FINAL REPORT

BUNKER HILL FACILITY NON-POPULATED AREAS OPERABLE UNIT 2 BIOLOGICAL MONITORING, 2001-2004

U.S. Fish and Wildlife Service
Upper Columbia Fish and Wildlife Office
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1.0 Background and Objectives

U.S. Fish and Wildlife Service (USFWS) biological monitoring activities conducted at the Bunker Hill Facility Non-Populated Areas operable unit (OU-2) (Fig. 1) and the South Fork Coeur d'Alene River (SFCdA) from 2001-2004 have been supported through an Interagency Agreement with the U.S. Environmental Protection Agency (USEPA). Consistent with the requirements outlined in the Record of Decision (ROD) for OU-2 (USEPA, 1992) and as stated in the recommendations and required actions outlined in USEPA (2000), these monitoring activities were designed to evaluate the status of biological resources and their habitat at the site, thereby monitoring the effectiveness of remedial actions related to those resources.

As identified in the biological monitoring work plan (USFWS, 2001a), USFWS conducted studies designed to evaluate two components of remedy with respect to biological resources. The first component investigated the status of aquatic and terrestrial wildlife populations and habitat quality in remediated areas. These studies included the evaluation of small mammal and songbird diversity and abundance, and current vegetation community structure in riparian and upland habitats. The second component evaluated exposure of biological resources to contaminants of concern, including arsenic (As), cadmium (Cd), lead (Pb), and zinc (Zn). These studies measured heavy metal concentrations in wildlife to determine if remedial activities have reduced ecological receptor heavy metal exposure. Some analytical results from the 2004 sampling effort have not been received and are therefore not presented in this report. These data will be presented to USEPA in additional reports. Sampling areas, studies conducted and sampling periods are presented in Table 1.

The selection of study areas within OU-2 was dependent upon a review of past remedial actions (USEPA, 2000), reconnaissance investigations of current habitat conditions, a review of relevant literature, previous studies conducted on site, and sampling site accessibility. Distinctions were also made between "gulch areas", "hillsides", and the Page Ponds and associated wetlands as defined in USEPA (2000). Reference areas were chosen based on proximity to the assessment areas, geologic or ecologic similarities to OU-2 sites, and relative lack of mining related impacts.

Representative species were selected for the purpose of evaluating the status (i.e., diversity and abundance) of aquatic and wildlife populations and to assess the exposure of these species to contaminants of concern (USEPA, 1992). Criteria for selecting representative species included:

- Trophic level representation
- Species presence in OU-2
- Availability of on-site and regional data
- Availability of supporting literature data

Selection also depended on identified exposure pathways and environmental risks as outlined in both the ROD (USEPA, 1992) and the Ecological Risk Assessment for the Bunker Hill Superfund Site (Science Applications International Corporation [SAIC], 1991).

Wildlife selected based on these criteria included:

- Small mammals (mice, voles, shrews)
- Songbirds (sparrows and robins)
- Waterfowl (mallard)
- Deer
- Elk

- Fish
- Aquatic invertebrates

Upper Columbia Fish and Wildlife Standard Operating Procedures (UCFWO SOPs) were developed and implemented for all studies conducted and a Quality Assurance Plan completed for the control of chemical analysis (USFWS, 2001b).

Student's t-tests and analysis of variance (ANOVA) were used to determine statistical differences between/among groups. Where statistically significant tests included data violating necessary parametric statistical assumptions, nonparametric tests were substituted. Statistical tests were assessed at $\alpha = 0.05$. Pearson product moment correlations were used to evaluate relationships between variables.

The following sections discuss the available results from the biological monitoring activities conducted within OU-2 from 2001-2004.

2.0 Vegetation Surveys

The vegetative composition within OU-2 has been severely modified over the past century by a combination of mining activities, logging, forest fires, and smelter emissions. Vegetation prior to industrial activities consisted primarily of coniferous forest. Major tree species in the area were ponderosa pine (*Pinus ponderosa*), western white pine (*Pinus monticola*), larch (*Larix occidentalis*), Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*) (SAIC, 1991). In 1974, the U.S. Soil Conservation Service documented over 12,000 acres of eroded or sparsely vegetated land in and around OU-2 (SAIC, 1991).

Beginning in the early 1970's numerous revegetation efforts, consisting of conifer and deciduous tree plantings, herbaceous ground cover seeding and soil amendment application, have been employed on site (SAIC, 1991; USEPA, 1992, CH2M Hill, 2003). Currently, CH2M Hill continues to implement and monitor a Hillsides Revegetation project, which began in 1997 (CH2M Hill, 2003)

Vegetative structure and diversity are indices of habitat quality and often correspond to wildlife use. Both vegetative and wildlife use indices can be used to determine an area's ecological recovery. Vegetation composition surveys were concentrated in areas where small mammal and avian population studies were conducted to provide habitat structure information that could be related to wildlife population dynamics in those areas. Target locations for surveys also included areas previously surveyed to provide information related to vegetation changes over time at remediated sites relative to reference areas.

2.1 Breeding Bird Survey Routes

2.1.1 Methods

Vegetation surveys were conducted in 2003 along the Bunker Hill Breeding Bird Survey (BBS) route (Fig. 2, at four observation points within OU-2 (BH-7, BH-12, BH-9, and BH-19) and 2 observation points above OU-2 (BH-29 and BH-30). Surveys were also conducted at 6 observation points along the Rochat Divide BBS route (Fig. 3). Observation points on each route were chosen to correspond in elevation and northerly aspect with that of the other route to reduce confounding ecological factors in comparisons. Daubenmire quadrats and radial plots were used to assess each observation point. Methods included:

> Daubenmire: Both the Bunker Hill and Rochat Divide BBS sample point routes were established along existing roads, with survey stops every ½ mile. Daubenmire sampling points were established at ten, 25 and 50 meter intervals (i.e., forest interior) on either side of these route stops (six sampling points/stop). Data collected included an estimation of total percent ground cover, as well as percent ground cover by grasses, forbs, clover, moss, litter/duff, rocks, and bare ground. The location of each sampling point was recorded as Universal Transmercator (UTM) coordinates using a Global Positioning System (GPS) unit.
>
> Radial Plots: A 10 m radial plot was randomly established from the center of each Daubenmire sampling point. All trees and shrubs within the plot were tallied and identified to species. Tree size was determined by measuring the diameter of the tree at breast height (dbh). Tree tallies consisted of counting the total number of mature (dbh.>17.7 in.), mid-size (dbh 11.8-17.7 in.), pole-size (dbh 4.7-11.8 in.), and seedling/sapling (dbh < 4.7 in.) trees within each plot. An estimation of tree height was determined by averaging the measured height of ten randomly selected trees per plot. Shrub tallies consisted of counting the total number of shrubs present within each plot. Estimation of shrub height was determined by averaging the measured height of ten randomly selected shrubs per plot.

2.1.2 Results

A summary of dominant tree species, number of tree species, dominant size-class, average tree height, dominant shrub species, and number of shrub species, average shrub height, dominant percent ground cover, and average litter depths per observation point are presented in Table 2.

Eleven tree species and 9 shrub species were documented on the Rochat Divide BBS route. Seven tree species and 5 shrub species were documented within OU-2 and points above OU-2. Total number of tree species was the same for points within and above OU-2. Dominant size class for trees was the same within and above OU-2 and Rochat Divide (i.e., seedling/sampling). However, the dominant tree species and average tree height differed among routes. Dominant tree species changed from western white-pine in OU-2 to Douglas fir above OU-2; western red cedar was the dominant tree species on Rochat Divide. Average tree height per sample plot increased from 10.1-16.8 ft in OU-2 to 32.4-49.7 ft above OU-2 to 29.4-62.3 ft on Rochat Divide. Dominant shrub species also changed from blue elderberry (*Sambuscus cerulea*) in OU-2 to common snowberry (*Symphoricarpos albus*); mallow ninebark (*Physocarpus malvaceus*) was the dominant shrub species on Rochat Divide. Douglas fir and common snowberry were also observed in greater frequency on the Rochat Divide BBS route than within OU-2. Rochat Divide had greater species diversity of both trees and shrubs and more total trees than the Bunker Hill BBS route. Grass was the dominant percent ground cover in OU-2, while forbs dominated the ground cover above OU-2 and on Rochat Divide. Average litter depths were 0.8 inches within OU-2, 1.9 inches above OU-2, and 2.5 inches on Rochat Divide.

2.2 Small Mammal Population Study Areas

2.2.1 Methods

Vegetation surveys within each small mammal-trapping grid and/or transect array on OU-2 and Latour Creek reference area (Figs. 4-5) was assessed in 2002 with Daubenmire quadrats and radial plots. Methods and procedures are given in UCFWO SOP # 1019.3761 and described in section 2.1.1.

2.2.2 Results

A summary of dominant tree species, number of tree species, dominant size-class, average tree height, dominant shrub species, and number of shrub species, average shrub height, dominant percent ground cover, and average litter depths per site are presented in Table 3.

Western white pine was the dominant tree species on all sites sampled in OU-2. Dominant size class was seedling/sapling at all sites and average tree height ranged from 8.9 to 11.2 ft. Blue elderberry was the dominant shrub species at both Government Gulch and Deadwood Gulch; common snowberry was the dominant shrub species at Magnet Gulch. Grass was the most prevalent ground cover at both Smelterville Flats and Magnet Gulch, whereas bare ground was most prevalent at both Deadwood Gulch and Government Gulch. Average litter depths ranged from 0.4-0.8 inches.

The Latour Creek reference area had greater species diversity of both trees and shrubs than OU-2. Eleven tree species and 9 shrub species were documented on the Latour Creek reference area, while 7 tree species and 5 shrub species were documented on OU-2. In addition, total numbers of trees and average tree heights were also greater on the Latour Creek reference area than in OU-2. For the Latour Creek reference area, western red cedar (*Thuja plicata*) was the dominant tree species. Dominant size class for trees was seedling/sapling. Average tree height was 39.6 ft. Mallow ninebark (*Physocarpus malvaceus*) was the dominant shrub species. The dominant ground cover was forbs rather than bare ground or grass observed in OU-2. Average litter depth was 2.5 inches.

2.2.3 Discussion

The differences observed in the current vegetation composition within OU-2 indicate a deficiency in tree canopy cover, species diversity, vegetative ground cover, and litter layer depths as compared to the typical vegetation components of reference areas. The predominant habitat in the region is a closed–canopy coniferous forest. The principle climax tree species include western hemlock, grand fir, and western red cedar (Daubenmire and Daubenmire, 1968). We observed this at our reference area, with western red cedar dominating. White pine, however, dominated OU-2 survey routes.

Of particular concern is the relative lack of vegetative ground cover and adequate litter layer depths. Both are key factors in the re-establishment of a functional ecosystem and also provide food, shelter and nesting habitat for a variety of wildlife species (SAIC, 1991). Vegetative ground cover protects soil from erosion, retains moisture, and provides cooler soil temperatures for seed germination. Litter layer typically provides a food base for microorganisms that degrade plant substances, recycle nutrients, and provide a food base to soil invertebrates (SAIC, 1991). Furthermore, bare ground also has the potential to increase exposure of ecological receptors to contaminants of concern which may be present in post-remediated site soils (SAIC, 1992).

As with any ecosystem subjected to major disturbances of soil and vegetative cover, the re-establishment of a functional ecosystem accompanied by ecological succession will be relatively slow. Yet, overall trends in plant community development on site are positive. Data collected by CH2M Hill, using aerial photographic interpretation of revegetation efforts, indicate that of the

1,089 acres planted during the Hillside Revegetation project, approximately 80.3 percent of the landscape has 50 percent cover or greater (CH2M Hill, 2003). Continued monitoring would provide further data regarding the vegetative recovery of OU-2 remediated areas.

2.3 Page Ponds Associated Wetlands Vegetation Mapping

2.3.1 Methods

Wetland vegetation was characterized in the Page Wetlands (East and West Swamps; Figure 6) in September 2002 and 2004 to evaluate changes in vegetation community structure and other habitat features compared to previous observations (Audet et al., 1999a). Field methods used were described by Audet et al. (1999) with one exception: while dominant habitat type and dominant vegetation type were identified via ground-truthing, a list of all vegetation observed was not compiled in 2002 or 2004.

In brief, field methods consisted of individual polygons delineated from aerial photos of wetlands using geographic information system (GIS) techniques. The polygons were then used to identify visually distinct habitat types in the wetlands. Ground-truthing of polygons was then conducted. The dominant species was recorded as well as a visual estimate of plant aerial cover along a meandering transect through each polygon. Results were then digitized into a GIS coverage using ArcView©.

2.3.2 Results

Habitat polygons generated in 1997 (Audet et al., 1999a), 2002 and 2004 of the East and West Swamps are illustrated in Figures 6-7. Tables 4 and 5 detail the dominant habitat type, dominant vegetation, and other species of vegetation present in each polygon.

A comparison of the 1997, 2002 and 2004 field data show little change in the overall vegetative composition of the dominant habitat types or plant species. The dominant habitat types in both wetlands were palustrine emergent and scrub-shrub. Dominant plant species observed in West Swamp included cattail (*Typha latifolia*), spike rush (*Eleocharis spp.*), sedges (*Carex spp.*), bullrush (*Scurpis spp*) ,spirea (*Spirea douglasii*), and birch (*Betula spp.*). Dominant plant species observed in East Swamp included sedges, cattail, sago pondweed (*Potamogeton pectinatus*), bladderwort (*Urticularia spp.*), thinleaf alder (*Alnus incana*) and field horsetail (*Equisetum arvense*).

Changes in habitat type, dominant vegetation and/or polygon delineation as compared to Audet et al. (1999) are identified in Table 5. The most significant changes appear to be in the west end of West Swamp. Increases in both palustrine emergent as well as cattail prevalence have occurred. In addition, the percent of open water and palustrine emergent habitat on the north-side of the Union Pacific rail ballast have increased substantially. Changes also occurred with respect to the delineation of individual polygons throughout East and West Swamps. Deposition of fill material, consisting of residential yard remediation wastes, has encroached into West Swamp, reducing the overall wetland area relative to the 1997 delineation (Fig. 6).

2.3.4 Discussion

The 1997, 2002, and 2004 comparisons of Page Wetlands vegetation community structure showed little change in the overall vegetative composition of the dominant habitat types or dominant plant species outside of changes observed in West Swamp and open water on the north-side of the Union Pacific rail ballast. Slight changes did occur with respect to the delineation of individual polygons throughout East and West Swamps.

Of particular concern is the continued use of the west bench area of the Page Ponds Wastewater Treatment Plant as a repository for residential yard soils. The ROD (USEPA, 1992) identified a portion of the remedial actions to be conducted at the Page Ponds complex as "the evaluation of wetlands associated with the Page Ponds areas for water quality, habitat considerations, and bio-monitoring". The established objectives and success criteria for these actions were to 1) minimize habitat destruction and 2) maintain habitats (USEPA, 2000). This fill material continues to encroach into the West Swamp, effectively reducing the overall wetland component and habitat and water quality. In accordance with ROD objectives and Executive Order 11990 (Protection of wetlands), it is recommended that mitigative measures be considered to compensate for the loss of wetland habitat.

3.0 Wildlife Population Monitoring

Based on vegetative surveys, OU-2 has suffered a loss of vegetative diversity and structure. These factors, combined with the presence of contaminants in an ecosystem, can have adverse effects on wildlife communities, affecting rates of mortality, birth, immigration, and emigration, thereby causing shifts in productivity and spatial distribution of populations in the environment. Negative population level effects can adversely affect the nature of community structure and function, such as decreasing species diversity, disrupting food webs, and shifting competitive advantages among species sharing a limited resource (SAIC, 1991).

Diversity and abundance of wildlife populations utilizing OU-2 were monitored 2001-2004 to evaluate the effects of remedial actions. Selection of wildlife for monitoring was dependent upon identified contaminant pathways and environmental risks as outlined in both the ROD (USEPA, 1992) and the Ecological Risk Assessment for the Bunker Hill Superfund Site (SAIC, 1991). Species selected for population monitoring included songbirds, small mammals, waterfowl, and fish.

3.1 Breeding Bird Surveys

3.1.1 Methods

A Breeding Bird Survey (BBS) route was established at OU-2 in June 2001. Survey points established above OU-2 and on Rochat Divide were used for assessment and comparison to the OU-2 route. Twenty-nine observation points were established within OU-2 and 5 observation points in areas above OU-2 (Figure 2). The previously established Rochat Divide BBS route was chosen as a reference site due to its geographical and elevational similarities to the OU-2 route (Figure 3). The Rochat Divide route was established and data is maintained by U.S. Geological Survey North American Breeding Bird Survey personnel (USGS, Patuxent wildlife Research Center). Surveys were conducted 2001-2004 in accordance with UCFWO SOP # 1019.3743. In brief, methods included:

- The OU-2 BBS route was sampled in mid June at the height of the songbird breeding season.
- Thirty-four survey points were established at ½-mile intervals along the route.
- Counts were conducted from outside a parked vehicle for 3 minutes at each survey point.

- Counts included individual birds seen and heard within 1/4 mile.
- The observer had extensive knowledge of songs, calls, and visual identification of all species of birds likely to be encountered.

3.1.2 Results

Table 6 presents the species of birds with the highest densities (individuals/route) observed along OU-2 BBS (2001-2004) and Rochat Divide BBS (2002-2004) routes. Comparisons of average number of bird species observed within OU-2 (78 species) during 2001-2004 relative to reference areas (81 species) indicate minor differences. In contrast, bird species observed along each route exhibited general trends. The species of birds with the highest densities observed on OU-2 were American robin (*Turdus migratorius*), violet-green swallow (*Trachycineta thalassina*), and warbling vireo (*Vireo gilvus*). Species of birds with the highest densities observed on Rochat Divide (2001-2004) were Swainson's thrush (*Catharus ustulatus*), yellow-rumped warbler (*Dendroica coronata*), and Townsend's warbler (*Dendroica townsendi*).

3.1.3 Discussion

A comparison of bird species diversity between OU-2 and reference areas indicate general trends in the habitat requirements of the species of birds observed at these sites. Species of birds within OU-2 are typically observed in open habitats such as grassland, savannah, and semiarid canyon habitats. These bird species typically forage on the seeds of grasses and forbs and construct nests on the ground and/or in low growing shrubs. These species represent birds with more adaptive characteristics and less stringent habitat requirements. In contrast, the species of birds observed in the reference area typically forage on seeds and insects found in conifer and mixed conifer habitats, and require tree cavities for nesting and brooding (Ehrlich et al., 1988). In general, species observed in reference areas represent those requiring more mature forested stands typical of areas dominated by forests in northern Idaho and that once dominated OU-2.

Based on BBS data, significant songbird community differences exist between OU-2 and reference areas. Our data suggests that forested vegetation supporting bird communities has not recovered within OU-2. Vegetation composition within OU-2 exhibited an even-age and single-size class of tree, lack of tree and shrub species diversity, and relatively little ground cover compared to reference areas. While the vegetation composition within OU-2 shows a positive trend in establishment, substantial growth of forested habitat and vegetative ground cover will be needed to produce bird community characteristics that are comparable to adjacent habitats. As vegetative diversity and structure improve within OU-2, a corresponding shift in avian communities to more closely represent reference areas is expected to occur.

3.2 Page Ponds and Associated Wetlands Waterfowl Surveys

3.2.1 Methods

Waterfowl surveys in Page Ponds and associated wetlands were conducted in the spring (March-May) and summer (June-August), 2001 and 2003. Data collected included species identification, numbers of individual species, waterfowl behavior (i.e., feeding, loafing and resting) and brood counts. The Page Ponds wetland complex was comprised of two wetlands (i.e., East and West Swamps) occurring on the east and west side of the Page Ponds Wastewater Treatment Plant (PPWTP). The treatment ponds consisted of four aeration lagoons and a stabilization pond, covering approximately 30 acres. Service personnel assigned numbers 1-5 (#1 being the stabilization pond) to the PPWTP sewage ponds for sampling purposes (Burch et. al., 1996). Sites surveyed included the Lower Ponds (i.e., sewage ponds located north of the Union Pacific railroad bed), East and West Swamps, and Ponds # 1, 2, 3, 4, and 5, of the PPWTP (Figure 8). All surveys were conducted following UCFWO SOP #1019.3740. Site location and study methods are given in Audet et. al. (1999).

