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Total Selenium and Selenium Species in Irrigation Drain Inflows to the Salton Sea, California, October 2007 and January 2008

Open-File Report 2008–1178

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors

Multiply	By	To obtain
	Length	
millimeter)	0.03937	inch (in.)
micrometer (µm)	0.0000393	inch (in.)
	Volume	
liter (L)	33.82	ounce, fluid (fl. oz)
milliliter (mL)	0.034	ounce, fluid (fl. oz)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
milligram (mg)	0.000035	ounce (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). .

Concentrations of chemical constituents in solid materials are given in micrograms per gram (µg/g).

Total Selenium and Selenium Species in Irrigation Drain Inflows to the Salton Sea, California, October 2007 and January 2008

By Thomas W. May, Michael J. Walther, Michael K. Saiki, and William G. Brumbaugh

Abstract

This report presents the results for two sampling periods (October 2007 and January 2008) during a 4-year monitoring program to characterize selenium concentrations in selected irrigation drains flowing into the Salton Sea, California. Total selenium, selenium species (selenite, selenate, organoselenium), and total suspended solids were determined in water samples, and total selenium was determined in sediment, detritus, and biota that included algae, plankton, midge larvae (family, Chironomidae), and two fish species—western mosquitofish (*Gambusia affinis*) and sailfin molly (*Poecilia latipinna*). In addition, sediments were analyzed for percent total organic carbon and particle size. Mean total selenium concentrations in water for both sampling periods ranged from 0.97 to 64.5 micrograms per liter, predominately as selenate, which is typical of waters where selenium is leached out of selenium-containing marine shales and associated soils under alkaline and oxidizing conditions. Total selenium concentrations (micrograms per gram dry weight) ranged as follows: algae, 0.95 to 5.99; plankton, 0.15 to 19.3; midges, 1.39 to 15.4; fish, 3.71 to 25.1; detritus, 0.85 to 21.7; sediment, 0.32 to 7.28.

Introduction

Monitoring surveys are being conducted by the U.S. Geological Survey (USGS) for 4 years to provide a profile of selenium concentrations in selected irrigation drain inflows to the Salton Sea, California. To accomplish this goal, total selenium, selenium species (selenite, selenate, organoselenium), and total suspended solids were determined in water samples, and total selenium in sediment, detritus, and biota that included algae, plankton, midge larvae (family, Chironomidae), and two fish species—western mosquitofish (*Gambusia affinis*) and sailfin molly (*Poecilia latipinna*). In addition, sediments were analyzed for percent total organic carbon and particle size. The results in this report were derived from samples collected during October 2007 and January 2008.

Methods

Field Collection and Preservation

The USGS sampling team used the laboratory at the U.S. Fish and Wildlife Service Sonny Bono Salton Sea National Wildlife Refuge (henceforth referred to as "the Refuge" in this report) for certain aspects of sample processing and for preparing samples for shipment during field trips to irrigation drains.

Unfiltered Water: Each total selenium water sample was poured through a 1-millimeter (mm) polypropylene sieve attached to a 1-liter (L) pre-cleaned borosilicate glass bottle. Upon collection, the water sample was acidified to less than pH 2 with 6 normal (N) hydrochloric acid (HCl), chilled to approximately 4 degrees Celsius (~4 ºC), and kept in the dark during transport to the USGS. Each water sample intended for analysis of total suspended solids (TSS) was poured through a 1-mm polypropylene sieve attached to a pre-cleaned wide-mouth 1-L polypropylene bottle. The TSS samples were chilled (~4 ºC) during transport to the USGS.

Filtered Water: Water for selenium speciation was filtered using a Geotech® peristaltic pump equipped with a standard pumphead and high-capacity 0.45 micrometer (µm) filter capsule certified for trace-element background. All tubing was acid-cleaned silicone; a new length was used at each site and for the blank. At each site, 1 L of deionized (DI) water was filtered through the filter capsule followed by site water. The first 200 milliliters (mL) of site water eluant were discarded, then 1 L of eluant was collected in an acid-cleaned 1-L borosilicate glass bottle, acidified, and stored as described earlier for unfiltered water.

Particulates: A polycarbonate Geotech® 142-mm plate filter apparatus was used with a 142-mm 0.4-µm polycarbonate filter. At each site, 0.5 L of DI water was filtered through the plate filter, followed by up to 1 L of site water; after volume notation, the filtrate was discarded. Each filter was placed in a pre-cleaned plastic petri dish (150 mm x 15 mm) with the particulate side up and sealed with its corresponding cover for freezer storage and transport to the USGS. The plate filtration

unit was rinsed with 0.1 percent nitric acid (HNO_3) followed by a DI water rinse after sampling was completed at each site.

Sediment: Five sampling points for sediment collection were identified along the length of each drain. At each sampling point, sediment was collected from 2 to 6 centimeters in depth with a stainless steel dredge. The dredge was cleared of mud and rinsed with site water while used within a drain; at a new site, the dredge was rinsed with DI water followed by site water before the first sample was collected. From each of the five sampling points, enough sediment to fill a 250-mL container was collected and mixed to form a composite sample (1,250-mL total). An aliquot of this composite was then placed into both a 120- and 500-mL polypropylene container for each drain sampled. All containers were placed on ice in the field. Samples were chilled (~4 ºC) during transport to the USGS.

Midge larvae and detritus: An insect sweep net was used to collect samples of midge larvae and detritus, which were then sorted and hand-picked with plastic tweezers in a polypropylene sieve, and stored temporarily in a plastic food-storage container on ice. After rinsing with DI water, samples were wrapped in plastic wrap, stored in separate plastic bags, and frozen.

Fish: Composite samples of western mosquitofish and sailfin molly were collected with seine nets and minnow traps; sampled material from each site was stored temporarily in a plastic food-storage container on ice. Upon return to the Refuge lab**,** the whole-body fish were measured for standard length, weighed, and rinsed with DI water. Each fish composite sample (n=36) was wrapped in plastic wrap and placed into a plastic bag and frozen.

Algae and Plankton: Algae were collected from floating masses or scraped from sticks and rocks at each drain site and stored temporarily in a sealable plastic food-storage container on ice. Following collection, the material was rinsed with DI water, wrapped with plastic wrap, stored in a sealable plastic bag, and frozen. Plankton was collected with a tow net; after draining site water, each sample was rinsed three times with DI water. The plankton and the DI rinsing water were placed in a 120-mL polypropylene container. Collected samples were stored on ice in the field and frozen immediately upon return to the Refuge.

Sampling History

The irrigation drain monitoring samples that are the subject of this report were received in five shipments and were collected by USGS personnel. Shipments were received by the Environmental Chemistry Branch Inorganic Section (henceforth referred to as “the lab” in this report) of the USGS shortly after collection to meet the 7-day holding time specified for TSS in water and the 14-day holding time for total organic carbon (TOC) in sediments.

