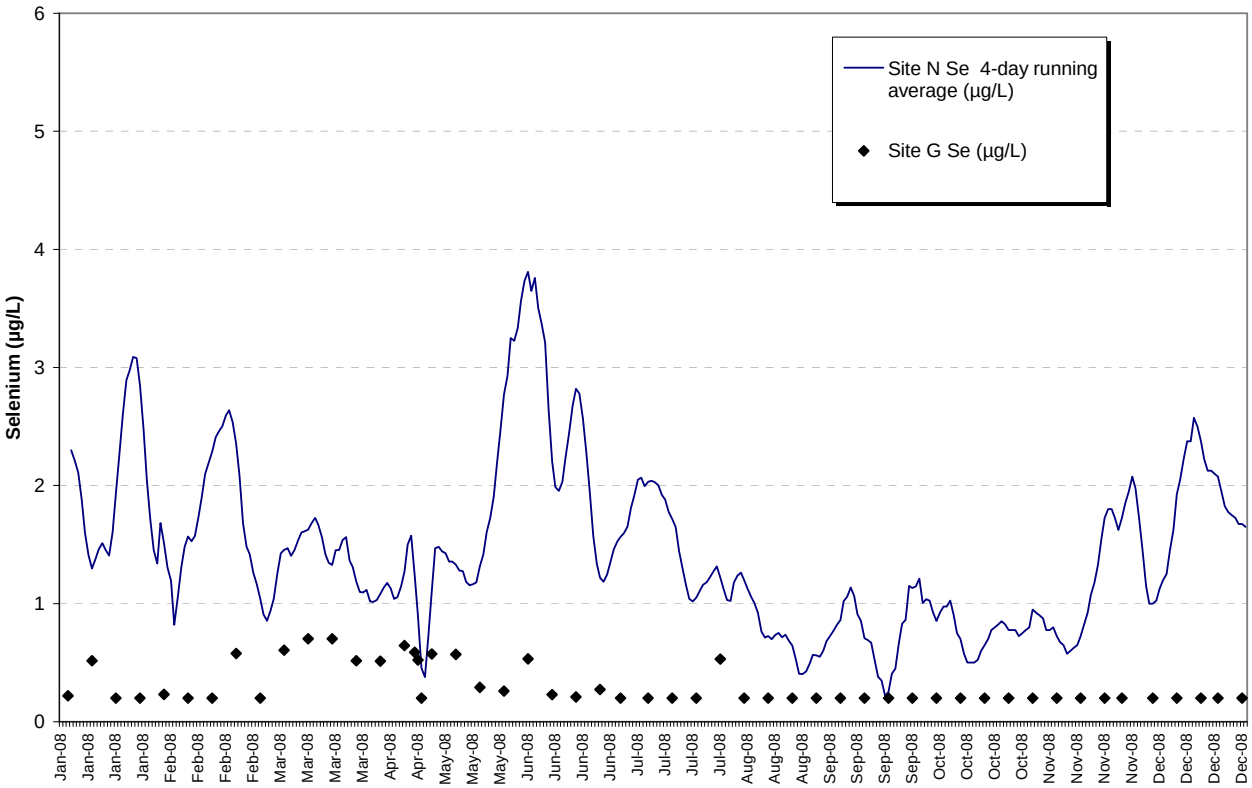

Figure 2. Selenium Concentration in the San Joaquin River
January 2009 - December 2009

