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Monticello Mill Tailings Site Macroinvertebrate Sampling for 2008 and Summary of Biomonitoring Studies

December 2008

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Executive Summary

In accordance with the Record of Decision for Operable Unit III (DOE 2004a), biomonitoring has been conducted annually at the U.S. Department of Energy's (DOE's) Monticello Mill Tailings Site (MMTS) since 2004, when toxicity thresholds for selenium (Se) were exceeded for some surface water and sediment samples. In 2008, the biomonitoring program consisted of sediment and surface water sampling, macroinvertebrate sampling, and avian surveys. Biomonitoring efforts are directed by the Biological Technical Assistance Group, which includes representatives from DOE, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the Utah Department of Environmental Quality. Biomonitoring in 2008 was conducted according to Program Directive MNT-08-03.

In the spring of 2008, kick net samples of aquatic macroinvertebrates were collected from two wetlands associated with the MMTS: Wetland 3 and the sediment retention pond. Sampling efforts in previous years occurred in May, but in 2008, sampling occurred in June because weather conditions delayed the development of macroinvertebrate populations in the area. Hester-Dendy samplers were placed in the sediment retention pond, but not enough colonization occurred to collect a sample. Kick net samples were analyzed for Se at the Battelle Marine Sciences Laboratory in Sequim, Washington.

All of the macroinvertebrate samples were above the no effects level for Se, and two of the six samples (at the inlet of Wetland 3 and the outlet of the sediment retention pond) exceeded the toxicity threshold. Analyses of macroinvertebrate feeding groups in the two sampled aquatic ecosystems indicate that predators are most abundant; detritivores and collector-gatherers comprise smaller, similar proportions of the sampled populations over time. A comparison of the 2008 results to previous years' data reveals that mean Se levels in macroinvertebrates in Wetland 3 are decreasing over time, while they may be trending upward in the sediment retention pond.

Summaries of surface water and other biomonitoring data are also included in this report to place the macroinvertebrate data in a larger context and facilitate future decision making. The largest source of water into Wetland 3 is Montezuma Creek. Se levels are decreasing over time in the surface waters of Montezuma Creek and in the low-volume high-Se seep that discharges into Wetland 3. In the surface waters and sediments of Wetland 3, no statistically significant trending has occurred. Se levels in surface waters at the sediment retention pond have trended upward, and Se levels in sediments may have trended downward.

Avian surveys did not detect any federally protected, State of Utah listed, or other avian species of concern nesting in or near the MMTS wetlands. The most common bird species using Wetland 3 include red-winged blackbirds, song sparrows, and sora. The most common bird species using the sediment retention pond are cliff swallows, violet-green swallows, song sparrows, and black phoebes.

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1.0 Introduction

In 2000, the U.S. Department of Energy (DOE) completed surface remediation at the Monticello Mill Tailings Site (MMTS), located near Monticello, Utah, under the Comprehensive Environmental Response, Compensation and Liability Act. The remediated area contains three manmade emergent wetlands (Wetlands 1, 2, and 3) and a sediment retention pond located approximately 1 mile east of the wetlands (Figure 1). Monitoring of surface water and sediment in these wetlands is specified in the *MMTS Operable Unit III Post-Record of Decision Monitoring Plan* (Monitoring Plan [DOE 2004b]). Biomonitoring has been conducted at the MMTS since 2004, when toxicity thresholds for selenium (Se) were exceeded for some surface water and sediment samples. The scope of biomonitoring is directed by the Record of Decision for OU III (DOE 2004a).

Se has the ability to accumulate in the aquatic food chain and potentially harm organisms. Toxicity thresholds and no effect levels are recommended ecological risk guidelines developed for aquatic ecosystems to indicate benchmark levels of Se that may be toxic to fish and wildlife (Table 1 [USFWS 1999]). Values above the no effects level but below the toxicity threshold are within the "level of concern."

Table 1. Ecological Risk Guidelines for Aquatic Ecosystems

Matrix	Units	No Effect	Level of Concern	Toxicity Threshold
Surface Water	µg/L	< 2	2−5	> 5
Sediment	mg/kg dry weight	< 2	2−4	> 4
Invertebrates	mg/kg dry weight	< 3	3−7	> 7

µg/L = micrograms per liter
mg/kg = milligrams per kilogram

The general approach for biomonitoring was determined in 2004 by the Biological Technical Assistance Group (BTAG), which includes representatives from DOE, the U.S. Environmental Protection Agency Region 8, the U.S. Fish and Wildlife Service, and the Utah Department of Environmental Quality. The macroinvertebrate sampling described in this report is one component of the biomonitoring; other components include surface water and sediment sampling and avian surveys.

In the spring of 2008, kick net samples of aquatic macroinvertebrates were collected from Wetland 3 and the sediment retention pond. Hester-Dendy substrate samplers (see Section 2.2) were also placed in four locations in the sediment retention pond and periodically monitored through the spring and summer. No samples were collected from the Hester-Dendy samplers because minimal colonization occurred. Macroinvertebrate samples were analyzed in the laboratory for Se. Field sampling activities are summarized in Section 2, and laboratory results are presented in Section 3. Section 4 contains a discussion of the results, including data from previous years, and Section 5 includes recommendations for future biomonitoring efforts.

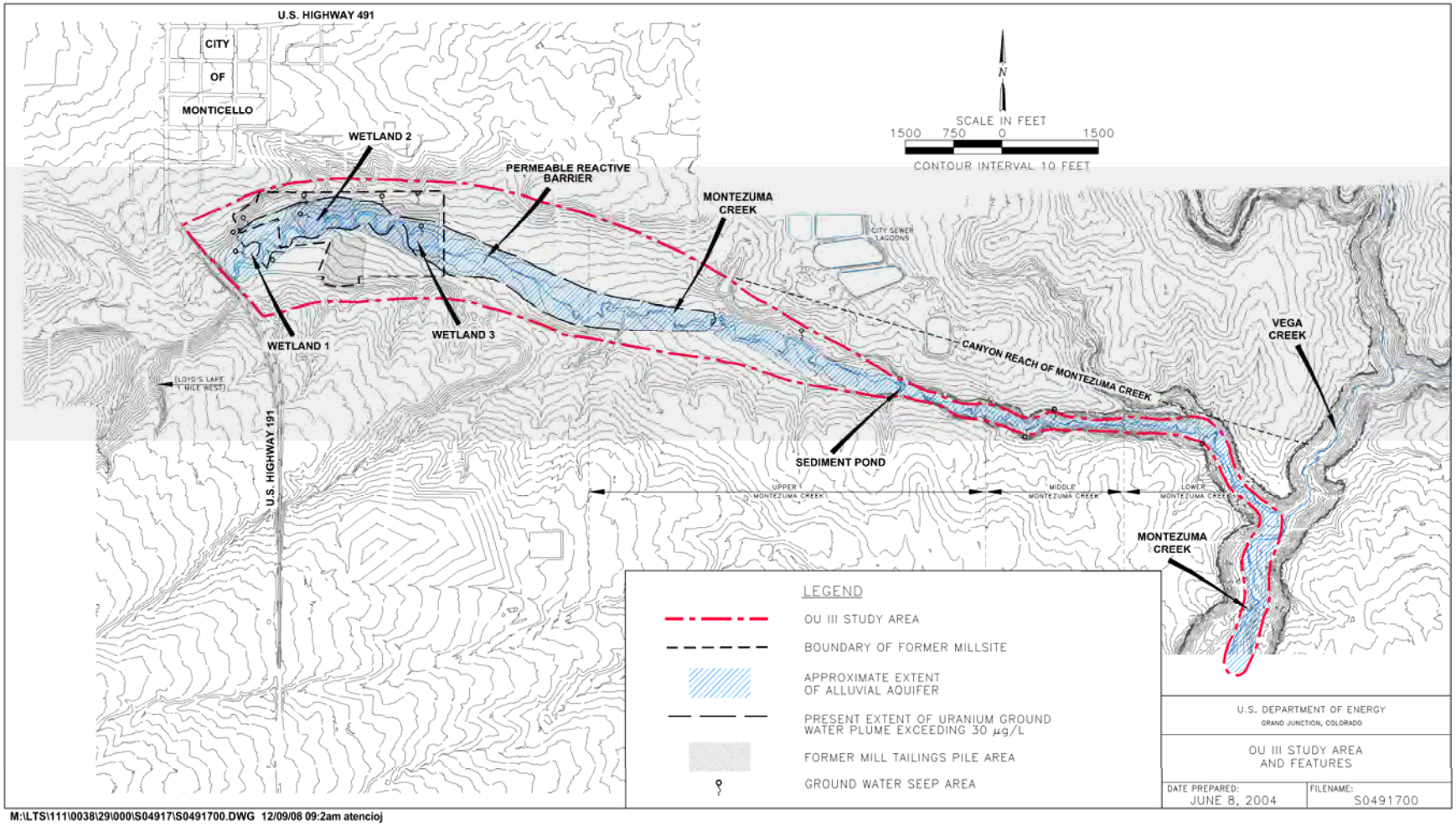

Figure 1. Location of Wetlands in Monticello, Utah

1.1 Biomonitoring at the Monticello Wetlands Before 2008

In 1995 and 1996, in support of the Remedial Investigation for Operable Unit III, a benthic macroinvertebrate study was conducted at locations in Montezuma Creek upstream and downstream from the millsite (Peterson et al. 2002). At that time, macroinvertebrate Se levels ranged from 9.9 milligrams per kilogram (mg/kg) approximately 1 kilometer (km) (0.6 mile) downstream from the millsite to 4.7 mg/kg approximately 4 km (2.5 miles) downstream from the millsite. Measurements from reference areas upstream from the millsite and on a nearby uncontaminated creek, Verdure Creek, ranged from 4.4 to 6.9 mg/kg Se. All of these values are greater than the no effects level. While Se levels in macroinvertebrates are naturally high in the area, they were additionally elevated in the regions downstream from the MMTS, where toxicity thresholds were exceeded in several locations.

Avian surveys, associated with the Ecological Risk Assessment for OU III (DOE 1998a), were done in 1995 and 1996. Protocol surveys for willow flycatchers were also performed in 1996 and 1997 (DOE 1998b). The northern goshawk, a State-listed species, was determined to exist in the area, but no threatened or endangered species were found during any of these surveys.

In 1995, quantitative and qualitative fish sampling was performed at multiple locations in Montezuma Creek and Verdure Creek. No fish were found in Montezuma Creek above its confluence with Verdure Creek (Smith et al. 1996).

Surface water quality monitoring associated with the Remedial Investigation for OU III has occurred in and near the MMTS since 1992; many additional sampling locations were added after remediation in 2001 and 2002. Most of these sampling locations occur at the discharge point of millsite seeps or in the Montezuma Creek channel. The biomonitoring plan (Section 6 of the Monitoring Plan), a multilevel phased approach, required that additional surface water and sediment sampling be conducted within the constructed wetland areas. Three levels of biomonitoring—sediment and surface water, macroinvertebrate sampling, and avian surveys—were performed in 2008, and the results are summarized in Section 4 of this report. Surface water and sediment sampling in the wetlands have been performed since 2004. Macroinvertebrate sampling became necessary when toxicity thresholds for surface water or sediment were exceeded at one or more sampling locations. This occurred for Wetland 3 surface water in 2004 and 2007, for Wetland 3 sediment in 2006 and 2007, and for sediment retention pond sediment in 2005 and 2007. Macroinvertebrate sampling was conducted in Wetlands 1, 2, 3, and the sediment retention pond in 2005. In 2006 and 2007, only Wetland 3 and the sediment retention pond were sampled. During all three sampling years, Se values for macroinvertebrates from at least one sampling point exceeded toxicity thresholds. In accordance with the biomonitoring plan, the BTAG evaluated the need to sample bird eggs or the need for other corrective actions. Results of the evaluation determined that avian surveys rather than egg sampling were required. Previous avian surveys, each with a different focus, were conducted in 2005 and 2006.

More information about potential Se receptors and exposure pathways in the Montezuma Creek area is contained in Appendix M of the Ecological Risk Assessment (DOE 1998), conducted prior to remediation. This risk assessment was updated after surface remediation was complete, and the update is provided in the *Remedial Investigation Addendum/Focused Feasibility Study* (DOE 2004c).

1.2 Chemistry and Mobility of Selenium in the Environment

The chemistry of Se is complex. In nature, Se exists as six stable isotopes, in three allotropic forms, and in five valence states (Eisler 1985). Se is found most commonly in four inorganic oxidation states. Selenate (SeO_4^{2-}) is the most oxidized form. It and selenite (SeO_3^{2-}) are soluble in water and are therefore potentially toxic in small concentrations to living organisms. Elemental selenium (Se^0) is insoluble in water and is therefore least toxic. Selenide (Se^{2-}) is the most reduced form of Se. It is usually not toxic in ecosystems because it oxidizes to elemental Se in the presence of air (Maiers et al. 1988).

Many living organisms, particularly microbes, have the ability to change Se compounds. Most reduce Se, rendering it less soluble (Maiers et al. 1988), but some organisms, particularly aquatic plants and microbes, through oxidation or methylation, convert insoluble forms of Se to soluble forms (Lemly and Smith 1987). Some biological processes convert inorganic Se compounds into volatile organic compounds (Bunn et al. 2008), which may leave the ecosystem. Concentrations of mobile forms of Se in the environment are also affected by pH. Acidic conditions tend to favor less soluble forms, while alkaline conditions tend to favor more soluble forms.

Sedimentary rocks, particularly Cretaceous marine shales (including Mancos Shale, which underlies the shallow alluvium at the MMTS), contain high concentrations of Se, and these substrates have created high Se soils in many places in the arid western United States (Eisler 1985). Rocks and soils with high concentrations of Se in combination with high-pH water often result in areas of high Se in the aquatic environment. The surface waters of Montezuma Creek have a high pH, with values ranging from 7.2 to 8.8 since millsite restoration.

Additional information on Se in the environment can be found in the 2007 macroinvertebrate monitoring report (Bunn et al. 2008).

1.3 Selenium in Aquatic Ecosystems

Se is essential to living organisms in trace amounts. However, the difference between essential and toxic concentrations is often not great (Maiers et al. 1988). Wetlands in the arid western United States are often more susceptible to Se accumulations than wetlands in other areas (Section 1.2). Elevated levels of Se in an ecosystem can result in damage to organisms, particularly vertebrates. Fish, mammals, and birds may experience mortality, reproductive abnormalities, growth retardation, behavioral modification, chromosomal aberrations, internal lesions, and other diseases (Eisler 1985). The most sensitive indicator of Se toxicity in aquatic birds is reproductive failure. Toxicity thresholds vary greatly by species, but invertebrates are often able to build up tissue concentrations of Se toxic to their predators but not to themselves (Lemly 1993).