The first set of samples was collected during October 11 to 14, 2007, received by the lab on October 16, 2007, and contained 15 TSS water samples, 18 water samples for total selenium, and 6 water samples for total dissolved selenium. The samples were assigned USGS-CERC batch number 1418 and USGS sample identification numbers 40912 to 40950.

The second set of samples was collected during October 11 to 16, 2007, received by the lab on October 18, 2007, and contained 16 TSS water samples, 30 total selenium sediment samples, 11 total dissolved selenium water samples, 8 TOC/PSA sediment samples, 8 total selenium sediment samples, and 15 particulate samples. The samples were assigned USGS batch number 1419 and USGS sample identification numbers 40951 to 41038.

The third set of samples was collected during October 13 to 21, 2007, received by the lab on October 31, 2007, and contained 42 fish samples, 21 algae samples, 21 midge samples, 21 detritus samples, and 21 plankton samples. The samples were assigned USGS batch number 1421 and USGS sample identification numbers 41068 to 41193.

The fourth set of samples was collected during January 10 to 12, 2008, received by the lab on January 15, 2008, and contained 15 TSS water samples and 44 total selenium water samples. The samples were assigned USGS batch number 1434 and USGS sample identification numbers 41569 to 41627.

The fifth set of samples was collected during January 12 to 16, 2008, received by the lab on January 17, 2008, and contained 16 TSS water samples and 18 total selenium water samples. The samples were assigned USGS batch number 1435 and USGS sample identification numbers 41628 to 41661.

Homogenization and Lyophilization

Frozen fish samples were minced with a small ceramic knife before freeze drying. Particulates, biota, detritus, and sediment samples were lyophilized in a Virtis Genesis® 35EL freeze dryer and percent moisture was determined as part of the lyophilization process; however, percent moisture was not determined for plankton samples because the sample matrix included DI water. After lyophilization, all midge larvae, detritus, plankton, algae, and fish samples were homogenized by grinding with a glass rod against the container surface. Dried sediment was placed into a plastic bag, sealed, and then further reduced in size by using a rolling pin on the plastic bag to produce a coarse powder product. Dried filters containing particulates did not require any additional homogenization after freeze drying.

Chemical Procedures

Total Selenium in Water: Before analysis, all water samples were stored in the dark at ~4 ºC. For the subsequent determination of total selenium in filtered and unfiltered samples, a 20-mL aliquot of each acidified water sample was subjected to an HNO_3–magnesium nitrate [$Mg(NO_3)_2$] ashing procedure followed by treatment with HCl. The ashing procedure consisted of three steps: boiling with HNO_3 for

solubilization and partial oxidation, ashing at 500 ºC with $Mg(NO_3)_2$ to complete the oxidation and decompose remaining organic matter, and heating with HCl to dissolve the ash and reduce selenium to the selenite (Se^{+4}) oxidation state required for detection by hydride generation atomic absorption spectrophotometry. Following reduction, digestates were diluted to ~100 mL with DI water, yielding a final acid matrix of 10 percent HCl.

Selenite + Selenate in Water: Ten mL of filtered water and 5 mL of concentrated HCl were placed in a 25-mL borosilicate test tube and heated to 125 to 130 ºC in a well incubator block for 3 to 4 hours. After cooling, the liquid was transferred into a 125-mL polyethylene bottle, and the final volume was adjusted to 50 mL with DI water; the final matrix was 10 percent HCl.

Filtered Particulates: A dried filter containing particulates was rolled up, cut into pieces, and the entire filter was put into a 100-mL glass beaker. The filter was then subjected to the ashing procedure as described earlier for total selenium in water. The same procedure was conducted on clean filters, which served as blanks.

Biota, Detritus, and Sediment: An approximately 0.25-gram (g) aliquant of each dried sample was subjected to a HNO_3–$Mg(NO_3)_2$ ashing procedure followed by HCl reduction for the determination of selenium. The steps in the procedure were the same as those described above for total selenium in water. Digestates were diluted to about 100 mL with DI water, yielding a final acid matrix of 10 percent HCl.

Instrumental Analysis

Total Selenium: Total selenium was determined in all ashed samples by flow injection hydride generation atomic absorption spectrophotometry (FIHGAAS). In this procedure, the digestate is mixed with an HCl-carrier solution, and then reduced by sodium tetrahydridoborate that has been stabilized with sodium hydroxide. Selenium in the sample is converted to volatile hydrogen selenide and transferred with argon carrier gas into a heated quartz cell mounted on an atomic absorption spectrophotometer for decomposition into atomic vapor and measurement.

Selenite in Water: An aliquot of each filtered water sample was analyzed directly by FIHGAAS after acidification to 10 percent HCl.

Selenate and Selenite in Water: As previously described, filtered water samples were subjected to hot HCl reduction for 3 to 4 hours using a well incubator block. Samples prepared in this manner were analyzed directly by FIHGAAS to provide selenate + selenite concentrations. The selenate concentration was calculated by difference using the formula:

$$\text{selenate} = (\text{selenate} + \text{selenite}) - \text{selenite}. \quad (1)$$

Particulate Selenium in Water: Selenium associated with filtered particulates was determined by analyzing ashed filters by FIHGAAS. The mass of selenium in micrograms for the particulates was divided by the volume of water filtered for each drain site (0.5 or 1.0 L) to produce a microgram per liter concentration.

Dissolved Organic Selenium in Water: Dissolved organic selenium was estimated using the following formula:

$$\text{dissolved organic selenium} = \text{total dissolved selenium} - (\text{selenate} + \text{selenite}). \quad (2)$$

Total Suspended Solids: Upon arrival at the USGS, all TSS samples were transferred to the Ecology Branch for TSS analysis. Total suspended solids were analyzed with methods recommended by the American Public Health Association (1998). Samples were brought to room temperature and mixed with a magnetic stirrer and subsequent manual inversions of the sample container. The sample was measured into a graduated cylinder, poured into a filtration apparatus, and filtered through a ProWeigh® glass fiber filter. The samples were prewashed three times in DI water, dried at 105 ºC, and weighed to the nearest 0.1 milligram (mg). Sample volume varied to yield a dried residue between 2.5 and 200 mg. For each volume of sample used, an equal volume of DI water also was filtered for a blank determination. After filtering, large or nonhomogeneous materials were removed from the filter, and the filter was rinsed with three 10-mL aliquots of DI water. Filters were then dried for at least 1 hour in a 103 to 105 ºC oven and cooled to room temperature in a desiccator; filter and residue were weighed to the nearest 0.0001 g. Drying, cooling, and weighing of the filter were repeated until the weight difference was less than (<) 4 percent or 0.5 mg, whichever was less. The average of these weights was used to determine the constant weight of the filter and residue, which was then corrected for any weight gain or loss of the blank. After subtracting the filter weight, this blank corrected dried residue in milligrams was divided by the sample volume in liters to yield TSS in milligrams per liter.

