FINAL

Focused Feasibility Study Report

Upper Basin of the Coeur d'Alene River, Bunker Hill Mining and Metallurgical Complex Superfund Site

Volume 4

Appendices E through G

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criterion/criteria
bgs	below ground surface
BLM	Bureau of Land Management
CCSeg04	Canyon Creek Segment 04
CCSeg05	Canyon Creek Segment 05
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COPC	contaminant of potential concern
CSM	conceptual site model
CTP	Central Treatment Plant, Kellogg, Idaho
cy	cubic yards
FFS	Focused Feasibility Study
FS	Feasibility Study
GIS	geographic information system
gpm	gallons per minute
HDS	high-density sludge
IDAPA	Idaho Administrative Procedures Act
INEEL	Idaho National Engineering and Environmental Laboratory
lb/day	pound(s) per day
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPV	net present value
O&M	operation and maintenance
OU	Operable Unit
PRG	preliminary remediation goal

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SFCDR	South Fork (of the) Coeur d'Alene River
SRB	sulfate-reducing bioreactor
SVNRT	Silver Valley Natural Resource Trust
TCD	typical conceptual design
USEPA	U.S. Environmental Protection Agency

APPENDIX E:

Development of Updated Woodland Park Components of Ecological Alternatives 3 and 4

E.1 Introduction

This appendix provides a detailed description of the process used to update the components of Ecological Alternatives 3 and 4 presented in the *Final (Revision 2) Feasibility Study Report, Coeur d'Alene Basin Remedial Investigation/Feasibility Study* (2001 FS Report; U.S. Environmental Protection Agency [USEPA], 2001b) that are specific to the Woodland Park area in the Upper Basin of the Coeur d'Alene River. Woodland Park is part of Operable Unit 3 (OU 3) of the Bunker Hill Mining and Metallurgical Complex Superfund Site, and is located in the Canyon Creek Watershed near the confluence with the South Fork Coeur of the d'Alene River (SFCDR) (Figure E-1). The updated Woodland Park components of Ecological Alternatives 3 and 4 described in this appendix are incorporated into the remedial alternatives for the Upper Coeur d'Alene Basin (Alternatives 3+ and 4+) that are described and evaluated in this Focused Feasibility Study (FFS) Report.

This appendix draws heavily on previous studies (discussed in Section E2.3), particularly the 2001 FS Report that identified and described Ecological Alternatives 3 and 4. The appendix also focuses on only the most promising of the previously identified remedial actions for Woodland Park. Therefore, the appendix does not identify general response actions, technology types, and process options as these were previously defined in the 2001 FS Report, with some updates provided in the *Draft Remedial Component Screening for the Woodland Park Area of Canyon Creek* (CH2M HILL, 2007b). With these exceptions, the methods used to develop the updated Woodland Park components of Ecological Alternatives 3 and 4 were consistent with USEPA guidance as defined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* [the Comprehensive Environmental Response, Compensation, and Liability Act] (USEPA, 1988).

E.1.1 Purpose

The purpose of this appendix is to present the process by which the Woodland Park components of Ecological Alternatives 3 and 4 in the 2001 FS Report (USEPA, 2001b) were updated, and to describe the updated components. These updated actions are incorporated into the remedial alternatives for the Upper Coeur d'Alene Basin (Alternatives 3+ and 4+) that are described and evaluated in this FFS Report.

E.1.2 Physical Setting

Canyon Creek and Woodland Park are located in the Upper Basin of the Coeur d'Alene River in northeastern Idaho (Figure E-1). The length of Canyon Creek is approximately 12 miles, from the headwaters in the Bitterroot Mountains to the confluence with the SFCDR near Wallace, Idaho. Historical mining and milling activities in the Canyon Creek Watershed, an area of approximately 22 square miles, have resulted in metals contamination of water, sediments, and soil. Dissolved zinc is the predominant metal contaminant in Canyon Creek water, but dissolved cadmium and particulate lead are also present. The 2001 FS Report states that "of the tributary watersheds to the South Fork, Canyon Creek is the largest source of mining-related impacts."

The Canyon Creek Watershed contains an estimated 127 source sites, 27 adits with drainage, and three surface water seeps (USEPA, 2001a). The resulting dissolved metals load in Canyon Creek is higher than in any other tributary of the SFCDR and, at the time of the Remedial Investigation (RI) for the Coeur d'Alene Basin (which relied upon data collected between 1991 and 1999), was estimated to contribute 20 to 25 percent of the total dissolved load in the SFCDR at its confluence with the North Fork of the Coeur d'Alene River (USEPA, 2002). Woodland Park is described in the 2001 FS Report as "the largest source of metals loading to the Canyon Creek Watershed". Data collected through August 2009, from ongoing surface water monitoring programs, suggest that Canyon Creek contributes approximately 15 to 20 percent of the total dissolved zinc load to the SFCDR at its confluence with the North Fork.

Woodland Park is defined as the area near the mouth of Canyon Creek, and is also referred to as Canyon Creek Segment 05 (CCSeg05).[1] The Canyon Creek Watershed is a steep-walled, deeply incised canyon. In the vicinity of Woodland Park, the gradient decreases and Canyon Creek opens into a U-shaped canyon. The extent of the alluvial aquifer is limited upstream from the Woodland Park area, where Canyon Creek occupies a narrow valley consisting primarily of exposed bedrock with no substantial alluvial deposits along its banks (Box et al., 1999). The thickness of the alluvial aquifer varies, but is generally less than 15 feet. In the Woodland Park area, the canyon widens and the alluvial aquifer becomes significantly thicker. The total thickness of alluvium observed in this area is as great as 50 feet. The saturated alluvium is thickest at the center of the Canyon Creek basin in the upper reaches of Woodland Park (beneath the Hecla-Star Tailings Ponds) and thinnest at the southern end of the watershed, as Canyon Creek approaches the confluence with the SFCDR. Data collected during the Canyon Creek Hydrologic Study (CH2M HILL, 2007a) suggest that the alluvial aquifer is characterized by a single water-bearing unit with significant horizontal to vertical anisotropy that imparts strong vertical gradients within the flow field.

Twelve source sites, one seep, and one adit with drainage are located in Woodland Park, according to the 2001 FS Report. The Bureau of Land Management (BLM) identification codes and names for these sites, based on the inventory of source sites conducted by the BLM in 1999 in support of the RI/FS for the Coeur d'Alene Basin, are referenced throughout this appendix. Figure E-2 shows the locations of the 12 source sites.

It should be noted that the Gem Portal and Star Mine adit discharges are not included in the description of Woodland Park source sites in this appendix, despite the fact that these adit discharges are currently conveyed by pipeline from their sources in Canyon Creek Segment 04 (CCSeg04) to CCSeg05 for discharge. The Gem Portal adit discharge is currently

[1] During the Remedial Investigation (RI), the watersheds in the Coeur d'Alene Basin were divided into segments to focus the investigation. CCSeg05 is one of the segments in the Canyon Creek Watershed, and was defined in the RI Report as "Woodland Park to the confluence with the South Fork Coeur d'Alene River" (USEPA, 2001a).

conveyed by pipeline to the northernmost Hecla-Star Tailings Pond, where it is then discharged directly to Canyon Creek. The Star Mine adit discharge is currently conveyed by pipeline to the southernmost Hecla-Star Tailings Pond, where it is then discharged to a receiving pond and eventually decanted to the Canyon Creek floodplain below for discharge. Because these sources originate in CCSeg04, they are not addressed by the suite of actions considered for Woodland Park but are addressed along with other upstream Canyon Creek sources in the FFS Report.

E.1.3 Organization of this Appendix

This appendix is organized into the following sections:

- **Section E.1, Introduction,** describes the purpose and objectives of this appendix and the physical setting of the Woodland Park area, and provides this overview of the appendix organization.
- **Section E.2, Impetus for Updating the Woodland Park Components of Ecological Alternatives 3 and 4,** describes the Selected Remedy for Woodland Park that is documented in the Record of Decision (ROD) for OU 3 (often referred to as the Interim ROD for OU 3; USEPA, 2002); discusses concerns with some of the components of that remedy; and summarizes studies conducted since the Interim ROD was issued that support the updating of the Woodland Park components of Ecological Alternatives 3 and 4 presented in the 2001 FS Report (USEPA, 2001b).
- **Section E.3, Development of the Updated Woodland Park Components of Ecological Alternative 3,** presents the approach and methodology used to update the Woodland Park components of Ecological Alternative 3 in the 2001 FS Report. These updated actions are incorporated into Alternative 3+ in this FFS Report.
- **Section E.4, Development of the Updated Woodland Park Components of Ecological Alternative 4,** presents the approach and methodology used to update the Woodland Park components of Ecological Alternative 4 in the 2001 FS Report. These updated actions are incorporated into Alternative 4+ in this FFS Report.
- **Section E.5, Summary of the Woodland Park Components of Remedial Alternatives 3+ and 4+,** summarizes the Woodland Park components of Alternatives 3+ and 4+ that are developed in this appendix and incorporated into these remedial alternatives in the overall FFS Report.
- **Section E.6, References,** lists the documents cited in this appendix.

Figures and tables referenced in the above sections are provided following Section E.6. Three attachments then provide supplemental information and data:

- **Attachment E-1, Detailed Cost Analyses of Individual Remedial Actions**
- **Attachment E-2, Documentation of the Simplified Tool for Predictive Analysis: Woodland Park (2006 Data)**
- **Attachment E-3, Detailed Cost Analyses of Remedial Options A through D**

E.2 Impetus for Updating the Woodland Park Components of Ecological Alternatives 3 and 4

This section provides context and rationale describing why the Woodland Park components of Ecological Alternatives 3 and 4 in the 2001 FS Report (USEPA, 2001b) are updated in this FFS Report. Woodland Park has been the subject of extensive study since the Interim ROD for OU 3 was completed (USEPA, 2002). The information obtained through these studies has provided an opportunity to refine the remedial actions for Woodland Park. Specifically, this section describes the following:

- The remedial actions for Woodland Park evaluated in the 2001 FS Report (Section E.2.1)
- the Selected Remedy for Woodland Park identified in the Interim ROD for OU 3, and concerns with this Selected Remedy that prompted additional study (Section E.2.2)
- A summary of the post-ROD remedial studies that have been completed, and how they have influenced the updating of the Woodland Park components of Ecological Alternatives 3 and 4 presented in the 2001 FS Report (Section E.2.3)

E.2.1 The 2001 Feasibility Study Report

From 1997 through 2001, USEPA collected samples of soil, sediments, groundwater, surface water, and other environmental media from the Upper and Lower Basins and conducted an RI/FS for the overall Coeur d'Alene Basin (USEPA, 2001a, 2001b). The RI/FS provided the basis for formulating the Selected Remedy that was then documented in the Interim ROD for OU 3 (USEPA, 2002). The study area for the RI/FS included the Canyon Creek Watershed, including Woodland Park (CCSeg05). The RI Report (USEPA, 2001a) states that "CCSeg05 contributes more than 50 percent of the dissolved zinc load from the Canyon Creek Watershed. Most of this load derives from contaminated sediments and associated groundwater in the impacted floodplain reaches of CCSeg05."

The risks posed to human health and the environment as a result of historical mining contamination were evaluated during development of the remedial alternatives presented in the 2001 FS Report. Six ecological alternatives were developed for the Upper and Lower Basins:

- Alternative 1: No Action
- Alternative 2: Contain/Stabilize with Limited Removal and Treatment
- Alternative 3: More Extensive Removal, Disposal, and Treatment
- Alternative 4: Maximum Removal, Disposal, and Treatment
- Alternative 5: State of Idaho Cleanup Plan
- Alternative 6: Mining Companies' Cleanup Plan

USEPA's preferred comprehensive ecological alternative in the 2001 FS Report was Alternative 3, and the Selected Remedy in the Interim ROD for OU 3 contains a prioritized subset of Alternative 3 actions. Alternative 3 targeted most contaminant sources in the Coeur d'Alene Basin outside Coeur d'Alene Lake through excavation, consolidation, disposal, capping, and treatment. This alternative was not the most aggressive and costly ecological alternative evaluated in the 2001 FS Report—this was Alternative 4—but

Alternative 3 was the remedy that would cause the fewest short-term impacts on the local communities, was most implementable, and was the least costly ecological alternative that met the statutory and regulatory requirements (USEPA, 2001b).

Alternatives 3 and 4 were the only ecological alternatives in the 2001 FS Report that were determined by USEPA to include National Oil and Hazardous Substances Pollution Contingency Plan (NCP)-compliant remedies for surface water. Therefore, these two alternatives provide a logical foundation upon which to develop the updated remedial alternatives for the Upper Coeur d'Alene Basin in the current FFS Report, as described in Section 1.0 of the report.

For the 12 Woodland Park source sites identified by BLM and shown in Figure E-2, Table E-1 summarizes the remedial actions proposed for Alternatives 3 and 4 in the 2001 FS Report. The actions included in each of these ecological alternatives are also summarized in the following subsections.

E.2.2.1 Ecological Alternative 3

Under Ecological Alternative 3 presented in the 2001 FS Report, contaminated sediments in the floodplain reaches in Woodland Park would be removed and placed in a regional repository. The location of the repository was assumed to be in or very near Woodland Park. An estimated 82,600 cubic yards (cy) of material would be excavated from Woodland Park and placed in the regional repository along with contaminated sediments from the adjacent Canyon Creek Segment CCSeg04. "The Hecla-Star Tailings Ponds would be provided with a high performance cap and hydraulic isolation using a slurry wall…. Groundwater collected in association with hydraulic isolation would receive active treatment." The Canyon Creek Silver Valley Natural Resource Trust (SVNRT) Repository would also be provided with a high-performance cap under Alternative 3.

"Hydraulic isolation is included under Alternative 3 to reduce metals loading to the creek from the contaminated floodplain sediments and associated groundwater…. For feasibility-level analysis of the alternatives, it was assumed that one-half of the total length of lower Canyon Creek (CCSeg05) would be hydraulically isolated. Hydraulic isolation would be provided by constructing impervious walls adjacent to one or both sides of the creek. Groundwater would be collected in trenches adjacent to the walls and conveyed to the active treatment plant [to be built] in Pinehurst."

Excavation and disposal of upland tailings in Woodland Park would also be conducted. Collection and active treatment of adit drainage would be included for the Canyon Silver (Formosa) Mine located within Woodland Park.

Ecological Alternative 3 in the 2001 FS Report also included the implementation of passive stream flow treatment in ponds near the mouth of Canyon Creek (a specific location was not identified) as an interim measure to control metals loading to the SFCDR. It was assumed that the ponds would be designed for a flow rate of 60 cubic feet per second (cfs). This was intended as an interim remedy prior to the implementation of the source control actions described above. In addition, Ecological Alternative 3 included the passive treatment of a seep at source site WAL041 identified by BLM.

E.2.2.2 Ecological Alternative 4

Under Ecological Alternative 4 in the 2001 FS Report, all materials from Woodland Park "that are probable sources of metals loading would be excavated and placed in a regional repository." The regional repository was assumed to "be constructed in the vicinity of Woodland Park, and would only accept material from the Canyon Creek Watershed." An estimated 3.2 million cy of waste material from Woodland Park would be placed in the repository. Floodplain tailings would be excavated from reaches throughout Woodland Park. Tailings from the Hecla-Star Tailings Ponds (about 2,400,000 cy) and the SVNRT Repository (about 600,000 cy) would be excavated and placed in the regional repository.

Upland tailings in areas of Woodland Park would be excavated and placed in a waste consolidation area (called a "local repository" in the 2001 FS Report) that would be constructed for the disposal of waste rock from several watershed segments. Upland waste rock in Woodland Park that was not a probable source of metals loading would be covered and re-vegetated. Collection and active treatment of adit drainage would be included for the Canyon Silver (Formosa) Mine located within Woodland Park.

E.2.2 The Selected Remedy for Woodland Park in the Interim ROD for OU 3

The Selected Remedy included in the Interim ROD for OU 3 (USEPA, 2002) was a prioritized subset of Ecological Alternative 3 remedial actions. The following excerpt from the Interim ROD describes the Selected Remedy for Canyon Creek:

"Implementation of a source-by-source cleanup in Canyon Creek, as is anticipated under Alternative 3 in the 2001 FS, would be very difficult, costly, and time consuming. The Selected Remedy for approximately 30 years of work in Canyon Creek will focus on identifying cost-effective technologies for improving downstream water quality in the South Fork and main stem of the Coeur d'Alene River and, ultimately, in Coeur d'Alene Lake and the Spokane River."

"One potentially cost-effective approach that will be evaluated is to intercept the creek water in lower Canyon Creek and remove metals using passive treatment. Under this approach, the individual metals sources in the Canyon Creek watershed would not be addressed during the Selected Remedy. Should creek water treatment prove effective after pilot studies, full-scale treatment would be implemented as part of the Selected Remedy in Canyon Creek. The development of innovative and potentially cost-effective water treatment in Canyon Creek would be effective in achieving desired reductions and potentially have application in other parts of the Basin (e.g., Ninemile Creek). "

It should be noted that the paragraph above ends as follows: "If passive treatment does not prove effective, alternative treatment and control systems to achieve the benchmark of at least 50 percent reduction of dissolved metals loads would be evaluated. Alternative actions may be used based on an evaluation against CERCLA remedy selection criteria."

The Interim ROD for OU 3 further states: "Selected remedies in Canyon Creek also include stabilization of dumps and stream banks that are sources of sediment and particulate metals in the creek, the South Fork, and the lower Coeur d'Alene River."

The surface water treatment approach outlined in the Interim ROD for OU 3 carried with it many potential disadvantages, including the relatively low efficiency of treating a high-volume, low-concentration water source making “pond” treatment approaches particularly challenging. In addition, implementability issues exist with the surface water treatment approach such as space limitations within the drainage for a passive treatment system, the high groundwater table and propensity for flooding, and community concerns.

When the Interim ROD was completed, there were two significant areas of uncertainty associated with the Selected Remedy for Woodland Park: (1) the effectiveness and implementability of the passive surface water treatment technology, and (2) the role of groundwater in surface water metals loading. Between 2002 and 2007, Woodland Park was an area of focused study to address these areas of uncertainty. These studies sought to identify and evaluate alternative approaches to achieving the ROD benchmark, including assessing alternative water treatment technologies and targeting relatively high-concentration, low-flow groundwater for treatment rather than surface water. In addition, related studies were conducted within the Upper Coeur d’Alene Basin between 2002 and 2007 that also provided information with which to address these areas of uncertainty. These post-ROD studies are summarized in the following section.

E.2.3 Post-ROD Remedial Studies

As discussed above, the Interim ROD for OU 3 alluded to areas of uncertainty associated with the Selected Remedy for Woodland Park. These areas of uncertainty (water treatment technologies and groundwater-surface water interactions) were then the focus of post-ROD studies conducted between 2002 and 2007. Because Ecological Alternative 4 (or a subset thereof) was not selected in the Interim ROD for OU 3, addressing uncertainties associated with actions included in Ecological Alternative 4 was not a focus of study during that period. As described above, Ecological Alternative 4 was a more aggressive remedy and relied less on the uncertainty areas of Ecological Alternative 3, such as groundwater surface water interactions.

The post-ROD studies were designed to address one or both of the areas of uncertainty associated with the Selected Remedy for Woodland Park. Water-treatment-focused studies included the following:

- **Zinc/Cadmium Symposium, September 2002 (INEEL, 2002).** This symposium, organized by the Idaho National Engineering and Environmental Laboratory (INEEL) and Idaho Senator Mike Crapo, focused on removing and/or stabilizing dissolved metals, primarily zinc and cadmium, throughout the Coeur d’Alene Basin. A diverse group of scientists, regulators, and concerned citizens attended this symposium to address the technical challenges of the environmental cleanup and to brainstorm new approaches to their resolution. Topics such as major technical challenges for water treatment and impacted sediments and new remediation technologies were presented.

- **Canyon Creek Treatability Study—Summary of Current Thinking (URS, 2003).** This memorandum documents the evolution in thinking that took place between the completion of the Interim ROD for OU 3 and the *Final Canyon Creek Treatability Study Phase I Report* (URS, 2005). The memorandum proposes high-density sludge (HDS) lime stabilization/co-precipitation, used in combination with Actiflo® (a high-speed ballasted-microsand solid-liquid separation technology patented and implemented by Veolia Water/Kruger), as an alternative to the passive treatment ponds outlined in the

Interim ROD for OU 3. Like the Interim ROD, the memorandum recommends treatment of 60 cfs of surface water to achieve the ROD treatment objectives. Treatability testing in support of this proposed treatment process was conducted as part of the Canyon Creek Phase I Treatability Study, described below and in URS, 2005).

- **Gem Portal Treatability Testing (Asarco, 2004).** This onsite pilot study evaluated treatment of the Gem Portal discharge using an anaerobic biological treatment system (sulfate reducing bioreactor), a lime precipitation system, and a floating sand filter. None of the systems tested in this study were found to achieve the desired degree of dissolved metals removal.
- **Canyon Creek Phase I Treatability Study (URS, 2005).** This bench-scale study was conducted to evaluate the effectiveness of lime addition for metals precipitation in various combinations with pH adjustment and addition of iron coagulants for iron co-precipitation. Solids/liquid separation testing was conducted on the resulting solution using flocculants and ballasted microsand. The results of the study confirmed that lime addition was effective for the precipitation of metals.
- **Canyon Creek Water Treatment Technology Evaluation (CH2M HILL, 2005).** This evaluation considered the water treatability testing conducted during the Canyon Creek Phase I Treatability Study, and assessed alternative approaches that could potentially provide equally effective, less costly, and more implementable means of achieving the treatment objectives. The alternative approaches were centered on the idea of collecting and treating low-volume, high-concentration groundwater rather than high-volume, low-concentration surface water. This evaluation provided the rationale for the design of the Canyon Creek Phase II Treatability Study (CH2M HILL, 2006a).
- **Apatite Testing at Nevada-Stewart Mine (on Pine Creek) (McCloskey, 2005) and Success Mine (on Ninemile Creek) (Yancy, 2006).** These studies both investigated the use of an apatite reactive bed system for dissolved metals removal. The Nevada-Stewart Mine study used aboveground vessels containing a mixture of gravel and apatite to treat mine drainage, and the Success Mine study used an interceptor wall that funneled groundwater into a below-grade treatment cell containing apatite. In these studies, the apatite systems were shown to effectively remove dissolved zinc from water, but significant design and operations issues were encountered (due to clogging) that remain to be resolved, especially for treatment of high flow rates.
- **Canyon Creek Phase II Treatability Study (CH2M HILL, 2006a).** This study included bench- and pilot-scale testing of several technologies, including reactive media beds, HDS, and sulfate-reducing bioreactors (SRBs). Both the HDS and SRB technologies were found to be effective for dissolved metals removal, and the results of this study provided preliminary design data with which to evaluate treatment options.
- **Abandoned Mine Lands Workshop: Biochemical Remediation Technologies (2007).** This workshop held in Coeur d'Alene, Idaho focused on the use of biochemical remediation technologies, including the state of the art in state, federal, and international applications, and factors to consider in deciding to use biochemical remediation.
- **Passive Treatment Systems Operated by BLM (ongoing).** BLM operates a number of passive treatment systems throughout the Coeur d'Alene Basin, all of which are

designed as SRBs. While no single report summarizes the experience with these systems, the work has contributed to the body of knowledge related to SRB operation and effectiveness.

- **Lime Precipitation with Settling Ponds for Solids/Liquids Separation—Conceptual Design (Pioneer Technical Services, 2007).** A design for a pilot-scale (300gallons-per-minute [gpm]) system was developed for Canyon Creek under a Clean Water Act grant administered by the State of Idaho. Because of land constraints, this option was not considered in the development of updated remedial actions for Woodland Park. The 300-gpm pilot plant was projected to require an area of 15 acres, and scaling-up of the plant for higher flow rates is expected to be only slightly less than linear based on flow (i.e., a flow rate of 600 gpm would require nearly 30 acres). Therefore, treatment of any of the flow rates considered in this appendix (approximately 600 gpm or above) would not be feasible given the available land at the site (available acreage is uncertain but likely to be less than 30 acres, maybe far less). Other technical issues associated with the proposed system remain unresolved, such as how treatment solids would be managed, how effluent would be effectively discharged to Canyon Creek given the aquifer conditions, the potential to mobilize additional metal from the subsurface if infiltration ponds are used, and the ability to meet projected stream discharge standards.

The Canyon Creek Hydrologic Study (CH2M HILL, 2007a) focused on understanding groundwater-surface water interactions in Woodland Park. This study, conducted in the fall of 2006, provided data with which to update the conceptual site model (CSM) of the Woodland Park area of Canyon Creek and to build a groundwater flow model. The updated CSM and groundwater flow model are used in this appendix to evaluate groundwater collection, groundwater and surface water management, and source control actions. Stations monitored during the study are shown in Figure E-2.

In addition to the Canyon Creek Hydrologic Study, the Canyon Creek Groundwater Metal Source Characterization Study (Wright et al., 2007) contributed to an improved understanding of dissolved metals fate and transport in the Woodland Park area. This study documented three sets of experiments designed to improve the understanding of contaminant release mechanisms in Canyon Creek. The experiments included sequential extraction tests to determine the operational speciation of the metals in sediments; leaching tests to determine the rate of release of metals under various chemical conditions; and column leaching tests to provide insight into the time scales for removal of the metals from the sediments.

Following the Canyon Creek Hydrologic Study, Woodland Park Remedial Component Screening was conducted (CH2M HILL, 2007b), which drew on the results of all the aforementioned studies and identified and evaluated a range of remedial actions for Woodland Park. These actions include groundwater-based approaches (French drains, stream liners) and a variety of water treatment technologies, including the surface water treatment approach outlined in the Selected Remedy in the Interim ROD for OU 3.

The post-ROD remedial studies summarized above addressed the primary areas of uncertainty associated with the Selected Remedy for Woodland Park and have contributed to an evolution in thinking as to how water could be effectively collected and treated. The results of these evaluations have confirmed the hypothesis that a remedial approach incorporating groundwater collection and treatment is likely to be as equally effective as and less costly than approaches based on source control alone or surface water treatment.

These studies, combined with data obtained during ongoing monitoring programs, also provide a basis for the updating of remedial alternatives to directly address groundwater in the Woodland Park area. In addition, more accurate predictions of the dissolved metals load reduction potentially achieved by remedial actions can now be made using the numerical groundwater flow model. These data and the groundwater flow model were not available when the 2001 FS Report was being prepared.

Sections E.3 and E.4, respectively, present the updated Woodland Park components of Ecological Alternatives 3 and 4 in the 2001 FS Report that are incorporated into Alternatives 3+ and 4+ in this FFS Report, and describe the process by which the components were updated. Section E.5 summarizes the Woodland Park components of Alternatives 3+ and 4+.

E.3 Development of the Updated Woodland Park Components of Ecological Alternative 3

This section describes the process used to update the Woodland Park components of Ecological Alternative 3 in the 2001 FS Report (USEPA, 2001b) for the purpose of inclusion in Alternative 3+ in this FFS Report. The approach and methodology used to update these components are discussed in Sections E.3.1 and E.3.2, respectively.

E.3.1 Approach

A range of individual remedial actions were identified to address source sites and groundwater metals loading to Canyon Creek. Individual remedial actions in Ecological Alternative 3 in the 2001 FS Report were included for comparison with groundwater-based approaches, previously developed as part of the Woodland Park Remedial Component Screening (CH2M HILL, 2007b). After these individual remedial actions were identified and evaluated, the actions that provided the greatest reduction in dissolved zinc load at the lowest cost were assembled in different combinations to develop four options to be considered for updating the Woodland Park components of Ecological Alternative 3. These options are described in Section E.3.3 and evaluated in accordance with CERCLA criteria in Sections E.3.4 and E.3.5.

The evaluation of remedial options presented in this appendix is based on data collected under base-flow conditions: i.e., during the dry season (the late summer and fall) when Canyon Creek is at a low flow rate and groundwater plays its largest role in contaminant transport to surface water. Groundwater plays a dominant role during low flow periods in Woodland Park and other alluvial areas because recharge of groundwater makes up most of the creek flow during this period as there is very little surface runoff or snowmelt occurring. These data were collected in the fall of 2006 as part of the Canyon Creek Hydrologic Study (CH2M HILL, 2007a) and represent the most complete synoptic dataset collected from base-flow groundwater and surface water monitoring locations in Woodland Park. This is also the dataset upon which the numerical groundwater model for Canyon Creek is calibrated. The 2006 base-flow dataset corresponds to a flow tier of 15 percent. [2]

E.3.2 Methodology

The methods used to develop the remedial options for updating the Woodland Park components of Ecological Alternative 3 consisted of two steps: an initial screening phase, and the identification of remedial options for evaluation. The initial screening phase evaluated individual remedial actions throughout Woodland Park, and the identification of remedial options process developed four different packages of remedial actions to be considered for the updating of the Woodland Park components of Ecological Alternative 3. These packages of remedial options were then evaluated using CERCLA criteria.

The primary metals of concern in Canyon Creek surface water are zinc, cadmium, and lead. Zinc and cadmium are principally present in the dissolved form, whereas lead is present in Canyon Creek primarily in particulate form. Therefore, lead is an important parameter for sediment contamination but less of an issue for water quality. Zinc makes up greater than 95 percent of the dissolved metals load from the Canyon Creek drainage area, with the remaining 5 percent being primarily cadmium (CH2M HILL, 2007b). Therefore, the discussion and subsequent evaluation of metal loads and concentrations in this appendix focus on dissolved zinc as an indicator metal.

The primary regulatory drivers for cleanup comprise the State of Idaho site-specific ambient water quality criteria (AWQC), which are concentration-based, hardness-dependent, and represent the conditions necessary to support aquatic life. In this evaluation, the effectiveness of the remedial options is assessed in terms of post-remediation dissolved metals concentrations, loads, and AWQC ratios (defined as the post-remediation concentrations divided by the AWQC for a given hardness) under base-flow conditions.

E.3.2.1 Initial Screening Phase for Individual Remedial Actions

The initial screening phase included (1) identifying potential remedial actions, (2) developing screening-level costs, (3) conducting implementability analyses, and (4) evaluating remedial effectiveness and the ratio of cost to dissolved metals load reduction. These screening steps were completed independently for each individual remedial action.

Individual remedial actions from Ecological Alternatives 3 and 4 in the 2001 FS Report were included in the initial screening phase. Additional individual actions, including French drains for groundwater collection and stream liners to prevent groundwater-surface water interaction, were included based on favorable results obtained during the Woodland Park Remedial Component Screening (CH2M HILL, 2007b). Table E-2 lists the individual remedial actions for Woodland Park that were identified during the initial screening phase. WP-1 through WP-8 comprise general categories of remedial actions and, within most of these, specific actions are identified for particular source sites.

[2] Based on the historical dataset for daily average flow at the mouth of Canyon Creek (Station CC-288). A flow tier of 15 percent means that 85 percent of daily average flows during the year are greater than that flow.

For this evaluation, all collected groundwater was assumed to be treated at the Central Treatment Plant (CTP) in Kellogg, Idaho. The Remedial Component Screening report (CH2M HILL, 2007b) compared a variety of treatment options and processes for Woodland Park groundwater, including active surface water treatment, onsite passive groundwater treatment using SRBs, onsite active treatment using HDS, and centralized treatment using HDS at the CTP. Of the options evaluated, active treatment at the CTP was demonstrated to be the least costly option, in terms of both capital costs and operation and maintenance (O&M) costs, despite the relatively high cost associated with the conveyance pipeline that would be needed between Woodland Park and the CTP in Kellogg. In addition, treatment at the CTP was considered to be more effective and at least as implementable as the other options evaluated.

After the list of potential remedial actions was developed, each individual action was assigned a screening-level (order-of-magnitude) cost. Screening-level costs for actions included in the 2001 FS Report were developed using the TCD costs included in that report, escalated to 2009 dollars using the *Engineering News Record Construction Cost Index*. Cost estimates for individual actions not included in the 2001 FS Report were either based on costs from the Remedial Component Screening report (escalated to 2009 dollars), or unit costs were developed by a construction cost estimator. Attachment E-1 presents the detailed cost analyses for all of the individual remedial actions; the cost estimates are summarized in Table E-2.

Next, an implementability screening was conducted. Two individual remedial actions included in Ecological Alternative 3 in the 2001 FS Report, and discussed in Section E.2.2.1, were eliminated during the implementability screening, and are therefore not shown in Table E-2: (1) passive stream flow treatment in ponds at the mouth of Canyon Creek , and (2) passive treatment of a seep at source site WAL041. The reasons for the exclusion of these remedial actions were as follows:

- The passive stream flow treatment remedial action was eliminated because it would be very difficult to implement. It would have a very large footprint and would significantly affect the community of Woodland Park. Based on treatability testing conducted since the 2001 FS Report was completed (McCloskey, 2005, and Yancy, 2006), the effectiveness of the proposed treatment process (apatite) is also likely to be low. Other treatment processes with greater effectiveness and reliability could be applied, but many of the same implementability issues would remain, regardless of the process. This remedial action would treat the majority of the flow from Canyon Creek but would not remove any source materials, and would therefore probably need to be operated in perpetuity. Because water from all but the highest peak flows in Canyon Creek would be sent to the CTP, Canyon Creek would be dry between the surface water treatment inlet structure and the SFCDR. Therefore, native aquatic life could not return to the creek as long as the plant was operating. In addition, both the estimated costs for this action and the cost per pound removed are relatively high (see Table 5.1.-1 in *Draft Remedial Component Screening for the Woodland Park Area of Canyon Creek* [CH2M HILL, 2007b]).
- The passive treatment of a seep at WAL041 was eliminated because there are no known seeps located in the vicinity of that source site. It was determined that this source was identified by BLM as the result of surface water pooling in this area; therefore, passive

treatment would be virtually impossible to implement because the source location may move from season to season.

Following the initial screening for cost and implementability, the remedial effectiveness and cost per pound of metals load removed of the individual remedial actions were evaluated. This evaluation included estimating dissolved zinc load reduction values for each individual remedial action under base-flow conditions. For the source control actions that included excavation, capping, and re-grading/re-vegetation, the Simplified Tool for Predictive Analysis was used to estimate load reduction.

The Simplified Tool was developed in 2008 to provide a simplified version of the Predictive Analysis that was used in the RI/FS for the Coeur d'Alene Basin (USEPA, 2001a, 2001b).[3] The Simplified Tool allows for the evaluation of source sites and the potential benefits of specific remedial actions for smaller segments of a stream, as opposed to the aggregated source sites and remedial actions evaluated using the Predictive Analysis. The *Working Technical Memorandum: Overview of the Simplified Predictive Analysis for Estimating Post-Remediation Water Quality* (CH2M HILL, 2008) presents the details of how the Simplified Tool was developed. It was used to develop estimates of load reduction in the initial screening phase for individual remedial actions described above, and is based on water quality data collected in September 2006 as documented in the *Canyon Creek Hydrologic Study Report* (CH2M HILL, 2007a). Documentation of the Simplified Tool as applied to the September 2006 data is included in this appendix as Attachment E-2.

For the slurry wall, stream liner, and French drain remedial actions, the numerical groundwater model was used, based on the September 2006 dataset, to estimate the reduction in dissolved zinc loads. A detailed description of the methodology and tools used for groundwater modeling in Woodland Park is included in Appendix A (Groundwater Modeling Analysis) in the FFS Report. The screening-level costs, load reduction estimates, and cost-benefit values (in millions of dollars per pound per day of dissolved zinc load reduction) are presented in Table E-2.

E.3.2.2 Development of Remedial Options for the Woodland Park Components of Alternative 3+

Upon completion of the initial screening phase, the following steps were taken to develop and evaluate remedial options for Woodland Park, and to determine the Woodland Park components of the updated Ecological Alternative 3 (i.e., Alternative 3+ in this FFS Report):

1. Assemble remedial options based on preliminary screening results.
2. Predict the effectiveness (in terms of dissolved zinc load reduction) of each option.
3. Develop cost estimates for each remedial option.
4. Evaluate cost-benefit ratios (in terms of millions of dollars per pound per day ($M/lb/day) of dissolved zinc removed) for the remedial options.
5. Estimate the Simplified-Tool-predicted post-remediation surface water quality (in terms of AWQC ratio) following the implementation of each remedial option.

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[3] The original *Technical Memorandum: Probabilistic Analysis of Post-Remediation Metal Loading* was developed in 2001 (URS Greiner, 2001b). That document was subsequently revised in 2007 and issued under the title *Technical Memorandum: A Predictive Analysis for Post-Remediation Metal Loading* (URS, 2007).

6. Evaluate and compare the options using CERCLA threshold criteria and primary balancing criteria.
7. Determine the Woodland Park components of Alternative 3+.

First, individual remedial actions retained from the initial screening phase were combined to create a total of four remedial options to be considered for Alternative 3+. The goal of updating Ecological Alternative 3 was to combine source control actions with groundwater-based actions to reduce dissolved metals loading to Canyon Creek to the same degree (as Ecological Alternative 3) and at less cost than could be achieved with source control actions alone. Section E.3.3 provides detailed descriptions of all four remedial options for the Woodland Park components of Alternative 3+.

After completion of the cost-benefit analysis (summarized in Table E-2) during the initial screening phase, certain source control remedial actions were found to have a relatively low ratio of cost to dissolved metals load reduction. These actions included upland tailings excavation at source site WAL039, floodplain sediment excavation at source site WAL040, and floodplain artificial fill excavation at source site WAL081. These three source sites are located downstream from the SVNRT Repository and the locations of proposed groundwater-based remedial actions. The actions associated with these three source sites are included in each of the remedial options for the Woodland Park components of Alternative 3+.

Groundwater-based actions (WP-8 in Table E-2) would provide relatively high reductions in dissolved metals in surface water at relatively low cost, but would not provide protectiveness against the potential for direct contact of humans or ecological receptors with contaminated materials. Therefore, to improve the protectiveness of these remedial options while maintaining a relatively low cost, modified source control actions were developed for inclusion in these options. These source control actions are based on actions included in Ecological Alternative 3 in the 2001 FS Report, but include smaller volumes of materials for removal, assuming that only surface materials would be excavated to provide protectiveness against direct contact.

These actions include shallow excavation of floodplain sediments at source sites OSB047, WAL010, WAL011, and WAL041. Shallow source excavation would consist of excavation of contaminated materials to approximately 2 feet below ground surface (bgs) and placement of the excavated materials in the regional repository. The objective of the shallow source control actions would be to reduce surface contamination (to a depth of 2 feet bgs) in the identified areas to below 530 milligrams per kilogram (mg/kg) of lead, which is the ecological preliminary remediation goal (PRG). To avoid potential recontamination of remediated floodplain areas due to flooding and sediment deposition, the shallow source control actions would be implemented following the remediation of source sites upstream from Woodland Park. In addition, some waste disposal capacity remains for placement of material at the SVNRT Repository (WAL042), and it is expected that it would be used during implementation of excavation actions. Therefore, a native soil cap is included for approximately half of source area WAL042 to reduce the potential for erosion.

It should be noted that because the SVNRT Repository contributes significantly to the overall metals loading to Canyon Creek, a number of options have previously been considered to address loading from this source (CH2M HILL, 2007b). These options include excavation and disposal of repository contents, capping, hydraulic containment (including the installation of upgradient slurry walls to prevent the flow of groundwater through the SVNRT Repository, surface water drainage improvements, and collection of downstream groundwater. Of the options considered, collection of downstream groundwater was determined to be an effective means of load reduction that could be implemented at a substantially lower cost than other options evaluated. Therefore, a groundwater-based approach has been retained for this evaluation, along with the completion of the soil cover to address the direct contact pathway. The groundwater-based approach consists of a "toe-drain" to be installed on the downgradient edge of the SVNRT Repository. The toe-drain would be designed to capture the majority of contaminated groundwater emanating from the SVNRT Repository and convey it to the CTP in Kellogg.

The source control actions discussed above are summarized in Table E-3, and are included in each of the newly developed remedial options for Alternative 3+ that are described and evaluated in Sections E.3.3 and E.3.4, respectively.

Following development of the remedial options, the total expected dissolved zinc load reduction to Canyon Creek was estimated for each remedial option. The load reduction values were estimated using the numerical groundwater model, calibrated to the September 2006 dataset from the Canyon Creek Hydrologic Study. As noted in Section E.3.1, the September 2006 dataset is the most complete synoptic dataset that is currently available for Woodland Park. The methods used to develop load reduction estimates for each Woodland Park remedial option are described in Appendix A (Groundwater Modeling Analysis) in the FFS Report. Some individual remedial actions for upland tailings and adit drainage collection were not modeled because they do not involve a groundwater component. The upland tailings are located outside the floodplain and, in general, do not increase dissolved metals loads to the Woodland Park aquifer; rather, loading from these sources to Canyon Creek is likely through surface water flow (runoff). For these actions, the Simplified Tool was used to estimate load reduction. The predicted surface water quality at the mouth of Canyon Creek (Station A7 shown in Figure E-2) was calculated for each remedial option based on the estimated load reduction. Section E.3.4 further explains the methods used for calculating the expected dissolved zinc concentration following the implementation of the remedial actions.

Feasibility level cost estimates (–30% to +50%), based on the estimates for the individual remedial actions, were developed for each remedial option. The detailed costs were calculated using TCD unit costs included in Section 5.0 of the FFS Report. Attachment E-3 presents the detailed cost analyses for all the remedial options developed for the Woodland Park components of Alternative 3+.

A cost-benefit evaluation was completed to compare the cost per pound of dissolved zinc load reduction for each remedial option, and the predicted post-remediation concentrations and AWQC ratios were calculated for each option. The remedial options were then analyzed in detail (Section E.3.4) and compared with each other (Section E.3.5) using criteria required by CERCLA guidance, including effectiveness, implementability, and cost. Finally, a remedial option for Woodland Park was identified for inclusion in Alternative 3+ in this FFS Report (Section E.3.6).

E.3.3 Description of Remedial Options for the Woodland Park Components of Alternative 3+

The following sections describe each of the four Woodland Park remedial options developed for potential inclusion in the updated Ecological Alternative 3 (i.e., Alternative 3+ in this FFS Report). Tables E-4 through E-7 list the remedial actions included in Options A through D, respectively, and Table E-8 summarizes the key components of each remedial option.

E.3.3.1 Option A: Stream Liners and Source Control Actions

Option A consists of focused source control actions and lining of Canyon Creek to reduce dissolved metals loading to the creek. The source control actions were chosen based on the results of the initial screening process described in Section E.3.2.1. The same source control actions are included each of the four remedial options. Table E-4 lists and Figure E-3 depicts the remedial actions included in Option A. Source control actions for Option A would include excavation and disposal of upland tailings at source site WAL039, floodplain sediments at source site WAL041, and floodplain artificial fill at source site WAL081. Additional shallow source control actions, as described in Section E.3.2.2, would be included in Option A: shallow source removal at source sites OSB047, WAL010, WAL011, and WAL041. Materials excavated during these shallow source removal actions would be disposed of at a regional repository. The objective of the shallow source removal would be to reduce lead concentrations in surface soil to below 530 mg/kg, to a depth of 2 feet bgs, at the four source sites identified above. Shallow source control actions within the Canyon Creek floodplain would not be implemented until after remediation had occurred upstream from Woodland Park, to avoid potential recontamination during flood events. In addition, the SVNRT Repository (WAL042) would be used for placement of contaminated material during excavation activities, and a native soil cap would be placed to reduce the risk from direct contact by human and ecological receptors through erosion of the repository.

Option A focuses on stream liners without the installation of French drains. To prevent "floating" of the liners, it is only feasible to line losing sections of the creek. Liner "float" could occur if liners were installed in gaining sections of the stream and without French drains. Therefore, Option A only specifies stream liners in upper Woodland Park, an area previously identified as a losing reach (CH2M HILL, 2007a; see Figure E-3).

E.3.3.2 Option B: French Drains and Source Control Actions

Option B consists of focused source control actions (identical to those included in all options evaluated) and French drains placed along Canyon Creek to collect metals-contaminated groundwater that would be treated at the CTP. The objective of the shallow source removal would be to reduce lead concentrations in surface soil to below 530 mg/kg at the four source sites identified in Section E.3.2.2. Shallow source control actions within the Canyon Creek floodplain would not be implemented until after remediation had occurred upstream from Woodland Park, to avoid potential recontamination during flood events. Table E-5 lists and Figure E-4 depicts the remedial actions included in Option B.

French drains would be located along Canyon Creek based on the groundwater modeling results and dissolved metals loading data collected during the Canyon Creek Hydrologic Study (CH2M HILL, 2007a). Option B would include French drains from upper Woodland Park to source site WAL040 and a cutoff drain near the lower end of Woodland Park, perpendicular to groundwater flow, as shown in Figure E-4. A French drain would also be constructed around the downgradient edge (“toe”) of the SVNRT Repository (WAL042) to collect metals-contaminated groundwater. Water collected by the French drains would be conveyed to the CTP for treatment via a proposed pipeline designed to collect water from multiple source sites within Canyon Creek and the Upper Coeur d’Alene Basin.

E.3.3.3 Option C: Stream Liners, French Drains, and Source Control Actions

Option C consists of focused source control actions (identical to those included in all options evaluated), and a combination of stream liners and French drains placed along Canyon Creek to reduce dissolved metals loading to the creek and to collect metals-contaminated water that would be treated at the CTP. The layout of the liners and drains is based on the groundwater option identified during the Remedial Component Screening for Woodland Park (CH2M HILL, 2007b) that provided the greatest load reduction to Canyon Creek for the least cost. The objective of the shallow source removal would be to reduce lead concentrations in surface soil to below 530 mg/kg at the four source sites identified in Section E.3.2.2. Shallow source control actions within the Canyon Creek floodplain would not be implemented until after remediation had occurred upstream from Woodland Park, to avoid potential recontamination during flood events. Table E-6 lists and Figure E-5 depicts the remedial actions included in Option C.

The stream liners and French drains would be placed at locations that would maximize the effectiveness in reducing metals loading via groundwater sources to Canyon Creek. The French drains would be placed along Canyon Creek, beginning near the Hecla-Star Tailings Ponds (Station A2) and extending downstream to source site WAL040 (Station A6). A cutoff drain would also be placed on the north side of source site WAL040, and a French drain would also be constructed around the downgradient edge (“toe”) of the SVNRT Repository. Water collected by the French drains would be conveyed via pipeline to the CTP for treatment. Lining of Canyon Creek would occur from the Hecla-Star Tailings Ponds to immediately downstream from the SVNRT Repository.

E.3.3.4 Option D: Extensive Stream Liners/French Drains and Source Control Actions

Option D consists of focused source control actions (identical to those included in all options evaluated), and an extensive combination of stream liners and French drains placed along Canyon Creek to reduce dissolved metals loading to the creek and to collect metals-contaminated water that would be treated at the CTP. The objective of the shallow source removal would be to reduce lead concentrations in surface soil to below 530 mg/kg at the four source sites identified in Section E.3.2.2. Shallow source control actions within the Canyon Creek floodplain would not be implemented until after remediation had occurred upstream from Woodland Park, to avoid potential recontamination during flood events. Table E-7 lists and Figure E-6 depicts the remedial actions included in Option D.

The stream liners and French drains would be placed at locations that would maximize the effectiveness in reducing the total amount of metals loading via groundwater sources to Canyon Creek. The French drains would be placed along Canyon Creek from upper Woodland Park (Station A1) to source site WAL040 (Station A6). Two cutoff drains would be installed, one at upper Woodland Park upstream from the stream liner and another on the northern side of source site WAL040, at the downstream end of the main drain. The cutoff drain upstream from the stream liner would be used to collect relatively clean groundwater and discharge it to the lined stream. The cutoff drain at the downstream end of Woodland Park would be similar to that used in Options B and C. A French drain would also be placed at the downgradient edge ("toe") of the SVNRT Repository. The stream liners would run nearly the entire length of the Woodland Park reach, from stations A1 to A6 at the upper end of source site WAL040.

E.3.4 Evaluation of Remedial Options for the Woodland Park Components of Alternative 3+

This section presents an analysis of each remedial option developed for Woodland Park using evaluation criteria specified in CERCLA guidance (USEPA, 1988). This analysis considers the Woodland Park remedial options in isolation from other actions planned for upstream segments of Canyon Creek, and provides estimates of effectiveness immediately following implementation of the remedial options. The analysis does not address additional decreases in contaminant concentrations and loading that may take place through natural source depletion processes following completion of the remedial actions.

Each remedial option is analyzed using CERCLA threshold criteria and primary balancing criteria. The threshold criteria relate to the statutory requirements that each remedial option must satisfy in order to be eligible for selection; they consist of overall protection of human health and the environment, and compliance with applicable or relevant and appropriate requirements (ARARs). The primary balancing criteria are the technical criteria upon which the detailed analysis is primarily based. They consist of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The individual criteria are described below, and notes regarding the use of the criteria for this specific evaluation are provided where applicable. Section 7.3.1 of this FFS Report provides additional information about the evaluation criteria in general.

1. **Overall Protection of Human Health and the Environment.** This criterion assesses the potential for the remedial option to achieve and maintain protection of human health and the environment. With the exception of cost, this is a unified assessment of all the criteria evaluated. Protectiveness is the primary requirement that remedial actions must meet under CERCLA. The options are assessed to determine whether they could achieve and maintain adequate protection of human health and the environment from unacceptable risks posed by contaminants present at the site, in both the short and the long term. This criterion is also used to evaluate how current and potential risks would be eliminated, reduced, or controlled through excavation, treatment, and/or other remedial activities.

2. **Compliance with ARARs.** This criterion is used to determine whether the remedial option would comply with ARARs of federal and state public health and environmental laws other than CERCLA, or to provide justification for invoking a waiver. Section 4 of the FFS Report describes ARARs in general (chemical-, location-, and action-specific) and the specific ARARs identified for the Upper Coeur d'Alene Basin, including Canyon Creek. The evaluation in this appendix focuses on the surface water ARARs, which are the State of Idaho site-specific AWQC (Idaho Administrative Procedures Act [IDAPA] 58.01.02). The effectiveness of each remedial option in achieving compliance with

ARARs for soil, sediments, and groundwater is not within the scope of this evaluation. However, a qualitative discussion of expected improvements in contaminant levels in each of these media is provided. The AWQC for dissolved metals are calculated as a function of hardness. The AWQC ratio is the ratio of the dissolved metal concentration in surface water to the AWQC for that metal (based on hardness), effectively giving the number of times the dissolved metal concentration exceeds the AWQC. The AWQC ratio is also correlated to a set of previously defined “fishery tiers” for the Coeur d’Alene Basin (URS Greiner, 2001a) which relate to the health of the fishery. Table E-9 presents the definitions and AWQC ratio ranges for the fishery tiers. AWQC ratios were calculated based on the predicted dissolved zinc load reduction for each remedial option, and are summarized in Table E-10. The AWQC for dissolved zinc is estimated to be 0.108 milligram per liter (mg/L) based on a hardness concentration of 41 mg/L (the average at Station A7) in September 2006, which is the same dataset used for groundwater modeling and effectiveness projections.

3. **Long-Term Effectiveness and Permanence.** This criterion addresses the long-term effectiveness and permanence of the protection of human health and the environment that would be provided by the remedial option. The primary components of this criterion are the magnitude of residual risks remaining at a site after cleanup goals have been achieved, and the adequacy and reliability of actions or controls that might be required to maintain the effectiveness of the remedy over time.

4. **Reduction of Toxicity, Mobility, or Volume through Treatment.** This criterion addresses the anticipated performance of the remedial option in permanently and significantly reducing the toxicity, mobility, and/or volume of hazardous substances at the site through treatment. The NCP has established a statutory requirement that treatment be used to address the principal site contamination and associated risks wherever practicable.

5. **Short-Term Effectiveness.** The short-term effectiveness criterion addresses any adverse effects that may be posed to human health and/or the environment during construction and implementation until cleanup goals are met. In this evaluation, the cost per dissolved zinc load reduction (lb/day) is compared to the predicted surface water quality immediately following implementation of the remedial actions.

6. **Implementability.** This criterion is used to evaluate the remedial option based on technical challenges related to implementation and the degree of disruption the actions would have on the surrounding community. This criterion also addresses administrative feasibility and the availability of required services and materials during implementation of the actions.

7. **Cost.** This criterion evaluates the cost of implementing the remedial option. The estimated cost of a remedial option encompasses all engineering, construction, and O&M costs incurred over the life of the project. In accordance with CERCLA guidance, cost estimates for the remedial options were developed with an expected accuracy range of –30% to +50%. Estimated costs are presented in terms of total capital cost, annual average of O&M cost, 30-year net present value (NPV) O&M cost, and total cost (30-year NPV). Attachment E-3 presents the detailed cost analyses for all four remedial options, and Table E-11 summarizes the costs. Maximum flow rates were used to estimate capital costs, and

average flow rates were used to estimate O&M costs for water treatment at the CTP. The maximum flow is estimated to be approximately 30 percent greater than the base-flow condition; this is based on estimates of high-flow conditions from the numerical groundwater model. Costs for conveyance piping for treatment at the CTP in Kellogg are only included from the source area to the mouth of Canyon Creek in Wallace. The conveyance piping from Wallace to Kellogg is estimated to cost approximately $12 million in capital costs. It will be used to transport water to the CTP from many source sites throughout the Upper Basin and is not included as part of this analysis.

It should be noted that the cost estimates provided in this appendix have been prepared to assist the evaluation of remedial options using the information available at the time of preparation. The final remediation costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final remediation scope and schedule, and other variable factors. As a result, the final remediation costs will vary from the costs presented in this appendix.

E.3.4.1 Option A: Stream Liners and Source Control Actions

Option A includes remedial actions with a focus on lining sections of Canyon Creek in Woodland Park to reduce dissolved metals loading via groundwater to the creek.

Overall Protection of Human Health and the Environment

Option A includes limited source control actions to reduce the risk of direct exposure to contaminated media, and includes stream liners to reduce the metals load to Canyon Creek. These actions would reduce direct human and ecological exposures to contaminated media, but would not substantially reduce the amount of contaminated groundwater leaching into Canyon Creek and the ultimate dissolved metals load to the creek.

Option A would be expected to reduce the dissolved metals concentrations at the mouth of Canyon Creek to 17.7 times the AWQC following the implementation of remedial actions in Woodland Park.

There would be minimal disturbance to the community during the implementation of Option A. Additionally, while mitigation measures would be implemented during construction activities, minimal short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

In summary, Option A would provide relatively low protectiveness of human health and the environment and would not address a significant proportion of the total dissolved metals loading to Canyon Creek.

Compliance with ARARs

The expected concentration of dissolved zinc at the mouth of Canyon Creek following the implementation of Option A is 1.91 mg/L (Table E-10), which is 17.7 times the AWQC for dissolved zinc.

The remedial actions that comprise this option do not directly target groundwater, but removal of significant quantities of source materials at the surface is likely to result in a decrease in contaminant concentrations in groundwater over time. Concentrations in soil and sediments would also be reduced to levels below the respective PRGs in some areas, although remediation of all known soil and sediment contamination is not an objective of this remedial option or any of the remedial options evaluated for Woodland Park.

Long-Term Effectiveness and Permanence

This remedial option comprises limited source control actions and stream liners. The source control actions would have a high degree of permanence and long-term effectiveness. The stream liners would also have a high degree of permanence, assuming adequate O&M was performed, but would have relatively low long-term effectiveness due to minimal reduction of the dissolved metals load to Canyon Creek.

Reduction of Toxicity, Mobility, or Volume through Treatment

Option A includes stream liners, limited excavation, and shallow source control actions. Option A does not include treatment.

Short-Term Effectiveness

Following the installation of stream liners and the implementation of source control actions, the dissolved zinc load in Woodland Park is expected to decrease by 32 lb/day. Based on this load reduction, it is expected that the water quality at the mouth of Canyon Creek would have an AWQC ratio of 17.7 (Table E-10). Based on the expected AWQC ratio, the mouth of Canyon Creek would be assigned a fishery tier value of 1 following the implementation of Option A. Fishery Tier 1 is defined as having no resident fish population and only adult and juvenile salmonids that transit occasionally to reach other habitat (Table E-9). This would represent a minor improvement over the current fishery quality (Fishery Tier 0, no fish present) at the mouth of Canyon Creek.

Implementability

Option A is focused on lining sections of Canyon Creek without using French drains. It is only technically feasible to line a stream without French drains in losing reaches of the stream. If liners were placed in gaining reaches of Canyon Creek without French drains, the upward pressure of the groundwater surface could displace the liners. For this reason, Option A only includes liners placed in the losing reaches of Canyon Creek.

Shallow source control actions would not be implemented until after sites upstream from Woodland Park had been remediated, in order to prevent potential recontamination during flood events.

The administrative feasibility of this remedial option is relatively high. The services and materials required for implementation of Option A should be available within northern Idaho and eastern Washington.

Cost

Detailed costs for Option A are presented in Attachment E-3, and the costs are summarized in Table E-11. The total capital cost for Option A would be $11.7 million. O&M costs total $366,000 in 30-year NPV terms ($29,500 for an annual average). The total cost (30-year NPV) for Option A is $12.0 million.

The ratio of total 30-year NPV cost to lb/day of dissolved zinc load removed for Option A would be $0.38 million per lb/day (Table E-11).

E.3.4.2 Option B: French Drains and Source Control Actions

Option B includes remedial actions with a focus on installing French drains along Canyon Creek in Woodland Park to collect and treat metals-contaminated groundwater.

Overall Protection of Human Health and the Environment

Option B includes limited source control actions to reduce the risk of direct exposure to contaminated media, and the installation of French drains along Canyon Creek to reduce dissolved metals loading to the creek. These actions would reduce direct human and ecological exposures to contaminated media, and would substantially reduce the amount of contaminated groundwater leaching into Canyon Creek.

Option B is expected to reduce the dissolved metals concentrations at the mouth of Canyon Creek to 16.3 times the AWQC following the implementation of remedial actions in Woodland Park.

There would be substantial disturbance to the community during the implementation of Option B because French drains would be installed in nearly all of Woodland Park (Figure E-4). Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

Despite these implementability issues, Option B would provide relatively moderate protection of human health and the environment by reducing (a) the potential for direct contact with contaminated materials, and (b) dissolved metals loading to Canyon Creek. However, although Option B would reduce dissolved metals loading to the creek, it also would drastically reduce the total flow in the creek due to the high volume of groundwater requiring treatment at the CTP. Therefore, Option B would achieve minimal improvement in dissolved metals concentrations in Canyon Creek.

Compliance with ARARs

The expected concentration of dissolved zinc at the mouth of Canyon Creek following the implementation of Option B is 1.76 mg/L (Table E-10), which is 16.3 times the AWQC for dissolved zinc.

Although groundwater would be collected and treated as part of Option B, remediation of groundwater and attainment of groundwater PRGs are not objectives of this remedial option. Groundwater would be collected only as a means of reducing contaminant concentrations in surface water. Removal of significant quantities of source materials at the surface would probably result in a decrease in contaminant concentrations in groundwater over time. Concentrations in soil and sediments would also be reduced to levels below the respective PRGs in many areas, although remediation of all known soil and sediment contamination is not an objective of this remedial option or any of the options evaluated for Woodland Park.

Long-Term Effectiveness and Permanence

This remedial option comprises limited source control actions and groundwater collection in French drains. The source control actions would have a high degree of permanence and long-term effectiveness. The French drains would also have a high degree of permanence, assuming adequate O&M was performed, and would have moderately high long-term effectiveness due to the significant reduction of the dissolved metals load to Canyon Creek.

Reduction of Toxicity, Mobility, or Volume through Treatment

Option B includes French drains along Canyon Creek, limited excavation, and shallow source control. French drains would collect contaminated groundwater that would be conveyed via pipeline to the CTP for treatment. The treatment process at the CTP (HDS) would reduce the toxicity, mobility, and volume of hazardous substances in groundwater (and indirectly, in surface water) through precipitation of metals. Treatment residuals from the process would include precipitated-metals sludge that would require disposal.

Short-Term Effectiveness

Following the installation of French drains and the implementation of source control actions, the dissolved zinc load in Woodland Park is expected to decrease by 102 lb/day. Based on this load reduction, it is expected that the water quality at the mouth of Canyon Creek would have an AWQC ratio of 16.3 (Table E-10). Based on the expected AWQC ratio, the mouth of Canyon Creek would be assigned a fishery tier value of 1 following the implementation of Option B. Fishery Tier 1 is defined as having no resident fish population and only adult and juvenile salmonids that transit occasionally to reach other habitat (Table E-9). This would represent a minor improvement over the current fishery quality (Fishery Tier 0, no fish present) at the mouth of Canyon Creek.

Implementability

Under Option B, French drains would be installed along Canyon Creek, but stream liners would not be installed. This would result in a large amount of flow, estimated to be a maximum of 3,611 gpm, through the French drains and would increase the necessary treatment capacity at the CTP. Option B would also include extensive construction of French drains throughout Woodland Park and would have a moderate impact on the local community during construction. Implementability issues would also be associated with the proposed pipeline to the CTP. Administrative issues such as access agreements and right-of-way negotiations with multiple communities and/or private owners would need to be worked out prior to construction of the pipeline, and could pose a significant challenge to the implementation of Option B.

The services and materials needed to implement the remedial option should be available regionally. The machinery needed to install the French drains is probably not available within northern Idaho, but should be available for mobilization from either Washington or Oregon.

Shallow source control actions would not be implemented until after sites upstream from Woodland Park had been remediated, to prevent potential recontamination during flood events.

Cost

Detailed costs for Option B are presented in Attachment E-3, and the costs are summarized in Table E-11. The total capital cost for Option B would be $33.0 million. O&M costs total $1.01 million in 30-year NPV terms ($81,700 for an annual average). The total cost (30-year NPV) for Option B is $34.0 million.

The ratio of total 30-year NPV cost to lb/day of dissolved zinc load removed for Option B would be $0.33 million per lb/day (Table E-11).

E.3.4.3 Option C: Stream Liners, French Drains, and Source Control Actions

Option C comprises a combination of stream liners, French drains, and source control actions designed to maximize the reduction of dissolved metals loading via groundwater to Canyon Creek, and to minimize cost.

Overall Protection of Human Health and the Environment

Option C includes source control actions to reduce the risk of direct exposure to contaminated media, and a combination of stream liners and French drains installed along Canyon Creek to reduce metals loading from groundwater. These actions would reduce direct human and ecological exposures to contaminated media, and reduce dissolved metals loading in Canyon Creek by collecting and treating groundwater.

Option C is expected to reduce the dissolved metals concentrations at the mouth of Canyon Creek to 11.7 times the AWQC following the implementation of remedial actions in Woodland Park.

There would be substantial disturbance to the community during the implementation of Option C because stream liners and French drains would be installed throughout Woodland Park (Figure E-5). Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

Despite these implementation issues, Option C would provide a relatively high degree of protectiveness of human health and the environment, although construction activities may result in some short-term increases in contaminant concentrations in surface water.

Compliance with ARARs

The expected concentration of dissolved zinc at the mouth of Canyon Creek following the implementation of Option C is 1.26 mg/L (Table E-10), which is 11.7 times the AWQC for dissolved zinc.

Although groundwater would be collected and treated as part of Option C, remediation of groundwater and attainment of groundwater PRGs are not objectives of this remedial option. Groundwater would be collected only as a means of reducing contaminant concentrations in surface water. Removal of significant quantities of source materials at the surface would probably result in a decrease in contaminant concentrations in groundwater over time. Concentrations in soil and sediments would also be reduced to levels below the respective PRGs in many areas, although remediation of all known soil and sediment contamination is not an objective of this remedial option or any of the options evaluated for Woodland Park.

Long-Term Effectiveness and Permanence

Option C would have a moderately high degree of long-term effectiveness and permanence. The source control actions would be effective over the long term and permanent because the source materials would be physically removed from the watershed. If properly maintained, the liners and drains should continue to provide the same degree of load removal over the long term and therefore would have a relatively high degree of long-term effectiveness and permanence.

Reduction of Toxicity, Mobility, or Volume through Treatment

Option C includes French drains and liners along Canyon Creek, limited excavation, and shallow source control actions. French drains would collect groundwater that would be conveyed to the CTP for treatment. The treatment process at the CTP (HDS) would reduce the toxicity, mobility, and volume of hazardous substances in groundwater (and indirectly, in surface water) through precipitation of metals. Treatment residuals from the process would include precipitated-metals sludge that would require disposal.

Short-Term Effectiveness

Following the installation of stream liners and French drains and the implementation of source control actions, the dissolved zinc load in Woodland Park is expected to decrease by 87 lb/day. Based on this load reduction, it is expected that the water quality at the mouth of Canyon Creek would have an AWQC ratio of 11.7 (Table E-10). Based on the expected AWQC ratio, the mouth of Canyon Creek would be assigned a fishery tier value of 1 following the implementation of Option C. Fishery Tier 1 is defined as having no resident fish population and only adult and juvenile salmonids that transit occasionally to reach other habitat (Table E-9). This would represent a minor improvement over the current fishery quality (Fishery Tier 0, no fish present) at the mouth of Canyon Creek.

Implementability

Under Option C, French drains and stream liners would be installed along Canyon Creek. No major technical or administrative feasibility issues are associated with installing stream liners and French drains in this portion of Woodland Park. Although mitigation measures would be implemented, there could be moderate disturbance to the community during installation of the liners and drains. However, the disturbance would be limited to a focused area. Implementability issues would also be associated with the proposed pipeline to the CTP. Administrative issues such as access agreements and right-of-way negotiations with multiple communities and/or private owners would need to be worked out prior to construction of the pipeline, and could pose a significant challenge to the implementation of the remedial option.

The services and materials needed to implement the Option C should be available regionally. The machinery needed to install the French drains is probably not available within northern Idaho, but should be available for mobilization from either Washington or Oregon.

Shallow source control actions would not be implemented until after sites upstream of Woodland Park had been remediated, to prevent potential recontamination during flood events.

Cost

Detailed costs for Option C are presented in Attachment E-3, and the costs are summarized in Table E-11. The total capital cost for Option C would be $20.0 million. O&M costs total $1.29 million in 30-year NPV terms ($104,000 for an annual average). The total cost (30-year NPV) for Option C is $21.3 million.

The ratio of total 30-year NPV cost to lb/day of dissolved zinc load removed for Option C would be $0.24 million per lb/day (Table E-11).

E.3.4.4 Option D: Extensive Stream Liners/French Drains and Source Control Actions

Option D comprises an extensive combination of stream liners and French drains as well as source control actions designed to maximize the reduction of metals-contaminated groundwater to Canyon Creek.

Overall Protection of Human Health and the Environment

Option D includes source control actions to reduce the risk of direct exposure to contaminated media, and an extensive combination of stream liners and French drains installed along Canyon Creek to reduce dissolved metals loading from groundwater. These actions would reduce direct ecological exposures to contaminated media, and would collect and treat contaminated groundwater leaching into Canyon Creek.

Option D is expected to reduce the dissolved metals concentrations at the mouth of Canyon Creek to 7.4 times the AWQC following the implementation of remedial actions in Woodland Park.

There would be substantial disturbance to the community during the implementation of Option D because stream liners and French drains would be installed in most of Woodland Park (Figure E-6). Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

In summary, Option D would have a relatively high degree of protectiveness of human health and the environment following the implementation of remedial actions, although this remedial option may result in some short-term increases in contaminant concentrations in surface water.

Compliance with ARARs

The expected concentration of dissolved zinc at the mouth of Canyon Creek following the implementation of Option D is 0.80 mg/L (Table E-10), which is 7.4 times the AWQC for dissolved zinc.

Although groundwater would be collected and treated as part of Option D, remediation of groundwater and attainment of groundwater PRGs are not objectives of this remedial option. Groundwater would be collected only as a means of reducing contaminant concentrations in surface water. Removal of significant quantities of source materials at the surface would likely result in a decrease in contaminant concentrations in groundwater over time. Concentrations in soil and sediments would also be reduced to levels below the respective PRGs in many areas, although remediation of all known soil and sediment contamination is not an objective of this remedial option or any of the remedial options evaluated for Woodland Park.

Long-Term Effectiveness and Permanence

This remedial option would have a moderately high degree of long-term effectiveness and permanence. The source control actions would be effective over the long term and permanent because the source materials would be physically removed from the watershed. If properly maintained, the liners and drains should continue to provide the same degree of load removal over the long term, and therefore would have a relatively high degree of long-term effectiveness and permanence.

Reduction of Toxicity, Mobility, or Volume through Treatment

Option D includes the installation of French drains and stream liners along with the implementation of source control actions. Contaminated groundwater collected in the French drains would be treated at the CTP. The treatment process at the CTP (HDS) would reduce the toxicity, mobility, and volume of hazardous substances in groundwater (and indirectly, in surface water) through precipitation of metals. Treatment residuals from the process would include precipitated-metals sludge that would require disposal.

Short-Term Effectiveness

Following the construction of stream liners and French drains and the implementation of source control actions for Option D, the dissolved zinc load in Woodland Park is expected to decrease by 119 lb/day. Based on this load reduction, it is expected that the water quality at the mouth of Canyon Creek would have an AWQC ratio of 7.4 (Table E-10). Based on the expected AWQC ratio, the mouth of Canyon Creek would be assigned a fishery tier value of 2 following the implementation of Option D. Fishery Tier 2 includes the presence of native or introduced salmonids and generally low salmonid densities (Table E-9). This would represent an improvement over the current fishery quality (Fishery Tier 0, no fish present) at the mouth of Canyon Creek.

Implementability

Under Option D, an extensive network of stream liners and French drains would be installed along Canyon Creek. No major technical or administrative issues are associated with the installation of liners and French drains. The construction of these liners and drains would have an impact on the community because the construction activities would occur throughout Woodland Park. Implementability issues would also be associated with the proposed pipeline to the CTP. Administrative issues such as access agreements and right-of-way negotiations with multiple communities and/or private owners would need to be worked out prior to construction of the pipeline, and could pose a significant challenge to the implementation of Option D.

The services and materials needed to implement the remedial option should be available regionally. The machinery needed to install the French drains is probably not available within northern Idaho, but should be available for mobilization from either Washington or Oregon.

Shallow source control actions would not be implemented until after sites upstream of Woodland Park had been remediated, to prevent potential recontamination during flood events.

Cost

Detailed costs for Option D are presented in Attachment E-3, and the costs are summarized in Table E-11. The total capital cost for Option D would be $45.6 million. O&M costs total $1.62 million in 30-year NPV terms ($130,000 for an annual average). The total cost (30-year NPV) for Option D is $47.3 million.

The ratio of total 30-year NPV cost to lb/day of dissolved zinc load removed for Option D would be $0.40 million per lb/day (Table E-11).

E.3.5 Comparative Analysis of Remedial Options for the Woodland Park Components of Alternative 3+

Using the findings of the detailed analysis presented in Section E.3.4, this section compares the Woodland Park remedial options with one another. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each remedial option, and to determine the appropriate remedial actions to be included in the Woodland Park components of Alternative 3+. The following sections describe the results of the comparative analysis in terms of the seven CERCLA evaluation criteria, and Table E-12 summarizes the findings.

E.3.5.1 Overall Protection of Human Health and the Environment

This section summarizes the overall protection of human health and the environment that is expected to result from implementation of each of the remedial options. The options are discussed in descending order of protectiveness, from most protective to least protective.

Option D includes source control actions to reduce the risk of direct exposure to contaminated media, and an extensive combination of stream liners and French drains installed along Canyon Creek to reduce dissolved metals loading to the creek. These actions would reduce direct ecological exposures to contaminated media, and would collect and treat contaminated groundwater leaching into Canyon Creek. Following the implementation of Option D, the dissolved zinc concentration is predicted to be 7.4 times the AWQC, the lowest post-remediation AWQC ratio to be achieved by any of the remedial options.

There would be substantial disturbance to the community during the implementation of Option D because stream liners and French drains would be installed in nearly all of Woodland Park (Figure E-6). Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

Option D would provide a relatively high degree of protectiveness of human health and the environment due to the high overall load reduction and, of all the remedial options, the lowest post-remediation AWQC ratio in Canyon Creek following implementation.

In summary, Option D would achieve the highest degree of protectiveness of human health and the environment of any of the remedial options evaluated for Woodland Park because it would contain targeted source removal actions to protect against direct contact, and would provide the greatest improvement in surface water quality. The long-term protectiveness of Option D would be dependent on the completion of O&M activities.

Option C includes source control actions to reduce the risk of direct exposure to contaminated media, and a combination of stream liners and French drains installed along Canyon Creek to reduce dissolved metals loading from groundwater. These actions would reduce direct human and ecological exposures to contaminated media, and reduce dissolved metals loading in Canyon Creek by collecting and treating groundwater. Following the implementation of Option C, the dissolved zinc concentration is predicted to be 11.7 times the AWQC.

There would be substantial disturbance to the community during the implementation of Option C because stream liners and French drains would be installed throughout Woodland

Park (Figure E-5), although this disturbance would be to a lesser degree than would be incurred with Option D. Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance. Despite these implementation issues, however, Option C would provide a relatively high degree of protectiveness of human health and the environment. The long-term protectiveness of Option C would be dependent on the completion of O&M activities.

Option B includes source control actions to reduce the risk of direct exposure to contaminated media, and the installation of French drains along Canyon Creek to reduce dissolved metals loading to the creek. These actions would reduce direct human and ecological exposures to contaminated media, and would substantially reduce the amount of contaminated groundwater leaching into Canyon Creek and the dissolved metals concentrations in the creek. Following the implementation of Option B, the dissolved zinc concentration is predicted to be 16.3 times the AWQC.

There would be substantial disturbance to the community during the implementation of Option B because French drains would be installed in nearly all of Woodland Park (Figure E-4). Additionally, while mitigation measures would be implemented during construction activities, short-term impacts to Canyon Creek or the SFCDR could result from sediment and soil disturbance.

Despite these implementability issues, overall Option B would provide a relatively moderate degree of protectiveness of human health and the environment by significantly reducing (a) the potential for direct contact with contaminated materials, and (b) dissolved metals loading to Canyon Creek. However, although Option B would reduce dissolved metals loading to the creek, it would also drastically reduce the total flow in the creek due to the high volume of groundwater treated at the CTP. Therefore, Option B would achieve a minimal improvement in dissolved metals concentrations in the creek. The long-term protectiveness of Option B would be dependent on the completion of O&M activities.

Option A includes source control actions to reduce the risk of direct exposure to contaminated media, and stream liners along Canyon Creek to reduce dissolved metals loading to the creek. These actions would reduce direct human and ecological exposure to contaminated media, but would not substantially reduce the amount of contaminated groundwater leaching into Canyon Creek and the dissolved metals concentrations in the creek. Following the implementation of Option A, the dissolved zinc concentration is predicted to be 17.7 times the AWQC.

There would be minimal disturbance to the community during the implementation of Option A and, while mitigation measures would be implemented during construction activities, minimal short-term impacts to Canyon Creek or the SFCDR would result from sediment and soil disturbance.

Of all the remedial options, Option A would be the least protective of human health and the environment because it would not address a significant proportion of the total dissolved metals loading to Canyon Creek. The long-term protectiveness of Option A would be dependent on the completion of O&M activities.

In summary, Option D would achieve the highest degree of overall protection of human health and the environment, followed by Options C, B, and A in descending order.

E.3.5.2 Compliance with ARARs

This evaluation shows that none of the Woodland Park remedial options alone would meet surface water ARARs for the Coeur d'Alene Basin immediately following the completion of remedial actions. Additional actions, as proposed in Ecological Alternatives 3 and 4 in the 2001 FS Report, would be needed in Canyon Creek upstream from Woodland Park to further improve surface water quality and eventually meet ARARs.

Table E-10 presents the predicted post-remediation concentrations at the mouth of Canyon Creek after implementation of each of the remedial options for Woodland Park. Option D (with an AWQC ratio of 7.4) would result in the lowest dissolved metals concentrations at the mouth of Canyon Creek, based on analysis of the predicted concentrations following implementation of the remedial actions for each remedial option. Option C would reduce dissolved metals loading substantially, but the AWQC ratio (11.7) would remain relatively high following remedial actions. Options A and B are estimated to have the highest post-remediation AWQC ratios of 17.7 and 16.3, respectively.

In summary, Option D would make the greatest strides towards achieving ARARs in surface water in Canyon Creek. Option C would make a moderate degree of progress towards the achievement of ARARs, while Options A and B would make relatively little progress.

E.3.5.3 Long-Term Effectiveness and Permanence

Option D would have the highest degree of long-term effectiveness and permanence because it would reduce metals concentrations the most. Options C and D would also have relatively high degrees of long-term effectiveness and permanence, but would remove less contaminated material than Option D. Option A, which relies solely on stream liners, would have slightly less long-term effectiveness and permanence than the other options due to the issues associated with installing liners without drains. While groundwater collection and treatment could also be a permanent solution as long as adequate O&M of systems was performed, the dynamics of the groundwater-surface water interaction could change over the life of the remedy, potentially leading to decreased effectiveness of the remedial options evaluated.

E.3.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The mobility, volume, and toxicity of dissolved metals would be reduced during the treatment of contaminated groundwater at the CTP. Options B, C, and D include some amount of treatment of contaminated water at the CTP, and therefore would reduce the mobility, toxicity, and volume of the dissolved metals at Woodland Park.

Option B would treat the highest volume of contaminated water of all the alternatives, and would achieve the greatest reduction in the toxicity, mobility, and volume of dissolved metals. Options C and D would treat relatively similar amounts of contaminated groundwater at the CTP. Option A does not include treatment. In summary, Option B would achieve the greatest reduction in the toxicity, mobility, and volume of contaminants, followed in descending order by Options D, C, and A.

E.3.5.5 Short-Term Effectiveness

The short-term effectiveness of each remedial option was evaluated based on the estimated AWQC ratio upon completion of remedial actions and the impact on the fishery at the mouth of Canyon Creek. The values associated with the AWQC ratio and the ratio of cost to dissolved metals load reduction for each option are included in Table E-10. In general, the projected short-term effectiveness is very similar to the projected long-term effectiveness of the options evaluated, assuming adequate O&M was performed. All of the remedial options would improve the existing AWQC ratio of 21.8 times the AWQC for dissolved zinc.

The projected post-remediation fishery tier (Table E-9) is based on the predicted AWQC ratio at the mouth of Canyon Creek calculated for each alternative. The fishery tiers define the health of the fishery and are ranked from 0 to 5, with Tier 0 defined as no fish present and Tier 5 indicating a healthy fishery. Options C and D would substantially improve the health of the fishery. Option D would have an estimated AWQC ratio of 7.4. The threshold for Fishery Tier 2 is an AWQC ratio between 7 and 10; therefore, Option D would probably result in the mouth of Canyon Creek as being in Fishery Tier 2. This would be the greatest short-term improvement in fishery quality achieved by any of the remedial options. Option C would have an estimated AWQC ratio of 11.7, which is in the range of Fishery Tier 1. Options A and B would have estimated AWQC ratios of 17.7 and 16.3 respectively, following remediation, which would also result in Fishery Tier 1. This would be a slight improvement in fishery quality, but it would take a very long time for natural source depletion to bring appreciable improvements in fish populations within Woodland Park.

In summary, Option D would be the most beneficial remedial option for the short-term health of the fish population at the mouth of Canyon Creek. Option C would provide a moderate improvement, and Options A and B would only provide slight improvement.

E.3.5.6 Implementability

This section analyzes the implementability of the remedial options in terms of both technical and administrative feasibility, availability of services and materials, and potential impacts to the human and ecological community in Woodland Park. The remedial options are discussed in descending order of implementability, starting with the most implementable option and ending with the least.

Option C would be most implementable remedial option because it is technically feasible and because the implementation of the Option C actions would be the least disruptive to the Woodland Park community. The liners and drains should be technically feasible to construct. The installation of liners and drains would be optimized to a relatively short reach of Canyon Creek, which would limit the impacts to the community as well as to Canyon Creek or the SFCDR during construction. Administrative feasibility issues would still be associated with the proposed pipeline to the CTP (requiring access agreements and right-of-way negotiations to be worked out with multiple communities and/or private owners prior to construction). Services and machinery needed to install the French drains would probably need to be mobilized from either Washington or Oregon. Shallow source control actions would be implemented after remedial actions had been completed upstream from Woodland Park, to avoid potential recontamination during flood events.

The implementability of Options B and D would be, for the most part, equal. Both of these alternatives would disrupt approximately the same amount of area during construction activities. Option D includes stream liners, which could have a slightly higher impact on Canyon Creek or the SFCDR during construction than Option B, which only includes French drains. Both alternatives include extensive construction activities throughout Woodland Park and would impact the local community. As with Option A, administrative feasibility issues would also be associated with the proposed pipeline to the CTP (requiring access agreements and right-of-way negotiations to be worked out with multiple communities and/or private owners prior to construction); services and machinery needed to install the French drains would probably need to be mobilized from either Washington or Oregon; and shallow source control actions would be implemented after remedial actions had been completed upstream from Woodland Park, to avoid potential recontamination during flood events.

Option A would have relatively fewer impacts on the local community, but there are technical implementability issues with installing stream liners without French drains. These liners can only be installed in losing reaches of a stream. The locations of the liners where it is feasible to locate them and problems encountered during installation could significantly affect the effectiveness of Option A. As with the other remedial options, shallow source control actions would be implemented after remedial actions had been completed upstream from Woodland Park, to avoid potential recontamination during flood events.

In summary, Option C would be the most implementable alternative, followed by Options D, B, and A in descending order.

E.3.5.7 Cost

This section discusses the costs of the remedial options, starting from lowest-cost option and ending with the highest-cost option. Detailed cost analyses for all of the remedial options are presented in Attachment E-3, and the costs are summarized in Table E-11.

The lowest total estimated cost would be for Option A, with an estimated total cost (30-year NPV) of $12.0 million. Since this option does not include water treatment, the O&M costs are relatively low, while capital costs are low because of the limited reach of Canyon Creek that could be lined without French drains.

The next lowest cost would be for Option C, with an estimated total cost (30-year NPV) of $21.3 million. This remedial option has a moderate cost because the chosen remedial actions are limited to lower-cost actions, and they target the most contaminated areas of Canyon Creek. Moderate O&M costs are associated with Option C because groundwater would be collected by French drains and treated at the CTP.

Option B has an estimated total cost (30-year NPV) of $34.0 million. The O&M costs for Option B are higher than those for the other options because of the high volumes of water that would be collected by French drains (without liners) and treated at the CTP.

Option D has an estimated total cost (30-year NPV) of $47.3 million. There would be a relatively high capital cost associated with Option D because of the greater lengths of stream liners and French drains that would be installed. The O&M costs are relatively high because of the amount of groundwater that would treated at the CTP.

Option A has the lowest estimated annual average O&M cost of $29,500 because, as noted above, no groundwater would be treated under this option. Alternatives B, C, and D have estimated annual average O&M costs of $81,700, $104,000, and $130,000, respectively.

The ratio of the total estimated 30-year NPV cost to the estimated load reduction for each option is included in Table E-11. Option C would have the lowest cost per load reduction, followed by Options A, B, and D in ascending order.

Option C would have the lowest ratio of estimated cost to estimated load reduction because the stream liners and French drains would be designed for installation at locations that would be most effective in preventing contaminated groundwater from entering Canyon Creek. Options B and D would both be very expensive, but would also provide a high degree of load reduction. Option A would be inexpensive by comparison, but would not significantly reduce dissolved metals loading to Canyon Creek.

E.3.6 Summary of the Woodland Park Components of Alternative 3+

Based on the evaluation of remedial options presented in Sections E.3.4 and E.3.5, using CERCLA criteria, the actions in Option C would achieve the best balance of trade-offs for a cleanup approach, and therefore comprise the Woodland Park components of Alternative 3+. Option C would maximize the load reduction for the cost by focusing on the collection of contaminated groundwater where the most potential exists for metals loading to Canyon Creek. The implementation of the Option C remedial actions would have a relatively smaller impact on the Woodland Park community compared to the other remedial options. Table E-6 lists and Figure E-5 depicts the remedial actions included in Option C. The Woodland Park components of Alternative 3+ include focused source control actions, a partial soil cap for the SVNRT Repository, creek lining, French drains, and water treatment at the CTP.

E.4 Development of the Updated Woodland Park Components of Ecological Alternative 4

As discussed in Section E.2.2.2, Ecological Alternative 4 in the 2001 FS Report (USEPA, 2001b) focused on excavation and disposal of contaminated materials and involves water treatment only for adit discharges, not for groundwater or surface water. Alternative 4 was designed in this manner because most source materials currently contributing to elevated metals concentrations in surface and groundwater would be removed, thereby eliminating the need to collect and treat these waters. The 2001 FS Report refers to Ecological Alternative 4 as “Maximum Removal, Disposal, and Treatment”.

The post-ROD studies in Canyon Creek have focused on identifying effective, implementable, and economical options to reduce the dissolved metals load in Canyon Creek and the SFCDR through either groundwater or surface water treatment. This information applies directly to the development of remedial components for Alternative 3+ in this FFS Report, but much less so to the development of remedial components for Alternative 4+.

Alternative 4+ was developed for the FFS to focus on source control actions similar to Ecological Alternative 4 in the 2001 FS Report. Areas of uncertainty associated with Ecological Alternative 4 primarily included the delineation of contaminated materials and subsequent areas and volumes assumed for remedial actions. Further analysis of these areas of uncertainty would be left to the Remedial Design phase. On this basis, the only change that has been made to the Woodland Park components of Ecological Alternative 4 is related to the water treatment technology identified for the single adit discharge receiving treatment, i.e., the Canyon Silver (Formosa) Mine adit discharge. Rather than the passive treatment identified in Ecological Alternative 4, this adit discharge would be connected to the conveyance pipeline to the CTP for treatment under Alternative 4+. This conveyance pipeline would extend beyond Woodland Park, servicing adit discharges in upstream areas. Since the pipeline would already be located in Woodland Park, the least costly treatment option for the Canyon Silver Mine adit discharge would be connection to the conveyance pipeline and water treatment at the CTP.

E.5 Summary of the Woodland Park Components of Alternatives 3+ and 4+

As described above, the Woodland Park components of Alternative 3+ are based on remedial Option C, which includes focused source control actions, a partial soil cap for the SVNRT Repository, creek lining, French drains, and water treatment at the CTP. Table E-6 lists and Figure E-5 depicts the remedial actions included in Option C.

Alternative 4+ actions would be equivalent to the actions for Ecological Alternative 4 that were identified in the 2001 FS Report (USEPA, 2001b), with the exception of the water treatment TCD. The Canyon Silver (Formosa) Mine adit discharge would receive treatment under Alternative 4+ and, rather than the passive treatment identified in Ecological Alternative 4, this adit discharge would be connected to the conveyance pipeline to the CTP for treatment under Alternative 4+. This conveyance pipeline would extend beyond Woodland Park, servicing adit discharges in upstream areas. Since the pipeline would already be located in Woodland Park, the least costly treatment option for the Canyon Silver Mine adit discharge would be connection to the conveyance pipeline and water treatment at the CTP. A list of Ecological Alternative 4 actions is provided in Table E-1 and, in addition to the adit discharge treatment described above, includes extensive excavation throughout Woodland Park and disposal at the Regional Repository, and regrading and revegetation of upland waste rock.

E.6 References

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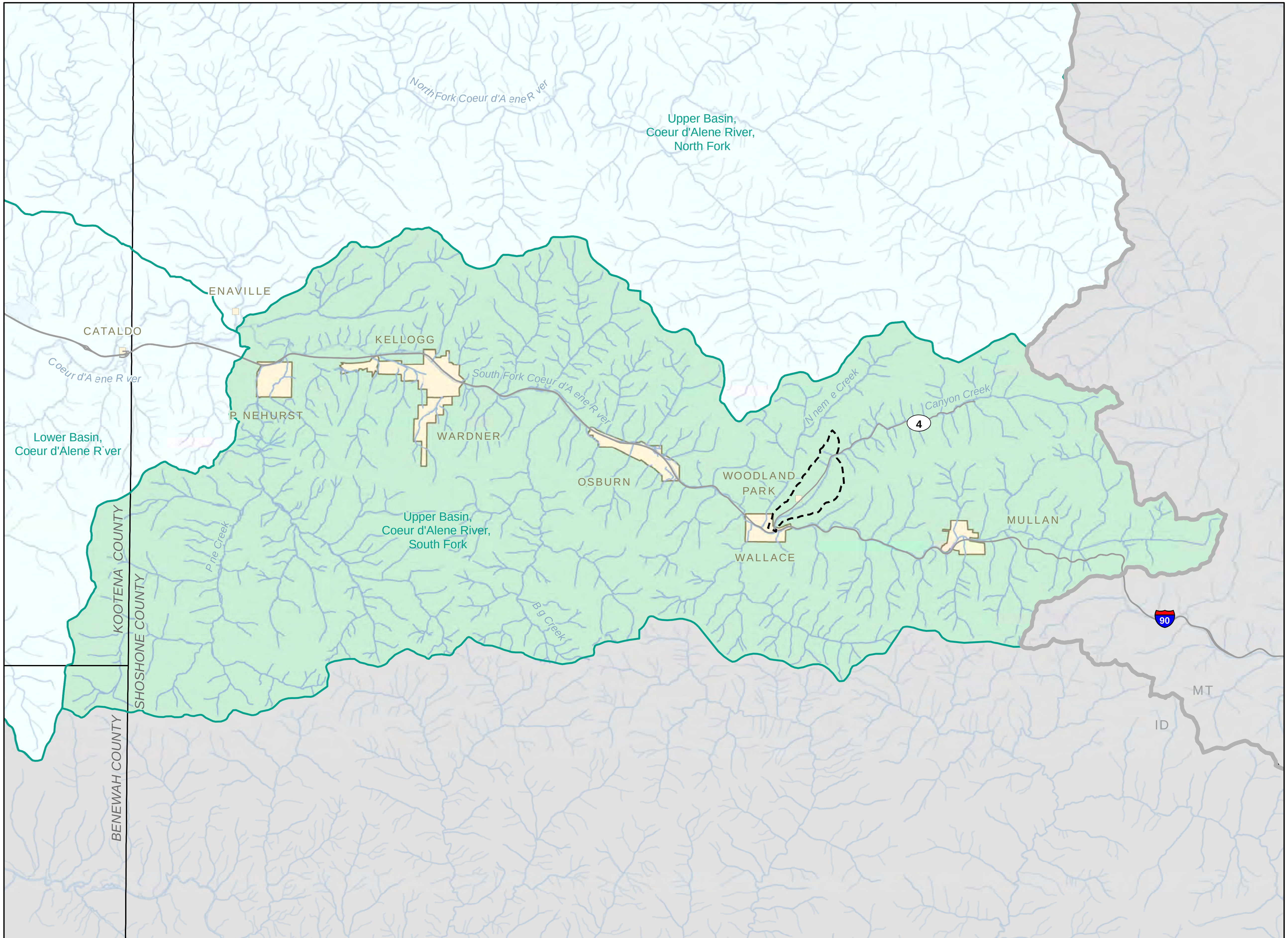
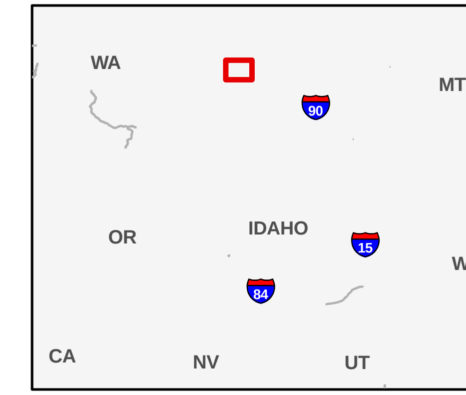
Figures





River/Creek
Woodland Park Study Area
Coeur d'Alene River Subbasin Boundary
Focused Feasibility Study Area
City Limit
County Boundary
State Boundary

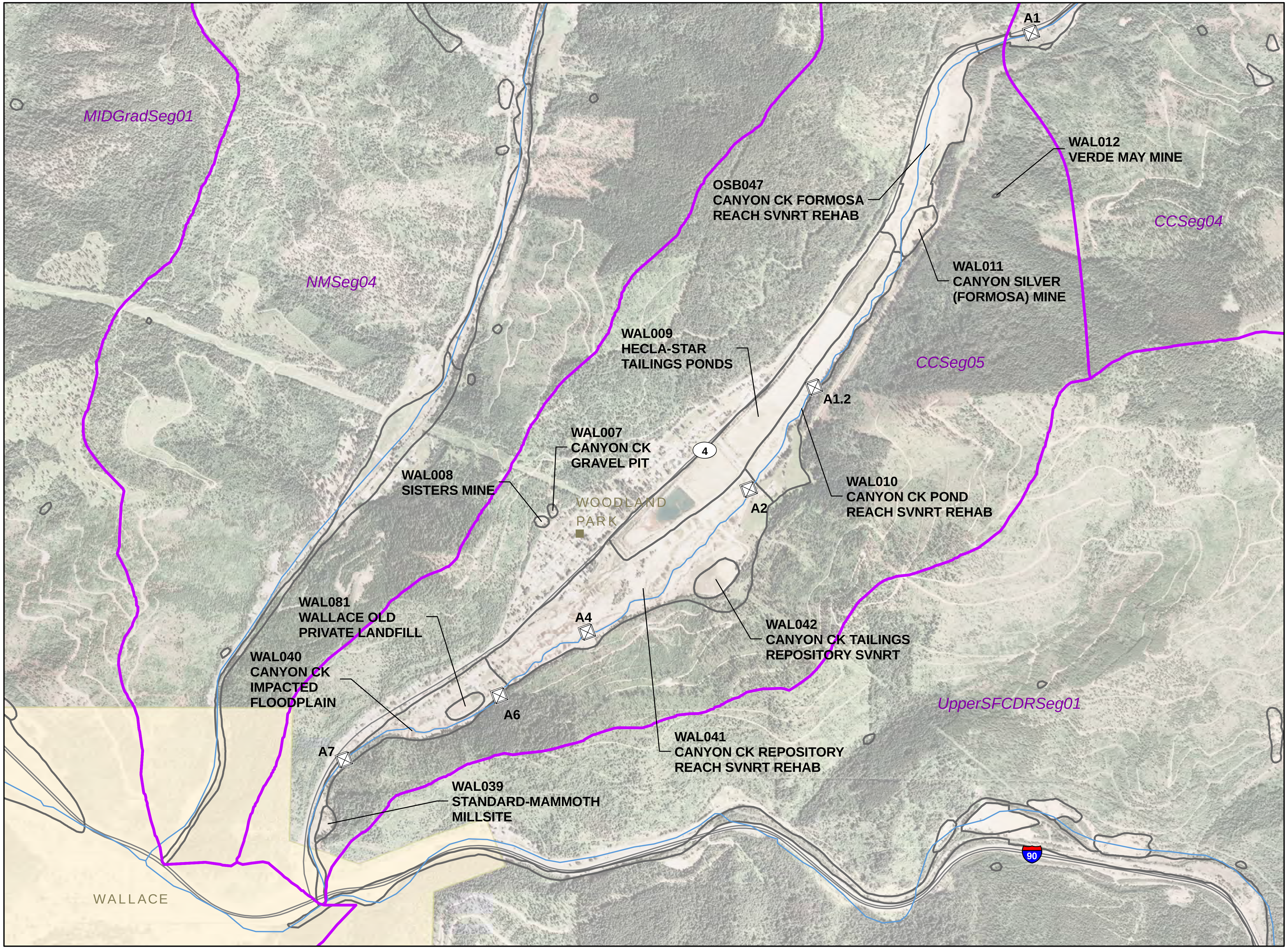
N

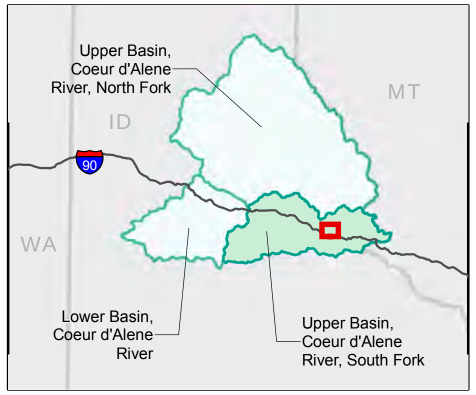
0 1 2 4 Miles

Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Figure E-1
Site Location Map
Updated Woodland Park Components
of Ecological Alternatives 3 and 4
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA





2006 Hydrologic Study Monitoring Station

River/Creek

Watershed Segment[2]

Site

WAL012 (Site ID)
VERDE MAY MINE (Site Name[1])

City Limit

N

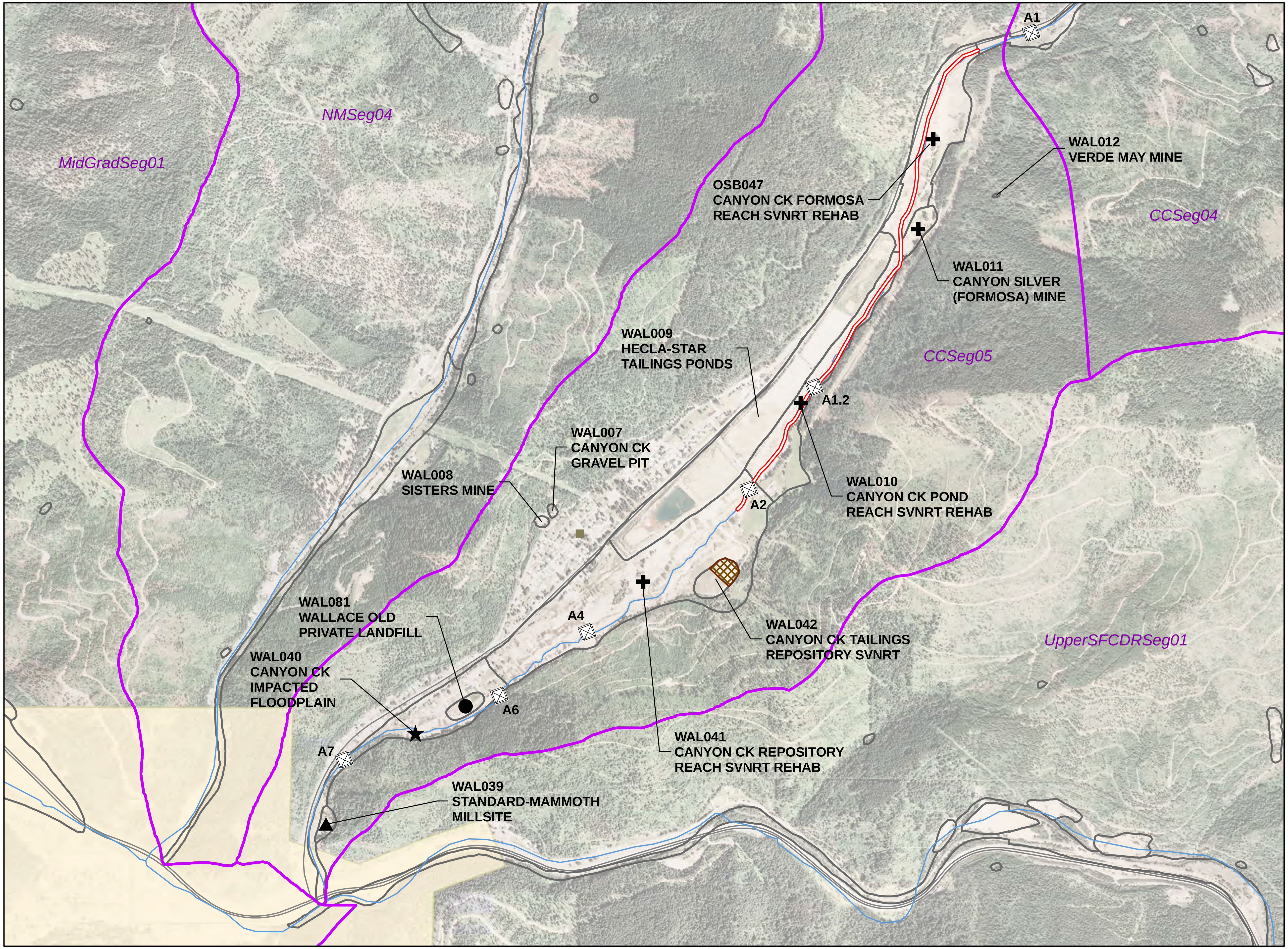
0 500 1,000 2,000 Feet

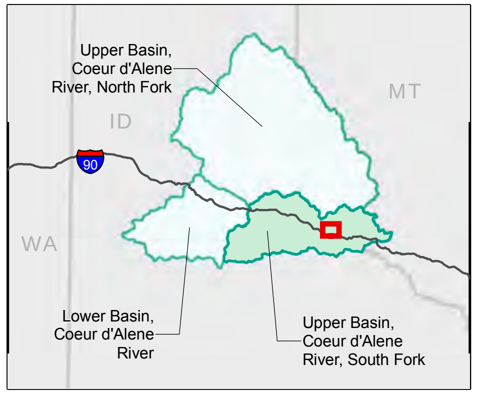
Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Notes:
1. The source IDs and names are based on the inventory of source sites conducted by the Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (U.S. Environmental Protection Agency [USEPA], 2001a, 2001b).
2. **CCSeg05** = Segment within the Upper Watershed of the Coeur d'Alene River Basin, designated as such to focus the 1997-2001 Remedial Investigation U.S. Environmental Protection Agency (USEPA, 2001a).

Figure E-2
Woodland Park Site Map
Updated Woodland Park Components of Ecological Alternatives 3 and 4
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA





2006 Hydrologic Study Monitoring Station

Source Control Actions:

- Excavate Floodplain Artificial Fill
- Excavate Floodplain Sediments
- Excavate Upland Tailings
- Shallow Source Control

WAL012 (Site ID)
VERDE MAY MINE (Site Name[1])

- River/Creek
- Stream Liner
- Native Soil Cap
- Watershed Segment[2]
- Site
- City Limit

N

0 500 1,000 2,000 Feet

Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Notes:
1. The source IDs and names are based on the inventory of source sites conducted by the Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (U.S. Environmental Protection Agency [USEPA], 2001a, 2001b).
2. **CCSeg05** = Segment within the Upper Watershed of the Coeur d'Alene River Basin, designated as such to focus the 1997-2001 Remedial Investigation U.S. Environmental Protection Agency (USEPA, 2001a).

Figure E-3
Option A:
Stream Liners and Source Control Actions
Updated Woodland Park Components of Ecological Alternatives 3 and 4
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

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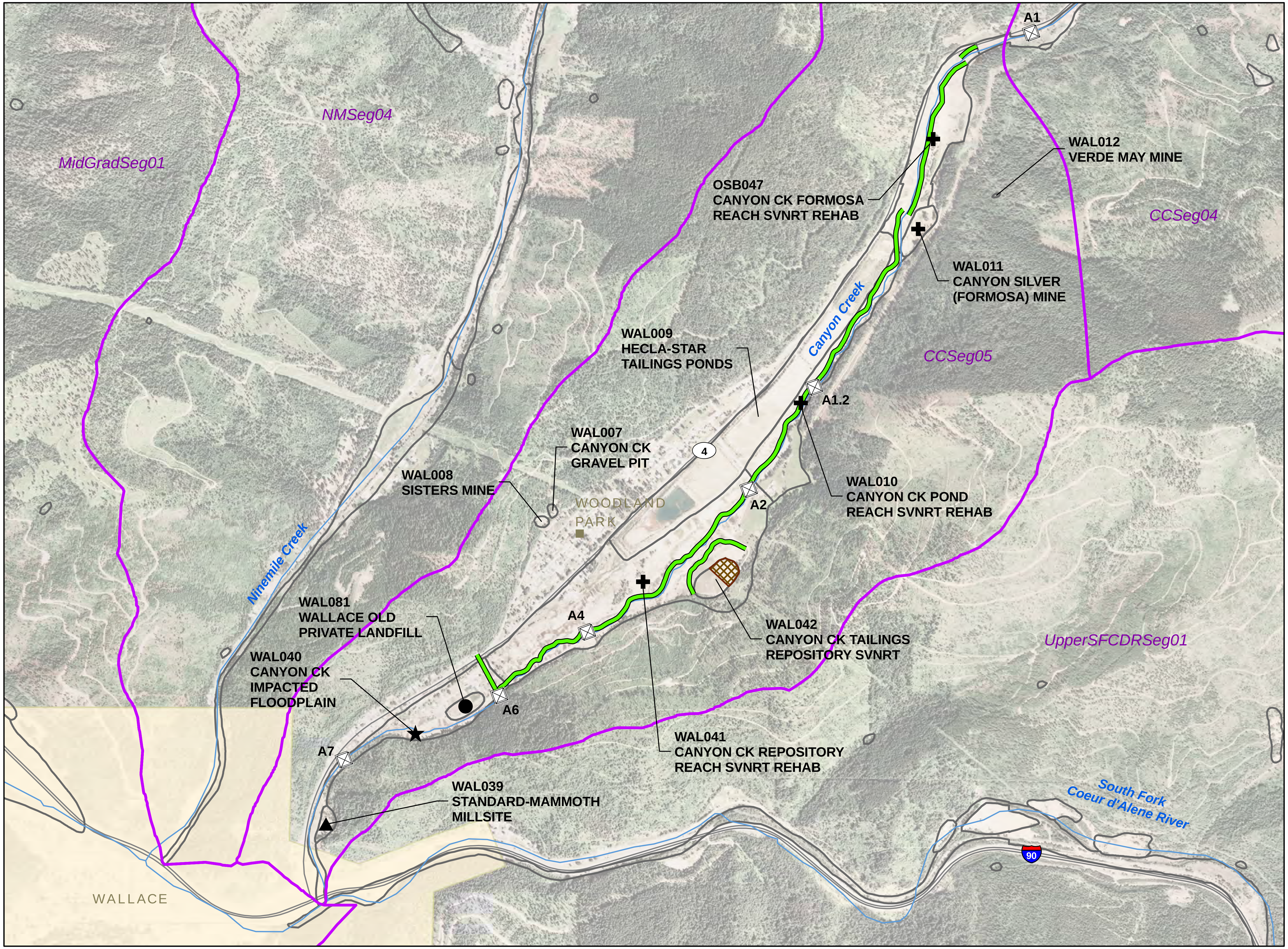
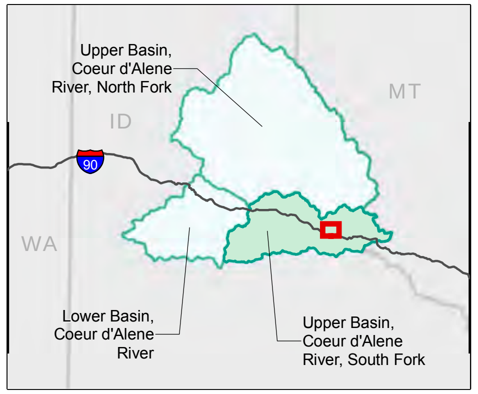




2006 Hydrologic Study Monitoring Station

Source Control Actions:

- Excavate Floodplain Artificial Fill
- Excavate Floodplain Sediments
- Excavate Upland Tailings
- Shallow Source Control

WAL012 (Site ID)
VERDE MAY MINE (Site Name[1])

- River/Creek
- French Drain
- Native Soil Cap
- Watershed Segment[2]
- Site
- City Limit

N

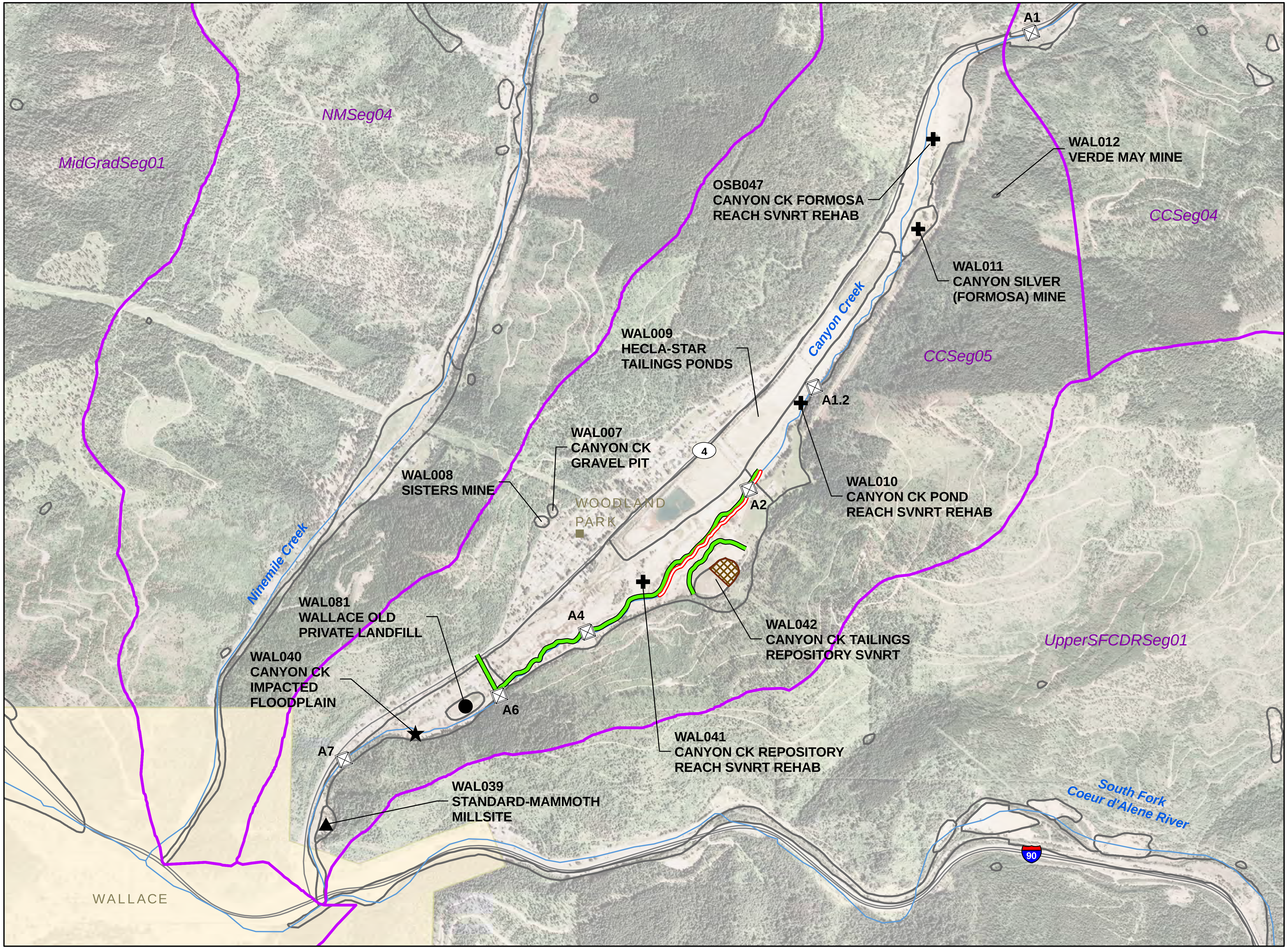
0 500 1,000 2,000 Feet

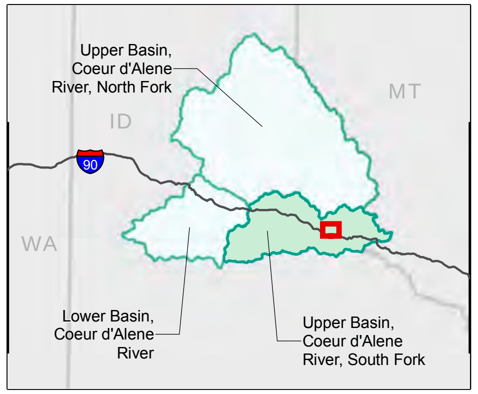
Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Notes:
1. The source IDs and names are based on the inventory of source sites conducted by the Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (U.S. Environmental Protection Agency [USEPA], 2001a, 2001b).
2. **CCSeg05** = Segment within the Upper Watershed of the Coeur d'Alene River Basin, designated as such to focus the 1997-2001 Remedial Investigation U.S. Environmental Protection Agency (USEPA, 2001a).

Figure E-4
Option B:
French Drains and Source Control Actions
Updated Woodland Park Components of Ecological Alternatives 3 and 4
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA





2006 Hydrologic Study Monitoring Station

Source Control Actions:

- Excavate Floodplain Artificial Fill
- Excavate Floodplain Sediments
- Excavate Upland Tailings
- Shallow Source Control

WAL012 (Site ID)
VERDE MAY MINE (Site Name[1])

- River/Creek
- French Drain
- Stream Liner
- Native Soil Cap
- Watershed Segment[2]
- Site
- City Limit

N

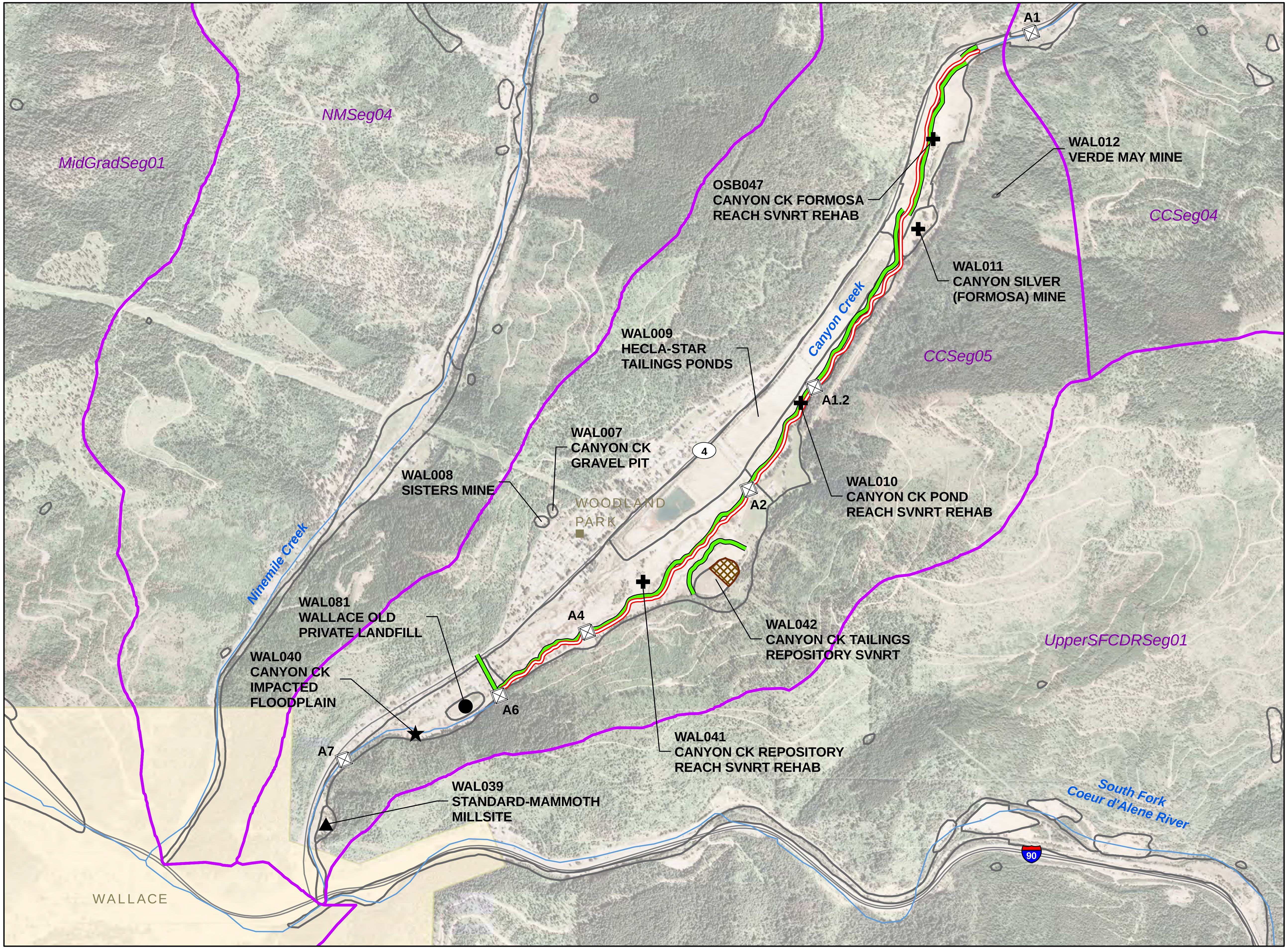
0 500 1,000 2,000 Feet

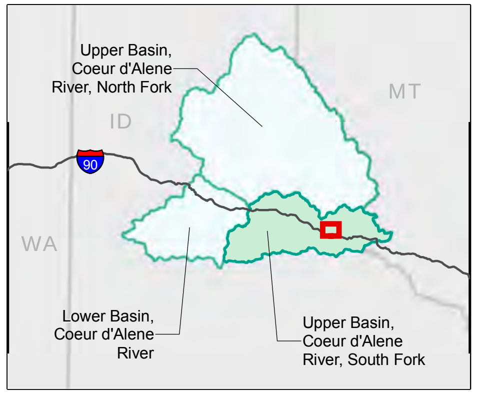
Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Notes:
1. The source IDs and names are based on the inventory of source sites conducted by the Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (U.S. Environmental Protection Agency [USEPA], 2001a, 2001b).
2. **CCSeg05** = Segment within the Upper Watershed of the Coeur d'Alene River Basin, designated as such to focus the 1997-2001 Remedial Investigation U.S. Environmental Protection Agency (USEPA, 2001a).

Figure E-5
Option C:
Stream Liners, French Drains, and Source Control Actions
Updated Woodland Park Components of Ecological Alternatives 3 and 4
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA





2006 Hydrologic Study Monitoring Station

Source Control Actions:

- Excavate Floodplain Artificial Fill
- Excavate Floodplain Sediments
- Excavate Upland Tailings
- Shallow Source Control
- **WAL012** (Site ID) **VERDE MAY MINE** (Site Name[1])
- River/Creek
- French Drain
- Stream Liner
- Native Soil Cap
- Watershed Segment[2]
- Site
- City Limit

N

0 500 1,000 2,000 Feet

Base Map Data:
NHDPlus (Hydrography, 2005);
ESRI (Roads, Jurisdictional Boundaries, 2006).

Notes:
1. The source IDs and names are based on the inventory of source sites conducted by the Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (U.S. Environmental Protection Agency [USEPA], 2001a, 2001b).
2. **CCSeg05** = Segment within the Upper Watershed of the Coeur d'Alene River Basin, designated as such to focus the 1997-2001 Remedial Investigation U.S. Environmental Protection Agency (USEPA), 2001a).

Figure E-6
Option D:
Extensive Stream Liners/ French Drains and Source Control Actions
Updated Woodland Park Components of Ecological Alternatives 3 and 4 Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

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Tables

TABLE E-1

2001 FS Report: Proposed Remedial Actions for Ecological Alternatives 3 and 4

Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Source Site	Source Site Name	Waste Type	Alternative 3	Alt. 3 TCD	Alternative 4	Alt. 4 TCD
OSB047	CANYON CK FORMOSA REACH SVNRT REHAB	Floodplain Sediments	Excavate/Dispose + Slurry Wall	C01b + C08 + C11	Excavate/Dispose	C01b + C08
		Groundwater	Active Treatment	TRMT-1	No Action	No Action
WAL007	CANYON CK GRAVEL PIT	Upland Waste Rock	No Action	No Action	Regrade/Revegetate	C02a
WAL008	SISTERS MINE	Upland Waste Rock	No Action	No Action	Regrade/Revegetate	C02a
WAL009	HECLA-STAR TAILINGS PONDS	Floodplain Tailings	Cap Tailings Impoundment	C09	Excavate/Dispose	C01 + C08
		Floodplain Sediments (underlying tailings pond)	Slurry Wall	C11	Excavate/Dispose	C01b + C08
		Groundwater	Active Treatment	TRMT-1	No Action	No Action
		Seep	No Action	No Action	No Action	No Action
WAL010	CANYON CK POND REACH SVNRT REHAB	Floodplain Sediments	Excavate/Dispose + Slurry Wall	C01b + C08 + C11	Excavate/Dispose	C01b + C08
		Groundwater	Active Treatment	TRMT-1	No Action	No Action
WAL011	CANYON SILVER (FORMOSA) MINE	Floodplain Sediments	Excavate/Dispose	C01b + C08	Excavate/Dispose	C01b + C08
		Upland Tailings	Excavate/Dispose	C01 + C07	Excavate/Dispose	C01 + C08
		Upland Waste Rock	No Action	No Action	Regrade/Revegetate	C02a
		Adit Drainage	Adit Drainage Collection + Passive Treatment	C10 + PT-1a	Adit Drainage Collection + Passive Treatment	C10 + PT-1a
WAL012	VERDE MAY MINE	Upland Waste Rock	No Action	No Action	Regrade/Revegetate	C02a
WAL039	STANDARD-MAMMOTH MILLSITE	Floodplain Sediments	No Action	No Action	No Action	No Action
		Upland Tailings	Excavate/Dispose	C01 + C07	Excavate/Dispose	C01 + C08
		Upland Waste Rock	No Action	No Action	Regrade/Revegetate	C02a
WAL040	CANYON CK IMPACTED FLOODPLAIN	Floodplain Sediments	Excavate/Dispose + Slurry Wall	C01b + C08 + C11	Excavate/Dispose	C01b + C08
		Surface Water	Stream Flow Treatment	PT-7	No Action	No Action
		Groundwater	Active Treatment	TRMT-1	No Action	No Action
WAL041	CANYON CK REPOSITORY REACH SVNRT REHAB	Floodplain Sediments	Excavate/Dispose + Slurry Wall	C01b + C08 + C11	Excavate/Dispose	C01b + C08
		Seep	Passive Treatment	PT-1a	No Action	No Action
		Groundwater	Active Treatment	TRMT-1	No Action	No Action
WAL042	CANYON CK TAILINGS REPOSITORY SVNRT	Floodplain Sediments	No Action	No Action	Excavate/Dispose	C01b + C08
		Floodplain Tailings	Cap Tailings Impoundment	C09	Excavate/Dispose	C01 + C08
WAL081	WALLACE OLD PRIVATE LANDFILL	Floodplain Artificial Fill	Excavate/Dispose	C01 + C07	Excavate/Dispose	C01 + C08

Notes:

Source sites and names were identified by the Bureau of Land Management (1999) based on geographic information system (GIS) coverage.
Typical conceptual design (TCD) identification numbers are from the 2001 Feasibility Study Report (U.S. Environmental Protection Agency, 2001b) and are defined as follows:

C01 = Excavation
C01b = Excavation (60% dry, 40% wet)
C02a = Regrade/Consolidate/Revegetate
C07 = Local Repository
C08 = Regional Repository
C09 = Cap Impoundments
C10 = Adit Drainage Collection
C11 = Hydraulic Isolation Using Slurry Wall
PT-1a = Passive Treatment
PT-7 = Passive Stream Flow Treatment
TRMT-1 = Active Treatment

TABLE E-2
Individual Remedial Actions Evaluated for Woodland Park during the Initial Screening Phase
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Individual Remedial Actions		Description	TCD Components	Waste Type	Origin[1]	Quantity	Total Cost (30 Year NPV)	Dissolved Zn Load Reduction (lbs/day)	Cost per lb/day Load Reduction ($M/[lb/day])
WP-1		Hydraulic isolation and active treatment of groundwater along Canyon Creek throughout Woodland Park	--	--					
	WP-1a	Slurry wall (hydraulic isolation) around entire perimeter of Hecla-Star Tailings Ponds (WAL009) and active treatment at CTP	C11 + WT01	Groundwater	Alternative 3	13,500 LF	$ 16,400,000	42	0.39
	WP-1b	Slurry wall (hydraulic isolation) parallel to Canyon Creek in OSB047 and active treatment at CTP	C11 + WT01	Groundwater	Alternative 3	3,000 LF	$ 7,830,000	2	3.91
	WP-1c	Slurry wall (hydraulic isolation) parallel to Canyon Creek in WAL010 and active treatment at CTP	C11 + WT01	Groundwater	Alternative 3	4,250 LF	$ 10,210,000	5	2.04
	WP-1d	Slurry wall (hydraulic isolation) parallel to Canyon Creek in WAL040 and active treatment at CTP	C11 + WT01	Groundwater	Alternative 3	5,500 LF	$ 11,810,000	0.0001	118,000
	WP-1e	Slurry wall (hydraulic isolation) parallel to Canyon Creek in WAL041 and active treatment at CTP	C11 + WT01	Groundwater	Alternative 3	8,000 LF	$ 23,900,000	74	0.32
	WP-1f	Slurry wall (hydraulic isolation) parallel to Canyon Creek (combining WP-1b, -1c, -1d, -1e)	C11 + WT01	Groundwater	Alternative 3	19,000 LF	$ 48,000,000	67	0.72
WP-2		Sediment excavation and placement in a regional repository	--	--					
	WP-2a	Sediment excavation at OSB047 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 3	13,940 CY	$ 897,000	0.629	1.43
	WP-2b	Sediment excavation at WAL010 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 3	4,050 CY	$ 261,000	0.18	1.45
	WP-2c	Sediment excavation at WAL011 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternatives 3 and 4	8,800 CY	$ 369,000	0.397	0.93
	WP-2d	Sediment excavation at WAL040 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 3	12,960 CY	$ 834,000	6.987	0.12
	WP-2e	Sediment excavation at WAL041 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 3	15,860 CY	$ 1,020,000	0.317	3.22
	WP-2f	Sediment excavation at OSB047 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	17,000 CY	$ 1,090,000	0.768	1.42
	WP-2g	Sediment excavation at WAL010 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	15,000 CY	$ 965,000	0.667	1.45
	WP-2h	Sediment excavation at WAL040 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	18,000 CY	$ 1,160,000	9.704	0.12
	WP-2i	Sediment excavation at WAL041 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	61,000 CY	$ 3,920,000	0.694	5.66
	WP-2j	Sediment excavation at WAL009 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	323,000 CY	$ 20,800,000	9.918	2.10
	WP-2k	Sediment excavation at WAL042 and placement in a regional repository	C01b + C08 + HAUL2	Floodplain Sediments	Alternative 4	61,000 CY	$ 3,920,000	0.153	25.7
WP-3		Cap tailings impoundments	--	--					
	WP-3a	Cap tailings impoundments at Hecla-Star Tailings Ponds (WAL009)	C09	Floodplain Tailings	Alternative 3	61.55 AC	$ 28,800,000	11.365	2.5
	WP-3b	Cap tailings impoundments at Canyon Creek Tailings Repository SVNRT (WAL042)	C09	Floodplain Tailings	Alternative 3	5.15 AC	$ 2,410,000	1.992	1.2
WP-4		Excavation and placement in regional repository	--	--					
	WP-4a	Excavation at Hecla-Star Tailings Ponds (WAL009)	C01 + C08 + HAUL2	Floodplain Tailings	Alternative 4	2,100,000 CY	$ 103,000,000	11.599	8.9
	WP-4b	Excavation at Canyon Creek Tailings Reposiory SVNRT (WAL042)	C01 + C08 + HAUL2	Floodplain Tailings	Alternative 4	600,000 CY	$ 29,400,000	2.033	14.5
WP-5		Excavation and placement in waste accumulation area above flood level	--	--					
	WP-5a	Excavation at Canyon Silver (Formosa) Mine (WAL011)	C01 + C07 + HAUL1	Upland Tailings	Alternatives 3 and 4	11,600 CY	$ 520,000	0.266	1.95
	WP-5b	Excavation at Standard-Mammoth Millsite (WAL039)	C01 + C07 + HAUL1	Upland Tailings	Alternatives 3 and 4	12,500 CY	$ 559,000	3.713	0.15
	WP-5c	Excavation at Wallace Old Private Landfill (WAL081)	C01 + C07 + HAUL1	Floodplain Artificial Fill	Alternative 3	2,850 CY	$ 127,000	1.666	0.08
	WP-5d	Excavation at Wallace Old Private Landfill (WAL081)	C01 + C07 + HAUL1	Floodplain Artificial Fill	Alternative 4	5,700 CY	$ 255,000	1.818	0.14
WP-6		Regrade/consolidate/revegetate	--	--					
	WP-6a	Regrade/consolidate/revegetate at WAL007	C02a	Upland Waste Rock	Alternative 4	0.44 AC	$ 67,900	0.0001	679
	WP-6b	Regrade/consolidate/revegetate at WAL008	C02a	Upland Waste Rock	Alternative 4	0.57 AC	$ 87,900	0.001	87.9
	WP-6c	Regrade/consolidate/revegetate at WAL011	C02a	Upland Waste Rock	Alternative 4	0.55 AC	$ 84,800	0.001	84.8
	WP-6d	Regrade/consolidate/revegetate at WAL012	C02a	Upland Waste Rock	Alternative 4	0.09 AC	$ 13,900	0.0001	139
	WP-6e	Regrade/consolidate/revegetate at WAL039	C02a	Upland Waste Rock	Alternative 4	1.96 AC	$ 302,000	0.057	5.30
WP-7		Adit drainage collection and treatment with permeable reactive trench at Canyon Silver (Formosa) Mine (WAL011)	C10 + WT03	Adit Drainage	Alternative 3 and 4	0.1 CFS	$ 1,030,000	0.11	9.34
WP-8		Creek lining and French drains along Canyon Creek	--	--					
	WP-8a	Creek lining A1-A2	C15 + WT01	Groundwater	2007 Report	16,300 LF	$ 8,700,000	32	0.27
	WP-8b	French drains A1-A6 with A6 cut-off	C15 + WT01	Groundwater	2007 Report	1,300 LF	$ 27,400,000	91	0.30
	WP-8c	SVNRT "toe" drain	C14	Groundwater	2007 Report	9,900 LF	$ 4,000,000	15	0.27
	WP-8d	Creek lining A2-A4; French drains A2-A6 with A6 cut-off	C14 + C15 + WT01	Groundwater	2007 Report	2,700 (liner); 6,500 (drains) LF	$ 15,000,000	79	0.19
	WP-8e	Creek lining A1-A6; French drains A1-A6 with A1 and A6 cut-offs	C14 + C15 + WT01	Groundwater	2007 Report	15,000 (liner); 16,500 (drains) LF	$ 41,300,000	114	0.36

Notes:

[1] Refers to origin of alternative. "Alternatives 3 and 4" refer to ecological alternatives in the 2001 Feasibility Study Report (U.S. Environmental Protection Agency, 2001b). "2007 Report" refers to the *Draft Remedial Component Screening for the Woodland Park Area of Canyon Creek* (CH2M HILL, 2007b).

