2.0 SITE CHARACTERISTICS

This section presents an overview of the site characteristics. The overview includes descriptions of the following:

- A summary of the conceptual site model (Section 2.1)
- A summary of the site, including geography and topography (Section 2.2)
- Site sampling (Section 2.3)
- Known and suspected sources of mining contamination (Section 2.4)
- Chemicals of potential concern and affected media (Section 2.5)
- Groundwater and surface water contamination (Section 2.6)
- Land use (Section 2.7)
- Groundwater and surface water usage (Section 2.8)

2.1 SUMMARY OF CONCEPTUAL SITE MODEL

A conceptual site model (CSM) for the basin (CH2M HILL 1998) was developed to provide an initial understanding of potential site contamination and help formulate an approach to conducting the RI/FS. The CSM was developed to convey (1) a summary of the sources of contamination, (2) mechanisms of contaminant release, (3) pathways of contaminant release and transport, and (4) ways in which human and ecological receptors in the basin are exposed to contaminants. The CSM was developed to help provide a structure for assembling information about the basin and data from a variety of sources.

The following are the primary sources (mining-related wastes), release mechanisms, affected media (or secondary sources), exposure routes and potential receptors that were identified as potentially important to the investigation and development of remedial alternatives. The conceptual site model is illustrated in Figure 2.1-1.

The following are primary sources (mining-related wastes):

- Mine adit drainage: Groundwater that enters mine workings can become contaminated through contact with various minerals within the mines

- Waste rock: Rock derived from mining activities (other than ore)

- Tailings: Discarded fractions of processed ores containing residual metals

The following are release mechanisms:

- Dissolution
- Water erosion
- Channel migration
- Wind erosion
- Mass wasting
- Chemical processes

The following are affected media secondary sources:

- Groundwater
- Surface water
- Sediment
- Upland soils

The following are the human health exposure routes for the receptors noted:

- Soil in home yards, street rights-of-way, commercial and undeveloped properties, common areas, and airborne dust generated at these locations—residents, visitors, workers, recreators

- House dust—residents, visitors

- Drinking water from local wells or surface water—residents, visitors, workers, recreators

- Aquatic food sources—subsistence residents, recreators

- Homegrown vegetables—residents

The following are the ecological exposure routes for the receptors noted:

- Soil—birds, mammals, terrestrial plants, soil invertebrates, soil microbes

- Sediment—birds, mammals, fish, aquatic invertebrates, aquatic plants, amphibians

- Surface water—birds, mammals, fish, aquatic invertebrates, aquatic plants

2.2 SUMMARY OF SITE

The Coeur d'Alene Basin, as defined for the RI/FS, extends from the Idaho-Montana border in the Bitterroot Mountains west to the confluence of the Spokane River and the Columbia River at Roosevelt Lake. The Coeur d'Alene Basin RI/FS includes the Coeur d'Alene River and associated tributaries (including portions that run through the BHSS), Coeur d'Alene Lake, and the Spokane River downstream to the Washington State Highway 25 bridge at the Spokane Arm of Lake Roosevelt. As described in Section 1.3, it does not include the BHSS, which is the subject of an existing RI/FS. The Coeur d'Alene River Basin alone encompasses approximately 1,475 square miles (3,800 square kilometers).

Based on the results of the RI (URSG and CH2M HILL 2001a), the human health risk assessment (TerraGraphics and URSG 2001), and the ecological risk assessment (URSG and CH2M HILL 2001b), the FS study area was focused on the areas with the greatest human health and ecological risks. The study areas for development of human health and ecological alternatives differ somewhat, and are defined in the following sections.

2.2.1 Ecological Alternatives

Some areas of the basin not currently identified as highly impacted have not been included in the ecological alternatives study area. These areas are the North Fork and the Spokane River below Upriver Dam. To focus remedial effort where it is most needed, alternatives have not been developed at this time for the North Fork, which is considered an area of relatively limited contamination. The Spokane River study area is limited to selected sites identified by the Washington Department of Ecology (Ecology) as areas under consideration for remedial action, or sites that are characteristic of features that could require cleanup.

The ecological alternatives study area encompasses four broad areas: the upper basin, the lower basin, Coeur d'Alene Lake, and the Spokane River. The upper basin includes the steep mountain canyons of the South Fork and its tributary gulches. As described in Section 1.3, most of the past and current mining activity was conducted in the upper basin. The upper basin drains an area of 300 square miles (777 square kilometers).