Se typically enters aquatic ecosystems in solution. It may remain in solution, or, more commonly, it is ingested or absorbed by organisms or bound with particulate matter such as clay particles or detritus. Even if it has accumulated in sediments in insoluble forms, it may not remain inert. Biological and chemical processes such as oxidation by plant photosynthesis or methylation by microbes convert it to mobile forms. Physical factors, such as currents and upwelling, also mobilize Se. Because of this cycling, Se may remain at elevated levels for extended periods of time in an aquatic ecosystem, even after discharge to the system has ceased.

Aquatic organisms often accumulate Se in concentrations one or more orders of magnitude greater than concentrations in their water or food (Lemly and Smith 1987).

2.0 Field Sampling Activities

Original field procedures for the macroinvertebrate biomonitoring at Monticello were developed by the Pacific Northwest National Laboratory (DOE 2005a) to meet DOE's Program Directive MSG 05-02 (DOE 2005b). Original field procedures included kick net, Hester-Dendy substrate, and light trap sampling at Wetlands 1–3 and the sediment retention pond. As the biomonitoring became more focused, the 2008 sampling effort required only kick net sampling at Wetland 3, and kick net and Hester-Dendy substrate sampling at the sediment retention pond. The field procedures were revised in 2006, 2007, and 2008 to reflect the changing scope of the sampling efforts. The scope changed each year in response to BTAG decisions as the previous year's data were collected and analyzed. All 2008 work was done in accordance with Program Directive MNT-08-03 (Appendix A), which includes a sampling and analysis plan detailing the revised field sampling procedures. Table 2 summarizes field sampling activities performed in 2008.

Table 2. Summary of 2008 Macroinvertebrate Field Sampling Activities by Date and Location

Field Sampling Activity	Date and Location	Conditions and Comments
Deployed Hester-Dendy samplers	4/23/08 Sediment retention pond (SRP)	Nine samplers were deployed at three locations in pond (at inlet, middle of north edge between inlet and outlet, and at outlet). Six (two at each location) were positioned horizontally on a stake at the sediment/water interface. Three (one at each location) were positioned vertically on a stake with the lower plate at substrate level.
Conducted kick net sampling	5/16/08 SRP	Samples collected 11:05–11:35 a.m. Mass of samples too low for Se analysis. Rescheduled sampling for mid-June.
Inspected and redeployed Hester-Dendy samplers	5/16/08 SRP	Water temperature at 2:36 pm was 13.4 ºC (56 ºF). Samplers placed in April were inspected for colonization. Some snails observed on samplers, but no other colonization. Redeployed two of the samplers to south edge of pond between inlet and outlet (both placed horizontally on the stake; one was taken from outlet and one was taken from middle of pond, north side).
Conducted kick net sampling	6/10/08 Wetland 3 and SRP	Wetland 3 inlet area, directly below discharge point of Seep 2, sampled 11:15 a.m.−12:40 p.m. Middle of Wetland 3, halfway between inlet and outlet, sampled 1:20−2:25 p.m. Wetland 3 outlet area sampled 2:25−4:00 p.m. Middle of sediment retention pond, located on the south edge halfway between inlet and outlet sampled 4:15−5:00 p.m. Samples cleaned and identified evening of 6/10/08.
Conducted kick net sampling	6/11/08 SRP	Sediment retention pond outlet sampled 8:15 – 9:00 a.m. Inlet sampled 9:15−10:00 a.m. Samples collected on 6/11/08 cleaned and identified. All samples shipped for analysis afternoon of 6/11/08.
Inspected Hester-Dendy samplers	5/16/08 – 7/22/08 SRP	No evidence of colonization observed during any of these inspections except 7/2/08 (see below). Dates of inspections: 5/16/08, 5/21/08, 6/11/08, 6/17/08, 7/2/08, and 7/22/08.
Inspected Hester-Dendy samplers	7/2/08 SRP	All samplers inundated and correctly placed when inspected. Two caddisfly cases observed on one sampler at pond outlet. Disassembled one sampler at inlet location to inspect all surfaces; no evidence of colonization. Reassembled and redeployed sampler at same location. Observations: large numbers of adult damselflies, heavy algae growth around shore; dead catfish at south end of pond between inlet and outlet. All samplers placed in slightly deeper locations after inspection because water level had dropped in pond.
Removed Hester-Dendy samplers	7/22/08 SRP	All samplers collected, disassembled, and inspected. No evidence of colonization except two empty caddisfly cases observed on 7/2/08 and several very small midge larvae. Biomass not large enough for analysis. Samplers not redeployed.

Kick net sampling (Figure 2) is the preferred method for collecting macroinvertebrates in areas where the emergent vegetation is dense and the water is shallow (Barbour et al. 1999), such as Wetland 3 and the margins of the sediment retention pond. Hester-Dendy substrate samplers (Figure 3) collect species that colonize underwater surfaces in relatively fast moving, deeper water. The sediment retention pond contains deeper water that potentially supports such species. Water levels in Wetland 3 are normally not sufficient for Hester-Dendy sampling.

Figure 2. Kick Net Sampling in Wetland 3 During 2007 Field Season

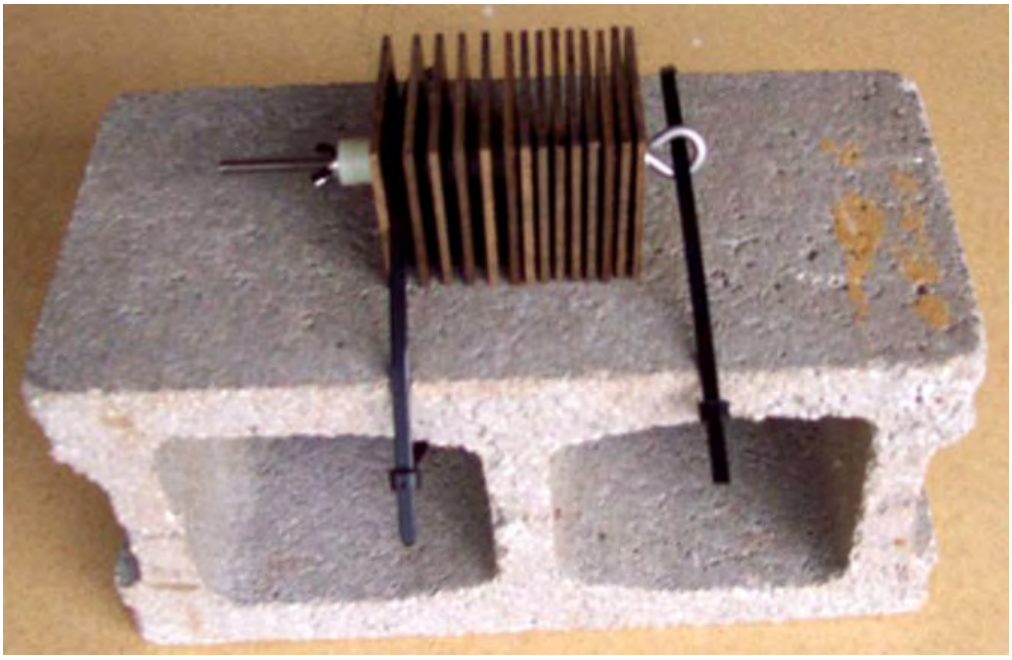

Figure 3. Hester-Dendy Substrate Sampler Used During 2005 Biomonitoring
In 2008, samplers were attached to posts rather than to cinder blocks.

2.1 Kick Net Sampling

Kick net collection of macroinvertebrates was conducted on May 16 and June 10–11, 2008. On May 16, kick net samples were collected at the sediment pond outlet, the location that yielded the greatest mass of macroinvertebrates in 2007. To accurately test for Se, a minimum wet mass of 3 grams (g) is required. After 35 minutes of sampling, the wet mass of the collected sample was 0.2 g, well short of the target value. In addition, several of the major taxonomic groups collected in previous years were not present. The species composition of this sample included five scuds (*Amphipoda*), one emerging subimago mayfly (*Ephemeroptera*), one mosquito larva (*Diptera – Culicidae*), two adult water beetles (*Coleoptera*), four larval predaceous diving beetles (*Coleoptera – Dytiscidae*), four small snails (*Gastropoda*), and one larval midge (*Diptera – Chironomidae*). The low mass of the sample indicated that additional time was needed for seasonal macroinvertebrate populations to develop. Development of these populations was delayed in 2008 by unusually low temperatures and higher-than-average snowfall the previous winter. Spring avian surveys indicated that the migration of most bird species was also delayed. During kick net sampling, subimago mayflies were observed in large numbers at the pond.

In 2008, water levels at all sampling locations were high enough to accommodate the kick net. In previous sampling years, the first sample stratum in Wetland 3 was the discharge point of water from Montezuma Creek through a constructed infiltration gallery. In 2008, the first sample stratum was changed to the discharge point of Seep 2. Although the volume of water discharged from the seep is much less than the volume from Montezuma Creek, the seep is the probable source of Se for the wetland area. Including this seep area in sampling is expected to better measure the maximum levels of Se present in macroinvertebrates in the aquatic ecosystem. Water depth at this “new inlet” of Wetland 3 was estimated to be 10–20 centimeters (cm), or

4−8 inches. At the middle region of Wetland 3, water depth was estimated to be 20–46 cm (8−18 inches) and ranged from 30 cm (12 inches) to over 61 cm (24 inches) in the outlet area. At the sediment retention pond, macroinvertebrates were collected in three areas containing emergent vegetation. Water depths in these areas ranged from approximately 15 to 61 cm (6–24 inches), depending upon how close to the shore emergent vegetation was found.

Three samples were collected from Wetland 3, and three samples were collected from the sediment retention pond. The wet mass of the samples ranged from 4.9 to 19.1 g. A small quantity of pond water was added to the samples after collection, and they were immediately placed on ice. After field collection, samples were taken indoors, rinsed with deionized water, identified, weighed, and transferred into pre-tared HDPE containers with no added water. They were then shipped to Sequim, Washington, for laboratory analysis. Samples were chilled at all times except during rinsing and identification. Procedures included creating a field duplicate from one sample for quality control (QC) and removing large macroinvertebrates (e.g., large snails) in the field to minimize sample bias. Table 3 summarizes the composition of the samples. Appendix B provides information about the habitat, feeding styles and diets of the types of macroinvertebrates found in the Monticello wetlands between 2005 and 2008.

In Wetland 3, the majority of macroinvertebrates collected at all locations were snails and water beetles. The composition of macroinvertebrates varied between the inlet, middle, and outlet areas. Snails were predominant at the inlet and outlet of the wetland, but beetles were predominant in the middle. Damselfly larvae (*Odonata–Zygoptera*) were relatively common at the outlet, but not at the inlet or middle. The remainder of the samples contained small numbers of dragonfly larvae (*Odonata–Anisoptera*), scuds, backswimmers (*Notonectidae*), larval midges (*Diptera−Chironomidae*) and mosquitoes, and aquatic earthworms (*Oligochaeta*).

Snails, dragonfly larvae, and damselfly larvae were the dominant macroinvertebrates in the sediment retention pond. Beetles, scuds, and true bugs (*Hemiptera*, including backswimmers and water boatmen [*Corixidae*]) were also found in smaller quantities. Mayflies and crayfish (*Decapoda*), common in previous sampling years, were rare in 2008. Snails were common throughout the pond. Beetles, the predominant type of macroinvertebrate at the outlet, were not found at the inlet. Dragonflies and damselflies were most abundant at the inlet and least abundant at the outlet. The sample with the largest wet mass, the sample producing the field duplicate, was collected at the middle of the sediment pond. Figure 4 illustrates the diversity of organisms collected at this location.

Table 3. Composition of Macroinvertebrate Samples

Location	Stratum	Sample Wet Weight (g)	Sample Composition (based on % of total wet mass of sample)
Wetland 3	S1(inlet)	7.9	*Gastropoda*–snails–73% *Coleoptera* (*Dytiscidae*)–predatory diving beetles–L[a]–16% *Amphipoda*–scuds–4% *Coleoptera*–beetles–A[b]–3% *Hemiptera* (*Notonectidae*)–backswimmers–A–1% *Odonata* (*Anisoptera*)–dragonflies–L–1% *Diptera* (*Culicidae*)–mosquitoes–L–1%
	S2(middle)	4.9	*Coleoptera* (*Dytiscidae*)–predatory diving beetles–L–77% *Coleoptera*–beetles–A–18% *Gastropoda*–snails–4% *Diptera* (*Culicidae*)–mosquitoes–L–0.5% *Amphipoda*–scuds–0.5%
	S3(outlet)	8.2	*Gastropoda*–snails–63% *Odonata* (*Zygoptera*)–damselflies–L–17% *Coleoptera* (*Dytiscidae* –predatory diving beetles–L–13% *Coleoptera*–beetles–A–5% *Oligochaeta*–aquatic earthworms–1% *Diptera* (*Chironomidae*)–midges–L–0.5%
Sediment Retention Pond	S1(inlet)	12.2	*Odonata* (*Anisoptera*)–dragonflies–L–36% *Gastropoda*–snails–35% *Odonata* (*Zygoptera*)–damselflies–L–21% *Hemiptera* (*Notonectidae*)–backswimmers–A–3% *Hemiptera* (*Corixidae*)–water boatmen–A–2% *Amphipoda*–scuds–2%
	S2(middle); Split 1	8.3	*Gastropoda*–snails–43% *Odonata* (*Anisoptera*)–dragonflies–L–25% *Odonata* (*Zygoptera*)–damselflies–L–11% *Coleoptera*–beetles–A–10% *Hemiptera* (*Corixidae*)–water boatmen–A–8% *Hemiptera* (*Notonectidae*)–backswimmers–A–1% *Coleoptera* (*Dytiscidae*)–predatory diving beetles–L–1% *Amphipoda*–scuds–1%
	S2(middle); Split 2	10.8	*Gastropoda*–snails–36% *Odonata* (*Anisoptera*)–dragonflies–L–24% *Odonata* (*Zygoptera*)–damselflies–L–22% *Coleoptera*–beetles–A–8% *Hemiptera* (*Corixidae*)–water boatmen–A–6% *Coleoptera* (*Dytiscidae*)–predatory diving beetles–L–2% *Hemiptera* (*Notonectidae*)–backswimmers–A–1% *Amphipoda*–scuds–1%
	S3(outlet)	14.9	*Coleoptera*–beetles–A–34% *Gastropoda*–snails–28% *Odonata* (*Zygoptera*)–damselflies–L–24% *Hemiptera* (*Corixidae*)–water boatmen–A–5% *Coleoptera* (*Dytiscidae*)–predatory diving beetles–L–5% *Odonata* (*Anisoptera*)–dragonflies–L–3% *Hemiptera* (*Notonectidae*)–backswimmers–A–1% *Ephemeroptera*–mayflies–L–0.5% *Amphipoda*–scuds–0.5%

