APPLIED INTELLECT

Near Final Draft

Bluebird and Blackjack Mines

Engineering Evaluation/Cost Analysis

Umatilla and Wallowa-Whitman National Forest, Oregon

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Prepared for:
US Forest Service
16400 Champion Way
Sandy, OR 97055

Prepared by:
Applied Intellect
345 Bobwhite Ct., Ste 230
Boise, ID 83706

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EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) has been prepared for the United States Department of Agriculture - Forest Service (USFS) Region 6 for work at the Bluebird and Blackjack Mines (the Sites) located in Grant County, Oregon. Applied Intellect, LLC (AI) was contracted by the USFS (Contract No. 12046W18D0009; Task Order: 12046W19F0009) to conduct this EE/CA under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The EE/CA satisfies environmental review requirements for removal actions, administrative record requirements for documentation of removal action selection, and provides a framework for evaluating and selecting alternative technologies. The primary objectives of the EE/CA are to:

- Evaluate existing studies and data from previous documents;
- Identify and address potential data gaps necessary to satisfy environmental review requirements;
- Identify applicable or relevant and appropriate requirements (ARARs) for the Sites;
- Conduct a screening level human health and streamlined ecological risk assessment;
- Identify the removal action objectives (RAO);
- Identify and screen potential removal technologies;
- Develop removal action alternatives;
- Analyze and evaluate alternatives for effectiveness, implementability, and cost;
- Recommend a removal action alternative(s) for the Sites; and
- Satisfy administrative record requirements for documenting the selected removal action(s).

This project involves a combined EE/CA for both the Blackjack and Bluebird Mines. The two locations have a similar operational history, are located only a mile apart, and are expected to be treated as a single location. The Bluebird and Blackjack Mines are located on public lands administered by the Umatilla and Wallowa-Whitman National Forests approximately 3 miles southwest of the town of Granite, Oregon. The Blackjack Mine is located approximately one mile upstream of the Bluebird Mine. Both Mines are located directly adjacent to Clear Creek within the Granite Mining District and have been the subject of numerous investigations during the last 20 years.

Environmental sampling at and around the Bluebird and Blackjack Mines was initiated by the USFS in 1980; however most detailed environmental studies began around 2003 and have continued since then. For both Sites, an assessment was implemented as part of this EE/CA to further evaluate the presence, concentrations, and volumes of potential contaminants. These assessments, conducted in June 2019, involved a site reconnaissance, sampling and laboratory analysis, and sludge volume estimates. A subsequent Data Gap Investigation was also completed in June 2020.

The EE/CA describes a screening level and subsequent quantitative human health risk assessment and streamlined ecological risk assessment for the Sites and establishes the potential magnitude of risk to human health and ecological receptors. Results from the quantitative human health risk assessment found that both cancer and non-cancer risks were within acceptable levels for the Sites. The screening level ecological risk assessment concluded the risks to be negligible and no further investigation is recommended.

Before developing treatment alternatives, removal action objectives (RAOs) were established based on the contaminants and media of interest, exposure pathways, and preliminary removal goals for the Sites. Based on results of previous site investigations and data collected as part of this EE/CA, the following are of primary concern at the Sites:

Blackjack Mine

- Reduce O&M costs for operation of existing mine water discharge pipeline;
- Identify long-term disposal options for iron-hydroxide sludge in the settling ponds;
- Evaluate natural treatment system options to improve water quality of mine water discharge; and
- Evaluate feasibility of reducing mine water discharge.

Bluebird Mine

- Reduce O&M costs for operation of existing mine water discharge pipeline;
- Identify long-term disposal options for iron-hydroxide sludge in the settling ponds; and
- Evaluate natural treatment system options to improve water quality of mine water discharge.

The selection of removal action alternatives is a tiered process involving (1) identifying and screening general removal technologies and processes applicable to the Sites, and (2) developing potential removal action alternatives capable of achieving the RAOs. The purpose of screening is to eliminate those technologies or processes that are not feasible and/or do not meet ARARs, while retaining potentially effective options for more detailed analysis. Typically, the proposed alternatives will consist of a combination of one or more of the retained removal actions and technologies.

Removal technologies and processes were identified and evaluated for the existing mine water collection pipelines, sludge settling/treatment ponds and a potential underground adit plug to reduce discharge of iron-rich mine waters. No alternatives were considered to treat discharge from the Red Boy Mine as it is located entirely on private property.

Potential general removal technologies and processes were identified from a review of technical literature and previous experience at similar sites. The general removal action categories include:

- **No Action** that involves leaving both Sites as is. The No Action alternative is used as a baseline to compare with the various alternatives;
- **Institutional Controls** that minimize or prevents public exposure by limiting access;

- **Engineering Controls (including disposal options)** that minimize uncontrolled migration and exposure to the environment or human contact; and
- **Treatment** that separates contaminants from the soil/water and waste material.

Within each of these categories, there are several potential removal technologies to be considered. During this initial screening step, the removal actions and potential technologies were evaluated based on the following criteria: effectiveness; compliance with ARARs; implementability; and cost.

Based on the screening results, each technology was either eliminated or retained for further consideration in the development of potential removal alternatives.

Nine potential removal action alternatives to manage mine wastes were developed from the general removal technologies retained from the preliminary screening process and are described as follows:

- **Alternative 1 - No Action;**
- **Alternative 2 – Remove Sludge to an On-Site Repository;**
- **Alternative 3 – Remove Sludge for Off-Site Disposal;**
- **Alternative 4 – Upgrade Existing Sludge Ponds at Blackjack Mine;**
- **Alternative 5 – Upgrade Existing Sludge Ponds at Bluebird Mine;**
- **Alternative 6 – Construct New Wetland Treatment Areas at Blackjack Mine;**
- **Alternative 7 – Construct New Wetland Treatment Areas at Bluebird Mine;**
- **Alternative 8 – Upgrade Water Collection and Pipeline Systems at Blackjack Mine; and**
- **Alternative 9 – Install Adit Plug(s) at Blackjack Mine.**

In a typical mining EE/CA the alternatives tend to be either-or. However, this project has two distinct and separate systems, and each system has multiple solutions. Therefore, a combination of alternatives is recommended. Also, within each alternative there are tasks that can be removed entirely. And within rejected alternatives there are individual task that can be implemented with other selected alternatives. Also, each alternative was costed as completely standalone. There is opportunity to conserve funds when in combination by having a common mobilization cost and other common tasks.

The preferred removal action alternatives combination is:

- **Alternative 3 – Move Sludge to an Off-Site Repository – Cost of $355,000;**
- **Alternative 4 – Upgrade Existing Sludge Ponds at Blackjack Mine – Cost from $368,000 to $395,000; and**
- **Alternative 5 – Upgrade Existing Sludge Ponds at Bluebird Mine – Cost from $133,000 to $224,000.**

1. INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) has been prepared for the United States Department of Agriculture - Forest Service (USFS) Region 6 for work at the Bluebird and Blackjack Mines (the Sites) located in Grant County, Oregon (Sheet 1). Applied Intellect, LLC (AI) was contracted by the USFS (Contract No. 12046W18D0009; Task Order: 12046W19F0009) to conduct this EE/CA under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This EE/CA identifies and evaluates potential removal action technologies and alternatives for the cleanup of mine wastes remaining at the Sites. This document fulfills the requirements of CERCLA (42 USC 9601 et seq., 1980), under the Superfund Accelerated Cleanup Model (SACM) and the National Contingency Plan (NCP, 40 CFR 300.415). The EE/CA was prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance for conducting non-time-critical removal actions under CERCLA (EPA, 1993).

The EE/CA satisfies environmental review requirements for removal actions, administrative record requirements for documentation of removal action selection, and provides a framework for evaluating and selecting alternative technologies. The primary objectives of the EE/CA are to:

- Evaluate existing studies and data from previous documents;
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This project involves a combined EE/CA for both the Blackjack and Bluebird Mines. The two locations have a similar operational history, are located only a mile apart, and are expected to be treated as a single location.

The following sections provide a brief description of the site location and history, site characteristics (topography, meteorology, geology, hydrology), surrounding land use, sensitive environments and summary of previous investigations.

1.1 Site Location and History

The Bluebird and Blackjack Mines are located on public lands administered by the Umatilla and Wallowa-Whitman National Forests approximately 3 miles southwest of the town of Granite, Oregon. The Blackjack Mine is located approximately one mile upstream of the Bluebird Mine. Both mines are located directly adjacent to Clear Creek within the Granite Mining District and have been the subject of numerous investigations during the last 20 years. Baker City is the closest population center in the region and is located approximately 53 miles east of the Sites (Sheet 2).

In addition to the Bluebird and Blackjack Mines on public lands, the nearby Red Boy Mine is located on private property on the west side of Clear Creek directly upstream of the Bluebird Mine (Sheet 2). Existing studies have indicated that the Red Boy has a significant impact to water quality in the existing settling ponds as it comingles with mine water discharge from the Bluebird (CES, 2013).

The following is a brief overview of the location and history of each site. Additional historical details are provided in the Site Inspection (SI) report (EA, 2003).

<u>Blackjack Mine Site</u>

The historic Blackjack Mine site is located on lands administered by the Umatilla National Forest. The site is located on the west side of Clear Creek at latitude 44° 47’ 09’ North, longitude 118° 27’ 59” West, in Section 14, Township 9 South, Range 35 East, Willamette Meridian (Sheet 2). The Blackjack Mine covers approximately 2 acres and contains an upper and lower adit. The upper adit is located approximately 90 vertical feet above Clear Creek. The lower adit is located approximately 30 vertical feet above Clear Creek.

Mining in this area began in the 1860s with the discovery of placer deposits in the gravels of Granite Creek, and in tributaries including Clear Creek. Placer mining was followed by lode mining as the gold was traced back to its sources. Limited information exists regarding the historical workings of the Blackjack Mine or production estimates. Mining claims at the site have dated back to 1898, proof of labor was filed with the County in 1902, and an adit was first mentioned in 1915. The historical records suggest that the mine had approximately 3,000 feet of underground workings and had been intermittently worked up to 1950 (EA, 2003).

<u>Bluebird Mine Site</u>

The historic Bluebird Mine is located on land administered by the Wallowa Whitman National Forest. The site is located off Grant County Road 24, at latitude 44° 45’ 59” North, longitude 118° 29’ 37” West, in Section 11, Township 9 South, Range 35 East, Willamette Meridian (Sheet 2). The site encompasses about 2 acres of moderate to steep hillsides and includes one adit located approximately 50 vertical feet above the elevation of nearby Clear Creek.

Mining claims at the site date back to 1897. According to personal communication with the USFS, two mill sites were located on the Bluebird claim (EA, 2003). Available historical information indicates development at the mine was moderate, but production was minimal. Total underground mine development includes approximately 2,500 feet of crosscuts with short drifts. An estimated 250 ounces of gold was produced from 1,500 tons of ore (Brooks, 1992). Approximately 6,000 cubic yards (cy) of waste rock are scattered over moderately-steep slopes at the Bluebird site (EA, 2003).

1.2 Topography

The Sites are located in the Blue Mountains at an approximate elevation of 4,600 feet above mean seal level (MSL). The general terrain consists of hills, valleys, ridges, and mountains. The Sites are situated near the base of the valley sidewalls along ridges that rise to approximate elevations of 6,000 feet above MSL and are situated within the Clear Creek sub-watershed of the John Day River. Clear Creek, which originates south of the Sites, forms the valley bottom directly adjacent to both mines. Additional information on surface water features in the area is presented in Section 1.6.

1.3 Meteorology

The climate in Grant County is:

- Semi-arid and lies within the northeastern Highlands Climatic Region;
- Marine influenced air movement is from the west, with much of the moisture released on the west slopes of the Cascade Mountains west of the Sites, causing semi-arid conditions at the Sites; and
- The majority of the precipitation occurs as snow in the winter with thunderstorms providing precipitation in the summer as air masses rise over the Blue Mountains.

Precipitation data was obtained from the Natural Resource Conservation Service (NRCS), National Water and Climate Center (NWCC) SNOTEL station 821 (Tipton) (NRCS, 2019). Station 821 is located approximately 9 miles south of the Sites, at an elevation of approximately 5,150 feet above MSL. Meteorological data indicates the following:

- Between 1981 and 2010, the annual average precipitation was 24.6 inches.

Temperature data was obtained from the Western Regional Climate Center (WRCC, 2019) for the nearby town of Granite:

- Between 1948 and 1967, the annual average temperature ranged from a low of 26.2°F to a high of 52.6°F. The maximum recorded high temperature was 99°F in July 1961 and minimum temperature -28°F in January 1950.

1.4 Geology

The following geologic summary was adapted from the SI (EA, 2003). The Bluebird and Blackjack Mines are in the Blue Mountains physiographic province located in northeastern Oregon and southeastern Washington. The Blue Mountains are comprised of a complex system of high plateaus, deep canyons, mountain ranges and broad valleys.

Approximately three fourths of the gold produced in Oregon has come from placer and lode deposits within the gold belt of the Blue Mountains. The primary area of gold occurrence is within Grant and Baker Counties in an area that measures approximately 100 miles long by 50 miles wide and extends from the Snake River on the east to John Day on the west. The gold belt is divided into several areas, which are further divided into districts based on the dominant intrusive bodies and their associated gold deposits. The Bluebird and Blackjack Mines are included in the southwestern part of the Granite District of the Elkhorn Mountains as identified by some authors and the northeastern part of the Greenhorn District of the Greenhorn Mountains area by others. This area is characterized by a greater concentration of small veins and has resulted in the development of numerous small mines and prospects.

The Bluebird and Blackjack Mines were developed in the Elkhorn Ridge Argillite, which is primarily dark-colored and siliceous with chert and minor amounts of tuff, sandstone and conglomerate. In places the brecciated rocks are silicified and iron-oxide stained.

Reports by Brooks and others (1992) described the following geology and mining activity:

<u>Blackjack Mine</u>

- Gold occurs in limonitic silicified shear zones in argillite and chert;
- Total underground mine development includes over 3,000 feet of workings; and
- Past production at the mine was listed as “none”.

<u>Bluebird Mine</u>

- Gold occurs in veins of crushed argillite that is cemented by quartz seams;
- Minor amounts of pyrite and arsenopyrite are present;
- Total underground mine development includes approximately 2,500 feet of crosscuts with short drifts; and
- An estimated 250 ounces of gold was produced from 1,500 tons of ore.

1.5 Hydrogeology

The hydrogeology of the area has not been studied but based on similar geology in other areas consists of a deeper groundwater system within the fractured bedrock. This limited system is likely intercepted by the underground mine workings and represented by the mine drainage water emanating from both mine adits. A very localized shallow system is also likely present within the alluvial valley bottoms and interacts with Clear Creek as a gaining stream.

A search of groundwater well records on file with the Oregon Water Resource Department (OWRD) identified only two wells within approximately one mile of either site. Both wells are located in private inholdings approximately one-half mile northwest of the Bluebird Mine in Section 10 (Township 9 South, Range 35 East). The wells are located along a ridge at a higher elevation than either mine site. Well Driller's reports indicate one well is only 28 feet in depth with a static water level of 25 feet below ground surface (bgs). The other well was drilled to a depth of 350 feet and encountered groundwater at a depth of 80 feet bgs, which subsequently rose to a static level of 9 feet bgs. The deeper well indicated the presence of clay to a depth of 80 feet and a green serpentinite from 80 to 350 feet.

1.6 Hydrology

Clear Creek forms the primary drainage in the area of the Sites. Clear Creek flows northward into Granite Creek approximately 1.1 miles downstream from the Bluebird Mine. Granite Creek then empties into the North Fork John Day River in approximately 5 miles. The North Fork John Day River is designated as a National Wild and Scenic River.

According to the SI, the Granite Creek watershed encompasses approximately 150 square miles with its headwaters originating in the Blue Mountains. Most of the water flow in the drainage area occurs as snowmelt in May and June, with limited precipitation from July through September. Therefore, summer base flows are low relative to spring snowmelt (EA, 2003).

1.7 Surrounding Land Use and Populations

The immediate area around the Sites is part of the Umatilla and Wallowa Whitman National Forests with a private land inholding centered around Congo Gulch and the historic Red Boy Mine. The private land inholding includes the closest residence to the Sites. A residence and several outbuildings are located on the west side of the valley floor approximately 1,000 feet upstream (south) of the Bluebird Mine. The private residence is located on the site of the historic Red Boy Mine and includes a draining adit, extensive areas of waste rock and mill tailings, numerous mine water sludge settling ponds and a mill site foundation. A second residence is located approximately 1,500 feet downstream (north) of the Bluebird Mine. This residence includes numerous outbuildings along the west side of the valley floor and a remote gravel airstrip located at a higher elevation on the valley sidewall. The small town of Granite is located approximately three miles northeast of the Sites. The town includes many part-time residents with an estimated population of 38 people in 2010.

Public use of the Sites appears limited as they are located on the opposite side of Clear Creek from the main public access road, though public access records are not maintained. In general, land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, camping, hunting, etc.).

A search of groundwater well records on file with the Oregon Water Resource Department (OWRD) identified only two wells within approximately one mile of either site. Both wells are

located in private inholdings approximately one-half mile northwest of the Bluebird Mine in Section 10 (Township 9 South, Range 35 East). A total of 12 wells are located within four miles of either site including the town of Granite, located approximately three miles to the northeast. Although no records are indicated on the OWRD website, the private residence at the historic Red Boy Mine is likely to have a groundwater well as a drinking water source.

1.8 Sensitive Environments

The SI report (EA, 2003) summarized the sensitive environments within 15 miles of the Sites as:

- North Fork John Day Wilderness Area;
- North Fork John Day Wild and Scenic River;
- Migratory pathways and spawning areas critical to the maintenance of protected anadromous fish species;
- Habitat potentially used by federal-designated threatened species; and
- Wetlands as defined by 40 CFR 230.3.

To further identify sensitive environments the U.S. Fish and Wildlife Service (USFWS) Information, Planning, and Consultation System (IPaC) was accessed to generate a Trust Resources Report for an area that is approximately one square mile around the Sites to identify species that are proposed, candidate, or listed as threatened and endangered and designated critical habitat areas that may be present. The Oregon Natural Heritage Information Center was also queried regarding observations of rare, threatened, or endangered species within a two-mile radius as part of the SI.

Clear Creek is considered a sensitive environment that provides migratory and spawning habitat that is critical to the maintenance of anadromous fish species (SAIC, 2005a,b; USFWS, 2019). Critical habitat for bull trout (*Salvelinus confluents*), a federally listed threatened species, is reported for Clear Creek (USFWS, 2019). The west slope cutthroat trout (*O. clarki lewisi*), reported within two miles of the Sites, is designated as a federal species of concern and a state-sensitive species. The interior redband trout (*O. mykiss gairdneri*), a state-sensitive species, also occurs in Clear Creek. The Columbia spotted frog (*Rana luteiventris*), a state-sensitive species, has been observed in a nearby side channel of Clear Creek (EA Engineering, 2003).

The Cassin's finch (*Carpodacus cassinii*), a migratory Bird of Conservation Concern, may occur during the summer breeding season within the vicinity of the Sites, with the highest likelihood of occurrence in June (USFWS, 2019). No Cassin's finches were observed at the Sites during the SI observations in 2003 (EA, 2003).

The 2019 IPaC report also indicates there is critical habitat for the federally listed endangered gray wolf (*Canis lupus*) within the region. The gray wolf is listed as endangered in the western 2/3rds of the State of Oregon but has been delisted in the eastern part of the state where the Sites are located (USFWS, 2015).

The following plants are listed as protected in Grant County: South Fork John Day milkvetch (*Astragalus diaphanous*) and arrow-leaf thelypody (*Thelypodium eucosmum*) (Oregon Department of Agriculture (2019a). The threatened milkvetch occurs in habitats on dry, barren slopes in gravelly, shallow soils overlying basalt in openings in juniper woodland at elevations ranging from 2,500 to 3,600 feet and is restricted to the South Fork of the John Day River within the Blue Mountains ecoregion (Oregon Department of Agriculture, 2019b). Arrow-leaf thelypody, also listed as threatened, occurs in shaded areas under junipers on dry slopes and in dry to moist areas in stream beds and along seeps and streams within juniper-sagebrush plant communities at elevations ranging from 1,640 to 5,500 feet (Oregon Department of Agriculture, 2019c). While the Sites are located within the Blue Mountains ecoregion, the elevation and vegetative cover types at the Sites do not support appropriate habitat for these protected plant species.

1.9 Previous Investigations

Environmental sampling at and around the Bluebird and Blackjack Mines was initiated by the USFS in 1980; however, that early information was not available. Most detailed environmental studies began around 2003 and have continued since then. The USFS, Region 6 provided 27 reports and data files for review as part of this EE/CA. A detailed bulleted summary of each report and analytical results of interest to this EE/CA are provided in Appendix 1. The reports and data files include:

- EA Engineering, Science, and Technology, Inc., 2003, Site Inspection – Bluebird and Blackjack Mines, Umatilla National Forest, Oregon, prepared for USDA-FS, Pendleton, Oregon;
- Umatilla National Forest, USFS, R6, March 2003, Abbreviated Preliminary Assessment, Blackjack Mine;
- USFS, R6; April 2003, Blackjack Mine 2003 TCRA Action Memo;
- EA Engineering, Science & Technology, January 2004, Site Inspection, Granite Creek Mines, Wallowa-Whitman National Forest, Oregon;
- Science Application International Corp., 2005, Final Engineering Evaluation/Cost Analysis, Bluebird Mine Site, Granite, Oregon, prepared for USDA-FS, Vancouver, Washington;
- Science Application International Corp., 2005, Final Engineering Evaluation/Cost Analysis, Blackjack Mine Site, Granite, Oregon, prepared for USDA-FS, Vancouver, Washington;
- Cascade Earth Sciences, May 2007, Non-Time Critical Removal Action Report, Bluebird Mine Portal, Wallowa-Whitman National Forest, Baker County, Oregon;
- Cascade Earth Sciences, February 2008, Non-Time Critical Removal Action Report, Blackjack Mine Portal and Pipeline, Wallowa-Whitman National Forest;
- Cascade Earth Sciences, April 2008, Bluebird Mine Plug Installation Closure Report, Wallowa-Whitman National Forest, Grant County, Oregon;
- US Forest Service, Willow-Whitman & Umatilla National Forest, September 2008, Watershed Action Plan (WAP) To Remove Barriers and Improve Stream Function on National Forest System Lands Within the Granite Creek Watershed (HUC 1707020202);

- Cascade Earth Sciences, February 2009, Final Operations and Maintenance Plan: Bluebird Mine Portal Plug, Seepage Dam, and Pipeline, Umatilla National Forest, Grant County, Oregon;
- Cascade Earth Sciences, February 2009, Final Operations and Maintenance Plan: Blackjack Mine Portal and Pipeline, Umatilla National Forest, Grant County, Oregon;
- Cascade Earth Sciences, March 2011, Technical Memorandum: Bluebird Mine October 2010 Post Removal Action Sampling Report;
- Cascade Earth Sciences, February 2013, Mine Seep Discharge and Settling Ponds Assessment – Blackjack Mine prepared for North Fork John Day Watershed Council and Umatilla National Forest;
- Cascade Earth Sciences, January 2013, Expanded Preliminary Assessment/Engineering Evaluation, Red Boy Mine – ECSI#2467 prepared for North Fork John Day River Watershed Council and Umatilla National Forest;
- Cascade Earth Sciences, August 2015, Technical Memorandum: Sludge Disposal Options – Blackjack and Bluebird Mines for U.S. Forest Service;
- Cascade Earth Sciences, September 2015, Technical Memorandum: Clear Creek Options Assessment: Hydraulic Modeling of Clear Creek and Treatment Ponds – Blackjack and Bluebird Mines, Umatilla National Forest, Oregon;
- Tetra Tech, December 2016, Blackjack Mine, Grant County, Oregon – Site Visit and Recommendations;
- Cascade Earth Sciences, May 2017, Site Characterization and Removal - Action Design, Bluebird and Blackjack Mines, Clear Creek Options Assessment;
- Ecology and Environment, June 2017, Mining District Site Recon and Prioritization, Granite Creek Watershed, Oregon. For the U.S. Environmental Protection Agency;
- USFS, 2018, TCLP Analyses of Bluebird and Blackjack Ponds Sludge Analyses. The US Forest Service obtained six samples of sludge from the Bluebird and Blackjack sludge ponds for TCLP (or SPLP) and total TAL metals. No samples exceeded TCLP limits for hazardous waste; and
- Tetra Tech, December 2018, Preliminary Sampling Results – Blackjack and Bluebird Mines, Oregon.

A brief overview of the previous investigations is provided below for each mine site and a more detailed summary in Appendix 1.

Blackjack

USFS efforts to prevent the upper adit mine water discharge from entering Clear Creek began in the 1960s. This work included the installation of a 4-inch diameter PVC pipe through a thin concrete portal plug that routed the adit drainage to the old south settling pond. Over time, this pipe was broken, and the drainage entered Clear Creek directly from the adit. During its period of use the historic basin gradually became sealed by sludge as noted when later investigators used it temporarily during adit re-opening (CES, 2008).

At some point in time before 2003 the 4-inch PVC pipeline was replaced by a 6-inch PVC pipeline that discharged to a roadside ditch east of Clear Creek (ostensibly by the USFS). However, this has not been documented.

In 2003 the USFS had an Abbreviated Preliminary Assessment (APA) conducted for the Blackjack Mine, as well as a SI completed for both Sites. The SI detected metals in the adit discharges above screening levels. Metals concentrations in soil and waste rock were also detected above screening levels for arsenic and iron. In 2005, the USFS had an EE/CA completed for each site for use in selecting a mitigation approach that would reduce the risk of adverse effects to the environment and/or to public health and welfare. The EE/CA included development of a streamlined human health and ecological risk assessment, which determined that no adverse effects to human health or terrestrial ecological receptors were expected and no removal action alternatives were developed.

Previous investigations estimated a total of approximately 1,400 cubic yards (cy) of waste rock located at the upper south adit and 12 cy of waste rock located at the lower north adit (SAIC, 2005). The latter volume was identified by CES (2008a) as low. An inactive settling pond (dry when inspected in 2003 and 2004) is located on the south portion of the site, west of Clear Creek. This pond was reportedly used to collect the upper adit water prior to installation of the current mine water pipeline. As discussed previously this basin has probably reached the end of its useful life. In September 2004, discharge from the main upper adit was measured at approximately 80 gallons per minute (gpm) and discharge from the lower adit was measured at 4 gpm.

Assessments conducted during 2003 – 2005 indicated elevated levels of barium and lead in surface water samples collected from Clear Creek both upstream and downstream of the Sites. Hardness values in the Creek ranged between 84 and 172 milligrams per liter (mg/L) as $CaCO3$ with a mean of 114 mg/L; the pH was 7.8 to 8.4 standard units.

Samples collected from the settling pond adjacent to, and downstream of the Blackjack discharge pipe identified aluminum, barium, cadmium, cobalt, iron, manganese, nickel, selenium, and zinc at levels exceeding risk-screening values. Evaluation of water chemistry data indicated that aluminum, iron, and manganese were precipitating in the ponds as oxides. Hardness of the pond water averaged 150 mg/L as $CaCO3$ and field pH ranged from 5.94 to 6.26. Dissolved oxygen in the pond water was slightly less than in Clear Creek (SAIC, 2005).

Water samples collected from the main (upper) adit and the lower adit discharge indicated barium, iron, manganese, mercury, and nickel at levels exceeding ecological screening values. The pH of the upper adit discharge was 5.49 in 2004 and 6.03 in 2003. The lower adit discharge water pH was 5.82. The main adit discharges approximately 14 pounds of iron per day (lb/day) into the settling pond and about 2 lb/day of manganese. Loading from the lower adit discharge was estimated as 1 lb/day of iron.

Sediment samples collected in Clear Creek identified arsenic, total chromium, copper, manganese, nickel, and silver at levels exceeding conservative sediment benchmark levels. These metals were identified at elevated concentrations at both upstream and downstream sampling locations. These sediment samples were reported as representative of only the fine fraction of the substrate habitat. Most of the substrate of Clear Creek is comprised of gravels, cobbles, and boulder-sized materials.