AC = acres; CFS = cubic feet per second; CTP = Central Treatment Plant in Kellogg, Idaho; CY = cubic yards; lf = linear feet; SVNRT = Silver Valley Natural Resource Trust

Typical Conceptual Design (TCD) identification numbers are from Section 5 in the Focused Feasibility Study Report and are defined as follows:.

TABLE E-2
Individual Remedial Actions Evaluated for Woodland Park during the Initial Screening Phase
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Individual Remedial Actions	Description	TCD Components	Waste Type	Origin[1]	Quantity	Total Cost (30 Year NPV)	Dissolved Zn Load Reduction (lbs/day)	Cost per lb/day Load Reduction ($M/[lb/day])

C01 = Excavation
C01b = Excavation (60% dry, 40% wet)
C02a = Regrade/Consolidate/Vegetative Cover (Lower Part of Pile in 100-Year Floodplain)
C07 = Local Repository Above Flood Level
C08 = Regional Repository
C09 = Impoundment Closure (includes capping and regrading)
C10 = Adit Drainage Collection
C11 = Hydraulic Isolation Using Slurry Wall
C14 = Creek Channel Lining
C15 = French Drain
HAUL1 = Haul to Local Repository
HAUL2 = Haul to Regional Repository
WT01 = Centralized High-Density Sludge (HDS) Treatment at CTP
WT03 = Onsite Passive Water Treatment Using Sulfate-Reducing Bioreactor (SRB) System

NOTE: The above costs are presented rounded to three significant figures
NOTE: The above cost opinion is a Feasibility-Study-level estimate with a nominal accuracy of –30 percent to +50 percent (–30/+50%).
NOTE: The above cost opinion is in 2009 dollars and does not include future escalation. The order-of-magnitude cost opinion shown has been prepared for guidance in project evaluation from the information available at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final project scope, the final project schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

TABLE E-2
Individual Remedial Actions Evaluated for Woodland Park during the Initial Screening Phase
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Individual Remedial Actions	Description	TCD Components	Waste Type	Origin[1]	Quantity	Total Cost (30 Year NPV)	Dissolved Zn Load Reduction (lbs/day)	Cost per lb/day Load Reduction ($M/[lb/day])

C01 = Excavation
C01b = Excavation (60% dry, 40% wet)
C02a = Regrade/Consolidate/Vegetative Cover (Lower Part of Pile in 100-Year Floodplain)
C07 = Local Repository Above Flood Level
C08 = Regional Repository
C09 = Impoundment Closure (includes capping and regrading)
C10 = Adit Drainage Collection
C11 = Hydraulic Isolation Using Slurry Wall
C14 = Creek Channel Lining
C15 = French Drain
HAUL1 = Haul to Local Repository
HAUL2 = Haul to Regional Repository
WT01 = Centralized High-Density Sludge (HDS) Treatment at CTP
WT03 = Onsite Passive Water Treatment Using Sulfate-Reducing Bioreactor (SRB) System

NOTE: The above costs are presented rounded to three significant figures
NOTE: The above cost opinion is a Feasibility-Study-level estimate with a nominal accuracy of –30 percent to +50 percent (–30/+50%).
NOTE: The above cost opinion is in 2009 dollars and does not include future escalation. The order-of-magnitude cost opinion shown has been prepared for guidance in project evaluation from the information available at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final project scope, the final project schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

TABLE E-3
Overview of Source Control Remedial Actions Included in Options A through D
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Remedial Action Description	Source Site(s)	Waste Type	Quantity
Shallow source control and placement in waste consolidation area	OSB047, WAL010, WAL011, WAL041	Floodplain sediments	10,663 CY
Sediment excavation and placement in regional repository	WAL040	Floodplain sediments	12,960 CY
Tailings exacavation and placement in regional repository	WAL039, WAL081	Upland tailings, floodplain artificial fill	15,350 CY
Native soil cap	WAL042	Floodplain tailings	2.6 AC

Notes:

AC = acres
CY =cubic yards

TABLE E-4
Summary of Option A Remedial Actions
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Remedial Action Description	Source Site(s)	Waste Type	Quantity
Shallow source control and placement in waste consolidation area	OSB047, WAL010, WAL011, WAL041	Floodplain sediments	10,663 CY
Sediment excavation and placement in regional repository	WAL040	Floodplain sediments	12,960 CY
Tailings exacavation and placement in regional repository	WAL039, WAL081	Upland tailings, floodplain artificial fill	15,350 CY
Native soil cap	WAL042	Floodplain tailings	2.6 AC
Stream lining along Canyon Creek from A1-A2	OSB047, WAL011, WAL010	Groundwater	9,900 LF

Notes:

AC = acres
CY =cubic yards
LF = linear feet

TABLE E-5
Summary of Option B Remedial Actions
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Remedial Action Description	Source Site(s)	Waste Type	Quantity
Shallow source control and placement in waste consolidation area	OSB047, WAL010, WAL011, WAL041	Floodplain sediments	10,663 CY
Sediment excavation and placement in regional repository	WAL040	Floodplain sediments	12,960 CY
Tailings exacavation and placement in regional repository	WAL039, WAL081	Upland tailings, floodplain artificial fill	15,350 CY
Native soil cap	WAL042	Floodplain tailings	2.6 AC
French drain along Canyon Creek from A1-A6 with A6 cutoff	OSB047, WAL011, WAL010, WAL041, WAL040	Groundwater	16,300 LF
French drain around SVNRT toe-drain	WAL042	Groundwater	1,300 LF

Notes:

AC = acres
CY =cubic yards
LF = linear feet
SVNRT = Silver Valley Natural Resource Trust

TABLE E-6
Summary of Option C Remedial Actions
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Remedial Action Description	Source Site(s)	Waste Type	Quantity
Shallow source control and placement in waste consolidation area	OSB047, WAL010, WAL011, WAL041	Floodplain sediments	10,663 CY
Sediment excavation and placement in regional repository	WAL040	Floodplain sediments	12,960 CY
Tailings exacavation and placement in regional repository	WAL039, WAL081	Upland tailings, floodplain artificial fill	15,350 CY
Native soil cap	WAL042	Floodplain tailings	2.6 AC
French drain along Canyon Creek from A2-A6 with A6 cutoff	WAL041, WAL040	Groundwater	6,500 LF
French drain around SVNRT toe-drain	WAL042	Groundwater	1,300 LF
Stream lining along Canyon Creek from A2-A4	WAL041	Groundwater	2,700 LF

Notes:

AC = acres
CY =cubic yards
LF = linear feet
SVNRT = Silver Valley Natural Resource Trust

TABLE E-7
Summary of Option D Remedial Actions
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Remedial Action Description	Source Site(s)	Waste Type	Quantity
Shallow source control and placement in waste consolidation area	OSB047, WAL010, WAL011, WAL041	Floodplain sediments	10,663 CY
Sediment excavation and placement in regional repository	WAL040	Floodplain sediments	12,960 CY
Tailings exacavation and placement in regional repository	WAL039, WAL081	Upland tailings, floodplain artificial fill	15,350 CY
Native soil cap	WAL042	Floodplain tailings	2.6 AC
French drain along Canyon Creek from A1-A6 with A1 and A6 cutoffs	OSB047, WAL011, WAL010, WAL041, WAL040	Groundwater	16,500 LF
French drain around SVNRT toe-drain	WAL042	Groundwater	1,300 LF
Stream lining along Canyon Creek from A1-A6	OSB047, WAL011, WAL010, WAL041	Groundwater	15,000 LF

Notes:

AC = acres
CY =cubic yards
LF = linear feet
SVNRT = Silver Valley Natural Resource Trust

TABLE E-8

Summary of Key Components of Options A through D

Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Alternative	Flow to Treatment (gpm)	Material Excavated (CY)	French Drain Total Length (ft)	Creek Liner Total Length (ft)
Option A: Stream Liners and Source Control Actions	0	39,000	0	9,900
Option B: French Drains and Source Control Actions	3611	39,000	17,600	0
Option C: Stream Liners, French Drains, and Source Control Actions	592	39,000	7,800	2,700
Option D: Extensive Stream Liners/French Drains and Source Control Actions	681	39,000	17,800	15,000

Notes:

CY = cubic yards
ft = feet
gpm = gallons per minute

TABLE E-9
Fishery Tier Definitions and Ranking System
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

FIshery Tier	Definition	COPC Concentration Range
Tier 0	No fish present	> 20x the chronic AWQC
Tier 1	No resident fish are present. Adult and juvenile salmonids (trout species) transit occasionally to reach spawning and rearing areas.	10x to 20x the chronic AWQC
Tier 2	Native or introduced salmonids (trout) are present, but with less than three year classes and generally low densities (less than 0.05 fish/m^2). Sculpins are generally absent, or present at very low densities.	7x to 10x the chronic AWQC
Tier 3	Three or more year classes of native or introduced salmonids are present. Trout densities are moderate to high (>0.05 fish/m^2) and young of the year fish, representative of spawning and rearing, are present. Sculpin are generally absent or present at very low densities.	3x to 7x the chronic AWQC
Tier 4	Three or more year classes of native or introduced salmonids are present. Salmonid densities are generally high (>0.10 fish/m^2) and young of the year are present, which indicates successful spawning and rearing. Sculpin are present at moderate to high densities.	1x to 3x the chronic AWQC
Tier 5	Three or more year classes of native or introduced salmonids are present at high densities (>0.10 fish/m^2), and young of the year and adult fish. A full range of native species predominate and are present at high densities.	Below the chronic AWQC

Notes:

From *Technical Memorandum: Interim Fishery Benchmarks for the Initial Increment of Remediation in the Coeur d'Alene River Basin* (URS Greiner, 2001a).

AWQC = ambient water quality criterion
COPC = contaminant of potential concern

TABLE E-10

Predicted Post-Remediation Water Quality at the Mouth of Canyon Creek, Woodland Park Actions Only (Station A7)

Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Woodland Park Remedial Option	Dissolved Zinc (mg/L) Pre-Remediation[1]	Flow[1] (cfs)	Dissolved Zinc (lb/day) Pre-Remediation[1]	AWQC Ratio[2] Pre-Remediation	Fishery Tier[4] Pre-Remediation	Load Reduction[3] (lbs/day) from Woodland Park Alternatives	Dissolved Zinc (mg/L) Post-Remediation	Post-Remediation Flow (cfs)	Dissolved Zinc (lb/day) Post-Remediation	AWQC Ratio[2] Post-Remediation	Dissolved Zinc Load Reduction Post-Remediation (%)	Fishery Tier[4] Post-Remediation
A	2.347	13.67	173	21.8	0	32	1.91	13.67	141.0	17.7	18.5%	1
B	2.347	13.67	173	21.8	0	102	1.76	7.48	71.0	16.3	25.0%	1
C	2.347	13.67	173	21.8	0	87	1.26	12.66	86.0	11.7	46.3%	1
D	2.347	13.67	173	21.8	0	119	0.80	12.50	54.0	7.4	65.9%	2

Notes:

[1] Pre-remediation concentrations, flows, and loads from the *Canyon Creek Hydrologic Study Report* (CH2M HILL 2007a).
[2] Ambient water quality criteria (AWQC) values calculated using hardness concentrations at station A7.
[3] Load reduction estimated from hydrologic modeling. See Appendix A in the FFS Report for details.
[4] Expected fishery tier following remedial activities based on post-remediation AWQC ratio. Defined in Table C-10 of Appendix C in URS Greiner (2001a).

cfs =cubic feet per second
lbs/day = pounds per day
mg/L = milligrams per liter

TABLE E-11

Options A through D: Summary of Costs, Load Reductions, and Ratios of Cost to Load Reduction

Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Alternative	Total Capital Cost	O&M Cost (Annual Average)	O&M Cost (30 Year NPV)	Total Cost (30 Year NPV)	Estimated Dissolved Zinc Load Reduction (lb/day)	NPV Cost/Load Reduction ($M/lb/day)
Option A - Stream Liners and Source Control Actions	$11,700,000	$29,500	$366,000	$12,000,000	32	$0.38
Option B - French Drains and Source Control Actions	$33,000,000	$81,700	$1,010,000	$34,000,000	102	$0.33
Option C - Stream Liners, French Drains, and Source Control Actions	$20,000,000	$104,000	$1,290,000	$21,300,000	87	$0.24
Option D - Extensive Stream Liners/French Drains and Source Control Actions	$45,600,000	$130,000	$1,620,000	$47,300,000	119	$0.40

Notes:

lb/day = pound(s) per day
$M/lb/day = millions of dollars per pound per day
NPV = net present value
O&M = operation and maintenance

NOTE: The above costs are presented rounded to three significant figures

NOTE: The above cost opinion is a Feasibility-Study-level estimate with a nominal accuracy of –30 percent to +50 percent (–30/+50%).

NOTE: The above cost opinion is in 2009 dollars and does not include future escalation. The order-of-magnitude cost opinion shown has been prepared for guidance in project evaluation from the information available at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final project scope, the final project schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

TABLE E-12
Comparative Analysis of Alternative 3+ Remedial Options for Woodland Park
Focused Feasibility Study, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

		Remedial Options			
Feasibility Criterion	**Description of Criterion**	**Option A** **Stream Liners and Source Control Actions**	**Option B** **French Drains and Source Control Actions**	**Option C** **Stream Liners, French Drains, and Source Control Actions**	**Option D** **Extensive Stream Liners/French Drains and Source Control Actions**
Threshold Criteria					
Overall Protection of Human Health and the Environment	Ability of alternative to achieve and maintain protection of human health and the environment	Does not effectively reduce metals loading due to implementability issues of installing liners only. Least protective of human health and the environment.	Effectively reduces groundwater loading to Canyon Creek, but also reduces flow; therefore, only slightly decreases metals concentrations. Overall, Option B only provides relatively moderate protection of human health and the environment.	Effectively reduces groundwater loading to Canyon Creek, but optimizes groundwater collection and treatment. Provides relatively high protectiveness of human health and the environment.	Effectively reduces groundwater loading to Canyon Creek through extensive collection/treatment. Provides the highest protectiveness of human health and the environment.
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	Ability of alternative to meet ARARs	AWQC ratio of 17.7 upon completion of remedial actions. Additional actions upstream from Woodland Park not evaluated.	AWQC ratio of 16.3 upon completion of remedial actions. Additional actions upstream from Woodland Park not evaluated.	AWQC ratio of 11.7 upon completion of remedial actions. Additional actions upstream from Woodland Park not evaluated.	AWQC ratio of 7.4 upon completion of remedial actions. Additional actions upstream from Woodland Park not evaluated.
Primary Balancing Criteria					
Long-Term Effectiveness	Ability of technology to be protective of human health and the environment without upset over the long-term	Long-term effectiveness and permanence of remedial actions should be similar to short-term effectiveness assuming adequate O&M is performed.	Long-term effectiveness and permanence of remedial actions should be similar to short-term effectiveness assuming adequate O&M is performed.	Long-term effectiveness and permanence of remedial actions should be similar to short-term effectiveness assuming adequate O&M is performed.	Long-term effectiveness and permanence of remedial actions should be similar to short-term effectiveness assuming adequate O&M is performed.
Reduction of Toxicity, Mobility or Volume through Treatment	Ability of alternative to reduce the mobility, toxicity, or volume of hazardous substances through treatment	No treatment included in this option.	Groundwater treatment would result in reduction of toxicity, mobility, and volume of dissolved metals in groundwater (and, indirectly, in surface water). Treatment residuals include precipitated-metals sludge requiring disposal. This option has the highest flow rate of collected groundwater and therefore the highest degree of reduction of toxicity, mobility, and volume through treatment.	Groundwater treatment would result in reduction of toxicity, mobility, and volume of dissolved metals in groundwater (and, indirectly, in surface water). Treatment residuals include precipitated-metals sludge requiring disposal. Under Option C, a comparable volume of groundwater would be collected and treated as would be under Option D.	Groundwater treatment would result in reduction of toxicity, mobility, and volume of dissolved metals in groundwater (and, indirectly, in surface water). Treatment residuals include precipitated-metals sludge requiring disposal. Under Option D, a comparable volume of groundwater would be collected and treated as would be under Option C.
Short-Term Effectiveness	Predicted AWQC ratio at the mouth of Canyon Creek immediately following remedial actions	17.7	16.3	11.7	7.4
Implementability	Ability of alternative to meet technical, administrative, and logistical challenges associated with implementation	Stream lining can only be installed in losing reaches of Canyon Creek. Limits area where stream liners can be installed, thus limiting load reduction potential.	Very high inflow of groundwater into drains without stream liners. Installation of extensive drains would be disruptive to extensive areas of the creek and the community. Implementability issues associated with construction of conveyance piping to the Central Treatment Plant (CTP).	The most implementable alternative. Installation of stream liners and drains would be disruptive to portions of the creek and the community. Implementability issues associated with construction of conveyance piping to the CTP.	Installation of extensive stream liners and drains would be disruptive to extensive areas of the creek and the community. Implementability issues associated with construction of conveyance piping to the CTP.
Cost	Total Capital Cost	$ 11,700,000	$	$ 20,000,000	$ 45,600,000
	O&M Cost (Annual Average)	$ 29,500	$ 33,000,000	$ 104,000	$ 130,000
	O&M Cost (30 Year NPV)	$ 366,000	$	$ 1,290,000	$ 1,620,000
	Total Cost (30 Year NPV)	$ 12,000,000	$ 81,700	$ 21,300,000	$ 47,300,000
	Net Present Value Cost of Zinc Load Reduction ($M/lb/day)	0.38	1,010,000 0.33	0.24	0.40

34,000,000

NOTE: The above costs are presented rounded to three significant figures
NOTE: The above cost opinion is a Feasibility-Study-level estimate with a nominal accuracy of –30 percent to +50 percent (–30/+50%).
NOTE: The above cost opinion is in 2009 dollars and does not include future escalation. The order-of-magnitude cost opinion shown has been prepared for guidance in project evaluation from the information available at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final project scope, the final project schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

Attachment E-1
Detailed Cost Analyses of Individual Remedial Actions

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-1: Hydraulic Isolation and Active Treatment at CTP

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (GPM)	QTY (MI)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-1a	C11e	Hydraulic Isolation	$ 595.00	13,500	--		$ 8,030,000	70%	$ 5,620,000	$ 13,700,000	0%	$ -	$ -	$ 13,700,000	WAL009
	WT01	Active Treatment	$ 679.00	--	183		$ 124,000	107%	$ 133,000	$ 258,000	99%	$ 9,940	$ 120,000	$ 380,000	
	C17e	Extraction Wells	$ 83,300.00	--	--	5	$ 417,000	70%	$ 292,000	$ 708,000	100%	$ 33,600	$ 417,000	$ 1,120,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	11,900	--		$ 699,000	70%	$ 489,000	$ 1,190,000	8%	$ 4,500	$ 55,900	$ 1,240,000	
	Total						**$ 8,570,000**		**$ 6,050,000**	**$ 14,600,000**		**$ 43,500**	**$ 540,000**	**$ 16,400,000**	
WP-1b	C11i	Hydraulic Isolation	$ 1,210.00	3,000	--		$ 3,630,000	70%	$ 2,540,000	$ 6,170,000	2%	$ 5,850	$ 72,600	$ 6,240,000	OSB047
	WT01	Active Treatment	$ 679.00	--	60		$ 40,600	107%	$ 43,000	$ 84,100	99%	$ 3,200	$ 40,200	$ 120,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	13,970	--		$ 820,000	70%	$ 574,000	$ 1,390,000	8%	$ 5,290	$ 65,600	$ 1,460,000	
	Total						**$ 4,490,000**		**$ 3,200,000**	**$ 7,650,000**		**$ 14,400**	**$ 178,000**	**$ 7,830,000**	
WP-1c	C11i	Hydraulic Isolation	$ 1,210.00	4,250	--		$ 5,140,000	70%	$ 3,600,000	$ 8,740,000	2%	$ 8,290	$ 103,000	$ 8,850,000	WAL010
	WT01	Active Treatment	$ 679.00	--	70		$ 47,700	107%	$ 51,000	$ 98,700	99%	$ 4,000	$ 47,200	$ 150,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	11,620	--		$ 682,000	70%	$ 477,000	$ 1,160,000	8%	$ 4,400	$ 54,600	$ 1,210,000	
	Total						**$ 5,870,000**		**$ 4,130,000**	**$ 10,000,000**		**$ 16,500**	**$ 205,000**	**$ 10,210,000**	
WP-1d	C11h	Hydraulic Isolation	$ 1,120.00	5,500	--		$ 6,160,000	70%	$ 4,310,000	$ 10,500,000	2%	$ 9,900	$ 123,000	$ 10,600,000	WAL040
	WT01	Active Treatment	$ 679.00	--	420		$ 285,000	107%	$ 305,000	$ 590,000	99%	$ 22,800	$ 280,000	$ 870,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	3,280	--		$ 193,000	70%	$ 135,000	$ 327,000	8%	$ 1,240	$ 15,400	$ 343,000	
	Total						**$ 6,640,000**		**$ 4,750,000**	**$ 11,390,000**		**$ 33,900**	**$ 421,000**	**$ 11,810,000**	
WP-1e	C11j	Hydraulic Isolation	$ 1,590.00	8,000	--		$ 12,700,000	70%	$ 8,900,000	$ 21,600,000	2%	$ 20,500	$ 254,000	$ 21,900,000	WAL041
	WT01	Active Treatment	$ 679.00	--	608		$ 413,000	107%	$ 442,000	$ 855,000	99%	$ 33,000	$ 410,000	$ 1,260,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	7,280	--		$ 427,000	70%	$ 299,000	$ 726,000	8%	$ 2,760	$ 34,200	$ 761,000	
	Total						**$ 13,600,000**		**$ 9,650,000**	**$ 23,200,000**		**$ 56,200**	**$ 698,000**	**$ 23,900,000**	
WP-1f	C11i	Hydraulic Isolation	$ 1,210.00	19,000	--		$ 23,000,000	70%	$ 16,100,000	$ 39,100,000	2%	$ 37,100	$ 460,000	$ 39,500,000	All of the above
	WT01	Active Treatment	$ 679.00	--	3510		$ 2,380,000	107%	$ 2,550,000	$ 4,930,000	99%	$ 190,000	$ 2,360,000	$ 7,300,000	
	PIPE-2	Conveyance Pipe -12"	$ 86.20	7,500	--		$ 647,000	70%	$ 453,000	$ 1,100,000	8%	$ 4,170	$ 51,700	$ 1,150,000	
	Total						**$ 26,000,000**		**$ 19,100,000**	**$ 45,100,000**		**$ 231,500**	**$ 2,873,000**	**$ 48,000,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-2: Sediment Excavation and Placement in Regional Repository

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (CY)	QTY (MI)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-2a	C01b	Excavation	$ 13.20	13,940		$ 180,000	70%	$ 130,000	$ 313,000	0%	$ -	$ -	$ 313,000	OSB047
	C08a	Regional Repository	$ 17.70	13,940		$ 247,000	70%	$ 173,000	$ 419,000	14%	$ 2,780	$ 34,500	$ 454,000	
	HAUL2	Waste Hauling	$ 1.10	13,940	5	$ 76,500	70%	$ 53,600	$ 130,000	0%	$ -	$ -	$ 130,000	
	Total					**$ 510,000**		**$ 360,000**	**$ 900,000**		**$ 2,780**	**$ 34,500**	**$ 897,000**	
WP-2b	C01b	Excavation	$ 13.20	4,050		$ 53,500	70%	$ 37,400	$ 90,900	0%	$ -	$ -	$ 90,900	WAL010
	C08a	Regional Repository	$ 17.70	4,050		$ 71,700	70%	$ 50,200	$ 122,000	14%	$ 810	$ 10,000	$ 132,000	
	HAUL2	Waste Hauling	$ 1.10	4,050	5	$ 22,200	70%	$ 15,600	$ 37,800	0%	$ -	$ -	$ 37,800	
	Total					**$ 147,000**		**$ 103,000**	**$ 251,000**		**$ 810**	**$ 10,000**	**$ 261,000**	
WP-2c	C01b	Excavation	$ 13.20	8,800		$ -	70%	$ -	$ -	0%	$ -	$ -	$ -	WAL011
	C08a	Regional Repository	$ 17.70	8,800		$ 156,000	70%	$ 109,000	$ 265,000	14%	$ 1,760	$ 21,800	$ 287,000	
	HAUL2	Waste Hauling	$ 1.10	8,800	5	$ 48,300	70%	$ 33,800	$ 82,100	0%	$ -	$ -	$ 82,100	
	Total					**$ 204,000**		**$ 143,000**	**$ 347,000**		**$ 1,760**	**$ 21,800**	**$ 369,000**	
WP-2d	C01b	Excavation	$ 13.20	12,960		$ 171,000	70%	$ 120,000	$ 291,000	0%	$ -	$ -	$ 291,000	WAL040
	C08a	Regional Repository	$ 17.70	12,960		$ 229,000	70%	$ 161,000	$ 390,000	14%	$ 2,590	$ 32,100	$ 422,000	
	HAUL2	Waste Hauling	$ 1.10	12,960	5	$ 71,200	70%	$ 49,800	$ 121,000	0%	$ -	$ -	$ 121,000	
	Total					**$ 472,000**		**$ 330,000**	**$ 802,000**		**$ 2,590**	**$ 32,100**	**$ 834,000**	
WP-2e	C01b	Excavation	$ 13.20	15,860		$ 209,000	70%	$ 147,000	$ 356,000	0%	$ -	$ -	$ 356,000	WAL041
	C08a	Regional Repository	$ 17.70	15,860		$ 281,000	70%	$ 197,000	$ 477,000	14%	$ 3,170	$ 39,300	$ 517,000	
	HAUL2	Waste Hauling	$ 1.10	15,860	5	$ 87,100	70%	$ 60,900	$ 148,000	0%	$ -	$ -	$ 148,000	
	Total					**$ 577,000**		**$ 404,000**	**$ 981,000**		**$ 3,170**	**$ 39,300**	**$ 1,020,000**	
WP-2f	C01b	Excavation	$ 13.20	17,000		$ 224,000	70%	$ 157,000	$ 381,000	0%	$ -	$ -	$ 381,000	OSB047
	C08a	Regional Repository	$ 17.70	17,000		$ 301,000	70%	$ 211,000	$ 512,000	14%	$ 3,390	$ 42,100	$ 554,000	
	HAUL2	Waste Hauling	$ 1.10	17,000	5	$ 93,300	70%	$ 65,300	$ 159,000	0%	$ -	$ -	$ 159,000	
	Total					**$ 619,000**		**$ 433,000**	**$ 1,050,000**		**$ 3,390**	**$ 42,100**	**$ 1,090,000**	
	C01b	Excavation	$ 13.20	15,000		$ 198,000	70%	$ 139,000	$ 337,000	0%	$ -	$ -	$ 337,000	WAL010
WP-2g	C08a	Regional Repository	$ 17.70	15,000		$ 266,000	70%	$ 186,000	$ 451,000	14%	$ 3,000	$ 37,200	$ 489,000	
	HAUL2	Waste Hauling	$ 1.10	15,000	5	$ 82,400	70%	$ 57,600	$ 140,000	0%	$ -	$ -	$ 140,000	
	Total					**$ 546,000**		**$ 382,000**	**$ 928,000**		**$ 3,000**	**$ 37,200**	**$ 965,000**	
	C01b	Excavation	$ 13.20	18,000		$ 238,000	70%	$ 166,000	$ 404,000	0%	$ -	$ -	$ 404,000	WAL040
WP-2h	C08a	Regional Repository	$ 17.70	18,000		$ 319,000	70%	$ 223,000	$ 542,000	14%	$ 3,590	$ 44,600	$ 586,000	
	HAUL2	Waste Hauling	$ 1.10	18,000	5	$ 98,800	70%	$ 69,200	$ 168,000	0%	$ -	$ -	$ 168,000	
	Total					**$ 655,000**		**$ 459,000**	**$ 1,110,000**		**$ 3,590**	**$ 44,600**	**$ 1,160,000**	
	C01b	Excavation	$ 13.20	61,000		$ 805,000	70%	$ 564,000	$ 1,370,000	0%	$ -	$ -	$ 1,370,000	WAL041
WP-2i	C08a	Regional Repository	$ 17.70	61,000		$ 1,080,000	70%	$ 756,000	$ 1,840,000	14%	$ 12,200	$ 151,000	$ 1,990,000	
	HAUL2	Waste Hauling	$ 1.10	61,000	5	$ 335,000	70%	$ 234,000	$ 569,000	0%	$ -	$ -	$ 569,000	
	Total					**$ 2,220,000**		**$ 1,550,000**	**$ 3,770,000**		**$ 12,200**	**$ 151,000**	**$ 3,920,000**	

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-2: Sediment Excavation and Placement in Regional Repository

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (CY)	QTY (MI)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
	C01b	Excavation	$ 13.20	323,000		$ 4,260,000	70%	$ 2,980,000	$ 7,250,000	0%	$ -	$ -	$ 7,250,000	WAL009
WP-2j	C08a	Regional Repository	$ 17.70	323,000		$ 5,720,000	70%	$ 4,000,000	$ 9,720,000	14%	$ 64,500	$ 800,000	$ 10,500,000	
	HAUL2	Waste Hauling	$ 1.10	323,000	5	$ 1,770,000	70%	$ 1,240,000	$ 3,010,000	0%	$ -	$ -	$ 3,010,000	
	Total					**$ 11,800,000**		**$ 8,230,000**	**$ 20,000,000**		**$ 64,500**	**$ 800,000**	**$ 20,800,000**	
	C01b	Excavation	$ 13.20	61,000		$ 805,000	70%	$ 564,000	$ 1,370,000	0%	$ -	$ -	$ 1,370,000	WAL042
WP-2k	C08a	Regional Repository	$ 17.70	61,000		$ 1,080,000	70%	$ 756,000	$ 1,840,000	14%	$ 12,200	$ 151,000	$ 1,990,000	
	HAUL2	Waste Hauling	$ 1.10	61,000	5	$ 335,000	70%	$ 234,000	$ 569,000	0%	$ -	$ -	$ 569,000	
	Total					**$ 2,220,000**		**$ 1,550,000**	**$ 3,770,000**		**$ 12,200**	**$ 151,000**	**$ 3,920,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-3: Cap Tailings Impoundments

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (AC)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-3a	C09	Cap Impoundments	$246,000	61.55	$ 15,100,000	70%	$ 10,600,000	$ 25,700,000	20%	$244,000	$ 3,030,000	$ 28,800,000	WAL009
	Total				**$ 15,100,000**		**$ 10,600,000**	**$ 25,700,000**		**$244,000**	**$ 3,030,000**	**$ 28,800,000**	
WP-3b	C09	Cap Impoundments	$246,000	5.15	$ 1,270,000	70%	$ 887,000	$ 2,150,000	20%	$ 20,400	$ 253,000	$ 2,410,000	WAL042
	Total				**$ 1,270,000**		**$ 887,000**	**$ 2,150,000**		**$ 20,400**	**$ 253,000**	**$ 2,410,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-4: Excavation and placement in Regional Repository

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (AC)	QTY (MI)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-4a	C01	Excavation	$ 4.20	2,100,000		$ 8,820,000	70%	$ 6,170,000	$ 15,000,000	0%	$ -	$ -	$ 15,000,000	WAL009
	C08a	Regional Repository	$ 17.70	2,100,000		$ 37,200,000	70%	$ 26,000,000	$ 63,200,000	14%	$ 419,000	$ 5,200,000	$ 70,000,000	
	HAUL2	Waste Hauling	$ 1.10	2,100,000	5	$ 11,500,000	70%	$ 8,070,000	$ 19,600,000	0%	$ -	$ -	$ 19,600,000	
	Total					**$ 57,500,000**		**$ 40,300,000**	**$ 97,800,000**		**$ 419,000**	**$ 5,200,000**	**$ 103,000,000**	
WP-4b	C01	Excavation	$ 4.20	600,000		$ 2,520,000	70%	$ 1,760,000	$ 4,280,000	0%	$ -	$ -	$ 4,280,000	WAL042
	C08a	Regional Repository	$ 17.70	600,000		$ 10,600,000	70%	$ 7,430,000	$ 18,100,000	14%	$ 120,000	$ 1,490,000	$ 19,500,000	
	HAUL2	Waste Hauling	$ 1.10	600,000	5	$ 3,290,000	70%	$ 2,310,000	$ 5,600,000	0%	$ -	$ -	$ 5,600,000	
	Total					**$ 16,400,000**		**$ 11,500,000**	**$ 27,900,000**		**$ 120,000**	**$ 1,490,000**	**$ 29,400,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-5: Excavation and Placement in Local Repository Above Flood Level

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (CY)	QTY (miles)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-5a	C01	Excavation	$ 4.20	11,600		$ 50,000	70%	$ 30,000	$ 80,000	0%	$ -	$ -	$ 80,000	WAL011
	C07	Local Repository	$ 14.70	11,600		$ 171,000	70%	$ 119,000	$ 290,000	22%	$ 3,020	$ 37,500	$ 327,000	
	HAUL2	Waste Hauling	$ 1.10	11,600	5	$ 64,000	70%	$ 45,000	$ 108,000	0%	$ -	$ -	$ 108,000	
	Total					**$ 280,000**		**$ 200,000**	**$ 480,000**		**$ 3,020**	**$ 37,500**	**$ 520,000**	
WP-5b	C01	Excavation	$ 4.20	12,500		$ 52,500	70%	$ 36,800	$ 89,300	0%	$ -	$ -	$ 89,300	WAL039
	C07	Local Repository	$ 14.70	12,500		$ 184,000	70%	$ 129,000	$ 312,000	22%	$ 3,260	$ 40,400	$ 353,000	
	HAUL2	Waste Hauling	$ 1.10	12,500	5	$ 69,000	70%	$ 48,000	$ 117,000	0%	$ -	$ -	$ 117,000	
	Total					**$ 305,000**		**$ 213,000**	**$ 518,000**		**$ 3,260**	**$ 40,400**	**$ 559,000**	
WP-5c	C01	Excavation	$ 4.20	2,850		$ 11,970	70%	$ 8,379	$ 20,349	0%	$ -	$ -	$ 20,349	WAL081
	C07	Local Repository	$ 14.70	2,850		$ 41,900	70%	$ 29,300	$ 71,200	22%	$ 743	$ 9,220	$ 80,400	
	HAUL2	Waste Hauling	$ 1.10	2,850	5	$ 15,600	70%	$ 11,000	$ 26,600	0%	$ -	$ -	$ 26,600	
	Total					**$ 69,500**		**$ 48,700**	**$ 118,000**		**$ 743**	**$ 9,220**	**$ 127,000**	
WP-5d	C01	Excavation	$ 4.20	5,700		$ 23,900	70%	$ 16,800	$ 40,700	0%	$ -	$ -	$ 40,700	WAL081
	C07	Local Repository	$ 14.70	5,700		$ 83,800	70%	$ 58,700	$ 142,000	22%	$ 1,490	$ 18,400	$ 161,000	
	HAUL2	Waste Hauling	$ 1.10	5,700	5	$ 31,300	70%	$ 21,900	$ 53,000	0%	$ -	$ -	$ 53,000	
	Total					**$ 139,000**		**$ 97,000**	**$ 236,000**		**$ 1,490**	**$ 18,400**	**$ 255,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not been modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-6: Regrade/Consolidate/Revegetate Upland Waste Rock (UWR)

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (AC)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-6a	C02a	Regrade/Consolidate/Revegetate	$ 84,300	0.44	$ 37,100	70%	$ 26,000	$ 63,100	13%	$ 389	$ 4,820	**$ 67,900**	WAL007
WP-6b	C02a	Regrade/Consolidate/Revegetate	$ 84,300	0.57	$ 48,100	70%	$ 33,600	$ 81,700	13%	$ 503	$ 6,250	**$ 87,900**	WAL008
WP-6c	C02a	Regrade/Consolidate/Revegetate	$ 84,300	0.55	$ 46,400	70%	$ 32,500	$ 78,800	13%	$ 486	$ 6,030	**$ 84,800**	WAL011
WP-6d	C02a	Regrade/Consolidate/Revegetate	$ 84,300	0.09	$ 7,590	70%	$ 5,310	$ 12,900	13%	$ 79	$ 986	**$ 13,900**	WAL012
WP-6e	C02a	Regrade/Consolidate/Revegetate	$ 84,300	1.96	$165,000	70%	$116,000	$281,000	13%	$ 1,730	$ 21,500	**$ 302,000**	WAL039

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-7: Adit Drainage Collection and ActiveTreatment

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LS)	QTY (GPM)	QTY (LF)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-7	C10	Adit Collection	$ 9,680.00	1	--	--	$ 9,680	70%	$ 6,780	$ 16,500	18%	$ 140	$ 1,740	$ 18,200	WAL011
	WT01	Active Treatment	$ 679.00	--	170	--	$ 116,000	107%	$ 124,000	$ 239,000	99%	$ 9,230	$ 115,000	$ 350,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	--	--	6,270	$ 368,000	70%	$ 258,000	$ 626,000	8%	$ 2,370	$ 29,400	$ 655,000	
	Total						**$ 493,000**		**$ 388,000**	**$ 882,000**		**$ 11,700**	**$ 146,000**	**$ 1,030,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

UPPER BASIN - WOODLAND PARK
EVALUATION OF INDIVIDUAL REMEDIAL ACTIONS
Preliminary Cost Estimate

WP-8: Creek Lining and French Drains Along Canyon Creek

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (GPM)	QTY (LS)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Source Site(s)
WP-8a	C14b	Stream Liner A1-A2	$ 505.00	9,900	--	--	$ 5,000,000	70%	$ 3,500,000	$ 8,500,000	4%	$ 16,100	$ 200,000	$ 8,700,000	Multiple
	Total						**$ 5,000,000**		**$ 3,500,000**	**$ 8,500,000**		**$ 16,100**	**$ 200,000**	**$ 8,700,000**	
WP-8b	C15b	French Drain A1-A6 with A6 Cut-off	$ 907.00	16,300	--	--	$14,800,000	70%	$10,300,000	$25,100,000	2%	$ 23,800	$ 296,000	$ 25,400,000	Multiple
	WT01	Active Treatment	$ 679.00	--	79	--	$ 50,000	107%	$ 60,000	$ 110,000	99%	$ 4,000	$ 50,000	$ 160,000	
	PIPE-3	Conveyance Pipe - 24"	$ 139.00	7,280		--	$ 1,010,000	70%	$ 708,000	$ 1,720,000	8%	$ 6,500	$ 81,000	$ 1,800,000	
	Total						**$15,800,000**		**$11,100,000**	**$27,000,000**		**$ 35,000**	**$ 430,000**	**$ 27,400,000**	
WP-8c	C15b	SVNRT French Drain	$ 907.00	1,300	--	--	$ 1,180,000	70%	$ 825,000	$ 2,000,000	2%	$ 1,900	$ 23,600	$ 2,030,000	Multiple
	WT01	Active Treatment	$ 679.00	--	585	--	$ 400,000	107%	$ 400,000	$ 822,000	99%	$ 31,700	$ 390,000	$ 1,220,000	
	PIPE-1	Conveyance Pipe - 6"	$ 58.70	7,280		--	$ 427,000	70%	$ 299,000	$ 726,471	8%	$ 2,760	$ 34,200	$ 760,000	
	Total						**$ 2,000,000**		**$ 1,550,000**	**$ 3,550,000**		**$ 36,400**	**$ 450,000**	**$ 4,000,000**	
WP-8d	C15b	French Drain A2-A6 with A6 Cut-off	$ 907.00	6,500	--	--	$ 5,900,000	70%	$ 4,130,000	$10,000,000	2%	$ 9,500	$ 118,000	$ 10,100,000	Multiple
	C14b	Stream Liner A2-A4	$ 505.00	2,700	--	--	$ 1,360,000	70%	$ 954,000	$ 2,320,000	4%	$ 4,400	$ 54,500	$ 2,370,000	
	WT01	Active Treatment	$ 679.00	--	637	--	$ 433,000	107%	$ 463,000	$ 896,000	99%	$ 35,000	$ 430,000	$ 1,320,000	
	PIPE-2	Conveyance Pipe - 12"	$ 86.20	7,280			$ 628,000	70%	$ 439,000	$ 1,070,000	8%	$ 4,000	$ 50,200	$ 1,120,000	
	Total						**$ 8,320,000**		**$ 5,980,000**	**$14,300,000**		**$ 52,000**	**$ 650,000**	**$ 15,000,000**	
WP-8e	C15b	French Drain A1-A6 with A1 and A6 Cut-offs	$ 907.00	16,500	--	--	$15,000,000	70%	$10,500,000	$25,400,000	2%	$ 24,100	$ 299,000	$ 25,700,000	Multiple
	C14b	Stream Liner A1-A6	$ 505.00	15,000	--	--	$ 7,580,000	70%	$ 5,300,000	$12,900,000	4%	$ 24,400	$ 303,000	$ 13,200,000	
	WT01	Active Treatment	$ 679.00	--	608	--	$ 413,000	107%	$ 442,000	$ 855,000	99%	$ 33,000	$ 410,000	$ 1,260,000	
	PIPE-2	Conveyance Pipe - 12"	$ 86.20	7,280		--	$ 628,000	70%	$ 439,000	$ 1,070,000	8%	$ 4,000	$ 50,200	$ 1,120,000	
	Total						**$23,600,000**		**$16,700,000**	**$40,200,000**		**$ 86,000**	**$ 1,060,000**	**$ 41,300,000**	

Notes:
[1] TCD = Typical Conceptual Design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source W*
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

Attachment E-2
Documentation of the Simplified Tool for Predictive Analysis: Woodland Park (2006 Data)

River Segment Dissolved Zinc Load

Dissolved Zinc Load at A1	52.0	lbs/day	Sept. 2006
Dissolved Zinc Load at A2	98.0	lbs/day	Sept. 2006
Dissolved Zinc Load Gain from Sources	46.0	lbs/day	

Adits/Seeps/Groundwater	Total Load (lbs/day)	Amount of Load in Reach (%)	Load in this Reach (lbs/day)		
Gem Portal 3 Discharge (WAL009)	21	100%	21.00	Sept. 2006 Data	
Hecla-Star Tailings Pond Underflow (WAL009)	18.45	45%	8.30	RI Data	Qtot = 205 gpm, Zn avg = 2-13 mg/L
Canyon Silver Formosa Mine Adit (WAL011)	0.11	100%	0.11	RI Data	Qtot= 0.1 cfs (assumed), 0.208 mg/L avg
Total Load from Adits/Seeps/Groundwater			29.41		
Dissolved Zinc Load Gain from Sources less adits/seeps/groundwater			16.59	This load used to calculate relative contribution of sources other than adits/seeps/groundwater below	

Pre-Remediation Dissolved Zinc Load Contributions (point estimates)

Source (Waste) Type (ST)	Relative Loading Potential (RLP)	Total Source Volume CY	PCT of Source in Reach %	Total Volume CY	Relative Total Volume CY	Source contribution % Total	Dissolved Zinc Load lbs/day
Canyon Cr Impacted FP Seds (BUR141)	0.795	22000	1%	198	157	0.1%	0.009
Verde May Mine UWR (WAL012)	0.003	2200	100%	2200	7	0.0%	0.000
Canyon Cr Formosa Reach FP Seds (OSB047)	0.795	17000	100%	17000	13515	4.7%	0.775
Canyon Silver (Formosa) FP Seds (WAL011)	0.795	8800	100%	8800	6996	2.4%	0.401
Canyon Silver (Formosa) Upland Tails (WAL011)	0.404	11600	100%	11600	4686	1.6%	0.269
Canyon Silver (Formosa) UWR (WAL011)	0.003	13000	100%	13000	39	0.0%	0.002
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.795	15000	98%	14625	11627	4.0%	0.667
Hecla Star Tailings Ponds FP Seds (WAL009)	0.795	323000	45%	145673	115810	40.1%	6.644
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	0.143	2100000	45%	947100	135435	46.8%	7.770
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.795	61000	2%	1037	824	0.3%	0.047
Total				1161233	289097	100%	16.585

Adits/Seeps/Groundwater		Dissolved Zinc Load (lbs/day)
Gem Portal 3 Discharge (WAL009)	21.00	21.00
Hecla-Star Tailings Pond Underflow (WAL009)	8.30	8.30
Canyon Silver Formosa Mine Adit (WAL011)	0.11	0.11
Total		29.41
Total Dissolved Zinc Load from all Sources		46.0

Remedial Effectiveness Factors (not all remedial actions are applicable for each source type or source area)

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action
Canyon Cr Impacted FP Seds (BUR141)	0.009	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Verde May Mine UWR (WAL012)	0.000	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Cr Formosa Reach FP Seds (OSB047)	0.775	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Silver (Formosa) FP Seds (WAL011)	0.401	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Silver (Formosa) Upland Tails (WAL011)	0.269	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Silver (Formosa) UWR (WAL011)	0.002	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.667	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla Star Tailings Ponds FP Seds (WAL009)	6.644	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	7.770	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.047	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Gem Portal 3 Discharge (WAL009)	21.000	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla-Star Tailings Pond Underflow (WAL009)	8.303	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Silver Formosa Mine Adit (WAL011)	0.112	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00

Dissolved Zinc Load After Remediation

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action
Canyon Cr Impacted FP Seds (BUR141)	0.009	0.000	0.002	0.002	0.000	0.002	0.000	0.004	0.000	0.001	0.009
Verde May Mine UWR (WAL012)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canyon Cr Formosa Reach FP Seds (OSB047)	0.775	0.008	0.140	0.194	0.023	0.171	0.039	0.357	0.008	0.085	0.775
Canyon Silver (Formosa) FP Seds (WAL011)	0.401	0.004	0.072	0.100	0.012	0.088	0.020	0.185	0.004	0.044	0.401
Canyon Silver (Formosa) Upland Tails (WAL011)	0.269	0.003	0.048	0.067	0.008	0.059	0.013	0.124	0.003	0.030	0.269
Canyon Silver (Formosa) UWR (WAL011)	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.002
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.667	0.007	0.120	0.167	0.020	0.147	0.033	0.307	0.007	0.073	0.667
Hecla Star Tailings Ponds FP Seds (WAL009)	6.644	0.066	1.196	1.661	0.199	1.462	0.332	3.056	0.066	0.731	6.644
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	7.770	0.078	1.399	1.942	0.233	1.709	0.388	3.574	0.078	0.855	7.770
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.047	0.000	0.009	0.012	0.001	0.010	0.002	0.022	0.000	0.005	0.047
Gem Portal 3 Discharge (WAL009)	21.000	0.210	3.780	5.250	0.630	4.620	1.050	9.660	0.210	2.310	21.000
Hecla-Star Tailings Pond Underflow (WAL009)	8.303	0.083	1.494	2.076	0.249	1.827	0.415	3.819	0.083	0.913	8.303
Canyon Silver Formosa Mine Adit (WAL011)	0.112	0.001	0.020	0.028	0.003	0.025	0.006	0.052	0.001	0.012	0.112

Source (Waste) Type (ST)	Alt 3 PCT	Alternative 3 Actions Identified in the FS (enter cell addresses manually, one value from each row)		Alt 4 PCT	Alternative 4 Actions Identified in the FS (enter cell addresses manually, one value from each row)	
Canyon Cr Impacted FP Seds (BUR141)	100%	0.000	Excavate/Dispose	100%	0.000	Excavate/Dispose
Verde May Mine UWR (WAL012)	0%	0.000	No Action	100%	0.000	Regrade/Reveg
Canyon Cr Formosa Reach FP Seds (OSB047)	82%	0.146	Excavate/Dispose	100%	0.008	Excavate/Dispose
Canyon Silver (Formosa) FP Seds (WAL011)	100%	0.004	Excavate/Dispose	100%	0.004	Excavate/Dispose
Canyon Silver (Formosa) Upland Tails (WAL011)	100%	0.003	Excavate/Dispose	100%	0.003	Excavate/Dispose
Canyon Silver (Formosa) UWR (WAL011)	0%	0.002	No Action	100%	0.001	Regrade/Reveg
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	27%	0.489	Excavate/Dispose	100%	0.007	Excavate/Dispose
Hecla Star Tailings Ponds FP Seds (WAL009)	100%	1.661	Hydraulic Isolation/Treatment	100%	0.066	Excavate/Dispose
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	100%	0.233	Cap	100%	0.078	Excavate/Dispose
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	26%	0.035	Excavate/Dispose	59%	0.020	Excavate/Dispose
Gem Portal 3 Discharge (WAL009)	100%	0.210	Active Treatment	100%	0.210	Active Treatment
Hecla-Star Tailings Pond Underflow (WAL009)	100%	2.076	Hydraulic Isolation	0%	8.303	No Action
Canyon Silver Formosa Mine Adit (WAL011)	100%	0.012	Passive Treatment	100%	0.001	Passive Treatment
		4.871	**Alt 3 Total**		**8.700**	**Alt 4 Total**

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Diss. Zinc Load After Alt. 3 Action (lbs/day)	Load Reducution (lbs/day)		Diss. Zinc Load After Alt. 4 Action (lbs/day)	Load Reducution (lbs/day)
Canyon Cr Impacted FP Seds (BUR141)	0.009	0.000	0.01		0.000	0.01
Verde May Mine UWR (WAL012)	0.000	0.000	0.00		0.000	0.00
Canyon Cr Formosa Reach FP Seds (OSB047)	0.775	0.146	0.63		0.008	0.77
Canyon Silver (Formosa) FP Seds (WAL011)	0.401	0.004	0.40		0.004	0.40
Canyon Silver (Formosa) Upland Tails (WAL011)	0.269	0.003	0.27		0.003	0.27
Canyon Silver (Formosa) UWR (WAL011)	0.002	0.002	0.00		0.001	0.00
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.667	0.489	0.18		0.007	0.66
Hecla Star Tailings Ponds FP Seds (WAL009)	6.644	1.661	4.98	45% used for this reach	0.066	6.58
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	7.770	0.233	7.54	45% used for this reach	0.078	7.69
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.047	0.035	0.01		0.020	0.03
Gem Portal 3 Discharge (WAL009)	21.000	0.210	20.79		0.210	20.79
Hecla-Star Tailings Pond Underflow (WAL009)	8.303	2.076	6.23		8.303	0.00
Canyon Silver Formosa Mine Adit (WAL011)	0.112	0.012	0.10		0.001	0.11

	Alt 3	Alt 4
Pre-Remediation Dissolved Zinc Load Gain	46.000	46.000
Post-Remediation Dissolved Zinc Load Gain	4.871	8.700
Benefit	41.129	37.300

Dissolved Zinc Load Benefits from Specific Actions	**Alt 3**	**Alt 4**
Canyon Cr Impacted FP Seds (BUR141)	0.009	0.009
Verde May Mine UWR (WAL012)	0.000	0.000
Canyon Cr Formosa Reach FP Seds (OSB047)	0.629	0.768
Canyon Silver (Formosa) FP Seds (WAL011)	0.397	0.397
Canyon Silver (Formosa) Upland Tails (WAL011)	0.266	0.266
Canyon Silver (Formosa) UWR (WAL011)	0.000	0.001
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.178	0.660
Hecla Star Tailings Ponds FP Seds (WAL009)	4.983	6.577
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	7.537	7.692
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.012	0.028
Gem Portal 3 Discharge (WAL009)	20.790	20.790
Hecla-Star Tailings Pond Underflow (WAL009)	6.227	0.000
Canyon Silver Formosa Mine Adit (WAL011)	0.100	0.111
Total	41.129	37.300

River Segment Dissolved Zinc Load

Dissolved Zinc Load at A2	98.0	lbs/day	Sept. 2006
Dissolved Zinc Load at A6	156.0	lbs/day	Sept. 2006
Dissolved Zinc Load Gain from Sources	58.0	lbs/day	

Adits/Seeps/Groundwater	Total Load (lbs/day)	Amount of Load in Reach (%)	Load in this Reach (lbs/day)		
Star Mine Portal Discharge (WAL009)	1	100%	1.00	Sept. 2006 Data	
Hecla-Star Tailings Pond Underflow (WAL009)	18.45	55%	10.15	RI Data	Qtot = 205 gpm, Zn avg = 2-13 mg/L
SVNRT Repository Underflow (WAL042)	36.15	100%	36.15	RI Data	Q = 6850 ft3/d, Zn = 50-124 mg/L
Total Load from Adits/Seeps/Groundwater			47.30		
Dissolved Zinc Load Gain from Sources less adits/seeps/groundwater			10.70	This load used to calculate relative contribution of sources other than adits/seeps/groundwater below	

Pre-Remediation Dissolved Zinc Load Contributions (point estimates)

Source (Waste) Type (ST)	Relative Loading Potential (RLP)	Total Source Volume CY	PCT of Source in Reach %	Total Volume CY	Relative Total Volume CY	Source contribution % Total	Dissolved Zinc Load lbs/day	
Canyon Cr Gravel Pit UWR (WAL007)	0.003	5000	100%	5000	15	0.0%	0.000	
Sisters Mine UWR (WAL008)	0.003	14000	100%	14000	42	0.0%	0.001	
Hecla Star Tailings Ponds FP Seds (WAL009)	0.795	323000	55%	177327	140975	31.5%	3.375	
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	0.143	2100000	55%	1152900	164865	36.9%	3.947	
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.795	8100	100%	8100	6440	1.4%	0.154	Located beneath repository
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	0.143	600000	100%	600000	85800	19.2%	2.054	Located in repository (impounded)
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.795	61000	98%	59963	47671	10.7%	1.141	
Canyon Cr Impacted Floodplain Seds (WAL040)	0.795	18000	7%	1242	987	0.2%	0.024	
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.795	15000	3%	375	298	0.1%	0.007	
Total				2018907	447092	100%	10.703	

Adits/Seeps/Groundwater		Dissolved Zinc Load (lbs/day)
Star Mine Portal Discharge (WAL009)	1.00	1.00
Hecla-Star Tailings Pond Underflow (WAL009)	10.15	10.15
SVNRT Repository Underflow (WAL042)	36.15	36.15
Total		47.30
Total Dissolved Zinc Load from all Sources		58.0

Remedial Effectiveness Factors (not all remedial actions are applicable for each source type or source area)

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action
Canyon Cr Gravel Pit UWR (WAL007)	0.000	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Sisters Mine UWR (WAL008)	0.001	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla Star Tailings Ponds FP Seds (WAL009)	3.375	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	3.947	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.154	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	2.054	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	1.141	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Cr Impacted Floodplain Seds (WAL040)	0.024	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.007	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Star Mine Portal Discharge (WAL009)	1.000	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Hecla-Star Tailings Pond Underflow (WAL009)	10.148	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
SVNRT Repository Underflow (WAL042)	36.150	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00

Dissolved Zinc Load After Remediation

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action
Canyon Cr Gravel Pit UWR (WAL007)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sisters Mine UWR (WAL008)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Hecla Star Tailings Ponds FP Seds (WAL009)	3.375	0.034	0.607	0.844	0.101	0.742	0.169	1.552	0.034	0.371	3.375
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	3.947	0.039	0.710	0.987	0.118	0.868	0.197	1.815	0.039	0.434	3.947
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.154	0.002	0.028	0.039	0.005	0.034	0.008	0.071	0.002	0.017	0.154
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	2.054	0.021	0.370	0.513	0.062	0.452	0.103	0.945	0.021	0.226	2.054
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	1.141	0.011	0.205	0.285	0.034	0.251	0.057	0.525	0.011	0.126	1.141
Canyon Cr Impacted Floodplain Seds (WAL040)	0.024	0.000	0.004	0.006	0.001	0.005	0.001	0.011	0.000	0.003	0.024
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.007	0.000	0.001	0.002	0.000	0.002	0.000	0.003	0.000	0.001	0.007
Star Mine Portal Discharge (WAL009)	1.000	0.010	0.180	0.250	0.030	0.220	0.050	0.460	0.010	0.110	1.000
Hecla-Star Tailings Pond Underflow (WAL009)	10.148	0.101	1.827	2.537	0.304	2.232	0.507	4.668	0.101	1.116	10.148
SVNRT Repository Underflow (WAL042)	36.150	0.362	6.507	9.038	1.085	7.953	1.808	16.629	0.362	3.977	36.150

Source (Waste) Type (ST)	Alt 3 PCT	Alternative 3 Actions Identified in the FS (enter cell addresses manually, one value from each row)		Alt 4 PCT	Alternative 4 Actions Identified in the FS (enter cell addresses manually, one value from each row)	
Canyon Cr Gravel Pit UWR (WAL007)	0%	0.000	No Action	100%	0.000	Regrade/Reveg
Sisters Mine UWR (WAL008)	0%	0.001	No Action	100%	0.000	Regrade/Reveg
Hecla Star Tailings Ponds FP Seds (WAL009)	100%	0.607	Hydraulic Isolation/Treatment	100%	0.034	Excavate/Dispose
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	100%	0.118	Cap	100%	0.039	Excavate/Dispose
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0%	0.154	No Action	100%	0.002	Excavate/Dispose
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	100%	0.062	Cap	100%	0.021	Excavate/Dispose
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	27%	0.836	Excavate/Dispose	59%	0.475	Excavate/Dispose
Canyon Cr Impacted Floodplain Seds (WAL040)	72%	0.007	Excavate/Dispose	100%	0.000	Excavate/Dispose
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	27%	0.005	Excavate/Dispose	100%	0.000	Excavate/Dispose
Star Mine Portal Discharge (WAL009)	100%	0.010	Active Treatment	100%	0.010	Active Treatment
Hecla-Star Tailings Pond Underflow (WAL009)	100%	2.537	Hydraulic Isolation	0%	10.148	No Action
SVNRT Repository Underflow (WAL042)	0%	36.150	No Action	0%	36.150	No Action
		40.488	**Alt 3 Total**		**46.878**	**Alt 4 Total**

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Diss. Zinc Load After Alt. 3 Action (lbs/day)	Load Reducution (lbs/day)		Diss. Zinc Load After Alt. 4 Action (lbs/day)	Load Reducution (lbs/day)
Canyon Cr Gravel Pit UWR (WAL007)	0.000	0.000	0.00		0.000	0.00
Sisters Mine UWR (WAL008)	0.001	0.001	0.00		0.000	0.00
Hecla Star Tailings Ponds FP Seds (WAL009)	3.375	0.607	2.77	55% used for this reach	0.034	3.34
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	3.947	0.118	3.83	55% used for this reach	0.039	3.91
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.154	0.154	0.00		0.002	0.15
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	2.054	0.062	1.99		0.021	2.03
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	1.141	0.836	0.31		0.475	0.67
Canyon Cr Impacted Floodplain Seds (WAL040)	0.024	0.007	0.02		0.000	0.02
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.007	0.005	0.00		0.000	0.01
Star Mine Portal Discharge (WAL009)	1.000	0.010	0.99		0.010	0.99
Hecla-Star Tailings Pond Underflow (WAL009)	10.148	2.537	7.61		10.148	0.00
SVNRT Repository Underflow (WAL042)	36.150	36.150	0.00		36.150	0.00

Pre-Remediation Dissolved Zinc Load Gain	58.000	58.000
Post-Remediation Dissolved Zinc Load Gain	40.488	46.878
Benefit	17.512	11.122

Dissolved Zinc Load Benefits from Specific Actions	**Alt 3**	**Alt 4**
Canyon Cr Gravel Pit UWR (WAL007)	0.000	0.000
Sisters Mine UWR (WAL008)	0.000	0.001
Hecla Star Tailings Ponds FP Seds (WAL009)	2.767	3.341
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	3.828	3.907
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.000	0.153
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	1.992	2.033
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.305	0.667
Canyon Cr Impacted Floodplain Seds (WAL040)	0.017	0.023
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.002	0.007
Star Mine Portal Discharge (WAL009)	0.990	0.990
Hecla-Star Tailings Pond Underflow (WAL009)	7.611	0.000
SVNRT Repository Underflow (WAL042)	0.000	0.000
	17.512	11.122

River Segment Dissolved Zinc Load

Dissolved Zinc Load at A6	156	lbs/day	Sept. 2006
Dissolved Zinc Load at A7	173	lbs/day	Sept. 2006
Dissolved Zinc Load Gain from Sources	17.0	lbs/day	
Adits/Seeps/Groundwater	Load (lbs/day)		
Total Load from Adits/Seeps/Groundwater	0.00		
Dissolved Zinc Load Gain from Sources less adits/seeps/groundwater	17.00	This load used to calculate relative contribution of sources other than adits/seeps/groundwater below	

Pre-Remediation Dissolved Zinc Load Contributions (point estimates)

Source (Waste) Type (ST)	Relative Loading Potential (RLP)	Total Source Volume CY	PCT of Source in Reach %	Total Volume cy	Relative Total Volume cy	Source contribution % Total	Total Zinc Load lbs/day
Canyon Cr Impacted Floodplain Seds (WAL040)	0.795	18000	92%	16560	13165	57.5%	9.779
Wallace Old Private Landfill FP Fill (WAL081)	0.795	5700	100%	5700	4532	19.8%	3.366
Standard Mammoth Millsite Upland Tails (WAL039)	0.404	12500	100%	12500	5050	22.1%	3.751
Standard Mammoth Millsite UWR (WAL039)	0.003	47000	100%	47000	141	0.6%	0.105
Total				81760	22888	100%	17.000

Adits/Seeps/Groundwater		Dissolved Zinc Load (lbs/day)
	0.00	0.00
Total	0.00	0.00
Dissolved Zinc Load from all Sources		17.0

Remedial Effectiveness Factors (not all remedial actions are applicable for each source type or source area)

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action
Canyon Cr Impacted Floodplain Seds (WAL040)	9.779	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Wallace Old Private Landfill FP Fill (WAL081)	3.366	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Standard Mammoth Millsite Upland Tails (WAL039)	3.751	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00
Standard Mammoth Millsite UWR (WAL039)	0.105	0.01	0.18	0.25	0.03	0.22	0.05	0.46	0.01	0.11	1.00

Dissolved Zinc Load After Remediation

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Excavate/Dispose	Hyd. Iso. (facilities)	Hyd. Iso (stream reach)	Impounded Tailings Hyd. Iso + Cap	Impounded Tailings Hyd. Iso. Only (active)	Excavate/ Low K cap	Regrade/Reveg	Treat Active	Treat Passive	No Action	Alt 3 PCT	Alternative 3 Actions Identified in the FS (enter cell addresses manually, one value from each row)		Alt 4 PCT	Alternative 4 Actions Identified in the FS (enter cell addresses manually, one value from each row)	
Canyon Cr Impacted Floodplain Seds (WAL040)	9.779	0.098	1.760	2.445	0.293	2.151	0.489	4.498	0.098	1.076	9.779	72%	2.808	Excavate/Dispose	100%	0.098	Excavate/Dispose
Wallace Old Private Landfill FP Fill (WAL081)	3.366	0.034	0.606	0.841	0.101	0.740	0.168	1.548	0.034	0.370	3.366	50%	1.700	Excavate/Dispose	100%	1.548	Excavate/Dispose
Standard Mammoth Millsite Upland Tails (WAL039)	3.751	0.038	0.675	0.938	0.113	0.825	0.188	1.725	0.038	0.413	3.751	100%	0.038	Excavate/Dispose	100%	0.038	Excavate/Dispose
Standard Mammoth Millsite UWR (WAL039)	0.105	0.001	0.019	0.026	0.003	0.023	0.005	0.048	0.001	0.012	0.105	0%	0.105	No Action	100%	0.048	Regrade/Reveg
													4.650	**Alt 3 Total**			

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Diss. Zinc Load After Alt. 3 Action (lbs/day)	Load Reducution (lbs/day)	Diss. Zinc Load After Alt. 4 Action (lbs/day)	Load Reducution (lbs/day)
Canyon Cr Impacted Floodplain Seds (WAL040)	9.779	2.808	6.97	0.098	9.68
Wallace Old Private Landfill FP Fill (WAL081)	3.366	1.700	1.67	1.548	1.82
Standard Mammoth Millsite Upland Tails (WAL039)	3.751	0.038	3.71	0.038	3.71
Standard Mammoth Millsite UWR (WAL039)	0.105	0.105	0.00	0.048	0.06
Pre-Remediation Dissolved Zinc Load Gain		17.000		17.000	
Post-Remediation Dissolved Zinc Load Gain		4.650		1.732	
Benefit		12.350		15.268	

Total Zinc Load Benefits from Specific Actions	**Alt 3**	**Alt 4**
Canyon Cr Impacted Floodplain Seds (WAL040)	6.970	9.681
Wallace Old Private Landfill FP Fill (WAL081)	1.666	1.818
Standard Mammoth Millsite Upland Tails (WAL039)	3.713	3.713
Standard Mammoth Millsite UWR (WAL039)	0.000	0.057
	12.350	15.268

Source (Waste) Type (ST)	Dissolved Zinc Load Contribution (lbs/day)	Dissolved Zinc Load After Alt. 3 Action (lbs/day)	Load Reducution (lbs/day)	Dissolved Zinc Load Contribution (lbs/day)	Dissolved Zinc Load After Alt. 4 Action (lbs/day)	Load Reducution (lbs/day)
A1-A2						
Canyon Cr Impacted FP Seds (BUR141)	0.009	0.000	0.009	0.009	0.00	0.009
Verde May Mine UWR (WAL012)	0.000	0.000	0.000	0.000	0.00	0.000
Canyon Cr Formosa Reach FP Seds (OSB047)	0.775	0.146	0.629	0.775	0.01	0.768
Canyon Silver (Formosa) FP Seds (WAL011)	0.401	0.004	0.397	0.401	0.00	0.397
Canyon Silver (Formosa) Upland Tails (WAL011)	0.269	0.003	0.266	0.269	0.00	0.266
Canyon Silver (Formosa) UWR (WAL011)	0.002	0.002	0.000	0.002	0.00	0.001
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.667	0.489	0.178	0.667	0.01	0.660
Hecla Star Tailings Ponds FP Seds (WAL009)	6.644	1.661	4.983	6.644	0.07	6.577
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	7.770	0.233	7.537	7.770	0.08	7.692
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.047	0.035	0.012	0.047	0.02	0.028
A2-A6						
Canyon Cr Gravel Pit UWR (WAL007)	0.000	0.000	0.000	0.000	0.000	0.000
Sisters Mine UWR (WAL008)	0.001	0.001	0.000	0.001	0.000	0.001
Hecla Star Tailings Ponds FP Seds (WAL009)	3.375	0.607	2.767	3.375	0.034	3.341
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	3.947	0.118	3.828	3.947	0.039	3.907
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.154	0.154	0.000	0.154	0.002	0.153
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	2.054	0.062	1.992	2.054	0.021	2.033
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	1.141	0.836	0.305	1.141	0.475	0.667
Canyon Cr Impacted Floodplain Seds (WAL040)	0.024	0.007	0.017	0.024	0.000	0.023
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.007	0.005	0.002	0.007	0.000	0.007
A6-A7						
Canyon Cr Impacted Floodplain Seds (WAL040)	9.779	2.808	6.970	9.7785	0.0978	9.6808
Wallace Old Private Landfill FP Fill (WAL081)	3.366	1.700	1.666	3.3658	1.5483	1.8175
Standard Mammoth Millsite Upland Tails (WAL039)	3.751	0.038	3.713	3.7509	0.0375	3.7134
Standard Mammoth Millsite UWR (WAL039)	0.105	0.105	0.000	0.1047	0.0482	0.0566
Total	44.288	9.015	35.273	44.288	2.489	41.799

Totals for each Alt 3. Action by BLM site:	***Load Reduction (lbs/day)***	Alternative
Canyon Cr Formosa Reach FP Seds (OSB047)	0.629	WP-2a
Canyon Silver (Formosa) FP Seds (WAL011)	0.397	WP-2c
Canyon Silver (Formosa) Upland Tails (WAL011)	0.266	WP-4a
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.180	WP-2b
Hecla Star Tailings Ponds FP Seds (WAL009)	7.750	WP-1a
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	11.365	WP-3a
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	1.992	WP-3b
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.317	WP-2e
Canyon Cr Impacted Floodplain Seds (WAL040)	6.987	WP-2d
Wallace Old Private Landfill FP Fill (WAL081)	1.666	WP-4c
Standard Mammoth Millsite Upland Tails (WAL039)	3.713	WP4b
	35.264	

Totals for each Alt 4. Action by BLM site:	***Load Reduction (lbs/day)***	Alternative
Verde May Mine UWR (WAL012)	0.000	WP-6d
Canyon Cr Formosa Reach FP Seds (OSB047)	0.768	WP-2f
Canyon Silver (Formosa) FP Seds (WAL011)	0.397	WP-2c
Canyon Silver (Formosa) Upland Tails (WAL011)	0.266	WP-5a
Canyon Silver (Formosa) UWR (WAL011)	0.001	WP-6c
Canyon Creek Pond Reach SVNRT FP Seds (WAL010)	0.667	WP-2g
Hecla Star Tailings Ponds FP Seds (WAL009)	9.918	WP-2j
Hecla Star Tailings Ponds FP Tails (impounded) (WAL009)	11.599	WP-4a
Canyon Creek Repository Reach SVNRT FP Seds (WAL041)	0.694	WP-2i
Standard Mammoth Millsite Upland Tails (WAL039)	3.713	WP-5b
Canyon Cr Gravel Pit UWR (WAL007)	0.000	WP-6a
Sisters Mine UWR (WAL008)	0.001	WP-6b
Canyon Creek Tailings Repository SVNRT FP Seds (WAL042)	0.153	WP-2k
Canyon Creek Tailings Repository SVNRT FP Tails (WAL042)	2.033	WP-4b
Canyon Cr Impacted Floodplain Seds (WAL040)	9.704	WP-2h
Wallace Old Private Landfill FP Fill (WAL081)	1.818	WP-5d
Standard Mammoth Millsite UWR (WAL039)	0.057	WP-6e
	41.790	

Attachment E-3
Detailed Cost Analyses
of Remedial Options A through D

Option A
Stream Liners and Source Control Actions

Creek Lining A1-A2

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (miles)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)
WP-8a	C14b	Stream Liner A1-A2	$ 505	9,900	--	$ 5,000,000	70%	$ 3,500,000	$ 8,500,000	4%	$ 16,100	$ 200,000	$ 8,700,000
	Total					**$ 5,000,000**		**$ 3,500,000**	**$ 8,500,000**		**$ 16,100**	**$ 200,000**	**$ 8,700,000**
Source Control Actions		See Source Control Action Cost Sheet											
	Total					**$ 1,860,000**		**$ 1,300,000**	**$ 3,160,000**		**$ 13,400**	**$ 166,000**	**$ 3,330,000**
Total Cost of Alternative						**$ 6,860,000**		**$ 4,800,000**	**$ 11,700,000**		**$ 29,500**	**$ 366,000**	**$ 12,000,000**

Notes:
[1] TCD = typical conceptual design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

Option B
French Drains and Source Control Actions

French Drain A1-A6 with A6 Cutoff and SVNRT Toe-Drain

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (miles)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)
WP-8b, WP-8c	C15b	French Drain (A1-A6, A6 cutoff, SVNRT Toe)	$ 907.00	17,600	--	$ 16,000,000	70%	$ 11,200,000	$ 27,100,000	2%	$ 25,700	$ 319,000	$ 27,500,000
	WT01	Active Treatment	$ 679.00	--	664	$ 451,000	107%	$ 483,000	$ 934,000	99%	$ 36,000	$ 447,000	$ 1,380,000
	PIPE-3	Conveyance Pipe - 24"	$ 139.00	7,280		$ 1,010,000	70%	$ 708,000	$ 1,720,000	8%	$ 6,520	$ 81,000	$ 1,800,000
	Total					**$ 17,400,000**		**$ 12,400,000**	**$ 29,800,000**		**$ 68,300**	**$ 847,000**	**$ 30,600,000**
Source Control Actions		See Source Control Action Cost Sheet											
	Total					**$ 1,860,000**		**$ 1,300,000**	**$ 3,161,038**		**$ 13,400**	**$ 166,000**	**$ 3,330,000**
Total Cost of Alternative						**$ 19,300,000**		**$ 13,700,000**	**$ 33,000,000**		**$ 81,700**	**$ 1,010,000**	**$ 34,000,000**

Notes:
[1] TCD = typical conceptual design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

Option C
Stream Liners, French Drains, and Source Control Actions

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (miles)		Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)
WP-8d, WP-8c	C15b	French Drain A2-A6 with A6 Cut-off, SVNRT drain	$ 907.00	7,800	--	--	$ 7,070,000	70%	$ 4,950,000	$ 12,030,000	2%	$ 11,400	$ 141,000	$ 12,200,000
	C14b	Stream Liner A2-A4	$ 505.00	2,700	--	--	$ 1,360,000	70%	$ 950,000	$ 2,320,000	4%	$ 4,400	$ 54,500	$ 2,370,000
	WT-01	Active Treatment	$ 679.00	--	1,329		$ 902,000	107%	$ 966,000	$ 1,870,000	99%	$ 72,100	$ 894,000	$ 2,760,000
	PIPE-2	Conveyance Pipe - 12"	$ 86.20	4,500			$ 388,000	70%	$ 272,000	$ 659,000	8%	$ 2,500	$ 31,000	$ 690,000
	Total						**$ 9,730,000**		**$ 7,140,000**	**$ 16,900,000**		**$ 90,400**	**$ 1,120,000**	**$ 18,000,000**
Source Control Actions			See Source Control Action Cost Sheet											
	Total						**$ 1,860,000**		**$ 1,300,000**	**$ 3,160,000**		**$ 13,400**	**$ 166,000**	**$ 3,330,000**
Total Cost of Alternative							**$ 11,600,000**		**$ 8,450,000**	**$ 20,000,000**		**$ 104,000**	**$ 1,290,000**	**$ 21,300,000**

Notes:
[1] TCD = typical conceptual design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

Option D
Extensive Stream Liners/French Drains and Source Control Actions

Remedial Action	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (miles)	Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)
WP-8e, WP-8c	C15b	French Drain A1-A6 with A1 and A6 Cut-offs, SVNRT drain	$ 907.00	17,800	--	$ 16,100,000	70%	$ 11,300,000	$ 27,400,000	2%	$ 26,000	$ 323,000	$ 27,800,000
	C14b	Stream Liner A1-A6	$ 505.00	15,000	--	$ 7,580,000	70%	$ 5,300,000	$ 12,900,000	4%	$ 24,400	$ 303,000	$ 13,200,000
	WT01	Active Treatment	$ 679.00	--	1,193	$ 810,000	107%	$ 867,000	$ 1,678,000	99%	$ 64,700	$ 803,000	$ 2,480,000
	PIPE-2	Conveyance Pipe - 12"	$ 86.20	3,280		$ 283,000	70%	$ 198,000	$ 481,000	8%	$ 1,820	$ 22,600	$ 503,000
	Total					**$ 24,800,000**		**$ 17,700,000**	**$ 42,500,000**		**$ 117,000**	**$ 1,450,000**	**$ 43,900,000**
Source Control Actions			See Source Control Action Cost Sheet										
	Total					**$ 1,860,000**		**$ 1,300,000**	**$ 3,160,000**		**$ 13,400**	**$ 166,000**	**$ 3,330,000**
Total Cost of Alternative						**$ 26,700,000**		**$ 19,000,000**	**$ 45,600,000**		**$ 130,000**	**$ 1,620,000**	**$ 47,300,000**

Notes:
[1] TCD = typical conceptual design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions:
Quantities for PIPE measured from GIS figure. Conveyance pipe quantities include pipe from each source to I-90 in Wallace. Does not include cost of conveyance line from Wallace to CTP.
Active treatment costs (capital and O&M) are based on *Technical Memorandum: Issues Associated with CTP Expansion for Other OU2/OU3 Source Waters* (CH2M HILL, 2006)
Quantities for active treatment are based on design (high) flow estimates from the numerical groundwater model.
Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified.
Indirect cost is assumed as 70% for all TCDs.

Source Control Actions
Applied to Options A through D

Source Site	TCD[1]	TCD Description	Direct Capital Unit Cost	QTY (LF)	QTY (MI)		Direct Capital Cost	Indirect Cost (%)	Indirect Capital Cost	Total Capital Cost	O&M Percentage[2] (30 YR NPV)	O&M Cost (Annual Average)	O&M Cost (30 YR NPV)	Total Cost (30 YR NPV)	Comments
OSB047	C01B	Excavation	$ 13.20	3,485			$ 46,000	70%	$ 32,000	$ 78,000	0%	$ -	$ -	$ 78,200	
	C08A	Regional Repository	$ 17.70	3,485			$ 61,700	70%	$ 43,000	$ 105,000	14%	$ 696	$ 8,636	$ 113,000	
	HAUL2	Waste Hauling	$ 1.10	3,485	5		$ 19,100	70%	$ 13,000	$ 33,000	0%	$ -	$ -	$ 32,500	
	Total						**$ 126,819**		**$ 88,800**	**$ 216,000**		**$ 696**	**$ 8,636**	**$ 224,000**	Shallow souce control
WAL010	C01B	Excavation	$ 13.20	1,013			$ 13,400	70%	$ 9,360	$ 22,700	0%	$ -	$ -	$ 22,700	
	C08A	Regional Repository	$ 17.70	1,013			$ 17,900	70%	$ 13,000	$ 30,000	14%	$ 202	$ 2,510	$ 33,000	
	HAUL2	Waste Hauling	$ 1.10	1,013	5		$ 5,600	70%	$ 3,890	$ 9,450	0%	$ -	$ -	$ 9,450	
	Total						**$ 36,845**		**$ 25,800**	**$ 62,600**		**$ 202**	**$ 2,510**	**$ 65,100**	Shallow souce control
WAL011	C01B	Excavation	$ 13.20	2,200			$ 29,000	70%	$ 20,000	$ 49,000	0%	$ -	$ -	$ 49,400	
	C08A	Regional Repository	$ 17.70	2,200			$ 38,900	70%	$ 27,000	$ 66,000	14%	$ 439	$ 5,450	$ 71,600	
	HAUL2	Waste Hauling	$ 1.10	2,200	5		$ 12,100	70%	$ 8,455	$ 20,500	0%	$ -	$ -	$ 20,500	
	Total						**$ 80,058**		**$ 56,000**	**$ 136,000**		**$ 439**	**$ 5,450**	**$ 142,000**	Shallow souce control
WAL039	C01	Excavation	$ 4.20	12,500			$ 53,000	70%	$ 37,000	$ 89,000	0%	$ -	$ -	$ 89,000	
	C08A	Regional Repository	$ 17.70	12,500			$ 221,000	70%	$ 155,000	$ 376,000	14%	$ 2,500	$ 31,000	$ 407,000	
	HAUL2	Waste Hauling	$ 1.10	12,500	5		$ 68,600	70%	$ 48,000	$ 117,000	0%	$ -	$ -	$ 117,000	
	Total						**$ 342,000**		**$ 240,000**	**$ 582,000**		**$ 2,500**	**$ 31,000**	**$ 613,000**	Same as Alt 3 action
WAL040	C01B	Excavation	$ 13.20	12,960			$ 171,000	70%	$ 120,000	$ 291,000	0%	$ -	$ -	$ 291,000	
	C08A	Regional Repository	$ 17.70	12,960			$ 229,000	70%	$ 161,000	$ 390,000	14%	$ 2,590	$ 32,100	$ 422,000	
	HAUL2	Waste Hauling	$ 1.10	12,960			$ 71,200	70%	$ 49,800	$ 121,000	0%	$ -	$ -	$ 121,000	
	Total						**$ 472,000**		**$ 330,000**	**$ 802,000**		**$ 2,590**	**$ 32,100**	**$ 834,000**	Same as Alt 3 action
WAL041	C01B	Excavation	$ 13.20	3,965			$ 52,300	70%	$ 36,600	$ 89,000	0%	$ -	$ -	$ 89,000	
	C08A	Regional Repository	$ 17.70	3,965			$ 70,200	70%	$ 49,100	$ 119,000	14%	$ 790	$ 9,800	$ 129,000	
	HAUL2	Waste Hauling	$ 1.10	3,965	5		$ 21,800	70%	$ 15,200	$ 37,000	0%	$ -	$ -	$ 37,000	
	Total						**$ 144,000**		**$ 101,000**	**$ 245,000**		**$ 790**	**$ 9,800**	**$ 255,000**	Shallow source control
WAL081	C01	Excavation	$ 4.20	2,850			$ 12,000	70%	$ 8,380	$ 20,300	0%	$ -	$ -	$ 20,300	
	C08A	Regional Repository	$ 17.70	2,850			$ 50,400	70%	$ 35,000	$ 86,000	14%	$ 569	$ 7,100	$ 92,800	
	HAUL2	Waste Hauling	$ 1.10	2,850	5		$ 15,600	70%	$ 11,000	$ 27,000	0%	$ -	$ -	$ 26,600	
	Total						**$ 78,100**		**$ 54,600**	**$ 133,000**		**$ 569**	**$ 7,100**	**$ 140,000**	Same as Alt 3 action
WAL042	C03	Native Soil Cap	$ 225,000.00	600,000		2.6	$ 579,000	70%	$ 406,000	$ 985,000	12%	$ 5,600	$ 69,500	$ 1,050,000	
	Total						**$ 579,000**		**$ 406,000**	**$ 985,000**		**$ 5,600**	**$ 69,500**	**$ 1,050,000**	Cap of 50% of SVNRT to reduce erosion potential
	TOTAL						**$ 1,860,000**		**$ 1,300,000**	**$ 3,160,000**		**$ 13,400**	**$ 166,000**	**$ 3,330,000**	

Notes:
[1] TCD = typical conceptual design
[2] O&M percentage multiplied by Total Direct Cost to calculate 30-year NPV O&M cost
Quantity (QTY) Abbreviations:
LF = linear feet
CY = cubic yards
AC = acres
CFS = cubic feet per second
MI = miles

Assumptions: Retained TCDs from 2001 FS Report have only been modified to bring costs to present value. O&M percentages have not be modified. Indirect cost is assumed as 70% for all TCDs.

NOTE: The above costs are presented rounded to three significant figures

NOTE: The above cost opinion is a Feasibility-Study-level estimate with a nominal accuracy of –30 percent to +50 percent (–30/+50%).

NOTE: The above cost opinion is in 2009 dollars and does not include future escalation. The order-of-magnitude cost opinion shown has been prepared for guidance in project evaluation from the information available at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, the final project scope, the final project schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

APPENDIX F

Remedial Options Considered But Not Evaluated in the Focused Feasibility Study

Contents

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Acronyms and Abbreviations

CIA	Central Impoundment Area
FFS	Focused Feasibility Study
gpm	gallons per minute
IDEQ	Idaho Department of Environmental Quality
mg/kg	milligrams per kilogram
NPV	net present value
O&M	operation and maintenance
OU	Operable Unit
PFT	Project Focus Team
PRB	permeable reactive barrier
SFCDR	South Fork of the Coeur d'Alene River
USEPA	U.S. Environmental Protection Agency

APPENDIX F

Remedial Options Considered But Not Evaluated in the Focused Feasibility Study

This appendix describes four different types of remedial options that were considered as the Focused Feasibility Study (FFS) was developed, but ultimately were not included in the remedial actions described and evaluated in the FFS Report. These remedial options included:

- **Limestone permeable reactive barrier (PRB**). An evaluation of *in situ* limestone PRB for treatment of contaminated groundwater focused on using a limestone PRB as a partial replacement of the French drains on the north side of the Central Impoundment Area (CIA) included in Operable Unit 2 (OU 2) Alternatives (c) and (d).
- **Remedial options for the western portion of OU 2.** A variety of options were considered for remediation of the western portion of OU 2 to address metals loading to surface water in this area.
- **Lime lagoon treatment system in the Woodland Park area of Canyon Creek.** This evaluation explored the concept of treating groundwater in surface ponds to remove metals. Extracted groundwater would be dosed with lime and conveyed to open-air lagoons for precipitation of metals.
- **Sedimentation basins for removal of suspended sediments.** This evaluation explored the potential configurations and effectiveness of sedimentation basins in both Smelterville Flats on the South Fork of the Coeur d'Alene River (SFCDR) and the Woodland Park area of Canyon Creek.

These options are described and discussed in Sections F.1 through F.4, respectively. Attachment F-1 provides documentation of the limestone PRB evaluation, and Attachment F-2 contains a Technical Memorandum documenting the sedimentation basin effectiveness evaluation.

F.1 Limestone Permeable Reactive Barrier

This section is intended to briefly summarize work associated with the potential remedial action of treating OU 2 groundwater using an *in situ* alkalinity-generating PRB. This idea was originally developed and proposed by the Idaho Department of Environmental Quality (IDEQ) and its consultants. Conceptually, the PRB would add alkalinity to the groundwater as it flows through the PRB (containing an alkaline material such as limestone), raising pH slightly, and thereby enhancing adsorption of dissolved metals to iron oxy-hydroxide precipitates downgradient of the PRB and reducing metals loading to the SFCDR in the Bunker Hill "Box". The PRB would be located in a position to intercept and treat groundwater containing elevated concentrations of dissolved metals upgradient from the SFCDR. For cost estimating purposes, it was assumed that the PRB would be 4,225 feet long and be located on the northwest side of the CIA, running east to west roughly parallel to the SFCDR.

Section F.1.1 lists the documentation associated with this evaluation and provided in Attachment F-1. Section F.1.2 summarizes technical feasibility issues of concern related to the limestone PRB. Section F.1.3 presents current cost estimates for the limestone PRB option in comparison to OU 2 Alternatives (c) and (d).

F.1.1 Documentation

Documents comprising development, feasibility evaluation, and cost estimating for a limestone PRB system are listed below and included in Attachment F-1.

Date and Reference	Brief Description
May 29, 2009 (Hickman et al., 2009)	Memorandum providing a brief evaluation of feasibility considerations.
June 29, 2009 (Wilkin, 2009)	Memorandum from Rick Wilkin/U.S. Environmental Protection Agency (USEPA) reviewing the document above.
July 22, 2009 (Niemet et al., 2009a)	Revision of the previous memorandum, reiterating discussion of feasibility considerations and developing more detailed design assumptions.
July 31, 2009 (Hopster et al., 2009)	Comments on the document immediately above from the IDEQ and its consultants.
August 11, 2009 (Niemet et al., 2009b)	CH2M HILL's responses to comments presented in the document immediately above.
August 31, 2009 (Stefanoff, 2009a)	Memorandum presenting cost estimates for three options for OU 2 Alternative 3 (described elsewhere): 3a – French drain; 3b – PRB 35 feet deep; 3c – PRB 25 feet deep.
September 9, 2009 (Stefanoff, 2009b)	Slides on PRB cost estimates presented at the Project Focus Team (PFT) meeting on 9 September 2009.

F.1.2 Technical Feasibility

Several issues related to limestone PRB feasibility were discussed in the documents listed in Section F.1.1 and provided in Attachment F-1. The main issues of concern with respect to this relatively unproven technology are:

- Uncertainty about treatment effectiveness, and the need for laboratory and field pilot testing
- Reversibility of treatment reactions, and the need to maintain the PRB system indefinitely
- Potential for clogging and bypass within and downgradient of the PRB
- Uncertainty about the PRB's effective service life
- Potential for armoring of reactive media (limestone) and shortening of lifespan
- Deep trenching implementation issues and high cost

F.1.3 Cost Estimates

Preliminary cost estimates for certain OU 2 remedial alternatives were presented in the last two documents listed in Section F.1.1. Due to some renaming and reorganization of the remedial alternatives, the identifiers and estimated costs were revised subsequent to the issuance of the cited documents. The OU 2 Alternative called "3a" in the cited documents (Stefanoff, 2009a, 2009b), does not include a PRB, and forms the basis for current OU 2 Alternatives (c) and (d). The main difference between OU 2 Alternatives (c) and (d) is that Alternative (d) includes stream lining up Government Gulch with a slurry cutoff wall and extraction wells at the upstream end of the liner, for collection of relatively clean water for discharge to the lined channel. The OU 2 Alternative called "3b" in the cited documents (including a 35-foot-deep PRB) forms the basis for the PRB component of OU 2 Alternatives (c) and (d), referred to as Alternatives (c2) and (d2). The OU 2 Alternative called "3c" in the cited documents (including a 25-foot-deep PRB) has been eliminated because it is believed that groundwater capture would be appreciably impaired using a shallower PRB (not extending to the depth of a relatively impermeable layer). Final cost estimates for the OU 2 remedial alternatives with a limestone PRB as a component [(c2 and d2)] are presented below, along with analogous alternatives without a limestone PRB [(c) and (d)] for comparison.

As shown below, the estimated costs for the alternatives with a PRB component are higher (in terms of total 30-year net present value [NPV] cost) than the corresponding alternatives with a French drain component. Given this projected higher cost and high degree of uncertainty related to effectiveness, these options were not carried forward in the FFS.

Remedial Alternative	Total Capital Cost	Annual O&M Cost	Total 30-Year NPV Cost
OU 2 Alternative (c)	$21,800,000	$467,000	$27,600,000
OU 2 Alternative (c2)	$27,900,000	$148,000	$29,800,000
OU 2 Alternative (d)	$32,900,000	$521,000	$39,400,000
OU 2 Alternative (d2)	$38,800,000	$207,000	$41,400,000

NPV = net present value; O&M = operation and maintenance

F.2 Remedial Options for the Western Portion of Operable Unit 2

Throughout the process of the development of the OU 2 remedial alternatives, various configurations of actions in the western portion of OU 2 (located within the Bunker Hill Box) were evaluated using the SFCDR Watershed model. The model is described in Appendix A of the FFS Report. The actions included:

- Lining of Grouse and Humboldt Creeks, and conveying the surface water to the south of Page Ponds directly to the SFCDR as part of the "liner only" alternatives
- Removing the weirs in the Page Swamps

- Lining of Page Ponds and the Smelterville wastewater treatment ponds
- Lining various portions of the SFCDR through the western portion of the Bunker Hill Box as part of the "liner only" alternatives
- Installing a French drain adjacent to the gaining section of the SFCDR in Smelterville Flats as part of the "drain only" alternatives

Various configurations of these actions were evaluated both individually and as part of the combined remedial alternatives for the Upper Coeur d'Alene Basin. During the remedial action evaluation process, it was determined that insufficient data were available with which to accurately assess the magnitude of groundwater-surface water interaction and the current distribution of surface and groundwater quality to the degree necessary to accurately assess the potential benefits of remedial actions in the Page Ponds area. Further evaluation of these actions was deferred until additional data could be collected. The coarse resolution of the topographic coverage in the western Box overall and the limited stream stage data for the western SFCDR resulted in uncertainty with regard to groundwater-surface water interaction in the Smelterville Flats area. In addition, historical groundwater-surface water interaction studies show that the dissolved zinc load to the SFCDR within the western portion of the Bunker Hill Box is relatively small when compared to the load gained within the eastern portion of the Box. Because of these factors, the actions listed above (except the lining of the Page Ponds and Smelterville wastewater treatment ponds) were only retained in OU 2 Alternative (e).

F.3 Lime Lagoon Treatment

A design for a pilot-scale (300 gallons-per-minute [gpm]) system was developed for Canyon Creek under a Clean Water Act grant administered by the State of Idaho. Because of land constraints, this option was not considered in the development of updated remedial actions for Woodland Park. The 300-gpm pilot plant was projected to require an area of 15 acres, and scaling-up of the plant for higher flow rates is expected to be only slightly less than linear based on flow (i.e., a flow rate of 600 gpm would require nearly 30 acres). Therefore, treatment of any of the flow rates considered in the FFS for Woodland Park (approximately 600 gpm or above) would not be feasible given the available land at the site (available acreage is uncertain but likely to be less than 30 acres, perhaps far less). Other technical issues associated with the proposed system remain unresolved, such as how treatment solids would be managed; how effluent would be effectively discharged to Canyon Creek given the aquifer conditions; the potential to mobilize additional metals from the subsurface if infiltration ponds were used; and the ability to meet projected stream discharge standards.

F.4 Sedimentation Basins

Configurations for sedimentation basins and their potential effectiveness were evaluated at two locations: Smelterville Flats on the SFCDR, and Woodland Park on Canyon Creek. The Technical Memorandum in Attachment F-2 presents the methodology and findings of the evaluation.

Alternative basin configurations were developed for both locations based on local site constraints such as topography and adjacent infrastructure. The analysis showed that the sedimentation basins at Smelterville Flats would be considerably more effective than those at Woodland Park. In addition, construction of one basin configuration at Smelterville Flats would likely reduce lead concentrations in sediments below the confluence of the SFCDR and the North Fork of the river (assuming complete mixing of sediments) to a level less than the 530 milligram per kilogram (mg/kg) preliminary remediation goal for flow conditions up to the 100-year event. However, the size of the basin required to achieve this level of performance is extremely large and would require construction of a large dam at Smelterville Flats, relocation of the Shoshone County Airport, and realignment of Interstate 90.

The results of this evaluation indicate that, for effective sediment removal in the Upper Basin, the sedimentation basin would need to be of such magnitude that it would be very difficult—if not impossible—to implement. For this reason, the sedimentation basin concept was not evaluated further in the FFS Report for the Upper Basin. However, future evaluations may include consideration of smaller-scale sedimentations basins that could remove a fraction of the sediment load and be combined with other actions to achieve remedial objectives.

F.5 References

Hickman, G., et al. May 29, 2009. *Evaluation of Groundwater pH Adjustment to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box*. Draft memorandum from CH2M HILL to Anne Dailey and Bill Adams/U.S. Environmental Protection Agency Region 10.

Hopster, D., et al. July 31, 2009. *Comments on Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box*. Memorandum to Anne Dailey and Bill Adams /U.S. Environmental Protection Agency Region 10 and Jim Stefanoff/CH2M HILL.

Niemet, M., et al. July 22, 2009 (2009a). *Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box*. Memorandum from CH2M HILL to Anne Dailey and Bill Adams/U.S. Environmental Protection Agency Region 10.

Niemet, M., et al. August 11, 2009 (2009b). *Response to Comments on Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box*. Draft memorandum from CH2M HILL to Anne Dailey and Bill Adams/U.S. Environmental Protection Agency Region 10.

Pioneer Technical Services. August 24, 2007. *100% Conceptual Design for the Canyon Creek Pilot-Scale Lime Lagoon Treatment System.* Prepared for the Idaho Department of Environmental Quality.

Stefanoff, J. August 31, 2009 (2009a). *Box Alternative 3 FFS Cost Estimates*. Memorandum from Jim Stefanoff/CH2M HILL to Joan Stoupa/CH2M HILL.

Stefanoff, J. September 9, 2009 (2009b). Slides from presentation at Project Focus Team meeting.

Wilkin, R. June 29, 2009. *Review of the technical memorandum titled "Evaluation of Groundwater pH Adjustment to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box"*. Memorandum from Richard Wilkin/USEPA to Anne Dailey/USEPA Region 10.

Attachment F-1
Documentation of Limestone Permeable Reactive Barrier (PRB) Evaluation

Attachment F-1: Documentation of Limestone Permeable Reactive Barrier (PRB) Evaluation

This attachment provides the documents listed below in sequential order. These documents comprise the development, feasibility evaluation, and cost estimating for the limestone permeable reactive barrier (PRB) remedial option. A current cost estimate is provided in the text of Appendix F.

Date and Reference	Brief Description
May 29, 2009 (Hickman et al., 2009)	Memorandum providing a brief evaluation of feasibility considerations.
June 29, 2009 (Wilkin, 2009)	Memorandum from Rick Wilkin/U.S. Environmental Protection Agency (USEPA) reviewing the document above.
July 22, 2009 (Niemet et al., 2009a)	Revision of the previous memorandum, reiterating discussion of feasibility considerations and developing more detailed design assumptions.
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September 9, 2009 (Stefanoff, 2009b)	Slides on PRB cost estimates presented at the Project Focus Team (PFT) meeting on 9 September 2009.

Evaluation of Groundwater pH Adjustment to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box

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DATE: May 29, 2009

Introduction

This memorandum presents rough conceptual design assumptions and discusses feasibility considerations for a remediation approach consisting of adjusting groundwater pH *in situ* to immobilize dissolved metals, and thereby reduce metals loading to the South Fork Coeur d'Alene River (SFCDR) in the Bunker Hill Box. Groundwater pH adjustment would be achieved using a permeable reactive barrier (PRB) that introduces alkalinity to the subsurface. The PRB would be located in a position to intercept and treat groundwater containing elevated concentrations of dissolved metals, principally zinc with lower levels of cadmium. This evaluation was performed to support the analysis of a geochemical approach proposed by TerraGraphics, a contractor to the Idaho Department of Environmental Quality (IDEQ), for reducing transport of dissolved metals in groundwater to the SFCDR. The principal removal mechanism reportedly achieved by this approach is adsorption of zinc to iron hydroxide.

Conceptual Design Assumptions

The area selected, for the purposes of this evaluation, as a representative implementation location for a pH-adjustment PRB is along the northern boundary of the Central Impoundment Area (CIA) (designated with red cross-hatching in **Figure 1**). This is the same area that is being considered for groundwater collection, using French drains, for treatment at the Bunker Hill Central Treatment Plant (CTP) in the focused ecological feasibility study (FEFS, in preparation). This is an area where groundwater contains relatively high concentrations of dissolved zinc and cadmium and where substantial metals loading to the SFCDR is occurring. The approximate length of this area is 4,150 ft, and the approximate saturated thickness assumed here as the depth interval for treatment is 11 ft (from the water table to the upper confining unit, roughly 9 ft below ground surface [bgs] to 20 ft bgs). The area around the A-4 ponds has also been mentioned in conference calls as a possible location for implementing the pH-adjustment approach, but that area was not considered in this evaluation, in part because contaminated groundwater emanating from the A-4 area could be intercepted and treated north of the CIA before reaching the SFCDR.

The following implementation scenarios were considered in this evaluation:

1. PRB created by injecting a liquid alkaline reagent using a linear array of vertical injection wells. Two liquid reagents were considered: aqueous solutions of sodium carbonate [Na_2CO_3] and sodium hydroxide [NaOH]. Note that other implementation approaches are possible for creating a liquid-reagent PRB for pH adjustment. These include a linear array of paired injection and extraction wells, a linear injection trench containing coarse granular media and horizontal perforated piping with vertical injection risers, and others. One or more of these options may provide practical benefits over the simple vertical injection well approach, but they would require additional groundwater flow modeling to evaluate and were not considered in detail here.

2. PRB created by trenching and backfilling with solid media consisting of an inert coarse granular material (e.g., pea gravel) and a solid alkaline reagent. Limestone [$CaCO_3$] was assumed to be the reagent used, although dolomite [$CaMg(CO_3)_2$] or magnesium carbonate [$MgCO_3$] are also possible.

Preliminary conceptual design assumptions for these scenarios are summarized in **Tables 1-3**. These assumptions could be used, after further development and refinement, as the basis for cost estimates, if warranted.

Feasibility Considerations

Treatment Effectiveness

A thorough evaluation of technology effectiveness would likely require laboratory and/or field pilot testing. We recommend the following steps for evaluating effectiveness: (1) geochemical modeling, (2) laboratory column testing, (3) field pilot testing. These three steps should be conducted in sequence to rigorously evaluate treatment effectiveness and design and operating parameters; however, if any step yields sufficiently negative results to indicate that feasibility at this site is unlikely, subsequent steps could be omitted.

Modeling was conducted by CH2M HILL, using the PHREEQC model and groundwater chemistry data for monitoring well BH-SF-E-0423-U (Oct-08 analysis), to obtain a preliminary indication of the treatment effectiveness that might be achievable by the pH-adjustment PRB approach. The modeling results indicate that the amount of dissolved zinc that would be removed by raising the groundwater pH from the ambient level (5.6) to 6.5 could be significant, but the simulations are very sensitive to unknown parameters, especially the amount of pre-existing solid iron hydroxide in the system prior to pH adjustment. For example, the modeling results indicate that very little zinc would be removed (about 0.05 mg/L out of an initial concentration of 29.4 mg/L, or <0.2%) by reaction with the incremental iron hydroxide that would be freshly precipitated as a result of the rise in pH. A far greater amount of zinc could be adsorbed to pre-existing iron hydroxide, which adsorbs more zinc with increasing pH. However, the amount of iron hydroxide initially present in the aquifer matrix is not known, and the model results are highly sensitive to the value chosen. At present it has not been demonstrated that groundwater along Bunker Creek is in equilibrium with solid phase iron oxide or hydroxide. If conditions are reducing, then no solids would be expected to be present, and increasing pH would have little if any effect on zinc concentrations. By contrast, if conditions are more oxidizing and iron oxides are present in amounts typical of oxidized, granitic material, then a rise in pH to 6.5 could remove most of the dissolved zinc present, according to model simulations. Thus, the sensitivity of the model to the assumed initial conditions prevents an accurate prediction of PRB effectiveness at this time.

On the basis of limited sensitivity analysis testing, the PHREEQC modeling predicts that as the assumed mass of iron hydroxide is increased, the effectiveness of zinc removal increases, but so does the amount of alkaline reagent (e.g., sodium carbonate, sodium hydroxide, or limestone) required to raise the pH to the desired level. This is due to the model's assumed reactivity of the iron hydroxide surface, which has active acid-base buffering properties as well as adsorptive properties. For example, if no iron hydroxide is initially present, the predicted amount of sodium carbonate required to raise the pH to 6.5 is only 62 mg/L, but almost no zinc is removed. If 2,700 mg/kg iron is assumed to be present in hydroxide form (based on dithionite extraction values for oxidized, dioritic alluvial material at another site), then the zinc removal is 89%, but the amount of sodium carbonate required increases to 511 mg/L. (Note: TerraGraphics assumed a much greater concentration of pre-existing iron hydroxide in their simulations, which, as expected from the modeling results described here, indicated high zinc removal efficiencies.) This modeling uncertainty underscores the need to conduct lab and/or pilot testing using actual aquifer material to accurately evaluate effectiveness and chemical requirements.

Implementability

Some of the more evident challenges associated with implementation of pH-adjustment PRBs in the Bunker Hill Box area are discussed below.

Reversibility of reactions. The zinc removal mechanism(s) potentially achievable by the pH-adjustment approach are reversible. Consequently, the pH adjustment systems would have to be maintained indefinitely – as long as low-pH groundwater emanates from upgradient areas – to prevent re-mobilization. Thus, system operation and maintenance requirements must be assumed to continue in perpetuity.

Clogging and bypass. The potential for clogging of the subsurface within and downgradient of a pH-adjustment PRB is high. Any PRB must have a hydraulic conductivity that is at least as high as the surrounding formation; otherwise, groundwater will tend to mound behind the PRB and bypass the treatment zone. Thus, the potential for clogging would be greatest for a liquid-phase PRB using conventional vertical injection (or injection and extraction) wells, since the media in the PRB is the same (with the same initial permeability) as that in the surrounding formation, and any amount of precipitate formation will tend to reduce permeability within the PRB zone. This problem would be somewhat less severe for the solid-phase limestone PRB or liquid-phase PRB using an injection trench because with these approaches the trench material can be selected to have a starting permeability that is much higher than the surrounding formation, providing some degree of leeway with respect to precipitate clogging. PHREEQC modeling conducted by CH2M HILL indicates that precipitation of calcite would be negligible at pH 6.5. However, it is impossible to create well-mixed conditions in the subsurface, so the pH in a liquid injection PRB system would be higher than the target pH near each injection point. For a solid-phase limestone PRB, there is no practical way to control pH at a selected target value; nevertheless, pH will tend to bew highest near the limestone surface. Wherever pH is higher than the target or downgradient value, the potential for precipitate formation and clogging/bypass will be greater. To investigate this issue, we conducted PHREEQC modeling for pH adjustment to 6.5, 7.5, and 8.5, using sodium carbonate and NaOH. Model results for when a moderate amount of pre-existing $Fe(OH)_3$ was assumed to be present indicate:

- Using sodium carbonate as the pH-adjustment reagent – minimal calcite precipitation at pH 6.5, but high calcite precipitation at pH 7.5 (168 mg/L) and pH 8.5 (235 mg/L), suggesting that subsurface clogging problems could be severe in the vicinity of injection points.
- Using sodium hydroxide as the pH-adjustment reagent – minimal calcite precipitation at all three pH values (6.5, 7.5, and 8.5), suggesting low potential for clogging due to calcite precipitation (although other precipitates may form, albeit at lower rates).

Radius-of-influence/well spacing/injection flow rates for liquid-phase PRB approach. CH2M HILL used the existing groundwater flow model for the Bunker Hill Box to investigate the relationship between injection flow rate and radius-of-influence (ROI) in the selected area north of the CIA. Using an assumed well spacing of 50 ft, an injection flow rate of 75 gpm was required to provide complete lateral coverage between wells – that is, to produce a 25-ft ROI. In other words, an injection flow of 150 gpm (216,000 gal/d) would be required per 100-ft length of PRB created using liquid injection via vertical injection wells with 50-ft spacing. Thus, this approach apparently would require a substantial quantity of make-up/injection water for a long PRB. In addition, the model results suggest that this rate of injection would create a hydraulic barrier that forces a portion of the groundwater moving from upgradient to flow around the PRB and that, in limited areas, some groundwater may discharge to the land surface. These modeling results suggest that other implementation options for creating a liquid-phase pH-adjustment PRB may be more favorable and should be considered. Other options include closer spacing of vertical injection wells, injection trench, and paired injection/extraction wells. Modeling of the paired injection/extraction well approach suggests that the injection flow rate per linear foot of PRB would be approximately half that for the simple injection (only) well approach described above.

Closer spacing of injection wells was used in the conceptual design assumptions developed for the liquid-ohase PRB scenarios in **Tables 1 and 2**. Here, 10-ft spacing of vertical injection wells was used, and an injection flow rate of 5 gpm per well was predicted by modeling to be adequate for achieving a 5-ft ROI. The tabulated data show that the total injection flow for a 4,500-ft PRB would be substantial, approximately 3 MGD.

Life span/width of solid-phase limestone PRB. The conceptual design assumptions developed for the limestone PRB scenario (**Table 3**) include a calculated estimate of PRB service life. This calculation is based on the mass of limestone in the PRB media, the groundwater flux through the PRB, and the limestone "demand" for raising the groundwater pH from ambient (5.6) to 7.4 determined through PHREEQC modeling. The pH of 7.4 was selected because there is no way to practically control pH using a limestone PRB (the water flowing through the PRB will dissolve an amount of limestone governed by kinetic and equilibrium factors between the liquid and solid phases), and modeling suggests that this pH may be around 7.4. Using an assumed 10-ft PRB width resulted in a predicted PRB lifespan of only 4.17 years. This is much shorter than a typical design service life for this type of system, which would commonly be 10 years or greater. (Note: if the PRB effluent pH were actually higher than 7.4, the limestone demand would be greater and the service life for a given width would be shorter.)

Armoring of limestone in a solid-phase PRB. In the presence of oxygen, ferrous iron [Fe2+] oxidation and precipitation of ferric oxy-hydroxide occurs rapidly at limestone surfaces where pH is near neutral or greater. Precipitation of ferric iron on limestone surfaces, referred to as armoring, can cause the remaining limestone inside the iron coating to become unavailable for use in supplying alkalinity, thereby reducing the pH adjustment capacity of the limestone provided. This phenomenon is well-known for treating acid rock drainage, and is the reason that anoxic limestone drains and other anaerobic passive treatment processes were developed for treating water containing elevated ferrous iron concentrations. The groundwater in the Bunker Hill Box appears to have a high potential for limestone armoring, which could reduce the effectiveness and increase the sizing and replacement requirements for a solid-phase PRB system.

Trenching for solid-phase limestone PRB (or liquid-phase PRB with injection trench). The abundant gravel, cobbles, and boulders in the Box area soils would likely make trenching complicated and expensive. It is expected that any open trench operation would require side-slope lay-back and shoring (e.g., trench box, sheet piling). Continuous trenching equipment would probably be unsuitable for use in this material.

Cost

As discussed below, the implementability issues described above have potentially significant implications for cost.

- Reversibility issue – PRB operations and maintenance (O&M) costs would continue indefinitely.
- Clogging and bypass issue – Clogging of the subsurface with precipitates could result in loss of permeability and bypass of the treatment zone, making the PRB ineffective after some period of time. This would incur the cost of constructing a replacement remediation system.
- ROI/well spacing/injection flow rate issue (liquid-phase PRBs) – This relationship controls the capital and operating costs associated with the number of wells, make-up water supply, reagent solution make-up requirements, pumping/power requirements, etc. Preliminary analysis indicates that all of these quantities would be relatively high.

- Chemical reagent costs – Geochemical modeling suggests that the dose requirements and costs for pH adjustment chemicals could be very high, especially for NaOH (see **Tables 1-3**).
- PRB lifespan/width issue (solid-phase PRBs) – This issue controls the system replacement interval and therefore has a dramatic effect on cost. Preliminary analysis suggests that a limestone PRB may need to have a considerable width to allow a reasonable lifespan. Land availability may constrain the possible PRB width in the area north of the CIA.
- Armoring issue (solid-phase PRBs) – Armoring could reduce the limestone utilization efficiency and increase sizing requirements and/or reduce the media replacement interval – any of which could substantially increase design and operating costs.
- Trenching issues (solid-phase PRBs or liquid-phase PRBs with injection trench) – The types of trenching measures mentioned above can increase installation costs considerably.

Table 1

Conceptual Design Assumptions for Liquid-Phase Sodium Carbonate PRB
(vertical injection wells)

Parameter	Units	Value	Basis/Notes
Site Data			
Season		April	Worst case
Location		N. of CIA	Assumed representative location
Depth to upper confining unit	ft bgs	20	Assumed from cross-sections
Depth to groundwater	ft bgs	9	Conceptual site model (CSM)
Saturated thickness	ft	11	
Soil type		Upper alluvial sand and gravel	
Seepage velocity	ft/d	20.5	CSM - Measured value at E-0423U
	ft/y	7,483	
Effective Porosity	v/v	0.3	Assumed
Hydraulic gradient	ft/ft	0.0044	Kellog/CIA
Hydraulic Conductivity	ft/d	390	CSM; Site-wide value (300-700)
pH	s.u.	5.6	gw chemistry for SF-E-0423 (Oct-08)
Zinc, dissolved	mg/L	29.4	gw chemistry for SF-E-0423 (Oct-08)
Cadmium, dissolved	mg/L	0.007	gw chemistry for SF-E-0423 (Oct-08)
Iron, dissolved	mg/L	22.2	gw chemistry for SF-E-0423 (Oct-08)
PRB Conceptual Design			
PRB length	ft	4,150	Length of French drain N. of CIA assumed in FEFS
PRB depth (tmt zone thickness)	ft	11	Saturated thickness
PRB interfacial area	ft^2	45,650	Calculated (L x T)
PRB groundwater flux	ft^3/d	935,825	Calculated (vel x area)
Well configuration	ft	Single line of verical inj wells	Assumed
Well depth	ft bgs	22	Assumed from cross-sections, allowing a 2-ft sump
Well diameter	in	4	Assumed
Well spacing	ft	10	Assumed (i.e., 5-ft ROI) - tentative, to be determined by modeling
Total injection wells		415	
Injection rate/well to achieve ROI	gpm/well	5	Existing groundwater model
Total injection rate (all wells)	gpm	2075	
	gal/d	2,988,000	
	ft^3/d	399,412	
	MG/month	89.6	Assuming a 30-d month
Sodium carbonate demand, to raise pH from ambient (5.6) to 6.5	mg/L	295	PHREEQC modeling using gw chemistry for SF-E-0423 (Oct-08), 0.09 M $Fe(OH)_3$
Sodium carbonate feed solution conc	mg/L	691	Calculated
Sodium carbonate usage rate	lb/d	17,234	Calculated
	ton/month	259	
Est. sodium carbonate cost	$/ton	275	Rough estimate from FMC
Est. annual chemical cost	$/y	$853,092	

* Note that Kathy Johnson presented data indicating a 100 mg/L sodium carbonate dose to raise pH from 5.5 to 6.5, based on PHREEQC modeling using different groundwater chemistry datasets and assumptions

Table 2

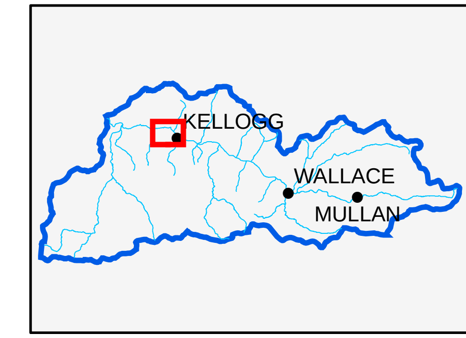
Conceptual Design Assumptions for Liquid-Phase Sodium Hydroxide PRB (vertical injection wells)

Parameter	Units	Value	Basis/Notes
Site Data			
Season		April	Worst case
Location		N. of CIA	Assumed representative location
Depth to upper confining unit	ft bgs	20	Assumed from cross-sections
Depth to groundwater	ft bgs	9	Conceptual site model (CSM)
Saturated thickness	ft	11	
Soil type		Upper alluvial sand and gravel	
Seepage velocity	ft/d	20.5	CSM - Measured value at E-0423U
	ft/y	7,483	
Effective Porosity	v/v	0.3	Assumed
Hydraulic gradient	ft/ft	0.0044	Kellog/CIA
Hydraulic Conductivity	ft/d	390	CSM; Site-wide value (300-700)
pH	s.u.	5.6	gw chemistry for SF-E-0423 (Oct-08)
Zinc, dissolved	mg/L	29.4	gw chemistry for SF-E-0423 (Oct-08)
Cadmium, dissolved	mg/L	0.007	gw chemistry for SF-E-0423 (Oct-08)
Iron, dissolved	mg/L	22.2	gw chemistry for SF-E-0423 (Oct-08)
PRB Conceptual Design			
PRB length	ft	4,150	Length of French drain N. of CIA assumed in FEFS
PRB depth (tmt zone thickness)	ft	11	Saturated thickness
PRB interfacial area	ft^2	45,650	Calculated (L x T)
PRB groundwater flux	ft^3/d	935,825	Calculated (vel x area)
Well configuration	ft	Single line of verical inj wells	Assumed
Well depth	ft bgs	22	Assumed from cross-sections, allowing a 2-ft sump
Well diameter	in	4	Assumed
Well spacing	ft	10	Assumed (i.e., 5-ft ROI) - tentative, to be determined by modeling
Total injection wells		415	
Injection rate/well to achieve ROI	gpm/well	5	Existing groundwater model
Total injection rate (all wells)	gpm	2075	
	gal/d	2,988,000	
	ft^3/d	399,412	
	MG/month	89.6	Assuming a 30-d month
NaOH demand, to raise pH from ambient (5.6) to 6.5	mg/L	424	PHREEQC modeling using gw chemistry for SF-E-0423 (Oct-08), 0.09 M $Fe(OH)_3$
NaOH feed solution conc	mg/L	993	Calculated
NaOH usage rate	lb/d	24,770	Calculated
	ton/month	372	
Est. NaOH cost	$/ton	600	Est. based on info from FMC - price highly variable. Est. is for 50% NaOH
Est. annual chemical cost	$/y	$5,350,427	

Table 3

Conceptual Design Assumptions for Solid-Phase Limestone PRB

Parameter	Units	Value	Basis/Notes
Site Data			
Season		April	Worst case
Location		N. of CIA	Assumed representative location
Depth to upper confining unit	ft bgs	20	Assumed from cross-sections
Depth to groundwater	ft bgs	9	Conceptual site model (CSM)
Saturated thickness	ft	11	
Soil type		Upper alluvial sand and gravel	
Seepage velocity	ft/d	20.5	CSM - Measured value at E-0423U
	ft/y	7,483	
Effective Porosity	v/v	0.3	Assumed
Hydraulic gradient	ft/ft	0.0044	Kellog/CIA
Hydraulic Conductivity	ft/d	390	CSM; Site-wide value (300-700)
pH	s.u.	5.6	gw chemistry for SF-E-0423 (Oct-08)
Zinc, dissolved	mg/L	29.4	gw chemistry for SF-E-0423 (Oct-08)
Cadmium, dissolved	mg/L	0.007	gw chemistry for SF-E-0423 (Oct-08)
Iron, dissolved	mg/L	22.2	gw chemistry for SF-E-0423 (Oct-08)
PRB Conceptual Design			
Trench length	ft	4,150	Length of French drain N. of CIA assumed in FEFS
Trench width	ft	10	Assumed
Trench depth (total)	ft	20	Assumed from cross-sections
Trench volume (total)	ft^3	830,000	Total excavation volume
	yd^3	30,741	
PRB depth (media thickness)	ft	11	Saturated thickness
PRB interfacial area	ft^2	45,650	Calculated (L x T)
PRB groundwater flux	ft^3/d	935,825	Calculated (vel x area)
PRB media volume (total)	ft^3	456,500	
	yd^3	16,907	
PRB media materials		Pea gravel and limestone	
Pea gravel/limestone ratio	v/v	3:1	Assumed (tentative)
Pea gravel volume	ft^3	342,375	
Limestone volume	ft^3	114,125	
Pea gravel bulk density	lb/ft^3	125	Assumed
Pea gravel weight	ton	21,398	
Limestone bulk density	lb/ft^3	118	Assumed
Limestone weight	ton	6,758	
Est. limestone cost	$/ton	35	Rough estimate from Graymont
Est. limestone cost for PRB	$	$236,547	
PRB hydraulic retention time	h	4.68	Assuming PRB media porosity = 0.4
Theoretical limestone req't to raise pH to 7.4	mg/L	152	PHREEQC modeling using gw chemistry for SF-E-0423 (Oct-08)
	lb/ft^3	0.009	
Theoretical life of limestone in PRB	y	4.17	Assuming PRB effluent is pH 7.5 (could be higher)



LEGEND

CIA GROUNDWATER SUPPRESSION AREA

A-4 GROUNDWATER SUPPRESSION AREA

N

0 500 1,000 2,000 Feet

Figure 1
Assumed Extent of Groundwater Suppression Areas within the Box

Evaluation of Pumping Requirements to Constrain Groundwater Levels during Winter Conditions

BUNKER HILL SUPERFUND SITE

CH2MHILL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION DIVISION
PO BOX 1198 • ADA, OK 74821

June 29, 2009

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Review of the technical memorandum titled "Evaluation of groundwater pH adjustment to reduce metals loading to the South Fork Coeur d'Alene River in the Bunker Hill Box"

FROM: Richard Wilkin, Ph.D., Environmental Geochemist
Subsurface Remediation Branch

TO: Anne Dailey, RPM
U.S. EPA Region 10

Per the request for technical assistance, the memorandum titled "Evaluation of groundwater pH adjustment to reduce metals loading to the South Fork Coeur d'Alene River in the Bunker Hill Box" (dated May 29, 2009), has been reviewed. The memo provides a first look at conceptual designs and feasibility of adjusting groundwater pH to retard the migration of metals in groundwater and consequently to reduce the overall load of metals to the South Fork Coeur d'Alene River. The following comments are presented for your consideration.

The site selected for evaluation is a region where groundwater contains elevated levels of dissolved zinc and cadmium. The saturated thickness considered for treatment is the depth interval from about 9 feet to 20 feet below ground surface. The approximate length of the treatment zone is 4150 feet. The memo includes two implementation scenarios: i) a permeable reactive barrier (PRB) created by injecting a liquid alkaline reagent; and, ii) a PRB created by trenching and filling the subsurface with limestone. The memo presents a preliminary discussion of treatment effectiveness, practical implementability, and costs associated with the two implementation scenarios.

Note in previous discussions, the so-called A-4 area was thought to be a good candidate for an in-situ remediation application, because of its smaller size and more defined zone of contamination. However, subsequent examination of the A-4 site showed that a PRB would be highly challenging to locate effectively. It is not worthwhile to treat water in the subsurface only to have the cleaned water interact with contaminated solids further down the hydraulic gradient.

The memo recommends that an appropriate series of steps to evaluate effectiveness would include, in sequence, geochemical modeling, lab-based column testing, and field pilot testing. This is a reasonable recommendation. Geochemical modeling with PHREEQC shows that zinc removal is expected with positive pH adjustments. However, the model results are highly dependent on largely unconstrained input parameters, such as the amount and surface area of potentially reactive surfaces, which would represent the sites for zinc removal as the pH increased. The modeling showed little to significant zinc removal depending on the selection of input parameters. This is fairly typical in modeling exercises, although the site-trends do show a strong pH-dependence on zinc concentrations, suggesting that a sorbing surface is present in the subsurface. Hydrous ferric oxide is typically taken as the *de facto* sorbing phase, but this phase may not be unique in offering surfaces capable of removing zinc from solution. As pointed out, the range of modeling outputs, that are highly dependent on assumed input parameters, underscores the need to conduct lab-scale tests for improved resolution of some of the key variables identified. In fact, my own opinion is that the geochemical modeling has about reached its practical level of usefulness at this point. In moving forward, it might useful to have model results (by all groups involved) collated with a clear record of variable input parameters. This record may help to better inform and serve as a point of comparison for future lab- and field-based testing.

In terms of practical implementation in the field, the memo lays out some of the typical issues often considered as obstacles in the field, such as reversibility, pore clogging, armoring, loss of hydraulic control, radius-of-influence evaluations, reactive barrier lifetime, and construction issues. This is an excellent list of issues that need to be dealt with and I see no significant omissions, although some of the topics could be more fully developed. The discussion raises a number of potential limitations for both the liquid-phase and solid-phase PRB scenarios. None of these issues, at this point, would appear to be obvious "show-stoppers" for PRB implementation; however, it is also equally clear that the PRB technology or in-situ pH adjustment is not likely to be an easy solution to the groundwater contamination problems.

Somewhat more concrete conclusions are reached in the section on projected costs. The liquid-phase PRB approach appears to be expensive at least compared to the limestone PRB design. In particular, the NaOH barrier seems to have exorbitant associated costs compared to the other scenarios considered. Further consideration might be given to intermittent injection scenarios are alternative delivery mechanisms, but the projected costs are not likely to significantly change in relation to one another. The information in the cost tables, which appear to be preliminary but well-prepared, will be useful in further refining any future work.

If you have any questions concerning these comments, please do not hesitate to call me at your convenience (Wilkin: 580-436-8874). I look forward to future interactions with you concerning this site.

cc: Linda Fiedler (5203P)
Rene Fuentes, Region 10
Bernard Zavala, Region 10
John Barich, Region 10

Marcia Knadle, Region 10
Howard Orlean, Region 10

Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box

TO: Anne Dailey/EPA
Bill Adams/EPA

FROM: Michael Niemet/CH2M HILL/CVO
Jim Stefanoff/CH2M HILL/SPK
Heather Perry/CH2M HILL/RDD
Gary Hickman/CH2M HILL/CVO
Joan Stoupa/CH2M HILL/SEA

DATE: July 22, 2009

Introduction

This memorandum presents conceptual design assumptions and discusses feasibility considerations for a limestone permeable reactive barrier (PRB) to reduce metals loading to the South Fork Coeur d'Alene River (SFCDR) in the Bunker Hill Box. Metals loading is reduced by introducing alkalinity to raise groundwater pH *in situ*, to promote downstream adsorption of dissolved metals to iron oxy-hydroxide precipitates. The PRB would be located in a position to intercept and treat groundwater containing elevated concentrations of dissolved metals, principally zinc with lower levels of cadmium. This evaluation was performed to support the analysis of a geochemical approach proposed by TerraGraphics, a contractor to the Idaho Department of Environmental Quality (IDEQ), for reducing transport of dissolved metals in groundwater to the SFCDR. The principal removal mechanism reportedly achieved by this approach is adsorption of zinc to iron oxy-hydroxide assumed to already be present within the soil matrix. The basis of design assumptions presented in this memorandum represent a more detailed evaluation of the conceptual limestone PRB assumptions presented in an earlier memorandum to EPA (CH2M HILL, May 29, 2009).