[a]L indicates larval life stages
[b]A indicates adult life stages

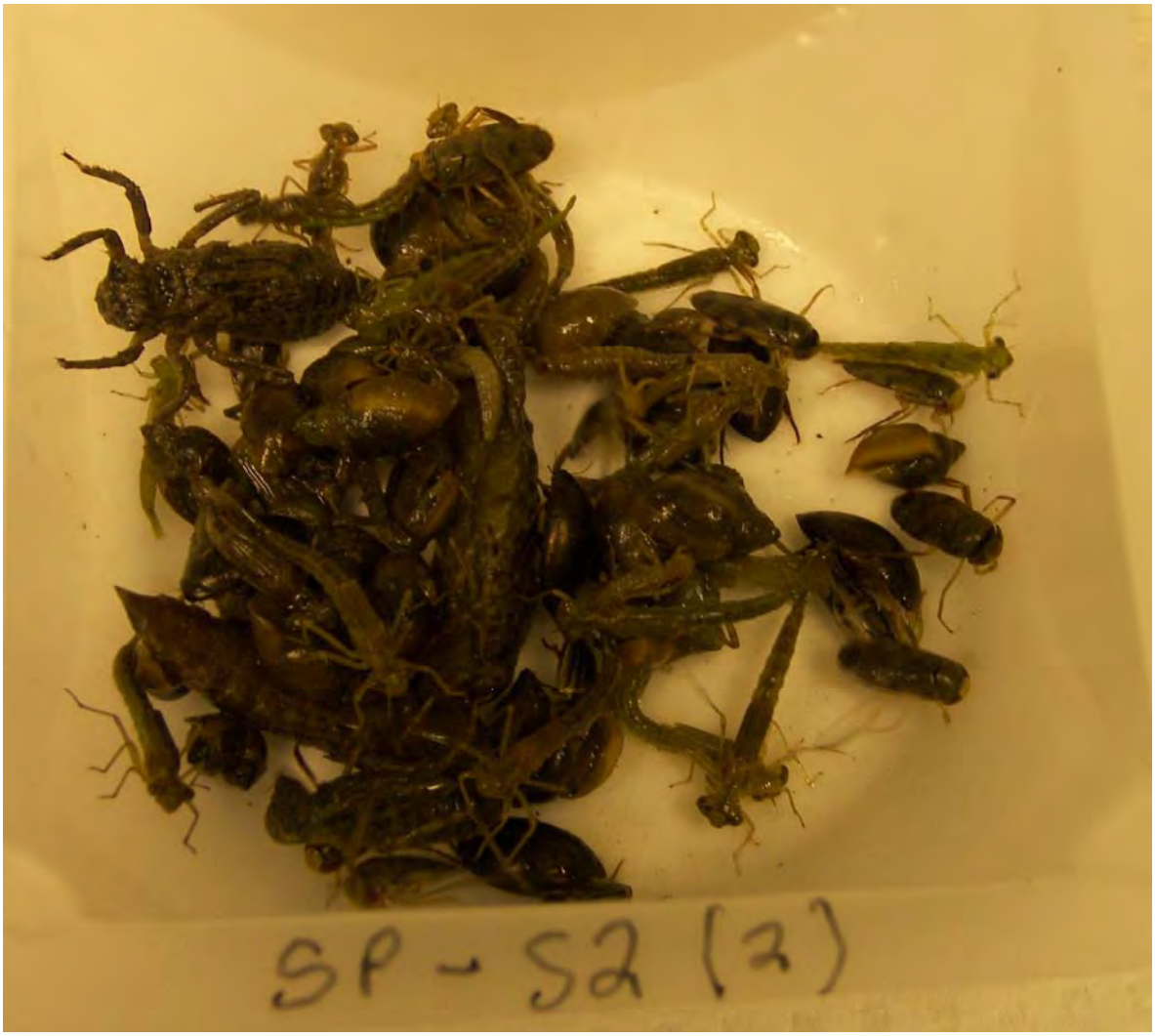

Figure 4. Examples of Macroinvertebrates Collected at the Sediment Retention Pond in 2008

2.2 Hester-Dendy Artificial Substrate Sampling

The Hester-Dendy artificial substrate samplers (Figure 3) were deployed at the sediment retention pond on April 23, 2008 (Table 2). The sampler plates were constructed of masonite, which contains both rough and smooth surfaces. Each sampler consisted of 14 round plates, 7.5 cm (3 inches) in diameter, spaced at varying distances, with a total surface area of 0.16 square meter. A total of nine samplers (three at each of three locations) were deployed in the pond. Three samplers were positioned near the pond inlet, three between the inlet and the outlet on the northern pond shore, and three near the pond outlet. Samplers were affixed to metal posts, and the bottom of each sampler was positioned at the sediment-water interface. Two samplers at each location were positioned horizontally on the stake, with the plates perpendicular to the surface of the water. This was the orientation of the samplers that were deployed in 2005, 2006, and the last portion of 2007. To increase the diversity of sampling methods and potentially increase the number of organisms collected in 2008, one of the three samplers at each location was positioned vertically on the stake, with the plates parallel to the water's surface.

On May 15, 2008, all samplers were inspected for colonization and redeployed. Except for snails, no colonization had occurred. Most of the samplers were repositioned at the same locations, but two of the samplers were placed on the south edge of the pond midway between the inlet and outlet. In April, high flow conditions were present at the inlet and outlet, which prevented safe crossing of the creek, but water levels had dropped by mid-May. One sampler from the outlet area and one from the middle area, both of which were positioned horizontally on the stake, were relocated.

Hester-Dendy samplers were inspected at regular intervals six times during the field season. No colonization was evident except on July 2, 2008, when two caddisfly (*Trichoptera*) cases were observed on one sampler in the semi-flowing water near the pond's outlet. Because these two organisms did not represent a large enough mass to test for Se, the samplers were redeployed. On July 22, 2008, all of the samplers were collected in Ziploc bags with pond water and transported on ice to the Monticello Field Office for disassembly. Disassembly and inspection of the plates confirmed that no significant colonization had occurred at any of the sampling locations. The previously observed caddisfly cases had been abandoned, and a small number of midge larvae (with a total mass of less than 0.1 g) were found.

Throughout the sampling period, large quantities of organic material and algae were observed in the sediment retention pond. On July 22, a dead catfish (15–20 cm [6–8 inches] in length) was also observed (it was probably moved into the pond from an outside area). Caddisflies are common macroinvertebrates in Montezuma Creek (Peterson et al. 2002), where higher oxygen levels associated with flowing water are expected, but the macroinvertebrate sampling data indicate that caddisflies are not abundant in the sediment retention pond. The Hester-Dendy samples collected in 2005 contained no caddisflies; the samples were composed of species also collected with kick nets (dragonfly and damselfly larvae, snails, aquatic worms, and midges). Numerous caddisfly larval cases were found in 2006, but the Hester-Dendy samplers were recovered after most were abandoned. Little caddisfly colonization was observed in 2008. Water quality conditions in some years may prevent populations of substrate feeders such as caddisflies from establishing. One contributing factor may be that in ponds like the sediment retention pond, high levels of nutrients and algae blooms can lead to oxygen depletion events, particularly on cloudy days and at night when mass die-backs of algae may occur (Brunson et al. 1994). Nutrient levels may have increased in 2007 and 2008 in the pond, when the landowner planted crop fields immediately upstream, providing additional nutrients that make algae blooms more likely.

3.0 Selenium Analysis

Kick net samples were analyzed for Se at the Battelle Marine Sciences Laboratory (MSL) in Sequim, Washington, according to the procedure outlined in a statement of work (Appendix C). The statement of work was developed from Program Directive MNT-08-03 (Appendix A).

Seven macroinvertebrate tissue samples were received at MSL on June 12, 2008, in good condition (i.e., no sample containers were broken or leaking). The temperature of the cooler on arrival was 2.1 ºC, within the appropriate range of 4 ± 2 °C. The kick net samples were frozen until Hester-Dendy collection. However, no adequate samples were recovered from the Hester-Dendy samplers, and the kick net samples were processed alone on July 28−31, 2008.

The tissue samples were removed from their shipping jars, freeze-dried (lyophilized) and homogenized using a ball-mill to determine percent dry weight. The homogenized samples were digested using nitric and hydrochloric acids in a sealed Teflon vessel by heating in an oven at 130 °C ±10 °C for a minimum of 8 hours. Digested samples were analyzed for Se using hydride generation flow injection atomic absorption spectroscopy (HGAA-FIAS). The base method for this procedure is EPA Method 270.3. All results were determined and reported in units of micrograms per gram (milligrams per kilogram) on a dry weight basis. Results of Se analysis are summarized in Table 4 and detailed in Appendix D, which also includes the laboratory's quality assurance/quality control narratives and chain of custody documentation.

Table 4. Results of Selenium Analysis

Location	Stratum	Sample Wet Wt (g)	Percent Moisture	Se (µg/g dry wt)	Geometric Mean (Geometric standard deviation)
Wetland 3	S1(inlet)	7.9	80.6	13.0	6.25 (1.70)
	S2(middle)	4.9	79.7	5.06	
	S3(outlet)	8.2	78.2	3.71	
Sediment Retention Pond	S1(inlet)	12.2	77.4	4.9	5.49 (1.27)
	S2(middle); Split 1	8.3	75.6	4.5	
	S2(middle); Split 2	10.8	75.0	4.32	
	S3(outlet)	14.9	79.3	7.64	

Table 4 contains individual sample data along with the geometric mean and geometric standard deviation for each wetland area. As in previous reports, the geometric mean is provided rather than the arithmetic mean (Bunn et al. 2008, Bunn et al. 2007). To calculate the geometric mean of the samples from the sediment retention pond, the geometric mean of the field duplicate samples (S2 Splits 1 and 2) was calculated, and this value was used to calculate the overall geometric mean. The 2008 samples contained no individual macroinvertebrates with a mass great enough to bias the sample, so all samples from all locations were used in calculating the mean values.

One field duplicate was collected to evaluate invertebrate sample variability. It was prepared by splitting the sample collected at the sediment pond stratum S2, after identification, into two individual samples with similar species composition. The samples were submitted in separate containers for individual analysis. The results of the field duplicate samples were similar, which indicates that the macroinvertebrates at the sampling location were consistently exposed to the highest level of available Se during 2008.

Data quality criteria for the analysis of Se include the method detection limit (MDL) and reporting limit (RL). The MDL is the sample concentration that can be detected above zero with a 99 percent confidence level for a given method (Corl et al. 2002). For this HGAA-FIAS analysis of macroinvertebrate tissues, the MDL is 0.0089 µg/g dry weight. The MDL values are determined annually, and the 2008 value is lower than the values for 2005, 2006, and 2007. It is also well below the value of 0.02 µg/g required in the statement of work (Appendix C). The RL is the level at which the concentration can be reported with a reasonable degree of accuracy and

precision. For this analysis the RL is determined to be 3.18 times the MDL, or 0.026 μg/g dry weight. Sample values were all greater than the RL.

The laboratory QC measures analyzed with the macroinvertebrate samples include a method blank, a matrix spike and matrix spike duplicate, a laboratory duplicate, and a laboratory control sample (blank spike), as discussed in the statement of work (Appendix C). Accuracy was also measured using standard reference material (SRM). A method blank was prepared in order to detect contamination associated with sample storage, preparation and instrumentation. Se was not detected at a level greater than the MDL. Known amounts of Se were added to sample aliquots to create matrix spikes. The percent recovery of each matrix spike measures the effects of the sample matrix itself on the accuracy. In 2008, there was sufficient material to analyze both a matrix spike and a matrix spike duplicate. The matrix spike recoveries ranged from 89−105 percent, within the QC criterion of 75–125 percent. The relative percent difference, a measure of precision of the analysis, was 16 percent, within the QC criterion of <20 percent. One laboratory duplicate was also processed to evaluate laboratory analytical precision. It was prepared by splitting a field sample (sediment pond S1) in the laboratory, following homogenization, into two independent samples. The relative percent difference was 2 percent, well within the QC criterion of <20 percent. A laboratory control sample was prepared by adding a known amount of Se to deionized water, then analyzed. The percent recovery, a measure of laboratory accuracy, was 103 percent, well within the QC criterion of 75–125 percent. The SRM analyzed with the macroinvertebrate samples was 1566b Oyster tissue, because there are no commercially available SRMs for invertebrate tissue. Percent recovery was 98 percent, demonstrating excellent laboratory analytical accuracy.

4.0 Discussion of Biomonitoring Results

In this section, the results of macroinvertebrate sampling are compared to previous years' data. Results of other portions of the biomonitoring effort—surface water sampling, sediment sampling, and avian surveys—are also discussed. These results are included to place the macroinvertebrate data in a larger context and facilitate future decision making.

Previous studies indicate that environmental Se in macroinvertebrates in the area is high. This is probably the result of elevated Se in surrounding rocks and soils coupled with high-pH water. Because Se levels of macroinvertebrates are elevated in background locations in Montezuma Creek and Verdure Creek (Peterson et al. 2002), it is probable that a portion of the Se measured during macroinvertebrate monitoring is attributable to naturally high background levels.

Levels of Se in macroinvertebrates are generally considered to measure bioaccumulation in an ecosystem better than traditional abiotic measurements (Peterson et al. 2002). This was supported by a comparison of 2007 data, which indicated that sediment and surface water results do not appear to predict Se concentrations in macroinvertebrate tissue in these Monticello aquatic ecosystems (Bunn et al. 2008). Scatterplots of the 2005–2008 data indicate no correlation between Se concentrations in sediment vs. macroinvertebrates or in surface water vs. macroinvertebrates.