The lower basin includes the lateral lakes and extensive floodplain wetlands. For development of the ecological alternatives, the lower basin study area is limited to the 100-year floodplain. Below Cataldo, the river flows into a broad, flat valley and takes on a meandering, depositional character with a fine-grained sediment bottom. From Rose Lake downstream, the river surface elevation is controlled by Post Falls Dam. The lower basin drains an area of 280 square miles (725 square kilometers).

Coeur d'Alene Lake drains an area of 3,741 square miles (9,690 square kilometers). Its two principal tributaries are the Coeur d'Alene River and the St. Joe River. At full pool, the lake covers 49.8 square miles (129 square kilometers) and has a maximum depth of 209 feet (63.7 meters).

The Spokane River flows from Coeur d'Alene Lake and is dammed at six locations above its terminus at Lake Roosevelt. Within the FS study area, the river bed primarily consists of coarse gravels and cobbles, and the floodplain and riparian zone are relatively narrow.

To facilitate analysis of processes at work in the basin, portions of the basin with similar geomorphology, stream gradients and amounts and types of mining wastes were grouped into CSM units. A more complete discussion on CSM unit boundaries is provided in Section 2 of Part 1 of the RI (URSG and CH2M HILL 2001a). For development of ecological alternatives in the FS Part 3, the basin was subdivided into the following CSM units and watersheds, which are illustrated in Figures 2.2-1 through 2.2-5. The area between the confluence of the North and South Forks and Cataldo is included in the lower basin study area for development of ecological alternatives.

- CSM Units 1 and 2 (upper basin)
    - Upper South Fork Watershed
    - Canyon Creek Watershed, including Segments 1 through 5
    - Ninemile Creek Watershed, including Segments 1 through 4
    - Big Creek Watershed, including Segments 1 through 4
    - Moon Creek Watershed, including Segments 1 and 2
    - Pine Creek Watershed, including Segments 1 through 3
    - South Fork Watershed, including Segments 1 and 2
- CSM Unit 3 (lower basin)
    - Main stem Coeur d'Alene River Watershed, including Midgradient Segment 4
    - Lower Coeur d'Alene River Watershed, including Segments 1 through 6
- CSM Unit 4 (Coeur d'Alene Lake)
    - Segment 1, the portion of the lake south of Coeur d'Alene River

  - Segment 2, the main body of the lake from the Coeur d'Alene delta northward

  - Segment 3, Wolf Bay Lodge arm

- CSM Unit 5 (Spokane River)

  - Spokane River Watershed, including Segments 1 and 2

2.2.2 Human Health Alternatives for Residential and Community Areas

For development of human health alternatives, the upper basin and lower basin were further divided into eight areas of investigation based on potential human health exposure, as shown on Figure 2.2-6:

- Mullan—the community of Mullan and the uppermost portion of the South Fork of the Coeur d'Alene River and its tributaries from Wallace to the headwaters of the river

- Burke/Ninemile—the lower portion of Canyon Creek and Ninemile Creek

- Wallace—the community of Wallace, located at the confluence of Canyon and Ninemile Creeks with the South Fork

- Silverton—the community of Silverton, located along the South Fork about 3 miles downstream from Wallace

- Osburn—the community of Osburn, located along the South Fork adjacent to Silverton

- Side Gulches—Moon Creek and Gulch, a portion of the South Fork watershed, residential areas of the Big Creek watershed, Montgomery, Nuckols, and Terror Gulches, Sunny Slopes, Twomile, and Elk Creek

- Kingston—portions of the Pine Creek, South Fork, and North Fork watersheds

- Lower Basin—Coeur d'Alene River west of Cataldo to Coeur d'Alene Lake

2.3 SITE SAMPLING

Beginning in 1997, the EPA collected samples of soil, sediment, groundwater, surface water, and other environmental media (e.g., indoor dust, lead-based paint, garden produce) and conducted an RI/FS. To guide field sampling efforts, a generic field sampling plan and quality assurance project plan were prepared that included descriptions of methods that would be used to collect and analyze samples, conduct field measurements, and manage data (URSG and CH2M HILL 1997). Numerous project-specific sampling plans were developed as field sampling plan addenda (FSPAs) to the base plan. Each FSPA was developed to address specific data gaps identified after reviewing available historical data and results of previous field sampling and analysis efforts. FSPAs were developed in general accordance with the EPA's data quality objectives process (USEPA 1994). The designs of the FSPAs are summarized in Table 2.3-1. Detailed descriptions of the investigations are presented in Section 4.2 of Part 1 of the RI (URSG and CH2M HILL 2001a).