Alternative Development

The area selected, for the purposes of this evaluation, as a representative implementation location for a limestone PRB is along the north-western boundary of the Central Impoundment Area (CIA). This is the same area that is being considered for groundwater collection, using French drains, for treatment at the Bunker Hill Central Treatment Plant (CTP) in the focused ecological feasibility study (FEFS, in preparation). For direct comparison to two French drain alternatives in the FEFS (Alternatives 3 and 4) the location of the limestone PRB is assumed to correspond to the east-west portion of the French drain (see attached Figures). This is an area where groundwater contains relatively high concentrations of dissolved zinc and cadmium and where substantial metal loading to the SFCDR is occurring.

For this evaluation, two alternatives (Alternatives 3a and 4a) were developed for direct comparison to the French drain alternatives; the new alternative differ from existing Alternatives 3 and 4 in that the east-west portion of the French drain is replaced by a limestone PRB. These alternatives were input into the site-wide numerical groundwater model in order to provide an additional level of refinement to the preliminary conceptual design assumptions presented in the May 29, 2009 memorandum. **Table 1** summarizes the revised design assumptions for the limestone PRB and compares these to the preliminary assumptions presented in the May 29, 2009 memorandum. It is assumed that after acceptance by EPA and IDEQ these assumptions may be used to prepare feasibility study-level cost estimates for Alternatives 3a and 4a.

Comparison to Preliminary Assumptions

As specified in the preliminary design assumptions, PRB construction will consist of trenching and backfilling with solid media consisting of an inert coarse granular material (e.g., pea gravel) and limestone [$CaCO_3$]. The approximate length of the PRB increased slightly from 4,150 to 4,225 ft to be consistent with that of the French drain. One of the most notable changes was the increase in the assumed depth to the upper confining unit from 20 to 35 ft bgs and the increase in the saturated thickness from 11 to24 ft. These changes were the result of using the modeling results along the full length of the PRB, instead of a single well location taken to representative of the entire area.

Another noteworthy change is the reduction in estimated groundwater flux into the PRB from 936,000 to 223,000 ft^3/day. This reduction is partly the result of using the model data along the full length of the PRB as well as the calculation for the original flux not accounting for the porosity of the aquifer. This difference in assumed flux, combined with the larger overall PRB volume, results in an increase in the expected life of the PRB from approximately 4 to perhaps in excess of 30 years.

Feasibility Considerations

These considerations were discussed in the May 29, 2009 memorandum but are summarized here with revisions based on current design assumptions where appropriate.

Treatment Effectiveness

A thorough evaluation of technology effectiveness would likely require laboratory and/or field pilot testing. This is because a major uncertainty is the presence and availability of sufficient iron oxy-hydroxide present in the down-gradient aquifer material to provide adsorption sites for dissolved zinc and cadmium. PHREEQC modeling conducted to date by TerraGraphics found excellent treatment effectiveness of near 100% when 10 moles per liter of iron oxy-hydroxide was assumed to be present. PHREEQC modeling performed by CH2M HILL indicated poor treatment effectiveness when it was assumed the only available iron oxy-hydroxide was the incremental amount that would be freshly precipitated from groundwater due to the increase in pH (i.e. no existing available iron oxy-hydroxide in the aquifer materials). If reducing conditions exist in the subsurface, then large amounts of precipitated iron oxy-hydroxide would not be expected to be present. However, site data showing a relationship between pH and dissolved zinc tends to support the assumption that there is solid iron oxy-hydroxide present.

Thus, the current range of potential effectiveness is from near zero to 100%. To better assess effectiveness, chemical requirements, and residence time, CH2M HILL believes it will be necessary to perform laboratory and on-site pilot testing, and maybe a geochemical assessment of the aquifer materials followed by laboratory and on-site pilot testing. We would be very interested in other possible approaches.

Implementability

Some of the more evident challenges associated with implementation of the limestone PRB are discussed below.

Reversibility of reactions. The zinc removal mechanism(s) potentially achievable by the pH-adjustment approach are reversible if oxidative conditions change to reducing and the pH drops. Consequently, the pH adjustment would have to be maintained indefinitely – as long as low-pH groundwater emanates from upgradient areas – to prevent re-mobilization. Thus, system operation and maintenance requirements must be assumed to continue in perpetuity.

Clogging and bypass. There is the potential for clogging of the subsurface within and downgradient of a pH-adjustment PRB over time as precipitates accumulate and the effective porosity declines. Any PRB must have a hydraulic conductivity that is at least as high as the surrounding formation; otherwise, groundwater will tend to mound behind the PRB and bypass the treatment zone. For a solid-phase limestone PRB, there is no practical way to control pH at a selected target value; consequently, pH will tend to be highest near the limestone surface. Wherever pH is higher than the target or downgradient value, the potential for precipitate formation and clogging/bypass will be greater.

Life span. Using an assumed 10-ft PRB width resulted in a predicted PRB lifespan of 39 years under perfect conditions of 100% limestone utilization with no clogging. (Note: if the PRB effluent pH were actually higher than 7.4, the limestone demand would be greater and the service life for a given width would be shorter.) Actual achievable life is difficult to predict without long-term in-situ testing.

Armoring. The precipitation of ferric iron on limestone surfaces, referred to as armoring, can cause the remaining limestone inside the iron coating to become unavailable for use in supplying alkalinity, thereby reducing the pH adjustment capacity of the limestone and the PRB lifespan. This phenomenon is well-known for treating acid rock drainage, and is the reason that anoxic limestone drains and other anaerobic passive treatment processes were developed for treating water containing elevated ferrous iron concentrations. The groundwater in the Bunker Hill Box appears to have a high potential for limestone armoring (assuming oxidative conditions needed for successful iron oxy-hydroxide precipitation), which could reduce the effectiveness and increase the sizing and replacement requirements for a solid-phase PRB system.

Trenching. The abundant gravel, cobbles, and boulders in the Box area soils would likely make trenching complicated and expensive. It is expected that any open trench operation would require side-slope lay-back and shoring (e.g., trench box, sheet piling). Continuous trenching equipment would probably be unsuitable for use in this material. Finally, the results of the modeling simulations indicate that the PRB depth would be 35 ft bgs on average, as opposed to 20 ft as previously believed, which significantly complicates trenching.

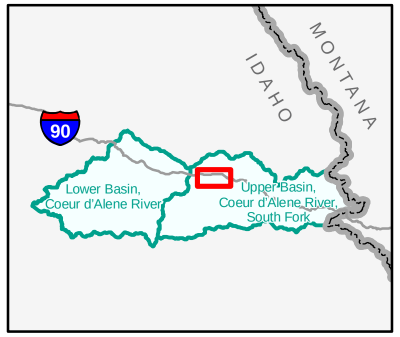
Cost Factors Related to Implementability

As discussed below, the implementability issues described above have potentially significant implications for cost. These factors will be considered when the cost estimate is prepared.

- Reversibility issue – PRB operations and maintenance (O&M) costs would continue indefinitely.
- Clogging and bypass issue – Clogging of the subsurface with precipitates could result in loss of permeability and bypass of the treatment zone, making the PRB ineffective after some period of time. This would incur the cost of constructing a replacement remediation system.
- Perpetual monitoring – Groundwater monitoring along the length of the PRB will need to be conducted indefinitely to ensure continued effectiveness of the remedy.

Table 1
Conceptual Design Assumptions for Solid-Phase Limestone PRB

Parameter	Units	Original Conceptual Assumptions		Revised Assumptions	
		Value	Basis/Notes	Value	Basis/Notes
Site Data					
Season		April	Worst case	Baseflow (Fall 2008)	
Location		N. of CIA	Assumed representative location	N. of CIA	
Depth to upper confining unit	ft bgs	20	Assumed from cross-sections	35	Average value from model; ranges from ~20 to 45 feet bgs
Depth to groundwater	ft bgs	9	Conceptual site model (CSM)	10.5	Average value from model; ranges from ~6.5 to 13.5 feet bgs
Saturated thickness	ft	11		24	Average value from model; ranges from ~9.5 to 34 feet
Soil type		Upper alluvial sand and gravel		Upper alluvial sand and gravel	
Seepage velocity	ft/d	20.5	CSM - Measured value at E-0423U	24	Average simulated velocity in model layers 1 and 2; ranges from 10 to 51.5 ft/d;calculated assuming a 15% porosity.
	ft/y	7,483		8,766	
Effective Porosity	v/v	0.3	Assumed	0.15	Assumed transport porosity of native materials; total porosity likely 30-40%
Hydraulic gradient	ft/ft	0.0044	Kellog/CIA	0.006	Average simulated velocity in model layers 1 and 2; ranges from 0.0025 to 0.0085
Hydraulic Conductivity	ft/d	390	CSM; Site-wide value (300-700)	600	Average value from model; ranges from 250 to 1,013 feet/day
pH	s.u.	5.6	gw chemistry for SF-E-0423 (Oct-08)	5.61	Average value; ranges from 5.46 - 5.76 in wells along PRB; data from Fall 2008 Field Measurements
Zinc, dissolved	mg/L	29.4	gw chemistry for SF-E-0423 (Oct-08)	25.5	Average value; ranges from 22.05 - 29.2 in wells along PRB; Data from Fall 2008 Sampling - low flow and BC Study
Cadmium, dissolved	mg/L	0.007	gw chemistry for SF-E-0423 (Oct-08)	0.15	Average value; ranges from 0.0071 - 0.46 in wells along PRB; Data from Fall 2008 Sampling - low flow and BC Study
Iron, dissolved	mg/L	22.2	gw chemistry for SF-E-0423 (Oct-08)	14.1	Average value; ranges from 6.56 - 22.7 in wells along PRB; Data from Fall 2008 Sampling - low flow and BC Study
PRB Conceptual Design					
Trench length	ft	4,150	Length of French drain N. of CIA assumed in FEFS	4,225	length assigned in model
Trench width	ft	10	Assumed	25	nodal spacing in model--conceptual design width to be 10 feet for cost estsimate
Trench depth (total)	ft	20	Assumed from cross-sections	35	Average value from model; ranges from ~20 to 45 feet bgs
Trench volume (total)	ft^3	830,000	Total excavation volume	1,478,750	using a 10-foot width
	yd^3	30,741		54,769	
PRB vertical thickness (of media)	ft	11	Saturated thickness	24	Average value from model; ranges from ~9.5 to 34 feet
PRB interfacial area	ft^2	45,650	Calculated (L x T)	101,400	
PRB groundwater flux	ft^3/d	935,825	Calculated (vel x area)	223,000	Darcy flow (average of 223,668 for 3a and 222,422 for 3b)
Hydraulic Conductivity of PRB Material	ft/d			1,500	Assumed in model simulations
Effective Porosity of PRB Material				0.3 - 0.4	Engineered material will have a higher porosity than native materials
Zinc loading to PRB	lb/d			353	Average of 355 for Alternative 3a and 351 for 3b
PRB media volume (total)	ft^3	456,500		1,014,000	
	yd^3	16,907		37,556	
PRB media materials		Pea gravel and limestone		Pea gravel and limestone	
Pea gravel/limestone ratio	v/v	3:1	Assumed (tentative)	3:1	
Pea gravel volume	ft^3	342,375		760,500	
Limestone volume	ft^3	114,125		253,500	
Pea gravel bulk density	lb/ft^3	125	Assumed	125	
Pea gravel weight	ton	21,398		47,531	
Limestone bulk density	lb/ft^3	118	Assumed	118	
Limestone weight	ton	6,758		15,012	
Est. limestone cost	$/ton	35	Rough estimate from Graymont	35	Does not include shipping
Est. limestone cost for PRB	$	$236,547		$525,429	Does not include shipping
PRB hydraulic retention time	h	4.68	Assuming PRB media porosity = 0.4	43.65	
Theoretical limestone req't to raise pH to 7.4	mg/L	152	PHREEQC modeling using gw chemistry for SF-E-0423 (Oct-08)	152	
	lb/ft^3	0.009		0.009	
Theoretical life of limestone in PRB	y	4.17	Assuming PRB effluent is pH 7.5 (could be higher)	39	Assumes 100% limestone consumption and no clogging



French Drain

CTP Effluent Discharge Pipeline

Source: 2006 NAIP; ESRI base
data (Interstates 2006, Major Highways 2008).

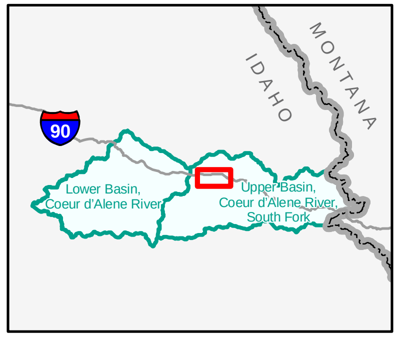
DRAFT CONCEPTUAL/ SCHEMATIC LAYOUT

N

0 1,250 2,500 5,000 Feet

Alternative 3:
Drain Only
Kellogg OU2
RA Box Models
BUNKER HILL SUPERFUND SITE

CH2MHILL



Lined Stream
CTP Effluent Discharge Pipeline
Groundwater Cutoff Walls
Line of Extraction Wells
French Drain

Source: 2006 NAIP; ESRI base data (Interstates 2006, Major Highways 2008).

DRAFT CONCEPTUAL/ SCHEMATIC LAYOUT

N
0 1,250 2,500 5,000 Feet

Alternative 4:
Combined Lining and Drains
Kellogg OU2
RA Box Models
BUNKER HILL SUPERFUND SITE

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w w w . t e r r a g r a p h i c s . c o m

MEMORANDUM

To: Anne Dailey, EPA, Seattle
Bill Adams, EPA, Seattle
Jim Stefanoff, CH2M Hill, Spokane

From: Diane Hopster, TerraGraphics, Spokane Valley
Robin Nimmer, TerraGraphics, Moscow
Dale Ralston, Ralston Hydrologic, Moscow
Kathryn Johnson, Johnson Environmental Concepts, SD
Andy Mork, IDEQ, Boise
Nick Zilka, IDEQ, Kellogg

Date: July 31, 2009

Subject: Comments on *Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in Bunker Hill Box*, Memorandum prepared by CH2M Hill for US EPA, July 22, 2009

Job Code: **2010-5060-20**

The purpose of this memorandum is to provides comments on *Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in Bunker Hill Box*, Memorandum prepared by CH2M Hill for US EPA, July 22, 2009.

Specific Comments

Comparison to Preliminary Assumptions, first paragraph – The change in the assumed depth of the upper confining unit from 20 to 35 feet is very significant relative to construction of any open trench for remedial action (for a PRB or a French drain). Problems with trench construction are elaborated on page 4. Given the short distance between the north toe of the CIA and the south right-of-way fence for I-90, we question whether a remediation action that involves an open trench to a depth of 35 feet is possible in this area.

We recommend that remedial analysis include the alternatives of constructing a PRB and/or a French drain to alternative depths shallower than the top of the confining layer. The reasons of including these alternatives in the remedial action analysis are listed below.

- The percentage capture of groundwater entering the SFCDR is likely not a direct function of the depth of penetration of the upper aquifer. Alluvial sediments typically have an anisotropic ratio of 10:1 (horizontal hydraulic conductivity to vertical hydraulic conductivity) or greater. This means that a trench constructed to the scour depth of sediments under the river channel likely will capture the vast majority of ground water entering the SFCDR in the reach north of the CIA. Upward groundwater flow from deeper portions of the upper aquifer is limited by the vertical hydraulic conductivity of the alluvial sediments below the bottom of the river scour channel. As an example, a 25-foot deep trench (PRB or French drain) would treat and/or capture the majority of groundwater flow if the trench bottom is about equal to or below the bottom of scour of the river channel. Construction of the trench to 35 feet likely would not result in an equivalent increase in the amount of ground water treated and/or captured. Based on the data given in Table 1 of the CH2M HILL memo, a 25-foot trench would penetrate the upper two-thirds of the upper aquifer while a 35-foot trench would penetrate the full thickness of the upper aquifer.

- There likely are steps in the feasibility and costs of trench construction that are dependent on depth. The cost would increase depending on the size of equipment needed, location of the vendors, and number of vendors. For example construction of a 5-foot deep trench could possibly be done by equipment that is readily available in the Silver Valley at a reasonable cost whereas construction of a 25-foot deep trench would likely require specialized equipment that may not be available in the Pacific Northwest with much greater associated costs. Finally, there may be only a few vendors that could construct a 35-foot deep trench.

- It is likely there are steps in the remedial effectiveness and costs of the trench construction that are dependent on depth. For example, if a 15-foot deep trench might decrease the loading by 50 percent at a relative cost of 20 units. The 25-foot trench might decrease the loading by 60 percent but at a relative cost 500 units.

The evaluation approach should be based on consideration of trench depth based on what is technologically feasible and cost effective.

Treatment Effectiveness, first paragraph (top of page 3) - The concern expressed about the presence of reducing conditions is inconsistent with the measurements of dissolved oxygen and ORP measured in the groundwater in the vicinity of the CIA. The data suggest seasonal and spatial variability between oxic and suboxic conditions. In addition, data are available that strongly indicate the presence of solid phase iron oxide or hydroxide in contact with the groundwater in the general area of the CIA. PHREEQC simulations using measured data generally show that amorphous $Fe(OH)_3$ is oversaturated or near equilibrium with the groundwater chemistry. In addition, INL concluded in the draft report from March 2009, on the basis of the three sequential extractions done on direct push cores from the area of the CIA, “that most of the iron is in the form of oxides”.

Treatment Effectiveness, second paragraph – Additional explanation is needed relative to what would be included in the “geochemical assessment of the aquifer materials.”

Yes, assessment of effectiveness should begin with laboratory testing. Initially batch tests with groundwater in contact with various media, perhaps at different water to solid ratios would provide simple, inexpensive data on adsorption. Analysis of the solid material before and after the batch tests by non-destructive methods such as x-ray diffraction, scanning electron microscopy, electron microprobe, and x-ray absorption spectroscopy would provide data to understand the mechanisms of sorption and the mass of adsorptive substrate such as hydrous iron and manganese oxides. Column tests following the batch tests would provide more detail on the reaction kinetics relative to flow rates.

Implementability, Reversibility of Reaction – Metal in the groundwater under a scenario of PRB exhaustion or plugging would revert back to concentrations before the PRB. The pH and redox conditions and metal concentrations in the groundwater under the CIA would not change due to a PRB installed at the down-gradient edge. The PRB simply would enhance ongoing reactions in the groundwater system, i.e. adsorption onto hydrous iron and manganese oxides. If the PRB were no longer effective or groundwater flowed around it, the steady-state concentrations in the up-gradient groundwater at the current conditions (pH 5.6 to 5.8 and DO 0.2 – 1 mg/l) would be re-established. In addition, due to the effects of time (aging) on iron hydrous oxides, the reversibility of adsorptive reactions will not be equivalent to the forward sorption processes. As aging occurs, the mineral form of iron hydrous oxides become more stable, i.e. the equilibrium concentrations in the groundwater will be lower and the trace metals more firmly incorporated into the mineral structure. The iron precipitates containing adsorbed zinc and other metals will be coated by more recent precipitates (the cause of the concern of plugging) slowing the de-sorbing and/or dissolution reactions of interior constituents. The degree to which metals would be re-mobilized with a drop in pH should be a topic for additional geochemical studies.

Implementability, Clogging and Bypass - The numerical model should be used to assess the impacts of clogging of the PRB and the resultant decrease in aquifer hydraulic conductivity in this area. The river gain along the north side of the CIA likely would be reduced. Changes in the interaction of ground water with the SFCDR downstream of the CIA would need to be assessed. See also our comment in "Reversibility of Reaction."

Implementability, Life span – What calculations led to a 10-foot thickness? Could the thickness be reduced due to the rapid chemical reaction times which would also reduce the amount of material to be excavated and refilled at the end of the PRB life-span?

Cost Factors - The need for PRB O&M is emphasized but other than media replacement at some point, what O&M unique to PRB would be necessary?

Regardless of which alternative is implemented, monitoring will be required.

Problems associated with construction of a trench to an average depth of 35 feet at the selected location along the north side of the CIA need to be addressed.

Table 1. Excellent detail. However, the variables in the spreadsheet should be updated to reflect current assumptions such as saturated thickness, trench depth etc.

An explanation is needed for the assumed ratio of 3:1 for the pea gravel to limestone ratio.

The notes for hydraulic gradient refer to simulated velocity. This needs to be corrected.

The theoretical limestone required to raise pH to 7.4 is expressed in terms of mg/l and lb/ft^3. These units are confusing.

General Comments

Combined Construction of a PRB and a French Drain

Consideration should be given to installation of a perforated pipe within any limestone permeable reactive barrier (PRB) that is constructed. The pipe would allow in-situ analysis of geochemical conditions within the PRB and also would allow the PRB to be used as a water collection system similar to a French drain.

The PRB application described in the CH2M HILL memo includes backfilling a 10-foot wide trench with material composed of 75 percent pea gravel and 25 percent limestone. A French drain would include a perforated pipe placed in backfill material with high hydraulic conductivity (similar to pea gravel) in a similar width trench. The primary differences between the two applications are the presence of 25 percent limestone in the PRB and the presence of a perforated pipe in the French drain.

We recommend that the remedial analysis include the alternative of combined construction of a PRB and a French drain. This would include placement of a perforated pipe in a trench backfilled with a combination of high hydraulic conductivity inert material and limestone. The reasons for including this alternative are listed below.

- Most of the increased cost associated with construction of a combined PRB and French drain versus just a French drain would be the purchase and placement of limestone as a 25 percent component of the backfill material. These costs likely would be small compared to trench construction costs.
- The combined PRB and French drain could be operated as a PRB until the geochemical effectiveness of the limestone is reduced by armoring. Inflatable packers likely would be placed at intervals in the perforated pipe during the period of PRB operation. The inflatable packers could then be removed and the facility could be used as a French drain for collection of water for treatment.
- The primary problem for the operation of a combined PRB/French drain is the potential clogging of the trench material with precipitates which would make the French drain less effective. The primary research question deals with the timing of the armoring of the limestone relative to the timing of the clogging of the pores. A combined PRB/French drain might be an effective alternative if armoring of the limestone is a major problem prior to clogging of the pores. A combined PRB/French drain would not be as effective as a remedial action if clogging of the pores preceded the armoring of the limestone.

Response to Comments on Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box

TO: Anne Dailey/EPA
Bill Adams/EPA

FROM: Michael Niemet/CH2M HILL/CVO
Jim Stefanoff/CH2M HILL/SPK
Gary Hickman/CH2M HILL/CVO
Joan Stoupa/CH2M HILL/SEA

DATE: August 11, 2009

Introduction

This memorandum provides responses to comments on the memorandum entitled *Design Assumptions for Limestone Permeable Reactive Barrier to Reduce Metals Loading to the South Fork Coeur d'Alene River in the Bunker Hill Box*, prepared by CH2M HILL for EPA, and dated July 22, 2009. The comments were provided by TerraGraphics, a contractor to the Idaho Department of Environmental Quality (IDEQ), and others, in a memorandum to EPA dated July 31, 2009. The comments were related to conceptual design assumptions and feasibility considerations for a limestone permeable reactive barrier (PRB) to reduce metals loading to the South Fork Coeur d'Alene River (SFCDR) in the Bunker Hill Box.

The purpose of the July 22 CH2M HILL memorandum was to convey recommended conceptual design assumptions to be used as basis for preparing estimated costs. The estimated costs will be developed to the same level of detail and accuracy being used for the other potential Box remedial actions. At this time there is insufficient information available to better assess the potential effectiveness of a PRB or its lifespan. Therefore, once the cost estimate is available, a decision to carry forward a PRB will be made only on the relative cost to a similarly located French drain system. If the PRB costs compare favorably then an alternative including a PRB will be developed for evaluation in the focused feasibility study (FFS).

Specific Comments

Comparison to Preliminary Assumptions, first paragraph

We agree that the increase in the average assumed depth to the upper confining unit from 20 to 35 feet is very significant. Furthermore, as shown in Table 1 of the July 22 memorandum, the numerical model indicates that the depth varies from 20 to as much as 45 feet below ground surface (bgs) along the length of the proposed PRB. We also agree that constructing a trench to the upper confining unit may face significant construction challenges, and at the least would add considerable technical challenges and cost to implementation of the remedy.

Given these concerns, it was suggested that a PRB and/or French drain alternative be considered to alternative depths shallower than the upper confining unit. While a shallower trench depth will improve constructability, it will also limit the effectiveness of the remedy, and the limitation on effectiveness will be much more pronounced for the PRB than the French drain. This is because water removal from the French drain will alter the local gradients such that water is flowing into the drain from both sides, resulting in a high degree of hydraulic capture. The PRB, if not fully-penetrating, will have underflow that will eventually flow into the SFCDR. The localized significance of the relative 10:1 reduction in vertical relative to horizontal conductivity is unknown. Based on the data in Table 1 of the July 22 memorandum, a 25-foot deep trench on average will penetrate 14 feet into the saturated zone and leave 10 feet of saturated zone without treatment (58% coverage). Note that a PRB shallower than the average depth to groundwater (approximately 11 feet) will not provide any treatment. Finally, a reduction in permeability over time of a PRB that is not fully-penetrating will increase the underflow beneath the PRB.

Recommendation: The limestone PRB should be designed to be fully-penetrating to the upper confining unit to maximize effectiveness. This will eliminate uncertainty in treatment effectiveness from bypass and will thus be more comparable to the French drain alternative. The remedial action along this reach needs to be very effective as this is the highest groundwater dissolved metals loading area to the SFCDR in the Box. However, for these preliminary cost estimates it is recommended that two estimates be developed to assess the sensitivity of cost to PRB depth. One estimate would be made assuming an average of 25 feet deep, and one assuming an average of 35 feet.

Treatment Effectiveness, first paragraph (top of page 3)

We agree that oxidation-reduction potential and the presence of iron oxide or hydroxide are major unknowns affecting the ultimate effectiveness of the limestone PRB.

Recommendation: Carry preliminary design assumptions forward assuming that geochemical conditions are conducive for effective treatment. Should the limestone PRB appear favorable in the cost estimate comparison, then additional studies will be needed to assess effectiveness, which would be performed post-ROD as part of preliminary design.

Treatment Effectiveness, second paragraph

Refer to previous response and recommendation.

Implementability, Reversibility of Reaction

The resulting precipitates downgradient of the PRB would represent a large reservoir of zinc that could potentially be released back into the dissolved phase and into the river if the pH returns to original conditions. It is unclear how aging will affect the reversibility and kinetics of zinc desorption from iron precipitates.

Recommendation: We agree that this is another valid topic for additional geochemical studies to refine design parameters should the limestone PRB be selected as a preferred alternative. No changes are required to preliminary design assumptions for the cost estimates at this time.

Implementability, Clogging and Bypass

We agree that clogging of the PRB will result in the diversion of a greater portion the groundwater flow downstream of the Central Impoundment Area (CIA). Additionally, clogging will cause groundwater to mound behind the PRB, which will increase the flow under the PRB (if not fully-penetrating to the upper confining layer). In either case, clogging of the PRB will result in increased flow of untreated groundwater to the river.

Recommendation: We disagree that additional numerical modeling is needed at this time related to PRB clogging. Numerical modeling related to clogging would become important for a failure mode analysis to be conducted at later phases in the design should the limestone PRB have potential cost effectiveness.

Implementability, Life span

The 10-foot PRB thickness was selected in order to provide a sufficiently long limestone life in the PRB. At 10-feet thick the estimated PRB life is 39 years assuming 100 percent limestone utilization. At 4-feet thick (similar to the French drain assumption) the estimated PRB life is reduced to a maximum of 16 years. Additionally, excavating and replacing the material is not a simple task, and will require essentially the same process and cost as the original installation. Therefore, it is advantageous to construct the PRB with a wider width to maximize life span and minimize replacement frequency.

Recommendation: We recommend maintaining the 10-foot PRB thickness assumption. The estimated 39 year limestone life is in order with US EPA's common assumption of a 30 year operations and maintenance (O&M) time frame for feasibility studies, with some contingency for limitations in actual limestone utilization (due to clogging, armoring, etc.). It is stressed that the estimated 39-year life may be overly optimistic due to armoring of the limestone by precipitates and gradual reduction in permeability due to localized precipitation of dissolved metals.

Cost Factors

The PRB is a passive remedy that requires no O&M other than replacement when it is clogged or spent and groundwater monitoring to insure continued treatment effectiveness. Groundwater monitoring for the PRB will be more extensive than for a French drain because drain effectiveness is readily assessed by measuring the flow and metal concentrations of the removed water, and by use of a few piezometers near the drain to track groundwater head versus the depth of the drain. For the PRB many monitoring wells will need to be installed both up gradient and down gradient along its length, and relatively frequent sampling will be needed to assess treatment performance.

Recommendation: The cost estimate will delineate installation and O&M costs of the PRB based on an assumed lifespan of 30 years. It is recommended that a total of 20 monitoring wells be included for the PRB, with 8 up gradient, 8 down gradient, and 4 within the PRB. It is recommended that 8 piezometers be assumed for the French drain, with these equally spaced along its length. It is also recommended that data loggers be assumed for each well or piezometer.

Table 1

The Revised Assumptions column of Table 1 represents the current design assumptions for the PRB to be carried forward to the cost estimate alternative and the FEFS. Should any of these assumptions change due to new information, the table will be revised accordingly.

The 3:1 pea gravel to limestone ratio was selected as a preliminary assumption to provide sufficient hydraulic conductivity and structural strength as the limestone dissolves. This will be revised if necessary based on bench- and pilot-testing at later phases in the design.

The notes for hydraulic gradient were incorrect and should read: "Average simulated hydraulic gradient in model layers 1 and 2; ranges from 0.0025 to 0.0085".

The theoretical limestone requirement to raise pH of groundwater to 7.4 is expressed in mg/L and lb/ft^3 to facilitate conceptual design and cost estimating.

Recommendation: Table 1 will be revised as needed prior to preparation of the cost estimate for the limestone PRB alternative. At present, no changes are warranted for the preliminary design assumption presented in the Revised Assumptions column.

General Comments

Combined Construction of a PRB and a French Drain

We agree that it would be a relatively insignificant cost to place a perforated pipe at the bottom of the limestone PRB trench during installation. If the PRB eventually becomes armored or the limestone is depleted without a loss of conductivity in the trench, then it would be possible to switch the PRB over to a French drain. However, if the PRB ultimately fails as a result of clogging, then conversion to a French drain would not be possible.

It should be noted, however, that the current assumed trench width is 4 feet for the French drain by itself as opposed to 10 feet for the limestone PRB. Therefore, the significant additional installation cost of the wider trench would not be warranted if the trench was to be used as a French drain for the vast majority of its useful life.

Recommendation: Installation of a perforated pipe will be included in the cost estimate for the limestone PRB.

Box Alternative 3 FFS Cost Estimates

TO: Joan Stoupa/CH2M HILL

FROM: Jim Stefanoff/CH2M HILL

DATE: August 31, 2009

This memorandum describes cost estimates for three options being considered for inclusion in the focused feasibility Study (FFS) for OU2 as Alternative 3. The estimates, their basis, and backup documentation are contained in the Excel Spreadsheet file, "OU2 Alternative 3 Options 20090831b.xls". Separate estimates are provided for the following Alternative 3 options:

Alternative 3a: French Drain
Alternative 3b: PRB 35 feet deep
Alternative 3c: PRB 25 feet deep

Alternative 3a includes a 4,225 foot-long French drain on the northwest side of the CIA running east-west, and a 1,000 foot-long French drain on the west side of the CIA running north-south. Alternative 3b replaces the 4,225 foot-long drain with a permeable reactive barrier (PRB) having an average depth of 35 feet. Alternative 3c is the same as 3b but uses an average PRB depth of 25 feet.

All alternatives include a groundwater sump and pump station to collect drain water and pump it to the CTP through a pipeline buried on the south side of the CIA. Both PRB alternatives include a drain pipe along the base of the PRB in the event the PRB becomes plugged or is found to not meet performance requirements. In such an event the drain could be used similar to that of Alternative 3a. Thus, the same size of sump and pipeline to the CTP are used for each alternative, yet smaller pumps are used for Alternatives 3b and 3c, which would need to be replaced by bigger pumps if the drain contingency was operated.

All alternatives include treatment at the CTP for drain water, and costs are included for CTP expansion. Alternative 3a uses 4,000 gpm, while Alternatives 3b and 3c use 400 gpm.

The "COST SUMMARY" tab of the Excel workbook summarizes and compares capital, annual O&M, and net present value (NPV) costs. An interest rate of 7% and a 30-year life is used for the NPV costs.

The costs are considered to be order-of-magnitude in accuracy (actual costs could be either 50% higher or 30% lower than the estimates). O&M costs are estimated by category of work and are tabulated in the workbook.

The estimates indicate each option has similar NPV costs. Alt 3a has the lowest capital but the highest O&M costs. This is due to treatment of 4,000 gpm compared to 400 gpm for the PRB systems.

The relative cost-effectiveness of the alternatives for reducing dissolved metal load to the SFCDR has not been determined. Alternative 3a uses standard technologies considered reliable and effective. The effectiveness of the PRB alternatives is more uncertain. A cost for changeout of the media for Alternatives 3b and 3c is provided and summarized on the COST SUMMARY tab.

ALTERNATIVE	Capital Cost w/o CTP Expansion	Capital Cost of CTP Expansion[1]	Capital Cost w/ CTP Expansion	Annual O&M w/o CTP	Annual O&M at CTP[1]	Total Annual O&M Cost	30-Year NPV of O&M[2]	TOTAL 30-YEAR PRESENT WORTH COST[2]
ALTERNATIVE 3a - French Drain	**$16,920,000**	**$5,681,000**	**$22,601,000**	**$293,000**	**$304,000**	**$597,000**	**$7,410,000**	**$30,010,000**
ALTERNATIVE 3b - PRB 35 feet deep	**$29,030,000**	**$603,000**	**$29,633,000**	**$272,000**	**$20,000**	**$292,000**	**$3,620,000**	**$33,250,000**
ALTERNATIVE 3c - PRB 25 feet deep	**$23,740,000**	**$603,000**	**$24,343,000**	**$272,000**	**$20,000**	**$292,000**	**$3,620,000**	**$27,960,000**

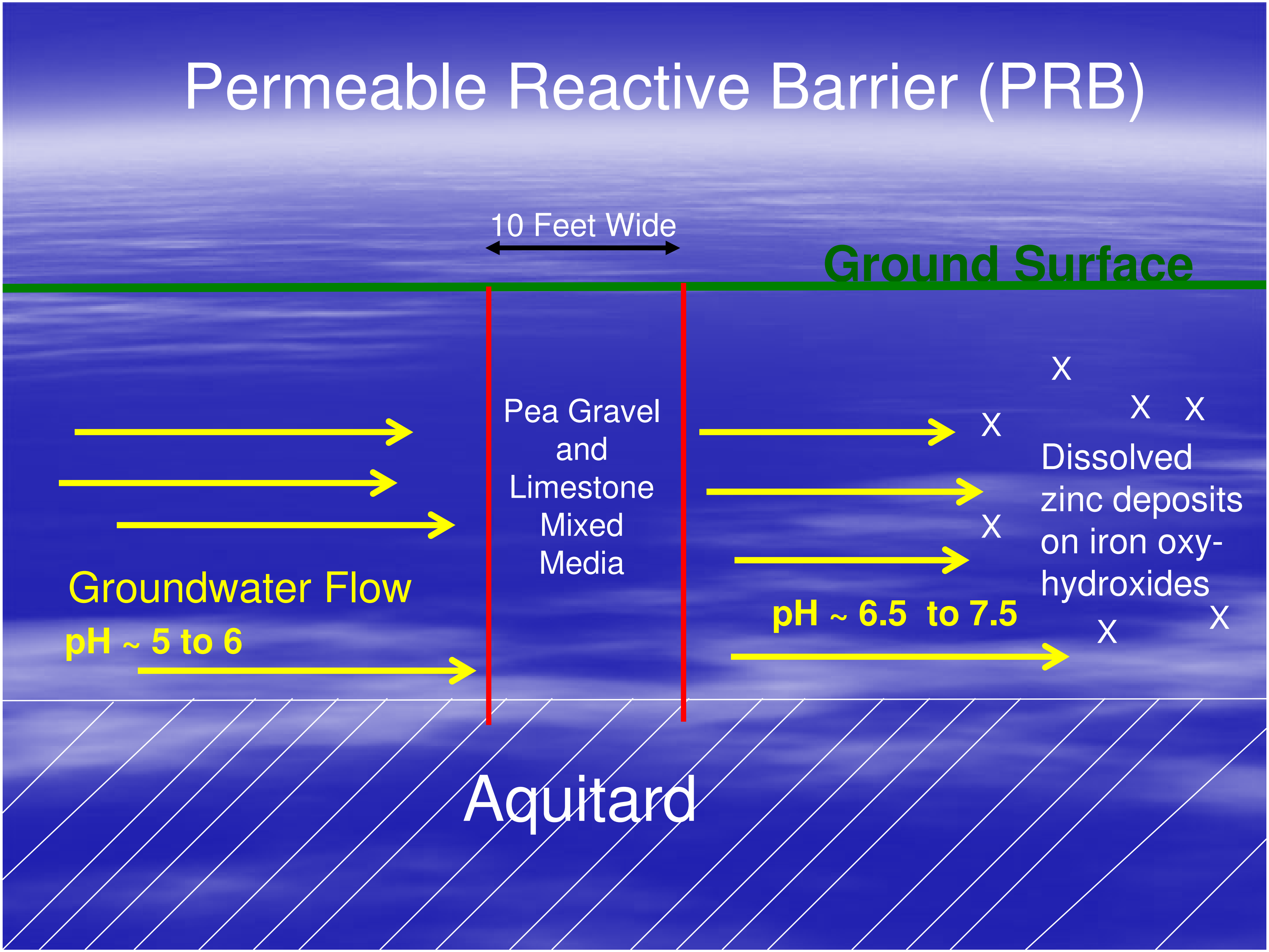
[1]CTP expansion and annual O&M based on these flows: Alt 3a = 4,000 gpm, Alt 3b and 3c = 400 gpm

[2]Present worth calculated using 7% interest.

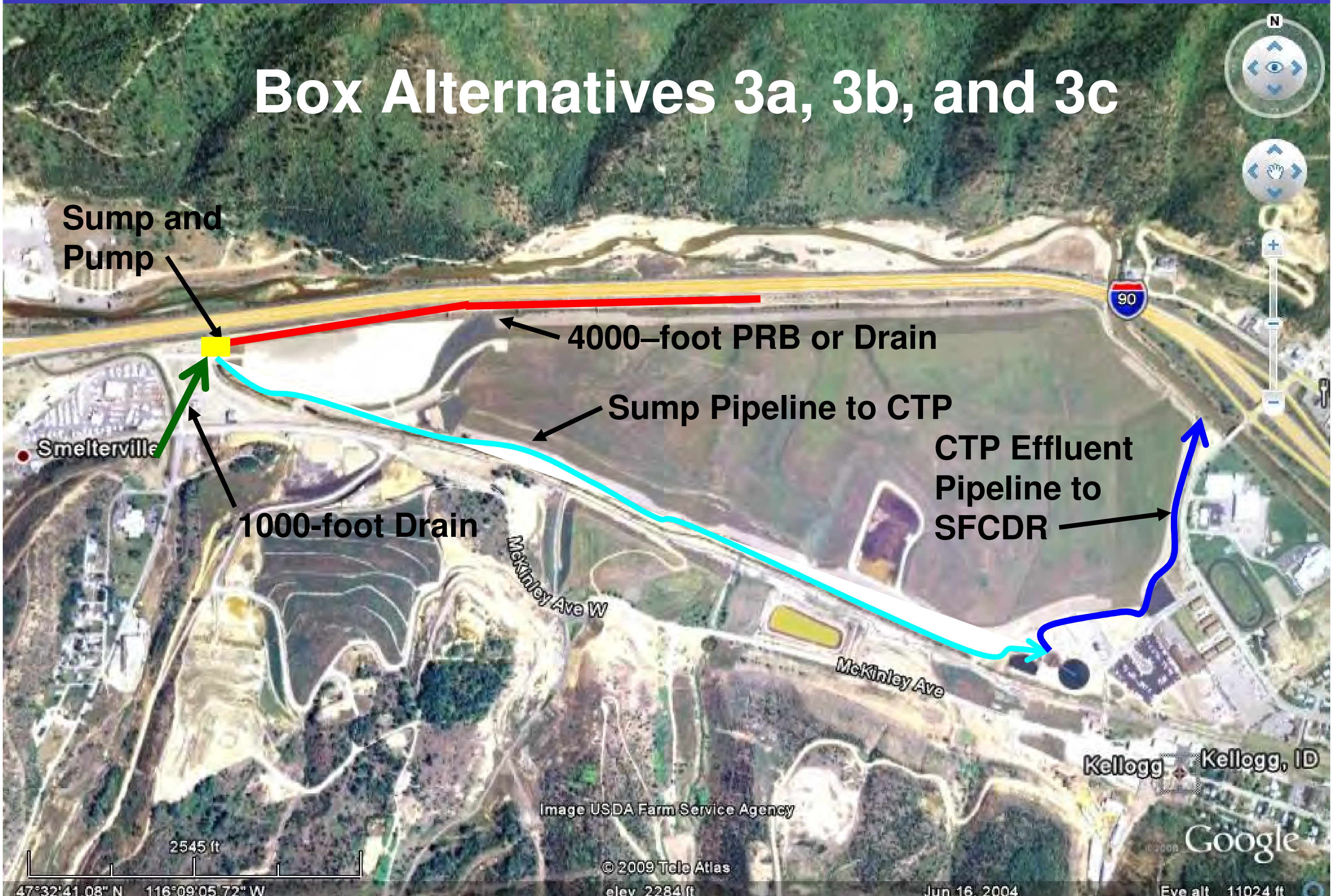
ALTERNATIVE	Changeout Cost	Present Worth if Occurs at Year 15[1]	TOTAL 30-YEAR PRESENT WORTH COST WITH 1 MEDIA CHANGEOUT AT YEAR 15[1]
ALTERNATIVE 3b - PRB 35 feet deep: 1 media changeout	**$19,470,000**	**$7,060,000**	**$40,310,000**
ALTERNATIVE 3c - PRB 25 feet deep: 1 media changeout	**$14,310,000**	**$5,190,000**	**$33,150,000**

[1]Present worth calculated using 7% interest.

NOTE: The above cost opinion is in 2009 dollars.
The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of preparation. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final schedule and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.


Permeable Reactive Barrier (PRB)
10 Feet Wide
Ground Surface
Pea Gravel and Limestone Mixed Media
Groundwater Flow
pH ~ 5 to 6
pH ~ 6.5 to 7.5
X
Dissolved zinc deposits on iron oxy-hydroxides
Aquitard

Box Alternatives 3a, 3b, and 3c



Cost Summary

Order-of-Magnitude Accuracy

ALTERNATIVE	Capital Cost w/o CTP Expansion	Capital Cost of CTP Expansion	Capital Cost w/ CTP Expansion	Annual O&M w/o CTP	Annual O&M at CTP	Total Annual O&M Cost	30-Year NPV of O&M	TOTAL 30-YEAR PRESENT WORTH COST[2]
ALTERNATIVE 3a - French Drain	**$16,920,000**	**$5,681,000**	**$22,601,000**	**$293,000**	**$304,000**	**$597,000**	**$7,410,000**	**$30,010,000**
ALTERNATIVE 3b - PRB 35 feet deep	**$29,030,000**	**$603,000**	**$29,633,000**	**$272,000**	**$20,000**	**$292,000**	**$3,620,000**	**$33,250,000**
ALTERNATIVE 3c - PRB 25 feet deep	**$23,740,000**	**$603,000**	**$24,343,000**	**$272,000**	**$20,000**	**$292,000**	**$3,620,000**	**$27,960,000**

ALTERNATIVE	Changeout Cost	Present Worth if Occurs at Year 15[1]	TOTAL 30-YEAR PRESENT WORTH COST WITH 1 MEDIA CHANGEOUT AT YEAR 15[1]
ALTERNATIVE 3b - PRB 35 feet deep: 1 media changeout	**$19,470,000**	**$7,060,000**	**$40,310,000**
ALTERNATIVE 3c - PRB 25 feet deep: 1 media changeout	**$14,310,000**	**$5,190,000**	**$33,150,000**

Attachment F-2
Sedimentation Basin Effectiveness Assessment, South Fork of the Coeur d'Alene River

Sedimentation Basin Effectiveness Assessment, South Fork of the Coeur d'Alene River

PREPARED FOR: U.S. Environmental Protection Agency Region 10

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DATE: July 2010

Purpose

The purpose of this Technical Memorandum (TM) is to describe possible sedimentation basin configurations at two locations: Smelterville Flats on the South Fork of the Coeur d'Alene River (SFCDR), and Woodland Park on Canyon Creek. This TM also assesses their expected effectiveness and describes the trade-offs among the respective configurations.

This evaluation was conducted in support of the Focused Feasibility Study for the Upper Coeur d'Alene Basin. The objective of this evaluation was to determine whether sedimentation basins could provide a viable means of reducing particulate lead concentrations in surface water in the Upper Basin.

Alternative Sedimentation Basin Configurations

Conceptual sedimentation basin configurations were developed using existing topography and aerial photography. Each basin is laid out as an in-line basin, meaning that it captures the full river discharge unlike off-line structures, which treat only a portion of the total flow diverted to the off-line basin. In-line structures have greater treatment volumes and higher sediment trapping efficiencies. In-line structures need a high-flow bypass spillway to protect the structure during extreme flood events. Isolation berms would be required to protect adjacent infrastructure such as roads, buildings, and airports. Other design considerations include upstream and downstream fish passage and recreational impacts. While there are many important design factors to consider, the purpose of the analysis presented in this TM is to evaluate the treatment performance of alternative sedimentation basins in order to estimate the level of treatment possible given the site constraints.

Preliminary basin-sizing calculations indicate that sedimentation basins need to be as large as possible in order to be effective; therefore, the alternatives considered in this TM use the maximum footprint available and include the relocation of adjacent infrastructure in order to gain more treatment volume. At both Smelterville Flats and Woodland Park, the alternatives considered are made progressively larger by increasing the height of the impoundment and/or increasing the size of the footprint. Computer-aided design (CAD) software was used to determine the extent and volume of inundation for each alternative. Each conceptual alternative is described below.

Alternatives for Smelterville Flats

Four conceptual basin configurations were developed for Smelterville Flats on the SFCDR:

- **Alternative SF1:** Includes four in-line basins in series with dam heights that range from 10 to 12 feet. The maximum area of inundation is approximately 227 acres with a treatment volume of 1,600 acre-feet.
- **Alternative SF2**: Includes one large basin with a 40-foot-high dam at the west end of Smelterville Flats. The maximum area of inundation is 247 acres with a treatment volume of 6,600 acre-feet. This alternative would require a higher isolation berm to protect Shoshone County Airport and Interstate 90 (I-90) as compared to Alternative SF1.
- **Alternative SF3:** Includes the same 40-foot-high dam as Alternative SF2, but with a larger footprint created by relocating the airport. The maximum area of inundation is approximately 349 acres with a treatment volume of 9,100 acre-feet. An isolation berm would still be needed to protect I-90.
- **Alternative SF4:** Includes the same 40-foot-high dam as Alternatives SF2 and SF3, but includes a larger footprint created by relocating the airport and moving I-90 to a location along the east valley wall that follows the old railroad alignment. The maximum area of inundation is approximately 532 acres with a treatment volume of 13,000 acre-feet.

The extent of each alternative for Smelterville Flats is shown in Exhibit 1. (Exhibits 1 through 13 are provided following the References section of this TM.)

Alternatives for Woodland Park

Three conceptual basin configurations were developed for Woodland Park on Canyon Creek:

- **Alternative WP1:** Includes 14 in-line basins in series with dam heights that range from 10 to 12 feet. The maximum area of inundation is approximately 49 acres with a treatment volume of 260 acre-feet.
- **Alternative WP2**: Includes four large basins with four 40-foot-high dams in series. The maximum area of inundation is 72 acres with a treatment volume of 1,500 acre-feet. Isolation berms may be necessary to protect the roadway.
- **Alternative WP3:** This alternative is the same as Alternative WP2 except that it also includes a large 80-foot-high dam upstream of the four 40-foot-high dams. The maximum area of inundation is approximately 104 acres with a treatment volume of 2,600 acre-feet. The adjacent roadway would need to be re-routed.

The layout and extent of each alternative for Woodland Park are shown in Exhibit 2.

Predicted Effectiveness

The analysis presented here is a feasibility-level analysis intended to quantify the general magnitude of predicted effectiveness over a range of sedimentation basin sizes at each location. The effectiveness of each alternative, at each location, was first evaluated independently without consideration for the cumulative effect of the sedimentation basins combined (that is, having basins in both Smelterville Flats and Woodland Park); this provides the expected range of effectiveness if only one facility were constructed. The effectiveness of basins in combination (with one alternative at each location) was then evaluated, providing a range of expected performance if facilities were constructed at both locations.

There are other design and operational factors that would influence the actual effectiveness but are difficult to quantify with any certainty; these are only discussed qualitatively.

Because this is a feasibility-level analysis, the goal is to evaluate what level of performance is possible within the design constraints. However, the ultimate goal would be to retain enough contaminated sediments within the sedimentation basin(s) so that the downstream concentration of deposited lead, below the confluence of the North and South Forks of the Coeur d'Alene River, would be less than the water quality target of 530 milligrams per kilogram (mg/kg) during all flow conditions, including extreme peak-flow events (e.g., 100-year floods). Therefore, the primary performance metric is the downstream concentration of lead below the confluence. The method for estimating this metric involves the following steps:

1. Estimate the trapping efficiency for each basin configuration, and quantify the expected mass of sediments that would be retained for a given flow based on the estimated trapping efficiency.
2. Apply the estimates of sediment mass to the mass-balance model in order to calculate the associated lead concentrations at multiple locations, with emphasis on the concentrations below the confluence.

Trapping Efficiency Calculations

A common measure of a sedimentation basin's effectiveness is its trapping efficiency, which is reported as the percentage of the sediment load retained in the basin relative to the total load flowing into it. Trapping efficiency (TE) is a function of the reservoir's physical dimensions (e.g., volume, depth, length, and width), the magnitude and variability of the incoming flow and sediment load, and the properties of the sediments.

Empirical data and methods have been shown to provide reasonable estimates of the effectiveness of sedimentation basins. Empirical methods provide a more reliable estimate than simplistic theoretical estimates, such as plug flow laminar settling analysis, because empirical methods indirectly account for the sediment transport capacity of water flowing through the reservoir. The most commonly used empirical methods include Churchill (1948), modified Churchill (Roberts, 1982), and Brune (1953). Both the Churchill method and the Brune method were applied and the results compared; the use of two methods increases the level of confidence in the predicted values.

Churchill developed a TE curve for sedimentation basins, small reservoirs, and flood control reservoirs (Churchill, 1948). This method correlates measured TEs to the sedimentation index (SI), which is defined as the ratio of retention time to the mean velocity of the water flowing through the basin. The TE is estimated based on the geometry of the basin and the inflow, and does not directly consider site-specific sediment properties. The Churchill curves were derived from sites dominated by silt-size materials. Therefore, the curves may over-predict TE if sediments are highly colloidal and may under-predict TE for coarser-grained sediments. The modified Churchill method (Roberts, 1982) uses the same empirical data, but correlates to a dimensionless SI index. The SI is calculated using the following equation:

Sedimentation Index (SI) = $(g * V^2) / (Q^2 * L)$

where:

g = acceleration of gravity in feet per second squared (ft/s^2)

V = volume of the sedimentation basin in cubic feet (ft^3)

Q = flow rate in cubic feet per second (ft^3/s)

L = length of the sedimentation basin (ft)

Brune (1953) developed a similar empirical relationship using an independent data set, and correlated TE to the ratio of the reservoir capacity to the average annual inflow volume. The Brune method can only provide average annual estimates of TE, and therefore cannot be used to provide event-based estimates.

The empirical relationships developed by Churchill and Brune are shown in Exhibit 3 (adapted from Garcia, 2008).

While both methods provide a reasonable and appropriate estimate of a sedimentation basin's TE, the Churchill method has the advantage of being able to estimate the TE as a function of flow rate (e.g., a 100-year flood). The Brune method was only applied to provide a check on the estimates computed using the Churchill method, which is the selected method for evaluating the performance of each sedimentation basin alternative.

The product of the TE analysis is a relationship between the flow rate and the mass of sediments retained in the sedimentation basin for each alternative. The TE relationship is then applied to the mass-balance budget for water, sediments, and lead in order to estimate the concentration of lead in suspended sediments downstream of the sedimentation basin(s). It is then assumed that the lead concentration in deposited sediments will be similar to that estimated for suspended sediments. The mass-balance model is described in the next section, followed by a summary of results.

Water, Sediment, and Lead Budget

The mass-balance approach accounts for all water, sediment, and lead loads flowing into and out of a conceptual model study area. In this case, the boundary for the conceptual model begins below the confluence of the North and South Forks of the Coeur d'Alene River and extends upstream to the U.S. Geological Survey (USGS) gauge on the SFCDR located above Smelterville Flats. This study area isolates the Smelterville Flats area and extends downstream to the location where the performance metric is evaluated (below the confluence). There are three gauged inputs to the model: the SFCDR upstream of Smelterville Flats (USGS gauge 12413300), Pine Creek near Pinehurst (USGS gauge 12413445), which enters the SFCDR below Smelterville Flats, and the North Fork near Enaville (USGS gauge 12413000), which combines with the SFCDR at the confluence. The effects of the Canyon Creek sedimentation basins in Woodland Park are accounted for by subtracting the estimated sediment and lead mass trapped in those basins from the loads flowing to the model above Smelterville Flats. A schematic of the mass-balance model is shown in Exhibit 4.

The performance of each alternative was evaluated over a range of flow conditions to quantify the full range of expected performance. The performance of sedimentation basins decreases as the flow into them increases. Therefore, the lowest performance occurs at the highest flow condition being evaluated; the 100-year flood event was the largest flood event considered for this analysis. While the 100-year event is an important flow scenario, it only considers a single, infrequent flow condition. The smaller, more frequent flows convey more sediment and lead mass over the long term, and the sedimentation basins are able to retain a higher fraction of the sediments and lead at lower flows. To characterize the performance at lower flows, several smaller flood recurrence intervals were considered (i.e., 50-year, 20-year, 10-year, 2-year, and 1.01-year[1]) in addition to a long-term scenario that included analysis of 11 years of continuous gauged flow data (1999 through 2009) recorded on Canyon Creek, and 22 years of continuous gauge data recorded on the SFCDR (1988 through 2009). Results for the peak flood events are referred to as event-based results, while results from the long-term scenario are reported as average annual values.

Suspended sediment inputs at each station were estimated using regression equations developed by the USGS (Berenbrock and Tranmer, 2008; Clark and Woods, 2001), with the exception of Pine Creek which was estimated using total suspended sediment (TSS) measurements collected at the Pine Creek gauge (12413445). Sediment transport regressions based on TSS generally underestimate the mass of suspended sediments in natural rivers (Gray et al., 2000); however, TSS data are the best available data for this location. The regression equations provide an empirical relationship between water discharge and suspended sediment discharge. This relationship provides the basis for an estimate of the mass of suspended sediments transported at a given flow rate. There is inherent uncertainty associated with using sediment transport regression analysis, but its use here is appropriate for a feasibility-level evaluation. A detailed description of the assumptions and limitations associated with sediment transport regression analysis is included in *Technical Memorandum D – Hydraulics and Sediment Transport (*CH2M HILL, 2010) in the TM series for the Enhanced Conceptual Site Model for the Lower Basin of the Coeur d'Alene River.

Regression analysis was also used to develop a relationship between river discharge and the mass of lead transported. The regression equations were developed using water quality data collected at each gauge location. The complete record of lead data was filtered to exclude

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[1] The theoretical return period is the inverse of the probability that the event will be exceeded in any one year. For example, a 10-year flood has a 1 / 10 = 0.1 or 10% chance of being exceeded in any one year. The return period of 1.01 year generally represents the average annual high flow event. The return period must always be greater than one because a 1-year return period would have a 100% probability, which is statistically invalid.

measurements taken prior to 1999, which was when larger-scale remediation activities generally ceased in the Upper Basin, although remediation activities continued in the Box through 2002. These remediation activities may have effectively reduced lead concentrations. The data set was also filtered to exclude low-flow data because high-flow conditions are the primary focus. The purpose of applying these filter criteria to the data is to develop a relationship that most closely represents the current condition and focuses on the high-flow events. Data collected prior to 1999 show higher levels of lead compared to current conditions. The low-flow data also tend to skew the regression curve, which results in an underestimate of lead concentrations at higher flows. A comparison of several regression curves fit to the subsets of data described above is included in Exhibit 5 to illustrate the need for these filter criteria.

The sediment and lead regression equations provide an estimate of transported sediment and lead mass as a function of flow. The concentration of lead is then calculated by dividing the mass of lead by the mass of sediments at each gauge. The total mass and associated volume of sediments help to quantify the rate of sediment accumulation in a sedimentation basin (which is important from a maintenance perspective), but the primary performance metric is the lead concentration of suspended sediments, which is inferred to represent the lead concentration in potentially deposited sediments. A conceptual illustration of how the water, sediment, and lead relationships are used to calculate lead concentrations is provided in Exhibit 6.

Model Validation

The mass-balance model was first developed for the current condition. Lead concentration results from the current condition model were then compared to measured lead concentrations of deposited sediment samples collected at various Basin Environmental Monitoring Program (BEMP) monitoring stations between 2004 and 2008. This comparison provides the best means of assessing the model's ability to accurately estimate lead concentrations in deposited sediments. The comparison assumes that lead concentrations in deposited sediments are representative of lead concentrations in suspended sediments.

A plot showing the comparison between measured and model-predicted lead concentrations is shown in Exhibit 7. Model results for the range of flows between the 2-year and 100-year flood events match closely with measured lead concentrations except at Pine Creek. The model over-predicts lead concentrations at Pine Creek, probably because of the use of a sediment regression equation based on TSS data that under-predicts the sediment mass and, as a result, over-predicts lead concentrations. This has a very minor impact on the overall mass-balance model because the lead and sediment loads from Pine Creek are small relative to the SFCDR. No adjustments were made to the initial regression equations because the results compared favorably with measured values. There is no BEMP station just past the confluence of the North and South Forks, and therefore no data are plotted on Exhibit 7 for this area.

Alternatives Analysis

The performance of the respective alternatives was assessed both independently and in combination (e.g., Alternative SF1 for Smelterville Flats in combination with Alternative WP1 for Woodland Park). With four alternatives for Smelterville and three for Woodland

Park, there are a total of seven independent scenarios and 12 scenarios that evaluate the combined effects of developing multiple sedimentation basin alternatives (one alternative at each location). The results of the performance analysis are presented below in terms of TE and downstream lead concentrations.

Results

The results of the TE analysis and the mass-balance model (downstream lead concentrations) are discussed below.

Trapping Efficiency Results

The TE estimates are relatively high for the low-flow scenarios, with a steady decrease in efficiency as the flows increase. The most efficient alternatives are those with the largest storage volumes; reservoir length and average depth are also important factors that lead to an increase in efficiency, but do not correlate as strongly as volume. Alternatives with the greatest volumes are those with high dams and flatter terrain.

The TE for the Smelterville Flats alternatives ranges from 58 to 93 percent at low flows, when sediment transport first begins (Exhibit 8). The TE for Alternative SF1 drops off rapidly at higher flows, with a TE of less than 5 percent during the 5-year event, and is completely ineffective at flows equal to and greater than the 20-year event. Alternatives SF2, SF3, and SF4 (all with a 40-foot-tall dam) perform much better over the full range of flows, but the performance still decreases considerably at higher flows. During the 100-year event, the TE is 0, 17, 26, and 38 percent for Alternatives SF1 through SF4, respectively.

At Woodland Park, the TE results are similar to those at Smelterville Flats. The TE estimates range from 91 to 100 percent for all three alternatives during low flows, when sediment transport first begins (Exhibit 9). Alternative WP1, with the smaller 10- to 12-foot-high dams, does not perform well during high flows; its TE drops to 11 percent during the 5-year event and is ineffective at flows equal to and greater than the 10-year event. Alternatives WP2 and WP3 (with large dams) perform well during higher flows; the TE for these alternatives during the 100-year event is 28 and 40 percent, respectively.

The TE of each alternative was also assessed using a long-term flow scenario (22 years for the Smelterville Flats alternatives and 11 years for the Woodland Park alternatives) to quantify the expected average annual performance. The average annual TEs for the Smelterville Flats alternatives are 14, 46, 55, and 65 percent for Alternatives SF1 through SF4, respectively. The average annual volume of sediments trapped ranges from 1,500 to 7,400 cubic yards, with an associated lead mass of 10 and 48 tons for Alternatives SF1 and SF4, respectively. For all the alternatives, the annual volume of accumulation is only 0.1 percent of the total sedimentation basin volume, which indicates that routine excavation would not be required in order to maintain the storage volume necessary for the basin's performance.

The average annual TEs at Woodland Park are 43, 82, and 89 percent for Alternatives WP1 through WP3, respectively. The annual volume of sediment accumulation ranges from 200 to 400 cubic yards, with an associated lead mass of 2 to 5 tons. The annual volume of sediment accumulation is negligible relative to the size of the sedimentation basin alternatives (less than one tenth of a percent); therefore, routine removal of sediments would not be needed in order to maintain trapping efficiency.

These average annual metrics also allow for a comparison between the TEs calculated using the Churchill method and those calculated using the Brune method, which only estimates average annual TE. This comparison shows that both methods provide very similar results, with an average difference of 8 percent. The Brune method estimates slightly greater TEs for the Smelterville Flats alternatives and slightly lower TEs for the Woodland Park alternatives.

Exhibit 10 contains a summary of the event-based and average annual trapping efficiencies for each alternative and a comparison to the estimates calculated using the Brune method.

The actual TEs would likely be lower than the estimates provided here for alternatives that use multiple basins, because the analysis inherently assumes that TEs for basins in series are equal to the TE of a single basin of equal volume. Basins in series would be expected to have lower efficiencies because considerable mixing would occur as water flowed from one basin to another.

The TE analysis is the first step in the process of evaluating the concentrations of lead in the suspended sediments downstream of the sedimentation basins. Results from the TE analysis were applied to the mass-balance model to compute lead concentrations for each alternative. The results are discussed in the next section.

Downstream Lead Concentrations

The concentration of lead in suspended sediments increases as a function of flow. Concentrations estimated by the model for the current condition are 7,000 and 16,800 mg/kg at Woodland Park for the 2-year and 100-year flow, respectively. The lead concentrations at Smelterville Flats are considerably lower, with a 2-year concentration of 2,400 mg/kg and a 100-year concentration of 2,800 mg/kg. Lead concentrations in the SFCDR are further diluted by cleaner sediments from Pine Creek, and concentrations in the river after the confluence of the SFCDR and the North Fork are greatly diluted by clean sediments from the North Fork. The estimated lead concentrations below the confluence are 500 mg/kg to 700 mg/kg (after complete mixing) for the 2-year and 100-year events, respectively. While the current concentrations below the confluence appear to be relatively low, the mass of contaminated sediments is much greater after mixing with the North Fork; therefore, large volumes of contaminated sediments must be removed in order to reduce the concentrations at this downstream location. All the lead concentration results reported below are referenced to a location downstream of the confluence and assume complete mixing with the North Fork sediments.

Analysis of the individual alternatives shows that the Smelterville Flats sedimentation basins are more effective than those located in Woodland Park. This is because the Woodland Park basins only capture the sediment load from Canyon Creek, while the Smelterville Flats basins are able to capture contaminated sediments from all upstream sources including Canyon Creek. The greatest reductions in lead concentrations are associated with the alternatives that include large dams and thus large treatment volumes.

Lead concentrations for all of the Smelterville Flats alternatives during the 2-year, 10-year, 50-year, and 100-year events are shown in Exhibit 11. Alternative SF1 only produces a slight reduction in lead concentrations and only during events less than the 10-year event. There is a significant gain in performance for Alternative SF2, which significantly reduces the lead concentrations below the water quality target level (530 mg/kg) during flow conditions up to the 10-year event, and reduces concentrations during the 100-year event to 610 mg/kg. Alternative SF3 further reduces lead concentrations, meets the water quality target during flow conditions up to the 50-year event, and reduces the 100-year concentration to 560 mg/kg. Alternative SF4 is able to reduce lead concentrations below the water quality target during all flow conditions, with a 100-year-event lead concentration of 500 mg/kg.

Results at Woodland Park show that Alternative WP1 is only effective at flows less than the 2-year event and only reduces the lead concentration by 15 mg/kg during the 2-year event. Alternative WP2 includes larger dams and treatment volumes, which enables it to reduce lead concentrations during all the flow events but only by an average of 44 mg/kg. Alternative WP3 provides only a minor improvement over Alternative WP2 by further reducing concentrations by an additional 8 mg/kg on average. None of the Woodland Park alternatives alone is capable of reducing the lead concentrations below the water quality target, except for during the 2-year event where lead concentrations are already below the water quality target under the current condition. Lead concentrations for all of the Woodland Park alternatives during the 2-year, 10-year, 50-year, and 100-year events are shown in Exhibit 12.

Every possible combination of alternatives was evaluated to quantify the effectiveness of constructing sedimentation basins at both locations. Lead concentrations for each of the 12 combinations are summarized in Exhibit 13. The biggest increases in effectiveness are associated with the increase in basin sizes at Smelterville Flats. The Woodland Park alternatives only provide a minor reduction in lead concentrations.

Assumptions and Limitations of the Effectiveness Analysis

A number of assumptions were required in order to assess the effectiveness of the respective sedimentation basin configurations. The assumptions included:

- The TE analysis for each alternative is based on the geometry of the sedimentation basin and the inflow, and does not directly consider site-specific sediment properties. The overarching assumption is that the empirical data used to develop the Churchill method are representative of site conditions in the Upper Coeur d'Alene Basin. The Churchill curves were derived from sites dominated by silt-size materials. Therefore, the curves may over-predict TE if sediments are highly colloidal and may under-predict TE for coarser-grained sediments.
- The SFCDR discharge at Smelterville Flats is proportional to its drainage area. The SFCDR discharge recorded at Pinehurst was reduced by 27 percent, the difference in drainage area between the two locations.
- The sediment transport rating curve developed for the SFCDR near Pinehurst is representative of the sediment transport characteristics at Smelterville Flats.

- Retention time is approximately equal to the reservoir capacity divided by the inflow rate.
- The mean velocity is approximately equal to the inflow rate divided by the average cross-sectional area.
- The concentration of lead measured from depositional samples is representative of the lead concentration of the suspended sediments at that location.
- The topographic resolution is high enough that the calculated sedimentation basin characteristics, such as pool volume and depth, are sufficiently accurate that they will not affect the conclusions of the evaluation.
- The TE of several reservoirs in series is comparable to a single larger reservoir of the same volume.
- Estimates of suspended lead concentrations just downstream of the confluence of the SFCDR with the North Fork are compared to the deposited sediment cleanup target of 530 mg/kg. This assumes that deposited sediments will have the same lead concentration as suspended sediments.

The above assumptions and limitations are considered reasonable for feasibility-level analysis.

Conclusions

The sedimentation basin effectiveness analysis evaluated the feasibility of constructing sedimentation basins at two locations, Smelterville Flats on the SFCDR and Woodland Park on Canyon Creek. Alternative basin configurations were developed based on local site constraints such as topography and adjacent infrastructure.

Smelterville Flats is relatively flat and adjacent to low-lying infrastructure including the Shoshone County Airport and I-90. The impoundment structures would include a berm at the downstream end of the basin and isolation berms along the southern boundary in order to protect the airport and I-90 from flooding. No isolation berm would be needed along the northern boundary because there is no infrastructure to protect; the basin would extend to the valley wall. Four alternatives were identified for Smelterville Flats: Alternative SF1 includes four basins that range in height from 10 to 12 feet; Alternative SF2 includes one 40-foot-tall dam with a berm protecting the airport and I-90; Alternative SF3 includes the same 40-foot-tall dam, but would also require relocating the airport; and Alternative SF4 is the largest basin, with a 40-foot-tall dam and a much larger inundation area that would require relocation of the airport and rerouting of I-90 adjacent to the old railroad grade.

At Woodland Park the terrain is steep and the available footprint is relatively narrow. Multiple basins in series would be needed to pond a sufficient volume for the basins to be effective. Three alternative basin configurations were identified at Woodland Park: Alternative WP1 includes 14 basins with 10- to 12-foot-tall impoundment berms; Alternative WP2 includes four basins with 40-foot-tall dams; and Alternative WP3 is similar to Alternative WP2 but also includes an additional 80-foot-tall dam upstream.

The ability of the respective alternatives to trap sediments was evaluated using the Churchill method to estimate the TE over a range of flow conditions. The Churchill method estimates the percentage of sediments trapped within the basin for a given flow. The primary factor influencing the TE is the volume of the basin. The TE estimates were then fed into the mass-balance model, which tracks the water, sediment, and lead mass entering and leaving Smelterville Flats and ultimately calculates the lead concentration in suspended sediments downstream of the confluence of the SFCDR with the North Fork. Lead and sediments trapped by the Woodland Park alternatives were subtracted from the load entering the model at Smelterville Flats.

All the alternatives were evaluated both independently and in combination (all possible combinations were evaluated). The performance metric was the lead concentration downstream of the confluence of the SFCDR with the North Fork, which assumes complete mixing of sediments between the North and South Forks of the river. The predicted concentration was compared to the water quality target of 530 mg/kg for deposited sediments.

The analysis shows that the sedimentation basins at Smelterville Flats would be considerably more effective than the Woodland Park alternatives, especially Alternatives SF2 through SF4 that include the higher 40-foot dam. The greatest increase in performance is associated with Alternative SF2; however, the predicted lead concentrations are still 80 mg/kg higher than the water quality target during the 100-year event. Alternative SF4 is the only independent alternative configuration that is predicted to reduce lead concentrations below the 530 g/kg target during all flow events up to the 100-year flood. Many of the alternatives in combination are predicted to meet the target. However, the added benefit from the Woodland Park basins is only minor and may not be cost-effective.

The feasibility analysis indicates that construction of Alternative SF4 at Smelterville Flats would likely reduce the lead concentration to a level less than the 530 mg/kg target for flow conditions up to the 100-year event. However, the size of the basin required to achieve this level of performance is extremely large and would require construction of a large dam at Smelterville Flats, relocation of the Shoshone County Airport, and realignment of I-90.

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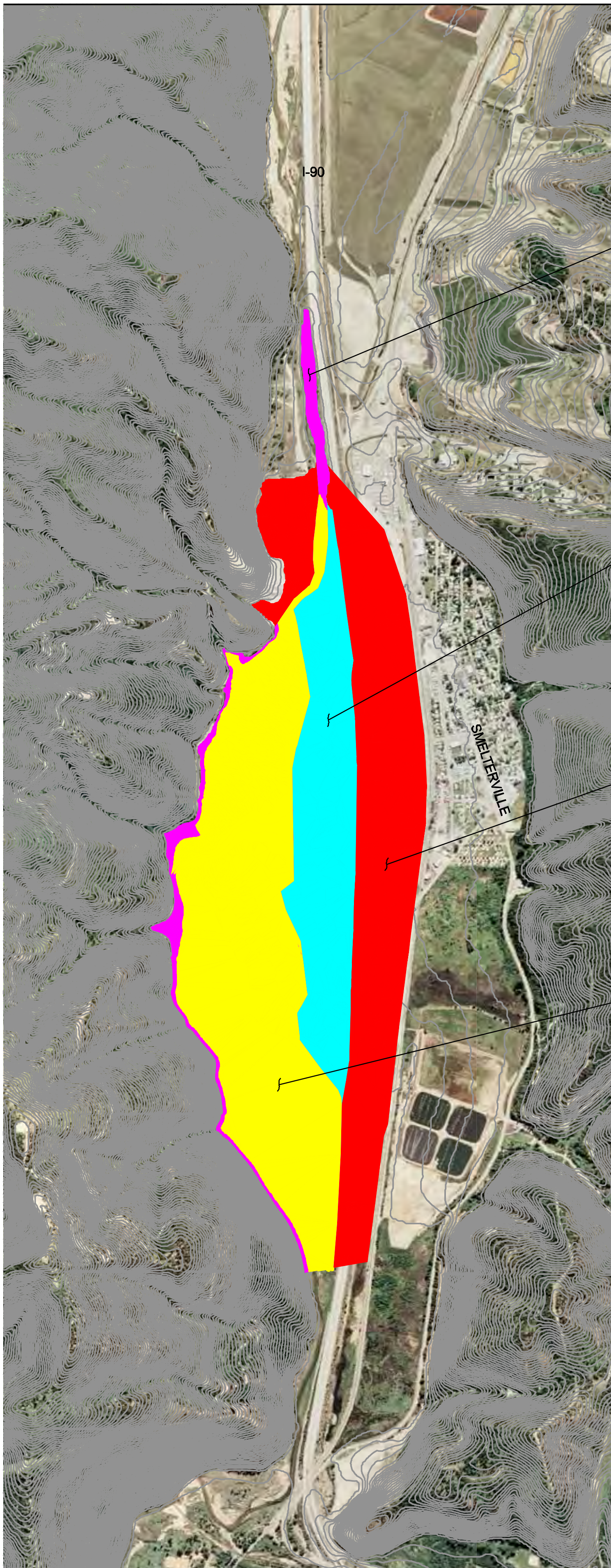


ALTERNATIVE SF2 - YELLOW & PURPLE - 1 BASIN @ 40 FT, AND HIGH BERM ALONG AIRPORT

AREA: 247 ACRES

VOLUME: 289,042,954 CF

MAXIMUM DEPTH: 40 FT

APPROXIMATE TREATMENT LENGTH: 8,000 FT

ALTERNATIVE SF3 - YELLOW, PURPLE, & BLUE - 1 BASIN @ 40 FT, MOVE AIRPORT ACROSS I-90, AND HIGH BERM ALONG I-90

AREA: 349 ACRES

VOLUME: 394,503,193 CF

MAXIMUM DEPTH: 40 FT

APPROXIMATE TREATMENT LENGTH: 8,000 FT

ALTERNATIVE SF4 - YELLOW, PURPLE, BLUE, & RED - 1 BASIN @ 40 FT, 10 FT MINIMUM DEPTH, MOVE AIRPORT, MOVE I-90 TO RAILROAD GRADE, AND HIGH BERM ALONG NEW I-90

AREA: 532 ACRES

VOLUME: 568,442,781 CF

MAXIMUM DEPTH: 40 FT

APPROXIMATE TREATMENT LENGTH: 8,000 FT

ALTERNATIVE SF1 - YELLOW - 4 BASINS @ 10 FT - 12 FT, AND LOW BERM ALONG AIRPORT

AREA: 227 ACRES

VOLUME: 69,181,068 CF

MAXIMUM DEPTH: 10 FT

APPROXIMATE TREATMENT LENGTH: 8,000 FT

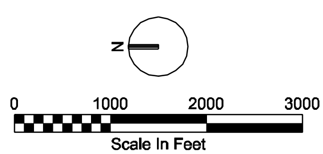


Exhibit 1
Smelterville Flats Sedimentation Basin Alternatives
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA

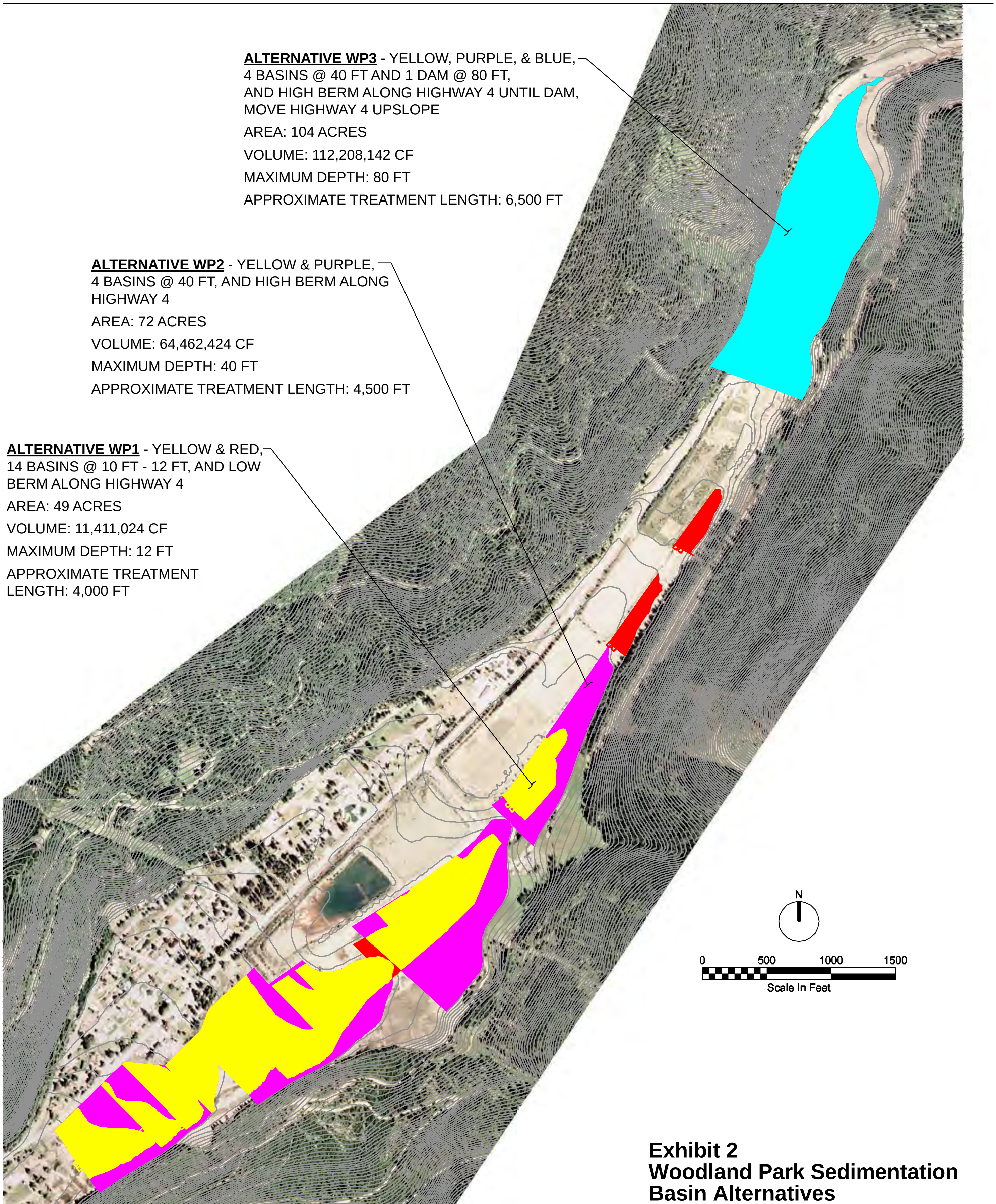
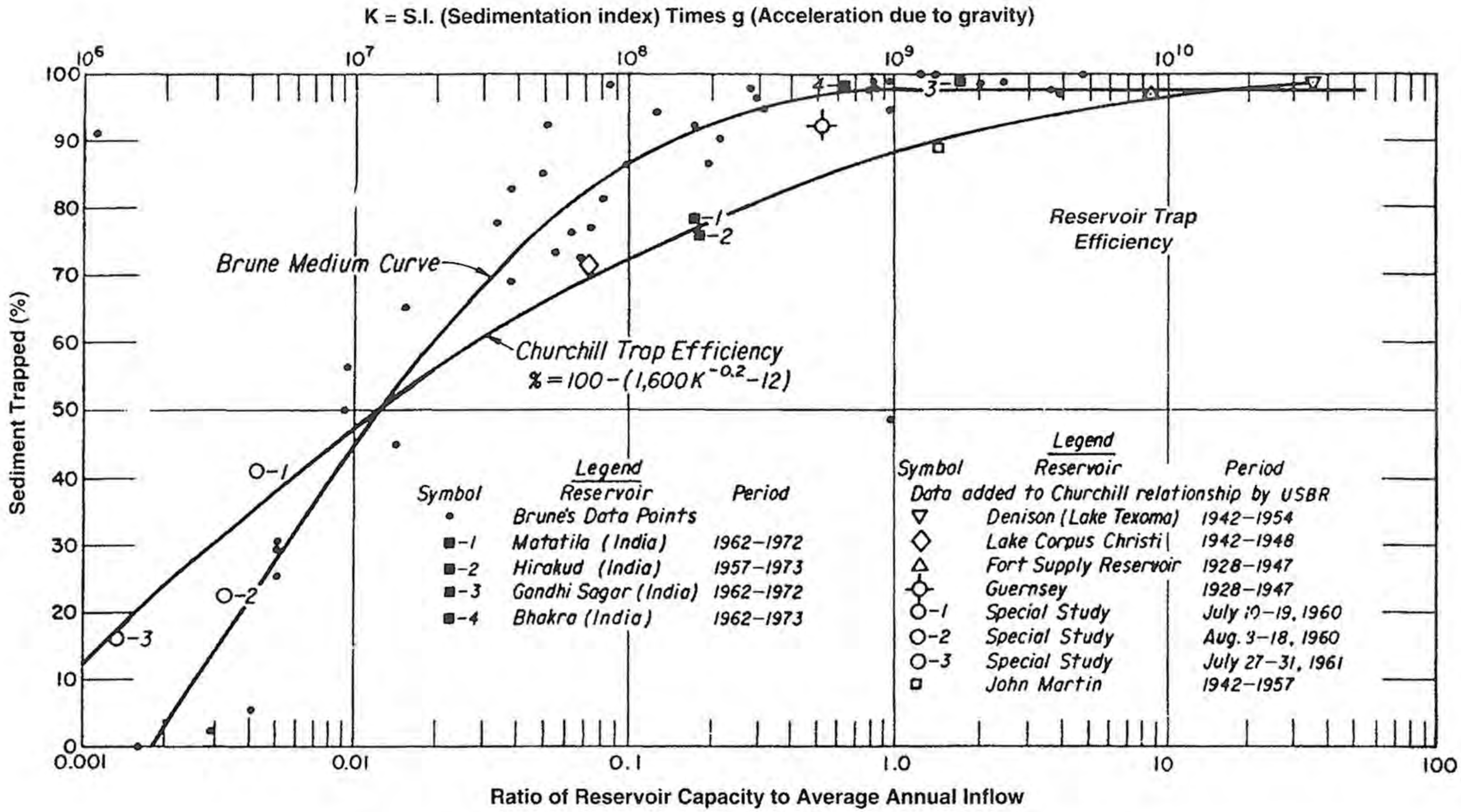
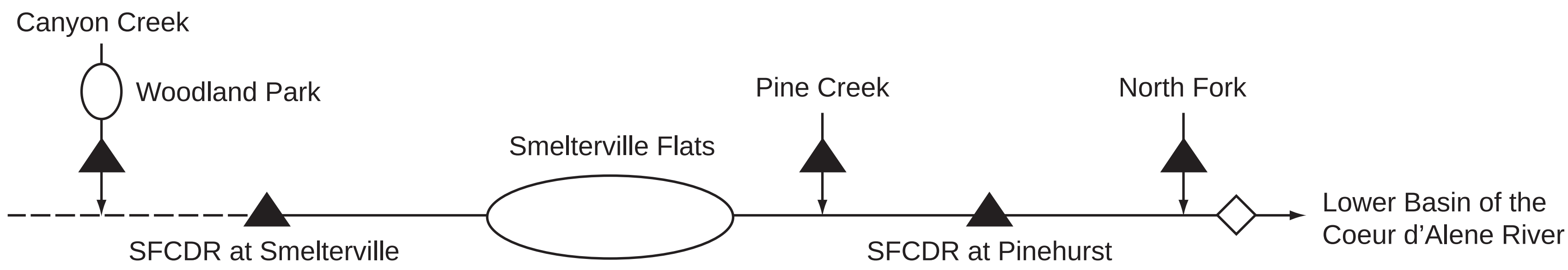


Exhibit 2
Woodland Park Sedimentation Basin Alternatives
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE



Adapted from M. Garcia, *Sedimentation Engineering*, 2008.

Exhibit 3
Empirical Relationships Developed Using the Churchill and Brune Methods
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE



Legend

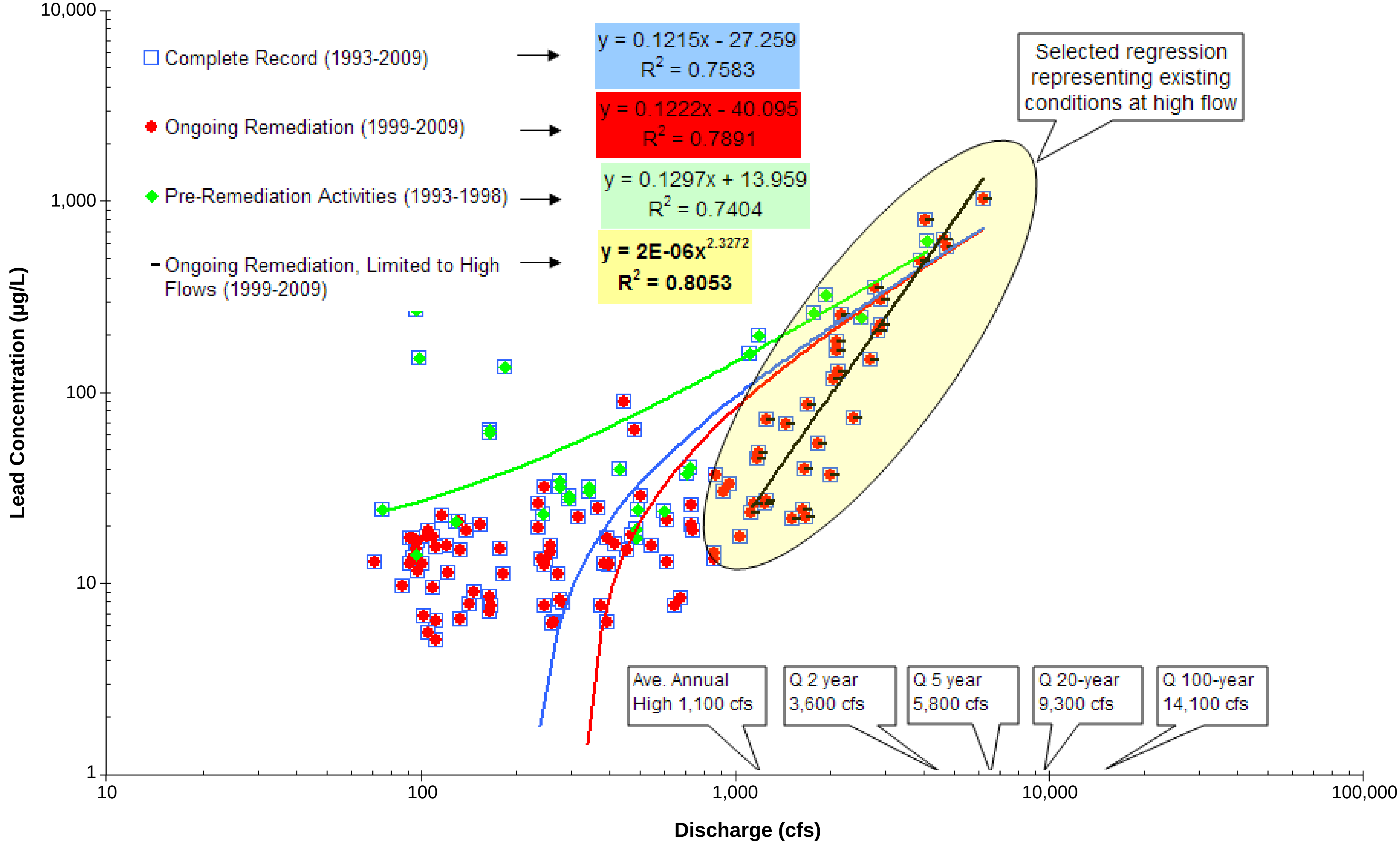
= Gauge Locations

= Sedimentation Basin Locations

= Water Quality Reference Location

SFCDR = South Fork of the Coeur d'Alene River

Exhibit 4
Conceptual Model Schematic for Water, Sediment, and Lead Mass Balance
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE



Legend

cfs = cubic feet per second

µg/L = micrograms per liter

Exhibit 5
Comparison of Multiple River Discharge-Lead Regression Equations
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

Flood Flows:

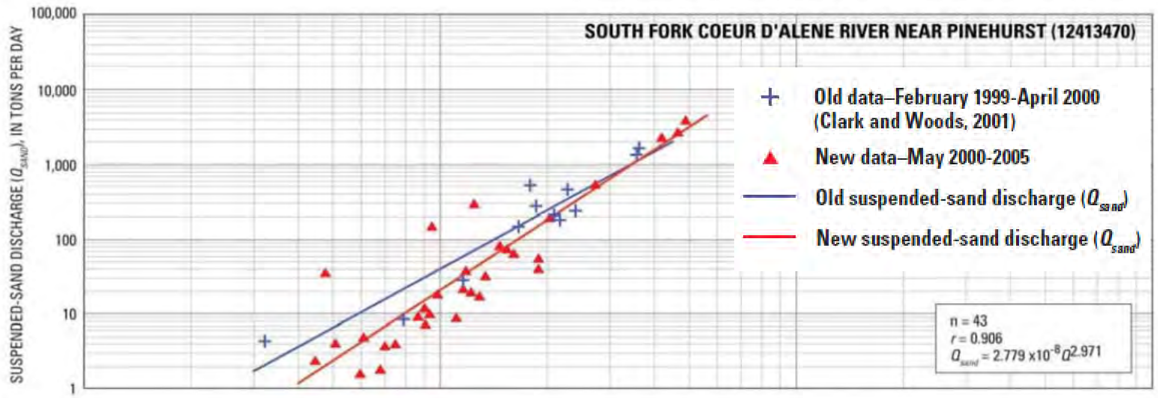
100-year

50-year

10-year

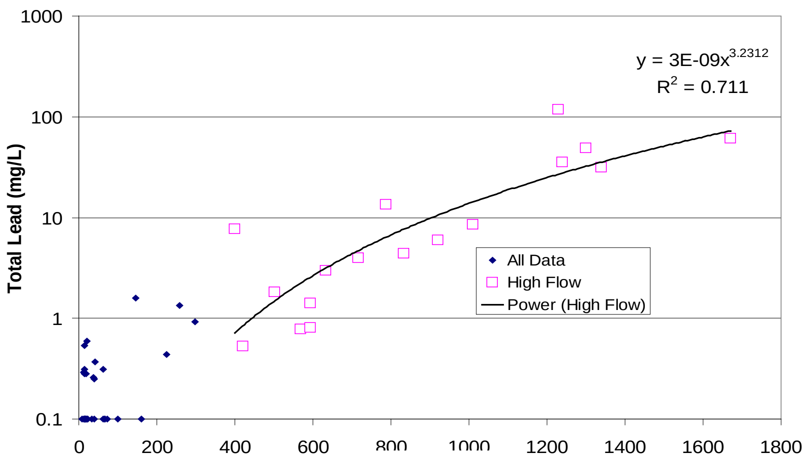
2-year

Sediment Regression



Flow (cfs)

Lead Regression



Sediment Mass (kg)

Lead Mass (kg)

Lead Concentration

C_{Pb} = Pb (mg) / Suspended Sediment (kg)

Legend

cfs = cubic feet per second

kg = kilograms

mg = milligrams

mg/L = milligrams per liter

Exhibit 6
Lead Concentration Calculation Procedure
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

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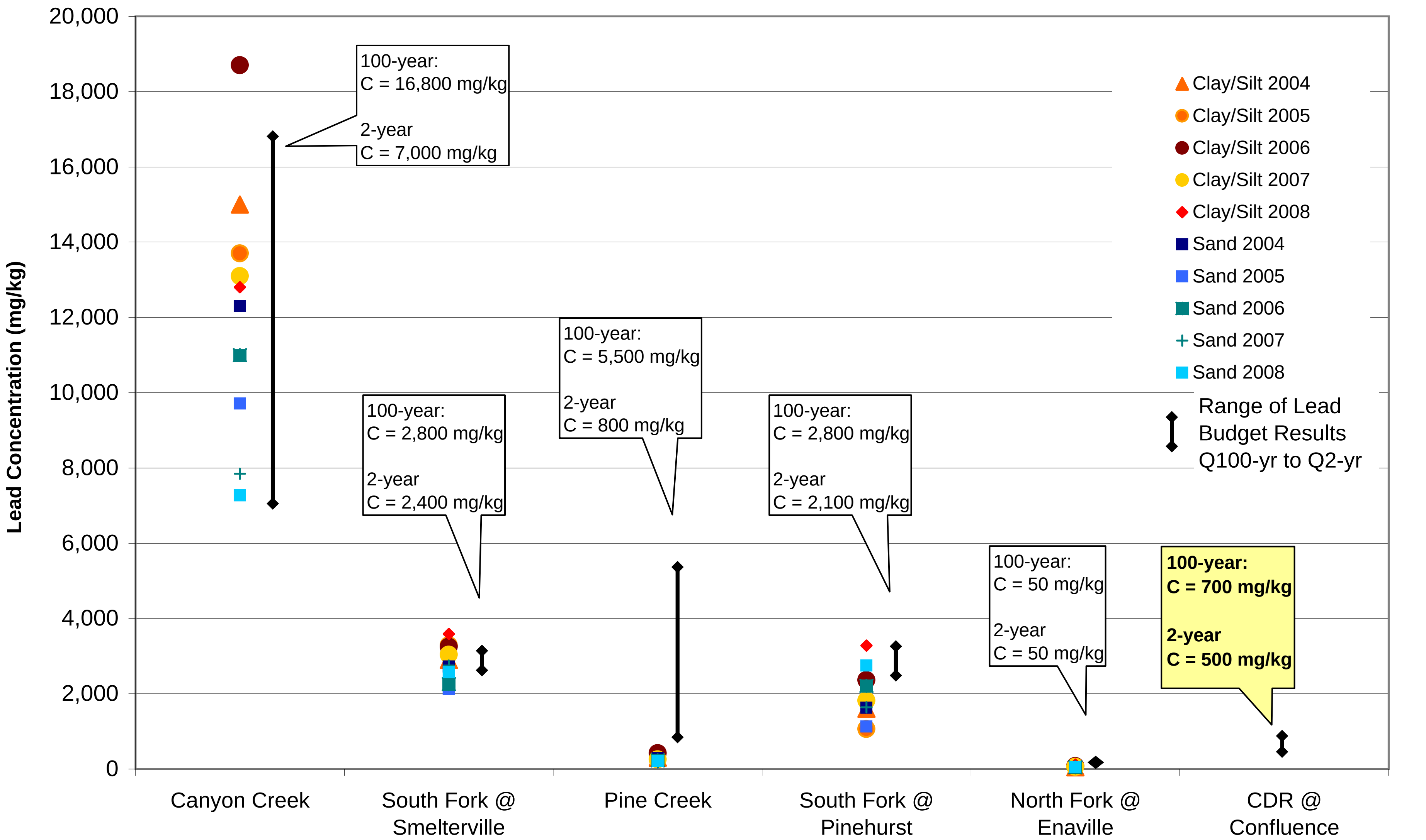


BEMP = Basin Environmental Monitoring Program
C = concentration
CDR = Coeur d'Alene River
mg/kg = milligrams per kilogram

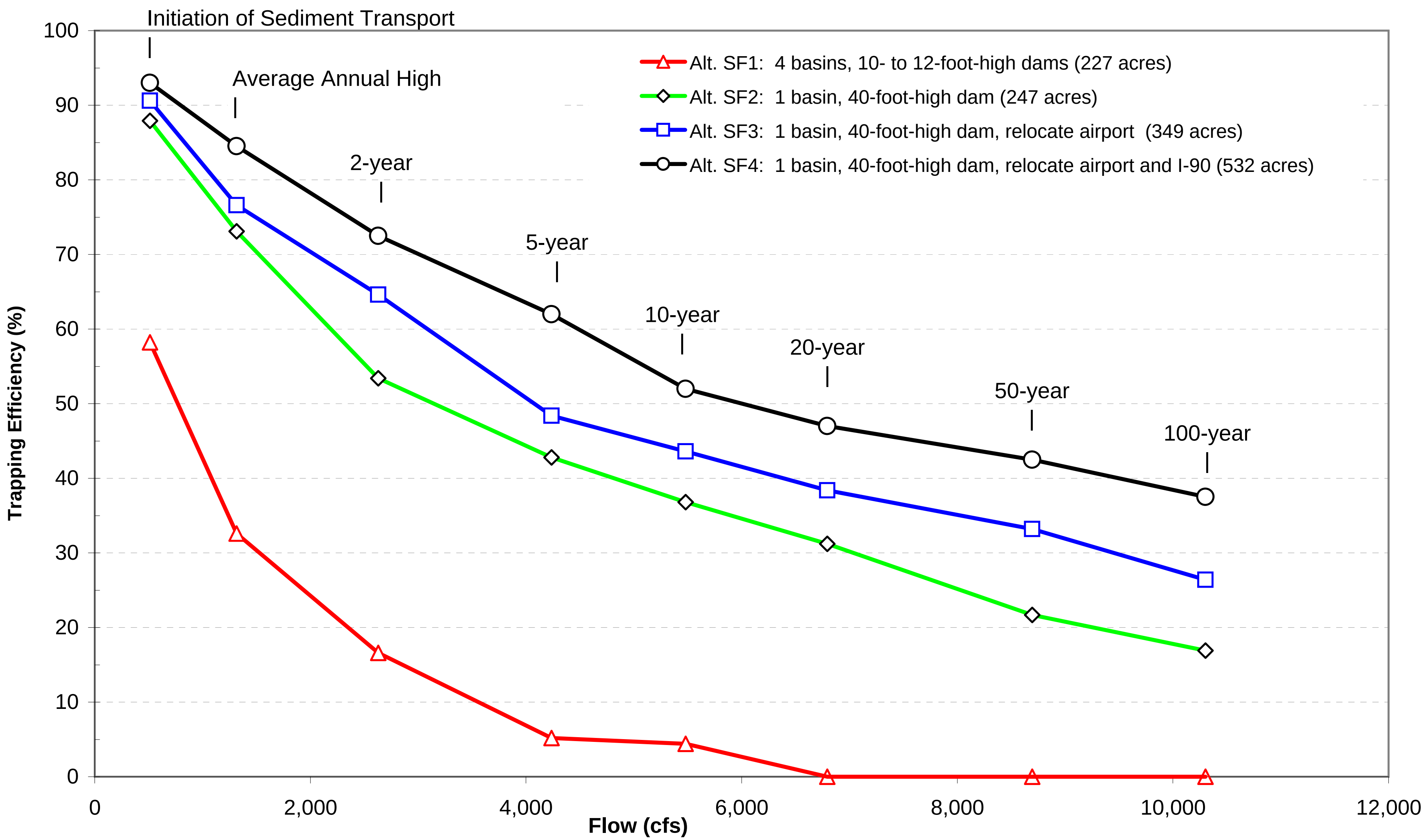
Exhibit 7

Comparison of Lead Budget Model Results to Measured Depositional Samples Collected at BEMP Stations, 2004-2008

Focused Feasibility Study

Upper Basin of the Coeur d'Alene River

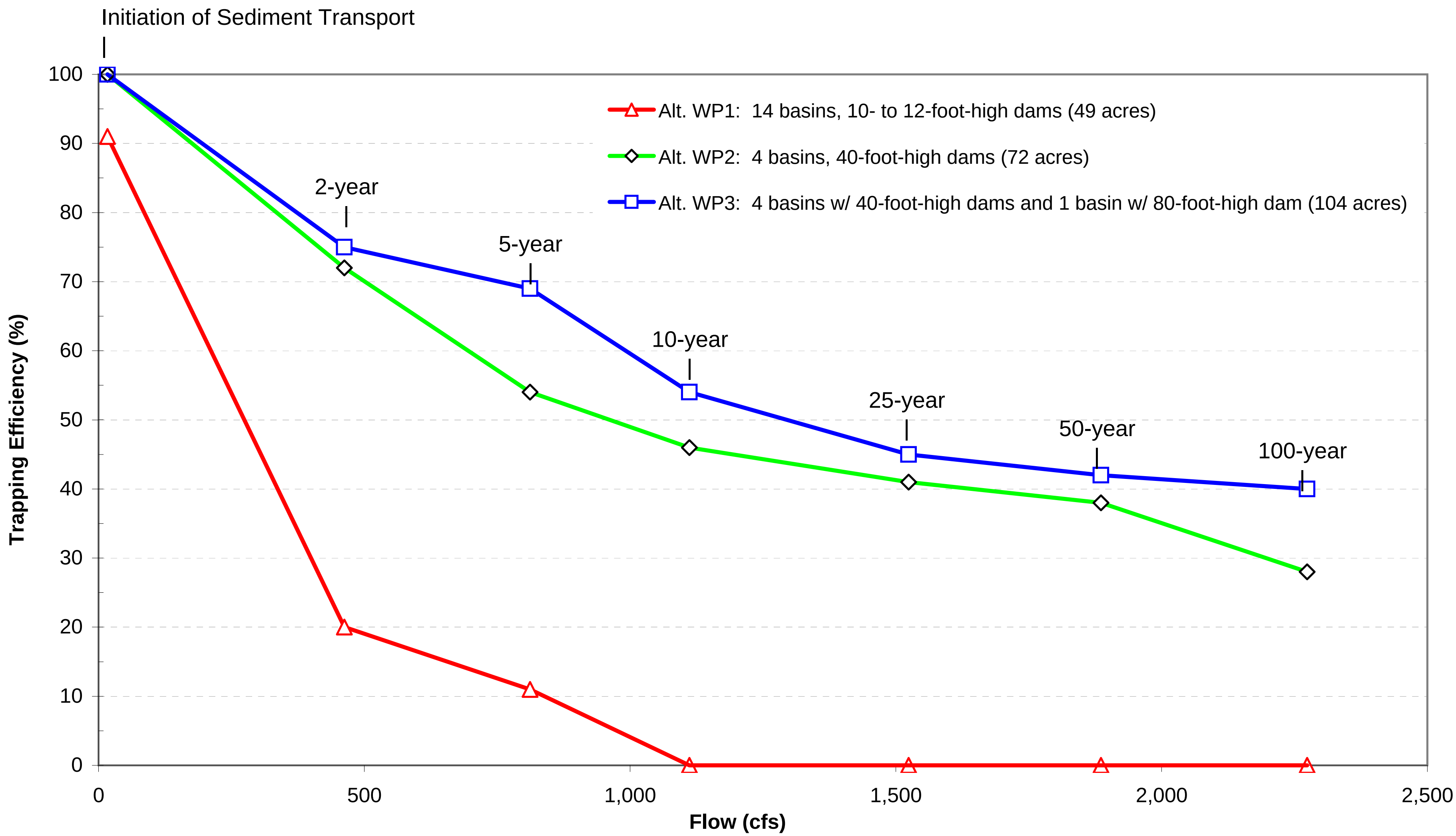
BUNKER HILL SUPERFUND SITE



cfs = cubic feet per second

Exhibit 8
Trapping Efficiency Estimates Calculated Using the Churchill Method for Each Smelterville Flats Alternative
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA



cfs = cubic feet per second

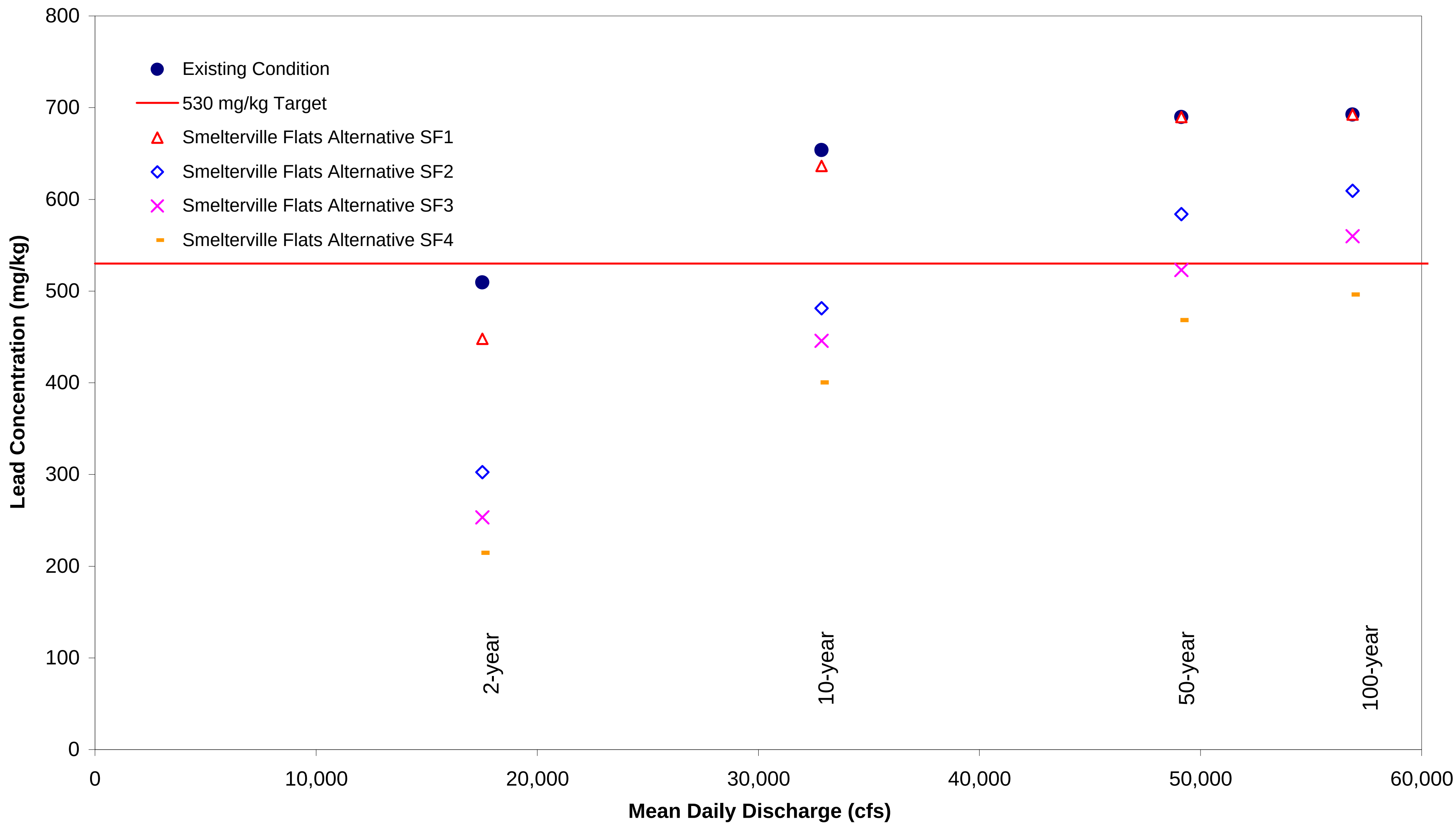
Exhibit 9
Trapping Efficiency Estimates Calculated Using the Churchill Method for Each Woodland Park Alternative
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

			Total Average Annual Performance Metrics						Event-Based Sediment Trapping Efficiency					
Location	**Area (acres)**	**Average Pool Depth (feet)**	**Trapping Efficiency (%) [Brune Method][a]**	**Trapping Efficiency (%) [Churchill Method]**	**Mass Trapped Sediment (tons)**	**Sediment Volume (cubic yards)**	**Annual Sediment Volume Trapped as Percentage of Reservoir Volume**	**Lead Mass Trapped (tons)**	**100-year**	**50-year**	**20-year**	**10-year**	**2-year**	**1.01-year[b]**
Smelterville Flats														
Alternative SF1	227	7	22%	14%	2,500	1,500	0.08%	10.0	0%	0%	0%	4%	17%	33%
Alternative SF2	247	27	58%	46%	8,400	5,200	0.07%	33.8	17%	22%	31%	37%	53%	73%
Alternative SF3	349	26	60%	55%	10,900	6,700	0.09%	40.4	26%	33%	38%	44%	65%	77%
Alternative SF4	532	25	71%	65%	11,900	7,400	0.10%	47.5	38%	43%	47%	52%	73%	85%
Woodland Park									**100-year**	**50-year**	**25-year**	**10-year**	**2-year**	
Alternative WP1	49	5	35%	43%	300	200	0.04%	2.23	0%	0%	0%	0%	20%	NA
Alternative WP2	72	20	72%	82%	500	300	0.02%	4.26	28%	38%	41%	46%	72%	NA
Alternative WP3	104	25	82%	89%	600	400	0.01%	4.65	40%	42%	45%	54%	75%	NA

[a] The Brune method trapping efficiency provides a second estimate to compare against the values calculated using the Churchill method.
[b] See footnote 1 in the text of this Technical Memorandum.

NA = not available

Exhibit 10
Predicted Effectiveness of Alternative Sedimentation Basins (Independently)
Focused Feasibility Study
Upper Basin Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

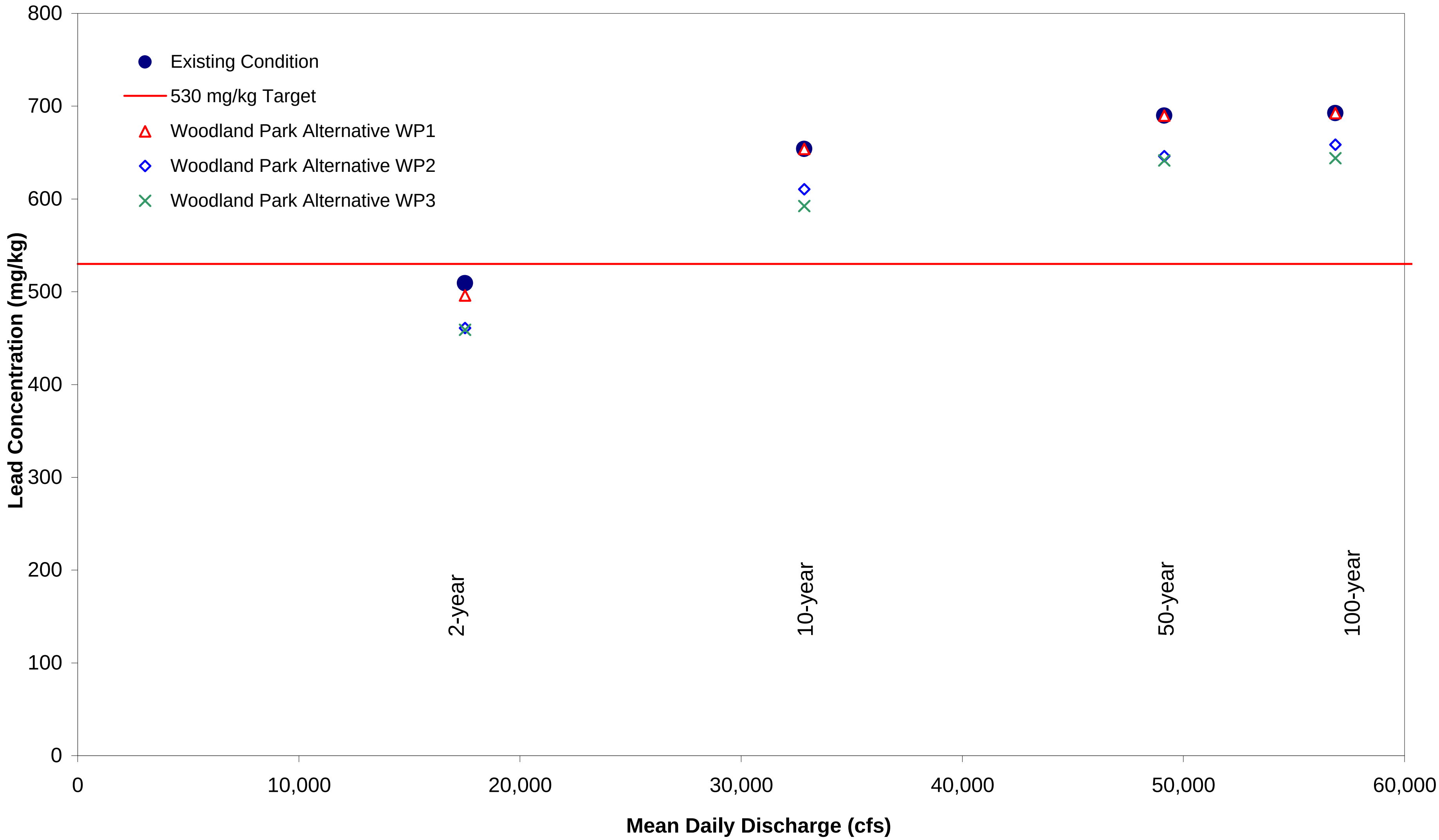


Note: Model results shown are lead concentrations just below the confluence of the North and South Forks of the Coeur d'Alene River.

cfs = cubic feet per second
mg/kg = milligrams per kilogram

Exhibit 11
Performance Summary of Alternative Sedimentation Basins Located at Smelterville Flats
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA

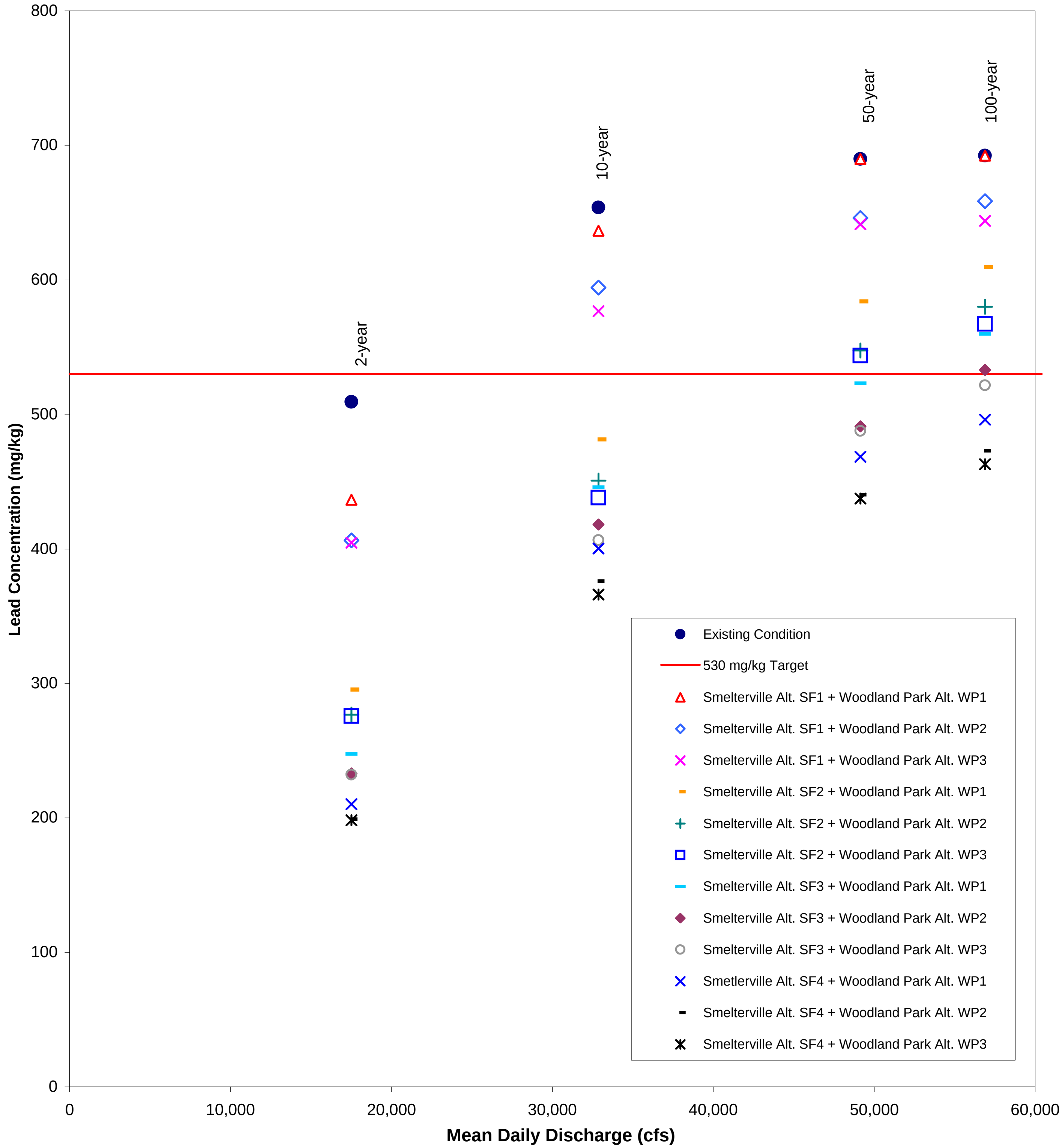


Note: Model results shown are lead concentrations just below the confluence of the North and South Forks of the Coeur d'Alene River.

cfs = cubic feet per second
mg/kg = milligrams per kilogram

Exhibit 12
Performance Summary of Alternative Sedimentation Basins Located at Woodland Park
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA



Note: Model results shown are lead concentrations just below the confluence of the North and South Forks of the Coeur d'Alene River.

cfs = cubic feet per second
mg/kg = milligrams per kilogram

Exhibit 13
Performance Summary of Alternative Sedimentation Basin Combinations
Focused Feasibility Study
Upper Basin of the Coeur d'Alene River
BUNKER HILL SUPERFUND SITE

EPA

APPENDIX G

Human Health Remedy Protection: Hydrologic Risk Characterization and Project Development

APPENDIX G
HUMAN HEALTH REMEDY PROTECTION
HYDROLOGIC RISK CHARACTERIZATION AND PROJECT DEVELOPMENT

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July 2010

TerraGraphics
Environmental Engineering, Inc.

www.terragraphics.com

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List of Acronyms and Abbreviations

µm	microgram
BDS	Idaho Bureau of Disaster Services
BEIPC	Basin Environmental Improvement Project Commission (Basin Commission)
BHSS	Bunker Hill Superfund Site, also Bunker Hill Mining and Metallurgical Complex
Box	Operable units 1 and 2 of the original BHSS
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response Compensation and Liability Act (Superfund)
cfs	cubic feet per second
CMP	Corrugated metal pipe
CUA	Common Use Area
DEM	digital elevation model
dl	deciliter
ESD	Explanation of Significant Difference
FEMA	Federal Emergency Management Agency
FFS	Focused Feasibility Study
GIS	Geographic Information Systems
HDPE	High Density Polyethylene
HEC	Hydrologic Engineering Centers
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HHRA	Human Health Risk Assessment
ICP	Institutional Controls Program
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IEUBK	Integrated Exposure Uptake Bio-kinetic
IRP	Infrastructure and Revitalization Plan
LHIP	Lead Health Intervention Program
M	million
NAS	National Academy of Science
NFF	National Flood Frequency Program
NRC	National Research Council of the NAS
O&M	Operations and Maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PHD	Panhandle Health District
ppm	parts per million
PRP	Potentially Responsible Party
RAO	Remedial Action Objective
ROD	Record of Decision
ROW	right-of-way
SFCDR	South Fork of the Coeur d'Alene River
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

SECTION 1.0 INTRODUCTION AND STRUCTURE

1.1 Introduction

The Bunker Hill Superfund Site encompasses a large geographic area including several communities ranging in population from a few hundred to a few thousand individuals. The human health remedial strategy depends on removal and replacement of contaminated surface soils and wastes and establishing a network of barriers to contain sub-surface contamination. This barrier network includes several square miles of durable surfaces consisting of asphalt, concrete, and structures as well as less-durable caps of clean soil, gravel, and vegetation. A Geographic Information Systems (GIS) analysis of the installed barriers indicates that to date, more than 23 million square feet of residential yard and common area barriers have been installed in Pinehurst, Smelterville, Kellogg, Wardner, Osburn, Silverton, Wallace and Mullan. In OU1 and OU2, the clean barrier and dust cap system extends over 5000 acres and encapsulates millions of cubic yards (cy) of contaminated sub-soils and waste material. In OU3, more than 5.9 million square feet (ft^2) of residential yard and common area barriers have been installed since 2004.

The barrier remedy strategy adopted for the cleanup requires the communities to live interactively with large volumes of contamination, in perpetuity. Sustaining these barriers is critical to the long-term success of this remedy. Inadequate performance of the barriers could result in elevated blood lead levels in children.

An objective of this Appendix is to provide the technical information that supports the evaluation of Alternative RP-1 (No Further Action) and Alternative RP-2 (Modifications to Selected Remedies to Enhance Protectiveness) included in Section 9 of the FFS Report. This Appendix analyzes the risks to the permanence of the existing human health remedies posed by stormwater drainage and localized flooding issues and provides an array of potential remedy protection projects that could mitigate this risk. This Appendix characterizes the risks to the human health barriers associated with these discrete threats: i) water containing contaminated sediment flooding remediated or “clean” areas, ii) stormwater causing scouring (erosion) of barriers, and iii) contaminated sediment being mobilized and carried into the communities by runoff and deposition. Appendix G considers threats to the remedy associated with failures of existing local drainage systems and flooding in areas with no existing water management systems. This Appendix also provides the technical process and procedures employed to characterize the risk and develop potential remedy protection projects.

1.2 Appendix G Structure

Appendix G is structured as follows:

Section 1 – Introduction briefly describes the Site human health remedy, the risks to the remedy that are evaluated in the Appendix, and presents the purpose of Appendix G.

Section 2 – Basis of Determining Threats to the Remedy and Risks identifies how the different types of threats and risks are categorized and establishes a basis for developing remedy protection projects to address the threats and risks to human health barriers installed as a component of the Site cleanup.

Section 3 – Technical Approach and Methods describes the process and procedures employed to develop the information presented within this appendix. A ***Watershed Screening*** analysis is performed to identify remedies at risk. ***Hydraulic Analyses*** are undertaken to estimate potential flood-related impacts and costs to repair or replace the affected remedies.

Section 4 – Remedy Threats Analysis and Characterization Results quantifies the remedy that is at risk for 5, 25 and 50 year design storm analyses. The associated economic value of the areas in terms of the cost to install the original remedy, cost of repair and re-remediation, and total cost to restore the impacted areas are presented. This information is provided for the No Further Action alternative (Alternative RP-1) evaluated in Section 9 of the FFS Report.

Section 5 – Basis for Remedy Protection Projects provides the technical basis for the remedy protection projects evaluated in the FFS Report. This section describes the Alternative RP-2 remedy protection projects that are evaluated in Section 9 of the FFS Report.

Attachment 1 – Community Impact Maps identifies the areas that are subject to risk of flooding, scour, and deposition of contaminated sediments. These maps are the product of the characterization results presented in Section 4.

Attachment 2 – Watershed Characterization Maps are GIS maps and imagery depicting drainage locations, streams, remediated and potentially to-be-remediated properties, general topography, streets/roads, parcels, and mining activity sites.

Attachment 3 – Design Alternative Schematics are provided to show the various remedy protection projects that are identified for the Alternative RP-2.

SECTION 2.0 TECHNICAL APPROACH AND METHODS

This section summarizes the analytical methods used to evaluate and characterize potential impacts to the in-place human health remedy. The objective is to describe how the work was conducted and provide a basis for the results presented in SECTION 3.0. The approach is intended to provide a uniform, systematic process that is based on sound engineering methods. This approach integrates hydraulic modeling, GIS analyses, field reconnaissance, and input from public officials.

2.1 Geographic Scope of the Analyses

An emphasis was placed on evaluating communities in the Basin that have both a high density of properties and human health related remedial actions that have occurred or will occur under CERCLA/Superfund. These eight primary communities are Pinehurst, Smelterville, Kellogg, Wardner, Osburn, Silverton, Wallace, and Mullan.

Smaller communities that are generally located in unincorporated areas are referred to as "side gulches" for the purpose of the remedy protection work. These side gulches present similar characteristics to the eight primary communities listed above on a smaller scale. Based on field observations, Kingston was determined to have rural characteristics and the two drainages, French and Hunt gulch, are characterized as side gulches. These side gulches are characterized based on cursory field visits, GIS query of the existing infrastructure, and a GIS query of the CERCLA/Superfund remedial actions within the areas. The side gulches include:

- Big Creek
- Willow Creek
- Elk Creek
- Moon Creek
- Montgomery Creek
- Shirttail Gulch
- Nuckols Gulch
- Silver Creek
- Slaughterhouse Gulch
- Terror Gulch
- Twomile Creek
- Ninemile Creek
- Canyon Creek
- Government Gulch
- Humboldt Gulch
- French Gulch
- Hunt Gulch
- Bunker Creek

Individual outlying properties are not within the scope of this effort. It is assumed issues with individual properties can be addressed under the existing Record of Decision (ROD) and Basin Property Remediation Program (BPRP).

2.2 Baseline Assumption

The hydrologic and hydraulic analyses were performed assuming existing conditions. The existing conditions were determined from an inventory of the existing stream conditions and in-place infrastructure, and did not include a detailed investigation of buried stormwater conveyance systems. There are several inherent considerations with this assumption as follows:

- The hydrologic analysis is based on the existing watershed conditions. The flood, scour, and sediment deposition characteristics could change as the watersheds change from logging, forest fire, development, and similar activities that could affect impervious area and other factors that affect watershed hydrology.
- The hydraulic analysis of the conveyance systems is based on the existing condition of the in-place infrastructure as determined by viewing the infrastructure from the surface. No inspections were conducted using Closed Circuit Television or confined space entry, and infrastructure was not tested for structural integrity. It was assumed that all infrastructure was in satisfactory condition and was not crushed, caved-in, or otherwise in a state to reduce conveyance capacity.
- The hydraulic analysis does not account for ice or debris jams. All model simulations of the existing channels and pipe systems assume 'clean conditions'.
- The hydraulic analysis assumes no capacity reduction from debris or trash, items that would have otherwise been cleared during on-going maintenance activities.

These are important factors to understand when interpreting the results of the analysis and when basing decisions on the results.

2.3 Approach Overview

The technical approach includes desktop analyses, limited field investigations, analytical computations, gathering feedback from local officials, and refinement. The following summarizes this process:

- Watershed Screening – was a preliminary analysis that identified areas to include or exclude from the subsequent detailed analysis. This involved developing a series of maps covering the entire Upper Basin that shows remediated properties (as of July 2009), unremediated properties, hillside creeks, mine and mill sites, watershed boundaries, and roadways. Maps were reviewed and the watersheds screened to create a short-list of areas for focused analysis. Limited field reconnaissance was conducted within communities and select watersheds to collect information about the existing drainage channels and infrastructure systems.
- Hydrologic Analysis - computed hydrologic conditions and stormwater runoff rates for watersheds that drain into the primary communities. Computed peak stormwater runoff rates for small watersheds within the communities and areas that can potentially run-on to the communities.
- Hydraulic Analysis - developed simplified HEC (Hydrologic Engineering Centers) models of the creeks that drain into the primary communities.