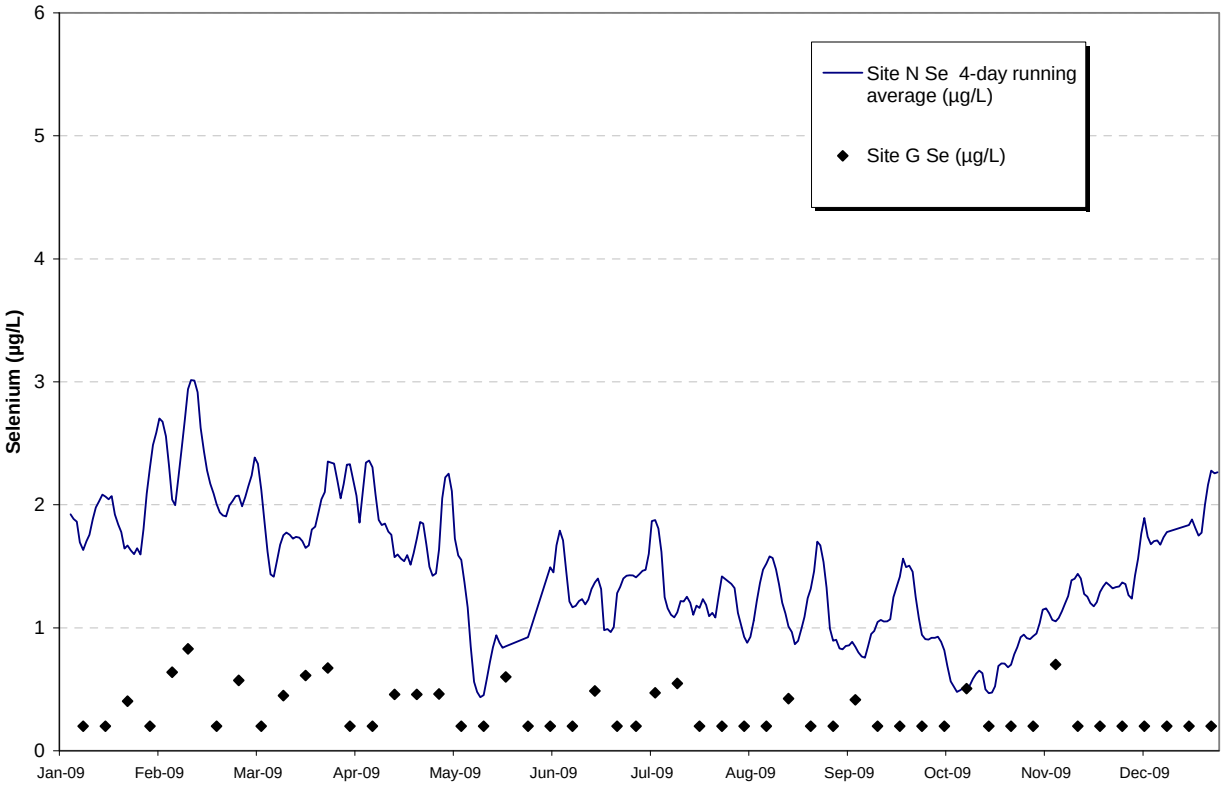

Figure 3. Monthly Mean Selenium Concentration at Site N
January 2008 - December 2008