3.2.2 Results

Average waterfowl use during the 2001 spring and summer surveys were 521.6 and 189.7 birds/survey, respectively. Pond #1 (x = 415.7.0 birds/survey) and Pond #2 (x = 49.1 birds/survey) had the highest average use for all waterfowl surveyed. The highest average use areas for all waterfowl observed during summer surveys included Pond #1 (x = 75.5 birds/survey), East Swamp (x = 68.1 birds/survey) and Pond #2 (x = 29.4 birds/survey). Tables 7 and 8 report species and location of waterfowl observed during the 2001 spring and summer surveys, respectively. Table 9 presents highest average waterfowl use areas for those surveys.

Average waterfowl use during the 2003 spring and summer surveys were 146.1 and 119.4 birds/survey respectively. Pond #1 (x = 28.5 bird/survey) and Pond #2 (x = 40.9 birds/survey) had the highest average use for all waterfowl observed during spring observations, and Pond #5 (x = 31.6) and Pond #2 (x = 23.8 birds/survey) had the highest average use during summer observations. Table 10 presents mean waterfowl use for all Page Ponds/Swamps and for Pond #1 during spring and summer surveys in 1995, 1997, 2001, and 2003 (Burch et al., 1996; Audet et al., 1999a; USFWS, 2002; USFWS, 2003).

Twenty-one species of waterfowl were observed during the 2001 spring and summer surveys. This number is similar to the number of species observed in 2003 (n = 23). Mallards (*Anas platyrhynchos*), Barrow's goldeneye (*Bucephala islandica*), redheads (*Aythya americana*) and green-winged teal (*Anas crecca*) were the most frequently observed waterfowl in both the 2001 and 2003 surveys.

3.2.3 Discussion

Comparisons of previous studies conducted at the site indicate a slight increase in waterfowl species diversity from 19 species observed in 1995 (Burch et. al., 1996) and 14 in 1997 (Audet et. al., 1999). Fluctuations in population densities between 1995 and 1997 (Burch et. al., 1996; Audet et. al., 1999) were also observed between 2001 and 2003 surveys.

Increase and decrease in waterfowl use/survey between years can potentially be attributed to various factors such as flyway population trends and weather conditions. However, it is likely that the continuing changes in water management and remedial activities at or near the Page facility may also be impacting waterfowl use. For example, the recent draining of Pond #1 has substantially reduced the available waterfowl habitat at the site. Continued deposition of fill in the West Swamp will reduce the available habitat for waterfowl and other wildlife as well. Additional surveys should be conducted in order to establish post-remedy conditions.

3.3 Small Mammal Population Surveys

3.3.1 Methods

Small mammal population surveys were conducted using Sherman traps and mark-recapture techniques in 2001 and 2003. Sites sampled in 2001 consisted of remediated gulches and unremediated hillside areas of Government, Magnet, and Deadwood Gulches, and the Smelterville Flats area. Population characteristics from 2001 sampling were compared to previous results (Herman, 1975). Sites sampled in 2003 included the gulch and hillside areas of Government Gulch and the Latour Creek reference area (Figs. 4-5). Government Gulch was chosen due to its similarity in topography, aspect, and elevation with Latour Creek, and resampled in 2003 to examine population differences between a study site and a reference area. All sites were trapped for 2 sessions, July-August. Each trapping session consisted of 3 consecutive nights. Each small mammal trapped during the first session received a numbered ear tag for future identification. Data collected during mark-recapture surveys included site location, grid and/or transect location, station number, species, sex, reproductive status, weight, age, and recaptured small mammal identification number. All surveys followed UCFWO SOP# 1019.3761. Methods included:

> <u>Government Gulch:</u> Due to topographical constraints (i.e. narrow canyon and existing road), traps within the defined "gulch areas" were placed in a 5 x 10 grid array (n = 50). Trapping on the adjoining east and west hillsides consisted of one 500-m transect per hillside (n = 100). Hillside transects were established approximately 100-200 m from the gulch area grid array.
>
> <u>Magnet Gulch:</u> Traps within the defined "gulch areas" were place in 5 x 10 grid arrays (n = 50). One 500-meter transect (n = 50 traps) was established in the "lower gulch" portion of the site, approximately 300 m from the upper gulch grid array and adjacent to Magnet Creek. The other 500-m trapping transect (n = 50) was established on the west side of the adjoining hillside, 100- 200 m from the gulch area.
>
> <u>Deadwood Gulch:</u> Traps within the defined "gulch areas" were placed in a 5 x 10 grid array (n = 50). Trapping on the adjoining east and west hillsides consisted of one 500-m transect per hillside (n = 100). Hillside transects were established approximately 100-200 m from the gulch area.
>
> <u>Smelterville Flats:</u> A 10 x 10 trap grid array (n = 100 traps) was established within the "Flats" portion of the site, and a 500-m transect array (n = 50) was used within the riparian section of the SFCDR.
>
> <u>Latour Creek (reference area):</u> Due to topographical constraints (i.e., narrow canyon and existing road), traps within the gulch area of Latour Creek were placed in one 2 x 5 (n = 10 traps) and two 4 x 5 (n = 40) grid arrays. Trapping on the adjoining west hillside consisted of one 500-m transect (n = 50). The hillside trapping transect was established approximately 100 m from the gulch area grid array.

Relative small mammal abundance was calculated as the total number of individuals captured per 100 trap nights. Chapman's unbiased version of the Lincoln-Petersen estimator was used to estimate population size and its associated variance (Lancia et al., 1994). The Shannon-Weiner index (Zar, 1999) was used to evaluate species diversity differences between years and sites.

3.3.2 Results

Table 11 presents total number, species, relative abundance, and estimated population size of small mammals captured per location in OU-2 in 2001 and 2003. Number of species and relative abundance of small mammals captured on OU-2 1975 and 2001, and Latour Creek reference area 2003 are presented in Table 12.

Three thousand, six hundred trap nights were sampled in 2001. Five hundred-twenty small mammals were captured in OU-2 representing 7 species in 6 genera. Deer mice (*Peromyscus maniculatus;* n = 422 individuals) were the most common species captured, representing 81% of the total population.

Six hundred trap nights were sampled in 2003. Sixty-six small mammals were captured from the Government Gulch area, representing 3 species in 3 genera. Fifty eight small mammals were captured from the Latour Creek reference area, representing 7 species in 4 genera. Deer mice were the predominant species captured at both locations, representing 71% (n = 47) and 52% (n = 30) of the populations, respectively. There was no significant difference between estimated small mammal population sizes (t_2 = 1.05; P = 0.403) for Latour Creek (107 ± 22; 9.5) and Government Gulch (96 ± 8; 7.3) in 2003, nor was there one for relative abundance (t_2 = 0.71; P = 0.552). Relative abundance and estimated population size of deer mice appeared to decrease at Government Gulch from 2001 (18.5 and 213 ± 10) to 2003 (7.3 and 96 ±8; Table 11).

Comparisons of male/female, adult/juvenile, and reproductive ratios are presented in Table 13. More adult males were caught (26% of total population) than females (20% of total population) in OU-2 in 2001 ($X^2_{1,520}$ = 3.913, P = 0.048). Of the adult female population 57% were reproductively active (i.e., pregnant and/or lactating). Juveniles comprised 54% of the total population. Equal numbers of adult females and males were captured from Government Gulch in 2003 (males = 30% of total population, females = 32% of total population; $X^2_{1,66}$ = 0.027; P = 0.869). Sixty-eight percent of the adult female population in 2003 was reproductively active, and juveniles comprised 39% of the total population. Equal numbers of adult females and males were captured from Latour Creek in 2003 (males = 29% of total population, females = 18% of total population; $X^2_{1,66}$ = 1.19; P = 0.275).

The Shannon-Weiner species diversity indices (H1, Table 14) at OU-2 in 2001 and Government Gulch in 2003 were below those from Herman's study in OU-2 in 1975 (Herman, 1975) and approximately half of that from the reference area.

3.3.3 Discussion

Small mammal relative abundance within OU-2 appeared greater in 2001 than observed by Herman (1975) in 1975 (Table 12). However, species diversity was less than observed by Herman (1975) and that from the reference area, apparently caused by habitat characteristic differences. Herman (1975) found habitat characteristics to differ with distance from smelter areas, with plant diversity continually increasing with smelter distance. Vegetation zones improved from "largely barren ground…containing five species or less…" with "heavily damaged" plants, to a conifer-dominated, multilayered vegetation zone comparable to background areas. Abundance of deer mice did not appear affected by smelter activities. However, small mammal species diversity correspondingly increased with increasing smelter distance (Herman, 1975). Species not observed in OU-2 in 2001 (i.e., northern pocket gopher [*Thomomys talpoides*]) were only observed by Herman (1975) beyond approximately five km from smelters, areas he generally considered conifer forests with heavy understory and diverse forb components. Mammal species also found at the Latour Creek reference area but not OU-2 in 2001, such as the southern red-backed vole (*Clethrionomys gapperi*), northern flying squirrel (*Glaucomys sabrinus*), and northern-pocket gopher, are common to forests of northern Idaho and can be found in relative abundance when specific habitat components are available (Hall, 1981; Foresman, 2000). Preferred habitat characteristics of these species include a heavy understory component (i.e., grasses, forbs and shrubs), mature conifer forests, and wet, marshy meadows (Hall, 1981; Foresman, 2000). While re-vegetation programs have been conducted in OU-2 since 1975, acidic soil conditions, lack of nutrients and water, rockiness of the soil, and steepness of hillside slopes have produced difficult vegetative growing conditions (USEPA, 2000). Resulting current habitat conditions lack vegetative ground cover and understory components, large diameter trees, and a diverse vegetative species composition, representing an early sessional stage of forest development (USFWS, 2003). Such habitat conditions tend to support the small mammal community structures (i.e., species composition and diversity) currently observed in OU-2. As vegetative diversity and structure improve within OU-2, a corresponding shift in small mammal communities to more closely represent reference areas is expected to occur.

We observed an apparent deer mouse population decline at Government Gulch from 2001 to 2003. Periodic population fluctuations in small mammal communities are not unusual, yet causes continue to be poorly understood (Oli and Dobson, 2000). Small mammal population dynamics can be influenced by a number of factors including the quantity and quality of food, availability of water, vegetative cover and structural heterogeneity of the forest floor (Oli and Dobson, 2000; Witt and Huntly, 2001). Factors influencing small mammal populations in OU-2 could be related to past and current remedial activities such as tree plantings, soil amendments, erosion control measures and the reestablishment of grasses and forbs. All of these measures have the potential to influence small mammal populations via habitat modification and disturbance.

Small mammal reproduction, measured by the number of adult females either pregnant and/or lactating, was higher in 2003 at the Latour Creek reference area than across OU-2 in 2001 and at Government Gulch in 2003. It is unclear whether differences are related to habitat quality or mining-related contaminants (see section 4.3) variables.

3.4 Fish Population and Stream Habitat Surveys

3.4.1 Fish Population Surveys

3.4.1.1 Methods

Fish population surveys were conducted September and October, 2003. Sampling sites consisted of 4 100-m sampling units in the South Fork Coeur d'Alene River (SFCDR) within OU-2 site boundaries (Fig. 8). Data collected from each sampling site consisted of water quality, fish population, and stream habitat inventories. Water quality parameters included pH, dissolved oxygen, conductivity, alkalinity, and temperature. Fish population surveys were conducted using multiple pass depletion and removal methods. Sampling methods followed UCFWO SOP #1019.3763.

Population size for individual sampling locations was estimated from catch data using the MicroFish 2.2 Interactive Program (VanDeventer and Platts, 1986). Estimates of total fish population per area sampled were calculated by dividing the population by the surface area of the site. Site surface area was calculated by multiplying the site length by the average site width (i.e., average of downstream, middle, and upstream width measurements). USFWS surveys to be conducted in 2005 will be reported to EPA in an amendment to this report.

3.4.1.2 Results

One hundred twenty-four fish were captured from all sites during fish population monitoring: 77 brook trout (*Salvelinus fontinalis*), 9 cutthroat trout, (*Salmo clarki*), 2 rainbow trout (*Onrcorhynchus mykiss*) and 36 other individuals including perch (*Percidae spp.*), mountain whitefish (*Prosopium williamsoni*), and sucker spp. (*Catostomus spp*) (Table 15). Estimates of total fish populations in the SFCDR within OU-2 ranged from 19 fish at SFR-2 to 65 fish at SFR-3. Estimates of fish populations per sampled area ranged from 0.013 fish/m^2 at SFR-2 to 0.041-fish/m^2 at SFR-3. Number of species captured ranged from 3 at SFR-2 to 6 at SFR-1 (Table 15).

3.4.1.3 Discussion

Overall actual catch trout densities utilizing the SFCDR within OU-2 in 2003 averaged 0.015 fish/m^2. This appears to be an increase from pre-remediation levels from surveys also using multiple pass depletion: means of 0.006 fish/m^2 from the OU-2 area 1987-1988 (Dames and Moore, 1989) and 0.008 fish/m^2 near Pine Creek 1994-1995 (as summarized in Stratus Consulting, 1999). We did not sample a reference location. However, our observed trout density was still 3.5 times lower than the North Fork of the Coeur d'Alene River (Dames and Moore, 1989), 6.2 times lower than the SFCDR above OU-2, and 9.8 times lower than the St. Regis River (as summarized in Stratus Consulting, 1999) pre-remediation reference sites.

Total fish densities at our 2003 OU-2 study sites averaged 0.021 fish/m^2. This was similar to the Dames and Moore (1989) pre-remediation mean OU-2 density (0.022 fish/m^2), but below the mean observed in 1994-1995 near Pine Creek (0.136 fish/m^2; as summarized in Stratus Consulting, 1999). Our 2003 post-remediation total fish density was still 41 times lower than the total fish density observed at the North Fork of the Coeur d'Alene (Dames and Moore, 1989), 18.5 times lower than the SFCDR above OU-2, and 10.9 times lower than the St. Regis River (as summarized in Stratus Consulting, 1999) pre-remediation reference sites.

The pre-remediation ecological risk assessment for OU-2 stated "Comparisons to relatively unimpacted ecosystems indicate a depression in aquatic community structure and function. Populations of benthic organisms and fish are low…" (SAIC and EP&T, 1991). Furthermore, following pre-remediation sampling, Dames and Moore (1989) concluded "…clearly, the fish populations throughout the SFCDR (South Fork Coeur d'Alene River) study reach are heavily stressed…the densities of fish are well below what would be expected in an unpolluted Idaho stream of similar physical characteristics and elevation." While the overall trout population utilizing the OU-2 area appears to have increased, mean overall fish densities do not seem to have increased following remediation. Previous data demonstrated that fish densities are depressed below mining influences relative to above influences (Stratus Consulting, 2000). Based on 2003 data, the overall fish population in the South Fork of the Coeur d'Alene River within OU-2 continues to be depressed as described in pre-remediation documents. A second season of fish population sampling in the fall of 2005 will provide data to further assess fish densities in this area.

3.4.2 Stream Habitat Surveys

3.4.2.1 Methods

Stream habitat surveys were conducted at the completion of the fish population survey in the same locations used for fish surveys (Fig. 8). Data collected during the stream habitat inventory included: habitat composition, canopy and in stream cover, channel length and width, substrate and pool counts. Survey methods followed UCFWO SOP # 1019.3763. Comparisons of this data to previous surveys and USFWS surveys to be conducted in 2005 will be reported to EPA in an amendment to this report.

3.4.2.2 Results

Stream habitat survey results are presented in Table 16. The average wetted channel width for the 4 sites on the South Fork Coeur d'Alene River within OU-2 was 14.3 m. Estimated bank full widths ranged from 20.9 m at SFR-1 to 94.0 m at SFR-4. Average depths were similar across all sites with an average of 0.40 m and a range of 0.26 m (SFR-4) to 0.51m (SFR-3). Habitat composition was similar at all sites. Runs and glides were the dominant component (60 to 80%), while pools were the least abundant habitat type. Substrate composition was also similar at all sites. Cobble was the dominant substrate at all sampling locations. Small boulders were the subdominant substrate at SFR-1 and 3; gravel was the subdominant substrate at reaches 2 and 4. Cover was similar for all sites sampled. Average canopy cover was 2.5% and average bank cover was 12.5%. Cover provided by woody debris greater than 10 cm in diameter at the base and a least 1 m in length was given a class rating based on the percent of the habitat unit that was covered with debris (i.e., 0-5% = 1, 6- 10% = 2). The riparian corridor for these sites consisted primarily of bare ground and received a woody debris classification of 1.

3.4.2.3 Discussion

Analysis and discussion of South Fork Coeur d'Alene River habitat within OU-2 will be presented in an addendum provided to USEPA following surveys to be conducted fall, 2005.

3.5 Amphibian and Reptile Population Surveys

3.5.1 Methods

Five amphibian and reptile population surveys were conducted during the spring amphibian breeding season (April-May 2001) and 5 surveys during the post-breeding season in July, 2001. Spring breeding season surveys consisted of visual estimates of adults and egg masses and audible point counts for calling adults. Post-breeding surveys consisted of visual estimates of adults, egg masses, and larvae. Surveys took place from 1 hour before sunset to 1 hour after sunset in 500-m segments with audible point counts every 100 m. Perimeter surveys were conducted for wetlands with areas less than 500 m^2. All surveys followed UCFWO SOP# 1019.3762.

Site selection for amphibian/reptile population surveys were based on a review of past remedial activities conducted on OU-2 and a reconnaissance investigation of the South Fork Coeur d'Alene River (SFCDR) and Smelterville Flats wetlands to determine the presence/absence of potential habitat. Surveys were conducted at the following locations:

Down River: This portion of the SFCDR is west of Smelterville Flats and extends down-river to the western boundary of OU-2. Emergent, sub-emergent, and riparian vegetation are present. Seven 500-m segments were established for surveying purposes.

Smelterville Flats: This portion of the SFCDR borders Smelterville Flats. Relatively large sections of this reach have been modified during past remedial activities, which include channel stabilization, sediment removal, and re-engineering. These activities have left minimal riparian habitat. Seven 500-m segments were established for surveying purposes.

Wetlands: Eight distinct palustrine and lacustrine wetlands are present on Smelterville Flats. All wetlands were surveyed using perimeter surveying techniques.

Reference Site: Little North Fork Coeur d'Alene River. This reference site was chosen due to its proximity to the assessment area, relative lack of metals of concern in sediments and water, and similarities in elevation and vegetative component with OU-2 survey locations.

3.5.2 Results

Few amphibians and reptiles (n = 11 adults in OU-2, 4 adults at reference; Table 17) were observed during spring and summer surveys. While all sites had at least one species present during at least one assessment sampling effort, collections did not provide adequate sample numbers to pursue an evaluation of population abundance and diversity or metal exposure.

3.5.3 Discussion

The lack of adequate habitat conditions along the SFCDR corridor appeared to limit amphibian populations. A three-year survey of amphibian populations in the Couer d'Alene Basin conducted by Beck et al. (1997) found that the majority of habitat for breeding amphibians in ponds was characterized as permanent or ephemeral, with emergent and sub-emergent vegetation along the shorelines and wet marshy areas adjacent to ponds. Breeding habitat in streams was characterized by relatively fast-moving water, rocky substrate with little or no sediment load, and large cobble and woody debris. While emergent vegetation in ponds and wetlands in the Smelterville Flats area was reestablishing, the frequency and abundance of this vegetation is thought to be inadequate for amphibian breeding success. The continued re-engineering and sediment removal conducted in the SFCDR has also appeared to produce low quality amphibian and reptile habitat. USFWS recommended that amphibian and reptile population surveys be suspended after the initial 2001 surveys. Additional surveys maybe warranted with the completion of SFCDR sediment removal activities and the reestablishment of suitable habitat in OU-2.

4.0 Wildlife Exposure to Contaminants of Concern

4.1 Passerine Blood Lead

Avian receptors may be exposed to contaminants of concern through the ingestion of contaminated soil or sediment, and/or contaminant uptake by prey items. A variety of songbirds utilize areas within OU-2 (Section 7.1). However, exposure to metals of concern in soil and resulting health effects had not been evaluated.

Physiological biomarkers are often used to determine whether organisms are being negatively affected by environmental stresses. For example, inhibition of delta-aminolevulinic dehydratase (ALAD), an enzyme related to hemoglobin production, has been positively correlated to lead body burdens (Blus et al 1995). Fifty percent ALAD inhibition has been determined to cause physiological impairment to wildlife (43 CFR 11.62). ALAD inhibition and blood and liver lead concentrations were examined to determine songbird exposure to lead in OU-2 compared to reference areas.