More than 10,000 samples were collected to support the remedial investigation. These samples, combined with the 7,000 additional samples collected independently by IDEQ, USGS, the mining companies, EPA under other regulatory programs (e.g., NPDES), and others provide a solid basis to support informed risk management decisions for Coeur d'Alene Basin mining waste contamination. However, the large geographic area of the basin made it impractical to collect sufficient data to fully characterize each source area or watershed. Further data collection will be necessary to support remedial design for areas identified as requiring cleanup. This may include areas where previous cleanup actions have taken place, such as floodplain areas of the UPRR right-of-way (ROW) or other areas where previous removal actions have addressed some, but not all, contamination present.

2.4 KNOWN AND SUSPECTED SOURCES OF MINING CONTAMINATION

As described in Section 1.3.1, the primary sources of mining-related contamination are wastes generated from the mines and mills located in the upper basin. The most important secondary sources are the tailings-impacted sediment and associated groundwater present throughout the historical floodplain of the upper and lower basin. In this section, zinc and lead loading is used to indicate the relative importance of the watersheds and basins as sources of contamination. Figures 2.4-1 and 2.4-2 present expected (estimated average) loads and concentrations of dissolved zinc and total lead, respectively, in surface water at selected locations in the upper and lower basins.[1]

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[1] The procedure used to calculate expected (estimated average) loads and concentrations of metals is described in FS Part 3, Section 1.4.3 and in a technical memorandum (URSG 2001b).

2.4.1 Upper Basin

This section describes the sources of mining-related contamination on a watershed-by-watershed basis. Figures 2.2-1 and 2.2-2 show the locations of the watersheds. Sources of mining-related contamination in the upper basin are summarized in Table 2.4-1. Waste quantities are summarized in Section 2.5.3. Based on sampling conducted between 1991 and 1999, the upper basin is the source of about 79 percent of the dissolved zinc load and about 24 percent of the estimated average total lead load in the Coeur d'Alene River at Harrison.

2.4.1.1 Canyon Creek

Of the tributary watersheds to the South Fork, Canyon Creek is the largest source of mining-related impacts. Mining in the area was predominantly conducted between Burke and Gem, with lesser amounts in Gorge Gulch, lower Canyon Creek below Gem, and above Burke. At least 13 millsites were located within the watershed, and milling occurred as far upstream as Burke on Canyon Creek and Hercules No. 4 on Gorge Gulch. An estimated 27,400,000 tons of tailings were generated from an estimated 34,800,000 tons of ore produced from mines in the Canyon Creek Watershed.[2]

The BLM identified 127 source areas in the Canyon Creek Watershed (BLM 1999). These sources include an estimated 560,000 cy of metals-impacted sediment, 2.8 million cy of tailings, 2.4 million cy of waste rock, and 27 adits with drainage.

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading is 556 pounds per day, or about 19 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of about 17 percent to 26 percent). Source areas below Burke cumulatively contribute more than 95 percent of the dissolved zinc load from the watershed. The largest sources are thought to be the tailings-impacted sediments contained within the broad floodplain adjacent to Woodland Park in Canyon Creek Segment 5 (CCSeg05) and discharging adits, former millsites, and sediments in CCSeg04.

2.4.1.2 Ninemile Creek

Mining in the Ninemile Creek Watershed was primarily concentrated along the East Fork of Ninemile Creek in four areas (Interstate-Callahan, Tamarack, Success, and Rex) and at Dayrock on the main stem. An estimated 4,100,000 tons of tailings were generated from an estimated 5,000,000 tons of ore produced from mines in the Ninemile Creek Watershed.

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[2] Estimated tailings generated from ores produced from each watershed were not necessarily disposed of within the watershed where the ores were mined.

The BLM identified 70 source areas in the Ninemile Creek Watershed (BLM 1999). These sources include an estimated 150,000 cy of metals-impacted sediment, 820,000 cy of tailings, 1.7 million cy of waste rock, and 15 adits with drainage.

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading is 275 pounds per day, or about 9 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of about 4 percent to 12 percent). Sources on the East Fork of Ninemile Creek contribute most of the dissolved zinc load.

2.4.1.3 Upper South Fork

Mills within the watershed included Alice, Gold Hunter, Golconda, Lucky Friday, Morning, National, and Snowstorm. Releases of tailings to the Upper South Fork Watershed took place as far upstream as Daisy Gulch (Stratus 1999). An estimated 19,900,000 tons of tailings were generated from an estimated 24,500,000 tons of ore produced from mines in the Upper South Fork Watershed.

The BLM identified 181 source areas in the Upper South Fork Watershed (BLM 1999). These sources include an estimated 1.2 million cy of metals-impacted sediment, 1.2 million cy of tailings, 3.1 million cy of waste rock, and 27 adits with drainage.