Sediment samples collected in the settling pond channel that receives the Blackjack Mine discharge contained antimony, arsenic, cadmium, total chromium, copper, manganese, mercury, nickel, and zinc at concentrations above preliminary screening values.

Porewater samples were collected from the creek upstream and downstream of the Blackjack Mine to evaluate shallow groundwater conditions. Barium and mercury were identified as exceeding ecological screening values.

Samples collected from soil and waste rock indicated aluminum, antimony, arsenic, cadmium, total chromium, copper, lead, manganese, mercury, nickel, selenium, thallium, vanadium, and zinc above preliminary screening values. The highest metal concentrations were found in the former south settling pond. The average arsenic concentration in Blackjack soils/wastes (25.2 mg/kg) was reported as approximately three times that of background soils (8.1 mg/kg).

Plant tissue samples (wild strawberry) identified iron, manganese, zinc, and cyanide at elevated levels relative to two background tissue samples. The cyanide detection was identified as a potential anomaly (SAIC, 2005).

Overall, previously completed assessment activities identified twenty-four inorganic chemicals as Chemicals of Interest (COIs) for the site: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. Of these, the following human health contaminants of potential concern (COPCs) were identified for the Blackjack Mine site:

- Soils/wastes: arsenic, iron;
- Surface water: arsenic;
- Sediment: aluminum, arsenic; and
- Multiple media: aluminum, arsenic, iron.

It must be noted that there has been significant historic mining and subsequent reclamation activity upstream of Blackjack Mine that probably has some impact to current water and sediment at Blackjack Mine. This has not been rigorously assessed but should be if any future watershed cleanup effort is performed in Clear Creek.

<u>Bluebird</u>

Efforts by the USFS to prevent mine drainage from the Bluebird adit to discharge directly into Clear Creek began in the 1960s. Major work began in the 1980s with the installation of a wooden bulkhead in the mine portal and a discharge pipe that diverted water south of the site and into a pond located on the west side of Clear Creek and Grant County Road 24, on private land. In the summer of 2004, the current 8-inch HDPE pipeline was installed to divert the mine water into a pond on lands administered by the USFS directly west of Clear Creek and the county road. The adit was fully opened in 2006 and a portal dam was constructed to more efficiently collect discharge for the 8-inch HDPE line. In late 2006 a concrete plug was installed in an effort to slow or terminate discharge. Seepage around the plug is collected behind a new portal dam for discharge to the existing 8-inch line. The flow rate on the pipeline discharge on September 9, 2004 was measured at 83 gpm.

Surface water samples collected from Clear Creek during 2003 indicated barium exceeded initial risk-screening levels both upstream and downstream of the Bluebird Mine. Antimony, cadmium, cobalt, copper, mercury, nickel, and selenium were not detected. The average hardness of Clear Creek water adjacent to the site was 106 mg/L as $CaCO3$; the pH was in the range of 7.61 to 8.42 standard units.

Water samples collected from the Bluebird Mine adit indicated concentrations of barium, cobalt, iron, manganese, mercury, nickel, and zinc exceeded ecological screening values. The pH of the mine discharge was 5.2 in 2003 and 5.13 in 2004. An estimate made during 2005 indicated the Bluebird mine water transported approximately 16 lb/day of iron into the settling pond and 5 lb/day of manganese. The combined loading for arsenic, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and zinc was estimated as less than 1 lb/day (SAIC, 2005).

Water samples collected from the settling pond indicated aluminum, barium, cadmium, cobalt, iron, manganese, nickel, and zinc exceeding one or more risk-screening values. The 2005 evaluation concluded that aluminum, iron, and manganese were precipitating in the pond.

Both Blackjack and Bluebird have significant operation and maintenance (O&M) costs associated with ongoing mine water and sludge management activities. Clear Creek contains threatened and endangered (T&E) species of anadromous fish, and a fish kill (cause unknown) was reported in 2015. Part of the O&M costs are caused by the Blackjack pipeline being undersized and apparently flat for the last 500 feet, and the Bluebird pipeline clearly constructed with a depression in the line as it passes beneath Clear Creek and the county road. Both situations exacerbate sludge deposition within the pipeline and make cleaning more difficult.

2. SITE CHARACTERIZATION

This section presents the results of a data gaps investigation conducted in June 2019 and June 2020 as part of this EE/CA, and updates to previous risk assessments conducted at the Sites.

2.1 Data Gaps Investigation

For both Sites, an initial assessment was implemented in 2019 to further evaluate the presence, concentrations, and volumes of potential contaminants. These assessments, conducted from June 10 through 13, 2019, involved a site reconnaissance, sampling and laboratory analysis, and sludge volume estimates. All site work was conducted in accordance with the approved Sampling and Analysis Plan (SAP) and Health and Safety Plan (HSP) included in the 2019 project Work Plan (AI, 2019).

Based on the results of the Preliminary Draft EE/CA a second Data Gaps investigation was also conducted in June 2020. This follow-on investigation consisted of the following items:

- Determine if the sludge from the on-site settling ponds could be disposed of in the Baker City Municipal Landfill rather than in an on-site repository;
- Investigate possible sites west of Clear Creek for use as a wetland treatment location for the Blackjack Mine;
- Prospect a potential replacement route for the Blackjack Mine discharge pipeline; and
- Complete additional sampling needed at both sites to complete a human health risk assessment (HHRA).

All work in 2020 was conducted in accordance with the Workplan Addendum (AI, 2020a).

2.1.1 Site Reconnaissance

A detailed site reconnaissance was conducted at both Sites that included locations identified by previous investigations and visual inspection of locations of key mine site features (e.g., adits, waste rock, sludge settling ponds, pipelines, equipment access, potential repository locations, etc.). The assessment also focused on examination of soil, water (both outfall sampling and flow measurements), vegetation, wildlife, drainage characteristics. Visual observations are described below, and key features are presented on Sheet 3 through 6. Site photographs documenting site conditions are presented in Appendix 2.

<u>Blackjack Mine Site</u>

The Blackjack Mine is located on the western side of the Clear Creek Valley approximately one mile upstream of the Bluebird Mine. The Blackjack Mine consists of two portals, an upper portal located approximately 90 feet above the valley floor and a lower portal located approximately 30 feet above the valley floor. The topography of the site is very steep. The reclaimed remnant of an access road is present along the steep hillside between the upper and lower adits. The following are key features at the Blackjack Mine:

- Both the upper and lower adits display open portal areas with metal bat gates preventing unauthorized access. A large waste rock pile beneath the upper adit is the most significant feature of the area, while a much smaller waste rock pile is located below the lower adit. Mine water discharge is collected behind dams within both adits and transported to the other side of the Clear Creek Valley in an underground pipeline.
- Mine water discharges from the pipeline into the hillside borrow ditch of County Road 24. Water flows along the ditch into a series of settling ponds created by earthen and rock dams. The ponds are filled with iron-hydroxide sludge that is a characteristic orange color.
- The ditch continues to flow towards the north and receives groundwater contribution through a series of seeps along the permeable road-base material that separates the ditch from Clear Creek.
- The water in the drainage clears quickly as the flows increase and pass through a series of natural wetland and riparian areas.
- The drainage from the Blackjack Mine ultimately discharges into Clear Creek after approximately 3,000 feet. The confluence is immediately downstream of the bridge stream crossing of County Road 24.
- Both portal areas were stabilized during previous site work with wire mesh, rock bolts and wood timbers.
- A waste rock apron extends below the upper portal area to the valley floor adjacent to Clear Creek. An eroded gully exposed to bedrock is present directly beneath the upper adit. The bedrock in the eroded gully displays orange staining and appears to represent mine water discharge prior to installation of the current pipeline system.
- The site is moderately vegetated with large pines, fir, and brush. Vegetation along the waste piles is much less than the rest of the mine area. Riparian vegetation is present along the banks of Clear Creek.
- Although not a part of the underground hard rock mining associated with the Blackjack Mine, the valley floor has been significantly altered by placer mining. The dredge mining created extensive areas of dredge piles and water filled depressions, largely composed of washed cobbles and boulders. A dredged area within a wider portion of the valley floor (approximately 1,000 feet upstream of the Blackjack Mine) has been graded flat to match the pre-mining topography as part of reclamation efforts in the area.

<u>Bluebird Mine Site</u>

The Bluebird Mine is located on the eastern side of the Clear Creek Valley approximately 50 feet above the valley floor. The topography of the site is steep. Surface topography has been altered by the past mining activities. The following are key features at the Bluebird Mine:

- An open portal area and a large waste rock pile are the most significant features of the area. A bat gate is present approximately 50 feet in from the portal.
- The portal area was recently stabilized with wood timbers.
- Mine water discharge is collected behind a dam within the adit and transported to the other side of the Clear Creek Valley in an underground pipeline.

- The pipeline discharges into a former dredge pond on the west side of County Road 24. The dredge pond serves as a settling pond and is filled with iron hydroxide precipitate with extensive areas of wetland vegetation colonizing around the margins.
- The settling pond discharge flows toward the north through a small channel area and discharges into a second large dredge pond that serves as a final natural treatment pond were the water has no surface outlet, but rather infiltrates into the coarse gravel substrate.
- The treatment pond is characterized by a much-reduced amount of iron hydroxide sludge and is much deeper than the upstream settling pond.
- A small area of orange staining was observed in a roadside ditch on the east side of County Road 24 directly across from the northern end of the settling pond. The ditch had a HDPE road culvert near its apparent source; however, no inlet was observed on the adjacent (west) side of the road. The ditch was dry at the time of the 2019 site visit but has reported very acidic levels of water historically.
- An area of interconnected dredge ponds associated with the upstream Red Boy Mine are present directly south of the Bluebird settling pond and are hydraulically connected to the Bluebird ponds through a series of road culverts and subsurface flow.
- The culvert connecting the Red Boy Ponds with the Bluebird settling pond was partially plugged by sludge during the 2019 site visit. A contractor doing maintenance work for the USFS on the mine water pipeline cleaned out the obstructed culvert. A noticeable drop in the water level of the Red Boy ponds was observed once the downstream culvert was cleared, confirming a direct hydrologic connection.
- On the east side of the valley a waste rock apron extends below the portal area to the valley floor adjacent to Clear Creek.
- The waste rock apron was heavily eroded prior to the construction of an underground plug and pipeline system that diverted the mine water discharge from surface flow to the current pipeline system.
- The historic surface water flow eroded a gulley down the centerline of the waste rock pile before curving north and terminated into an excavated depression located on a flat area of the valley floor. This area displays a reddish coloration in the soil at the bottom of the excavation, likely the result of iron precipitates from the historic mine water drainage.
- The site is moderately vegetated with large pines, fir, and brush. Vegetation along the waste piles is much less than the rest of the mine, and absent on several piles. Extensive riparian vegetation is present along both sides of Clear Creek.
- Although not a part of the underground hard rock mining associated with the Bluebird Mine, the valley floor has been significantly altered by placer mining. The dredge mining created extensive areas of dredge piles and water filled depressions, largely composed of washed cobbles and boulders.

2.1.2 Sampling and Laboratory Analysis

2019 Site Sampling

The purpose of the 2019 sampling and laboratory analysis was to determine the volume of iron hydroxide sludge in settling ponds and confirm metals concentrations and water quality characteristics in various media evaluated during previous studies.

AI mobilized a two-person field crew to collect sludge, mine waste, soil, and water samples. Sampling included:

- Collection of samples from the waste rock piles and from locations selected to represent background conditions;
- Collection of mine water discharge samples to evaluate sludge generation rates and water treatment criteria; and
- Assessment of the depth of the sludge ponds through direct field measurements and potential thickness/density of sludge deposits throughout the water profile through vertical sampling using a clear tube sludge-sampling device that was deployed by hand from an inflatable rubber raft.

<u>Soil and Waste Rock Sampling</u>
Soil and waste rock samples included:

- Seven samples from the Bluebird waste rock pile (BLU-WR-1 through BLU-WR-6; Sheet 3);
- Six samples from the Blackjack waste rock pile (BLK-WR-1 through BLK-WR-6; Sheet 4);
- Five background samples at Bluebird (BLU-BG-1 through BLU-BG-5; Sheet 3); and
- Five background samples at Blackjack (BLK-BG-1 through BLK-BG-5; Sheet 4).

The background samples were obtained near the Sites in comparable rock units in areas clearly not impacted by mining, including runoff and colluvium from impacted uphill locations. All soil / waste samples were submitted for laboratory analysis of the analytes listed in Table 1. Analytical methods are also listed in Table 1.

<u>Mine Water Sampling</u>
Mine water samples were collected from the pipeline discharge of both the Bluebird and Blackjack Mines. Water samples included:

- Sample from Blackjack pipeline discharge (BLK-PD-1); and
- Sample from Bluebird pipeline discharge (BB-PD-1).

Pipeline discharge locations are displayed on Sheets 5 and 6. Water samples were analyzed for metals and general water quality parameters (see Table 2). Measured field parameters include pH, redox, temperature, conductivity, and dissolved oxygen. Samples were also submitted for testing at Applied Polymer Systems located in Marquette, Michigan. This test determined the ability of polymers to enhance flocculation and settlement of amorphous solids, and select an appropriate filter fabric for the Geotube.

Pond Water and Sludge Sampling

Water/sludge sample location are identified on the Blackjack and Bluebird settling ponds as shown in Sheets 7 and 8. The samples were obtained in conjunction with sludge measurements. Settling pond water/sludge samples were obtained using a discrete clear tube sludge-sampler. Three sludge samples were collected at the Blackjack ponds, two at the primary Bluebird settlement pond, and three in the extended treatment pond to the northeast of the primary Bluebird settling pond. An inflatable raft was used to collect samples from the deeper portions of the settling ponds without disturbing the pond bottom. The sampler was slowly pushed into the water/sludge column at each chosen location for the full depth before being closed. It was slowly and carefully raised, and the visual density profile and thickness recorded. The entire sludge sample was analyzed for total solids by EPA Method 2540. Sludge samples were also obtained for submission to Analytical Laboratories in Boise, Idaho for density (% solids) and WaterSolve LLC, Caledonia, Michigan for performance testing of various sludge dewatering procedures (e.g., Geotubes).

Laboratory Analysis

Soil samples were submitted to Pace Analytical in Mount Juliet, TN for metals analysis. Water samples were submitted to Silver Valley Labs in Kellogg, Idaho. Copies of original laboratory reports are presented in Appendix 3.

Soil and Waste Rock Results

The results of soil/waste rock sample analyses are summarized in Table 1. Arsenic, chromium and iron were elevated at both the Bluebird and Blackjack waste rock piles. Manganese was also elevated at the Blackjack site. Concentrations were similar to those detected in prior investigations.

Water Results

Analytical results of mine water discharge samples are presented in Table 2. Water results indicate the primary contaminants are elevated iron concentrations and trace concentrations of cadmium, copper, nickel, and zinc that may exceed criteria at certain times.

Sludge Results

Results of laboratory tests on sludge samples for % solids are presented in Table 3. Results for performance testing of Geotube products are summarized in written reports presented in Appendix 3. The reports indicate the sludge can be effectively removed and dewatered by Geotube products to allow for transport for disposal purposes.

2020 Site Sampling

Additional Soil Sampling

Results from the screening level human health risk assessment presented in the Preliminary Draft EE/CA indicated that waste rock/soil for the Blackjack Mine slightly exceeded manganese and cobalt standards and waste rock/soil for the Bluebird Mine slightly exceeded the arsenic standard. Based on these results, it was determined that a quantitative human health risk assessment should be performed to further evaluate site-specific exposures and risks based on human receptors identified by USFS (e.g., workers and recreators). Additionally, it was determined that the quantitative human health risk assessment should evaluate a sub-250 µm fraction of soil that is the most likely to adhere to human hands and represent an exposure pathway.

In support of the quantitative human health risk assessment, AI collected additional soil samples as part of the Data Gap Investigation at locations near the previously evaluated waste piles (AI, 2020b). Specifically, five sampling areas (SAs) were identified at each mine site as shown in Sheet 5 and 6. The SAs were selected to target areas outside of previously investigated waste rock piles that would be accessible to the public and USFS workers. Sampling procedures are described in more detail in the 2020 Data Gaps Report included in Appendix 4, and analytical results in comparison to generic screening levels are shown in Appendix 4 Tables 1 and 2.

Geotube Demonstration

Sludge from the discharges at both mines exhibit low solids percentages ranging from 8.8 to 17.5 %, Table 3. The average % solids was 11.8 %, and the sludge was very fluid. This kind of waste is very difficult to manage, transport, and dispose of. At some point the sludge will fill the settlement basins at both the Blackjack and Bluebird Mines and/or develop potential for significant discharge to Clear Creek, most notably from the Blackjack settlement ponds. In the future the sludge will ultimately require removal and disposal at an appropriate location and facility. The primary choices are:

1. Disposal in an engineered on-site repository; or
2. Transport to and disposal at the Baker City Municipal Landfill.

Alternative 1 was evaluated by Cascade Earth Sciences in 2013 and 2015. The approach was to use vactor trucks to remove the sludge, transport the sludge to a nearby engineered repository, and densify the sludge in Geotubes at the repository location. This approach had a variety of issues including the cost to transport large amounts of water with the sludge, discharge of this water at the repository site, and construction and maintenance cost of the repository. The proposed repository location in a USFS rock quarry would also delete a material source for road maintenance.

Alternative 2 would require dewatering of sludge on-site in Geotubes with reject water returning to the source ponds. Landfill disposal would require that condensed sludge within the Geotubes would not fail the toxicity characteristic leaching procedure (TCLP) (EPA Method 1311) test for

Resource Conservation and Recovery Act (RCRA) Hazardous Waste as well as pass the "paint filter" test, EPA Method 9095B. Material that fails TCLP criteria must be disposed of in a RCRA Subtitle C hazardous waste landfill, of which the Baker City Landfill is not one. The "paint filter" test determines if the waste will release free liquid, which would not be permitted in the Baker City Landfill. The concept for full-scale sludge removal is that a suction pump or other device would be used to pump sludge under controlled pressure from the settlement ponds into a Geotube within a dump truck bed lined with a disposable high-density polyethylene (HDPE) liner to prevent accidental discharge during transport and to permit discharge of reject water from the Geotube through a valve attached to the liner. When full, the Geotube would be transported to the Baker City Landfill, and the Geotube and liner would be dumped directly into the landfill. The major advantage of this approach is that an on-site repository with the attendant risks and long-term maintenance would not be constructed. The uncertainties are:

1. Would the condensed sludge pass the paint filter test?
2. Would the condensed sludge still pass the paint filter test after a 60-mile trip to the landfill?

AI proposed to evaluate the uncertainties by conducting a small-scale pilot test that consisted of filling two small (7 ft x 4 ft) Geotubes in the bed of a lined dump truck. Because the pH of the Bluebird and Blackjack sludge are significantly different, a separate Geotube was used for each material. Both Geotubes consisted of Tencate GT50D fabric as identified during the initial EE/CA sampling in 2019 to be the optimal material. A technician from WaterSolve LLC, Caledonia, Michigan, an experienced Geotube consultant oversaw the operation in support of AI. A flocculant, Solve 137, was injected into the sludge to enhance dewatering. The locations of sludge removal at Bluebird and Blackjack are illustrated by the red dots on Sheet 2. A schematic of the procedure is provided in Sheet 12. Heavy equipment (truck and excavator) were provided by Justus Excavation & Trucking, LLC of Haines, Oregon.

Results of the pilot test indicated that samples from both geotubes easily passed the paint filter test and the material was suitable for disposal at the Baker City Landfill. A detailed description of the pilot study is provided in the Data Gaps Report included in Appendix 4.

<u>Alternative Blackjack Treatment Pond Site Evaluation</u>

During preparation of the Preliminary Draft EE/CA it was recommended that a new wetlands treatment system be considered on the west side of Clear Creek. This has several advantages over the existing system on the east side of Clear Creek including:

1. The existing system is adjacent to the county road and illustrates a visual impact by the orange precipitate; a wetland on the west side would be largely out-of-sight;
2. The existing system incorporated a borrow ditch as a convenience, but is difficult to maintain; a wetland on the west side would be specifically designed for effective maintenance;

3. The existing wetlands is long, narrow, and shallow with a direct connection to Clear Creek; a west-side wetlands could be designed to be deeper and much shorter without a direct connection to Clear Creek; and
4. The existing wetlands requires a long pipeline from the Blackjack adit which goes under Clear Creek and has a flat gradient in the Clear Creek valley; a west side location would use a much shorter pipeline with a much steeper gradient.

The disadvantages of a west side wetlands include:

1. Additional construction for the wetlands, pipeline, and roads would disturb additional USFS land;
2. Access road operation and maintenance (O&M) would be entirely supported by the USFS; the existing system utilizes a county road; and
3. Multiple crossing of Clear Creek would be required for construction and O&M; none is required at the current existing system.

The largest single unknown relative to the application of a west side wetlands is the infiltration rate of the existing terrain at the proposed location of the new wetlands. The existing wetlands – although directly connected to Clear Creek - is approximately 2,500 feet long, whereas the proposed west side wetlands would be terrain-limited to approximately 400 feet in length. Without adequate subsurface infiltration, part of the water would require surface discharge, and this water must meet regulatory criteria prior to discharge. The surface area may be inadequate, or the design may be complicated with attendant O&M costs.

To determine the infiltration rate at the proposed new wetlands location AI located four tests pits in which infiltration test would be performed. The depth of the pits were determined by the profile encountered. Infiltration tests were performed by partially filling the pits with water and measuring the infiltration rate directly. Samples of underlying soil were also obtained at the anticipated depth of the wetland to perform infiltration calculations based on percentage of fines. These tests were performed by Strata Geotech, Spokane, Washington.

The locations of the four selected test pits are illustrated in Sheet 9. A detailed description of the test pits and infiltration tests is presented in the Data Gaps Report presented in Appendix 4. An infiltration analysis was performed to determine if the location of the proposed wetlands would be able to manage the 90 gpm outflow from the Blackjack Mine. Operation would preferably maintain a zero surface discharge to Clear Creek, which would require 100% infiltration of water discharged from the Blackjack Mine.

Three test pits were excavated within the proposed boundary of the main wetlands, designated BLK-TP1, BLK-TP2 and BLK-TP3. Installation of these test pits is described in Section 3.2 of the Data Gap Report.

The grain size (e.g., % fines) analysis for sampled soils was used to calculate the hydraulic conductivity of underlying soil at each test pit location, which in turn, was used to calculate a respective normalized outflow rate (Appendix 4, Data Gap Report - see calculation in Attachment 3). A unit infiltration rate was determined, based on the size of each test pit (Appendix 4, Infiltration Calculations, Table 1).

Each test pit was then allocated a respective portion of the proposed wetlands area, as depicted in Appendix 4 (Infiltration Calculations, Figure 1). These sub-areas measured approximately 4,200 square feet (sf), 10,200 sf and 9,430 sf for test pits BLK-TP1, BLK-TP2 and BLK-TP3, respectively. A wetlands operating depth of 2.0 ft was assumed to calculate the infiltration capacity of each respective sub-area. These infiltration capacities were determined to be 673 gpm, 65 gpm and 1,512 gpm for areas represented by test pits BLK-TP1, BLK-TP2 and BLK-TP3, respectively. Summed, the overall total infiltration capacity for the entire proposed wetlands would be approximately 2,250 gpm.

This 2,250 gpm infiltration rate would reasonably be assumed as the initial infiltration rate, and would decrease over time as the wetlands became biologically established, and sediments/sludges began to seal the formation. In time, maintenance would be required to remove sludges causing the sedimentation (in order to maintain a zero-discharge solution), or alternatively provide an outlet from the wetlands to discharge into Clear Creek.

Lower Blackjack Pipeline Survey

No actual surveys by a licensed surveyor exist of the lower Blackjack pipeline. An un-surveyed as-built drawing by CES in 2008 indicates that the pipeline is completely flat from a point on the east side of Clear Creek to the original outfall at a point in the borrow ditch just past the county road, a distance of approximately 400 feet. This pipeline layout creates a natural deposition point for precipitates to block flow, resulting in a possible overflow in the portal area to Clear Creek. An option for improving this as identified in the preliminary draft EECA is to extend the pipeline a greater distance down the valley before passing under the county road to a point in the borrow ditch that is lower in elevation than the existing outfall.

To complete this survey a potential outfall was identified, the pipeline was exposed in an excavated pit west of Clear Creek, and the points were surveyed. Sheet 9 illustrates the surveyed elevations and a possible pipeline route.

Results of the pipeline survey indicate that the existing pipeline exhibits a drop of 1.18 ft over the 400 ft length between the exposed pipe in the pit and the point 4612.33 for a gradient of 0.003 ft/ft. The total gradient at the existing outflow is a drop of 2.38 ft along the full length of 613 ft for a gradient of 0 0039 ft/ft The proposed new route as shown on Sheet 23 would yield a drop of 2.5 ft along a length of 800 ft for a gradient of 0.0031 ft/ft. There is thus no apparent advantage to relocating the pipeline.

2.1.3 Quality Assurance Quality Control

Quality assurance/quality control (QA/QC) procedures employed as part of this project included field and laboratory QA/QC activities as detailed in the SAP (AI, 2019). A detailed assessment of QA/QC activities are presented in Appendix 5.

The relative percent difference (RPD) for the solid samples included one waste rock and one background sample soil duplicate. The waste rock duplicate was collected from the Bluebird waste rock pile (BLU-WR-6) and was labeled as sample BLU-WR-7 and the background soil duplicate was collected at the Blackjack Mine (BLK-BG-5) and was labeled as sample BLK-BD-6. The waste rock duplicate RPD ranged from 0.13 to 39.8%, which is within acceptable levels. The background soil duplicate RPD ranged from 1.22 to 141.7%, of which two analytes exceed the acceptable RPD range of 50%. The higher RPD for this sample pair is attributed to sample heterogeneity. No site samples were flagged as unacceptable.

Water sample QC included the collection of one blind field duplicate. The duplicate was collected from the mine water pipeline discharge at the Blackjack Mine (BLK-PD-1) and was labeled as sample BLK-ADIT-RES. The RPD ranged from 0 to 1.8%, which is well within acceptable levels.

The analytical data reported for this sampling event are acceptable for use in this investigation.

2.1.4 Sludge Volume Estimates

Sludge formed by precipitation of metals from the adit discharges is present at both the Blackjack and Bluebird Mines. The volume of accumulated sludge currently present in settling ponds near the mines and predicted future sludge generation rates were evaluated as part of the data gaps analysis. Results of this evaluation are summarized in this section.

<u>Accumulated Sludge Volume</u>

The volume of accumulated sludge in settling ponds at the Blackjack and Bluebird pipeline discharges was estimated on the basis of sludge thickness measurements. The sludge thickness was measured using an inflatable raft and a clear plastic sludge sampling tube that obtained a complete undisturbed core of the pond bottom. Sludge thickness was generally greater toward the center of the various settling pond areas, decreasing toward the edges. The maximum thickness measured was 3.5 feet at the Bluebird settling pond and 2.5 feet at Blackjack settling pond.

Estimation of sludge volumes was complicated by variability in the sludge thickness from location to location, as well as the irregular shapes of the pond areas. The surface area of each pond was measured using detailed aerial imagery obtained by the USFS drone program. Estimated sludge volumes in each area are summarized in Table 4. Details regarding the volume estimation calculations and assumptions are included in Appendix 6.

Sludge Generation Rate

The rates of sludge generation associated with the Blackjack and Bluebird Mine pipeline discharges were estimated using the USGS PHREEQC modeling program. PHREEQC is a computer program that is designed to perform a wide variety of aqueous geochemical calculations. This model utilizes chemical equilibrium relationships together with site-specific data including flow rate, pH, and results of chemical analyses to estimate the rate of sludge generation on a mass per time basis. The bulk density of the sludge was then used to estimate the volumetric generation rate. All of the modeled sludge generation was assumed by the model to precipitate as ferric hydroxide ($Fe(OH)_3$).