4.1.1 Methods

We examined ALAD inhibition in relation to lead body burdens from songbirds utilizing OU-2 areas and a reference area to determine correlations and evaluate the effectiveness of remediation in protecting avian insectivore receptors. Hematocrit packed cell volume (PCV) was also used as an indicator of lead exposure and effects.

For nesting songbirds, it is important to determine whether contaminant body burdens are the result of exposure to contaminants within the spatial confounds of interest. Analysis of stomach contents provides information on recent exposures, allowing researchers to examine local contamination and ingestion of local soil and/or sediment (Beyer et al., 1999). Aluminum, an element common in soil but highly indigestible, is used as a marker of sediment ingestion (Cherney et al. 1983). We used the ratio of aluminum concentrations in soil vs. aluminum concentration in ingesta at each site to predict lead concentrations in ingesta. We then correlated predicted ingesta lead concentrations with observed lead concentrations to determine how much ingested lead was the result of ingested soil.

Songbird blood sampling for ALAD and PCV was conducted in Smelterville Flats and Pinehurst riparian areas along the SFCDR in OU-2 in 2002. Songbird ingesta, liver, and blood lead and ALAD sampling was conducted within OU-2 in June, 2003 on hillside areas of Government, Magnet, and Deadwood Gulch. Songbird ingesta, liver, and blood lead and ALAD sampling was again conducted on the Smelterville Flats and Pinehurst riparian areas June-July, 2004 in order to more thoroughly evaluate routes of exposure. Reference samples were collected June and/or July each year along the Little North Fork Coeur d'Alene River (LNFCDR). Figure 9 identifies sampling locations.

Species of birds selected for blood collection included American robin (*Turdus migratorius*)*,* song sparrow (*Melospiza melodia),* and Swainson's thrush (*Catharus ustulatus*). These bird species were identified by USEPA (2001) as ecological receptors at high to moderate risk of exposure and have been documented on OU-2 (USFWS, 2002). Known to feed on terrestrial and soil invertebrates, these bird species may thus be consuming metals of concern in post remediated areas within OU-2.

All birds were captured using mist nets following UCFWO SOP # 1019.3757. In each study area, nets were placed in optimum locations for collection of targeted species. All birds captured were removed from the nets and identified to species. Data collected on all target bird species included species identification, approximate age, sex, breeding status, weight, and overall condition.

All blood samples collections followed UCFWO SOP #1019.3765. In brief, blood was collected from the bird's jugular vein using a sterile hypodermic needle and heparinized 1cc syringe. The target volume of blood for song sparrows and Swainson's thrush was 300 to 400 µl, and 500 to 600 µl for American robins. After blood collection, the hypodermic needle was removed from the syringe, and approximately 30 µl of blood was drawn into a hematocrit capillary tube. The exact volume of blood remaining in the syringe was recorded and then transferred into a 2-ml cryogenic vial. The cryogenic vial was then immediately placed into liquid nitrogen until shipment to the University of Wyoming, Laramie, WY (UW), for blood lead analysis, and the Patuxent Wildlife Research Center (PWRC), Laurel, MD, for ALAD determination. Hematocrit blood samples were centrifuged and percent hematocrit determined using a microhematocrit capillary tube reader.

Birds that did not survive the blood collection process were dissected for liver and ingesta collection. Liver and ingesta samples collections followed UCFWO SOP #1019.3766 and #1019.3767. Liver samples were placed into a weight-tared 2-ml cryogenic vial and weight of the sample was recorded. Liver samples were then frozen at -20º until shipment to UW for liver lead analysis. Ingesta samples were placed into a tared cryogenic tube and frozen in liquid nitrogen. Samples were frozen until shipment to UW for lead analysis.

Soil lead concentrations were not specifically examined as part of the USFWS biomonitoring work plan within the OU-2 remediated areas. However, soil samples were collected at Government Gulch and Magnet Gulch in 2003, Smelterville Flats and Pinehurst in 2004, and in the Little North

Fork reference area (2003 and 2004) as part of the USFWS songbird health evaluation to determine soil lead-songbird health correlations. Soil samples were collected as composites of 5 subsamples from mist net sites at each capture location. The 5 subsamples were soil collections from 0-2 inches in depth from the center of the net, and from 10 m in each cardinal direction from the center point. Soil samples were sent to UW for analysis of lead concentrations.

Because ALAD activity and hematocrit packed cell volume (PCV) were the only songbird parameters measured in 2002, this data is presented separately in Section 4.1.2.1. Data from 2004 sampling had not been analyzed at the time of this report. Analyses presented in Section 4.1.2.2 are therefore limited to 2003 data. A more comprehensive evaluation of 2003 and 2004 data, including routes of exposure and health of avian receptors in relation to lead concentrations in post remediation soil, will be presented to USEPA in a separate report.

4.1.2 Results

4.1.2.1 2002 Sampling

ALAD units from American Robins examined from the Smelterville Flats assessment area (n = 2) ranged from 10-34 (x = 22.0). ALAD units of American robins from the reference area (n = 8) ranged from 143–251 (x = 204.1; Table 18). Compared to mean ALAD from reference area birds, ALAD levels in the blood of individual American robins from the Smelterville Flats assessment area were reduced by 63-90% (x = 77%).

Mean ALAD values in song sparrows captured on the Smelterville Flats and Pinehurst assessment areas were significantly lower from those of the reference area (P <0.05). Ten of 11 song sparrows (91%) from OU-2 had ALAD inhibition greater than 50% relative to reference (Table 18). Mean ALAD values in Swainson's thrush captured on OU-2 assessment areas were also significantly lower than reference area values (P < 0.05). Eight of 16 (50%) Swainson's thrushes captured from the OU-2 assessment areas had ALAD inhibition greater than 50% relative to reference (Table 18).

Differences in PCV at the assessment areas (pooled Smelterville Flats and Pinehurst data), and reference areas were not significantly different for American robin (P = 0.16), song sparrow (P = 0.78) or Swainson's thrush (P = 0.84).

4.1.2.2 2003 Sampling

Soil Lead Concentrations
Mean soil lead concentrations differed significantly among locations sampled, with mean concentrations increasing from the reference area (24.6 mg/kg) to Government Gulch (171 mg/kg) to Magnet Gulch (1201 mg/kg), and Smelterville (3320 mg/kg) (Table 19).

Soil Ingestion Rates
Songbird ingesta samples were limited within OU-2 (Table 20), preventing the evaluation of soil ingestion differences among sites for each species. A more extensive analysis of soil ingestion rates using the complete Coeur d'Alene Basin data set will be presented in a separate report to USEPA.

Percent soil in ingesta was arcsine transformed for correlation analysis (Zar, 1999). Using available OU-2 data, percent soil in ingesta of all songbirds was negatively correlated to mean soil lead concentration across sites (*P* = 0.015). However, soil lead concentrations accounted for only 28% of the variation in soil ingestion (r^2 = 0.287).

Soil Lead Exposure
Predicted lead vs. observed lead in ingesta was positively correlated and nearly statistically significant (r^2 = 0.17; P = 0.062). Only 3 samples were collected from Government Gulch. The result from 2 of these varied greatly from the regression, with more lead predicted than observed. Correlation significance increased after removing the Government Gulch samples (r^2 = 0.40; P = 0.005). A more extensive analysis of soil lead exposure using the complete Coeur d'Alene Basin data set will be presented in a separate report to USEPA.

ALAD Inhibition
Sample sizes, measured ALAD units and ALAD inhibition relative to the reference site are given in Table 20.

- Overall ALAD inhibition was positively related to blood lead concentrations.
- Samples with >50% ALAD inhibition (all at Deadwood and Magnet Gulches) had corresponding blood lead samples above 0.13 ug/kg.
- Blood lead samples (all from robins) >0.2 mg/kg had corresponding ALAD inhibition >67%.
- Measured ALAD units varied by species across sites, with American robins having significantly less ALAD units than in song sparrows.
- The Government and Deadwood Gulch American Robin values were below the reference site mean, and the mean Magnet Gulch value was significantly below that of the reference mean.
- Song sparrow blood ALAD units did not differ between Government Gulch and the reference site.
- Means or single sample Swainson's thrush ALAD values decreased from the reference location to Government Gulch, Magnet Gulch and finally to Deadwood Gulch. Magnet Gulch was significantly lower than the reference area.

Lead Body Burden
Blood lead
Sample sizes and blood lead results are given in Table 20.

- Mean blood lead was higher in American Robins at Magnet Gulch than the reference area. The Government Gulch value was above the 95% confidence interval from the reference area.
- Mean blood lead in song sparrows was higher at Government Gulch than the reference area.
- Mean blood lead in Swainson's thrushes increased from Government Gulch to Magnet Gulch to Deadwood Gulch. Mean blood lead was significantly higher at Deadwood Gulch than the reference area.
- No song sparrows or Swainson's thrushes were observed with blood lead concentrations > 0.167 mg/kg.
- All blood lead samples >0.2 mg/kg, corresponding to >50% ALAD inhibition, were collected from Magnet and Deadwood Gulches.

Liver lead
Sample sizes and liver lead results are given in Table 20.

- No American robin liver samples were collected from study locations.

- Song sparrow livers were sampled from the reference area and Government Gulch. Only 2 liver samples were collected from Government gulch, precluding statistical analysis. However, liver lead concentrations (1.084 and 8.613 mg/kg) were 8.6 and 68.5 times that of the reference mean (0.126 mg/kg).
- Swainson's thrush livers were sampled from the reference area and Magnet and Government Gulches. Only 2 samples were collected from each gulch, precluding statistical analysis. However, Magnet Gulch (0.042 and 5.59 mg/kg) and Government Gulch (0.681 and 3.616 mg/kg) concentrations were 2.3-29.8 times higher than the reference location mean (0.188 mg/kg).

4.1.3 Discussion

The results of initial data indicate that American robins, song sparrows, and Swainson's thrush utilizing the Smelterville Flats and Pinehurst riparian areas of OU-2 are being exposed to lead levels sufficient to cause physiological impacts and adverse effects. Clean replacement soils for OU-2 were considered to contain <100ppm lead (USEPA, 1992). Mean lead soil concentrations at Government and Magnet Gulches and Smelterville remain above this standard. More extensive soil sampling is required to more accurately determine mean soil concentrations in these and other post remediated areas.

Blood lead levels >0.167 mg/kg were not observed in 2 of 3 songbird species sampled. Behavior or physiology in these species may prevent them from accumulating blood levels above this point. On the contrary, blood lead in this range may be indicative of acutely toxic levels to certain songbird species, precluding us from capturing and examining such individuals. An investigation into physiological effects of blood lead above levels we observed for these species would be required to determine acute thresholds. In contrast, we observed blood lead levels up to 1.13 mg/kg and corresponding ALAD inhibition up to 88.8% in American robins. American robins as a species may be able to tolerate higher blood lead/ALAD inhibition than other songbird species sampled.

Songbirds in general do not appear to be consuming different amounts of soil at different sites. Pathway analysis showed songbird lead exposure to be from soil ingestion, corroborating correlated differences among location lead concentrations in soil and bird blood.

Songbirds we examined within OU-2 remediated areas had blood lead levels determined to be indicative of physiological impairment to wildlife. Furthermore, mean liver lead concentrations and ALAD inhibition were higher at OU-2 post remediation areas than reference areas. Lead contaminated soil at Magnet Gulch appears to be eliciting the greatest negative effects in songbirds of the locations studied within OU-2.

4.2 Waterfowl Blood Lead Evaluation

Lead poisoning has been identified as the cause of death in waterfowl utilizing the Coeur d'Alene River Basin floodplain (Audet et al., 1999b; Sileo et al., 2001). Waterfowl lead exposure in the Coeur d'Alene Basin occurs mainly through ingestion of lead-contaminated sediment during normal feeding behaviors (Blus et al., 1991; Beyer et al., 1998; Blus et al, 1999; Henny et al., 2000 Audet et al., 1999b). To date, 11 species of waterfowl utilizing Basin floodplain habitat have been documented as being poisoned by lead (Audet et al., 1999b; Sileo et al., 2001; USFWS, unpublished data). Previous studies completed in Basin floodplain wetlands found sediments in many areas with lead concentrations sufficient to cause sublethal and lethal effects to several species of waterfowl (Beyer et al., 2000).

The Page Ponds wetland complex is comprised of two wetlands (East and West swamps; Figure 8), occurring on the east and west side of the Page Ponds Wastewater Treatment Plant, and are some of the only available wetland areas to waterfowl within OU-2. Bunker Hill Mill began depositing mine tailings at Page Ponds around 1927 (USEPA, 2002). Since 1991, the Page Ponds soil repository has been used as the primary soil repository for the Bunker Hill Institutional Control Program. In addition, the Page repository was used for disposal of soil generated from the residential yard remediation program, consisting of soils containing >1,000 mg/kg lead (USEPA, 2002), which is above the ROD cleanup level for lead in sediment of 530 mg/kg (USEPA, 2002). We examined blood lead concentrations in waterfowl utilizing the Page Ponds area to evaluate effects of lead contaminated sediment in those wetlands.

4.2.1 Methods

Mallard trapping and blood collection was conducted in the East swamp, July 2003. All waterfowl were captured with funnel traps following UCFWO SOP #1019.3742. Traps were placed at the waters edge where preening and loafing activity had been observed. Traps were baited with cracked corn and left open overnight. Data collected on waterfowl captured included species identification, approximate age, sex, and weight. Waterfowl were aged based on feather morphology and wear (Dimmick and Pelton, 1996).

Blood samples were collected following UCFWO SOP #1019.3712. In brief, 3 ml of blood was collected from the bird's jugular vein using a sterile hypodermic needle and a heparinized 3 cc syringe. The hypodermic needle was then removed from the syringe and the blood placed into a 3 ml cryogenic vial. The cryogenic vial was immediately placed on wet ice, transported back to UCFWO and stored in a -20 degree Fahrenheit freezer until shipment to the Manchester Environmental Laboratory, Seattle, WA, for blood lead analysis.

Blood lead concentrations were compared to previous studies (Mullens and Burch, 1993; Burch et al., 1996; Audet et al., 1999a) and to concentrations considered elevated in waterfowl (Pain, 1996) to determine exposure to lead for waterfowl utilizing the Page Ponds area.

4.2.2 Results

Blood samples were collected from 37 juvenile and adult mallards. Table 21 presents mean, range, and standard deviation of blood lead concentrations. Mean blood lead did not statistically differ between ages, sexes, or ages within sex. Mean blood lead concentrations in adult and juvenile males and adult females were in the range considered clinical poisoning for waterfowl (0.05-0.10 mg/kg; Pain, 1996). Mean juvenile female blood lead (1.54 mg/kg) was above the threshold considered severe clinical poisoning (Pain, 1996).

4.2.3 Discussion

The Page Ponds wetland complex provides some of the only available wetland areas to waterfowl within OU-2 and the Silver Valley. Waterfowl use surveys indicated the presence of nesting and brooding individuals USFWS (2003). Blood lead data indicated that waterfowl juveniles and adults utilizing this area continued to be exposed to lead at clinically toxic levels.

The Page Ponds wetland complex is the likely source of lead exposure to metals of concern for waterfowl studied at this location. Sampling in 1993 showed that sediment the West and East

Swamps within the complex contained lead concentrations up to 26,800 mg/kg and 5990 mg/kg, respectively (McCulley, Frick, and Gilman, Inc., 1994), well above the ROD cleanup level for lead in sediment of 530 mg/kg (USEPA, 2002). Sediment within the complex has not been remediated, and probably constitutes the major exposure source. The current use of the complex as an uncapped repository for soil generated from the USEPA OU-1 yard remediation program is also of concern. Lead concentrations in yard remediated soil are >1000 mg/kg (USEPA, 1991), more than twice that of ROD cleanup levels and concentrations shown to cause negative physiological effects in waterfowl (Beyer et al., 2000).

Mean blood lead concentrations in Mallards collected from the East swamp in 1993, 1995, and 1997 were 2.0, 0.86, and 2.68 µg/g, respectively (Mullins and Burch, 1993; Burch et. al., 1996; Audet et. al., 1999). No downward trends are apparent in overall lead concentrations in mallards utilizing Page Ponds wetlands. Continued monitoring will provide valuable information regarding the continued use of the Page Pond wetland complex in managing the site for the protectiveness of ecological receptors.

4.3 Small Mammal Metals Evaluation

4.3.1 Small Mammal Whole-Body Metals

Small mammals may be exposed to metals through ingestion of contaminated soil, food or water, or from inhalation of contaminated soil. Life history traits of each species, including diet, burrowing activity and hibernation, can affect metal exposure (Hunter et al., 1987; Ma, 1996). The level of exposure to different environmental contaminants can therefore vary within and between species.

Deer mice (*Peromyscus maniculatus*) and voles (*Microtus spp*.) were the predominant species on all small mammal evaluation sites. These species represent relatively similar ecological life histories, although differences in foraging strategies exist (Foresman, 2001). Deer mice tend toward omnivory, whereas meadow voles are more strict herbivores and species of shrews (*Sorex spp*.) are insectivores. Given differences in life history traits, especially foraging strategy and burrowing behaviors, differences in metal exposure and thus body tissue residue concentrations between these species are expected. In addition, differences in habitat within or between sites (i.e., possible differences in food resources) could play a role in promoting differential exposure between species. Small mammals were collected at the completion of small mammal population surveys, 2001-2003 to evaluate small mammal exposure to metals of concern.

4.3.1.1 Methods

Sampling sites consisted of those selected for population surveys (Figure 4). Seventy Victor mousetraps (snap traps) per site were placed within the previously established grid and/or transect trapping arrays (i.e., OU-2 and Latour Creek reference area). All sites were trapped for 2-4 days. Procedures for the collection of small mammals for metals evaluation followed UCFWO SOP #1019.3761.

All small mammals collected were placed in individual Ziploc bags and archived in a -20 C freezer at UCFWO until being shipped on wet ice to the Manchester Environmental Laboratory for metal residue analysis.

4.3.1.2 Results

Two-hundred thirteen small mammals were collected from both OU-2 and the Latour Creek reference area 2001-2003. Table 22 presents sample size, geometric mean, standard deviation, range and wet weight (ww) metal concentrations in whole body deer mice collected from OU-2 and Latour Creek reference areas.

Metal concentration levels in whole body deer mice collected in 2001 from OU-2 varied between sites. Arsenic concentrations were significantly higher at Deadwood Gulch than Government or Magnet Gulch ($P < 0.05$). Cadmium concentrations at both Government and Magnet Gulch were significantly higher than at Deadwood Gulch ($P < 0.001$) and Smelterville Flats ($P < 0.001$). Lead concentrations at Magnet Gulch and Smelterville Flats were higher than at Government Gulch ($P < 0.001$). Zinc concentrations were significantly higher at Government Gulch than Deadwood Gulch ($P < 0.001$). Deer mouse cadmium, lead and zinc concentrations were highest at Magnet Gulch, with geometric means of 0.34, 10.79, and 41.04 mg/kg ww, respectively.

Arsenic and cadmium concentrations in deer mice collected from Government Gulch in 2002 were not significantly different from 2002 reference area samples ($P = 0.192$ and $P = 0.128$, respectively). Both lead and zinc concentration levels were significantly higher than those of the reference area ($P < 0.001$). No differences existed between metal concentrations in deer mice collected from Government Gulch and Deadwood Gulch in 2003 ($P = 0.13$-0.34).

Several of the metals examined at each OU-2 site in 2001, 2002 and 2003 were higher than the 2002 reference site (Table 22). The overall combined averages of cadmium, lead, and zinc in whole body deer mice collected from OU-2 areas in 2001 were significantly higher than those collected from the reference area in 2002 ($P < 0.001$). Arsenic concentration levels were not significantly different ($P = 0.164$; Table 22). The overall combined averages of cadmium, lead, and zinc from whole body deer mice collected from OU-2 areas in 2001, 2002, and 2003 were significantly higher than those of reference area samples ($P = 0.001$).

Sample size, geometric mean, standard deviation, range and wet weight (ww) of metal concentrations in whole body Vole species collected from OU-2 and Latour Creek reference areas are presented in Table 23. Metal concentrations in whole body vole species collected from OU-2 in 2001 varied between sites. Arsenic concentrations were significantly higher at both Deadwood Gulch and Magnet Gulch than Smelterville Flats ($P< 0.05$). Cadmium and lead concentrations were significantly higher at Magnet Gulch than Smelterville Flats ($P = 0.001$). Zinc concentrations were not significantly different among sites ($P = 0.733$). Arsenic, cadmium, and lead concentrations in voles were highest in Magnet Gulch, with geometric means of 0.16, 0.41, and 22.34 mg/kg ww, respectively. Mean zinc concentration (38.94 mg/kg ww) was highest in voles collected for Government Gulch (Table 23).