- Characterize Risk – evaluated flooding, scour, and deposition. Conducted a slope analysis of the terrain and roadways using a digital elevation model. Identified flood, scour, and deposition areas and developed a series of maps showing flood, scour, and deposition for the primary communities (impact maps). Impact maps were reviewed with elected officials and staff. Quantified remedy-at-risk based on impact maps. Costs to re-remediate areas shown on the impact maps were estimated.
- Develop preliminary engineered solutions that could be implemented to mitigate the risks identified through the analysis.

The following sections provide an expanded description of the methods used for the remedy protection project analysis.

2.4 Watershed Screening

The SFCDR watershed contains numerous sub-basins, many of which flow through or near the communities in the Upper Basin. The purpose for screening the watersheds is to identify those that pose a potential flood risk to the human health remedial actions which have occurred or will occur under CERCLA/Superfund.

The watershed screening was conducted using GIS maps and imagery depicting drainage locations, streams, remediated and to-be-remediated properties, general topography, streets/roads, parcels, and mining activity sites. The maps used for the watershed screening are included as Attachment 2 to this appendix. Initial review of these maps identified the creeks/ hillside drainages that drain through or near the communities in the Upper Basin and thus pose the greatest risk to the communities. Watersheds that do not drain through or near a community were not considered for further analysis. From this point, field reconnaissance was performed and the GIS maps further evaluated in regard to remediated parcel locations, to verify the need for additional analysis of the remaining watersheds.

A preliminary evaluation of GIS maps and imagery showed there are 37 creeks/hillside drainages within the SFCDR watershed that drain through or near the communities in the Upper Basin. A more rigorous visual analysis in GIS and field visits to the watersheds revealed that 3 of the 37 watersheds are unpopulated, drain directly to the SFCDR, and will not impact the human health remedy. The screening identified 34 watersheds that have human health remedy protection considerations. Table 1 presents the watershed screening results.

Table 1. Watershed Screening Results Summary

Ref Map No.	Closest Community	Watershed Name	Continue Additional Analysis (Y/N)	Field Reconnaissance Notes and Research Findings
1	Kingston	Hunt Gulch	Y	Several stream crossings in remediated areas with need for additional analysis.
2	Kingston	French Gulch	Y	Creek flows through remediated areas and adjacent to a high concentration of residential properties. Need for further analysis.

Table 1. Watershed Screening Results Summary

Ref Map No.	Closest Community	Watershed Name	Continue Additional Analysis (Y/N)	Field Reconnaissance Notes and Research Findings
3	Pinehurst	Pine Creek	Y	Stream flows adjacent to community with need for additional analysis.
4	Pinehurst	Little Pine Creek	Y	Stream flows adjacent to remediated residential areas with need for additional analysis.
5	Page	Silver Creek	Y	Stream flows adjacent to Lower Page Road and remediated residential areas within the community. Need for additional analysis.
6	Smelterville	Grouse Creek	Y	Occurrence of flooding in the past. Stream flows along the southern perimeter of town and adjacent to remediated residential properties.
7	Smelterville	Government Gulch	Y	Stream flows along east side of town and adjacent to several remediated areas. Creek designed and constructed to convey 100-yr storm event as part of Government Gulch.
8	Kellogg	Bunker Creek	Y	Hydrologic/Hydraulic analysis completed by TerraGraphics in 2008. Analysis focused on 100-yr storm event. No remediated parcels in direct downstream flood path of small storm events, potential for significant impacts to Smelterville or Kellogg for large storms. Influenced by SFCDA flooding issues to large degree.
9	Kellogg	Jackass Creek	Y	Stream intersects remediated and developed areas (including High School) with a need for further analysis.
10	Kellogg	Italian Gulch	Y	Stream intersects central community and flows underground through town in piping system. Flood potential in need of further analysis and information.
11	Wardner	Milo Creek	Y	Stream intersects central community. Occurrence of flooding in the past. Smaller side tributaries within watershed. Extensive mining activity areas.
12	Slaughterhouse Gulch	Slaughterhouse Gulch	Y	Stream flows adjacent to remediated areas and residential property.
13	Montgomery Gulch	Montgomery Creek	Y	Stream flows adjacent to remediated residential properties with several crossings of potential concern.
14	Elizabeth Park	Elk Creek	Y	Stream intersects remediated residential areas. Need for further analysis.

Table 1. Watershed Screening Results Summary

Ref Map No.	Closest Community	Watershed Name	Continue Additional Analysis (Y/N)	Field Reconnaissance Notes and Research Findings
15	Elk Creek	Moon Creek	Y	Several stream crossings in remediated residential areas. Creek flows behind and through several properties with need for need for additional analysis.
16	Big Creek	Big Creek	Y	Flows adjacent to Sunshine Mill Complex and remediated areas. Further evaluation is necessary based on lack of information currently available.
17	West of Osburn	Rosebud Gulch	Y	Stream is diverted 90-degrees and flows adjacent to Leisure Acres Trailer Park. Possibility of bank failure and resultant flooding should be evaluated further. Definite need for further analysis.
18	Terror Gulch	Terror Gulch	Y	Stream flows behind remediated residential properties with need for additional analysis.
19	Osburn	McFarren Gulch	Y	Stream intersects central community and flows through town in an open channel. need for further analysis.
20	Osburn	Jewell Creek	N	No remediated parcels in downstream flood path. No residential properties or areas of concern.
21	Twomile	Twomile Creek	Y	Creek flows adjacent to a few remediated properties. There are residential areas near stream crossings that may be remediated in the future.
22	Osburn	Meyer Creek	Y	Stream intersects central community with need for further analysis. Stream is piped through town in a combination of 18-inch and 36-inch diameter CMP culverts. Approximately 1800 feet of pipe, sized for a 10-year storm event. Occurrence of flooding in the past.
23	Northeastern Osburn	Shirttail Gulch	Y	One potential crossing of concern (culvert) which would inundate a small un-remediated residential area if it failed. Due to potential for future remediation, however, further analysis should be considered.
24	Osburn	Shields Gulch	Y	Three 90-degree bends in creek pose flooding threat. Stream flows immediately adjacent to Elementary School with several crossings. Need for further analysis.

Table 1. Watershed Screening Results Summary

Ref Map No.	Closest Community	Watershed Name	Continue Additional Analysis (Y/N)	Field Reconnaissance Notes and Research Findings
25	Nuckols Gulch	Nuckols Gulch	Y	Several stream crossings exist along Nuckols Gulch Road close to residential properties. There is a portion of remediated property close to creek and potential for future remediation within the creek vicinity.
26	West Side of Silverton	Unnamed Creek	Y	One potential crossing of concern (culvert) which would inundate remediated residential area if it failed. Culvert and portions of the channel appear to be in poor condition and have minimal capacity. Creek flows adjacent to remediated residential property with a definite need for further analysis.
27	South of Silverton	Lake Creek	N	No remediated parcels in downstream flood path. No residential properties or areas of concern.
28	Silverton	Revenue Gulch	Y	Stream intersects central community. Stream flows directly adjacent to Markwell/Revenue Gulch Street with several crossings of concern. 1996 flood occurred due to failure of culvert under Park Street. Repairs were made upstream of the culvert (channel reconstruction and culvert replacement), though concerns remain that the downstream channel is undersized.
29	Wallace	Ninemile Creek	Y	Flows adjacent to remediated properties with need for additional analysis.
30	Placer Creek	Placer Creek	Y	1980s USACE project put creek into a concrete channel through town.
30A	Wallace	Printers Creek	Y	Not identified on maps. Located on west edge of Map 30A. Flooded City pool in 1997 flood. April 19, 1938 Spokane Daily Chronicle - “splurged water into business district and having water running down main streets.”
31	Woodland Park	Canyon Creek	Y	Stream flows adjacent to community and both remediated and un-remediated properties. Need for further analysis.
32	North of Stull	Trowbridge Gulch	N	No remediated parcels in downstream flood path. No residential properties or areas of concern.
33	Mullan	Mill Creek	Y	Stream intersects central community with definite need for further analysis. Stream flows adjacent to several remediated residential properties with several crossings of potential concern.

Table 1. Watershed Screening Results Summary

Ref Map No.	Closest Community	Watershed Name	Continue Additional Analysis (Y/N)	Field Reconnaissance Notes and Research Findings
34	Mullan	Boulder Creek	Y	Stream intersects central community with three crossings of potential concern adjacent to remediated residential properties. Need for additional analysis.
35	Mullan	Gold Hunter Creek	Y	No remediated parcels in potential downstream flood path. However, do not have enough information about where the stream flows into/under the Lucky Friday Mine Complex area such that further analysis is necessary.
36	East of Mullan	Willow Creek	Y	Culvert under Friday St. poses threat to adjacent remediated areas. Culvert and stream capacity should be further evaluated to determine flooding potential.

Following the initial screening, watersheds were divided into two categories for the purpose of determining which watersheds required detailed hydrologic and hydraulic analysis. The categories are:

Category I – includes watersheds that contribute flows to the main drainage systems of the eight primary Upper Basin communities. Geographically, these watersheds appear likely to impact large areas within the communities during a flood event.

Category II – includes watersheds that are described as "side gulches". These present similar characteristics as the Category I watersheds but would impact a considerably smaller area of the Human Health remedy. These side gulches are characterized based on cursory field visits, GIS query of the existing infrastructure, and a GIS query of the CERCLA/Superfund remedial actions within the areas.

The following sections describe the hydrologic and hydraulic analysis conducted for the Category I watersheds. Hydrologic and hydraulic analyses were not conducted for the Category II watersheds. The general characteristics of the Category II watersheds discussed in Section 3.4 were determined from additional GIS analysis and field work.

2.5 Hydrologic Methods

The hydrologic analysis to determine the volume and peak stormwater discharge was conducted in general accordance with the procedures and methods identified in the *Bunker Hill Superfund Site Stormwater Management Plan Criteria and Engineering Standards* (Welch Comer & Associates 1994). Although this document was written for the Box communities, it contains fundamental engineering standards and criteria that are applicable to the Basin.

The Rational Method (Chow, 1988) was used to estimate peak flows within the small urban areas. The USGS Regional Regression equations for Idaho were used in the USGS StreamStats application to estimate flows for the watersheds. StreamStats is an integrated GIS application developed through a cooperative effort of the USGS and ESRI, Inc. StreamStats uses ArcIMS, ArcSDE, ArcGIS, and ArcHydro Tools. It incorporates a map-based user interface for site selection; a Microsoft Access database that contains information for data-collection stations; a GIS program that delineates drainage basins and measures basin characteristics; and a GIS database that contains land elevation models, historical weather data, and other data needed for delineations, for measuring drainage-basin characteristics, and for locating sites of interest in the user interface.

The StreamStats user interface can be manipulated to zoom in by various methods to select locations where information is desired. When a USGS data-collection station is selected, information for the station appears in a pop-up Web browser window. When an ungaged site is selected, StreamStats computes the drainage-basin boundary for the site and presents it to the user in the map frame. The user can then check the validity of the boundary and use the EditBasin tool to make any necessary corrections. After the user indicates that the boundary is correct, StreamStats measures the drainage-basin characteristics for the site. The values are then input to a separate program, the USGS National Flood Frequency Program (NFF), which is a Microsoft Windows application that contains all of the USGS-developed equations for estimating flood-frequency statistics in the nation. The NFF has been modified for StreamStats to contain equations for estimating other types of streamflow statistics. The NFF estimates the streamflow statistics for the ungaged site and then StreamStats presents the statistics and basin characteristics for the site in a pop-up Web-browser window. All of the equations in the NFF are documented through links to each individual state from the NFF Web site.

All of the watersheds evaluated are ungaged sites. The equations used to estimate streamflow statistics for ungaged sites were developed through a process known as regionalization. This process involves use of regression analysis to relate streamflow statistics computed for a group of selected streamgaging stations (usually within a state) to basin characteristics measured for the stations. Basin characteristics measured for ungaged sites can be entered into the resulting equations to obtain estimates of the streamflow statistics. The flow estimates provided from StreamStats assume natural flow conditions at the site.

Flows are calculated for existing watershed conditions. It is assumed that impacts from future developments will be mitigated through existing stormwater ordinances and future, post-development, stormwater runoff rates will be equal to existing runoff rates.

Storms included in the analysis are the 5, 25, and 50 year storm events (all 24 hour events). The impact maps included as Attachment 1 are based on the modeling results for these three storms. These storm events were selected to provide insight regarding the range of risks as a function of large (50 year), medium (25 year) and small (5 year) storm event scenarios. The 50 year peak flowrate was selected for the preliminary design of the remedy protection projects. Selection of the 50 year storm is based on general engineering practice and is supported by information obtained during a literature search on the application of design storms for stormwater design (BHHS SWP 1994, ITD 2009, WDOT 2008). In summary, the literature search revealed that the design of remedy protection projects to a 50-year peak flowrate is consistent with, and in some cases more protective than, standards developed for the Bunker Hill Superfund Site, the State of Idaho Transportation Department, and the Washington State Department of Transportation (WSDOT). The analysis also considered the effects of the 100-year peak flowrate on the nearby landscape, infrastructure, and habitable structures. This was accomplished by running the 100-year storm event through the design alternative models to identify any areas with excessive flooding. Though not designed for the 100-year peak flowrate, engineered structures designed for the 50 year peak flowrate should provide a 'satisfactory level of protection for the 100-year storm' (*BHSS Stormwater Management Plan, Criteria and Engineering Standards*, *March 1994*).

2.6 Estimating Peak Flow Rates from Contributing Water Sources

Peak flow rates corresponding to the 5, 25 and 50 year design storm for the watersheds were obtained from the Idaho USGS Regional Regression (via StreamStats). The existing HEC models that were developed for previous studies of Grouse Creek and Meyer Creek were used to estimate flows in these two systems (TerraGraphics 1999, 2005). The Rational Method was used to calculated peak stormwater runoff rates for urbanized areas within the communities and off-site areas that contribute flows. Stormwater runoff flow rates for the different design storms were calculated using the methods prescribed by the *Bunker Hill Superfund Site Stormwater Management Plan Criteria and Engineering Standards* (Welch Comer & Associates 1994). The Rational Method was used to calculate peak stormwater runoff rates in all urban areas.

2.7 Hydraulic Analysis of Creeks

Hydraulic models were developed using the USACE Hydrologic Engineering Centers River Analysis System (HEC-RAS) program. The methods, model inputs, and model assumptions are summarized below.

For each of the creeks evaluated, the first step in the hydraulic analysis was to create a one-dimensional steady-state model using HEC-RAS to represent the current creek and infrastructure conditions. To do so, a large amount of field data was collected for each creek reach of concern. These data included representative cross sections at reasonable reach lengths along the stream, channel material descriptions, approximate channel slopes, and any information related to stream crossings such as bridges and culverts. Specifically, information such as shape, material, rise, span, length, and slope were recorded for culverts. Bridges required similar information, such as length, width, deck thickness, and clear height. Pictures were taken throughout the field reconnaissance process and referred to often during the model creation stage.

To obtain reach lengths between cross sections and better approximate the channel slope for input into HEC-RAS, AutoCAD® drawings of each site were utilized with aerial images and topographic data imported into them. AutoCAD® was also utilized for culvert lengths in circumstances where field measurements could not be easily obtained. Additionally, data were incorporated from the *Upper Basin Drainage Assessment* (BEIPC 2008). Manning's coefficient values were assumed based on the field notes descriptions, relying heavily on pictures taken during the field work.

Apart from one or two exceptions where survey data from past projects were available, all field data were obtained for this analysis through manual field work alone. As a result, the cross sections and existing topography used in most of the models are relatively simplified. The exceptions are Grouse Creek, Pine Creek, and portions of Little Pine Creek along the golf course where survey data were obtained and used to make HEC-RAS models in recent projects. These models were utilized for these three creeks and modified as needed based on collected field data.

Because analyses for a majority of the creeks did not rely on survey data, the information gathered from the field work had to be manually input into HEC-RAS. To aid in this process, an

Excel template was created that allowed for input of cross-section, bridge, and culvert information obtained from the field. Based on the set-up of the Excel sheet, after certain cells were filled in, the data were sorted and set-up to be easily input into HEC-RAS as prompted by the program. In general, except for models based on survey data, the elevations are relative and do not portray exact elevations.

With existing geometry files created in HEC-RAS for each creek of concern, the last input required into the program prior to running a steady state analysis were steady flow data. Storms included in the analysis of each model are the 5, 25, and 50 year events (all 24 hour). As described in the section on Hydrologic Methods, these values were generally determined for each of the drainages using the USGS StreamStats application. The exception to this is Grouse Creek. Instead, peak flow values were selected in reference to the *Smelterville Flood Hydrology and Stormwater Conveyance System Improvement Study* (TerraGraphics 1999), in which HEC-1 was utilized in conjunction with more in-depth research to evaluate the flows along Grouse Creek.

Clogging and failure of stormwater infrastructure has resulted in past flood events. Sediment transport, bedload, or debris transport was not explicitly modeled. Locations where typical O&M practices can prevent clogging of the conveyance system are assumed to be clear of debris and functioning with full design capacity for the analysis.

2.8 Remedy Threats Characterization

Several different conditions pose threats to the human health remedy. The primary threats evaluated and included in this remedy protection analyses are from stormwater that either transports contaminated sediment into previously remediated areas, or breaches existing barriers through scour and exposes underlying contamination, or both.

The primary tool for characterizing the threats to the remedy is the set of community impact maps. The impact maps are included as Attachment 1 to this appendix. These maps show the areas that are at risk to flooding, barrier scour, and deposition of contaminated sediments under the 5, 25, and 50-yr, 24-hour storm events. The following sections describe the remedy threats characterization analytical processes.

The first step in the analysis was to identify areas that would be impacted (wet/flooded) during each of the three storm events. These areas were delineated based on the following information sources:

- Hydraulic analyses of existing infrastructure and creek channels
- Input from local officials such as Mayors and public works staff with knowledge of past flooding,
- Infrastructure assessments completed for the Drainage Control and Infrastructure Revitalization Plan (DCIRP, TerraGraphics 2009) and maps of existing stormwater systems,
- Drainage assessment reports completed by the Basin Environmental Improvement Project Commission (BEIPC 2008, 2009),
- GIS digital elevation models,
- Existing topographic data conducted for projects within the basin,

- Existing stormwater reports (Smelterville, TerraGraphics 1999; Pinehurst, TerraGraphics 2004), and
- Additional field investigations of existing drainage systems.

2.9 Stormwater Inundation

Areas that may be inundated (covered) by stormwater during the different storm events are delineated on the impact maps based on topography, conditions observed in the field, and the results of the analyses of existing infrastructure systems.

2.10 Scour of Barriers

Based on general engineering practice, an unpaved area is considered vulnerable to scour if the velocity of stormwater exceeds 5 feet per second. This general assumption was validated by comparing the slope and theoretical velocities to areas of the Site where scour has occurred. Areas that are susceptible to scour based on topography and cover materials are identified and mapped based on the following steps and as described below:

- Determine areas that are susceptible to scour based on hydraulic analysis (theoretical areas).
- Map the theoretical areas.
- Overlay areas where scour has been observed in past storm events to verify the theoretical areas.
- Discuss scour areas with remediation staff and city/county personnel to verify ‘problem’ areas and to determine the depth and area of scour previously observed.
- Develop map of potential scour zones for each community for each of the 5-, 25-, and 50-year storm events.

The potential for stormwater to scour existing barriers was evaluated and quantified based on stormwater water velocity as a function of ground slope. For the purpose of this analysis, it is assumed that open channels with velocities greater than 3 feet per second have the potential to scour away barriers along the banks of vegetated open channels. This corresponds to areas with slopes greater than 3% and is based on general engineering practice. (Chow, 1988)

The primary tool for identifying ground slopes is a digital elevation model (DEM) created in GIS using 30-meter topography data. The DEM was used to calculate street slopes on a block-by-block basis. Due to the coarseness of the DEM, the slope maps were only used as general guidance for locating extremely flat and extremely steep areas within the communities. Areas with slopes greater than 3% as determined from the slope maps were verified in the field for scour potential.

Stormwater runoff that occurs on gravel ROWs is considered shallow concentrated flow. Average velocities of shallow concentrated flows were determined as a function of the ground slope using the following nomagraph provided by USDA TR-55 Technical note number N4 (USDA, 1986).

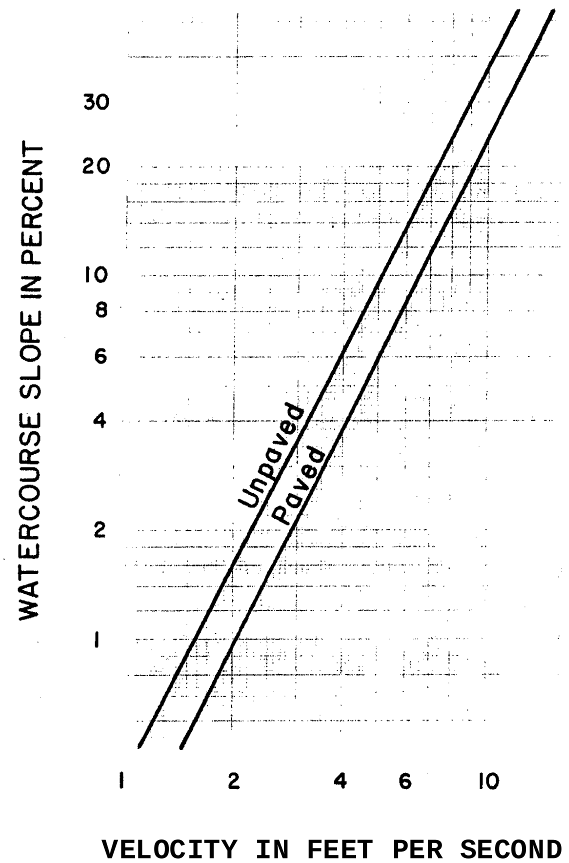

Figure 1. Slope v. Velocity Nomagraph.

The slope maps used in the scour analysis are included in Attachment 1.

2.11 Contamination Sources

Sources of contamination may be either transported into a community by stormwater run-on or exposed through barriers scoured by stormwater. Sources include contamination located under the installed barriers, upland sources such as mine/mill sites, or hillsides impacted from historical smelter emissions.

Potential contamination sources were identified under the premise that if there is a source, or sources of contamination, and there is a mechanism to expose the contamination or transport it into the community, then the remedy is at risk.

2.11.1 Exposure to Contamination from Scour Areas

The overall human health cleanup strategy for the Site relies on removal of surface and near-surface contamination and installation of clean barriers over contaminated materials left in place. If the barriers are scoured from stormwater runoff, there is a potential to expose subsurface contamination and the remedy is at risk both within the scour areas and downstream where contaminated sediment may be transported and deposited.

The community impact maps included as Attachment 1 show the potential scour areas that were identified from modeling and field reconnaissance.

2.11.2 Mining Activity Sites

A presumptive approach was used to evaluate mining activity as potential contamination sources. This approach was necessary because quantitative data for all the dispersed sites do not exist. The presumption works in two ways: if there are no mining activity sites within a watershed, it was presumed that there are no sources of contamination. Conversely, if there are mining activity sites within a watershed, it was presumed that there are potential sources of contamination and the sites were further evaluated using GIS, field investigations and interviews with local officials to determine the proximity of the sites to creeks and the communities.

Mining activity sites were identified using a GIS layer previously developed during an inventory of source sites conducted by the U.S. Bureau of Land Management (BLM) in 1999 in support of the Remedial Investigation/Feasibility Study (RI/FS) for the Coeur d'Alene Basin (EPA, 2001a, 2001b). The sites are displayed on the watershed maps included as Attachment 2. A subset of the basin-wide layer was created to include mining activity sites located within the watersheds and hillside drainages screened under the remedy protection analysis. The subset of activity sites was tabulated and used to examine the location and name of the sites relative to the creeks, watersheds, communities, remediated properties, and similar data used to characterize the risks to the remedy. The GIS attributes provide basic data such as name, unique identification reference numbers, and a general description, but do not contain information about the composition of the materials at the location.

2.11.3 Hillsides

Contamination from hillsides is primarily an issue for Box communities that are located within the historic zone of influence of the Bunker Hill Smelter emissions (USEPA, 2005). This issue is documented in the 1999 and 2005 Five Year Review document.

2.11.4 Localized Stormwater Ponding

It is presumed that localized stormwater ponding is a risk to the remedy if there are sources of contamination within the ponded area. If sources of contamination are present in areas where localized stormwater ponding occurs (the bathtub scenario), there is a risk of the contamination mixing with the stormwater and being deposited onto the remedy. Because deteriorating asphalt roadways with underlying contamination will be addressed as part of the existing remedy, they are not considered a source of contamination for the remedy protection analysis.

2.12 Sediment Deposition

Sediment that is deposited during flood conditions will vary in depth, geographic extent, and type of material that is deposited. The analysis assumes there is the same level of risk for all of the area designed within the sediment deposition community impact maps. The following points are the basis of this assumption:

- Sediment mixes uniformly with stormwater if sources of contaminated sediment are available.

- Sediment deposits in areas that are impacted by stormwater.
- Sediment is mobilized in scour areas and mixes uniformly with stormwater.

2.13 Human Health Remedy-At-Risk Cost Analysis

This section presents the methods used for the human health remedy at-risk cost analysis. The purpose is to quantify the costs to re-remediate exterior soil barriers at-risk to scour and recontamination from deposition of contaminated sediments resulting from high precipitation runoff and flood events. These costs are the basis for the development of Alternative RP-1 (No Further Action) of the FFS Report. The at-risk areas are identified through hydraulic modeling and characterization work conducted during preparation of the FFS Report. Section 3.1 of Appendix G presents the results of the Cost Analysis.

2.13.1 Method for Determining Costs

The cost of remediating or re-remediating areas impacted by scour or contaminated sediment deposited by flood waters for all of the design storms is calculated based on a unit price of $5.17 per square foot. This unit price is based on a three point average of the cost benchmarks described below.

i.) Milo Creek 1997 Flood Response. The average cost to re-remediate properties after the flood event is estimated at $5.23 per square foot (2009 dollars). Based on information provided by PHD, the Milo Creek flood response required $550,000 to re-remediate approximately 50 yards in Wardner and Kellogg. The remediation work included a mixture of ‘greenings’ and complete re-remediation. Greenings involved replacing sod and surface restoration with minimal removals. Complete re-remediation comprised removal of 12-inches of soil and installation of barriers. For the purpose of computing the dollar per square foot unit costs, it is assumed that approximately 150,000 square feet of area was re-remediated based on an estimate of 3,000 square feet per property that required re-remediation. This results in an average cost of $3.67 per square foot in 1997 dollars. Indexing to 2009 dollars at the observed construction cost inflation rate of 3.2% per year equals $5.23. The observed construction cost inflation rate is calculated based on the Construction Cost Index escalation factor of 1.456 determined from the 1997 to 2009 Engineering News Record.

ii.) Basin Property Remediation Program Average Costs (BPRP). The average remediation costs for BPRP is based on information provided by IDEQ is $5.35 per square foot (2009 dollars). This includes administrative and direct construction costs. In 2009, approximately 6,570,000 square feet was remediated at a construction cost of $20,900,000. This equates to $3.18 per square foot. This does not include sampling or disposal costs.

iii.) Engineer cost opinion. An engineer’s cost opinion was developed assuming a 4-inch removal and in-kind replacement. This results in an average unit cost of $4.94 per square foot. This is calculated based on an assumption that 33% less materials such as sod and fill material will be required compared to the overall program requirements for a re-remediation effort. It is estimated that $2.75 of the current remediation program unit cost relates to construction costs. Assuming that 50% of construction costs are materials, and

33% less materials are required for 4-inch removal compared to the overall program average, the result is $4.94 per square foot ($5.35 - $2.75 x 50% x 30%)

2.13.2 Cost Escalation Factors

Several factors may result in escalated construction costs. The assumed cost to re-remediate was not escalated for any of these factors; however, these are presented to establish a context for the re-remediation cost.

- A large-scale flood may result in an emergency declaration as observed during the 1997 Milo Creek Flood, or at least the need for an urgent response due to human health issues. Construction contracts awarded under these conditions may not be competitively bid and may result in escalated construction costs.
- There may be a need for a rapid cleanup response to prevent materials from migrating or being tracked within a community, which would increase the geographic extent of the impacted area.
- The local communities do not have the equipment or staff to manage a significant cleanup effort, nor are the public works staff equipped to conduct remediation work. This will result in all work being contracted out.
- There is a limited amount of clean soil and gravel materials available in the Basin. Materials will need to be hauled in as is currently done for the remediation program. Large sources may not be readily available and may need to be specially processed to provide the volumes necessary.
- Fuel costs may outpace general inflation.
- At present, the yard remediation program is active and construction contractors are under contract with IDEQ to conduct cleanup work at the Site. Through experience, these contractors have gained efficiency in conducting the work and this helps control the costs. These contractors indicated verbally at an August 2009 BEIPC meeting that the institutional knowledge of doing the yard remediation work will be lost as the crews leave the basin for other projects at the end of the remediation program.

2.13.3 Area Calculations for Cost Analysis

The post-event remediation costs are a function of the remediation status and ground covers within the areas depicted on the impact maps. Due to this limitation of the GIS data, it is necessary to make assumptions and determine the remediated and non-remediated areas mathematically. The following paragraphs describe the assumptions and methods applied to develop the areas used for the cost analysis. Table 2 summarizes the findings from this analysis. The impact maps referenced are included at Attachment 1.

Flood Area

Total Area is the geographic area of the mapped flood area depicted on the community flood maps. The total area is determined by measuring the area of the flood polygons using GIS. This area is variable and depends on the extent of flooding determined from the hydraulic modeling.

Remediated Parcel Area is the sum of the geographic area of the remediated parcels located within the mapped flood area depicted on the community flood maps. This value is determined using GIS by intersecting the remediated parcel layer with the flood area layer. For parcels that are split by the flood area, only the area of the parcel within the flood area is included in the sum.

Remediated ROW Area is the sum of the remediated ROW areas within the mapped flood area depicted on the community flood maps. This value is mathematically calculated as 5% of the remediated parcel area. This assumed percentage was determined by examining aerial imagery. The examination found most city lots are roughly 50-feet wide by 100-feet long and the typical gravel ROW is at least 5-feet wide. Typically, under the yard remediation program, ROWs that front parcels are remediated in conjunction with the parcel.

Scour Area

Total Area is the geographic area of the mapped scour area depicted on the community maps. The total area is determined by measuring the area of the scour polygons using GIS.

Total Parcel Area is the sum of the geographic area of all parcels located within the mapped scour areas. This value is determined using GIS by intersecting the parcel layer with the scour layer. For parcels that are split by the scour area, only the area of the parcel that is within the scour area is included in the sum.

Remediated Parcel Area is a subset of the total parcel area. This is the sum of the geographic area of all the remediated parcels that are located within the mapped scour areas.

Paved Streets Area is an estimated value calculated by multiplying the length of paved streets determined from GIS by an assumed pavement width of 20-feet.

Gravel ROW Area is an estimated value calculated by subtracting the paved street area from the total ROW area.

Total Effective Scour Area is an estimated value calculated as 5% of the pervious parcels area plus the gravel ROW area that is within the mapped scour areas. This includes remediated and non-remediated properties and remediated and non-remediated right-of-ways.

Total Effective Remediated Scour Area is an estimated value calculated as 5% of the remediated pervious parcels area plus the remediated gravel ROW area that is within the mapped scour areas.

Deposition Area

Total Area is the geographic area of the mapped deposition area depicted on the community maps. The total area is determined by measuring the area of the deposition polygons using GIS.

Total Remediated Parcel Area is the sum of the geographic area of all remediated parcels located within the mapped deposition areas. This value is determined using GIS by intersecting the parcel layer with the deposition layer. For parcels that are split by the deposition area, only the area of the parcel within the deposition area is included in the sum.

Effective Remediated Parcel Area is the pervious area of the remediated parcels. This is calculated by multiplying the total remediated parcel area by the percent pervious. The percent pervious was determined by manually measuring the pervious areas in AutoCAD® and dividing the result by the total parcel area. The values assume that 100% of the pervious area of the remediated parcel within the deposition polygon was remediated.

Effective Remediated ROW Area is an estimated value that is calculated as 5% of the remediated parcel area. This is calculated similar to the Remediated ROW Area described under the flood area.

Total Effective Remediated Area is the sum of the Effective Remediated Parcel Area and the Effective Remediated ROW Area.

Table 2. Flood, Scour, Deposition Area Impact Area Summary.

		FLOOD AREA (SF)			SCOUR AREA (SF)							DEPOSITION AREA (SF)				
		Total Area	Remediated Parcel Area	Remediated ROW Area	Total Area	Total Parcel Area	Remediated Parcel Area	Paved Streets Area	Gravel ROW Area	Total Effective Scour Area	Total Effective Remediated Scour Area	Total Area	Total Remediated Parcel Area	Effective Remediated Parcel Area	Effective Remediated ROW Area	Total Effective Remediated Area
KELLOGG	5-YR	4,928,530	260,800	13,040	93,676	55,746	49,130	3,700	34,230	37,017	36,687	73,580	64,485	50,814	3,224	54,038
	25-YR	4,996,615	306,910	15,346	93,676	55,746	49,130	3,700	34,230	37,017	36,687	154,745	111,030	97,373	5,552	102,925
	50-YR	5,059,240	343,810	17,191	93,676	55,746	49,130	3,700	34,230	37,017	36,687	236,245	127,340	113,715	6,367	120,082
MULLAN	5-YR	2,082,290	474,550	23,728	468,730	67,890	67,890	219,375	181,465	183,841	97,143	241,825	53,510	45,323	2,676	47,998
	25-YR	2,427,615	709,060	35,453	1,368,660	917,270	647,635	230,933	220,458	245,682	67,430	832,000	296,425	263,522	14,821	278,343
	50-YR	2,889,765	965,365	48,268	1,536,535	1,078,615	755,265	233,558	224,363	254,024	70,390	1,233,650	442,870	387,068	22,144	409,212
OSBURN	5-YR	4,544,790	578,560	28,928	0	0	0	0	0	0	0	293,385	284,200	240,433	14,210	254,643
	25-YR	5,304,140	969,570	48,479	61,685	61,685	0	0	0	2,313	0	1,298,900	700,200	605,673	35,010	640,683
	50-YR	5,488,040	1,094,340	54,717	61,685	61,685	0	0	0	2,313	0	1,541,150	856,970	747,278	42,849	790,126
PINEHURST	5-YR	4,070,855	789,020	39,451	0	0	0	0	0	0	0	1,235,400	605,390	592,071	30,270	622,341
	25-YR	6,615,840	1,482,150	74,108	17,375	11,875	3,415	4,700	800	1,186	911	4,107,410	1,350,640	968,409	67,532	1,035,941
	50-YR	8,206,240	2,264,070	113,204	55,310	48,910	23,150	5,500	900	2,490	1,652	5,550,575	2,052,445	1,697,372	102,622	1,799,994
SILVERTON	5-YR	1,621,860	255,550	12,778	349,880	12,700	0	190,875	146,305	146,940	13,975	564,245	173,260	122,668	8,663	131,331
	25-YR	2,060,110	523,270	26,164	480,600	141,680	74,250	192,125	146,795	153,171	17,316	810,900	302,520	228,100	15,126	243,226
	50-YR	2,773,710	1,005,160	50,258	562,940	224,020	165,490	192,125	146,795	155,756	20,595	1,399,850	665,655	489,922	33,283	523,205
SMELTERVILLE	5-YR	1,682,530	248,520	12,426	46,855	18,835	16,150	18,000	10,020	10,962	10,828	223,100	158,985	136,250	7,949	144,199
	25-YR	3,893,200	1,842,040	92,102	64,250	36,230	33,550	18,000	10,020	11,832	11,698	1,046,740	708,385	558,207	35,419	593,627
	50-YR	5,067,400	2,833,850	141,693	67,775	39,755	36,550	18,000	10,020	12,008	11,848	2,133,540	1,385,675	1,094,683	69,284	1,163,967
WALLACE	5-YR	1,864,555	0	0	406,380	0	0	205,700	200,680	200,680	0	166,805	270	270	14	284
	25-YR	1,988,085	27,870	1,394	482,840	76,145	15,500	205,700	200,995	204,041	620	323,385	16,020	16,020	801	16,821
	50-YR	2,135,765	54,530	2,727	562,660	155,175	29,645	205,700	201,785	206,828	963	678,660	38,145	36,390	1,907	38,298
WARDNER	5-YR	888,600	36,075	1,804	441,538	324,858	9,440	9,250	107,430	122,049	4,415	194,750	116,460	116,460	5,823	122,283
	25-YR	888,600	36,075	1,804	441,538	324,858	9,440	9,250	107,430	122,049	4,415	194,750	116,460	116,460	5,823	122,283
	50-YR	888,600	36,075	1,804	441,538	324,858	9,440	9,250	107,430	122,049	4,415	194,750	116,460	116,460	5,823	122,283

2.14 Limitations of the Technical Approach

Since the technical data are intended to establish a level of confidence upon which decisions are based, it is important to qualify the limitations of the analysis.

- There is a heavy dependence on existing stormwater infrastructure and creek channels to collect and convey stormwater from the communities. The analysis assumes the existing infrastructure will continue to function and be maintained to provide at least a level-of-service analyzed for this effort. The amount of area within the communities that would be at risk if the existing infrastructure fails is not determined.
- There are limitations within the application of the StreamStats data. Flow rate monitoring was not conducted. The peak design storm flow rates used to determine flooding risk from the primary watersheds are based on a statistical flow analysis from other watersheds.
- The physical attributes and representation of the existing drainage channels and infrastructure in the models are based on limited field investigations. Measurements were taken at significant changes in geometry and slopes were estimated using hand-held inclinometers. Channel capacity is highly sensitive to slope and survey-grade elevation data would produce more accurate modeling results.
- Existing stormwater infrastructure was modeled and evaluated based on what can be seen from the surface. No confined space entry or subsurface explorations were conducted. There may be conditions inside of culverts and pipelines that are not accounted for in the modeling.
- Remediated and non-remediated areas are not explicitly mapped or contained in a database. Assumptions were made, as presented in this appendix, to determine the areas at risk.

SECTION 3.0 REMEDY THREAT ANALYSIS AND CHARACTERIZATION RESULTS

This section presents the results of the technical analysis approach described in Section 2.0. The objective is to characterize the risk by quantifying the square foot of remedy that is impacted by the 5, 25, and 50 year storm events and the related costs. The characterization results establish the basis of a No Further Action alternative by quantifying the amount and economic value of the remedy that is expected to be impacted, and would require re-remediation for the different storm conditions. This section quantifies the information displayed on the Community Impact Maps that are included as Attachment 1.

3.1 Impacts to the Remedy for Primary Communities

Table 3 displays the square feet of area impacted by stormwater runoff, scour, and deposition of contaminated sediment. The table shows that there is risk to the human health remedy within each of the eight communities. The total area of the human health remedy at risk is the sum of the area impacted by scour and the area impacted by sediment deposition.

Figure 2 shows the Total Estimated Areas at Risk from Table 3 graphically.

Table 3. Square Feet of Area Impacted by Runoff, Scour, and Deposition

Community	Design Storm	Area Impacted by Stormwater Runoff	Area Impacted by Scour(1)	Area Impacted by Deposition(2)	Total Estimated Area at Risk
KELLOGG	5-YR	4,928,530	37,017	54,948	91,965
	25-YR	4,996,615	37,017	107,296	144,314
	50-YR	5,059,240	37,017	130,972	167,989
MULLAN	5-YR	2,082,290	183,841	66,830	250,671
	25-YR	2,427,615	245,682	331,901	577,583
	50-YR	2,889,765	254,024	488,290	742,314
OSBURN	5-YR	4,544,790	0	255,562	255,562
	25-YR	5,304,140	2,313	700,553	702,866
	50-YR	5,488,040	2,313	858,544	860,858
PINEHURST	5-YR	4,070,855	0	685,342	685,342
	25-YR	6,615,840	1,186	1,311,618	1,312,804
	50-YR	8,206,240	2,490	2,149,807	2,152,297
SILVERTON	5-YR	1,621,860	146,940	170,430	317,370
	25-YR	2,060,110	153,171	294,064	447,235
	50-YR	2,773,710	155,756	596,624	752,380
SMELTERVILLE	5-YR	1,682,530	10,962	150,611	161,573
	25-YR	3,893,200	11,832	627,462	639,294
	50-YR	5,067,400	12,008	1,238,754	1,250,761
WALLACE	5-YR	1,864,555	200,680	16,937	217,617
	25-YR	1,988,085	204,041	47,558	251,598
	50-YR	2,135,765	206,828	102,349	309,177
WARDNER	5-YR	888,600	122,049	130,112	252,161
	25-YR	888,600	122,049	130,112	252,161
	50-YR	888,600	122,049	130,112	252,161

(1) Includes scour in remediated area and ROWs. (2) Includes both remediated and "clean" areas.

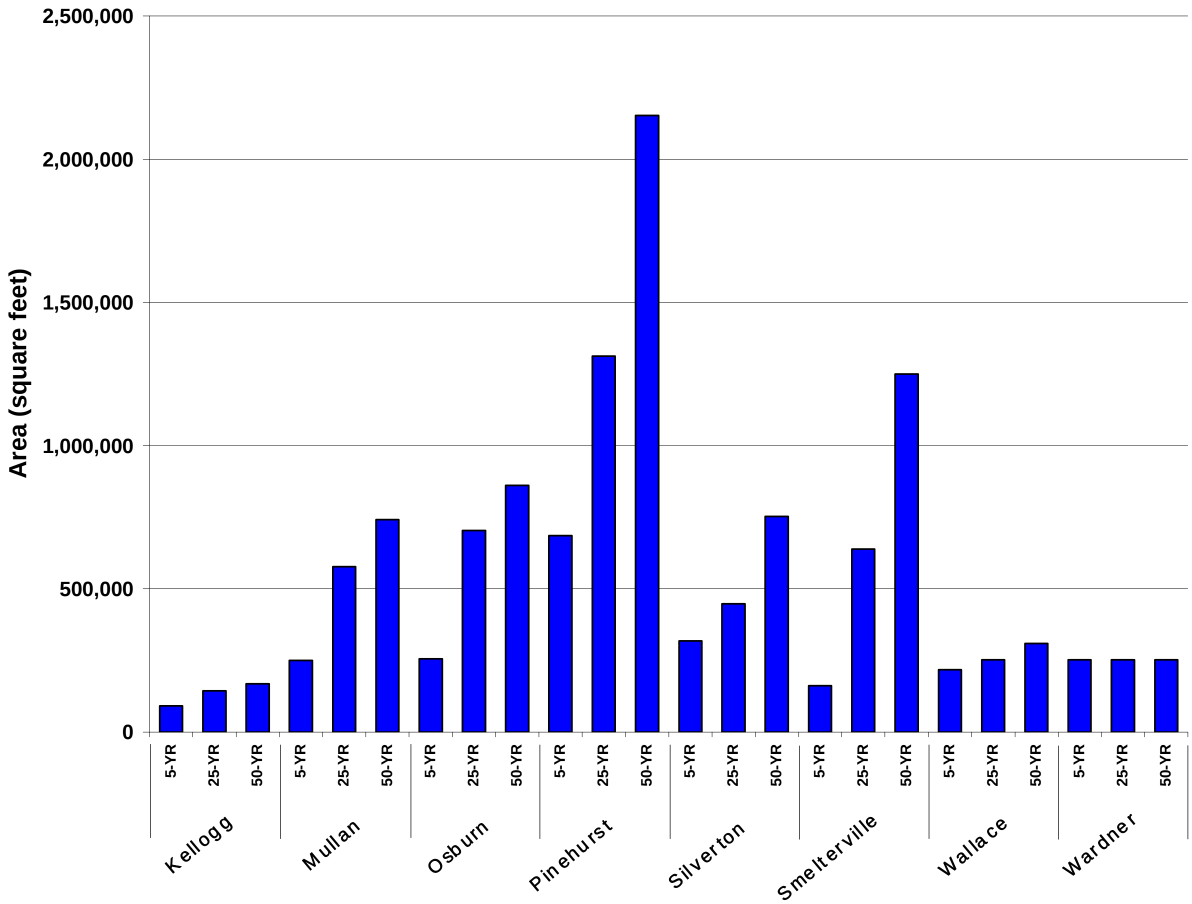

Figure 2. Total Estimated Area-at-Risk Community Summary.

The costs associated with the human health remedy at risk within the impact areas are presented in Table 4. The last column is used to evaluate the cost of the No-Action alternative.

The cost to install the original remedy that is at-risk to scour and deposition should be interpreted as the cost to do the work initially (2009 dollars). The cost to re-remediate areas with scour and deposition should be interpreted as the cost to clean up the remedy that is damaged. The cost to remediate currently unremediated area within scour and deposition areas should be interpreted as new areas that would be impacted and need to be cleaned up. The last column in the table is the total cost to remediate areas impacted by scour and deposition. This should be interpreted as the cost to cleanup and restore a human health remedy within the impact areas. The process used to calculate the values presented in Table 4 are as follows:

Cost of Installed Remedy Within Scour and Deposition Areas is the estimated original cost to install the remedy that is at risk in the scour and deposition areas. This is calculated as the sum of the Cost of Total Effective Remediated Scour Area and the Cost of Total Effective Remediated Area Within Deposition Areas.

Cost to Re-Remediate Area Within Scour and Deposition Areas is the estimated cost to re-remediate previously remediated areas that are within the mapped scour and deposition areas.

This is calculated by multiplying the Total Effective Remediated Areas within the mapped scour and deposition polygons by the calculated three point cost average ($5.17/square foot).

Cost to Remediate Previously Unremediated Area Within Deposition Areas is the estimated cost to remediate yards and ROW areas that were not currently remediated under the existing yards program. This includes yards and ROWs that are within the mapped deposition areas. This is calculated by multiplying the unremediated areas by the calculated three point cost average ($5.17/square foot). The unremediated area is calculated as 10% x (Total Area minus the Total Remediated Parcel Area). Ten percent is the unremediated area percent perviousness based on examination of aerial imagery of the deposition zones.

No Further Action Cost should be interpreted as the estimated total cost to restore the areas identified within the scour and deposition maps to pre-event conditions after the associated storm event. This may be similarly described as the minimum cost to address CERCLA/Superfund installed barriers and newly contaminated areas caused by a flood event. This should not be construed to be the full cost for a flood event response because it does not account for damage to structures, damage to existing infrastructure systems, or costs for general cleanup of streets and facilities.

The unremediated areas should not be assumed to be currently "clean". The extent of contamination within these areas is uncertain at this time as the remediation program is still in progress. A portion of the unremediated areas may be slated for remediation at some point in the future. This implies that $5.17/square foot is a low-end estimate of the cost to remediate these areas.

Table 4. Remedy-at-risk Cost Summary

	Design Storm	Cost to Install Original Remedy Currently At-Risk To Scour and Deposition	Cost to Re-Remediate Area Within Scour and Deposition Areas	Cost to Remediate Currently Undremediated Area Within Scour and Deposition Areas	Total Cost to Remediate Areas Impacted by Scour and Deposition
KELLOGG	5-YR	$ 486,000	$ 470,000	$ 5,000	$ 475,000
	25-YR	$ 747,000	$ 723,000	$ 23,000	$ 746,000
	50-YR	$ 839,000	$ 811,000	$ 57,000	$ 868,000
MULLAN	5-YR	$ 777,000	$ 751,000	$ 98,000	$ 849,000
	25-YR	$ 1,850,000	$ 1,789,000	$ 277,000	$ 2,066,000
	50-YR	$ 2,566,000	$ 2,481,000	$ 409,000	$ 2,890,000
OSBURN	5-YR	$ 1,363,000	$ 1,317,000	$ 5,000	$ 1,322,000
	25-YR	$ 3,428,000	$ 3,314,000	$ 310,000	$ 3,624,000
	50-YR	$ 4,228,000	$ 4,087,000	$ 354,000	$ 4,441,000
PINEHURST	5-YR	$ 3,330,000	$ 3,219,000	$ 326,000	$ 3,545,000
	25-YR	$ 5,548,000	$ 5,363,000	$ 1,426,000	$ 6,789,000
	50-YR	$ 9,639,000	$ 9,318,000	$ 1,810,000	$ 11,128,000
SILVERTON	5-YR	$ 778,000	$ 752,000	$ 203,000	$ 955,000
	25-YR	$ 1,394,000	$ 1,348,000	$ 263,000	$ 1,611,000
	50-YR	$ 2,910,000	$ 2,813,000	$ 380,000	$ 3,193,000
SMELTERVILLE	5-YR	$ 830,000	$ 802,000	$ 34,000	$ 836,000
	25-YR	$ 3,239,000	$ 3,131,000	$ 175,000	$ 3,306,000
	50-YR	$ 6,291,000	$ 6,082,000	$ 387,000	$ 6,469,000
WALLACE	5-YR	$ 2,000	$ 2,000	$ 87,000	$ 89,000
	25-YR	$ 94,000	$ 91,000	$ 159,000	$ 250,000
	50-YR	$ 211,000	$ 204,000	$ 332,000	$ 536,000
WARDNER	5-YR	$ 678,000	$ 656,000	$ 41,000	$ 697,000
	25-YR	$ 678,000	$ 656,000	$ 41,000	$ 697,000
	50-YR	$ 678,000	$ 656,000	$ 41,000	$ 697,000
TOTAL	5-YR	$ 8,240,000	$ 7,966,000	$ 795,000	$ 8,761,000
	25-YR	$ 16,976,000	$ 16,410,000	$ 2,673,000	$ 19,083,000
	50-YR	$ 27,359,000	$ 26,447,000	$ 3,767,000	$ 30,214,000

3.2 Results Summary

The risks to the human health remedy are characterized based on modeling analysis, field reconnaissance, and input from local officials. Table 5 summarizes the key findings from the modeling and field work. Descriptions of the stream characteristics and modeling analyses are included in Section 3.2.1.

Table 5. Characterization Results Summary

AREA - Drainage	Modeling Results Summary	Field Observation Summary
Pinehurst		
Little Pine Creek	Channel undersized with problematic bridge and culvert crossings. Capacity issues for the 5 year storm event along D Street, at the Golf Course, through the Avista property, and along West Shoshone County Park.	90-degree bend with bridges, residential bridge crossings, golf course not remediated, West Shoshone County Park, potential for impact to remediated areas.
Smelterville		
Grouse Creek	Channel capacity issues from J Street to series of culverts. Culverts undersized and cause significant backwater effects. Culverts must be upsized in addition to channel improvements to pass 50 year storm.	90-degree bends, channel capacity and grade decreases going downstream, culverts undersized at Main and Breeden Street.
Silver King eroding slope	Area was identified during field investigations and conversations with local officials. Was not modeled.	Off-road vehicles eroding slope, un-vegetated eroding of steep slope via gravity, steep slope erosion could recontaminate homes at base of hill.
Kellogg		
Jackass Gulch	The existing channel capacity adjacent to the hospital is not sufficient with the backwater effects of the culvert downstream. The culvert south of the High School is undersized for 25 and 50 year storm event. The remaining reaches modeled adequately convey the 50 year storm.	Eroding entrance to culvert, unstabilized portions of channel immediately upstream of culvert (adjacent to the hospital parking lot).
Italian Gulch	Detention basin and inlet to culverts adequately pass the 50 year storm event.	48" & 30" culverts in parallel provide adequate capacity if maintained. Heavily vegetated detention basin exists at inlet to culverts.
Northern Drainage – Chestnut Street (Holmes Gulch)	For 25 and 50 year storm event, the inlet backs up and floods property to the south. Detention basin depth not adequate to store and convey larger storm events.	16’ W x 12’ L x 2’ D detention basin directs drainage through metal grate to inlet pipe under town, concrete head wall only. Channel “Y” at north end of Chestnut Street upstream of inlet.
Northern Drainage – Riverside Avenue	Detention basin and pipe inlet adequately pass the 50 year storm event.	20’ W x 10’ L x 6’ D detention basin directs drainage through metal grate to 12” diameter PVC pipe, appears to be in good condition with concrete headwall and side walls.
South Drainage – South Maple Street	Drainage was not modeled.	
Northern Drainage – Division Street	Drainage was not modeled.	6’ L x 1’ W x 2’ D metal grate / catch basin in-place at bottom of hillside with 6” PVC pipe outlet, concrete wall immediately to the north, debris buildup inside grate, no apparent upstream channel.

Table 5. Characterization Results Summary

AREA - Drainage	Modeling Results Summary	Field Observation Summary
Northern Drainage – Mullan Avenue	Drainage was not modeled.	No upstream channel or drainage inlet visible.
SW Kellogg – West Portland Avenue Road	Area was identified during field investigations and conversations with local officials and was not modeled.	Wooden flume installed along south side of gravel road, existing pipe that runs north to Ohio in poor condition, inadequate grading and scour common.
Bunker Creek	Not modeled for this analysis due to previous work performed. Refer to: *Bunker Creek Study: Hydrologic and Hydraulic Models for the Bunker Creek System in Kellogg, Idaho* (TerraGraphics 2008).	Restricted flows will cause backwater flooding on west side of Kellogg. Potential impacts to Smelterville.
O'Connor Street Inlet Structure	Area was not modeled.	Old concrete inlet structure. Minimal access for maintenance. CMP outlet pipe. Steep gravel road downstream of system.
Mine Road Behind City Hall	Area was not modeled.	Several large waste piles. IDEQ personnel have indicated extensive localized stormwater ponding in this area after thunderstorms.
Wardner		
Steep eroding hillsides on west slope of Wardner	Area was not modeled.	Ongoing erosion into back of yards.
Sierra Nevada Road	Area was not modeled.	Scour on gravel road and then at bend flows onto paved Wardner road.
Bunker Chance Mine Dump (east side of Wardner)	Area was not modeled.	Mine dump is adjacent to small number of remediated properties.
Area above Reed Landing - undercuts/debris/flood	Area was not modeled.	Material. East & West fork Milo Creek junction. Overwhelms water-district dam.
Osburn		
Rosebud Creek/Gulch	'Mystery' culvert undersized for 5, 25, and 50 year storm event. Capacity issues along portions of channel adjacent to Leisure Acres (will not pass greater than 5 year storm). Channel along park will not pass 5 year flow.	Creek at toe of mine revegetated test plots along Leisure Acres, marginal channel embankments (illegal dumping of soil and grass clippings), single 'mystery' culvert choke point (at park it is 2 culvert outlets), shallow channel through park, flows into Gene Day Pond.
McFarren Gulch	Existing channel capacity and stream crossings along the modeled reach adequately convey the 50 year storm. Minor possible choke point under Mullan Street, though little threat to remedy exists due to topography present at location.	Open confined channel through community. Could be carrying particulate Pb from upstream mine sources (Coeur d'Alene Mine); creek flows along toe of mine and failure at mine dump could adversely impact channel hydraulic capacity; 8 stream crossings identified.
Meyer Gulch	Drainage was not modeled. Design information collected from the *Meyer Creek Final Report* (TerraGraphics 2005) in addition to field investigations.	Inlet area with grate - could get clogged, flows into culvert underneath town, lot for sale downstream of inlet could serve at a potential over-flow option, upstream contamination sources. Blow-out of inlet structure is biggest concern.

Table 5. Characterization Results Summary

AREA - Drainage	Modeling Results Summary	Field Observation Summary
Shields Gulch	Majority of culverts undersized. Flooding likely in multiple locations for storm events greater than 25 year frequency. Includes inundation at the Old Yellowstone and Mullan culverts, along portions of the reach adjacent to the school, and in the field area upstream of the I-90 culverts.	Two ninety-degree bends, creek flows adjacent to school; grade flattens out at downstream end and parking lot of school gets flooded routinely, school has been remediated, Coeur Mine (active mine site) is at upstream end, 10 existing stream crossings along reach.
Silverton		
Revenue Gulch	Some form of inundation and flooding expected at all 7 culvert crossings during the 50-year flood event. I-90 culvert of particular concern (currently undersized for 25 year storm). If culverts are replaced with a bridge or upsized, the existing channel capacity is adequate.	Small mine dump (Western Union) source in community, open channel through town adjacent to homes and Markwell, 7 culvert crossings and 10 bridges identified, possible capacity issues, minimal channel modifications possible through town due to existing topography and features.
Cross Streets – Between Western and Markwell	Revenue Gulch was modeled considering a discharge of 40 cfs from this area downstream of the 5th St bridge. Channel capacity no longer adequate along certain sections and two driveway bridges now expected to cause flooding during 50-year event.	The possibility exists to send flows from the steep east-west cross streets in this area to Revenue Gulch. Due to existing topography, would need to run a pipe down to 5th St before discharging to creek. Runoff currently concentrates in a natural low running north-south, 'homeowner' drain systems present, ponding and scour common.
Cross Streets – area west of Western Avenue	This area was not specifically modeled. However, discharge of flow from this area to Revenue Gulch at a location south of 1st Street was considered during the proposed design of Revenue Gulch.	On Western Avenue there is a steep north-south street that funnels flow during precipitation. 'Homeowner' drain systems present and inadequate, scour common.
Unnamed Creek (west of Sather Field at north end of Anderson Way)	Flooding expected at culvert for all modeled storm events. Channel capacity downstream of this is inadequate to convey 50 year flow.	Farm at upper end of gulch. One culvert crossing of concern in poor condition with large flat residential area directly to the south. Channel capacity greatly decreases to small drainage ditch after culvert.
Wallace		
Placer Creek	Not explicitly modeled for this analysis and assumed to be functioning as intended by the USACE design.	USACE designed concrete channel.
Printer Creek	Model indicates flooding at the inlet for both the 25 and 50 year storm event (assumes 'clean' water and inlet conditions).	Inlet structure has become clogged in the past, resulting in overland flow that traveled into the Wallace public swimming pool. Inlet structure goes into a culvert that connects into the city drainage system. Minimal scour potential.
Southern Hills – Steep Road Areas	This area was identified during field investigations and conversations with local officials and was not modeled.	Roads run east-west and are relatively flat. Steep hillsides exist; potential for flow from precipitation carrying contaminated sediment. Slopes well vegetated such that contaminated flow should be minimal. Potential slope failures currently exist.

Table 5. Characterization Results Summary

AREA - Drainage	Modeling Results Summary	Field Observation Summary
High Street	Area was identified during field investigations and through conversations with local officials. Modeling was not performed.	Steep road with scour common, turns corner at bottom, potential deposition area.
Mullan		
Mill Creek (upstream of FEMA structure)	This area was not modeled but identified as a threat to the remedy based on field investigations and as a result of conversations with local officials.	Current FEMA overflow pipe in-place and sized for 25 year storm per design report (Welch-Comer). Upstream sources exist. Channel capacity likely undersized, resulting in flow down streets and through yards. Scour and deposition expected as a result of such events.
Mill Creek (downstream of FEMA structure)	Channel capacity issues along section of stream prior to culvert under 2nd Street; overtopping of banks expected. Four culverts undersized that must be upsized or replaced with a bridge to pass the 50 year storm event.	Existing channel is both open channel and below-grade. Little to no information available for subsurface reaches (including size, capacity, and condition). Several residences are located directly over the creek with virtually no maintenance capabilities available for infrastructure in place. Seven culvert crossings and 6 bridges identified. The primary channel seems to be the risk.
Mill Street	This area was identified during field investigations and conversations with local officials. Modeling work was not performed.	Steep street: curb and gutter on upper ¾ of street and then lower portion transitions to none, creating a scour area. Intersection drainage problem exists at Bingville & Mill Street. Existing dirt/gravel ditch along west side of street.
Tiger Creek	This drainage was identified during field investigations and as a result of conversations with local officials and homeowners, and was not modeled using HEC-RAS.	Pinch point on creek near 8th and Fir Street, steep lots and roads, no mine dumps, scour potential.
South end of Second Street	Not modeled. This area was identified through field work and as a result of discussions with locals.	No functioning drainage system in place. Ponding common in the flat area to the south of Court Loop, adjacent to Second Street. Recontamination of this area occurred after remediation.
South of I-90 – Copper Street Neighborhood	This area was not specifically modeled, but was identified as a threat to the remedy based on field investigations and through discussions with local officials.	Four catch basins along Idaho Street convey water in old concrete lined ditch to a dry well at Copper and Idaho Street. Copper Street is curb/gutter. Unnamed drainage cuts through center of this area and poses great flooding threat; is piped underground near Oregon Street and discharges to Boulder Creek. Steep lots and streets, scour potential.
South of I-90 – Third Street Neighborhood	Not modeled; identified based on field work and as result of discussions with local officials.	Steeply sloped area. Paved ditches along each side of Third Street with three catch basins located at Oregon and 3rd Street. No drainage infrastructure on sloped streets east of 3rd Street. Scour potential and greater run-on potential in this area than other areas of Mullan.
Northwest Mullan – Dewey Street Neighborhood	This area of Mullan was identified as a threat to the remedy based on field investigations and conversations with local officials; it was not modeled.	Steep lots and streets, scour potential, greater run-on potential than other areas observed in Mullan. Existing drainage infrastructure is minimal: grass lined ditch along Dewey Street and four catch basins along southern edge of this area. Pipe exposed above road surface.

3.2.1 Pinehurst

3.2.1.1 Little Pine Creek

The Little Pine Creek watershed is located immediately southeast of Pinehurst and is approximately 2.5 square miles in size. As the lower reach of Little Pine Creek approaches town, it first flows under the Hill Street bridge, then turns nearly 90 degrees to the northeast and flows under the Maple Street Bridge (refer to Attachment 2 Figure 2-4). From here, the creek continues along the eastern side of D Street where it flows under four driveway crossings, through the recently replaced Fairview Street culvert, then enters the Pinehurst Golf Course area (where channel modifications were recently completed as part of the Pine Creek Sediment Reduction Project, funded by a Clean Water Act Grant). After the golf course, Little Pine Creek flows under the Country Club Lane culvert and continues north along Avista Property before crossing through a small box culvert and entering West Shoshone County Park. Shortly downstream from here, the stream opens up, crosses under a bridge that leads to the KOA campground, and then disperses throughout an area much like a wetland. Ultimately, Little Pine Creek discharges to Pine Creek after passing through one culvert under the I-90 overpass and two dual culverts under Division Street.

As identified during past flooding events, the Little Pine Creek channel is undersized and has problematic bridge and culvert crossings. Modeling of the existing creek conditions confirms this, identifying capacity issues for the 5, 25, and 50 year storm events along D Street, at the Golf Course, through the Avista property, and through the reach of creek adjacent to the county park.

3.2.2 Osburn

3.2.2.1 Rosebud Gulch

Rosebud Gulch is located on the west end of Osburn. The mouth of Rosebud Gulch is just south of the intersection of South Johnson and West Yellowstone, but the creek is routed west around the Leisure Acres neighborhood and Gene Day Park (refer to Attachment 2 Figure 2-17). Prior to flowing adjacent to Leisure Acres, Rosebud Gulch crosses under two gravel roads just south of town through an adequately sized pipe arch culvert. Just downstream of this crossing the stream leaves its defined channel and flows through approximately 800 feet of forested area. The stream is collected below this area by a berm that has been built up along the southwest portion of Leisure Acres, creating a 90 degree bend in the channel alignment. During field reconnaissance, it was noted that this berm appears to be broken and undefined in certain areas, such that the structural stability and effectiveness of this berm to adequately convey water is of concern. The stream flows west along the trailer park for approximately 350 feet (decreasing in capacity as it does so) then enters a 24-inch diameter CMP culvert that flows under a residential parcel. At some point underground, the stream transitions from this single culvert to dual 20-inch culverts, before discharging to an open channel at the southern edge of Gene Day Park. From here, the channel quickly converges down to a small drainage ditch that flows along the southern side of the park loop until reaching Gene Day Pond. One known culvert currently exists along this ditch.

3.2.2.2 McFarren Gulch

Located to the south of Osburn is the McFarren Gulch watershed, which is approximately 3 square miles in size. There are 29 historical mine activity sites identified in this watershed, the largest of which is the Coeur D'Alene Mine and Mill Site (refer to Attachment 2 Figure 2-19). . Runoff from this site flows directly into McFarren Creek as a result of precipitation events. McFarren Creek generally flows through town in a confined open channel, although side walls have been reinforced with concrete in a few sections. For this analysis, the creek was evaluated from the Coeur D'Alene Mill Site, running north through town just west of Jefferson Street until it discharges to the SFCDR. In the vicinity of the Coeur d'Alene Mine and Mill Sites, the east bank of McFarren Creek is composed of mine tailings. Based on field observations and location of the mine tailings relative to McFarren Creek, there could be potential scouring of the toe of the mine waste material during storm events that could deposit material into the channel. Between the south end of Osburn and Interstate-90 a total of eight stream crossings were identified during field investigation. Based on the results of the existing creek model, it was determined that, in general, the existing channel capacity and stream crossings adequately convey the 50 year storm. The exception to this is the concrete box culvert under Mullan Street, which was indicated as a small choke point for the 25 and 50 year storm events. While a small amount of inundation would be expected at this choke point, little threat to the remedy exists due to the topography present at this location. Rather than flooding outward and affecting nearby property, it is expected that water would stay within the vicinity of the creek, simply flowing over Mullan Street and back into the channel.

3.2.2.3 Shields Gulch

Shields Gulch is located on the east side of Osburn. Within the vicinity of Osburn, the existing open channel alignment contains two 90-degree bends before the main channel drains northeast towards I-90 and discharges to the SFCDR (refer to Attachment 2 Figure 2-24). Field reconnaissance identified one bridge and nine culvert crossings along this reach, several of which pose a flooding threat to the elementary school main parking lot and entrance, located adjacent to approximately 1000 linear feet of the stream. Modeling of Shields Gulch indicated that some form of inundation and flooding would be expected at eight of the nine culvert crossings during the 50-year peak flow. The modeling accounts for the new culvert installed in 2009 that is located approximately 100 feet south of the Trail of the Coeur d'Alene.

3.2.2.4 Meyer Creek

Meyer Creek originates less than 1 mile southwest of Osburn (refer to Attachment 2 Figure 2-22). Just south of town, Meyer Creek transitions from an open channel to a pond, from which water enters a pipe through a grizzly debris trap near St. Elmo Mine Road. From here, Meyer Creek is conveyed through town in a combination of 18-inch and 36-inch corrugated metal pipe before discharging to a ditch that borders the Zanetti property, and ultimately flows to the SFCDR. According to the "Meyer Creek Preliminary Assessment Report" (TerraGraphics 2005), the pipe system is approximately 50 years old and does not have enough capacity to convey the drainage from the watershed. The pipeline system generally runs at 7 to 10 percent slope along the upper portion, but suddenly reduces to 0.4 percent slope at approximately the longitudinal midpoint. In this lower reach, two storm sewer inlets contribute flow to the Meyer Creek Pipe. City staff indicated that Meyer Creek has flooded in the past prior to the BPRP in

Osburn. Given the presence of active and historical mines working in the watershed, contaminated sediments would likely be deposited in the community and pose a significant threat to the remedy in the event of a flood.

3.2.3 Kellogg

3.2.3.1 Jackass Creek

Located to the northwest of Kellogg is the Jackass Creek watershed, which is approximately 2.70 square miles in size. The lower reach of this creek passes along the eastern edge of Kellogg for approximately 1 mile before discharging to the SFCDR south of I-90 (refer to Attachment 2 Figure 2-9). As Jackass Creek approaches Kellogg, it first flows east of the High School complex, eventually winding its way to the west side of the Hospital. Just upstream of the hospital complex, Jackass creek transitions to a concrete trapezoidal channel for approximately 165 feet. From here, the creek passes through a 50 feet long culvert into a slightly different configured channel with a vertical concrete wall along the eastern side. This channelized reach is directly adjacent to the hospital parking lot and exists for approximately 260 linear feet before the creek enters a 480 feet long culvert that conveys the flow until resurfacing just south of Cameron Street. Before discharging to the SFCDR, the creek passes under I-90 through a concrete box culvert. Based on the existing creek geometry model, a majority of Jackass Creek adequately conveys the 50 year storm event. The exception is the second channelized portion of the creek directly adjacent to the hospital. With the backwater effects of the culvert at the downstream end of this creek section, the existing channel capacity is not quite sufficient.

3.2.3.2 SW Kellogg – West Portland Road

The existing drainage infrastructure includes a wooden flume along the south side of Portland Road, which drains east towards a concrete vault that collects the water and ultimately conveys it through an existing pipe that runs directly north to Ohio Street (refer to Attachment 2 Figure 2-8). The City's Public Works staff has indicated that erosion caused by stormwater runoff is common along the gravel road and shoulders, causing scour. Reasons for this include the poor condition of the flume and the inadequate grading of the road along certain sections, which fails to direct stormwater to the flume. Relatively large scour areas were observed in the field during an investigation conducted for this analysis. The area along Portland Road in southwest Kellogg currently poses a threat to the remedy.

3.2.3.3 Northern Drainage – Chestnut Street (Holmes Gulch)

Holmes Gulch is a small drainage located to the north of Kellogg (refer to Attachment 2 Figure 2-9). After flowing adjacent to Chestnut Street for approximately 100 feet, the drainage enters a subsurface conveyance system and is piped underground through town. Specifically, water at the bottom of the drainage is directed through a 2 foot wide x 1 foot high metal grate to an inlet pipe located at the end of a 16 foot wide x 12 foot long x 2 foot deep detention basin. The base of the detention basin is well vegetated, with a concrete head wall and natural bank sides in-place to contain water until a depth of 1 foot is reached, at which point water begins to drain through the inlet pipe. Based on the existing creek geometry model developed for this reach, flooding to the south of the detention basin is expected for a storm event equal to or greater than the 25 year frequency however there are no apparent sources of contamination or scour risks.

3.2.3.4 Northern Drainage – Riverside

Flowing towards Kellogg just north of Riverside Street near Miner's Hat Realty is a small, unnamed drainage (refer to Attachment 2 Figure 2-10). As the drainage reaches Kellogg, water is directed to a 1 foot diameter PVC pipe at the end of a 20 foot wide x 10 foot long x 6 foot deep detention basin, where it is conveyed underground until discharging to the SFCDR. The detention basin is fenced in with a concrete headwall and side walls, and appears to be in good condition. Modeling of this Unnamed Gulch indicated that the detention basin and pipe inlet of this drainage adequately pass the 50 year storm event.

3.2.4 Silverton

3.2.4.1 Revenue Gulch

Revenue Gulch drains a 1.80 square mile watershed northeast of the town of Silverton. The lower reach of this creek passes through town in an open channel parallel to Revenue Gulch Road and Markwell Avenue, ultimately entering a concrete box culvert on the southern edge of town that runs under I-90 and discharges to the SFCDR (refer to Attachment 2 Figure 2-28). Field reconnaissance identified 7 culvert crossings and 10 bridges along this reach, many of which provide direct access to residential property from Markwell Avenue. Based on the modeling of the existing stream geometry, some form of inundation and flooding would be expected at all seven culvert crossings during the 50-year flood event. Because the creek flows directly between Markwell Avenue and the adjacent residential properties to the east, minimal channel modifications can be made to the existing creek geometry to increase the existing capacity.

3.2.4.2 NW Silverton – The Neighborhood West of Western Avenue

In general, the area of town located west of Western Avenue receives drainage from the hillsides to the northwest of Silverton. To address this runoff and the associated nuisance flooding, several small drainage features such as storm drains and culverts exist in the area and appear to have been installed solely by homeowners. While these 'homeowner' systems are effective at reducing stormwater ponding on specific properties, they are unconnected systems that tend to move water from one property to the next, never adequately addressing the drainage that occurs throughout the entire area. These systems do not prevent stormwater runoff draining from the public ROW onto private property, resulting in the common occurrence of scour, which poses a threat to the remedy. This area was identified during field investigations and conversations with local officials.

3.2.4.3 Area between Western and Markwell

Inadequate drainage infrastructure exists in the area of Silverton located between Western and Markwell Avenues, which receive drainage from the wooded hillsides north of town. Surface runoff concentrates in a natural low area running north to south approximately halfway between Western and Markwell Avenue. Similar to other parts of town, small 'homeowner' drain systems have been installed to convey water through private properties. Despite the efforts to contain drainage, these existing systems are relatively ineffective in collecting and conveying stormwater. The roads are inadequately graded and fail to direct stormwater to catch basins; ponding commonly occurs after rainfall events and water frequently flows into streets and yards.

Erosion caused by stormwater runoff is common and has resulted in the need to remediate certain areas multiple times in the past. This area was identified during field investigations and conversations with local officials.

3.2.4.4 Unnamed Creek

On the west edge of Silverton, an unnamed creek drains a very small watershed area of less than 0.25 square mile. While the drainage generally flows on the outer edge of Silverton, there is one culvert crossing of concern that poses a potential threat to the remedy (refer to Attachment 2 Figure 2-26). This culvert, located just north of Strope Street under Anderson Way, was identified in the field as an 18-inch diameter CMP culvert in extremely poor condition. The existing outlet is partly caved in, with sediment filling up the bottom 9-inches of the culvert. According to the HEC-RAS model created, flooding is likely to occur at this culvert for the 5, 25, and 50 year storm events, potentially causing a large portion of flat residential area south of this choke point to become inundated. The existing channel downstream of the culvert, which is essentially a small drainage ditch that flows to the SFCDR, also provides inadequate capacity for the 50 year storm event.

3.2.5 Mullan

3.2.5.1 Mill Creek

Mill Creek drains a 3.8 square mile watershed north of the town of Mullan (refer to Attachment 2 Figure 2-33). The lower reach of the creek passes through the town for approximately 1 mile before discharging to the SFCDR. While the Mill Creek channel is the main conveyance for this stream, an overflow diversion structure and pipeline constructed in 1997 flow down Second Street and provide flood protection along this drainage. The overflow structure is located on the parcel between 420 and 440 Second Street and, for the purposes of this design analysis, is assumed to divert a flow of 90 cfs from the existing Mill Creek channel based on information found in the “Preliminary Design Report – Mill Creek Diversion Pipeline” (Welch Comer & Associates 1997). Downstream of the overflow structure, Mill Creek has been channelized through portions of Mullan, changing continually from various forms of lined channel to natural streambed. In several circumstances, residences are located directly over the channel, housing unique culverts and pipelines with virtually no maintenance capabilities. As a result of field reconnaissance, seven culvert crossings and six bridges were identified along this reach. Mill Creek flows underground for roughly 800 feet in four sections as it is diverted under Second Street, Hunter Street, and a few residences. Modeling of Mill Creek indicated that some form of inundation and flooding would be expected at four of the seven culvert crossings during the 50-year storm event. Additionally, for approximately 175 linear feet of open channel section the stream would likely overtop the banks during the 50-years storm.

3.2.5.2 Tiger Creek

Tiger Creek (as referred to by local residents) is located on the northeast edge of Mullan between Mill Creek and Gold Hunter Gulch. Just north of Fir Street, the creek flows into an existing 18-inch diameter CMP pipe that runs through a residential backyard to a catch basin in Fir Street (refer to Attachment 2 Figure 2-33). The existing pipe is undersized, on a very steep grade, and is above ground through the yard. From the catch basin, the pipe then runs underground to the southeast until it surfaces again just west of the football field. From here, the creek winds around the Lucky Friday tailings pond until it flows into the SFCDR. Local homeowners have indicated the stream has flooded in the past. This problem area was identified during field investigations and conversations with local officials and homeowners.

3.2.5.3 South end of Second Street

The remediated area at the south end of Second Street in Mullan is currently at risk of recontamination by the deposition of contaminated sediments. There is currently no functioning drainage system in-place in this vicinity, such that stormwater flows off Second Street just south of Court Loop and tends to pond in the low flat-lying area to the south. City staff indicated that this area was recontaminated after initial remedial actions and is likely to occur again without the implementation of an adequate drainage system. This area of concern was identified during field investigations and conversations with local officials.

3.2.5.4 Copper Street Neighborhood

Located on the southeastern edge of Mullan (south of I-90) is the Copper Street neighborhood. Boulder Creek flows along the western side of the area, while a small unnamed creek that conveys runoff and water from the southeast hillsides flows through the center of the area (refer to Attachment 2 Figure 2-34). Four existing catch basins along Idaho Street collect and convey water in an old concrete-lined ditch to a dry well at Copper and Idaho. Copper Street has curb and gutter on both sides, generally conveying runoff to the dry well. A dirt/gravel ditch along Boulder Creek Road conveys runoff to the unnamed creek, which flows through a culvert under Montana Street and then along the hill between Boulder and Seventh Streets. From here the creek is piped underground for approximately 350 feet and discharges to Boulder Creek. The condition of the piping system for this creek is unknown, though flooding of this system would have the potential to do significant damage to nearby homes and the remedy. Active erosion has been observed in this area in the past. This area was identified as an area of concern to the remedy based on field investigations and conversations with local officials.

3.2.5.5 Dewey Street Neighborhood

The Dewey Street neighborhood, located in the northwest portion of Mullan, receives drainage from the hillsides above Upper Dewey Street. The existing drainage infrastructure is minimal and consists of a grass-lined ditch along Dewey Street and four catch basins that run along the southern edge of this area. The pipe running between these drains is exposed above the road surface and rusted through due to past deterioration of the roadway. While this existing set-up is meant to adequately convey runoff to curb and gutter along Hunter Street just east of Residence Street, and then drain to a catch basin and directly into Mill Creek, water generally tends to flow freely down the streets and gravel shoulders, causing erosion and scour. This area of Mullan was identified as a threat to the remedy based on field investigations and conversations with local officials.

3.2.5.6 Mill Street

Located on the western edge of Mullan, Mill Street receives drainage from the wooded hillside northwest of town, in addition to receiving drainage that is diverted from the Tennis Row neighborhood. While curb and gutter exist along the upper part of Mill Street, the lower portion from Daisy Loop and south relies on a dirt/gravel ditch along the west side of the street. The ditch conveys runoff from this area through the Morning Star Mill site. The area at the bottom of Mill Street does not have a defined discharge path and meanders through the Morning Shop. Due to the abrupt halt in curb and gutter half way down Mill Street, as well as inadequate drainage ditches and lack of drainage features in place, nuisance flooding and erosion of the gravel ROWs are common in this area and present a threat to the remedy. This area was identified during field investigations and conversations with local officials.

3.2.5.7 Third Street Neighborhood

The Third Street neighborhood, located on the southwest edge of Mullan (south of I-90), relies on minimal and deteriorating existing infrastructure to adequately convey drainage. The area is steeply sloped, with runoff generally draining in paved ditches along each side of Third Street to three catch basins located at Oregon and Third Street. No drainage infrastructure currently exists on the sloped streets east of Third Street in this area, while drainage from south of Huntington is conveyed to an infiltration area along Yale Street. The major concerns in this area include scour of east-west streets and the poor condition and size of culverts in the Third Street drainage ditches. This area was identified as an area of concern to the remedy based on field investigations and conversations with local officials.

3.2.6 Smelterville

3.2.6.1 Grouse Creek

The Grouse Creek watershed is located immediately south of Smelterville and is approximately 1 square mile in size. As Grouse Creek approaches the central part of town, it turns 90 degrees to the west and flows along the southern boundary of Smelterville (refer to Attachment 2 Figure 2-6). The outer bank of this corner is reinforced by a concrete wall. From here, the creek travels in an open channel along the southern edge of town before passing through two 36-inch diameter concrete culverts, one under Main Street and the other under Breeden Street. At this series of culverts, the stream is forced to make two 90-degree bends before discharging into the East Page Swamp. According to the existing creek model, from the reinforced concrete wall to about J Street, Grouse Creek has sufficient capacity to convey and contain the 50 year storm event. After this point, however, the channel loses grade and becomes much smaller and more constricted. Currently, this reach of the creek will not pass an event much larger than the 5 year frequency. The existing model also indicated capacity issues with the series of culverts; in addition to necessary channel improvements upstream, both must be upsized such that backwater effects become less significant.

3.2.7 Wallace

3.2.7.1 Printer’s Creek

Printer’s Creek originates south of Wallace and drains a very small watershed area of less than half a square mile. Just south of Garitone and Residence Streets, Printer’s Creek enters a subsurface conveyance system and is piped underground through town until it discharging to the SFCDR. The existing inlet structure consists of a 21 foot long x 3 foot wide structure with concrete vertical walls and inclined bar screens to catch debris. City personnel have indicated in the past that this system occasionally floods at the existing inlet structure. Most recently, in 1997, the system overflowed to the public swimming pool, washing out some areas on the south part of town. The model developed for Printer's Creek indicates a small amount of flooding would be expected for both the 25 and 50 year storm event.

3.2.7.2 Placer Creek

Placer Creek, which flows through the western edge of Wallace, drains a watershed area of approximately 15 square miles. In response to local flooding in the 1980s, the USACE designed and constructed a concrete channel for Placer Creek, which flows along several residences and ultimately discharges to the SFCDR just west of Second Street. The channel appears to provide adequate flood protection for this area of town and is currently in good condition. This creek was not modeled for this analysis and is assumed to be functioning as intended by the USACE.

3.2.8 Wardner

3.2.8.1 Milo Creek

Milo Creek, which flows through the town of Wardner, drains a watershed area of just over 2.5 square miles (refer to Attachment 2 Figure 2-11). A flood control system is currently in place for Milo Creek; this was built following the 1997 Milo Creek flood event and is designed to convey the 100 year storm. The system was not modeled for this analysis and is assumed to be functioning as intended by the design.

3.2.8.2 Areas of Risk in Wardner

Aside from Milo Creek, there are three areas within Wardner that present risks to the remedy. These include the east facing slope on the west of the canyon, the area around Bunker Chance Mine, and the area at the interface between the Sierra Nevada and Bunker Hill dirt/gravel road. These areas were identified during field investigations and through conversations with the local officials.

3.3 Contamination Sources

3.3.1 Mining Activity Sites with Potential Impacts to Remedy

There are 24 mining activity sites in the area with potential risks to the Human Health Remedy. These sites were identified during the development of the impact maps, based on input from local officials, limited field reconnaissance, and a visual analysis of the watershed maps included as Attachment 2. The sites are listed in Table 6. With the exception of the Page sites located in OU 1, the sites are located in watersheds that drain into the eight primary communities.

Table 6. Mining Activity Sites with Potential Impacts to Remedy

Site Name	BLM Site ID	Community	Drainage
Operable Units 1 and 2			
Blackhawk Mine	KLW018	Smelterville	Grouse Creek
General Mine	KLW077	Pinehurst	Little Pine Creek
Bunker Chance Mine Dump	KLW065	Wardner	Milo Creek
Ranger Mine	KLW019	Smelterville	Grouse Creek
Lease Mill site	KLW101	Smelterville	Grouse Creek

Table 6. Mining Activity Sites with Potential Impacts to Remedy

Site Name	BLM Site ID	Community	Drainage
Last Chance Mill site	KLW107	Wardner	Milo Creek
North Bunker Hill Mine	KLW064	Wardner	Milo Creek
Page Mine	KLW014, KLW015	Page	Silver Gulch
Page Mill site	KLW144	Page	Silver Gulch
Page Mine Rock Dumps	KLW013	Page	Silver Gulch
Operable Unit 3			
St. Elmo Mine	WAL014	Osburn	Meyer Creek
Coeur d'Alene Mine	POL019	Osburn	McFarren Gulch
Coeur d'Alene Mill site	KLE074	Osburn	McFarren Gulch
Coeur Mine (Rainbow/Mineral Point)	WAL015	Osburn	Shields Gulch
Western Union Mine Dump	WAL002	Silverton	Revenue Gulch
Silverton Prospect Lower Adit	OSB073	Silverton	Revenue Gulch
Silverton Prospect Upper Adit	OSB030	Silverton	Revenue Gulch
Silver Dollar Mine	KLE034	Osburn	Rosebud Gulch
Silver Summit Mine	KLE035	Osburn	Rosebud Gulch
Shields Gulch Impacted Riparian	WAL034	Osburn	Shields Gulch
Gold Hunter No. 6	MUL038	Mullan	Gold Hunter Creek
Morning No. 6	MUL019	Mullan	(Unnamed)
Morning No. 5	MUL028	Mullan	Mill Creek
Independence Mine	MUL021	Mullan	Mill Creek

The mining activity sites may pose additional risks to the remedy aside from being potential contamination sources. Local officials have indicated concern about creeks undercutting these sites, resulting in mass movement of material into the drainage channels. This could potentially temporarily dam the creeks and potentially result in a large surge of water that could overwhelm the downstream systems. Field investigations were not conducted to observe the conditions at all of the mining activity sites for the remedy protection analysis. Site specific conditions such as proximity to creeks, materials, and similar physical parameters that influence the risks with respect to the remedy are generally unknown at this time.

3.4 Side Gulches

Eighteen side gulches were identified, based on screening procedures described in Section 3.4, with characteristics that present potential risks to the human health remedy. Hydraulic modeling and impact maps were not developed for these areas for reasons presented earlier. The characteristics of the side gulches are presented in Table 7.

Table 7. Side Gulch Characterization

Watershed Name	Closest Community	Existing Infrastructure Summary	Remediated Parcel Estimate
Big Creek	Big Creek	5 culvert crossings (Trail of the CDA, High Water Rd, Sunshine Mill Complex Access Road, Sunshine Tailing Pond Loop, North American Mine Access). 4200 linear feet (lf) of stream (upstream of sunshine tailing pond and repository). 2 miles of total stream flows along remediated properties, tailing pond, and repository.	520 lf of remediated properties within 100 ft of stream. 2500 lf of remediated property within 1000 ft of stream.
Willow Creek	East of Mullan	2 culvert crossings (I-90, Friday Ave). 1500 linear feet of stream.	300 lf of remediated properties within 100 ft of stream. 900 lf of stream flows through remediated properties.
Elk Creek	Elizabeth Park	5 culvert crossings (Appleburg, E Park Dr, Trail of the CDA, E Park Dr loop). 6500 total linear feet of stream: - East Fork Elk Creek: 2200 lf - West Fork Elk Creek: 4300 lf	2700 lf of stream flows through remediated parcels. 4800 lf of stream flows through or adjacent to remediated properties.
Moon Creek	Elk Creek	6 culvert crossings (Moon Gulch Rd (2), Loper Rd, Elk Creek Rd, Silver Valley, I-90). 2 miles of total stream flows along area where remediation has been carried out.	4640 lf of stream flows through remediated parcels. 7800 lf of stream flows through or adjacent to remediated properties.
Montgomery Creek	Montgomery Gulch	4 culvert crossings (Swinnerton Gulch Rd, Robinson Creek Rd, Silver Valley Rd, I-90). 2.65 miles (14000 lf) of stream.	1550 lf of stream flows within 300 ft of remediated properties. 3300 lf of stream flows through remediated properties.
Shirttail Gulch	Northeastern Osburn	2 culvert crossings (Steins Rd, Nuckols Gulch Rd). 1200 linear feet of stream.	1200 lf of stream flows near non-remediated residential properties.
Nuckols Gulch	Nuckols Gulch	6 culvert crossings: - 1 under Steins Rd - 3 under private drives - 2 under Nuckols Gulch Rd 4750 lf of stream within the vicinity of culvert crossings. 3400 lf of stream from start of remediated area to the SFCDR.	1400 lf of stream flows through remediated properties.

Table 7. Side Gulch Characterization

Watershed Name	Closest Community	Existing Infrastructure Summary	Remediated Parcel Estimate
Silver Creek	Page	1 culvert crossing (Upper Page Rd). 3000 linear feet of stream.	3000 lf of stream flows through remediated properties.
Slaughterhouse Gulch	Slaughterhouse Gulch	1 culvert crossing (Main-Wardner St). 1400 linear feet of stream.	235 lf of stream flows through remediated properties. 1300 lf of stream flows through or adjacent to remediated properties (within 50 ft).
Terror Gulch	Terror Gulch (NW Osburn)	2 culvert crossings (Sunny Slopes Rd and private area). 4500 linear feet of stream.	650 lf of stream flows adjacent to remediated properties. 1350 lf of stream flows through remediated properties.
Twomile Creek	Twomile	2 to 4 culvert crossings (Nuckols Gulch Rd, residential drives). 5600 linear feet of stream.	350 lf of stream flows within 250 ft of remediated properties. 225 lf of stream flows through remediated properties.
Ninemile Creek	Wallace	6 bridge and/or culvert crossings (Ninemile Creek Rd at multiple locations, Zanetiville Loop Entrance, Creekside Rd, Trail of the CDA, residential drives). 3.6 miles (19000 lf) of stream from start of remediated area to the SFCDR.	1400 lf of stream flows through remediated properties. 2600 lf of stream flows within 200 ft of remediated properties.
Canyon Creek	Woodland Park	10 culvert and/or bridge crossings (Grays Bridge Rd, Gruber Rd, Burke Rd at multiple locations, Yellow Dog Rd at multiple locations, private drives, residential driveways). 6.9 miles (36500 lf) of stream from start of remediated area to the SFCDR.	150 lf of stream flows through remediated properties. 6900 lf (1.3 miles) of stream flows adjacent to remediated properties within 250 ft. 15400 lf (2.9 miles) of stream flows adjacent to remediated properties within 1000 ft.
Bunker Creek	Kellogg	2 culvert crossings with multiple culverts at each crossing. Concrete box culvert discharge to SFCDA River.	Rails-to-Trails along alignment.
Hunt Gulch	Kingston	7 culvert crossings (Hunt Gulch Rd at two locations, Finlay Loop, Silver Valley Rd, I-90, Riverview Rd, residential driveway). 5000 linear feet of stream.	850 lf of stream flows through remediated properties. 1400 lf of stream flows within 100 ft of remediated properties. 2070 lf of stream flows within 350 lf of remediated properties.

Table 7. Side Gulch Characterization

Watershed Name	Closest Community	Existing Infrastructure Summary	Remediated Parcel Estimate
French Gulch	Kingston	4 culvert crossings (Newburn, Beamis, Silver Valley Rd, I-90). 6000 linear feet of stream.	1250 lf of stream flows through remediated properties.
Government Gulch	Silver King	4 culvert crossings (I-90, McKinley, Government Gulch Road, Zinc Plant Access). 1 Gabion Dam. Over 8000 linear feet of stream.	1000 lf of stream flows adjacent to remediated commercial property. 7000 lf of stream flows through non-populated remediated property.
Humboldt Gulch	Page	2 culvert crossings (both under Lower Page Rd). 3750 linear feet of stream.	2100 lf of stream flows through or adjacent to remediated properties.

SECTION 4.0 BASIS FOR REMEDY PROTECTION PROJECTS

This section presents an array of infrastructure-related solutions that could mitigate risks to Site human health barriers. Remedy Protection projects are developed as Site-specific solutions or Objective-specific solutions depending on whether the problems are particular to a location, or can be generally implemented to solve problems common to different communities or neighborhoods. These are projects that reduce the risk of exposure to contaminated material by preventing the material from being exposed or deposited within the communities following storm events. The projects are cumulatively an alternative to the No Further Action scenario and are dependent on the specific remedial element and the roles the affected infrastructure plays in the community. The No Further Action alternative is discussed and evaluated within Section 9 of the FFS Report based on information provided within SECTION 3.0 of this appendix. The long term performance of the remedy protection projects will depend, in part, on O&M of the systems. The basis for remedy protection projects to address issues within the side gulches is presented in Section 4.3 of Appendix G.

4.1 Project Development

The Alternative RP-2 was developed by the EPA and IDEQ FFS Remedy Protection project team using an iterative process that relied on a combination of data obtained during field visits, hydraulic modeling analysis, GIS analysis, and input from local officials. After evaluating the initial characterization results presented in Table 5, the project team assembled a list of technologies and process options that could be employed to mitigate the risks identified. The technologies and process options are standard engineering practices for stormwater and drainage management. These options are consistent with the existing stormwater and drainage management systems that are currently in use in many areas of the Site. Table 8 provides a list of the technologies and process options.

Table 8. Technology and Process Options

Technology	Process Option	Description
Creek Channel Modifications	Channel Hydraulic Capacity Improvements	Increase in cross-sectional area (widening, deepening, increasing bank height, and/or removal of material)
	New Channel	Re-route creek to new channel; develop new channel
	Channel Stabilization - Vegetation	Bank stabilization (vegetation, other)
	Channel Stabilization - Riprap	Bank stabilization (riprap)
	Channel Stabilization - Concrete	Bank stabilization (concrete channel)
	Channel Realignment	Change in channel alignment to remove sharp bend and improve hydraulic capacity of the channel
	Creek Culvert - Box	Concrete box/bridge (new or replacement) for roadways and/or driveway stream crossings
	Creek Culvert - Pipe	Installation of new pipe culverts or replacement of existing culverts with larger sizes
Inlet and Diversion Structures	Diversion Structure	Diversion structure for high-flow bypass
	Inlet Structure	New or improved existing inlet structure to collect creek flows

Table 8. Technology and Process Options

Technology	Process Option	Description
Drainage Improvements	Stormwater Drainage Network	Network of inlets, catch basins, pipes, and vaults for conveyance of local precipitation runoff; either new discharge location or tie into existing system
	High-Flow Bypass Drainage Network	Network pipes and manholes/vaults for conveyance of creek high-flow bypass; either new discharge location or tie into existing system
	Drainage Network Maintenance Improvements to Existing Drainage System	Installation of manhole or cleanout in existing drainage system to allow for more effective cleaning and maintenance of existing infrastructure
	High-Capacity Stormwater Inlet	Cattle guard or oversized Department of Transportation-type inlet structure to collect runoff; tie into drainage system
	Rolling Dip	Rolling dip on roadway surface to channel water
Road Shoulder Improvements	Road Shoulder - Pavement	Pavement of roadway shoulder
	Road Shoulder - Gravel	Replacement of contaminated road shoulder gravel with clean materials.
	Road Shoulder - Armoring	Placement of larger rock along road shoulder to limit scouring
	Paved Roadside Ditches	Paved roadside ditches (asphalt); either add new ditches and/or line existing with asphalt
	Rock-Lined Roadside Ditches	Rock-lined roadside ditches with rock sized for estimated flow velocities and with check dams if necessary
	Curb and Gutter	Curb and gutter network
	Rolled Curb	Rolled concrete curb across driveway approaches
Inspection	Visual Observation and Documentation	Observation and documentation of watersheds and drainage systems

The remedy protection projects were developed by selecting one or more of the technology options presented in Table 8 and applying them in the hydraulic models at locations where a project need was identified through the characterization work. The process of using the model involved adding technologies and process options into the model and sizing them until the 50-year design storm could be conveyed through the system without flooding. Generally, culverts and bridges were first evaluated to determine if replacement of such crossings alone would adequately allow conveyance of the 50-year design flow. Changes to the culvert/bridge shape, size, or material were analyzed utilizing built-in HEC-RAS functions, and in some cases, proved sufficient to pass the design flow. Where applicable, culvert entrance loss coefficients were changed, as well as Manning's coefficient values for the selected pipe material. Unless the design dictated otherwise, the upstream and downstream invert crossing values were kept constant between the existing and design models. Through use of photos and notes taken during field reconnaissance, appropriate topographical assumptions were made dictating limits on the maximum allowable culvert size or bridge clear height at each crossing.

In circumstances where crossing alterations alone resulted in inadequate conveyance of the design flow, channel modifications were next considered. To do this, altered cross sections were input into the HEC-RAS design models at locations with capacity limitations. Channel cross-section modifications such as increasing the channel bottom width (i.e. moving the toe outward) or increasing the channel height were first explored, followed by more drastic alterations such as increasing the overall channel footprint or installing a concrete channel. Similar to the evaluation of crossings, assumptions were made based on existing data and photos, allowing for creation of geometry and topography constraints. In general, altered cross sections were input into HEC-RAS assuming a constant streambed elevation between both the existing and design models. Where necessary, cross-sections at new stations were interpolated using HEC-RAS, allowing for the most accurate design model possible. Additionally, Manning's coefficient values were altered where applicable. For instance, for the Little Pine Creek design concrete channel, the Manning's n coefficient was reduced to account for lower channel resistance.

In one or two circumstances, the design modeling included alteration to the channel alignment. Examples include Shields Gulch, where the design channel runs north of the elementary school rather than south, and Grouse Creek. Similar to the development of the existing models, utilization of AutoCAD® provided valuable information for input into HEC-RAS, such as approximate reach lengths between design cross sections and slope of the existing ground. Additionally, photos and field data were considered.

4.2 Remedy Protection Project Descriptions

This section describes the remedy protection projects developed for each community that could be implemented to mitigate damage to the remedy during storm events. These descriptions correspond with the maps included as Attachment 3.

4.2.1 Pinehurst

4.2.1.1 Little Pine Creek

Hydraulic modeling indicates that Little Pine Creek does not have capacity to convey the design storms and poses a significant threat to the remedy, particularly in regard to the likelihood of flood occurrence and deposition of contaminated sediment. To combat the problem areas along Little Pine Creek identified by HEC-RAS modeling, several channel alterations and the replacement of multiple stream crossings would be required (refer to Attachment 3 Figures 3-2 and 3-3). Specifically, these design components occur along two reaches of Little Pine Creek: along D Street and downstream of the golf course. Although the reach of Little Pine Creek through the golf course only has the capacity to successfully pass the 2 year peak flow, it is not a remediated area and flooding would not affect many residential properties.

Along the first design reach of Little Pine Creek, channel alterations would need to start just upstream of the Hill Street bridge with the construction of a 1 foot berm on the west bank. Modifications would need to continue to D Street, where installation of a new rectangular concrete channel (12 feet wide x 3-6 feet high, depending on the existing topography) would be necessary from downstream of the Maple Street bridge to approximately 200 linear feet upstream of the Fairview culvert. Due to existing geometry limitations of Little Pine Creek between D Street and adjacent residences, an earthen channel is unlikely to fit along this reach that would adequately convey the 50 year storm event. In addition to channel modifications, the four existing driveway bridges would need to be replaced along this reach. Because the concrete channel provides a wider opening, the capacity of these new bridges would increase, reducing backwater effects that currently contribute to flooding. Refer to Attachment 3 Figures 3-4 to 3-7 for a depiction of design cross sections through this first reach. The second reach of Little Pine

Creek with proposed design components starts north of Country Club Lane on Avista property (downstream of the golf course) and continues through West Shoshone County Park. To adequately convey the 50 year storm through this reach, channel modifications would be necessary for a total of approximately 1000 linear feet. Channel alterations vary along this reach, but would include channel widening, construction of small berms on one or both banks, and changes to the existing longitudinal slope (refer to Attachment 3 Figures 3-8 and 3-9 illustrating design cross sections through this reach). Additionally, the existing concrete box culvert under the park entrance road would need to be replaced with a single span bridge, as would the existing wood bridge on the south side of the park.

4.2.2 Smelterville

4.2.2.1 Grouse Creek

A design alternative could be developed to adequately address the existing concerns Grouse Creek presents to the remedy (refer to Attachment 3 Figure 3-11). In this scenario, channel modifications would be made that include the installation of a new vertical 4.5 feet tall concrete wall along the north side of the creek. This wall would begin just after the first 90-degree bend (flush with the existing concrete wall) and would run approximately 2000 linear feet to the west, stopping where the creek is diverted under Main Street. With limited space available for channel modifications, the construction of this wall provides a relatively large amount of stream capacity that would be difficult to obtain along this existing creek alignment using any other form of channel alteration. Additional channel modifications would be necessary along the southern bank where Grouse Creek flows adjacent to Main Street, requiring the construction of a 0.7 feet tall berm along the southern bank. Refer to Attachment 3 Figures 3-12 and 3-13 for an illustration of design cross sections for Grouse Creek. Rather than replace the two existing culverts under Main and Breeden Streets to reduce backwater effects and prevent flooding, this alternative would incorporate the construction of a new 4.5 feet x 8 feet concrete box culvert across this intersection. This new culvert not only provides adequate capacity to pass the 50 year storm event, but removes the need for two 90-degree bends in the creek alignment at this location. The existing culverts would need to be abandoned.

4.2.3 Kellogg

4.2.3.1 Jackass Creek

The design alternative for Jackass Creek aims to protect the remedy by addressing channel capacity issues identified during watershed characterization. Specifically, the channelized portion of the creek adjacent to the hospital is of concern due to backwater effects from the culvert at the downstream end of this creek section. To prevent flooding at this location during the 50-year storm event, the proposed design would require that the channel be modified. As shown in Attachment 3 Figures 3-15 and 3-16, the west channel toe would need to be cut back by 2 feet and lined with riprap up to the top of the bank for approximately 260 linear feet. This alteration provides increased channel capacity without increasing the channel footprint and provides stability at channel locations previously identified during field investigation as unstable. Additionally, installation of riprap at the entrance of the two culverts within the hospital vicinity would be necessary to prevent erosion.

4.2.3.2 Italian Gulch

As described previously in the watershed characterization results, Italian Gulch poses little risk to the remedy provided the existing stormwater system continues to function. Modeling indicated that the existing detention basin and pipe inlet of this drainage through Kellogg adequately contain the 50 year storm event. As a result, no project design alternative was developed for this drainage.

4.2.3.3 Bunker Creek

At this time, no project design alternative has been developed for Bunker Creek within Kellogg. As described previously, Bunker Creek is categorized as a side gulch.

4.2.3.4 Northern Drainage – Chestnut Street (Holmes Gulch)

No design alternative was developed for the Holmes Gulch drainage. While flooding is expected to the south of the existing detention basin for a storm event equal to or greater than the 25 year frequency, watershed characterization concluded that no contamination sources exist in the watershed and scour potential is low.

4.2.3.5 Northern Drainage – Riverside

As described previously in the watershed characterization results, the small unnamed drainage that flows into Kellogg just north of Riverside Street poses little risk to the remedy. Modeling indicated that the existing detention basin and pipe inlet of this drainage through Kellogg adequately contain the 50 year storm event. As a result, no project design alternative was developed for this drainage.

4.2.3.6 SW Kellogg – West Portland Road Avenue

A proposed design alternative was developed to address the inadequate drainage infrastructure currently in-place along Portland Road in southwest Kellogg and provide protection to the remedy (refer to Attachment 3 Figures 3-17 and 3-18). This scenario would involve constructing a rock lined ditch (4 ft x 0.5 ft x 2 ft trapezoidal channel) along the south side of Portland Road in place of the existing wooden flume, draining west towards the existing concrete vault. Removal and replacement of this vault would be necessary, as well as replacement of the existing pipe that runs directly north to Ohio Street; suggested replacements for these existing drainage features include a 4 ft x 4 ft x 4 ft concrete inlet and approximately 300 linear feet of 36-inch diameter CHDPE pipe, respectively. To ensure that stormwater is directed toward this ditch and subsurface conveyance system, rock water bars would need to be installed at 250-foot intervals and the gravel road would be re-graded to drain south.

4.2.4 Wardner

4.2.4.1 Milo Creek

No project design alternative was developed for Milo Creek. The creek is assumed to be functioning as intended by the previously designed and constructed flood control system installed following the 1997 Milo Creek flood event.

4.2.4.2 Areas of Human Health Remedy at Risk in Wardner

A proposed design alternative was developed for the community of Wardner to protect the remedy, specifically addressing erosion and scour issues (refer to Attachment 3 Figure 3-20). The proposed design includes the installation of two 10 ft x 6 ft x 4 ft cast-in-place concrete vaults across both Sierra Nevada Road and Main Street, each with an overlying 12 ft x 6.5 ft grid to allow for the collection of drainage and sediment. The intent is to capture water and sediment at the interface between the gravel and paved roads. These systems should be designed to be self-flushing by casting as much slope as possible into the base of the structures. Water collected in these vaults would be conveyed underground through two 36-inch diameter CHDPE pipes, ultimately discharging to the concrete Milo Creek basin.

4.2.5 Osburn

4.2.5.1 Rosebud Gulch

Modeling and watershed characterization of Rosebud Gulch determined that the stream channel geometry downstream of the forested area would require relatively significant alterations to adequately convey the 50 year storm event. As shown on Attachment 3 Figure 3-22 for Rosebud Gulch, all culverts downstream of this point would need to be upsized and replaced, in addition to increasing the channel capacity along Leisure Acres and Gene Day Park. The existing ditch along the southern side of the park must be slightly widened, while the existing berm along Leisure Acres must be increased to a minimum height of 4 feet starting just downstream of the 90 degree bend. Additional channel modifications are necessary for approximately 100 feet upstream of the culvert out of the trailer park to prevent flooding and accommodate backwater effects due to the culvert. Refer to Attachment 3 Figures 3-23 and 3-24 illustrating design cross-sections for Rosebud Gulch. Where necessary, the berm adjacent to Leisure Acres would need to be filled in so that no gaps exist. In a more detailed design analysis, the berm would need to be evaluated more thoroughly to determine the structural stability of the existing material; depending on the results, more extensive alterations to the berm might be necessary, such as replacement of the existing material in addition to simply increasing the bank height. The design modeling confirmed that the three existing culverts which convey water out of the trailer park area can be replaced with a single 48-inch diameter CMP culvert. Additionally, the existing culvert crossing adjacent to the park would require the installation of a bridge with a clear height of 2 feet.

4.2.5.2 McFarren Gulch

As described previously during the watershed characterization results, the McFarren Gulch channel through Osburn appears to have adequate capacity to convey the design storms. A project was not developed for McFarren Gulch since the channel appears to have adequate capacity. There may be potential risks associated with the Coeur mine located upstream of the community. The stream cuts through the toe of the waste pile and may undercut the material. The mass movement of material into the creek may present risks to the community.

4.2.5.3 Meyer Creek

To adequately address the existing concerns Meyer Creek presents to the remedy, the existing Meyer Creek pipe would need to be replaced with a new pipe in an alternative alignment down

Sixth Street (as shown in Attachment 3 Figure 3-25). The total length for this pipe would be approximately 2850 feet, starting at the existing inlet and terminating next to the Zanetti property just east of Walnut Street. To reach Sixth Street, Meyer Creek would need to be conveyed in a buried pipe system north along St Elmo Mine Rd, northwest along Fir street, northeast on Seventh Street, and finally northwest along Larch Street. Manholes would need to be installed at these bends in the pipe alignment and additionally at five locations along Sixth Street. Based on simple pipe sizing calculations, 24-inch diameter CHDPE pipe should be sufficient for the new pipeline to adequately convey the 50 year storm event. To further protect the remedy from flooding and effectively divert Meyer Creek to the new pipe alignment, modifications to the existing inlet structure would be necessary and are included in the proposed design (refer to Attachment 3 Figure 3-26). The existing Meyer Creek pipe should be maintained for operation, with minimal flow to the pipe controlled by an overflow weir constructed as part of the new inlet structure. This new pipe could be built almost entirely in existing City ROW and provides considerable opportunity to for the City to improve the storm drainage system. Such costs have not been accounted for in this project.

4.2.5.4 Shields Gulch

The proposed design alternative for Shields Gulch involves the abandonment of approximately 2700 linear feet of existing channel. As shown on the design alternative drawings for Shields Gulch (Attachment 3 Figures 27 and 28), construction of a new earthen channel would be recommended starting just north of Mullan Street and running parallel to I-90. This would alleviate the need to replace many of the culverts along the existing alignment, with the intent of reducing the risk of floods at or near the elementary school. Additionally, this would eliminate one of the 90-degree bends and diverts the flow along an area that would be affected less drastically in the event of a flood greater than the 50-year event. For this alternative to function, three of the existing culverts need to be replaced and upsized, while one new culvert would need to be installed along the new alignment. Overall, with increased culvert sizes, the existing channel capacity is adequate; however, approximately 65 linear feet of channel will need to be modified just south of Mullan Street.

4.2.6 Silverton

4.2.6.1 Revenue Gulch

Revenue Gulch was determined to present a significant threat to the remedy based on hydrologic and hydraulic modeling, particularly at culvert crossings where channel and culvert capacity issues exist and contribute to flooding during the 50 year storm event. To address these concerns, the proposed design alternative includes the installation of an overflow structure and pipe beginning north of Park Street and running south along Markwell Avenue, discharging back to Revenue Gulch just south of the First Street bridge. The required overflow pipe capacity is 76 cubic feet per second (cfs), resulting in a minimum CHDPE pipe diameter of 36 inches. The total length of pipe required for the overflow system would be 2075 lineal feet. Upstream of Park Street, however, three existing culverts would need to be upsized and replaced with CMP arch culverts, while a forth culvert would need to be replaced by a single span bridge. Downstream of First Street, the existing box culvert under I-90 would also need to be upsized and replaced. Refer to Attachment 3 Figures 3-30 and 3-33 for a depiction of the design components discussed above.

While the overflow pipe and design components discussed above are sufficient to prevent flooding and risks to the remedy, an additional component addressing drainage issues in northwest Silverton and the area between Markwell and Western Avenues was included as part of this proposed design alternative. Specifically, it involves the installation of a stormwater conveyance system at both of these locations, which would tie into the proposed design overflow pipe. As shown on Attachment 3 Figure 3-30, this stormwater system includes 14 manholes, each with a pair of catch basins diverting drainage underground to CHDPE storm drain pipes. These systems would greatly improve the drainage in these areas, preventing scour from occurring along gravel ROWs and along private property. 10 additional manholes are to be installed down Markwell Avenue, allowing for the storm sewer tie-ins to the overflow pipe and relatively easy maintenance and accessibility. Refer to the design drawings, in Attachment 3 Figures 3-31 through 3-32 for Silverton, identifying pipe sizes, which range from 16-inch to 42-inch diameter CHDPE pipe.

4.2.6.2 Unnamed Creek

To adequately address the existing concerns Unnamed Creek in Silverton presents to the remedy, the existing culvert just north of Strope Street under Anderson Way would need to be replaced with 24 linear feet of 22-inch diameter CHDPE culvert. In addition, the channel downstream of the culvert would need to be increased to a 12 ft x 3 ft x 3 ft trapezoidal channel, allowing for adequate passage of the 50 year storm event prior to discharging to the SFCDR (Attachment 3 Figures 3-34 and 3-35).

4.2.7 Wallace

4.2.7.1 Placer Creek

Based on the watershed characterization results, no project design alternative was developed for Placer Creek. The creek is assumed to be functioning as intended by the previously constructed USACE project.

4.2.7.2 Printer's Creek

To adequately address the existing concerns Printer's Creek presents to the remedy, the existing inlet structure would need to be removed and replaced with an inlet having greater capacity. As indicated in the proposed design drawings, an inclined trash rack with a 5 ft long x 8 ft tall headwall and two 15 ft long x 8 ft tall wingwalls would be sufficient (refer to Attachment 3 Figures 3-37 through 3-39). Additionally, a new 5 feet diameter precast concrete manhole would need to be installed at a depth of 10 feet at the bottom of the hill near Hotel Street, where the existing pipe transitions from steep to flat. This would allow for increased maintenance capabilities at this portion of pipe, where issues that could lead to flooding and/or pipe failure appear likely to occur.

4.2.8 Mullan

4.2.8.1 Mill Creek

The modeling of Mill Creek showed that a number of issues currently exist in regard to the creek geometry which could negatively effect the existing remedy. To address these concerns, the proposed design alternative focuses primarily on the inadequate culvert crossings and channel capacity issues on the northern reach of Mill Creek through town. As shown in Attachment 3 Figure 3-41, channel geometry improvements begin at the first two culvert crossings downstream of the existing FEMA overflow structure, where 4 ft high x 4 ft long concrete wingwalls would need to be constructed at each culvert entrance to prevent scour and direct flow into these structures. Between these culverts, revegetation and re-grading of the stream banks should be performed to improve channel stability and stream passage. Just downstream of the second culvert, the existing concrete open channel section would need to be upsized and reconstructed, with a new and larger concrete box culvert installed at the end of this section that follows a new alignment under Second Street. This new alignment alleviates the need to replace the two existing undersized culverts through this area (one of which resides directly under a house) and increases future maintenance capabilities. The two culverts would be plugged and filled with CDF grout upon installation of the new concrete box culvert. Aside from the work described above, the design alternative includes the replacement of two culvert crossings (one under Fisher Street and the other just north of the Trail of the Coeur d'Alenes) with precast concrete bridges with footings and a minimum clear height of 2.5 ft. These are intended to prevent flooding and inundation that occur and contribute to recontamination of the remedy.

In addition to the work performed downstream of the FEMA overflow structure, approximately 50 linear feet of existing gravel road on northern Second Street (upstream of the overflow structure) would need to be excavated and re-graded to provide a 1.5 feet rolling dip directing water to Mill Creek (Attachment 3 Figures 3-42 and 3-43). Without this modification, stormwater runoff flows down Second Street, causing scour and negatively affecting residential areas and the remedy downhill from this location. The rolling dip could prevent this from occurring, providing an adequate path for conveyance of drainage directly to Mill Creek.

4.2.8.2 Tiger Creek

To adequately address the existing concerns Tiger Creek presents to the remedy, the existing creek alignment would need to be altered and replaced with a system of culverts and asphalt lined ditch along the east side of Eighth Street and the north side of the abandoned railroad (refer to Attachment 3 Figures 3-44 to 3-46). Water could be diverted to the southwest just north of Fir Street through an inclined trash rack inlet structure with a 3 ft long x 4 ft tall headwall and 8 ft long x 4 ft tall wingwalls. From here, Tiger Creek would flow through approximately 205 linear feet of new 24-inch diameter CMP until daylighting to the new asphalt lined ditch (2.5 ft deep with 1:1 side slopes) just south of Fir Street. This ditch runs south to the abandoned railroad, then turns 90 degrees to the east and discharges back to the existing Tiger Creek alignment. Under Hunter Street, a second 24-inch diameter CMP culvert would need to be constructed. This proposed design alternative decreases the likelihood of flooding north of Fir Street and better controls local drainage throughout this region of Mullan.

4.2.8.3 South End of Second Street

To protect the existing remedy along the south end of Second Street in Mullan, a proposed design alternative was developed. As shown in the design drawings (Attachment 3 Figures 3-47 through 3-49), this design recommends the installation of a rock lined ditch (10 ft x 4 ft x 3 ft trapezoidal channel) starting just south of Court Loop to convey drainage from Second Street that currently tends to spread out and pond at this location. The ditch would run south along the west side of Second Street to the Trail of the Coeur d'Alenes, through an 18-inch diameter

CHDPE culvert under the trail, then southwest for approximately 650 linear feet until discharging to Mill Creek. Specifically, stormwater from Second Street would be collected and conveyed to the design ditch through 18-inch diameter CHDPE pipe stemming from a dual inlet catch basin (ITD CB Type 6) with a 4 feet sump, located at the intersection of Second and Court Streets.

4.2.8.4 Copper Street Neighborhood

The proposed design alternative for the Copper Street neighborhood in southeast Mullan aims to provide more adequate drainage infrastructure as a means to protect the remedy and is illustrated in Attachment 3 Figure 3-50. In this scenario, local drainage would be conveyed along asphalt lined ditches and through small subsurface stormwater conveyance systems, ultimately discharging west to Boulder Creek. Specifically, construction of 2.5 feet deep asphalt lined ditches with 1:1 sides slopes along Montana, Oregon, Idaho, and Eight Streets would be necessary to adequately convey drainage west to Copper Street. At this location, stormwater would be discharged to an underground conveyance system. The first system begins at the intersection of Idaho and Copper Streets where one new catch basin and storm drain manhole would be installed (in-place of the existing dry well), diverting water underground to a new 24-inch diameter CHDPE storm pipe running north under the I-90 overpass. A second storm drain manhole would be installed just north of I-90 where the new storm drain pipe turns 90-degrees and runs west, allowing for discharge of stormwater to Boulder Creek. The second subsurface conveyance system includes the construction of 24-inch diameter CHDPE pipe down Copper Street starting at Montana Street and running north. Catch basins and storm drain manholes at both Oregon and Seventh Streets would direct stormwater to the new storm drain pipe, which meets up with a new 6 ft x 6 ft concrete manhole located along Copper Street mid-block between Idaho and Oregon Streets. A new 48-inch diameter CMP culvert additionally ties into this manhole (in-place of existing infrastructure) from the southeast, with the intent of more adequately conveying the unnamed creek from a point just north of Oregon Street. Water would exit this design manhole to the west through 48-inch diameter CMP and will discharge to Boulder Creek. In addition to the infrastructure described above, 13 new 18-inch diameter culverts would be installed where driveways and road crossings currently intersect the asphalt ditches.

4.2.8.5 Dewey Street Neighborhood

The proposed design alternative for the Dewey Street Neighborhood in northwest Mullan involves the installation of asphalt lined ditches (2.5 ft deep with 1:1 side slopes) and a small stormwater conveyance system, ultimately diverting drainage to either Mill Creek or the curb and gutter portion of Mill Street (see Attachment 3 Figure 3-51). The intent of this infrastructure is to better convey drainage through this area, preventing the occurrence of scour, which poses a threat to the remedy. Specifically, construction of approximately 380 linear feet of asphalt lined ditch along portions of Dewey and Lower Dewey Streets would allow for adequate conveyance of drainage to Hunter Street. From here, stormwater would enter two new catch basins with 4 feet sumps and run underground to the east through new 18-inch diameter CHDPE pipe (installed in place of the existing infrastructure). This pipe would be connected to four other newly installed catch basins along Hunter Street collecting local drainage, ultimately discharging stormwater to Mill Creek just east of First Street. New 18-inch diameter CMP culverts would be placed where existing roads and driveway crossings are currently located. South of Hunter

Street, approximately 365 linear feet of additional asphalt lined ditch would be installed along portions of Dewey and Davis Street, daylighting to the curb and gutter portion Mill Street.

4.2.8.6 Mill Street

A proposed design alternative was developed to address the inadequate drainage infrastructure currently in-place along Mill Street in Mullan and provide protection to the remedy. As shown in Attachment 3 Figures 3-52 to 3-54, this alternative involves the construction of 2.5 feet deep asphalt lined ditches with 1:1 side slopes along both sides of Mill Street, starting at Daisy Loop and running south along the portion of road currently lacking curb and gutter. Just southwest of the intersection of Cottage Grove and Mill Street, the drainage would be conveyed from these ditches to a rock lined ditch (10 ft x 2 ft x 3 ft trapezoidal channel) running west until discharging to the SFCDR. Installation of two new dual inlet catch basins (ITD CB Type 6) with 4 feet sumps along Bingville and Mill Street would be necessary to collect drainage from the upper part of Mill Street and the hillside drainages to the northwest of Mullan. Drainage would be collected in these catch basins and conveyed underground to the asphalt ditches through approximately 140 linear feet of 15-inch diameter CHDPE culvert. Additionally, seven 18-inch diameter CHDPE culverts and one 30-inch diameter CHDPE culvert would be installed at existing road, trail, and/or driveway crossings present in this vicinity. This proposed design alternative would help prevent nuisance flooding and mitigate the occurrence of scour.

4.2.8.7 Third Street Neighborhood

The proposed design alternative for the Third Street Neighborhood in southwest Mullan aims to provide more adequate drainage infrastructure as a means to protect the remedy. Specifically, 2.5 feet deep asphalt lined ditches with 1:1 side slopes should be constructed along the east-west streets, conveying drainage west, with updates being made to the existing drainage infrastructure in place along Third Street (refer to Attachment 3 Figure 3-55). This includes installation of four new 24-inch diameter CHDPE pipe culverts along Third Street in place of existing culverts in poor condition, and reconstruction of existing drainage ditches to match those being added along the east-west streets. Additionally, installation of two new catch basins and one storm drain manhole at the intersection of Oregon and Third Streets would be recommended in place of the existing infrastructure. Sumped inlets would be recommended to catch debris and prevent clogging of the catch basins.

4.3 Side Gulches

Characterization of the remediated properties, creeks and stormwater systems presented in Section 3.4 indicates that there are 18 side gulches with potential remedy protection issues. Table 9 shows general characteristics of the side gulches that can be used to identify commonalities in the physical characteristics of these areas.

Table 9. Side Gulch General Characteristics Summary

Watershed Name	Watershed Area (MI)	Length to Width Ratio	Approximate Number of Crossings	Stream Length (LF)	Length of Stream Fronting Remediated Areas (LF)	Peak Flow 25-yr (cfs)
Big Creek	29.9	2.9	5	10560	2000	1530
Bunker Creek(1)	2.8	2.5	2.0	24000	0	145
Canyon Creek	22.1	4.2	10	36500	7150	903
Elk Creek	2.4	2.2	5	6500	5000	113
French Gulch	4.7	3.1	4	6000	1250	291
Government Gulch	2.9	4.9	4	8000	8000	177
Humboldt Gulch	0.7	3.3	2	3750	2100	35.8
Hunt Gulch	1.7	3.4	7	5000	850	102
Montgomery Creek	7.1	3.1	4	14000	3300	359
Moon Creek	9.1	2.1	6	10560	10000	477
Ninemile Creek	11.5	4.5	6	19000	1400	526
Nuckols Gulch	2.0	2.6	6	8150	1400	141
Shirttail Gulch(2)	0.4	4.3	2	1200	0	40.4
Silver Creek	0.9	4.5	1	3000	3000	21.9
Slaughterhouse Gulch	0.7	2.8	1	1400	500	37.7
Terror Gulch	3.0	3.1	2	4500	2000	182
Twomile Creek	5.1	2.0	4	5600	225	328
Willow Creek	3.3	3.1	2	1500	900	183
AVERAGES:	6.3	3.3	4.1	9401	2726	311

1. Bunker creek has multiple culverts at each crossing to Slag Pile Area. Does not include I-90 Culvert. Does not account for remediation along rails-to-trails. Includes Deadwood Gulch, Magnet Gulch and Railroad Gulch.
2. Remedial actions are anticipated to occur in Shirttail Gulch but were not complete prior to the side gulch characterization.

Based on cursory field visits, GIS analysis, and the physical traits presented in Table 9, it appears that many of these gulches present similar general traits and physical characteristics. An average typical side gulch contains approximately 4 crossings (locations where streams intersect roadways) and contains a creek that flows along roughly 3000 feet of remediated property. The side gulches contain remediated properties and streams that flow adjacent to remediated areas, contain culverts and bridge crossings of the channels, and experience stormwater run-on from adjacent areas. The characteristics of the side gulches are similar to the open channel systems for Little Pine, Grouse, Revenue, Shields, Rosebud, Mill, McFarren, and to a lesser extent Jackass and the Unnamed Creek in western Silverton. Risks to the remedy were identified for these open channel systems within the primary communities and it is reasonable to assume that similar risks will be identified for the side gulches. Further, the types of remedy protection projects that have been developed for the primary communities can reasonably be expected to address risks to the human health barriers in side gulches

The process for characterizing the risks to human health barriers and developing remedy protection projects for the side gulches could be accomplished using the methodology employed for the primary communities that is described in this appendix.