4.1 Selenium in Macroinvertebrates

Figure 5 compares macroinvertebrate data from Wetland 3. For all years, the geometric mean was within the level of concern. The mean has trended downward in this wetland during the monitoring period (statistically significant to the 99 percent confidence level). Three individual samples exceeded the toxicity threshold: the samples from the middle of the wetland in 2005 and 2007, and the sample from the "new inlet" in 2008. Because of low water levels in 2007, 2008 was the first sampling of macroinvertebrates from the "new inlet" area. The "old inlet" is the location where water from Montezuma Creek, the primary source of water into Wetland 3 (see Section 2.1), enters the wetland from an underground infiltration area, but the new inlet potentially represents the wetland area's highest Se levels. Even with the elevated levels at the new inlet area, mean Se levels for Wetland 3 have trended downward.

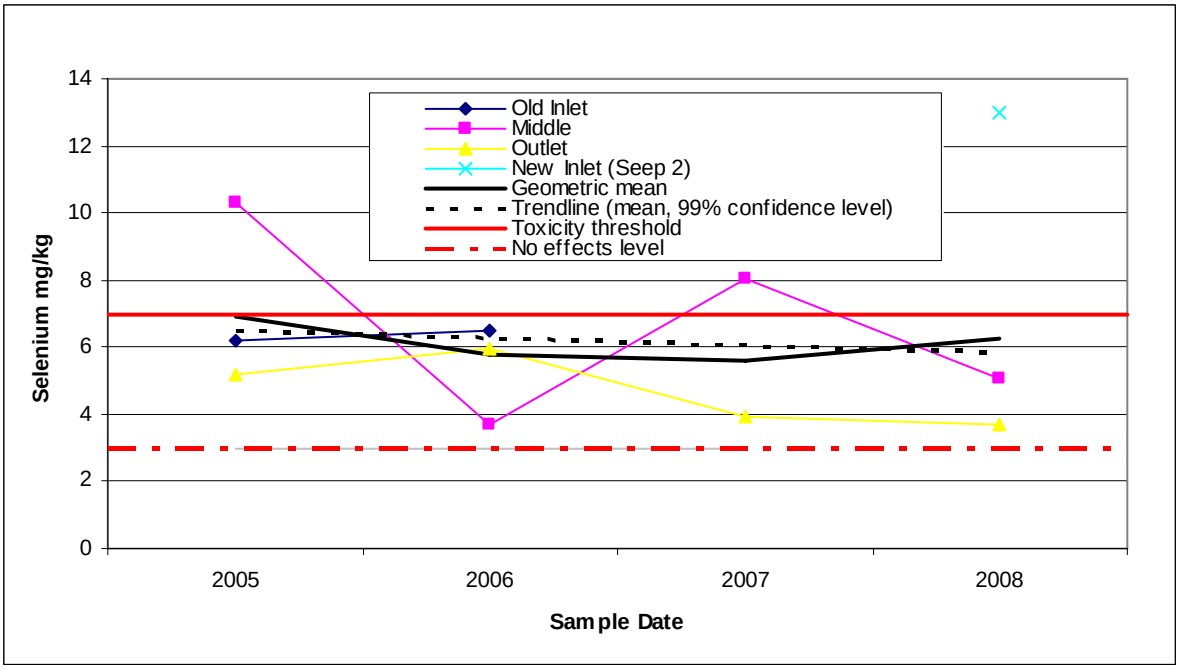

Figure 5. Wetland 3 Macroinvertebrate Data 2005–2008

Macroinvertebrate data from the sediment retention pond are shown in Figure 6. As in Wetland 3, the geometric mean was within the level of concern in all sampling years. The toxicity threshold was exceeded only at the middle sampling location in 2007 and at the outlet in 2008. However, the geometric mean values may have trended upward during the monitoring period. The upward trend is statistically significant at the 90 percent confidence level, but not at the 95 percent confidence level.

Hester-Dendy samplers were deployed in the sediment retention pond on four occasions (2005−2008), and in years when samples were successfully collected, sample recovery weights were small. Because of this, samples had to be composited for analysis. The largest sample mass, collected in 2006 from three samplers, totaled 2.18 g, below the 3-g minimum guideline for laboratory analysis. In 2006, 20.89 g of macroinvertebrates were collected with kick nets at the same location in approximately 3 hours.

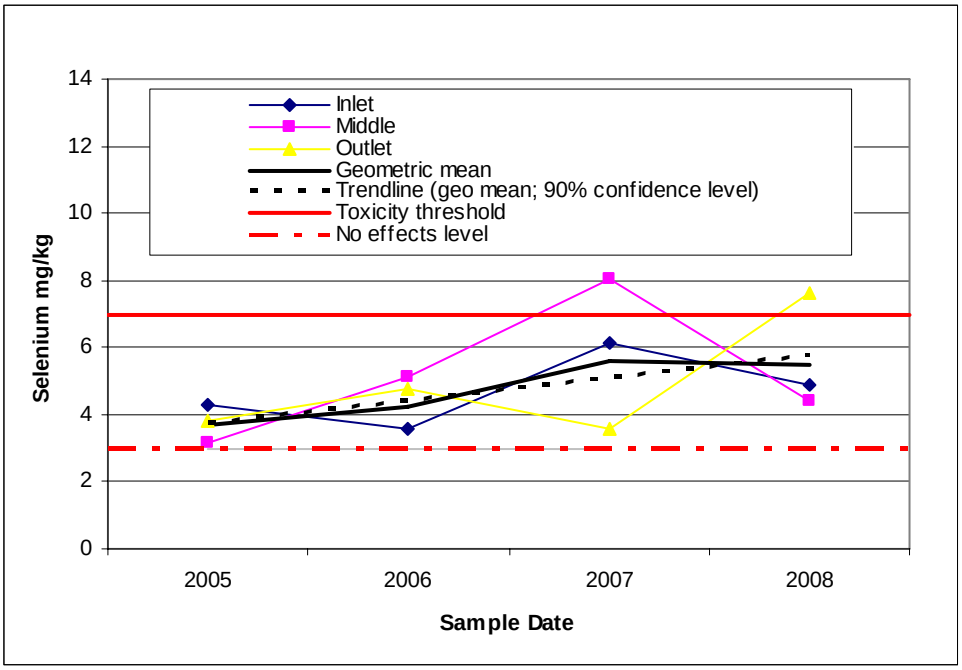

Figure 6. Sediment Retention Pond Macroinvertebrate Data from 2005–2008

4.2 Macroinvertebrate Feeding Groups

Table 5 summarizes the distribution of macroinvertebrate functional feeding groups between 2005 and 2008. The 2005−2007 data are estimated from previous reports, and values are weighted according to the proportion of the total mass of all samples collected from each wetland area. Feeding group categories are based on trophic level rather than feeding style. The category "collector-gatherers" also includes scrapers and filter feeders; these feeding types consume primarily algae, protozoa, and tiny macroinvertebrates. Detritivores consume mainly detritus (decaying organic matter), although their diet may contain other things, and predators primarily consume other macroinvertebrates. These results indicate that predators are the most common feeding group collected by kick nets in both wetland areas. Numbers of detritivores and collector-gatherers are similar. Predators appear to be more abundant relative to other groups in the sediment retention pond than in Wetland 3. Most of the taxa recovered from Hester-Dendy samplers were also recovered from kick net samples, indicating that the different sampling techniques are not sampling substantially different food sources for avian species.

Table 5. Macroinvertebrate Feeding Group Distribution (percent) in Kick Net Samples

	Wetland 3			Sediment Retention Pond		
	Detritivores	**Collector-gatherers**	**Predators**	**Detritivores**	**Collector-gatherers**	**Predators**
2005	16	16	67	30	10	61
2006	7	28	65	15	27	58
2007	45	37	19	14	10	77
2008	19	17	64	25	30	45
Mean	**22**	**25**	**54**	**21**	**19**	**60**

4.3 Surface Water

Surface water samples were collected and analyzed for Se in Wetlands 1 and 2 between October 2004 and April 2007. Se in Wetland 1 has remained below the no effects level since October 2005, and no samples exceeded the toxicity threshold during the monitoring period. No samples from Wetland 2 were above the no effects level. Because Se benchmarks have not been exceeded in these wetlands, BTAG agreed to discontinue monitoring in these areas. Results from these wetlands are included in the 2007 monitoring report (Bunn et al. 2007).

In all surface water samples collected from Wetland 3 and the sediment retention pond, unfiltered aliquots were taken because they represent exposure to macroinvertebrates better than filtered aliquots. Figure 7 compares the results of surface water sampling in Wetland 3 from 2004 through 2008. The geometric mean has remained near the no effects level. No statistically significant positive or negative trends in the mean Se levels in surface water exist in Wetland 3. The toxicity threshold was exceeded in October 2004, April 2007, and April 2008 at the inlet, the location where high-Se Seep 2 discharges into the wetland. No other Wetland 3 surface water samples exceeded the toxicity threshold, and most remained below the level of concern.

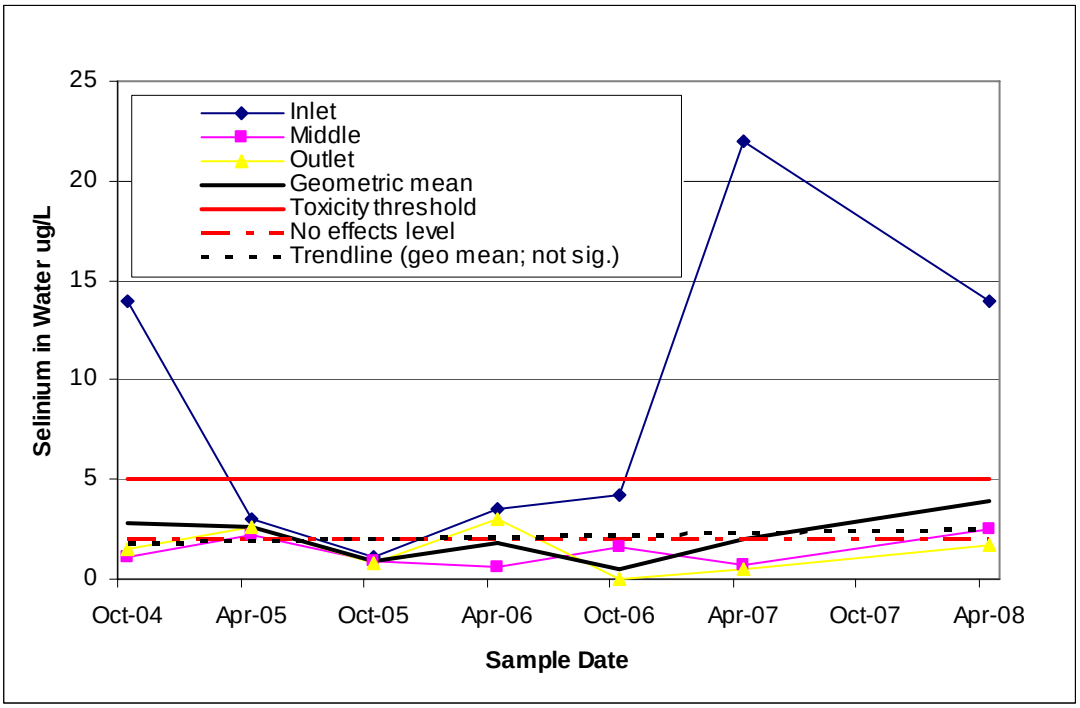

Figure 7. Surface Water Sampling Data from Wetland 3

Se in sampled surface water at the sediment retention pond is summarized in Figure 8. In the pond, the geometric mean has remained within the level of concern during the entire monitoring period. During the monitoring period, Se levels have trended upward (statistically significant at the 99 percent confidence level). However, the trendline is not a projection line, and levels of Se have remained constant since October 2006. No sample has exceeded the toxicity threshold at the sediment retention pond during the monitoring period.

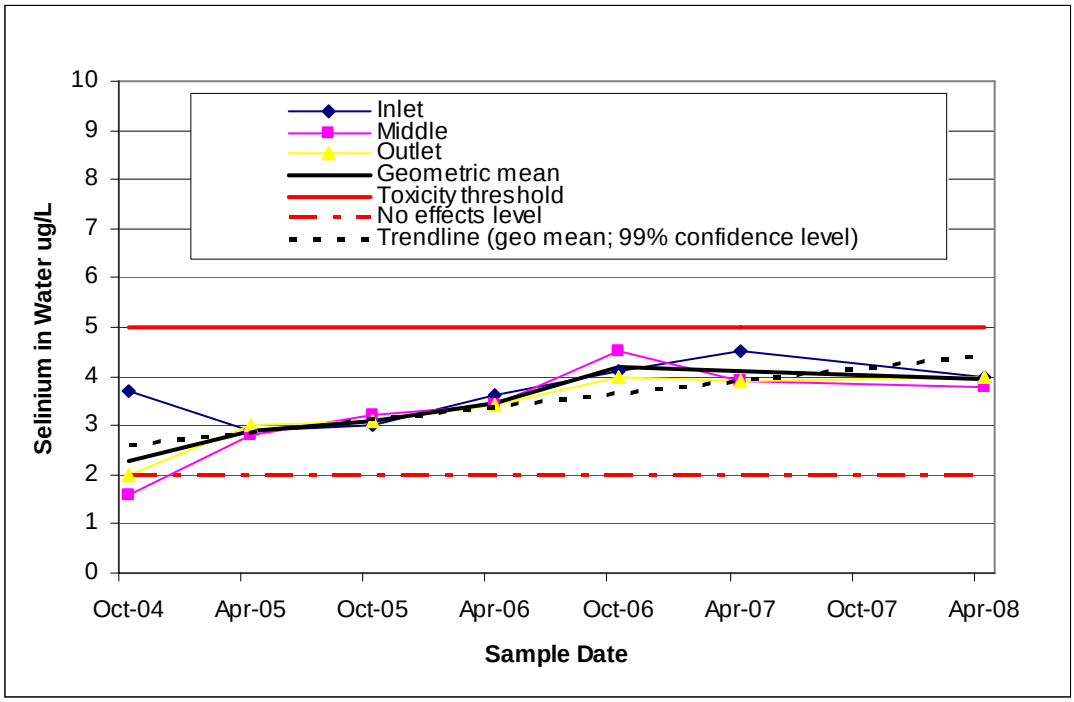

Figure 8. Surface Water Sampling Data from the Sediment Retention Pond

The majority of the water supply into the former mill site wetlands comes from Montezuma Creek. Surface water quality at many locations in Montezuma Creek and at the discharge point of the MMTS seeps is monitored under a separate program. Figure 9 shows Se levels in Montezuma Creek surface water upstream, at, and downstream from the mill site.