The overall combined averages of cadmium, lead, and zinc concentrations in whole body vole species collected from OU-2 in 2001 were significantly higher than those of reference area samples collected in 2002 ($P < 0.001$). Arsenic concentrations in 2001 were significantly higher ($P < 0.05$) at Magnet Gulch than the reference area in 2002.

Table 24 presents sample size, geometric mean, standard deviation, range and wet weight (ww) of metal concentrations in whole body shrew species collected from OU-2 and Latour Creek reference areas. Metal concentrations in whole body shrew species collected from OU-2 in 2001 varied among locations. Arsenic concentrations at Magnet Gulch were significantly higher than Smelterville Flats ($P= 0.001$). Government Gulch had significantly higher cadmium levels than both Smelterville Flats and Magnet Gulch ($P= 0.001$), and lead concentration levels were higher at both Magnet Gulch and Deadwood Gulch than Government Gulch ($P= 0.001$). Zinc concentrations were not significantly different among sites ($P = 0.651$). Arsenic concentrations were highest at Magnet and Deadwood Gulches; cadmium was highest at Government Gulch; lead and zinc were highest at Deadwood Gulch (Table 24).

Arsenic, lead, and zinc concentrations in shrew species collected from Government Gulch in 2002 were significantly higher than 2002 reference area samples ($P = 0.001$). No significant differences existed in cadmium concentrations ($P = 0.249$).

Arsenic, lead, cadmium and zinc in shrew species collected in 2003 were significantly higher at Government Gulch than at the Latour Creek reference area ($P < 0.001$). The overall combined averages of cadmium, lead, and zinc from whole body shrew species collected from OU-2 areas in 2001, 2002, and 2003 were significantly higher than those of reference area samples ($P = 0.001$).

Whole body cadmium concentrations were significantly higher ($P < 0.001$) in shrew species collected in OU-2 than deer mice and vole species. Both shrew and vole species had significantly higher ($P < 0.001$) whole body lead concentrations than deer mice.

No significant differences existed between whole body metal concentrations from small mammals collected on hillsides or from remediated gulch areas within each site ($P = 0.06$-0.47).

4.3.1.3 Discussion

Previous studies of lead and cadmium concentration levels in small mammals collected from areas within OU-2 indicate that exposure to lead and cadmium remained unchanged and relatively constant between 1975 and 1987 (Table 25; Szumski, 1999). Current data indicates a decrease in exposure of small mammals to lead within OU-2. Soil remediation in areas evaluated appears to be reducing small mammal exposure to metals of concern. However, current data also indicates that metal concentrations in small mammals utilizing OU-2 areas continue to be elevated above reference samples. Furthermore, no difference appears to exist in small mammal exposure to metals of concern between remediated gulch areas and unremediated hillsides. The continued subchronic exposure of small mammals utilizing OU-2 to elevated metals concentrations may be of concern. Previous studies suggest that subchronic exposure to lead can produce persistent deficits in learning ability and behavior in mammals that are asymptomatic. Low-level lead exposure has also shown to elicit an increased susceptibility to disease (Szumski, 1999) and reproductive impairment (Ma, 1996). Small mammal reproduction within OU-2 appeared reduced relative to our reference site (section 3.3.2, Table 13). Subchronic metal exposure may be contributing factor. A diminished learning capacity, susceptibility to disease and reproductive impairment during a critical developmental phase of a small mammal may also have consequences for individual long-term survival.

4.3.2 Small Mammal Liver Tissue Evaluation

4.3.2.1 Methods

A subset of deer mice collected during metals evaluation surveys was selected for liver metal analysis. Deer mice were selected for liver dissection due to their abundance on both OU-2 and the Latour Creek reference area. Individuals selected for liver samples were removed from the storage freezer and allowed to thaw. All instruments were decontaminated following UCFWO SOP #1019.3707 prior to liver removals and in between samples. Labeling and documentation of liver tissue followed UCFWO SOP #1019.3701. Removed livers were placed in separate labeled, laboratory cleaned sample jars. All samples were frozen at -20 C until shipment to the Manchester Environmental Laboratory for metal analysis.

4.3.2.2 Results

Number, mean, standard deviation, and range of metal concentrations (mg/kg dry weight) in the liver of deer mice (*Peromyscus maniculatus*) collected from OU-2 and Latour Creek reference areas are presented in Table 26. Liver cadmium and lead concentrations were significantly higher from mice collected in several OU-2 areas than from reference areas ($P < 0.001$). Mean liver arsenic and lead concentrations did not differ among OU-2 areas. The mean cadmium liver concentration at Smelterville Flats (0.58 mg/kg) was lower than at Magnet Gulch (2.87 mg/kg) and Government Gulch (3.57 mg.kg) ($P < 0.001$). Mean lead liver concentrations were highest at Magnet Gulch (1.75 mg/kg ww). No significant differences existed between liver metal concentrations from small mammals collected on hillsides or from remediated gulch areas within each site ($P = 0.06$-0.47).

4.3.2.3 Discussion

Ma (1996) reports that a liver lead concentration above 5 mg/kg dw indicates toxic exposure to lead in mammals; levels above 10 mg/kg dw indicate acute lead poisoning. While liver lead concentrations in OU-2 samples were below these values, two samples collected from the Deadwood Gulch and Government Gulch assessment areas had liver Pb values of 3.76 and 4.36 mg/kg dw, respectively. Ma (1996) indicates that such exposure conditions may produce reproductive impairment, such as decreased fertility and retarded development of the fetus. Small mammal reproduction within OU-2 appeared reduced relative to our reference site (section 3.3.2, Table 13). Subchronic metal exposure may be contributing factor.

Cooke and Johnson (1996) suggest that a paucity of data exists on the effects of cadmium on ecological receptors. However, cadmium has no known beneficial biological functions. Negative physiological effects of dietary exposure to cadmium include growth depression, hypertension, anemia, bleaching of incisors and renal dysfunction (Cooke and Johnson, 1996). The continued exposure of small mammals inhabiting OU-2 to metal concentrations above those of reference values is of concern. Furthermore, no difference appears to exist in small mammal exposure to metals of concern between remediated gulch areas and unremediated hillsides. It is unclear whether gulch remediation has been successful in protecting small mammals from effects of heavy metals of concern.

4.4 Aquatic Invertebrate and Fish Metals Evaluation

4.4.1 Methods

Whole-body fish were collected in September 2002 and fish and aquatic invertebrates collected in September 2003 and 2004 for metals residue analysis. Fish and invertebrates were collected at fish population sampling locations (see section 2.4.3.3.2.4; Figure 8) following UCFWO SOP # 1019.3764. Methods of collection included dip nets and a backpack electrofishing unit. Seven composite aquatic invertebrate samples were collected from four reaches of the South Fork of the Coeur d'Alene River within OU-2, September and October 2003 and August and September 2004 in accordance with UCFWO SOP #1019.3763.

4.4.2 Results

4.4.2.1 Fish

Twenty brook trout (*Salvelinus fontinalis*) and one sucker (*Catostomus spp*.) were analyzed for arsenic, cadmium, lead and zinc. Mean mg/kg wet weight metals concentrations for trout were 0.743 for arsenic, 1.497 for cadmium, 7.860 for lead and 199.571 for zinc. Values in mg/kg for the sucker were 0.218 for arsenic, 1.20 for cadmium, 5.546 for lead and 145.314 for zinc (Table 27).

The mean zinc value we observed was well above levels showing no effects reported for brook trout. However, literature reference values were results of specific organs analyzed, not full body burdens, possibly making comparisons incompatible. Using fingerling and juvenile rainbow trout for comparison, the mean arsenic concentration appeared below those causing negative effects. Literature reference values for whole body effects levels for adults were not available. Further examination is required to determine whether brook trout arsenic tissue residues in OU-2 are similar for adults and juveniles. The mean cadmium concentration appeared to be above levels causing reduced growth and survival in brook trout juveniles. However, whole body effects levels for adults were not available. Further examination is required to determine whether brook trout cadmium tissue residues in OU-2 are similar for adults and juveniles. The mean lead concentration was within concentrations showing no effects to brook trout.

4.4.2.2 Aquatic invertebrates

Wet weight concentrations differed among sites for arsenic, cadmium and zinc. Arsenic was higher in reach 1 than 4. Cadmium was higher in reach 2 than 3 and 4. Zinc was higher in reach 2 than 4. General trends showed arsenic, cadmium and zinc to be highest at reach 2, then decreasing to reach 1, to reach 3, and lowest at reach 4 (Table 28). Means we observed for cadmium and lead were below negative effects levels. Literature zinc thresholds vary, and may be based on route of exposure (i.e., sediment versus water concentrations). No values were available for arsenic.

4.4.3 Discussion

Metals tissue residues in the area of the South Fork of the Coeur d'Alene River examined appear highest in reach 2. This may be due to its spatial relation to the Central Impoundment Area (CIA), which is an unlined, capped tailings repository. While reaches 3 and 4 are upstream of the CIA, reach 2 is directly downstream (Fig. 8). Any potential metals releases from the CIA would result in metals loading at this point in the river, corresponding to elevated tissue concentrations in aquatic resources utilizing this area.

Tissue concentrations observed in brook trout appear to be elevated above levels causing physiological impairment. However, uncertainties remain regarding effects threshold values and routes of exposure. A continued evaluation of metals concentrations in fish and aquatic invertebrates within OU-2 and at reference locations is recommended to determine tissue concentration trends as remedial activities continue in OU-2 and OU-3..

4.5 Wildlife Fecal Soil Ingestion and Metals Evaluation

Organisms can be exposed to contaminants of concern through the ingestion of contaminated soil or sediment, and/or through contaminant uptake by prey items. Wildlife receptors may ingest a substantial amount of soil during various activities, including feeding, grooming and burrowing. Ingestion of soil may then expose them to environmental contaminants (Beyer et al., 1994).

Estimates of percent soil in feces are conducted to examine incidental exposure through the soil consumption pathway.

4.5.1 Methods

Opportunistic collection of wildlife feces was conducted 2001-2003 in order to evaluate the extent of soil ingestion and metal exposure in several wildlife species utilizing OU-2 post-remediation areas. Collection and processing methods are described in USFWS (2003). Percent acid-insoluble ash (%AIA) is an estimate of the sediment content of the feces, approximated from the weight of the acid-insoluble ash divided by the dry weight of the fecal sample. Fecal samples were collected from sites within OU-2 and reference sites and analyzed for %AIA. Percent soil ingestion rates were calculated from the %AIA content of the feces and the estimated digestibility of the diet (Beyer et al., 1998). Separate fecal samples were concurrently collected from sites within OU-2 and reference sites and analyzed for metal concentrations. Fecal %AIA and metal concentrations were used together to determine exposure to metals of concern for ecological receptors utilizing OU-2.

4.5.2 Results

4.5.2.1 Fecal Sediment Content

One hundred-ninety eight goose, elk and deer fecal samples were collected and submitted for %AIA content analysis from 2001-2003 (Table 29). Soil ingestion rates did not differ among years within locations. Data was therefore pooled across years for each species. Combined years soil ingestion rates did not differ among locations within species. Results indicate that geese, elk and deer utilizing OU-2 areas are not consuming more sediment than those using reference areas. Mean percent soil ingestion rates and standard errors were 12.99±1.12% for goose, 1.12±0.29% for elk, and 3.60±1.20% for deer.

4.5.2.2 Fecal Metal Concentrations

A total of 233 moose, coyote, Canada goose, deer and elk fecal samples were collected for metal residue analysis from 2001-2003 (Table 29). Where a sufficient number of samples were collected for multiple years within a site, yearly trends in mean concentrations were examined.

Two moose fecal samples were collected at Smelterville Flats and 2 at the Little North Fork of the Coeur d'Alene River (LNF) in 2001. While mean lead concentration at Smelterville was approximately half of that at the reference location, means for aluminum, cadmium and zinc were 1.5, 3.3 and 8.8 times higher, respectively. The small sample sizes precluded statistical comparison.

Five coyote scats were collected in 2001: one at Government Gulch, one at Smelterville Flats, and three along the LNF reference area. Mean OU-2 coyote scat lead, zinc and cadmium were 15.7, 6.4 and 17.6 times higher, respectively, than mean reference site concentrations. While samples sizes were too small to conduct statistical analysis, these differences suggest that coyotes within remediated areas were ingesting substantially higher metal concentrations than those outside the area.

Canada goose fecal samples were collected at Smelterville Flats in 2001 and 2003, and from Lewiston, ID in 2003 as a reference location. Means for aluminum, lead, and zinc were higher at

Smelterville than at the reference area. Both 2001 and 2003 cadmium concentrations from Smelterville were higher than those observed from the 2003 reference area. Cadmium concentrations increased at Smelterville from 2001 to 2003.

Deer fecal samples were collected from Magnet, Government and Deadwood Gulches, Smelterville, and the LNF reference area. Deer fecal sample sizes from 2002 were small, precluding accurate statistical analysis between remediated sites and the reference site for samples collected that year. However, means for lead, cadmium and zinc were higher in all sampled remediated sites than the reference location. Deer fecal lead, cadmium and zinc from 2003 samples were higher at all three sampled remediation sites than the reference site, with samples from Smelterville having the highest mean concentration of all three metals.

Deer zinc and cadmium concentrations increased from 2001 to 2003 at the LNF reference site. Aluminum increased from 2002 to 2003 at Deadwood Gulch. Deer samples from Smelterville increased in cadmium, zinc and lead from 2001 to 2003. While lead changes weren't statistically different, lead concentrations at Smelterville increased from 45 mg/kg in 2001, to 85 mg/kg in 2002 and to 195 mg/kg in 2003.

Elk fecal samples were collected from Magnet, Government, and Deadwood Gulches, Smelterville, and the LNF reference area. For 2002 elk fecal samples, cadmium and lead were higher at all three sampled remediated sites than the reference area. Additionally, zinc was higher at Smelterville and Deadwood Gulch than the reference area. Zinc was higher in 2003 at Government Gulch than the reference area, and lead concentrations were nearly statistically higher.

Elk zinc, cadmium and lead concentrations increased from 2001 to 2003 at the reference site. Zinc, cadmium and lead decreased at Magnet Gulch from 2001 to 2002. Zinc decreased at Smelterville from 2001 to 2002.

4.5.3 Discussion

While the ecological receptors we examined do not appear to be consuming more soil in OU-2 remediated areas than reference areas, exposure to heavy metals of concern are elevated at remediated areas. Metal concentrations in all four species sampled from remediated areas appear to be well above reference locations. Furthermore, tissue concentrations for certain metals in Canada Geese and deer appear to be increasing in OU-2 areas. While increases were also observed for some metals at the LNF reference area in deer, OU-2 concentrations remain several times higher than those at LNF. Additional moose and coyote fecal collection would allow more accurate site comparisons and examination of moose exposure trends. Heavy metal exposure for receptors of interest (i.e., large mammals, migratory birds, etc.) within OU-2 remediated areas remains a concern.

5.0 Summary and Recommendations

5.1 Biological Monitoring Summary

U.S. Fish and Wildlife Service (USFWS) biological monitoring activities conducted at the Bunker Hill Facility Non-Populated Areas OU-2 from 2001-2004 were designed to provide remedial project managers with multiple lines of evidence regarding the effectiveness of remediation in protecting ecological receptors utilizing OU-2. Based on information collected, habitat quality appears to be improving within OU-2. However, a number of ecological receptors continue to be negatively affected by mining-related heavy metals, even at remediated sites.

A deficiency exists within OU-2 in tree canopy cover, species diversity, vegetative ground cover and litter layer depths compared to reference areas. Tree height and dominant tree species observed in OU-2 demonstrated that the area has not yet returned to the principal climax vegetation associations observed in the region. Erosion, plant germination, and a lack of forest dwelling wildlife habitat will continue to be problematic due to the lack of vegetative ground cover. The reestablishment of a functional climax ecosystem is expected to be a relatively slow process, especially due to the smelter-related denuding of hillsides, high soil metals concentrations still present, lack of soil nutrients and continuing remedial activities. However, preliminary data indicates that replanting efforts are having a positive affect on vegetation establishment (CH2M Hill, 2003).

Avian and small mammal populations differ between OU-2 and reference areas, with population characteristics within OU-2 resembling those observed in early forest seral stage or savannah type habitats. Avian species typical of northern Idaho forested habitats were at lower densities within OU-2 than reference areas. Small mammal relative abundance appeared greater in 2001 than in a previous study within OU-2 (Herman, 1975), but species diversity was reduced and approximately half that of the reference area. As OU-2 vegetation components mature to more closely resemble those of climax communities typical of northern Idaho, wildlife population characteristics are expected to adjust accordingly.

Our data indicates a decrease in exposure of small mammals to lead within OU-2. However, heavy metal body residues of deer mice, shrews and voles utilizing OU-2 remain above those of reference areas. Furthermore, no difference appears to exist in small mammal exposure to metals of concern between remediated gulch areas and unremediated hillsides; remediation activities have not appeared to reduce exposure of small mammals to metals of concern. Arsenic, cadmium, lead and zinc tissue concentrations were highest at Magnet and Government Gulches.

Small mammal liver lead concentrations we observed were below the acute toxic threshold for mammals. However, the continued subchronic exposure of small mammals to elevated metal concentrations within OU-2 to may be of concern, and may possibly be causing deficits in learning ability and behavior, an increased susceptibility to disease, and reproductive impairment. Impairments during critical small mammal developmental phases may have consequences for individual long-term survival. We also observed a decrease in our small mammal reproduction index in OU-2 relative to a reference area.

Based on 2004 sampling, the trout and overall fish populations in the South Fork of the Coeur d'Alene River (SFCDR) within OU-2 appear to have increased or remained stable following remediation. However, trout densities were still 3.5-9.8 times lower than pre-remediation reference site densities, including within the SFCDR above OU-2. Likewise, total fish densities were 10.9-41 times lower than pre-remediation reference site densities, including within the SFCDR above OU-2. Fish populations utilizing the SFCDR within OU-2 apparently continue to be at a depressed state similar to that prior to remediation activity. Zinc and cadmium concentrations in brook trout appeared to be above negative effects thresholds. It is likely that zinc and cadmium are negatively affecting trout utilizing the SFCDR in OU-2. A second season of sampling in fall, 2005 will augment data on current OU-2 densities.

Arsenic, cadmium and zinc were generally higher in aquatic invertebrates collected directly downriver from the OU-2 Central Impoundment Area (CIA). Aquatic invertebrates with elevated metal concentrations become a source of contaminant uptake for fish that consume them. The elevated metal concentrations in aquatic invertebrates utilizing the SFCDR in OU-2 constitute a dietary pathway for exposure of fish to metals of concern.

USFWS surveys in 2001 produced only 11 amphibian individuals along the SFCDR in OU-2 and 4 at a reference area along the North Fork Coeur d'Alene River. Reasons for the lack of amphibians and reptiles observed during surveys are unknown. Lack of suitable habitat is a possible factor.

In addition to the potential subchronic toxicological effects described above, tissue metal concentrations in several wildlife groups are above thresholds shown to elicit negative physiological effects, and concentrations in some receptors examined appear to be increasing. Passerines, specifically American robins, song sparrows and Swainson's thrush utilizing the remediated Smelterville Flats and Magnet Gulch areas, as well as the unremediated Pinehurst riparian areas of OU-2, are being exposed to lead levels sufficient to cause adverse physiological impacts. Blood ALAD inhibition >50% has been determined to cause physiological impairment to wildlife (43 CFR 11.62). Blood ALAD levels collected from several species utilizing Smelterville Flats, Deadwood Gulch and Magnet Gulch were reduced >50% compared to mean ALAD from reference area birds. In addition, mean liver lead concentrations were higher at OU-2 post remediation areas than reference areas.

Lead concentrations were determined in surface soil samples collected as part of the songbird health evaluation. Mean soil lead concentrations differed significantly among locations sampled, with mean concentrations increasing from the reference area (24.6 mg/kg) to Government Gulch (171 mg/kg), Magnet Gulch (1201 mg/kg) and Smelterville (3320 mg/kg). Correspondingly, songbird blood and liver lead levels examined were typically highest at Government and Magnet Gulches (2004 Smelterville blood and liver lead results have not yet been analyzed). Clean replacement soils for OU-2 were considered to contain <100 mg/kg lead (USEPA, 1992). If replacement soils were, in fact, initially below this level, they do not all appear to still be so. Songbirds in general do not appear to be consuming different amounts of soil at different sites. Differences in soil lead concentrations, therefore, are likely the reason for differences in passerine lead body residues. Operable Unit-2 remediated site surface soil does not currently appear protective of avian receptors.