Results of the PHREEQC modeling provide minimum and maximum estimates of sludge generation on a mass basis (Table 5). These estimates were converted to volumetric rates (cubic yards per year) based on measured density of existing sludge. Details regarding this estimation process are included in Appendix 6. Actual sludge generation may vary day-to-day due to changes in adit discharge flow rate and/or chemistry.

As detailed in Appendix 6, the volumetric sludge generation rates provided above are likely to be lower than actual sludge generation volumes due to the poorly consolidated nature of the precipitated metals. These values are also impacted by day-to-day variations in adit discharge flow and chemistry. Given the current estimated volume of sludge accumulated in the settling ponds at the mines, a total of approximately 785 cubic yards, and an assumed historic cumulative discharge to the settling ponds of approximately 20 years leads to an estimated annual generation rate of 39.2 cubic yards per year. The actual sludge generation rate is expected to vary within a range of approximately 10 to 45 cubic yards per year.

Sludge Management

Sludge management is expected to involve measures designed to dewater the sludge following removal, such as polymer addition and use of Geotubes. These measures are expected to increase the solids content of the sludge up to 35% compared with the current precipitated sludge in the ponds. Although the above range of sludge generation rates leads to a volume of up to approximately 785 cubic yards of sludge over a 20-year operational interval, actual disposal volumes following dewatering are expected to be on the order of 275 cubic yards per 20-year operational interval.

2.2 Risk Assessment

Mining activities at the Sites have been impacting the land since the early 1900s. Human and ecological receptors near the Sites may be exposed to contaminants via mine waste sources (e.g., waste rock, mine water discharge). The area is used for recreation, fishing, and logging, and generated mine waste has contributed to metals in soils. The area also provides habitat to ecological receptors. Groundwater sampling was not conducted as part of this investigation. Groundwater is not used for drinking water at the Sites and future use as a drinking source is not anticipated because the USFS does not allow use of unpermitted wells.

This section describes:

- Conceptual Site Model;
- Screening level human health risk assessment;
- Streamlined ecological risk assessment; and
- Quantitative human health risk assessments conducted for the Sites and establishes the potential magnitude of risk to human health receptors.

2.2.1 Conceptual Site Model

The Conceptual Site Model (CSM) provides a framework for assessing risk by identifying the contaminant sources, transport mechanisms, and potential exposure pathways, exposure routes, and receptors. The CSM identifies:

- The environmental setting and contaminants known or suspected to exist at the Sites;
- Contaminant fate and transport mechanisms that may exist at the Sites;
- Mechanisms of toxicity associated with contaminants and potential receptors;
- Complete exposure pathways that may exist at the Sites; and
- Potentially exposed populations.

A CSM developed for both the human health and ecological receptors at the Sites is shown on Sheets 10 and 11, respectively. The CSM is based on existing data and the current and likely future conditions at the Sites.

2.2.2 Screening Level Human Health Risk Assessment

This section presents the rationale for the selection of the contaminants of potential concern (COPCs) for the Blackjack and Bluebird Mines and is also presented in more detail in Appendix 7. The selection of COPCs was conducted in accordance with the Oregon Department of Environmental Quality (ODEQ) Human Health Risk Assessment Guidance (ODEQ, 2010) and USEPA risk assessment guidance (USEPA, 1989).

Data Sets

The soil data collected by AI (2019) were used to select soil COPCs for the Blackjack and Bluebird Mine sites. The Sites were evaluated separately due to the geographical distance between the two. It should be noted that only waste rock samples were collected in 2019, not soil samples. For the purpose of this assessment the waste rock samples were evaluated as soil samples. However, human receptors may or may not be exposed to waste rock in the same manner that they are exposed to soil.

The results from surface water and sediment samples collected by TetraTech (2018) for Clear Creek and the sediment samples collected by E&E (2017) for Clear Creek were used to select

COPCs for those media. The surface water samples were analyzed for both total and dissolved metals, however, only total metals results were evaluated in the COPC screen because these are more representative of what human receptors would contact while swimming or wading. Adit water samples were not evaluated because humans would not be exposed to these media while swimming or wading. Background samples were collected and analyzed for each media in all of the data sets used.

COPC Selection Process

Comparison to Risk-Based Screening Levels

The waste rock/soil, surface water and sediment samples were analyzed for all Target Analyte List metals. In accordance with the ODEQ and EPA guidance, the screening process begins with a comparison to a risk-based screening level (RBSL). An RBSL is a concentration of a chemical in a medium that is believed to pose negligible health risk to a specified population of human receptors. For carcinogens, this is an exposure point concentration (EPC) that corresponds to a lifetime cancer risk of 1 in a million or 10^{-6}. For non-carcinogens, this is an EPC that corresponds to a Hazard Quotient (HQ) of 1.

For this initial screening assessment, RBSLs for use in the COPC selection protocol were derived from EPA's Regional Screening Level (RSL) table (EPA, 2019), using values that are protective of occupational workers. The ODEQ guidance recommends for screening purpose, the EPC is the maximum contaminant concentration to be compared to the RBSL. If the maximum detected concentration does not exceed the RBSL, it may be concluded that the chemical does not pose a significant risk to humans and is not a COPC. If the maximum detected concentration for the contaminant does exceed the RBSL, the ODEQ recommends that the 90% Upper Confidence Limit on the Arithmetic Mean (UCLM) be calculated as the EPC for the contaminant to be compared to the RBSL. If the 90% UCLM exceeds the RBSL, then the contaminant is retained and further evaluated as a beneficial mineral and/or compared to background concentrations before determining whether it is a COPC.

In addition to the potential risk posed by an individual analyte, any screening must take into consideration the risk posed by multiple analytes simultaneously within a given media. It is possible a few analytes that would be screened out with concentrations just below an RSL of 1 could exceed a cumulative Hazard Index of 1. For this reason, an additional condition is used to screen non-carcinogens. A non-carcinogenic chemical is screened in if:

$$C/RSL > 0.1 \quad \text{and} \quad SUM(C/RSL) > 1$$

For carcinogens, individual RBSLs are based on an excess lifetime cancer risk of 10^{-6}. It is highly unlikely that chemicals would exceed ODEQ's cumulative standard of 10^{-5} with all concentrations below their RBSLs. Therefore, ODEQ does not require a cumulative risk screen for carcinogens that are below RBSLs.

Essential Nutrients

According to the USEPA, chemicals that are essential human nutrients, are present at low concentrations, and are toxic only at high doses may be screened out (USEPA, 1989). Examples of essential nutrients that may qualify are calcium, iron, magnesium, potassium and sodium.

Comparison to Background

Analytes which exceed their respective RBSLs and are not essential nutrients are further evaluated by comparing the EPCs to background levels. Each of the data sets evaluated for waste rock/soil, surface water and sediment included background or reference samples. Due to the small number of background samples collected, a Background Threshold Value (BTV) was calculated and compared to the maximum contaminant concentration or the 90% UCLM (when an adequate number of samples were available to estimate a 90% UCLM). The BTV value was calculated using ProUCL 5.1 (USEPA, 2016) and using the 95% upper tolerance limit based on the appropriate distribution of the data.

Results of the Initial COPC Selection Process

The results of the COPC selection process are shown in Tables 1 and 2 (waste rock/soil), Table 3 (surface water) and Table 4 (sediment). These tables are located in Appendix 7. The following COPCs were identified for the Blackjack and Bluebird Mine Sites:

- Waste rock/soil for Blackjack Mine: manganese and cobalt;
- Waste rock/soil for Bluebird Mine: arsenic;
- Surface Water for Clear Creek: none; and
- Sediment for Clear Creek: none.

Secondary Screening – Comparison to BLM Site-Specific Screening Levels

An additional step suggested in the EE/CA workplan was to also screen the analytes against the BLM Screening Levels for recreational users provided in the BLM Technical Memorandum *Screening Assessment Approaches for Metals in Soils at BLM HazMat/AML Sites* (2017). Since these values are less conservative than the occupational values used above it is not necessary to re-screen all analytes. Only the analytes which were identified as COPCs from the occupational screen were evaluated against the BLM recreational screening levels. The BLM recreational screening levels assume that a person will visit the site 14 days/year for 26 years as both a child and an adult. When the COPCs identified in the occupational screen are compared to the BLM values, the contaminants in waste rock/ soils are above the BLM value divided by 10 (in accordance with Oregon DEQ risk assessment guidance) and remain as COPCs. The following COPCs were identified for the Blackjack and Bluebird Mine sites (Table 5 located in Appendix 7) and should be evaluated further in a site-specific quantitative human health risk assessment.

- Waste rock/soil for Blackjack Mine: manganese and cobalt;

- Waste rock/soil for Bluebird Mine: arsenic;
- Surface Water for Clear Creek: none; and
- Sediment for Clear Creek: none.

2.2.3 Quantitative Human Health Risk Assessment

This section presents the rationale and results of the quantitative human health risk assessment conducted at Blackjack and Bluebird Mines, with the full report presented in Appendix 7.

Data Sets

Quantification of exposure and risk to human receptors from COPCs was performed after the collection of additional soil samples in the summer of 2020. At this time, AI collected 5 additional soil samples from the Bluebird site and 5 additional soil samples from the Blackjack site to resolve issues pertaining to data gaps. Each site was divided into 5 sampling unit (SU) areas and 10-20 composite samples were collected in a grid pattern from each of the SU areas. The soil samples were sieved to less than 250 microns and analyzed by ICP-AES (Method 6010) for Target Analyte List Metals. Because the 2019 samples were grab samples collected from waste rock and the 2020 samples were composite soil samples (which are more representative of human exposures) the two data sets were evaluated separately. Separate EPCs, exposure and risk were calculated for the waste rock samples and for the composite soil samples in the risk assessment.

Quantification of Exposure

Exposure pathways considered in the quantitative human health risk assessment were ingestion and inhalation, with an assumption of the same individual being exposed from childhood through adulthood and exposure calculated as the time-weighted average lifetime exposure for non-cancer and cancer risks as recommended in USEPA guidance (1989). Recreational visitors (both adults and children) were considered as receptors in the selection of exposure parameters, with exposure assumptions based on EPA's Standard Default Exposure Assumptions with the exception of exposure frequencies, which are based on BLM's recommended screening exposure of 14 days/year for recreational visitors. Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) parameters used in the quantitative human health risk assessment are shown in Table 6, located in Appendix 7. Each mine site was considered one exposure area (or decision unit) in the quantitative human health risk assessment, with exposures and risks calculated separately at each site. Exposure point concentrations (EPCs) were calculated as 90% of the Chebyshev upper confidence limit (UCL); outputs are shown in Table 7, Appendix 7. Site-specific bioavailability data was not collected at either site; therefore, the quantitative human health risk assessment used default bioavailability values of 60% for arsenic in soil (USEPA 2012) and 100% for all other analytes.

Toxicity Assessment

Non-cancer effects and cancer effects were evaluated in the quantitative human health risk assessment. Non-cancer effects were evaluated from Reference Dose (RfD) for oral exposure or Reference Concentration (RfC) for inhalation exposure. The RfD and RfC are estimates derived from a "No-observed-adverse-effect-level" (NOAEL) or a "Lowest-observed adverse-effect-level" (LOAEL) if a reliable NOAEL is not available; an uncertainty factor may be applied if data are limited. RfD and RfCs used to estimate non-cancer effects in this risk assessment are shown in Table 8 of Appendix 7. Cancer risks were evaluated from Slope Factors (SFs) for ingestion and Unit Risk (UR) for inhalation; the SFs and URs used in this assessment are shown in Table 8, Appendix 7.

Risk Characterization Approach

The potential for non-cancer effects is evaluated by comparing the estimated exposure concentration for a receptor over a specified time period to a reference threshold that represents the exposure below which it is unlikely for even sensitive populations to experience adverse health effects (USEPA, 1989). This ratio of exposure to toxicity is called a Hazard Quotient (HQ). When a receptor is exposed to a COPC by more than one route, or is exposed to more than one COPC, these values may be summed to yield a hazard Index (HI). If the HQ or HI value is equal to or less than one, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ or HI exceeds one, there is some possibility that non-cancer effects may occur, although an HQ or HI above one does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all toxicity values. However, the larger the HQ or HI value, the more likely it is that an adverse effect may occur. The ODEQ Human Health Risk Assessment Guidance (ODEQ, 2010) recommends an acceptable non-cancer HQ and HI of 1.0.

The excess risk of cancer from exposure to a chemical is described in terms of the probability that an exposed individual will develop cancer because of that exposure. Excess cancer risks are summed across all carcinogenic chemicals and all exposure pathways that contribute to exposure of an individual in a given population. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, the EPA considers excess cancer risks that are below 1E-06 to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (EPA, 1991b), although this is evaluated on a case by case basis, and the stakeholders may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action. The ODEQ Human Health Risk Assessment Guidance (ODEQ, 2010) recommends that individual cancer risks below 1E-6 and cumulative cancer risks below 1E-05 are acceptable.

Results

The following is a summary of the risk calculations is presented in Tables 9 and 10 of Appendix 7.

Quantitative human health risk assessment results from soil data for a recreational visitor indicate the following:

- Non-cancer risks for the recreational visitor from the ingestion of soil and inhalation of soil particulates were well below a HI of 1.0 for both the RME and CTE exposure scenarios for both the Bluebird and Blackjack Mine Sites;
- The RME and CTE cancer risks for all exposure pathways and COPCs at the Bluebird and Blackjack Mine Sites were below or within EPA's acceptable risk range of 1E-06 to 1E-04. The cumulative cancer risks were also below ODEQ's acceptable risk management criteria of 1E-05;
- At Bluebird Mine, the RME cancer risk was 3E-06. The CTE cancer risk was 2E-07; and
- At Blackjack Mine, the RME cancer risk was 2E-11. The CTE cancer risk was 4E-12.

Quantitative human health risk assessment results from waste rock data for a recreational visitor indicate the following:

- Non-cancer risks to the recreational visitor from the ingestion of waste rock and inhalation of particulates for all COPCs were also well below an HI of 1 for both the RME and CTE exposure scenarios for both the Bluebird and Blackjack Mine Sites;
- The RME and CTE cancer risks for all exposure pathways and COPCs at the Bluebird and Blackjack Mine Sites were below or within EPA's acceptable risk range of 1E-06 to 1E-04. The cumulative cancer risks were also below ODEQ's acceptable risk management criteria of 1E-05;
- At Bluebird Mine, the RME cancer risk was 5E-06. The CTE cancer risk was 3E-07; and
- At Blackjack Mine, the RME cancer risk was 7E-11. The CTE cancer risk was 2E-11.

Uncertainties

The following uncertainties were identified in the quantitative human health risk assessment and are described in more detail in Appendix 7:

- Uncertainties from exposure pathways not evaluated;
- Uncertainties from chemicals not evaluated;
- Uncertainties in exposure point concentrations;
- Uncertainties in human exposure parameters;
- Uncertainties in chemical absorption;
- Uncertainties in toxicity values; and
- Uncertainties in risk estimates.

2.2.4 Ecological Risk Assessment

A Screening Level Ecological Risk Assessment (SLERA) was prepared for the Sites and is included in Appendix 8. Potential risk to ecological receptors may exist at the Sites from exposure to mine waste, mine water discharge, sludge and soil. It is important to understand the habitat characteristics at the Sites to identify ecological receptors and exposure pathways that should be evaluated in the SLERA. Those areas of the Sites that do not support habitat (e.g., bare waste rock, bare soil, gravel, or otherwise disturbed areas) or that do not have complete exposure pathways to ecological receptors are eliminated from further assessment in ecological risk assessment process (EPA, 2015).

In 2014, Oregon DEQ convened the Ecological Risk Assessment Technical Workgroup to provide input aimed at improving the ecological risk assessment process in Oregon. The final recommendations of this workgroup are provided in the May 2017 *Ecological Risk Assessment Technical Workgroup Recommendation Report*. The workgroup recommended terrestrial habitat be excluded from further ecological risk assessment where the local land use designation does not require conservation, or the habitat is smaller than 0.5-acre. Neither the land use nor habitat size exclusion applies where threatened and endangered species or critical habitat are potentially present on-site. Similarly, the DEQ Level I Scoping is intended to identify sites that are obviously devoid of ecological important species or habitats and/or where exposure pathways are obviously incomplete. Because the habitat at the Sites is not smaller than 0.5 acres, and the region provides critical habitat for spotted owl, terrestrial habitat at the Sites cannot be excluded from ecological risk assessment on the basis of the Oregon DEQ criteria.

Per the U.S. EPA Region 6 *Ecological Exclusion Criteria Worksheet*, general information about the site, its physical characteristics, ecological habitats and receptors, can be used to identify incomplete or insignificant exposure pathways, thus eliminating the need for further ecological evaluation at these areas (EPA, 2015). According to the worksheet, property “wholly contained within contiguous land characterized by pavement, buildings, landscaped area, functioning cap, roadways, equipment storage area, manufacturing or process area, or other surface cover or structure, or otherwise disturbed ground” meets the exclusion criteria. Areas that are bare soil or tailings meet these criteria and are also “not attractive to wildlife or livestock, including threatened or endangered species; these areas do not serve as valuable habitat, foraging area, or refuge for ecological communities” (EPA, 2015).

Based on these exclusion criteria, areas of disturbed ground including waste rock can be excluded from further ecological evaluation. Any exposure experienced by wildlife on these highly disturbed areas would most likely be incidental and brief and would likely occur while animals are passing through to access other areas that provide more suitable habitat for foraging, breeding, or refuge. BLM (2016) suggests the ecological screening step is dependent on various qualitative endpoints, such as habitat, availability of food and shelter, and general ecological “attractiveness” of the site and proximity to waterways. BLM AML sites that consist of tailings or waste rock piles provide little or no functional habitat for ecological receptors (BLM, 2016). The mine features at the Sites (waste rock) do not provide habitat for ecological receptors and were therefore excluded from further ecological evaluation.

The purpose of this SLERA is to summarize the information available for the Sites from earlier studies, and to evaluate whether exposures to site-related contaminants in terrestrial and aquatic environments have the potential to result in adverse effects to plant and animal populations (i.e., ecological receptors) at the Sites. Chemicals that were retained as COPECs for each exposure area are summarized in Appendix 8.

Mining-related metals that have the potential to adversely impact ecological receptors were identified for soil/waste rock, but only at the Bluebird Mine, where arsenic, mercury, and iron were identified as COPECs. Eight metals were identified as COPECs in Clear Creek sediment; however, for most constituents, upstream sediment concentrations were similar to those for samples collected adjacent to the Sites, most likely indicating upstream mining influences. Manganese in surface water was retained as a COPEC for cumulative risk to aquatic receptors; however, the upstream exposure concentration for manganese is identical to the site concentration. Only one constituent, aluminum, was identified as a COPEC for wildlife exposure to the Blackjack outfall as a drinking water source, based on cumulative risk. Iron was retained as COPEC because there is no wildlife drinking water SLV for iron.

Protected species were identified for Clear Creek including bull trout, westslope cutthroat trout, interior redband trout, and the Columbia spotted frog. The Columbia spotted frog, westslope cutthroat trout, and possibly the redband trout have been observed in the vicinity of the Sites. Protection of these species and their habitats should be considered when developing remedial alternatives that might affect Clear Creek. Data collected on the benthic macroinvertebrate and fish communities in Clear Creek showed no site influences on these populations.

Plant tissue data showed most metals concentrations were within the range of background concentrations and leach test samples from waste rock indicated low potential for contaminant release and low potential for bioavailability.

Data are adequate to support this screening-level risk assessment. The most significant exposure pathways are direct contact to/uptake of metals in soil by plants and terrestrial invertebrates, and benthic invertebrate exposure to Clear Creek sediment. Limited exposure due to habitat constraints reduces the likelihood of population-level effects from exposure to metals in soil at the Sites; risks are more probable for individual receptor organisms. Upstream sediment concentrations were similar to concentrations from samples collected adjacent to the Sites. Risks cannot be concluded to be negligible, but it is likely that risks to ecological receptors are low from exposure to metals at the Sites. Any remediation that might occur to mitigate site concerns will also reduce exposure and risk to ecological receptors, if care is taken to not further damage habitat while carrying out remedial actions. Therefore, it is our recommendation that no further investigation is required for the Bluebird and Blackjack Mines to draw conclusions regarding ecological risk.

3. SITE CLEANUP CRITERIA

ARARs are "applicable" or "relevant and appropriate" federal and state environmental requirements used to:

1. Evaluate the extent of site cleanup needed;
2. Scope and develop removal action alternatives; and
3. Guide the implementation and operation of the preferred alternative(s).

Applicable requirements include cleanup standards and other substantive requirements, criteria, or limitations promulgated under federal or state laws that apply to hazardous substances and removal actions at the Sites. Relevant and appropriate requirements are not applicable to the Sites but may be suitable for use because they address issues or problems sufficiently similar to those present at the Sites. In addition to ARARs, federal and state environmental and public health guidance and proposed standards that are not legally binding but may prove useful are "to be considered" standards. The ARARs for the Sites are discussed below and summarized in Appendix 9.

The NCP (40CFR 300.415(j)) establishes that a removal action shall "to the extent practical, considering the exigencies of the situation, attain ARARs under federal environmental or state environmental facility siting laws." To determine whether compliance with ARARs is practicable, two factors are specified in 40 CFR 415(j):

- Urgency; and
- Scope of the removal action.
  - The scope of the removal action is often directed at minimizing and mitigating a potential hazard rather than totally eliminating the hazard; even though a particular standard may be an ARAR for a particular medium, it may be outside the scope of the immediate problem the removal action is addressing.

The ARARs were used to determine the design specifications and performance standards for the project. They are grouped as federal or State of Oregon ARARs, and are identified by a statutory or regulatory citation, followed by a brief explanation of the ARAR, and whether the ARAR is applicable, or relevant and appropriate (see Appendix 9).

- Administrative requirements are not ARARs and thus do not apply to actions conducted entirely onsite. Administrative requirements are those that involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement.
- The CERCLA program has its own set of administrative procedures, which assure proper implementation of CERCLA. The preamble to the final NCP states that the application of additional or conflicting administrative requirements could result in delay or confusion.
- Provisions of statutes or regulations that contain general goals that merely express legislative intent about desired outcomes or conditions, but are non-binding, are not

ARARs. In accordance with Section 121(e) of CERCLA, no permits are required for removal actions conducted onsite.

3.1 Soil Standards

The potential soil ARARs are based on Oregon state and federal standards for the protection of human health and are summarized in Appendix 7 and 8. Based on analytical results of surface soil/mine waste samples collected during the previous SI and data gaps investigation, and results of the quantitative HHRA no COPCs exceed soil ARARs:

3.2 Water Standards

The potential water ARARs are based on Oregon state standards and federal standards for the protection of human health and the environment and are summarized in Appendix 7 and 8. Based on analytical results of surface water and sediment for Clear Creek no COPCs were identified as part of the Human Health Risk Assessment (Appendix 7).

4. IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

This section discusses the goals and objectives of a CERCLA non-time critical removal action at the Blackjack and Bluebird Mine Sites. The general goal of a removal action is to protect human health and the environment by preventing or minimizing the potential release of a hazardous substance and reducing the potential for direct contact and transport of contaminants to the environment.

Before developing treatment alternatives, removal action objectives (RAOs) were established based on the contaminants and media of interest, exposure pathways, and preliminary removal goals for the sites. Based on results of previous site investigations and data collected as part of this EE/CA, the following are of primary concern at the Sites:

Blackjack Mine

- Reduce O&M costs for operation of the existing mine water discharge pipeline;
- Identify long-term disposal options for iron-hydroxide sludge in the settling ponds;
- Evaluate natural treatment system options to improve water quality of mine water discharge; and
- Evaluate feasibility of reducing mine water discharge.

Bluebird Mine

- Reduce O&M costs for operation of the existing mine water discharge pipeline;
- Identify long-term disposal options for iron-hydroxide sludge in the settling ponds; and
- Evaluate natural treatment system options to improve water quality of mine water discharge.

Human health exposure pathways that have been identified and include dermal contact with contaminated materials, inhalation of airborne contaminants in windblown mine waste, and ingestion of contaminated soil, water and fish. The environmental pathways by which COCs in the mine waste or contaminated soil mobilize and migrate into the environment include:

- Overland flow (run-off) across the mine waste during precipitation events and snowmelt;
- Percolation through the mine waste and leaching of COCs into baseflow;
- Erosion during flooding or high precipitation events; and
- Wind transport and dispersion of mine waste.

The RAOs are aimed at protecting human health and the environment based upon chemical-specific ARARs (if available), site-specific risk-related factors (such as exposure to chemicals), and other available information. The objectives allow for a range of treatment and (or) containment alternatives to be developed. The non-time-critical human health related RAO established for both Sites include the elimination or reduction of the potential risk to human health and the environment from mine water discharge.

4.1 Removal Action Scope

The scope of removal actions evaluated in this EE/CA focus on:

1. Reducing O&M costs for operation of the existing mine water discharge pipeline;
2. Identifying long-term disposal options for iron-hydroxide sludge in the settling ponds;
3. Evaluating natural systems treatment options to improve water quality of mine water discharge; and
4. Evaluating the feasibility of reducing or terminating mine water discharge.

5. IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The selection of removal action alternatives is a tiered process involving (1) identifying and screening general removal technologies and processes applicable to the Sites, and (2) developing potential removal action alternatives capable of achieving the RAOs. The purpose of screening is to eliminate those technologies or processes that are not feasible and/or do not meet ARARs, while retaining potentially effective options for more detailed analysis. Typically, the proposed alternatives will consist of a combination of one or more of the retained removal actions and technologies.

Removal technologies and processes were identified and evaluated for the existing mine water collection pipelines, sludge settling/treatment ponds and potential underground adit plug to reduce discharge of iron-rich mine waters. No remedial evaluation was conducted for mine waste rock as no significant exceedances were identified. In addition, no alternatives were considered to treat discharge from the Red Boy Mine as it is located entirely on private property.

The following sections discuss the identification and screening of potential removal technologies, and the development of potential removal alternatives.

5.1 Identification and Screening of Removal Action Options and Alternatives

Potential general removal technologies and processes were identified from a review of technical literature and previous experience at similar sites. The general removal action categories include:

- **No Action** that involves leaving both Sites as is. The No Action alternative is used as a baseline to compare with the various alternatives;
- **Institutional Controls** that minimize or prevents public exposure by limiting access;
- **Engineering Controls (including disposal options)** that minimize uncontrolled migration and exposure to the environment or human contact; and
- **Treatment** that separates contaminants from the soil and waste material.

Within each of these categories, there are several potential removal technologies to be considered. During this initial screening step, the removal actions and potential technologies were evaluated based on the following criteria:

- Effectiveness;
- Compliance with ARARs;
- Implementability; and
- Cost.

Based on the screening results, each technology was either eliminated or retained for further consideration in the development of potential removal alternatives (see Table 6).

Available site information regarding contaminant types and concentrations, and on-site physical characteristics, was used in the screening process. Two factors that commonly influence technology screening are: (1) the presence or concentration and types of contaminants that limit the applicability of many types of treatment processes; and (2) site conditions that limit the ability to install or deploy certain technologies. Major site limitations often include limited area, steep topography, remoteness, absence of electrical power, and lack of adequate cover/growth media for reclamation.

The general removal action alternatives are discussed in the following sections and Table 7.

5.1.1 No Action

No action consists of leaving both Sites as is. This removal technology is **retained**, as required for consideration by the NCP, and serves as a baseline for comparison with other removal actions.

5.1.2 Institutional Controls

Institutional controls are administrative and/or legal controls that help minimize risk and/or protect the integrity of a remedy by limiting future land use or preventing access to the Sites. Examples include deed restrictions to prohibit residential use of the Sites and fencing and warning signs to discourage access to the Sites. While such controls may not effectively achieve cleanup goals, they are often used to augment other removal alternatives. Therefore, institutional controls are ***retained*** for combination with other technologies, but are ***not retained*** as a stand-alone alternative.