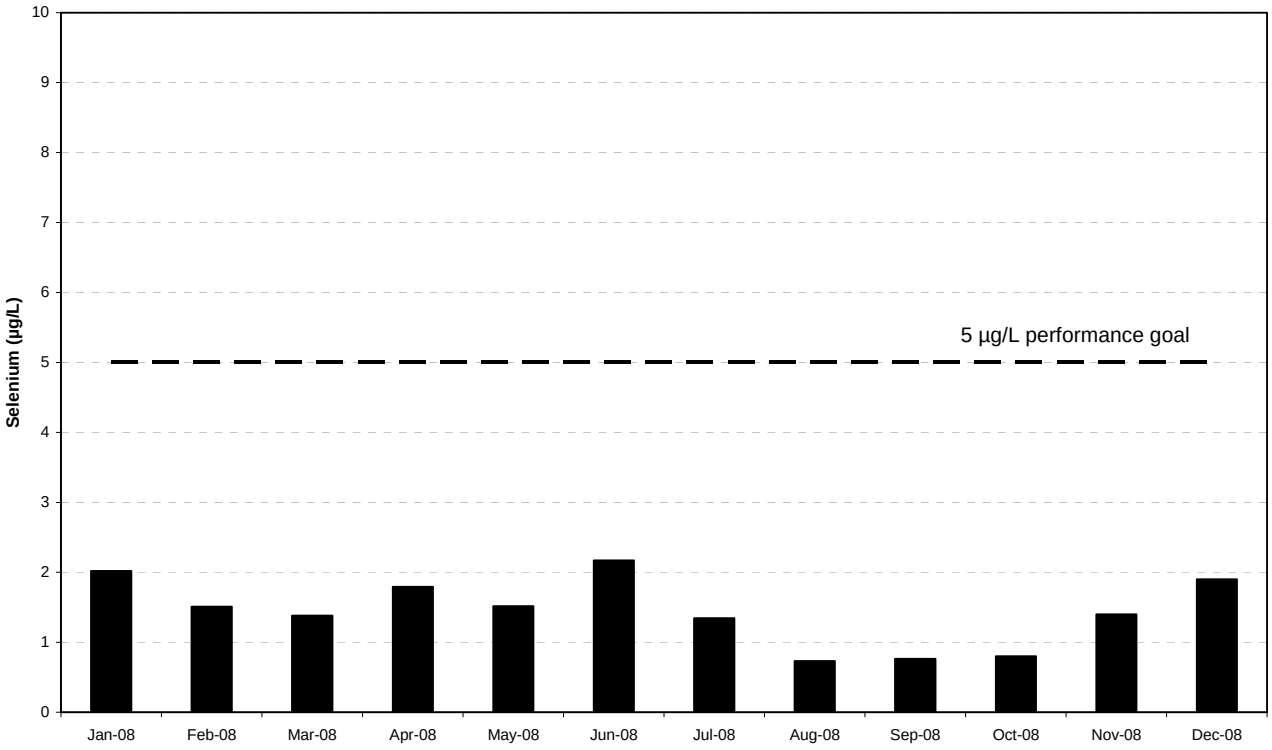

Figure 4. Monthly Mean Selenium Concentration at Site N
January 2009 - December 2009

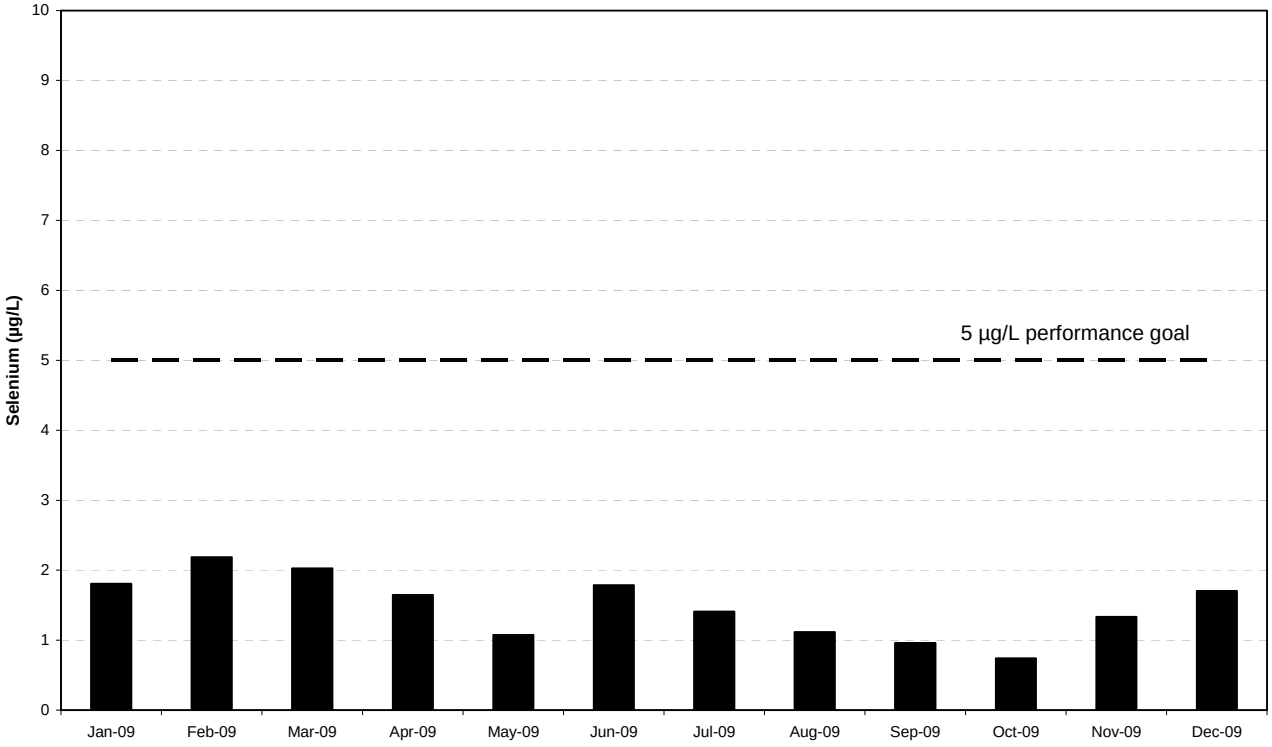

Figure 5. Mean Monthly Selenium Concentration in the Grassland Wetland Supply Channels
January 2008 - December 2008