Blood lead concentrations in waterfowl utilizing the Page Ponds wetland complex are above thresholds considered clinical and acute clinical poisoning, and no downward trends are apparent in mallard blood lead concentrations from samples collected 1993-2003. The Page Ponds wetland complex contains the largest remaining wetland areas in OU-2 and the Silver Valley. These wetlands continue to support a large and diverse population of waterfowl. However, lead-contaminated sediment concentrations up to 26,800 mg/kg and 5990 mg/kg in the West and East Swamps are well above OU-3 ROD sediment cleanup levels, remain unremediated within the complex, and likely serve as a major source of metals exposure to waterfowl using the wetlands. Furthermore, the continued use of the complex as an uncapped repository for soil is also of concern for two main reasons: 1) Continued deposition of fill in the West Swamp will reduce the available habitat for waterfowl and other aquatic wildlife in OU-2. Wetland mitigation measures should be considered to replace wetland area lost due to remedial activities at the Page Pond complex. 2) Soil generated from the USEPA OU-1 yard remediation program deposited at the Page Ponds repository is more than twice that of ROD cleanup levels. Soil and sediment in this complex are the likely sources causing lead poisoning in waterfowl utilizing the site.

Opportunistic collection of moose, coyote, Canada goose, deer and elk fecal samples in OU-2 and reference areas from 2001-2003 demonstrated that ecological receptors utilizing OU-2 were being exposed to metals of concern at rates higher than reference areas. While no differences existed in soil ingestion rates for each receptor between OU-2 and reference sites, concentrations of several metals of concern were higher in feces from every receptor examined from OU-2 areas than from reference sites. Furthermore, metals in deer and elk feces increased in OU-2 areas from 2001-2003, indicating that these receptors are being exposed to more metals of concern as time goes on. Confirmation soil samples have not been taken in post remediated areas to evaluate the success of engineered caps in protecting ecological receptors.

5.2 Future Monitoring Recommendations Summary

Surface soil and sediment samples are a vital component in examining whether soil and sediment metal concentrations in remediated areas are protective of ecological receptors. Our data indicates that soil metal concentrations in remediated areas are above levels outlined in the ROD. Surface soil and sediment monitoring should be conducted to determine and monitor soil cap integrity.

Waterfowl utilizing the Page Pond wetland complex appear to be suffering from lead poisoning. Soil/sediment metals concentration analysis, as well as additional wildlife toxicity monitoring, should be conducted at the Page Pond wetland complex to ensure that future remedial activities reduce lead exposure to ecological receptors at the Page Ponds complex.

Passerine songbirds appear to continue to be negatively affected by contaminants in OU-2. Further examination and monitoring should be conducted to evaluate whether post remediation lead soil concentrations remain above levels toxic to songbirds and to determine trends in songbird lead body burdens.

There is an apparent lack of burrowing invertebrates inhabiting OU-2 post remediated areas (USFWS personal observation). Terrestrial burrowing invertebrate collections and/or post remediated soil invertebrate toxicity testing are necessary to evaluate whether surface metal concentrations are inhibiting the establishment of invertebrates.

Vegetation monitoring is a necessary component of evaluating the success of remediation activities and should be continued. Results will provide project managers information regarding success in recovery of remediated areas, and allow them to make decisions regarding necessary steps (i.e., natural attenuation, soil amendments, plantings, etc.) required to achieve remedial goals. Correlations between future vegetative states and wildlife tissue concentration trends will also allow managers to make informed decisions regarding corrective measures necessary to reduce exposure to metals of concern for ecological receptors.

Wildlife community differences between OU-2 and reference areas are likely in part due to vegetation requirements lacking in post remediated areas. As vegetation components in remediated areas improve, wildlife species diversity and populations more closely resembling those of unaffected areas would be expected to correspondingly improve. Due to the slow pace of forest regeneration and successional development, USFWS does not expect to observe corresponding changes in wildlife populations on a yearly basis. Small mammal populations, therefore, should be examined every 5 years rather than yearly. Breeding bird and waterfowl surveys are the exception as they are required as an integral part of a comprehensive evaluation of avian productivity and survival within OU-2. Protocols used for bird surveys are nationally based and require annual surveys. This approach is similar to that established in the BEMP. As vegetation components within OU-2 improve, we also expect amphibian use to improve. Observational amphibian surveys should be reinstated to evaluate the repopulation of OU-2 wetland areas by amphibian receptors.

Further examination should be conducted to evaluate whether receptors utilizing OU-2 with elevated tissue metal concentrations are incurring negative physiological effects. Further investigation regarding subchronic exposure of small mammals and avian receptors to metals of concern in OU-2 is recommended to determine if any long-term physiological or population effects are occurring. Continued monitoring of tissue metals concentrations is also vital in evaluating the success of remedial activities through observations of downward trends in tissue concentrations.

Small mammal sampling regimes for this report included linear riparian and hillside transects and gulch, upland and floodplain grids. These regimes provided population data and baseline data regarding small mammal exposure to metals of concern. However, sampling grids were not large enough to evaluate differences in small mammal exposure across sites to determine exposure hot spots or specific areas within sites requiring further remediation management. For example, small mammals collected at Smelterville Flats had a wide range of lead concentrations. Concentrations represented ranges from near background to extremely elevated. This may be a reflection of hot spots where remedial action deficiencies exist. Future sampling should be modified to include a more comprehensive site sampling grid.

Previous *in situ* and laboratory bioassays confirmed that surface water in South Fork Coeur d'Alene River and Canyon Creek locations, as well seep water from the Bunker Hill Central Impoundment Area, caused acute toxicity to and avoidance by trout and other fish species (Bauer, 1975, Hornig et al., 1988; Dames and Moore, 1989; Woodward et al., 1997a; Woodward et al., 1997b; Goldstein et al., 1999). Fish populations utilizing OU-2 appear to continue to be depressed. Surface water metal concentrations need to be monitored in the future and related to fish toxicity thresholds to evaluate the effectiveness of remedial activities in protecting fish resources.

Areas available for long-term disposal of remediated soil/sediment, such as capacity at the Page repository, are a concern. A new or expanded facility will be required to accommodate future needs. Several factors will need to be considered when evaluating long-term disposal needs, including assessment of existing and new waste streams, material handling and segregation, vehicle decontamination procedures, site access, and site management (USEPA, 2005). The introduction of remediation wastes into new areas will likely increase exposure to contaminants of concern by ecological receptors. Ecological monitoring should be included in the development and use of future repositories as a part of site management plans to ensure the protection of ecological receptors.

Operable Unit-2 long-term biomonitoring needs should be coordinated with the Basin Environmental Management Plan (BEMP). Biomonitoring activities previously established in OU-2 and currently initiated in OU-3 will allow an Operable Unit level and comprehensive Basin-wide evaluation of remedial effectiveness in reducing or eliminating risk to ecological receptors from contaminants of concern.

The following previously established activities are recommended for continued biomonitoring within OU-2:

- Waterfowl blood collection;
- Songbird blood collection;
- Small mammal metals evaluation;
- Fish metals evaluation;
- Aquatic invertebrate collection;
- Breeding Bird Surveys;
- Monitoring Avian Productivity and Survivorship (MAPS);

- Page/Swamp Waterfowl Surveys;
- Page Ponds wetland vegetation mapping.

In addition, the following activities are recommended to be included in future biomonitoring within OU-2:

- Songbird histopathology;
- Surface soil/sediment sampling;
- Terrestrial invertebrate collection and/or invertebrate soil toxicity testing;
- Amphibian population monitoring.

6.0 References

Audet, D.J., M.R. Snyder, and J.K. Campbell. 1999a. Biological monitoring at the Page Pond Wastewater Treatment Plant ponds and wetlands on the Bunker Hill Superfund Site, Idaho, 1997. U.S. Fish and Wildlife Service. Prepared for Environmental Protection Agency, IAG no. DW 14957137-01-0.

Audet, D.J., Creekmore, L.H., Sileo, L., Snyder, M.R., Franson, J.C., Smith, M.R., Campbell, J.K., Meteyer, C.U., Locke, L.N., McDonald, L.L., McDonald, T.L., Strickland, D., and Deeds, S. 1999b. Wildlife use and mortality investigation in the Coeur d'Alene Basin 1992-1997. U.S. Fish and Wildlife Service, Spokane, Washington.

Bauer, S. 1975. Coeur d'Alene fishery studies. Idaho Department of Fish and Game Project Performance Report 1974.

Beck, J.M., J. Janovetz, and C.R. Peterson. 1997. Amphibians of the Coeur d'Alene basin: A survey of Bureau of Land Management Lands. Final report by the Department of Biological Sciences Idaho State University Pocatello, Idaho and the Department of Zoology Washington State University Pullman, Washington. 13 pp.

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingested by wildlife. *Journal of Wildlife Management*. 58:375-382.

Beyer, W.N., D.A. Audet, A Morton, J.K. Campbell and L. LeCaptain. 1998. Exposure of waterfowl ingesting Coeur d'Alene river basin sediments. *Journal of Environmental Quality*. 27:1533-1538.

Beyer, W.N., Spann, J. and D. Day. 1999. Metal and sediment ingestion by dabbling ducks. *The Science of the Total Environment*. 231:235-239.

Beyer, W.N., D.J. Audet, G.H. Heinz, D.J. Hoffman, and D. Day. 2000. Relation of waterfowl poisoning to sediment lead concentrations in the Coeur d'Alene River Basin. Ecotoxicology 9: 207-218.

Blus, L.J., Henny, C.J., Hoffman, D.J. and R.A. Grove. 1991. Lead toxicosis in tundra swans near a mining and smelting complex in northern Idaho. Archives of Environmental Contamination and Toxicology 21:549-555.

Blus, L.J., Henny, C.J., Hoffman, D.J. and R.A. Grove. 1995. Accumulation in and effects of lead and cadmium on waterfowl and passerines in Northern Idaho. *Environmental Pollution*. 89:311-318.

Burch, S., D. Audet, M. Snyder, and L. LeCaptain. 1996. Evaluation of metals accumulation in aquatic biota and mallard ducks from the Page Pond wetlands and sewage ponds on the Bunker Hill Superfund Site, Idaho. U.S. Fish and Wildlife Service. Prepared for the Environmental Protection Agency, IAG no. DW 14957137-01-0.

CH2M Hill. 2003. Hillsides revegetation project, 2003 operational monitoring program annual report. Prepared for USEPA. Contract No. 68-W-98-228.

Cherney, J.H., Robinson, D.L., Kappel, L.C., Hembry, F.G. and R.E. Ingraham. 1983. Soil contamination and elemental concentrations of forages in relation to grass tetany. Agronomy Journal. 75:447-451.

Cooke J.A. and M.S. Johnson. 1996. In *Environmental contaminants in wildlife*. W.N. Beyer, G.H. Heinz and A.W. Redmond-Norwood, eds. Lewis Publishers, Boca Raton. pp. 377-388.

Dames and Moore. 1989. Bunker Hill RI/FS: technical memorandum: revised data evaluation report. Aquatic biology sampling, subtask 2.9: aquatic ecology and toxicology.

Daubenmire and Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Agricultural Research Center, College of Agricultural and Home Economics. Washington State University.

Dimmick, R.W. and M.R. Pelton. 1996. Criteria of sex and age. In Research and management techniques for wildlife and habitats. Fifth edition, revised. The Wildlife Society, Bethesda, Maryland. pp. 169-214.

Ehrlich, P.R., D.S. Dobkin, and D.Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster Inc. New York.

Foresman, K.R. 2001. The wild mammals of Montana. Special Publication No. 12. American Society of Mammalogists. Allen Press., Inc. Lawrence, KS.

Hall, E.R. 1981. The mammals of North America. 2PndP ed. John Wiley & Sons. New York.

Henny, C.J., Blus, L.J., Hoffman, D.J., Sileo, L., Audet, D.J. and M.R. Snyder. 2000. Field evaluation of lead effects on Canada geese and mallards in the Coeur d'Alene River Basin, Idaho. Archives of Environmental Contamination and Toxicology 39:97-112.

Herman, S.G. 1975. Lead and cadmium in soils, vegetation and small mammals near Kellogg, Idaho. Evergreen State College. 81 pp.

Hornig, C.E., Terpening, D.A. and M.W. Bogue. 1988. Coeur d'Alene Basin EPA water quality monitoring 1972-1986. Epa-910/9-88-216. Prepared by U.S. Environmental Agency, Region X.

Hunter, B.A., M.S. Johnson, and D.J. Thompson. 1987. Ectotoxicology of copper and cadmium in a contaminated grassland ecosystem. *Journal of Applied Ecology*. 24:601-614.

Lancia, R.A., J.D. Nichols, and K.H. Pollock. 1994. Estimating the number of animals in wildlife populations. In *Research and Management Techniques for Wildlife and Habitats.* T.A. Bookhout eds. The Wildlife Society, Allen Press, Inc. Lawrence, Kansas. pp. 215-253.

Ma, W.C. 1996. Lead in mammals. In *Environmental Contaminants in Wildlife*. W.N. Beyer, G.H. Heinz and A.W. Redmond-Norwood, eds. Lewis Publishers, Boca Raton. pp. 281-296, 341-356.

McCulley, Frick, and Gilman, Inc. 1994. Bunker Hill Superfund Site draft Page Pond remedial design report. Prepared for ASARCO Incorporated, Hecla Mining Company, and Sunshine Mining Company.

Mullins and Burch. 1993. Evaluation of lead in sediment and biota east and west Page swamps, Bunker Hill Superfund Site, Idaho. Prepared for the Environmental Protection Agency, IAG No. DW 14957070-01-0.

Oli, M.K. and F.S. Dobson. 2000. Population cycles in small mammals: the α-hypotheses. *Journal of Mammalogy*. 82:573-581.

Pain, D.J. 1996. Lead in waterfowl. In *Environmental contaminants in wildlife*. W.N. Beyer, G.H. Heinz and A.W. Redmond-Norwood, eds. Lewis Publishers, Boca Raton. pp. 251-264.

SAIC and EP&T. 1991. Ecological risk assessment for the Bunker Hill Superfund Site. Prepared by Science Applications International Corporation and Ecological Planning and Toxicology for the U.S. Environmental Protection Agency, Region X.

SAIC. 1991. Ecological Risk Assessment for the Bunker Hill Superfund Site. Prepared for the Environmental Protection Agency.

Sileo, L. Creekmore, L.H., Audet, D.J., Snyder, M.R., Meteyer, C.U., Franson, J.C., Locke, L.N., Smith, M.R. and D.L. Finley. 2001. Lead poisoning of waterfowl by contaminated sediment in the Coeur d'Alene River. Archives of Environmental Contamination and Toxicology 41:364-368.

Stratus Consulting. 1999. Coeur d'Alene River Basin NRDA aquatic resources monitoring 1994-1998: a summary of sampling sites, sampling methods, and results. Prepared for the U.S. Department of the Interior, Coeur d'Alene Tribe, and U.S. Department of Agriculture by Stratus Consulting Inc., Boulder, CO.

Stratus Consulting. 2000. Report of injury assessment and injury determination: Coeur d'Alene Basin natural resource damage assessment. Prepared for the U.S. Department of the Interior, U.S. Department of Agriculture, and Coeur d'Alene Tribe by Stratus Consulting Inc., Boulder, CO.

Swiergosz, R., M. Zakrzewska, K. Sawicka-Kapusta, K. Bacia and I. Janowska. 1998. Accumulation of Cadmium in and its effect on bank vole tissues after chronic exposure. *Ecotoxicology and Environmental Safety*. 41:130-136.

Szumski, M.J. 1999. The effects of mining on mammals of the Coeur d'Alene river basin. USFWS, Expert Report.

USEPA. 1991. Record of Decision, Bunker Hill Mining and Metallurgical Complex residential soils operable unit, Shoshone County, Idaho. U.S. Environmental Protection Agency Report.

USEPA. 1992. Record of Decision, Bunker Hill Mining and Metallurgical Complex, Shoshone County, Idaho. U.S. Environmental Protection Agency Report.

USEPA. 2000. First 5-Year Review of the Non-Populated Area Operable Unit, Bunker Hill Mining and Metallurgical Complex, Shoshone County, Idaho. U.S. Environmental Protection Agency Report.

USEPA. 2001. Final Ecological Risk Assessment. Coeur d'Alene Basin Remedial Investigation/Feasibility Study. U.S. Environmental Protection Agency Report.

USFWS. 2001a. Work Plan for Biological Monitoring at the Bunker Hill Facility Non-Populated Areas. Prepared by the Upper Columbia Fish and Wildlife Office, Spokane, Washington.

USFWS. 2001b. Bunker Hill Facility Biological Monitoring Investigations, Quality Assurance Plan. Prepared by the Upper Columbia Fish and Wildlife Office, Spokane Washington.

USFWS. 2002. Bunker Hill Non-Populated Areas Operable Unit, Biological Monitoring-2001, Annual Report of Preliminary Data. Prepared by the Upper Columbia Fish and Wildlife Office, Spokane, Washington.

USFWS. 2003. Bunker Hill Non-Populated Areas Operable Unit, Biological Monitoring-2002, 2nd Annual Report of Preliminary Data. Prepared by the Upper Columbia Fish and Wildlife Office, Spokane, Washington.

USEPA. 2005. Five-year review report, second five-year review for Bunker Hill Mining and Metallurgical Complex Superfund Site, Operable Units 1,2, and 3, Idaho and Washington. Draft. USEPA. Seattle, Washington.

USGS, Patuxent Wildlife Research Center. 2001. Species list, North American breeding bird survey route, Ida-901: Rochat Divide. www.mbr-pwrc.usge.gov/cgi-bin/rtena.pl?33907UT.

USGS, Patuxent Wildlife Research Center. Breeding Bird Surveys. 2004. http;//www.mp2-pwrc.usgs.gov.bbs/.

VanDeventer, J. and W. Platts. 1986. MicroFish 2.2 Interactive Program. Microsoft Corp.

Witt, W.C. and N. Huntly. 2001. Effects of isolation on red-backed voles (*Clethroinomys gapperi*) and deer mice (*Peromyscus maniculatus*) in a sage-steppe matrix. *Canadian Journal of Zoology*. 79(9):1597 – 1603.

Woodward, D.F., Goldstein, J.N. and A.M. Farag. 1997a. Cutthroat trout avoidance of metals and conditions characteristic of a mining waste site: Coeur d'Alene River, Idaho. *Transactions of the American Fisheries Society* 126:699-706.

Woodward, D.F., Farag, A., Reiser, D. and B. Brumbaugh. 1997b. Metals accumulation in the food-web of the Coeur d'Alene Basin, Idaho: assessing exposure and injury to wild trout. Draft. Report prepared by USGS-BRD.

Zar, J.H. 1999. Biostatistical analysis. Fouth Ed. Prentice Hall, Upper Saddle River, New Jersey

Tables

Table 1: USFWS Biological Monitoring Studies, 2001-2004.		
Sampling Area	**Studies conducted**	**Sampling period**
Page Ponds and associated wetlands	Waterfowl surveys	April-August 2001/2003
	Waterfowl blood collection (blood Pb)	July 2003
	Wetland vegetation mapping	August 2002/2004
Smelterville Flats	Amphibian and reptile surveys	Spring and summer 2001
	Small mammal population surveys	July-September 2001
	Small mammal collection (metal residues)	September 2001
	Wildlife fecal collection (metal residues, AIA)	June-October 2001/2002/2003
	Songbird blood collection (blood Pb, ALAD, soil)	July 2002/2004
Government Gulch (defined gulch and hillside areas)	Small mammal population surveys	July-September 2001/2003
	Small mammal collection (metal residues)	September 2001/2002/2003
	Vegetation surveys	July-September 2001
	Songbird blood collection[1] (blood Pb, ALAD, soil)	June 2003
Magnet Gulch (defined gulch and hillside areas)	Small mammal population surveys	July-September 2001
	Small mammal collection (metal residues)	September 2001/2003
	Vegetation surveys	July-September 2001
	Songbird blood collection[1] (blood Pb, ALAD, soil)	June 2003
Deadwood Gulch (defined gulch and hillside areas)	Small mammal population surveys	July-September 2001
	Small mammal collection (metal residues)	September 2001/2002/2003
	Vegetation surveys	July-September 2001
	Songbird blood collection[1] (blood Pb, ALAD, soil)	June 2003
Site Wide	Breeding Bird Surveys	June 2001/2002/2003/2004
	Wildlife fecal collection (metal residues,% AIA)	June-September 2001/2002/2003
South Fork Coeur d'Alene River	Amphibian and reptile surveys	Spring and summer 2001
	Fish population surveys	September 2003
	Fish collection (metal residues)	September 2002
	Riparian habitat surveys	September 2003
	Aquatic invertebrate collection (metal residues)	September 2003/2004
Rochat Divide / Latour Creek (reference) `	Breeding Bird Surveys	June 2001/2002/2003/2004
	Small mammal population surveys	July-September 2003
	Small mammal collection (metal residues)	July-August 2002/2003
	Vegetation surveys	July-August 2002/2003
Little North Fork Coeur d'Alene River (reference)	Songbird blood collection (blood Pb, ALAD, soil)	June-August 2002/2003
	Wildlife fecal collection (metal residues,% AIA)	June-September 2001/2002/2003

[1] Songbird blood collection was conducted on hillside areas only.