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Attachment G-1
Community Impact Maps

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Bunker / ROD_2009/ 1_1_pinehurst_flood	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 1-1
PRINT DATE: January 5, 2010	PROJECT MANAGER: D. Forseth		**Pinehurst Flood Areas**
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

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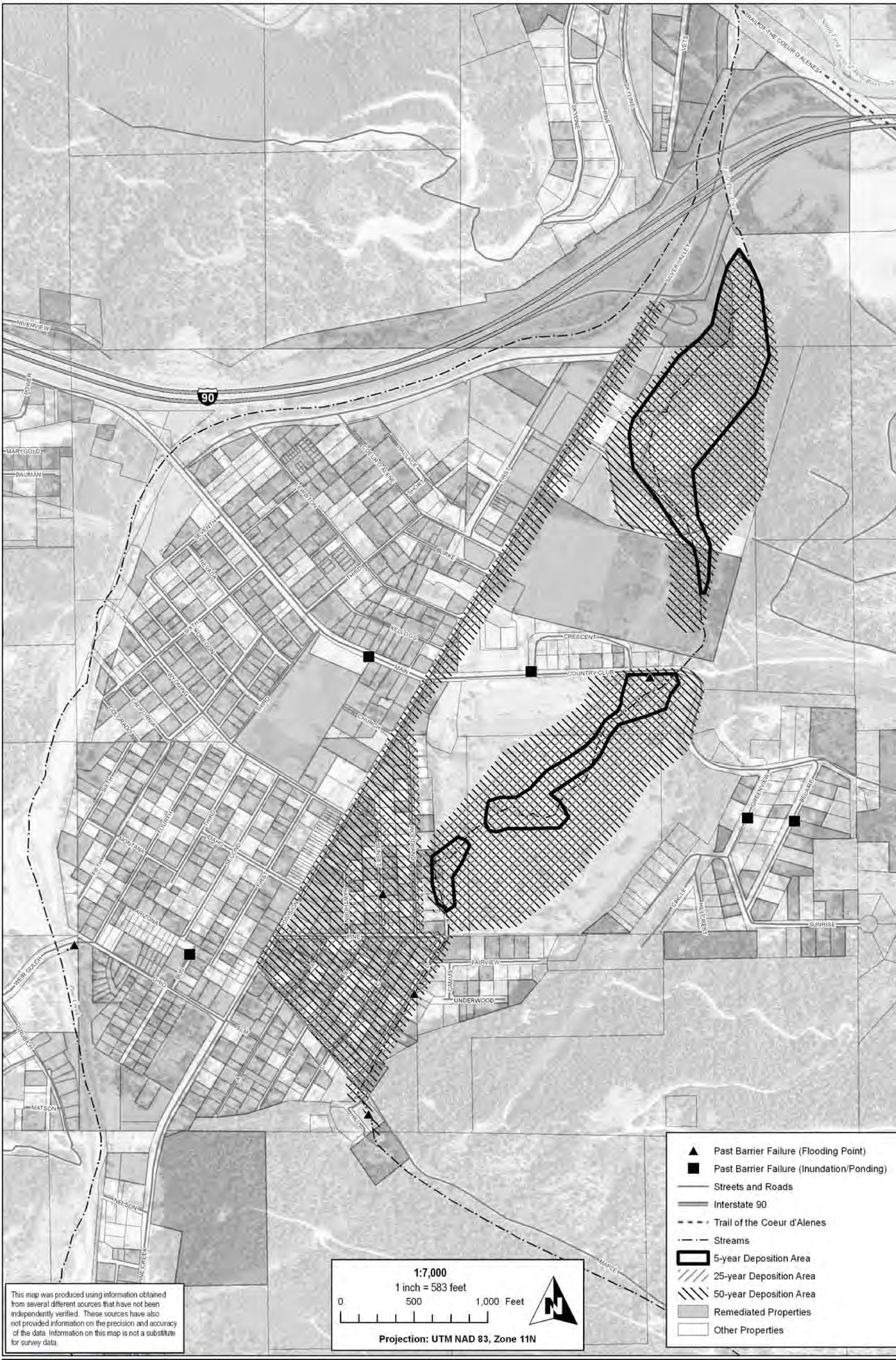
FILE: Bunker / ROD_2009/1_2_pine_slope	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin
PRINT DATE: January 5, 2010	PROJECT MANAGER: D. Forseth	
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey	

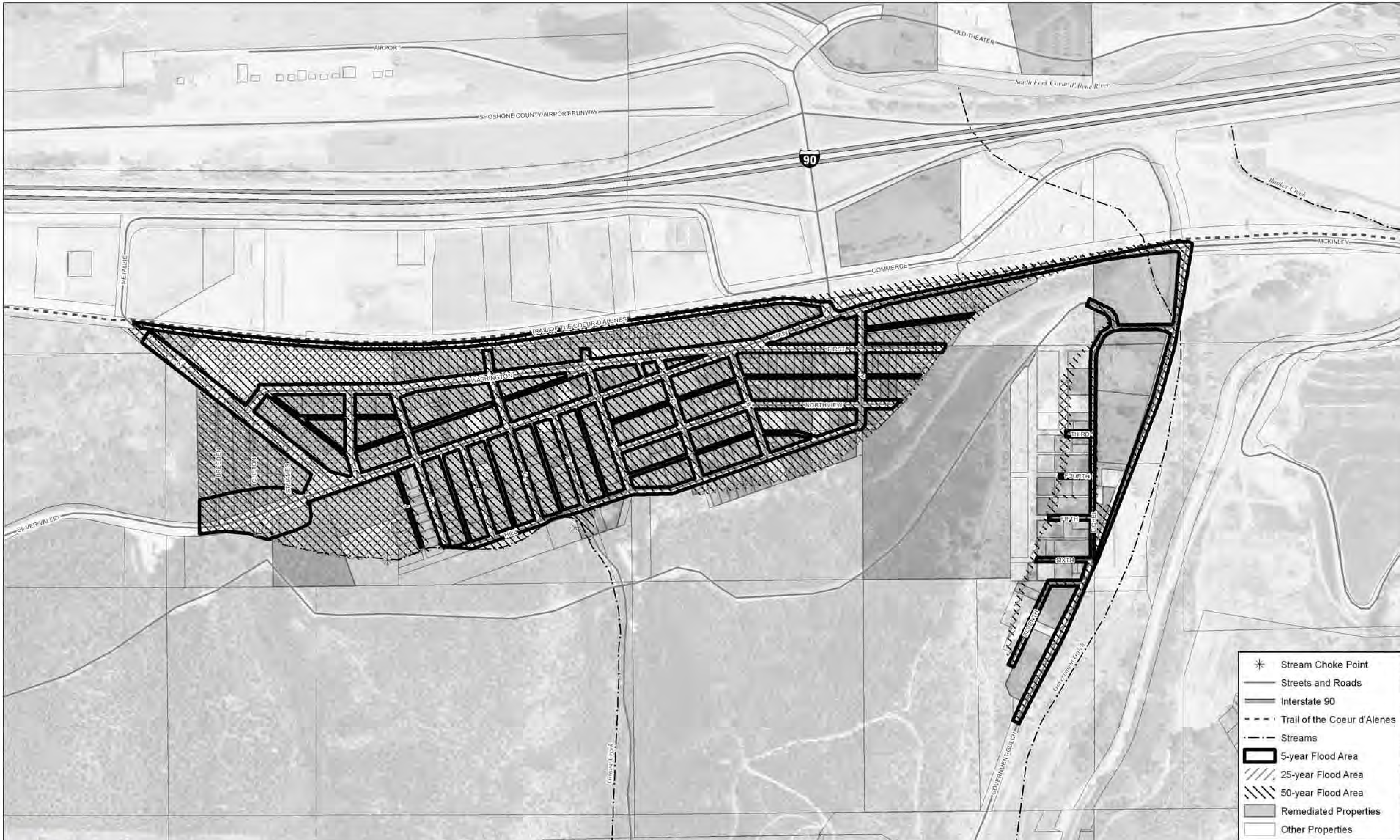
Figure 1-2
Pinehurst Slope Analysis

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE: Bunker / ROD_2009/ 1_3_pinehurst_scour	REQUESTOR: D. Forseth	PROJECT NAME: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**Figure 1-3**
	PRINT DATE: January 5, 2010	PROJECT MANAGER: D. Forseth		**Pinehurst Scour Areas**
	PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		



This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_4_pinehurst_depo PRINT DATE January 5, 2009 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 1-4 **Pinehurst Deposition Areas**



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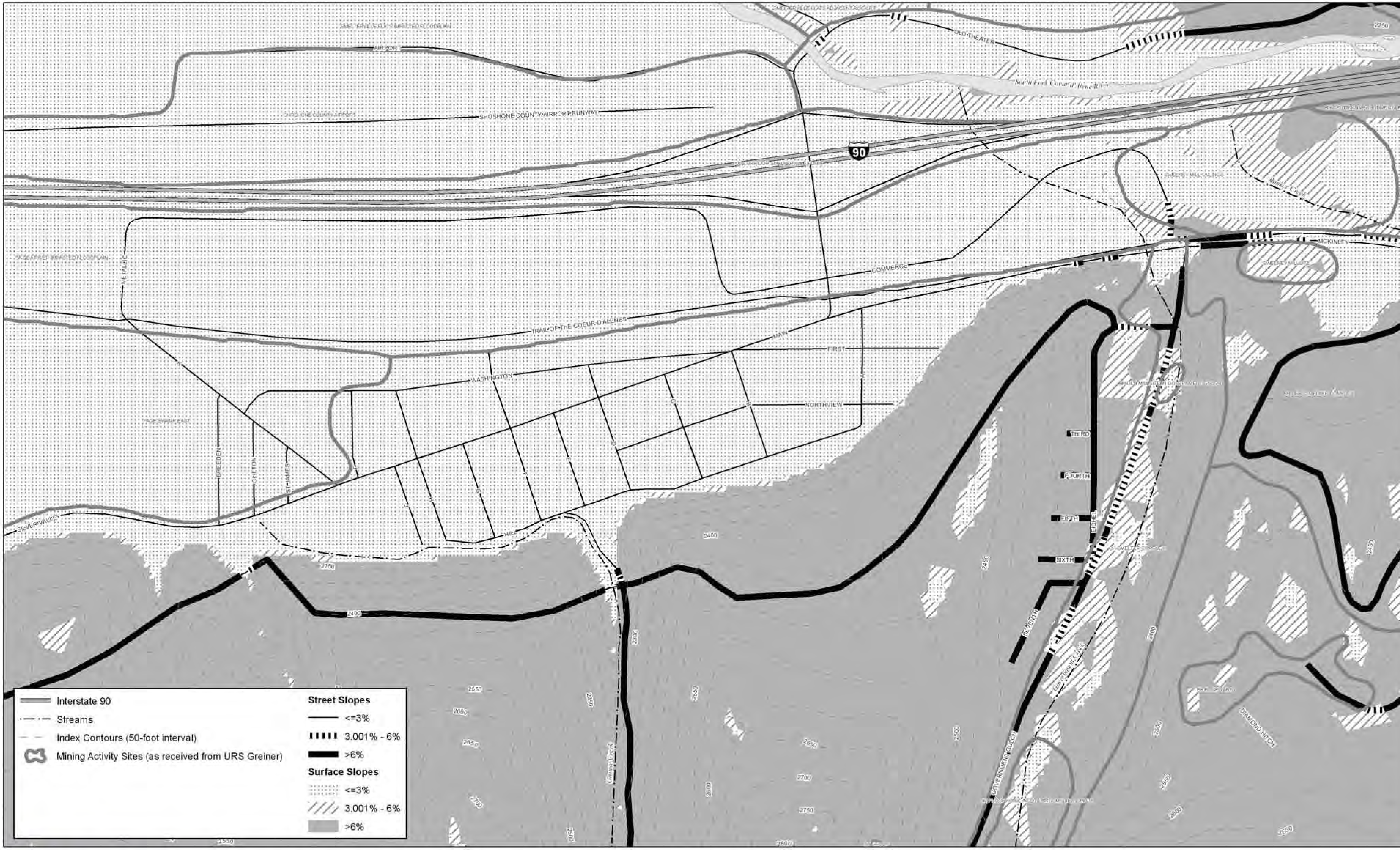
FILE: Bunker / ROD_2009/1_5_smelt_flood	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:6,000 1 inch = 500 feet 0 200 400 600 Feet Projection: UTM NAD 83, Zone 11N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-5
PRINT DATE: January 5, 2010	PROJECT MANAGER: D. Forseth				**Smelterville Flood Areas**
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey				

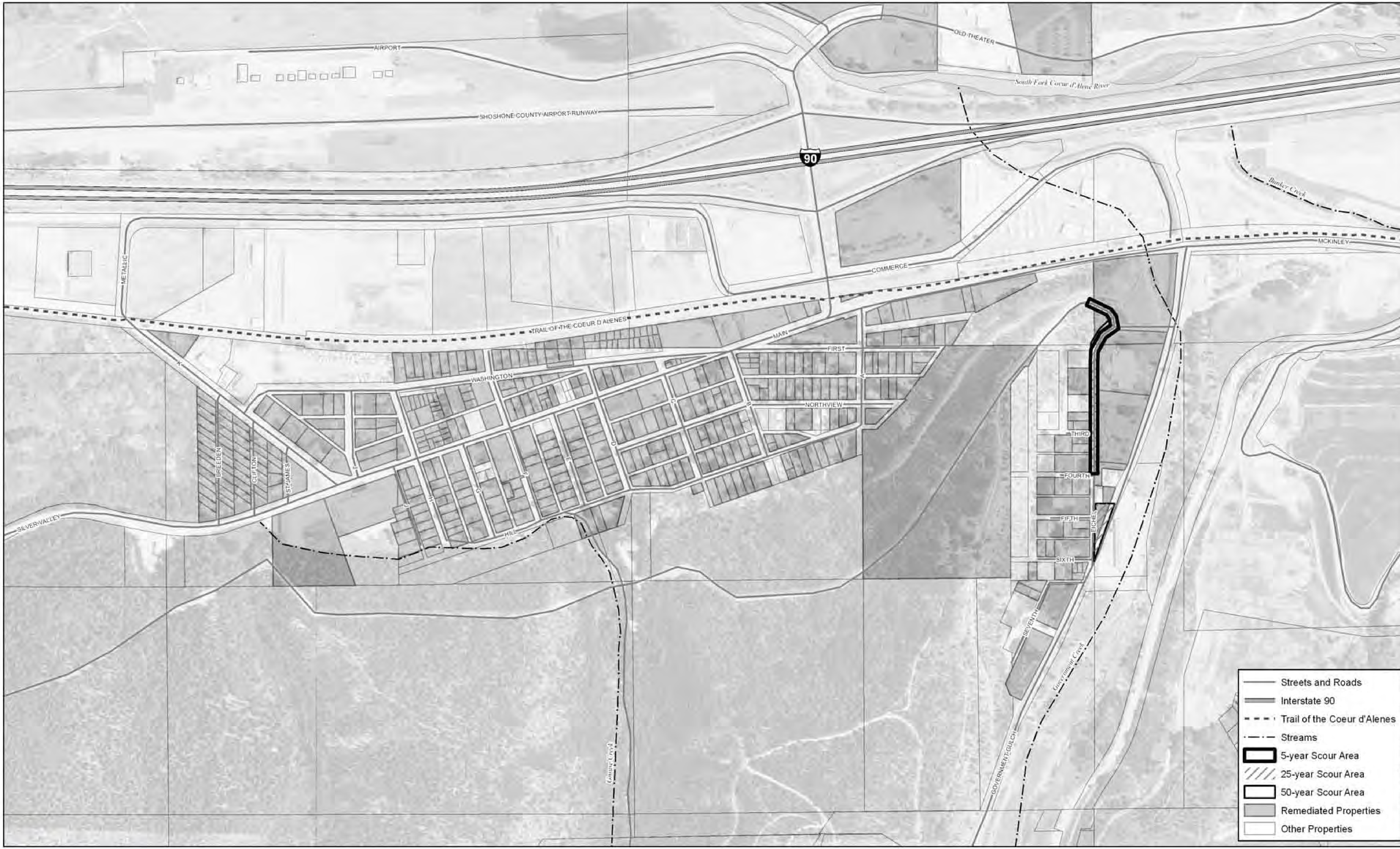


File: Bunker / ROD_2009/ G1_6_smelt_slope	Requestor: D. Forseth	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:6,000; 1 inch = 500 feet; 0 200 400 600 Feet; Projection: UTM NAD 83, Zone 11N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.
Print Date: January 22, 2010	Project Manager: D. Forseth			
Project Number: 2010-5050	Cartographer: B. Bailey			

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

Figure 1-6

Smelterville Slope Analysis

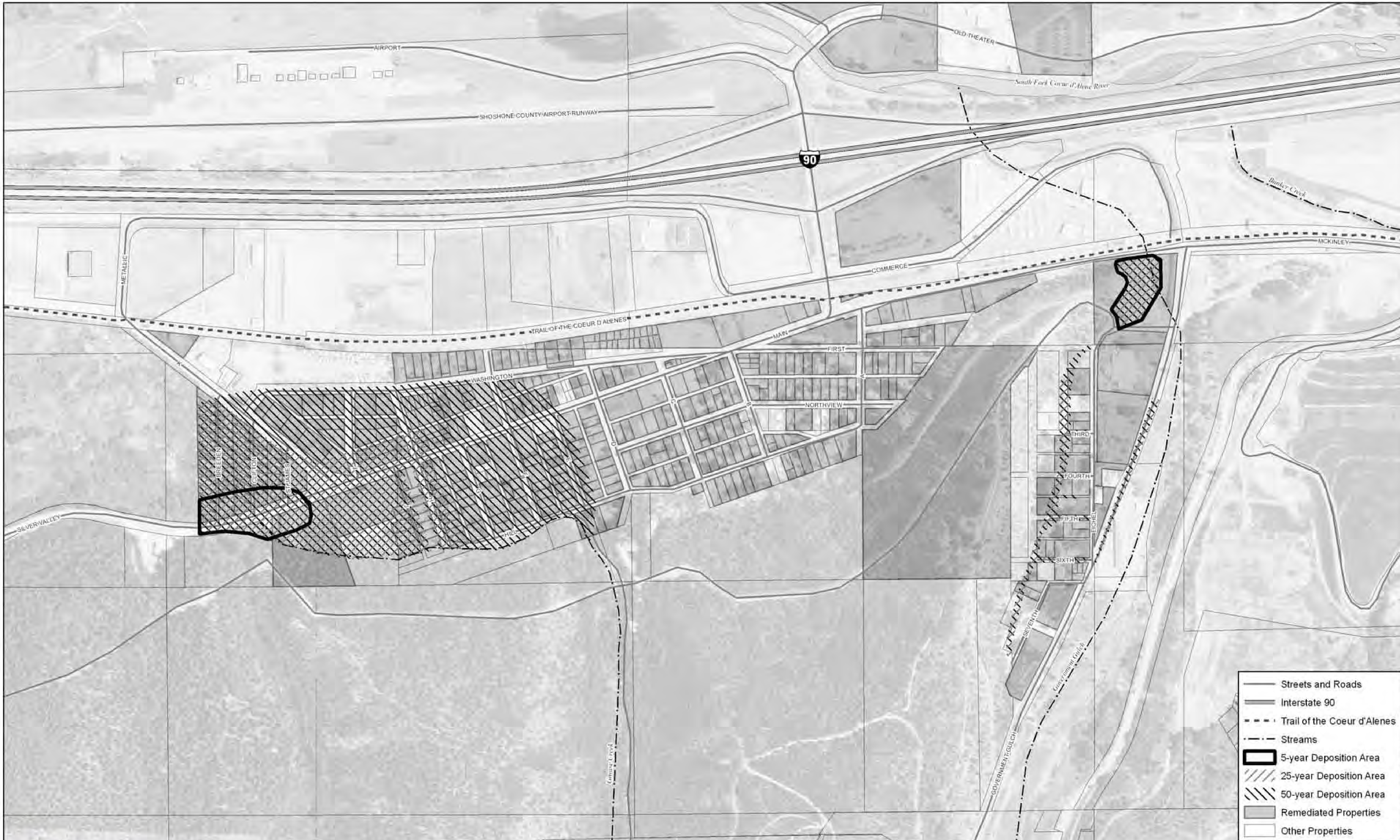


TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

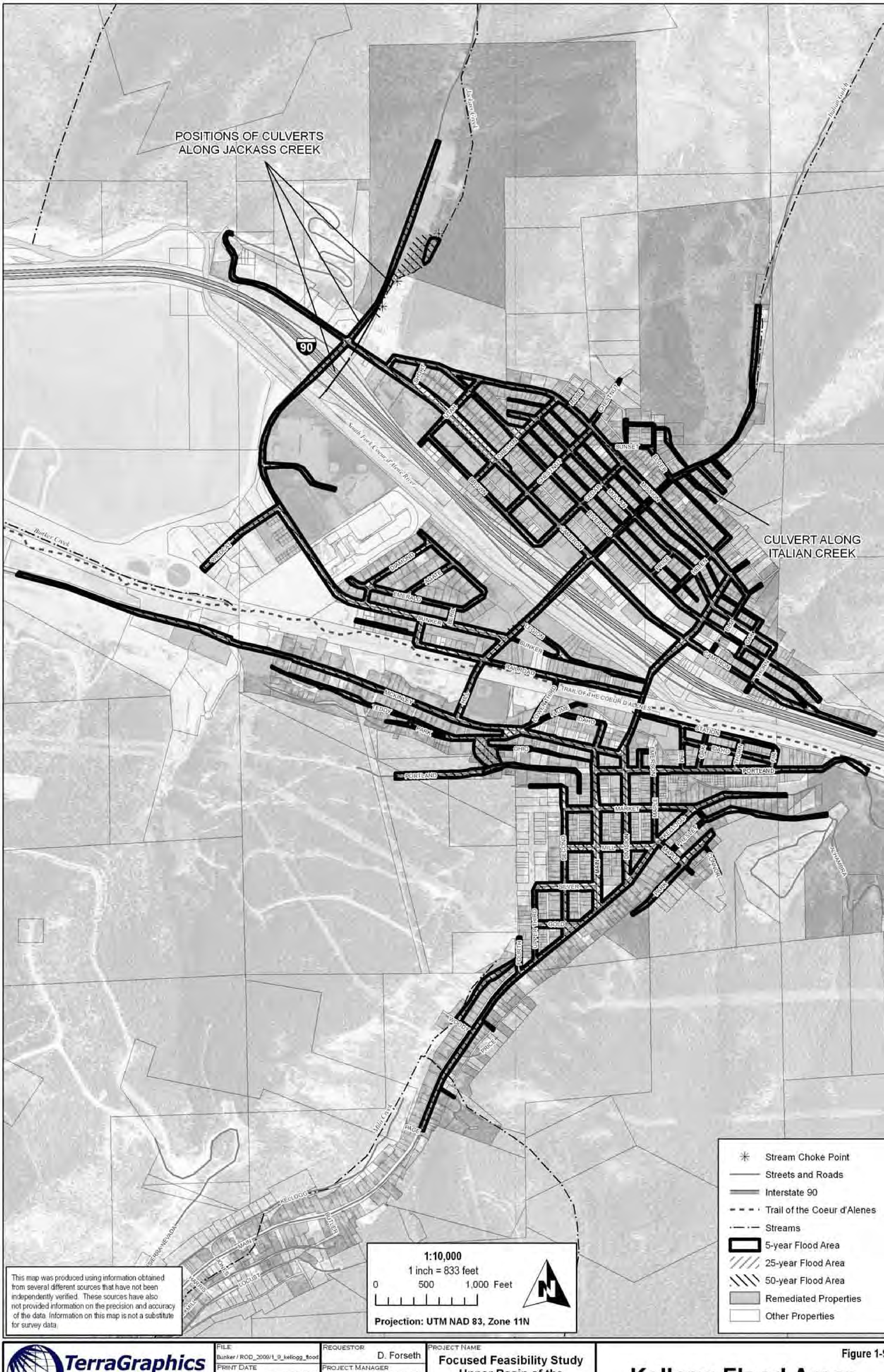
FILE Bunker / ROD_2009/1_7_smelt_scour	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:6,000 1 inch = 500 feet
PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		0 500 1,000 Feet
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

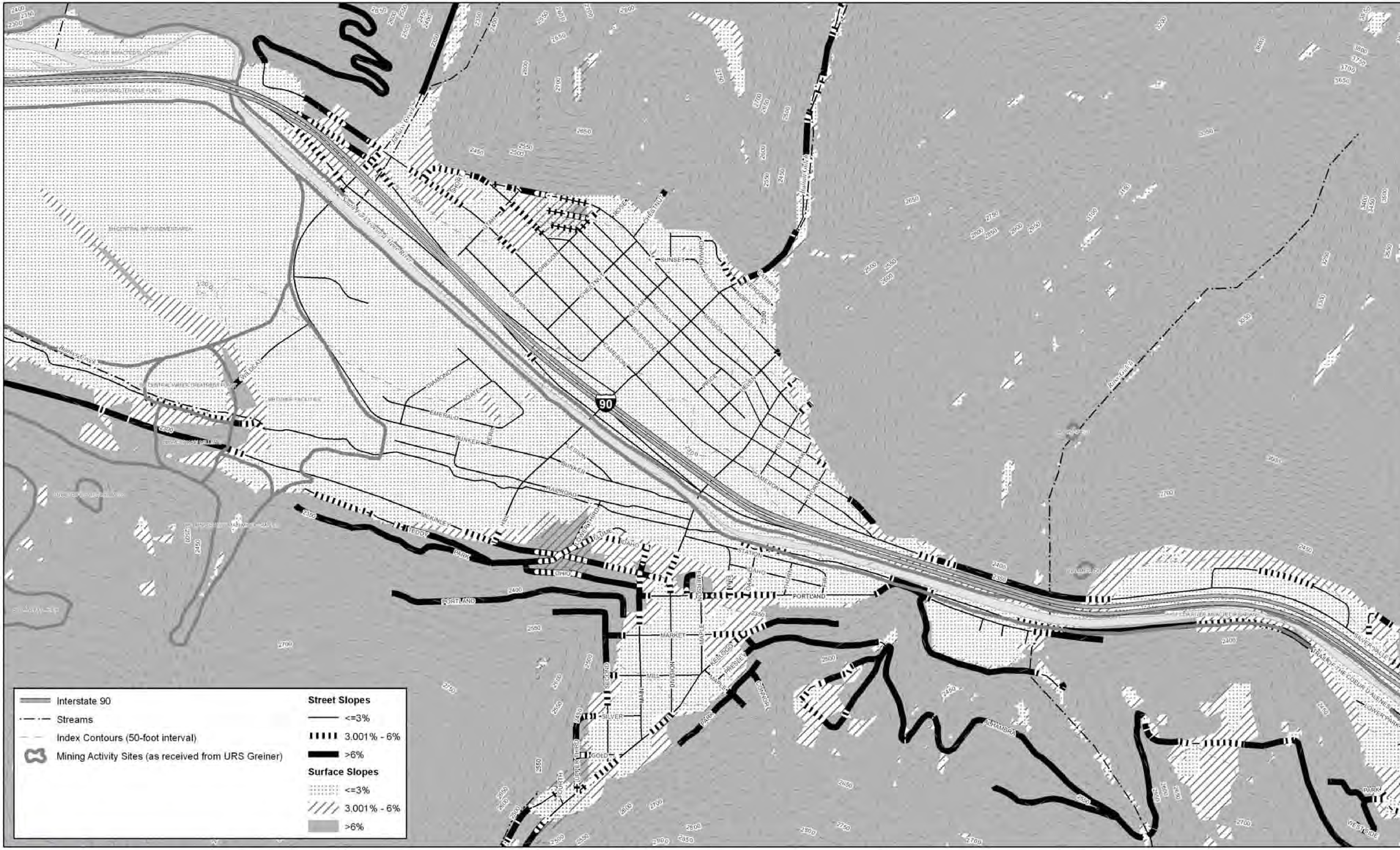
Figure 1-7
Smelterville Scour Areas



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/1_8_smelt_depo PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:6,000 1 inch = 500 feet 0 500 1,000 Feet Projection: UTM NAD 83, Zone 11N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-8 **Smelterville Deposition Areas**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/1_9_kellogg_flood	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 1-9
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Kellogg Flood Areas**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ G1_10_kell_slope	
PRINT DATE	January 22, 2010	
PROJECT NUMBER	2010-5050	
REQUESTOR	D. Forseth	
PROJECT MANAGER	D. Forseth	
CARTOGRAPHER	B. Bailey	

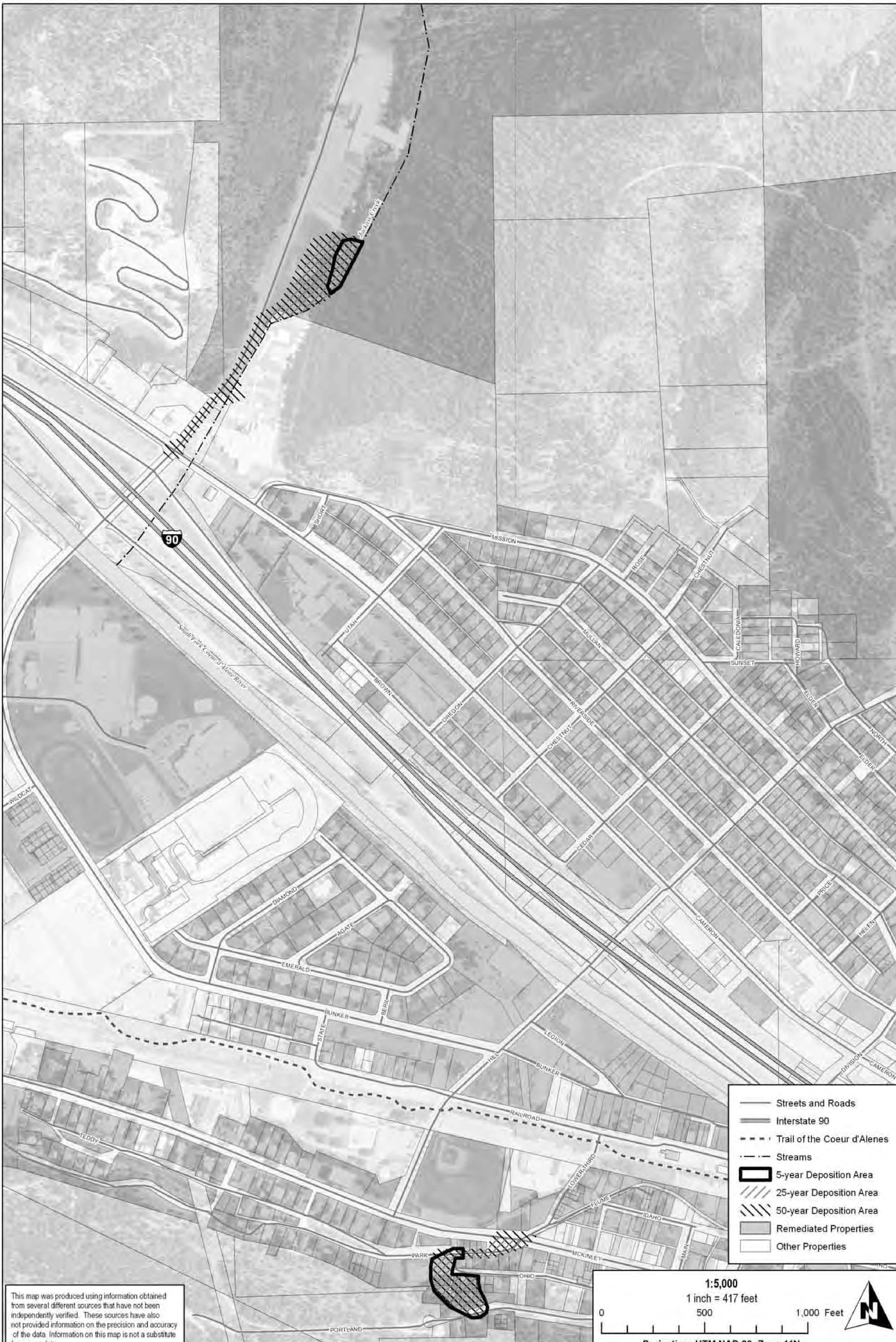
PROJECT NAME
Focused Feasibility Study
Upper Basin of the
Coeur d'Alene River

1:10,000
1 inch = 833 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-10
Kellogg Slope Analysis

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/ 1_11_kellogg_scour Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 1-11 **Kellogg Scour Areas**



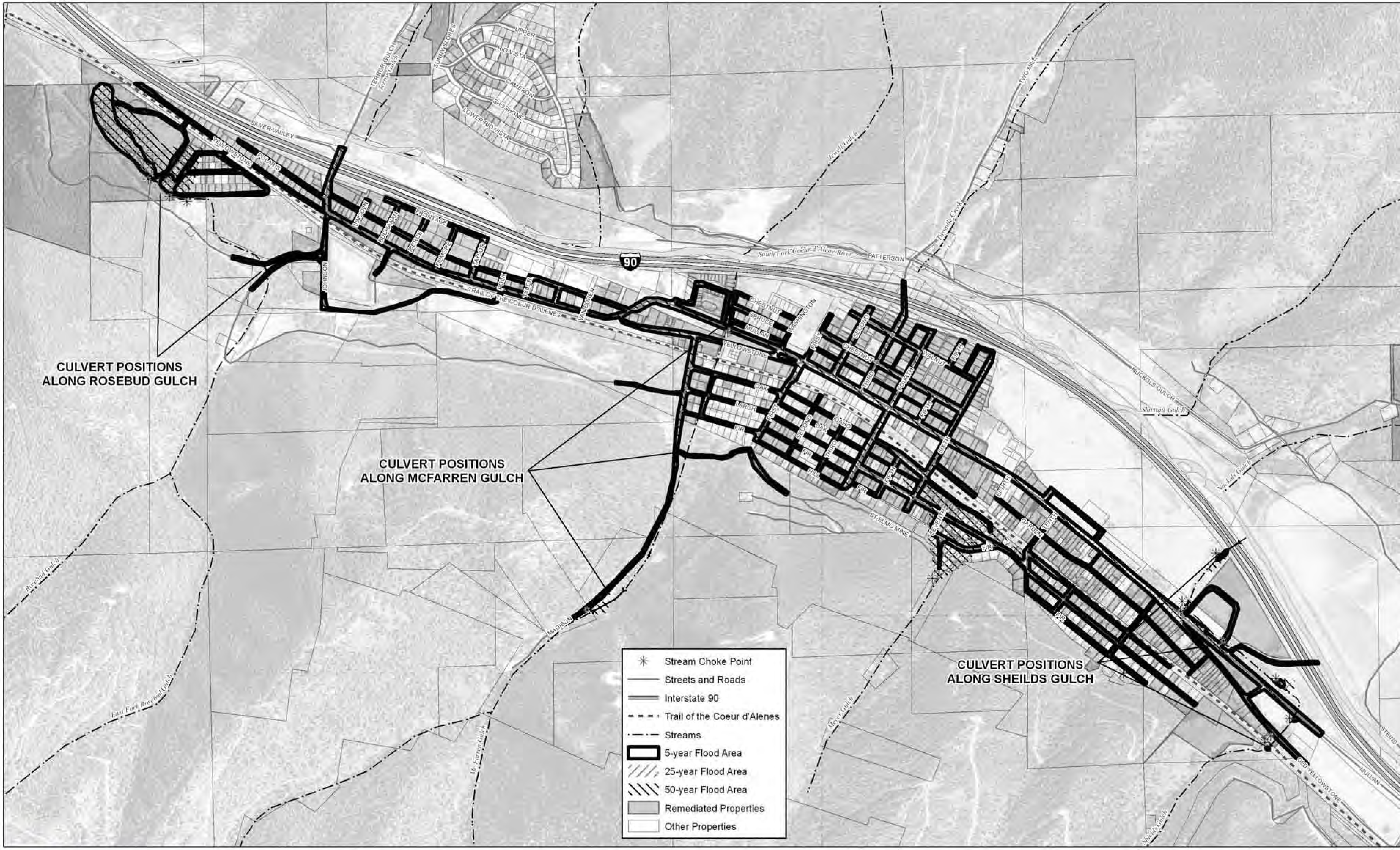
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_12_kellogg_depo	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 1-12
	PRINT DATE December 9, 2009	PROJECT MANAGER D. Forseth		**Kellogg Deposition Areas**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/1_13_ward_flood PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**1:7,000** 1 inch = 583 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-13 **Wardner Flood Areas**

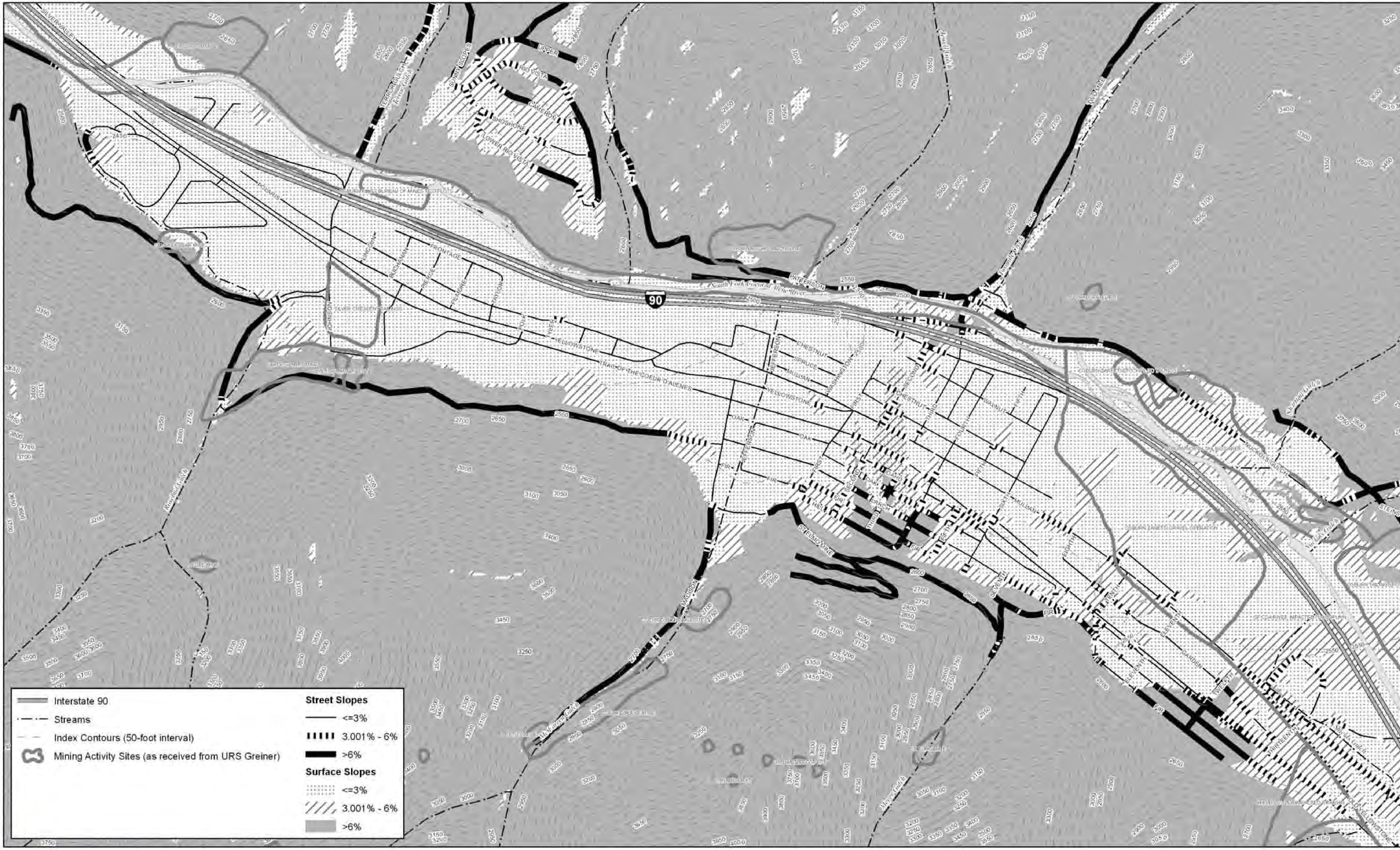
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ G1_14_ward_slope PRINT DATE January 22, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**1:5,000** 1 inch = 417 feet 0 200 400 600 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Figure 1-14** **Wardner Slope Analysis**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/f_15_ward_scour PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:7,000 1 inch = 583 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Figure 1-15** **Wardner Scour Areas**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/1_16_ward_depo PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:7,000 1 inch = 583 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Figure 1-16** **Wardner Deposition Areas**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/ 1_17_osburn_flood Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:12,000 1 inch = 1,000 feet 0 500 1,000 Feet Projection: UTM NAD 83, Zone 11N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-17 **Osburn Flood Areas**



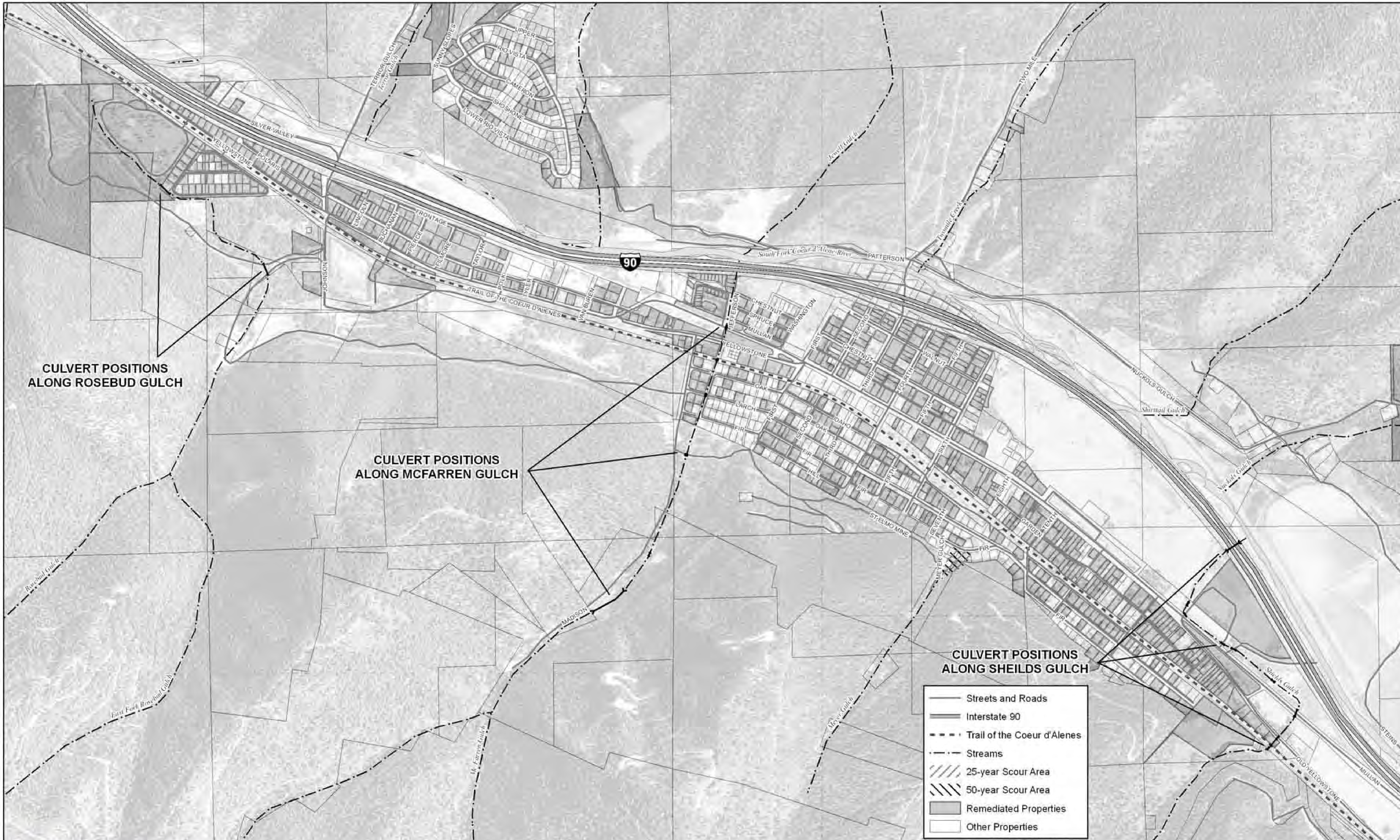
TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Bunker / ROD_2009/ G1_18_osburn_slope	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:11,000 — 1 inch = 917 feet — 0 500 1,000 Feet — Projection: UTM NAD 83, Zone 11N
PRINT DATE: January 22, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-18

Osburn Slope Analysis

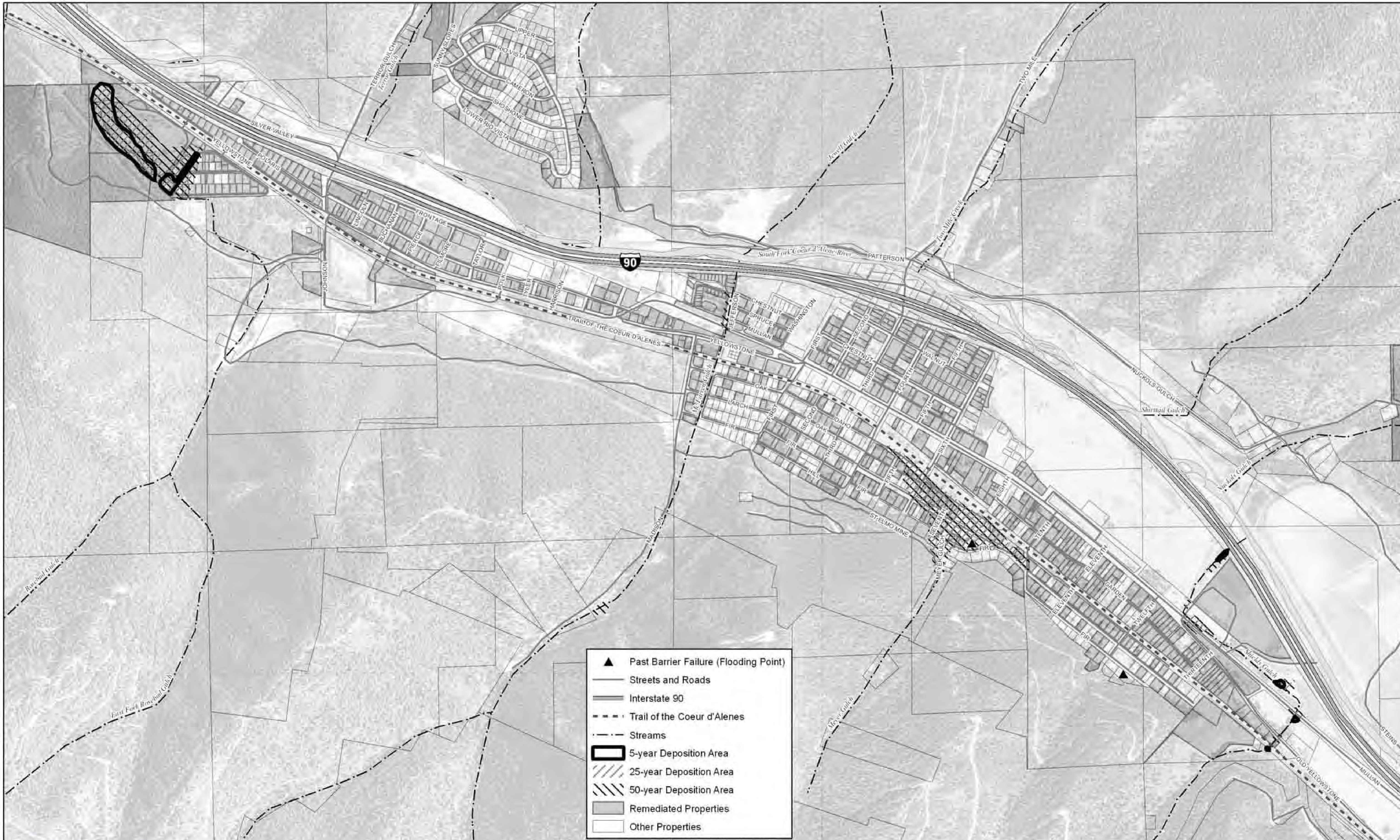


TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_19_osburn_scour PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**1:12,000** 1 inch = 1,000 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-19

Osburn Scour Areas



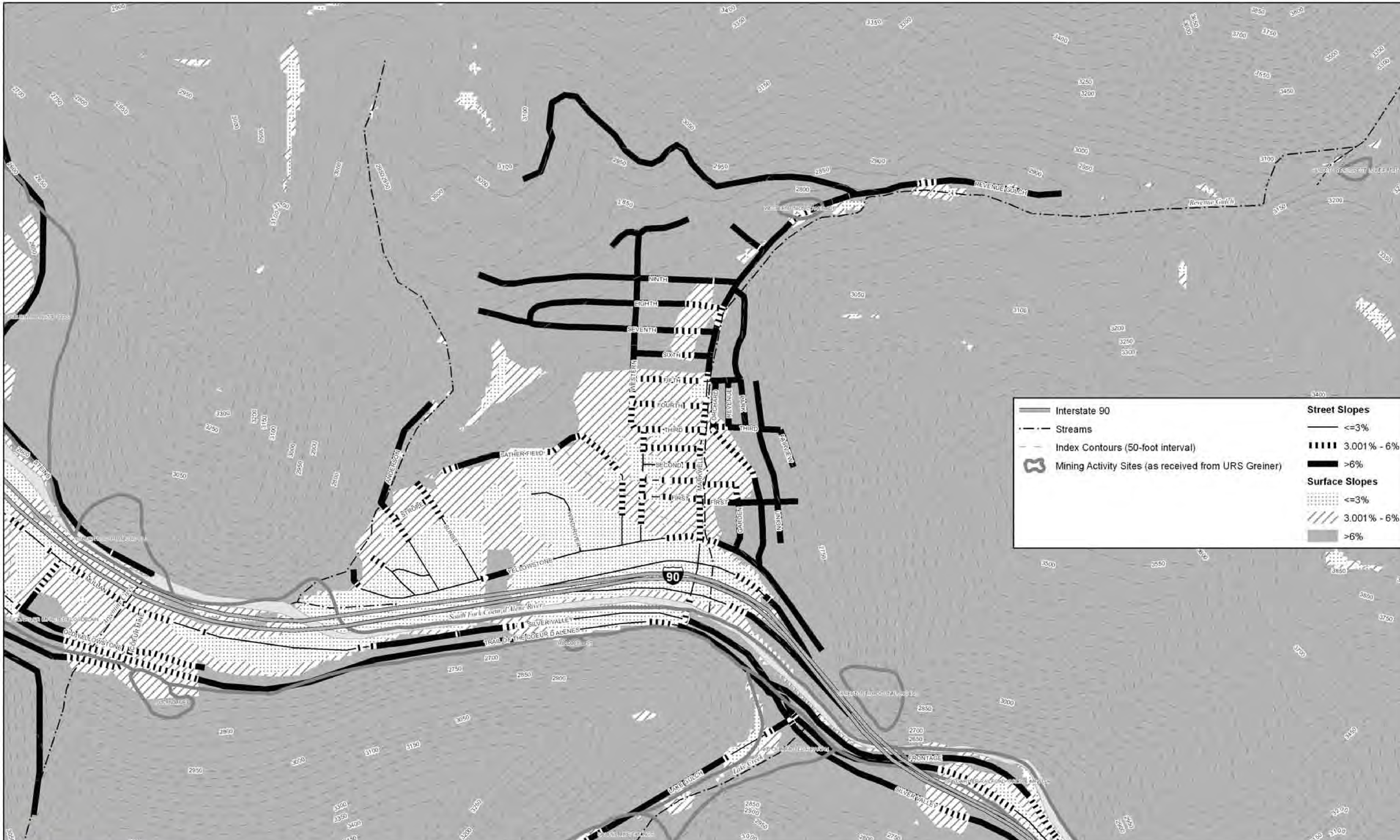
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_20_osburn_depo	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:12,000 1 inch = 1,000 feet 0 500 1,000 Feet Projection: UTM NAD 83, Zone 11N
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-20

Osburn Deposition Areas

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_21_silverton_flood; PRINT DATE January 6, 2010; PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth; PROJECT MANAGER D. Forseth; CARTOGRAPHER B. Bailey	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:6,000 1 inch = 500 feet 0 200 400 600 Feet Projection: UTM NAD 83, Zone 11N	N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-21 Silverton Flood Areas



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ G1_22_silverton_slope PRINT DATE January 22, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:8,000 1 inch = 667 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-22 **Silverton Slope Analysis**

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Bunker / ROD_2009/ 1_23_silverton_scour	REQUESTOR: D. Forseth	PROJECT NAME:	
PRINT DATE: January 6, 2010	PROJECT MANAGER: D. Forseth	**Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

1:6,000
1 inch = 500 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

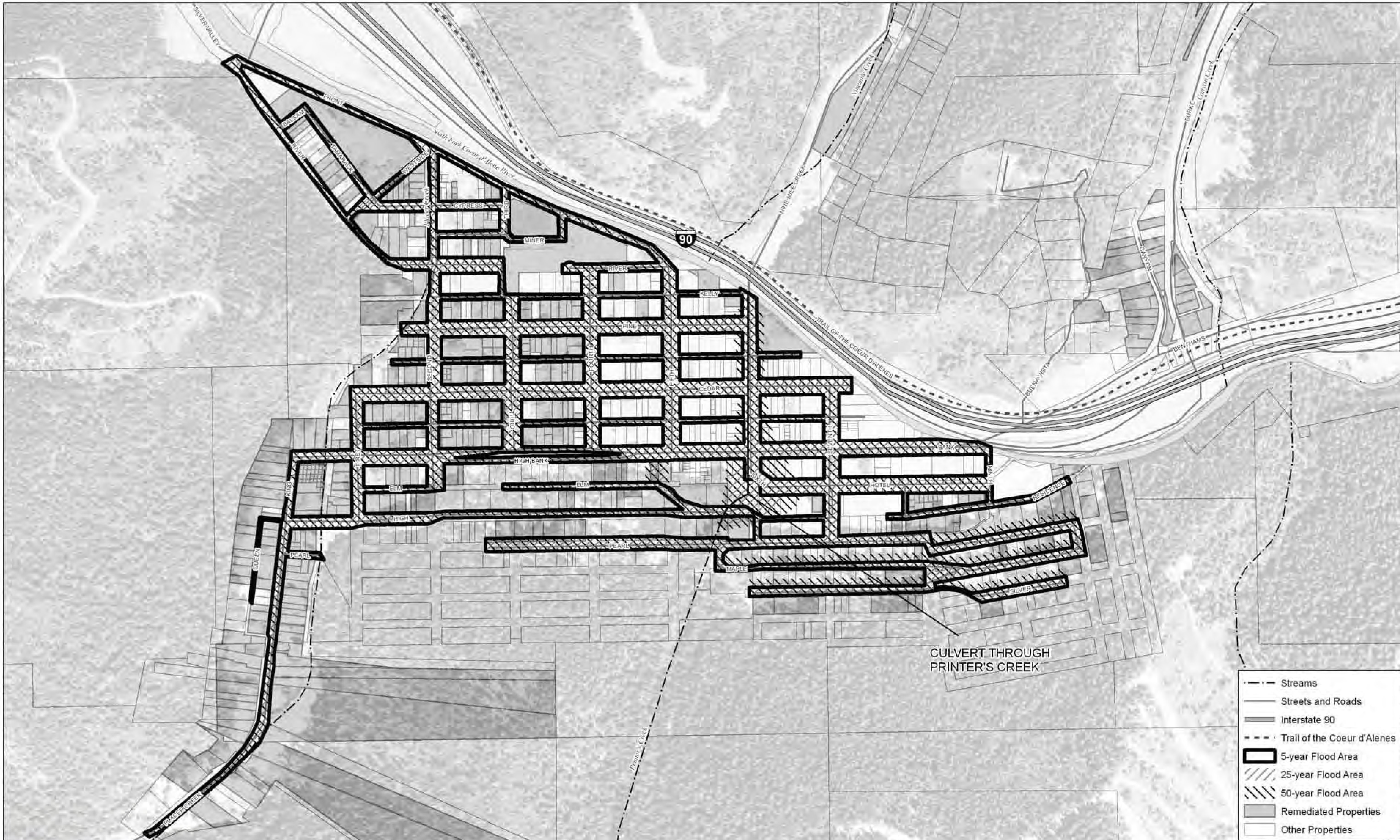
N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-23

Silverton Scour Areas

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_24_silverton_depo PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:6,000 1 inch = 500 feet 0 200 400 600 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-24 **Silverton Deposition Areas**



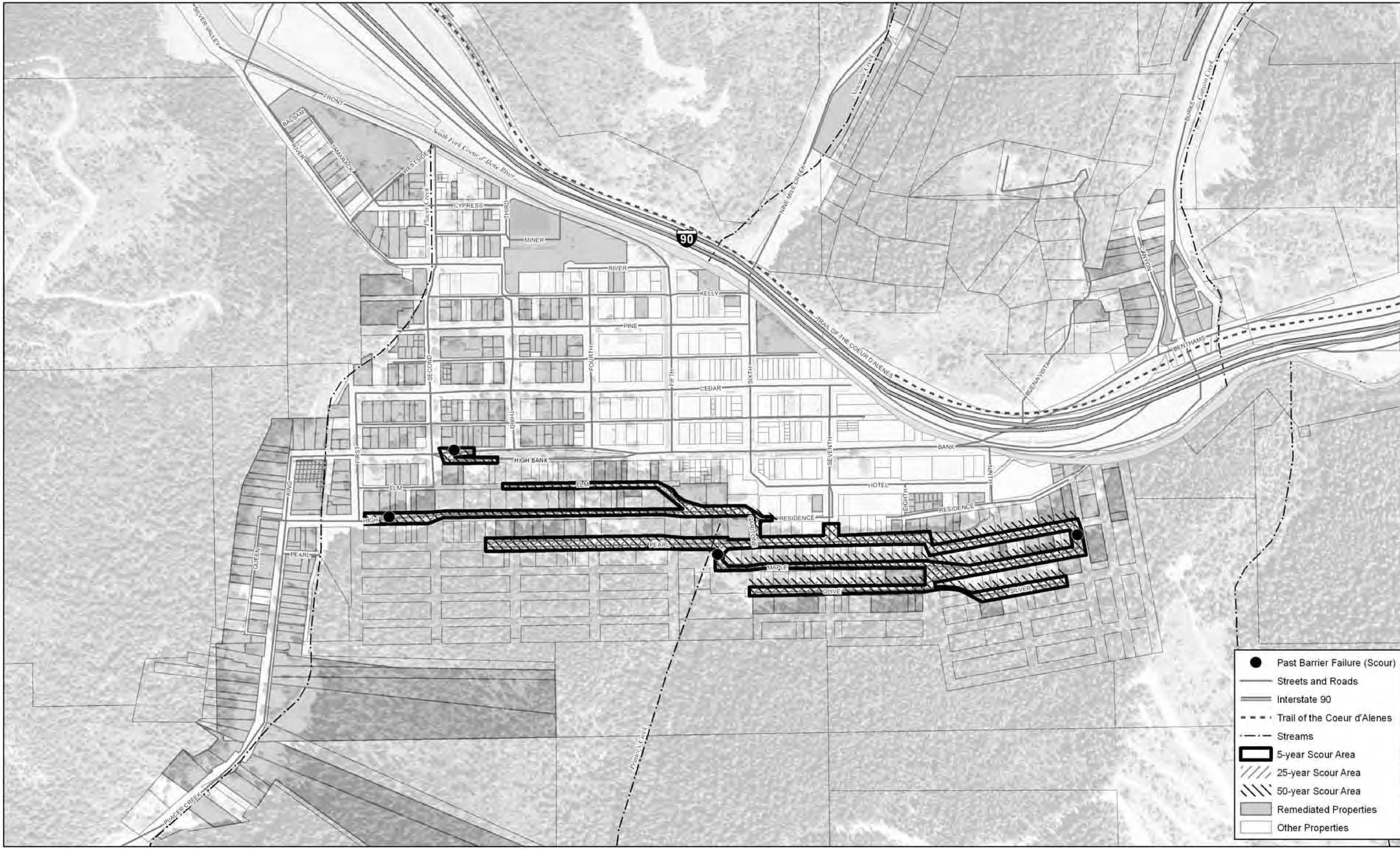
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_25_wallace_flood PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:5,000 1 inch = 417 feet 0 200 400 600 Feet Projection: UTM NAD 83, Zone 11N	N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-25 **Wallace Flood Areas**

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Bunker / ROD_2009/ G1_26_wallace_slope	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	1:6,500 1 inch = 542 feet; 0 500 1,000 Feet; Projection: UTM NAD 83, Zone 11N
PRINT DATE: January 22, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-26
Wallace Slope Analysis



TerraGraphics
Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ 1_27_wallace_scour	REQUESTOR	D. Forseth
PRINT DATE	January 6, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

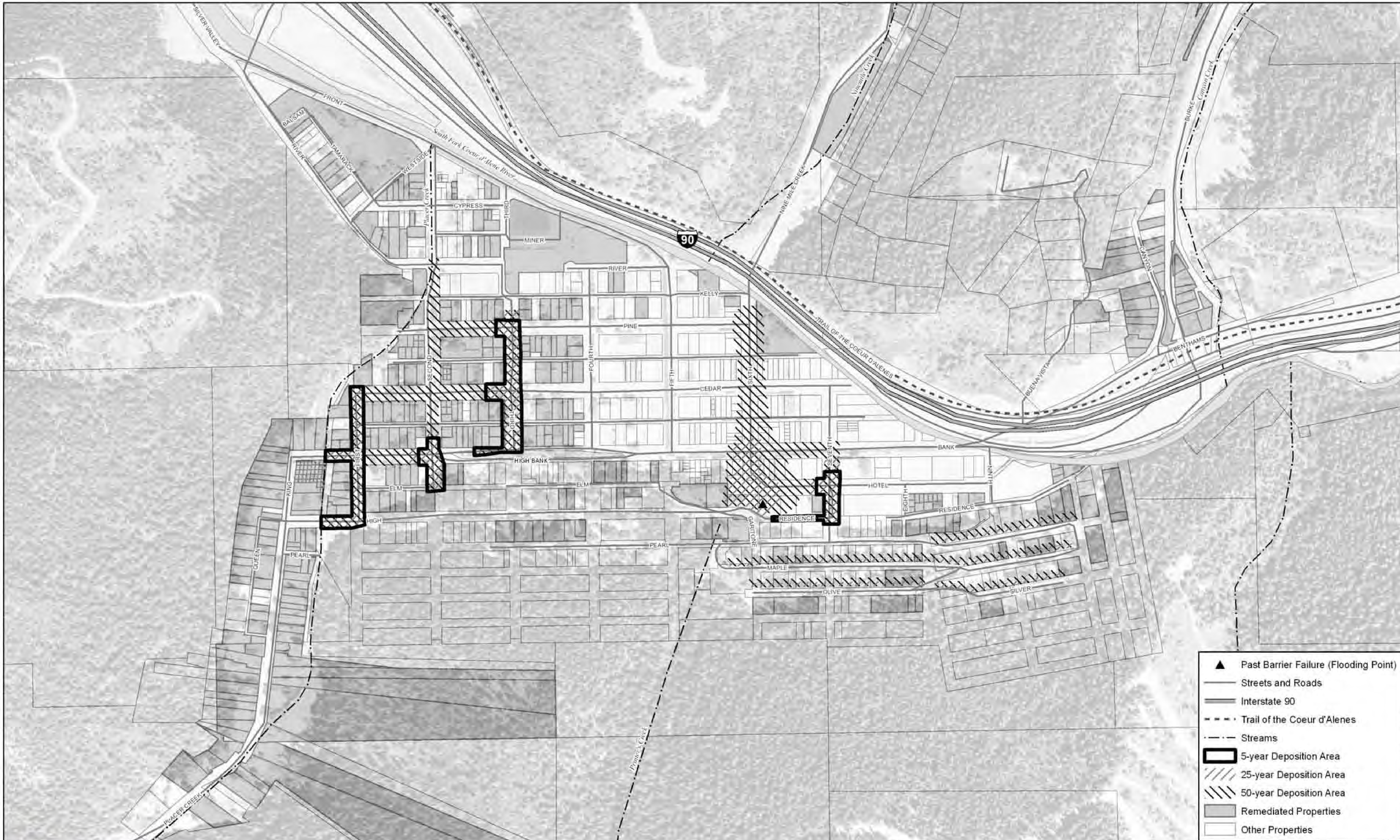
1:5,000
1 inch = 417 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

N

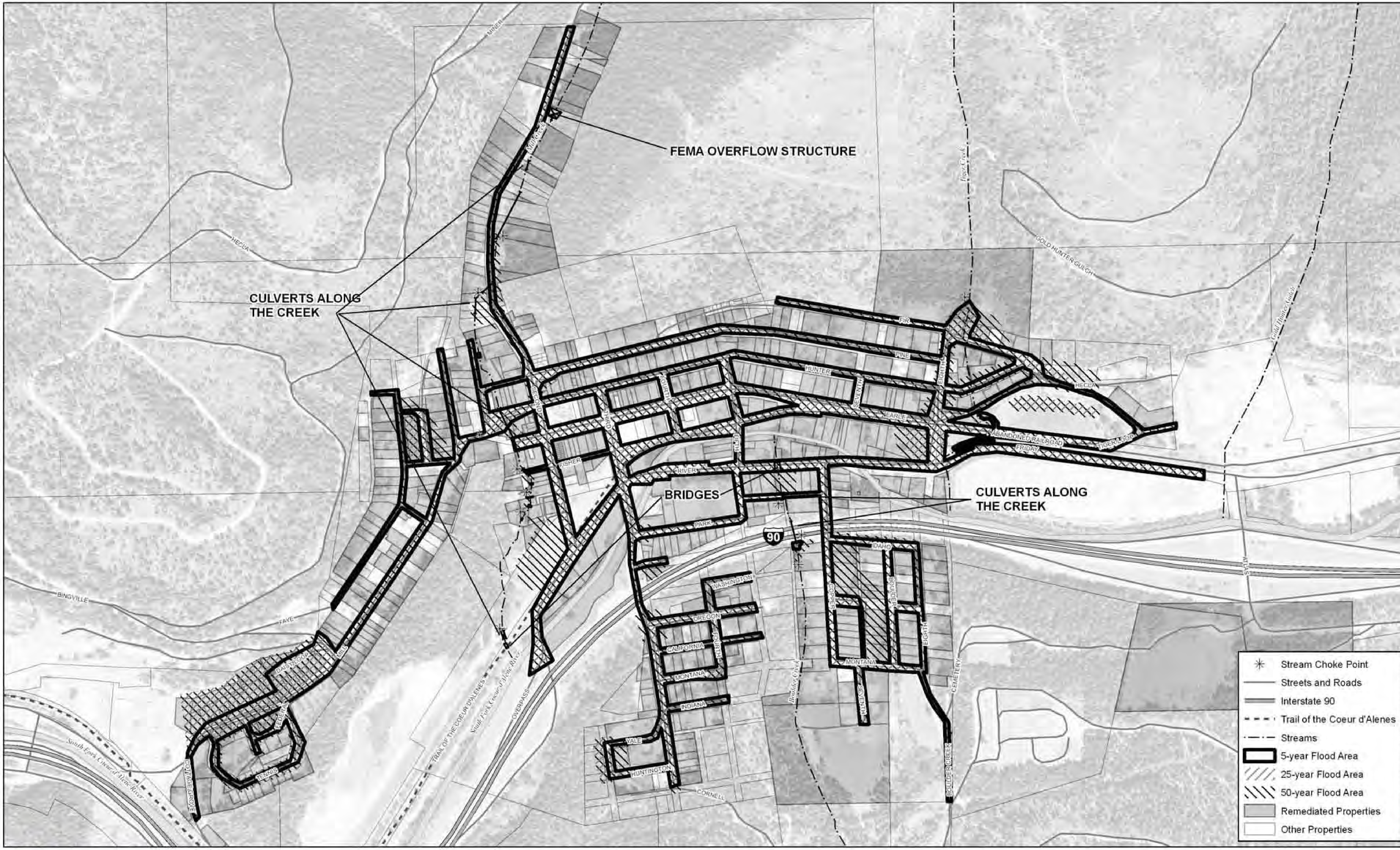
This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-27

Wallace Scour Areas



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 1_28_wallace_depo PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:5,000 1 inch = 417 feet 0 200 400 600 Feet Projection: UTM NAD 83, Zone 11N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Figure 1-28 **Wallace Deposition Areas**



TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE Bunker / ROD_2009r 1_29_mullan_flood
PRINT DATE January 6, 2010
PROJECT NUMBER 2010-5050

REQUESTOR D. Forseth
PROJECT MANAGER D. Forseth
CARTOGRAPHER B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:6,000
1 inch = 500 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-29
Mullan Flood Areas

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/ G1_30_mullan_slope Print Date: January 22, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:8,000 1 inch = 667 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-30

Mullan Slope Analysis

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ 1_31_mullan_scour	REQUESTOR	D. Forseth
PRINT DATE	January 6, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:6,000
1 inch = 500 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-31
Mullan Scour Areas

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ 1_32_mullan_depo	REQUESTOR	D. Forseth
PRINT DATE	January 6, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

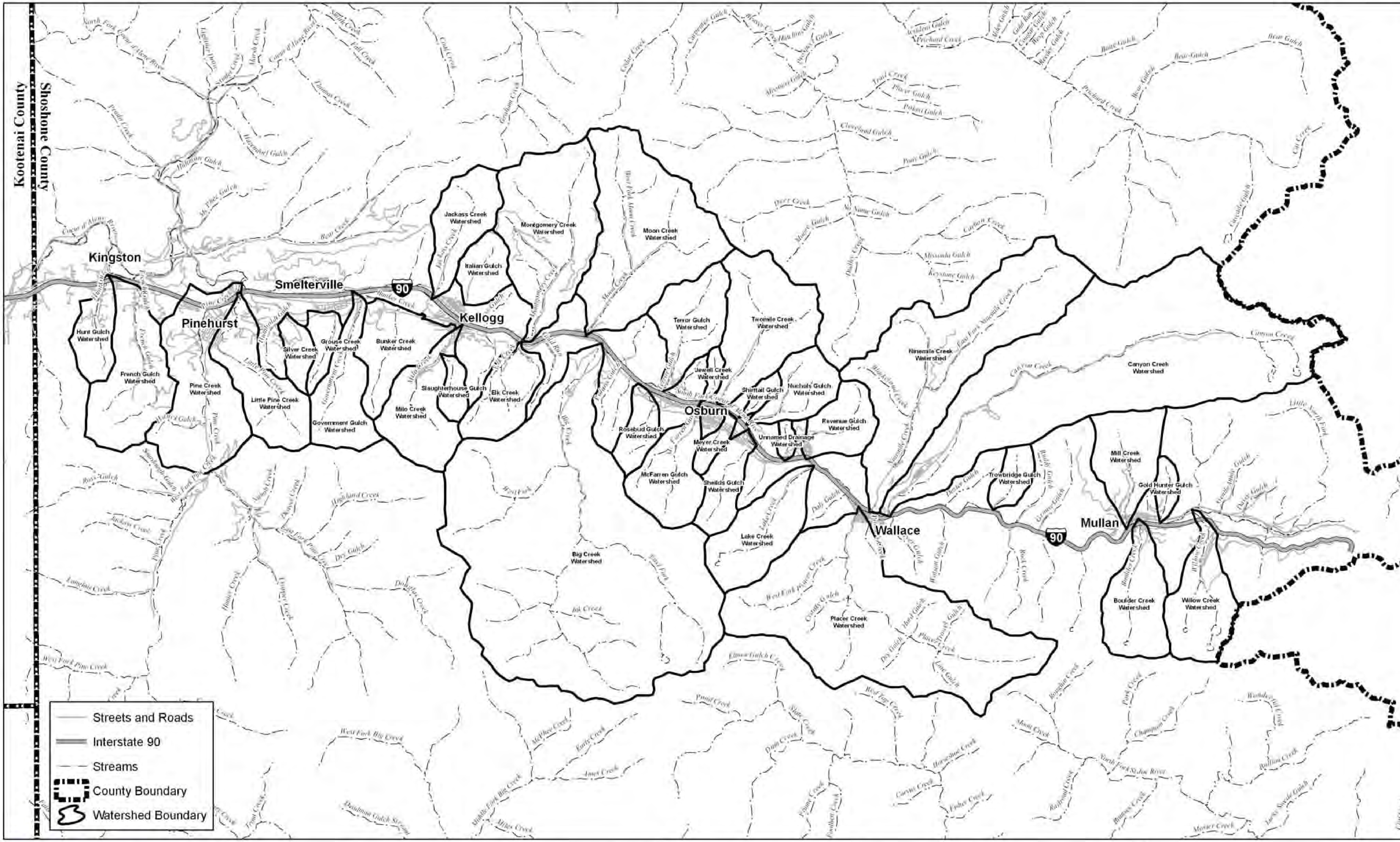
1:6,000
1 inch = 500 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Figure 1-32
Mullan Deposition Areas

Attachment G-2
Watershed Characterization Maps



TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Bunker / ROD_2009/G2_index	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin
PRINT DATE: January 6, 2010	PROJECT MANAGER: D. Forseth	
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey	

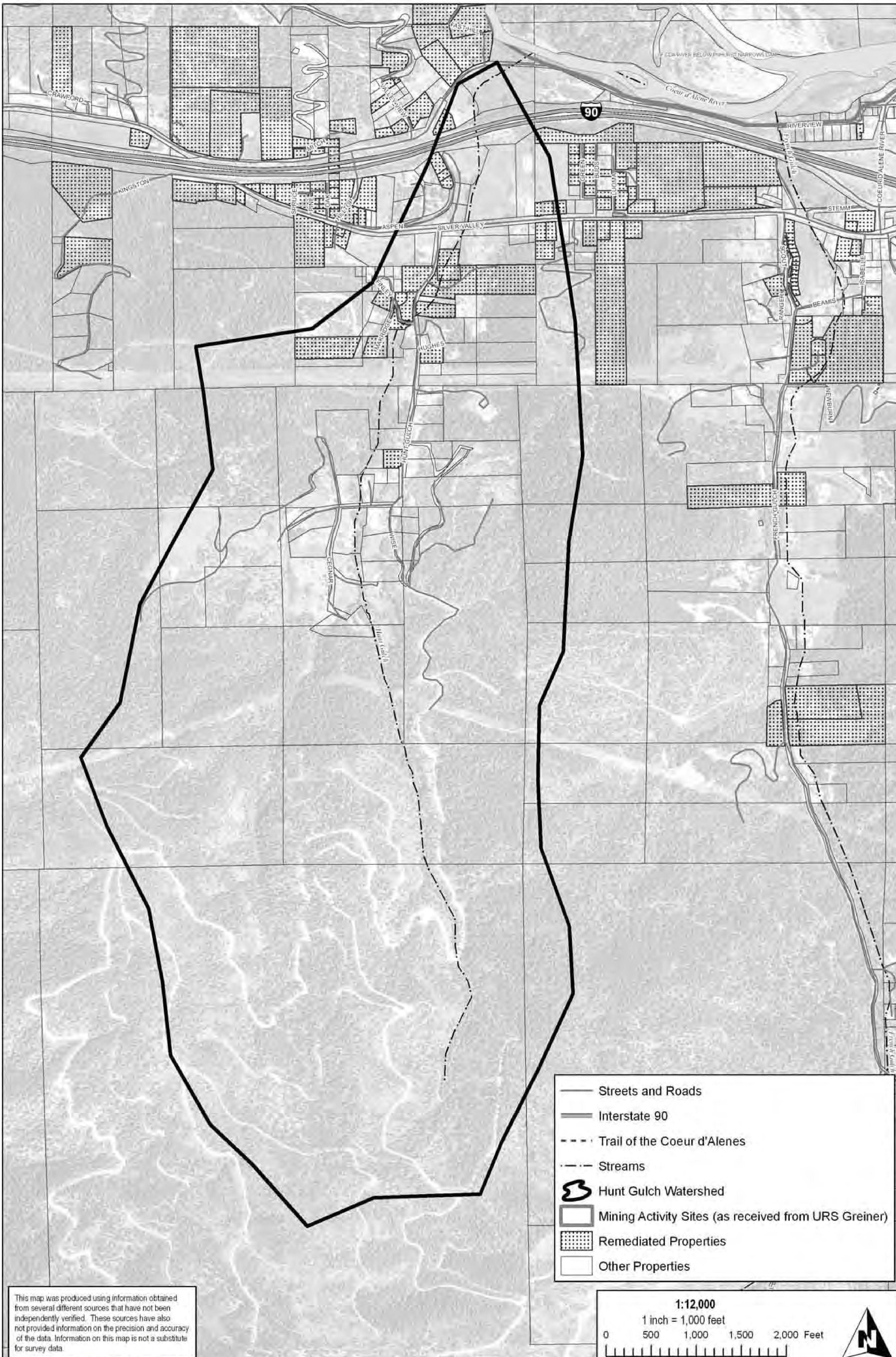
This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

1:125,000
1 inch = 10,417 feet
0 2 4 Miles

N

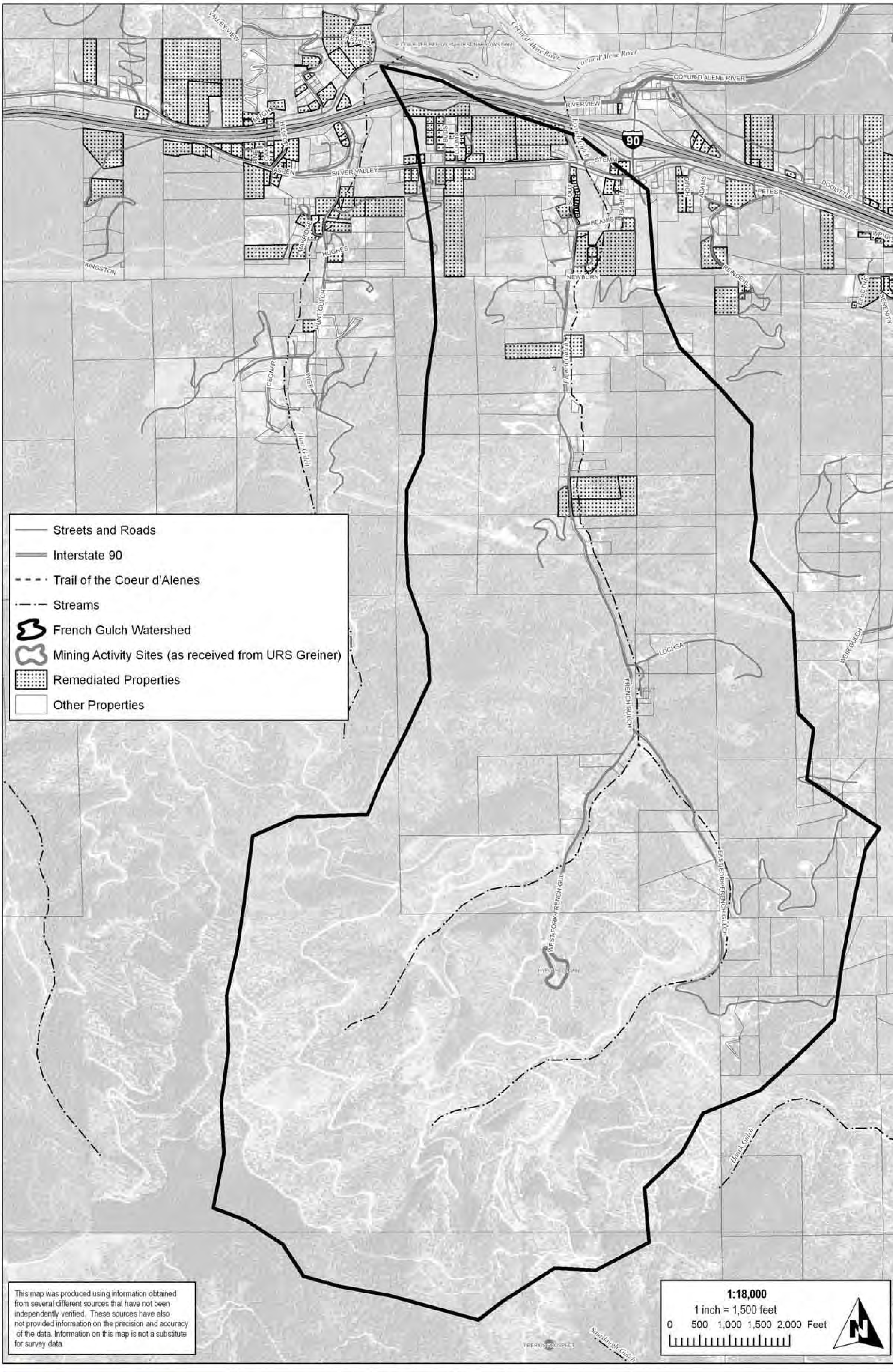
Figure 2-INDEX

Watershed Index

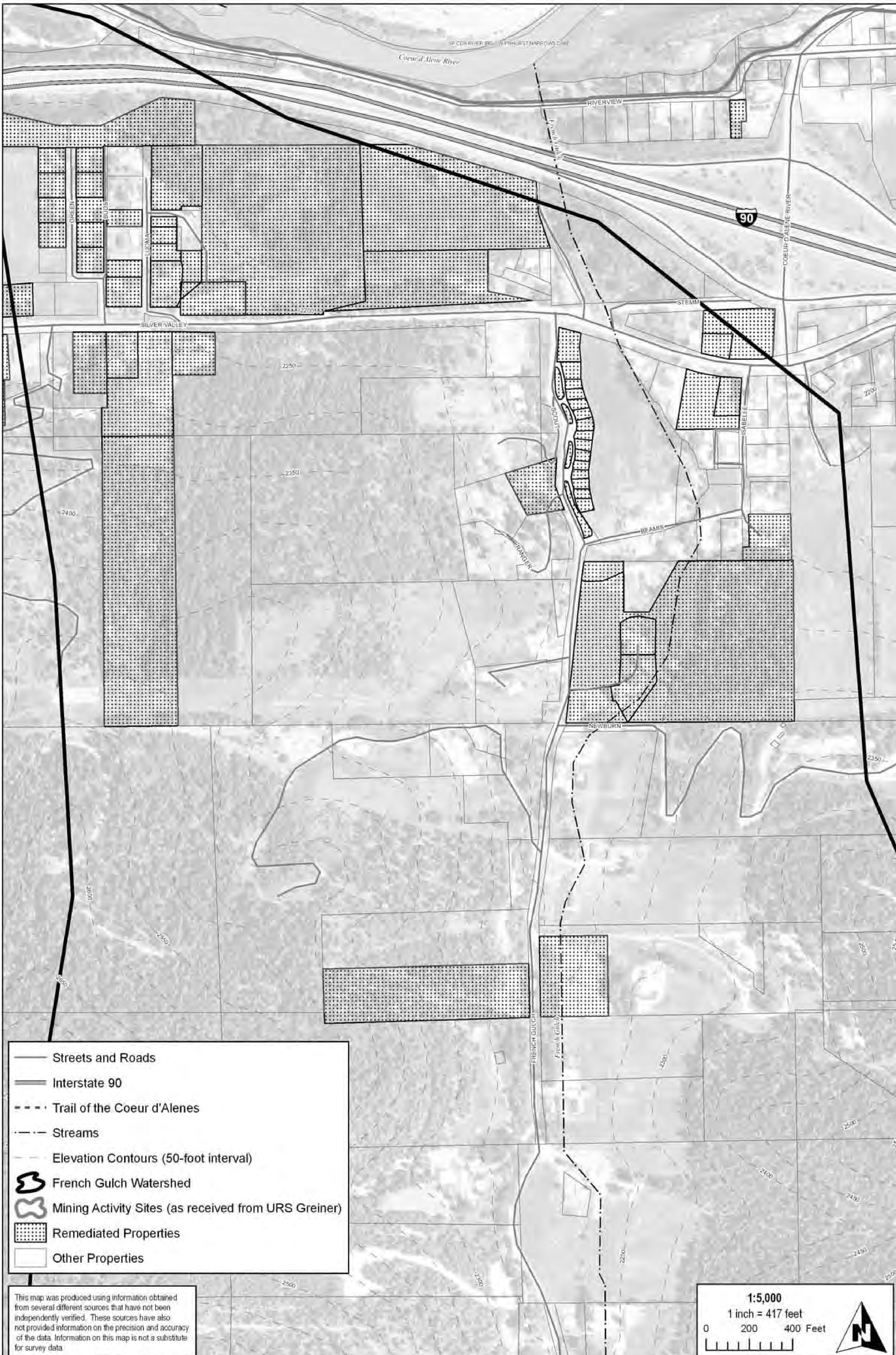


TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_1_hunt Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-1 **Hunt Gulch Watershed**

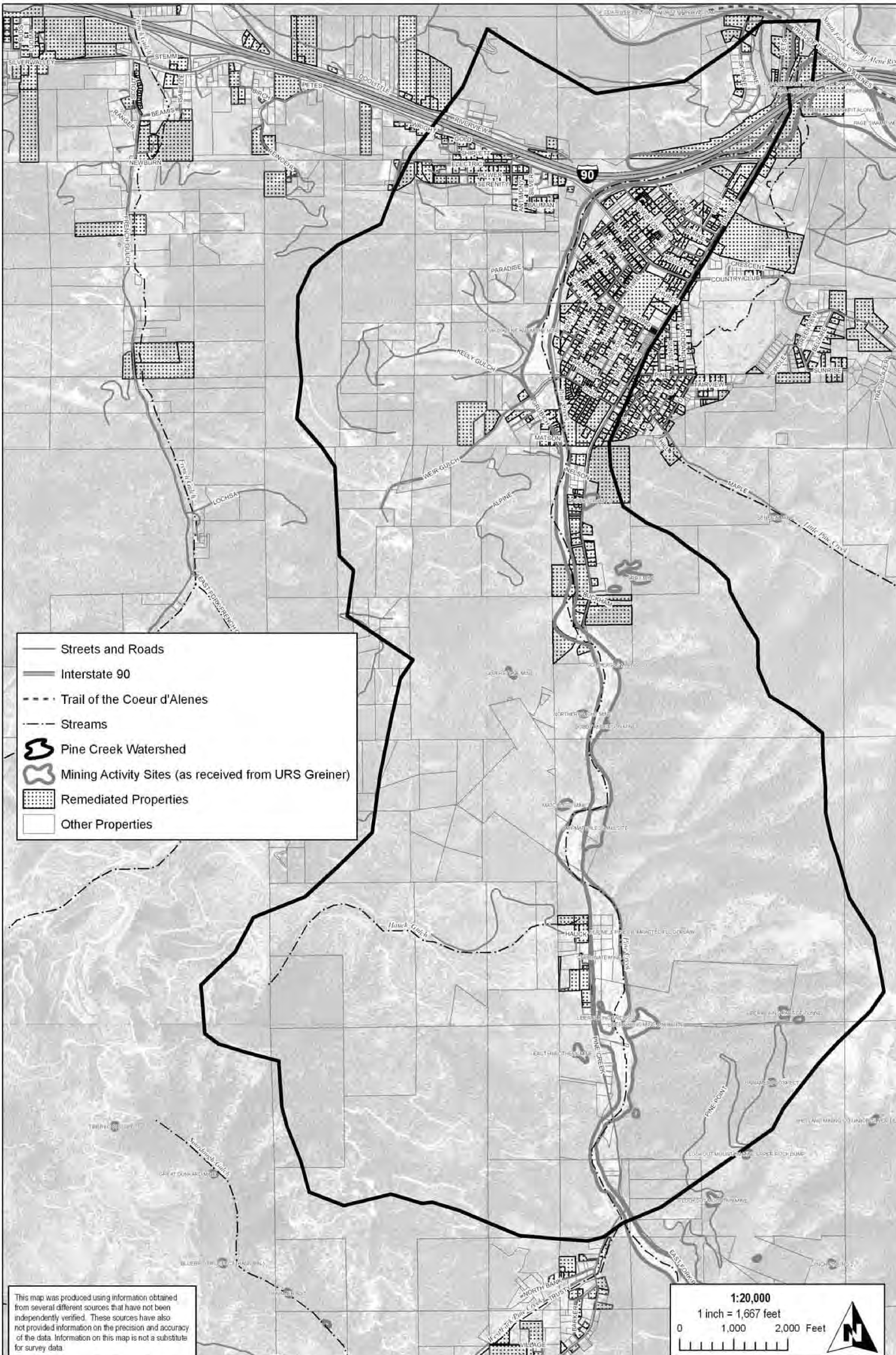
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_1_hunt_a	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-1A
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Hunt Gulch Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



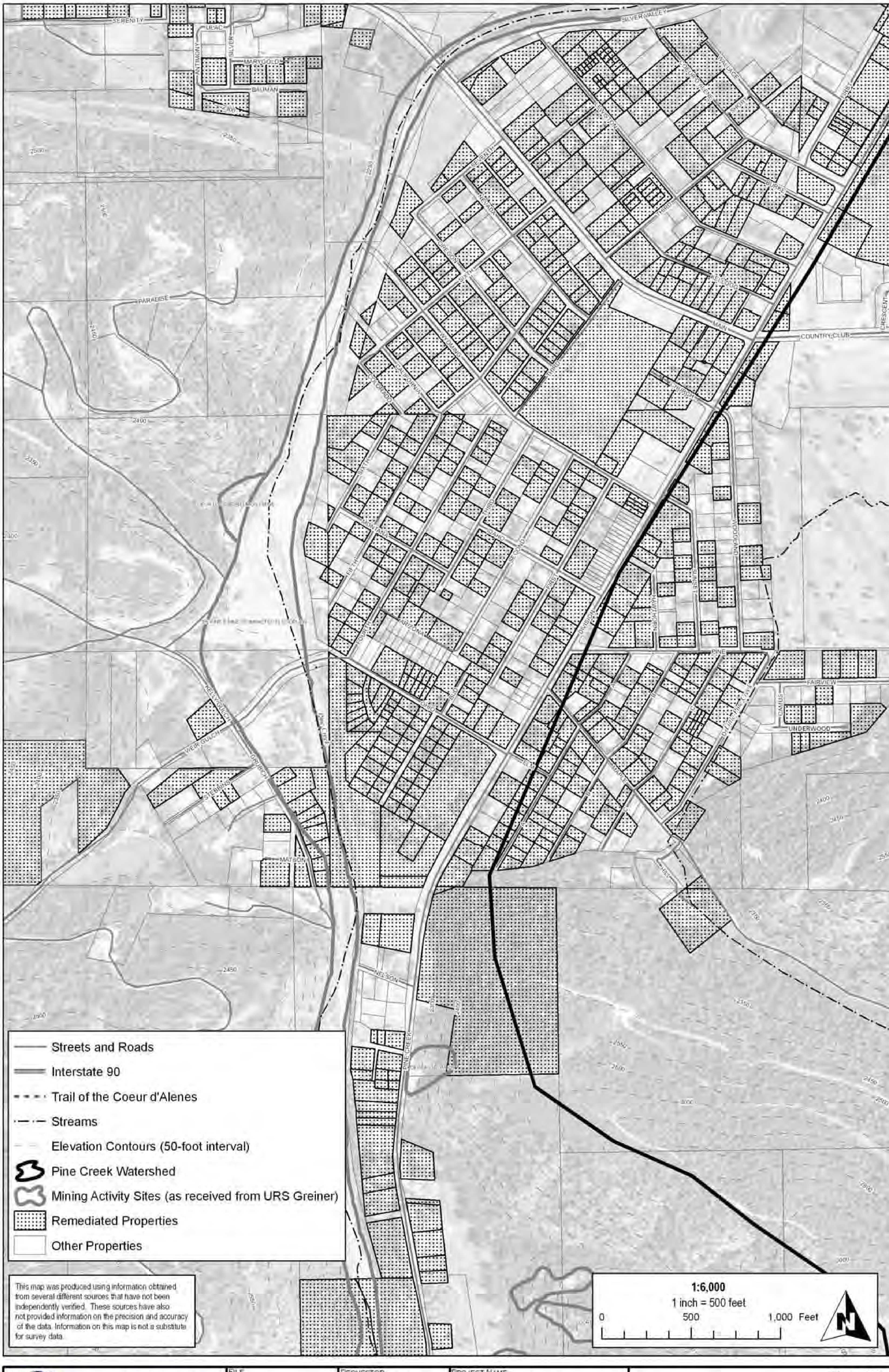
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_2_french	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-2 French Gulch Watershed
	Print Date: January 6, 2010	Project Manager: D. Forseth		
	Project Number: 2010-5050	Cartographer: B. Bailey		



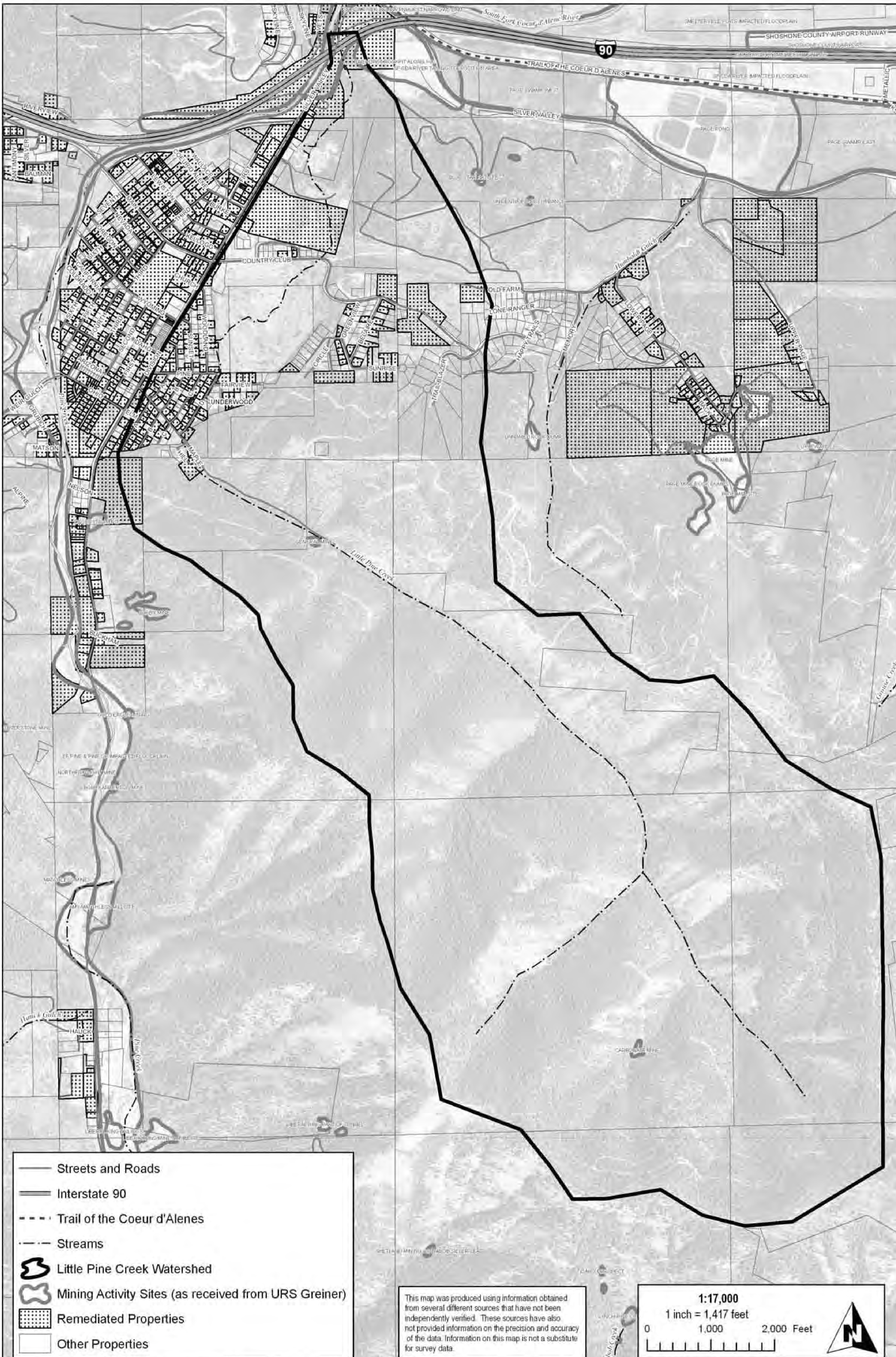
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_2_french_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-2A
	Print Date: January 6, 2010	Project Manager: D. Forseth		**French Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_3_pine Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-3 **Pine Creek Watershed**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_3_pine_a Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-3A Pine Creek Watershed



TerraGraphics Environmental Engineering, Inc.
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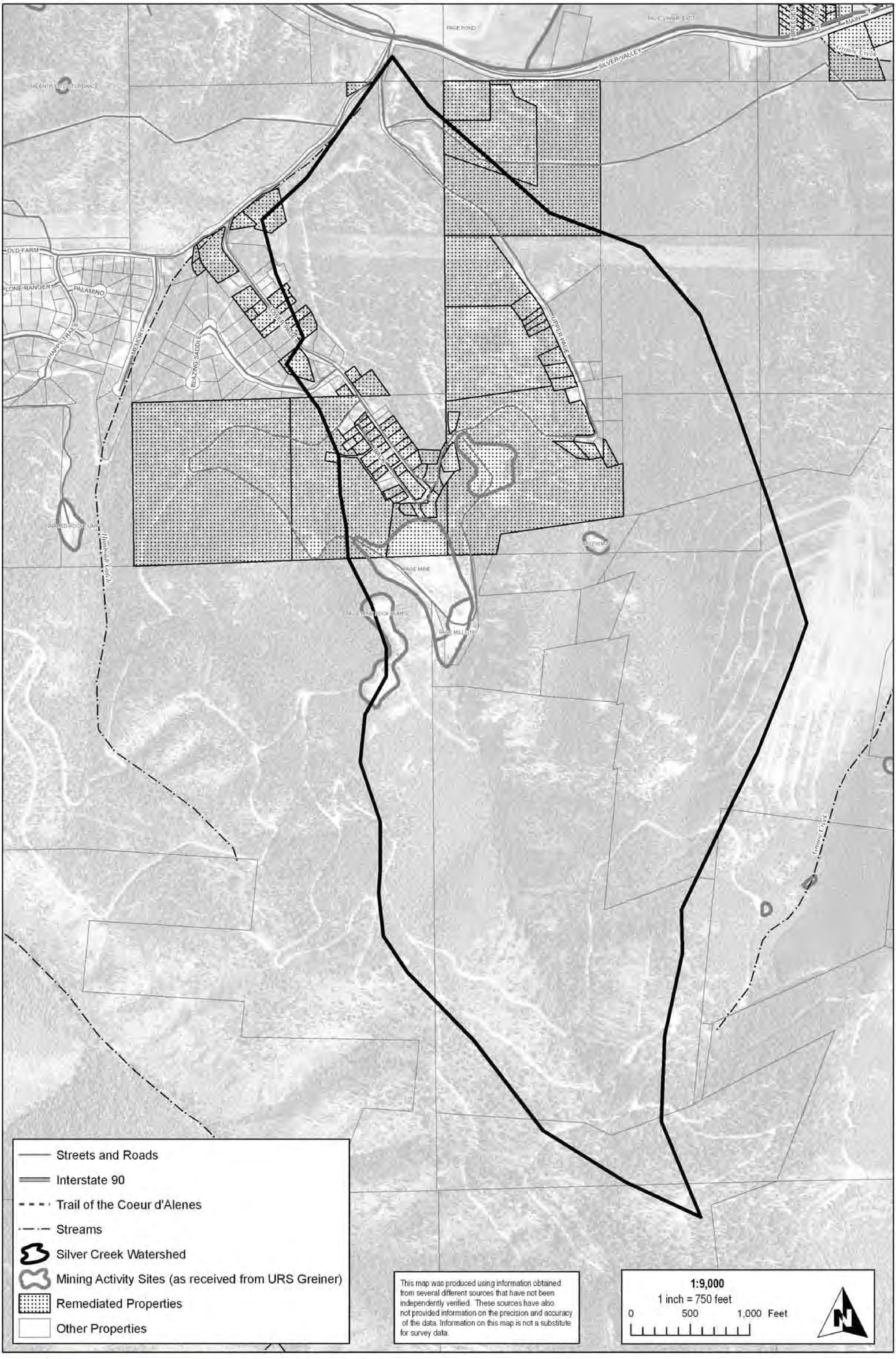
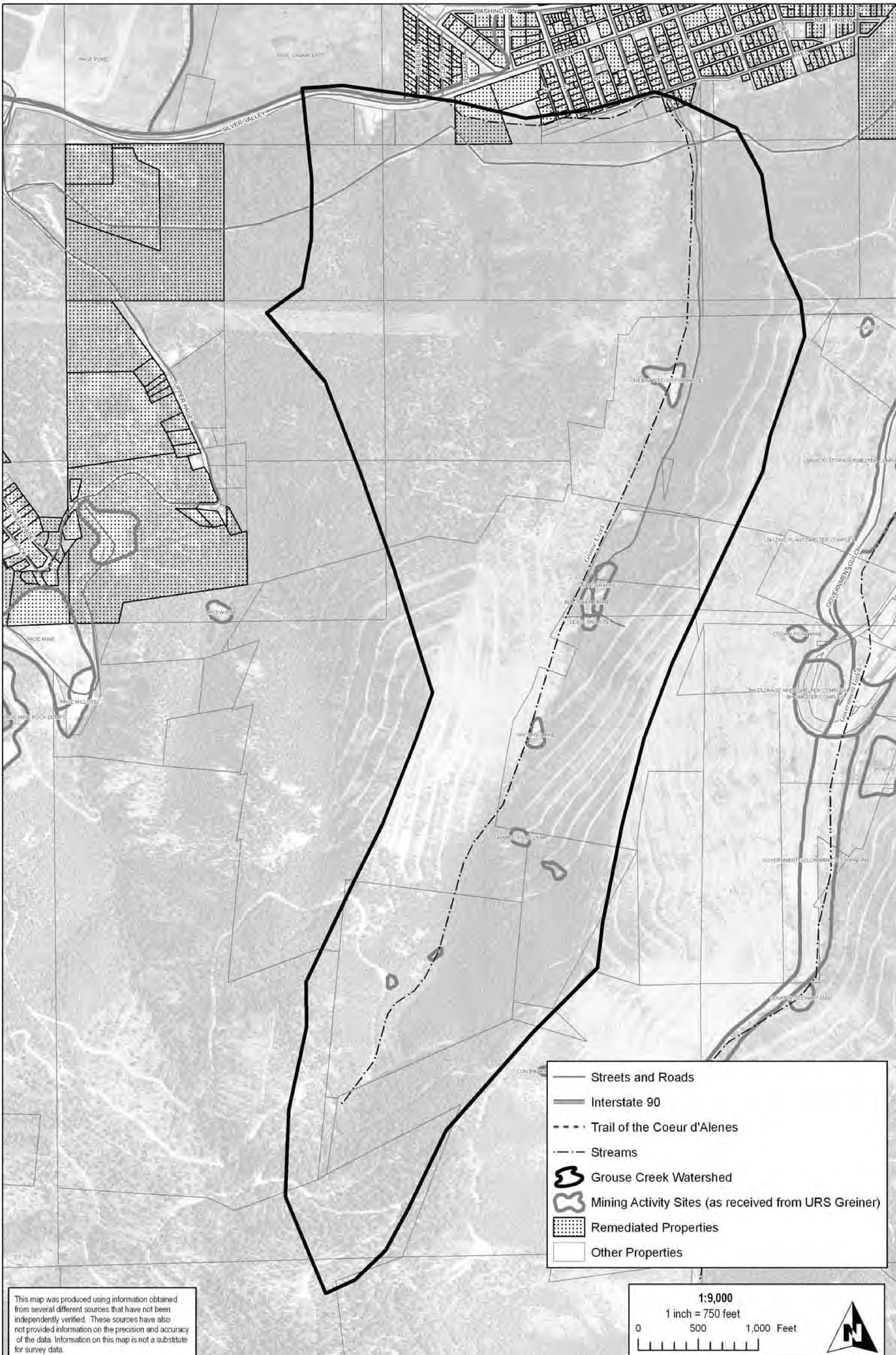
File	Requestor	Project Name	
Bunker / ROD_2009/2_4_lilpine	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-4
Print Date: January 6, 2010	Project Manager: D. Forseth		**Little Pine Creek Watershed**
Project Number: 2010-5050	Cartographer: B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_4_ltlpine_a Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-4A **Little Pine Creek Watershed**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_5_silver	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-5
	Print Date: January 6, 2010	Project Manager: D. Forseth		**Silver Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE: Bunker / ROD_2009/2_5_silver_a	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-5A
	PRINT DATE: January 6, 2010	PROJECT MANAGER: D. Forseth		Silver Creek Watershed
	PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_6_grouse	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-6
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Grouse Creek Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

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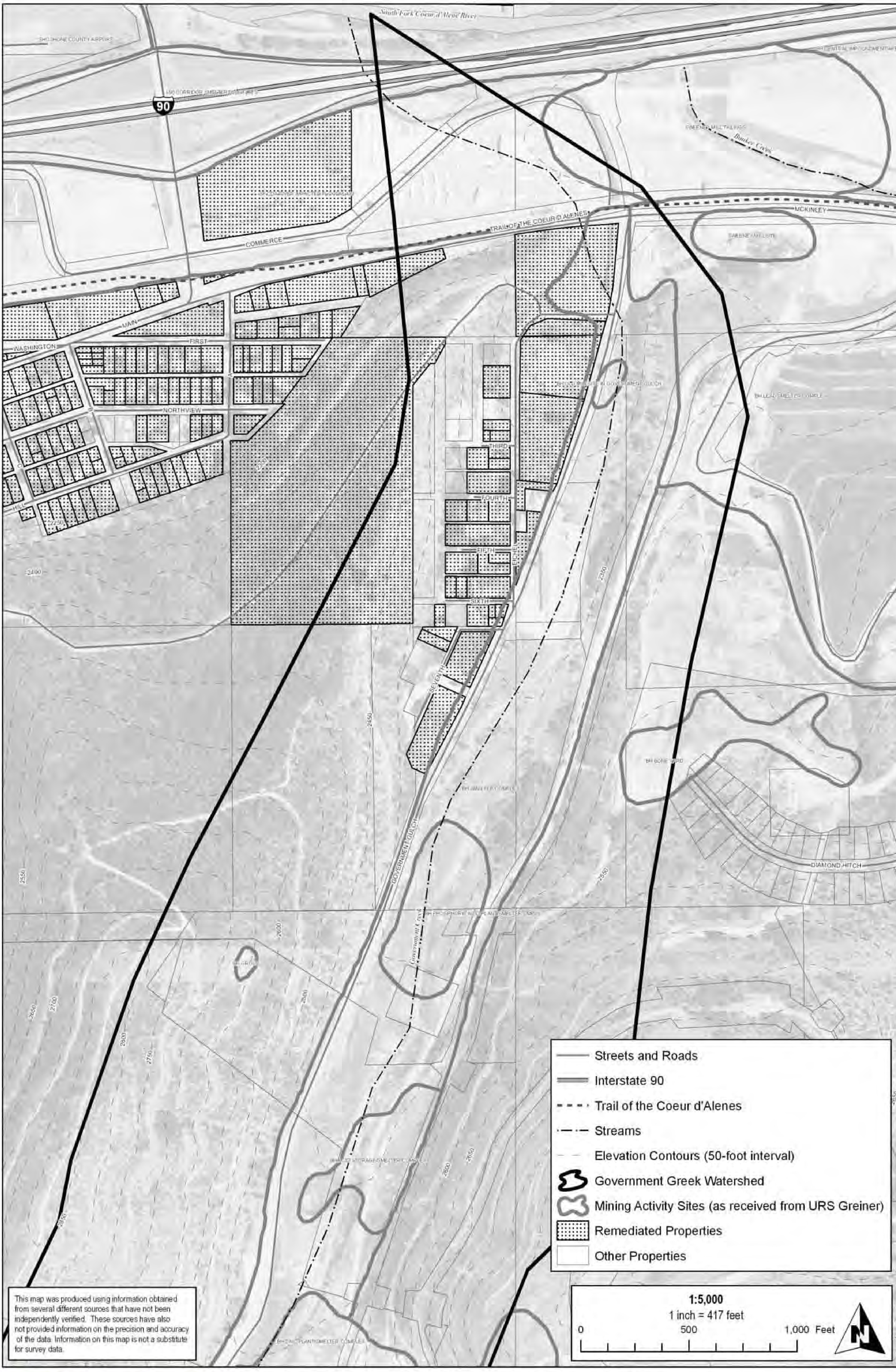
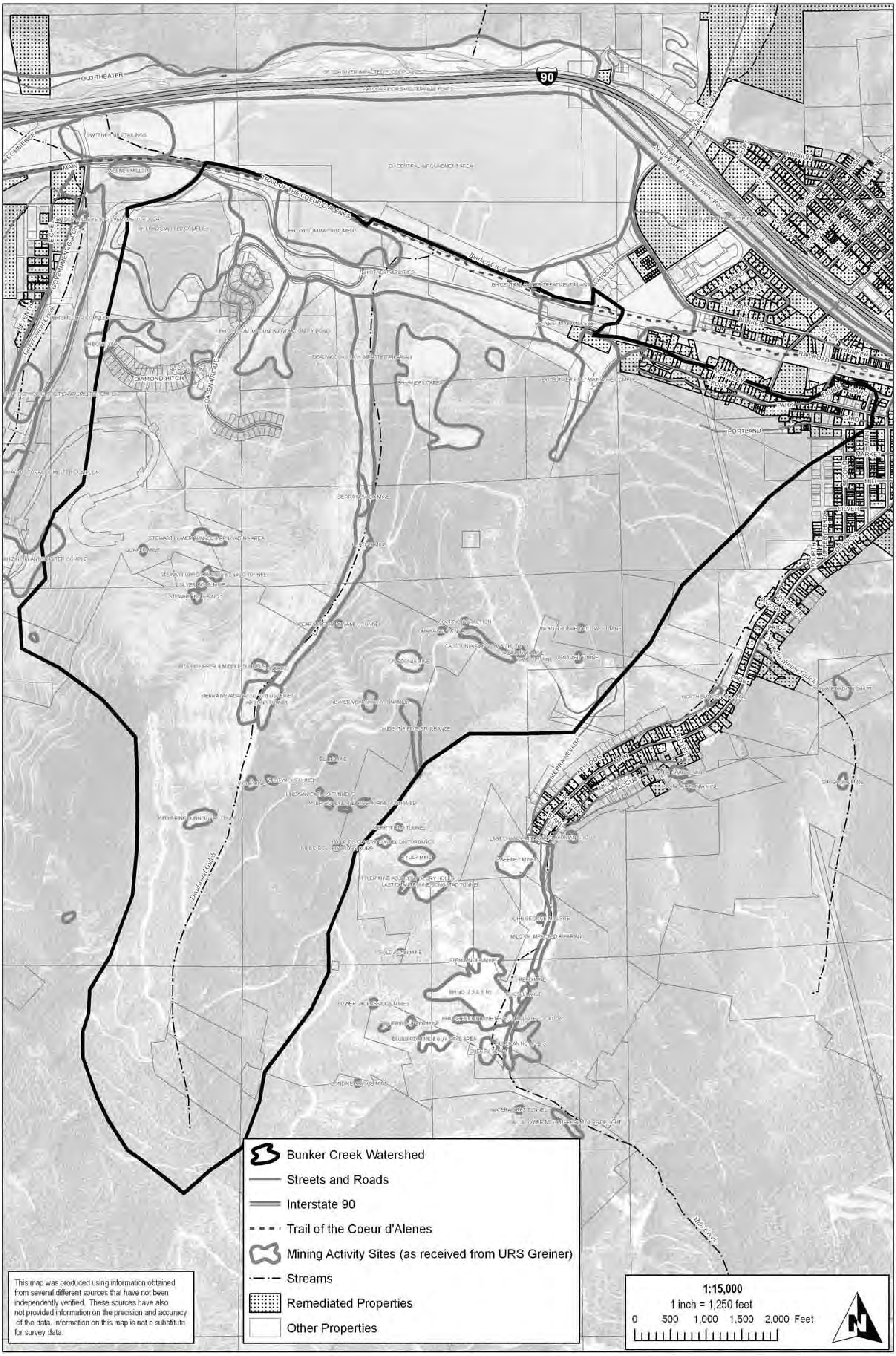
File: Bunker / ROD_2009/2_6_grouse	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-6A	
Print Date: January 6, 2010	Project Manager: D. Forseth		**Grouse Creek Watershed**	
Project Number: 2010-5050	Cartographer: B. Bailey			

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_7_gg	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-7 Government Creek Watershed
	Print Date: January 6, 2010	Project Manager: D. Forseth		
	Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_7_gg_a	Requestor: D. Forseth	Project Name	Figure 2-7A
	Print Date: January 6, 2010	Project Manager: D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Government Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



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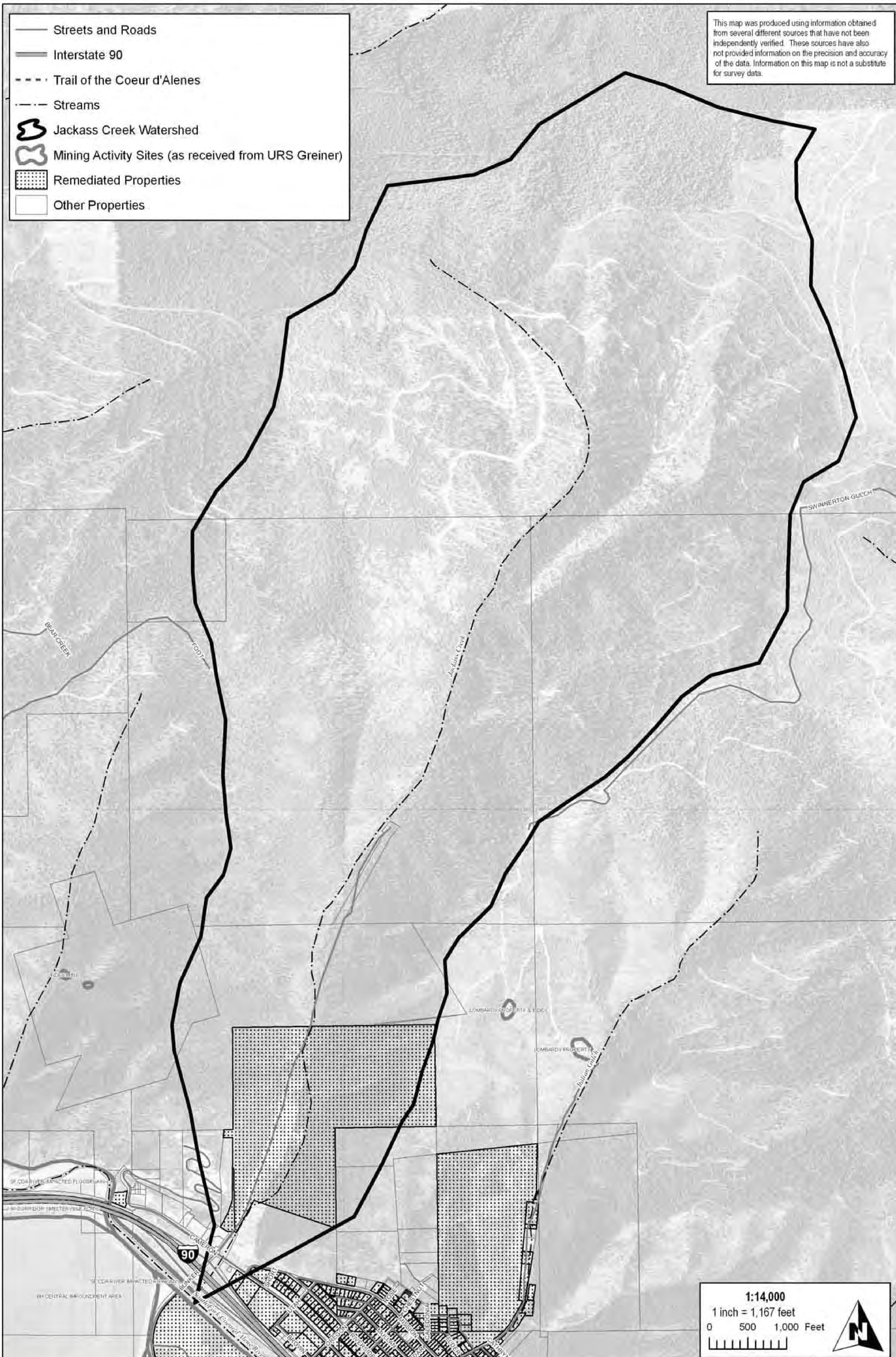
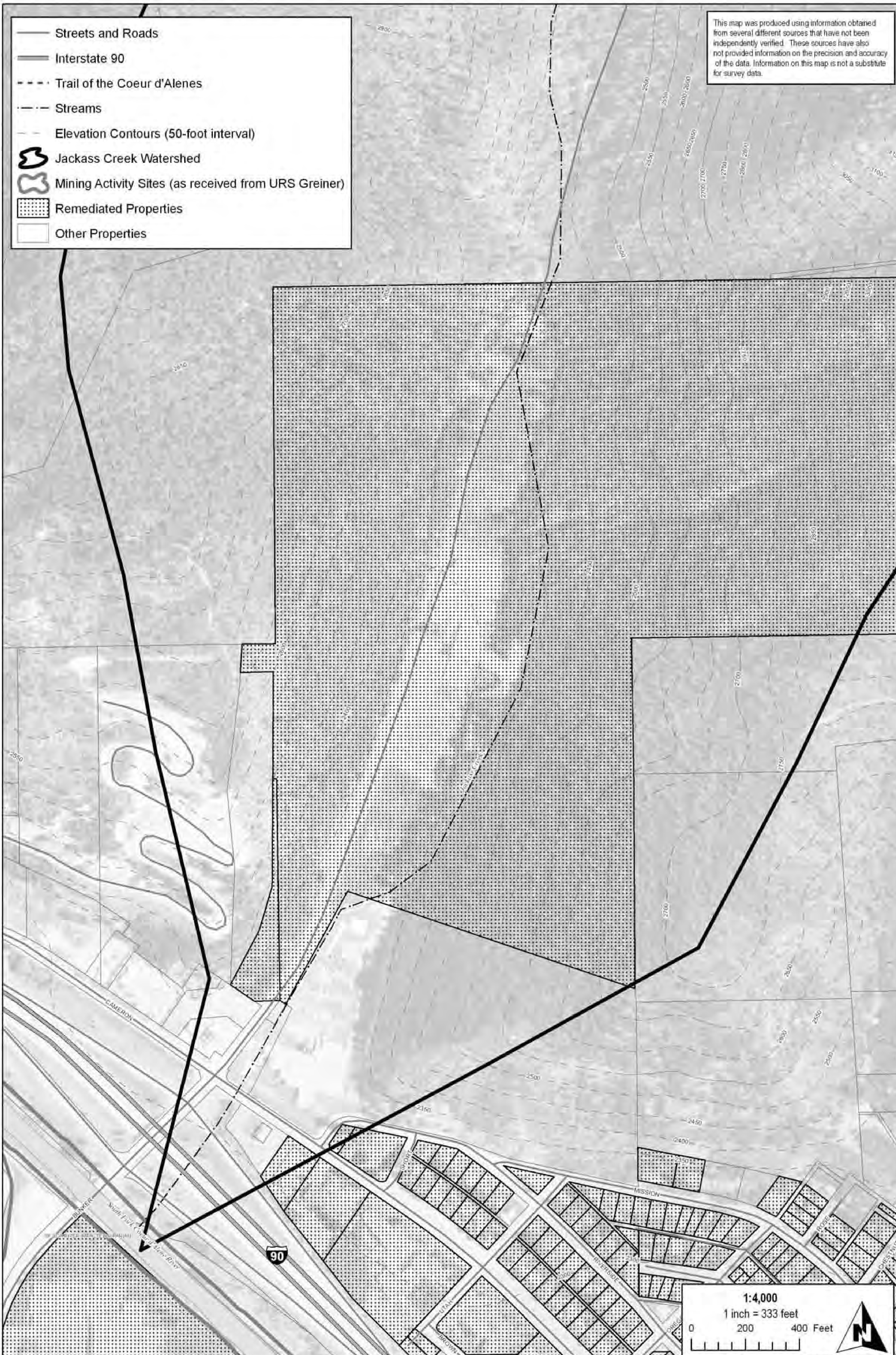
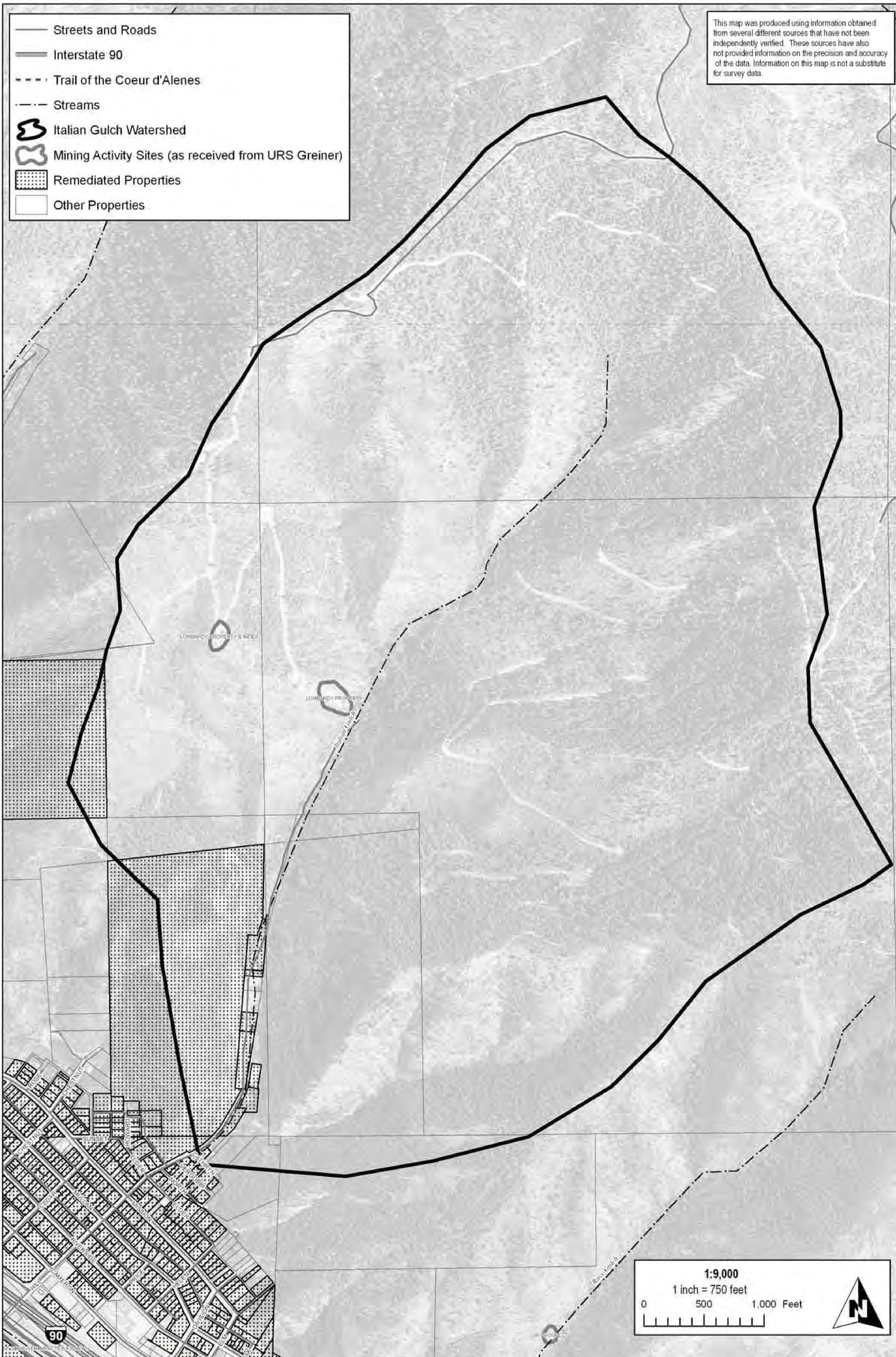
FILE	REQUESTOR	PROJECT NAME	Figure 2-8
Bunker /ROD_2009/2_8_bunker	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Bunker Creek Watershed**
PRINT DATE: January 6, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		



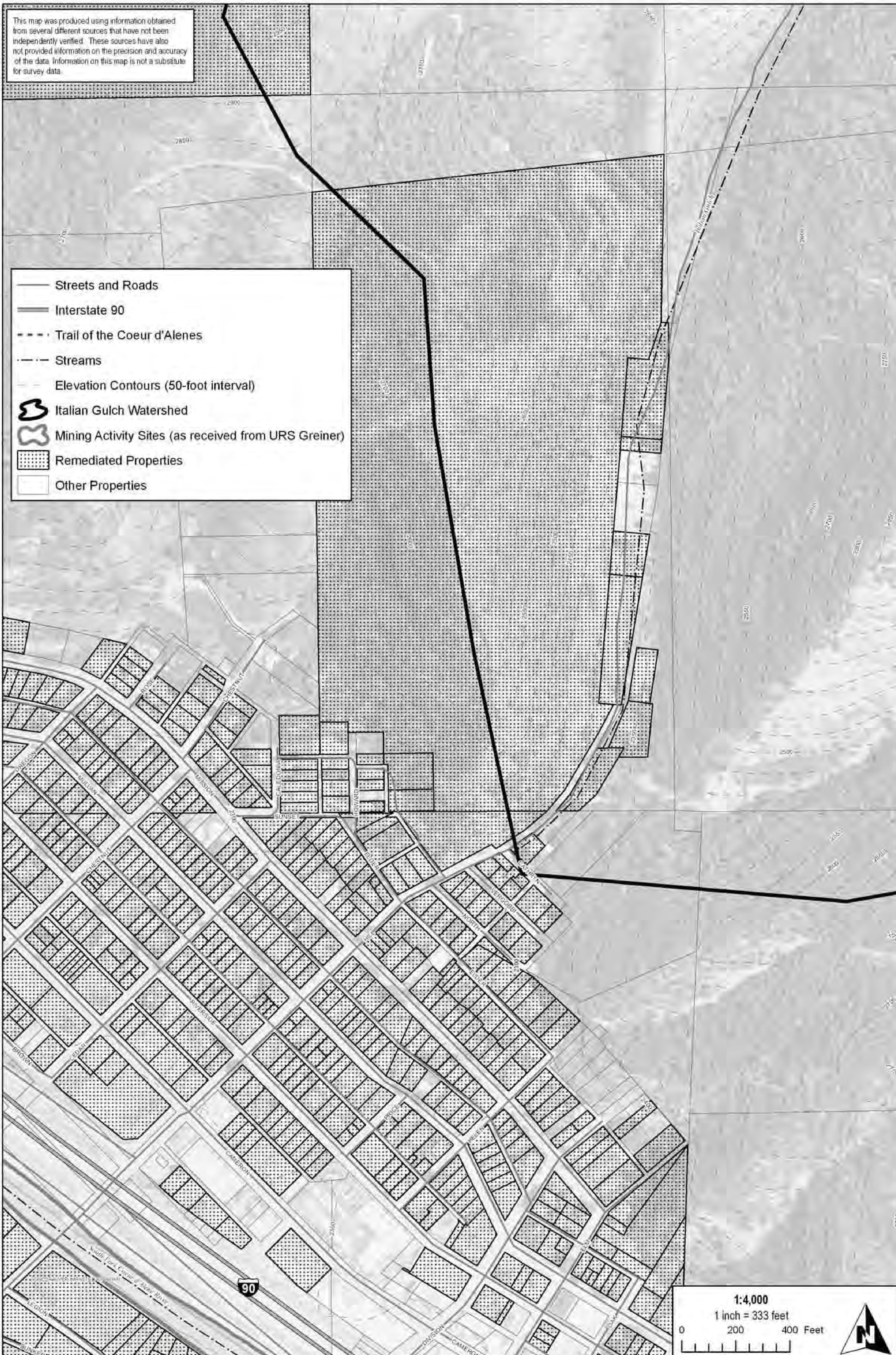
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_9_jackass	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-9
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		Jackass Creek Watershed
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



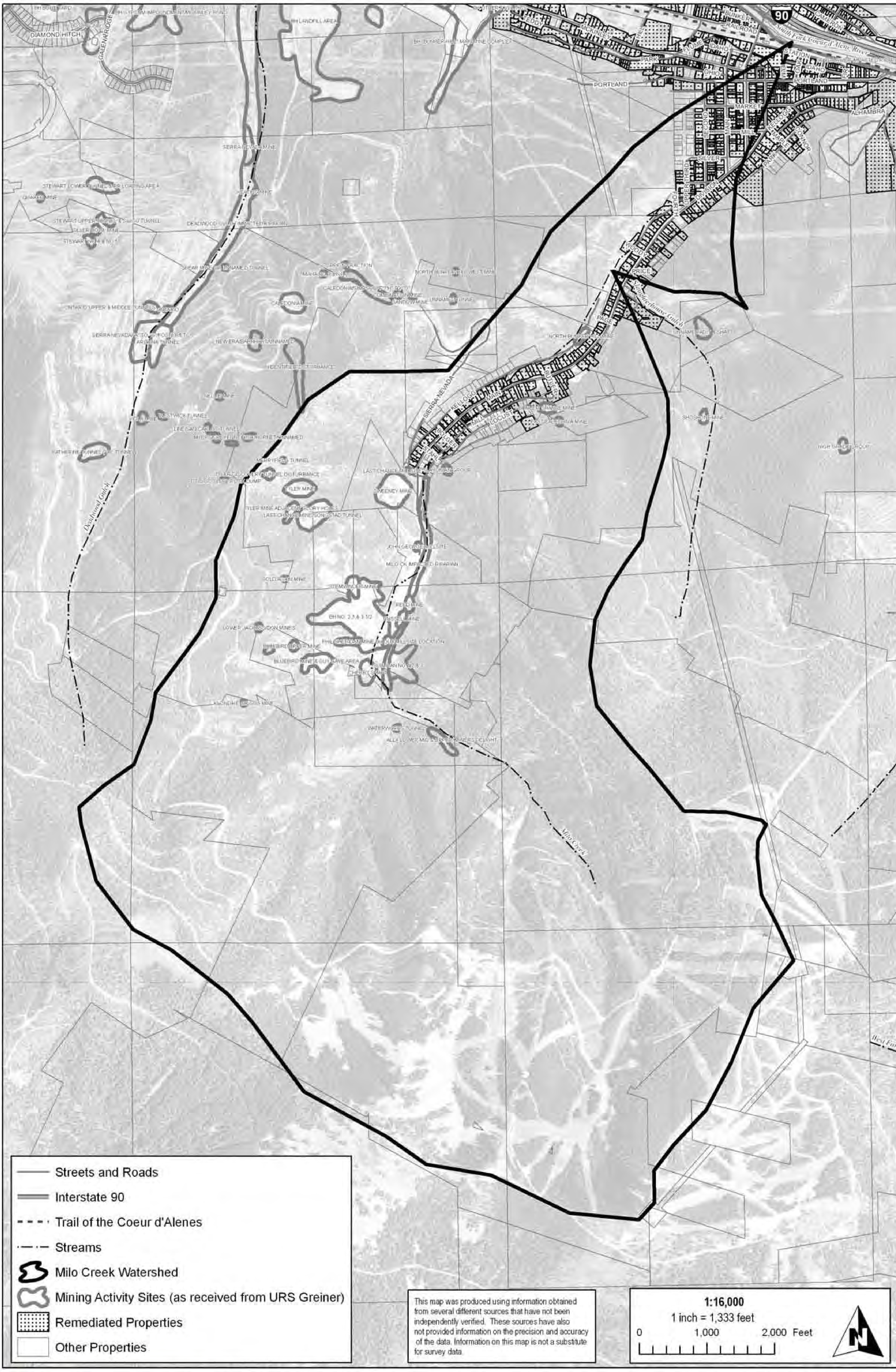
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_9_jackass_a Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-9A **Jackass Creek Watershed**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_10_italian	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-10
	Print Date: January 6, 2010	Project Manager: D. Forseth		**Italian Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_10_italian_a PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-10A **Italian Gulch Watershed**