Particle-size Analysis: Sediment samples designated for particle size analysis (PSA) were transferred to the USGS Ecology Branch upon arrival. The method requires use of a Bouyoucos hydrometer, adapted from American Society for Testing and Materials (2003). Wet sediment was sieved through a 2-mm sieve to remove any particles larger than coarse sand, and then dried at 60 ºC using a convectional drying oven. Approximately 100 g of dried sediment was mixed with 250 mL of DI water and 100 mL of a 50 mg/L sodium hexametaphosphate solution. A stir bar was added and the mixture was stirred with a magnetic stirring plate. After calibrating the hydrometer, the suspended sediment mixture was transferred to a sedimentation cylinder and the volume adjusted to 1 L with DI water. After allowing for thermal equilibration, the temperature was recorded. Cylinder contents were then thoroughly mixed, and the hydrometer was inserted into the suspension. The meniscus reading was taken after 30 seconds and the hydrometer was removed and dried. After 120 minutes, the hydrometer was reinserted and the meniscus

read again. All hydrometer meniscus readings were corrected by adjusting +0.25 for each degree above 18 ºC and -0.25 for each degree below 18 ºC. Percent fractions were determined as follows:

grams sand = sediment dry weight – (corrected 30 second reading – corrected calibration);
percent sand = grams sand/sediment dry weight x 100;
grams clay = sediment dry weight – (corrected 120 minute reading – corrected calibration);
percent clay = grams clay/sediment dry weight x 100; and
percent silt = 100 – (percent sand + percent clay).

Total Organic Carbon: TOC was determined with a Universal Instruments Corporation (UIC) Model 5014 Coulometer that determines carbon in any carbon dioxide (CO_2) containing gas stream (Universal Instruments Corporation, 1999). The coulometer is used as a detector with different carbon front-end units and can detect carbon in the range of 0.01 micrograms (µg) to 100 mg. The coulometer cell is filled with a proprietary solution containing monoethanolamine and a colorimetric pH indicator. Platinum (cathode) and silver (anode) electrodes are positioned in the cell. The cell assembly is then placed in the coulometer cell compartment between a light source and a photodetector in the coulometer. As a CO_2 gas stream passes into the cell, the CO_2 is quantitatively absorbed, reacting with the monoethanolamine to form a titratable acid. This acid causes the color indicator to fade. A photodetector monitors the change in the color of the solution as a percent transmittance (%T). As the %T increases, the titration current is automatically activated to electrochemically generate base at a rate proportional to the %T (approximately 1,500 µg carbon/minute). When the solution returns to its original color (original %T), the current stops.

For TOC analysis, total carbon (TC, µg/mg) and total inorganic carbon (TIC, µg/mg) are determined. Total carbon is determined by combustion of weighed sediments at 925 ºC. In TIC analysis, weighed sediments are exposed to heated 2 Normal sulfuric acid. Any inorganic carbonates are reduced to mineral components and CO_2 gas. The gas is carried in high purity oxygen to the coulometer cell, where it is measured by the procedure described above. Percent TOC is calculated as follows:

$$\text{Percent TOC} = [(TC - TIC)/1000] \times 100 \quad (3)$$

Quality Assurance

Samples were processed through the preparative and analytical flow scheme in 15 analytical blocks for selenium, 2 blocks for TSS, and 1 block each for PSA and TOC. Each block was assigned a block initiation date (BID) used to identify samples and quality-control samples/materials prepared and analyzed collectively as a unit. For samples analyzed by atomic absorption for total selenium, predigestion quality control included digestion blanks, replicates, spikes, and reference solutions. Analytical quality control for selenium included calibration verification solutions, replicate analyses, and analysis spikes. Quality control for the TSS determination included a reference solution, duplicates, and replicates. Quality control for sediment PSA and TOC included duplicates and replicates.

Results

Total Selenium: Total selenium concentrations [micrograms per liter, (µg/L)] in unfiltered water samples for the October 2007 samples are listed in table 1. Mean selenium concentrations were most elevated in water from Trifolium Storm drain (20.9) followed by Q drain (8.93). The lowest mean selenium concentration was from Trifolium 19 drain (0.97). Data for the January 2008 samples are listed in table 2. Mean selenium concentrations were highest in Q drain (64.5) followed by Trifolium Storm drain (43.8) and Trifolium 18 drain (32.3). The lowest mean selenium concentration was from T drain (1.14).

Total Dissolved Selenium and Selenium Species: Dissolved selenite, dissolved selenate, dissolved organic selenium, total dissolved selenium, and particulate selenium concentrations (µg/L) from filtered water samples collected during the October 2007 sampling are presented in table 3. The dissolved organic selenium fraction is assumed to include seleno-amino acids and dissolved seleno- peptides, Se(0) as a pseudo-dissolved microcolloid, and inorganic Se(-II) species (Cutter and Bruland, 1984). Speciation revealed that selenium in the sampled drains exists predominately as selenate (85 to 95 percent) followed by selenite (5 to 15 percent), typical of waters where selenium is leached out of selenium-containing marine shales and associated soils under alkaline and oxidizing conditions.

Total Suspended Solids: TSS concentrations (mg/L) in unfiltered water collected during the October 2007 and January 2008 samplings are presented in table 4. TSS concentrations ranged from a high of 597 (Trifolium 20 drain) to a low of 8.0 (Former Trifolium 20 drain) for the October 2007 collection, and a high of 780 (W drain) to a low of 6.65 (Former Trifolium 20 drain) for the January 2008 collection.

Biota: Percent moisture and concentrations of selenium (micrograms per gram (µg/g) dry weight) in biota (algae, plankton, midge larvae, western mosquitofish, and sailfin molly) are presented in table 5. Selenium concentration ranges for each matrix were as follows: algae, 0.95 to 5.99; plankton, 0.15 to 19.3; midges, 1.39 to 15.4; and fish, 3.71 to 25.1.

Detritus and Sediment: Percent moisture and selenium concentrations (µg/g dry weight) in detritus and sediment are presented in table 6. Selenium in detritus ranged from 0.85 to 21.7, and from 0.32 to 7.28 in sediment. The particle size analyses of sediments, expressed as percent sand, silt, and

Table 1. Total selenium concentrations in duplicates of unfiltered irrigation drain water samples, Salton Sea, California, October 2007.