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading is 89 pounds per day, or about 3 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of less than 1 percent to about 8 percent).

2.4.1.4 Big Creek

Mining and milling in the watershed was historically concentrated at the Sunshine mine and mill within the lower Big Creek Watershed. An estimated 11,000,000 tons of tailings were generated from an estimated 12,400,000 tons of ore produced from mines in the watershed. Tailings generated in the Big Creek Watershed were primarily sluiced to the South Fork prior to 1968. Since 1968, tailings have been contained in two tailings ponds in the lower watershed.

The BLM identified 68 source areas in the Big Creek Watershed (BLM 1999). These sources include an estimated 200,000 cy of metals-impacted sediment, 1.3 million cy of tailings, 1.1 million cy of waste rock, and 7 adits with drainage.

Sampling conducted between 1991 and 1999 indicates that the Big Creek Watershed has contributed less than 1 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork. The measured concentrations of metals in Big Creek are typically less than screening levels. The small loading is consistent with the history of tailings disposal in the watershed.

2.4.1.5 Moon Creek

Mining and milling in the watershed was concentrated in the East Fork drainage. An estimated 3,800 tons of tailings were generated from an estimated 4,600 tons of ore produced from mines in the watershed. The BLM identified 14 source areas in the Moon Creek Watershed (BLM 1999). Most of the sources in the watershed were contained as a result of removal actions conducted by the USFS in 1999 and 2000.

2.4.1.6 Pine Creek

Mining in the area was predominantly concentrated along the East Fork of Pine Creek and its tributaries. An estimated 2,500,000 tons of tailings were generated from an estimated 3,200,000 tons of ore produced from mines in the watershed.

The BLM identified 131 source areas in the Pine Creek Watershed (BLM 1999). Completed or ongoing removal actions have addressed containment of much of the source material. The remaining sources include an estimated 280,000 cy of metals-impacted sediment, 200,000 cy of tailings, 1.4 million cy of waste rock, and 21 adits with drainage.

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading is 90 pounds per day, or about 3 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of approximately 2 to 5 percent).

2.4.1.7 South Fork Watershed

Within the Study Area. An estimated 9,400,000 tons of tailings were generated from an estimated 9,800,000 tons of ore produced from mines in the watershed. The BLM identified 174 source areas in the South Fork Watershed, not including the BHSS (BLM 1999). These sources include an estimated 4.7 million cy of metals-impacted sediment, 4.5 million cy of tailings, 2.0 million cy of waste rock, and 15 adits with drainage.

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading from the Wallace to Elizabeth Park reach is 354 pounds per day, or about 12 percent of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of about 8 percent to 20 percent). The largest sources are thought to be the contaminated sediments and associated groundwater contained within the floodplain that is present throughout the length of the reach.

Within the BHSS. The BHSS was the location of the most intensive mining and processing activity within the basin. At least 11 mills, a lead smelter, a zinc electrolytic plant, and a phosphoric acid plant operated within the BHSS. An estimated 47,800,000 tons of ore were produced from mines in the BHSS. Tailings produced prior to 1926 were discharged directly to streams. Tailings were placed in Page Pond beginning in 1926 and the Central Impoundment Area beginning in 1928 (Stratus 2000).

Based on sampling conducted between 1991 and 1999, the expected (estimated average) value of dissolved zinc loading from the BHSS is about 1,500 pounds per day, or slightly more than one-half of the dissolved zinc load in the South Fork at its confluence with the North Fork (with a range of about 44 percent to 58 percent). Extensive remedial actions have been conducted within the BHSS beginning in 1995 and are ongoing. These actions are described in Section 1.3.2.2 of this document and in Section 1.1.6 of the FS Part 3.

2.4.2 Lower Basin

Mining and milling were not conducted within the lower basin, and primary sources of contamination are not present in the area. The lower basin is the location of very large volumes of secondary source material that is derived from deposition of tailings-impacted sediment from the upper basin and that is present within the streambed, streambanks, floodplains, wetlands, and lateral lakes of the lower basin.

The expected (estimated average) value of dissolved zinc loading from the lower basin is 684 pounds per day, or about 18 percent of the dissolved zinc loading in the river at Harrison. Remobilization of sediment in the streambed and streambanks of the lower basin is a substantial source of total lead loading. The expected value of total lead loading from the lower basin is 1,010 pounds per day, or about 67 percent of the total lead loading in the river at Harrison.