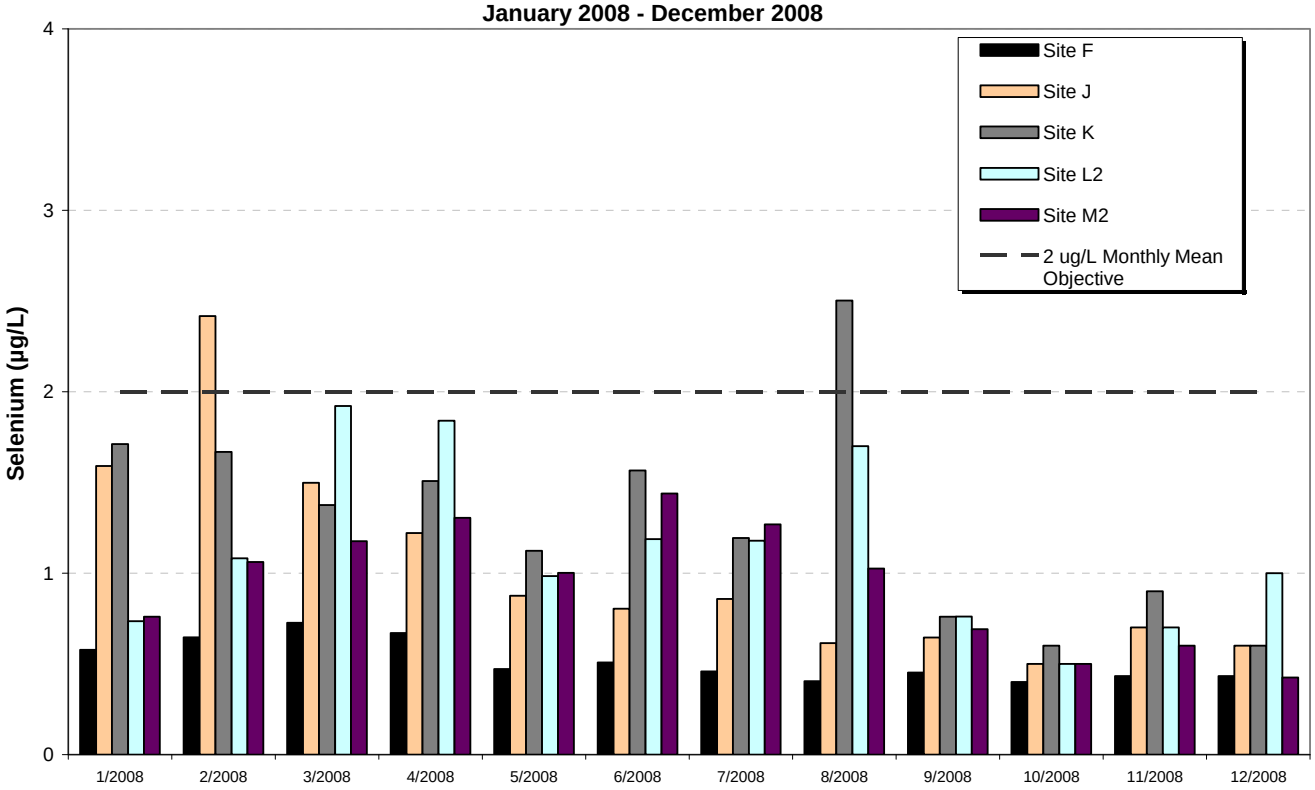

Figure 6. Mean Monthly Selenium Concentration in the Grassland Wetland Supply Channels
January 2009 - December 2009