[USGS, U.S. Geological Survey; ID, identification; Rep, field replicate; µg/L, microgram per liter; SD, standard deviation; ---, no data; <, less than; nc, not collected]

USGS ID	Field ID	Drain name/ID	Collection date	Total selenium concentration			SD
				Rep 1 (µg/L)	Rep 2 (µg/L)	Mean (µg/L)	
40994	BLANK-1	---	10/18/07	< 0.20	---	---	---
40995	BLANK-2	---	10/18/07	< 0.20	---	---	---
40996	BLNDWATSE10	---	10/15/07	5.09	---	---	---
40997	BLNDWATSE10B	---	10/16/07	3.04	---	---	---
40939,40940	LKLNWATSE10	Lack & Lindsey Pond	10/12/07	2.78	2.71	2.75	0.05
41000,41001	NLD1WATSE10	Niland 1	10/16/07	1.72	1.81	1.76	0.06
41002,41003	NLD2WATSE10	Niland 2	10/16/07	2.02	2.08	2.05	0.05
41004,41005	NLD3WATSE10	Niland 3	10/16/07	3.05	3.04	3.05	0.01
41006,41007	NLD4WATSE10	Niland 4	10/16/07	1.32	1.40	1.36	0.06
nc[1]	OOOOWATSE10	O	---	---	---	---	---
40927,40928	PPPPWATSE10	P	10/14/07	5.30	5.24	5.27	0.04
nc[1]	POEDWATSE10	Poe Rd	---	---	---	---	---
40937,40938	PUMCWATSE10	Pumice	10/11/07	6.84	6.86	6.85	0.01
40929,40930	QQQQWATSE10	Q	10/14/07	8.85	9.02	8.93	0.12
40931,40932	RRRRWATSE10	R	10/14/07	3.47	3.66	3.56	0.14
40933,40934	SSSSWATSE10	S	10/14/07	2.97	2.85	2.91	0.09
41008,41009	SFWHWATSE10	San Felipe Wash	10/15/07	2.35	2.24	2.29	0.08
nc[1]	TTTTWATSE10	T	---	---	---	---	---
41010,41011	TR01WATSE10	Trifolium 1	10/12/07	5.45	5.47	5.46	0.01
40935,40936	TR12WATSE10	Trifolium 12	10/12/07	4.69	4.87	4.78	0.12
41012,41013	TR13WATSE10	Trifolium 13	10/15/07	4.58	4.72	4.65	0.10
nc[1]	TR14WATSE10	Trifolium 14	---	---	---	---	---
nc[1]	TR18WATSE10	Trifolium 18	---	---	---	---	---
40947,40948	TR19WATSE10	Trifolium 19	10/11/07	0.99	0.95	0.97	0.03
40998,40999	FT20WATSE10	Former Trifolium 20	10/15/07	6.45	6.55	6.50	0.07
nc[1]	TR20WATSE10	Trifolium 20	---	---	---	---	---
41014,41015	TR22WATSE10	Trifolium 22	10/15/07	8.46	8.4	8.4	0.05
41016,41017	TR23WATSE10	Trifolium 23	10/15/07	5.43	5.28	5.36	0.10
41018,41019	TRSTWATSE10	Trifolium Storm	10/12/07	21.1	20.7	20.9	0.21
41020,41021	UUUUWATSE10	U	10/14/07	1.07	1.13	1.10	0.04
40941,40942	VLO5WATSE10	Vail 5	10/11/07	2.24	2.58	2.41	0.24
41022,41023	WWWWWATSE10	W	10/14/07	3.25	3.28	3.26	0.02
nc[1]	ZSPLWATSE10	Z Spill	---	---	---	---	---

[1]Drain was one of seven selected for intensive sampling (see table 3).

Table 2. Total selenium concentrations in duplicates of unfiltered irrigation drain water samples, Salton Sea, California, January 2008.

[USGS, U.S. Geological Survey; ID, identification; Rep, field replicate; µg/L, micrograms per liter; SD, standard deviation; <, less than]

USGS ID	Field ID	Drain name/ID	Collection date	Total selenium concentration			SD
				Rep 1 (µg/L)	Rep 2 (µg/L)	Mean (µg/L)	
41660	Blank 1	---	01/16/08	< 0.21	---	---	---
41661	Blank 2	---	01/16/08	< 0.21	---	---	---
41586	BLNDWATSE11	---	01/10/08	6.27	---	---	---
41587	BLNDWATSE11B	---	01/12/08	1.2	---	---	---
41600,41601	LKLNWATSE11	Lack & Lindsey Pond	01/11/08	4.17	4.24	4.20	0.04
41644,41645	NLD1WATSE11	Niland 1	01/14/08	1.62	1.74	1.68	0.09
41646,41647	NLD2WATSE11	Niland 2	01/14/08	10.2	10.3	10.2	0.10
41648,41649	NLD3WATSE11	Niland 3	01/14/08	2.70	2.41	2.56	0.20
41650,41651	NLD4WATSE11	Niland 4	01/14/08	2.38	2.66	2.52	0.20
41584,41585	OOOOWATSE11	O	01/12/08	4.38	4.32	4.35	0.04
41588,41589	PPPPWATSE11	P	01/12/08	2.14	2.23	2.19	0.07
41622,41623	POEDWATSE11	Poe Rd	01/10/08	6.23	5.64	5.94	0.41
41598,41599	PUMCWATSE11	Pumice	01/12/08	6.52	6.61	6.56	0.07
41590,41591	QQQQWATSE11	Q	01/12/08	64.0	65.0	64.5	0.72
41592,41593	RRRRWATSE11	R	01/12/08	2.61	2.73	2.67	0.09
41594,41595	SSSSWATSE11	S	01/12/08	1.19	1.12	1.15	0.05
41610,41611	SFWHWATSE11	San Felipe Wash	01/10/08	2.33	2.40	2.36	0.05
41618,41619	TTTTWATSE11	T	01/12/08	1.21	1.08	1.14	0.09
41652,41653	TR01WATSE11	Trifolium 1	01/15/08	6.64	6.58	6.61	0.05
41596,41597	TR12WATSE11	Trifolium 12	01/11/08	9.28	9.11	9.19	0.13
41654,41655	TR13WATSE11	Trifolium 13	01/11/08	4.68	4.63	4.66	0.04
41656,41657	TR14WATSE11	Trifolium 14	01/11/08	3.60	2.81	3.20	0.56
41620,41621	TR18WATSE11	Trifolium 18	01/10/08	32.3	32.3	32.3	0.02
41624,41625	TR19WATSE11	Trifolium 19	01/10/08	1.48	1.39	1.44	0.06
41604,41605	FT20WATSE11	Former Trifolium 20	01/10/08	4.76	4.84	4.80	0.05
41626,41627	TR20WATSE11	Trifolium 20	01/10/08	4.71	4.86	4.78	0.10
41606.41607	TR22WATSE11	Trifolium 22	01/10/08	5.28	4.92	5.10	0.25
41608,41609	TR23WATSE11	Trifolium 23	01/10/08	2.79	2.76	2.77	0.02
41658,41659	TRSTWATSE11	Trifolium Storm	01/15/08	43.8	43.8	43.8	0.05
41616,41617	UUUUWATSE11	U	01/12/08	1.37	1.44	1.40	0.05
41602,41603	VL05WATSE11	Vail 5	01/12/08	2.88	2.79	2.83	0.07
41614,41615	WWWWWATSE11	W	01/12/08	3.54	3.51	3.52	0.02
41612,41613	ZSPLWATSE11	Z Spill	01/12/08	3.87	3.86	3.86	0.01

Table 3. Total dissolved selenium, dissolved selenium species, and particulate selenium concentrations in filtered irrigation drain water samples, Salton Sea, October 2007.