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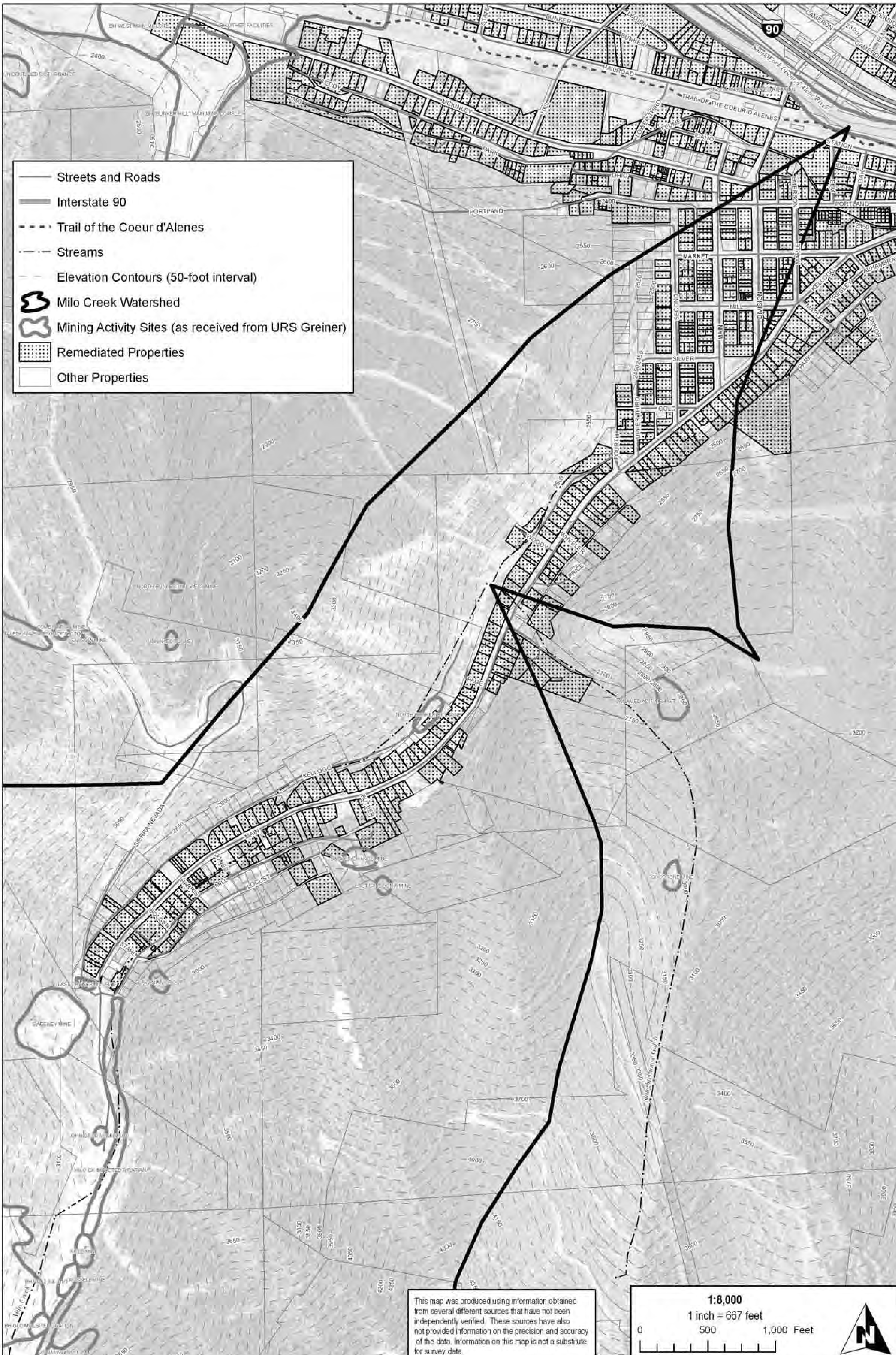
File	Requestor	Project Name	Figure 2-11
Bunker / ROD_2009/2_11_milo	D. Forseth	**Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**Milo Creek Watershed**
Print Date: January 6, 2010	Project Manager: D. Forseth		
Project Number: 2010-5050	Cartographer: B. Bailey		



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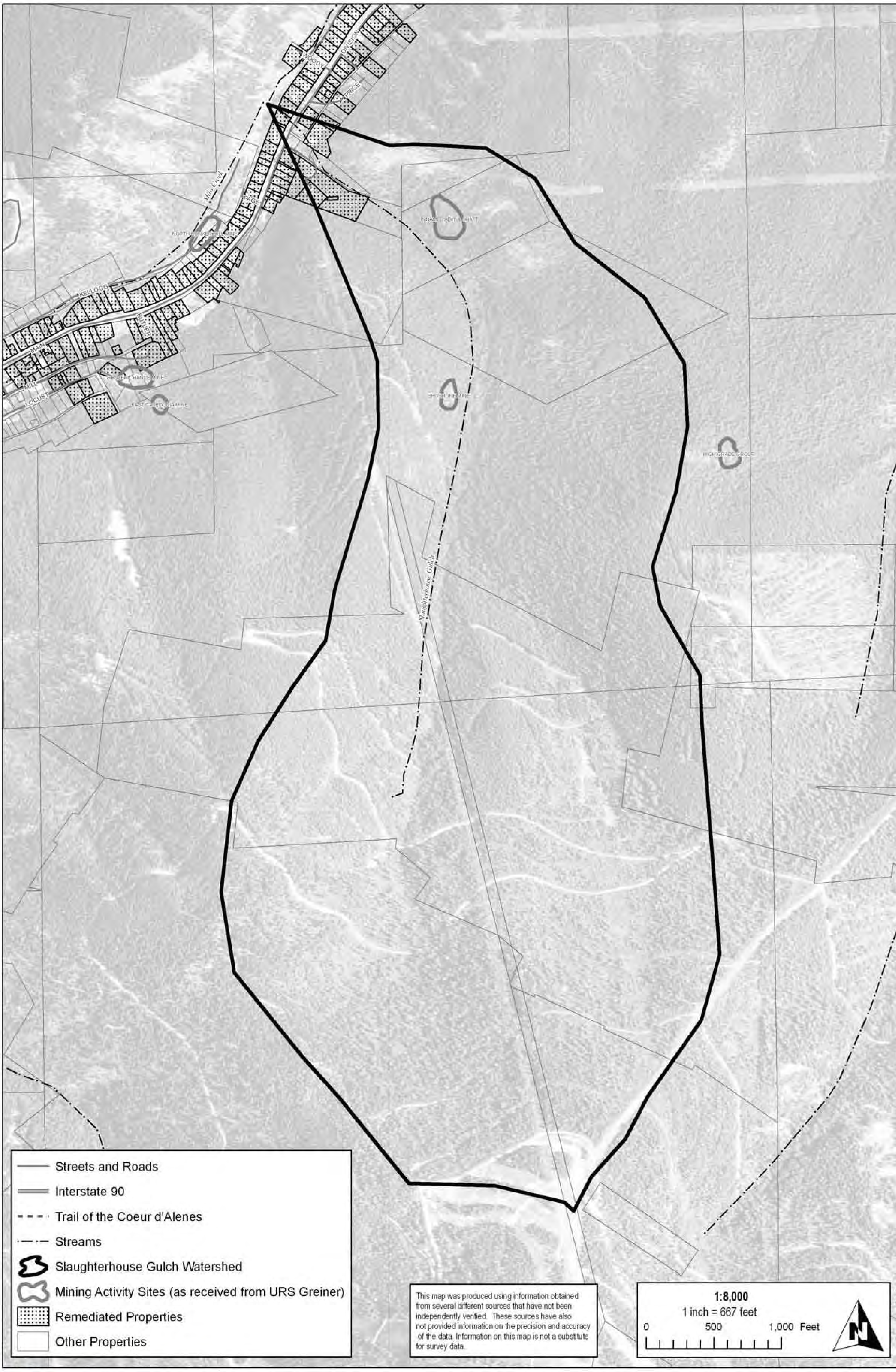
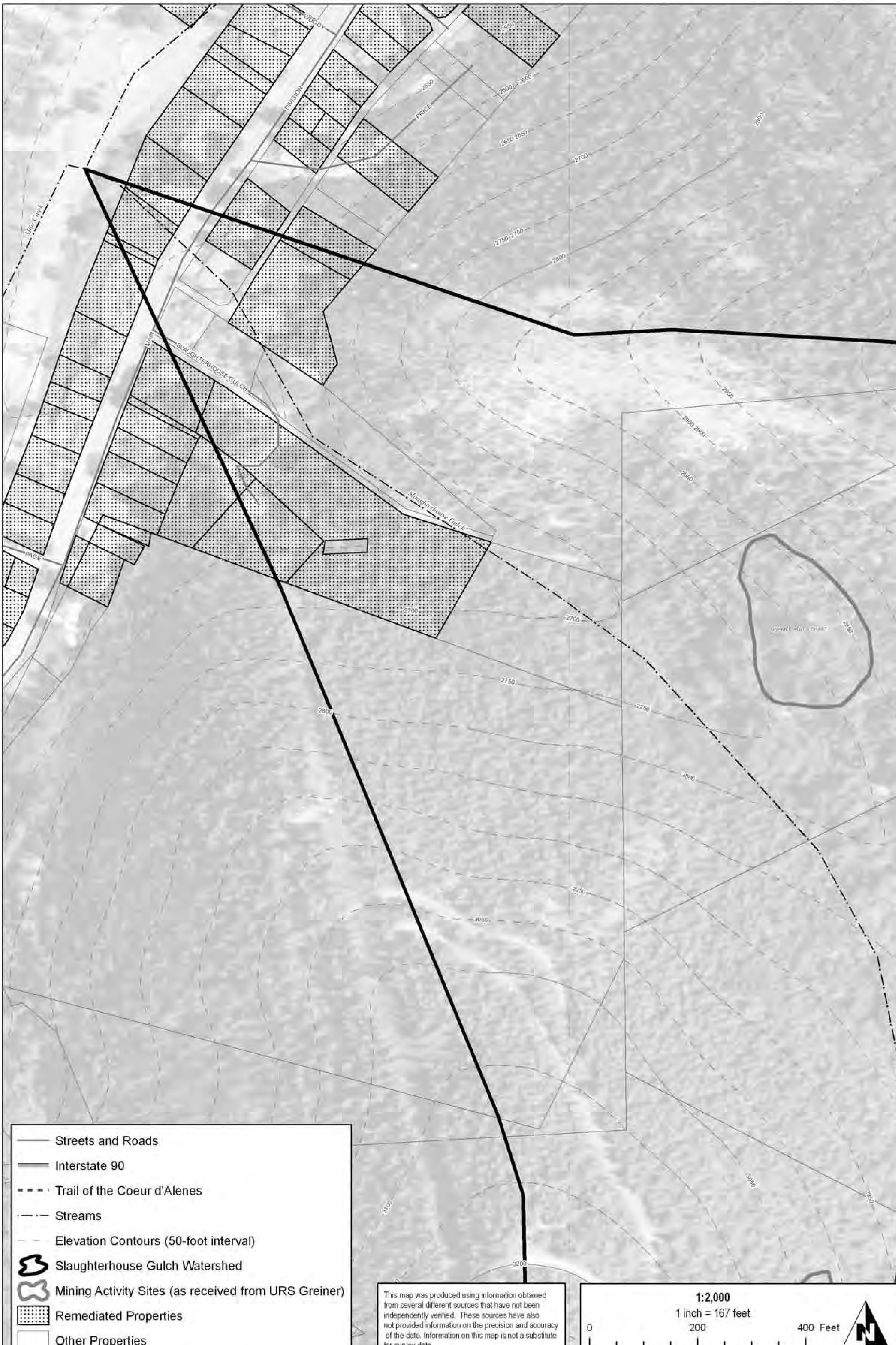
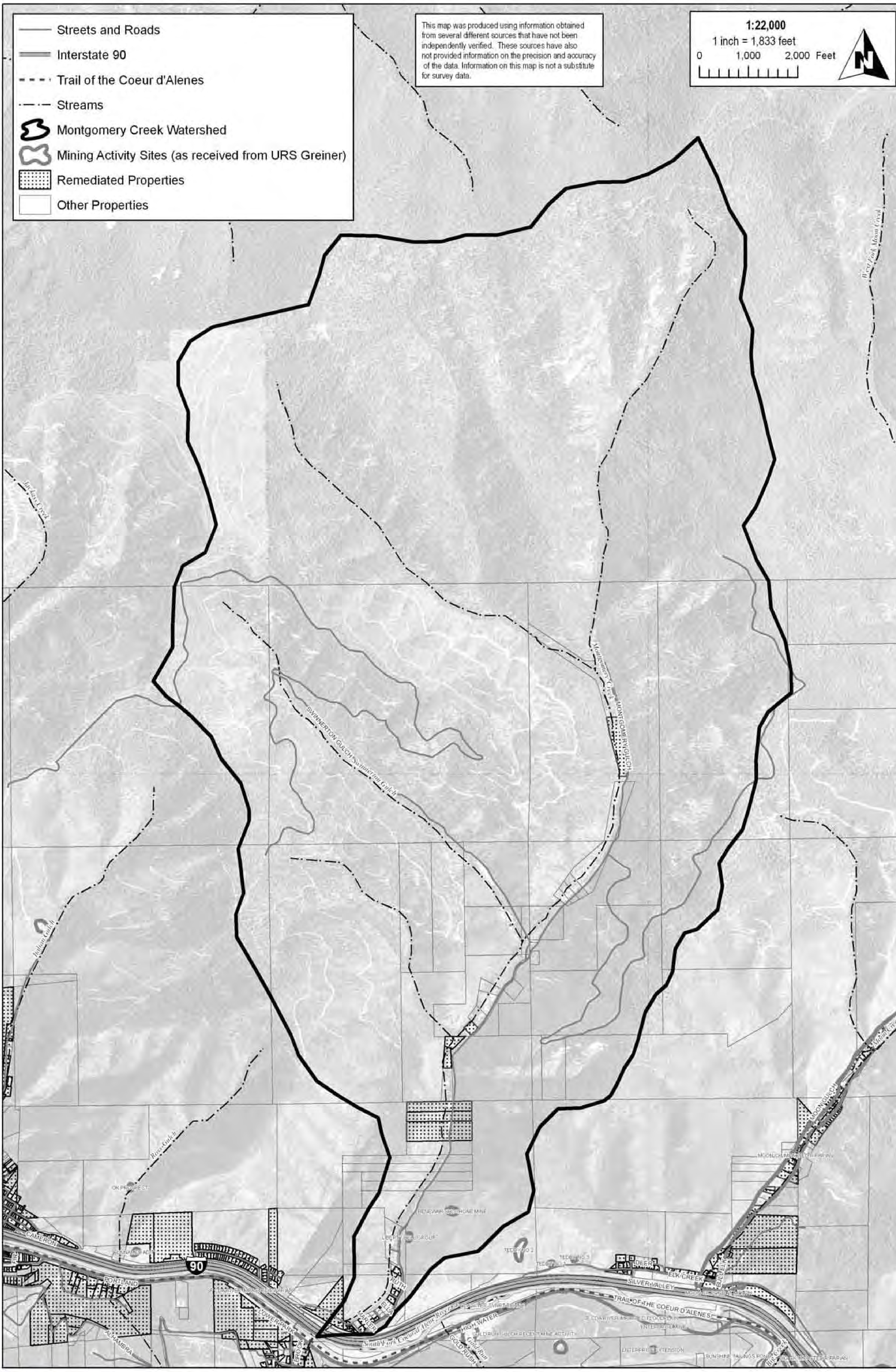
FILE	REQUESTOR	PROJECT NAME	
Bunker / ROD_2009/2_11_milo_a	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-11A
PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Milo Creek Watershed**
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 2_12_slaughterhouse	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-12 **Slaughterhouse Gulch Watershed**
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/ 2_12_slaughterhouse_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-12A
	Print Date: January 6, 2010	Project Manager: D. Forseth		**Slaughterhouse Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



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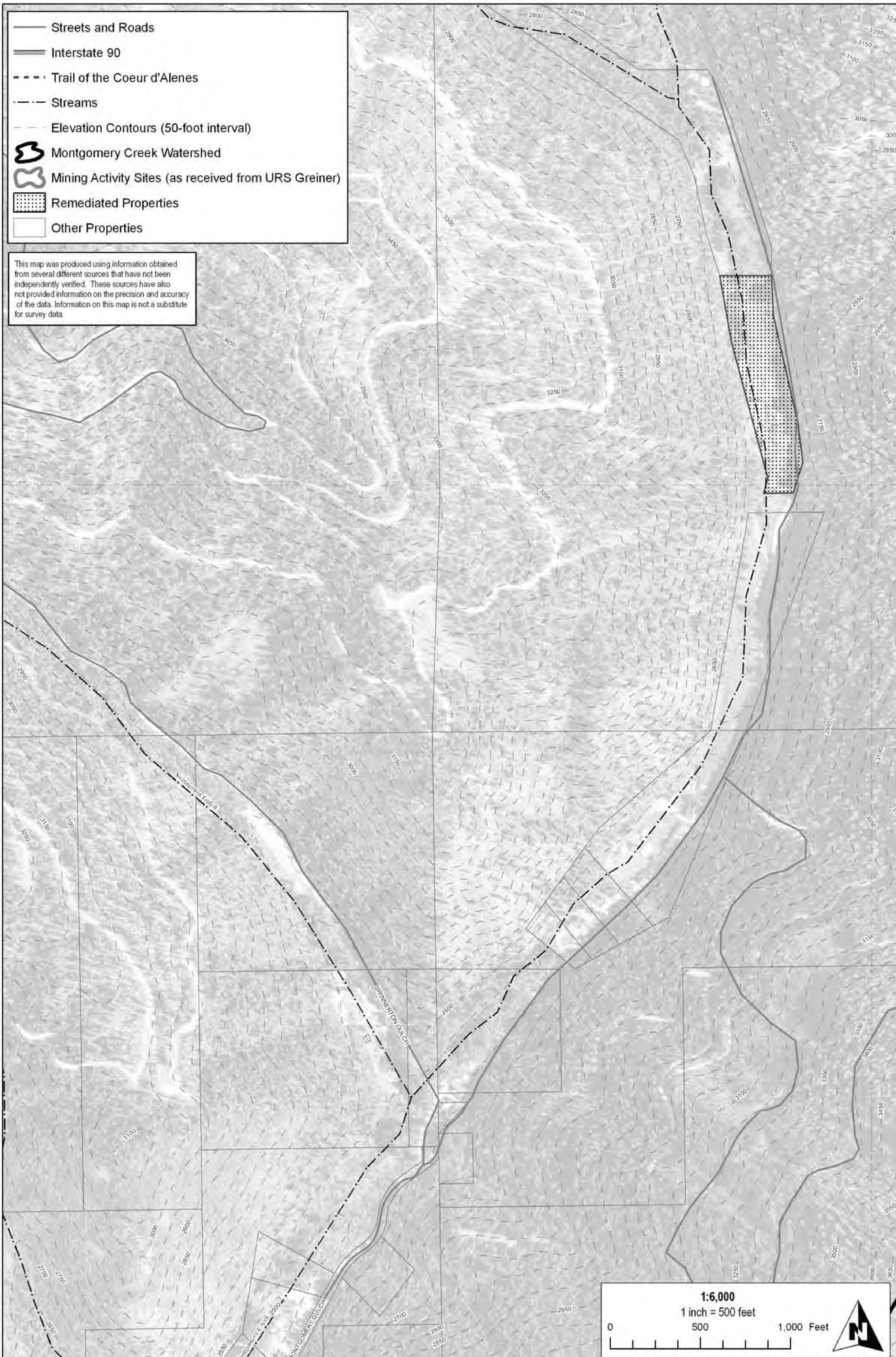
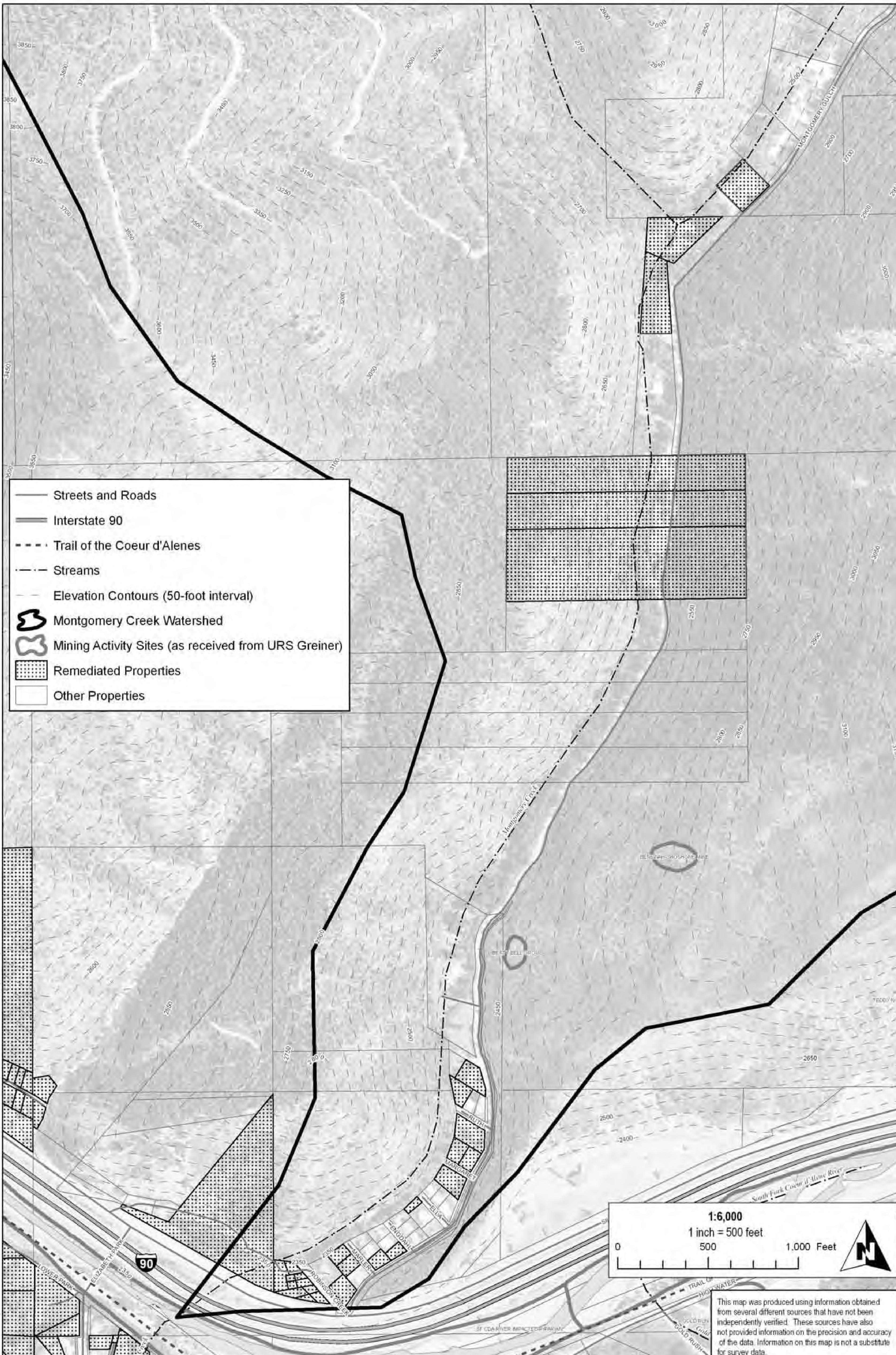
FILE Bunker / ROD_2009/ 2_13_montgomery	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-13
PRINT DATE January 6, 2009	PROJECT MANAGER D. Forseth		Montgomery Creek Watershed
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

Figure 2-13
Montgomery Creek Watershed

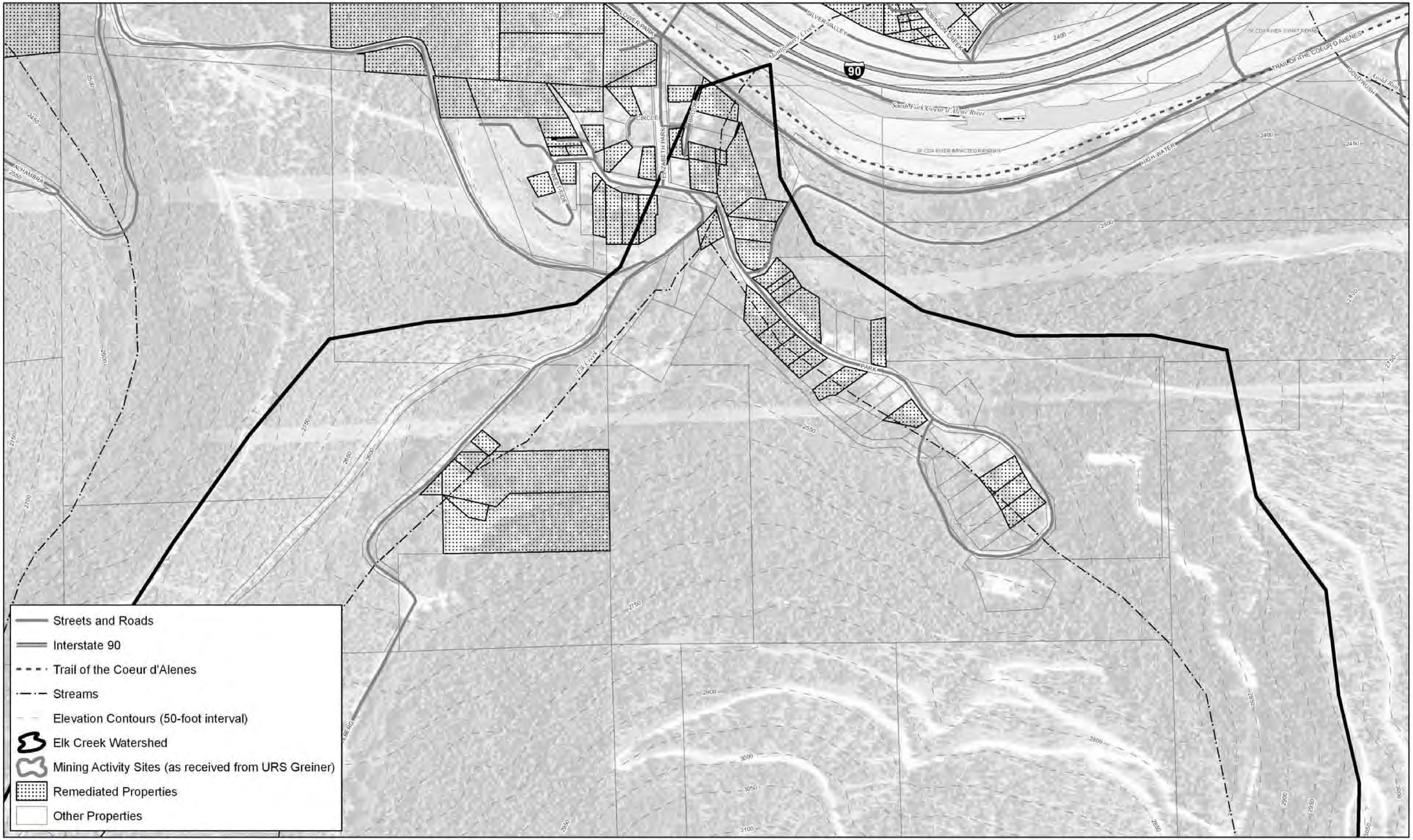


TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 2_13_montgomery_a	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-13A
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Montgomery Creek Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ 2_13_montgomery_b	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-13B Montgomery Creek Watershed
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_14_elk Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-14 **Elk Creek Watershed**



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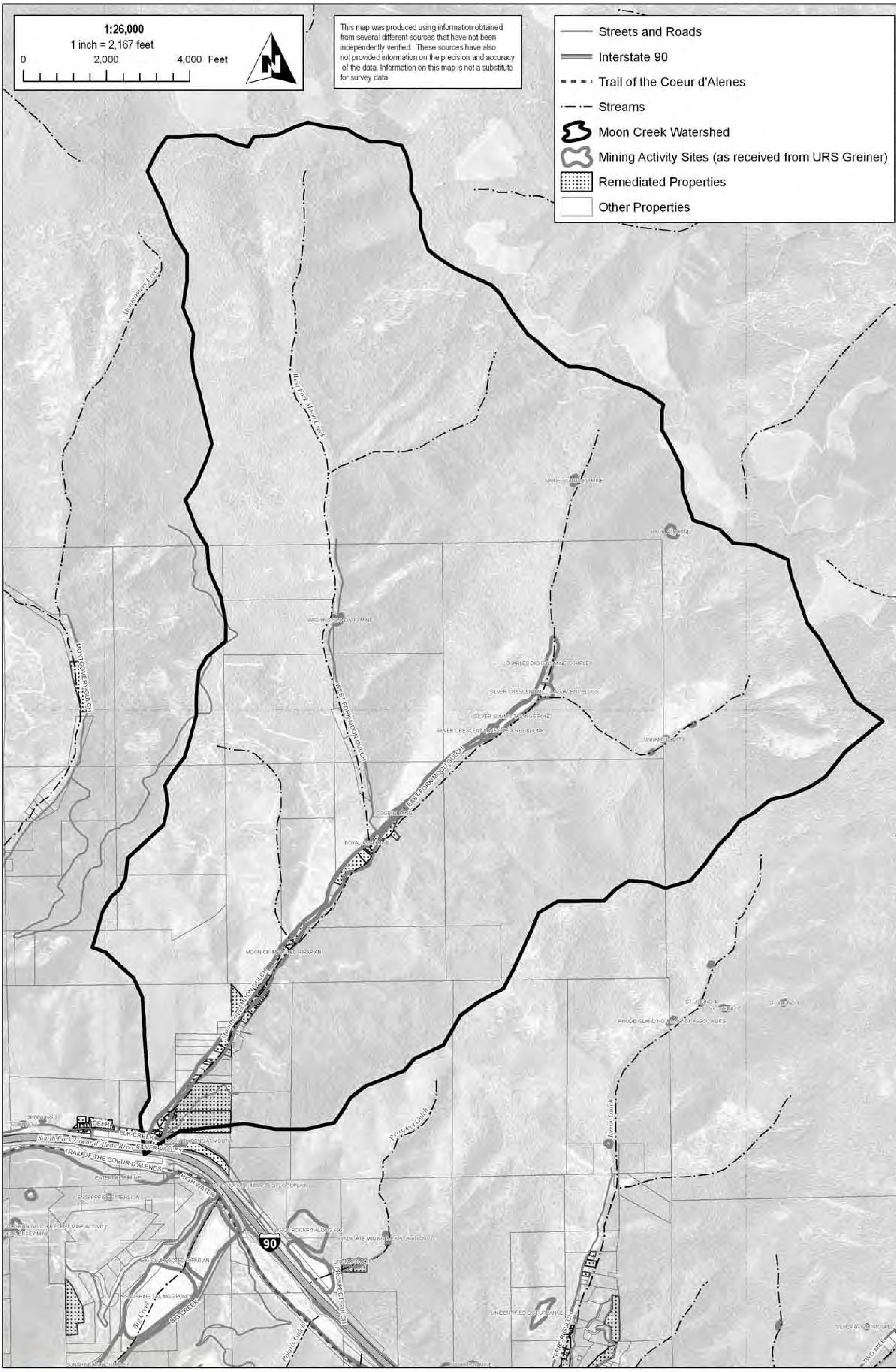
www.TerraGraphics.com

FILE: Bunker / ROD_2009/2_14_elk_a	REQUESTOR: D. Forseth	PROJECT NAME: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.
PRINT DATE: January 7, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

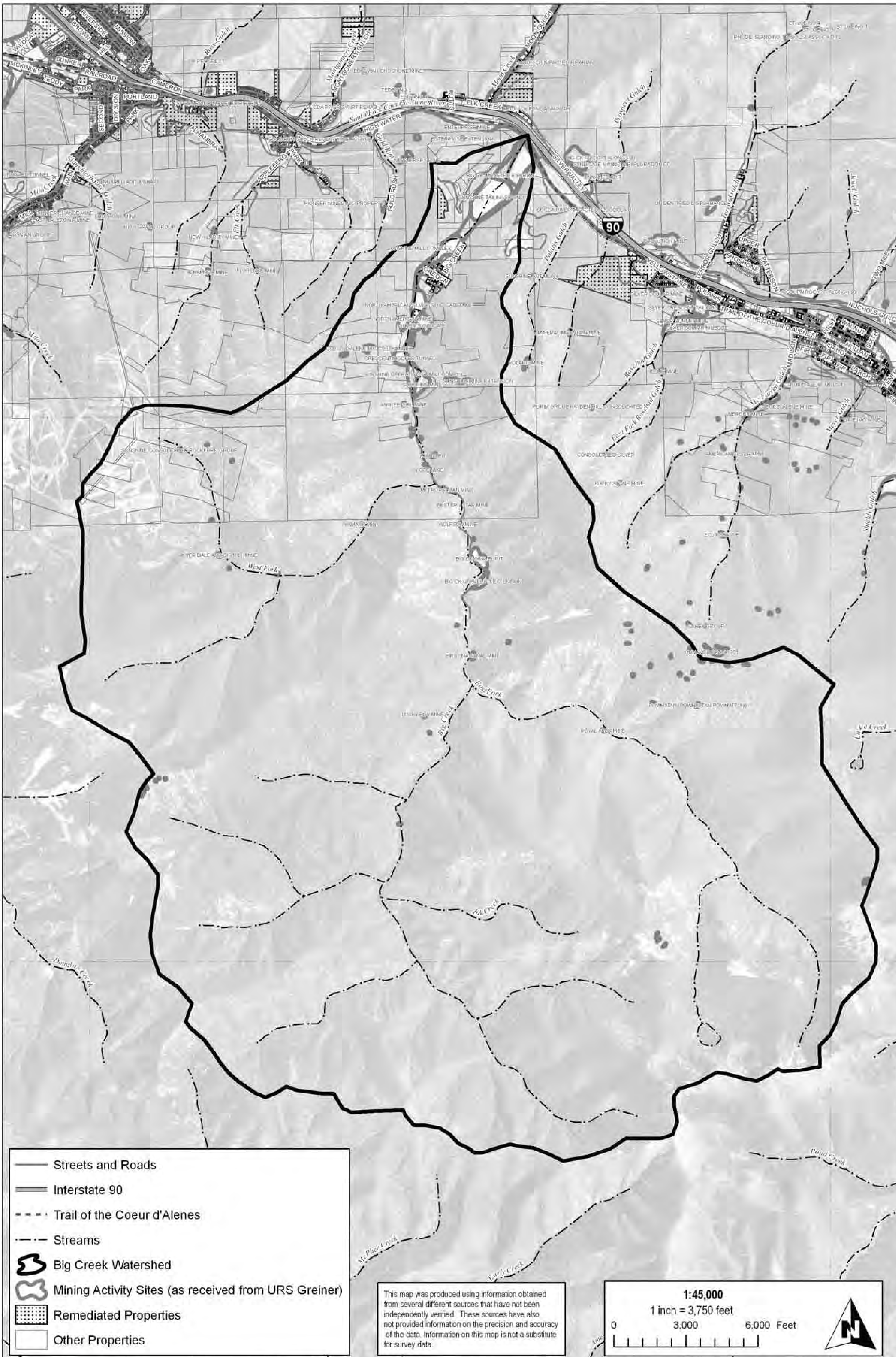
1:5,000
1 inch = 417 feet
0 400 800 Feet

Figure 2-14A
Elk Creek Watershed



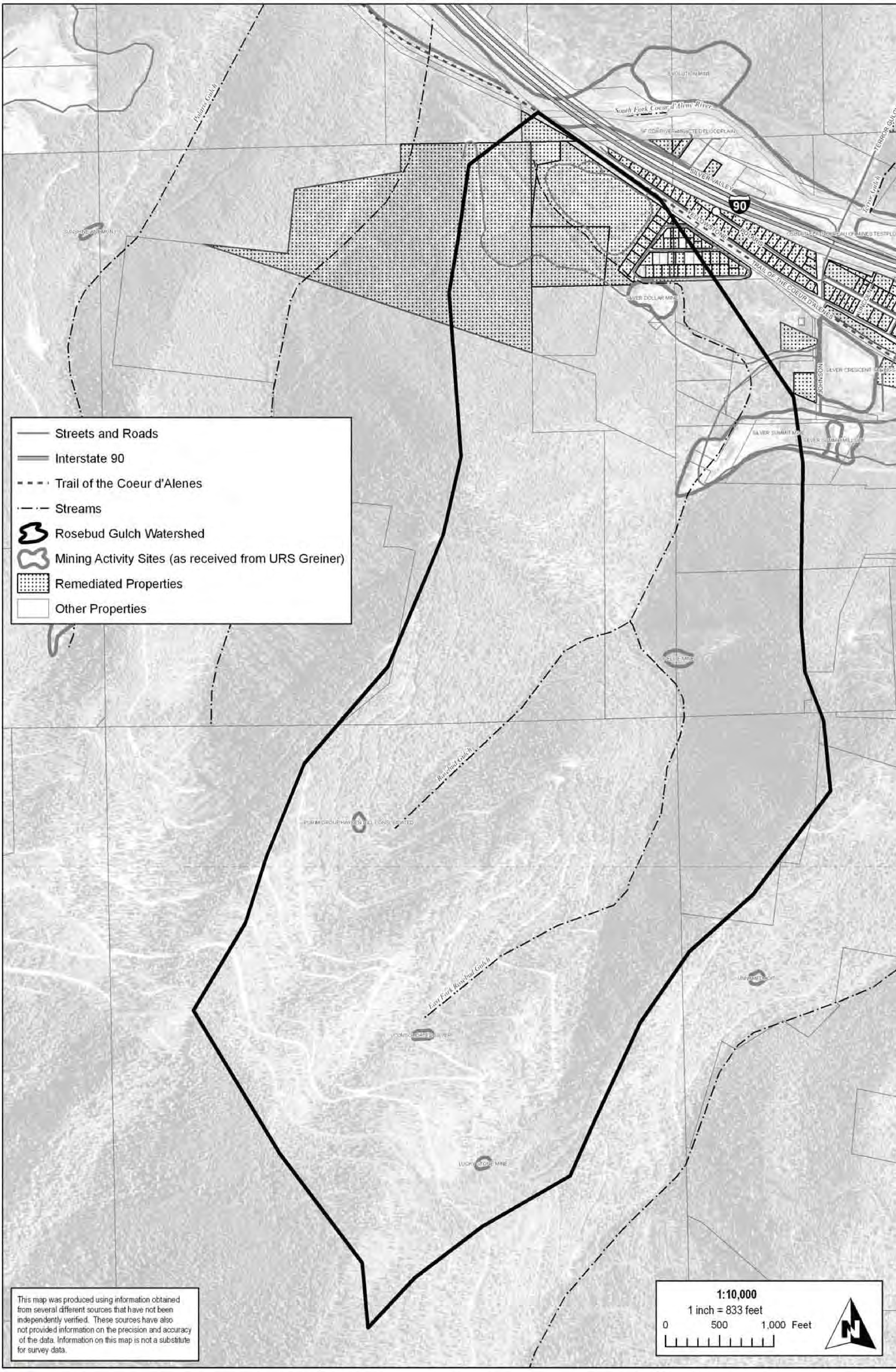
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_15_moon	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-15
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		**Moon Creek Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_15_moon_a PRINT DATE January 7, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-15A **Moon Creek Watershed**



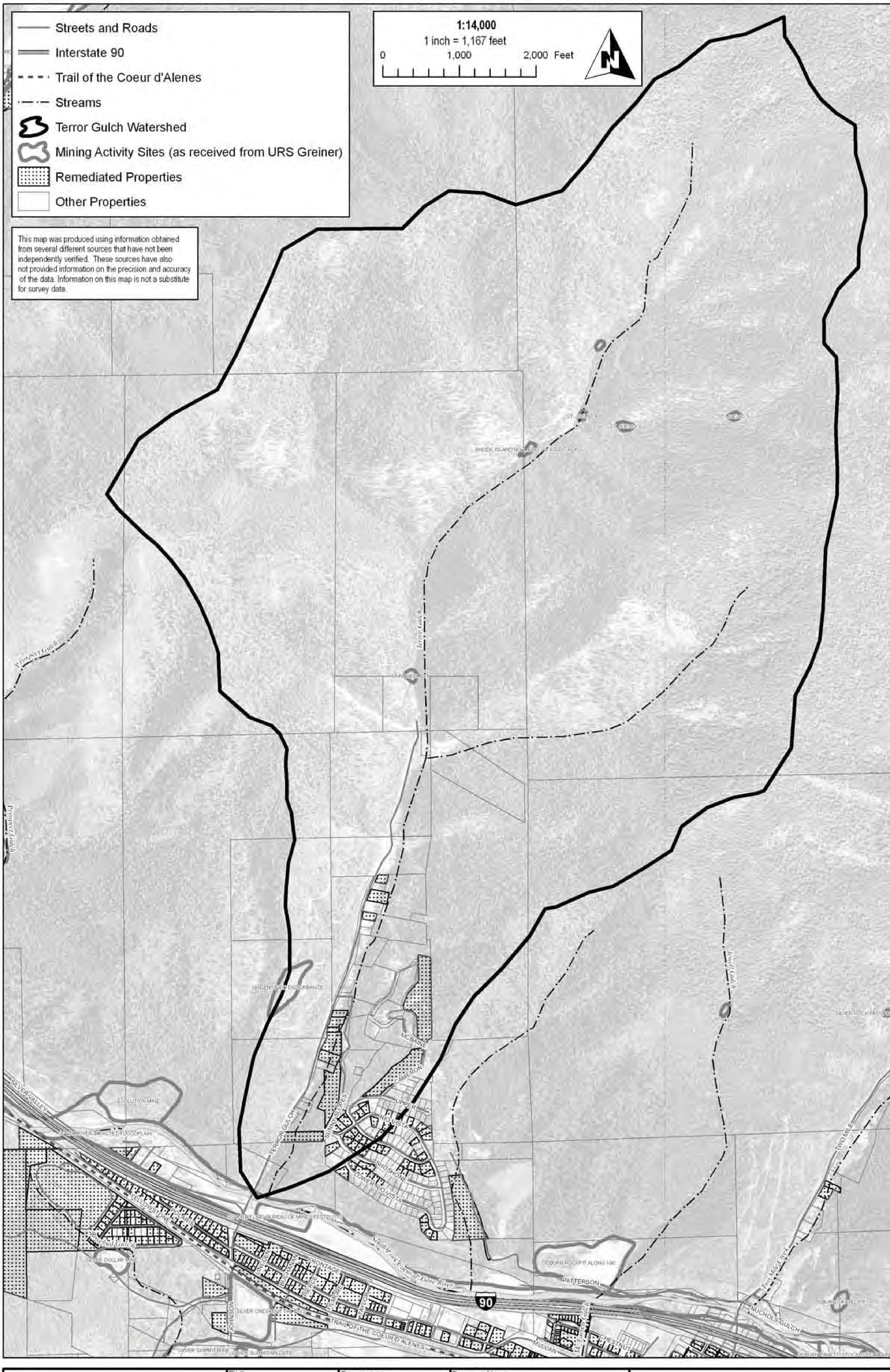
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_16_big	REQUESTOR D. Forseth	PROJECT NAME	Figure 2-16
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Big Creek Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_16_big_a Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-16A **Big Creek Watershed**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_17_rosebud	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-17
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Rosebud Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

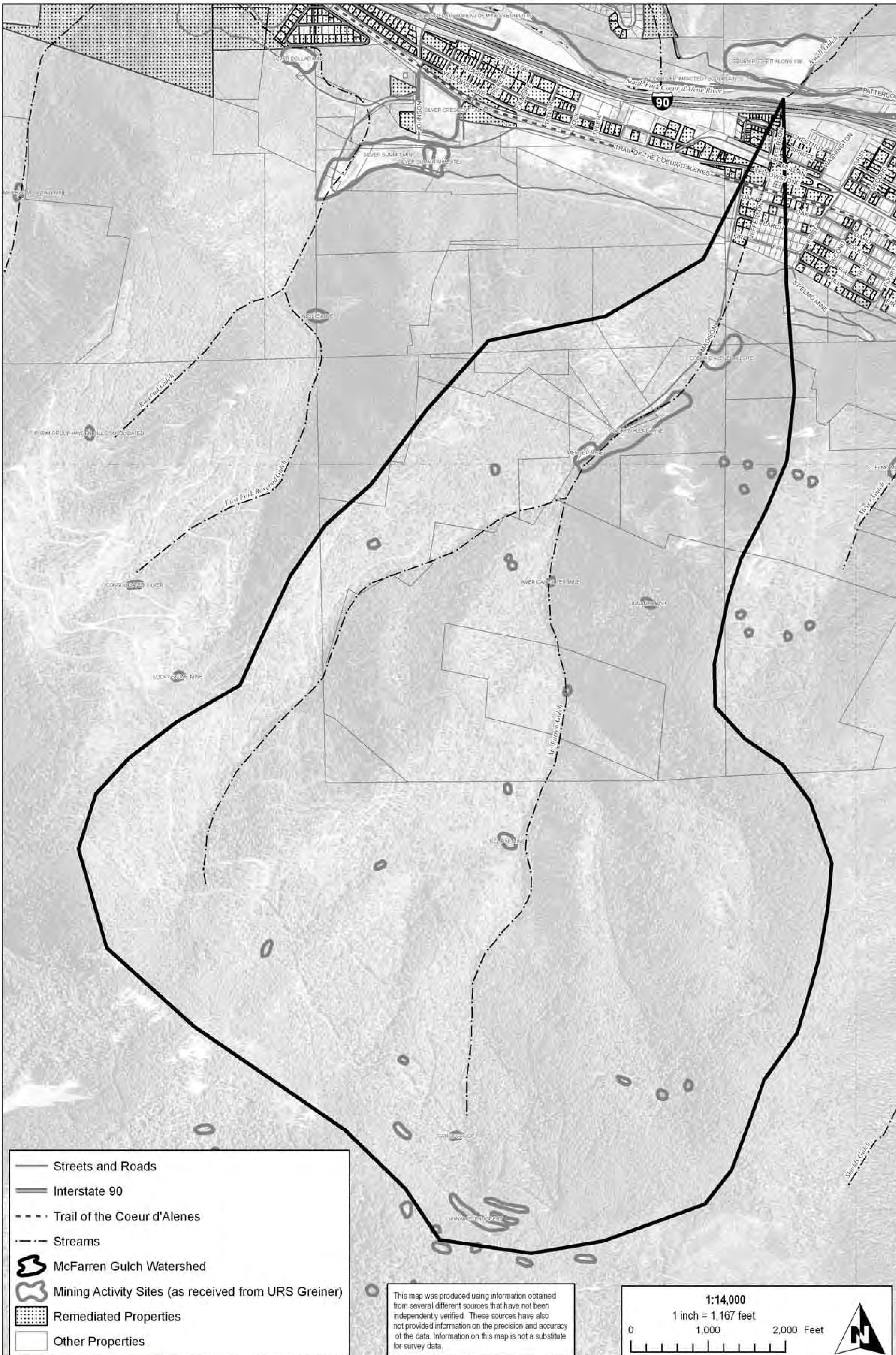
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_17_rosebud_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-17A
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Rosebud Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



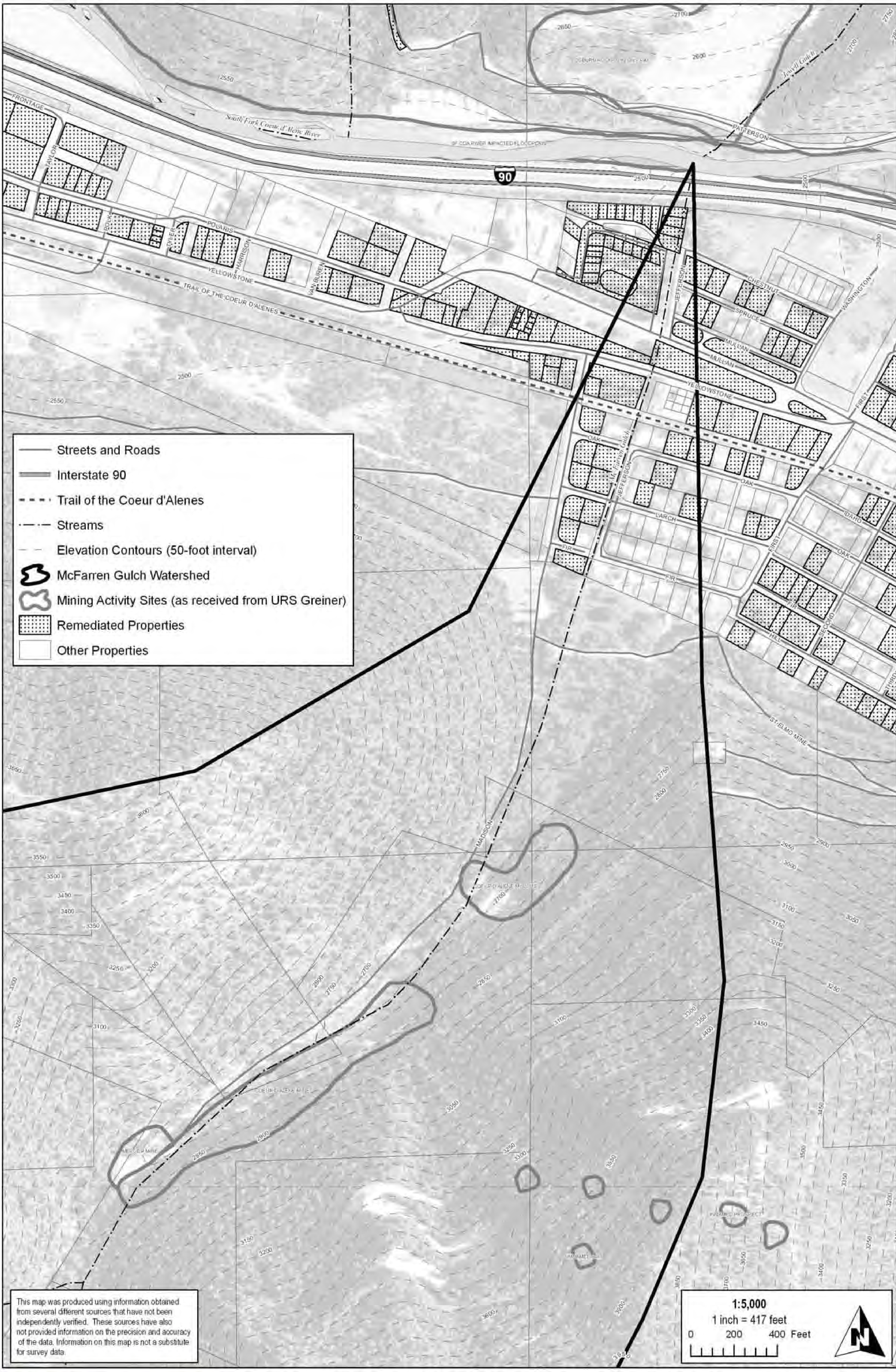
TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

File	Requestor	Project Name	Figure 2-18
Bunker / ROD_2009/2_18_terror	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Terror Gulch Watershed**
Print Date: January 7, 2010	Project Manager: D. Forseth		
Project Number: 2010-5050	Cartographer: B. Bailey		

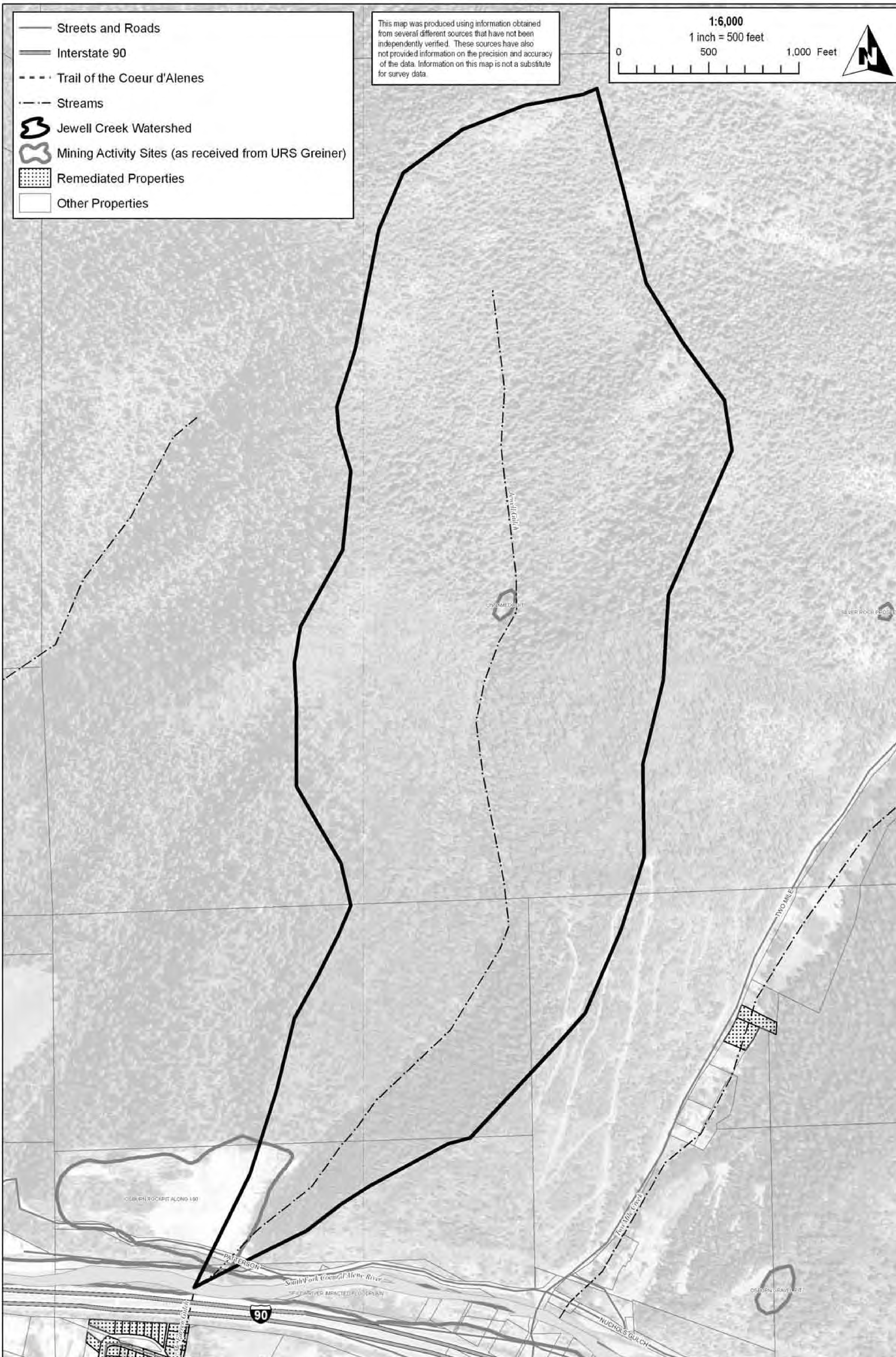
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_18_terror_a	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-18A
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		**Terror Gulch Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



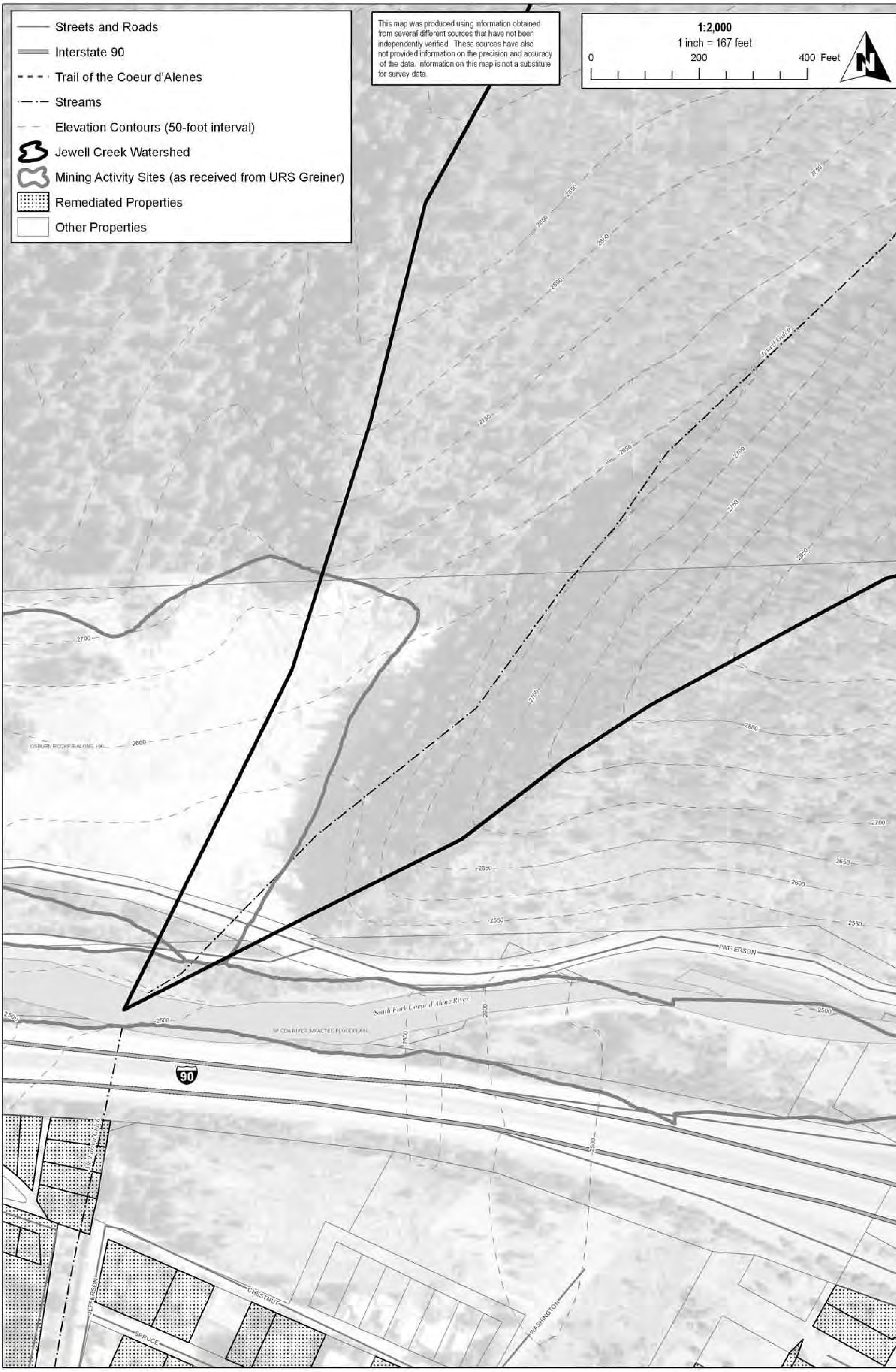
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/2_19_mcfarren Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-19 **McFarren Gulch Watershed**



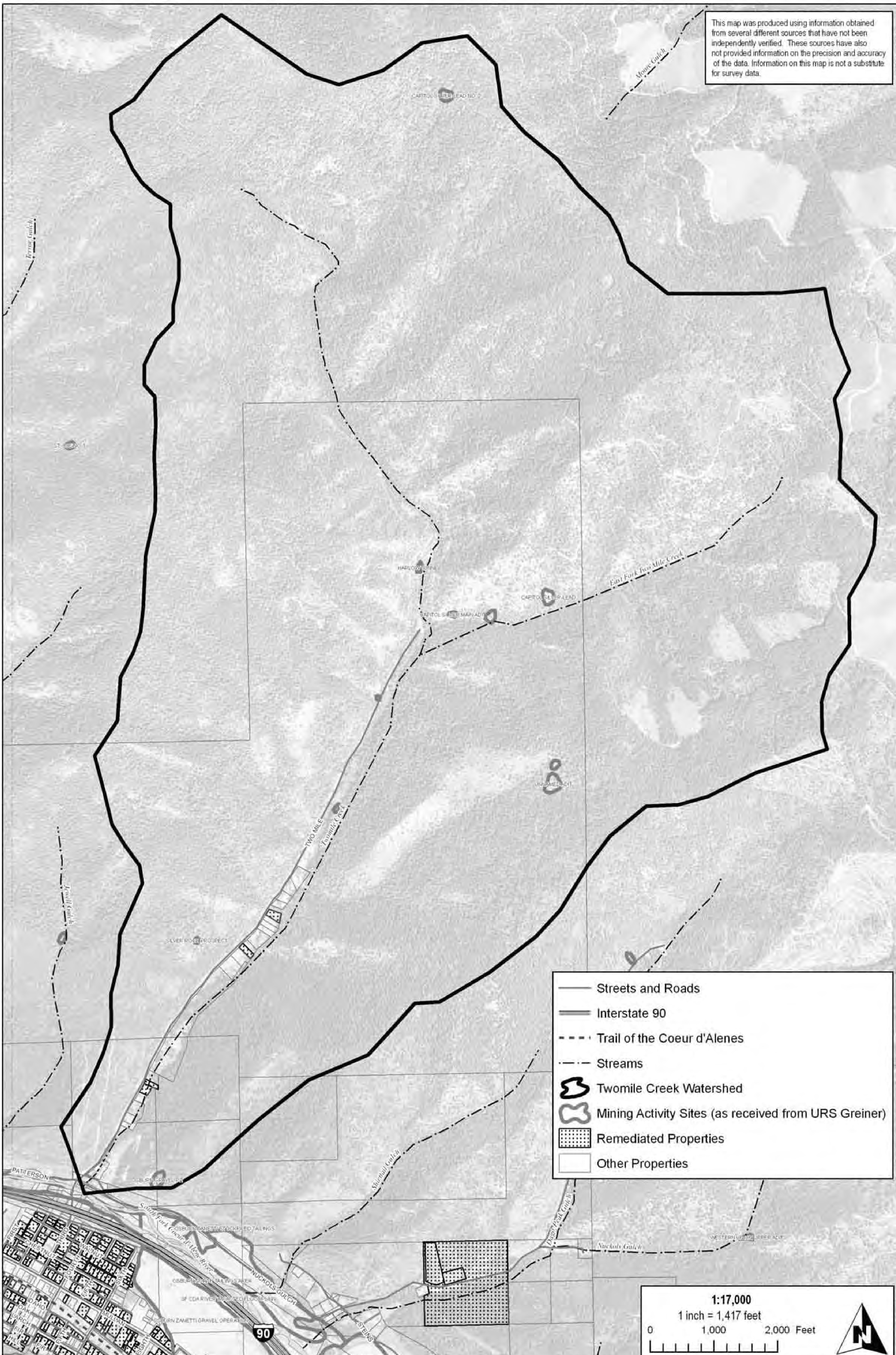
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_19_mcfarren_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-19A
	Print Date: January 7, 2010	Project Manager: D. Forseth		**McFarren Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



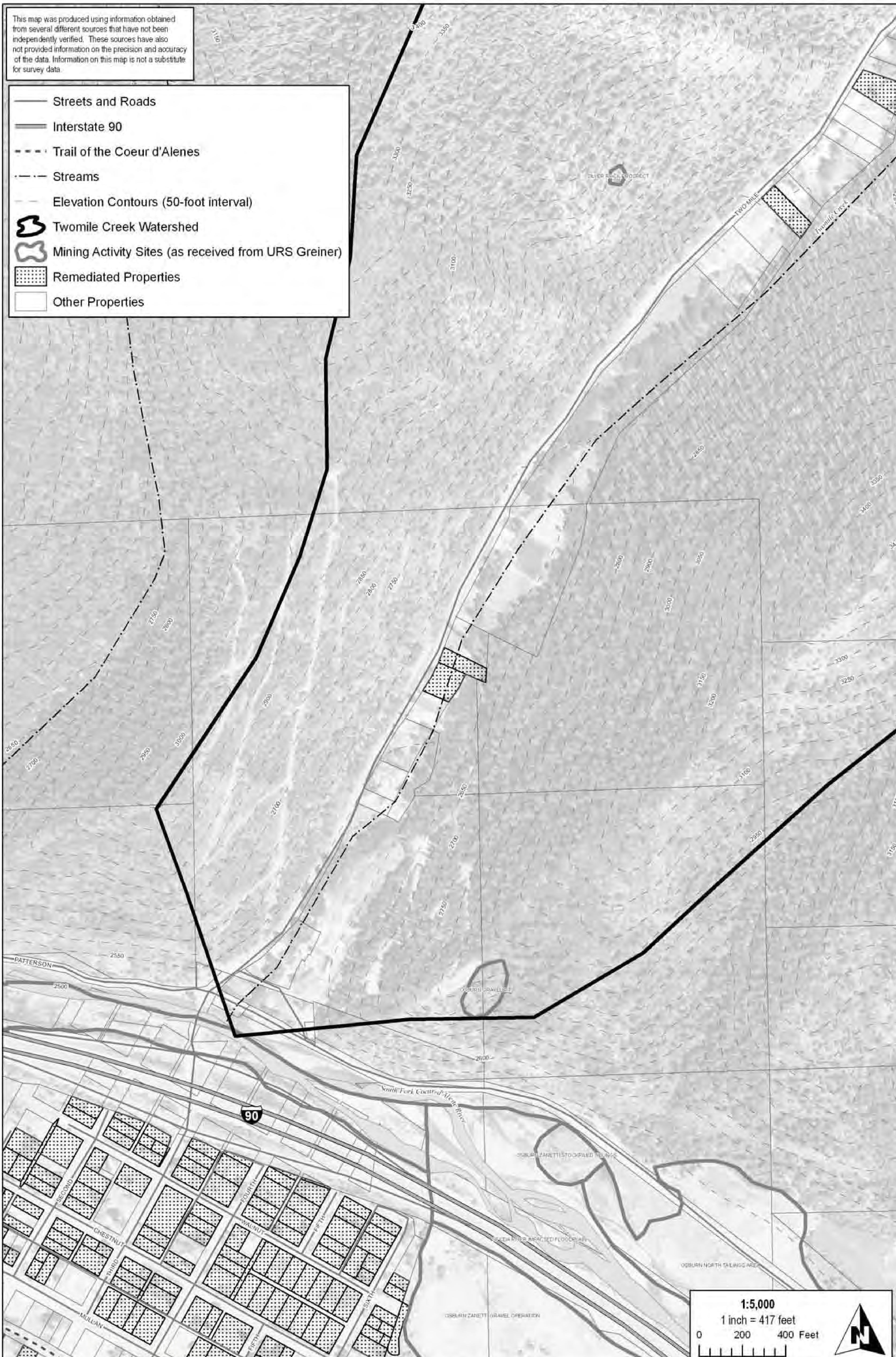
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_20_jewell	Requestor: D. Forseth	Project Name	Figure 2-20
	Print Date: January 6, 2010	Project Manager: D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Jewell Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_20_jewell_a Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-20A Jewell Gulch Watershed



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_21_twomile	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-21
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Twomile Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		



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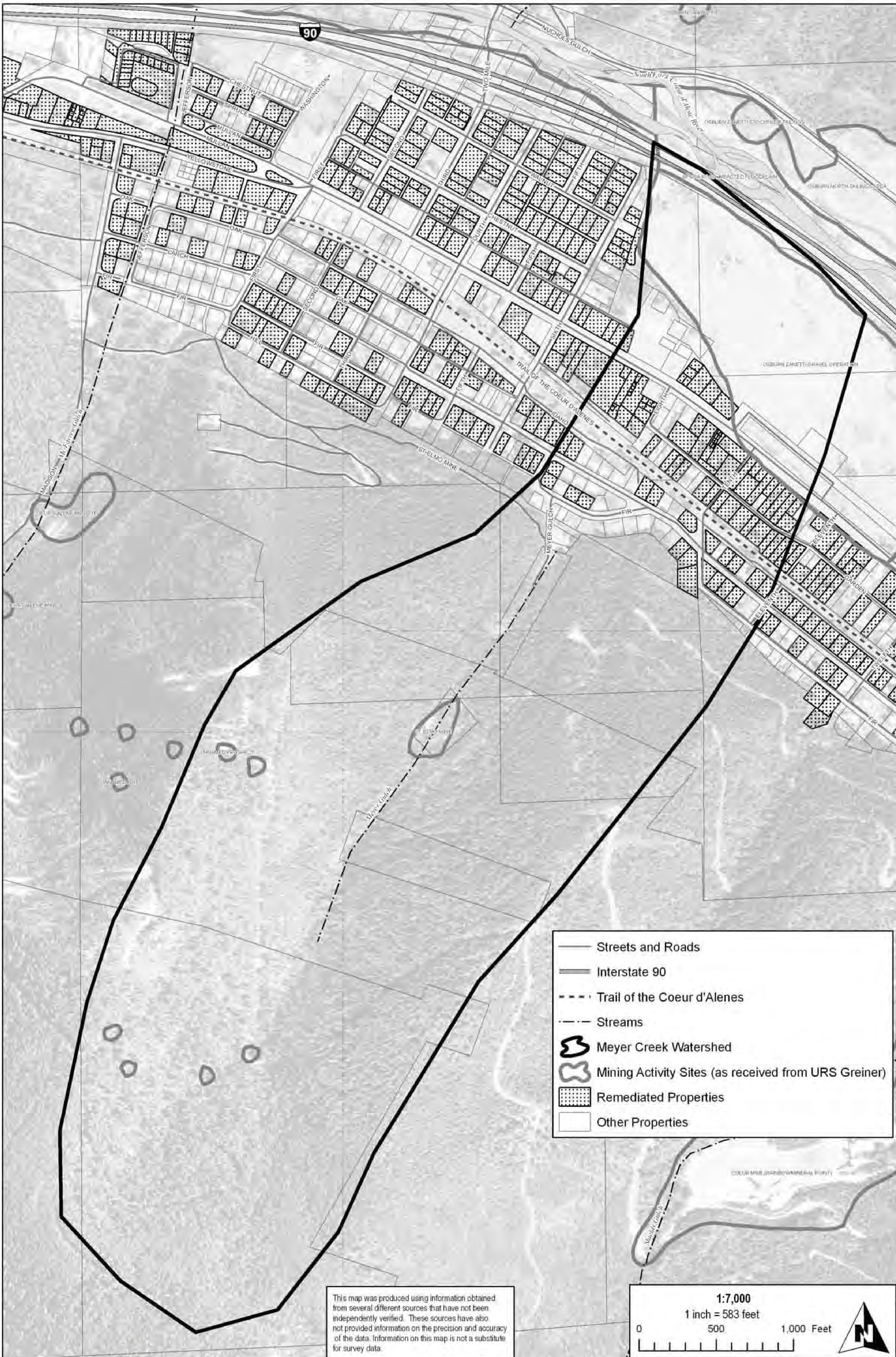
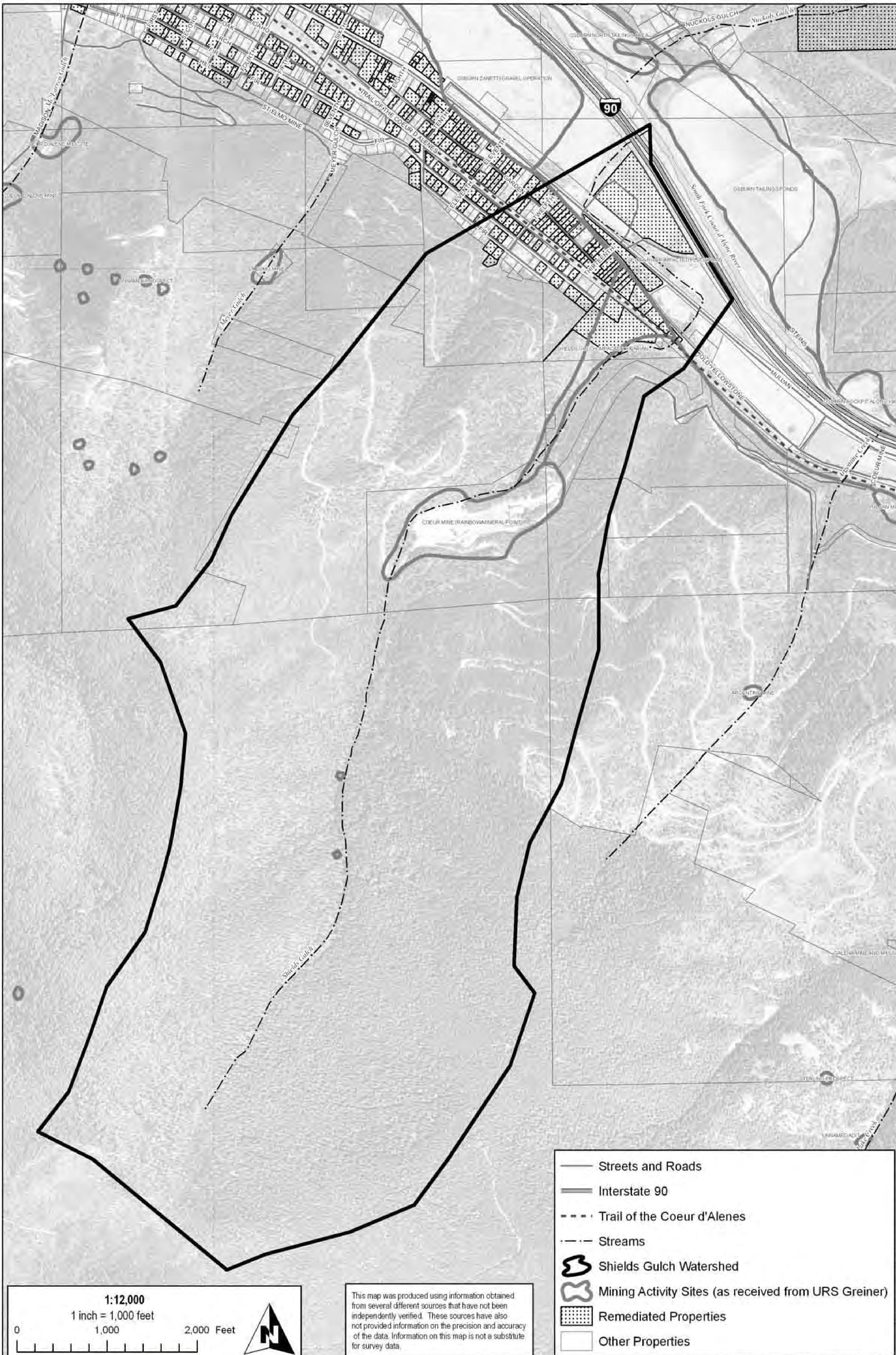
FILE Bunker / ROD_2009/2_21_twomile_a	REQUESTOR D. Forseth	PROJECT NAME	Figure 2-21A
PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth	**Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**Twomile Creek Watershed**
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_22_meyer	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-22
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Meyer Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

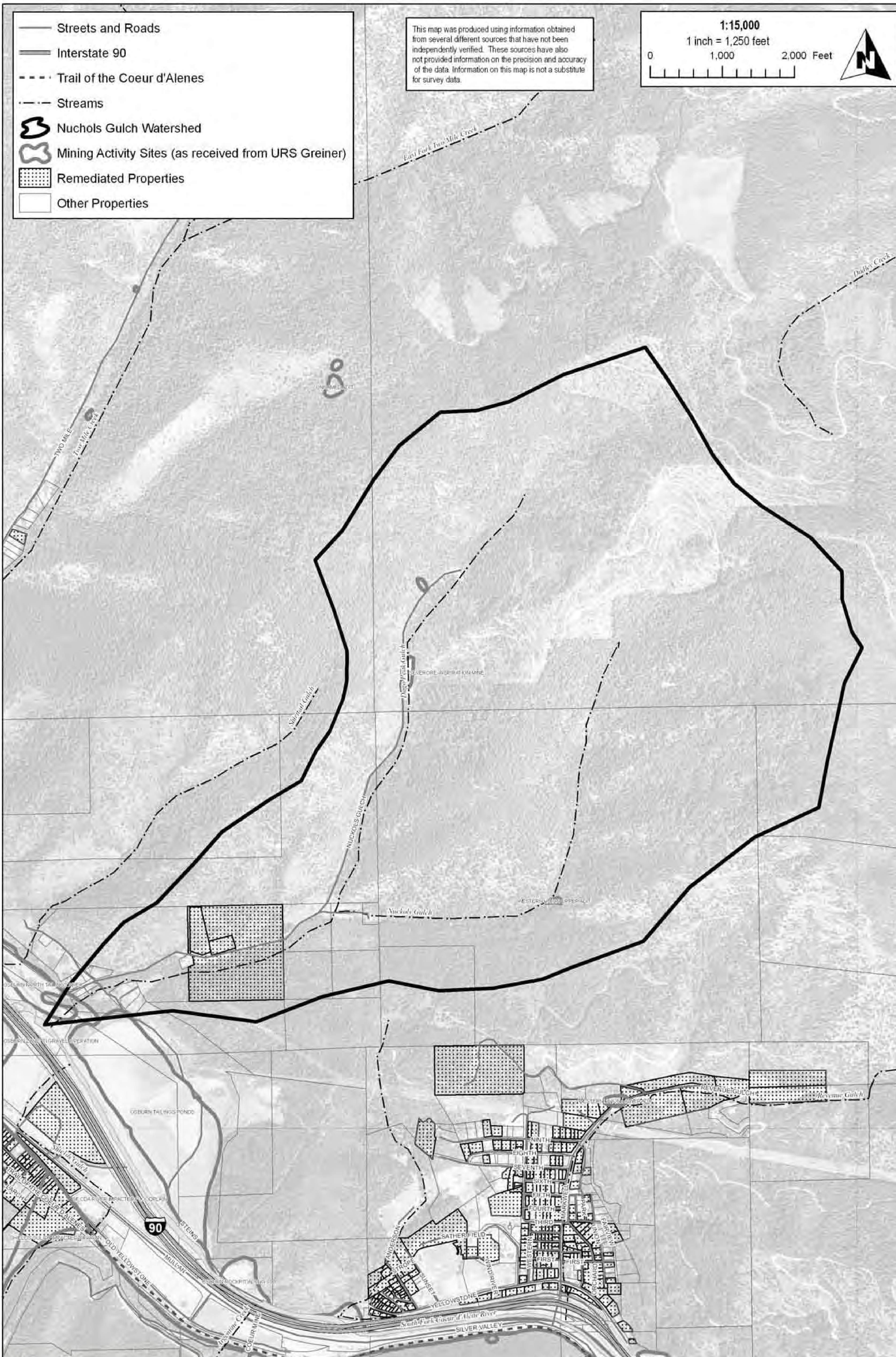
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_22_meyer_a PRINT DATE January 7, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-22A **Meyer Creek Watershed**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_23_shirttail	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-23 **Shirttail Gulch Watershed**
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_24_shields PRINT DATE January 6, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-24 **Shields Gulch Watershed**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_24_shields_a	REQUESTOR D. Forseth	PROJECT NAME Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-24A
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		**Shields Gulch Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROS_2009/2_25_nuckols Print Date: January 6, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-25 **Nuckols Creek Watershed**

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE Bunker / ROD_2009/2_25_nuckols_a	REQUESTOR D. Forseth	PROJECT NAME	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	1:4,000
PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin		1 inch = 333 feet
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey			0 200 400 Feet

Figure 2-25A

Nuckols Gulch Watershed

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FILE: Bunker / ROD_2009/2_26_unnamed	REQUESTOR: D. Forseth	PROJECT NAME: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-26
PRINT DATE: January 7, 2010	PROJECT MANAGER: D. Forseth		**Unnamed Drainage Watershed West of Silverton**
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

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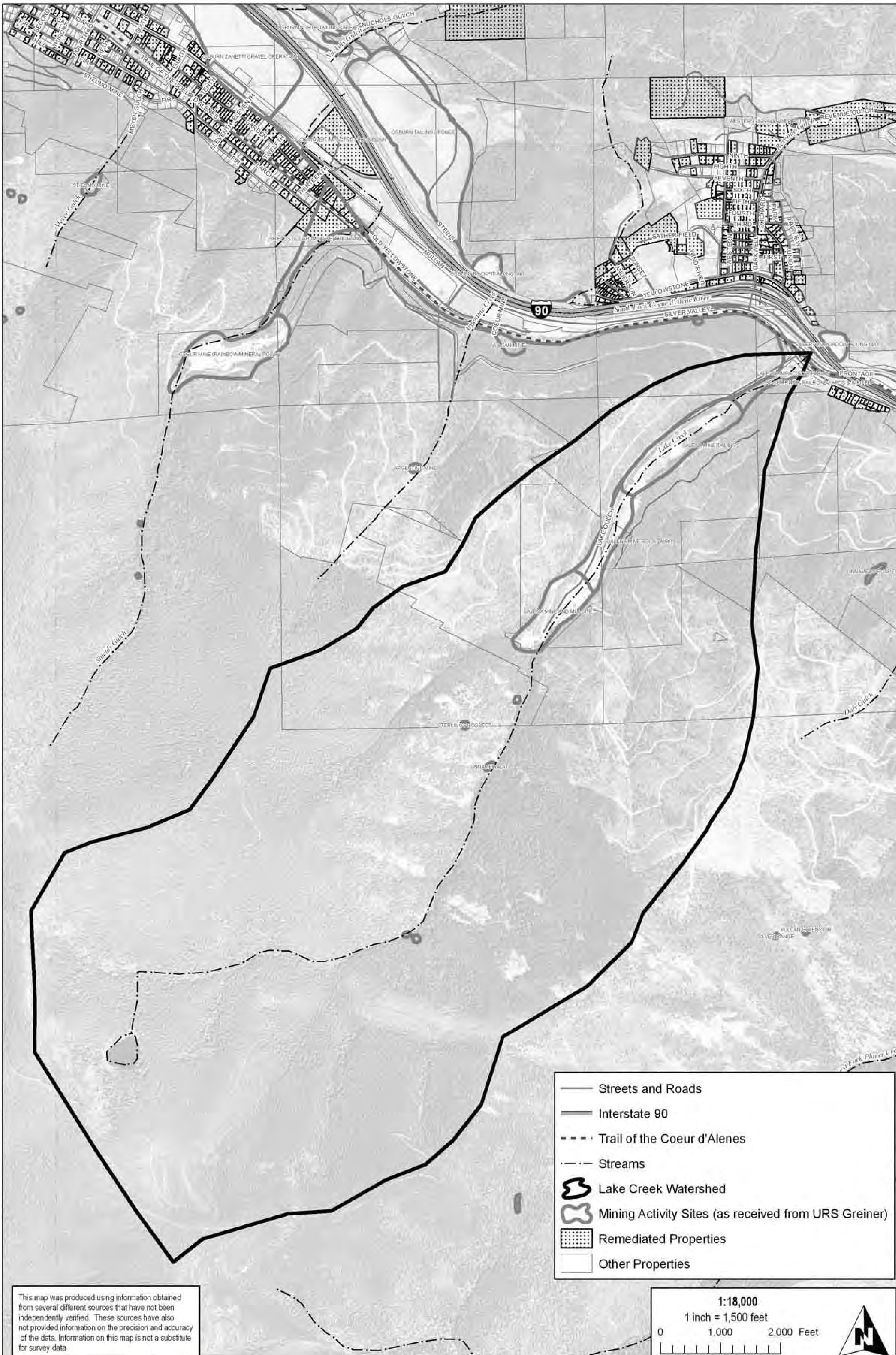
FILE	Bunker / ROD_2009/ 2_26_unnamed_a	REQUESTOR	D. Forseth	PROJECT NAME
PRINT DATE	January 7, 2010	PROJECT MANAGER	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey	

Figure 2-26A

Unnamed Drainage Watershed West of Silverton

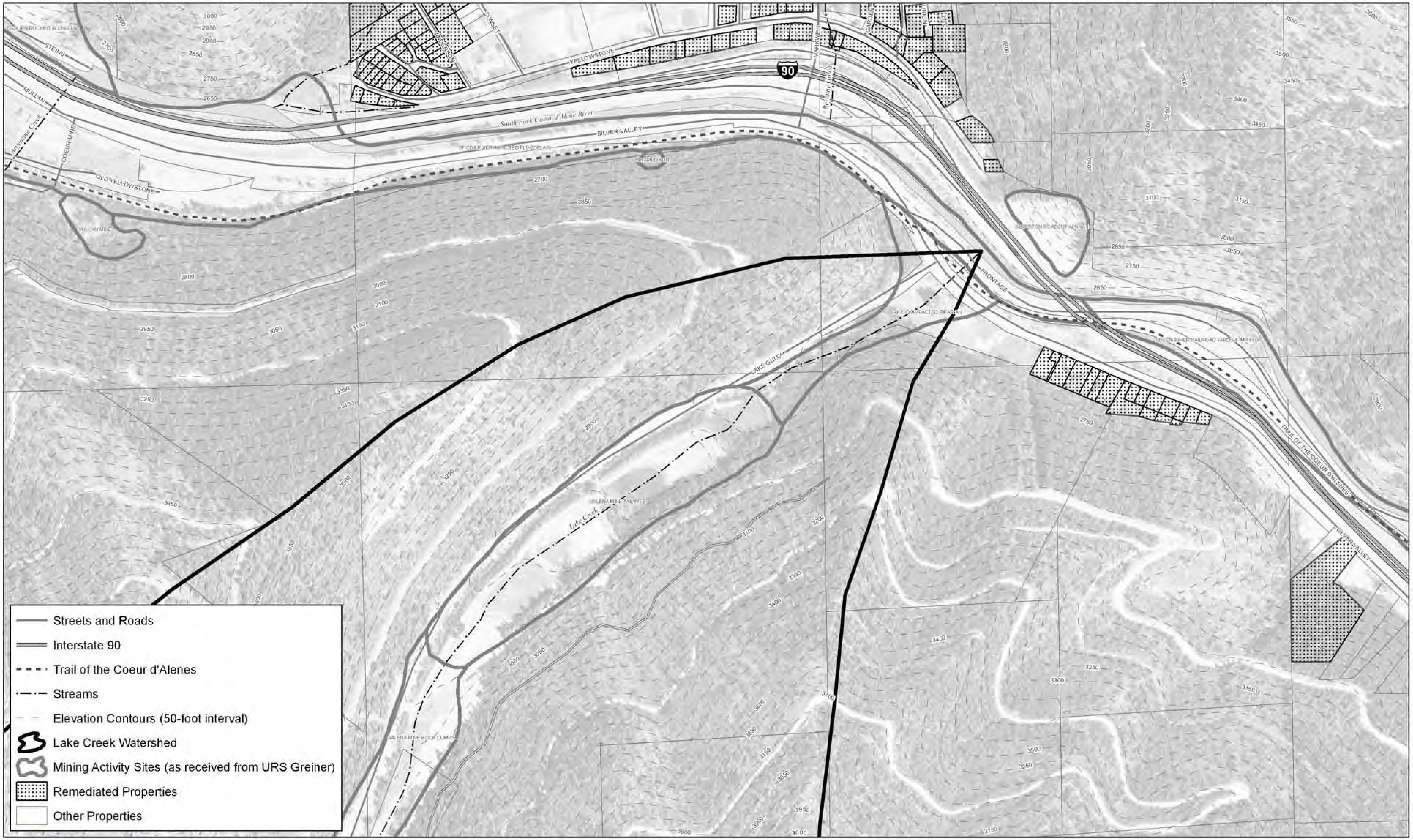


This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_27_lake Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-27 Lake Creek Watershed

Figure 2-27

Lake Creek Watershed



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FILE	Bunker / ROD_2009/2_27_lake_a	REQUESTOR	D. Forseth
PRINT DATE	January 7, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

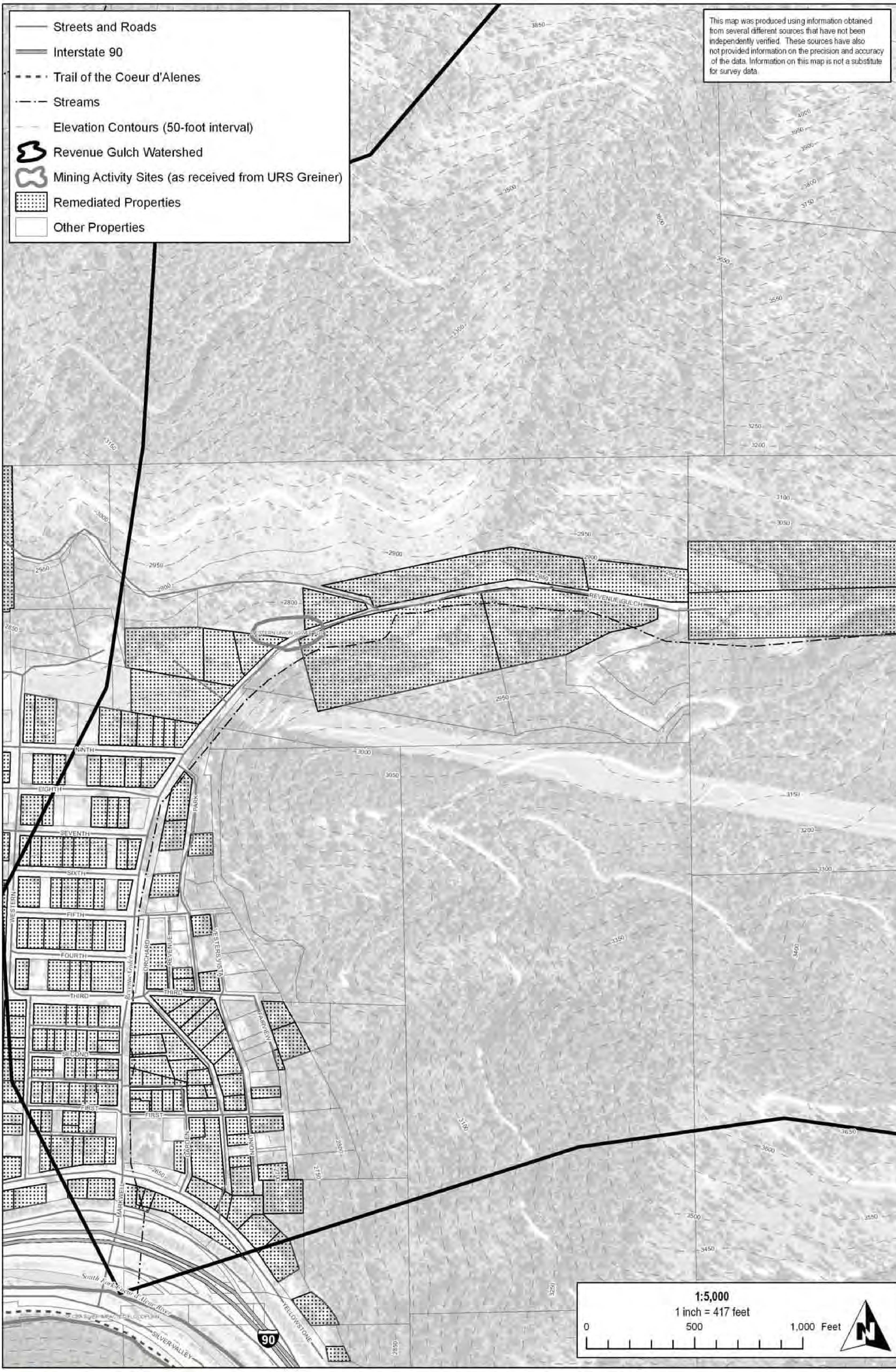
This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

1:6,000
1 inch = 500 feet
0 500 1,000 Feet

Figure 2-27A
Lake Creek Watershed

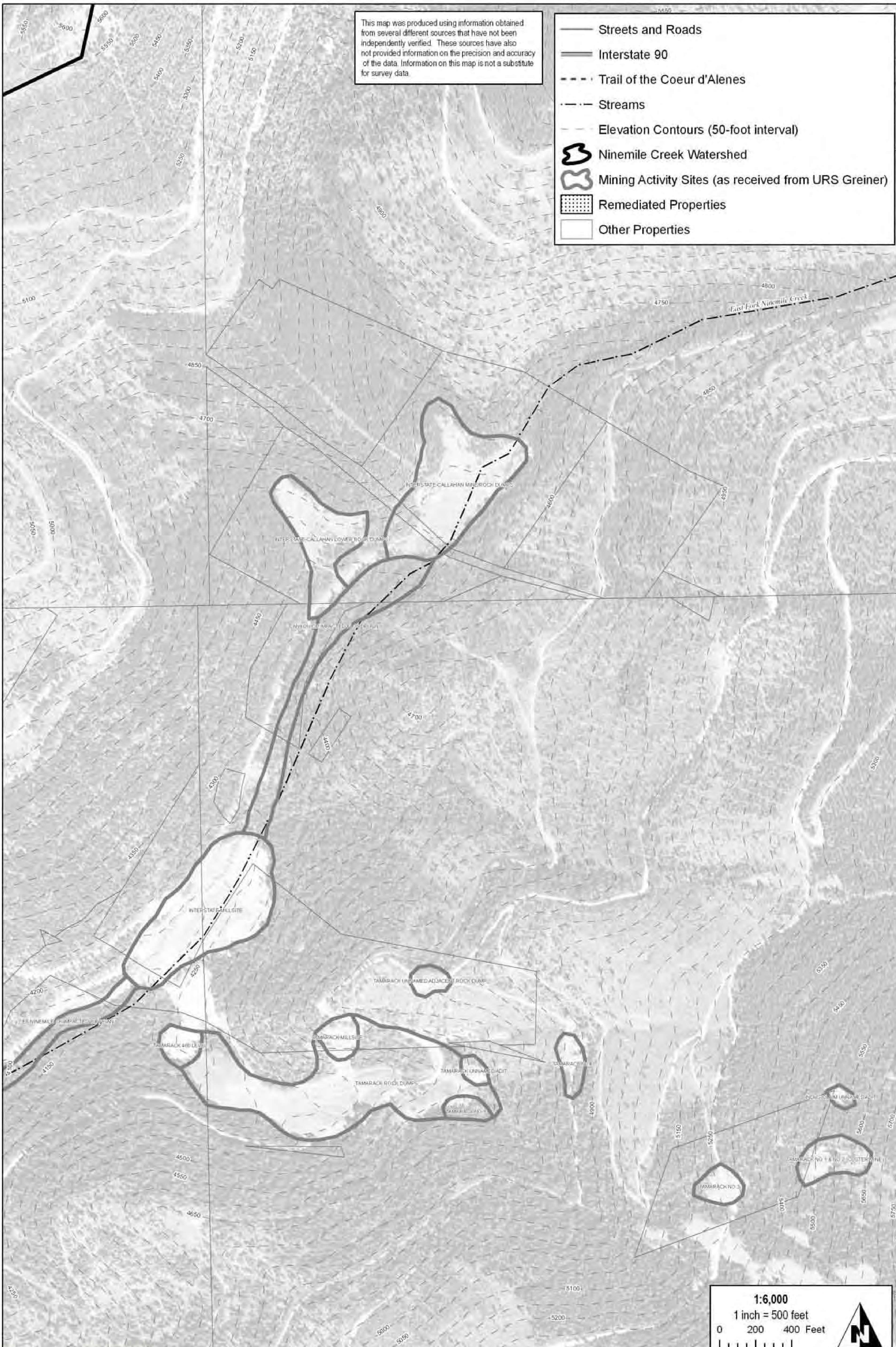
FILE Bunker / ROD_2009/2_28_Revenue	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-28
PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		**Revenue Gulch Watershed**
PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_28_revenue_a Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-28A **Revenue Gulch Watershed**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_29_ninemile	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Ninemile Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

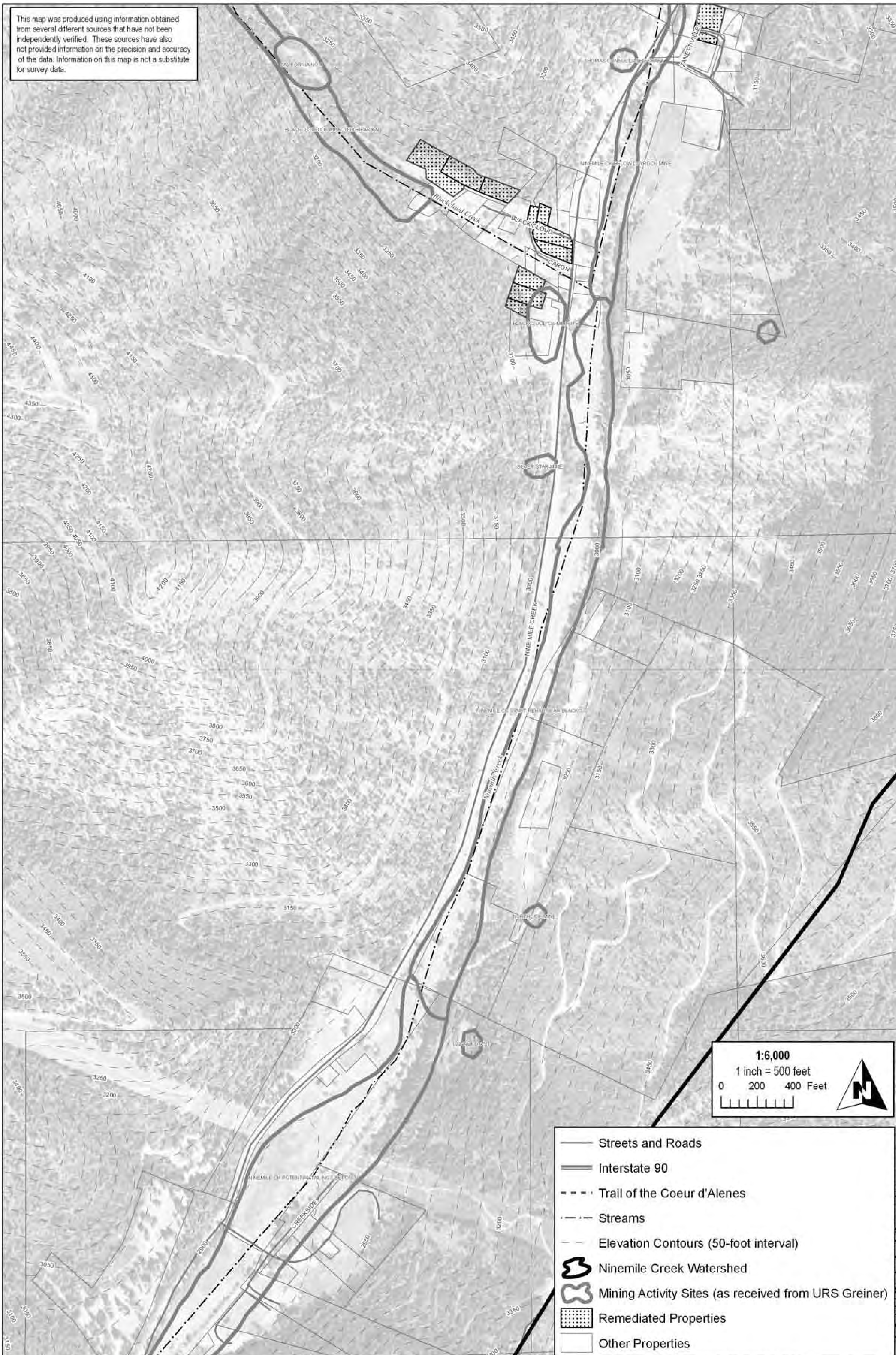


TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/2_29_ninemile_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29A
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Ninemile Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

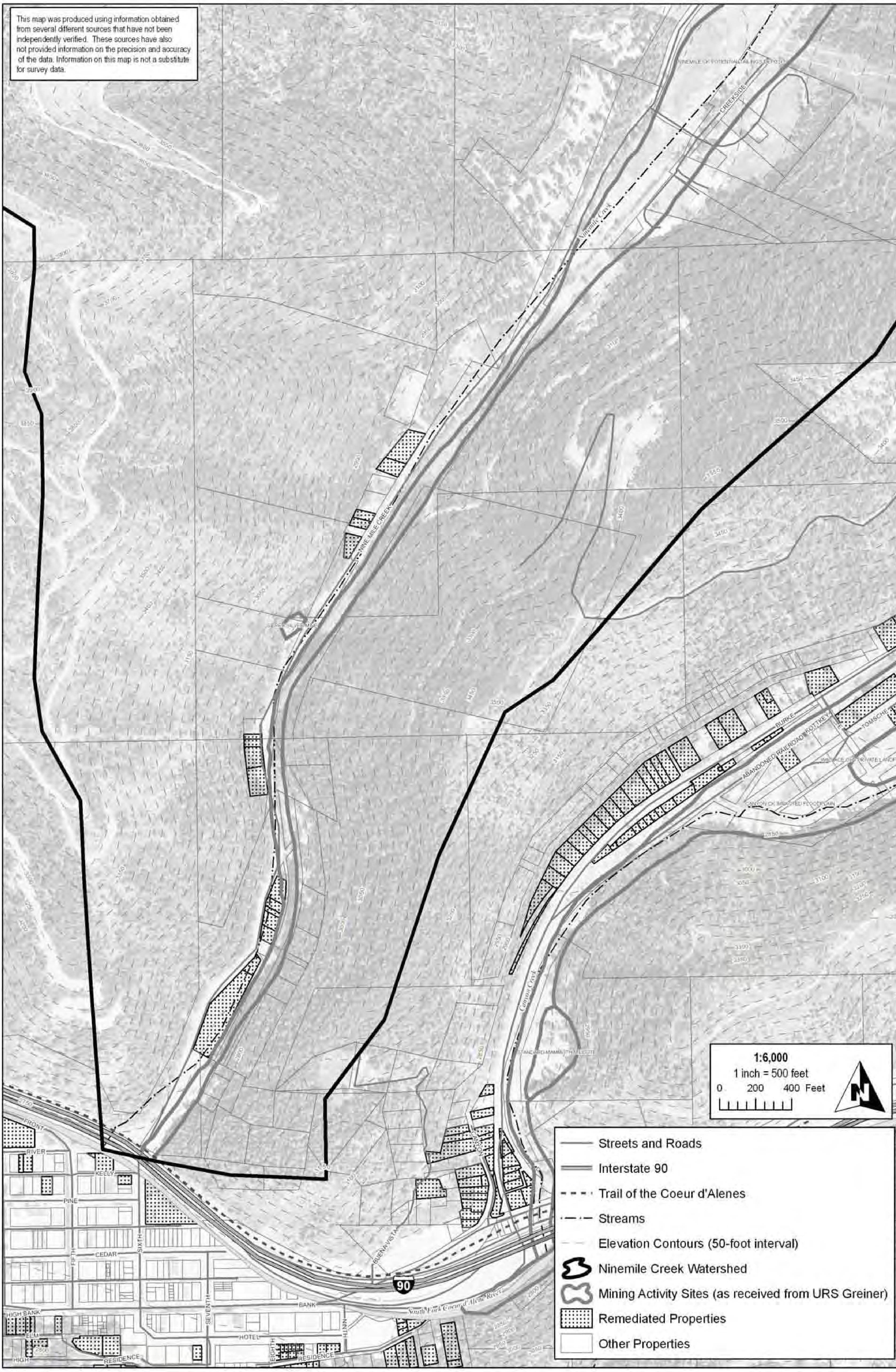
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_29_ninemile_b Print Date: January, 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29B **Ninemile Creek Watershed**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_29_ninemile_c	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29C
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Ninemile Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

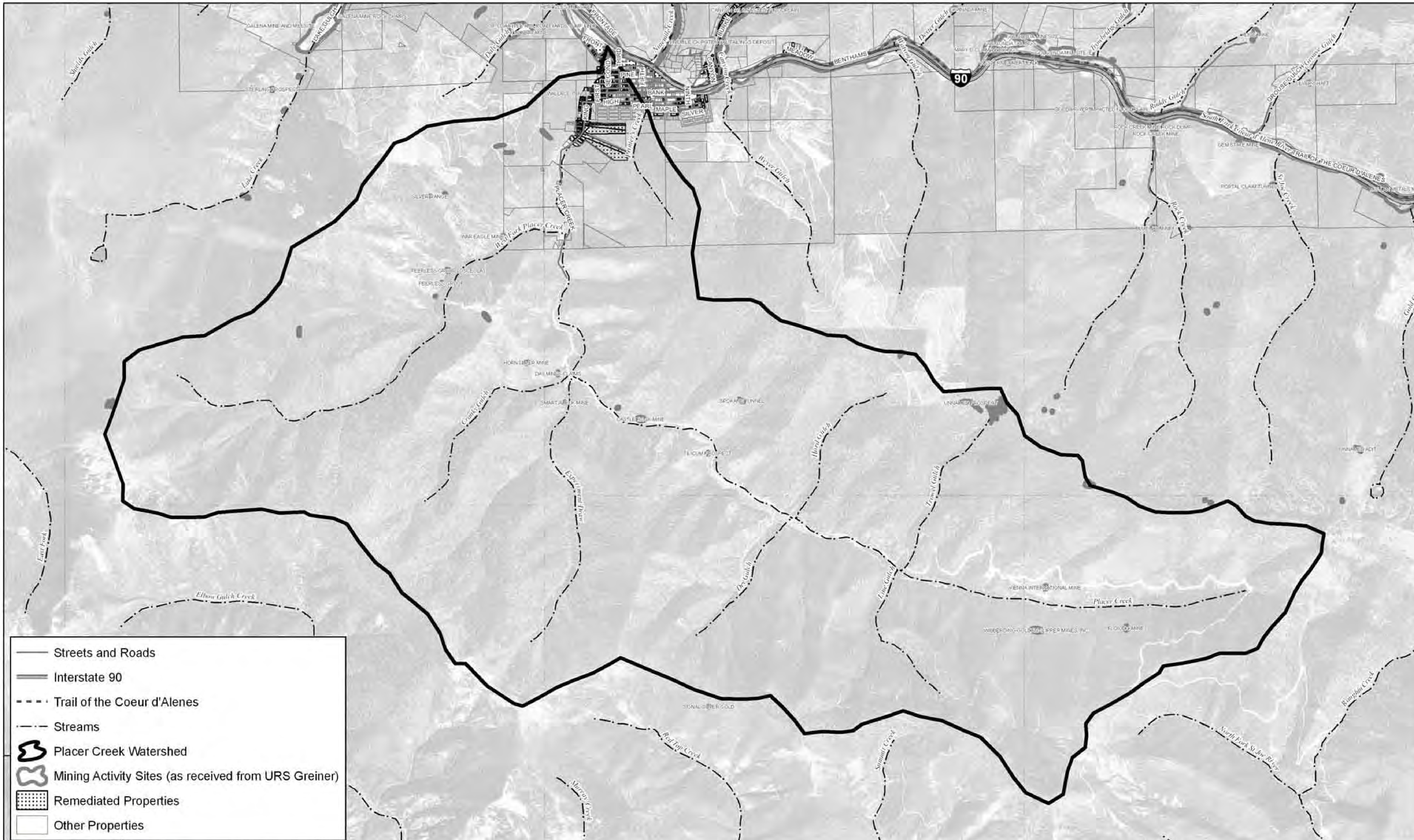
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_29_ninemile_d	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29D Ninemile Creek Watershed
	Print Date: January 7, 2010	Project Manager: D. Forseth		
	Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_29_ninemile_e PRINT DATE January 7, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-29E **Ninemile Creek Watershed**



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / ROD_2009/2_29_ninemile_f Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-29F **Ninemile Creek Watershed**



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FILE	Bunker / ROD_2009f2_30_placer	
PRINT DATE	January 7, 2010	
PROJECT NUMBER	2010-5050	
REQUESTOR	D. Forseth	
PROJECT MANAGER	D. Forseth	
CARTOGRAPHER	B. Bailey	

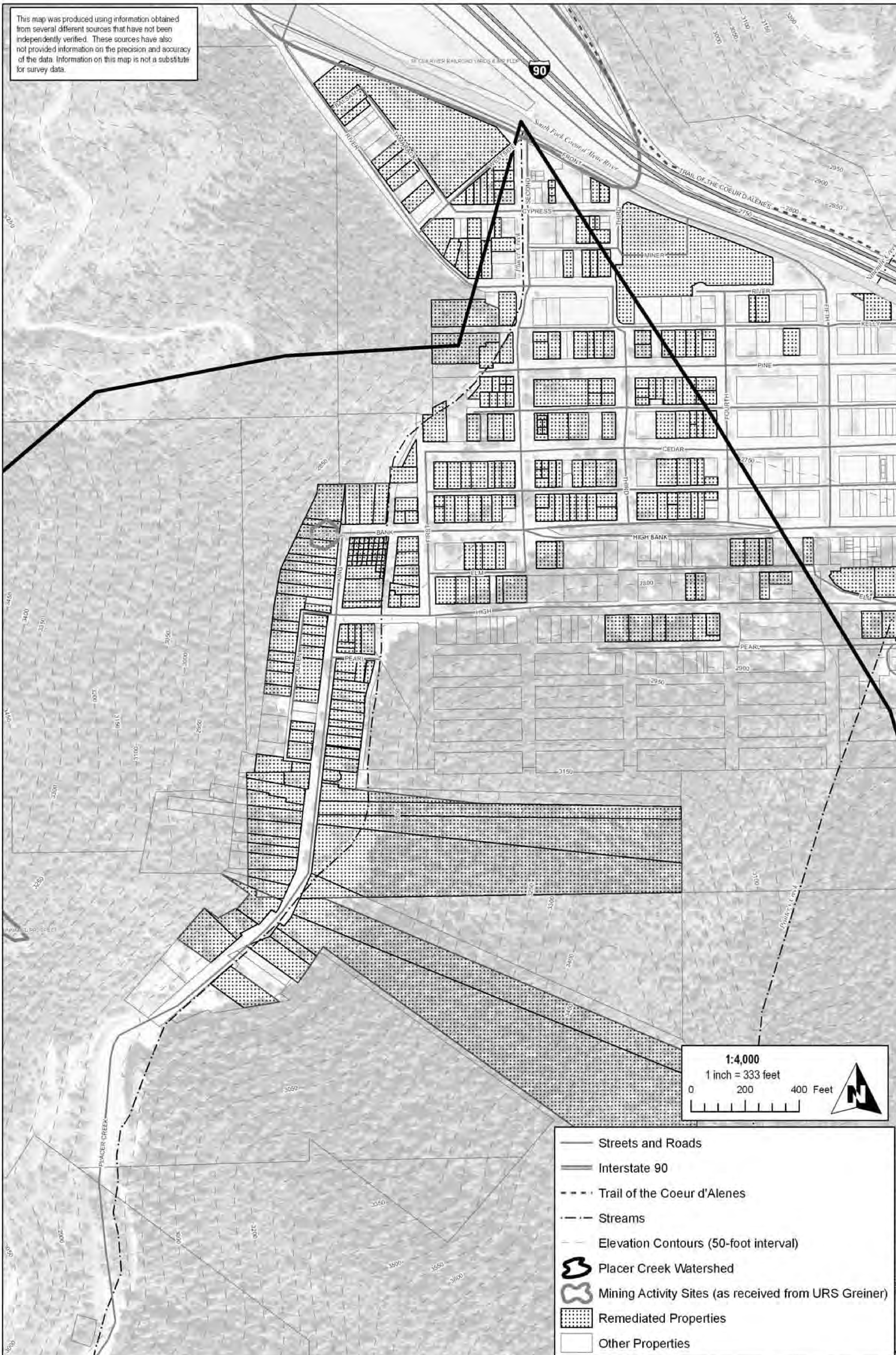
PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

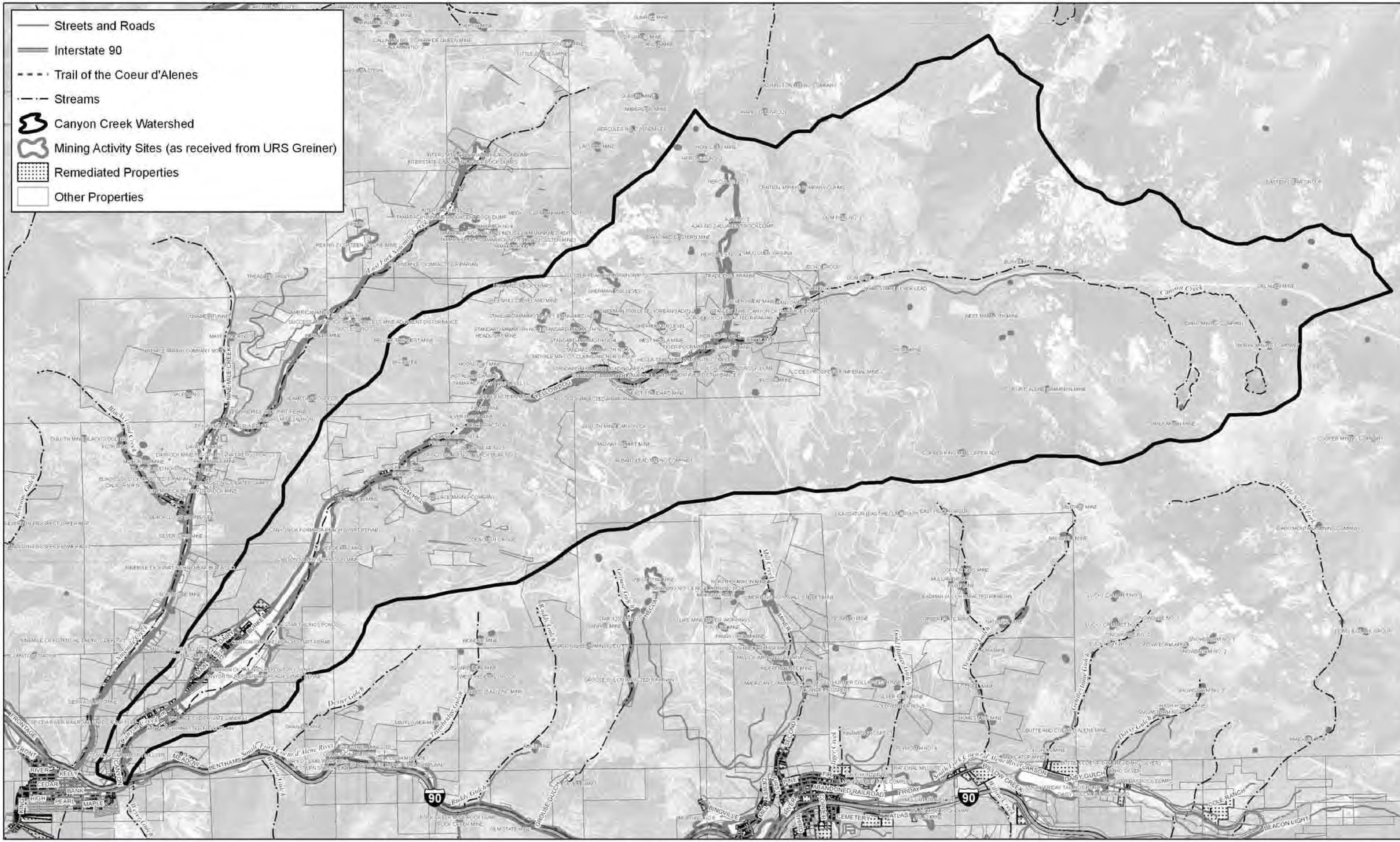
1:35,000
1 inch = 2,917 feet
0 2,000 4,000 Feet

N

Figure 2-30
Placer Creek Watershed



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker/ROD_2009/2_30_placer_a Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-30A **Placer Creek Watershed**



TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

File: Bunker /ROD_2009/2_31_canyon	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin
Print Date: January 7, 2010	Project Manager: D. Forseth	
Project Number: 2010-5050	Cartographer: B. Bailey	

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

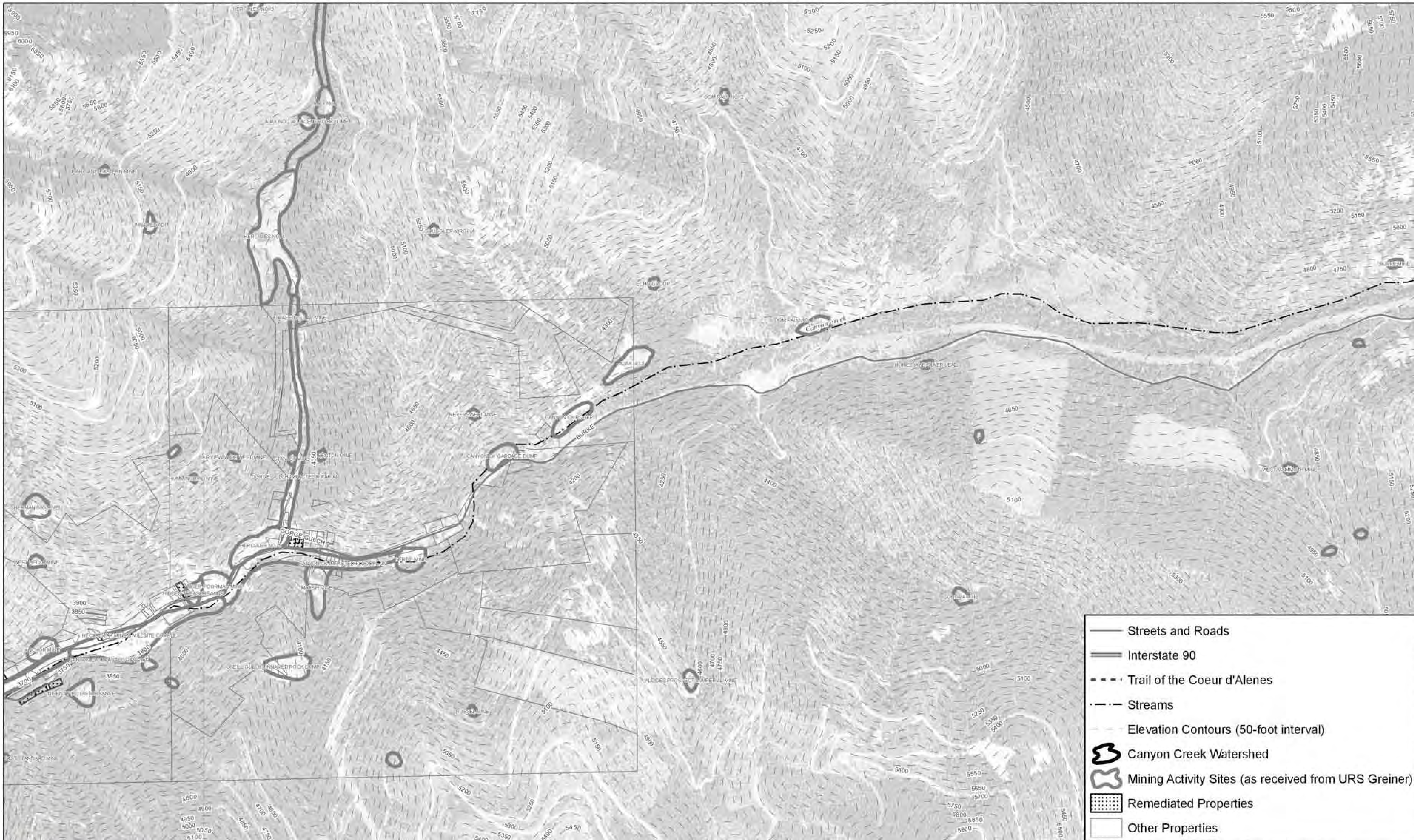
1:45,000
1 inch = 3,750 feet
0 2,000 4,000 Feet

Figure 2-31
Canyon Creek Watershed

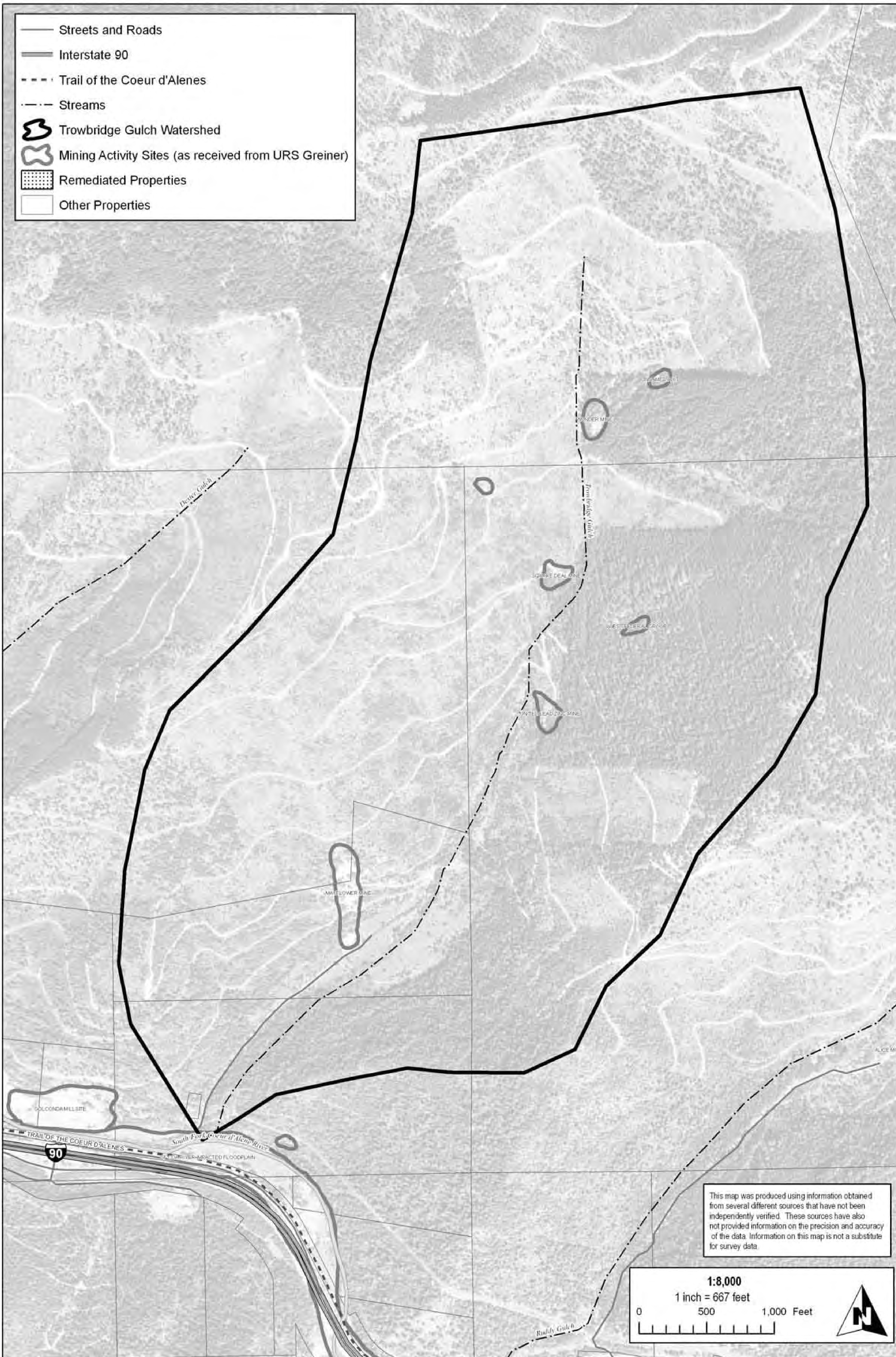
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/2_31_canyon_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-31A
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Canyon Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/2_31_canyon_b Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-31B **Canyon Creek Watershed**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_31_canyon_c PRINT DATE January 7, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-31C **Canyon Creek Watershed**



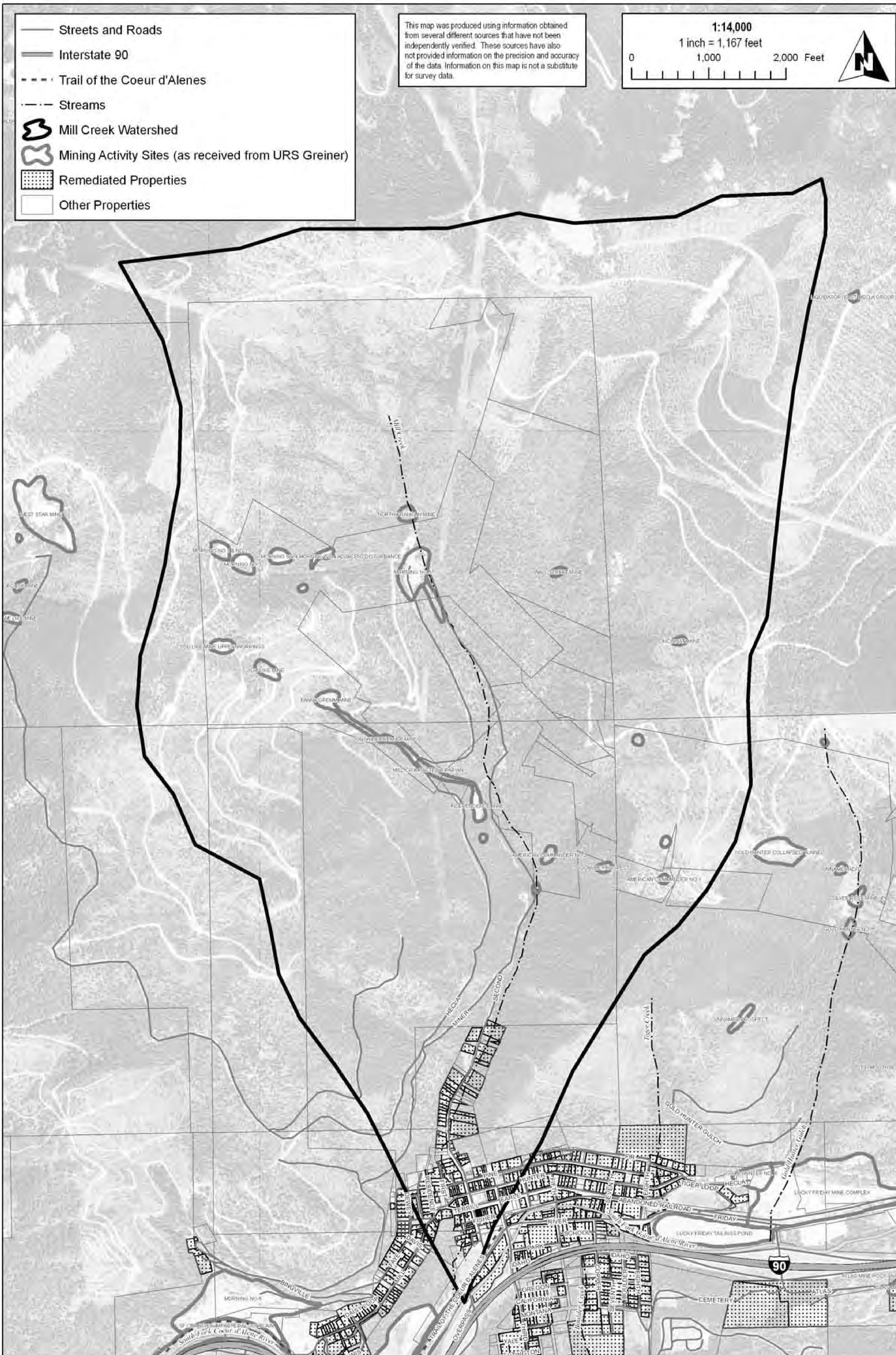
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/2_31_canyon_d Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	1:12,000 1 inch = 1,000 feet 0 1,000 2,000 Feet	Figure 2-31D Canyon Creek Watershed



TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	REQUESTOR	PROJECT NAME	Figure 2-32
Bunker/ROD_2009/2_32_trowbridge	D. Forseth	**Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	**Trowbridge Gulch Watershed**
PRINT DATE: January 7, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker /ROD_2009/ 2_32_trowbridge_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-32A
	Print Date: January 7, 2010	Project Manager: D. Forseth		**Trowbridge Gulch Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

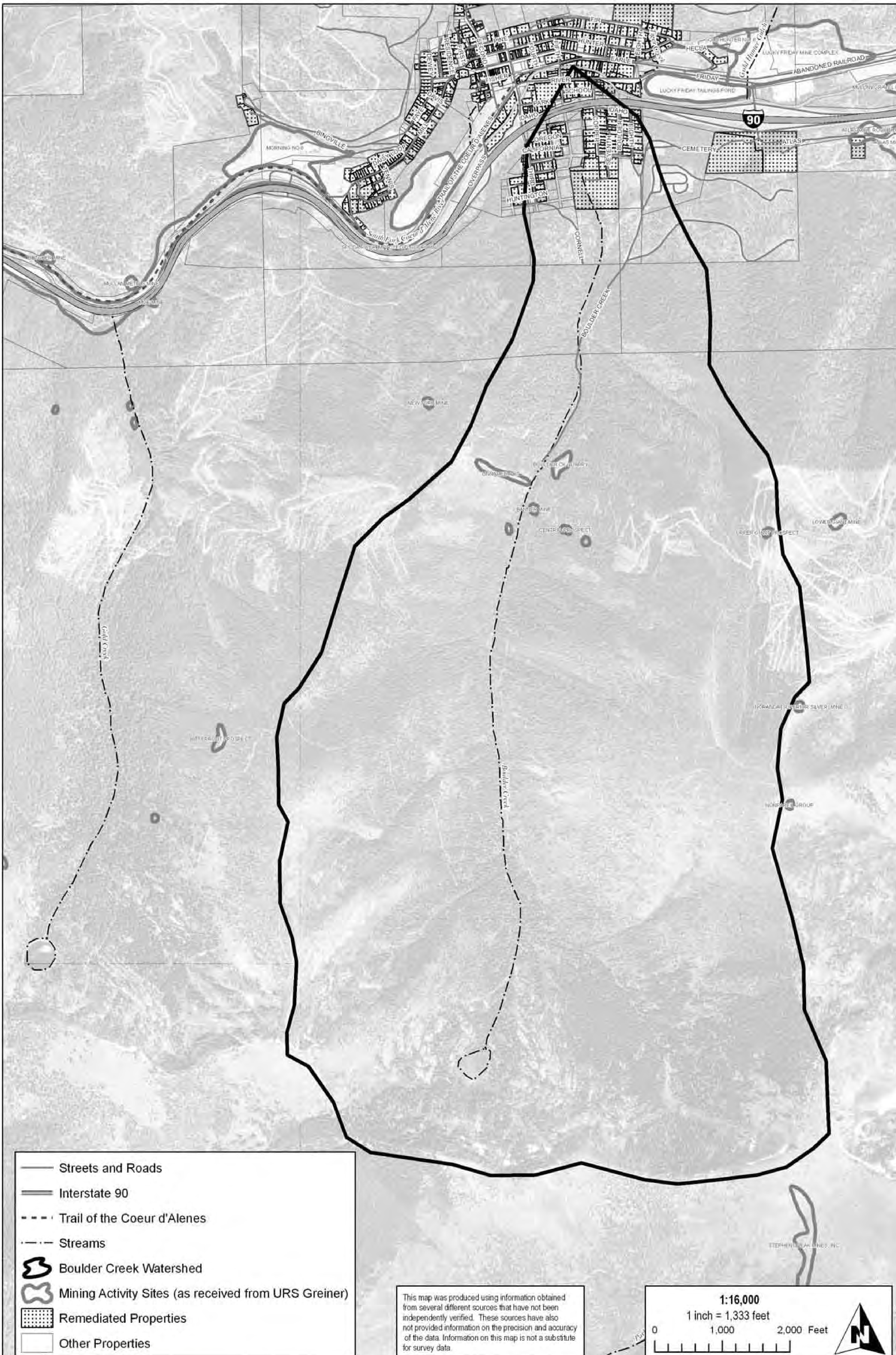


TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

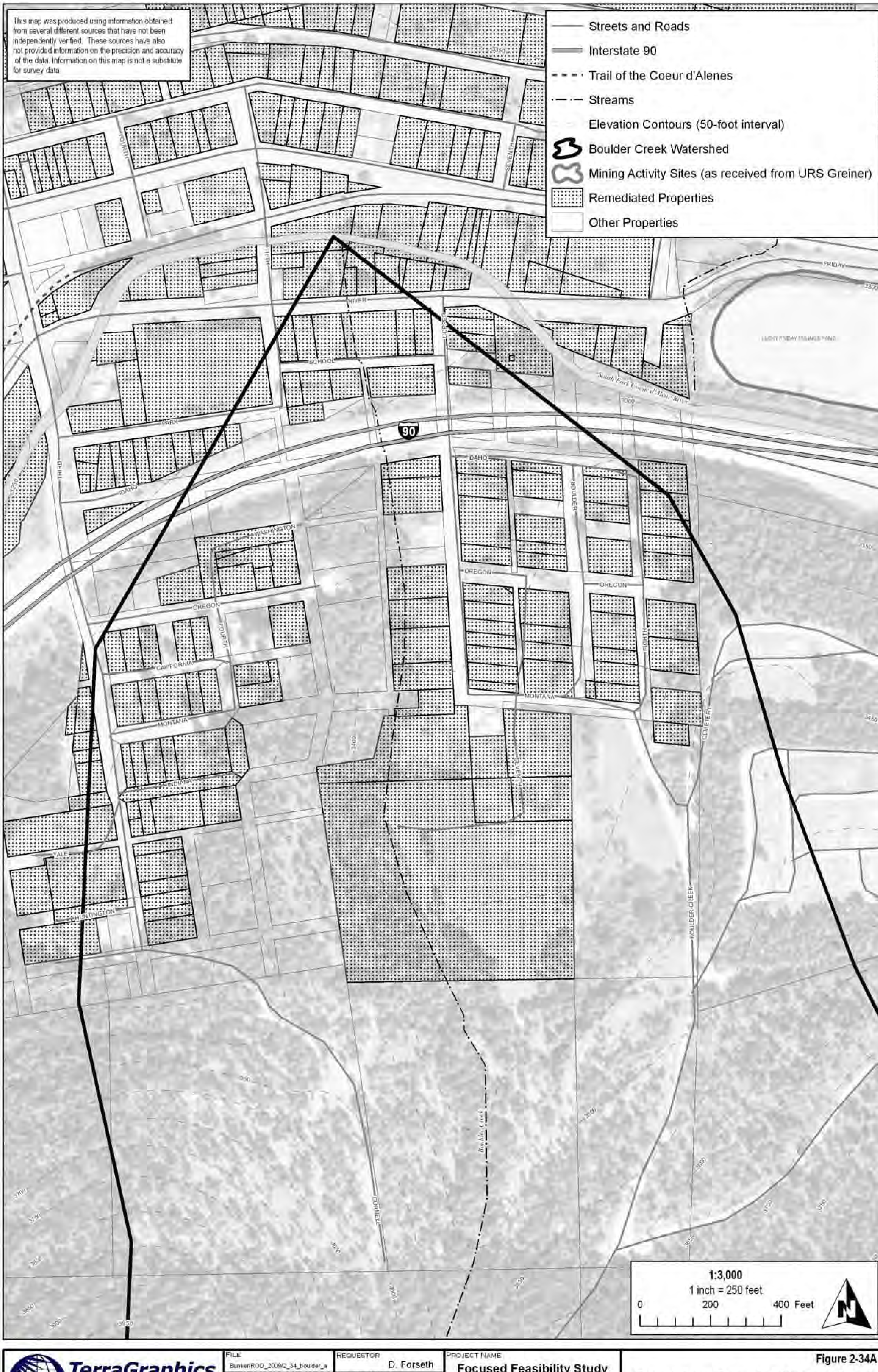
FILE	REQUESTOR	PROJECT NAME	Figure 2-33
Bunker /ROD_2009/2_33_mill	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Mill Creek Watershed
PRINT DATE: January 7, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

File: Bunker/ROD_2009/2_33_mill_a	Requestor: D. Forseth	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-33A
Print Date: January 7, 2010	Project Manager: D. Forseth		**Mill Creek Watershed**
Project Number: 2010-5050	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker/ROD_2009/2_34_boulder	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-34
	PRINT DATE January 7, 2010	PROJECT MANAGER D. Forseth		**Boulder Creek Watershed**
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

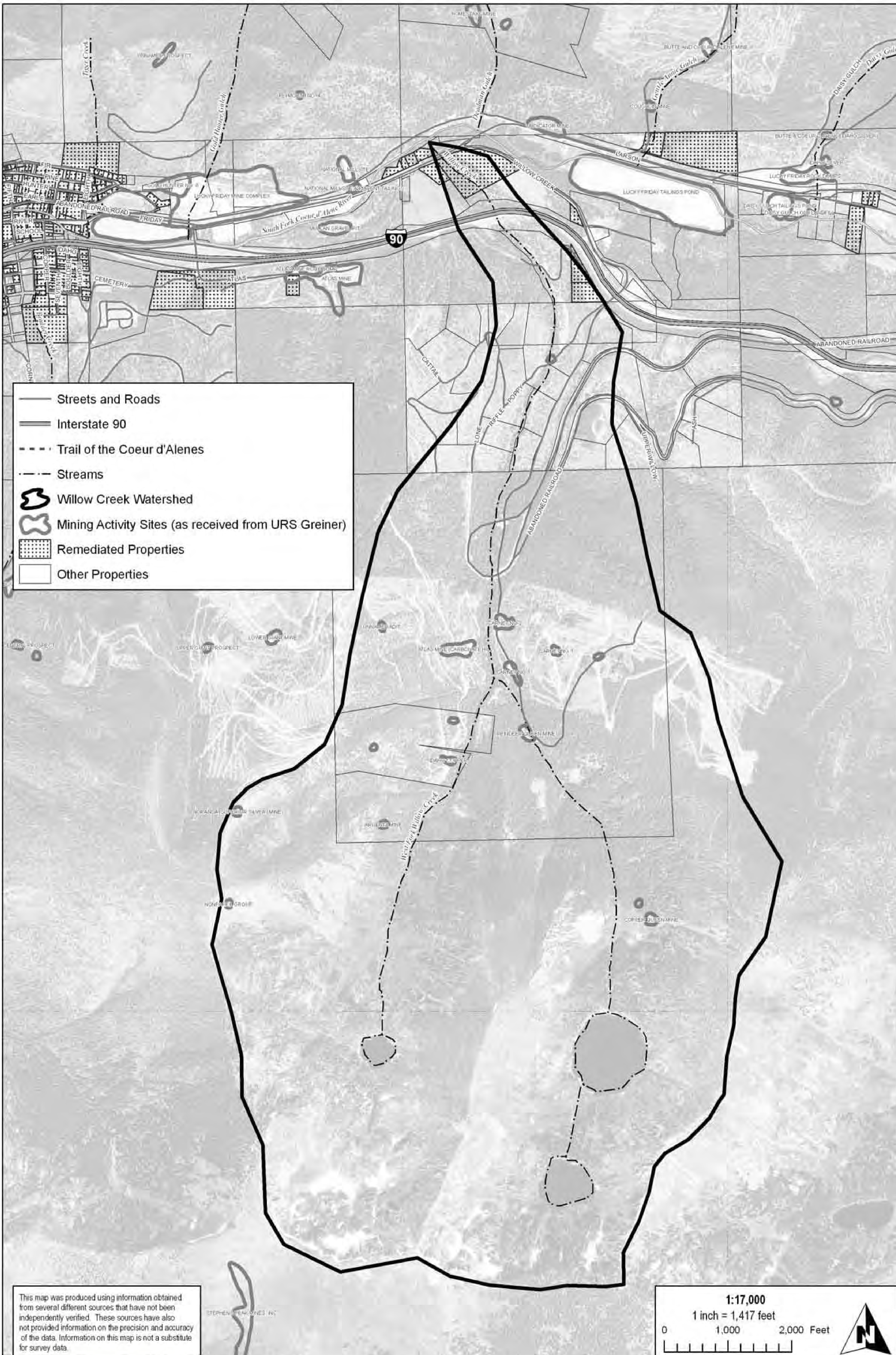


TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

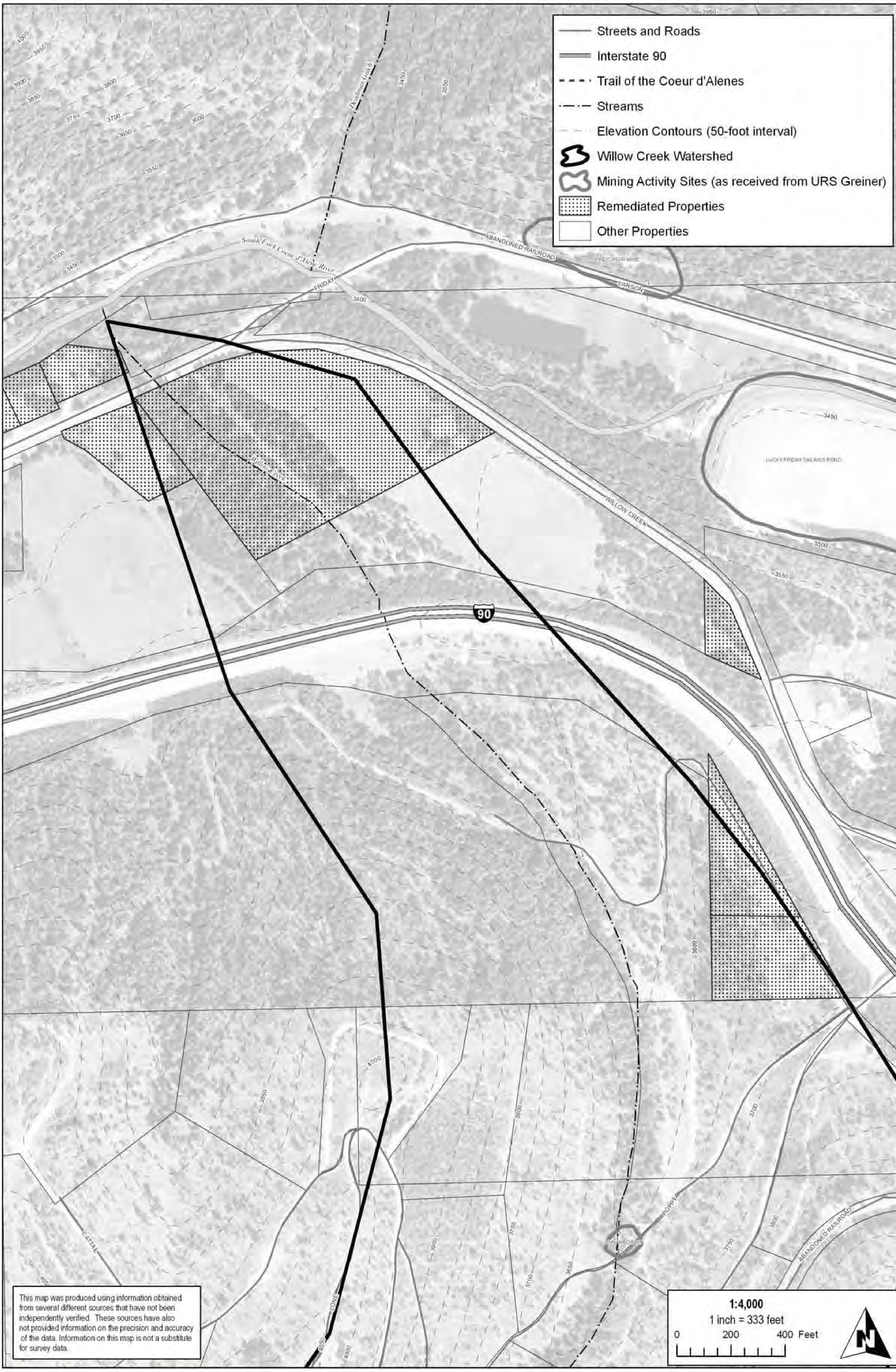
FILE	REQUESTOR	PROJECT NAME	Figure 2-34A
Bunker/ROD_2009/2_34_boulder_a	D. Forseth	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	**Boulder Creek Watershed**
PRINT DATE: January 7, 2010	PROJECT MANAGER: D. Forseth		
PROJECT NUMBER: 2010-5050	CARTOGRAPHER: B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/2_35_goldhunter	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-35 **Gold Hunter Creek Watershed**
	PRINT DATE January 6, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker / Watersheds_2009/ 2_35_goldhunter_a	Requestor: D. Forseth	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-35A
	Print Date: January 6, 2010	Project Manager: D. Forseth		**Gold Hunter Creek Watershed**
	Project Number: 2010-5050	Cartographer: B. Bailey		

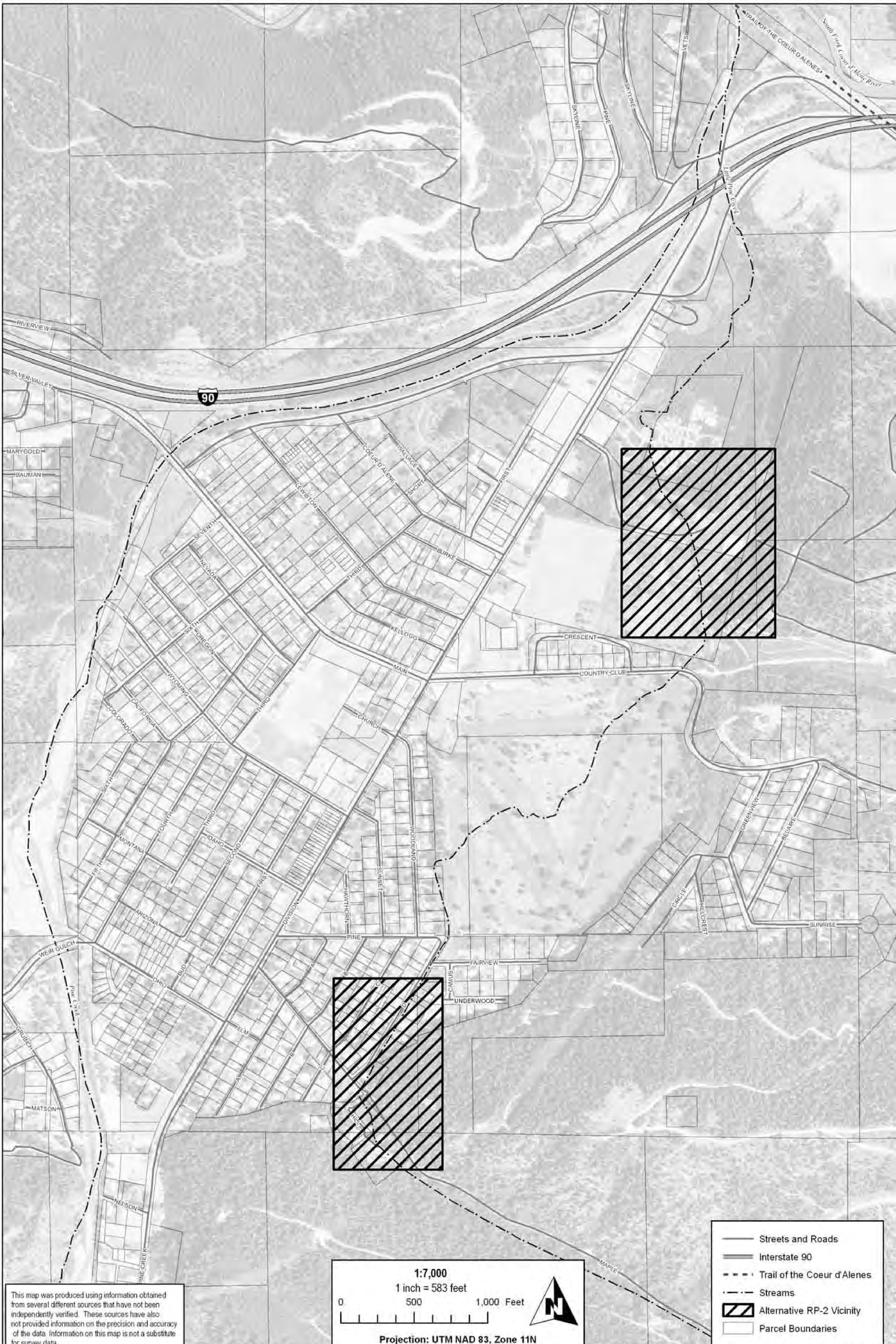


TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker/ROD_2009/2_36_willow Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin	Figure 2-36 Willow Creek Watershed



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Bunker/ROD_2009/2_36_willow_a Print Date: January 7, 2010 Project Number: 2010-5050	Requestor: D. Forseth Project Manager: D. Forseth Cartographer: B. Bailey	Project Name: **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	Figure 2-36A **Willow Creek Watershed**

Attachment G-3
Design Alternative Schematics



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/ G_pinehurst_overview	REQUESTOR D. Forseth	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	FIGURE 3-1 **Alternative RP-2 Vicinity Map Pinehurst, Idaho**
	PRINT DATE January 25, 2010	PROJECT MANAGER D. Forseth		
	PROJECT NUMBER 2010-5050	CARTOGRAPHER B. Bailey		

DESIGN ALTERNATIVE

LITTLE PINE CREEK, PINEHURST

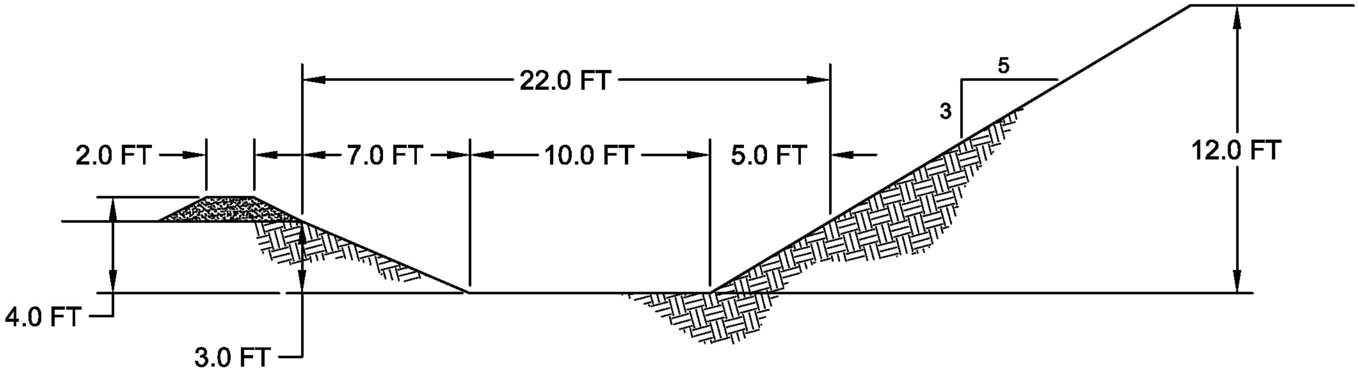
*Terra*Graphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1" = 100' DRAWN BY: C.HALEY ENGINEER: D.FORSETH	LITTLE PINE CREEK, PINEHURST REMEDY PROTECTION	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, W. ZONE, FT DATE: 1/22/2010 SHEET: 1 OF 8

FIGURE 3-2

TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050	LITTLE PINE CREEK, PINEHURST	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, W. ZONE, FT
	SCALE: 1" = 225'			DATE: 1/22/2010
	DRAWN BY: C.HALEY	REMEDY PROTECTION		SHEET: 2 OF 8
	ENGINEER: D.FORSETH			

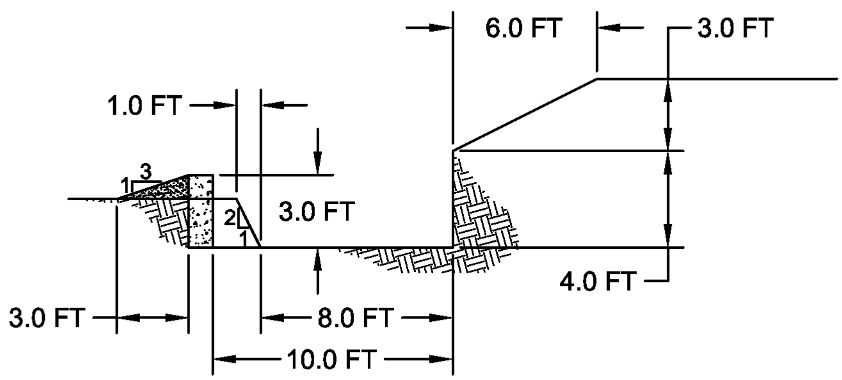
FIGURE 3-3

NOTE: THE CUT INDICATED INCLUDES THE 1' OF CONCRETE, IF APPLICABLE.



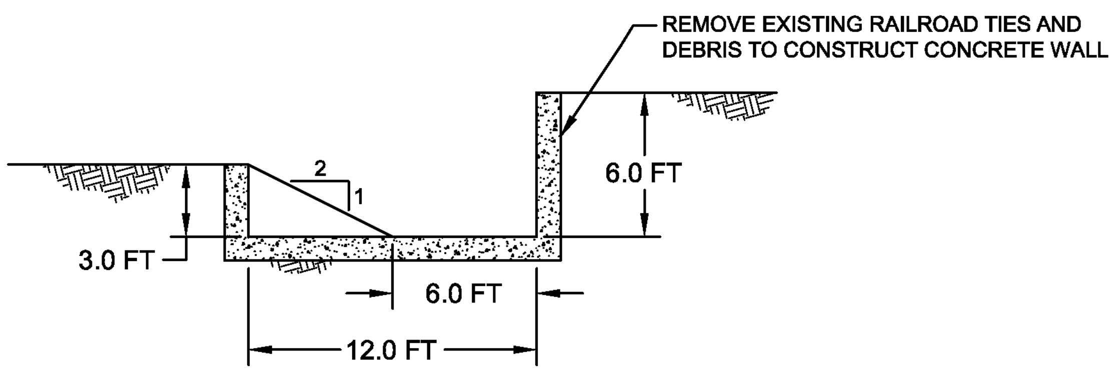
1/1 TYPICAL XS - INCREASE LEFT BANK HEIGHT TO 4-FT
SCALE: 1" = 8'

CUT = N/A
FILL = 4.00 CF/LF
LENGTH = 165 LF



2/1 TYPICAL XS - CONSTRUCT 3' VERTICAL CONCRETE WALL ALONG LEFT SIDE OF CHANNEL
SCALE: 1" = 8'

CUT = 5.00 CF/LF
FILL = 1.50 CF/LF
LENGTH = 80 LF



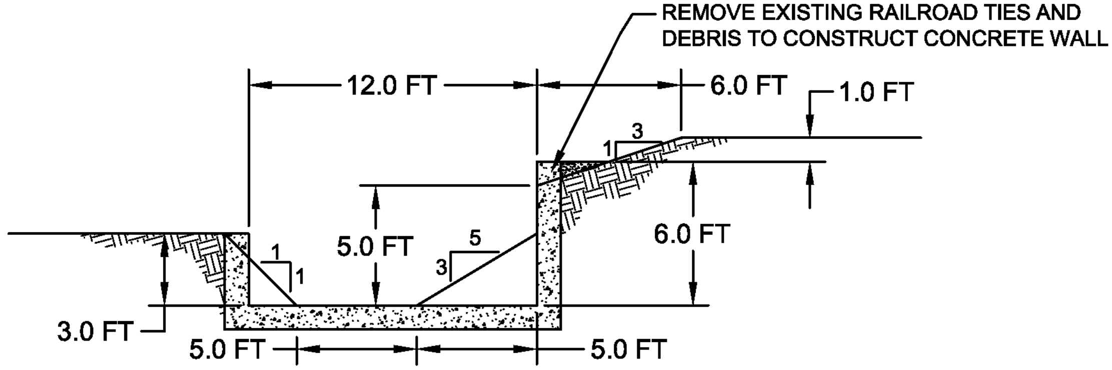
3a/1 TYPICAL XS - CONSTRUCT 12' x 3' (LEFT SIDE) x 6' (RIGHT SIDE) CHANNEL
SCALE: 1" = 8'

CUT = 26 CF/LF
FILL = NA
LENGTH = 50 LF

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	LITTLE PINE CREEK - CROSS SECTIONS	DATE: 11/10/2009
	ENGINEER: D.FORSETH		SHEET: 3 OF 8

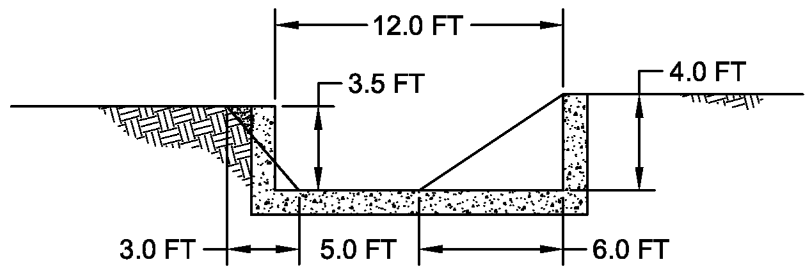
FIGURE 3-4

NOTE: THE CUT INDICATED INCLUDES THE 1' OF CONCRETE, IF APPLICABLE.



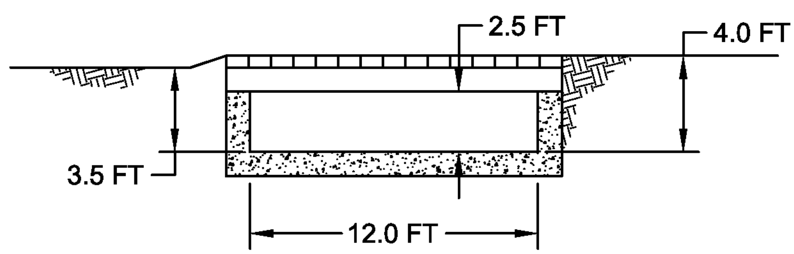
3b/1 TYPICAL XS - CONSTRUCT 12' x 3' (LEFT SIDE) x 6' (RIGHT SIDE) CHANNEL
SCALE: 1" = 8'

CUT = 31.20 CF/LF
FILL = 0.70 CF/LF
LENGTH = 100 LF



4/1 TYPICAL XS - CONSTRUCT 12' x 3.5' (LEFT SIDE) x 4.0' (RIGHT SIDE) CHANNEL
SCALE: 1" = 8'

CUT = 32.30 CF/LF
FILL = 0.60 CF/LF
LENGTH = 125 LF



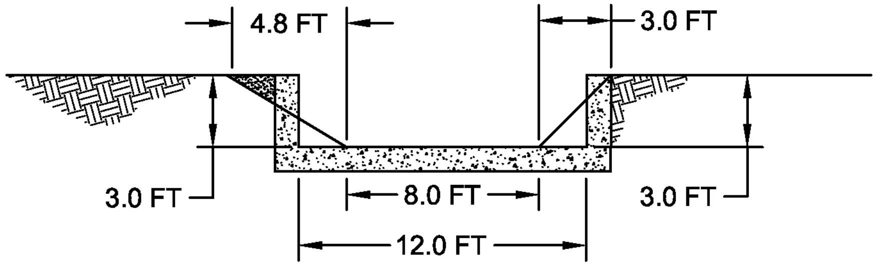
5/1 TYPICAL XS - NEW 14' x 26' DRIVEWAY BRIDGE (#1)
SCALE: 1" = 8'

CUT = N/A
FILL = N/A
LENGTH = 26 LF

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	LITTLE PINE CREEK - CROSS SECTIONS	DATE: 11/10/2009
	ENGINEER: D.FORSETH		SHEET: 4 OF 8

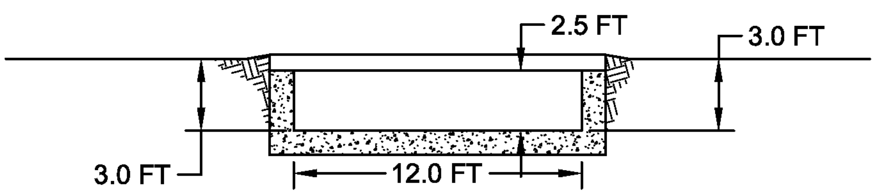
FIGURE 3-5

NOTE: THE CUT INDICATED INCLUDES THE 1' OF CONCRETE, IF APPLICABLE.



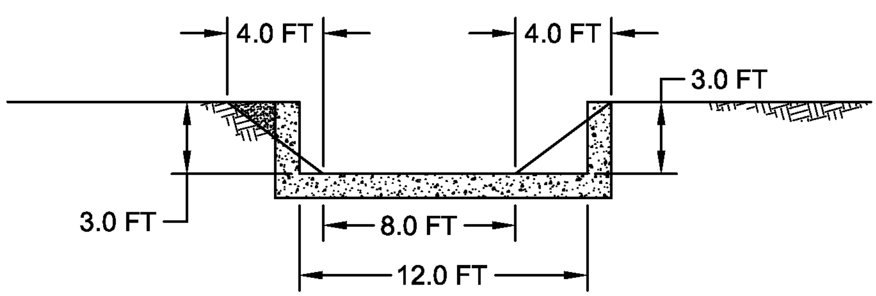
6a/1 TYPICAL XS - CONSTRUCT 12' x 3' RECTANGULAR CONCRETE CHANNEL
SCALE: 1" = 8'

CUT = 21.80 CF/LF
FILL = 1.20 CF/LF
LENGTH = 105 LF



7/1 TYPICAL XS - NEW 14' x 15' DRIVEWAY BRIDGE (#2)
SCALE: 1" = 8'

CUT = N/A
FILL = N/A
LENGTH = 15 LF



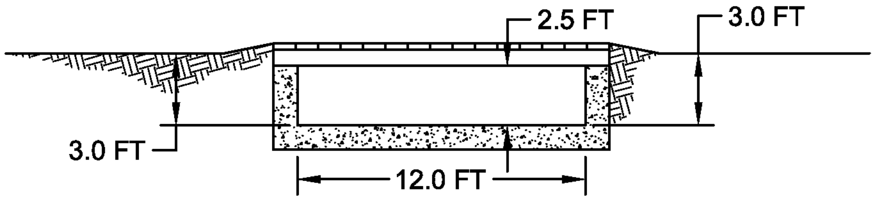
6b/1 TYPICAL XS - CONSTRUCT 12' x 3' RECTANGULAR CONCRETE CHANNEL
SCALE: 1" = 8'

CUT = 21.50 CF/LF
FILL = 1.50 CF/LF
LENGTH = 105 LF

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	LITTLE PINE CREEK - CROSS SECTIONS	DATE: 11/10/2009
	ENGINEER: D.FORSETH		SHEET: 5 OF 8

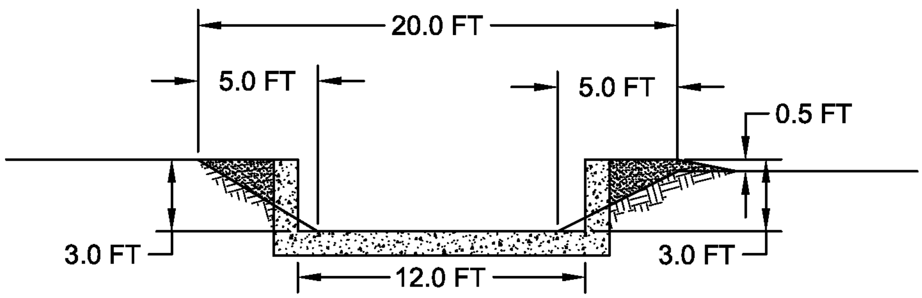
FIGURE 3-6

NOTE: THE CUT INDICATED INCLUDES THE 1' OF CONCRETE, IF APPLICABLE.



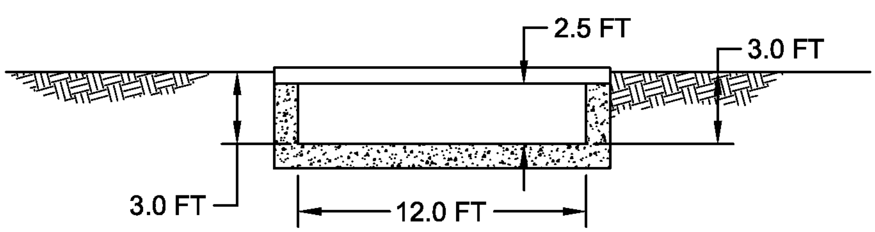
8/1 TYPICAL XS - NEW 14' x 18' DRIVEWAY BRIDGE (#3)
SCALE: 1" = 8'

CUT = N/A
FILL = N/A
LENGTH = 18 LF



6c/1 TYPICAL XS - CONSTRUCT 12' x 3' RECTANGULAR CONCRETE CHANNEL
SCALE: 1" = 8'

CUT = 16.20 CF/LF
FILL = 7.00 CF/LF
LENGTH = 180 LF

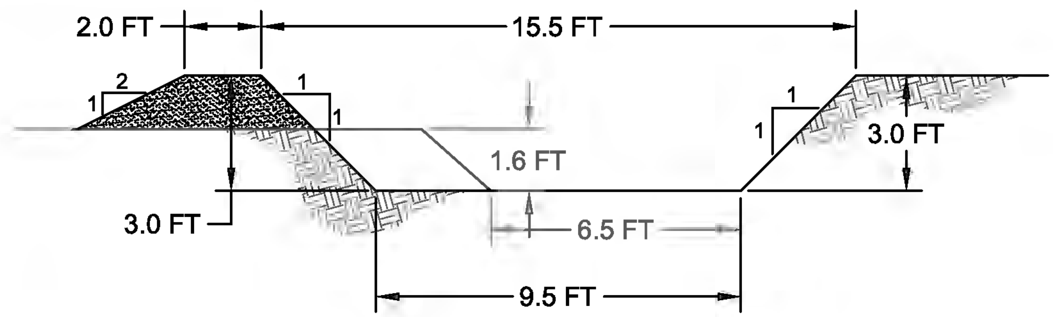


9/1 TYPICAL XS - NEW 14' x 16' DRIVEWAY BRIDGE (#4)
SCALE: 1" = 8'

CUT = N/A
FILL = N/A
LENGTH = 16 LF

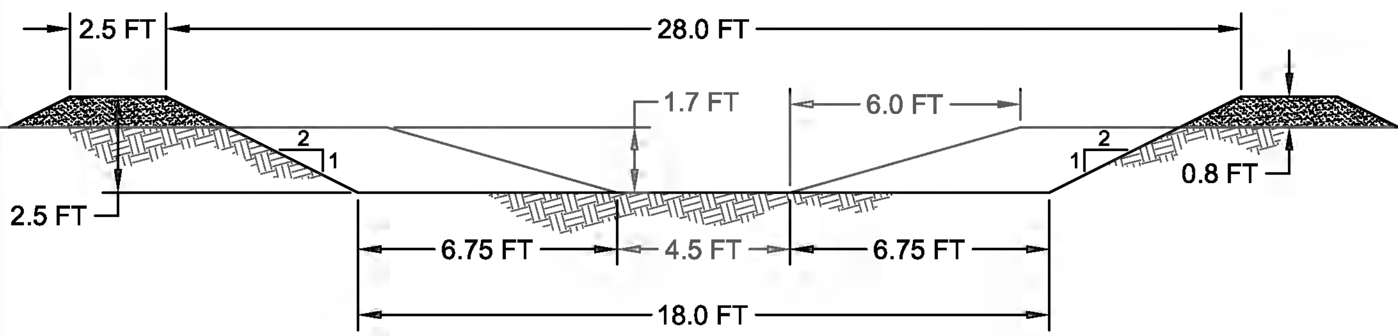
TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	LITTLE PINE CREEK - CROSS SECTIONS	DATE: 11/10/2009
	ENGINEER: D.FORSETH		SHEET: 6 OF 8

FIGURE 3-7



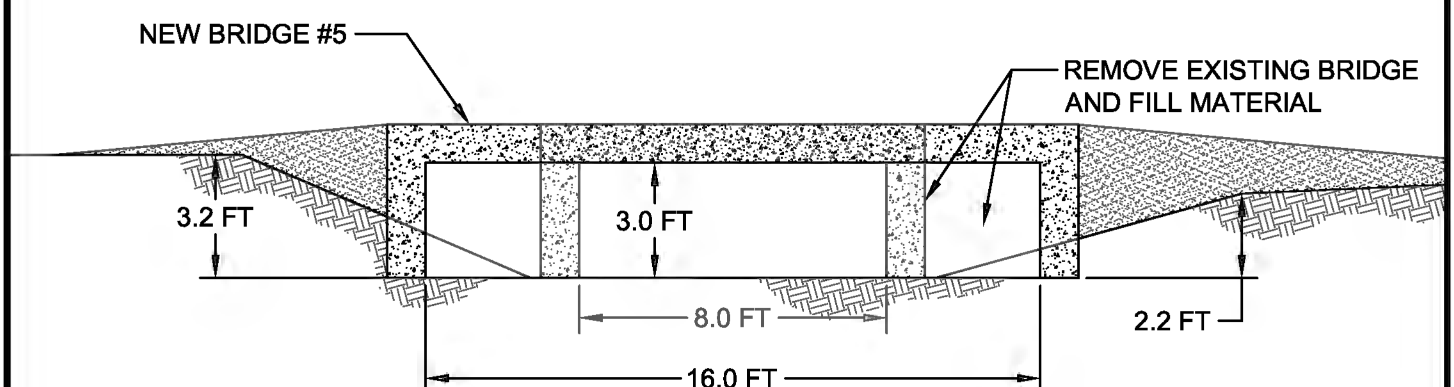
10/2 TYPICAL XS - INCREASE LEFT BANK HEIGHT TO 3 FT
SCALE: 1" = 5'

CUT = 4.64 CF/LF
FILL = 5.74 CF/LF
LENGTH = 330 LF



11/2 TYPICAL XS - WIDEN CHANNEL AND INCREASE BANK HEIGHTS TO 2.5 FT
SCALE: 1" = 5'

CUT = 18.53 CF/LF
FILL = 6.56 CF/LF
LENGTH = 270 LF

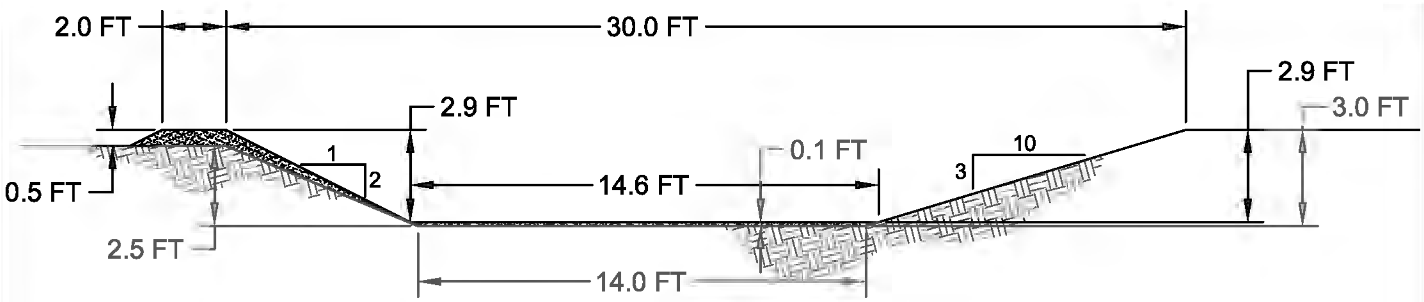


12/2 TYPICAL XS - NEW 18' x 28' BRIDGE AT PARK
SCALE: 1" = 5'

CUT = 40 CF/LF
FILL = N/A
LENGTH = 28 LF

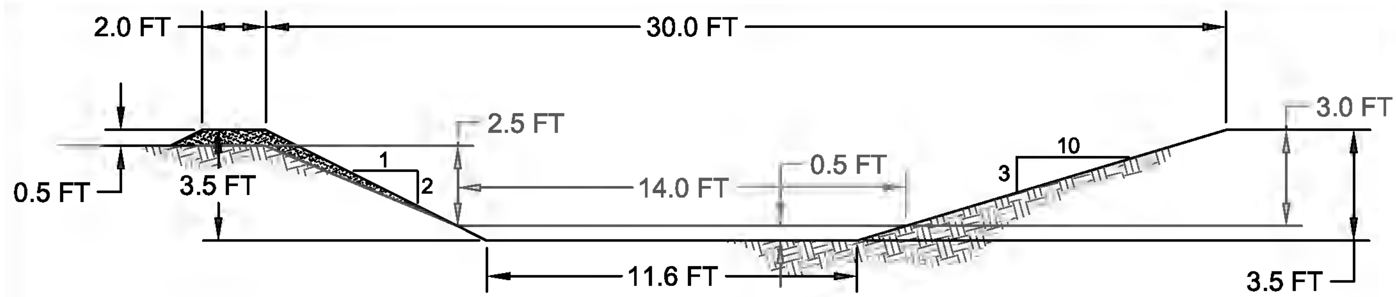
TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION LITTLE PINE CREEK - CROSS SECTIONS	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY		DATE: 11/10/2009
	ENGINEER: D.FORSETH		SHEET: 7 OF 8

FIGURE 3-8



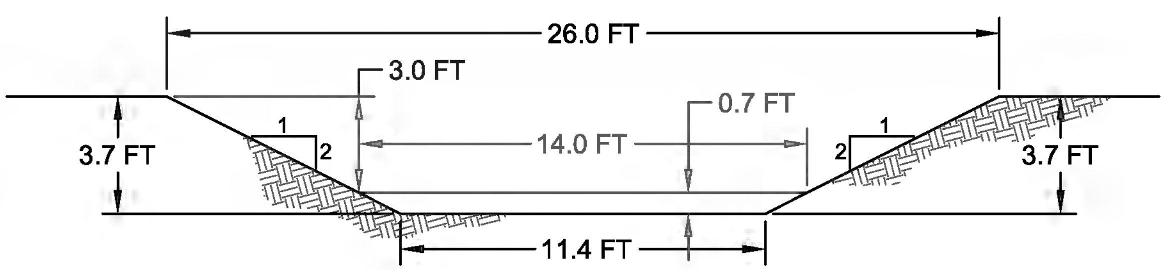
13/2 TYPICAL XS - INCREASE LEFT BANK AND CHANNEL SLOPE
SCALE: 1" = 6'

CUT = N/A
FILL = 4.45 CF/LF
LENGTH = 170 LF



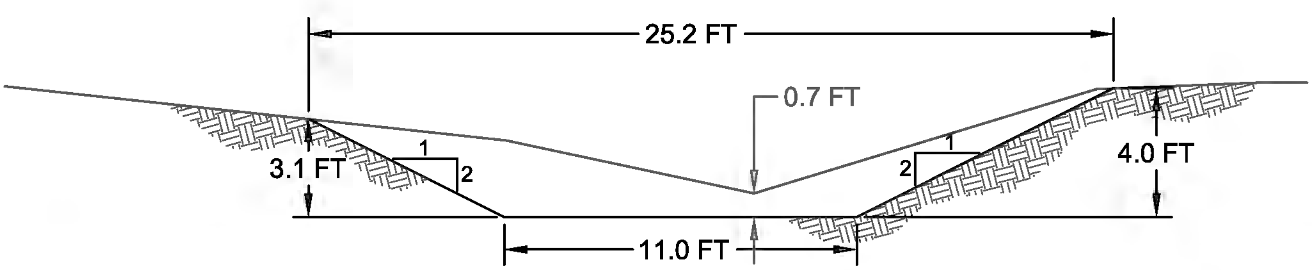
14/2 TYPICAL XS - INCREASE LEFT BANK AND CHANNEL SLOPE
SCALE: 1" = 6'

CUT = 5.85 CF/LF
FILL = 2.74 CF/LF
LENGTH = 120 LF



15/2 TYPICAL XS - INCREASE CHANNEL SLOPE
SCALE: 1" = 6'

CUT = 8.25 CF/LF
FILL = N/A
LENGTH = 55 LF



16/2 TYPICAL XS - INCREASE CHANNEL SIZE AND SLOPE
SCALE: 1" = 6'

CUT = 31.00 CF/LF
FILL = N/A
LENGTH = 55 LF

TerraGraphics Environmental Engineering, Inc.

SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
DRAWN BY: C.HALEY	LITTLE PINE CREEK - CROSS SECTIONS	DATE: 11/10/2009
ENGINEER: D.FORSETH		SHEET: 8 OF 8

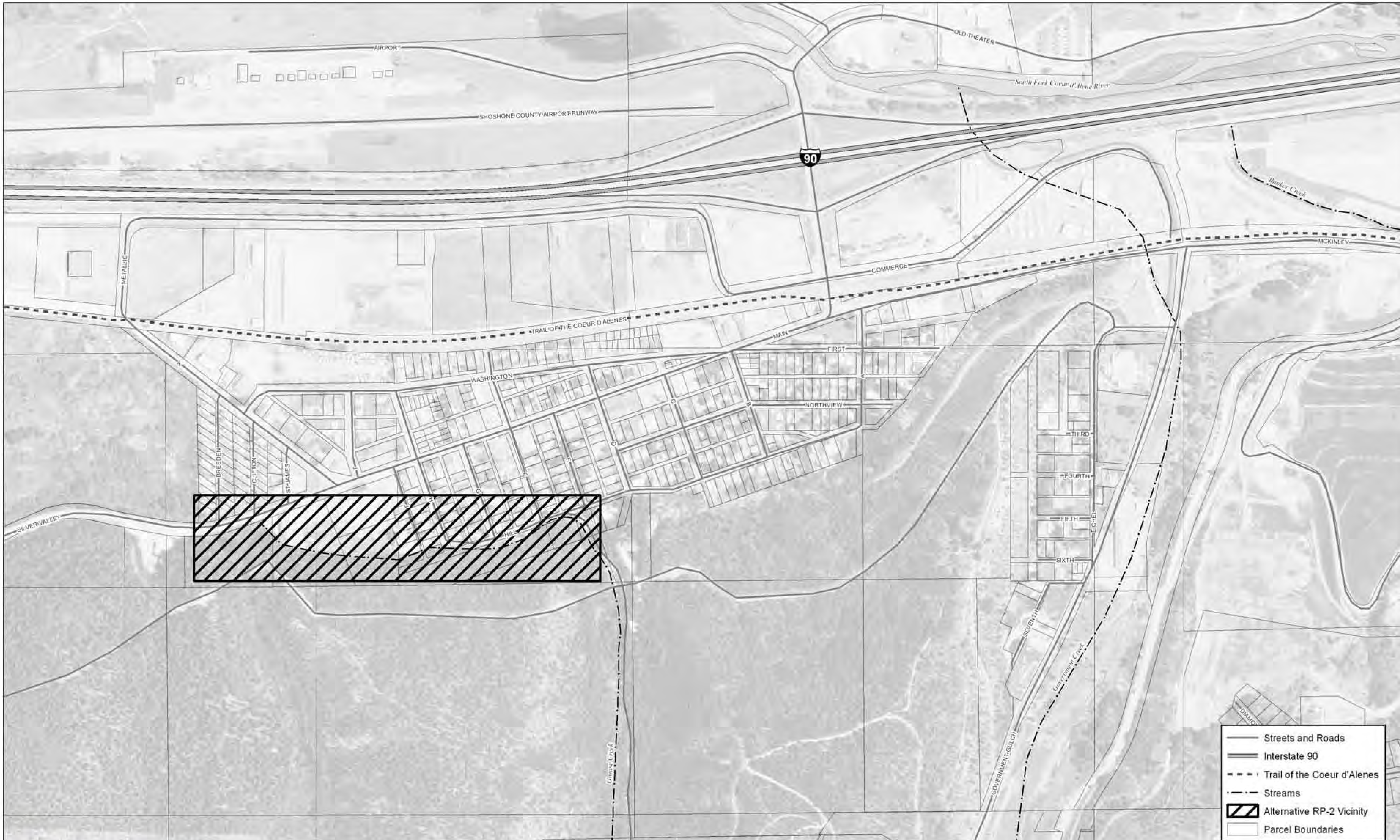
FIGURE 3-9

COST ESTIMATE QUANTITIES
PINEHURST, IDAHO

LITTLE PINE CREEK - ALTERNATIVE 1

REF	DESCRIPTION	QTY	UNIT
1	CHANNEL MODIFICATION - INCREASE LEFT BANK HEIGHT TO 4 FT WITH 1 FT TALL BERM (XS 1)	165	LF
2	RECONSTRUCT EXISTING CHANNEL TO 10' x 3' CHANNEL WITH 3 FT VERTICAL CONCRETE WALL ALONG LEFT SIDE OF CHANNEL (XS 2)	80	LF
3	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3' (L) x 6' (R) CONCRETE CHANNEL (XS 3a)	50	LF
4	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3' (L) x 6' (R) CONCRETE CHANNEL (XS 3b)	100	LF
5	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3.5' (L) x 4' (R) CONCRETE CHANNEL (XS 4)	125	LF
6	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3' CONCRETE CHANNEL (XS 6a)	105	LF
7	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3' CONCRETE CHANNEL (XS 6b)	105	LF
8	RECONSTRUCT EXISTING EARTHEN CHANNEL TO 12' x 3' CONCRETE CHANNEL (XS 6c)	180	LF
9	CHANNEL MODIFICATION - INCREASE LEFT BANK HEIGHT TO 3 FT WITH 1.4 FT TALL BERM (XS 10)	330	LF
10	RECONSTRUCT EXISTING CHANNEL BY WIDENING TO 28' x 18' x 2.5' EARTHEN CHANNEL WITH 0.8 FT TALL BERM ON RIGHT AND LEFT BANK (XS 11)	270	LF
11	CHANNEL MODIFICATIONS - CONSTRUCT 0.5 FT TALL BERM ON LEFT BANK AND INCREASE CHANNEL BOTTOM BY 0.1 FT TO ACCOUNT FOR SLOPE ALTERATIONS (XS 13)	170	LF
12	CHANNEL MODIFICATIONS - CONSTRUCT 0.5 FT TALL BERM ON LEFT BANK AND DECREASE CHANNEL DEPTH BY 0.5 FT TO ACCOUNT FOR SLOPE ALTERATIONS (XS 14)	120	LF
13	CHANNEL MODIFICATIONS - DECREASE CHANNEL DEPTH BY 0.7 FT TO ACCOUNT FOR SLOPE ALTERATIONS (XS 15)	55	LF
14	RECONSTRUCT EXISTING CHANNEL TO 25.2' x 11' x 3.1' (L) x 4' (R) EARTHEN CHANNEL AND DECREASE CHANNEL DEPTH BY 0.7 FT TO ACCOUNT FOR SLOPE ALTERATIONS (XS 16)	55	LF
15	REPLACE EXISTING WOOD DRIVEWAY BRIDGE WITH 14' x 26' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 2.5 FT (BRIDGE 1, XS 5).	1	EA
16	REPLACE EXISTING STEEL DRIVEWAY BRIDGE WITH 14' x 15' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 2.5 FT (BRIDGE 2, XS 7)	1	EA
17	REPLACE EXISTING WOOD DRIVEWAY BRIDGE WITH 14' x 18' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 2.5 FT (BRIDGE 3, XS 8)	1	EA
18	REPLACE EXISTING DRIVEWAY BRIDGE WITH 14' x 16' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 2.5 FT (BRIDGE 4, XS 9)	1	EA
19	REPLACE EXISTING C0NCRETE BOX CULVERT (3' x 8' x 28') WITH 18' x 28' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 3 FT (BRIDGE 5, XS 12)	1	EA
20	REPLACE EXISTING WOOD BRIDGE (12' x 4') WITH 14' x 4' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 3.6 FT (BRIDGE 6)	1	EA

Note: Reference Items 11 through 14 were altered for a constant design slope of 0.4%. The existing slope between these XS's varies from 0.08% to 1.5%



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www.TerraGraphics.com

FILE	Bunker / ROD_2008/G_smelt_overview	REQUESTOR	D. Forseth
PRINT DATE	January 25, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:6,000
1 inch = 500 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

FIGURE 3-10
Alternative RP-2 Vicinity Map
Smelterville, Idaho

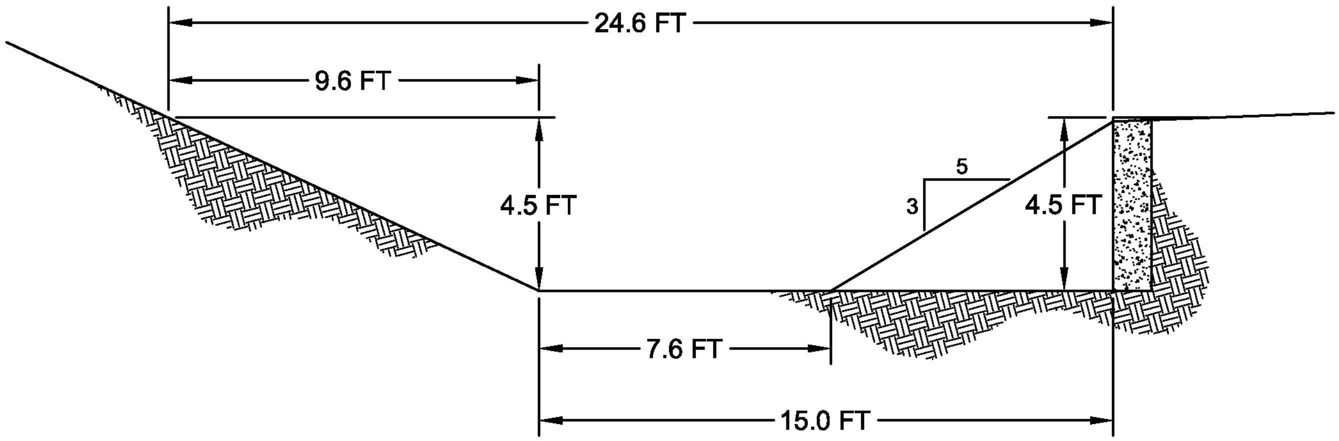
DESIGN ALTERNATIVE

GROUSE CREEK, SMELTERVILLE

TerraGraphics Environmental Engineering, Inc.

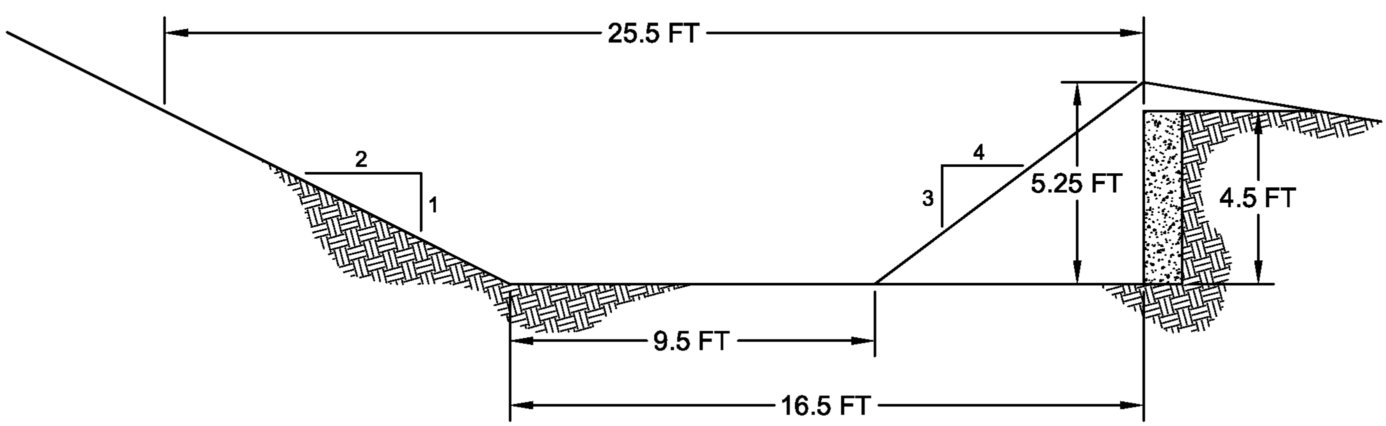
DRAWN: C.HALEY	PROJECT NO.: 2010-5050	GROUSE CREEK, SMELTERVILLE	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT
ENGINEER: D.FORSETH	SCALE: 1" = 200'			DATE: 1/22/2010
CHECKED:	APPROVED:	REMEDY PROTECTION		SHEET: 1 OF 3
	DATE: 1/22/2010			

FIGURE 3-11



1/1 TYPICAL XS - CHANNEL MODIFICATIONS
SCALE: 1" = 5'

CUT = 20.60 CF/LF
FILL = 0.04 CF/LF
LENGTH = 335 LF

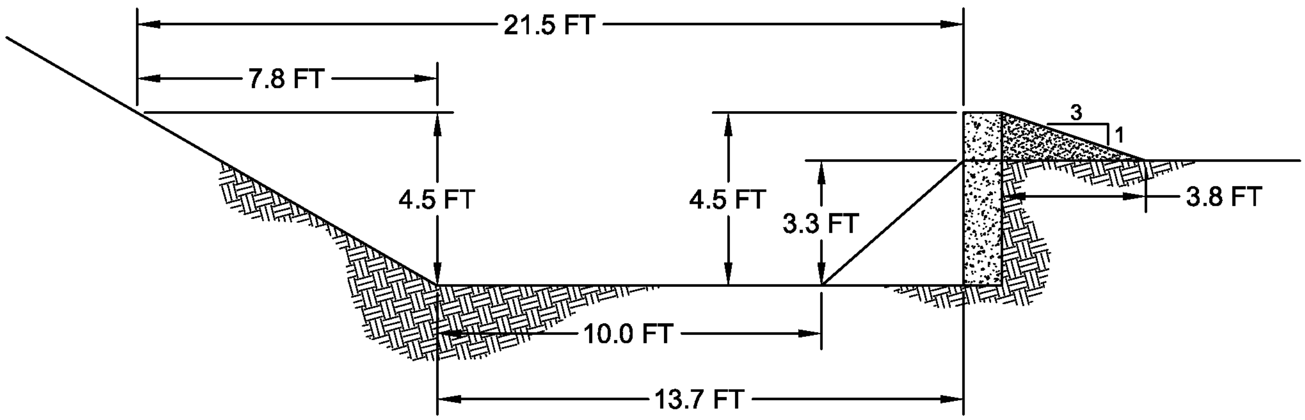


2/1 TYPICAL XS - CHANNEL MODIFICATIONS
SCALE: 1" = 5'

CUT = 24.60 CF/LF
FILL = N/A
LENGTH = 620 LF

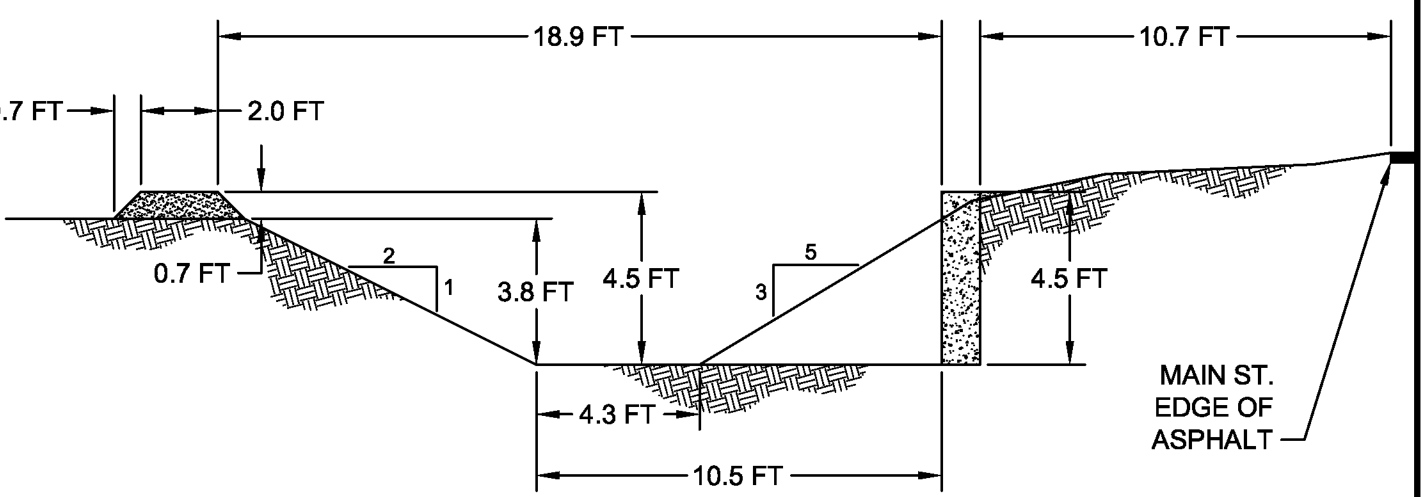
TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	GROUSE CREEK - CROSS SECTIONS	DATE: 10/30/2009
	ENGINEER: D.FORSETH		SHEET: 2 OF 3

FIGURE 3-12



3/1 TYPICAL XS - CHANNEL MODIFICATIONS
SCALE: 1" = 5'

CUT = 9.30 CF/LF
FILL = 2.35 CF/LF
LENGTH = 880 LF



4/1 TYPICAL XS - CHANNEL MODIFICATIONS ADJACENT TO MAIN STREET
SCALE: 1" = 5'

CUT = 16.00 CF/LF
FILL = 2.00 CF/LF
LENGTH = 160 LF

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	GROUSE CREEK - CROSS SECTIONS	DATE: 10/30/2009
	ENGINEER: D.FORSETH		SHEET: 3 OF 3

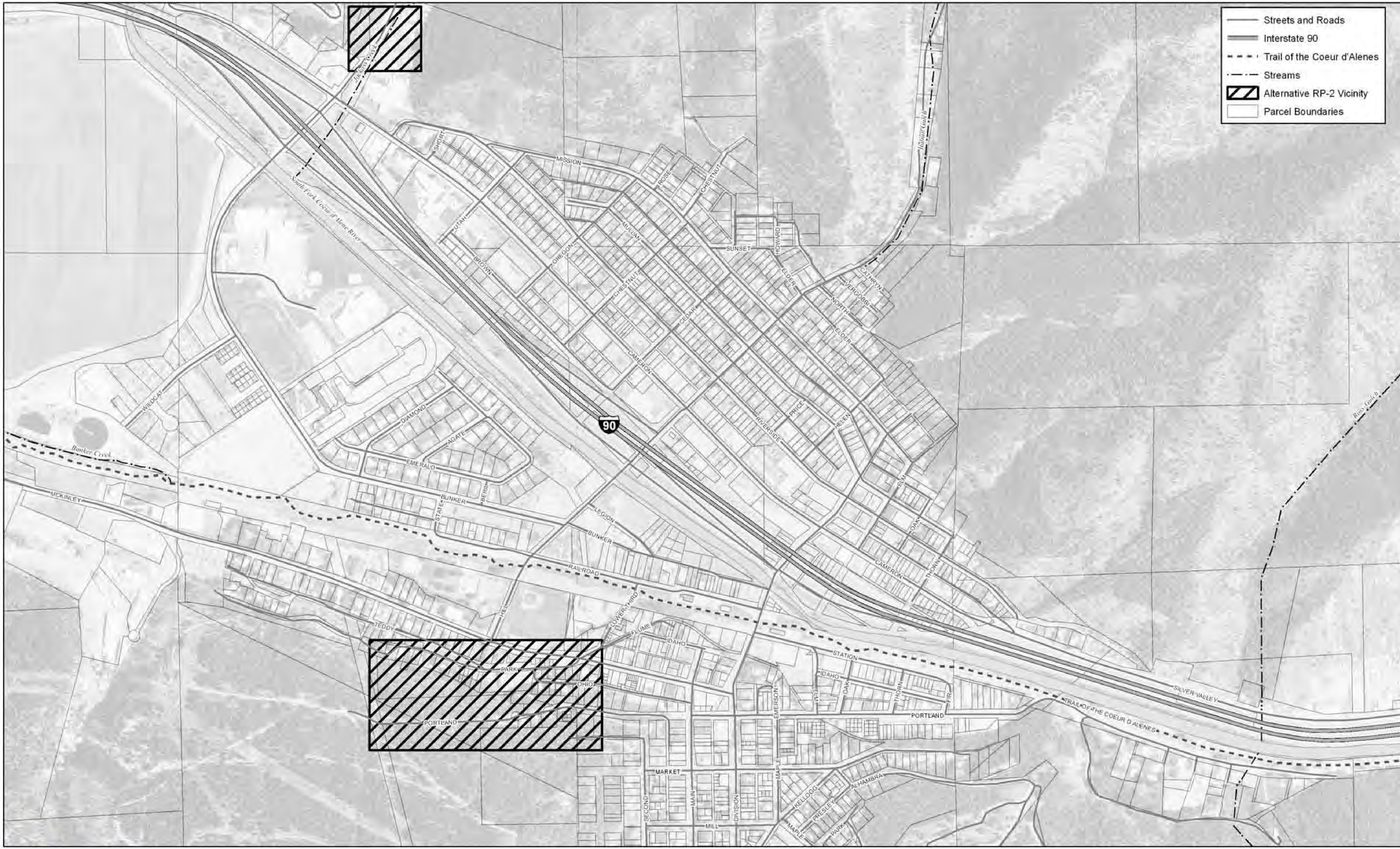
FIGURE 3-13

REMEDY PROTECTION

COST ESTIMATE QUANTITIES
SMELTERVILLE, IDAHO

GROUSE CREEK

REF	DESCRIPTION	QTY	UNIT
1	ABANDON EXISTING 36"∅ CONCRETE CULVERT (CULVERT 1)	60	LF
2	ABANDON EXISTING 36"∅ CONCRETE CULVERT (CULVERT 2)	50	LF
3	INSTALL/CONSTRUCT NEW 4.5' x 8' CONCRETE BOX CULVERT (ALLOWS FOR 2' TO 3' COVER UNDER MAIN STREET) (CULVERT 3)	105	LF
4	RECONSTRUCT EXISTING CHANNEL - INSTALL 4.5' TALL VERTICAL CONCRETE WALL ALONG NORTH SIDE OF CREEK (XS 1)	335	LF
5	RECONSTRUCT EXISTING CHANNEL - INSTALL 4.5' TALL VERTICAL CONCRETE WALL ALONG NORTH SIDE OF CREEK (XS 2)	620	LF
6	RECONSTRUCT EXISTING CHANNEL - INSTALL 4.5' TALL VERTICAL CONCRETE WALL ALONG NORTH SIDE OF CREEK (XS 3)	880	LF
7	RECONSTRUCT EXISTING CHANNEL - INSTALL 4.5' TALL VERTICAL CONCRETE WALL ALONG NORTH SIDE OF CREEK AND 0.7' BERM ON SOUTH SIDE OF CREEK (XS 4)	160	LF



TerraGraphics
Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ G_kellogg_overview	REQUESTOR	D. Forseth	PROJECT NAME	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin
PRINT DATE	January 25, 2010	PROJECT MANAGER	D. Forseth		
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey		

1:7,200
1 inch = 600 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

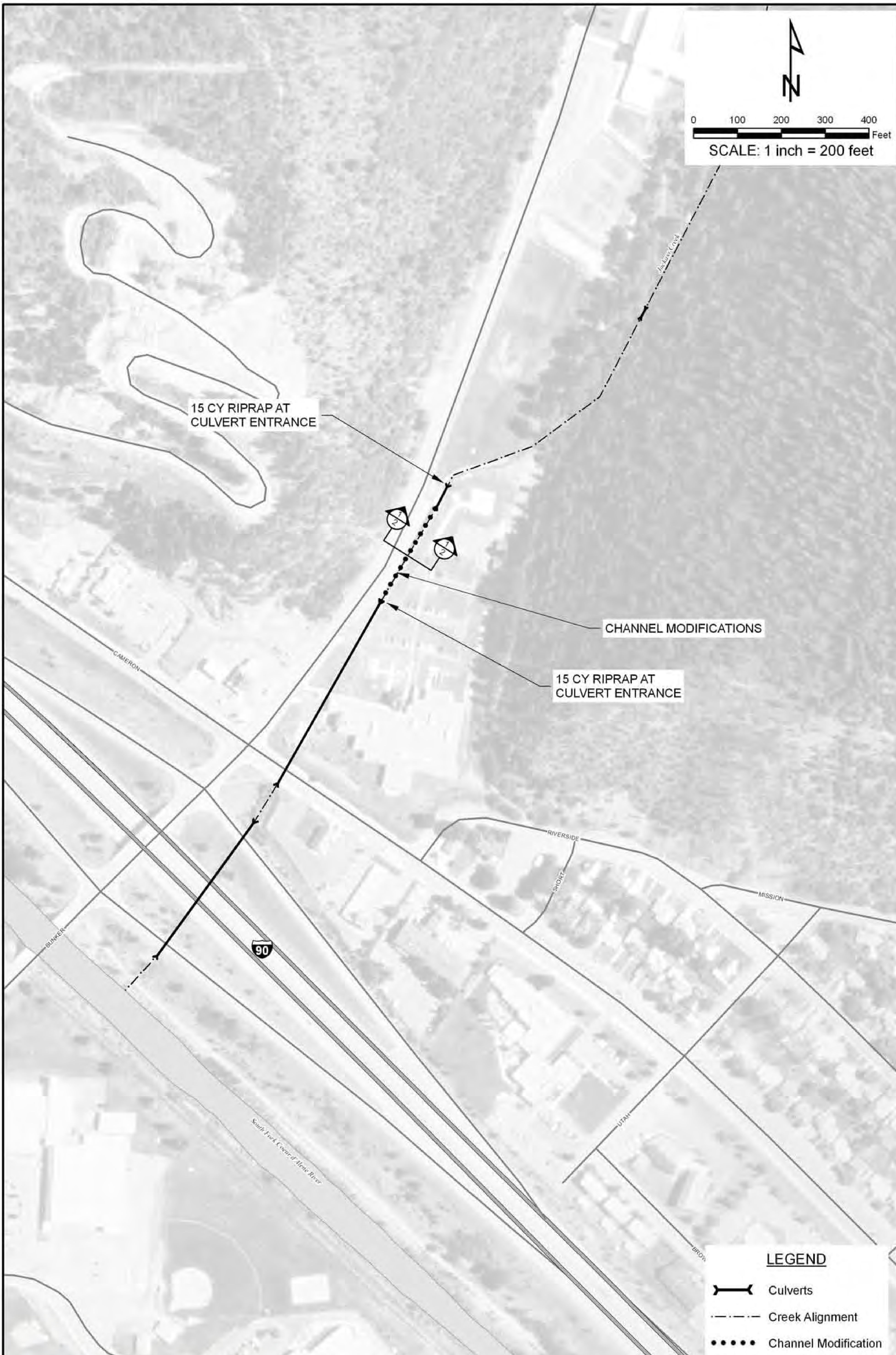
N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

FIGURE 3-14
Alternative RP-2 Vicinity Map
Kellogg, Idaho

DESIGN ALTERNATIVE

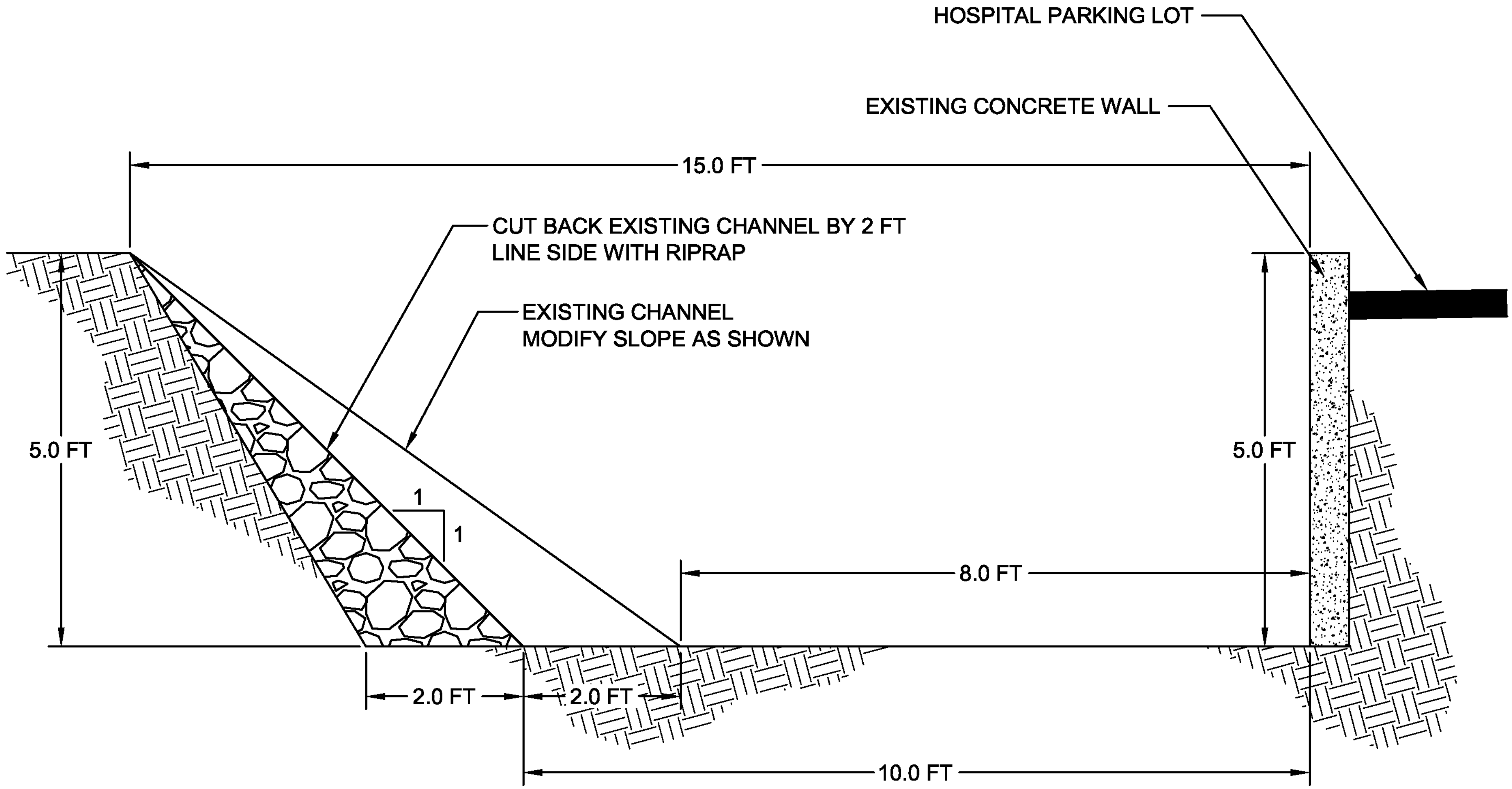
JACKASS CREEK, KELLOGG



TerraGraphics Environmental Engineering, Inc.

PROJECT NO.:	2010-5050	JACKASS CREEK, KELLOGG	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, UTM ZONE 11N
SCALE:	1" = 200'			DATE: 10/22/2009
DRAWN BY:	C. HALEY	REMEDY PROTECTION		SHEET: 1 OF 2
ENGINEER:	D. FORSETH			

FIGURE 3-15



1/1 TYPICAL XS - CHANNEL MODIFICATIONS ALONG HOSPITAL
SCALE: 1" = 2'

CUT = 15.00 CF/LF
FILL (RIPRAP) = 5.00 CF/LF
LENGTH = 260 LF

FIGURE 3-16

TerraGraphics Environmental Engineering, Inc.	DRAWN BY: C.HALEY	PROJECT NO: 2010-5050	PROJECT NAME: JACKASS CREEK REMEDY PROTECTION	CROSS SECTIONS
	PROJECT MANAGER: D.FORSETH	DATE: 1/11/2010		

COST ESTIMATE QUANTITIES
KELLOGG, IDAHO

JACKASS CREEK

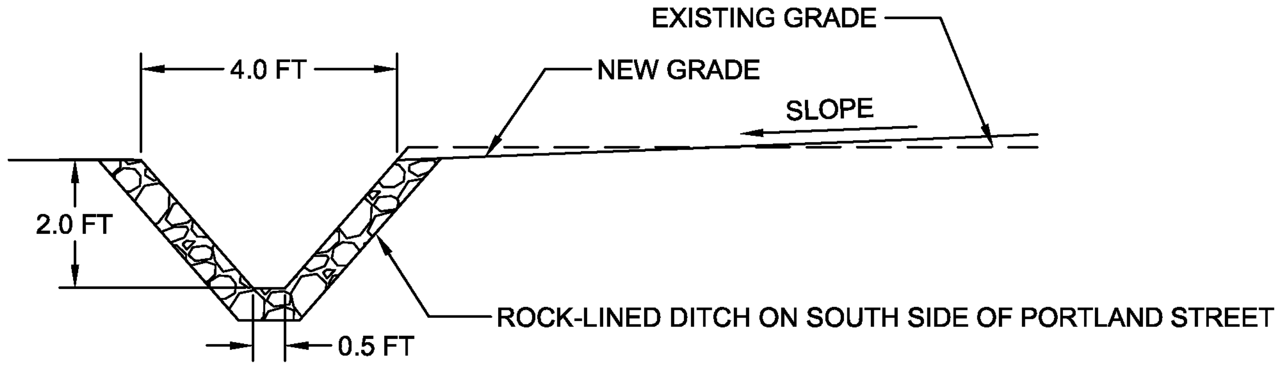
REF	DESCRIPTION	QTY	UNIT
1	RECONSTRUCT EXISTING CHANNEL TO 15' x 12' x 5' CHANNEL (XS 1)	260	LF
2	LINE SIDE OF CHANNEL WITH RIPRAP (5.00 CF/LF)	260	LF
3	LINE CULVERT ENTRANCE WITH 15 CY OF RIP RAP	2	EA

DESIGN ALTERNATIVE

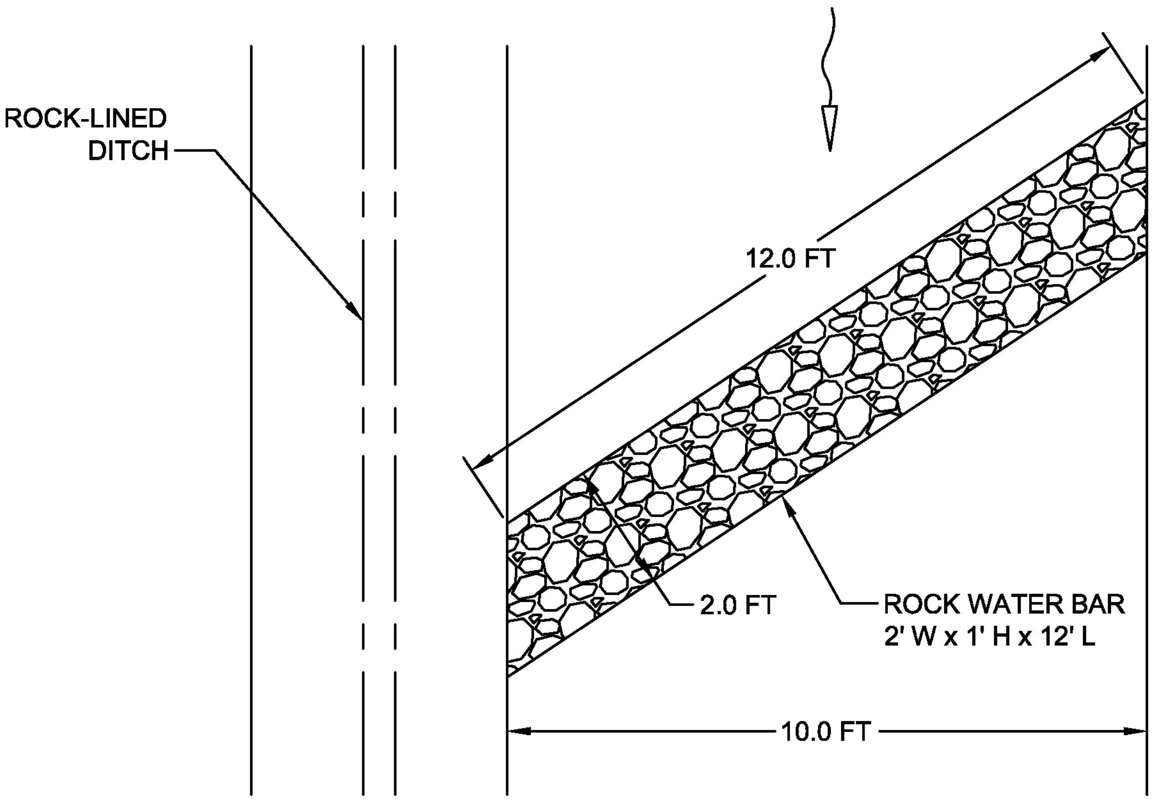
PORTLAND ROAD, SW KELLOGG

SCALE: 1" = 150'	TerraGraphics Environmental Engineering, Inc.	KELLOGG, IDAHO	DESIGN ALTERNATIVE PORTLAND RD	PROJECT NO: 2010-5050
DRAWN BY: C.HALEY				DATE: 1/22/2010
ENGINEER: D.FORSETH		REMEDY PROTECTION		SHEET: 1 OF 2

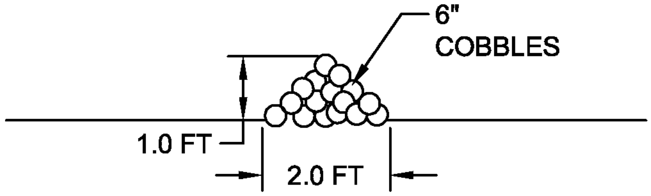
FIGURE 3-17



1/1 GRAVEL ROAD & DITCH SECTION
SCALE: 1" = 3'



2/1 ROCK WATER BARS - PLAN VIEW
SCALE: 1" = 3'



3/1 ROCK WATER BARS - PROFILE VIEW
SCALE: 1" = 3'

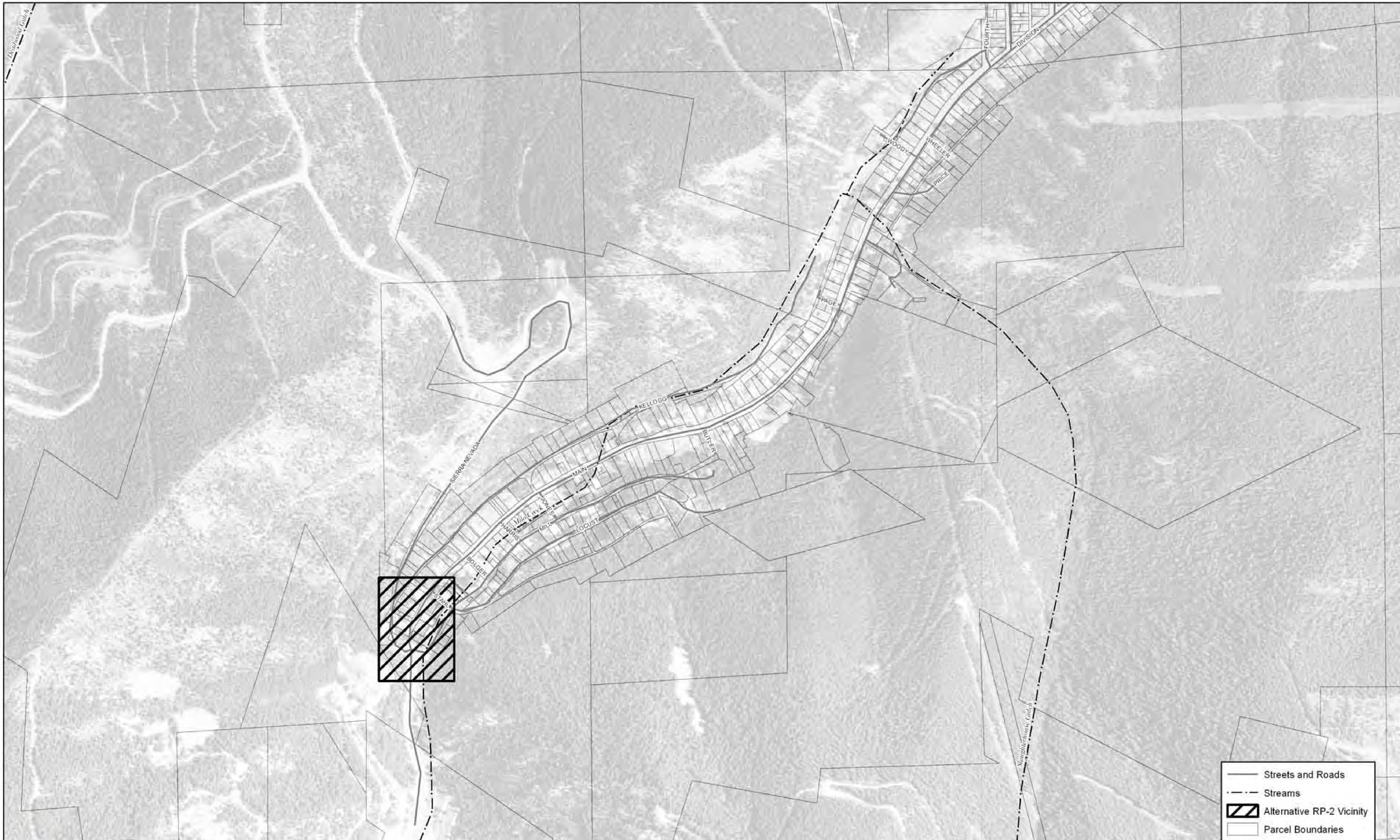
TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	PORTLAND RD, KELLOGG - DETAILS	DATE: 11/20/2009
	ENGINEER: D.FORSETH		SHEET: 2 OF 2

FIGURE 3-18

COST ESTIMATE QUANTITIES
KELLOGG, IDAHO

PORTLAND ROAD IMPROVEMENTS

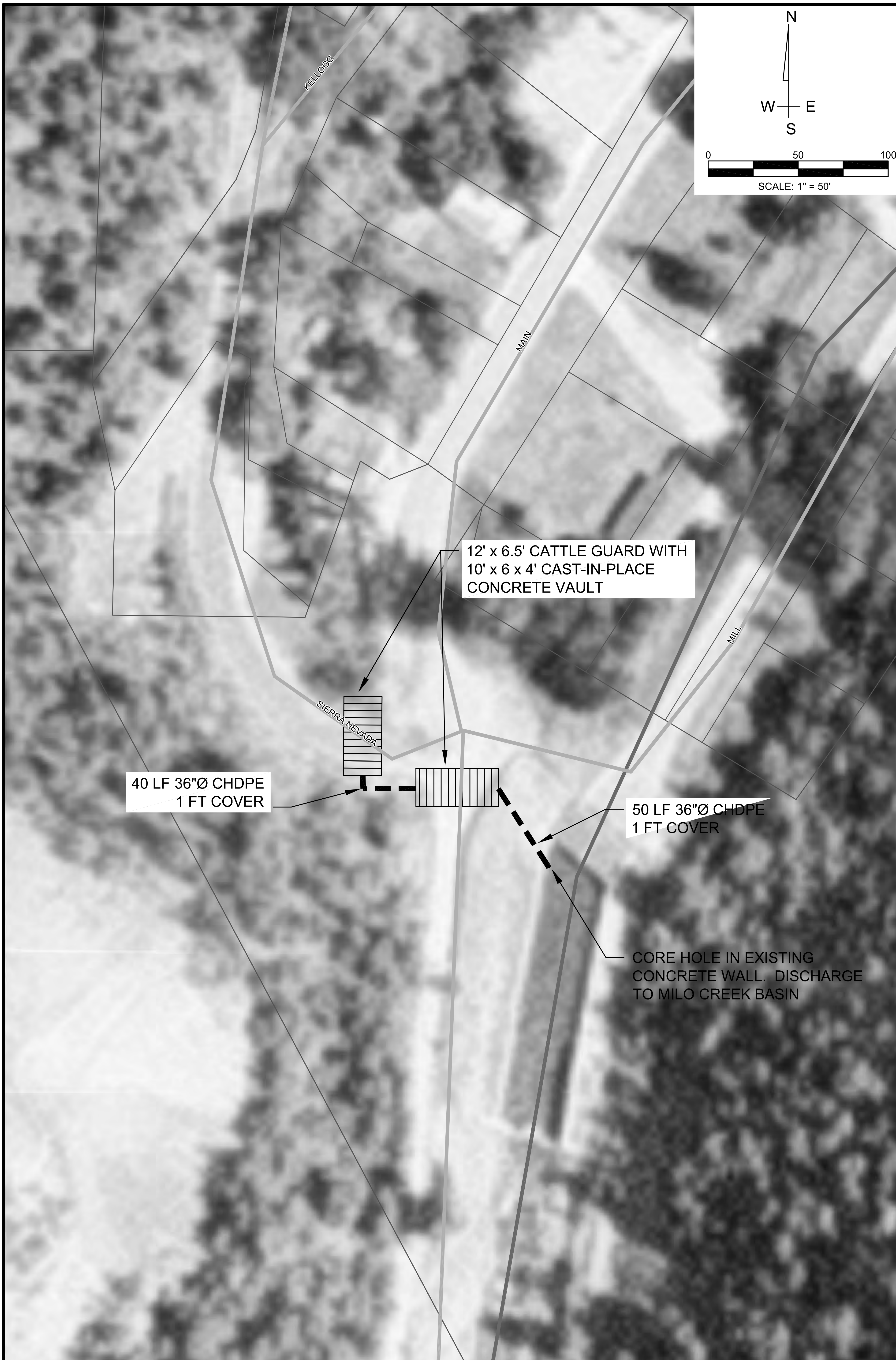
REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT 4' x 0.5' x 2' ROCK-LINED DITCH ALONG SOUTH SIDE OF PORTLAND ROAD. MUST FIRST REMOVE EXISTING WOODEN 1' x 1' x 1' FLUME.	1070	LF
2	INSTALL 300 LF OF 36"∅ CHDPE PIPE IN PLACE OF EXISTING PIPE. CONNECT TO EXISTING CONCRETE INLET.	300	LF
3	REMOVE AND REPLACE EXISTING CONCRETE VAULT WITH 4' x 4' x 4' CONCRETE INLET	1	LS
4	INSTALL 2' W x 1' H x 12' L ROCK WATER BARS AT 250 FT SPACINGS ALONG PORTLAND ROAD (4 TO 5 ROCK BARS TOTAL)	1	LS
5	RE-GRADE GRAVEL ROAD (PORTLAND ROAD) TO DRAIN SOUTH TOWARDS NEW DITCH	1070	LF



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Bunker / ROD_2009/G_ward_overview PRINT DATE January 25, 2010 PROJECT NUMBER 2010-5050	REQUESTOR D. Forseth PROJECT MANAGER D. Forseth CARTOGRAPHER B. Bailey	PROJECT NAME **Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin**	1:7,000 1 inch = 583 feet 0 500 1,000 Feet **Projection: UTM NAD 83, Zone 11N**	N	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	FIGURE 3-19 **Alternative RP-2 Vicinity Map Wardner, Idaho**

DESIGN ALTERNATIVE

MILO CREEK, WARDNER



TerraGraphics Environmental Engineering, Inc.

PROJECT NO.: 2005-3350	MILO CREEK, WARDNER	PROPOSED DESIGN	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT
SCALE: 1"=50'			
DRAWN BY: K. KINCELLA	REMEDY PROTECTION		DATE: 1/22/2010
ENGINEER: D. FORSETH			SHEET: SHEET 1 OF 1

FIGURE 3-20

COST ESTIMATE QUANTITIES
WARDNER, IDAHO

MILO CREEK

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT 40 LF OF 36"∅ CHDPE PIPE WITH 1 FT COVER	40	LF
2	CONSTRUCT 50 LF OF 36"∅ CHDPE PIPE WITH 1 FT COVER	50	LF
3	INSTALL 12' X 6.5' CATTLE GUARD WITH 10' x 6' x 4' CAST-IN-PLACE CONC VAULT	2	EA

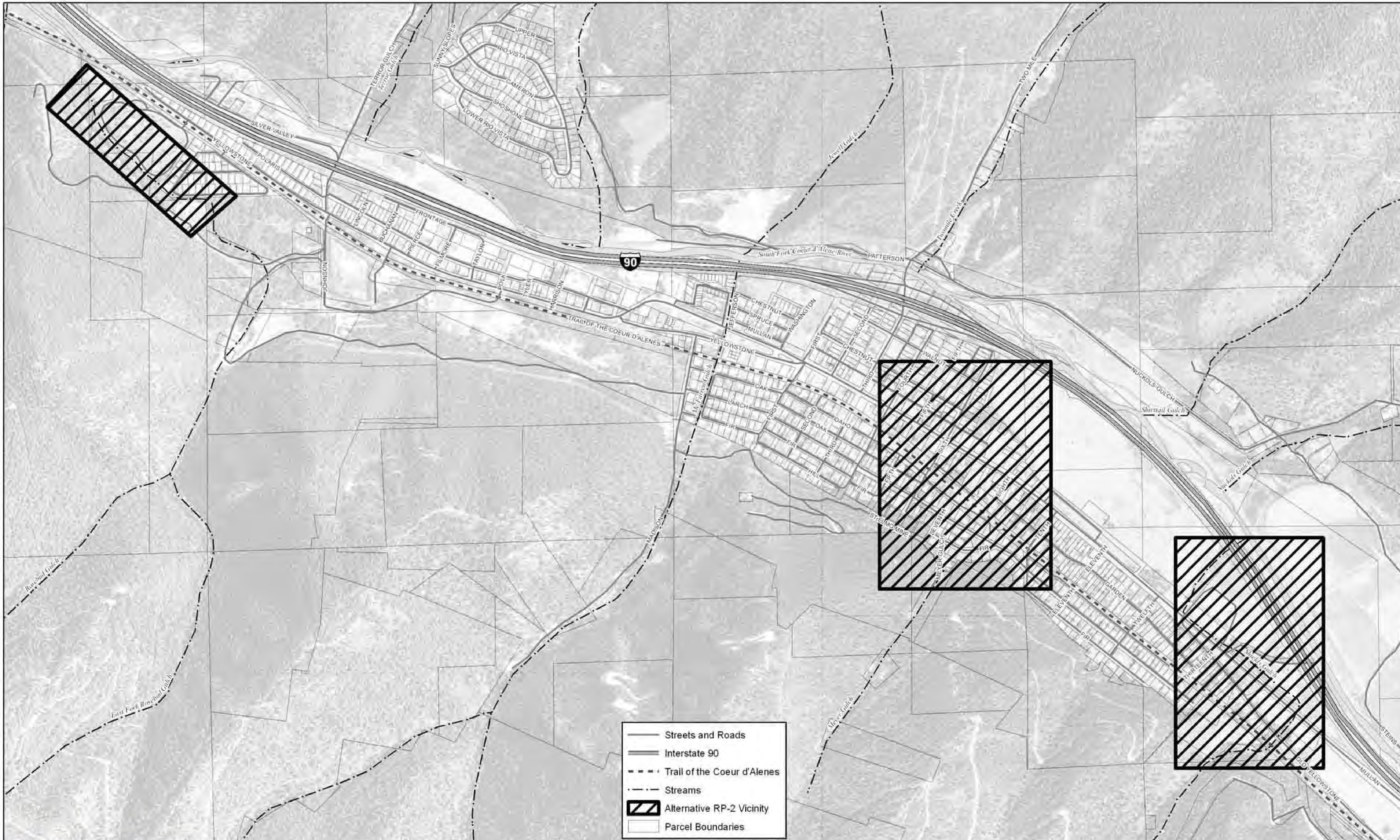


FIGURE 3-21

Alternative RP-2 Vicinity Map
Osburn, Idaho

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

File	Bunker / ROD_2009/ G_osburn_overview
Print Date	January 25, 2010
Project Number	2010-5050
Requestor	D. Forseth
Project Manager	D. Forseth
Cartographer	B. Bailey
Project Name	Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:12,000
1 inch = 1,000 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

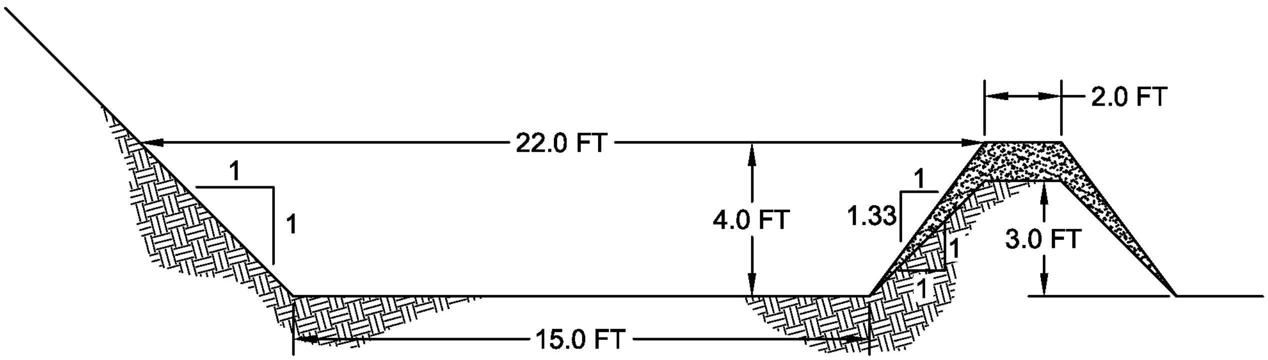
DESIGN ALTERNATIVE

ROSEBUD GULCH, OSBURN

TerraGraphics Environmental Engineering, Inc.

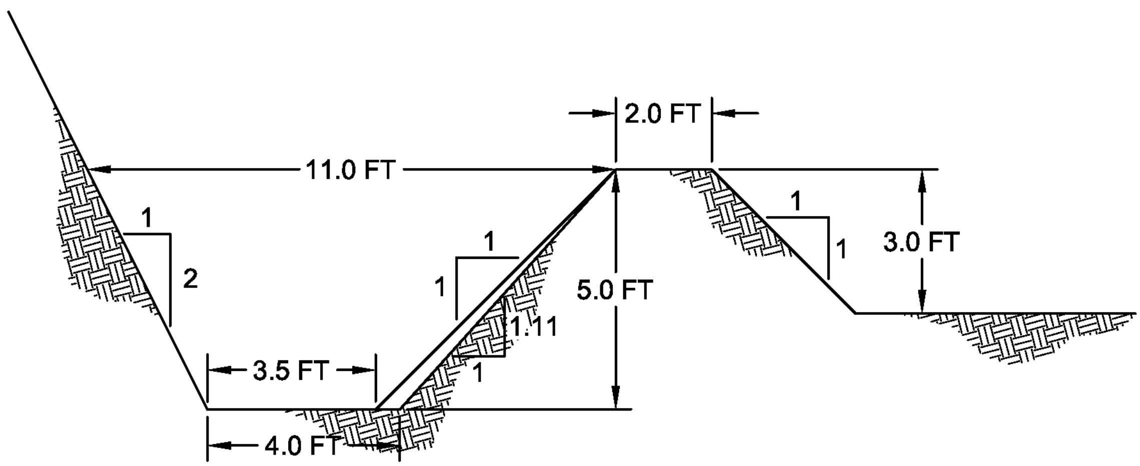
PROJECT NO.: 2010-5050	ROSEBUD GULCH, OSBURN	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, W. ZONE, FT
SCALE: 1" = 225'			DATE: 1/25/2010
DRAWN BY: C.HALEY	REMEDY PROTECTION		SHEET: 1 OF 3
ENGINEER: D.FORSETH			

FIGURE 3-22



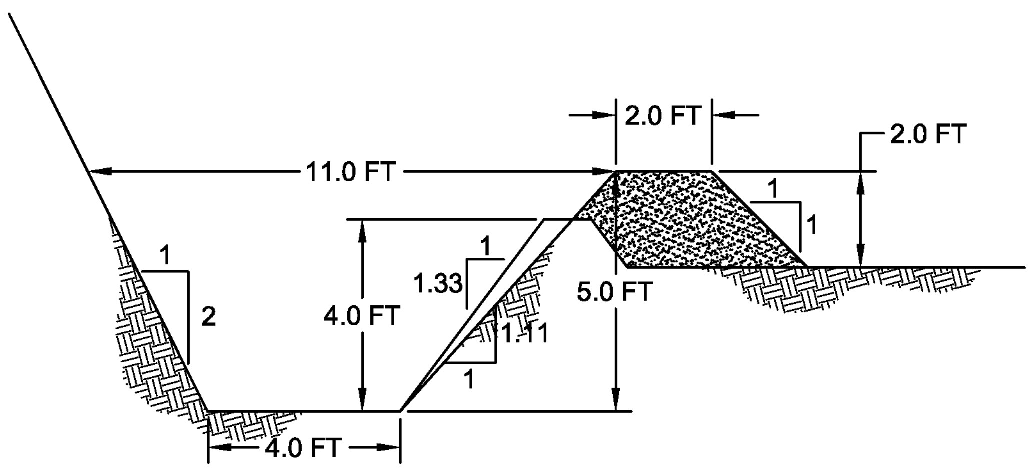
CUT = N/A
FILL = 5.00 CF/LF
LENGTH = 310 LF

1/1 TYPICAL XS - INCREASE RIGHT BANK HEIGHT
SCALE: 1" = 5'



CUT = 1.25 CF/LF
FILL = N/A
LENGTH = 45 LF

2a/1 TYPICAL XS - CHANNEL MODIFICATIONS AT START OF XS 2
SCALE: 1" = 4'

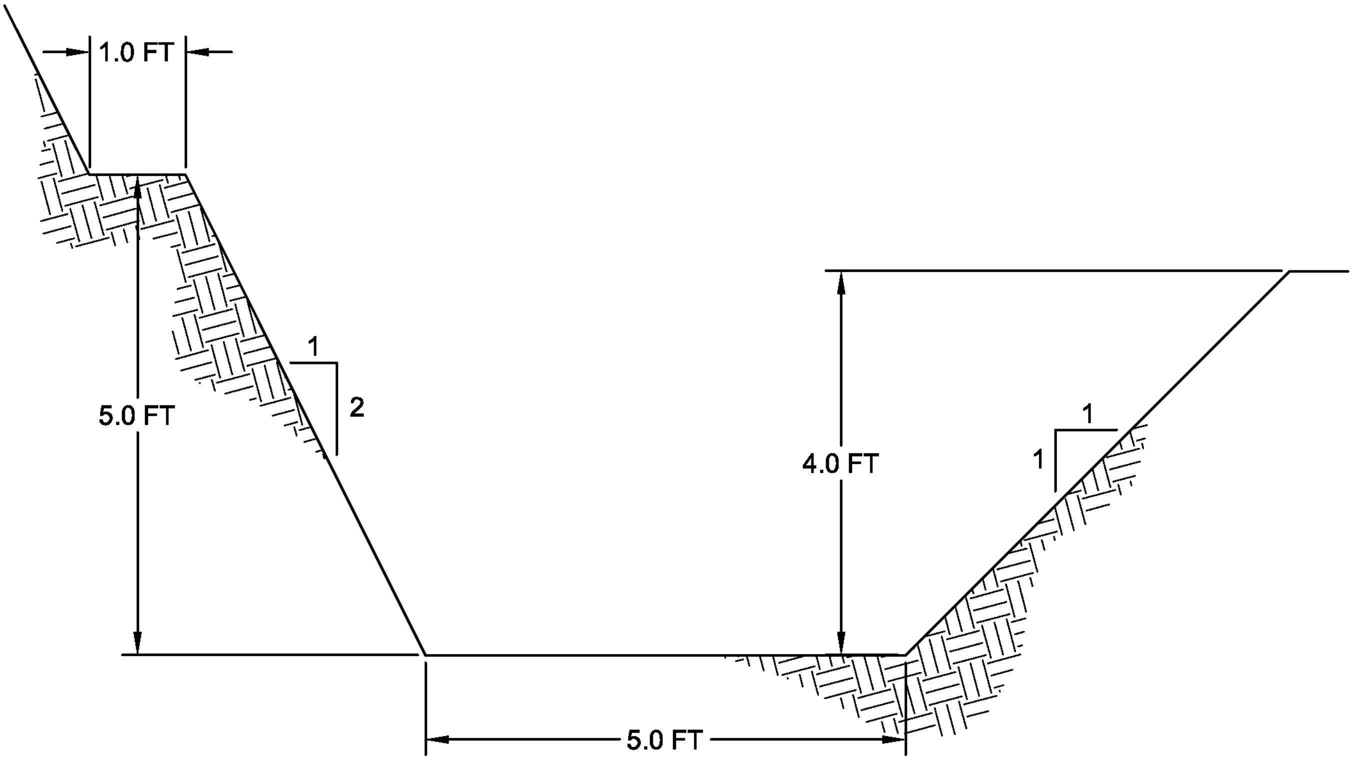


CUT = 1.20 CF/LF
FILL = 11.57 CF/LF
LENGTH = 45

2b/1 TYPICAL XS - CHANNEL MODIFICATIONS AT END OF XS 2
SCALE: 1" = 4'

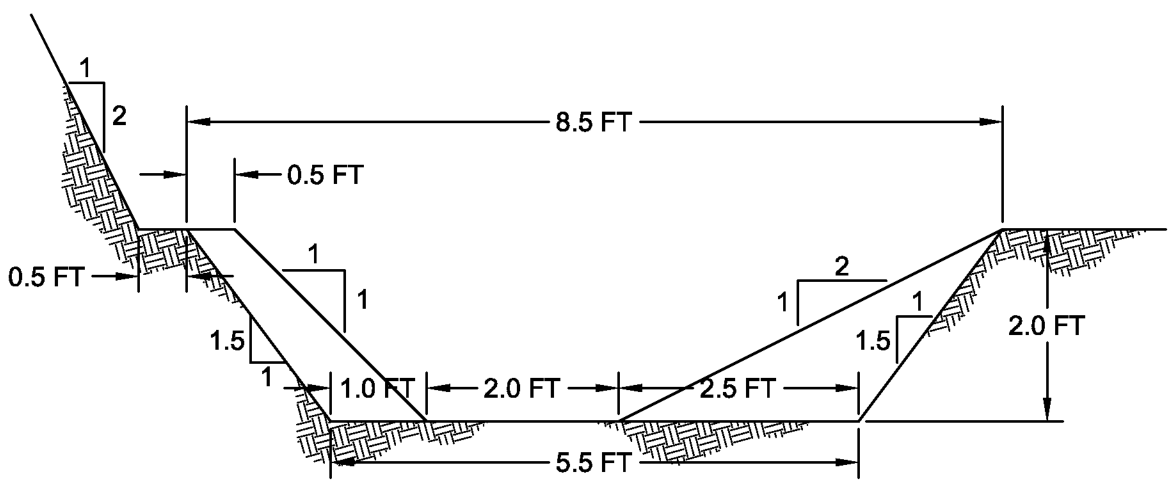
TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	ROSEBUD GULCH - CROSS SECTIONS	DATE: 10/19/2009
	ENGINEER: D.FORSETH		SHEET: 2 OF 3

FIGURE 3-23



3/1 TYPICAL XS - JUST DOWNSTREAM OF CULVERT
SCALE: 1" = 2'

CUT = N/A
FILL = N/A
LENGTH = N/A



4/1 TYPICAL XS - CHANNEL MODIFICATIONS THROUGH PARK
SCALE: 1" = 2'

CUT = 4.00 CF/LF
FILL = N/A
LENGTH = 1330 LF

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION ROSEBUD GULCH - CROSS SECTIONS	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY		DATE: 10/19/2009
	ENGINEER: D.FORSETH		SHEET: 3 OF 3

FIGURE 3-24

COST ESTIMATE QUANTITIES
OSBURN, IDAHO

ROSEBUD GULCH

REF	DESCRIPTION	QTY	UNIT
1	REPLACE EXISTING CULVERTS (ONE 24"∅ CMP AND TWO 20"∅ CMP) WITH ONE 48"∅ CMP (CULVERT 1)	130	LF
2	REPLACE EXISTING PARK CULVERT WITH A 10.5' x 16' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 2' (BRIDGE 1)	1	EA
3	RECONSTRUCT RIGHT CHANNEL BANK WITH 1' BERM (XS 1)	310	LF
4	RECONSTRUCT EXISTING CHANNEL TO 11' x 4' x 4' EARTHEN CHANNEL (XS 2 - a & b)	90	LF
5	RECONSTRUCT EXISTING CHANNEL TO 8.5' x 5.5' x 2' EARTHEN CHANNEL (XS 4)	1330	LF

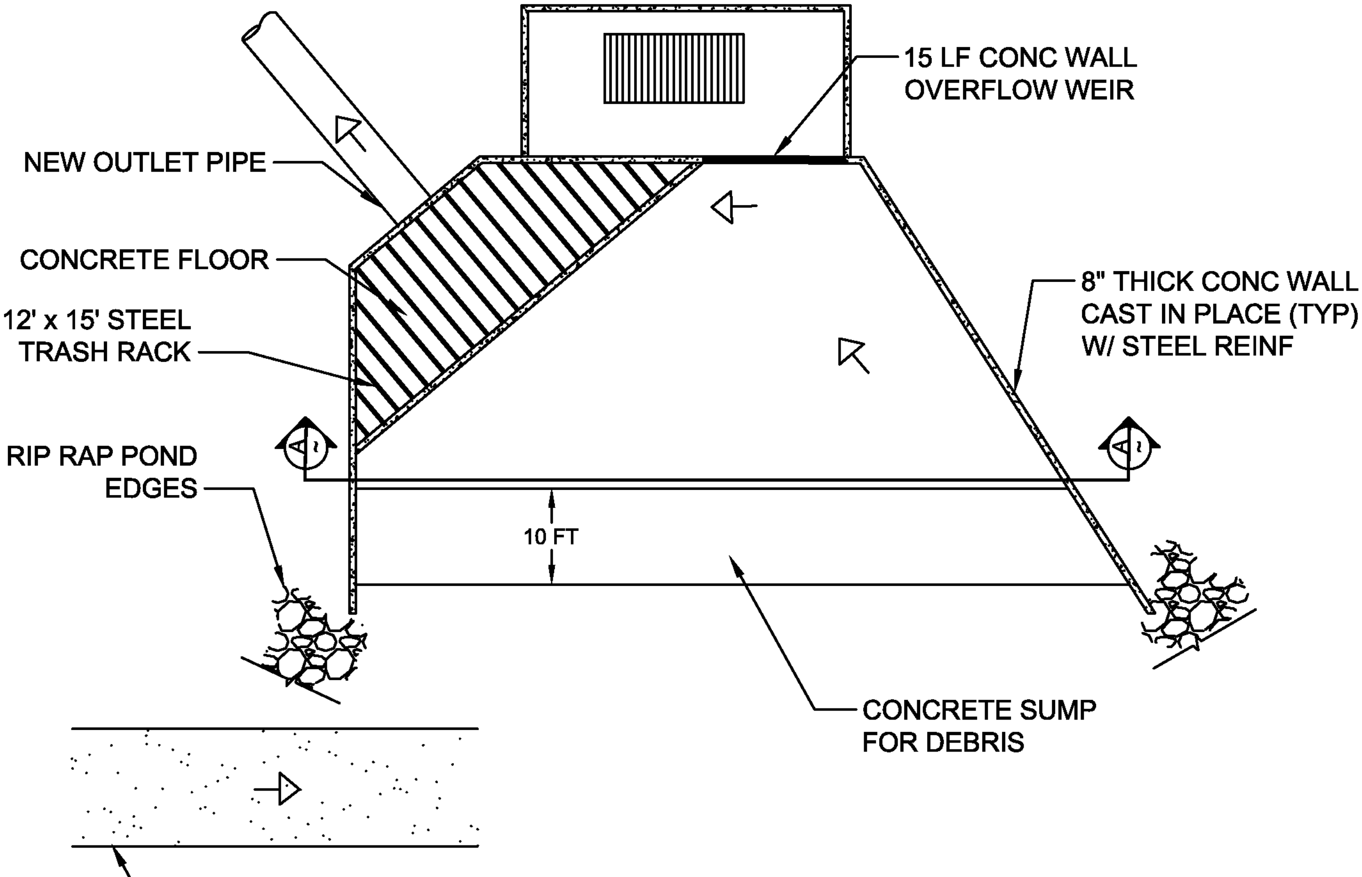
Note: Culvert 1 must be mitered to conform to the fill slope or shall be installed with a headwall

DESIGN ALTERNATIVE

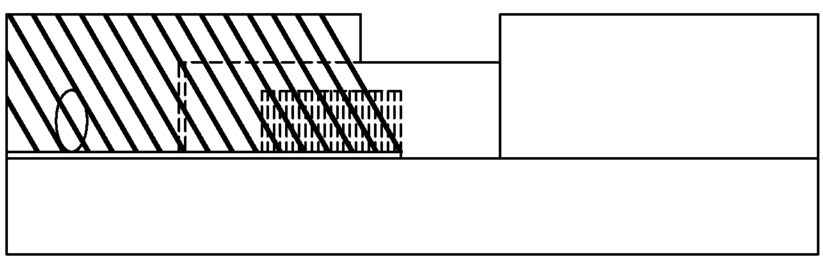
MEYER CREEK, OSBURN

TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1" = 200' DRAWN BY: C.HALEY ENGINEER: D.FORSETH	MEYER CREEK, OSBURN REMEDY PROTECTION	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, W. ZONE, FT DATE: 1/25/2010 SHEET: 1 OF 1

FIGURE 3-25



PLAN VIEW



SECTION A - A

PROFILE LOOKING DOWNSTREAM

0 10 20

SCALE: 1" = 20'

TerraGraphics Environmental Engineering, Inc.	SCALE: 1"=20'	PROJECT: REMEDY PROTECTION PROPOSED MEYER CREEK INLET STRUCTURE	PROJECT NO: 2010-5050
	DRAWN BY: K.KINCELLA		DATE: 1/11/2010
	ENGINEER: D.FORSETH		SHEET: 1 OF 1

FIGURE 3-26

COST ESTIMATE QUANTITIES
OSBURN, IDAHO

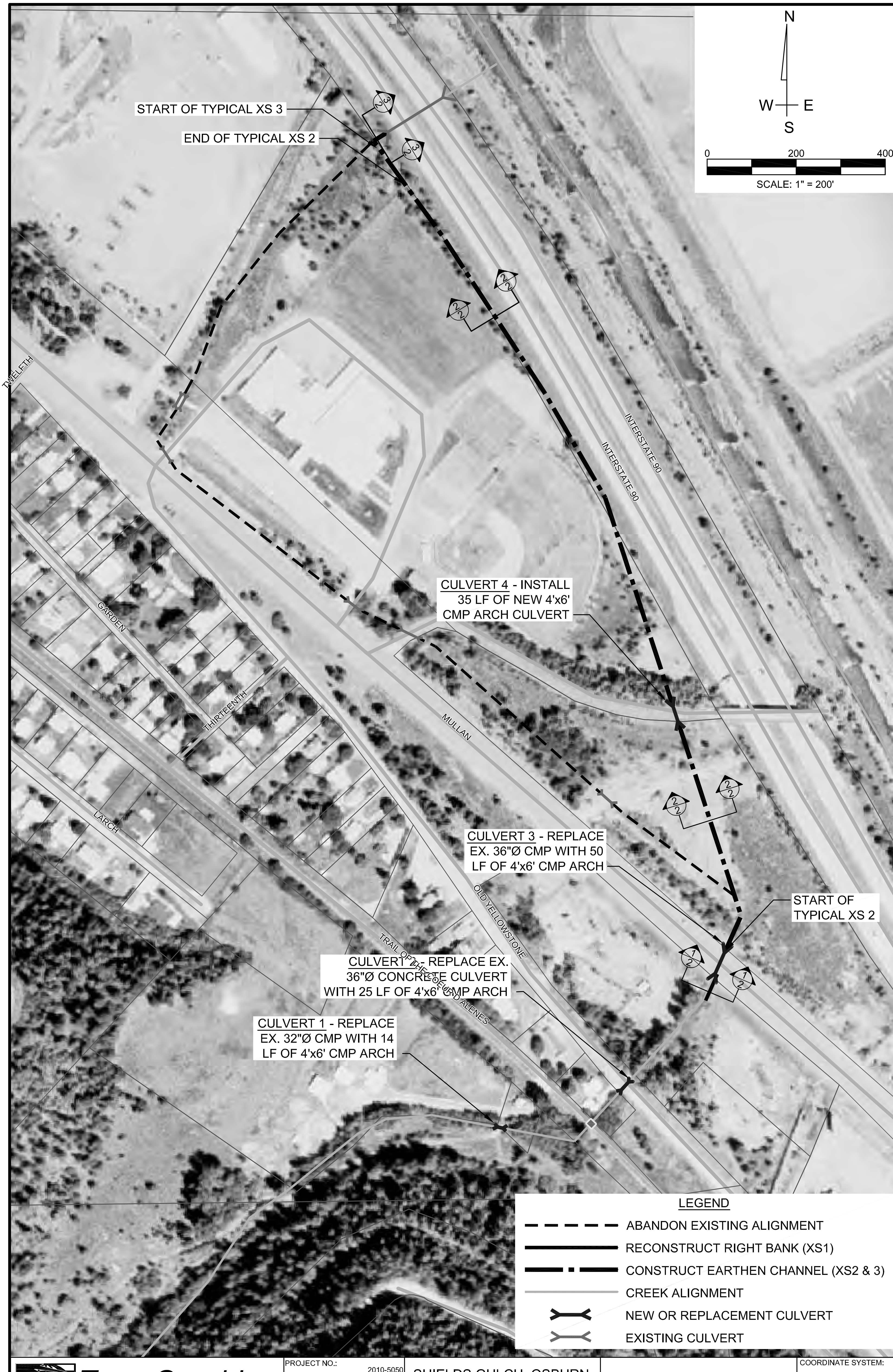
MEYER CREEK

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT 65 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT (PIPE 1)	65	LF
2	CONSTRUCT 420 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7 FT (PIPE 2)	420	LF
3	CONSTRUCT 110 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 8 FT (PIPE 3)	110	LF
4	CONSTRUCT 250 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 8 FT (PIPE 4)	250	LF
5	CONSTRUCT 375 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7 FT (PIPE 5)	375	LF
6	CONSTRUCT 250 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 8 FT (PIPE 6)	250	LF
7	CONSTRUCT 455 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7 FT (PIPE 7)	455	LF
8	CONSTRUCT 410 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT (PIPE 8)	410	LF
9	CONSTRUCT 350 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT (PIPE 9)	350	LF
10	CONSTRUCT 150 LF OF 24"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT (PIPE 10)	150	LF
11	FURNISH AND INSTALL NEW 48"∅ MANHOLE	9	EA
12	ABANDON 360 LF OF EXISTING MEYER CREEK PIPE	1	LS
13	MODIFY INLET STRUCTURE	1	LS

Note: Average pipe depths (Ref 1 through 10) are approximated from the ground surface to the bottom of the pipe

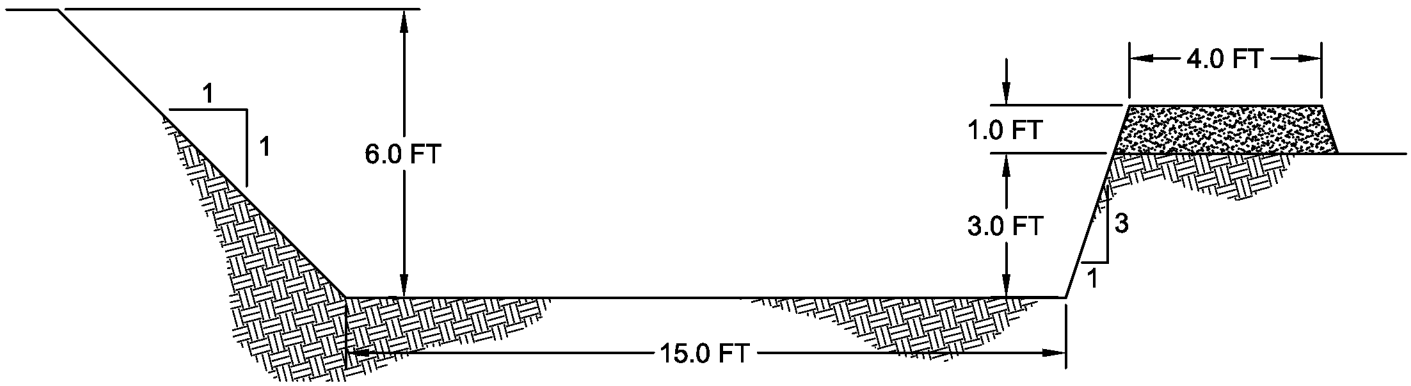
DESIGN ALTERNATIVE

SHIELDS GULCH, OSBURN



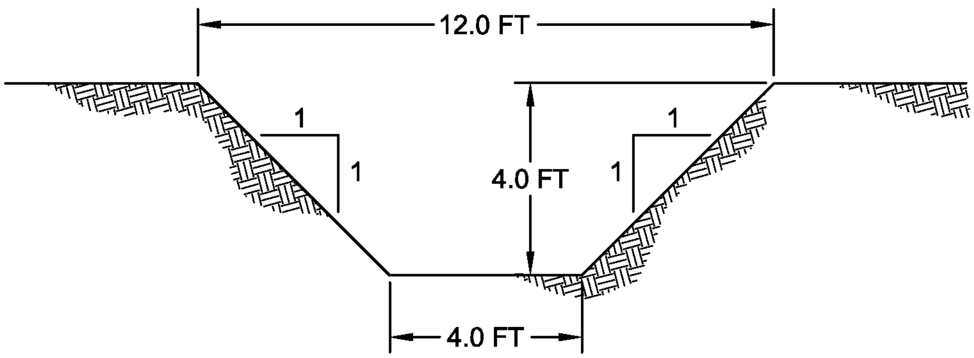
TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1" = 200' DRAWN BY: C.HALEY ENGINEER: D.FORSETH	SHIELDS GULCH, OSBURN REMEDY PROTECTION	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, W. ZONE, FT DATE: 1/25/2010 SHEET: 1 OF 2

FIGURE 3-27



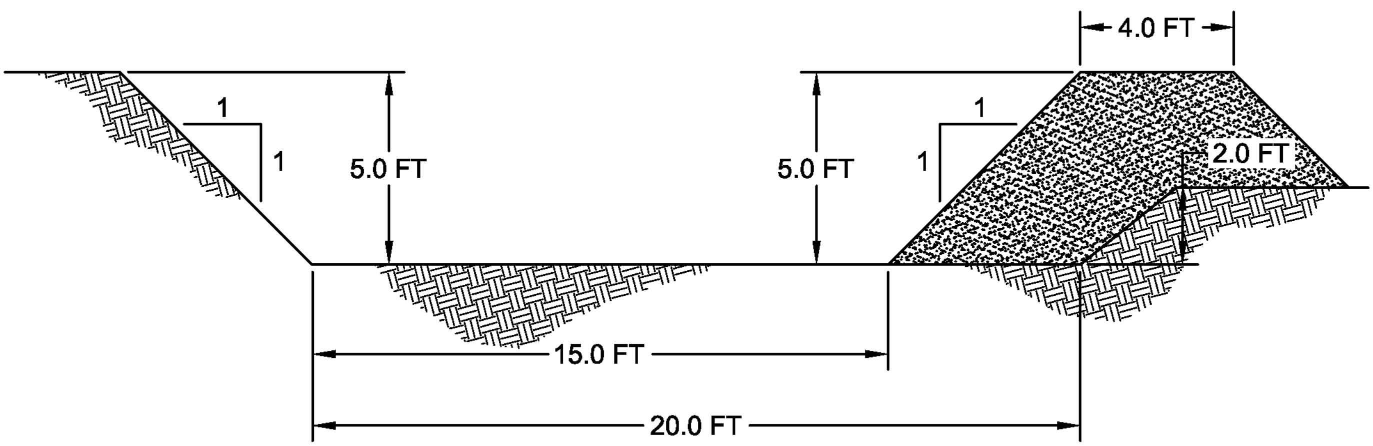
CUT = N/A
FILL = 4.33 CF/LF
LENGTH = 65 LF

1/1 TYPICAL XS - RECONSTRUCT RIGHT BANK
SCALE: 1" = 4'



CUT = 32.00 CF/LF
FILL = N/A
LENGTH = 1890 LF

2/1 TYPICAL XS - NEW EARTHEN CHANNEL ALIGNMENT
SCALE: 1" = 4'



CUT = N/A
FILL = 31.50 CF/LF
LENGTH = 155 LF

3/1 TYPICAL XS - END PORTION OF NEW ALIGNMENT
SCALE: 1" = 5'

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED DRAWN BY: C.HALEY ENGINEER: D.FORSETH	PROJECT: REMEDY PROTECTION SHIELDS GULCH - CROSS SECTIONS	PROJECT NO: 2010-5050 DATE: 10/16/2009 SHEET: 2 OF 2

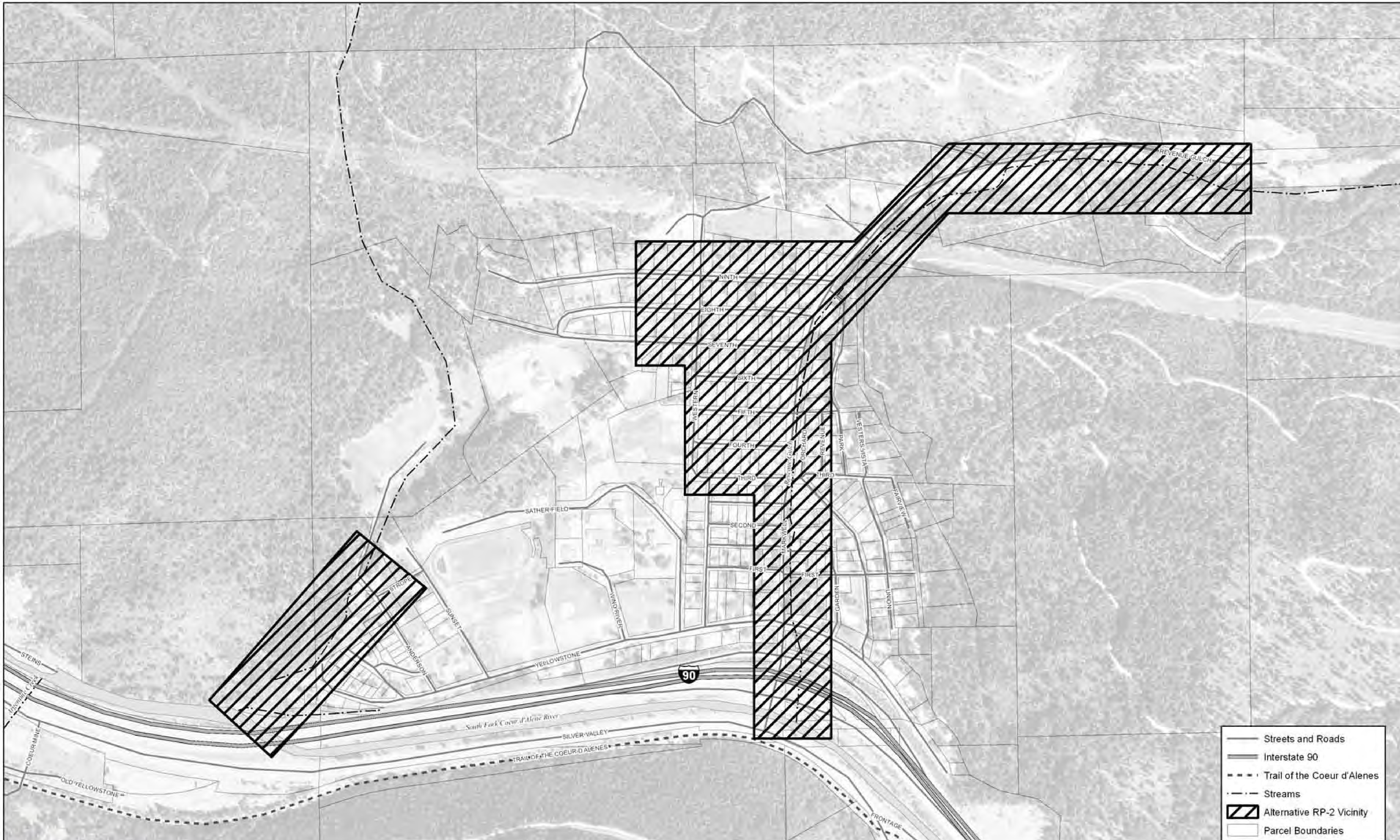
FIGURE 3-28

COST ESTIMATE QUANTITIES
OSBURN, IDAHO

SHIELDS GULCH

REF	DESCRIPTION	QTY	UNIT
1	REPLACE EXISTING 32"∅ CMP CULVERT WITH 4'x6' CMP ARCH (CULVERT 1)	14	LF
2	REPLACE EXISTING 36"∅ CONCRETE CULVERT WITH 4'x6' CMP ARCH (CULVERT 2)	25	LF
3	REPLACE EXISTING 36"∅ CMP CULVERT WITH 4'x6' CMP ARCH (CULVERT 3)	50	LF
4	INSTALL NEW 4'x6' CMP ARCH CULVERT (CULVERT 4)	35	LF
5	RECONSTRUCT RIGHT CHANNEL BANK WITH 1' BERM (XS 1)	65	LF
6	CONSTRUCT 12' x 4' x 4' EARTHEN CHANNEL (XS 2)	1890	LF
7	CONSTRUCT 25' x 15' x 5' EARTHEN CHANNEL (XS 3)	155	LF

Note: All culverts (Ref. 1 through 4) must be mitered to conform to the fill slope or shall be installed with a headwall



TerraGraphics
Environmental Engineering, Inc.
www.TerraGraphics.com

FILE	Bunker / ROD_2009/ G_silverton_overview	REQUESTOR	D. Forseth
PRINT DATE	January 25, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:6,000
1 inch = 500 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

FIGURE 3-29
Alternative RP-2 Vicinity Map
Silverton, Idaho

DESIGN ALTERNATIVE

REVENUE GULCH, SILVERTON

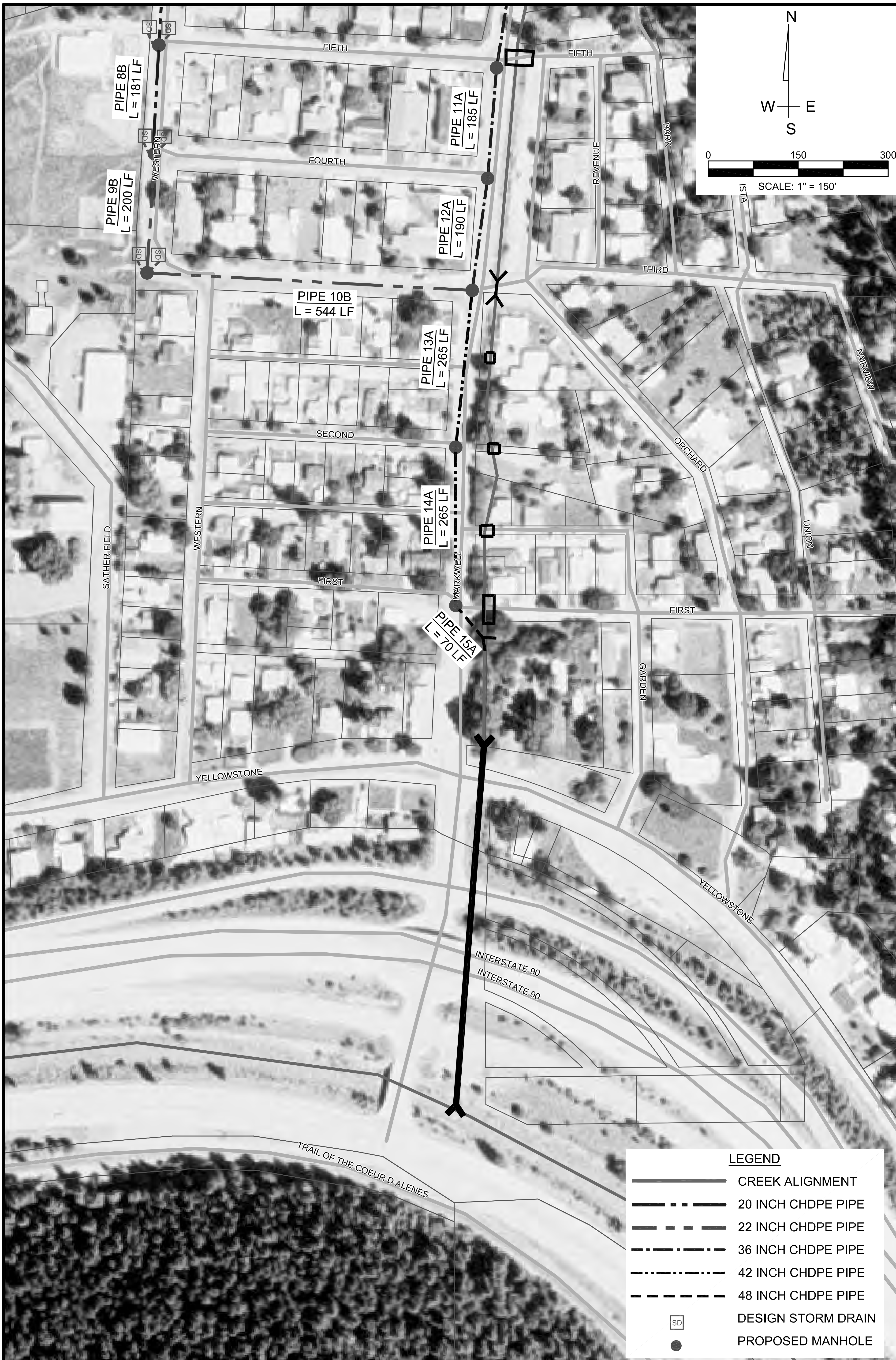
TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1"=350' DRAWN BY: K.KINCELLA ENGINEER: D.FORSETH	REVENUE GULCH, SILVERTON REMEDY PROTECTION	PROPOSED DESIGN	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT DATE: 11/17/09 SHEET: 1 OF 4

FIGURE 3-30

TerraGraphics Environmental Engineering, Inc.