Legend entries in Figure 9 are in order from upstream locations to downstream locations. In Montezuma Creek, concentrations of Se in surface water have generally been at or above the no effects level since 1995, both at mill site and at downstream sampling locations. After the MMTS remediation period (2000−2003), Se levels increased, but they have trended downward since 2003. The increase in Se after remediation probably resulted from groundwater leaching Se from unweathered Mancos Shale exposed by scraping during tailings removal.

Two of the MMTS seeps emerge from the hillside above Wetland 3. Seep 3 emerges above the millsite access road and probably contributes water to Seep 2. Seep 2 emerges from the north bank of Wetland 3. Se levels in the seeps' surface water at the discharge points have been elevated since monitoring began in 2001. However, Se levels in groundwater at Seep 2 and Seep 3 have trended downward over time (Figure 10). The downward trend is significant at the 99 percent level for Seep 3 and at the 90 percent level for Seep 2.

4.4 Sediments

Sediments in Wetlands 1 and 2 were sampled for Se between October 2004 and April 2007. Because levels were consistently below the no effects level, and no upward trending was apparent, BTAG approved discontinuing monitoring in these areas. Results from these wetlands are included in the 2007 monitoring report (Bunn et al. 2008).

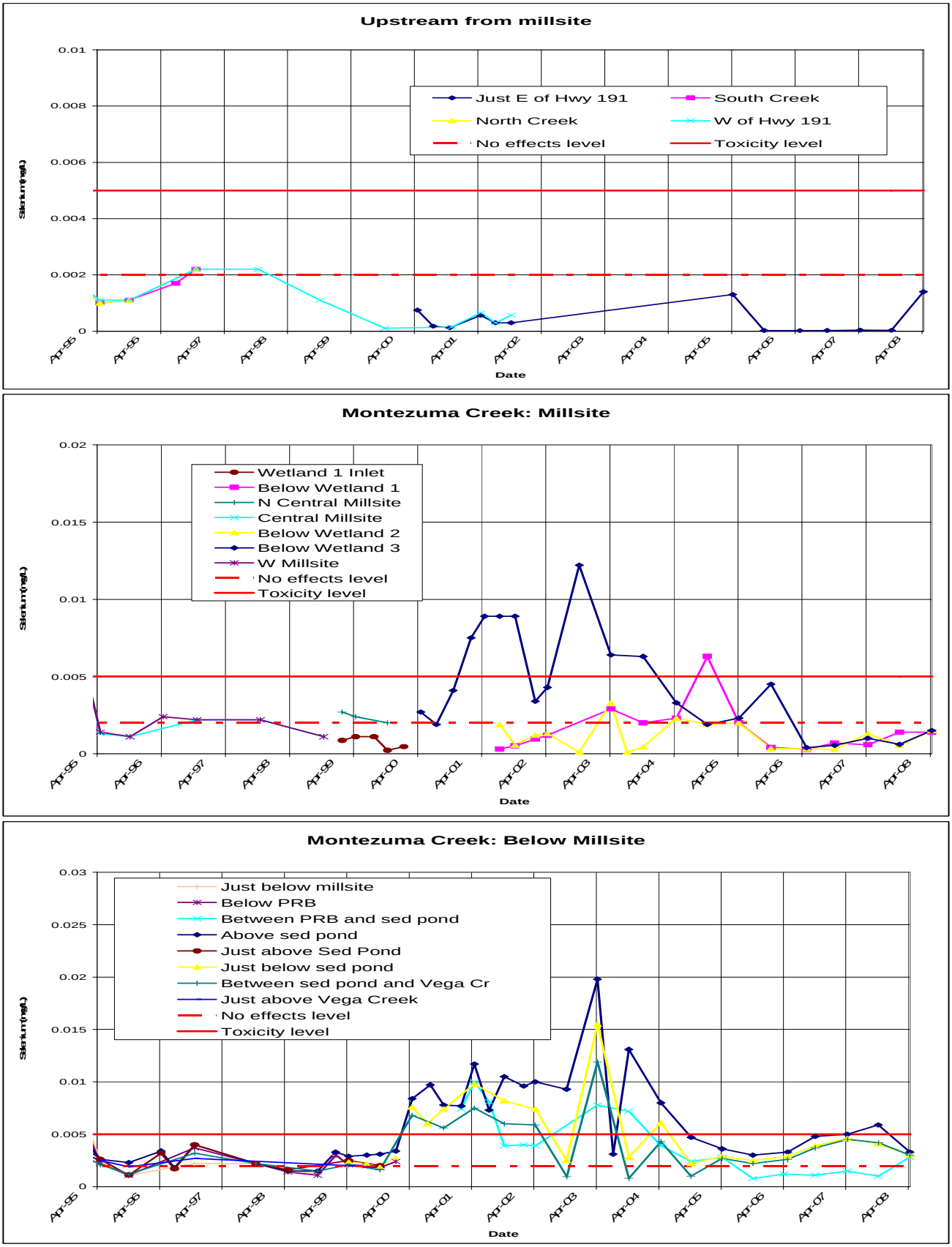

Figure 9. Selenium in Surface Water Samples from Montezuma Creek, 1995−2008

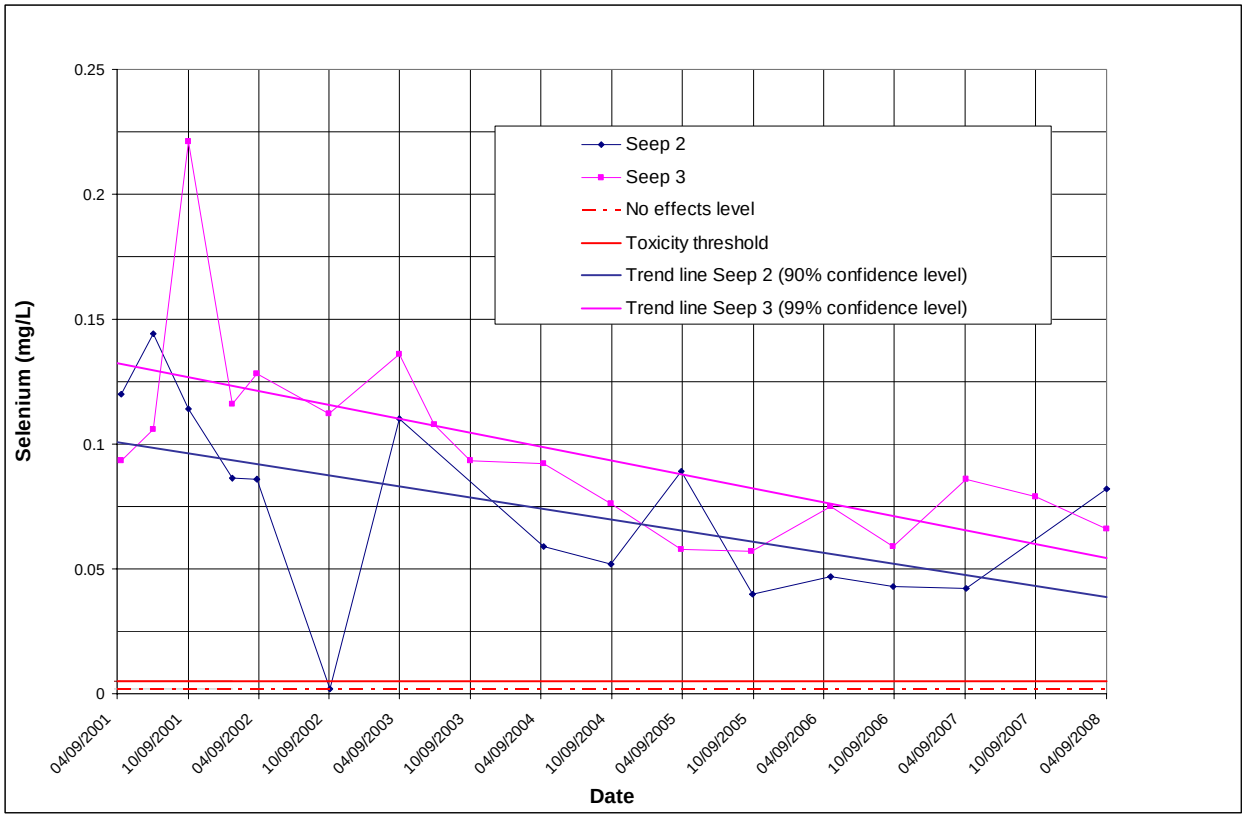

Figure 10. Selenium in Surface Water Samples from Seeps Discharging Above Wetland 3

Figure 11 shows the results of sediment sampling in Wetland 3 from 2004 through 2008. Although the mean value has remained below the no effects level and no statistically significant upward or downward trends exist, the toxicity threshold was exceeded on two occasions in the inflow area (April 2006 and April 2007).

Variability of samples is high in the inflow area of Wetland 3, located below the discharge point of Seep 2. A comparison of April water levels during runoff to levels of Se in sediments indicates that in high runoff years (2005 and 2008), Se values at the inflow area were low, but in low runoff years (2006 and 2007) Se values were high. This may be related to sediment loading in the inflow area during low runoff years, the result of increased biological activity during high runoff years when the inflow area contains deeper surface water, or both. Biological activity may also account for the observation that Se levels in sediments drop in October, as activity will have occurred throughout the previous summer. Variability is not high in sediments in other portions of the wetland.

Se levels in sampled sediments at the sediment retention pond are summarized in Figure 12. In the pond, the geometric mean has never exceeded the toxicity threshold, and it has remained below the level of concern since 2005. It may have trended downward during the monitoring period (statistically significant at the 90 percent confidence level, but not the 95 percent confidence level). However, the toxicity threshold was exceeded in the outflow area in October 2005 and at the inflow area in April 2007.

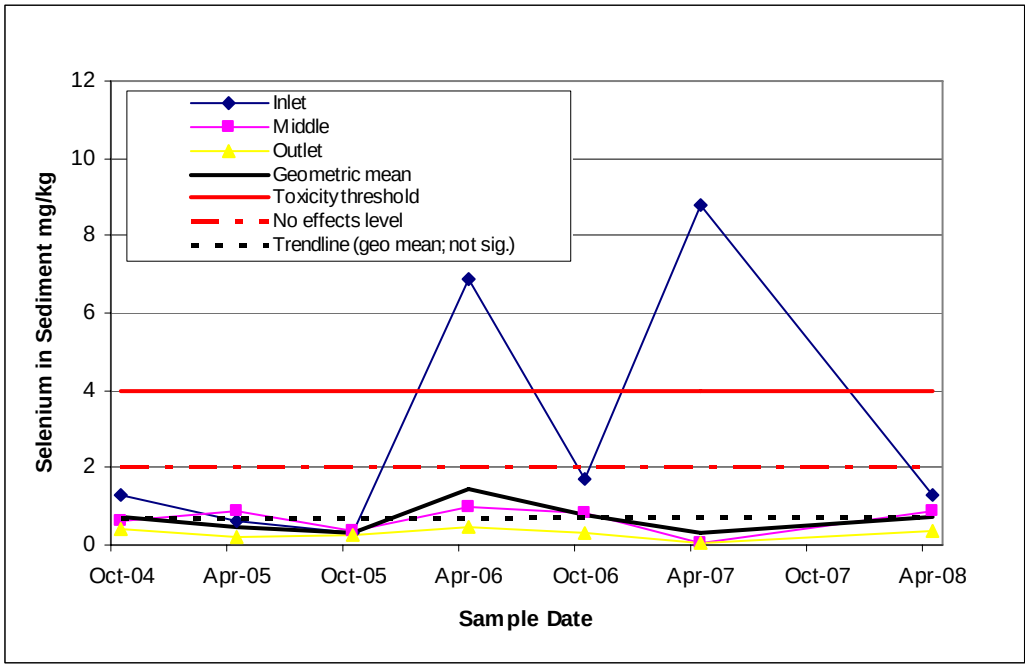

Figure 11. Sediment Sampling Data from Wetland 3

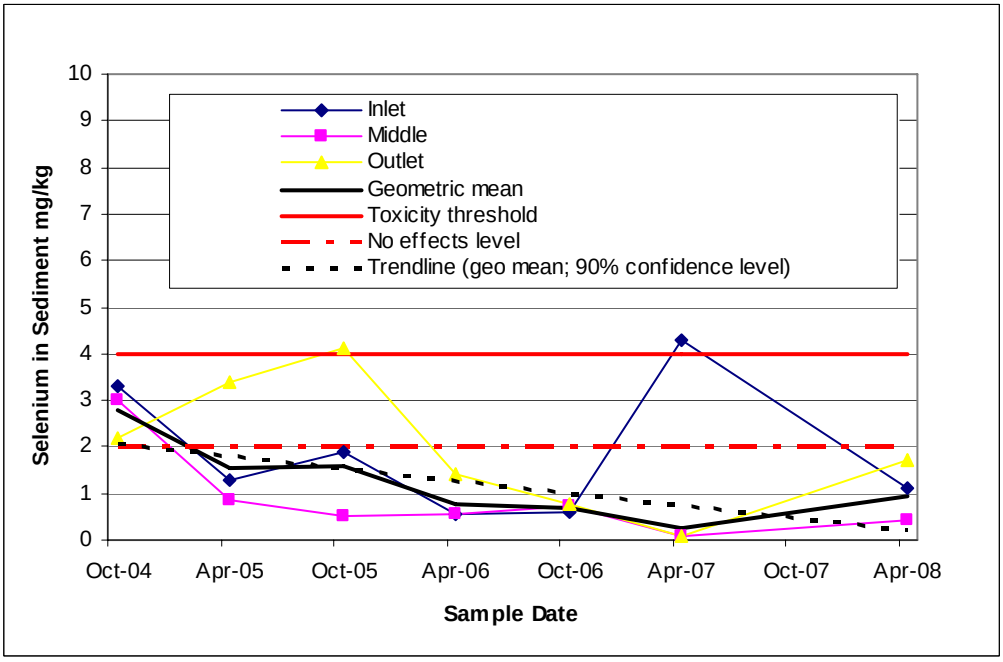

Figure 12. Sediment Sampling Data from the Sediment Retention Pond

4.5 Avian Surveys

Avian surveys were conducted at the sediment retention pond and at Wetlands 1, 2, and 3 in 2005. The purposes of the 2005 field surveys and nesting studies were to determine which avian species were present and to identify the most abundant species at each location. Red-winged blackbirds were most abundant at the emergent wetlands, and swallows, particularly cliff swallows, were most abundant at the sediment retention pond. Detailed results of these surveys are provided in *2005 Avian Wetland Surveys at the Monticello Mill Tailings Site* (DOE 2005c).