[USGS, U.S. Geological Survey; ID, identification; Rep, replicate; $[Se0_3]^{-2}$, selenite; $[Se0_4]^{-2}$, selenate; Se, selenium; µg/L, micrograms per liter; ---, no data; <, less than; bold italicized values are greater than method quantification limit, but less than method detection limit; these values have higher uncertainty]

USGS ID	Field ID	Drain name/ID	Rep	Collection Date	Dissolved $[Se0_3]^{-2}$ (µg/L)	Calculated dissolved[1] $[Se0_4]^{-2}$ (µg/L)	Calculated dissolved organic[2] Se (µg/L)	Measured total dissolved Se (µg/L)	Measured particulate[3] Se (µg/L)	Calculated total[4] Se (µg/L)
40983	BLNKWADSE10	---	1	10/16/07	< 0.04	< 0.06	---	< 0.19	0.003	---
40984	BLNKWADSE10B	---	2	10/16/07	< 0.04	< 0.06	---	< 0.19	0.001	---
40985	BLNDWADSE10	---	---	10/16/07	0.72	3.1	0.26	4.0	0.10	4.1
40986	OOOOWADSE10	O	1	10/14/07	0.85	7.75	0.99	9.59	0.13	9.72
40987	OOOOWADSE10B	O	2	10/14/07	0.89	8.31	0.44	9.64	0.15	9.79
40945	POEDWADSE10	Poe Rd	1	10/11/07	0.20	4.6	0.80	5.60	0.025	5.6
40946	POEDWADSE10B	Poe Rd	2	10/11/07	0.18	4.4	0.71	5.31	0.020	5.3
40990	TTTTWADSE10	T	1	10/14/07	***0.13***	0.40	0.17	0.70	0.014	0.72
40991	TTTTWADSE10B	T	2	10/14/07	0.19	0.35	0.30	0.84	0.019	0.86
40988	TR14WADSE10	Trifolium 14	1	10/15/07	0.46	16.24	1.67	18.37	0.029	18.39
40989	TR14WADSE10B	Trifolium 14	2	10/15/07	0.46	15.84	2.97	19.27	0.039	19.30
40943	TR18WADSE10	Trifolium 18	1	10/12/07	2.34	14.9	0.00	16.5	0.086	16.6
40944	TR18WADSE10B	Trifolium 18	2	10/12/07	2.28	14.1	0.53	16.9	0.10	17.0
40949	TR20WADSE10	Trifolium 20	1	10/11/07	0.23	3.34	0.51	4.08	0.080	4.16
40950	TR20WADSE10B	Trifolium 20	2	10/11/07	0.23	3.05	0.98	4.26	0.092	4.35
40992	ZSPLWADSE10	Z Spill	1	10/16/07	0.77	3.09	0.52	4.38	0.11	4.49
40993	ZSPLWADSE10B	Z Spill	2	10/16/07	0.79	3.02	0.61	4.42	0.12	4.54

[1]Calculated dissolved $[Se0_4]^{-2}$ = measured ($[Se0_4]^{-2}$ + $[Se0_3]^{-2}$) - measured $[Se0_3]^{-2}$.

[2]Calculated dissolved Organic Se = measured total dissolved Se - measured ($[Se0_4]^{-2}$ + $[Se0_3]^{-2}$).

[3]Measured particulate Se = µg of Se in filtered particulates divided by volume of site water filtered.

[4]Calculated total Se = measured particulate Se + measured total dissolved Se.

Table 4. Total suspended solids concentrations in unfiltered Salton Sea irrigation drain water samples, October 2007 and January 2008.

[ID, identification; USGS, U.S. Geological Survey; TSS, total suspended solids; mg/L, milligram per liter]

Field ID	Drain name/ID	October 2007		January 2008	
		USGS ID	TSS (mg/L)	USGS ID	TSS (mg/L)
BLNDWATSS	Blind A	40966	9.20	41581	65.1
BLNDWATSS	Blind B	40926	21.2	41641	693
LKLNWATSS	Lack & Lindsey Pond	40925	26.8	41580	34.1
NLD1WATSS	Niland 1	40951	83.2	41628	48.3
NLD2WATSS	Niland 2	40952	62.0	41629	56.9
NLD3WATSS	Niland 3	40953	339	41630	77.8
NLD4WATSS	Niland 4	40954	49.0	41631	47.3
OOOOWATSS	O	40912	383	41640	351
PPPPWATSS	P	40913	101	41639	68.7
POEDWATSS	Poe Rd	40917	38.0	41574	16.5
PUMCWATSS	Pumice	40920	214	41583	155
QQQQWATSS	Q	40914	82.0	41638	72.5
RRRRWATSS	R	40915	116	41637	590
SSSSWATSS	S	40959	68.9	41636	67.7
SFWHWATSS	San Felipe Wash	40964	68.8	41571	27.2
TTTTWATSS	T	40958	26.0	41635	77.7
TR01WATSS	Trifolium 1	40922	88.0	41643	50.3
TR12WATSS	Trifolium 12	40924	53.2	41579	70.3
TR13WATSS	Trifolium 13	40961	47.4	41577	25.7
TR14WATSS	Trifolium 14	40960	48.4	41578	24.5
TR18WATSS	Trifolium 18	40916	10.0	41573	31.9
TR19WATSS	Trifolium 19	40918	10.4	41575	49.5
FT20WATSS	Former Trifolium 20	40965	8.00	41569	6.65
TR20WATSS	Trifolium 20	40919	597	41576	134
TR22WATSS	Trifolium 22	40963	71.6	41570	48.1
TR23WATSS	Trifolium 23	40962	295	41572	64.9
TRSTWATSS	Trifolium Storm	40923	10.6	41642	13.5
UUUUWATSS	U	40957	22.8	41634	82.0
VLO5WATSS	Vail 5	40921	116	41582	60.3
WWWWWATSS	W	40956	76.5	41633	780
ZSPLWATSS	Z Spill	40955	158	41632	71.7

Table 5. Selenium concentrations in biota samples collected from Salton Sea irrigation drains, October 2007.