5.1.3 Engineering Controls

Engineering controls are engineered measures designed to minimize the potential for human exposure to contamination by either limiting direct contact with contaminated areas or controlling migration of contaminants to and through environmental media. Engineering controls can consist of pipelines, sludge settling ponds, containment (repository disposal), surface (erosion) control and source termination (adit plugs). Containment may be on-site or off-site.

The following Engineering Controls are ***retained*** for further analysis.

<u>Pipelines</u>
Pipelines are used to transport water and waste material over significant distances and can be placed under roads or streams. Various materials and diameters can be used depending on flow rates and waste properties. Pipelines typically include valves to control flow and multiple cleanouts to facilitate cleaning and removal of any precipitates or sludge buildup that can block the pipeline. Sufficient elevation drop is required when transporting suspended solids to reduce buildup within flat areas or low spots in the pipeline.

Sludge Settling Ponds

Ponds can be engineered to facilitate the settling of sludges and suspended particles from water. Settling pond design features include size, dimensions, and retention time to ensure sufficient residence time for settling of particles. The ponds should also be designed to be easily maintained and facilitate removal of sludge from the pond bottom. The ponds can be lined or unlined.

Containment

Containment controls are intended to eliminate direct contact and fugitive emissions from contaminated materials by placing a cover over the material. Containment is a presumptive remedy that is applicable to the Sites. The cover can also be designed to minimize infiltration of precipitation and surface water through the waste material, thereby reducing contaminant leaching. Covering waste material in-place can be a viable alternative when excavation and treatment or disposal costs are prohibitive. However, covering waste in place usually requires capping large areas, particularly at locations where waste deposits are relatively shallow. Cover systems may also be employed to cap waste that has been consolidated or placed in a repository. Success of a cover system will depend on several factors such as the relative toxicity and mobility of contaminants in the waste, ability to establish a vegetative cover, amount of available soil, and surface water controls.

The cover design is a function of the level of hazard posed by the contaminated material, future land uses, and site-specific factors. Potential cover systems range from a simple soil cover to an engineered RCRA hazardous waste cap and liner. A variety of cover materials are available and include materials ranging from natural soils to synthetic materials. These include:

- Soil covers with vegetation;
- Synthetic cover systems with soil and vegetation; and
- Clay covers with soil and vegetation.

Surface Controls

Surface controls are used to minimize contaminant migration resulting from surface water and wind erosion. Typical controls include consolidation, grading, surface water containment or diversion, erosion protection, and revegetation. These controls alone will not eliminate direct contact with the contaminated material, so they are usually used to augment other technologies such as containment. Surface controls are usually incorporated into all reclamation designs.

Source Termination

Often contaminants become such only when they escape their source or containment. Remediation consists of terminating this release. This can take the form of capping a ruptured pipe, preventing mixing of incompatible materials, or stopping an adit discharge. A frequently proposed method of terminating mine water discharge is to install a concrete plug within an underground adit. This approach can be viable but requires that: 1) No other linked underground workings daylight, 2) The rock is not highly porous or permeable, and 3) a plug can be installed at a location where the hydrostatic head will not exceed the lithostatic load. Mine plugs can often shift the point of water discharge to other features/locations and not actually solve the problem. In addition, the unknown subsurface conditions and high cost of working underground makes this technology one of the most expensive remedial options.

5.1.3.1 On-Site Disposal

On-site disposal consists of excavating, consolidating, and placing the untreated waste materials and debris in an engineered on-site repository. This applies to Bevill-exempt solid wastes from the processing of ores and minerals. Mine process reagents or other materials that are not Bevill-exempt may require disposal in a RCRA hazardous waste repository, if they fail to meet TCLP criteria.

The disposal area design is dependent on such things as available space for construction, toxicity, mobility, and type of waste. The design could range from simply consolidating the materials in an existing waste area to a fully encapsulated repository with a leachate collection system. The latter would likely be required if on-site disposal is selected for waste material that fails RCRA TCLP criteria. Consolidation of material from both Sites in a single repository is preferable. An unlined repository is envisioned for this alternative if only waste material and sludge from the on-site settling ponds are included (i.e., does not fail TCLP standards). Capping alternatives for the repository were discussed above under containment.

On-site disposal can be a permanent source control measure that effectively eliminates direct contact with the contaminated material and minimizes contaminant migration. However, depending on the level of design required, costs can be high.

5.1.3.2 Off-Site Disposal

Off-site disposal involves excavating/pumping the waste materials and sludge for transport to an off-site disposal facility permitted to accept such materials. Off-site disposal options include a nearby, permitted solid-waste, Subpart D landfill or a distant RCRA Subpart C permitted facility. Non-Bevill exempt hazardous materials would require disposal in a RCRA Subpart C hazardous waste facility. Less toxic materials could be disposed of in a permitted solid waste Subpart D landfill. However, many Subpart D landfills will not accept mining waste.

5.1.4 Treatment

Many treatment technologies and process options are available and applicable for mine waste; however, most are not considered feasible for remote abandoned mine sites because of high O&M costs or unproven technologies. Treatment can include many forms such as in-situ destruction, vitrification, chemical immobilization (i.e., phosphate addition to fixate metals in-situ), natural treatment systems (e.g., wetlands and phytoremediation). Constructed wetlands are useful as a lower maintenance natural system treatment approach, if the proper conditions exist. Wetlands can provide additional filtration, aeration, and help to promote iron-based sludge production. Additional treatment technologies can also include physical filtration and dewatering of sludge through the use of suction pumps and Geotubes. These low technology filtration systems can be easily customized to a variety of site conditions and sludge volumes. Geotubes are well suited to sites that only require periodic filtration of material. Treatment is ***retained*** for further analysis.

5.2 Components of the Removal Action Scope

Specific removal actions are required to achieve the RAOs described in Section 4. Technologies described and retained above (Section 5.1) include: institutional controls (fencing, signs and land use restrictions); engineering controls (pipeline upgrades, improvements to sludge settling ponds, source termination), consolidation of mine water sludge in an on-site engineered repository, or off-site disposal; and treatment (wetlands, Geotubes). These technologies have been assembled into specific alternatives for comparative analysis and estimation of costs.

Nine potential removal action alternatives to manage mine wastes were developed from the general removal technologies retained from the preliminary screening process. The original project proposal suggested ten potential alternatives, but one alternative was eliminated after further evaluation indicated it was not physically feasible. The listed alternatives are not alternatives in the normal EE/CA format that requires that a specific alternative be selected. The alternatives herein should be viewed as independent “tools” that can be selected in combination. Also, within each alternative are individual tasks which are also tools that can be incorporated into other alternatives. These tasks are more clearly defined in the costing spreadsheets in Appendix 11.

These alternatives are described as follows:

- **Alternative 1 – No Action:** No removal actions would be performed, and the Sites would remain as is. This alternative provides a basis for alternatives cost comparisons.
- **Alternative 2 – Remove Sludge to an On-Site Repository:** A repository will be constructed at a selected site on USFS property. The sludge from the existing Bluebird and Blackjack settlement and treatment ponds will be pumped into Geotubes mounted in tilt-bed trailers where it will consolidate from an in-place density of approximately 12% to approximately 35%. Discharge water from the Geotubes will be returned to the source pond. When filled, the Geotubes will be transported to the repository and dumped in an organized fashion to facilitate capping and minimize repository size. When completed the repository will be capped with a 2-3-foot-thick soil cover and revegetated. The repository will be surrounded with an 8-ft-high fence to exclude large animals. The repository location is illustrated on Sheets 2 & 13. The pumping/dewatering system is illustrated in Sheet 12.
- **Alternative 3 – Remove Sludge for Off-Site Disposal:** The sludge from the existing Bluebird and Blackjack settlement and treatment ponds will be pumped into Geotubes mounted in tilt-bed trailers and dump trucks where it will consolidate from an in-place density of approximately 12% to approximately 35%. Discharge water from the Geotubes will be returned to the source pond. All Geotubes will be transported to the Baker City

Sanitary Landfill, a distance of 60 miles. No sludge samples fail TCLP and samples collected during the 2020 Data Gap Investigation indicated the material would not fail the Paint Filter tests.

- **Alternative 4 – Upgrade Existing Sludge Ponds at Blackjack Mine:** The existing sludge settling ponds are awkward for sludge removal and contain a significant amount of wood debris and vegetation mats, all of which make sludge removal relatively difficult and expensive. This alternative proposes that all vegetation debris be removed and disposed on-site in a small repository or in the Bluebird Mine north treatment pond. The ponds would be re-contoured for greater volume and easier maintenance. The existing dams will be replaced with a more durable and less permeable design. Final depth of the settling ponds will be limited to 3-feet for safety (see Sheet 15). Road construction is not necessary. This alternative also incorporates relocation of the current discharge pipeline in the valley by moving the outfall farther downstream as illustrated on Sheet 20. Using disposal in the Bluebird north treatment pond is less costly than repository construction. To enhance settlement a polylog box is recommend for installation at the pipeline outfall (Sheet 23).
- **Alternative 5 – Upgrade Existing Sludge Ponds at Bluebird Mine:** The existing sludge ponds are awkward for sludge removal and contain a significant amount of wood debris and vegetation mats, all of which make sludge removal relatively difficult and expensive. This alternative proposes that all vegetation debris be removed and disposed on-site in a small repository or in the Bluebird Mine north treatment pond. The ponds would be re-contoured for greater volume and easier maintenance. The existing dam at the north end of the Bluebird north treatment pond will be replaced with a taller, more durable, and less permeable design for added surge capacity. Final depth of the upgraded sludge settlement pond will be limited to 3-feet for safety. Road construction to provide better pond access will be required. See Sheet 16. To enhance settlement a polylog box is recommend for installation at the pipeline outfall (Sheet 16).
- **Alternative 6 – Construct New Wetland Treatment Areas at Blackjack Mine:** The existing ponds at the Blackjack Mine are inefficient, the base exhibits flat areas that fill quickly, the overflow water discharges directly to Clear Creek, the sludge is unsightly to the public and could erode into Clear Creek, the existing pipeline is flat in the valley bottom and prone to plugging. This alternative includes construction of a new system west of Clear Creek that eliminates these issues (Sheet 17). A new pipeline and access road will allow the pipeline to exhibit a continual grade that does not pass under Clear Creek. The treatment system will consist of the following path: 1) the discharge enters a settlement basin design for easy sludge maintenance, 2) Water exiting the prior pond will pass through an alkylation system to raise pH and accelerate iron oxidation. 3) This treated water then enters another settlement basin designed for easy maintenance. Water exits the prior basin into an engineered wetland for final treatment. The wetland also acts as an infiltration basin; there will be no surface discharge to Clear Creek. The old pipeline will remain in place for emergency use. A polylog box at the pipe discharge to add flocculant for enhanced settling is recommended . The lower adit dams are also leaking, too tall (4-feet high) for safe maintenance, and do not have an overflow drain or sludge

removal drain. This alternative includes replacing these dams with the design illustrated in Sheet 20.

- **Alternative 7 – Construct New Wetland Treatment Areas at Bluebird:** The existing sludge settling ponds at the Bluebird Mine are inefficient, the sludge is unsightly to the public, and pH remains acidic throughout the system. This alternative involves construction of a new wetland in the same location that eliminates or at least minimizes these issues (See Sheet 18). The treatment system will consist of the following path: 1) the discharge enters a settlement basin designed for easy sludge maintenance, 2) Water exiting the prior pond will pass through an alkylation system to raise pH and accelerate iron oxidation. 3) This treated water then enters another settlement basin designed for easy maintenance. Water exits the prior basin into an engineered wetland for final treatment. The wetlands also act as an infiltration basin; there will be no surface discharge to Clear Creek. A polylog box at the pipe discharge to add flocculant for enhanced settling is recommended (see Sheets 14 and 16). There is no viable pathway for re-routing the existing pipeline, which is adequately sized at 8-inches. pH will increase slightly, but not to a preferred level, because of input from the upstream Red Boy settlement ponds. (Note: This Alternative will not be effective or easy to construct until ARD production at the Red Boy site that discharges to the Bluebird ponds is controlled.).
- **Alternative 8 – Upgrade Water Collection and Pipeline Systems at Blackjack Mine:** The existing water collection and conveyance at the Blackjack Mine is flat in the valley bottom and prone to plugging. It is also undersized at 6-inches diameter. This alternative proposes to remedy this by constructing a new dam in the upper adit for an enlarged 8-inch pipe (Sheet 21 and 22), replacing the entire line with 8-inch diameter pipe, constructing a usable access road for maintenance along the entire length, and extending the pipe downstream in the drainage before crossing under the county road to maintain a continual slope. The proposed discharge location will be beyond the flat problem area in the existing ditch. A polylog box will be installed at the pipe discharge to add flocculant for enhanced settling (Sheets 14 and 15).
- **Alternative 9 – Install Adit Plug(s) at Blackjack Mine:** A frequently proposed method of terminating mine discharge is to install a concrete plug. This approach can be viable but requires that 1) No other linked workings daylight, 2) The rock is not highly permeable, and 3) a plug can be installed at a location where the hydrostatic head will not exceed the lithostatic load. At the Blackjack Mine the following sequence of tasks are required: 1) Re-open the portal and remove the existing dam and bat gate, 2) Remove the known cave-in and support this area extensively, 3) "Slash" the existing adit to an appropriate depth (estimated at 400 feet), 4) Evaluate the ground condition through RQD/RMD approaches and geologic mapping, 5) Identify obvious discharge from the wall rock, 6) Drill exploration holes and perform packer testing to determine hydraulic conductivity and guide a grouting program, 7) Select an appropriate plug location, 8) Design the plugs, 9) Install the high pressure plug with piping using non-shrinking and sulfate-resistant concrete with stainless steel reinforcement, 10) Backfill the adit with stockpiled "slash" rock supplemented with other rock as needed for long-term ground support, 11) Install the low pressure plug, 12) Construct a seepage collection dam, 13) Attach all piping, and 14) Re-install the bat gate and connect piping. Plug installation is extremely expensive

and does not always work well; the evaluation and location phases are absolutely critical. A conceptual design is provided in Sheet 23. In the event that the mine must be drained in the future the existing pipeline will remain in place and be connected to the plug drain line.

6. COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section presents an analysis and evaluation of the RAOs developed from the general removal technology screening. The following subsections present the evaluation criteria, construction elements common to all action alternatives, and a detailed analysis of the removal action alternatives.

6.1 Components of the Removal Action Scope

Each removal action alternative was evaluated based on the following criteria:

- Effectiveness;
- Ease of implementation; and
- Relative cost.

Effectiveness is defined as the ability of an alternative (relative to other options in the same technology sub-category) to:

- Achieve RAOs – pertains to the ability of an alternative to achieve, at least to some degree, the project RAOs;
- Protect human health and the environment – addresses whether the remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls;
- Comply with ARARs – addresses whether a remedy will meet state and federal environmental statutes;
- Provide long-term effectiveness and permanence – refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met;
- Provide short-term effectiveness – qualitatively addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

Ease of implementation encompasses both the technical and administrative feasibility of implementing a removal action alternative. It also takes into account legal considerations. Factors of particular consideration include construction and operational feasibility; availability of equipment, and personnel; community acceptance; and the ability to obtain necessary permits for off-site actions.

The relative costs of each alternative are evaluated based on professional experience, engineering judgment, and standard cost estimating tools. Primary cost considerations include (1) capital costs, (2) approximated engineering and design costs, and (3) annual operation and maintenance (O&M) costs based on 3 years of post-construction monitoring and maintenance.

The costs are estimated at the conceptual level, as defined by the American Association of Cost Engineers. The estimated costs are intended for alternative comparison only and are not for construction bid purposes. Assumptions specific to each alternative regarding construction tasks and post-construction maintenance and monitoring activities are discussed in the following Sections 6.2 and 6.3. The estimated costs for each task are summarized in Table 8 and described in detail in Appendix 11.

6.2 Construction Elements Common to All Action Alternatives

The action alternatives (2 through 8) involve conventional construction elements that are common. Alternative 9 involves more specialized construction. Examples are discussed below:

- Alternatives 2 and 3, removal of sludge from both the Blackjack and Bluebird Mines, would both involve removing sludge from the ponds and ditch areas and de-watering of the sludge for transport to either an on-site or off-site repository.
- Alternatives 4 and 5, upgrading the existing sludge pond at both the Blackjack and Bluebird Mines, would involve using excavators and conventional earthmoving equipment to clean out, deepen, and re-contour the existing ponds and ditches for added capacity and improved drainage flows. These features would also improve settling and treatment capacity.
- Alternatives 6 and 7, construction of new wetland treatment areas at both the Blackjack and Bluebird Mines, would involve conventional earthmoving equipment (e.g., excavator and light dozer) to build the wetlands treatment areas. For Alternative 6 at the Blackjack Mine, earthmoving equipment would be used to relocate the ponds and pipeline on one side of the creek before constructing the wetlands treatment. For Alternative 7 at the Bluebird Mine, no relocation would be required, and earthmoving equipment would be used to improve the existing features in-place and construct the wetlands treatment.
- Alternative 8, upgrading the water collection and pipeline systems at the Blackjack Mine, would involve earthmoving equipment to remove and install new 8-inch diameter HDPE lines. The new piping subgrade would be designed and constructed for improved positive flow through the lines. This alternative could also be used in combination with other alternatives. At the Bluebird Mine the pipe is already 8-inch diameter, and there is no feasible rerouting of the line. Therefore, this alternative is not recommended for consideration at the Bluebird Mine.
- Alternative 9, installing adit plug(s) at the Blackjack Mine requires more specialized equipment, such as a grouting plant, rock drilling and blasting equipment, underground haulage equipment, and ground support. In addition, drill hole packers and hydraulic conductivity testing would be required to assess requirements and locations for grouting.

6.3 Detailed Analysis of Alternatives

The following subsections and Table 7 present a detailed analysis of the removal action alternatives based on the criteria discussed above. The removal action alternatives are conceptual designs only. The estimated material quantities were rounded for consistency with cost estimating spreadsheets and to facilitate internal review and verification. Maintenance and monitoring costs were limited to a three-year period following removal action.

6.3.1 Alternative 1 – No Action

This alternative consists of leaving the Sites as is in the present condition. No reclamation would be performed, and no further investigation or monitoring would be conducted.

Effectiveness
This alternative will not achieve any of the project RAOs or comply with ARARs. There would be no protection of the environment. Sludge discharge from the Bluebird and Blackjack Mines would continue and require constant maintenance and repair. Sludge would continue to accumulate at both Sites and ultimately require removal and disposal.

Implementability
This alternative is both technically and administratively feasible. However, agency and public acceptance is limited.

Cost
There are no capital costs associated with this alternative. However, there may be significant long-term costs associated with future impacts or releases, and existing O&M costs will continue.

Summary
This alternative is required for comparative purposes by the NCP.

6.3.2 Alternative 2 – Remove Sludge to an On-Site Repository

This alternative consists of pumping out and de-watering the sludge from the ponds and drainage ditch at both the Blackjack and Bluebird Mines and transporting the sludge to a proposed on-site repository. Sludge dewatering and containment could be accomplished using Tencate Geotube® or equivalent textile containers. This would involve pumping the sludge through the Geotube at the pond location and would be more efficient and effective than for example, excavating, de-watering, and transporting de-watered sludge in dump trucks. De-watering and containment of sludge in such textile containers is a three-step process:

- The sludge/slurry is pumped into the textile container or “bag” staged on a truck and pup. Environmentally safe polymers such as polyacrylamide are added to the sludge bag, binding the solids together and separating the water. The containers’ unique fabric confines the fine grains of material.
- Clear effluent water drains from the textile container for conveyance back into the ditches and ponds via discharge lines from the trucks. As the sludge in the container dewaters, volume reduction occurs and over 99% of the solids are captured. Sludge density is anticipated to be up to 35% solids. Actual sludge density during the Data Gap study averaged approximately 24% for a concentration factor of 2:1.

- After the final cycle of filling and dewatering, the solids continue to densify due to desiccation as residual water escapes through the fabric. Volume reduction can be as high as 90% over a long period in the repository. The full container(s) are then transported for disposal into the on-site repository.

The construction of the on-site repository site would include:

- Access road improvements for sludge transport;
- Strip/stockpile available topsoil/organic material for cover;
- Excavation of the designed repository perimeter and depth;
- Stockpiling of excavated material to be used as temporary cover; and
- Diversion ditches to intercept run-on water and transport it around the repository.

The on-site repository will not require an engineered impermeable cap. Instead, an engineered soil cover will be sufficient for covering the textile bags in-place between sludge placement events. The soil cover will be seeded with an approved seed mix for native plants compatible to the area. Institutional controls (fencing around the repository perimeter) would be installed. A stockpile of cover material would be stored/maintained near the repository for future sludge placement events and long-term maintenance. Long-term cover material could also be generated from Alternative 4 (upgrading the existing ponds) discussed below.

<u>Effectiveness</u>
The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. Consolidating and managing the waste in an on-site repository would be protective of the public and environment, and the visibility of the sludge along clear creek would be reduced. The short-term effectiveness of sludge removal will immediately increase the capacity of the ponds. However, the ponds will require long-term maintenance as sludge continues to accumulate over time. Short term effectiveness is rated as moderate, long term as moderate.

<u>Implementability</u>
This alternative is both technically and administratively feasible. The alternative is relatively easy to implement using conventional equipment and technologies that demonstrate high efficiency in dewatering sludge. Implementability is low to moderate.

<u>Cost</u>
Capital costs consist primarily of Geotubes and fencing. The total cost is dominated by equipment and labor. The total cost includes removal of all existing sludge now on-site. This would probably require repetition every 20 years with minor removal at select “bottleneck” locations every 5-10 years. Total cost for complete removal including cost of repository construction is $598,000.

Summary
This alternative complies with all ARARs. However, the inflow from the adjacent Red Boy Mine will continue to maintain acidic pH in the Bluebird ponds.

6.3.3 Alternative 3 – Remove Sludge for Off-Site Disposal

This alternative is identical to the Alternative 2 described above, except that the waste would be disposed of off-site. The following evaluation addresses off-site disposal of the sludge.

The sludge was determined non-hazardous, and the capability of meeting paint filter test requirements was verified during the Data Gap investigation. The nearest Subtitle D facility in Baker City, Oregon will accept the sludge. The Baker City facility is approximately a 120-mile round trip from the Sites over a significant mountain pass.

Procedures

- Sludge is removed and dewatered in the manner described in Alternative 2;
- We know from prior tests that the sludge passes TCLP; and
- The Paint Filter Test (EPA Method SW-846 Test Method 9095B) is required for landfill disposal and was performed successfully on this sludge during the Data Gap investigation.

Effectiveness
This alternative is both technically and administratively feasible. The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. There will be no repository that requires perpetual maintenance, and the visibility of the sludge would be reduced along Clear Creek. Additionally, the removed sludge would not be susceptible to release to the environment during catastrophic flooding. Effectiveness is rated as high. However, the inflow from the adjacent Red Boy Mine will continue to maintain acidic pH in the Bluebird ponds.

Implementability
This alternative is both technically and administratively feasible. The alternative is relatively easy to implement using conventional equipment and technologies that demonstrate high efficiency in dewatering sludge. Implementability is high.

Cost
Capital costs consist primarily of trailer modifications and Geotubes and fencing. The total cost is dominated by equipment and labor. The total cost includes removal of all existing sludge now on-site. This would probably require repetition every 20 years with minor removal at select "bottleneck" locations every 5-10 years. Total one-time cost for complete removal is $355,000, considerably less than an on-site repository.

Summary
This alternative complies with all ARARs.

6.3.4 Alternative 4 – Upgrade Existing Sludge Ponds at Blackjack Mine

Upgrading of the existing sludge ponds involves the following:

- Remove all woody vegetation and root balls from the current ponds;
- Deepen and expand the ponds to allow for greater sludge volume and enhanced maintenance;
- Transport all excavated material for disposal to:
    - The north Bluebird Treatment Pond for disposal in deep water; or
    - To the Repository for disposal in a new engineered internal repository.
- Improve the check dams by making them taller and less "leak" prone;
- Extend the discharge line to a further downgradient point that maintains a constant grade; and
- Add a polylog box at the outlet to enhance flocculation of ferric-oxyhydroxide precipitates.

Effectiveness

The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. Expanding the capacity of the settling ponds and applying flocculant will enhance sludge accumulation in the settling ponds, thereby making sludge management more effective. Long-term effectiveness is low as the ponds will continue to refill with sludge; short-term effectives is rated moderate.

Implementability

Overall, this alternative is technically and administratively feasible. Re-contouring and deepening of the existing settling ponds, and construction of a treatment pond is highly implementable with conventional excavating equipment. Polymer flocculant logs are easy to install and are low maintenance. Implementability is rated as moderate.

Cost

There are low to moderate capital and maintenance costs associated with re-contouring the settling ponds and constructing treatment ponds. The polymer flocculant logs require low to moderate capital and maintenance costs. The total one-time cost is $395,000 if a repository is constructed for the debris and soil, or $368,000 if the debris is disposed of in the Bluebird Treatment pond.

Summary

Generally, this alternative meets all ARARs and is effective, implementable, and is of low to moderate cost.

6.3.5 Alternative 5 – Upgrade Existing Sludge Ponds at Bluebird Mine

Upgrading of the existing sludge ponds involves the following:

- Construct a crude access road around the settling pond only (The north Bluebird Treatment pond will not be recontoured at this time.);
- Remove all existing dead trees, woody brush, and root balls for easier maintenance access;
- Removing all the existing grasses for disposal to:
    - The Bluebird Treatment Pond for disposal in deep water; or
    - To a small repository for disposal in a new engineered internal repository.
- Recontour the ponds for easier maintenance and access; and
- Add a polylog box at the adit discharge outfall.

Effectiveness

The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. Expanding the capacity of the settling ponds and applying flocculant will enhance sludge accumulation in the settling ponds, thereby making sludge management more effective. Long-term effectiveness is low as the ponds will continue to refill; short-term effectiveness is low to moderate. However, the pH is likely to remain acidic, because of the Red Boy inflow.

Implementability

This alternative is technically feasible using conventional earthmoving equipment. Administrative feasibility may be of concern because of the pond's connection via a culvert to mine water discharge from the active prospect at the upstream Red Boy ponds. Overall implementability is considered moderate.

Cost

There are low to moderate capital and maintenance costs associated with re-contouring the ponds and constructing treatment ponds. The polymer flocculant logs require low to moderate capital and maintenance costs. The cost if a repository is constructed is $224,000; it is $133,000 if the waste is deposited in the north Bluebird Treatment pond.

Summary

Generally, this alternative meets all ARARs and is effective and implementable.

6.3.6 Alternative 6 – Construct New Wetland Treatment Areas at Blackjack Mine

This alternative consists of creating a new wetland to treat the Blackjack drainage. A conceptual design study was completed and is presented in Appendix 10. The old wetlands and piping will remain intact for emergency use. A new setting pond with associated wetlands will be constructed on the west side of Clear Creek. This will permit construction of a pipeline along the hillside with no low spots along the route as the existing system. The settling pond will be more amenable to cleanout; the wetlands will be a true engineered wetland. The terminal end of the wetland system will be an infiltration basin that eliminates direct stream discharge.

Steps for construction are as follows:

- Based on discharge chemistry, a conceptual treatment system has been designed:
  - Polylogs will be installed to minimize the settlement pond size;
  - Settlement time will determine residence time and settlement pond design should be based on laboratory settlement tests; and
  - The size and layout as well as the chemical objectives of the wetlands will determine if the system should be oxic or anoxic. Oxic is the anticipated approach, and the size and treatment length will be based on chemistry of the settlement basin discharge.
- The new pipeline route from the Upper Adit to the proposed treatment location must be surveyed; and
- Locate the treatment system at the lowest possible elevation to enable construction of a discharge line from the lower adit to the new system.

Replace both lower Blackjack portal dams, because they leak and are not amenable to removal of accumulated sludge from behind the dams.

Effectiveness
The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. Long term effectiveness is moderate; short term effectiveness is high. Proximity to Clear Creek and the long-term infiltration capacity (reduced by precipitate plugging of soils) are unknown.