Additional avian surveys were conducted in 2006 to further characterize the most common species, particularly waterfowl, using the wetland areas. As in 2005, the predominant species observed at the emergent wetlands was the red-winged blackbird, and the predominant species at the sediment retention pond were swallows. Small numbers of mallards and Canada geese were suspected to be nesting at the sediment retention pond. Large numbers of waterfowl were routinely observed at the municipal sewage treatment lagoons, located approximately 0.25 mile north of the pond. Detailed results of these surveys are in *Office of Legacy Management 2006 Avian Wetland Surveys Monticello Mill Tailings Site* (DOE 2006).

Comprehensive avian surveys were conducted in 2008. The surveyors were trained and experienced in the identification of threatened, endangered, and sensitive bird species. The purpose of the 2008 surveys was to determine whether federally protected, State of Utah listed, or other avian species of concern not identified in previous surveys occur on or near Wetland 3 or the sediment retention pond. Eight field surveys were conducted between May 2 and August 12, 2008. In addition, five willow flycatcher surveys were conducted between May 22 and July 16, 2008. Although migrant willow flycatchers were observed at the sediment retention pond in May and June, additional surveys determined that they did not nest in the area. The subspecies of willow flycatcher was not identified, but southwest willow flycatchers (federally listed as endangered) potentially occur in the area. A migrating bobolink, listed by the State of Utah, was observed once at Wetland 3. Three Birds of Conservation Concern (as listed by the U.S. Fish and Wildlife Service) species were also observed: a black-throated gray warbler at the sediment retention pond, a Virginia's warbler at the sediment retention pond, and a breeding pair of northern harriers at Wetland 3. Detailed results of the 2008 surveys are included in *Avian Wetland Surveys at Monticello Mill Tailings Site, 2008* (DOE 2008).

Many observed species do not typically feed on aquatic macroinvertebrates or do not feed exclusively in the MMTS wetland areas. Species potentially consuming the highest quantities of macroinvertebrates from Wetland 3 (i.e., they were suspected to be nesting in the area and/or were observed feeding from the sediments and water) include the red-winged blackbird, song sparrow, and sora. Species potentially consuming the highest quantities of macroinvertebrates from the sediment retention pond include the cliff swallow, violet-green swallow, song sparrow, and black phoebe. All of these avian species are common and widespread in the region.

5.0 Recommendations for Future Activities

Because BTAG guides the biomonitoring efforts, BTAG will provide input into decisions about the frequency and scope of future monitoring. However, some recommendations can be offered for consideration from the past 4 years of biomonitoring results.

In the 2007 report, it was suggested that Se levels in surface water and sediment are not good predictors of Se in macroinvertebrates (Bunn et al. 2008). Even with an additional year of monitoring data, no correlations could be detected between levels of Se in sediment vs. macroinvertebrates or in surface water vs. macroinvertebrates. Surface water and sediment monitoring do not appear to predict Se bioaccumulation in the wetlands as well as macroinvertebrate monitoring alone. Surface water samples will continue to be collected in nearby locations (e.g., in Montezuma Creek below Wetland 3 and Seep 2) under a separate monitoring program. Therefore, separate surface water and sediment monitoring could potentially be discontinued.

Although substrate-dwelling organisms such as caddisflies are abundant in faster flowing portions of Montezuma Creek, conditions do not appear to be conducive for colonization at the sediment retention pond. In some years, conditions may be somewhat favorable (e.g., 2005), but small sample sizes indicate that such organisms would make up a small portion of the avian diet compared to organisms collected with kick nets. Therefore, Hester-Dendy substrate sampling could potentially be discontinued.

Variability in the macroinvertebrate Se data may be reduced by collecting additional samples. Trends, if any, appear to be developing slowly in Wetland 3 and the sediment retention pond. Therefore, a sampling strategy that may better predict Se bioaccumulation would consist of more comprehensive sampling on a less frequent basis (e.g., in conjunction with the 5-year reviews). Comprehensive sampling would include more sampling locations within Wetland 3 and the sediment retention pond and/or several sampling events during the field season.

Results do not conclusively indicate a risk to fish or wildlife from Se in the MMTS wetlands. Avian surveys, particularly the protocol willow flycatcher surveys conducted in 2008, indicate that threatened, endangered, State-listed, or other avian species of concern do not use the MMTS wetlands for extended periods of time and do not breed in the area. Therefore, risk to these species from elevated Se in macroinvertebrates is low.

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Appendix A

Program Directive MNT-08-03

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Program Directive

Program/Project MMTS OUIII Post-ROD Biomonitoring **Directive No.** MNT-08-03

Task Order No. LM-501-06-502

Initiated By: Linda Sheader, Biologist/Ecologist

Affected Documents: MMTS OU III Post-Record of Decision (ROD) Monitoring Plan

Directive Subject: Aquatic macroinvertebrate sampling and analysis for OU III biomonitoring.

Justification: Collection of aquatic macroinvertebrates for chemical analysis is a component of the OU III biomonitoring program in progress to evaluate selenium accumulation in the wetlands environments at OU III, as required by the Record of Decision for Operable Unit III, signed in May 2004.

Directive: Continue macroinvertebrate sampling and analysis for selenium in 2008 in accordance with the attached procedures. The scope of work and methodology was developed in consultation with the biological technical assistance group (BTAG) for OU III biomonitoring. The attached procedures are similar to those described in previous program directives except that additional Hester-Dendy samplers will be placed in the sediment pond and monitored more frequently in May and June to optimize macroinvertebrate collections.

Review and Concurrence:

Linda Tegelman, Quality Assurance — Date: 03 24 2008

Timothy Bartlett, Site Manager — Date: 3/24/08

Task Order Manager Approval to Issue:

Carl Jacobson, Task Order Manager — 3/24/08

Effective Date: March 21, 2008 **Expiration Date:** September 30, 2008

Distribution: w/ Attachments
Task Order Managers Directive Log
Jalane Glasgow - Record File # 2.7
Linda Sheader – OU III Information Repository (2 copies)
Holders of all affected documents

Macroinvertebrate Sampling and Analysis Plan
2008 Field Season

I. Introduction

The U.S. Department of Energy (DOE) completed surface remediation at the Monticello Mill Tailings Site (MMTS), located near Monticello, Utah, under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The remediated area currently supports three large manmade wetlands and a sediment retention pond, located approximately one mile east of the wetlands (map attached). The *MMTS Operable Unit III Post-Record of Decision Monitoring Plan* (DOE 2004) specifies post-remediation monitoring of groundwater, surface water, and sediment for selenium. Selenium has the ability to accumulate in the aquatic food chain and potentially harm organisms, particularly avian species that feed on macroinvertebrates with elevated levels. Therefore, biomonitoring has been conducted at the former MMTS since 2005, when selenium benchmark levels were exceeded for some surface water/sediment samples. The *Operable Unit III Remedial Investigation, Appendix M – Ecological Risk Assessment* (DOE 1998) discusses the potential receptors and exposure pathways in detail.

The locations and general approach for biomonitoring were determined in 2004 by the Biological Technical Assistance Group (BTAG), including representatives from DOE, the U.S. Environmental Protection Agency Region VIII, the U.S. Fish and Wildlife Service, and the Utah Department of Environmental Quality. Macroinvertebrate sampling was accomplished at the site in 2005, 2006, and 2007. Results indicate that, during these years, levels of selenium in macroinvertebrate tissues, while not exceeding toxicity levels (7 mg/kg Se dry weight), did exceed levels of concern (3 mg/kg Se dry weight) in Wetland 3 and the sediment retention pond. 2008 macroinvertebrate sampling will focus on these two wetlands, as the results from previous years exclude Wetland 1 and Wetland 2 from further sampling.

In previous monitoring years, the composition of species collected on artificial substrate (Hester-Dendy) samplers differed from the composition of species collected with kick nets. Therefore, characterization of selenium in macroinvertebrate tissue in the sediment retention pond is more complete with both methods than only one. Because previous years' sampling efforts have not yielded adequate sample sizes for full analysis for the Hester-Dendy samplers, particular attention will be paid to these collections. Additional samplers will be deployed at each sampling location utilizing two different orientations of the sampling devices.

In addition to macroinvertebrate sampling, sediment/surface water sampling and avian surveys, which are covered under separate program directives and plans (MNT-08-01 and MNT-08-02, respectively), will continue in Wetland 3 and the sediment retention pond as part of the biomonitoring effort.

II. Scope

Field sampling will be performed by S.M. Stoller personnel and will consist of procuring necessary field equipment, planning field activities, traveling to the field site, and collecting macroinvertebrate samples. Kick net samples will be collected in May 2008 in three locations at Wetland 3 and three locations at the sediment retention pond. Also, three Hester-Dendy samplers

will be deployed at each of 3 locations (for a total of 9 samplers) in the sediment retention pond. The samplers will be deployed in April 2008 and collected in May or June as necessary.

Sample identification and preparation will be performed by S.M. Stoller personnel and will consist of storing samples, cleaning, sorting and identifying macroinvertebrate species, and preparing samples for shipment to the laboratory.

Sample analysis will be performed by the Battelle Marine Sciences Laboratory in Sequim, Washington according to protocols established in previous monitoring years. The laboratory will provide results in an electronic data format.

A report documenting all the field activities and laboratory results will be prepared by S.M. Stoller personnel, and interpretation will consider results of sampling efforts in the past and current regulatory benchmarks. Finalization of the report will include incorporation of comments received from DOE and BTAG.

III. Field Sampling Procedures

The purpose of the field sampling effort is to collect macroinvertebrates for selenium analysis to determine if the macroinvertebrates in Wetland 3 and the sediment retention pond remain at or above levels of concern. Both wetlands will be sampled using kick nets. The deeper sediment retention pond will also be sampled using Hester-Dendy samplers. The use of both techniques will ensure that a greater diversity of macroinvertebrates in the pond is collected.

Each kick net or Hester-Dendy sample for selenium analysis will have a minimum mass of 3 g wet weight, although larger samples, up to 10 g wet weight, are preferred. A portable balance will be utilized to estimate the weight of each kick net sample in the field, and this weight will be recorded in field notes. If the goal of collecting a mass of 3 g wet weight per sample cannot be achieved, then samples for a location will be composited prior to analysis.

A. Kick net samples

Three replicate kick net samples will be collected at each of the wetlands in mid-May. Wetland 3 will be visually divided into three parts corresponding to the flow of water through the wetland from the selenium source (Seep 2). The up-gradient sample will be collected at the outlet of Seep 2; the mid-gradient sample will be collected half way between Seep 2 and the outlet of Wetland 3; and the down-gradient sample will be collected at the outlet. The sediment retention pond will be similarly divided into three sampling areas. The up-gradient sample will be collected near the inlet; the mid-gradient sample will be collected on the north edge of the sediment retention pond, approximately half way between the inlet and outlet; and the down-gradient sample will be collected near the outlet. The sampling locations correspond to those sampled for surface water and sediment under a separate Program Directive (MNT-08-01 [DOE 2008]).

An aquatic kick net with 500 um mesh netting will be used to collect macroinvertebrate samples. Prior to sampling each wetland, the net will be cleaned using a non-phosphate detergent, followed by 2−5 percent nitric acid wash, and three rinses with laboratory-grade deionized water. The pre-cleaning process is designed to minimize contamination prior to use. The net will be worked around the perimeter of the wetland and in areas where there is open water between the

emergent vegetation. The traditional kick net technique may also be employed, where the sampler gently kicks the water and substrate up-gradient from the net, driving macroinvertebrates into it. If macroinvertebrates are observed on the submerged vegetation, they will also be collected. Because they may bias samples, exceptionally large macroinvertebrates, such as large crayfish and snails, will not be collected. Field personnel will wear Nitrile gloves during sample collection, and gloves will be changed between wetlands.

Macroinvertebrates will be removed from the kick nets with pre-cleaned plastic forceps and placed in sterile pre-weighed standard plastic collection bottles. Every attempt will be made to minimize detritus and other plant materials in the samples. To minimize potential predation between macroinvertebrate groups, water will not be added to the sample containers.

B. Artificial substrate samples

Three Hester-Dendy samplers will be deployed in each of three locations (for a total of 9 samplers) in the sediment retention pond. These locations will correspond to the kick net sampling locations described above. The samplers will be deployed in early- to mid-April and monitored in mid-May during kick net sampling. If necessary, they will be monitored on a weekly basis after this time to ensure that they are removed at the peak of colonization.

The Hester-Dendy samplers are artificial substrate systems that allow water-column sampling of macroinvertebrates. The device consists of 14 masonite plates spaced at varying widths, and it has a total surface area of 0.16 m^2. The samplers will remain in the pond for 4 to 8 weeks, during which time they will be colonized by periphyton and later by macroinvertebrates, which feed on the periphyton. Each sampler will be anchored to a cinder block or a metal post to prevent migration and excessive sedimentation. The plates of two of the samplers in each location will be oriented vertically (as in 2005 and 2006), and one will be oriented horizontally (the more typical orientation) to create a diversity of sampling substrates and maximize the diversity of the organisms collected.

The samplers will be retrieved by placing a collection bag around the sampler while still submerged, detaching the sampler from the anchoring device, decanting excess water, and sealing the collection bag. This method will minimize the loss of insects from the sampler while they are being retrieved. The samplers will be chilled in the field and transported to the laboratory, where organisms will be picked off the plates with pre-cleaned plastic forceps for identification and preparation.

C. Sample Preparation and Preservation, and Quality Control

The field samplers will make qualitative notes, as practicable, during the collection of samples. These notes may include information about the macroinvertebrates' functional feeding groups (e.g., detritivores, predators, and filter feeders), the relative abundances of various groups, and/or field conditions. As soon as possible after collection, samples will be chilled in the field and transported to the laboratory where they will be identified, rinsed, and prepared for shipment. All samples will be kept at or below 4°C during storage and shipping. Standard chain of custody methods and labels will be used for all collected samples.