Table 2. Dominant tree species, number of tree species, dominant size class, average tree height, dominant shrub species, number of shrub species, average shrub height, dominant percent ground cover, and average litter depth at corresponding elevational points along the Bunker Hill (BH) and Rochat Divide (RD) BBS routes.

Route/Stop #	Elevation	Dominant tree species	Number of tree species	Dominant size class	Average tree height	Dominant shrub species	Number of shrub species	Average shrub height	Dominant percent ground cover	Average litter depth
BH-7	2384 ft	Western white pine	1	seed / sap[1]	11.2 ft	Blue elderberry	2	10.1 ft	grass	0.8 in
RD-14	2324 ft	Western red cedar	11	seed / sap	46.5 ft	Mountain maple	6	13.5 ft	forbs	2.1 in
BH-12	2534 ft	Western white pine	2	seed / sap	14.2 ft	Blue elderberry	3	12.4 ft	grass	1.1 in
RD-19	2567 ft	Western red cedar	7	seed / sap	29.5 ft	Mallow ninebark	7	6.3 ft	forbs	2.7 in
BH-9	2670 ft	Western white pine	4	seed / sap	10.1 ft	Blue elderberry	4	4.8	grass	0.4 in
RD-22	2691 ft	Engleman spruce	9	Pole[2]	39.7 ft	Mallow ninebark	7	10.6 ft	forbs	3.1 in
BH-19	2948 ft	Western white pine	7	seed / sap	16.8 ft	Blue elderberry	5	6.7 ft	grass	0.9 in
RD-25	2961 ft	Western red cedar	11	Mid-size[3]	57.3 ft	Mallow ninebark	9	13.3 ft	forbs	2.6 in
BH-29[a]	4725 ft	Douglas fir	7	Pole	49.7 ft	common snowberry	4	9.3 ft	forbs	1.3 in
RD-34	4647 ft	Engleman spruce	11	Mid-size	62.3 ft	Service berry	5	12.3 ft	forbs	2.1 in
BH-30[a]	4902 ft	Western white pine	7	Pole	32.4 ft	common snowberry	5	5.4 ft	forbs	2.5 in
RD-37	4907 ft	Engleman spruce	9	Pole	29.4 ft	Service berry	5	4.5	forbs	2.5 in

[1] Trees < 4.7 inch DBH; [2] Trees Trees 4.7 – 11.8 inch DBH; [3] Trees 11.9 – 17.7 inch DBH
[a] Vegetation sampling points above the Bunker Hill OU-2 unit

Table 3: Dominant tree species, number of tree species, dominant size-class, average tree height, dominant shrub species, number of shrub species, average shrub height, dominant percent ground cover and average litter depths in OU-2 and Latour Creek reference site small mammal population study areas.

Location	Dominant tree species	Number of tree species	Dominant size class	Average tree height	Dominant shrub species	Number of shrub species	Average shrub height	Dominant percent ground cover	Average litter depth
Smelterville Flats	Western white pine	1	Seedling/sapling[1]	11.2 ft	Non-observed	0	-	Grass	0.8 in
Government Gulch	Western white pine	3	Seedling/sapling[1]	8.9	Blue elderberry	2	10.1 ft	Bare ground	0.5 in
Magnet Gulch	Western white pine	4	Seedling/sapling[1]	10.1 ft	Common snowberry	4	4.8	Grass	0.4 in
Deadwood Gulch	Western white pine	7	Seedling/sapling[1]	10.1	Blue elderberry	5	9.2	Bare ground	0.4 in
Latour Creek (reference)	Western red cedar	11	Seedling/sapling[1]	39.6 ft	Mallow ninebark	9	6.3 ft	Forbs	2.5 in

[1] Trees < 4.7 inch DBH

Table 4: Habitat and vegetation in the West and East Swamps of the Page Pond Wastewater Treatment Plant, 1997 (Audet et al., 1999).

Polygon	Dominant habitat type	Dominant vegetation	Other species present
1 (West)	palustrine emergent (persistent)	cattail *(Typha latifolia)*	Reed canarygrass *(Phalaris arundinacea);* thinleaf alder *(Alnus incana);* Geyer willow *(Salix geyeriana);* redtop *(Agrostis stolonifera)*
2 (West)	scrub shrub	Geyer willow *Salix geyeriana);* paper birch *(Betula papyrifera)*	shrub: thinleaf alder (*Alnus incana);* spirea (*Spirea douglasii);* white pine *(Pinus monticola);* ponderosa pine (*Pinus ponderosa);* Bebb's willow (*Salix bebbiana);* water birch (*Betula occidentalis);* various mosses and lichens. Understory: redtop (*Agrostis stolonifera);* small fruited bullrush (*Scirpus microcarpus);* field horsetail (*Equisetum arvense)*
3 (West)	scrub shrub	species composition as in polygon 2	species composition as in polygon 2
4 (West)	sedge/grass	small fruited bullrush *(Scirpus microcarpus);* western portion of polygon: inflated sedge *(Carex vesicaria);* beaked sedge *(Carex rostrata)*	redtop *(Agrostis stolonifera);* soft rush *(Juncus effusus);* slender rush *(Juncus tenuis);* toad rush *(Juncus bufonis); Juncus spp.; Eleocharis spp.; Carex spp.;* yellow water lily *(Nuphar polysepalum);* Geyer willow *(Salix geyeriana);* Bebb's willow *(Salix bebbiana);* Watson's willow herb *(Epilobium watsonii);* paper birch *(Betula papyrifera);* water birch *(Betula occidentalis)*
5 (West)	scrub shrub	northwest end: spirea (*Spirea douglasii);* north edge: paper birch (*Betula papyrifera);* water birch (*Betula occindentalis)*	northwest end: paper birch *(Betula papyrifera)/* water birch *(Betula occidentalis)* hybrids; small fruited bullrush *(Scirpus microcarpus);* American mannagrass (Glyceria grandis); north edge: field horsetail *(Equisetum arvense);* skunk cabbage *(Lysichitum americanum);* mosses; redtop *(Agrostis stolonifera);* spirea *(Spirea douglasii);* American mannagrass (Glyceria grandis); *Juncus spp.;* thinleaf alder *(Alnus incana***);** sitka alder (*Alnus sinuata);* Geyer willow *(Salix geyeriana);* Bebb's willow *(Salix bebbiana)*
6 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	single species observed
7 (West)	scrub shrub	species composition as in polygon 5	species composition as in polygon 5; black cottonwood (*Populus balsamifera)*
8 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	single species observed
9 (West)	sedge/grass	species composition as in polygon 4; western end: redtop (*Agrostis stolonifera)*	species composition as in polygon 4;
10 (West)	sedge/grass	species composition as in polygon 4; western end: redtop (*Agrostis stolonifera)*	species composition as in polygon 4
11 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	marsh cinquefoil (*Potentilla palustris)*

Table 4 (Continued).			
Polygon	**Dominant habitat type**	**Dominant vegetation**	**Other species present**
12 (West)	scrub shrub	spirea (*Spirea douglasii)*	paper birch *(Betula papyrifera)*/water birch *(Betula occidentalis);* hybrids; small fruited bullrush *(Scirpus microcarpus;* American mannagrass (Glyceria grandis); cattail *(Typha latifolia)*
13 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	species composition as in polygons 8 and 11
14 (West)	palustrine aquatic bed	yellow water lily (*Nuphar polysepalum)*	floating-leaf pondweed *(Potamogeton natans);* water milfoil *(Mynophyllum spicatum;* lesser bladderwort *(Urticularia minor);* fragrant water lily *(Nymphaea odorata);* simplestem burreed *(Sparganium emersum)*
15 (West)	palustrine emergent (non-persistent)	creeping spikerush *(Eleocharis palustris)*	American mannagrass *(Glyceria grandis);* northern mannagrass *(Glyceria borealis); Carex sp.* Sago pondweed (*Potamogeton pectinatus*); floating-leaf pondweed *(Potamogeton natans);* redtop *(Agrostis stolonifera);* spirea *(Spirea douglasii);* hardstem bullrush *(Scirpus acutus); Lvcopus* sp.; water milfoil *(Mynophyllum spicatum);* lesser bladderwort *(Urticularia minor);* slender rush *(Juncus tenuis);* needle spikerush *(Eleocharis acicularis);* simplestem burreed *(Spargonium emersum).* Yellow water lily *(Nuphar polysepalum);* cattail *(Typha latifolia);* field horsetail *(Equisetum arvense);* ticklegrass *(Agrostis scabra);* common mare's tail (*Hippuris vulgaris);* Berchtold's pondweed (*Potamogeton berchtoldii);* little meadow foxtail (*Alopecus aequalis)*
16 (West)	palustrine aquatic bed	species composition as in polygon 14	species composition as in polygon 14
17 (West)	palustrine emergent (persistent)	common reed (*Phragmites australi);* redtop (*Agrostis stolonifera)*	cattail (*Typha latifolia);* spirea (*Spirea douglasii);* thinleaf alder (*Alnus incana);* black cottonwood (*Populus balsamifera)*
18 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	single species observed
19 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	single species observed
20 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*	single species observed
21 (West)	palustrine aquatic bed	American water plantain (*Alisma plantago-aquatica)*	single species observed
22 (East)	scrub shrub	thinleaf alder (*Alnus incana);* field horsetail (*Equisetum arvense)*	spirea *(Spirea douglasii);* cascara *(Rhamnus purshiana);* black cottonwood *(Populus balsamifera);* moss spp.; lichen spp.; bracken fern *(Pteridium aqiulinum);* service berry (*Amelanchier alnifolia);* queencup beadlilv *(Clintonia unifolia);* black hawthorn *(Crataegus douglasii);* redosier dogwood *(Cornus stolonifera);* paper birch *(Betula papyrifera);* western white pine *(Pinus monticola);* water birch *(Betula occidentalis);* pacific willow *(Salix lasiandra);* redtop *(Agrostis stolonifera);* ticklegras

Table 4 (Continued).			
Polygon	**Dominant habitat type**	**Dominant vegetation**	**Other species present**
23 (East)	palustrine emergent (persistent)	cattail (*Typha latifolia);* sago pondweed (*Potamogeton pectinatus);* greater bladderwort (*Utricularia vulgaris);*lesser bladderwort (*Utricularia minor)*	lesser duckweed *(Lemna minor);* moss spp.; needle spikerush *(Eleocharis acicularis);* Watson's willow herb *(Epilobium watsonsii);* speedwell *(Veronica spp.);* small-fruited bullrush *(Scirpus microcarpus);* Bebb's willow *(Salix bebbiana);* Drummond willow *(Salix drummondii);* redosier dogwood *(Cornus* stolonifera); thinleaf alder *(Alnus incana); Carex* .spp.; inflated sedge *(Carex vesicaria);* beaked sedge *(Cares rostrata);* soft rush *(Juncus effusus);* few-flowered spikerush *(Eleocharis pauciflora)*
24 (East)	upland	field horsetail (*Equisetum arvense);* redtop (*Agrostis stolonifera)*	black cottonwood (*Populus balsamifera*); western white pine (*Pinus monticola*); kinnikinnick *(Arctostaphylos uva-ursi);* black hawthorn *(Crataegus douglasii);* ticklegrass *(Agrostis scabra);* paper birch *(Betula papyrifera);* coyote willow *(Salix exigua);* Geyer willow *(Salix geyeriana);* slender rush *(Juncus tenuis);* goldenrod *(Solidago canadensis);* water birch *(Betula occidentalis)*
25 (East)	palustrine aquatic bed	sago pondweed (*Potamogeton pectinatus);* few flowered spikerush (*Eleocharis pauciflora)*	lesser duckweed *(Lemna minor); greater* bladderwort *(Utricularia vulgaris);* lesser bladderwort *(Utricularia minor);* Berchtold's pondweed *(Potamogeton berchtoldii);* needle spikerush *(Eleocharis acicularis);* green algae; black cottonwood *(Populus balsamifera);* Geyer willow *(Salix geyeriana)*
26 (East)	palustrine aquatic bed	sago pondweed (*Potamogeton pectinatus););* Berchtold's pondweed *(Potamogeton berchtoldii);*	lesser duckweed *(Lemna minor); gr*eater bladderwort *(Utricularia vulgaris);* lesser bladderwort *(Utricularia minor);* green algae; soft rush *(Juncus effusus);* cattail *(Typha latifolia);* needle spikerush *(Eleocharis acicularis);* few-flowered spikerush *(Eleocharis pauciflora)*
27 (East)	palustrine emergent (non-persistent)	beaked sedge (*Carex rostrata);* inflated sedge (*Carex vesicaria)*	bluejoint reedgrass *(Calamagrostis canadensis);* small-fruited bullrush *(Scirpus microcarpus);* black hawthorn *(Crataegus douglasii);* Watson's willow herb *(Epilobiun watsonii); Carex spp.;* tufted loosestrife *(Lysimachia thyrsiflora);* Geyer willow *(Salix geyeriana):* paper birch *(Betula papyrifera);* spirea *(Spirea douglasii);* Bebb's willow *(Salix bebbiana);* tufted hairgrass *(Deschampsia caspitosa):*false hellebore (*Veratrum sp.);* bluegrass *(Poa sp.);* liverwort; redtop *(Agrostis stolonifera);* violet *(Viola sp.)*
28 (East)	scrub-shrub	paper birch (*Betula papyrifera);* water birch (*Betula occidentalis);* redtop (*Agrostis stolonifera)*	spirea *(Spirea douglasii);* western white pine *(Pinus monticola);* thinleaf alder *(Alnus incana);* inflated sedge *(Carex vesicaria): Carex sp.,*fescue (Festuca sp.); ticklegrass *(Agrostis scabra));* black hawthorn *(Cratagus douglasii);* Geyer willow *(Salix geyeriana)*
29 (East)	scrub-shrub	Bebb's willow (*Salix bebbiana);* Geyer willow (*Salix geyeriana)*	two species observed
30 (East)	scrub-shrub	spirea (*Spirea douglasii);* Geyer willow (*Salix geyeriana)*	Bebb's willow (*Salix bebbiana);* coyote willow (*Salix exigua)*

Table 4 (Continued).			
Polygon	**Dominant habitat type**	**Dominant vegetation**	**Other species present**
31 (East)	scrub-shrub	species composition as in polygon 30	species composition as in polygon 30
32 (East)	scrub-shrub	species composition as in polygon 30	species composition as in polygon 30
33 (East)	scrub-shrub	spirea (*Spirea douglasii)*	single species observed

Table 5: Habitat and vegetation types characterized in the West and East Swamps of the Page Pond Wastewater Treatment Plant, 2002 and 2004.

Polygon	Dominant habitat	Dominant vegetation
1 (West)	palustrine emergent (persistent)	cattail *(Typha latifolia)*
2 (West)	scrub shrub	Geyer willow (*Salix geyeriana);* paper birch *(Betula papyrifera)*
3 (West)	scrub shrub	species composition as in polygon 2
4 (West)	sedge/grass	small fruited bullrush *(Scirpus microcarpus);* western portion of polygon: inflated sedge *(Carex vesicaria);* beaked sedge *(Carex rostrata)*
5 (West)	scrub shrub	northwest end: spirea (*Spirea douglasii);* north edge: paper birch (*Betula papyrifera);* water birch (*Betula occindentalis)*
6 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*
7 (West)	scrub shrub	species composition as in polygon 5
8 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*
9 (West)	sedge/grass	species composition as in polygon 4; western end: redtop (*Agrostis stolonifera)*
10 (West)	sedge/grass	species composition as in polygon 4
11 (West)	palustrine emergent (persistent)	cattail (*Typha latifolia)*
12 (West)	scrub shrub	spirea (*Spirea douglasii)*
13 (West)	*fill material	*fill material
14 (West)	*upland dike	*Reed canarygrass (*Phalaris arundinacea);* wild rice (*Zizania aquatica*); redosier dogwood (*Cornus stolonifera)*
15 (West)	*palustrine emergent (persistent)	creeping spikerush *(Eleocharis palustris);* cattail (*Typha latifolia)*
16 (West)	*open water	*open water
17 (West)	palustrine emergent (persistent)	*cattail (*Typha latifolia);* common reed (*Phragmites australi)*
18 (West)	*palustrine emergent (persistent) incorporated into polygon 15	*cattail (*Typha latifolia)*
19 (West)	*palustrine emergent (persistent) incorporated into polygon 15	*cattail (*Typha latifolia)*
20 (West)	*palustrine emergent (persistent) incorporated into polygon 15	*cattail (*Typha latifolia)*

Table 5 (Continued).		
Polygon	**Dominant habitat**	**Dominant vegetation**
21 (East)	*palustrine emergent (persistent) incorporated into polygon 15	*cattail (*Typha latifolia)*
22 (East)	scrub shrub	thinleaf alder (*Alnus incana);* field horsetail (*Equisetum arvense)*
23 (East)	palustrine emergent (persistent)	cattail (*Typha latifolia);* sago pondweed (*Potamogeton pectinatus);* greater bladderwort (*Utricularia vulgaris);*lesser bladderwort (*Utricularia minor)*
24 (East)	upland	field horsetail (*Equisetum arvense);* redtop (*Agrostis stolonifera)*
25 (East)	palustrine aquatic bed	sago pondweed (*Potamogeton pectinatus);* few flowered spikerush (*Eleocharis pauciflora)*
26 (East)	*palustrine aquatic bed incorporated into polygon 25	*sago pondweed (*Potamogeton pectinatus);* few flowered spikerush (*Eleocharis pauciflora)*
27 (East)	palustrine emergent (non-persistent)	beaked sedge (*Carex rostrata);* inflated sedge (*Carex vesicaria)*
28 (East)	scrub-shrub	paper birch (*Betula papyrifera);* water birch (*Betula occidentalis);* redtop (*Agrostis stolonifera)*
29 (East)	scrub-shrub	Bebb's willow (*Salix bebbiana);* Geyer willow (*Salix geyeriana)*
30 (East)	scrub-shrub	spirea (*Spirea douglasii);* Geyer willow (*Salix geyeriana)*
31 (East)	scrub-shrub	species composition as in polygon 30
32 (East)	scrub-shrub	species composition as in polygon 30
33 (East)	scrub-shrub	spirea (*Spirea douglasii);* beaked sedge (*Carex rostrata);* inflated sedge (*Carex vesicaria)*
34 (East)	*sedge/grass	*small fruited bullrush *(Scirpus microcarpus);* inflated sedge *(Carex vesicaria);* beaked sedge *(Carex rostrata)*
*Changes in habitat type and/or dominant vegetation as compared to Audet et al. (1999) or changes in polygon delineation.		

Table 6: Species of birds observed at densities >15 birds per route (in bold) and their associated comparison route during OU-2 and Rochat Divide breeding bird surveys, 2001-2004.