Implementability
This alternative is technically feasible using conventional earthmoving equipment. Overall implementability is considered low to moderate, because of the significant amount of construction.

Cost
The cost of this alternative is $378,000, but the site improvements are significant.

Summary
Overall, this alternative is possibly effective, may meet requirements and is of reasonable cost. Maintenance should be lower than the current system, and the new discharge line will not have low spots.

6.3.7 Alternative 7 – Construct New Wetland Treatment Areas at Bluebird Mine

Between the Bluebird Settling pond and the Bluebird Treatment pond is an approximately 80-foot long, weakly established "volunteer" wetland. Approximately the first half is a semi-open shallow pond. This alternative involves replacing this system with an engineered wetland consisting of a settlement basin, an alkylation segment, another settlement basin, and a true wetlands polish treat/infiltration area. A conceptual design study was completed and is presented in Appendix 10. The procedures include:

- Construct an engineered wetland as described for the Blackjack Mine; and
- The dam at the north end of the Treatment pond can be raised to allow additional storage in the future if infiltration rates decrease due to plugging by precipitants.

Effectiveness

The alternative will not be fully compliant with all ARARs, and agency and public acceptance is less likely, because of ARAR non-compliance due to the contribution from the Red Boy Mine. This alternative involves extensive new construction. Long- and short-term effectiveness are both low. This alternative is probably not viable until Red Boy ARD is terminated.

Implementability

This alternative is technically feasible using conventional earthmoving equipment. Administrative feasibility may be of concern because of the site connection via a culvert to the active prospect at the Red Boy ponds. Overall implementability is considered low to moderate.

Cost

The cost of this alternative is $356,000, but the system may work poorly because of the acidic water from Red Boy.

Summary

Overall, this alternative will be only marginally effective at a high cost. Generally, meets metals water quality criteria, but will not meet pH requirements.

6.3.8 Alternative 8 – Upgrade Water Collection and Pipeline Systems at Blackjack Mine

The existing system is maintenance and labor intensive. There are low spots in the pipeline that collect sludge. The Following steps should be taken:

- Replace the existing 6-inch line with an 8-inch HDPE line to provide greater time between cleanings (Note: 10-and 12-inch pipe will be difficult to bury and clean);
- Design a permanent ford across Clear Creek for vehicle access; and
- Evaluate the cost to move the outlet approximately 250 feet farther down gradient in the treatment ditch.

Effectiveness

The alternative will comply with all ARARs, and agency and public acceptance is likely, because of ARAR compliance. Larger diameter piping could result in less clogging and less frequent maintenance.

Implementability
This alternative is highly feasible and may be implemented as part of other alternatives. This alternative is feasible using conventional construction equipment and readily available materials (*e.g.*, HDPE piping). Implementability is rated low to moderate, because of costs relative to improvements.

Cost
The cost of this alternative is $290,000.

Summary
Overall, this alternative is effective and implementable, but at a higher cost.

6.3.9 Alternative 9 – Install Adit Plug(s) at Blackjack Mine

A common thought is to simply plug an adit with concrete to terminate discharge in the same manner as putting a cork in a bottle. In the case of underground mines this is a very simplistic approach and is rarely feasible without detailed evaluation. Problems arise from workings that either daylight or are close enough to the surface to leak, open faults/fractures through which discharge is simply rerouted following pressurization, highly fractured or permeable rock through which drainage will leak pervasively, scenarios where multiple expensive plugs underground become necessary to terminate flow, scenarios that require extensive expensive grouting programs to terminate flow, etc. A conceptual model is illustrated in Sheet 23. Steps necessary at Blackjack to evaluate and install a plug(s) include:

- Conduct an extensive search for old underground mine maps;
- Complete a surface structural geologic map;
- Improve the existing access road to permit use by mining equipment;
- Design a temporary repository for any and all waste removed from the mine including sludge and blasted rock from enlarging procedures;
- Remove the existing water control dam(s) and install a temporary bypass system for use during underground operations;
- Re-enter the mine and begin advance by:
  - Installing ventilation, water, and compressed air lines (all to be advanced as needed);
  - Removing any cave ins;
  - Installing appropriate ground support;
  - Draining water from all workings; and
  - Slashing (drilling/blasting/mucking) ribs and back as needed for equipment access.
- Carry the preceding as far in as necessary to:
  - Identify areas that are near surface or may “daylight;”
  - Determine that “high quality” rock is identified to support a plug installation;
  - Ensure that the depth is beyond the surface fracture/degradation zone; and

  - Ensure any plug(s) will be far enough in that expected pressure head will not exceed lithostatic load.
- Evaluate the following:
  - Complete a detailed underground geologic map;
  - Conduct a Rock Quality Data Investigation;
  - Conduct a discharge flow measurement program to determine quantitatively the sources of discharge water;
  - Develop a Rock Mass Rating for the mine, possibly including uniaxial strength measurements;
  - Conduct a drilling program with packer tests to determine the hydraulic conductivity of the rock mass; and
  - From the above, design and cost a grouting program to seal the immediate plug area as well as potential larger scale leaks.
- Design a plug system by:
  - Selecting a location in competent rock that:
    - Will prevent hydrostatic head from overcoming the lithostatic load;
    - Will minimize seepage as well as grouting requirements; and
    - Incorporates seismic acceleration considerations.
- Design the plug itself that:
  - Is composed of shrink proof concrete;
  - Contains an instrumented and valved discharge line in the event pressure relief is needed;
  - Install a portal dam to intercept the inevitable seepage for collection and external disposal; and
  - Install portal entry protection.

Notes:
1. Often more than one plug is necessary along the adit;
2. There is always a risk that the plugs may cause discharge at other surface locations;
3. Once installed, a plug is difficult to remove; and
4. Parts of the above approach are applicable for designing plugs for the Lower Blackjack Adit as well as a grouting program for the Bluebird Mine to reduce seepage.

<u>Effectiveness</u>
Installing a plug could be highly effective in eliminating the discharge and long-term sludge management issues associated with the Blackjack Mine. However, there are significant uncertainties associated with fractures, locating the plug with respect to the opening, significant costs, and safety issues. Long- and short-term effectiveness is high if the plug is successful.

<u>Implementability</u>
Technical implementability could be of concern with uncertainties in rock quality, fractures between the plug and the opening, and grouting. Implementation of this alternative poses' additional safety concerns. Implementability is rated very low, because of this.

Cost

Costs will be significant in re-opening the mine to perform this alternative, determining rock quality, grouting, and other technical issues. Cost are rated high to very high at $1,634,000, and this cost assumes low-problem ground with a limited grouting program. Undoubtedly costs will be significantly higher.

Summary

Overall, this alternative could be effective but requires risk management (technical and safety) considerations and cost evaluations. This in combination with high cost make this a less attractive alternative, especially in light of the fact that the drainage is not acidic.

6.3.10 Data Gaps

Depending on which alternatives are selected additional site information may be required to more adequately evaluate the alternatives. Although a Data Gap investigation was performed, additional information may be needed for a final engineering design. This includes:

- Conducting laboratory settlement tests on sludge to finalize settlement pond design criteria; and
- Confirming an oxic wetland design, subsurface soil characteristics and infiltration rates, soil sorption characteristics, etc. based on desired treatment standards.

7. RECOMMENDED REMOVAL ACTION ALTERNATIVE

A Comparative Analysis of Removal Action Alternatives is provided in Table 8.

In a typical mining EE/CA the alternatives tend to be either-or. However, this project has two distinct and separate systems, and each system has multiple solutions. Therefore, a combination of alternatives is recommended. Also, within each alternative there are tasks that can be removed entirely. And within rejected alternatives there are individual task that can be implemented with other selected alternatives. Also, each alternative was costed as completely standalone. There is opportunity to conserve funds when in combination by having a common mobilization cost and other common tasks.

The preferred removal action alternatives combination is:

- **Alternative 3 – Move Sludge to an Off-Site Repository** (Note: Cost can be reduced here by not removing sludge from the Bluebird north pond at this time);
- **Alternative 4 – Upgrade Existing Sludge Ponds at Blackjack Mine** (Note: Use debris disposal in the north Bluebird Treatment Pond rather than a new repository.); and
- **Alternative 5 – Upgrade Existing Sludge Ponds at Bluebird Mine** (Note: Use debris disposal to Bluebird north pond).

The following alternatives are rejected for the associated reasons:

- **Alternative 2 – Remove Sludge to On-Site Repository**
  - Alternative 3 is less costly; and
  - For Alternative 2 an on-site repository will need to be maintained (Alternative 3 does not require repository maintenance).
- **Alternative 6 – Construct New Wetland Treatment Area at Blackjack Mine**
  - Potential for direct discharge to Clear Creek is not fully known;
  - Infiltration rates and potential for long-term soil plugging are not fully known;
  - Soil sorption is unknown; and
  - There are more unknowns than Alternative 4, which is working as-is, but can be improved.
- **Alternative 7 – Construct New Wetlands Treatment Areas at Bluebird Mine**
  - The acid discharge from Red Boy makes construction of a truly functional wetlands extremely expensive; and
  - The Red Boy issue should be solved first.
- **Alternative 8 – Upgrade Water Collection and Piping Systems at Blackjack Mine**
  - Although the existing line is at capacity, it is not imperative to enlarge the pipe at this time.
- **Alternative 9 – Install Adit Plugs at Blackjack Mine**
  - This is a very expensive and high-risk alternative;
  - It does not appear justified because the drainage is not acidic; and

- It may be worth taking the alternative through Task 6 to at least drain the mine and cursorily examine ground conditions.

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TABLES

Table 1. Bluebird and Blackjack Mines Soil and Waste Rock Analytical Results

		BLK-WR-1		BLK-WR-2		BLK-WR-3		BLK-WR-4		BLK-WR-5		BLK-WR-6		BLU-WR-1		BLU-WR-2		BLU-WR-3		BLU-WR-4		BLU-WR-5		BLU-WR-6		BLU-WR-7 [a]	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Aluminum	mg/kg	3860	J5	3290		2360		1720		7700		3600		3490		1700		3980		8280		12600		3020		3320	
Antimony	mg/kg	1.93	J J6	1.3	J	<2.11		<2.07		<23.6		1.65	J	22.1	J	2.18		2.51		3.13		2.04	J	5.65		4.62	
Arsenic	mg/kg	12.7		10.3		0.493	J	5.28		<23.6		2.32		25.7	J	30.5		17.7		41.3		21.1		99.8		128	
Barium	mg/kg	162	J5	109		104		80.3		223		103		15.6		48.2		69.3		100		113		75.4		75.5	
Cadmium	mg/kg	0.608		0.145	J	<0.527		<0.518		<5.89		0.252	J	1.4	J	0.0827	J	0.143	J	0.243	J	0.428	J	<0.526		<0.538	
Calcium	mg/kg	1340	J5	220		12.5	J	66.7	J	706	J	114		<1580		15.2	J	28.1	J	141		353		27	J	28.7	J
Chromium	mg/kg	29.8		10.1		25		4.6		28.4		8.33		7.82	J	4.46		13.2		22.7		29.5		4.09		5.3	
Cobalt	mg/kg	19.6		4.41		0.245	J	0.586	J	108		28.8		<15.8		3.78		6.49		6.89		12.7		1.47		1.55	
Copper	mg/kg	105		64.7		6.84		12.7		124		58.4		159		27.6		54.3		66.9		72.8		20.3		30.4	
Iron	mg/kg	33400	O1 V	19000		2520		6730		92900		31900		381000		16600		31200		36500		34100		13700		18800	
Lead	mg/kg	11.6		8.98		16.8		5.81		26.7		6.33		10.6		7.72		11.2		13.9		11.9		15.8		15.6	
Magnesium	mg/kg	2390	J3 J5 J6	522		129		114		3040		255		135	B J	82.4	J	954		3200		4230		257		325	
Manganese	mg/kg	860	O1 V	251		4.25		21.9		12600		2770		245		265		180		266		321		41.4		48.1	
Mercury	mg/kg	0.265		0.0856		0.51		0.0497	B	0.136		0.119		0.0788	B	0.678		0.599	B J5 J	0.37		0.186		0.235		0.281	
Nickel	mg/kg	46		20		5.55		6.2		286		62.7		8.67	J	10.4		19.8		22		30.4		6.34		6.59	
Selenium	mg/kg	2.64		1.07	J	<2.11		<2.07		7.37	J	1.84	J	10.6	J	0.894	J	1.45	J	2.28		1.45	J	3.35		3.44	
Silver	mg/kg	<1.07		<1.05		<1.05		<1.04		<11.8		<1.06		<15.8		<1.06		<1.05		<1.06		<1.08		0.554	J	0.439	J
Thorium	mg/kg	3.69	J	3.58	J	4.73	J	2.57	J	2.27	J	2.17	J	0.82	J	1.31	J	3.27	J	4.23	J	5.09	J	3.39	J	4.02	J
Tin	mg/kg	1.36	B J J6	1.34	B J	1.1	B J	1.18	B J	<58.9		1.4	B J	<78.8		0.977	B J	1.53	B J	2.08	B J	1.59	B J	1.22	B J	1.21	B J
Vanadium	mg/kg	50.5		16.9		23.4		10		28.1		13.6		<31.5		13.4		19.5		32.2		44.2		15.5		20.8	
Zinc	mg/kg	80.9	J6	46.6		8.12		15.1		491		98.4		186		49.1		65		67		59.4		20.5		26.1	
Method 9045D pH	su	7.92	T8					5.65	T8			4.75	T8	3.54	T8	4.03	T8					5.63	T8	4.11	T8	4.06	T8
Total Solids	%	93.6		95.5		94.8		96.5		84.9		94.5		63.5		94.8		95.4		94.4		92.9		95		93	

		BLU-BG-1		BLU-BG-2		BLU-BG-3		BLU-BG-4		BLU-BG-5		BLK-BG-1		BLK-BG-2		BLK-BG-3		BLK-BG-4		BLK-BG-5		BLK-BG-6 [b]	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Aluminum	mg/kg	27800		12400		20400		17900		16700		26800		17900		20300	O1 V	18800		3270		2580	
Antimony	mg/kg	2.39	J	0.954	J	1.47	J	1.24	J	<2.45		<2.28		<2.38		0.999	J J6	<2.38		6.65	J	9.98	J
Arsenic	mg/kg	16.5		5.21		22.6		14.7		9.29		2.55		1.44	J	2.95		4.4		13		21.8	J
Barium	mg/kg	324		222		276		243		275		418		258		606	V	848		91.9		78.8	
Cadmium	mg/kg	0.568	J	0.181	J	0.567		0.318	J	0.6	J	0.423	J	0.282	J	0.592	J	1.02		0.583	J	<5.86	
Calcium	mg/kg	853		2160		2580		866		2250		2640		1440		5460	J3 V	7290		69.7	J	58	J
Chromium	mg/kg	29.4		10.1		38.5		18.4		21.5		12.7		15.3		16.5		12.2		12.5		11.1	J
Cobalt	mg/kg	9.19		4.91		16.4		10.2		10.5		9.99		6.73		13.8		13.1		20.5		23	
Copper	mg/kg	58.2		20.3		120		67.2		45.1		31.1		22.6		49		42.1		81.1		73.7	
Iron	mg/kg	55900		12100		36000		23700		21400		16700		20900		27800	O1 V	19000		136000		198000	
Lead	mg/kg	10.1		5.89		8.75		10.9		9.44		5.81		8.5		8.05		7.32		10.1		11.1	
Magnesium	mg/kg	1490		977		5010		3220		2550		1920		1300		2180	J6	1680		186	B J	96.7	B J
Manganese	mg/kg	522		495		498		520		839		2660		900		3650		4700		347		307	
Mercury	mg/kg	0.0541	B	0.0354	B	0.0421	B	0.013	B J	0.0264	B	0.0366	B	0.0299	B	0.0574	B	0.0655	B	0.261		1.53	
Nickel	mg/kg	28.5		16.8		29.5		33.9		31.8		30.7		35.4		41.9		24.7		112		129	
Selenium	mg/kg	1.92	J	0.832	J	2.91		1.1	J	1.69	J	1.12	J	1.19	J	1.69	J	1.71	J	<11.1		<23.4	
Silver	mg/kg	<1.23		<1.22		<1.12		<1.17		<1.22		<1.14		<1.19		<1.18		<1.19		<5.57		<11.7	
Thorium	mg/kg	3.95	J	2.28	J	3.04	J	4.71	J	3.77	J	2.34	J	2.54	J	2.15	J	1.78	J	2.01	J	1.44	J
Tin	mg/kg	2.15	B J	1.69	B J	1.83	B J	2.02	B J	1.61	B J	2.25	B J	1.83	B J	2.1	B J	1.82	B J	<27.9		<58.6	
Vanadium	mg/kg	49.4		19.4		66.9		32.1		34.1		32.2		32.5		37.9		31.1		19.6		13.3	J
Zinc	mg/kg	89.6		37		55.5		73.8		75.9		77.7		49		88.3	J6 O1	214		384		533	
Method 9045D pH	su	5.54	T8	6.67	T8	6.7	T8	6.45	T8	6.42	T8	6.78	T8	6.61	T8	7.1	T8	6.99	T8	6.6	T8	6.52	T8
Total Solids	%	81.3		82.3		89.3		85.4		81.8		87.8		83.9		84.5		84.2		89.7		85.3	

[a] Duplicate of BLU-WR-6

[b] Duplicate of BLK-BG-5

B - The same analyte is found in the associated blank.

J - The identification of the analyte is acceptable; the reported value is an estimate.

J3 - The associated batch QC was outside the established quality control range for precision.

J5 - The sample matrix interfered with the ability to make any accurate determination; spike value is high

J6 - The sample matrix interfered with the ability to make any accurate determination; spike value is low

O1 - The analyte failed the method required serial dilution test and/or subsequent post-spike criteria. These failures indicate matrix interference.

Q - Qualifier

T8 - Sample(s) received past/too dose to holding time expiration.

V - The sample concentration is too high to evaluate accurate spike recoveries.

Table 2. Bluebird and Blackjack Mines Surface Water Analytical Results

Analyte	Units	BLK-PD-1		BB-PD-1		BLK-ADIT-RES [a]
		Total	Dissolved	Total	Dissolved	Total
Aluminum	mg/L	0.56	0.4	< 0.08	< 0.08	0.56
Antimony	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	0.0345	0.033	0.0116	0	0.0344
Cadmium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Calcium	mg/L	5.54	5.4	5.92	6	5.44
Chromium	mg/L	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Cobalt	mg/L	0.034	0.032	0.0376	0	0.0335
Copper	mg/L	0.0825	0.07	< 0.01	< 0.01	0.0814
Iron	mg/L	11.8	10.9	22.8	20	11.8
Lead	mg/L	< 0.0075	< 0.0075	< 0.0075	< 0.0075	< 0.0075
Magnesium	mg/L	8.22	7.91	13.5	13	8.18
Manganese	mg/L	2.24	2.2	7.01	7	2.26
Nickel	mg/L	0.0871	0.084	0.102	0	0.0864
Potassium	mg/L	1.12	1.08	1.47	1	1.11
Selenium	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silicon	mg/L	5.23	5	6.27	6	5.24
Silver	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/L	2.83	2.74	2.78	3	2.78
Thallium	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Tin	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Zinc	mg/L	0.121	0.12	0.112	0	0.121
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Acidity to pH 8.3	mg/L	< 10	-	64.7	-	-
Alkalinity	mg/L	7.3	-	12.1	-	-
Total Dissolved Solids	mg/L	103	-	177	-	-
Chloride	mg/L	0.47	-	0.6	-	-
Fluoride	mg/L	0.109	-	0.185	-	-
Sulfate (as SO4)	mg/L	51.4	-	94	-	-
Field Parameters						
pH	su	6.03	-	6.5	-	-
Eh	mV	0.2	-	-4	-	-
EC	microS/cm	163	-	260	-	-
Temperature	centigrade	9.5	-	9.97	-	-
DO	mg/L	7.02	-	8.22	-	-
Flow	gpm	75	-	60	-	-

[a] Duplicate of BLK-PD-1

mg/L – milligrams per liter

Table 3. Bluebird and Blackjack Mines Total Solids / Sludge Results

Sample ID	Result (%)	Sludge Thickness (ft)	Notes
BLU-TP-1	10.0	1	
BLU-TP-3	8.8	0.7	
BLU-TP-5	10.1	0.7	
BLK-TP-1	14.2	1	
BLK-TP-2	10.0	1.5	
BLK-SP-1	11.8	0.88	Composite, 4 locations
BLK-SP-2	12.2	-	Not measured
BLK-SP-3	17.5	1.5	

Table 4. Impoundment Surface Areas and Sludge Volumes

Impoundment	Sludge Surface Area (sq ft)	Sludge Volume (cu yd)
Bluebird Treatment Pond (BLU-TP)	16,177	434
Bluebird Settlement Pond (BLU-SP)	5,512	184
Bluebird Adit (Dam to Plug) [a]	N/A	N/A
Blackjack Settling Pond BLK-SP1	598	19
Blackjack Settling Pond BLK-SP2	3,566	121
Blackjack Ditch (BLK-Ditch)	2,209	27
Total	**28,063**	**785**

[a] Indicates this value is not included in the total to facilitate costing of sludge removal from ponds and calculation of daily sludge discharge to ponds.

Note: At a densification factor of 2:1 the transported sludge volume will be 393 cu yds, which will require 44 16-foot Geotubes for transport.

Table 5. Estimated Sludge Generation Rates

Location	Sludge Generation (kg/day)		Sludge Generation Rate (cubic yard/year)	
	Min	Max	Min	Max
Blackjack Mine	6.6	9.2	6.1	6.3
Bluebird Mine	13.9	14.3	2.8	4
Total	**20.5**	**23.5**	**9**	**10.3**

kg/day – kilograms per day

Note: These generation rates are based on forward modeling of the outfalls of both mines.

Table 6. Removal Action Technology Screening Matrix

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	O&M	Land Impact	Pros	Cons	Retained?
No Action										
No action	No action	Leave feature(s) as is	0	0	0	None	None	Low cost, simple	No risk reduction	Yes
Institutional Controls										
Access Restrictions, Community Education and Outreach	Fencing and signs	Fences Installed around Repository and signs posted to notify public of risks	Low	High	Low	Moderate	Minimal	Low cost, simple	Does not stop contaminant migration or prevent small animal contact	Yes
On-Site Repository										
Engineering Controls	On-site repository	Excavate a drained, capped repository and locate all sludge and criteria soil within and cap	High	Moderate	Moderate	Moderate	Moderate	Effective, prevents contaminant erosion and human contact	Waste remains on-site with ongoing O&M	Yes
Off-Site Disposal - Subpart D Landfill										
Engineering Controls	Off-site disposal	Haul mine waste to off-site RCRA-D permitted landfill for disposal	High	Moderate	Moderate	Low	Low	Very effective, waste is removed from the site	Potential liability with off-site disposal	Yes
Off-Site Disposal - Subpart C Landfill										
Engineering Controls	Off-site disposal	Haul mine waste to off-site RCRA-C permitted landfill for disposal of Hazardous Waste	High	Moderate	High	Low	Low	Very effective, waste is removed from the site	Highest cost	No
Pipeline Replacement										
Engineering Controls	Pipeline replacement	Replace existing pipeline(s) with larger, better designed systems	Moderate	Moderate	High	High	Low	Moderately effective, improved discharge and lower O&M	High cost	Yes
Treatment Pond Upgrades										
Engineering Controls	Treatment Pond Upgrades	Improve existing treatment ponds for easier access and maintenance	Moderate	Moderate	Moderate	Moderate	Low	Moderately effective, improved access for lower O&M	Moderate cost	Yes
Adit Plugs										
Engineering Controls	Open adits and install concrete plugs	Open adit(s) evaluate for plug location, install plug(s) to terminate discharge	Can be effective	Low	Extremely High	Can be low	Low	Can be effective, lower discharge, lower O&M	Effectiveness not known until underground examination, very high cost	Yes
On-Site Treatment										
Treatment	Construction of improved wetlands	Replace existing pseudo-wetlands system with an engineered, improved system	Moderate	Moderate	High	Moderate	Moderate	Moderately effective and improvement over existing systems	Waste remains temporarily on-site, continual O&M, remaining visual impacts	Yes

Table 7. Removal Action Alternatives Developed for Analysis

Alternative	Description	Applies To
1 - No Action	Site remains as is.	Entire Site
2 - Remove Sludge to an On-Site Repository	A repository will be constructed at a selected site on USFS property. The sludge from the existing Bluebird and Blackjack settlement and treatment ponds will be pumped into Geotubes mounted in trucks where it will consolidate from an in-place density of approximately 12% to approximately 35%. Discharge water from the Geotubes will be returned to the source pond. When filled, the Geotubes will be transported to the repository and dumped in an organized fashion to facilitate capping and minimize repository size. When completed the repository will be capped with a 2-3-foot-thick soil cover and revegetated. The repository will be surrounded with an 8-ft-high fence to exclude large animals.	Entire Site
3 - Remove Sludge to Off-Site Disposal	The sludge from the existing Bluebird and Blackjack settlement and treatment ponds will be pumped into Geotubes mounted in trucks where it will consolidate from an in-place density of approximately 12% to approximately 35%. Discharge water from the Geotubes will be returned to the source pond. All Geotubes will be transported to the Baker City Sanitary Landfill, a distance of 60 miles.	Entire Site
4 - Upgrade Existing Sludge Ponds at Blackjack Mine	The existing sludge ponds are awkward for sludge removal and contain a significant amount of wood debris and vegetation mats, all of which make sludge removal relatively difficult and expensive. This alternative proposes that all vegetation debris be removed and disposed on-site in a small repository or in the Bluebird Mine north pond. The ponds would be re-contoured for greater volume and easier maintenance. Final depth should be limited to 3-feet for safety. Road construction is not necessary	Blackjack Mine Site
5 - Upgrade Existing Sludge Ponds at Bluebird Mine	The existing sludge ponds are awkward for sludge removal and contain a significant amount of wood debris and vegetation mats, all of which make sludge removal relatively difficult and expensive. This alternative proposes that all vegetation debris be removed and disposed on-site in a small repository or in the Bluebird Mine north pond. The ponds would be re-contoured for greater volume and easier maintenance. Final depth should be limited to 3-feet for safety. Road construction for pond access will be required.	Bluebird Mine Site
6 - Construct New Wetland Treatment	The existing ponds at the Blackjack Mine are inefficient, the base exhibits flat areas that fill quickly, the overflow water discharges directly to Clear Creek, the	Blackjack Mine Site

Alternative	Description	Applies To
Areas at Blackjack Mine	sludge is visibly offensive and could erode into Clear Creek, the existing pipeline is flat in the valley bottom and prone to plugging. This alternative proposes to construct a new system west of Clear Creek that eliminates these issues. A new pipeline and access road will allow the pipeline to exhibit a continual grade that does not pass under Clear Creek. The treatment system will consist of the following path: 1) the discharge enters a settlement basin design for easy sludge maintenance, 2) Water exiting the prior pond will pass through an alkylation system to raise pH and accelerate iron oxidation. 3) This treated water then enters another settlement basin designed for easy maintenance. Water exits the prior basin into an engineered wetland for final treatment. The wetlands also act as an infiltration basin; there will be no surface discharge to Clear Creek. The old pipeline will remain in place for emergency use. A polylog box will be located at the pipe discharge to add flocculant for enhanced settling. This alternative has a variety of unknowns.	
7 - Construct New Wetland Treatment Areas at Bluebird Mine	The existing ponds at the Bluebird Mine are inefficient, the sludge is visibly offensive, and pH remains acidic through the system. Also, the existing pipeline includes a depression in the valley bottom and is prone to plugging. This alternative includes construction of a new wetland in the same location that eliminates or at least minimizes these issues. The treatment system will consist of the following path: 1) the discharge enters a settlement basin designed for easy sludge maintenance, 2) Water exiting the prior pond will pass through an alkylation system to raise pH and accelerate iron oxidation. 3) This treated water then enters another settlement basin designed for easy maintenance. Water exits the prior basin into an engineered wetland for final treatment. The wetlands also act as an infiltration basin; there will be no surface discharge to Clear Creek. A polylog box will be located at the pipe discharge to add flocculant for enhanced settling. There is no viable pathway for re-routing the existing pipeline, which is adequately sized at 8-inches. pH may increase slightly, but not to a preferred level, because of input from Red Boy.	Bluebird Mine Site