[USGS, U.S. Geological Survey; ID, identification; µg/g, microgram per gram; ---, no data]

USGS ID	Field ID	Matrix	Drain name/ID	Moisture (percent)	Selenium (µg/g dry weight)
41119	OOOOALGTSE10A	algae	O	56.9	3.16
41120	OOOOALGTSE10B	algae	O	55.1	3.22
41121	OOOOALGTSE10C	algae	O	55.3	3.16
41116	POEDALGTSE10A	algae	Poe	54.6	1.35
41117	POEDALGTSE10B	algae	Poe	54.7	1.32
41118	POEDALGTSE10C	algae	Poe	55.0	1.32
41110	TTTTALGTSE10A	algae	T	65.1	0.97
41111	TTTTALGTSE10B	algae	T	64.8	0.96
41112	TTTTALGTSE10C	algae	T	64.9	0.95
41122	TR14ALGTSE10A	algae	Trifolium 14	66.2	3.31
41123	TR14ALGTSE10B	algae	Trifolium 14	69.4	3.28
41124	TR14ALGTSE10C	algae	Trifolium 14	66.9	3.32
41128	TR18ALGTSE10A	algae	Trifolium 18	63.4	5.99
41129	TR18ALGTSE10B	algae	Trifolium 18	63.3	5.73
41130	TR18ALGTSE10C	algae	Trifolium 18	62.9	5.84
41113	TR20ALGTSE10A	algae	Trifolium 20	60.4	2.44
41114	TR20ALGTSE10B	algae	Trifolium 20	60.5	2.47
41115	TR20ALGTSE10C	algae	Trifolium 20	59.7	2.53
41125	ZSPLALGTSE10A	algae	Z Spill	60.0	3.88
41126	ZSPLALGTSE10B	algae	Z Spill	61.1	3.69
41127	ZSPLALGTSE10C	algae	Z Spill	62.5	3.75
41182	OOOONPTSE10A	plankton	O	---	2.58
41183	OOOONPTSE10B	plankton	O	---	2.90
41184	OOOONPTSE10C	plankton	O	---	3.05
41179	POEDNPTSE10A	plankton	Poe	---	0.21
41180	POEDNPTSE10B	plankton	Poe	---	0.15
41181	POEDNPTSE10C	plankton	Poe	---	0.15
41173	TTTTNPTSE10A	plankton	T	---	1.05
41174	TTTTNPTSE10B	plankton	T	---	0.59
41175	TTTTNPTSE10C	plankton	T	---	0.55
41185	TR14NPTSE10A	plankton	Trifolium 14	---	4.54
41186	TR14NPTSE10B	plankton	Trifolium 14	---	4.04
41187	TR14NPTSE10C	plankton	Trifolium 14	---	2.88
41191	TR18NPTSE10A	plankton	Trifolium 18	---	12.9
41192	TR18NPTSE10B	plankton	Trifolium 18	---	17.9
41193	TR18NPTSE10C	plankton	Trifolium 18	---	19.3
41176	TR20NPTSE10A	plankton	Trifolium 20	---	1.56
41177	TR20NPTSE10B	plankton	Trifolium 20	---	2.23
41178	TR20NPTSE10C	plankton	Trifolium 20	---	2.00

Table 5. Selenium concentrations in biota samples collected from Salton Sea irrigation drains, October 2007.—Continued

[USGS, U.S. Geological Survey; ID, identification; µg/g, microgram per gram; ---, no data]

USGS ID	Field ID	Matrix	Drain name/ID	Moisture (percent)	Selenium (µg/g dry weight)
41188	ZSPLNPTSE10A	plankton	Z Spill	---	1.47
41189	ZSPLNPTSE10B	plankton	Z Spill	---	0.84
41190	ZSPLNPTSE10C	plankton	Z Spill	---	0.39
41140	OOOOCHITSE10A	midge	O	78.4	4.11
41141	OOOOCHITSE10B	midge	O	76.2	3.62
41142	OOOOCHITSE10C	midge	O	79.7	4.26
41137	POEDCHITSE10A	midge	Poe	69.8	3.92
41138	POEDCHITSE10B	midge	Poe	76.0	5.45
41139	POEDCHITSE10C	midge	Poe	68.4	3.01
41131	TTTTCHITSE10A	midge	T	78.5	5.89
41132	TTTTCHITSE10B	midge	T	78.8	6.02
41133	TTTTCHITSE10C	midge	T	79.9	6.49
41143	TR14CHITSE10A	midge	Trifolium 14	79.9	5.40
41144	TR14CHITSE10B	midge	Trifolium 14	80.1	5.40
41145	TR14CHITSE10C	midge	Trifolium 14	80.2	5.31
41149	TR18CHITSE10A	midge	Trifolium 18	79.2	15.4
41150	TR18CHITSE10B	midge	Trifolium 18	76.1	12.8
41151	TR18CHITSE10C	midge	Trifolium 18	79.6	14.5
41134	TR20CHITSE10A	midge	Trifolium 20	74.9	2.21
41135	TR20CHITSE10B	midge	Trifolium 20	74.8	1.95
41136	TR20CHITSE10C	midge	Trifolium 20	73.8	1.39
41146	ZSPLCHITSE10A	midge	Z Spill	78.1	2.58
41147	ZSPLCHITSE10B	midge	Z Spill	77.2	2.62
41148	ZSPLCHITSE10C	midge	Z Spill	77.9	2.30
41086	OOOOGMBTSE10A	mosquitofish	O	77.1	4.43
41087	OOOOGMBTSE10B	mosquitofish	O	77.5	4.76
41088	OOOOGMBTSE10C	mosquitofish	O	77.9	4.20
41089	OOOOSLMTSE10A	sailfin molly	O	75.3	4.21
41090	OOOOSLMTSE10B	sailfin molly	O	75.9	3.71
41091	OOOOSLMTSE10C	sailfin molly	O	76.2	4.50
41080	POEDGMBTSE10A	mosquitofish	Poe	77.3	5.89
41081	POEDGMBTSE10B	mosquitofish	Poe	77.3	5.97
41082	POEDGMBTSE10C	mosquitofish	Poe	77.9	5.44
41083	POEDSLMTSE10A	sailfin molly	Poe	76.7	4.65
41084	POEDSLMTSE10B	sailfin molly	Poe	76.2	5.27
41085	POEDSLMTSE10C	sailfin molly	Poe	76.7	4.68
41068	TTTTGMBTSE10A	mosquitofish	T	77.3	4.09
41069	TTTTGMBTSE10B	mosquitofish	T	78.4	3.72
41070	TTTTGMBTSE10C	mosquitofish	T	78.7	3.94