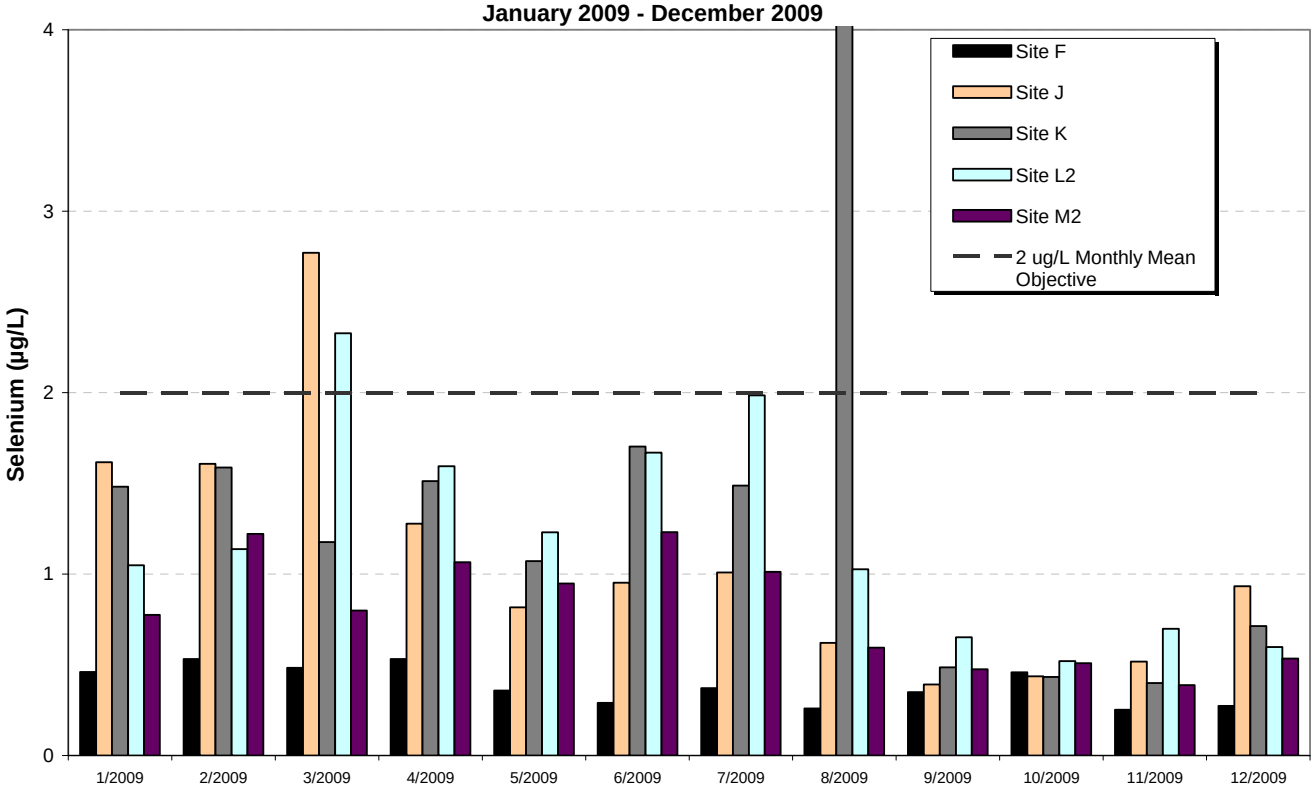

Figure 7. Weekly Grab Selenium Concentration at Site D
January 2008 - December 2008