Macroinvertebrate samples will be rinsed, sorted, and identified by Stoller personnel. Individual macroinvertebrates will be removed from collection jars in the laboratory, rinsed with deionized water on filter paper, examined, and identified to Order and Family (when possible). The samples will then be chilled and prepared for shipment to the Battelle Marine Sciences Laboratory for selenium analysis. One sample will be split for quality control. Composite samples will not be prepared unless the wet weight for a particular wetland is less than 1 g.

To assess the quality of the field sampling technique, two types of quality control samples will be collected, field duplicates and equipment blanks. One field duplicate will be collected in the field. A second field duplicate will be a split of a composite sample prepared after identification and sorting. Care will be taken to make field duplicates indistinguishable to the lab so that personnel performing analyses cannot determine which samples are duplicates.

Equipment blanks are used to verify that selenium-contaminated equipment does not affected the quality of the samples. One field blank (deionized water rinse water that has rinsed all pre-cleaned field equipment to be used) will be prepared prior to sampling and submitted to the laboratory for analysis.

IV. Laboratory Test Analyses

The goal of the macroinvertebrate field sampling effort is to provide the following samples to the laboratory for selenium analysis:

- three samples collected with kick nets from wetland 3
- three samples collected with kick nets from the sediment retention pond
- three samples collected from Hester-Dendy samplers from the sediment retention pond
- one field duplicate (collected in the field)
- one split sample (prepared in the laboratory)
- one 1 equipment blank

The samples will be analyzed by Battelle Marine Sciences Laboratory according to the guidelines included in a separate Statement of Work. These guidelines are summarized below:

A. Percent Moisture Determination

The samples collected will arrived at the laboratory “as collected” and require that the percent moisture be determined to allow the selenium results to be reported on a dry weight basis. Percent moisture is determined as the percent ratio of wet to dry weight for the entire sample. Dry weights will be determined by placing the wet sample in a pre-tared, pre-cleaned sample container, lyophilizing (freeze drying) the entire sample, and then recording the change in weights.

B. Low-Level Trace Metals Analysis

The required analytical method for analyzing selenium in the macroinvertebrate samples is EPA Method 270.3, gaseous hydride atomic absorption.

Sample preparation must include:

- lyophilizing the samples and then homogenizing them using a ball-mill prior to digestion
- digesting an aliquot of approximately 0.5 g of each dried, homogeneous sample by combining with nitric and hydrochloric acids (aqua regia) in a Teflon vessel and heating in an oven at 130°C (±10°C) for a minimum of eight hours
- diluting with deionized water to achieve analysis volume, then submittal of analysis.

The digested samples must be analyzed for selenium using hydride generation flow injection atomic absorption spectroscopy (HGAA-FIAS).

- All results will be determined and reported in units of mg/kg on a dry-weight basis.
- The detection limit for selenium in the macroinvertebrate samples will be based on a methods detection limit (MDL) and reporting limit (RL) study performed by the laboratory. MDLs for trace metals are determined in accordance with 40 CFR Part 136 Appendix B.
- The RL is calculated by multiplying the target analyte MDL by 3.18. The value 3.18 is based on the Student's-t value for 7 to 10 replicates, the number of replicates usually analyzed to generate the MDL.
- The MDL for tissues must be less than 0.02 mg/kg dry weight with an RL less than 0.07 mg/kg dry weight.

C. Laboratory Quality Control

Internal quality control (QC) is an important part of the measurement system to ensure that analytical results are reliable and that data integrity is maintained. Laboratory performance will be evaluated through analysis of laboratory quality control samples (in conjunction with field quality control samples, as appropriate).

The analytical performance of the laboratory will be validated by reviewing the results from analysis of the blank, matrix spike, duplicate, and quality control check samples. The following describes the batch preparative quality control samples that are required by the analytical method.

- Method Blank (MB): A Method Blank consists of Type II ASTM water that is subjected to the sample preparation or extraction procedures and analyzed as a sample. It serves to measure contamination associated with preparation and analysis. One MB is required for the 20 samples or fewer samples. If the analyte of interest is above the RL, corrective action must be taken.
- Matrix Spike (MS): A Matrix Spike is an aliquot of sample to which a known amount of analyte has been added. It is subjected to the sample preparation or extraction procedures and analyzed as a sample. The stock solutions used for spiking are purchased or prepared

independently of calibration standards. One MS is required for every 20 or fewer samples analyzed. The spike recovery measures the effects of interferences in the sample matrix and reflects the accuracy of the determination.

- Matrix Spike Duplicate (MSD): A Matrix Spike Duplicate is an additional aliquot of sample to which known amounts of analyte have been added and subjected to the same preparation and analytical scheme as the original sample. The Relative Percent Difference (RPD) between MS and MSD measures the precision of a given analysis. One MSD will be required for every 20 or fewer samples analyzed.

- Laboratory Control Sample (LCS): Laboratory Control Sample is created from a standard reference material which is a material similar in nature to the sample being processed [traceable to the National Institute of Standards and Technology (NIST) or other agencies, to the extent possible]. A known amount of analyte is added to an aliquot of Type II ASTM water. The LCS is subjected to the sample preparation or extraction procedure and analyzed as a sample. One LCS will be required every 20 or fewer samples analyzed.

- Laboratory Replicate Sample (LRS): Laboratory Replicate Samples are used to assess the homogenization techniques. Samples are homogenized, and then divided into two equal parts for analysis. Care is taken to make both samples representative of materials present, including heterogeneities. If possible, at least one sample will be prepared and analyzed as a LRS.

Laboratory results will be available approximately 45 days after the samples have been received. The laboratory will provide the results to Stoller in electronic form.

V. Data Report

The data report will be prepared by S.M. Stoller and submitted to DOE by September 30, 2008. The report will include the following information.

- A summary of the dates, times and locations of the field sampling activities
- Any communications with federal and state agencies, and other professional biologists
- Any communications or direction from DOE
- A summary of the field activities, GPS data (if applicable) and any maps generated
- A summary of the laboratory test analyses including results, methods, detection limits, and laboratory qualifiers
- Education/qualifications of field samplers
- Comparison of results from macroinvertebrate samples to ecological risk guidelines and benchmarks
- Recommendation for follow-on activities
- References

The report will be reviewed by DOE and transmitted to EPA and UDEQ by November 1, 2008.

VI. References

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Appendix B

Macroinvertebrates Collected or Observed in 2008
Habitat, Feeding Style and Diet

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Macroinvertebrate Taxon and Common Name	Habitat	Feeding Style and Diet
Amphipoda (scuds)	Totally aquatic. Dwell on bottom or in upper sediment layer.	Usually omnivores, but most common food is detritus.
Oligochaeta (aquatic earthworms)	Most burrow into underwater silt, mud, or detritus. Totally aquatic.	Most collector gatherers (eat algae, bacteria, protozoa); few are engulfer predators, eating live prey whole.
Coleoptera – Dytiscidae (predatory diving beetles)	Larvae can be found throughout aquatic environment, but are commonly climbers in shallow weedy areas like pond margins.	Piercer predators (inject, liquefy and suck juices of victims). Adults are engulfer predators, eating live prey of any feeding style whole.
Coleoptera (adult stage) (beetles)	Live throughout aquatic environment.	Wide variety of feeding styles except shredder-detritus eaters.
Decapoda (crayfish)	Totally aquatic. Live two to eight years. Spend most of time hidden in crevices or detritus.	Omnivores, but primary food is decaying vegetation.
Diptera – Chironomidae (midges)	Different species live throughout aquatic environment. Larvae often live on underwater surfaces and in sediment/detritus.	Most larvae are collector gatherers, which eat organic components of surrounding sediments, expelling the indigestible portion.
Diptera – Culicidae (mosquitoes)	Larvae live on water surface. Adults are terrestrial. Short-lived insects.	Collector filterers / collector gatherers, sweeping bacteria, protozoa, algae, fungi, and detritus out of the water.
Ephemeroptera (mayflies)	Larvae usually dwell on bottom surfaces or burrow into sediment. Subimagos and adults live on/near surface water.	Most are collector gatherers (detritus eaters) or scrapers (microscopic algae eaters)
Gastropoda (snails)	Surfaces of rocks, sediments, and vegetation	Most are scrapers (eat live algae and detritus); some shred live or dead plant material on bottom; some are collector filterers.
Hemiptera – Corixidae (water boatmen)	Swim on or around aquatic plants or along bottom.	Collector gatherers, eating algae, protozoa, and tiny macroinvertebrates like midges.
Hemiptera – Notonectidae (backswimmers)	Water surface, free swimming or cling to vegetation. Entire life cycle is aquatic.	Piercer predators (pierce and inject prey then suck fluid out); consume wide range of taxa from all feeding groups including vertebrates.
Odonata – Anisoptera (dragonflies)	One to several years as aquatic larva; crawl on or cling to underwater surfaces, or live on top of or within sediment. Adults are terrestrial.	Engulfer predators (eat entire living organisms); consume wide range of taxa from all feeding styles, including vertebrates. Size of prey increases as larva grows.
Odonata – Zygoptera (damselflies)	One to several years as aquatic larva; typically crawl on and cling to underwater surfaces. Adults are terrestrial.	Engulfer predators (eat entire living organisms); consume wide range of taxa from all feeding styles, including vertebrates. Size of prey increases as larva grows.
Trichoptera (caddisflies)	Three months to two years as aquatic larva; typically crawl on underwater surfaces and build cases attached to substrates. Short-lived adults typically live on vegetation near water.	Most are omnivores, feeding on other organisms, fresh plant material, decaying organisms. Some are filter feeders.

References: Bunn et al. 2008 and Voshell 2002.

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Appendix C

Statement of Work Provided to Battelle Marine Sciences Laboratory for 2008 Selenium Analysis

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Statement of Work
Monticello Processing Site
Macroinvertebrate Analysis

I. Purpose

The collection of macroinvertebrates for selenium analyses is necessary to satisfy the requirements of Section 6.2 of the *Monticello Mill Tailings Site Operable Unit III Post-Record of Decision Monitoring Plan* (DOE 2004). The concern is that increased concentrations of selenium in groundwater at some locations noted since completion of mill site remediation will lead to increases in selenium in surface water and sediment in wetland habitat that can affect wildlife (particularly avian species) from the consumption of selenium through the food web.

II. Sample Collection and Submittal

Macroinvertebrate samples will be collected in the spring of 2008 at three constructed wetlands and the sediment retention pond at the Monticello Mill Tailings Site. Samples will include:

- three samples collected with kick nets from wetland 3
- three samples collected with kick nets from sediment pond
- three samples collected from Hester-Dendy samplers from sediment pond
- one field duplicate
- one split sample (prepared in the laboratory)
- one 1 field blank (water).

Stoller will determine the species composition of the samples, and prepare "wet" samples for shipment to the Battelle Marine Science Laboratories (laboratory) in Sequim, WA for analysis. The kick net samples and Hester-Dendy samples will be collected at different times. Stoller can send the samples to the laboratory as they are collected, to be stored frozen at the laboratory until all samples have been received and analysis proceeds.

Sample collection using kick nets is anticipated for mid-May 2008. The Hester-Dendy artificial substrate sampling devices will be deployed in April or May 2008 and retrieved for sample harvesting and shipment to the laboratory in mid-June 2008.

III. Laboratory Analyses

A. Percent Moisture Determination

The samples collected will arrived at the laboratory “as collected” and require that the percent moisture be determined to allow the selenium results to be reported on a dry weight basis. Percent moisture is determined as the percent ratio of wet to dry weight for the entire sample. Dry weights will be determined by placing the wet sample in a pre-tared, pre-cleaned sample container, lyophilizing (freeze drying) the entire sample, and then recording the change in weights.

B. Low-Level Trace Metals Analysis

The required analytical method for analyzing selenium in the macroinvertebrate samples is EPA Method 270.3, gaseous hydride atomic absorption.

Sample preparation must include:

- lyophilizing the samples and then homogenizing them using a ball-mill prior to digestion
- digesting an aliquot of approximately 0.5 g of each dried, homogeneous sample by combining with nitric and hydrochloric acids (aqua regia) in a Teflon vessel and heating in an oven at 130°C (±10°C) for a minimum of eight hours
- diluting with deionized water to achieve analysis volume, then submittal of analysis.

The digested samples must be analyzed for selenium using hydride generation flow injection atomic absorption spectroscopy (HGAA-FIAS).

- All results will be determined and reported in units of mg/kg on a dry-weight basis.
- The detection limit for selenium in the macroinvertebrate samples will be based on a methods detection limit (MDL) and reporting limit (RL) study performed by the laboratory. MDLs for trace metals are determined in accordance with 40 CFR Part 136 Appendix B.
- The RL is calculated by multiplying the target analyte MDL by 3.18. The value 3.18 is based on the Student's-t value for 7 to 10 replicates, the number of replicates usually analyzed to generate the MDL.
- The MDL for tissues must be less than 0.02 mg/kg dry weight with an RL less than 0.07 mg/kg dry weight.

C. Laboratory Quality Control

Internal quality control (QC) is an important part of the measurement system to ensure that analytical results are reliable and that data integrity is maintained. Laboratory performance will be evaluated through analysis of laboratory quality control samples (in conjunction with field quality control samples, as appropriate).

The analytical performance of the laboratory will be validated by reviewing the results from analysis of the blank, matrix spike, duplicate, and quality control check samples. The following describes the batch preparative quality control samples that are required by the analytical method.

- Method Blank (MB): A Method Blank consists of Type II ASTM water that is subjected to the sample preparation or extraction procedures and analyzed as a sample. It serves to measure contamination associated with preparation and analysis. One MB is required for

the 20 samples or fewer samples. If the analyte of interest is above the RL, corrective action must be taken.

- Matrix Spike (MS): A Matrix Spike is an aliquot of sample to which a known amount of analyte have been added. It is subjected to the sample preparation or extraction procedures and analyzed as a sample. The stock solutions used for spiking are purchased or prepared independently of calibration standards. One MS is required for every 20 or fewer samples analyzed. The spike recovery measures the effects of interferences in the sample matrix and reflects the accuracy of the determination.

- Matrix Spike Duplicate (MSD): A Matrix Spike Duplicate is an additional aliquot of sample to which known amounts of analyte have been added and subjected to the same preparation and analytical scheme as the original sample. The Relative Percent Difference (RPD) between MS and MSD measures the precision of a given analysis. One MSD will be required for every 20 or fewer samples analyzed.