Table 5. Selenium concentrations in biota samples collected from Salton Sea irrigation drains, October 2007.—Continued

[USGS, U.S. Geological Survey; ID, identification; µg/g, microgram per gram; ---, no data]

USGS ID	Field ID	Matrix	Drain name/ID	Moisture (percent)	Selenium (µg/g dry weight)
41071	TTTTSLMTSE10A	sailfin molly	T	75.9	4.38
41072	TTTTSLMTSE10B	sailfin molly	T	77.2	4.36
41073	TTTTSLMTSE10C	sailfin molly	T	77.4	4.92
41092	TR14GMBTSE10A	mosquitofish	Trifolium 14	76.5	5.68
41093	TR14GMBTSE10B	mosquitofish	Trifolium 14	77.8	6.03
41094	TR14GMBTSE10C	mosquitofish	Trifolium 14	78.1	5.78
41095	TR14SLMTSE10A	sailfin molly	Trifolium 14	73.3	4.41
41096	TR14SLMTSE10B	sailfin molly	Trifolium 14	73.0	3.97
41097	TR14SLMTSE10C	sailfin molly	Trifolium 14	73.4	4.58
41104	TR18GMBTSE10A	mosquitofish	Trifolium 18	78.3	14.7
41105	TR18GMBTSE10B	mosquitofish	Trifolium 18	78.1	14.5
41106	TR18GMBTSE10C	mosquitofish	Trifolium 18	77.2	13.2
41107	TR18SLMTSE10A	sailfin molly	Trifolium 18	78.2	25.1
41108	TR18SLMTSE10B	sailfin molly	Trifolium 18	77.6	24.0
41109	TR18SLMTSE10C	sailfin molly	Trifolium 18	76.9	24.3
41074	TR20GMBTSE10A	mosquitofish	Trifolium 20	80.8	4.98
41075	TR20GMBTSE10B	mosquitofish	Trifolium 20	80.4	5.22
41076	TR20GMBTSE10C	mosquitofish	Trifolium 20	81.3	5.01
41077	TR20SLMTSE10A	sailfin molly	Trifolium 20	78.1	4.62
41078	TR20SLMTSE10B	sailfin molly	Trifolium 20	77.9	4.65
41079	TR20SLMTSE10C	sailfin molly	Trifolium 20	78.2	4.79
41098	ZSPLGMBTSE10A	mosquitofish	Z Spill	76.8	5.49
41099	ZSPLGMBTSE10B	mosquitofish	Z Spill	76.8	6.00
41100	ZSPLGMBTSE10C	mosquitofish	Z Spill	76.3	5.81
41101	ZSPLSLMTSE10A	sailfin molly	Z Spill	74.8	4.67
41102	ZSPLSLMTSE10B	sailfin molly	Z Spill	76.3	4.16
41103	ZSPLSLMTSE10C	sailfin molly	Z Spill	76.7	4.85

Table 6. Selenium concentrations in detritus and sediment samples collected from Salton Sea irrigation drains, October 2007.

[USGS, U.S. Geological Survey; ID, identification; µg/g, micrograms per gram]

USGS ID	Field ID	Matrix	Drain name/ID	Moisture (percent)	Selenium (µg/g dry weight)
41161	OOOODETTSE10A	detritus	O	73.5	4.75
41162	OOOODETTSE10B	detritus	O	75.8	4.37
41163	OOOODETTSE10C	detritus	O	75.2	2.54
41158	POEDDETTSE10A	detritus	Poe	80.3	2.44
41159	POEDDETTSE10B	detritus	Poe	84.4	6.55
41160	POEDDETTSE10C	detritus	Poe	81.0	3.74
41152	TTTTDETTSE10A	detritus	T	77.2	1.48
41153	TTTTDETTSE10B	detritus	T	71.5	1.30
41154	TTTTDETTSE10C	detritus	T	73.3	0.85
41164	TR14DETTSE10A	detritus	Trifolium 14	70.9	4.39
41165	TR14DETTSE10B	detritus	Trifolium 14	78.6	5.72
41166	TR14DETTSE10C	detritus	Trifolium 14	76.7	3.79
41170	TR18DETTSE10A	detritus	Trifolium 18	80.0	16.4
41171	TR18DETTSE10B	detritus	Trifolium 18	81.4	13.3
41172	TR18DETTSE10C	detritus	Trifolium 18	80.8	21.7
41155	TR20DETTSE10A	detritus	Trifolium 20	78.1	2.61
41156	TR20DETTSE10B	detritus	Trifolium 20	75.8	1.76
41157	TR20DETTSE10C	detritus	Trifolium 20	75.7	2.35
41167	ZSPLDETTSE10A	detritus	Z Spill	72.3	3.59
41168	ZSPLDETTSE10B	detritus	Z Spill	75.3	3.37
41169	ZSPLDETTSE10C	detritus	Z Spill	76.4	3.62
40982	BLNDSDTSE10	sediment	Blind	23.0	0.32
40979	OOOOSDTSE10	sediment	O	48.6	0.97
40976	POEDSDTSE10	sediment	Poe	23.6	0.33
40980	TTTTSDTSE10	sediment	T	40.0	0.47
40978	TR14SDTSE10	sediment	Trifolium 14	56.0	2.40
40977	TR18SDTSE10	sediment	Trifolium 18	59.3	7.28
40975	TR20SDTSE10	sediment	Trifolium 20	52.2	1.39
40981	ZSPLSDTSE10	sediment	Z Spill	55.9	1.44

clay, are presented in table 7. Percent sand ranged from 19.6 to 64.5; percent silt from 17.8 to 53.3; and percent clay from 8.98 to 41.6. Percent TOC in sediments is given in table 8 and ranged from 0.03 to 1.73.

Quality Control Results

Calibration Verification: During the selenium determinations, a calibration verification solution (Spex Claritas PPT®; Cat No. CLSe2-2Y) was analyzed at the beginning and end of each analytical run. Calibration was considered acceptable if the check solution was within plus or minus 10 percent of the actual concentration (3 µg/L), which was achieved during all analyses.

Reference Materials: Recoveries of selenium from QC Plus + Trace Metals Quality Control Standard [n=8 (8 samples)] and National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 1640 Trace Elements in Natural Water (n=8) averaged 99 percent. Recoveries of selenium from NIST SRM 2704 Buffalo River sediment (n=1) and National Research Council Canada (NRCC) SRM PACS-1 marine sediment (n=1) were 100 percent. The International Atomic Energy Agency (IAEA) copepod reference material MA-A-1 (n= 3) and the Institute for Reference Materials and Measurements Certified Reference Material (CRM) 414 Trace Elements in Plankton (n=3) all exhibited selenium recoveries of 100 percent. Recoveries of selenium in NRCC CRM DORM-2 dogfish muscle (n=2) and IAEA CRM 407 whole-body fish (n=2) averaged 100 and 97 percent. Recoveries of TSS from a TSS reference solution (Environmental Resource Associates Hardness Wastewater Standard 507; n=4) were 100 percent. The recovery of total carbon from a carbon reference material (Environmental Resource Associates Nutrients in Soil 542; n=1) was 100 percent.