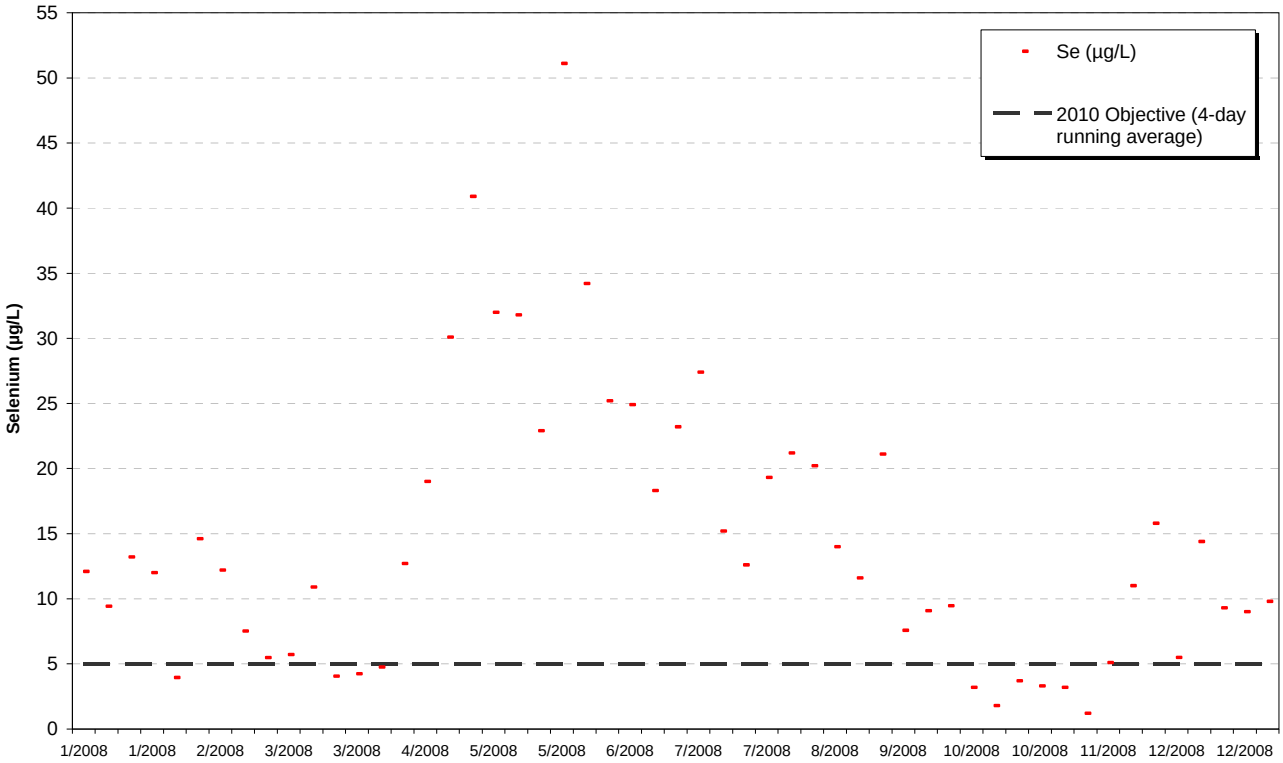

Figure 8. Weekly Grab Selenium Concentration at Site D
January 2009 - December 2009