Alternative	Description	Applies To
8 - Upgrade Water Collection and Pipeline Systems at Blackjack Mine	The existing water collection and conveyance at the Blackjack Mine is flat in the valley bottom and prone to plugging. It is also undersized at 6-inches diameter, and cleaning access is partially by foot only. This alternative proposes to remedy this by constructing a new dam in the upper adit for an enlarged 8-inch pipe, replacing the entire line with 8-inch diameter pipe, constructing a usable access road along the entire length, and extending the pipe in the drainage before crossing under the county road to maintain a continual slope. The proposed discharge location will be beyond the flat problem area in the existing ditch. A polylog box will be located at the pipe discharge to add flocculant for enhanced settling.	Blackjack Mine Site
9 - Install Adit Plug(s) at Blackjack Mine	A frequently proposed method of terminating mine discharge is to install a concrete plug. This approach can be viable but requires that 1) No other linked workings daylight, 2) The rock is not highly porous or permeable, and 3) a plug can be installed at a location where the hydrostatic head will not exceed the lithostatic load. At the Blackjack Mine the following sequence of tasks are required: 1) Re-open the portal and remove the existing dam and bat gate, 2) Remove the known cave-in and support this area extensively, 3) "Slash" the existing adit to an appropriate depth (estimated at 400 feet), 4) Evaluate the ground condition through RQD/RMD approaches and geologic mapping, 5) Identify obvious discharge from the wall rock, 6) Drill exploration holes and perform packer testing to determine hydraulic conductivity and guide a grouting program, 7) Select an appropriate plug location, 8) Design the plugs, 9) Install the high pressure plug with piping using non-shrink and sulfate-resistant concrete with stainless steel reinforcement, 10) Backfill the adit with stockpiled "slash" rock supplemented with other rock as needed, 11) Install the low pressure plug, 12) Construct a seepage collection dam, 13) Attach all piping, and 14) Re-install the bat gate. Plug installation is extremely expensive and does not always work well; the evaluation and location phases are absolutely critical.	Blackjack Mine Site

Table 8. Comparative Analysis of Removal Action Alternatives

Assessment Criteria	Alternative 1 - No Action	Alternative 2 - Remove Sludge to an On-Site Repository	Alternative 3 - Remove Sludge to Off-Site Disposal	Alternative 4 - Upgrade Existing Sludge Ponds at Blackjack Mine	Alternative 5 - Upgrade Existing Sludge Ponds at Bluebird Mine	Alternative 6 - Construct New Wetland Treatment Areas at Blackjack Mine	Alternative 7 - Construct New Wetland Treatment Areas at Bluebird Mine	Alternative 8 - Upgrade Water Collection and Pipeline Systems at Blackjack Mine	Alternative 9 - Install Adit Plug(s) at Blackjack Mine
Overall Protectiveness of Public Health, Safety, and Welfare	No protection	High - Access to waste by people and biota is precluded.	High - Access to waste by people and biota is precluded.	Moderate – Short- and long-term O&M is lessened.	Moderate – Short- and long-term O&M is lessened.	Moderate – Metal removal should be more efficient, and the system is more isolated from the public than current system.	Low – Effectiveness of the system is decreased by the Red Boy acidic water influx.	Moderate – Short- and long-term O&M is lessened.	High - Access to waste by people and biota is precluded, if discharge is terminated.
Compliance with ARARs	Does not comply	Compliant	Compliant	Compliant, but must be completed in conjunction with other alternatives.	Compliant, but must be completed in conjunction with other alternatives.	Compliant	Not fully compliant – Pond water is likely to remain acidic.	Compliant	Compliant
Long-term Effectiveness and Permanence	None	Moderate - Access to waste by people and biota is precluded; however, sludge will need to be periodically removed.	Moderate - No sludge material remains on-site; however, sludge will need to be periodically removed.	Moderate – O&M is required.	Moderate – O&M is required.	Moderate – O&M is required.	Low – Water is likely to remain acidic.	Moderate – O&M is required.	High – If discharge terminates.
Reduction in Toxicity, Mobility, and Volume	None	Low – Does not reduce mobility, toxicity or volume. Not a treatment or reduction technology.	High - No sludge material remains on-site. Mobility, toxicity, and volume are eliminated.	Low – Does not reduce toxicity or mobility and must be completed in conjunction with other alternatives.	Low – Does not reduce toxicity or mobility and must be completed in conjunction with other alternatives.	Moderate - Does not reduce mobility, toxicity or volume. Not a treatment or reduction technology, water quality is better and sludge precipitation is improved.	Low – Quality of water will improve slightly but is likely to remain acidic.	Low – Does not reduce mobility, toxicity or volume. Not a treatment or reduction technology.	High – If discharge terminates. Toxicity mobility, and volume are reduced or eliminated.
Short-term Effectiveness	None	Moderate – Sludge will be removed from ponds but will remain on-site in the repository.	High - No sludge material remains on-site.	Low – Does not reduce toxicity or mobility and must be completed in conjunction with other alternatives.	Low – Does not reduce toxicity or mobility and must be completed in conjunction with other alternatives.	High – Sludge precipitation and metal removal are enhanced; access and visibility are reduced.	Low – Quality of water will improve slightly but is likely to remain acidic.	Moderate – O&M is lowered.	High – If discharge terminates. Toxicity mobility, and volume are reduced or eliminated.

Assessment Criteria	Alternative 1 - No Action	Alternative 2 - Remove Sludge to an On-Site Repository	Alternative 3 - Remove Sludge to Off-Site Disposal	Alternative 4 - Upgrade Existing Sludge Ponds at Blackjack Mine	Alternative 5 - Upgrade Existing Sludge Ponds at Bluebird Mine	Alternative 6 - Construct New Wetland Treatment Areas at Blackjack Mine	Alternative 7 - Construct New Wetland Treatment Areas at Bluebird Mine	Alternative 8 - Upgrade Water Collection and Pipeline Systems at Blackjack Mine	Alternative 9 - Install Adit Plug(s) at Blackjack Mine
Implementability	Not applicable	Low to Moderate - Significant construction is required, and Sludge is difficult to extract and densify.	Moderate – Sludge is difficult to extract and densify.	Moderate – Excavation and transport is required.	Moderate – Excavation and transport is required.	Low to Moderate – Significant construction and long-term O&M are required.	Low to Moderate – Significant construction and long-term O&M are required.	Low to Moderate – Significant construction and long-term O&M are required.	Very Low – Cost is extremely high and discharge termination is uncertain.
State and Community Acceptance	Not acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Marginally Acceptable, because of remaining unknowns	Probably Not Acceptable, because of remaining acidity with high cost.	Acceptable	Acceptable
Cost	**$0**	**$598,000**	**$355,000**	**$395,000 - Repository $368,000 - Pond**	**$224,000 - Repository $133,000 - Pond**	**$378,000**	**$356,000**	**$290,000**	**$1,635,000+**

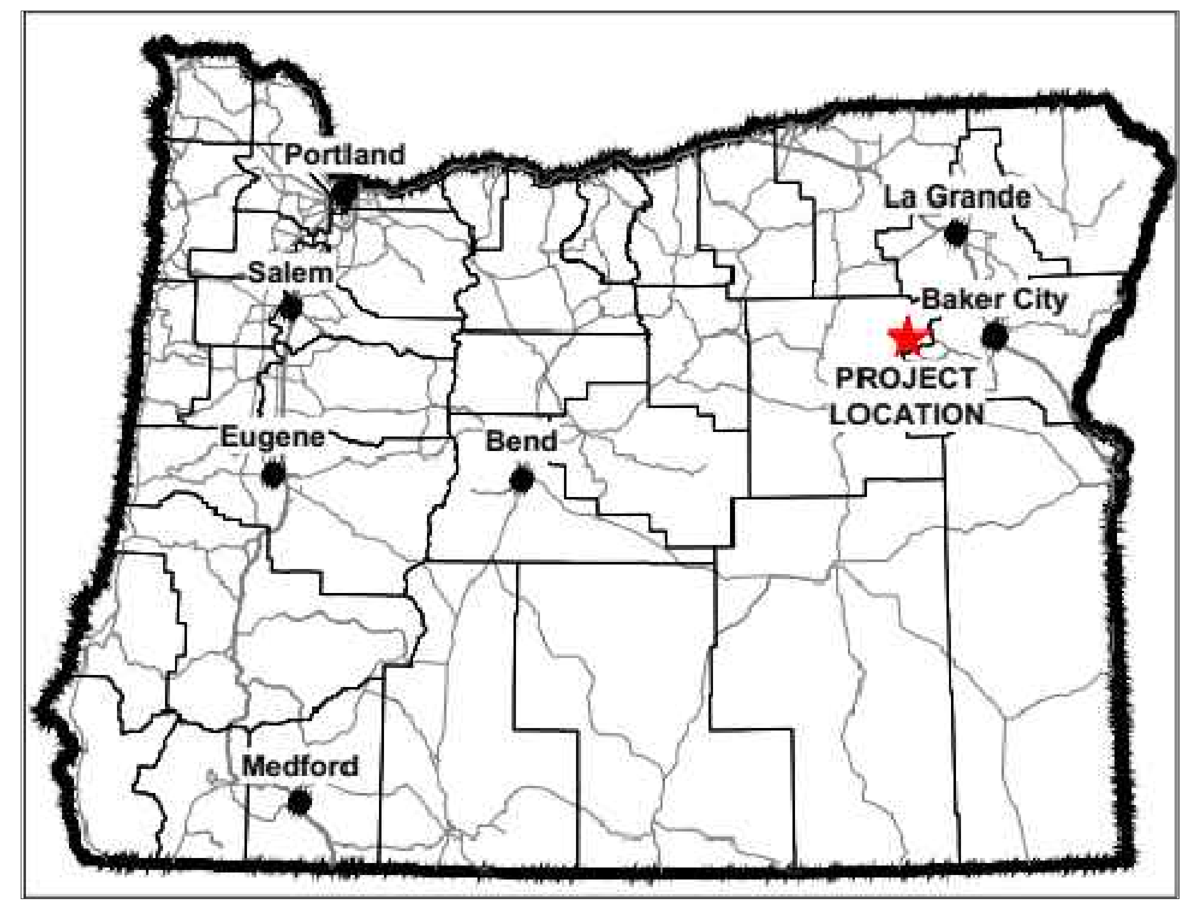
DRAWING SHEETS

UNITED STATES FOREST SERVICE
BLUEBIRD AND BLACKJACK MINES EE/CA

INDEX OF SHEETS

SHEET NO.	SHEET TITLE	REVISION
1	PROJECT LOCATION AND INDEX OF SHEETS	1
2	SITE LOCATION	1
3	BLUEBIRD SOIL SAMPLE LOCATIONS	0
4	BLACKJACK SOIL SAMPLE LOCATIONS	0
5	BLUEBIRD ADDITIONAL SOIL SAMPLE LOCATIONS	0
6	BLACKJACK ADDITIONAL SOIL SAMPLE LOCATIONS	0
7	BLUEBIRD VOLUME ESTIMATES	0
8	BLACKJACK VOLUME ESTIMATES	0
9	BLACKJACK PIPELINE SURVEY	0
10	HUMAN HEALTH CONCEPTUAL SITE MODEL	0
11	ECOLOGICAL HEALTH CONCEPTUAL SITE MODEL	0
12	GEOTUBE PUMPING SCHEMATIC	0
13	PROPOSED REPOSITORY LOCATION	0
14	POLYLOG BOXES	0
15	BLACKJACK PONDS UPGRADE	0
16	BLUEBIRD PONDS UPGRADE	0
17	BLACKJACK MINE WETLAND TREATMENT SYSTEM	0
18	LOWER BLACKJACK ADIT INFILTRATION POND	0
19	NEW LOWER BLACKJACK ADIT DAMS	0
20	NEW UPPER BLACKJACK ADIT DAMS	0
21	BLACKJACK ADIT DAMS	0
22	REPLACE/REROUTE BLACKJACK MINE PIPELINE	0
23	CONCEPTUAL BLACKJACK ADIT PLUG PROFILE	0

PROJECT LOCATION



CITY LOCATIONS FROM https://simplemaps.com/data/us-cities

REVISIONS:			
No. 1	ADD. FIGURES FROM DATA GAP INVESTIGATION	12/08/2020 DATE	OS INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	A. BARENDT	11/15/2019 DATE
DRAWN:	A. BABRENDT	11/15/2019 DATE
CHECKED:	B. LAMBETH	11/15/2019 DATE

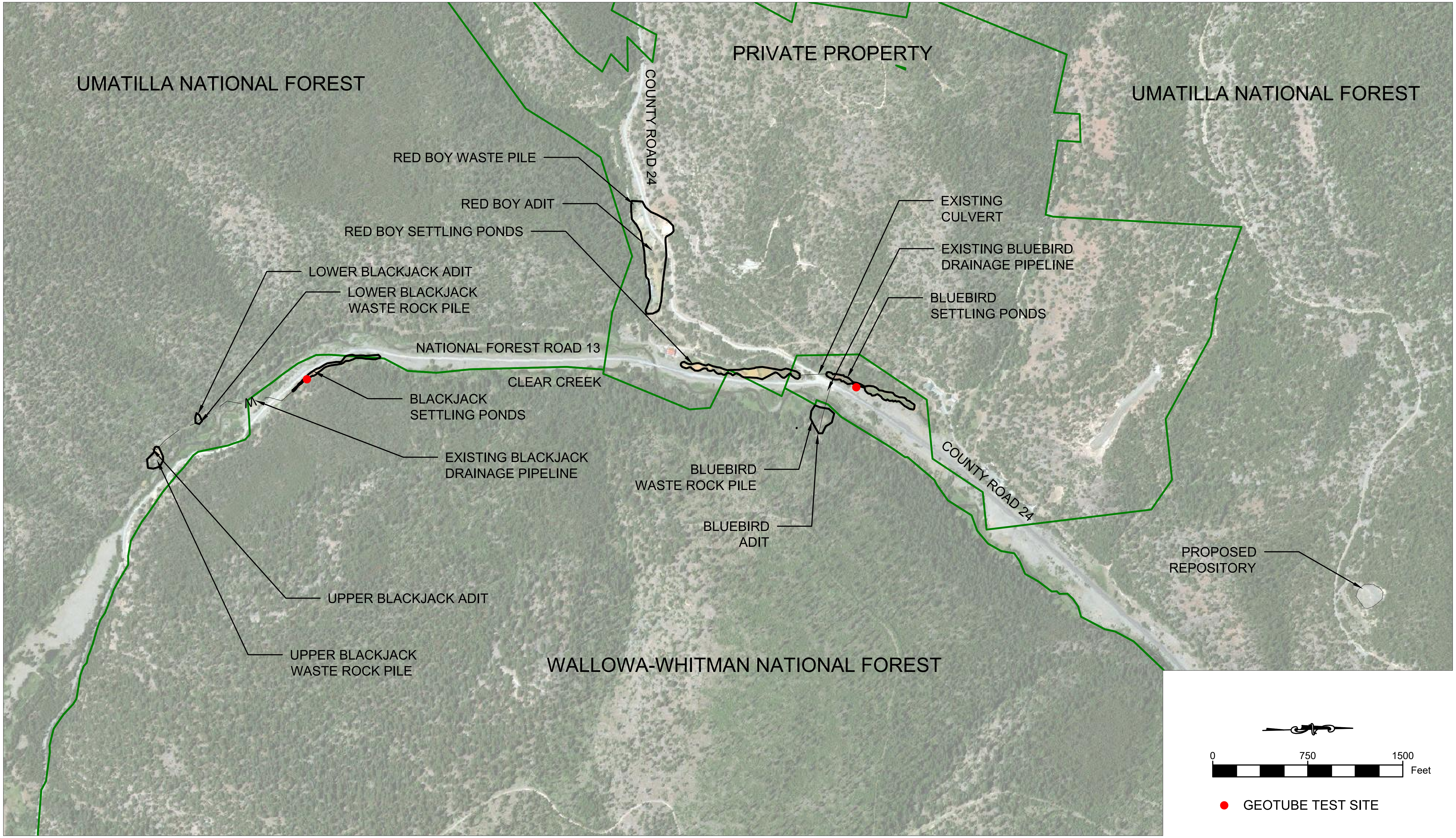
PROJECT NAME: **BLUEBIRD/BLACKJACK EE/CA**

TITLE: **PROJECT LOCATION AND INDEX OFSHEETS**

REVISION DATE: **11/15/2019**

DRAWING NO.: **1**

SHEET **1 OF 23**



REVISIONS:			
No. 1	ADDED GEOTUBE TEST SITE LOCATIONS	12/8/2020 DATE	OS INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	P. HUNTER	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	P. HUNTER	11/15/2019 DATE

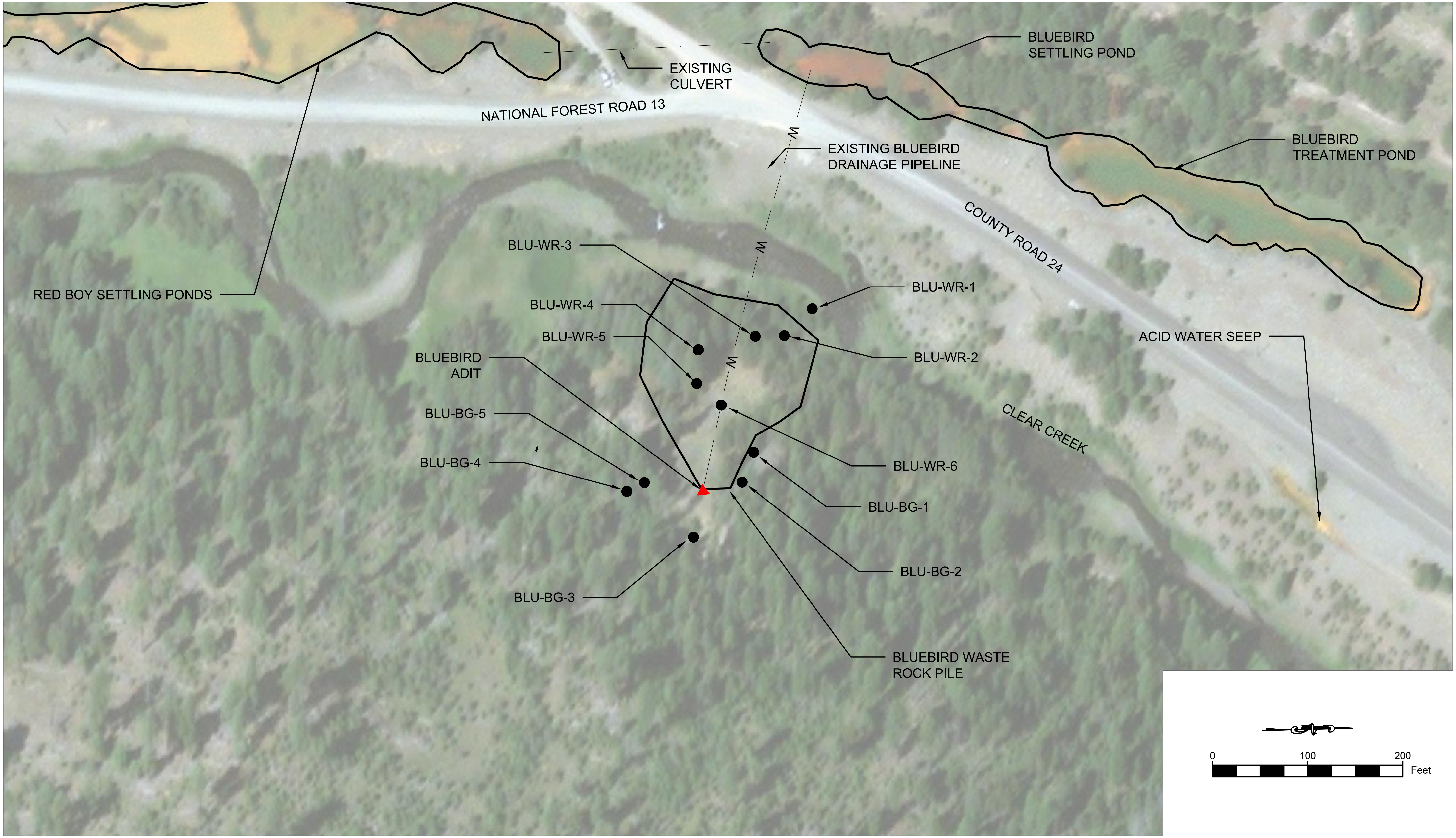
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
SITE LOCATION

REVISION DATE
12/8/2020

DRAWING NO.
2

SHEET
2 OF 23



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No. 1	DATE	INITIALS
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No. 3	DATE	INITIALS

DESIGN:	P. HUNTER	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	P. HUNTER	11/15/2019 DATE

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLUEBIRD SOIL SAMPLE LOCATIONS

REVISION DATE
11/15/2019

DRAWING NO.
3

SHEET
3 OF 23

REVISIONS:

No.		DATE	INITIALS
No. 1		DATE	INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	P. HUNTER	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	P. HUNTER	11/15/2019 DATE

PROJECT NAME

BLUEBIRD/BLACKJACK EE/CA

TITLE

BLACKJACK SOIL SAMPLE LOCATIONS

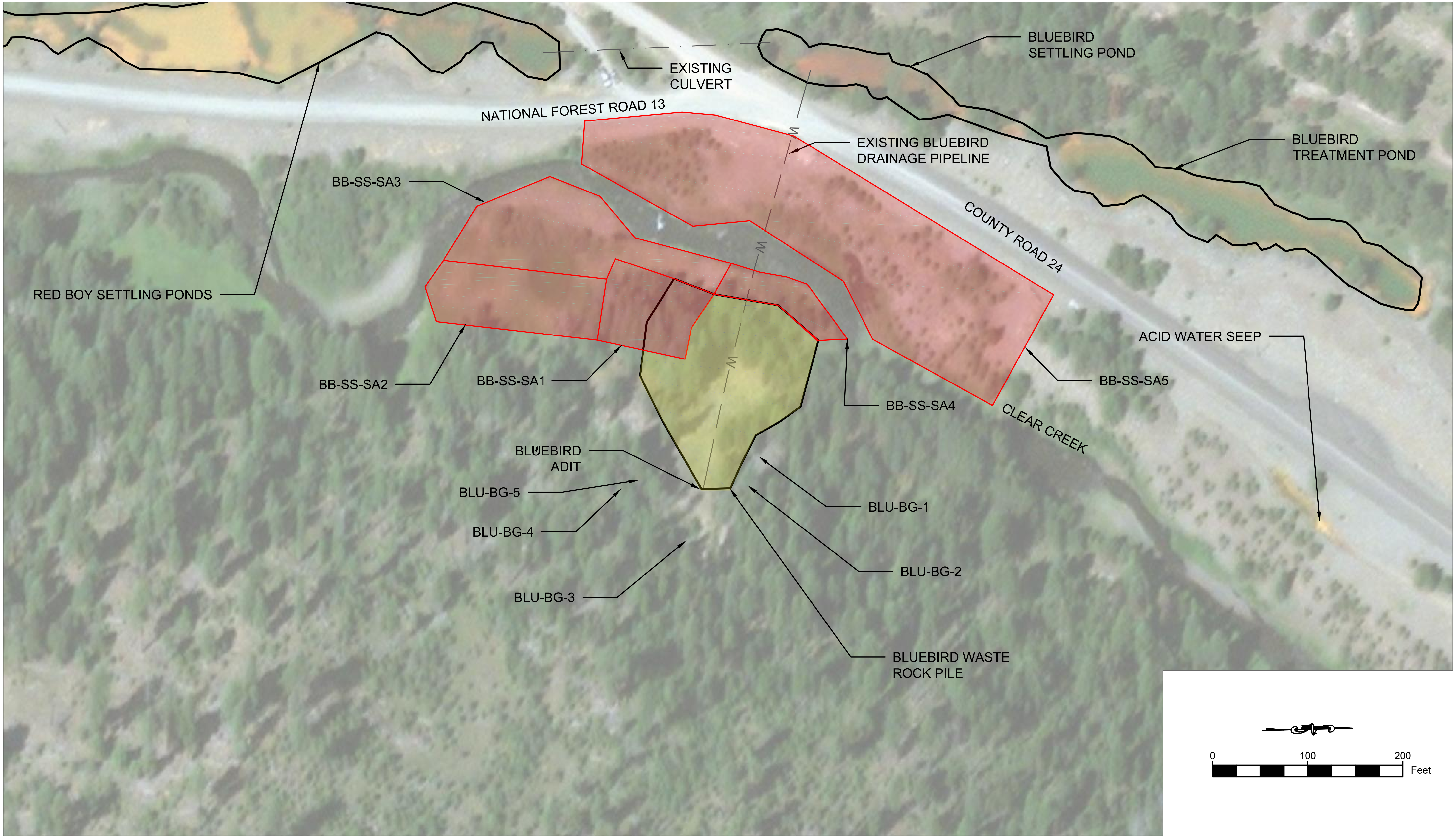
REVISION DATE

11/15/2019

DRAWING NO.