- Laboratory Control Sample (LCS): Laboratory Control Sample is created from a standard reference material which is a material similar in nature to the sample being processed [traceable to the National Institute of Standards and Technology (NIST) or other agencies, to the extent possible]. A known amount of analyte is added to an aliquot of Type II ASTM water. The LCS is subjected to the sample preparation or extraction procedure and analyzed as a sample. One LCS will be required every 20 or fewer samples analyzed.

- Laboratory Replicate Sample (LRS): Laboratory Replicate Samples are used to assess the homogenization techniques. Samples are homogenized, and then divided into two equal parts for analysis. Care is taken to make both samples representative of materials present, including heterogeneities. If possible, at least one sample will be prepared and analyzed as a LRS.

IV. Schedule

Laboratory results must be available approximately 45 days after the samples have been received.

V. Deliverables

A. Data Report

The laboratory will submit a data report to Stoller in PDF format that must include the following information:

- A case narrative that describes the contents of the data package and provides an index of samples submitted and the laboratory sample IDs. A description of problems encountered in sample receipt, login, and analysis shall also be included in the narrative. The case narrative shall describe the circumstances leading to the use of data qualifiers and list the affected samples. All case narratives shall include a signed statement affirming that the

analytical work and data package have been reviewed and are in compliance with the requirements of this document.

- Signed and dated Chain of Custody forms received with each sample shipment, indicating sample receipt and custody by the laboratory.

- An analytical report including the percent moisture and selenium concentration for each sample. The selenium results shall be reported in units of µg/g, dry weight. The laboratory shall provide the MDL and RL. For each sample, the matrix description, units of measure, data qualifier(s), method of analysis, digestion date, and analysis date shall be provided. The laboratory shall not use mathematical "less than" signs in reporting the analytical results.

- A QC report with the results of all QC samples analyzed with the field samples including results for method blanks, LCS samples, MS/MSD samples, and replicate samples.

B. Electronic Data Deliverable

The laboratory will provide electronic deliverable of analytical results to Stoller in a comma delimited text file.

Appendix D

Results of Selenium Analysis

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Analytical Chemistry Data Package
Inorganics Analysis

Project: Monticello 2008

Analysis of Se in Macroinvertebrates

Battelle Project No. 55178
CF No. 2908

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Monticello Macroinvertebrates 2008
Se in Tissue
(Units: ug/g dry wt, data are not blank corrected)

MSL Code	SPONSOR CODE	Field Sample ID	Matrix	Collection Date	Analytical Batch	Percent Moisture	Se	SD Se	% RSD
						CAS CODE:	7782-49-2		
						Method:	HGAA-FIAS		
						Units:	µg/g dry wt.		
Laboratory Achieved Method Detection Limits (MDLs)							**0.0082**		
Reporting Limit (RL)							**0.026**		
2908-1	W3-S1	MNT01	invertebrates	06/10/2008	F073108B	80.6	13.0 →	0.091	1%
2908-2	W3-S2	MNT01	invertebrates	06/10/2008	F073108B	79.7	5.06	0.068	1%
2908-3	W3-S3	MNT01	invertebrates	06/10/2008	F073108B	78.2	3.71	0.019	1%
2908-4	SP-S1	MNT01	invertebrates	06/11/2008	F073108B	77.4	4.90	0.030	1%
2908-5	SP-S2(1)	MNT01	invertebrates	06/10/2008	F073108B	75.6	4.50	0.015	0%
2908-6	SP-S2(2)	MNT01	invertebrates	06/10/2008	F073108B	75.0	4.32	0.008	0%
2908-7	SP-S3	MNT01	invertebrates	06/11/2008	F073108B	79.3	7.64 →	0.024	0%
Procedural Blanks									
Blank072808	BLANK				F073108B		0.0082 U		
Blank Spike Results									
LCS072808	LCS				F073108B		2.07		
	Spike concentration						*2.0*		
	PERCENT RECOVERY, LCS-1						**103%**		
Matrix Spike Results									
2908-7 MS	SP-S3	MNT01	invertebrates		F073108B	79.3	13.1		
2908-7 MSD	SP-S3	MNT01	invertebrates		F073108B	79.3	12.1		
2908-7	SP-S3	MNT01	invertebrates	06/11/2008	F073108B	79.3	7.64		
	Spike concentration, MS						5.21		
	Spike concentration, MSD						5.06		
	PERCENT RECOVERY, MS						**105%**		
	PERCENT RECOVERY, MSD						**89%**		
	RPD						**16%**		
Replicate analysis Results									
2908-4	SP-S1	MNT01	invertebrates	06/11/2008	F073108B	77.4	4.90	0.030	1%
2908-4 DUP	SP-S1	MNT01	invertebrates	06/11/2008	F073108B	77.4	4.80	0.016	0%
	Mean						4.85		
	RPD						**2%**		
Standard Reference Material									
1566b072808	SRM		Oyster Tissue		F073108B	0.0	2.02	0.033	2%
	certified value						2.06		
	range						±0.15		
	percent recovery SRM 1566b						**98%**		

* Duplicate analysis not within QC criterion of <20% RPD
& SRM outside QC criterion of ±20% Recovery
N Matrix spike outside QC criterion of ±25%
U Analyte not detected above the MDL, MDL reported
J Analyte detected greater than the MDL, but less than the RL
RPD Relative Percent Difference
SD Standard Deviation for n = 3

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QA/QC NARRATIVE

PROJECT: Monticello Invertebrates
PARAMETER: Selenium (Se)
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: Macroinvertebrates

SAMPLE CUSTODY AND PROCESSING: Seven tissue samples were received on 06/12/08. All samples were received in good condition (i.e., no sample containers were broken or leaking). The project was assigned a Battelle central file (CF) identification number (2908) and samples were entered into the MSL sample tracking and project management system. The samples were held for analysis until the Hester-Dendy collection. However, there were no samples recovered from the Hester-Dendy collectors and the kick-net samples were processed as a single batch.

SAMPLE PROCESSING INFORMATION:

Lab Sample IDs:	**2908*1-7**
Description:	Macroinvertebrates
Collection date	06/10/08 and 06/11/08
Laboratory arrival date	06/12/08
Cooler temp. on arrival	2.1°C
Digestion Date (Aqua Regia, MSL-I-024)	07/28/08
HGAA-FIAS Analysis Date (Se, MSL-I-030)	07/31/08

METHODS: All tissue samples were freeze-dried and homogenized using a ball-mill prior to digestion according to Battelle SOP MSL-C-003, Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue. Tissue samples were digested according to Battelle SOP MSL-I-024, Mixed Acid Tissue Digestion. An approximately 500-mg aliquot of each dried, homogeneous sample was combined with nitric and hydrochloric acids (aqua regia) in a Teflon vessel and heated in an oven at 130°C (±10°C) for a minimum of eight hours. After heating and cooling, deionized water was added to the acid-digested tissue to achieve analysis volume. Digested samples were analyzed for Se using hydride generation flow injection atomic absorption spectroscopy (HGAA-FIAS) according to Battelle SOP MSL-I-030, Determination of Metals in Aqueous and Digestate Samples by HGAA-FIAS. The base method for this procedure is EPA Method 270.3. Tissue results were determined and reported in units of µg/g on a dry-weight basis.

HOLDING TIMES: The project specific holding time is one year in tissue and six months for water samples. Holding times were achieved for all samples.

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of MS/MSD Recovery	Replicate Precisions (RPD)	SRM Accuracy (PR)	Matrix	MDL	Reporting Limit
Se	HGAA-FIAS	75-125%	±20%	80%-120%	Tissue	0.0082 µg/g dry wt.	0.026 µg/g dry wt.

RPD = Relative Percent Difference
PR = Percent Recovery

QA/QC NARRATIVE

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the annual MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of cellulose or chicken breast for tissue (tissue matrices with metals low enough to perform an acceptable MDL study). The MDLs are determined using the same methodology as the samples. The reporting limit (RL) is determined as 3.18 times the achieved MDL. Data are evaluated and flagged in accordance with the following criteria:

- U The analyte was not above the MDL, MDL was reported.
- J The value is less than the achieved reporting limit, but greater than the MDL.
- N Matrix spiked sample was outside the QC criterion of 75-125% recovery.
- & SRM was outside the QC criterion of 80-120% recovery.
- * Duplicate analysis outside QC criterion of ±20% relative percent difference.

METHOD BLANKS: One method blank was prepared with the tissue samples. Se was not detected at a level greater than the MDL.

LABORATORY CONTROL SAMPLE (LCS) ACCURACY: One laboratory control sample (LCS) was analyzed with these samples. The percent recovery was within the QC criterion of 75-125% recovery.

MATRIX SPIKE (MS/MSD) ACCURACY: There was sufficient material to analyze a matrix spike and duplicate matrix spike. The matrix spike recoveries were within the QC criterion of 75-125% recovery.

REPLICATE PRECISION: Two measures of reproducibility were analyzed with the samples: 1) a laboratory duplicate, which is a split of the sample carried through the preparation and analysis as two individual samples and 2) duplicate matrix spikes. Laboratory reproducibility was expressed as the relative percent difference (RPD) between the replicate results. All measure were within the QC criterion of <20% RPD.

STANDARD REFERENCE MATERIAL ACCURACY: Analytical accuracy was expressed as the percent recovery of the measured value relative to the certified value of a standard reference material (SRM). The SRM 1566b Oyster tissue was used as the tissue matrix and percent recoveries were within the QC criterion of 80-120% recovery.

cc: Project Manager/Central File
Login File 2908

SAMPLE LOGIN

(SOP# MSL-A-001)

Project Manager: Brandenberger
Date Received: 06/12/08
Batch: 1

PROJECT: Monticello

SPONSOR CODE	Site Description	BATTELLE CODE	MATRIX	STORAGE LOCATION	PARAMETERS REQUESTED	COLLECTION DATE	INITIALS
W3-S1	MNT01	2908-1	tissue	Deep Freezer D-1	Se	06/10/08	MLFM
W3-S2	MNT01	2908-2	tissue	Deep Freezer D-1	Se	06/10/08	MLFM
W3-S3	MNT01	2908-3	tissue	Deep Freezer D-1	Se	06/10/08	MLFM
SP-S1	MNT01	2908-4	tissue	Deep Freezer D-1	Se	06/11/08	MLFM
SP-S2(1)	MNT01	2908-5	tissue	Deep Freezer D-1	Se	06/10/08	MLFM
SP-S2(2)	MNT01	2908-6	tissue	Deep Freezer D-1	Se	06/10/08	MLFM
SP-S3	MNT01	2908-7	tissue	Deep Freezer D-1	Se	06/11/08	MLFM

Stoller
Legacy Management Team

Chain of Custody / Sample Submittal Form

RIN: 08061675 COC: 08061675.1.1

PO #: Cost Number: 1-501-1-06-502-4-02 Sampler(s): Linda Sheader

Project: Monticello Laboratory: Battelle Marine Science Laboratories

Address: 1529 West Sequim Bay Road Phone: 360 681 4564

Matrix: FA - Fauna Turnaround (Days): 28 Sequim, Washington 98382 Fax:

Ship #	Ticket Number	Date / Time Sampled	Site	Location	Container	# Cont.	Preservation	Matrix	Comp.	Grab	Filtered	QC	Analysis
1	GHV 902	06/10/2008 12:40	MNT01	W3-S1	HDPE 125 mL	1	4 C	FA			N		Se 2908-1
1	GHV 903	06/10/2008 16:00	MNT01	W3-S2	HDPE 125 mL	1	4 C	FA			N		Se 2
1	GHV 904	06/10/2008 14:25	MNT01	W3-S3	HDPE 125 mL	1	4 C	FA			N		Se 3
1	GHV 905	06/11/2008 10:00	MNT01	SP-S1	HDPE 125 mL	1	4 C	FA			N		Se 4
1	GHV 906	06/10/2008 17:00	MNT01	SP-S2(1)	HDPE 125 mL	1	4 C	FA			N		Se 5
1	GHV 907	06/10/2008 17:00	MNT01	SP-S2(2)	HDPE 125 mL	1	4 C	FA			N		Se 6
1	GHV 908	06/11/2008 09:00	MNT01	SP-S3	HDPE 125 mL	1	4 C	FA			N		Se 2908.7

Relinquished by (signature)	Date	Time	Relinquished by (signature)	Date	Time	Relinquished by (signature)	Date	Time
Received by (signature)	**Date**	**Time**	**Received by (signature)**	**Date**	**Time**	**Received by (signature)**	**Date**	**Time**
[signature]	06/12/08	1000						

Central File #: N Sample No(s): 1 – Project Manager: JMB

TO BE COMPLETED BY PROJECT MANAGER (prior to arrival when possible)

Matrix: tissue WP# m16158

Yes	No	
	✓	Navy-type Project (requires high-level sample tracking procedures)
	✓	Filter Samples: Amount: Same sample: Time of sample:
✓		Freeze dry sample(s) - samples will be weighed and placed in ultralow temp freezer (Lab# 130)
✓		Special instructions: contact PM when samples arrive

Sample Preservation Instructions:

Date To Archive: Date To Dispose:

TO BE COMPLETED UPON SAMPLE ARRIVAL/LOG-IN

Yes	No	N/A	Indicate in Appropriate Box
	N/A		Was a custody seal present?
		N/A	Was the custody seal intact?
N/A			Was cooler(s) temperature(s) within acceptable range of 4±2°C or frozen? (If multiple coolers, note temp. of each) 2.1 °C °C
		N/A	Was Project Manager notified of any custody/login discrepancies (cooler temp, sponsor codes, etc)? Comment/Remedy:
N/A			Were all chain of custody forms signed and dated?
	N/A		Were samples filtered at MSL?

Sample condition(s): Acceptable Other (explain):

Container type: Teflon Poly Glass Spec Other:

Notes:

Completed By: [signature] Date/Time: 09/12/08 1000

SAMPLE PRESERVATION

- [N/A] Sample(s) were preserved at MSL
- [ ] Sample(s) were preserved prior to arrival at MSL (noted on CoC / Sample / per PM Instruction)
- [ ] Random pH checked for ~10% of samples (use dip paper) Sample IDs:
- [ ] Complete pH check required for project (use pH meter and record on pH Record form)

If preservation necessary, record Acid Lot#

Type:
- [ ] 0.2% HNO3 Notes:
- [ ] 0.5% HCl (Hg samples) Notes:
- [N/A] Refrigerate/Freeze Notes: Deep freeze B-1
- [ ] Other Notes:

Completed By: [signature] Date/Time: 09/12/08 1010

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