Table 7. Particle size distributions in sediment samples collected from Salton Sea irrigation drains, October 2007.

[USGS, U.S. Geological Survey; ID, identification; >, greater than; mm, millimeter]

USGS ID	Field ID	Drain name/ID	Particle size category			
			> 2 mm (percent)	Sand (percent)	Silt (percent)	Clay (percent)
40974	BLNDSDTOC10	Blind	0.22	63.8	18.6	17.4
40971	OOOOSDTOC10	O	0.64	20.8	36.9	41.6
40968	POEDSDTOC10	Poe Rd	0.17	64.5	17.8	17.5
40972	TTTTSDTOC10	T	0.50	34.7	33.6	31.3
40970	TR14SDTOC10	Trifolium 14	0.74	20.6	53.3	25.3
40969	TR18SDTOC10	Trifolium 18	0.13	60.7	30.2	8.98
40967	TR20SDTOC10	Trifolium 20	0.16	26.3	36.9	36.6
40973	ZSPLSDTOC10	Z Spill	0.58	19.6	44.4	35.4

Table 8. Percent total organic carbon in sediment samples collected from Salton Sea irrigation drains, October 2007.

[USGS, U.S. Geological Survey; ID, identification]

USGS ID	Field ID	Drain name/ID	Total organic carbon (percent)
40971	BLNDSDTOC10	Blind	0.66
40968	OOOOSDTOC10	O	0.03
40972	POEDSDTOC10	Poe	0.45
40970	TTTTSDTOC10	T	1.00
40969	TR14SDTOC10	Trifolium 14	1.73
40967	TR18SDTOC10	Trifolium 18	1.00
40973	TR20SDTOC10	Trifolium 20	0.64
40974	ZSPLSDTOC10	Z Spill	0.16

Analytical and Method Precision: Instrumental precision for selenium as determined by repeated analysis of a standard throughout the run for each block (n=15) was less than 5 percent relative standard deviation (RSD). Relative percent differences (RPDs) between field duplicates (n=72) of unfiltered and filtered water samples analyzed for selenium or selenium species mostly were ≤(less than or equal) 10 (n=65), but 7 duplicates exhibited greater RPDs of 11, 12, 14, 18, 25, and 33 attributed to low selenium concentrations (0.13 to 3.6 µg/L). Field duplicates of selenium in filtered particulates produced RPDs ranging from 8.8 to 31 RPD, with the elevated RPDs again attributed to low selenium concentrations (0.014 to 0.15 µg/L). Relative standard deviations (RSDs) for triplicate field samples of detritus (n=7), algae (n=7), plankton (n=7), midge larvae (n=7), and whole-body fish (n=14) analyzed for selenium were as follows: algae, 0.6 to 2.6 percent; plankton, 8.5 to 60 percent; detritus, 3.8 to 50 percent; midge larvae, 1.0 to 30 percent; and whole-body fish, 1.9 to 10 percent. The larger RSDs for some of the matrices resulted in some cases from the low selenium concentrations involved to other cases that reflected more the natural variation of selenium in the sample (i.e., detritus and plankton). Laboratory method precision for triplicate (n=17) preparation and analysis of samples for selenium were <3 percent RSD. Method duplicates of the various matrices produced RPDs as follows: detritus, 0.1 percent; water, 2.4 and 7.6 percent; sediment (n=8), 0.4 to 8.5 percent. Method replicates of the various matrices produced percent RSDs as follows: particulate selenium, 1.6; plankton, 1.3; algae, 0.6; sediment, 3.5; water (n=10), 0.5 to 9.4; midge larvae, 5.3 and 7.0; fish (n=3), 2.5 to 3.2. Duplicate analysis of water samples for TSS (n=6) resulted in RPDs ranging from 0.4 to 7.3 percent, whereas triplicate analysis for TSS (n=4) resulted in RSDs <5 percent. Triplicate analyses of a sediment and a sediment control material for PSA resulted in RSDs <7 percent for the fractions. The duplicate analysis of a sediment for TOC resulted in an RPD of 3.4 percent.

Spikes: Recoveries of selenium [Se^{+4}, selenate (Se^{+6}), or selenomethionine] spiked into filter blanks (n=2) and water samples (n=26) ranged from 93 to 109 percent and averaged 99 percent. Recoveries of selenium spiked into sediment (n=2), detritus (n=1), and biota (n=14) ranged from 94 to 108 percent, and averaged 100 percent. Recoveries of selenium spikes added to water during analysis (n=18) ranged from 97 to 108 percent, and averaged 104 percent; analysis spikes of sediment (n=2), filtered particulates (n=2), detritus (n=2), and biota (n=11) ranged from 95 to 108 percent, and averaged 102 percent.

Blank Equivalent Concentrations: Blank equivalent concentrations (BECs) were computed for selenium for each matrix and for TSS blanks analyzed with each set of drain water samples. All BECs were less than or equal to their respective method detection limits (MDLs) with the exception of plankton, where the BEC was about twice the MDL (0.013 µg/g compared to 0.006 µg/g). BECs for TSS were less than or equal to their respective MDLs. TSS sample data were corrected for procedural blanks, whereas total selenium sample data were not blank corrected.

Instrument Detection, Method Detection, and Method Quantitation Limits: The FIHGAAS instrument detection limit for selenium was 0.02 µg/L, and for TSS was 0.10 and 0.12 mg/L. Method detection limits (MDL) for each matrix for selenium were computed for each analytical block (n=15) using the formula:

$$3(SD_b^2 + SD_s^2)^{1/2} \quad (4)$$

where

SD_b is standard deviation of a blank (n=3); and

SD_s is standard deviation of a low level sample or spiked sample (n=3).

The results were water, 0.043 to 0.21 µg/L; filtered particulates, 0.001 µg/L; sediment, 0.011 and 0.012 µg/g dry weight; algae, 0.029 µg/g dry weight; midge larvae, 0.017 µg/g dry weight; plankton, 0.006 µg/g dry weight; detritus, 0.029 µg/g dry weight; and whole-body fish, 0.005 and 0.012 µg/g dry weight. Method quantitation limits (MQLs) for each matrix were calculated as 3.3 x MDLs. Method detection limits for TSS were 3.6 and 2.4 mg/L and MQLs were 11.7 and 7.9 mg/L. Overall, quality control results for the study were within acceptable limits as specified by USGS.

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