4

SHEET **4** OF **23**



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	Name	Date
DESIGN:	P. HUNTER	11/15/2019
DRAWN:	O.SALMON	10/5/2020
CHECKED:	P. HUNTER	11/6/2020

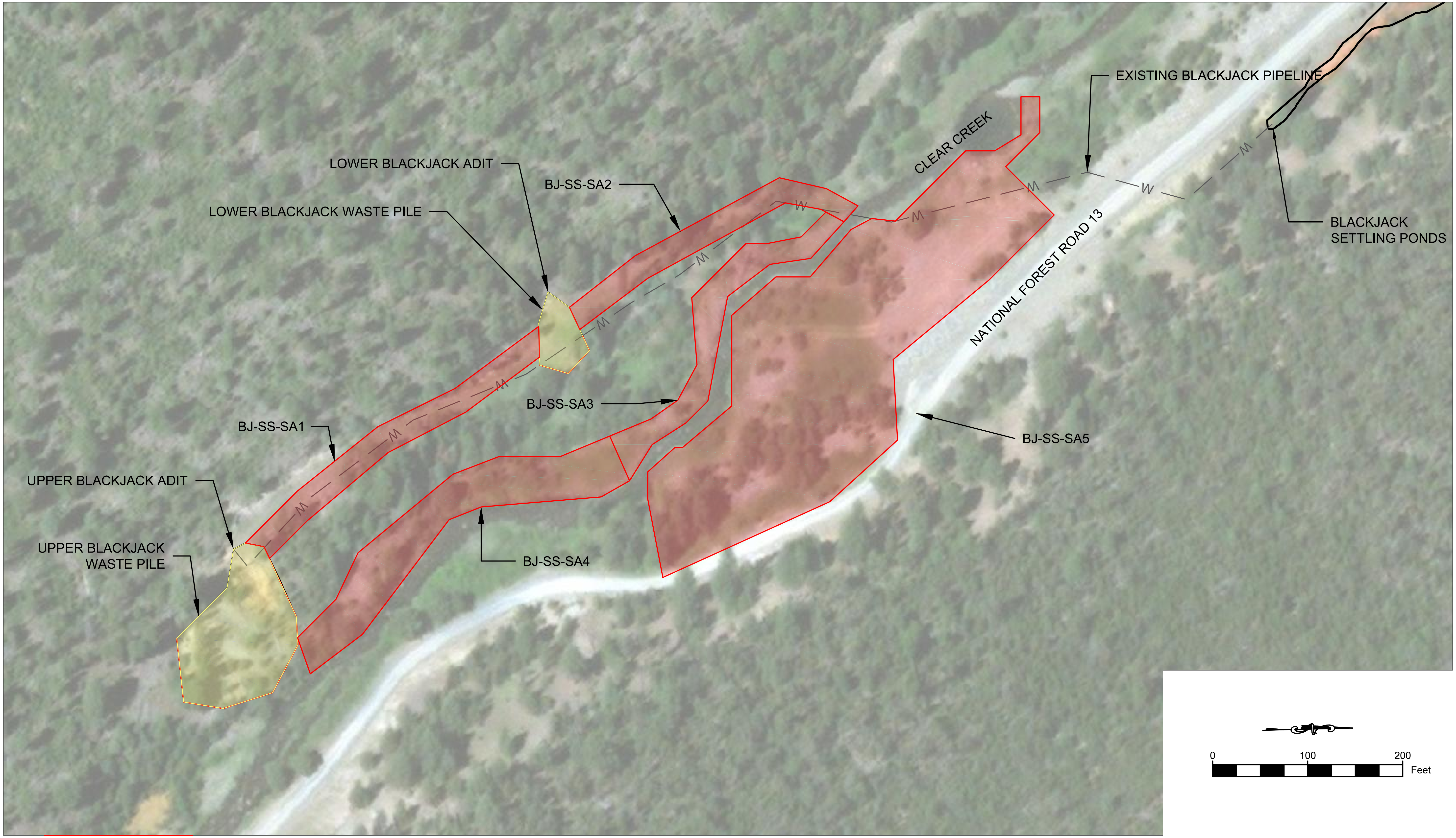
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLUEBIRD ADDITIONAL SOIL SAMPLE LOCATIONS

REVISION DATE
11/6/2020

DRAWING NO.
5

SHEET **5** OF **23**



REVISIONS:

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DESIGN:	P. HUNTER	11/15/2019
DRAWN:	O. SALMON	4/21/2020
CHECKED:	P. HUNTER	11/6/2020

PROJECT NAME

BLUEBIRD/BLACKJACK EE/CA

TITLE

BLACKJACK ADDITIONAL SOIL SAMPLE LOCATIONS

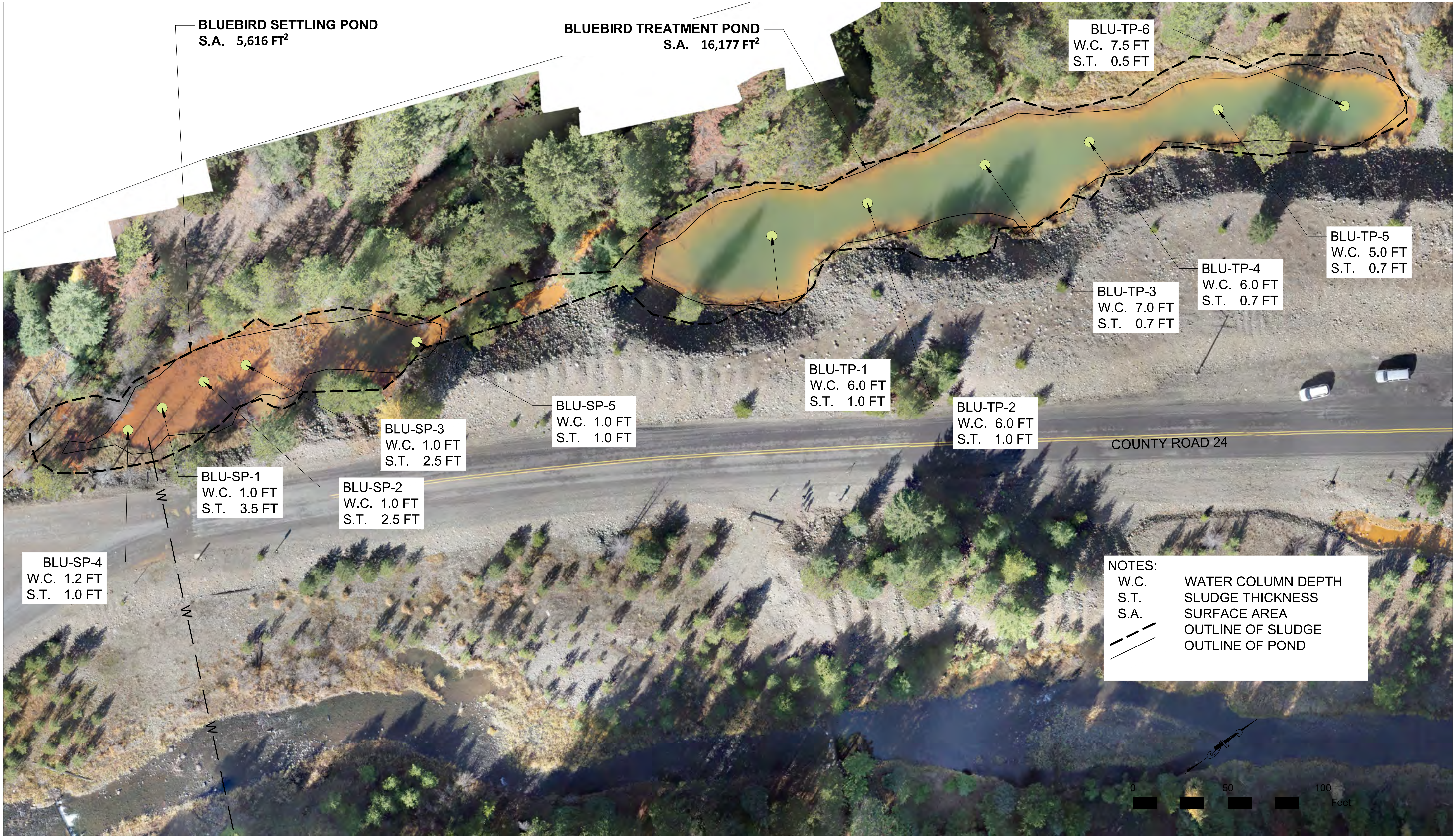
REVISION DATE

11/6/2020

DRAWING NO.

6

SHEET **6** OF **23**



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REVISIONS:

No.		DATE	INITIALS
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2			
3			

		DATE
DESIGN:	P. HUNTER	11/15/2019
DRAWN:	A. BARENDT	11/15/2019
CHECKED:	P. HUNTER	11/15/2019

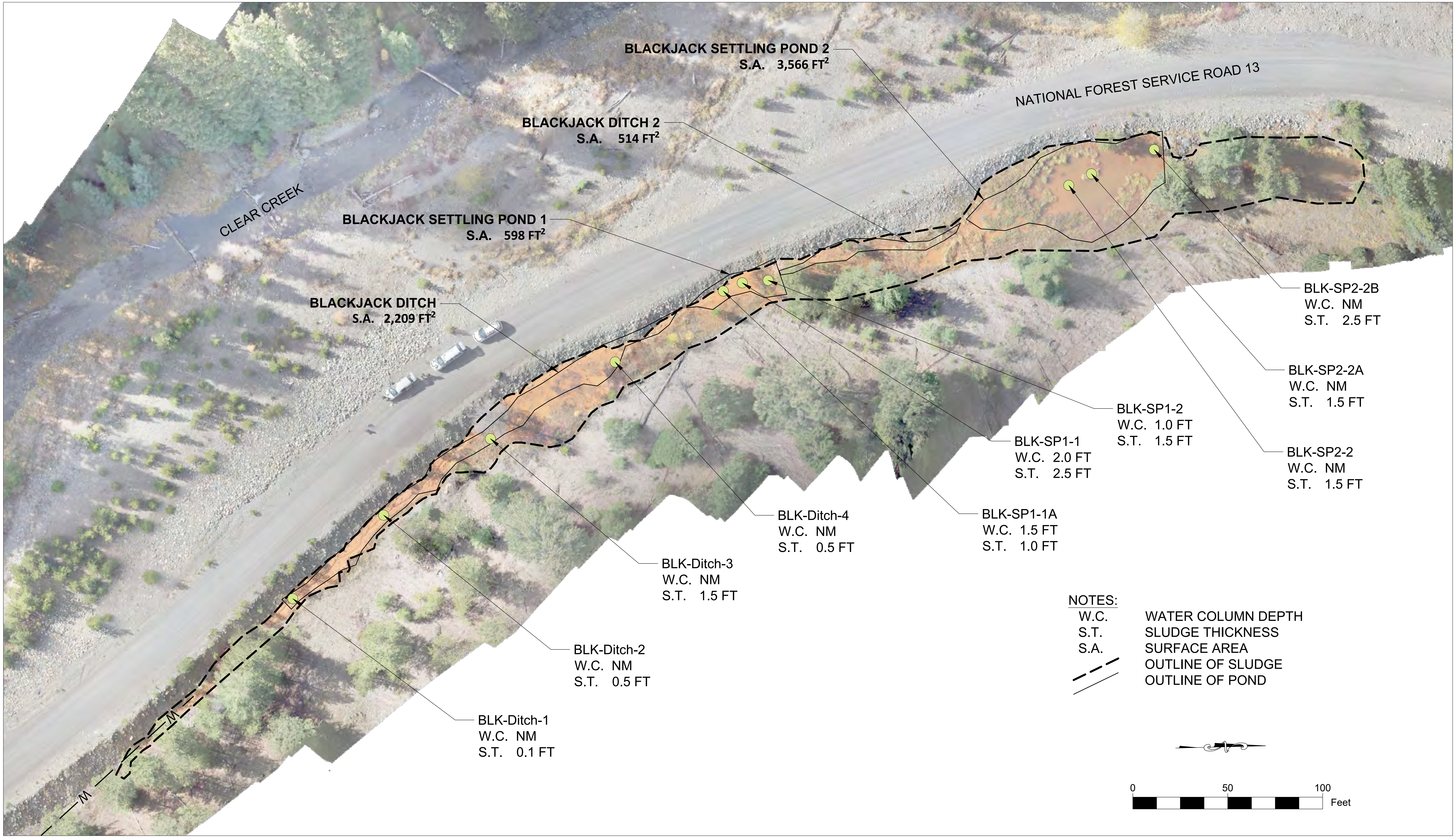
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLUEBIRD VOLUME ESTIMATES

REVISION DATE
11/15/2019

DRAWING NO.
7

SHEET
7 OF 23



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REVISIONS:

No.	Revision	DATE	INITIALS
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2			
3			

	Name	DATE
DESIGN:	P. HUNTER	11/15/2019
DRAWN:	A. BARENDT	11/15/2019
CHECKED:	P. HUNTER	11/15/2019

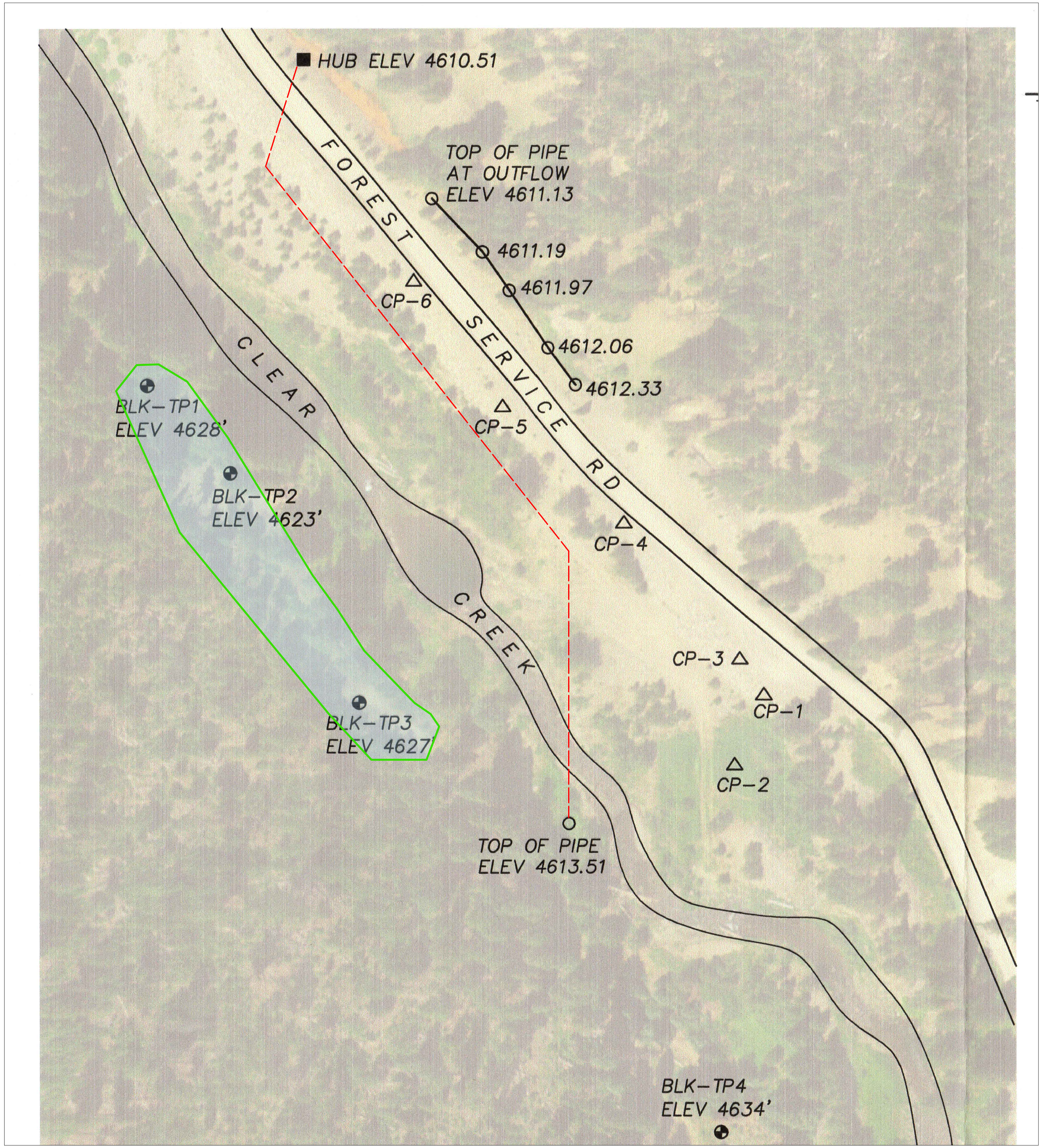
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLACKJACK VOLUME ESTIMATES

REVISION DATE
11/15/2019

DRAWING NO.
8

SHEET
8 OF **23**



LEGEND

○	SPOT ELEVATIONS ON TOP OF PIPE
⊕	TEST PITS
△	CONTROL POINT
■	HUB SET AT LOCATION OF PROPOSED OUTFLOW
– – – – (red)	APPX. PROPOSED NEW PIPELINE ROUTE
(green outline)	APPX. PROPOSED NEW WETLAND TREATMENT POND

Point No.	Northing	Easting	Elevation	Description
2	19944.65	29977.06	4617.52	Cotton Spindle
3	20028.64	29981.27	4621.78	Cotton Spindle
4	20136.80	29888.82	4620.21	Cotton Spindle
5	20229.57	29792.42	4620.61	Cotton Spindle
6	20329.35	29722.60	4620.25	1 1/2" Aluminum Cap
105	20395.43	29737.46	4611.13	Top of pipe at Outflow
107	19899.06	29845.58	4613.51	Top of Pipe on West side of Creek
116	20505.84	29635.53	4610.51	Hub at proposed Outflow

TEST PIT	NORTHING	EASTING	ELEVATION
BLK-TP1	20247.15	29511.33	4628
BLK-TP2	20177.49	29576.48	4623
BLK-TP3	19995.18	29678.36	4627
BLK-TP4	19653.53	29966.08	4634

NOTE: Fieldwork for this exhibit was performed June 20, 2020 and represent field conditions found at that time only. Elevation are based on an assumed datum,. Basis of bearings are based on Geodetic North taken at CP−1.

0 100 200 Feet

DESIGN: ______ DATE
DRAWN: ______ DATE
CHECKED: - ______ - DATE

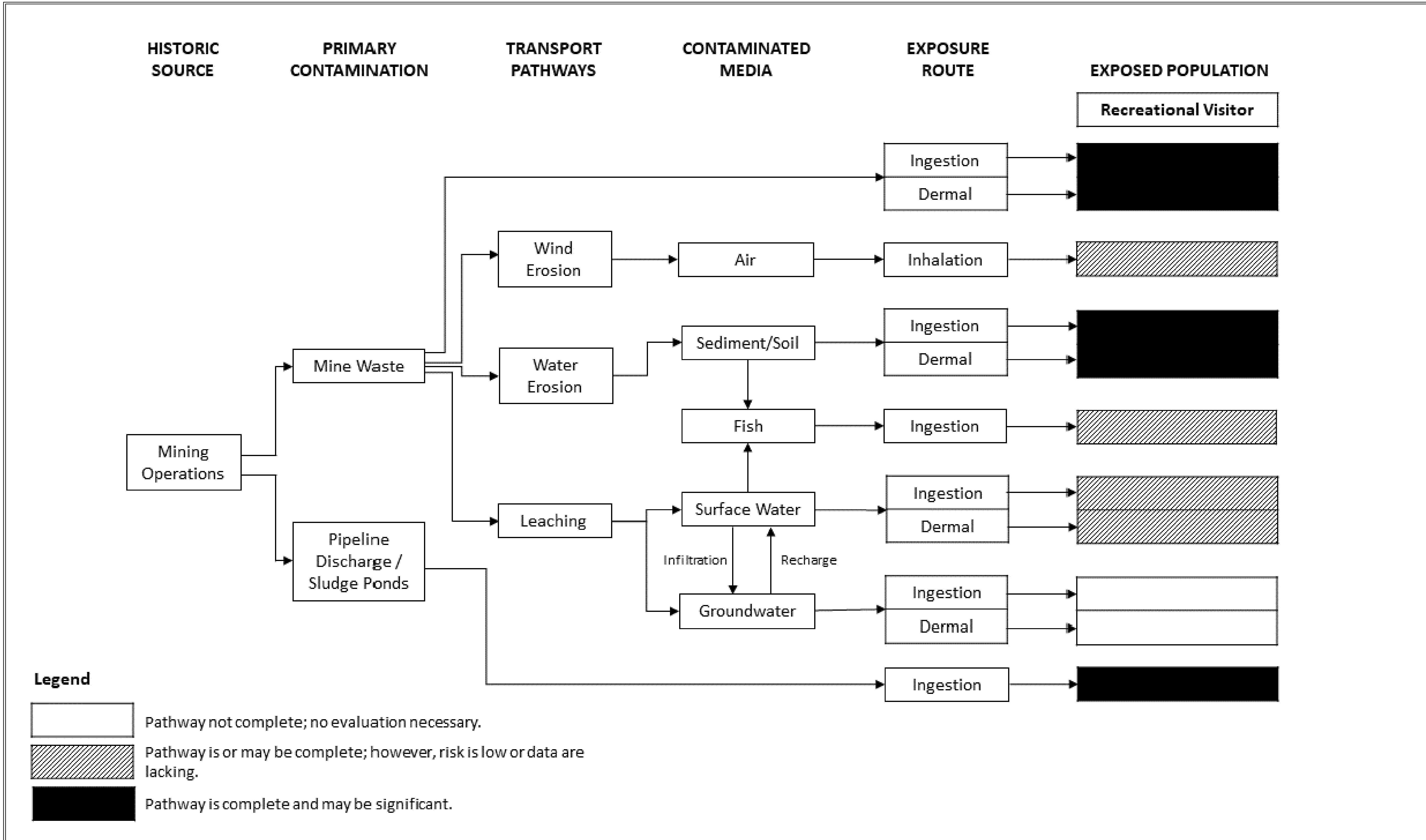
PROJECT NAME **BLUEBIRD/BLACKJACK EE/CA**

SECTION **BLACKJACK TEST PIT LOCATION & PIPELINE SURVEY**

REVISION DATE **11/6/2020**

DRAWING NO. **9**

SHEET **9** OF **23**



REVISIONS:			
No. 1		DATE	INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	C. MAXFIELD	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	P. HUNTER	11/15/2019 DATE

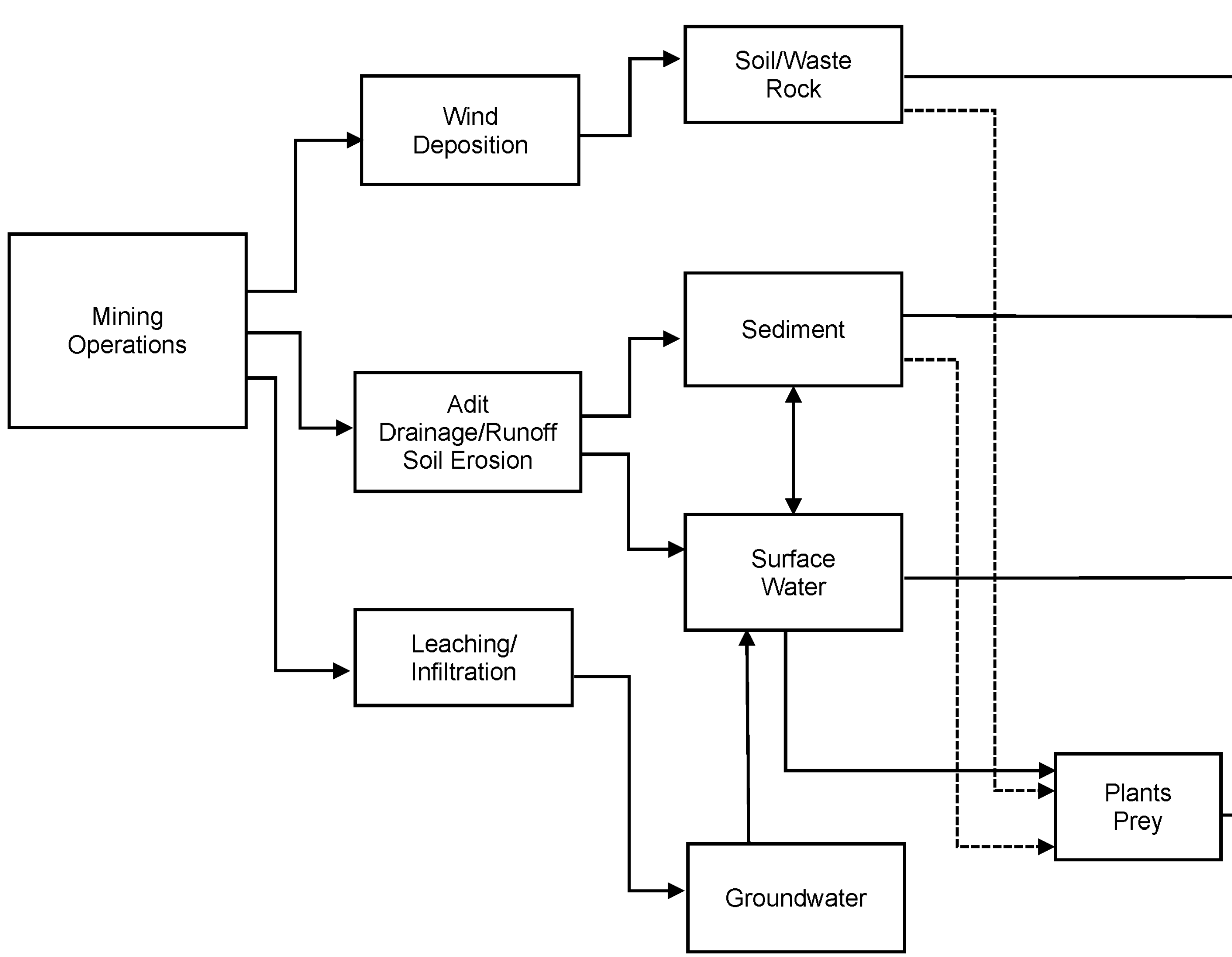
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
HUMAN HEALTH CONCEPTUAL SITE MODEL

REVISION DATE
11/15/2019

DRAWING NO.
10

SHEET
10 OF **23**



Exposure Route	Plants	Soil Invertebrates	Birds / Mammals	Benthic Invertebrates	Fish
Incidental Ingestion		○	○		
Direct Contact/Uptake	●	●	○		
Inhalation			○		
Incidental Ingestion			○	○	○
Direct Contact/Uptake	○		○	●	○
Ingestion	○		●	○	○
Direct Contact/Uptake	○		○	●	●
Ingestion		○	○	○	○

(Ecological Receptors)

○ Potentially complete exposure pathway; however, insignificant/not evaluated.
● Complete and significant exposure pathway; evaluated in SLERA.
☐ Incomplete exposure pathway; no evaluation necessary.