2.4.3 Coeur d'Alene Lake

Similar to the lower basin, no primary source materials are present within the Coeur d'Alene Lake study area. Secondary source material derived from tailings-impacted sediment transported from the upper and lower basins is present within the lake. An estimated 44 million (Bookstrom et al. 2001) to 50 million (Horowitz et al. 1995) cubic yards of mining-impacted sediments are present in the lake. Median concentrations of total cadmium, lead, and zinc in enriched sediments are 56 mg/kg, 1,800 mg/kg, and 3,500 mg/kg, respectively (Woods and Beckwith 1997). These high sediment concentrations have the potential to release metals to the lake and, ultimately, to the Spokane River.

2.4.4 Spokane River

Similar to the lower basin, no primary source materials are present within the Spokane River study area. Secondary source material derived from tailings-impacted sediment transported from the upper and lower basins is present within the Spokane River study area. Because the floodplain is relatively narrow, the volumes of source material in the study area are small compared to the upper and lower basins.

2.5 CHEMICALS OF POTENTIAL CONCERN AND AFFECTED MEDIA

This section describes the procedure used to identify chemicals of potential concern (COPCs) and affected media for the basin (Sections 2.5.1 and 2.5.2). The COPCs and affected media were further evaluated in the human health and ecological risk assessments, as described in Section 3. A description of quantities of mining-related waste present in the basin follows in Section 2.5.3.

2.5.1 Screening of Chemicals of Potential Concern

Based on preliminary screening results of the human health and ecological risk assessments, 10 chemicals of potential concern (COPCs) were initially identified for inclusion and evaluation in the RI/FS. The COPCs and appropriate corresponding media (soil, sediment, groundwater, and surface water) are summarized in Table 2.5-1. Of these, only arsenic is considered to be a carcinogen.

For each of the COPCs, a screening level was selected. The screening levels were used in the RI to help identify source areas and media of concern that would be carried forward for evaluation in the risk assessments and the FS. Screening levels were compiled from applicable risk-based criteria and background concentrations. If a risk-based criterion was less than the background concentration, the background concentration was selected as the screening level. Selected screening levels are listed in Tables 2.5-2 through 5.2-4. Screening levels are not remediation goals. Preliminary remediation goals (PRGs) are described in Section 2 of FS Part 2 for protection of human health and Section 2 of FS Part 3 for protection of ecological receptors. For example, the screening level for total zinc in surface water (30 µg/L), which is based on protection of aquatic plants, was not carried through as a PRG. The hardness-dependent AWQC has been identified as the PRG.

2.5.2 Concentrations of Chemicals of Potential Concern in Affected Media

To illustrate the nature and extent of contamination across the basin, available metals data were grouped into categories corresponding to sources and affected media and screened against the selected screening levels. The categories include:

- Source areas—upland source areas, floodplain sediments, floodplain tailings, adits, seeps, and outfalls
- Soil—upland soils in areas not identified by the BLM as source areas, residential yards, and common use areas
- Sediment—sediments not identified by the BLM as a source area
- Groundwater
- Surface water—rivers, streams, and lakes
- Residential dust
- Drinking water

Media with at least one screening level exceedance are shown in Table 2.5-5. Complete results are presented in Attachment 1. Fish, vegetables, and interior and exterior lead-based paint were not screened for COPCs in the RI; however, these media were evaluated in the human health risk assessment (TerraGraphics and URSG 2001).

Additionally, surface water metals data were analyzed using a probabilistic model to estimate average concentrations and mass loading at locations throughout the basin. Estimated concentrations were compared to surface water screening levels and estimated mass loading was compared to total maximum daily loads established by EPA under the Clean Water Act for specific reaches of the Coeur d'Alene River system. Results are shown in Table 2.5-6.

Based on the screening in the remedial investigation, no metals or media were screened out. All were carried forward in the human health and ecological risk assessments, where chemicals of concern were identified (see Section 3).

2.5.3 Quantities of Waste

As described in Sections 1.3 and 2.4, past mining-related activities have resulted in the discharge of large quantities of primary source material to the environment. Much of the primary source material has been commingled with existing soil and sediment in the basin. Examples include the mixing of tailings discharged to streams with riverborne sediment and smelter emissions deposited in soil in residential areas. As a result, the total volume of impacted materials in the basin is extremely large.

In this section, estimates of total quantities of waste are presented. The actual quantities of waste removed, contained, or treated would vary between the alternatives. The alternatives are described in Section 5. For the human health alternatives, quantities are summarized in terms of numbers of residences exceeding potential cleanup levels for each of the primary potential exposure media as discussed in Section 4 of the FS Part 2. For the ecological alternatives, the quantities of waste remediated under each alternative are presented in Sections 5 (upper basin), 6 (lower basin), 7 (Spokane River), and 8 (Coeur d'Alene Lake), of the FS Part 3.