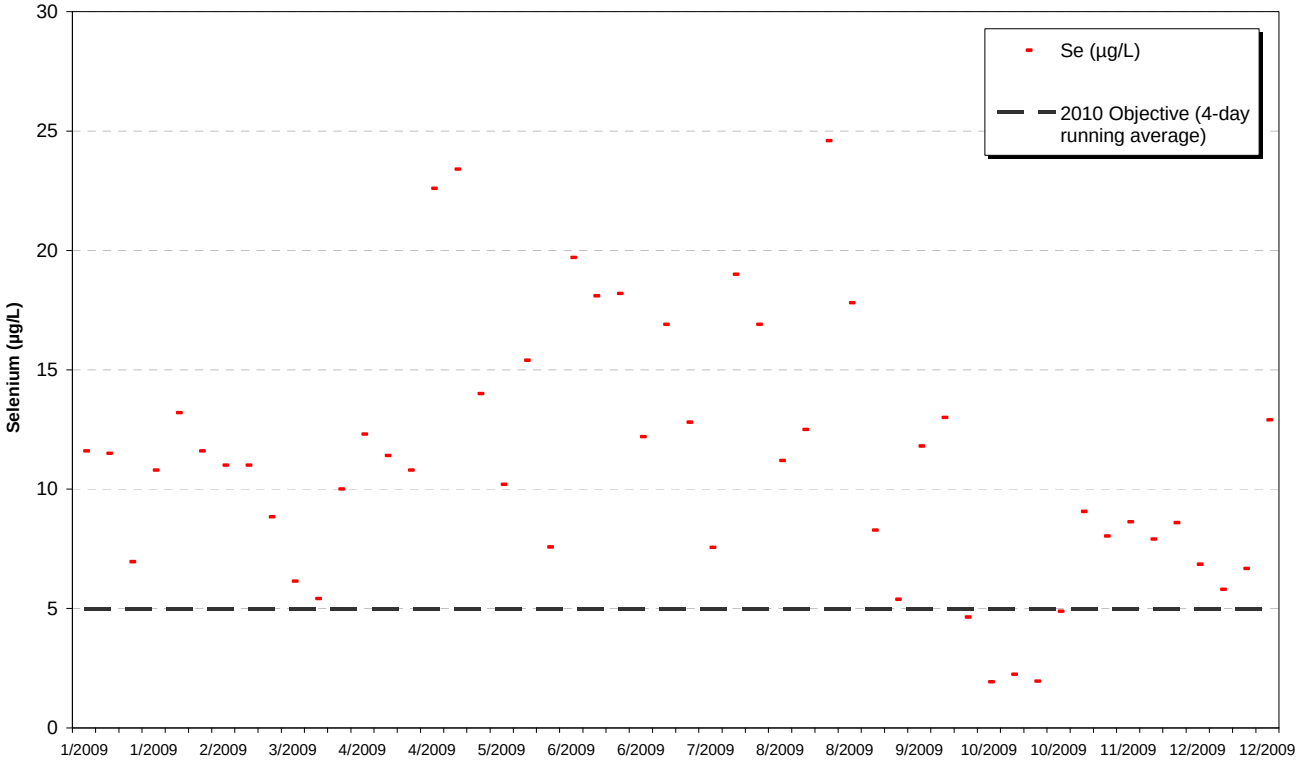

Figure 9. Weekly Grab Selenium Concentration at Site C
January 2008 - December 2008

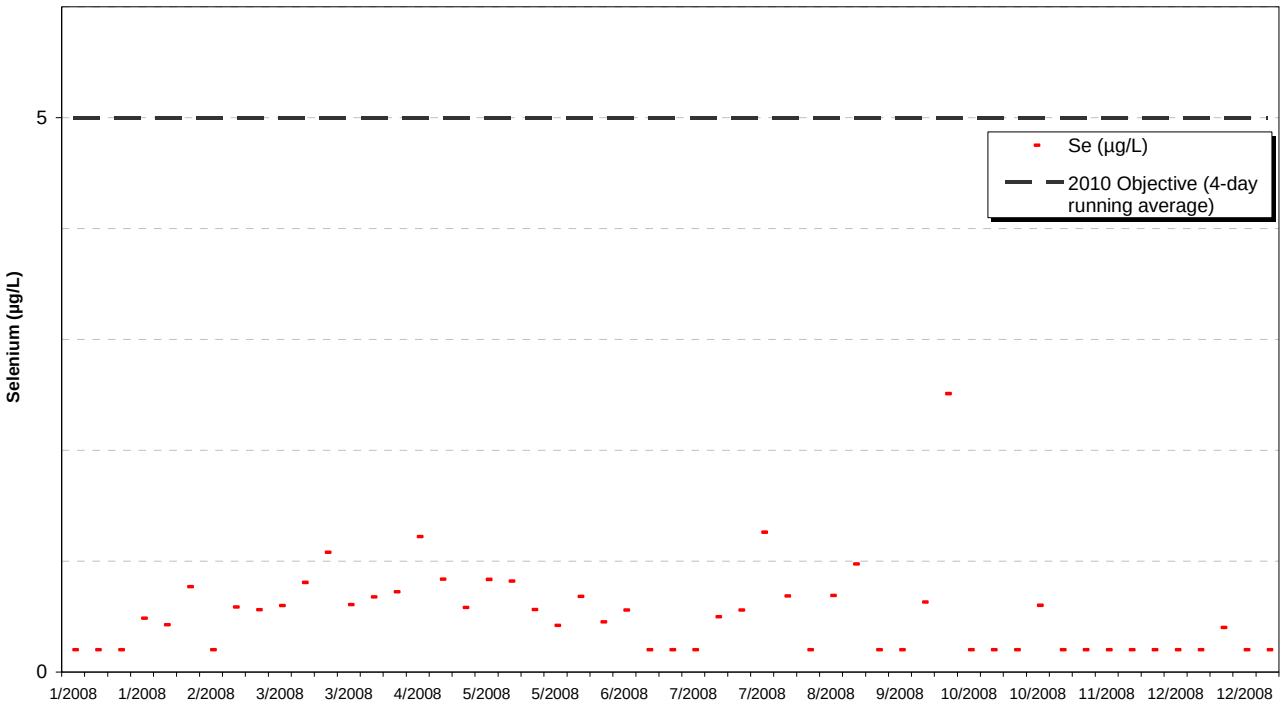

Figure 10. Weekly Grab Selenium Concentration at Site C
January 2009 - December 2009