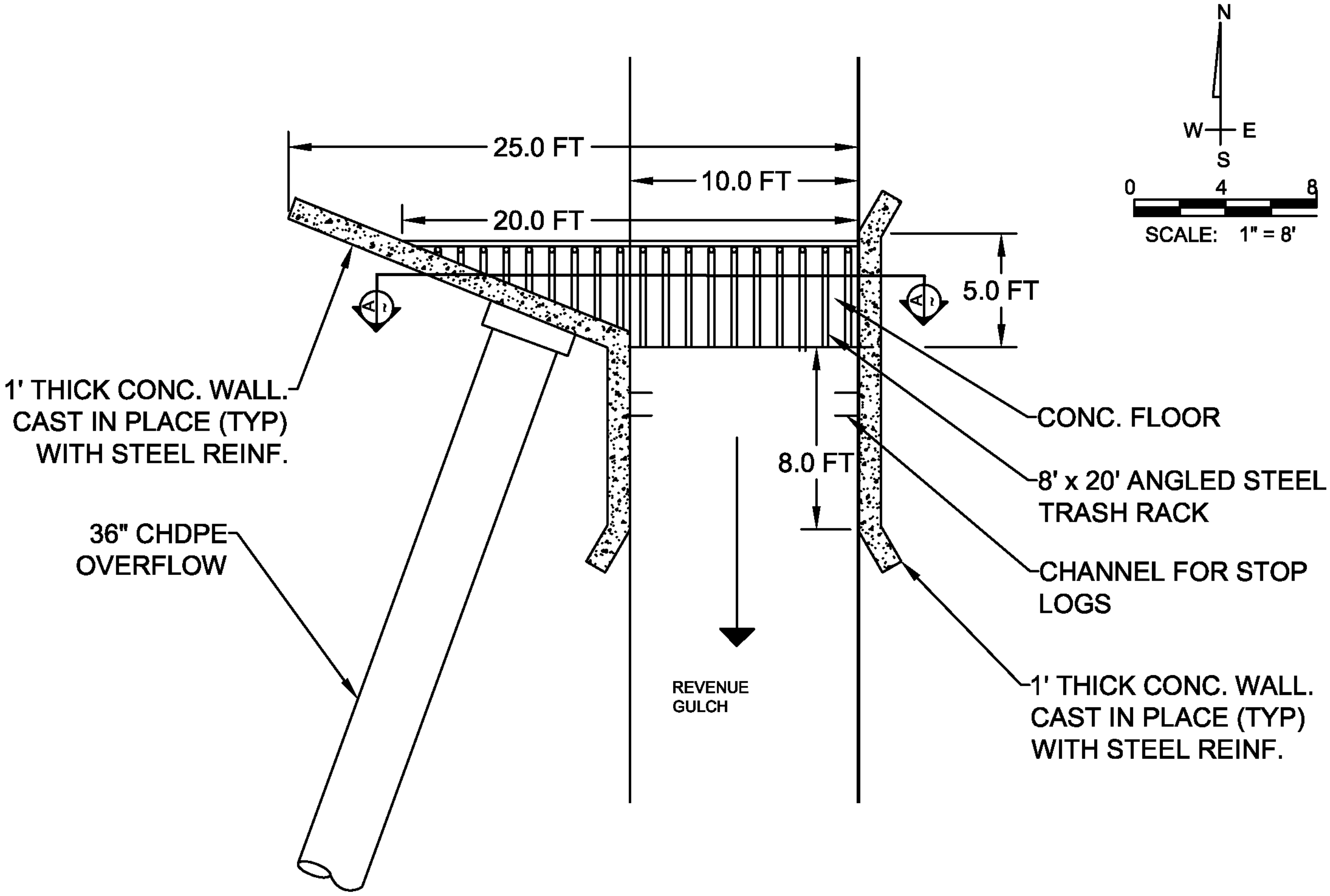
PROJECT NO.: 2010-5050	REVENUE GULCH, SILVERTON	PROPOSED STORM SEWER LAYOUT	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT
SCALE: 1" = 150'			DATE: 11/17/09
DRAWN BY: C.HALEY	REMEDY PROTECTION		SHEET: 2 OF 4
ENGINEER: D.FORSETH			

FIGURE 3-31

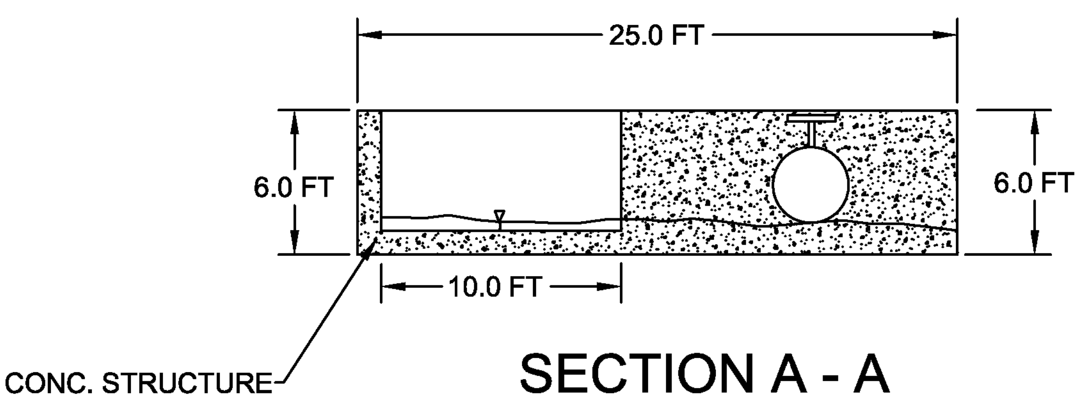


TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1" = 150' DRAWN BY: C.HALEY ENGINEER: D.FORSETH	REVENUE GULCH, SILVERTON REMEDY PROTECTION	PROPOSED STORM SEWER LAYOUT	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT DATE: 11/17/09 SHEET: 3 OF 4

FIGURE 3-32



PLAN VIEW



SECTION A - A

PROFILE LOOKING DOWNSTREAM

TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 8'	PROJECT: REMEDY PROTECTION PROPOSED REVENUE GULCH OVERFLOW STRUCTURE	PROJECT NO: 2010-5050
	DRAWN BY: K. KINCELLA		DATE: 11/19/2009
	ENGINEER: D. FORSETH		SHEET: 4 OF 4

FIGURE 3-33

COST ESTIMATE QUANTITIES
SILVERTON, IDAHO

REVENUE GULCH - DESIGN ALTERNATIVE

REF	DESCRIPTION	QTY	UNIT
1	REPLACE EXISTING CULVERT (48"∅ CMP) WITH ONE 56"∅ CMP (CULVERT 1)	38	LF
2	REPLACE EXISTING CULVERT (15 LF OF 48"∅ CMP) WITH 15' x 32' SINGLE SPAN BRIDGE WITH A CLEAR HEIGHT OF 5' (BRIDGE 1)	1	EA
3	REPLACE EXISTING CULVERT (48"∅ CMP) WITH ONE 5.6' x 7.9' PIPE ARCH CMP (CULVERT 2)	32	LF
4	REPLACE EXISTING CULVERT (48"∅ CMP) WITH ONE 6.1' x 8.8' PIPE ARCH CMP (CULVERT 3)	22	LF
5	REPLACE EXISTING CULVERT (BOX CULVERT) WITH ONE 3' x 7.5' BOX CULVERT (CULVERT 4)	550	LF
6	INSTALL/CONSTRUCT OVERFLOW STRUCTURE	1	EA
7	CONSTRUCT 235 LF OF 18"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 1A)	235	LF
8	CONSTRUCT 210 LF OF 18"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 2A)	210	LF
9	CONSTRUCT 210 LF OF 18"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 3A)	210	LF
10	CONSTRUCT 200 LF OF 18"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 4A)	200	LF
11	CONSTRUCT 80 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 5A)	80	LF
12	CONSTRUCT 290 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 6A)	290	LF
13	CONSTRUCT 225 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 7A)	225	LF
14	CONSTRUCT 190 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 8A)	190	LF
15	CONSTRUCT 190 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 9A)	190	LF
16	CONSTRUCT 205 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 10A)	205	LF
17	CONSTRUCT 185 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 11A)	185	LF
18	CONSTRUCT 190 LF OF 36"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 7.5 FT TO INVERT (PIPE 12A)	190	LF
19	CONSTRUCT 265 LF OF 42"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 13A)	265	LF
20	CONSTRUCT 265 LF OF 42"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 14A)	265	LF
24	CONSTRUCT 70 LF OF 48"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 5.5 FT TO INVERT (PIPE 15A)	70	LF
25	FURNISH AND INSTALL NEW 48"∅ MANHOLE AT A DEPTH OF 6 TO 8 FT	14	EA
26	FURNISH AND INSTALL NEW STORM DRAIN	8	EA

Note: Culverts 1 through 4 must be mitered to conform to the fill slope or shall be installed with a 90 degree headwall

WEST OF WESTERN AVE - DESIGN ALTERNATIVE

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT 206 LF OF 16"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 1B)	206	LF
2	CONSTRUCT 220 LF OF 16"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 2B)	220	LF
3	CONSTRUCT 229 LF OF 16"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 3B)	229	LF
4	CONSTRUCT 192 LF OF 18"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6 FT TO INVERT (PIPE 4B)	192	LF
5	CONSTRUCT 196 LF OF 20"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 5B)	196	LF
6	CONSTRUCT 183 LF OF 20"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 6B)	183	LF
7	CONSTRUCT 192 LF OF 20"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 7B)	192	LF
8	CONSTRUCT 181 LF OF 20"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 8B)	181	LF
9	CONSTRUCT 200 LF OF 22"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 9B)	200	LF
10	CONSTRUCT 554 LF OF 22"∅ CHDPE PIPE AT AN AVERAGE DEPTH OF 6.5 FT TO INVERT (PIPE 10B)	544	LF
11	FURNISH AND INSTALL NEW 48"∅ MANHOLE AT A DEPTH OF 6 TO 8 FT	10	EA
12	FURNISH AND INSTALL NEW STORM DRAIN	20	EA

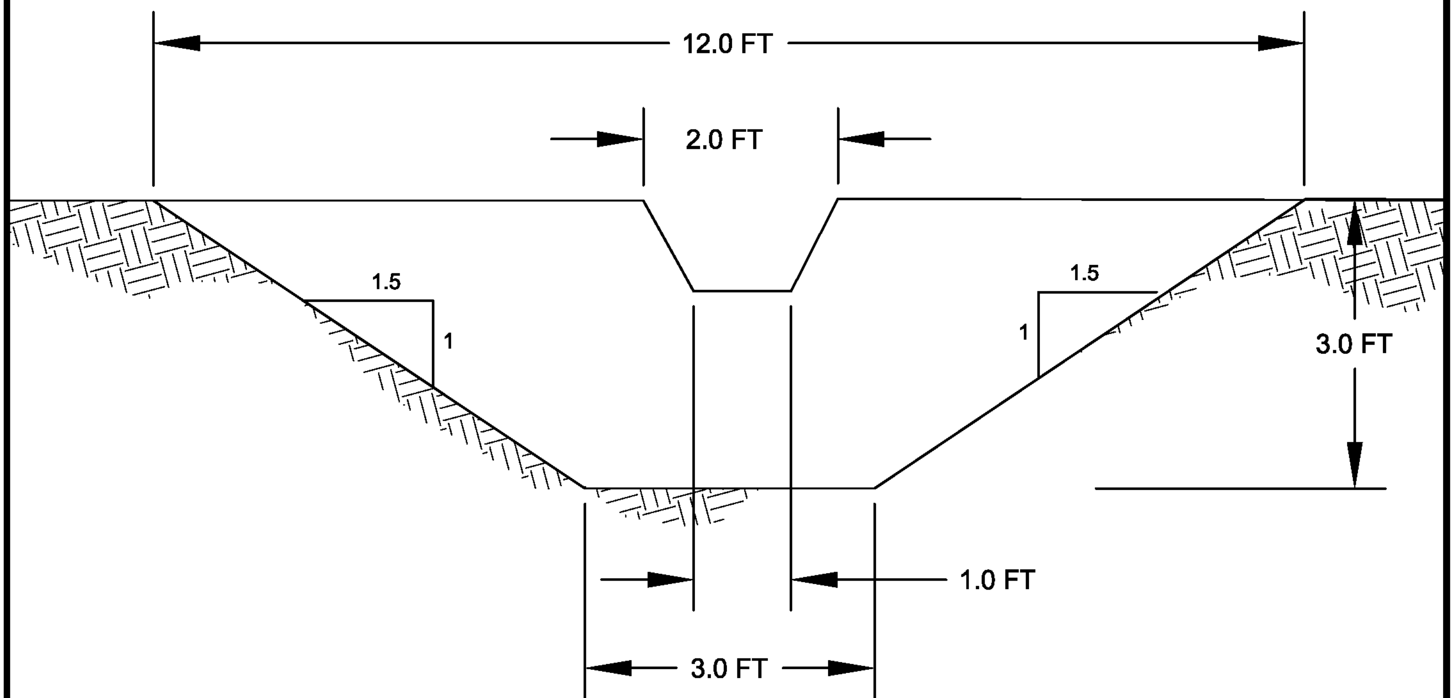
DESIGN ALTERNATIVE

UNNAMED CREEK, SILVERTON

TerraGraphics
Environmental Engineering, Inc.

PROJECT NO.: 2010-5050	UNNAMED CREEK, SILVERTON	PROPOSED DESIGN	COORDINATE SYSTEM:	NAD 83, ISP, WEST ZONE, FT
SCALE: 1"=200'				
DRAWN BY: K.KINCELLA	REMEDY PROTECTION		DATE:	11/12/09
ENGINEER: D.FORSETH			SHEET:	1 OF 2

FIGURE 3-34



CUT = 21.1 CF/LF
FILL = N/A
LENGTH = 1115 LF

1/1 TYPICAL XS - CHANNEL MODIFICATIONS
SCALE: 1" = 2'

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: K.KINCELLA	UNNAMED CREEK - CROSS SECTION	DATE: 11/12/2009
	ENGINEER: D.FORSETH		SHEET: 2 OF 2

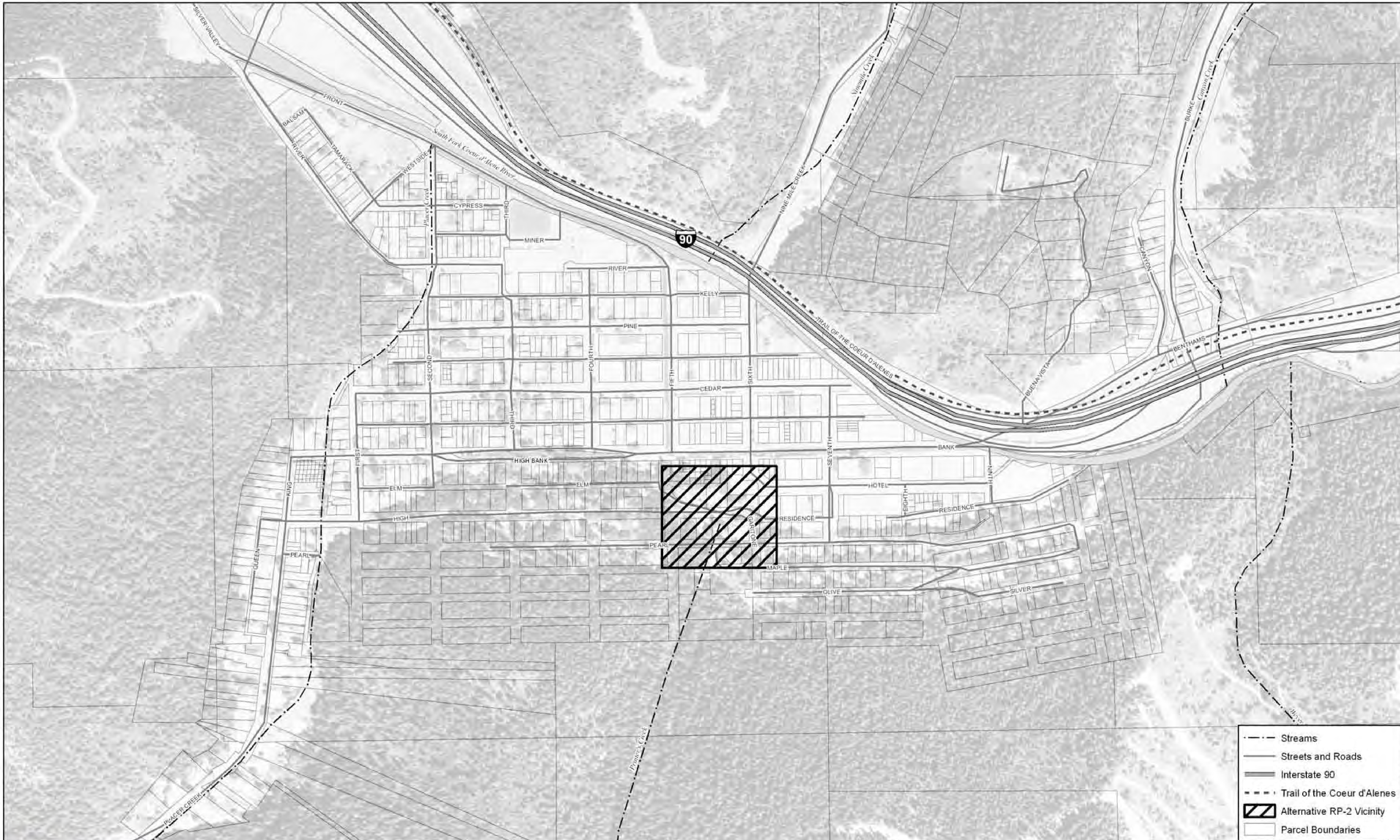
FIGURE 3-35

COST ESTIMATE QUANTITIES
SILVERTON, IDAHO

UNNAMED CREEK

REF	DESCRIPTION	QTY	UNIT
1	REPLACE EXISTING CULVERT (12"∅ CMP) WITH ONE 22"∅ CMP (CULVERT 1)	24	LF
2	RECONSTRUCT EXISTING CHANNEL TO 12' x 3.0' x 3.0' EARTHEN CHANNEL (XS 1)	1115	LF

Note: Culverts must be mitered to conform to the fill slope or shall be installed with a 90 degree headwall



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FILE	Bunker / ROD_2009/ G_wallace_overview	REQUESTOR	D. Forseth
PRINT DATE	January 25, 2010	PROJECT MANAGER	D. Forseth
PROJECT NUMBER	2010-5050	CARTOGRAPHER	B. Bailey

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

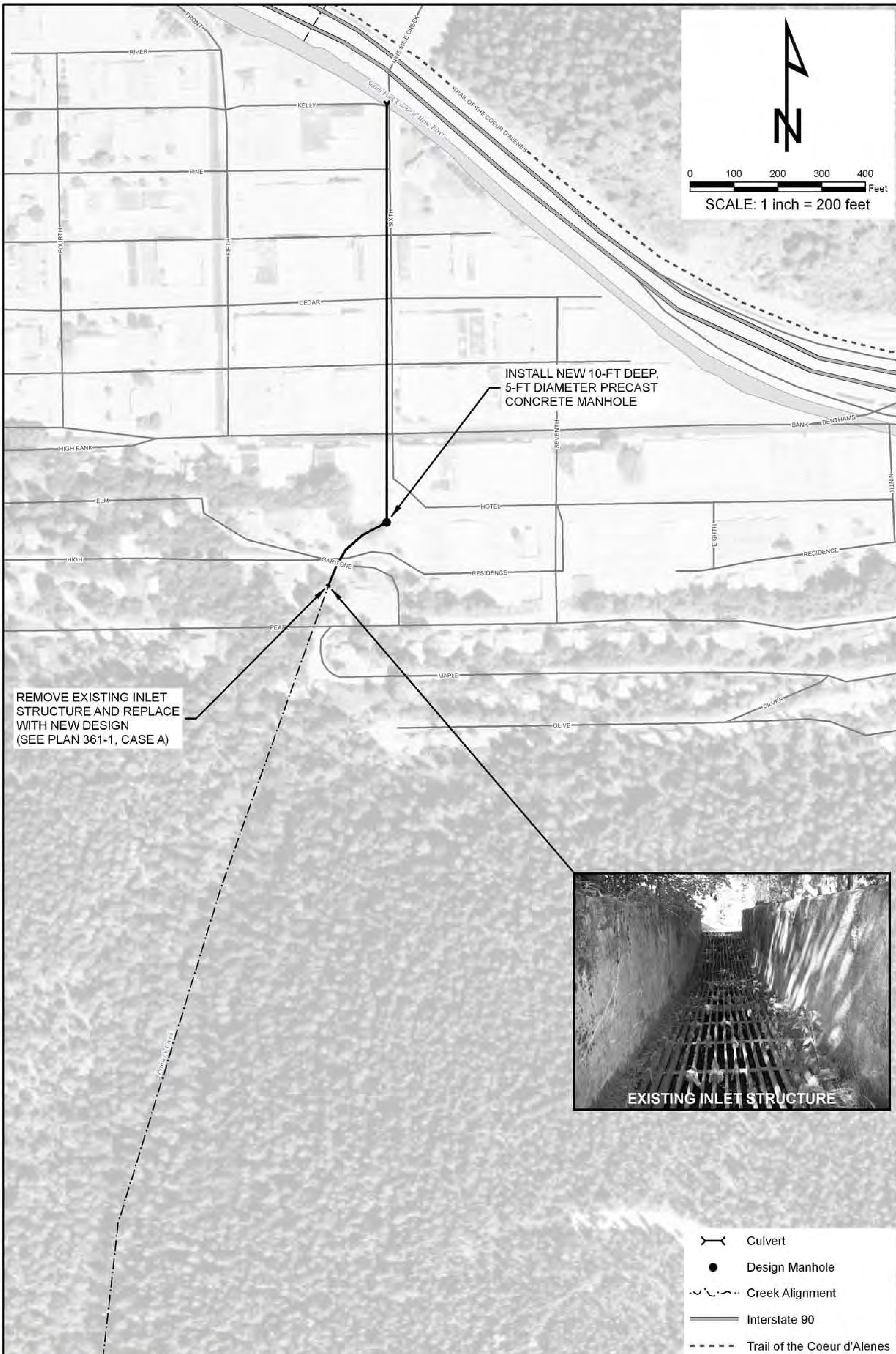
1:5,000
1 inch = 417 feet
0 200 400 600 Feet
Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

FIGURE 3-36
Alternative RP-2 Vicinity Map
Wallace, Idaho

DESIGN ALTERNATIVE

PRINTER’S CREEK, WALLACE

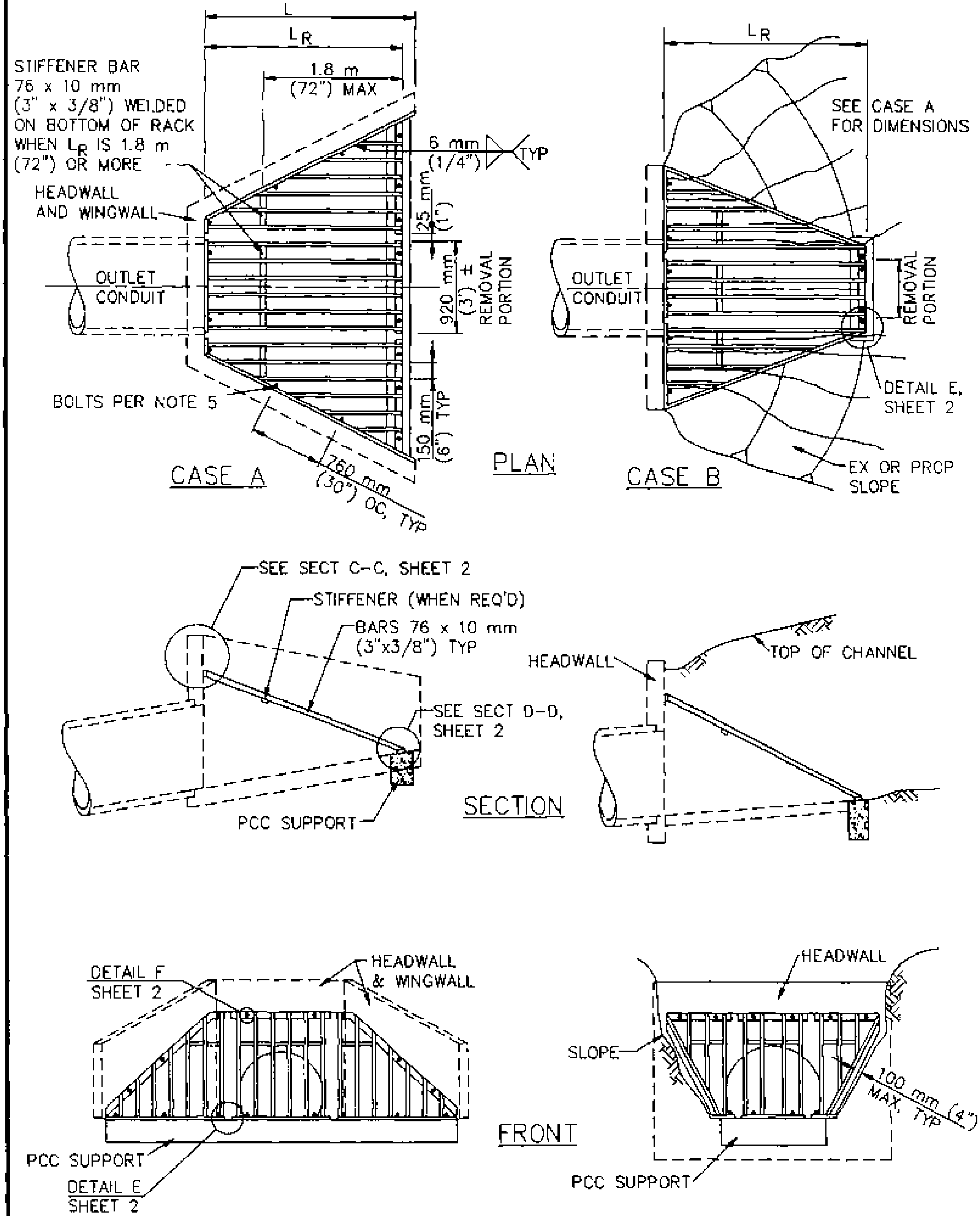


TerraGraphics
Environmental Engineering, Inc.

PROJECT NO.: 2010-5050	PRINTER'S CREEK, WALLACE	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, UTM ZONE 11N
SCALE: 1" = 200'			DATE: 11/5/2009
DRAWN BY: C. HALEY	REMEDY PROTECTION		SHEET: 1 OF 1
ENGINEER: D. FORSETH			

FIGURE 3-37

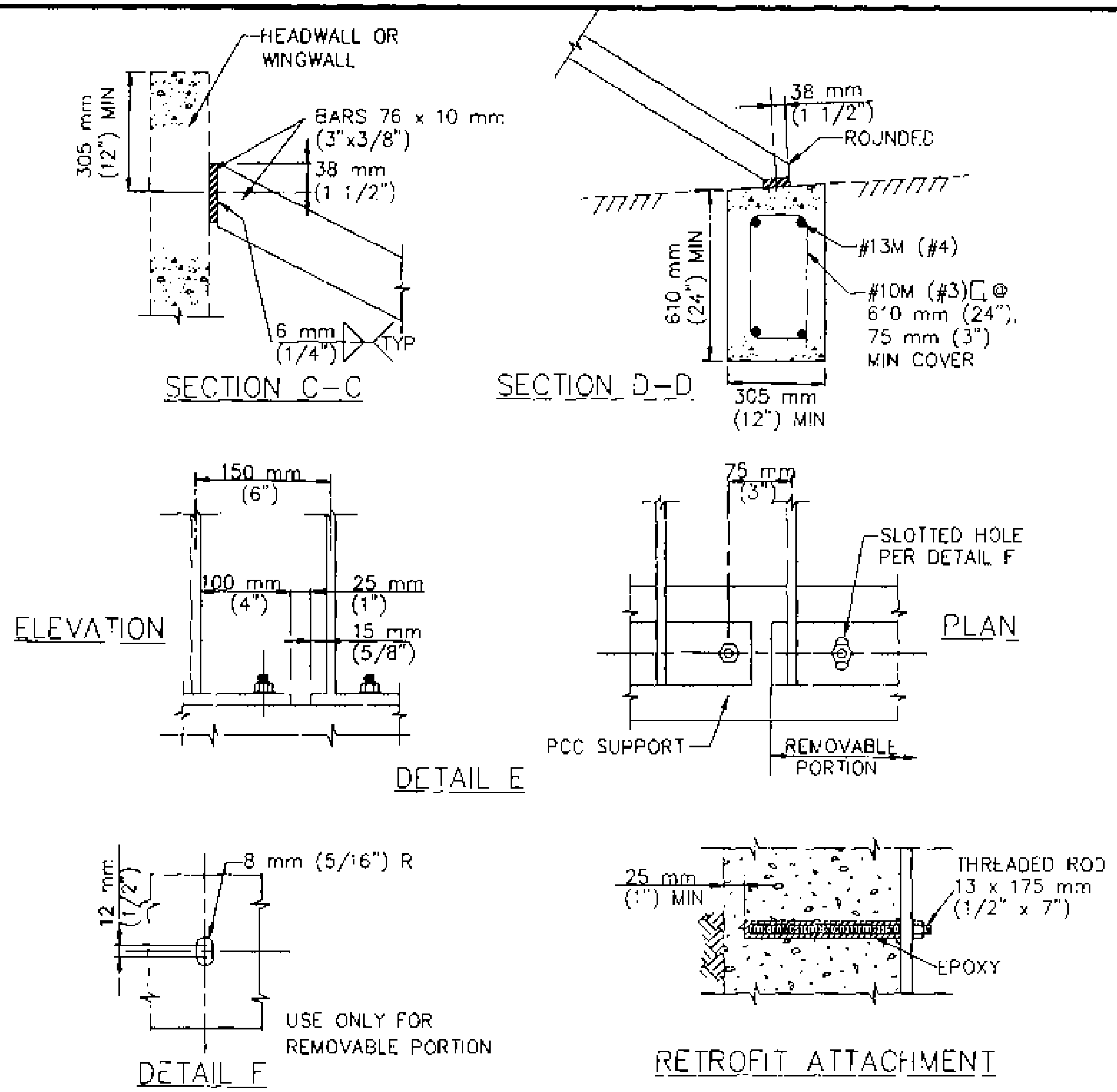
Proposed Printer's Creek Inlet Structure: Case A with 15' long x 8' tall wingwalls & 5' long x 8' tall headwall



STANDARD PLANS FOR PUBLIC WORKS CONSTRUCTION

PROMULGATED BY THE PUBLIC WORKS STANDARDS INC. GREENBOOK COMMITTEE 1993 REV. 2005	**TRASH RACK (INCLINED)**	STANDARD PLAN METRIC **361–1**
	USE WITH STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION	SHEET 1 OF 2

FIGURE 3-38



NOTES

1. MAXIMUM SIZE OF OUTLET FOR THIS RACK IS 1200 mm (48") PIPE OR 1.2 m (48") WIDE RCB. MAXIMUM LENGTH OF RACK L_R IS 3 m (10'-0").
2. ADJUST L_R SO THAT THE SLOPE OF THE RACK IS APPROXIMATELY 2 HORIZONTAL TO 1 VERTICAL.
3. THE PCC SUPPORT IS NOT NEEDED IF THE INLET STRUCTURE HAS A SUITABLE CUTOFF WALL. THE PCC SUPPORT SHALL NOT REPLACE THE CUTOFF WALL.
4. GALVANIZE RACK AFTER FABRICATION.
5. BOLTS SHALL BE 13 x 175 mm (1/2"x7"). BOLTS FOR REMOVABLE PORTION SHALL BE STAINLESS STEEL. PROVIDE WASHERS AT EACH BOLT.
6. SUBMIT SHOP DRAWINGS PER SSPWC 2-5.3.3. FOR RETROFIT WORK, INCLUDE DETAILS FOR ATTACHMENT TO EXISTING STRUCTURE.

STANDARD PLANS FOR PUBLIC WORKS CONSTRUCTION	STANDARD PLAN METRIC
TRASH RACK (INCLINED)	**361–1** SHEET 2 OF 2

COST ESTIMATE QUANTITIES
WALLACE, IDAHO

PRINTER'S CREEK

REF	DESCRIPTION	QTY	UNIT
1	FURNISH AND INSTALL NEW 10-FT DEEP, 5-FT ∅ PRECAST CONCRETE MANHOLE	1	EA
2	REMOVE EXISTING INLET STRUCTURE	1	LS
3	CONSTRUCT NEW INLET STRUCTURE (SEE PLAN 316-1, CASE A WITH 15' LONG x 8' TALL WINGWALLS AND 5' LONG x 8' TALL HEADWALL)	1	LS

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FILE	Bunker / ROD_2009r G_mullan_overview	
PRINT DATE	January 25, 2010	
PROJECT NUMBER	2010-5050	
REQUESTOR	D. Forseth	
PROJECT MANAGER	D. Forseth	
CARTOGRAPHER	B. Bailey	

PROJECT NAME
Focused Feasibility Study Upper Basin of the Coeur d'Alene River Basin

1:6,000
1 inch = 500 feet
0 500 1,000 Feet
Projection: UTM NAD 83, Zone 11N

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

FIGURE 3-40

Alternative RP-2 Vicinity Map
Mullan, Idaho

DESIGN ALTERNATIVE

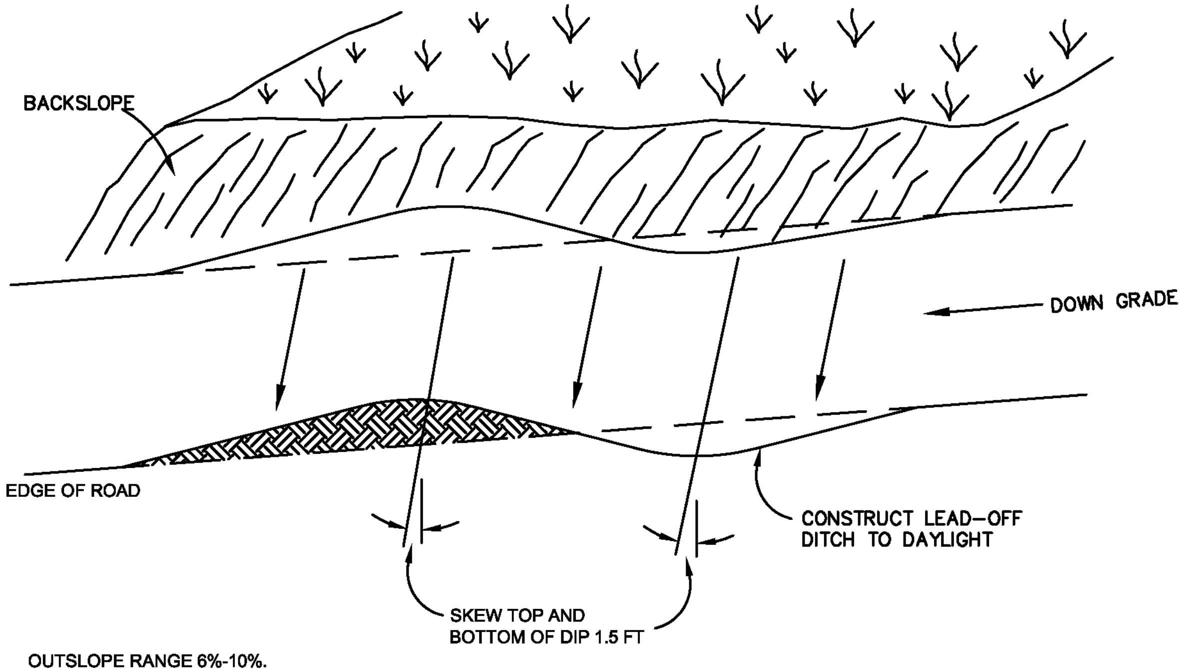
MILL CREEK, MULLAN

TerraGraphics Environmental Engineering, Inc.	PROJECT NO.: 2010-5050 SCALE: 1" = 225' DRAWN BY: K.KINCELLA ENGINEER: D.FORSETH	MILL CREEK, MULLAN REMEDY PROTECTION	PROPOSED DESIGN ALTERNATIVE	COORDINATE SYSTEM: NAD 83, ISP, WEST ZONE, FT DATE: 11/12/09 SHEET: 1 OF 3

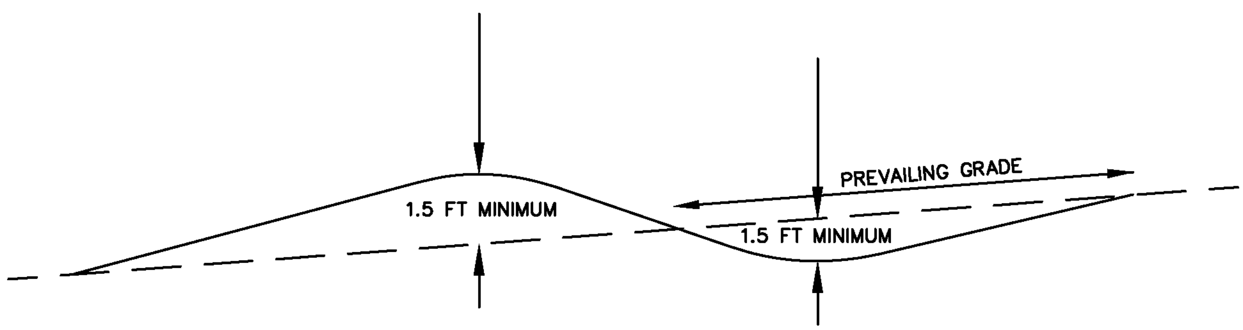
FIGURE 3-41

TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 150'	PROJECT: REMEDY PROTECTION UPPER MILL CREEK - DESIGN ALTERNATIVE	PROJECT NO: 2010-5050
	DRAWN BY: K.KINCELLA		DATE: 1/25/2010
	ENGINEER: D.FORSETH		SHEET: 2 OF 3

FIGURE 3-42



1/2 ROLLING DIP - PLAN VIEW
NOT TO SCALE



2/2 ROLLING DIP - PROFILE VIEW
NOT TO SCALE

TerraGraphics Environmental Engineering, Inc.	SCALE: AS NOTED	PROJECT: REMEDY PROTECTION UPPER MILL CREEK - DESIGN DETAILS	PROJECT NO: 2010-5050
	DRAWN BY: K.KINCELLA		DATE: 11/18/2009
	ENGINEER: D.FORSETH		SHEET: 3 OF 3

FIGURE 3-43

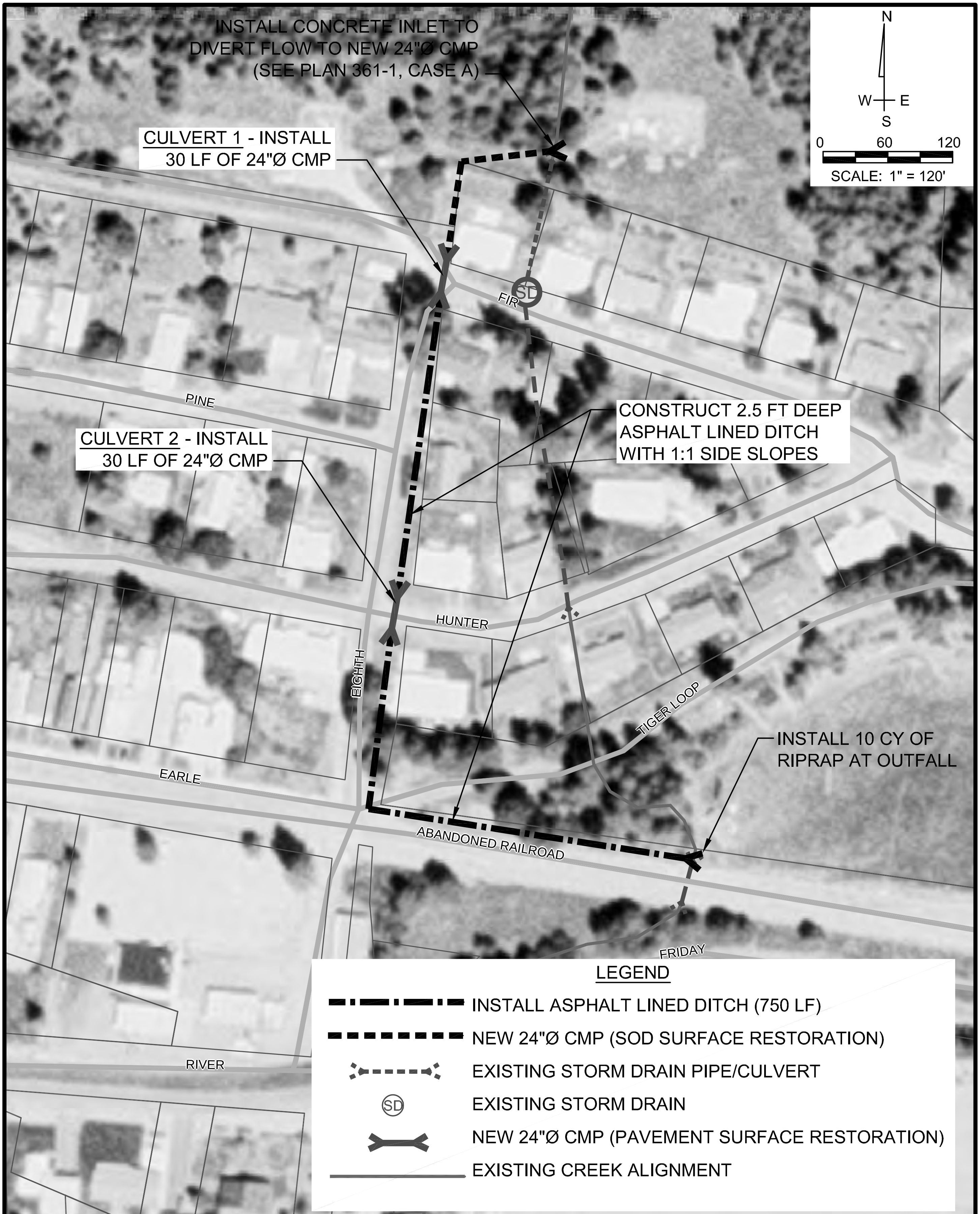
COST ESTIMATE QUANTITIES
MULLAN, IDAHO

MILL CREEK

REF	DESCRIPTION	QTY	UNIT
1	RE-GRADE AND VEGETATE 140 LF OF STREAM BANKS	140	LF
2	CONSTRUCT 4' HIGH x 4' LONG CONCRETE WINGWALLS AT CULVERT ENTRANCE	2	EA
3	RECONSTRUCT EXISTING CONCRETE OPEN CHANNEL (2.5' H x 4.33' W) TO 3' H x 6' W CONCRETE CHANNEL	175	LF
4	CONSTRUCT 325 LF OF 3.5' HIGH x 6' WIDE CONCRETE BOX CULVERT ALONG NEW ALIGNMENT (CULVERT 1). MUST FIRST REMOVE 80 LF OF EXISTING 3' x 6' CONCRETE BOX CULVERT	325	LF
5	PLUG AND FILL EXISTING CULVERTS (80 LF OF 3' x 6' CONCRETE BOX CULVERT AND 100 LF OF 58"∅ CMP) WITH CDF GROUT	1	LS
6	INSTALL RIPRAP AT CULVERT 1 OUTFALL	10	CY
7	REPLACE TWO EXISTING 32"∅ HDPE CULVERTS IN PARALLEL WITH 15' W x 25' L PRECAST CONCRETE BRIDGE WITH FOOTINGS AND A CLEAR HEIGHT OF 2.5 FT (BRIDGE 1)	1	EA
8	REPLACE TWO EXISTING 36"∅ CMP CULVERTS IN PARALLEL WITH 15' W x 20' L PRECAST CONCRETE BRIDGE WITH FOOTINGS AND A CLEAR HEIGHT OF 2.5 FT (BRIDGE 2)	2	EA
9	EXCAVATE AND REGRADE 50 LF OF EXISTING GRAVEL ROAD TO PROVIDE 1.5 FT ROLLING DIP	1	LS

DESIGN ALTERNATIVE

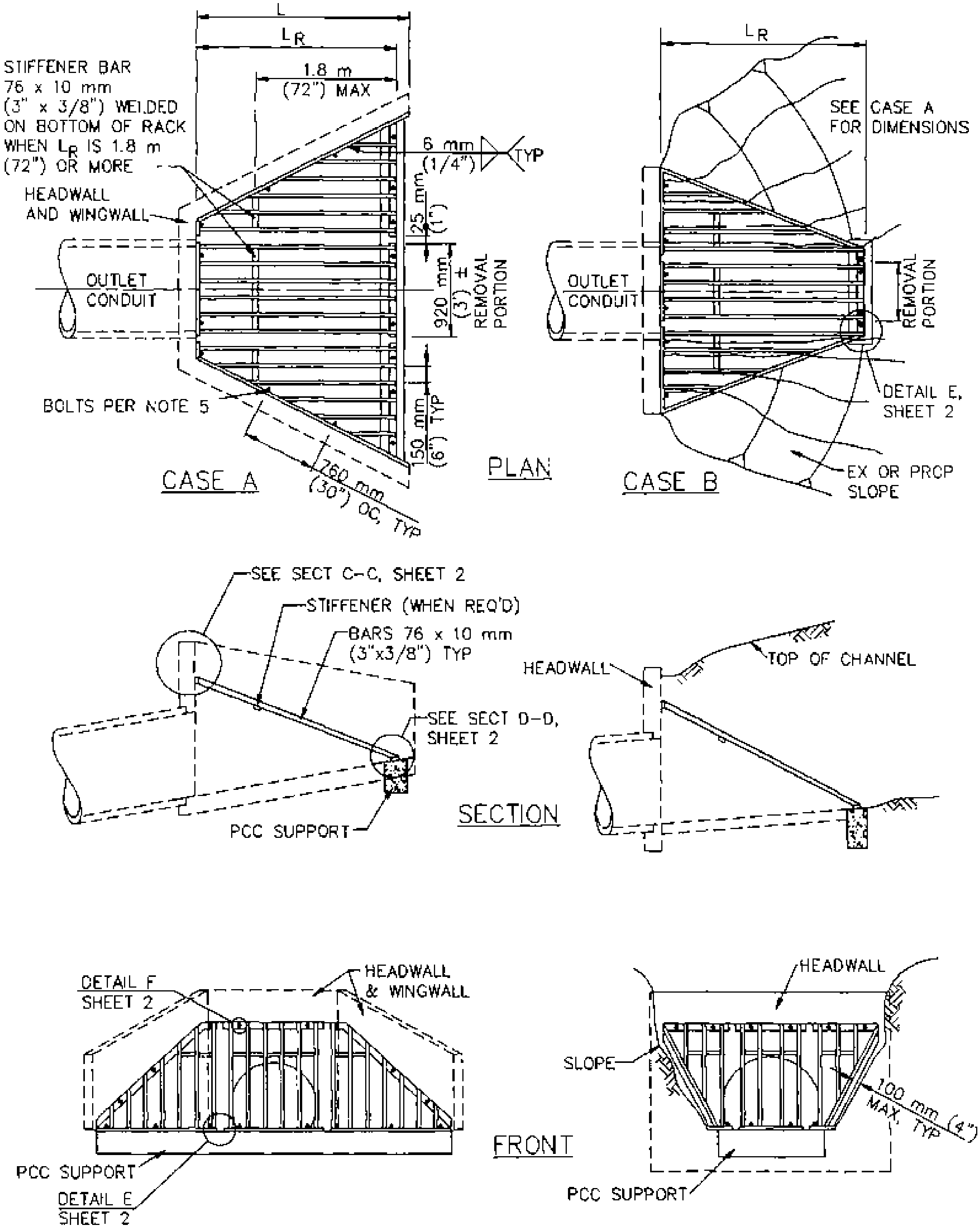
TIGER CREEK, MULLAN



TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 120'	PROJECT:	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	REMEDY PROTECTION	DATE: 1/25/2010
	ENGINEER: D.FORSETH	TIGER CREEK - DESIGN ALTERNATIVE	SHEET: 1 OF 1

FIGURE 3-44

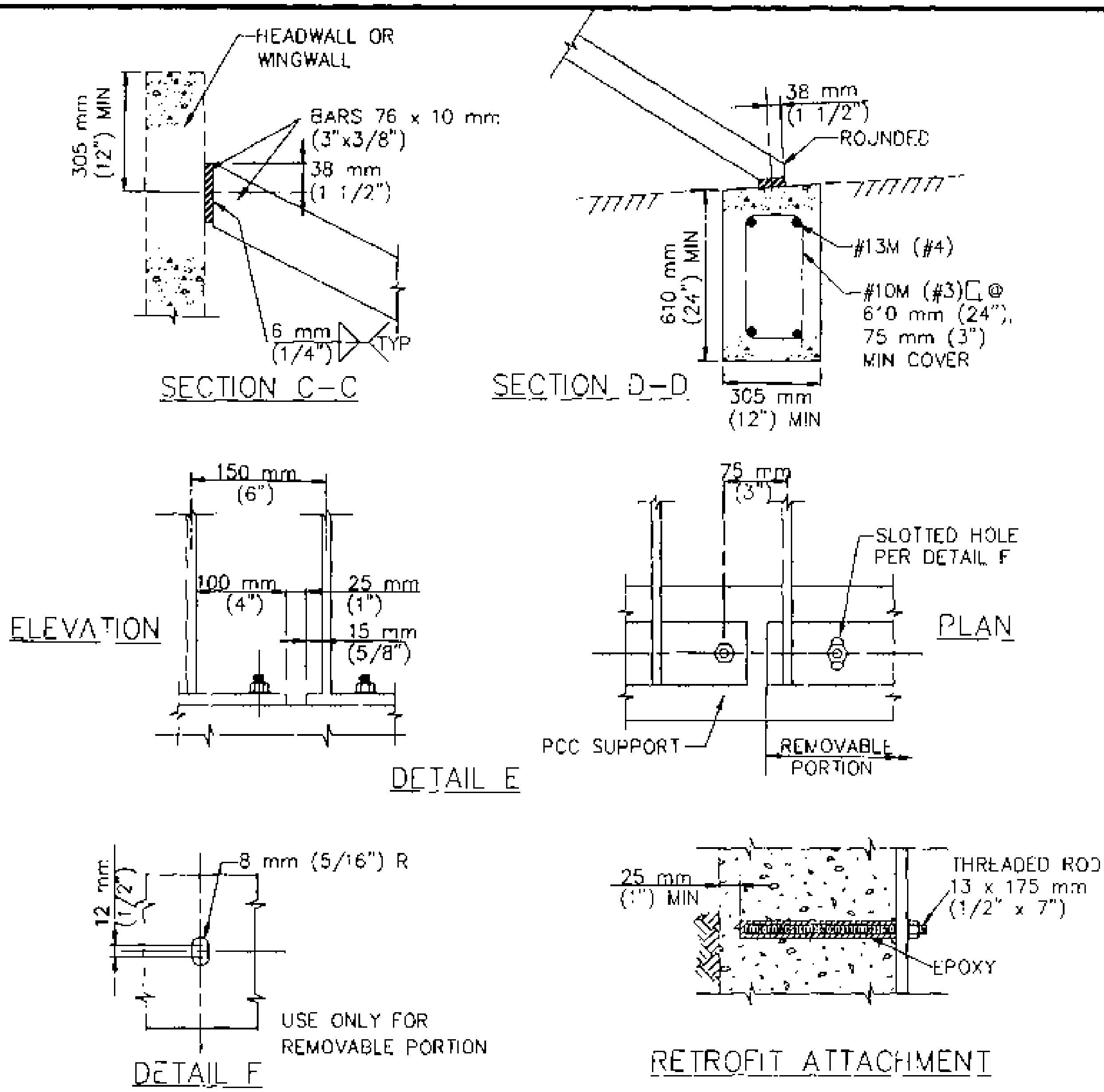
Proposed Tiger Creek Inlet Structure: Case A with 8' long x 4' tall wingwalls & 3' long x 4' tall headwall



STANDARD PLANS FOR PUBLIC WORKS CONSTRUCTION

PROMULGATED BY THE PUBLIC WORKS STANDARDS INC. GREENBOOK COMMITTEE 1993 REV. 2005	**TRASH RACK (INCLINED)**	STANDARD PLAN METRIC **361–1**
	USE WITH STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION	SHEET 1 OF 2

FIGURE 3-45



NOTES

1. MAXIMUM SIZE OF OUTLET FOR THIS RACK IS 1200 mm (48") PIPE OR 1.2 m (48") WIDE RCB. MAXIMUM LENGTH OF RACK L_R IS 3 m (10'-0").
2. ADJUST L_R SO THAT THE SLOPE OF THE RACK IS APPROXIMATELY 2 HORIZONTAL TO 1 VERTICAL.
3. THE PCC SUPPORT IS NOT NEEDED IF THE INLET STRUCTURE HAS A SUITABLE CUTOFF WALL. THE PCC SUPPORT SHALL NOT REPLACE THE CUTOFF WALL.
4. GALVANIZE RACK AFTER FABRICATION.
5. BOLTS SHALL BE 13 x 175 mm (1/2"x7"). BOLTS FOR REMOVABLE PORTION SHALL BE STAINLESS STEEL. PROVIDE WASHERS AT EACH BOLT.
6. SUBMIT SHOP DRAWINGS PER SSPWC 2-5.3.3. FOR RETROFIT WORK, INCLUDE DETAILS FOR ATTACHMENT TO EXISTING STRUCTURE.

STANDARD PLANS FOR PUBLIC WORKS CONSTRUCTION	STANDARD PLAN METRIC
TRASH RACK (INCLINED)	**361–1** SHEET 2 OF 2

FIGURE 3-46

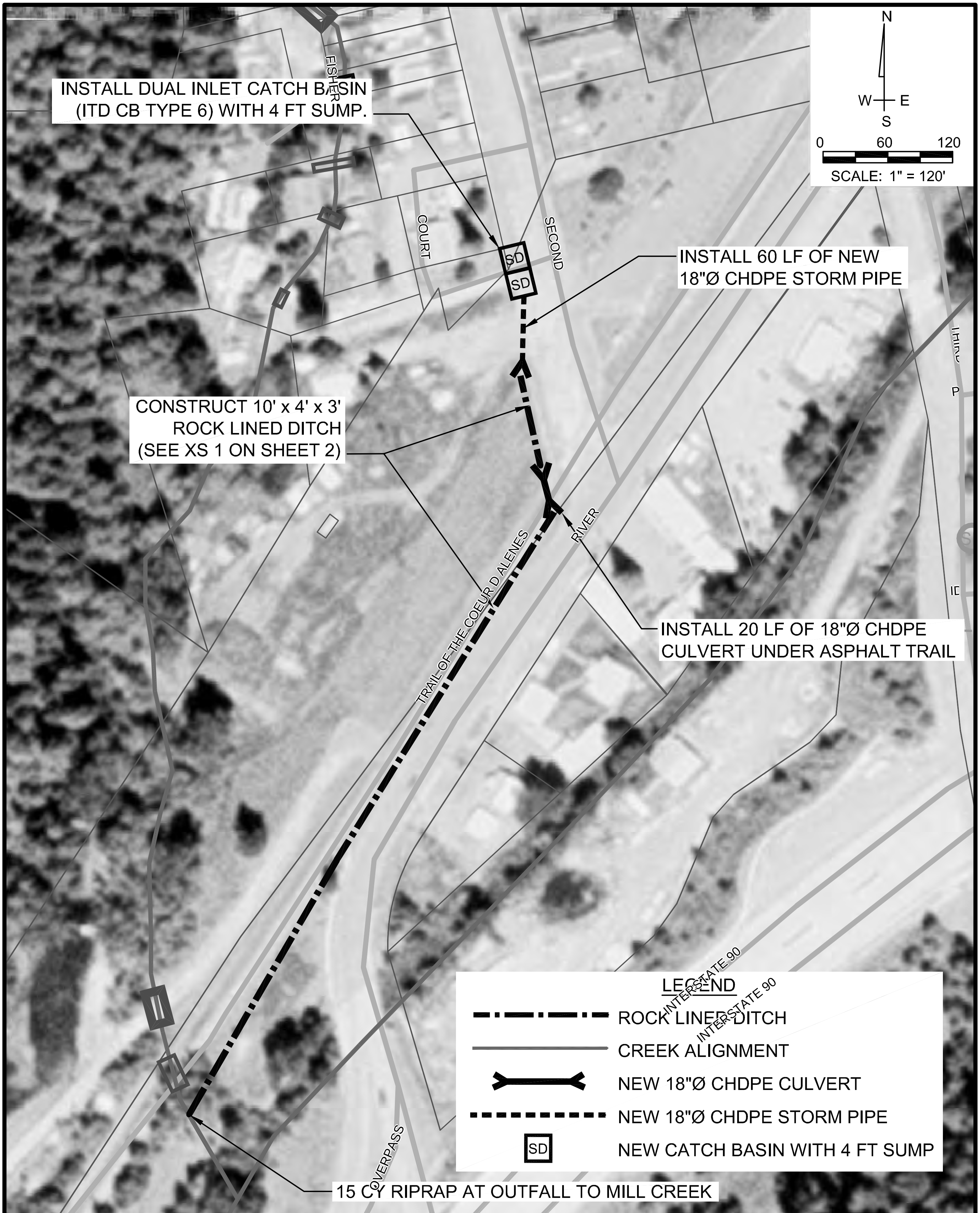
COST ESTIMATE QUANTITIES
MULLAN, IDAHO

TIGER CREEK

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT CONCRETE INLET STRUCTURE (SEE PLAN 316-1, CASE A WITH 8' LONG x 4' TALL WINGWALLS AND 3' LONG x 4' TALL HEADWALL)	1	EA
2	INSTALL 175 LF OF 24"∅ CMP. 1 FOOT COVER WITH SOD SUFRACE RESTORATION.	175	LF
3	INSTALL 750 LF OF ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES)	750	LF
4	INSTALL 30 LF OF 24"∅ CMP (CULVERT 1). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	30	LF
5	INSTALL 30 LF OF 24"∅ CMP (CULVERT 2). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	30	LF
6	INSTALL RIPRAP AT OUTFALL	10	CY

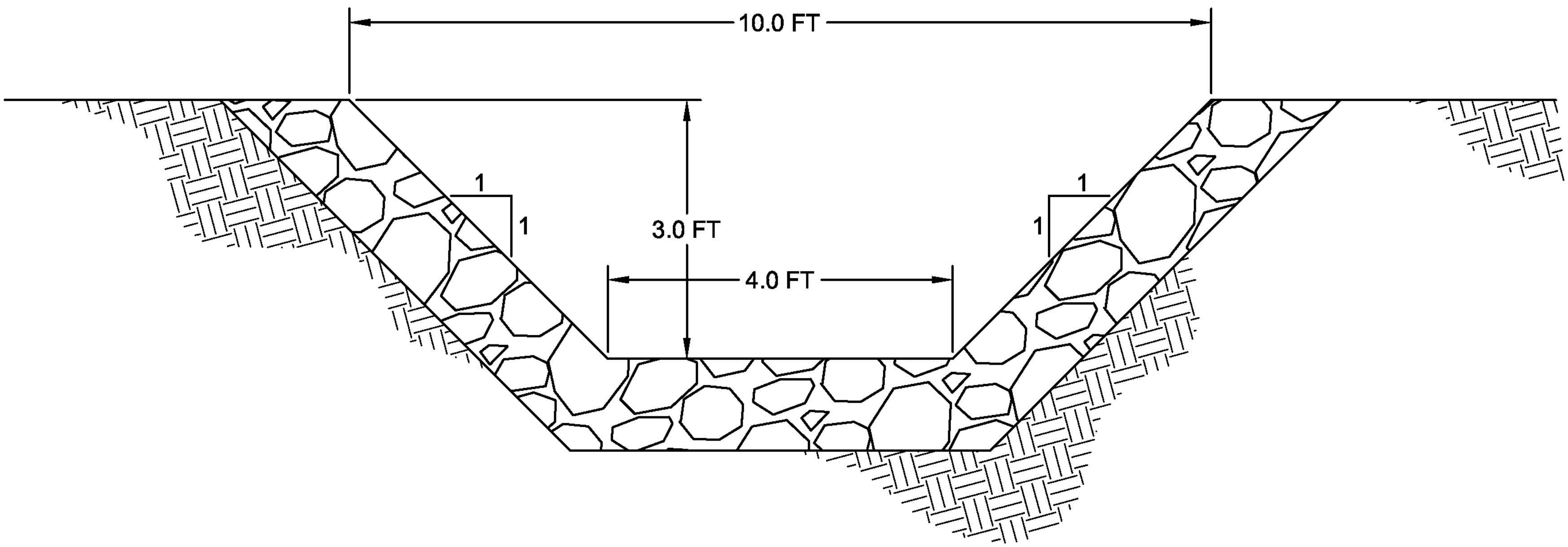
DESIGN ALTERNATIVE

SOUTH END OF 2ND STREET, MULLAN



TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 120'	PROJECT: REMEDY PROTECTION	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY	S. END OF 2ND ST - DESIGN ALTERNATIVE	DATE: 1/25/2010
	ENGINEER: D.FORSETH		SHEET: 1 OF 2

FIGURE 3-47

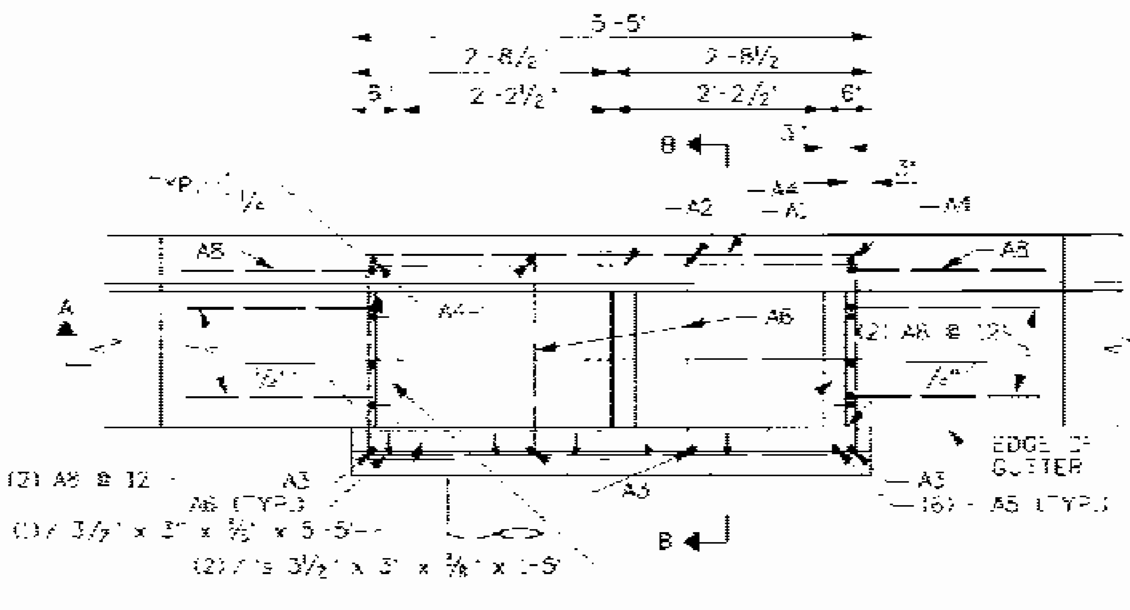


1/1 TYPICAL XS - DITCH DETAIL
SCALE: 1" = 2'

0 1 2
SCALE: 1" = 2'

SCALE: AS NOTED DRAWN BY: C.HALEY ENGINEER: D.FORSETH	TerraGraphics Environmental Engineering, Inc.	MULLAN, IDAHO REMEDY PROTECTION	DESIGN ALTERNATIVE CROSS SECTION S. END OF 2ND STREET
PROJECT NO: 2010-5050 DATE: 11/19/2009 SHEET: 2 OF 2			

FIGURE 3-48



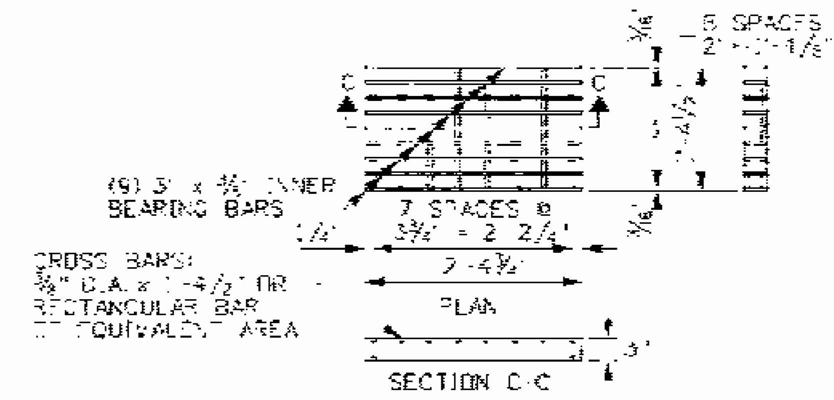
PLAN

BAR LIST

MARK	LOCATION	SIZE	TOTAL LENGTH	NO.	SKETCH
A1	FLOOR & WALLS	4	5'-1"	2	5'-1"
A2	WALLS	4	15'-1"	3	5'-0" / 5'-0" / 1' MIN. OVERLAP
* A3	FRONT WALL	4	3'-7"	4	3'-7"
* A4	BACK WALL	4	4'-1"	4	4'-1"
A5	GRATE DOWEL	4	7"	10	5"
A6	WALL	4	2'-2"	2	2'-2"
A7	GUTTER & SIDE WALLS	4	2'-9"	4	2'-0"
A8	CURB & BACK WALL	4	3'-3"	2	2'-3"

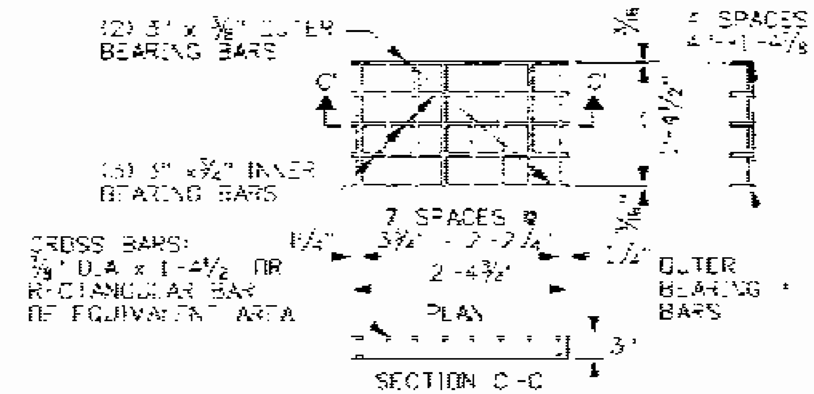
113.75 L.F. AT 0.668 LBS/FT. = 76.00 LBS

* (SEE NOTE NO. 7)



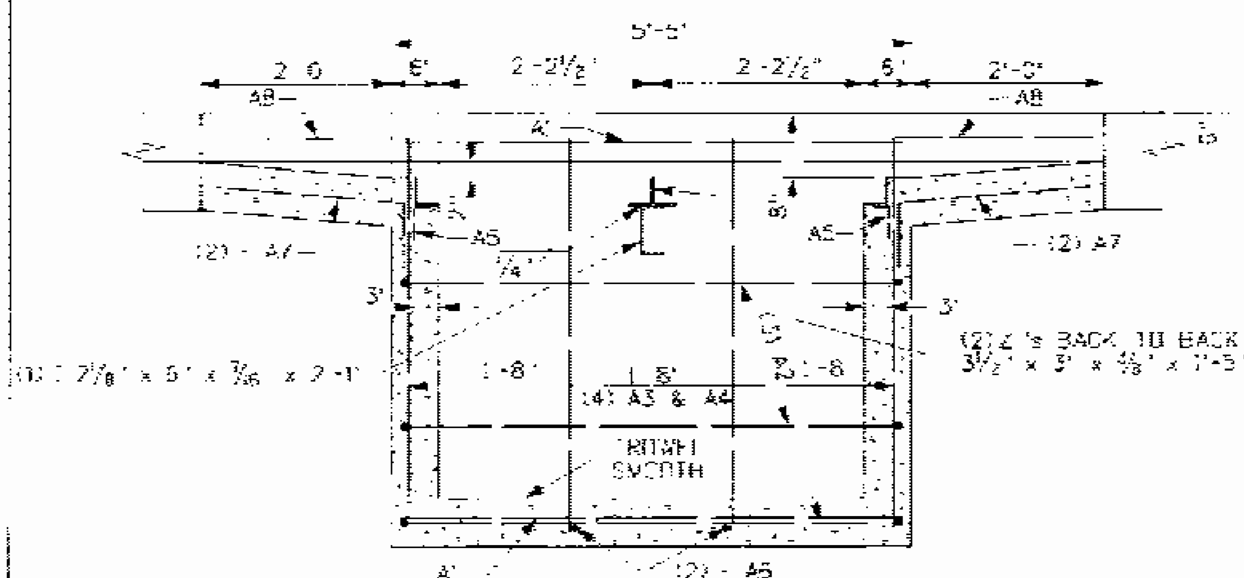
GRATE A (STEEL)

(WEIGHT : APPROXIMATELY 68 LBS., SEE NOTE 9)

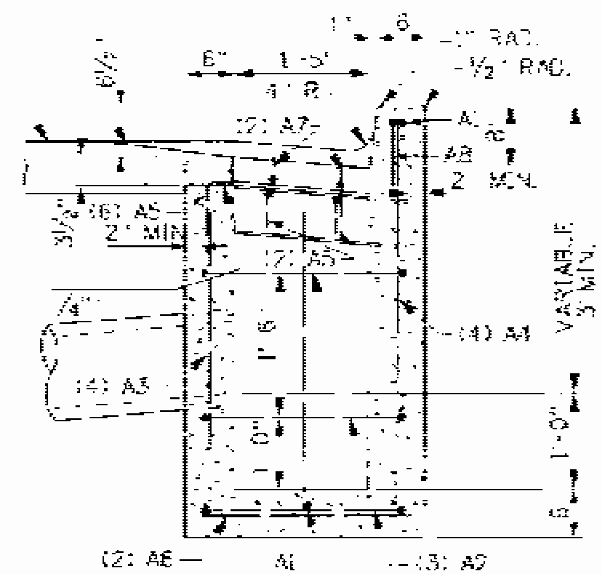


GRATE B (STEEL)

(WEIGHT : APPROXIMATELY 79 LBS., SEE NOTE 9)



SECTION A-A



SECTION B-B

NOTES

1. CATCH BASINS MAY EITHER BE PRECAST OR CAST-IN-PLACE. PRECAST UNITS SHALL MEET THE REQUIREMENTS OF ASTM C913. PRIOR APPROVAL OF THE SHOP DRAWING WILL BE REQUIRED ON MODIFIED UNITS.
2. CAST-IN-PLACE CATCH BASINS SHALL CONFORM TO SECTION 609 - MINOR STRUCTURES OF THE CURRENT ITD STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION.
3. A 1" SIDE DRAFT IS ALLOWED FOR FORM REMOVAL.
4. THE GRADE LINE OF THE TOP INSIDE OF ANY PIPE SHALL ENTER AT A POINT NO LOWER THAN THE TOP INSIDE OF THE OUTLET PIPE.
5. PIPES CAN ENTER OR LEAVE THE BOX IN ANY DIRECTION. ALL CONNECTIONS AND BROKEN AREAS SHALL BE GROUTED SMOOTH.
6. STEEL ANGLES SHALL BE SET SO THAT EACH BEARING BAR OF PREFABRICATED GRATE SHALL HAVE FULL BEARING ON BOTH ENDS. THE FINISHED TOP OF CONCRETE SHALL BE EVEN WITH THE ANGLE/GRATE SURFACE. THE STRUCTURAL STEEL NEED NOT BE PAINTED BUT SHALL MEET THE REQUIREMENTS OF ASTM A 36.
7. ALL METAL REINFORCEMENT USED SHALL BE NO. 4 BARS. THE METAL REINFORCEMENT SHALL BE SMOOTH CUT TO ACCOMMODATE PIPES. VERTICAL BARS NEED TO BE LENGTHENED FOR CATCH BASINS DEEPER THAN 4'-6".
8. GRATE B WILL BE USED ONLY WHEN SPECIFIED.
9. GRAY IRON CAST TO THE DIMENSIONS GIVEN FOR THE STEEL GRATES MAY BE USED. THE CASTINGS SHALL CONFORM TO AASHTO M306 CLASS 35B GRAY IRON CASTINGS.
10. CATCH BASIN GRATES MAY EITHER BE RESISTANCE WELDED OR ARC WELDED. IN EITHER CASE THE GRATE SHALL BE TRUE AND FLUSH.
11. NOT TO SCALE.

CATCH BASIN - DETAILS

REVISIONS								
NO.	DATE	BY	NO.	DATE	BY	NO.	DATE	BY
1	10-80		6	3-97	MSM			
2	4-82		7	12-04	MSM			
3	3-84		8	11-08	LRV			
4	1-89							
5	12-94	MSM						

SCALES SHOWN ARE FOR 11" X 17" PRINTS ONLY

CADD FILE NAME: e6d_1108.dgn

DRAWING DATE: OCTOBER, 1980

IDAHO TRANSPORTATION DEPARTMENT

BOISE, IDAHO

ASSISTANT CHIEF ENGINEER (DEVELOPMENT)

CHIEF ENGINEER

STANDARD DRAWING

FIGURE 3-49

CATCH BASIN TYPE 6

English

STANDARD DRAWING NO.

E-6-D

SHEET 1 OF 1

PROFESSIONAL ENGINEER REGISTERED 6506 11/03/08 STATE OF IDAHO TED E. MASON

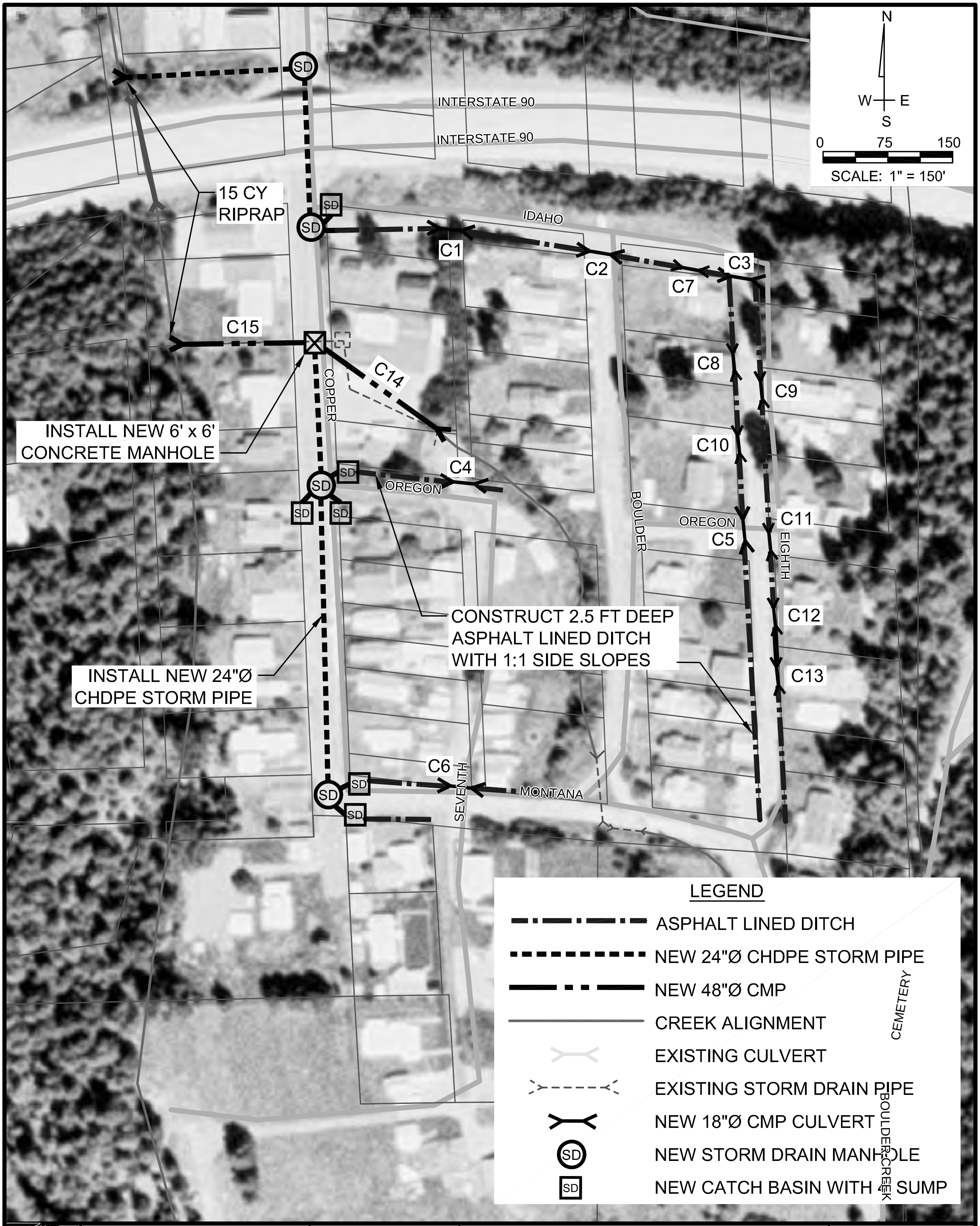
COST ESTIMATE QUANTITIES
MULLAN, IDAHO

SOUTH END OF SECOND STREET

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT 10' x 4' x 3' ROCK LINED DITCH ALONG WEST SIDE OF SECOND ST (XS 1)	110	LF
2	CONSTRUCT 10' x 4' x 3' ROCK LINED DITCH ALONG SOUTH SIDE OF THE TRAIL OF THE COEUR D'ALENES (XS 1)	655	LF
3	INSTALL 60 LF OF NEW 18"∅ CHDPE STORM PIPE (3 FT COVER)	60	LF
4	INSTALL 20 LF OF 18"∅ CHDPE CULVERT UNDER TRAIL OF THE COEUR D'ALENES (CULVERT 1). 3 FT COVER WITH PAVEMENT SURFACE RESTORATION	20	LF
5	INSTALL NEW DUAL INLET CATCH BASIN (ITD CATCH BASIN TYPE 6) WITH 4 FT SUMP. SEE ITD STANDARD DRAWING E-6-D.	1	EA
6	INSTALL RIPRAP AT OUTFALL TO MILL CREEK	15	CY

DESIGN ALTERNATIVE

COPPER ST NEIGHBORHOOD, MULLAN



TerraGraphics
Environmental Engineering, Inc.

SCALE: 1" = 150'	PROJECT:		PROJECT NO: 2010-5050
DRAWN BY: C.HALEY	REMEDY PROTECTION		DATE: 1/25/2010
ENGINEER: D.FORSETH	COPPER ST. AREA - DESIGN ALTERNATIVE		SHEET: 1 OF 1

FIGURE 3-50

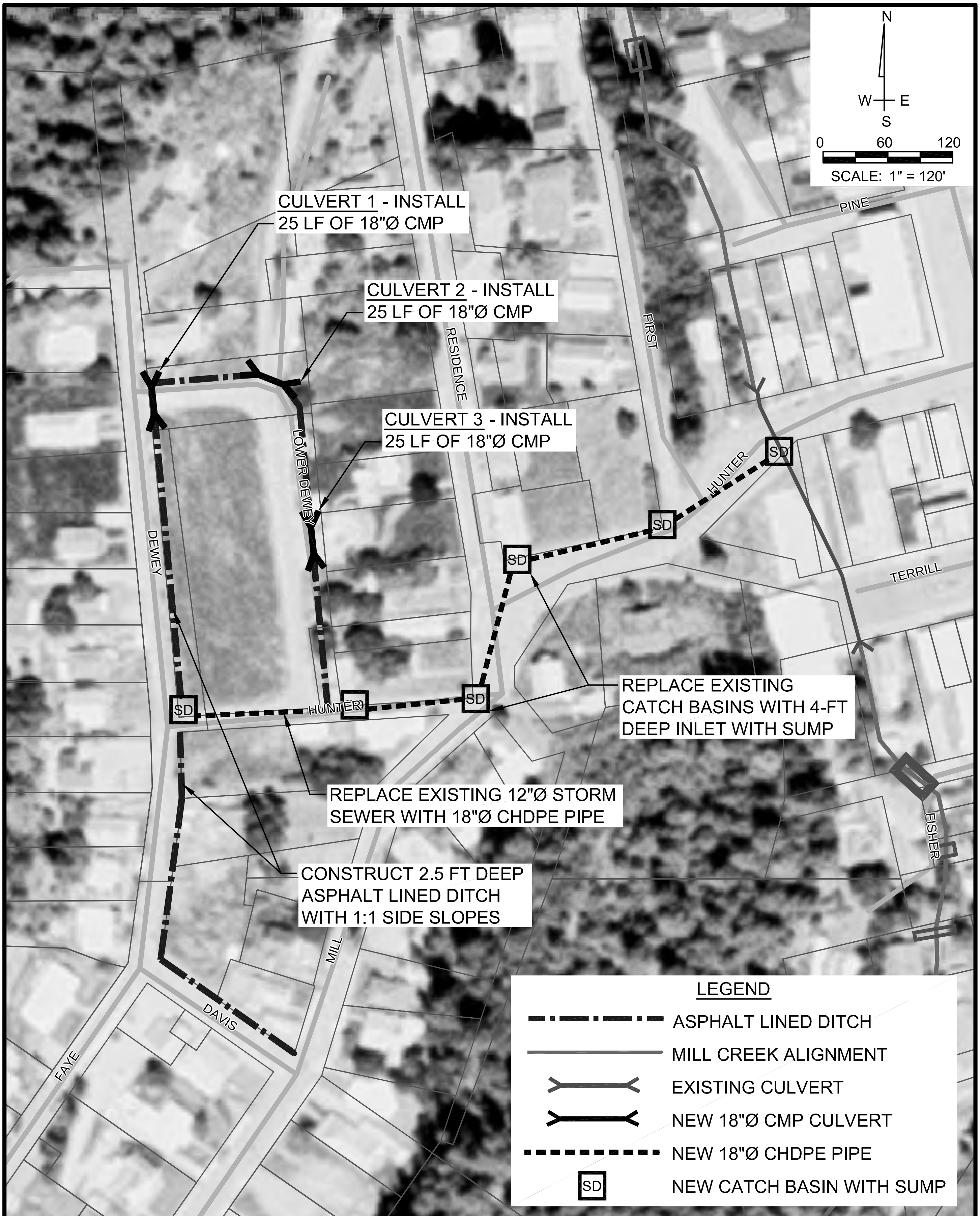
COST ESTIMATE QUANTITIES
MULLAN, IDAHO

COPPER STREET NEIGHBORHOOD

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG SOUTH SIDE OF IDAHO STREET	400	LF
2	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG IDAHO STREET EAST AND WEST SIDES OF EIGHTH STREET	1100	LF
3	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG NORTH SIDE OF OREGON STREET	205	LF
4	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG MONTANA STREET	305	LF
5	INSTALL SIX (6) 25 LF 18"∅ CMP CULVERTS WITH A 1.5 FT COVER (CULVERTS 1 THROUGH 6)	1	LS
6	INSTALL SEVEN (7) 20 LF 18"∅ CMP CULVERTS WITH A 1.5 FT COVER (CULVERTS 7 THROUGH 13)	6	LS
7	INSTALL 310 LF OF 48" CMP CULVERT WITH AN AVERAGE COVER OF 3.5 FT (CULVERT 14 AND 15)	1	LS
8	INSTALL 915 LF OF NEW 24"∅ CHDPE STORM PIPE (4 FT AVERAGE COVER)	915	LF
9	REMOVE EXISTING DRYWELL, 4 EXISTING CATCH BASINS, AND 285 LF OF EXISTING STORM DRAIN PIPE ALONG IDAHO STREET	1	LS
10	FURNISH AND INSTALL NEW 6' x 6' CONCRETE MANHOLE AT A DEPTH OF 8 FT	1	EA
11	FURNISH AND INSTALL NEW 48"∅ STORM MANHOLE AT A DEPTH OF 6 FT	4	EA
12	FURNISH AND INSTALL NEW CATCH BASIN WITH 4' SUMP	6	EA
13	INSTALL 15 CY RIPRAP AT CULVERT/PIPE OUTFALL	2	LS

DESIGN ALTERNATIVE

DEWEY ST NEIGHBORHOOD, MULLAN



TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 120' DRAWN BY: C.HALEY ENGINEER: D.FORSETH	PROJECT: REMEDY PROTECTION DEWEY ST AREA - DESIGN ALTERNATIVE	PROJECT NO: 2010-5050 DATE: 1/25/2010 SHEET: 1 OF 1

FIGURE 3-51

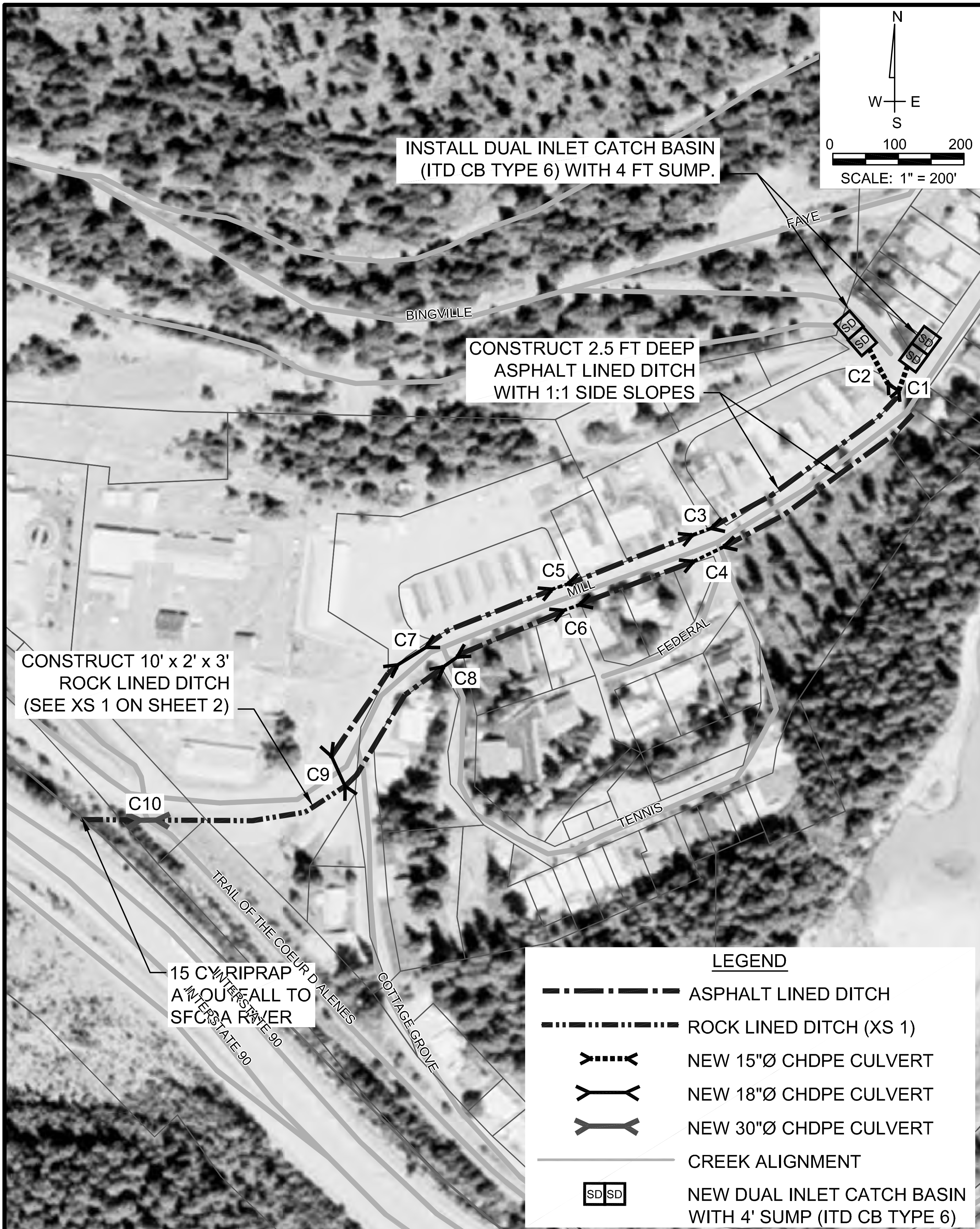
COST ESTIMATE QUANTITIES
MULLAN, IDAHO

DEWEY ST NEIGHBORHOOD

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG NORTH SIDE OF LOWER DEWEY ST	100	LF
2	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG EAST SIDE OF LOWER DEWEY ST (DAYLIGHT TO HUNTER ST)	280	LF
3	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG EAST SIDE OF DEWEY ST AND NORTH SIDE OF DAVIS (DAYLIGHT TO MILL ST)	365	LF
4	INSTALL 25 LF OF 18"∅ CMP CULVERT (CULVERT 1). 1.5 FT COVER WITH PAVEMENT SURFACE RESTORATION	25	LF
5	INSTALL 25 LF OF 18"∅ CMP CULVERT (CULVERT 2). 1.5 FT COVER WITH PAVEMENT SURFACE RESTORATION	25	LF
6	INSTALL 25 LF OF 18"∅ CMP CULVERT (CULVERT 3). 1.5 FT COVER WITH GRAVEL SURFACE RESTORATION	25	LF
7	REPLACE EXISTING CATCH BASIN WITH 4-FT DEEP INLET W/SUMP (TO CATCH DEBRIS)	6	EA
8	REPLACE EXISTING 12"∅ STORM SEWER WITH 18"∅ CHDPE PIPE (3 FT COVER)	650	LF

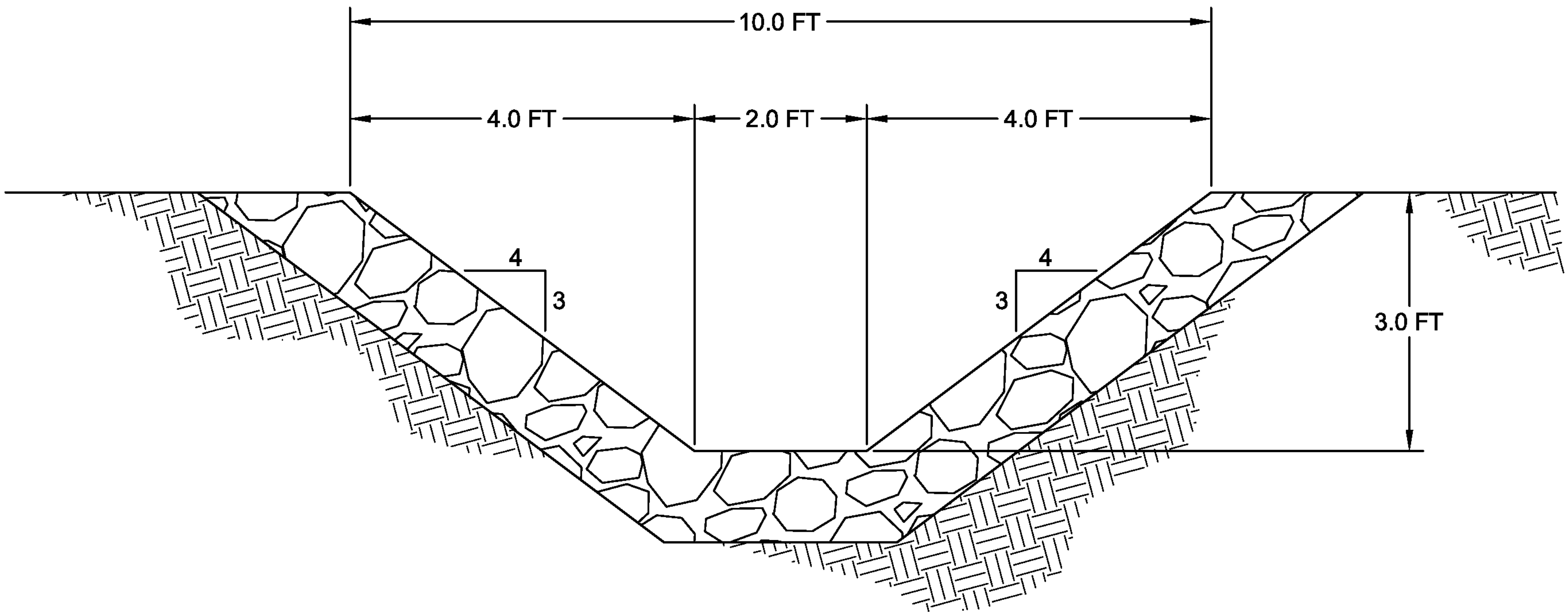
DESIGN ALTERNATIVE

MILL STREET, MULLAN



TerraGraphics Environmental Engineering, Inc.	SCALE: 1" = 200'	PROJECT: REMEDY PROTECTION MILL ST, MULLAN - DESIGN ALTERNATIVE	PROJECT NO: 2010-5050
	DRAWN BY: C.HALEY		DATE: 1/25/2010
	ENGINEER: D.FORSETH		SHEET: 1 OF 2

FIGURE 3-52

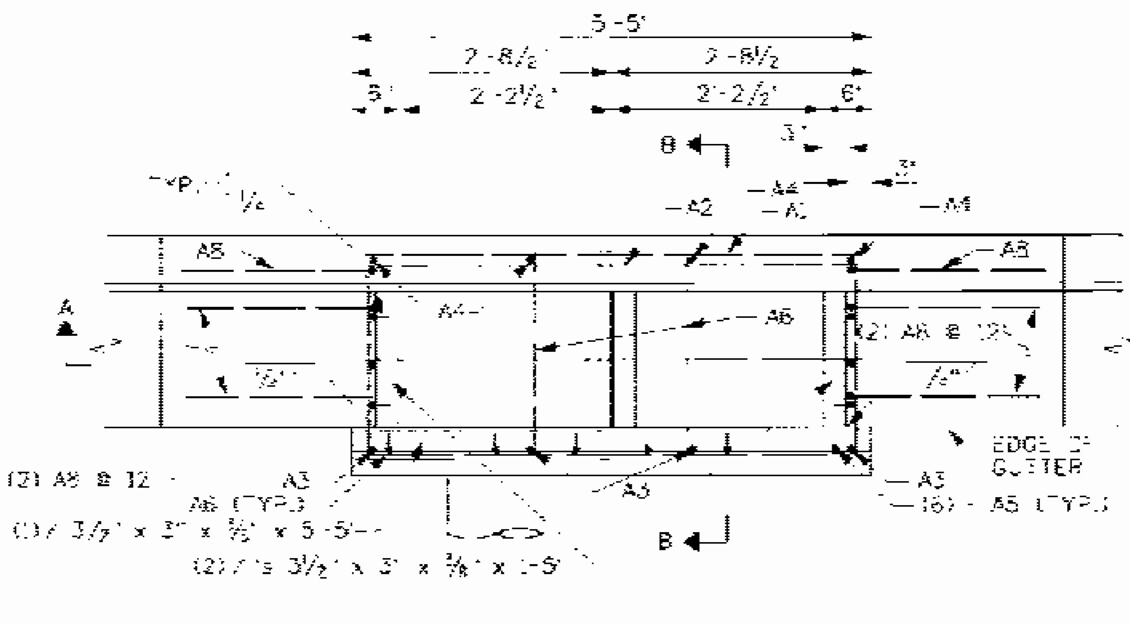


TYPICAL XS - ROCK LINED CHANNEL DITCH DETAIL
SCALE: 1" = 2'

0 1 2
SCALE: 1" = 2'

SCALE: AS NOTED	TerraGraphics Environmental Engineering, Inc.	MULLAN, IDAHO	DESIGN ALTERNATIVE CROSS SECTION	PROJECT NO: 2010-5050
DRAWN BY: C.HALEY		REMEDY PROTECTION	MILL STREET, MULLAN	DATE: 11/20/2009
ENGINEER: D.FORSETH				SHEET: 2 OF 2

FIGURE 3-53



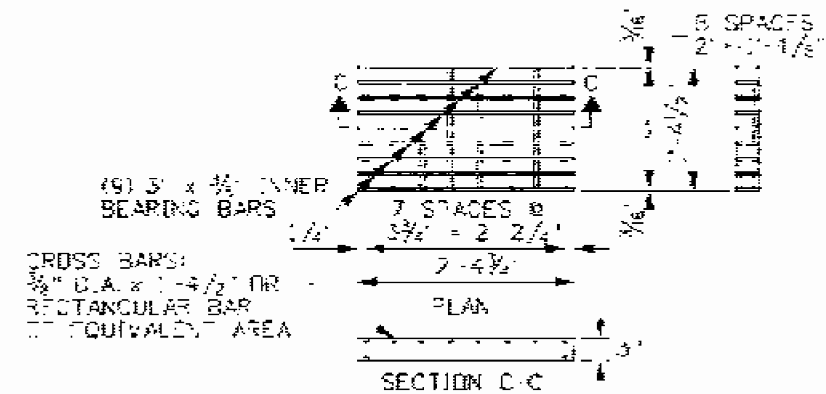
PLAN

MARK	LOCATION	SIZE	TOTAL LENGTH	NO.	SKETCH
A1	FLOOR & WALLS	4	5'-0"	2	5'-0"
A2	WALLS	4	15'-0"	3	5'-0" / 5'-0" / 1' MIN. OVERLAP
* A3	FRONT WALL	4	5'-7"	4	3'-7"
* A4	BACK WALL	4	4'-1"	4	4'-1"
A5	GRATE DOWEL	4	7"	10	5"
A6	WALL	4	2'-2"	2	2'-2"
A7	GUTTER & SIDE WALLS	4	2'-9"	4	2'-0"
A8	CURB & BACK WALL	4	3'-3"	2	2'-0"

BAR LIST

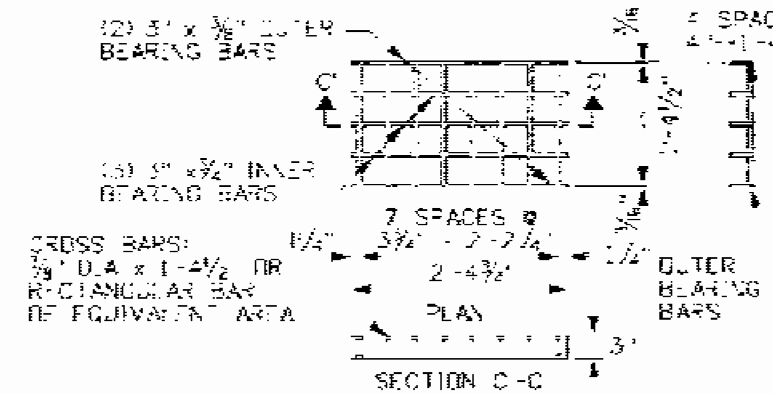
113.75 L.F. AT 0.668 LBS/FT. = 76.00 LBS

* (SEE NOTE NO. 7)



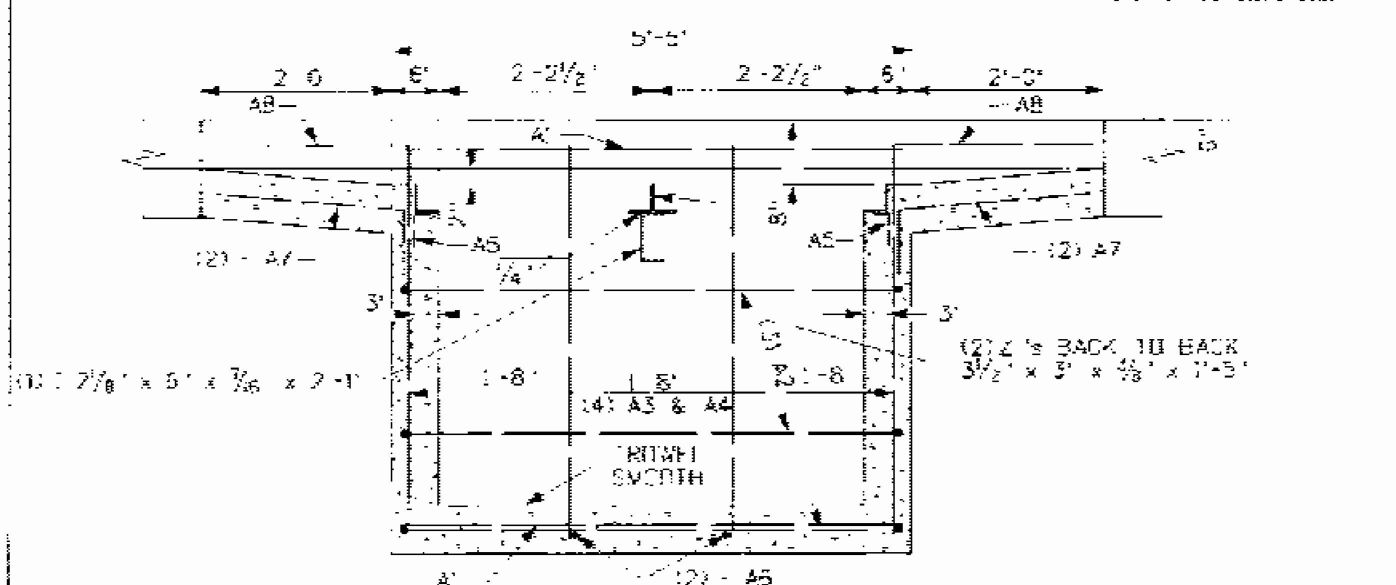
GRATE A (STEEL)

(WEIGHT : APPROXIMATELY 56 LBS., SEE NOTE 9)

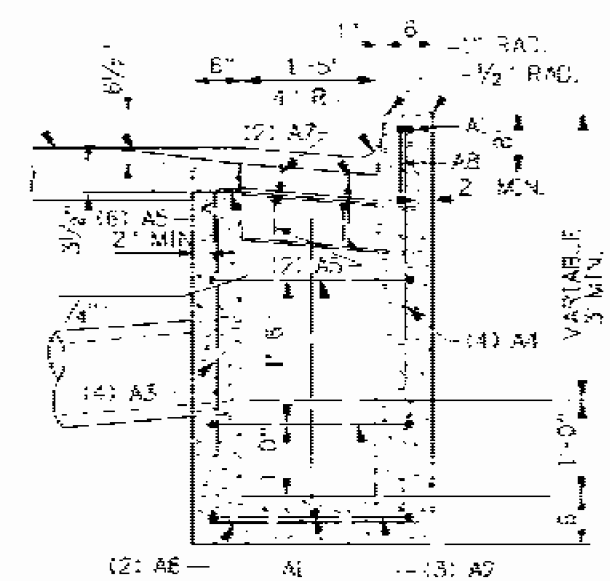


GRATE B (STEEL)

(WEIGHT : APPROXIMATELY 79 LBS., SEE NOTE 9)



SECTION A-A



SECTION B-B

NOTES

1. CATCH BASINS MAY EITHER BE PRECAST OR CAST-IN-PLACE. PRECAST UNITS SHALL MEET THE REQUIREMENTS OF ASTM C913. PRIOR APPROVAL OF THE SHOP DRAWING WILL BE REQUIRED ON MODIFIED UNITS.
2. CAST-IN-PLACE CATCH BASINS SHALL CONFORM TO SECTION 609 - MINOR STRUCTURES OF THE CURRENT ITD STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION.
3. A 1" SIDE DRAFT IS ALLOWED FOR FORM REMOVAL.
4. THE GRADE LINE OF THE TOP INSIDE OF ANY PIPE SHALL ENTER AT A POINT NO LOWER THAN THE TOP INSIDE OF THE OUTLET PIPE.
5. PIPES CAN ENTER OR LEAVE THE BOX IN ANY DIRECTION. ALL CONNECTIONS AND BROKEN AREAS SHALL BE GROUTED SMOOTH.
6. STEEL ANGLES SHALL BE SET SO THAT EACH BEARING BAR OF PREFABRICATED GRATE SHALL HAVE FULL BEARING ON BOTH ENDS. THE FINISHED TOP OF CONCRETE SHALL BE EVEN WITH THE ANGLE/GRATE SURFACE. THE STRUCTURAL STEEL NEED NOT BE PAINTED BUT SHALL MEET THE REQUIREMENTS OF ASTM A 36.
7. ALL METAL REINFORCEMENT USED SHALL BE NO. 4 BARS. THE METAL REINFORCEMENT SHALL BE SMOOTH CUT TO ACCOMMODATE PIPES. VERTICAL BARS NEED TO BE LENGTHENED FOR CATCH BASINS DEEPER THAN 4'-6".
8. GRATE B WILL BE USED ONLY WHEN SPECIFIED.
9. GRAY IRON CAST TO THE DIMENSIONS GIVEN FOR THE STEEL GRATES MAY BE USED. THE CASTINGS SHALL CONFORM TO AASHTO M306 CLASS 35B GRAY IRON CASTINGS.
10. CATCH BASIN GRATES MAY EITHER BE RESISTANCE WELDED OR ARC WELDED. IN EITHER CASE THE GRATE SHALL BE TRUE AND FLUSH.
11. NOT TO SCALE.

CATCH BASIN - DETAILS

REVISIONS								
NO.	DATE	BY	NO.	DATE	BY	NO.	DATE	BY
1	10-80		6	3-01	MSM			
2	4-82		7	12-04	MSM			
3	3-84		8	11-08	LRV			
4	1-89							
5	12-94	MSM						

SCALES SHOWN ARE FOR 11" X 17" PRINTS ONLY

CADD FILE NAME: e6d_1108.std

DRAWING DATE: OCTOBER, 1980

IDAHO TRANSPORTATION DEPARTMENT

BOISE, IDAHO

ASSISTANT CHIEF ENGINEER (DEVELOPMENT)

CHIEF ENGINEER

STANDARD DRAWING

FIGURE 3-54

CATCH BASIN TYPE 6

English

STANDARD DRAWING NO.

E-6-D

SHEET 1 OF 1

PROFESSIONAL ENGINEER REGISTERED 6506 11/03/08 STATE OF IDAHO TED E. MASON

COST ESTIMATE QUANTITIES
MULLAN, IDAHO

MILL STREET IMPROVEMENTS

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG SOUTH SIDE OF MILL STREET	960	LF
2	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES) ALONG NORTH SIDE OF MILL STREET	925	LF
3	CONSTRUCT 10' x 2' x 3' ROCK LINED DITCH (XS 1)	390	LF
4	INSTALL 60 LF OF 15"∅ CHDPE PIPE WITH 2 FT COVER (CULVERT 1)	60	LF
5	INSTALL 80 LF OF 15"∅ CHDPE PIPE WITH 2 FT COVER (CULVERT 2)	80	LF
6	INSTALL 30 LF OF 15"∅ CHDPE CULVERT WITH 2 FT COVER (CULVERT 3)	30	LF
7	INSTALL 50 LF OF 15"∅ CHDPE CULVERT WITH 2 FT COVER (CULVERT 4)	50	LF
8	INSTALL TWO (2) 25 LF 15"∅ CHDPE CULVERTS WITH 2 FT COVER (CULVERT 5 & 6)	1	LS
9	INSTALL TWO (2) 50 LF 18"∅ CHDPE CULVERTS WITH 1.5 FT COVER (CULVERT 7 & 9)	1	LS
10	INSTALL 25 LF OF 18"∅ CHDPE CULVERT WITH 1.5 FT COVER (CULVERT 8)	25	LF
11	INSTALL 25 LF OF 30"∅ CHDPE CULVERT UNDER TRAIL OF THE COEUR D'ALENES (CULVERT 10). 3 FT COVER WITH PAVEMENT SURFACE RESTORATION.	25	LF
12	INSTALL NEW DUAL INLET CATCH BASIN (ITD CATCH BASIN TYPE 6) WITH 4 FT SUMP. SEE ITD STANDARD DRAWING E-6-D.	2	EA
13	INSTALL 15 CY RIPRAP AT OUTFALL TO SOUTH FORK COEUR D'ALENE RIVER	15	CY

DESIGN ALTERNATIVE

3RD STREET NEIGHBORHOOD, MULLAN

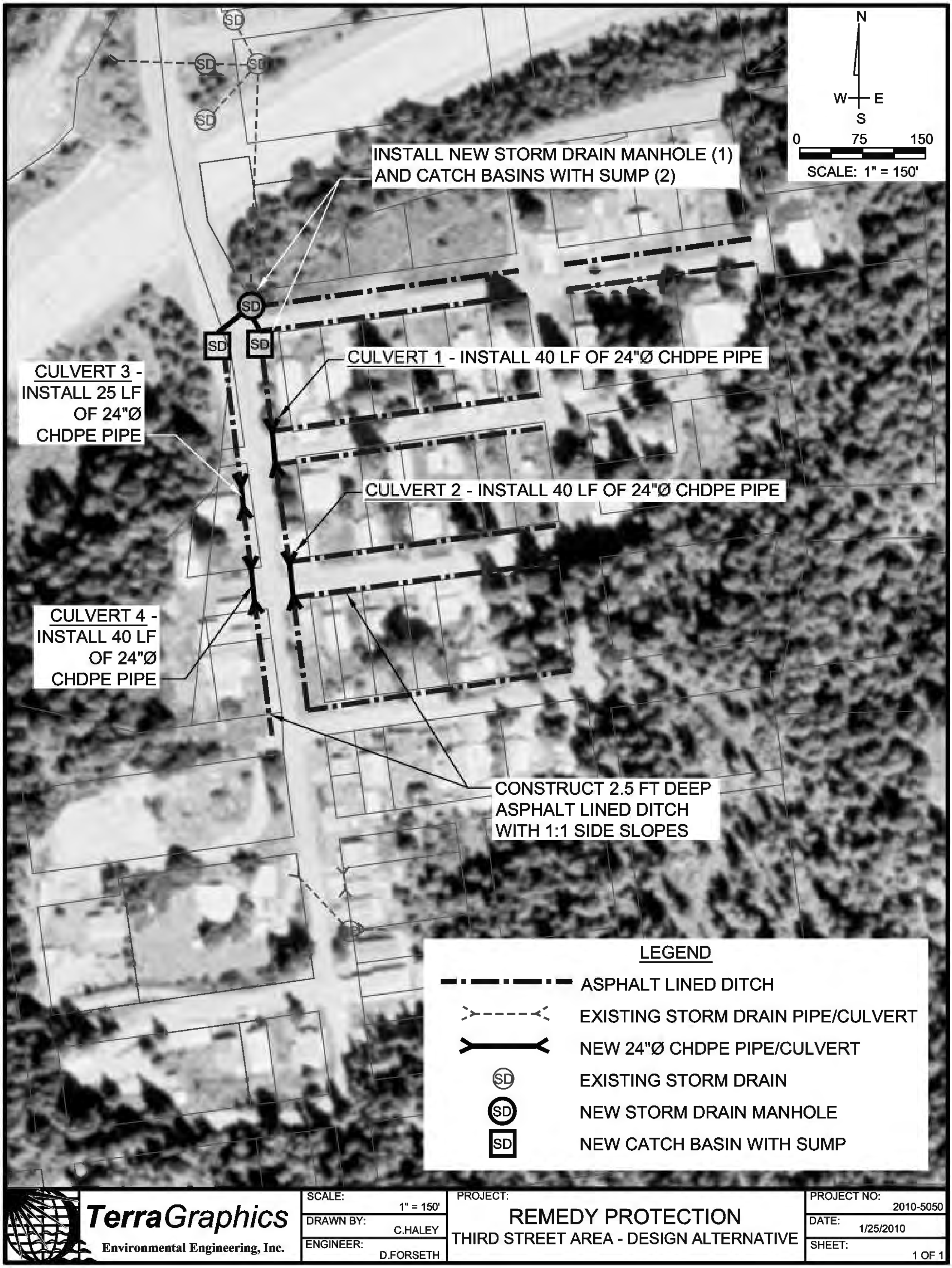

N
W
E
S
0
75
150
SCALE: 1" = 150'
INSTALL NEW STORM DRAIN MANHOLE (1) AND CATCH BASINS WITH SUMP (2)
SD
CULVERT 1 - INSTALL 40 LF OF 24"Ø CHDPE PIPE
CULVERT 3 - INSTALL 25 LF OF 24"Ø CHDPE PIPE
CULVERT 2 - INSTALL 40 LF OF 24"Ø CHDPE PIPE
CULVERT 4 - INSTALL 40 LF OF 24"Ø CHDPE PIPE
CONSTRUCT 2.5 FT DEEP ASPHALT LINED DITCH WITH 1:1 SIDE SLOPES
LEGEND
ASPHALT LINED DITCH
EXISTING STORM DRAIN PIPE/CULVERT
NEW 24"Ø CHDPE PIPE/CULVERT
EXISTING STORM DRAIN
NEW STORM DRAIN MANHOLE
NEW CATCH BASIN WITH SUMP
TerraGraphics
Environmental Engineering, Inc.
SCALE: 1" = 150'
DRAWN BY: C.HALEY
ENGINEER: D.FORSETH
PROJECT: REMEDY PROTECTION
THIRD STREET AREA - DESIGN ALTERNATIVE
PROJECT NO: 2010-5050
DATE: 1/25/2010
SHEET: 1 OF 1

FIGURE 3-55

COST ESTIMATE QUANTITIES
MULLAN, IDAHO

THIRD STREET NEIGHBORHOOD

REF	DESCRIPTION	QTY	UNIT
1	CONSTRUCT ASPHALT LINED DITCH (2.5 FT DEEP WITH 1:1 SIDE SLOPES)	3400	LF
2	INSTALL 55 LF OF 24"∅ CHDPE PIPE BETWEEN NEW CATCH BASINS AND NEW STORM DRAIN MANHOLE. 2 FOOT AVERAGE COVER WITH ASPHALT SURFACE RESTORATION.	55	LF
3	REMOVE EXISTING CULVERT AND INSTALL 40 LF OF 24"∅ CHDPE PIPE (CULVERT 1). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	40	LF
4	REMOVE EXISTING CULVERT AND INSTALL 40 LF OF 24"∅ CHDPE PIPE (CULVERT 2). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	40	LF
5	REMOVE EXISTING CULVERT AND INSTALL 25 LF OF 24"∅ CHDPE PIPE (CULVERT 3). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	25	LF
6	REMOVE EXISTING CULVERT AND INSTALL 40 LF OF 24"∅ CHDPE PIPE (CULVERT 4). 1 FOOT COVER WITH PAVEMENT SURFACE RESTORATION.	40	LF
7	FURNISH AND INSTALL NEW 48"∅ MANHOLE AT A DEPTH OF 6 FT	1	EA
8	FURNISH AND INSTALL NEW CATCH BASIN WITH SUMP	2	EA