2.5.3.1 Human Health Alternatives

Estimated numbers of residences with lead in yard soil at concentrations exceeding potential cleanup levels are shown in Table 2.5-7. Estimated numbers of residences with drinking water containing metals at concentrations exceeding one or more maximum concentration levels (MCLs) are shown in Table 2.5-8. Estimated numbers of residences with house dust containing lead at concentrations exceeding potential thresholds are shown in Table 2.5-9.

2.5.3.2 Ecological Alternatives

To increase specificity in the development of alternatives, the ecological alternatives identify remedial actions by "source types" (or media). The source types are:

- CSM Units 1 and 2 (upper basin)
  - Tailings piles[3]
  - Waste rock piles
  - Adits
  - Tailings-impacted floodplain sediment[4]

[3] Including tailings impoundments and mixed tailings-waste rock piles; tailings piles may be located in floodplains or uplands.
[4] Includes associated groundwater, which is a primary pathway for metals loading to surface water.

- CSM Unit 3 (lower basin)
  - River banks and levees
  - Riverbed sediments
  - Wetland sediments
  - Lateral lake sediments
  - Other floodplain area sediments
  - Cataldo/Mission Flats dredge spoils

- CSM Unit 4 (Coeur d'Alene Lake)
  - Lake bed sediments

- CSM Unit 5 (Spokane River)
  - Beach/bank sediments
  - In-stream sediments

The source types (or media) in the upper basin include the mining-related wastes that are primary sources and impacted floodplains sediments that have become secondary sources. Source types in the lower basin, Coeur d'Alene Lake, and the Spokane River represent mining-waste impacted areas or "environments" that have become secondary sources as a result of transport and deposition of contaminated materials from the upper basin.

Table 2.5-10 summarizes quantities of waste by source type. The soil (tailings and waste rock) and sediment source types are quantified by volume (cubic yards). Adits are quantified using dissolved zinc loading (in pounds of zinc per day)[5]. Loading was used as a metric because it more closely represents the impact of an adit discharge on the surface water receiving body than discharge or concentration alone.

Most of the dissolved metals loads in the river system come from the upper basin. The relative contributions of floodplain sediments, tailings, waste rock, and adits to the dissolved metals loads from the upper basin were estimated using a probabilistic analysis (see FS Part 3, Section 1.4.3 for a description of the probabilistic analysis). Based on this analysis, floodplain sediments have been identified as the largest source of dissolved metals loads, contributing an estimated 71 percent of the total load from the upper basin, not including the BHSS. The relative contributions of various source types to dissolved metals loading are shown in Figure 2.5-1.

[5] Loading is the quantity of metal transported in stream flow (usually measured as pounds of metal per day, #/d). Loading is calculated by multiplying the stream flow (or discharge, usually measured as cubic feet of flow per second, cfs) and the metal concentration in the stream flow (usually measured as micrograms per liter, µg/L). A units conversion factor of 0.00538 is used in the calculation.

In addition to the volumes of tailings-impacted sediments listed in Table 2.5-11, there are substantial volumes of impacted sediments in Coeur d'Alene Lake and the Spokane River. The volume of impacted sediments in the lake has been estimated to be about 44 million (Bookstrom et al. 2001) to 82 million tons (Horowitz et al. 1995). The total volume of impacted sediments in the Spokane River has not been estimated; however, estimated removal volumes are identified in Section 7 of the FS Part 3.

Measured concentrations of metals in all source types exceeded the screening levels for at least one of the seven ecological COPCs. To illustrate, pooled metal concentration data from the entire basin were used to calculate the probability that the true average concentration of a metal in a given source type at any given location is greater than the applicable screening level. In this analysis, tailings were subdivided into upland and floodplain tailings and upland concentrates and process wastes; waste rock was subdivided into upland and floodplain waste rock. Results for arsenic, cadmium, lead, and zinc for the six source types evaluated are presented in Table 2.5-11. The relative proportions of estimated sources of dissolved zinc load in the upper basin are illustrated in Figure 2.5-1. As shown in Table 2.5-11, except for arsenic in adit and seep drainage, the probability that the average concentration exceeds screening levels for these four metals is high, ranging from 45 to 100 percent. This analysis indicates that total volumes of various source materials can be considered equivalent to the volume of source materials exceeding screening levels, since at least one metal exceeds its screening level with nearly 100 percent probability for each source type.