	2001		**2002**		**2003**		**2004**		**2001-2004 Combined Average**	
Species	**OU-2**	**Rochat Divide**	**OU-2**	**Rochat Divide**	**OU-2**	**Rochat Divide**	**OU-2**	**Rochat Divide**	**OU-2**	**Rochat Divide**
American robin	**23**	**19**	**59**	**26**	**25**	**17**	**20**	**32**	**31.8**	23.5
Brewer's blackbird			**17**	2					4.3	0.52
Cedar waxwing							5	**17**	1.6	4.3
Chipping sparrow					**16**	6	**19**	**28**	8.8	8.5
Golden-crowned kinglet			3	**22**					0.8	5.5
Hammonds flycatcher							5	**15**	1.3	3.6
MacGillivray's warbler	7	**17**	**16**	11		**18**	5	**22**	7.0	**17**
Orange-crowned warbler			**15**	**17**	7		13	**29**	8.8	11.5
Oregon junco	12	**17**	**21**	**20**	9	**27**	13	**15**	**16.7**	14.8
Pine sisken	3								0.8	
Red-breasted nuthatch					3	**19**			0.8	4.8
Ruby-crowned kinglet							4	**17**	10	4.3
Song sparrow			**15**	**17**	8	**17**	10	**17**	8.3	12.8
Spotted towhee							**17**		4.3	
Swainson's thrush	8	**30**	**23**	**29**	**16**	**49**	**18**	**32**	**16.3**	**35**
Townsend's warbler			**16**	**25**	8	**28**			6	**13.3**
Violet-green swallow			**39**	12	**26**	1	**41**	13	**26.5**	6.5
Warbling vireo	**25**	**12**	**52**	**15**	**26**	**15**	**35**	0	**34.5**	10.5
Western tanager					7	**18**	2	**35**	2.3	13.3
Western wood-pewee							5	**17**	1.3	4.3
Winter wren			2	**15**					0.5	3.8
Yellow-rumped warbler	**18**	**20**	**38**	**18**	**17**	**38**	**19**	**34**	**23**	**27.5**

Table 7: Mean bird use per survey (n=10) by species and location during spring surveys conducted at Page Ponds and associated wetlands during 2001 and 2003 observations.

Species	**Lower Ponds**	**West Swamp**	**East Swamp**	**Pond # 1**	**Pond # 2**	**Pond # 3**	**Pond # 4**	**Pond # 5**
American coot		2.0	0.5	2.0				
American wigeon			0.2	16.9	0.2			2.5
Barrow's goldeneye	0.28			5.7	6.0	0.7	4.4	1.9
Bufflehead	0.28			1.8	0.2			2.2
Canada goose		0.9	0.5	2.8	0.1	0.1	0.8	0.6
Canvasback		1.0	0.5	0.2	1.7			
Cinnamon teal	0.42		0.2	0.9	0.4	0.3		1.1
Common goldeneye	0.42		0.2	45.0	13.9	1.3	5.0	6.7
Common merganser			0.4					
Eurasian wigeon			0.5	1.7	.2			0.2
Great blue heron			0.1	0.4	0.1		0.1	
Greater scaup					0.8		0.8	0.3
Green-winged teal			0.2	5.0	0.8			
Northern harrier							0.1	
Lessor scaup				2.9	0.2		0.2	0.1
Mallard	1.2	2.2	3.6	30.1	13.8	2.4	2.7	4.3
Northern pintail				3.6				
Northern Shoveler			0.1	9.1	0.6			0.7
Pied-billed grebe		.2	.1					
Red-head duck	2.1		3.1	3.9	2.0	1.8	0.6	1.1
Ring-necked duck		0.6	0.7	0.6	3.0		0.2	2.4
Ruddy duck								.1
Tundra swan			0.2	3.0				
Wood duck		1.2		0.4		0.6		0.7
All Waterfowl	**4.7**	**8.1**	**11.2**	**136.0**	**44.0**	**7.2**	**14.9**	**24.9**

Table 8: Mean bird use per survey (n=13) by species and location during summer surveys conducted at Page Ponds and associated wetlands during 2001 and 2003 observations.

Species	Lower Ponds	West Swamp	East Swamp	Pond #1	Pond #2	Pond #3	Pond #4	Pond #5
American coot	0.08	1.61	2.38					
American wigeon			0.31	0.15		0.31		0.15
Barrow's goldeneye								
Blue-winged teal	0.46		0.31	1.0	0.15	0.31		0.69
Bufflehead				1.23	.31			
Canada goose		0.15	0.15					
Canvasback					0.46			
Cinnamon teal	0.38	0.08	0.23	1.7	0.85	0.23	0.61	0.92
Common goldeneye				3.2				0.31
Green-winged teal	1.61	0.08	0.85	1.8	1.5	1.5	0.77	1.15
Hooded merganser			0.23					
Lesser scaup				1.61	0.23			0.23
Mallard	3.31	2.0	12.2	21.7	12.1	5.2	2.5	7.2
Northern pintail				0.61				0.08
Northern shoveler	0.38		0.69	2.7	3.0	0.31		0.92
Redhead	0.69		7.1	2.8	6.3	1.5	0.23	0.92
Ring-necked duck			3.8	0.31	0.54		0.46	0.77
Ruddy duck			0.85	0.38	0.85		0.23	
Wood duck		0.38	1.3	0.38	0.15			0.08
All waterfowl	**6.9**	**4.5**	**31.3**	**39.6**	**27.2**	**9.3**	**5.2**	**13.5**

Table 9: Highest average (number birds observed per survey) use areas by species for Page Ponds and associated wetlands during 2001 and 2003 observations.

Species	Spring	Summer	Summer - hatch year[1]
American coot	Pond #1 and West Swap	East Swamp	East Swamp
American wigeon	Pond #1	Pond #3 and East Swamp	N/O[2]
Barrow's goldeneye	Pond #2	N/O	N/O
Blue-winged teal	N/O	Pond #1	Pond #1
Bufflehead	Pond #5	Pond #1	N/O
Canada goose	Pond #1	East and West Swamps	N/O[2]
Canvasback	Pond #2	Pond #2	N/O
Cinnamon teal	Pond #5	Pond #1	N/O
Common goldeneye	Pond #1	Pond #1	N/O
Common merganser	East Swamp	N/O	N/O
Common snipe	N/O	Pond #1	N/O
Eastern kingbird	N/O	East Swamp	N/O
Eurasain wigeon	Pond #1	N/O	N/O
Great blue heron	Pond #1	East Swamp	East Swamp
Greater scaup	Pond #2 and Pond #4	N/O	N/O
Green-winged teal	Pond #1	Pond #1	Pond #2
Hooded merganser	N/O	East Swamp	N/O
Killdeer	N/O	Pond #1	N/O
Lesser scaup	Pond #1	Pond #1	Pond #1
Mallard	Pond #1	Pond #1	East Swamp
Northern harrier	Pond #4	N/O	N/O
Northern pintail	Pond #1	Pond #1	N/O
Northern shoveler	Pond #1	Pond #2	Pond #2
Osprey	N/O	East Swamp	N/O
Pied-billed grebe	West Swamp	N/O	N/O
Redhead	Pond #1	East Swamp	Pond #2
Ring-billed gull	N/O	Pond #1	N/O
Ring-necked duck	Pond #2	East Swamp	N/O
Ruddy duck	Pond #5	Pond #2 and East Swamp	N/O
Spotted sandpiper	N/O	Pond #1	N/O
Tundra swan	Pond #1	N/O	N/O
Wilson's phalarope	N/O	Pond #1	N/O
Wood duck	West Swamp	East Swamp	N/O
Yellowleg	N/O	Pond #1	N/O

[1] Hatch year = this year's young. [2] N/O Not observed in ponds/wetlands during the season's surveys.

Table 10: Mean waterfowl use (birds per survey) for all Page Ponds/Swamps and for Pond #1 during spring and summer seasons in 1995 (Burch et al., 1996), 1997 (Audet et al., 1999), 2001 (USFWS, 2002) and 2003.

Area / Season	1995	1997	2001	2003
Page Ponds/Swamps				
Spring	276.5	57.5	521.6	146.1
Summer	129.2	105.9	189.7	119.4
Pond # 1				
Spring	237.5	28.0	415.7	28.5
Summer	136.0	32.6	75.5	1.2

Table 11: Species numbers, relative abundance, and estimated small mammal population for mark recapture surveys 2001 and 2003.

Site / Species / Field season	Number of individuals in each species per site[1]	Relative abundance per 100 trap nights	Estimated small mammal population[2]
<u>Smelterville Flats / 2001</u>			
deer mouse (*Peromyscus maniculatus*)	67	7.4	71 ± 6
meadow vole (*Microtus pennsylvanicus*)	31	3.4	
masked shrew (*Sorex cenerius*)	1	0.1	
Total	**99**	10.9	
<u>Government Gulch / 2001</u>			
deer mouse (*Peromyscus maniculatus*)	156	17.3	213 ± 10
montane vole (*Microtus montanus*)	8	0.8	
masked shrew (*Sorex cenerius*)	3	0.3	
western jumping mouse (*Zapus princes*)	1	0.1	
Total	**168**	**18.5**	
<u>Magnet Gulch / 2001</u>			
deer mouse (*Peromyscus maniculatus*)	93	10.3	183 ± 5
montane vole (*Microtus montanus)*	18	2.0	
masked shrew (*Sorex cenerius*)	14	1.5	
yellow-pine chipmunk *(Tamias amoenus*)	5	0.5	
short-tailed weasel (*Mustela erminia)*	1	0.1	
Total	**131**	**14.4**	
<u>Deadwood Gulch / 2001</u>			
deer mouse (*Peromyscus maniculatus)*	106	11.7	277 ± 3
montane vole (*Microtus montanus)*	9	1.0	
masked shrew (*Sorex cenerius*)	4	0.4	
yellow-pine chipmunk (*Tamias amoenus*)	3	0.3	
Total	**122**	**13.4**	
<u>Government Gulch / 2003</u>			
deer mouse (*Peromyscus maniculatus*)	47	5.2	96 ± 8
montane vole (*Microtus montanus*)	9	1.0	
masked shrew (*Sorex cenerius*)	10	1.1	
Total	**66**	**7.3**	
<u>Latour Creek (reference) / 2003</u>			
deer mouse (*Peromyscus maniculatus*)	30	5.0	107 ± 22
montane vole (*Microtus montanus*)	3	0.5	
meadow vole (*Microtus pennsylvanicus*)	5	0.8	
southern red-backed vole (*Clethrionomys gapperi*)	9	1.5	
masked shrew (*Sorex cenerius*)	3	0.5	
vagrant shrew (*Sorex vagrans*)	4	0.6	
northern flying squirrel (*Glaucomys sabrinus)*	4	0.6	
Total	**58**	**9.5**	

[1] Values presented are individuals captured. Individuals recaptured were not double counted.
[2] Values are estimated mean ± the 95% confidence interval.

Table 12: Number of species and relative abundance of small mammals captured on OU-2 1975 and 2001, and Latour Creek reference area 2003.

Site / species / Field season	Total number individuals captured / species	Relative abundance / 100 trap nights.
OU-2 / 2001[1]		
deer mouse (*Peromyscus maniculatus*)	422	11.7
meadow vole (*Microtus pennsylvanicus*)	31	0.9
montane vole (*Microtus montanus*)	35	1.0
masked shrew (*Sorex cenerius*)	22	0.6
yellow-pine chipmunk (*Tamias amoenus*)	8	0.2
western jumping mouse (*Zapus princes*)	1	0.03
short-tailed weasel (*Mustela erminia*)	1	0.03
Total	**520**	**14.5**
OU-2 / Herman, 1975[2]		
deer mouse (*Peromyscus maniculatus*)	238	9.2
meadow vole (*Microtus pennsylvanicus*	15	0.6
masked shrew (*Sorex cenerius*)	5	0.2
Yellow-pine chipmunk (*Tamias amoenus*)	27	1.0
western jumping mouse (*Zapus princes*)	12	0.5
water shrew (*Sorex palustris*)	3	0.1
northern pocket gopher (*Thomomys talpodes*)	2	0.1
bushy-tailed woodrat (*Neotoma cinerea*)	1	0.04
Total	**303**	**11.7**
Latour Creek (reference) / 2003[3]		
deer mouse (*Peromyscus maniculatus*)	30	5.0
montane vole (*Microtus montanus*)	3	0.5
meadow vole (*Microtus pennsylvanicus*)	5	0.8
southern red-backed vole (*Clethrionomys gapperi*)	9	1.5
masked shrew (*Sorex cenerius*)	3	0.5
vagrant shrew (*Sorex vagrans*)	4	0.6
northern flying squirrel (*Glaucomys sabrinus)*	4	0.6
Total	**58**	**9.5**

[1] Relative abundance calculated at 3600 trap nights.
[2] Relative abundance calculated at 2600 trap nights.
[3] Relative abundance calculated at 600 trap nights.

Table 13: Total number small mammals, ratio of male to female, percent reproductive and percent juveniles captured during USFWS mark- recapture surveys 2001 and 2003.

Site / Field Season	Total No. Small mammal captured	% Adult Male[1]	% Adult Male reproductive[2]	% Adult Female[1]	% Adult Female reproductive[3]	% Juvenile Males[2]	% Juvenile Females[3]
OU-2 / 2001	520	26	62	20	57	50	57
Government Gulch /2003	66	30	83	32	68	50	20
Latour Creek / 2003	44	29	85	18	88	58	39

[1] Percent of total population.
[2] Percent of male population.
[3] Percent of female population.

Table 14: OU-2 and reference area small mammal Shannon-Weiner diversity indices.

Measure	OU-2 / 2001	Herman / 1975	Latour Creek reference / 2003	Government Gulch / 2003
Species	7	8	7	3
Individuals	520	303	58	66
H_1	1.069	1.222	2.188	1.153
H_1-Max	2.807	3	2.857	1.584
D_1	1.737	1.777	0.691	0.431
D_1 pct	61.905	59.257	22.059	27.236
Evenness	38.094	40.742	77.94	72.763

H_1 = species diversity index of present community.
H_1-Max = maximum diversity; all species are represented in equal proportions.
D_1 = H_1-Max - H_1 (divergence from equiprobability).
D_1 pct = D_1/ H_1-Max.
Evenness = percent relative abundance with which each species is represented in an area (H_1/H_1-Max).

Table 15: Number of fish captured and estimated populations, South Fork Coeur d'Alene River, 2003.

Site	Date	Area Sampled (m^2)	Number of Species Captured	Fish Captured								Estimated Population							
				Brook Trout		Cutthroat Trout		Rainbow Trout		Other [a]		Brook Trout		Cutthroat Trout		Rainbow Trout		Other [a]	
				#	#/m^2	#	#/m^2	#	#/m^2	#	#/m^2	#	#/m^2	#	#/m^2	#	#/m^2	#	#/m^2
SFR-1	10/06/03	1530	6	16	0.01	5	0.003	1	0.001	6	0.004	18	0.012	6	0.004	1	0[b]	5	0.003
SFR-2	10/08/03	1330	3	8	0.005	0	0	0	0	10	0.006	9	0.006	0	0	0	0	10	0.007
SFR-3	10/09/03	1580	4	37	0.023	1	0.001	0	0	13	0.008	40	0.025	2	0.001	0	0	23	0.014
SFR-4	10/15/03	1280	4	16	0.01	3	0.002	1	0.001	7	0.004	18	0.014	4	0.003	1	0[b]	5	0.003

[a] Other fish include perch, mountain whitefish, and sucker
[b] Unable to estimate population due to irregular or non-descending depletion

Table 16: Stream habitat survey data, South Fork Coeur d'Alene River 2003.

		Average Width			Habitat Composition			Substrate		Cover			
Site	Length (m)	Wetted Channel (m)	Bank Full (m)	Average Depth (m)	Riffle (%)	Run/ Glide (%)	Pool (%)	Dominant	Sub-dominant	Canopy (%)	Bank (%)	Riparian Corridor Composition	Woody Debris Class
SFR 1	100	15.3	20.9	0.48	10	80	10P[1]	cobble	small boulder	10	25	grasses	1
SFR 2	100	13.3	37.3	0.38	20	60	20P[2]	cobble	gravel	0	10	bare ground/shrubs	1
SFR 3	100	15.8	38.3	0.51	10	80	10P[2]	cobble	small boulder	0	5	bare ground	1
SFR 4	100	12.8	94.0	0.26	20	70	10P[2]	cobble	gravel	0	10	bare ground	1

[1] class-2 pool
[2] class-1 pool

Table 17: Numbers of amphibians and reptiles observed during spring (April - May) and summer (July) population surveys 2001.				
Site / Season	**Species observed**	**Number of adults present**	**Number of egg masses present**	**Number of larvae present**
Down river / Spring	None observed	-	-	-
Smelterville Flats / Spring	Western toad (*Bufo boreas*)	1	-	-
Wetlands / Spring	Pacific treefrog (*Hyla regilla*) Western toad (*Bufo boreas*)	3 2	- -	-
Little North Fork Coeur d'Alene River / Spring	Garter snake (*Thomnophis* spp.)	1	-	-
Down River / Summer	spotted frog (*Rana pretiosa*) bull frog (*Rana catesbeiana*) tailed frog (*Ascaphus truei*)	1 2 1	- 2 -	- - -
Smelterville Flats / Summer	tailed frog (*Ascaphus truei*) bull frog (*Rana catesbeiana*)	- 1	4 -	- -
Wetlands / Summer	None observed	-	-	-
Little North Fork Coeur d'Alene River / Summer	unknown amphibian tailed frog (*Ascaphus truei*)	- 3	110 - -	- - -

Table 18: Mean (range in parenthesis) blood ALAD, standard deviation (SD) and number of samples (*n*) for percent ALAD inhibition, and hematocrit in American robins, song sparrows, and Swainson's thrush inhabiting Smelterville Flats, Pinehurst, and the Little North Fork Coeur d'Alene River reference area in northern Idaho, June–July 2002.

Species/study area	ALAD[a]			Percent ALAD inhibition		Hematocrit[b]	
	n	Mean	SD	Mean	SD	Mean	SD
American robin/Smelterville Flats	2	22.0 (10.0 - 34.0)	17.0	77 (63 - 90)	0.19	43 (37 - 49)	8.5
American robin/reference	8	204 (143 - 251)	41.3	NA[c]		51 (43 - 57)	6.4
Song sparrow/Smelterville Flats	7	68.9 (6.0 - 217)	72.6	79 (33-98)	0.22	49 (28 - 54)	9.4
Song sparrow/Pinehurst	4	53.5 (18.0 - 147)	62.6	84 (55 - 95)	0.19	52 (48 - 60)	5.3
song sparrow/reference	12	325 (156 - 561)	101	NA[c]		48 (31 - 59)	9.2
Swainson's thrush/Smelterville Flats	11	157 (45.0 - 317)	77.0	50 (-0.02 - 86)	0.24	48 (42 - 58)	4.5
Swainson's thrush/Pinehurst	4	192 (92.0 - 312)	98.1	39 (0.0 - 71)	0.31	49 (40 - 56)	8.1
Swainson's thrush/reference	14	312 (240 - 535)	74.0	NC[c]		47 (27 - 60)	9.1

[a] aminolevulinic acid dehydratase activity
[b] Percentage of packed cell volume
[c] NA = Not applicable for reference area: ALAD inhibition calculated by dividing individual assessment area ALAD values by mean reference value.

Table 19: Soil lead concentrations in samples collected during passerine blood lead surveys.

Location / Year Sampled		Pb mg/kg dw
Government Gulch / 2003	Mean SD Range n	171 99 (86.6 – 324) 5
Magnet Gulch / 2003	Mean SD Range n	1201 544 (592 – 1842) 5
Pinehurst / 2004	Mean SD Range n	692 503 (340 – 2801) 4
Smelterville / 2004	Mean SD Range n	3320 426 (2801 – 3709) 4
LNFCdA reference / 2002 / 2004	Mean SD Range n	24.6 13 (2.34 – 32.6) 5

Table 20: Number (*n*), mean, range, standard deviation (SD), for blood Pb, liver Pb, ingesta Pb, ALAD unit, and percent ALAD inhibition in American robins, song sparrows, and Swainson's thrush utilizng Smelterville Flats, Pinehurst, and the Little North Fork Coeur d'Alene River reference area in northern Idaho, 2003 and 2004. Highlighted rows signify reference areas.