2.6 GROUNDWATER AND SURFACE WATER CONTAMINATION

As discussed in Section 1, past mining practices have resulted in the broad distribution of mine wastes throughout much of the upper and lower basins. Metal contamination associated with this material continues to move within the hydrologic/hydrogeologic system from the upper and lower basins downstream into Coeur d'Alene Lake and the Spokane River. There is a high degree of interconnection and exchange of metals between groundwater and surface water in the basin. The following sections summarize the hydrologic/hydrogeologic system and metal migration.

2.6.1 Groundwater Systems

Regional groundwater flow systems within the Coeur d'Alene River valley can be divided broadly as follows:

- Groundwater flow through unconsolidated alluvial deposits (alluvial aquifers) within the river floodplain and major tributaries

- Groundwater flow through naturally fractured metasedimentary bedrock

- Localized occurrences of groundwater in the upper basin, such as perched zones within the native colluvium and saturated mine wastes within above-grade piles and impoundments

Detailed description of the groundwater systems are presented in Volumes 1 through 4 of the RI (URSG and CH2M HILL 2001a).

Summary information on the hydrogeology of the basin is presented in Table 2.6-1.

Contaminated sediments transported in the Coeur d'Alene River Basin are derived from bank erosion, channel migration, bed material remobilization, and sediments from waste deposits adjacent to stream channels. Sediment is generally incorporated and transported as suspended load (smaller particles that travel in the flowing water) or bedload (larger particles that travel along the bottom of the channel) during the high-flow stream discharges during spring and summer snowmelt. The quantity of the sediment transported typically increases as stream discharge increases, as does the particle size moved. Even during low-flow conditions, some sediment transport occurs as very fine particles that are kept in suspension by moving water. Sediment transport in the basin is summarized as follows:

- The upper South Fork Coeur d'Alene River Basin tributaries (e.g., Canyon Creek) have high gradients (slope) and typically flow in confined channels that limit the capacity to store sediment. Therefore, these areas produce much of the sediment transported by the overall system. Some sediment storage is possible in areas in the upper basin where there are active floodplains (e.g., Woodland Park).

- The South Fork generally has lower gradients that allow for more sediment to be stored (e.g., Osburn Flats) than in the tributaries. In areas where the stream channel has not been channelized or banks protected, the channels often display a meandering and braided channel form. These braided channels may deposit sediment in one area while incorporating sediment from another area. As with the tributaries, the quantity of sediment transported, as well as the particle size, increases at larger stream discharges, but some sediment transport occurs at low discharges. Sediment sources in the South Fork are from bank erosion, channel migration, channel bed material remobilization, and sediment from the upper watersheds and tributary streams.

- In the lower Coeur d'Alene River, which consists of a broad floodplain with numerous lakes and wetlands adjacent to the channel, the gradient of the channel is very low. The many wetlands, lakes and broad floodplains in this section of the river provide abundant storage for storm water. These areas store water during large discharges and mute peak discharges at downstream locations. Due to the low gradient, this section of the river does not transport appreciable quantities of gravel; however, sand, silt, and clay-sized particles are transported. Storage of sediment occurs in the broad floodplain, wetland, and lakes adjacent to the channel. The quantity of sediment transported increases at higher discharges; however, some sediment load is transported at low discharges. Sediment sources in the lower Coeur d'Alene River include bank erosion, channel bed remobilization, and sediment from the upper watersheds, tributary channels, and the South Fork. Channel migration does not appear to be a significant source of sediment, because the channel alignment has been relatively constant through time.

- Little sediment is transported through Coeur d'Alene Lake except during flood events. Most of the sediment entering the lake is deposited as deltas at the mouth of each tributary. Most of the fine material carried in by the Coeur d'Alene River is deposited in the lake before the water discharges into the Spokane River.

- The Spokane River is noted for its lack of fine sediments and its "armored" surface. Relatively little fine-grained, metal-laden sediment is deposited on the tightly packed, coarse gravels that make up the riverbed throughout its shallow reaches. Very little sediment accumulates in the Spokane River channel, because the river carries very little suspended sediment at low flow.

Summary information on hydrology of the river system, along with summary information on hydrogeology, is presented in Table 2.6-1. Summary information on sediment transport in the basin is also presented in Table 2.6-1.

2.6.2 Flow Direction and Surface Water/Groundwater Interaction

The overall direction of flow in the aquifer system varies but is mainly parallel or subparallel to the axis of the streams and rivers. However, the flow direction during low and high stream-flow conditions may have components that are more perpendicular to the stream or river.

Interactions between groundwater and surface water occur in many portions of the basin. These were documented between Kellogg and Pinehurst Narrows as part of the BHSS investigations (Dames & Moore 1991). More recently, the USGS conducted studies of surface water-groundwater interaction in Canyon Creek and along the South Fork in the Osborn Flats and Smelterville areas (USGS 2000). Surface water can act as a pathway to shallow alluvial groundwater (losing reach) that, in turn, can recharge downgradient surface waters (gaining reach).

Losing stream reaches occur where the valley floor widens, such as at Woodland Park on Canyon Creek and at Osburn Flats on the South Fork Coeur d'Alene River, and gaining stream reaches occur where the valley constricts.

In the lower Coeur d'Alene River Basin, for example, near Killarney Lake or Mission Flats, a small but quantifiable amount of groundwater flows to the river. However, as the river rises and falls, the shallow groundwater system, particularly the upper few feet, is constantly undergoing mixing of river water or precipitation with water moving downward from the previous occurrence of recharge (Spruill 1993).

2.6.3 Contaminant Transfer Between Soil, Sediment, Surface Water, and Groundwater

The primary sources of metals observed in surface water and groundwater are tailings mixed with alluvium, tailings piles, and waste rock piles located within the basin. Metals are released primarily through oxidation of sulfides in the source materials.

In the oxidation process, metals (e.g., lead, zinc, and cadmium) are transformed from a highly immobile to a relatively mobile state. This transformation takes place as sulfides come into contact with water and the atmosphere, are oxidized, and are replaced by minerals and solid phases (e.g., oxides and sulfates) with greater potential mobility. The oxidation process itself may release hydrogen ions and lower the pH. Metals tend to be more soluble (and mobile) at lower pH values. Even at neutral pH values, however, high metal concentrations may be found.

After release from ores, tailings, and waste materials, metals migrate in dissolved (ionic) and particulate forms (as adsorbed metals and as primary and secondary minerals) in groundwater and surface water. Source release mechanisms, movement, and attenuation of metals in surface waters and groundwaters are illustrated in Figure 2.1-1. Detailed information is provided in Section 3.3 of Part 1 of the RI (URSG and CH2M HILL 2001a).

2.7 LAND USE

The majority of the population of the basin lives in the cities of Coeur d'Alene and Post Falls, Idaho, and Spokane, Washington, which have populations exceeding 24,000, 7,000, and

177,000 people, respectively. All of the other communities in the basin have populations below 2,000. Land development in the basin is summarized as follows:

- With the exception of the three larger cities, the majority of the basin is rural, undeveloped land. In the upper basin, development related to mining activity, including towns, support services, and transportation, was more widespread than it is today.

- About 32 percent of Kootenai County and 75 percent of Shoshone County are federally-managed lands, primarily National Forest lands. These areas are rich in natural resources including forests, wildlife, and tributaries and streams that support a variety of aquatic organisms. Many of these areas are inaccessible due to the lack of roads and the difficult terrain.

- Interstate 90 (I-90) is the main highway through the area. I-90 spans east to west along the South Fork Coeur d’Alene River, then just north of Coeur d’Alene Lake through the cities of Coeur d’Alene and Post Falls, and continues west along the Spokane River through the city of Spokane. There is substantial development of a secondary road system for transportation within the basin.

Based on the findings of the risk assessments, land uses in the basin include:

- Residential
- Recreational/common use
- Agricultural
- Light urbanization or industrialization

2.8 GROUNDWATER AND SURFACE WATER USAGE

Both groundwater and surface water are used as drinking water sources in the basin. Within the upper basin and lower basin, about 57 percent of residences obtain water from a public source and 43 percent obtain water from a private source. Groundwater occurs in the sand and gravel present in the stream valleys of the upper basin (“valley fill aquifers”), in discontinuous sand and gravel layers in the lower basin, and in fractures in bedrock. Some private drinking water wells obtain water from the shallow aquifers that contain elevated levels of metals. The Rathdrum Prairie Aquifer, which is a sole-source aquifer, is present in Spokane County.

Groundwater usage within the Coeur d’Alene River Basin is mostly concentrated within the larger communities located along the valley flanks and valley bottom areas. Several investigators (MFG 1996; Piske 1990; Norbeck 1974) included well inventories as part of their investigations of the groundwater resource. Well yields of up to several hundred gallons per minute have been reported for larger alluvial production wells within the South Fork Coeur d'Alene River valley. Few deep wells were identified by the well inventories compiled for the lower main stem of the Coeur d'Alene River. Wells installed in the bedrock aquifer system generally have lower average yields due to the lower intrinsic permeability of the metasedimentary units.

Surface water and groundwater use in the basin is summarized in Table 2.8-1.