Species / Location / Year Sampled		Mean Percent Soil in ingesta	Blood Pb (mg/kg ww)	Liver Pb (mg/kg ww	Ingesta Pb (mg/kg dw)	ALAD Unit	% ALAD Inhibition
American robin / Government Gulch / 2003	Mean		0.163			81.6	38%
	SD		N/A			N/A	N/A
	Range		N/A			N/A	N/A
	n		1			1	1
American robin / Magnet Gulch / 2003	Mean		0.715			25.3	81%
	SD		0.383			12.6	9.5%
	Range		(.324 – 1.134)			(14.9 – 43.5)	(67% - 89%)
	n		4			4	4
American robin / Deadwood Gulch / 2003	Mean		0.656			23.3	82%
	SD		0.522			N/A	N/A
	Range		(.286 – 1.025)			N/A	N/A
	n		2			1	1
American robin / LNFCDA / 2003	Mean	0.565	0.050	0.13	6.1	133	0%
	SD	0.172	0.0466	0.05	1.2	34.1	26%
	Range	(0.44-0.76)	(.014 - .129)	(.08 - .20)	(4.8 – 7.2)	(88.2 – 187)	(-.41% - 34%)
	n	3	6	4	3	6	6
Song Sparrow/ Government Gulch / 2003	Mean		0.055	1.64	12.9	149	14%
	SD		0.045	2.19	N/A	52.6	31%
	Range		(.011 - .097)	(.09 – 3.19)	N/A	(111.4 – 186)	(-8% - 35%)
	n		4	2	1	2	2
Song Sparrow/ Deadwood Gulch / 2003	Mean						
	SD						
	Range						
	n						

Table 20 (continued)

Song Sparrow/ LNFCDA / 2003	Mean SD Range n	0.252 0.167 (0.103-0.521) 6	-.004 0.017 (-.024 - .055) 23	0.09 0.13 (.02 - .43) 9	2.5 1.2 (1.1 – 4.1) 6	172 31.9 (127 – 236) 18	0% 19% (-37% - 26%) 18
Swainson's Thrush / Government Gulch / 2003	Mean SD Range n	0.007 0 0.007-0.007 1	0.045 0.047 (.011 - .100) 4	0.64 0.53 (.19 – 1.22) 3	0.8 N/A N/A 1	174 4.1 (169 – 178) 3	11% 2.1% (9% - 13%) 3
Swainson's Thrush / Magnet Gulch / 2003	Mean SD Range n	0.003 0.002 (0.001-0.004) 2	0.105 0.078 (.017 - .167) 3	0.94 1.11 (.16 – 1.72) 2	10.3 7.3 (5.2 – 15.4) 2	118 41.9 (82.3 – 164) 3	40% 22% (16% - 58%) 3
Swainson's Thrush / Deadwood Gulch / 2003	Mean SD Range n		0.265 0.187 (.158 - .545) 4			84.7 N/A N/A 1	56% N/A N/A 1
Swainson's Thrush / LNFCDA / 2003	Mean SD Range n	0.107 0.204 (0.005-0.410) 4	-0.009 0.021 (-.037 - .030) 12	0.08 .04 (.04 - .16) 6	4.4 8.0 (-.1 – 16.4) 4	195 51.7 (99.6 – 285) 12	0% 27% (-46% - 49%) 12
Chipping Sparrow / Government Gulch / 2003	Mean SD Range n	0.558 0 (0.558-0.558) 1					
Dark eyed junco / Government Gulch / 2003	Mean SD Range n	0.021 0.030 (0.003-0.056) 3					

Table 21: Numbers (*n*), mean, standard deviation (SD), and range of blood Pb (mg /kg ww) concentrations in Mallard ducks (*Anas platyrhynchos*) collected from Page Ponds Associated Wetlands, 2003.

Blood Pb (mg / kg) wet weight	Total	Male	Female	Adult	Juvenile	Adult Male	Adult Female	Juvenile Male	Juvenile Female
Mean	0.94	0.75	1.12	0.84	1.04	0.75	0.88	0.75	1.54
SD	0.90	0.51	1.14	0.89	0.91	0.73	0.99	0.39	1.32
Range	(0.16 – 4.05)	(0.17 – 2.1)	0.15 – 4.05)	(0.16 – 3.86)	(0.17 – 4.05)	(0.19 – 2.10)	(0.16 – 3.86)	(0.75 – 1.49)	(0.21 – 4.05)
# Samples collected	37	18	19	18	19	6	12	12	12

Suggested interpretations of blood lead concentrations in waterfowl (Pain, 1996).

Background	< 0.20 mg / kg ww
Subclinical poisoning	0.20 < 0.50 mg /kg ww
Clinical poisoning	0.50 – 1.00 mg / kg ww
Severe clinical poisoning	> 1.00 mg kg ww

Table 22: Number (*n*), geometric mean, standard deviation (SD), and range of metal concentrations (mg/kg wet weight) in whole-body deer mice (*Peromyscus maniculatus*) collected from OU-2 and Latour Creek reference areas.

Site	Field season	*n*		As mg/kg ww	Cd mg/kg ww	Pb mg/kg ww	Zn mg/kg ww
Smelterville Flats	2001	18	Mean SD Range	0.18* 0.09 (0.04 – 0.33)	0.21* 0.11 (0.05 – 0.41)	10.27* 6.63 (1.30 – 24.50)	35.15* 10.72 (26.10 – 74.01)
Government Gulch	2001	29	Mean SD Range	0.18* 0.17 (0.03 – 0.72)	0.37* 0.48 (0.11 – 2.75)	4.40* 3.69 (0.90 – 15.90)	35.38* 4.97 (25.52 – 45.83)
Government Gulch	2002	6	Mean SD Range	0.18* 0.17 (0.03 – 0.45)	0.12 0.13 (0.05 – 0.40)	1.26* 2.27 (0.41 – 6.07)	30.14* 3.05 (27.99 – 35.86)
Government Gulch	2003	9	Mean SD Range	0.07 0.05 (0.04 – 0.18)	0.21* 0.22 (0.08 – 0.78)	4.26* 4.62 (13.12 – 1.12)	31.18* 3.96 (27.31 – 37.44)
Magnet Gulch	2001	12	Mean SD Range	0.15 0.09 (0.03 – 0.34)	0.38* 0.17 (0.15 – 0.67)	10.79* 3.35 (5.60 – 15.00)	41.04* 5.62 26.94 – 47.74)
Deadwood Gulch	2001	21	Mean SD Range	0.24* 0.17 (0.04 – 0.82)	0.17 0.08 (0.05 – 0.34)	8.55* 8.2 (1.20 – 32.50)	30.30* 4.21 (22.09 – 38.28)
Deadwood Gulch	2003	7	Mean SD Range	0.07 0.04 (0.03 – 0.13)	0.12 0.07 0.04 – 0.23)	2.72* 2.15 (0.91 – 6.73)	28.70 * 3.26 (24.01 – 34.58)
Bunker Hill OU-2 (combined averages)	2001/2002/ 2003	102	Mean SD Range	0.16 0.12 (0.03 – 0.72)	0.27* 0.29 (0.04 – 2.75)	6.66* 0.12 (0.41 – 32.50)	33.35* 6.54 (22.09 – 74.01)
Latour Creek (reference)	2002	26	Mean SD Range	0.09 0.50 (0.04 – 2.48)	0.15 0.39 (0.02 – 2.03)	0.13 0.07 (0.04 – 0.34)	26.47 4.44 (19.32 – 41.76)

*Significantly higher than the reference area.

Table 23: Number (*n*), geometric mean, standard deviation (SD), and range of metal concentrations (mg/kg wet weight) in whole-body Vole species[1] (*Microtus spp.*) collected from OU-2 and Latour Creek reference area.

Site	Field season	*n*		As mg/kg ww	Cd mg/kg ww	Pb mg/kg ww	Zn mg/kg ww
Smelterville Flats	2001	12	Mean	0.15	0.20	5.91*	33.47*
			SD	0.21	0.16	11.37	10.98
			Range	(0.03 – 0.82)	(0.05 – 0.66)	(0.50 – 41.60)	(23.63 – 65.99)
Government Gulch	2001	3	G Mean	0.16	0.44*	8.34*	38.94*
			SD	0.14	0.52	12.10	19.20
			Range	(0.07 – 0.33)	(0.12 – 1.04)	(1.10 – 22.30)	(27.10 – 63.30)
Magnet Gulch	2001	9	Mean	0.51*	0.75*	19.89*	36.66*
			SD	0.69	0.43	12.02	10.48
			Range	(0.12 – 2.31)	(0.31 – 1.44)	(6.40 – 45.10)	(27.54 – 59.50)
Deadwood Gulch	2001	2	Mean	0.39*	0.41*	6.23*	35.98*
			SD	0.01	0.28	1.27	0.26
			Range	(0.11- 0.12)	(0.22 – 0.62)	(5.30 – 7.10)	(35.80 – 36.17)
Bunker Hill OU-2 (combined averages)	2001	26	Mean	0.11	1.20*	8.41*	36.26*
			SD	0.24	0.34	9.19	10.23
			Range	(0.03 – 2.31)	(0.05 – 1.44)	(0.50 – 45.10)	(23.63 – 65.99)
Latour Creek (reference)	2002	8	Mean	0.16	0.08	0.07	24.54
			SD	0.07	0.03	0.1	2.81
			Range	(0.03 – 0.19)	(0.05 – 0.15)	(0.02 – 0.29)	20.58 – 29.14)

[1] No distinctions were made between meadow voles and montane voles for metals analysis.

*Significantly higher than the reference area.

Table 24: Number (*n*), geometric mean, standard deviation (SD), and range of metal concentrations (mg/kg wet weight) in whole - body Shrew spp[1] (*Sorex spp.*) collected from OU-2 and Latour Creek reference area.

Site	Field season	*n*		As mg/kg ww	Cd mg/kg ww	Pb mg/kg ww	Zn mg/kg ww
Smelterville Flats	2001	3	Mean SD Range	0.09 0.06 (0.04 – 0.17)	1.15 0.61 (0.69 – 1.90)	6.14* 3.86 (3.40 – 10.90)	46.06* 4.07 (39.35 – 47.30)
Government Gulch	2001	3	Mean SD Range	0.17 0.04 (0.12 – 0.19)	4.94* 2.25 (3.23 – 7.57)	3.24* 1.88 (1.90 – 5.60)	45.61* 2.51 (43.23 – 48.14)
Government Gulch	2002	7	Mean SD Range	0.19* 0.07. (0.10 – 0.29)	0.91 1.06 (0.45 – 3.46)	1.26* 7.22 (3.96 – 25.31)	40.81* 2.68 (38.18 – 45.34)
Government Gulch	2003	11	Mean SD Range	0.08 0.11 (0.04 – 0.42)	2.76 2.71 (0.92 – 8.60)	3.01 2.53 (0.98 – 8.93)	43.98 5.48 (38.68 – 52.95)
Magnet Gulch	2001	6	Mean SD Range	0.18* 0.06 (0.14 – 0.31)	0.98* 1.16 (0.71 – 3.72)	6.09* 15.12 (4.50 – 43.40)	42.67* 7.01 (42.20 – 59.14)
Deadwood Gulch	2001	7	Mean SD Range	0.18* 0.05 (0.13 – 0.27)	2.93* 2.84 (1.26 – 9.36)	14.17* 12.18 (5.40 – 40.80)	45.69* 9.60 (38.11 – 64.14)
Bunker Hill OU-2 (combined averages)	2001/2002/ 2003	37	Mean SD Range	0.17 0.08 (0.04 – 0.41)	2.85* 2.44 (0.45 – 9.36)	10.46* 10.67 (0.98 – 43.39)	44.92* 6.30 (38.11 – 64.14)
Latour Creek (reference)	2002	6	Mean SD Range	0.07 0.03 (0.03 – 0.12)	0.52 0.45 (0.34 – 1.52)	0.33 0.13 (0.16 – 0.55)	30.52 2.87 (26.34 – 35.14)
Latour Creek (reference)	2003	8	Mean SD Range	0.18 0.30 (0.04 – 0.86)	0.74 1.03 (0.41 – 3.47)	0.30 0.05 0.25 – 0.38)	34.18 2.17 (31.09 – 36.51)
Latour Creek (combined averages)	2002/2003	14	Mean SD Range	0.17 0.17 (0.04 – 0.66)	0.65 0.87 (0.13 – 3.47)	0.34 0.09 0.17 – 0.55)	26.53 12.33 (5.39 – 40.82)

[1] No distinctions were made between masked shrew and vagrant shrew species for metals analysis.
* Significantly higher than the reference area.

Table 25: Geometric mean and (range) of lead and cadmium concentrations[1] (mg/kg wet weight) in whole-body small mammals collected from previous studies conducted in OU-2.

Reference	Species/Site		Pb mg/kg ww	Cd mg/kg ww
	Deer mouse			
Herman (1975)	Deadwood Gulch (lower)	Mean Range	83.6 (32.2 – 345.8)	1.4 (0.8 – 3.6)
	Deadwood Gulch (middle)	Mean Range	15.1 (3.2 – 64.8)	1.2 (0.6 – 4.2)
	Deadwood Gulch (upper)	Mean Range	7.3 (2.2 – 19.9)	3.0 (1.2 – 9.7)
	Government Gulch	Mean Range	18.1 (2.8 – 69.4)	0.8 (0.5 – 1.1)
	Drive-In Gulch	Mean Range	44.0 (12.3 – 158.1)	2.0 (0.4 – 10.2)
Blus et al. (1987)	Kellogg (near tailings ponds)	Mean Range	55.3 (52.7 – 58.0)	0.58 (0.42 – 0.81)
Dames and Moore (1990)	Deadwood Gulch	Mean Range	15.3 (10.8 – 21.6)	1.0 (0.4 – 2.7)
Henny et al. (1994)	Kellogg	Mean Range	40.3 (33.7 – 45.3)	0.3 -
	Kellogg Airport	Mean Range	43.9 (7.4 - 1640)	0.7 (0.3 – 5.5)
	Vole spp.			
Blus et al. (1987)	Kellogg (near tailings ponds)	Mean Range	54.7 (23.5 – 173.0)	0.65 (0.50 – 0.84)
Henny et al. (1994)	Kellogg	Mean Range	23.2 (19.5 – 27.7)	- -
	Kellogg Airport	Mean Range	18.2 -	0.6 -

[1]As cited in Szumski, 1999.

Table 26: Number (*n*), mean, standard deviation (SD), and range of metal concentrations (mg/kg dry weight) in the liver of deer mice (*Peromyscus maniculatus*) collected from OU-2 and Latour Creek reference.

Site	*n*		As mg/kg dw	Cd mg/kg dw	Pb mg/kg dw
Smelterville Flats	5	Mean SD Range	0.66 0.07 (0.60 – 0.77)	0.58*a 0.25 (0.32 – 1.00)	1.00* 1.04 (0.31 – 1.65)
Government Gulch	13	Mean SD Range	0.55 0.17 (0.37 – 0.94)	3.57*b 3.20 0.38 – 9.92)	1.33* 1.04 (0.30 – 4.36)
Magnet Gulch	10	Mean SD Range	0.61 0.21 (0.31 – 1.10)	2.87*b 2.68 0.98 – 9.61)	1.75* 1.21 (0.41 – 4.20)
Deadwood Gulch	9	Mean SD Range	0.72 0.20 (0.48 – 1.00)	0.96*ab 0.40 (0.39 – 1.6)	1.41* 1.08 (0.37 – 3.76)
Bunker Hill OU-2 (combined averages)	37	Mean SD Range	0.66 0.15 (0.31 – 1.10)	2.3* 2.61 (0.32 – 9.92)	1.42* 1.03 (0.30 – 4.36)
Latour Creek (reference)	11	Mean SD Range	0.66 0.24 (0.39 – 1.10)	0.31 0.11 (0.15 – 0.50)	0.11 0.11 0.03 – 0.42)

* Significantly higher than the reference area.
Concentrations followed by different letters are significantly different.

Table 27: Mean (range) metal concentrations in composite whole-body fish collected during the South Fork Coeur d'Alene river diversion, 2002.

Species	***n***	**measure**	**As mg/kg dw**	**Cd mg/kg dw**	**Pb mg/kg dw**	**Zn mg/kg dw**
Brook trout	20	Mean	0.74	6.31	33.00	842
		SD	0.20	1.30	7.05	191
		Range	(0.44 – 1.20)	(4.50 – 8.83)	(21.90 – 49.50)	(433 – 1180)
Sucker spp.	1	Reported value	0.93	5.13	23.70	621

Table 28: Mean metals concentration (mg/kg dry weight) in aquatic invert samples (*n*= 7 samples / reach / year) collected 2003 and 2004 in the South Fork Coeur d'Alene River.

Reach / Year Sampled		As mg/kg dw	Cd mg/kg dw	Pb mg/kg dw	Zn mg/kg dw
Reach 1 / 2003	Mean	17.75	19.21	1577.86	1617.14
	SD	7.00	3.60	2597.95	275.54
	Range	(9.95-29.6)	(11.8-22.7)	(243-7440)	(1260-2020)
Reach 2 / 2003	Mean	15.14	20.17	386.29	2132.86
	SD	12.51	3.15	298.43	442.93
	Range	(5-40.9)	(14.2-24.5)	(117-815)	(1300-2660)
Reach 3 / 2003	Mean	11.60	14.30	590.71	1862.86
	SD	3.17	2.77	170.44	428.40
	Range	(9.31-18.6)	(11.4-19.7)	(368-851)	(1430-2610)
Reach 4 / 2003	Mean	11.84	15.11	887.00	1858.57
	SD	12.35	4.33	367.10	564.40
	Range	(4.7-39.1)	(10.2-20.7)	(559-1500)	(1370-2940)
Reach 1 / 2004	Mean	32.00	45.43	1148.43	3154.29
	SD	3.40	10.48	180.03	560.26
	Range	(28-38.3)	(30.6-57.9)	(920-1350)	(2140-3770)
Reach 2 / 2004	Mean	11.94	24.18	378.54	2185.71
	SD	7.93	17.70	293.62	1686.07
	Range	(1.8-25.9)	(2.25-54)	(22.8-831)	(170-5460)
Reach 3 / 2004	Mean	9.81	13.40	466.43	1862.86
	SD	2.41	3.47	168.77	421.89
	Range	(5.36-12.6)	(8.62-19.00)	(242-718)	(1190-2510)
Reach 4 / 2004	Mean	7.18	16.31	2664.57	1787.14
	SD	3.45	2.27	5710.27	516.94
	Range	(2.4-13.5)	(12.9-19.1)	(169-15600)	(1020-2510)

Table 29: Species, sample collection location, sample size, mean metal concentration, percent soil and percent soil ingestion of wildlife fecal samples, OU-2, 2001-2003. Highlighted rows indicate reference areas.

Year	Site	Species	mean Al	mean Pb.	Mean Zn	Mean Cd	N	%soil content	%soil ingestion
2001	LNF CdA	Bear	627	1.06	92.7	1.63	1		
2001	Magnet Gulch	Coyote	2340.00	137.00	991.00	19.50	1		
2001	Gov.Gulch	Coyote	261.00	25.10	213.00	1.34	1		
2001	LNF CdA	Coyote	2890.00	5.15	93.73	0.59	4		
2001	Smelterville Flats	Deer	918.00	44.99	630.75	9.06	8	4.40	0.79
2001	LNF CdA	Deer	2743.33	3.42	63.97	0.95	3		
2002	Deadwood Gulch	Deer	779.00	28.10	643.00	7.90	2	5.92	1.46
2002	Govt. Gulch	Deer	508.09	40.17	596.36	10.46	11	3.18	0.24
2002	Smelterville Flats	Deer	1112.00	85.30	580.00	9.09	2	7.53	2.21
2002	LNF CdA	Deer	994.00	6.55	255.75	3.10	4		
2003	Smelterville Flats	Deer	954.30	195.18	936.00	32.43	10	5.34	0.81
2003	Deadwood Gulch	Deer	2154.44	103.36	675.22	11.12	9	8.57	2.74
2003	Magnet Gulch	Deer	2060.90	76.64	650.00	15.90	10	15.29	10.48
2003	LNF CdA	Deer	1529.05	3.76	162.81	2.32	20	6.69	4.97
2001	Magnet Gulch	Elk	678.91	54.00	722.91	12.10	23	4.54	0.43
2001	Smelterville Flats	Elk	887.22	43.14	638.44	6.02	9	5.06	0.64
2001	LNF CdA	Elk	696.00	1.03	66.96	0.93	5		
2002	Deadwood Gulch	Elk	1192.38	42.58	578.63	8.13	8	5.31	0.78
2002	Magnet Gulch	Elk	1106.00	6.60	176.80	3.70	6	6.35	1.39
2002	Smelterville Flats	Elk	785.75	45.13	498.75	7.94	8	5.99	1.18
2002	LNF CdA	Elk	847.75	3.71	218.75	1.40	4		
2003	Govt. Gulch	Elk	901.60	38.22	432.40	8.19	10	4.71	0.42
2003	LNF CdA	Elk	867.75	3.79	206.45	3.92	20	4.37	2.46
2001	Smelterville Flats	Goose	3062.91	294.18	650.36	3.39	11	15.15	7.36
2003	Smelterville Flats	Goose	1927.95	431.60	926.45	8.55	20		
2003	Lewiston, ID	Goose	1871.84	2.25	40.56	0.39	19	18.51	17.92
2001	Smelterville Flats	Moose	867.00	22.70	289.50	8.03	2		
2001	LNF CdA	Moose	585.00	41.40	88.75	0.91	2		

Figures