REVISIONS:
No. 1 ____ DATE INITIALS
No. 2 ____ DATE INITIALS
No. 3 ____ DATE INITIALS

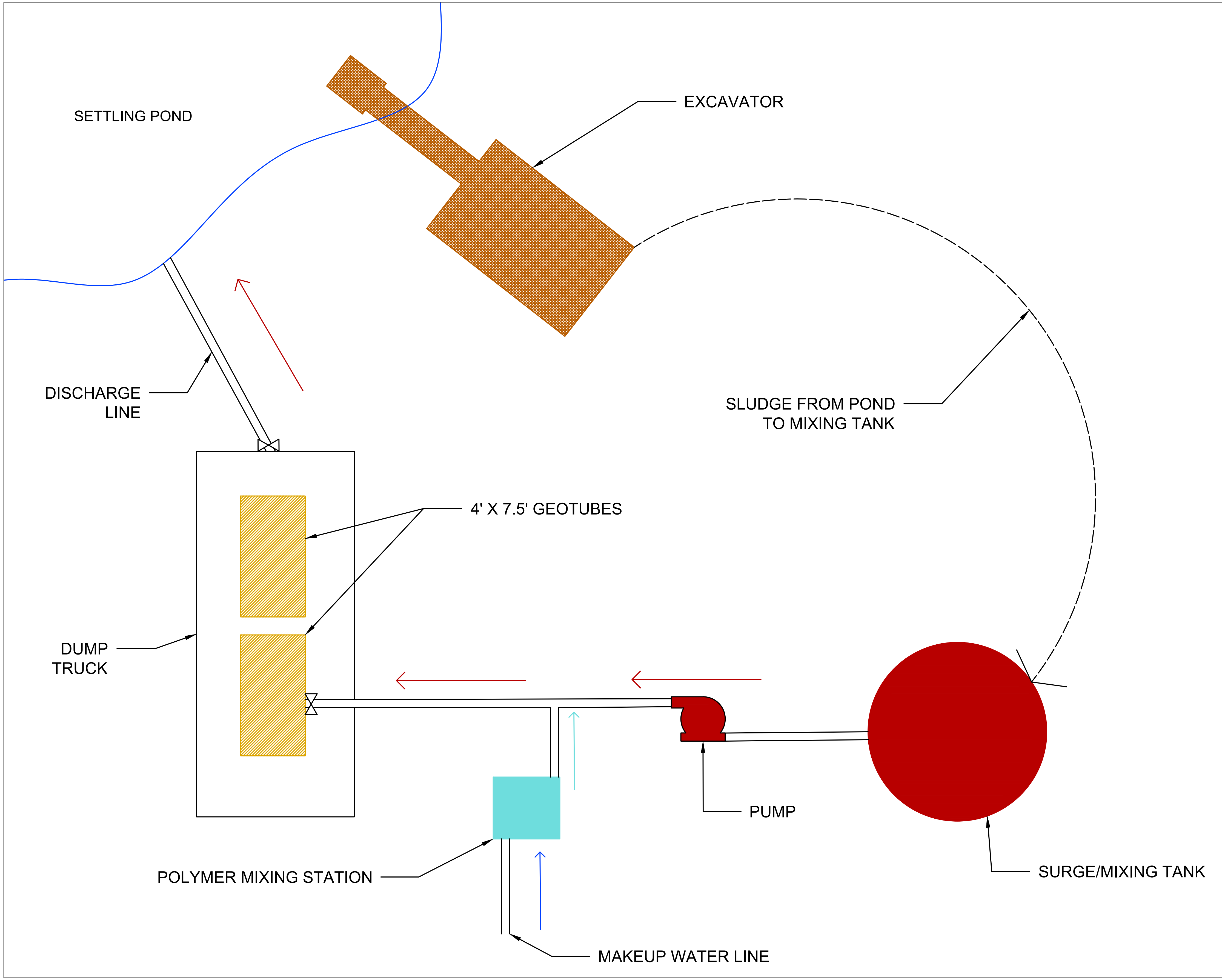
DESIGN: C. MAXFIELD 11/15/2019 DATE
DRAWN: A. BARENDT 11/15/2019 DATE
CHECKED: P. HUNTER 11/15/2019 DATE

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA
TITLE
ECOLOGICAL HEALTH CONCEPTUAL SITE MODEL

REVISION DATE
11/15/2019

DRAWING NO.
11

SHEET
11 OF 23



PUMPING OPERATIONS AND POLYMER MIXING AT BLUEBIRD SETTLING POND

GEOTUBE IN DUMP TRUCK AT BLUEBIRD SETTLING PONDS DURING PUMPING OPERATIONS

REVISIONS:

No.		DATE	INITIALS
1			
2			
3			

		DATE
DESIGN:	B. LAMBETH	11/6/2020
DRAWN:	O. SALMON	11/6/2020
CHECKED:	B. LAMBETH	11/6/2020

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

SECTION
GEOTUBE PUMPING SCHEMATIC

REVISION DATE
11/6/2020

DRAWING NO.
12

SHEET
12 OF 23

REVISIONS:			
No. 1		DATE	INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	B. LAMBETH	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	B. LAMBETH	11/15/2019 DATE

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
PROPOSED REPOSITORY LOCATION

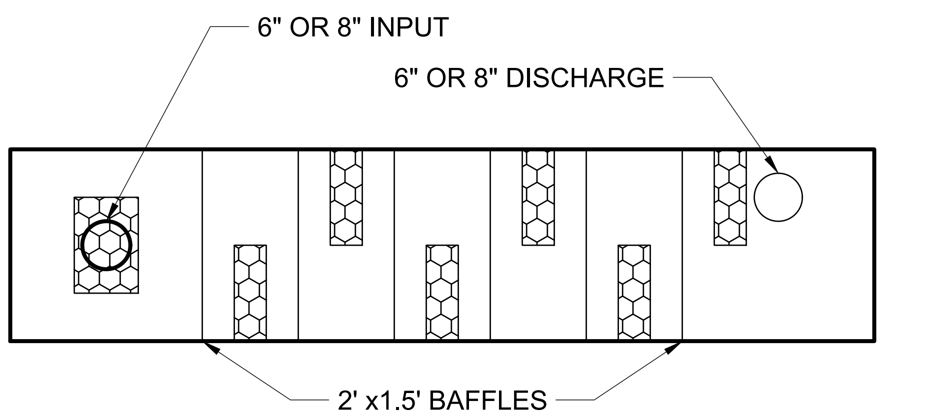
REVISION DATE
11/15/2019

DRAWING NO.
13

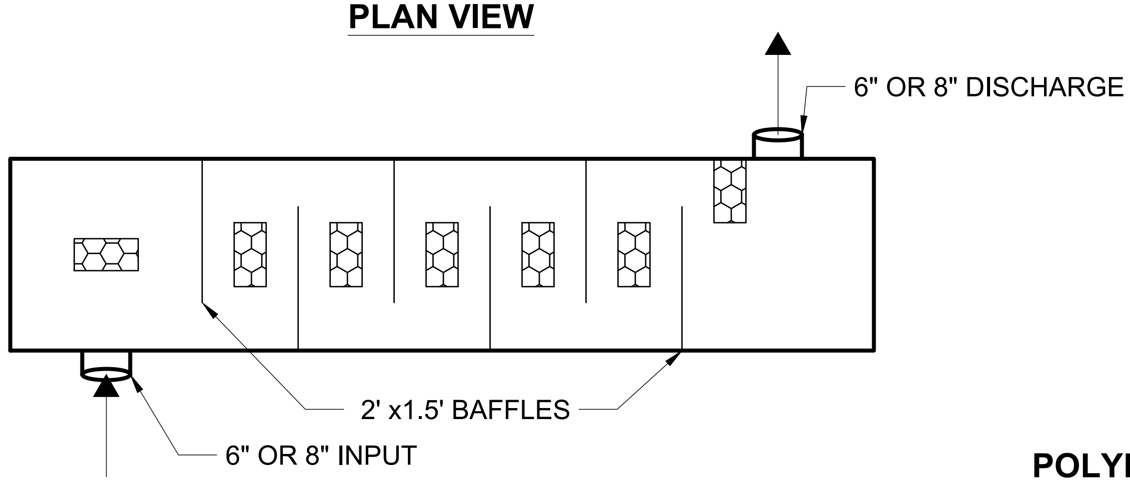
SHEET
13 OF **23**

BLUEBIRD POLYLOG VESSEL

CROSS SECTION

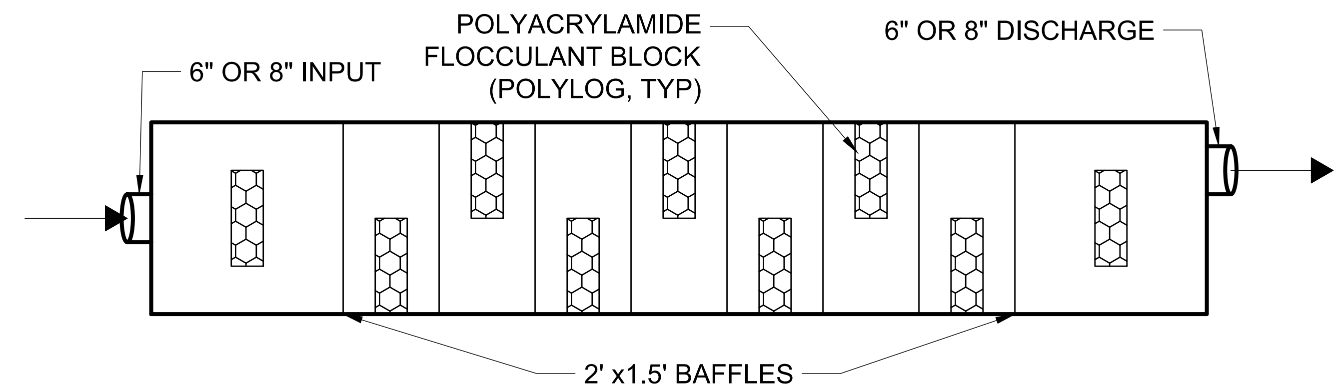


PLAN VIEW



BLACKJACK POLYLOG VESSEL

CROSS SECTION



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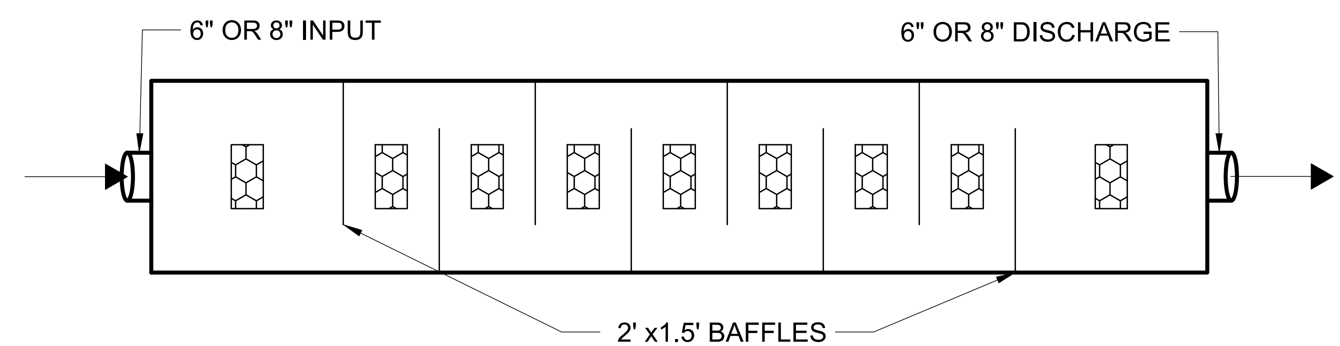
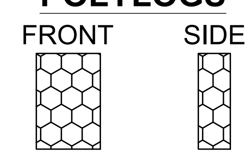
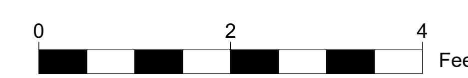


POLYLOGS





REVISIONS:		
No. 1	DATE	INITIALS
No. 2	DATE	INITIALS
No. 3	DATE	INITIALS

DESIGN:	B. LAMBETH	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	B. LAMBETH	11/15/2019 DATE

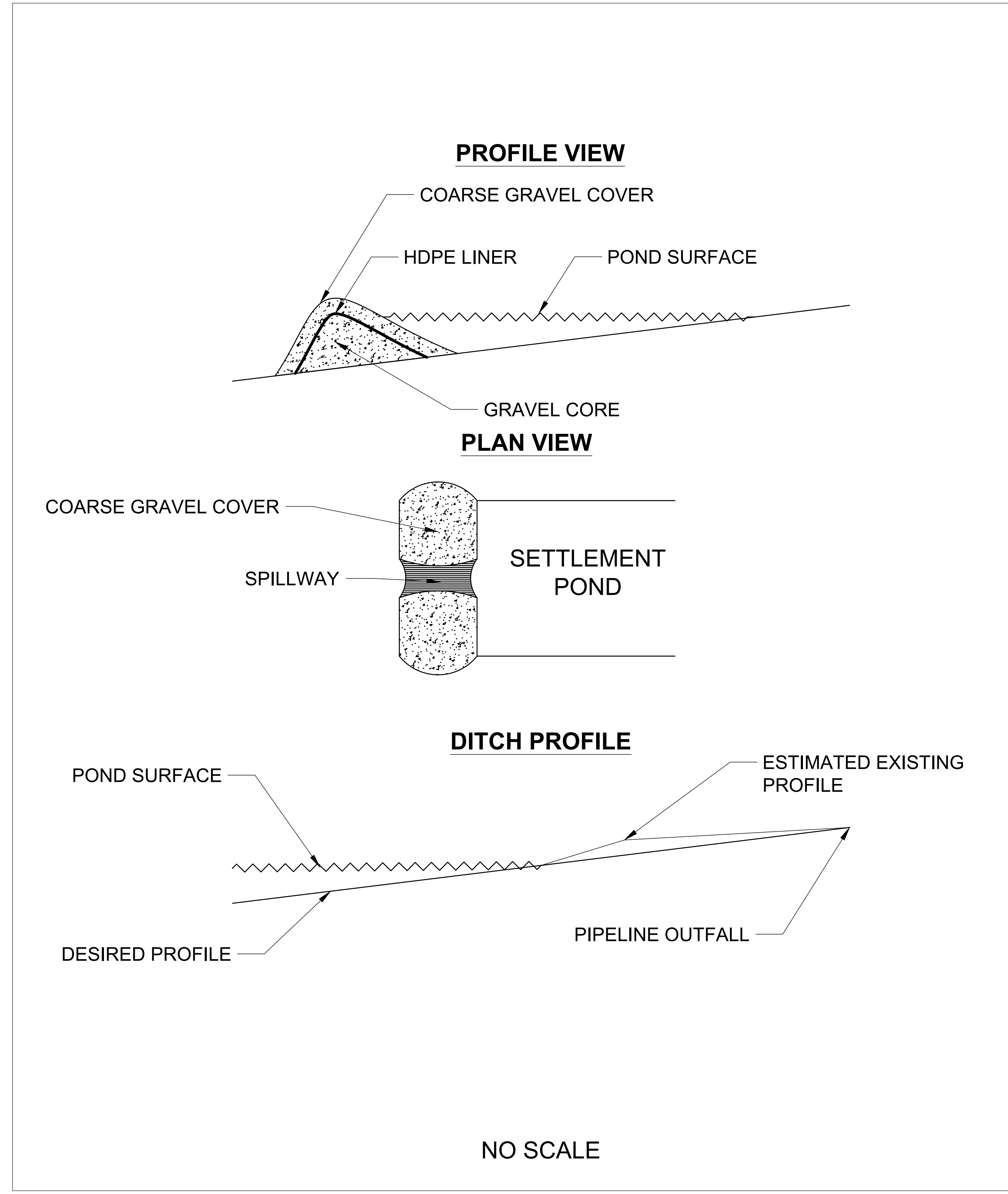
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
POLYLOG BOXES

REVISION DATE
11/15/2019

DRAWING NO.
14

SHEET **14** OF **23**



REVISIONS:

No.		DATE	INITIALS
1			
2			
3			

			DATE
DESIGN:	B. LAMBETH	11/15/2019	
DRAWN:	A. BARENDT	11/15/2019	
CHECKED:	B. LAMBETH	11/15/2019	

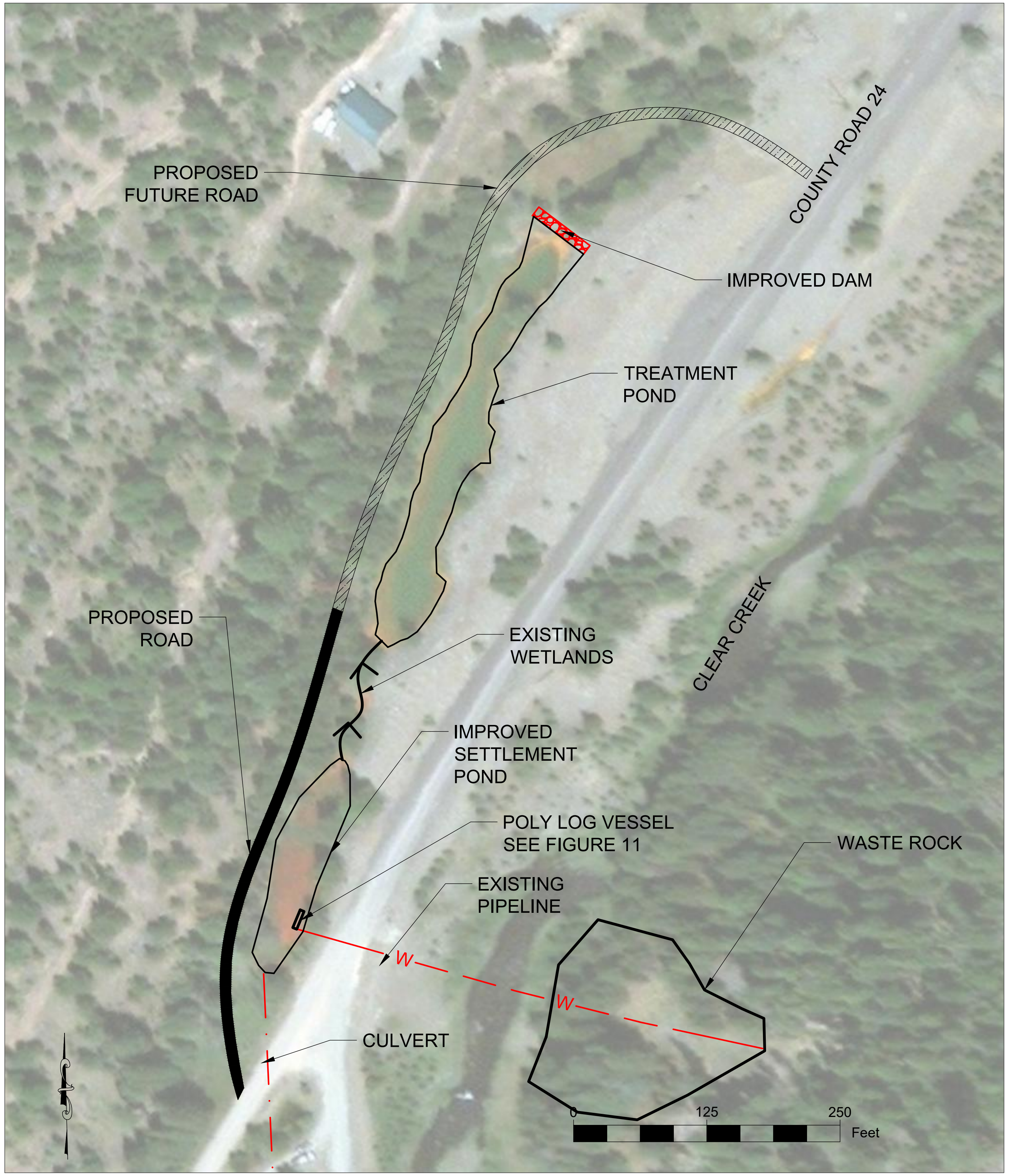
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLACKJACK PONDS UPGRADE

REVISION DATE
11/15/2019

DRAWING NO.
15

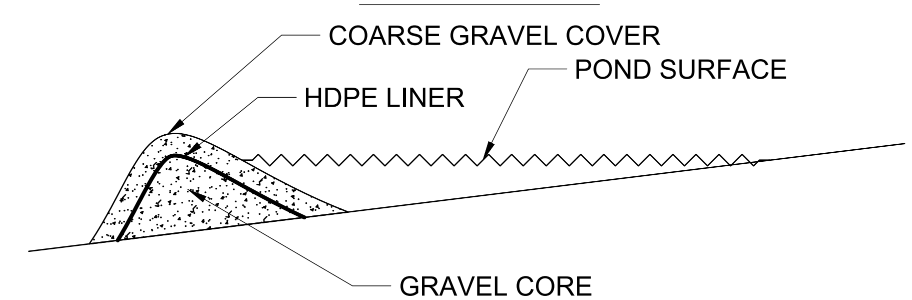
SHEET
15 OF 23



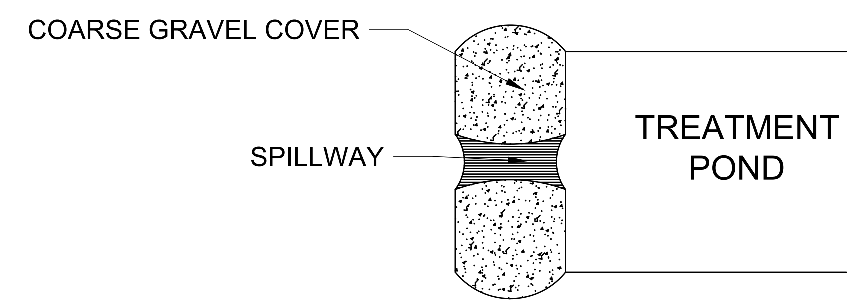
NOTES:

1. PROPOSED FUTURE ROAD WILL NOT BE NEEDED UNTIL INFILTRATION POND REQUIRES MAINTENANCE;
2. IMPROVED DAM WILL BE ONE FOOT HIGHER THAN EXISTING WITH AN IMPERMEABLE CORE;
3. EXISTING WETLANDS WILL REMAIN INTACT UNLESS REPLACED WITH AN ENGINEERED WETLANDS;
4. IMPROVED SETTLEMENT POND:
   - 4.1. EXISTING VEGETATION AND SLUDGE WILL BE REMOVED AND STORED AT THE REPOSITORY OR PLACED IN THE TREATMENT POND;
   - 4.2. THE SIDES AND BOTTOM WILL BE SMOOTH AND EVEN;
   - 4.3. THE POND WILL BE BACKFILLED IF NEEDED TO A MAXIMUM DEPTH OF 3 FEET; AND
   - 4.4. MAINTENANCE ACCESS WILL BE PROVIDED VIA THE PROPOSED ROAD AND THE COUNTY ROAD (WITH SOME IMPROVEMENTS)

PROFILE VIEW



PLAN VIEW



NO SCALE

REVISIONS:		DATE	INITIALS
No. 1			
No. 2			
No. 3			

		DATE
DESIGN:	B. LAMBETH	11/15/2019
DRAWN:	A. BARENDT	11/15/2019
CHECKED:	B. LAMBETH	11/15/2019

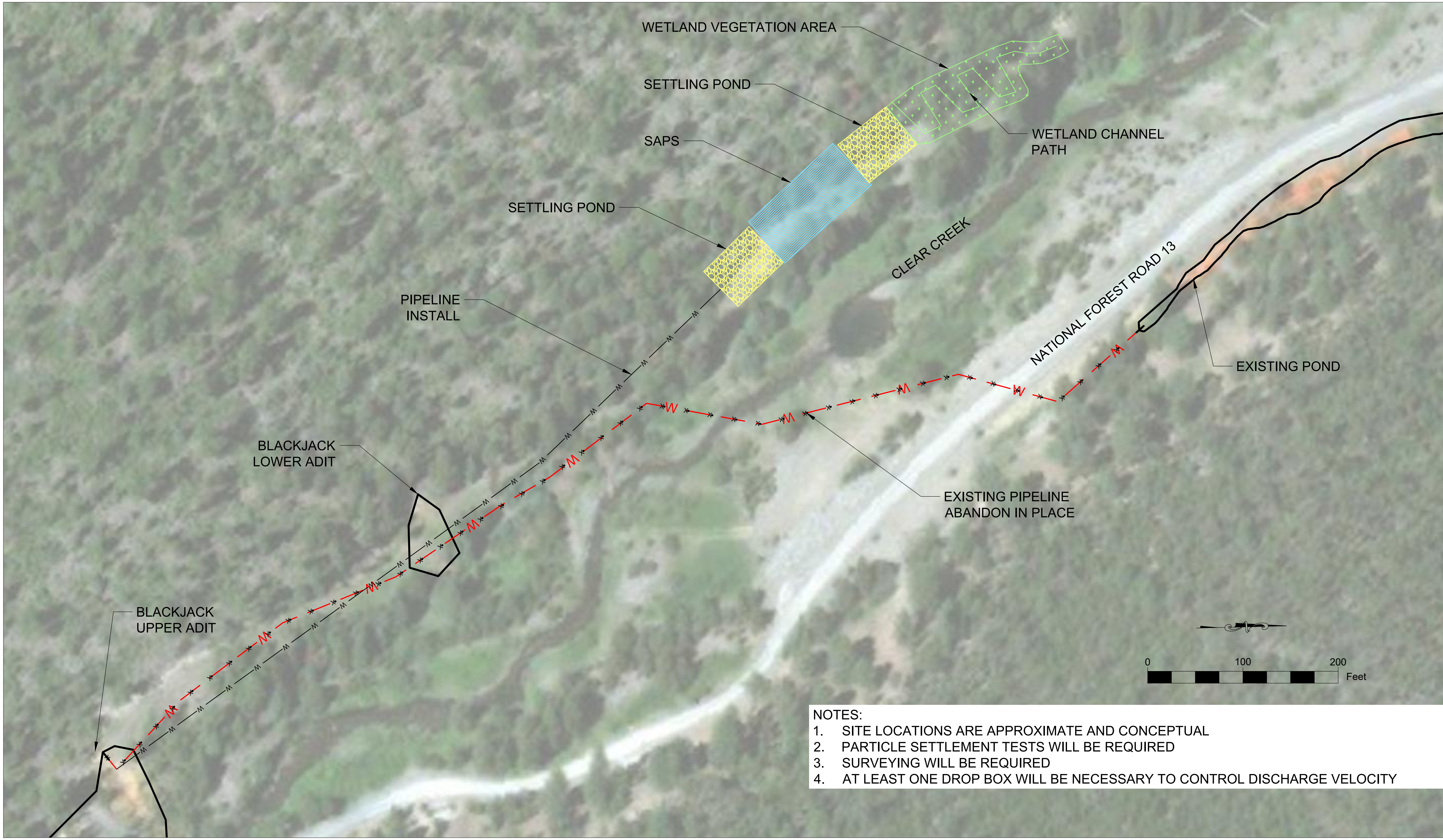
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLUEBIRD PONDS UPGRADE

REVISION DATE
11/15/2019

DRAWING NO.
16

SHEET
16 OF 23



NOTES:
1. SITE LOCATIONS ARE APPROXIMATE AND CONCEPTUAL
2. PARTICLE SETTLEMENT TESTS WILL BE REQUIRED
3. SURVEYING WILL BE REQUIRED
4. AT LEAST ONE DROP BOX WILL BE NECESSARY TO CONTROL DISCHARGE VELOCITY

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CHECKED:	B. LAMBETH	11/15/2019

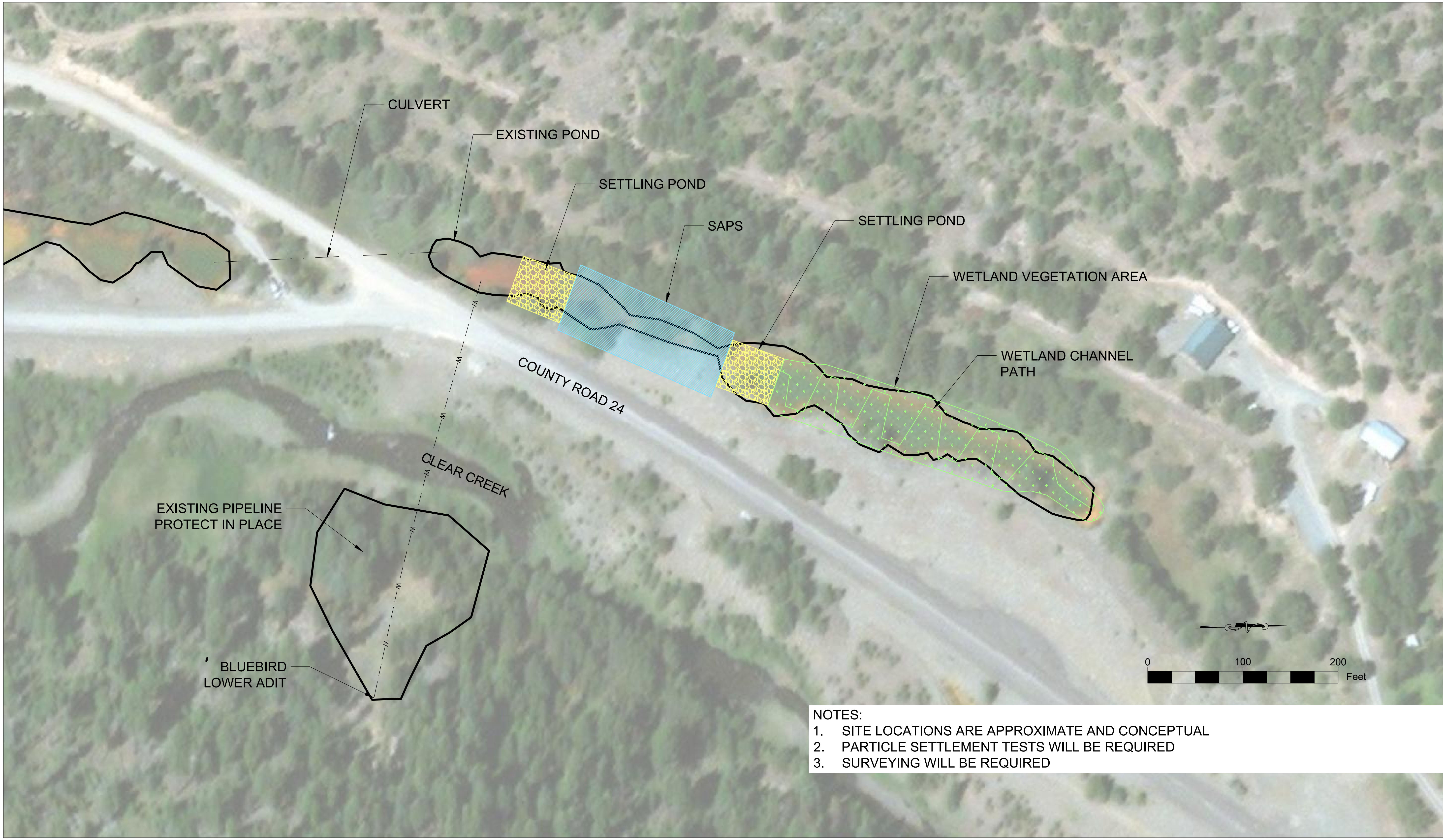
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLACKJACK MINE WETLAND TREATMENT SYSTEM

REVISION DATE
11/15/2019

DRAWING NO.
17

SHEET
17 OF 23



NOTES:
1. SITE LOCATIONS ARE APPROXIMATE AND CONCEPTUAL
2. PARTICLE SETTLEMENT TESTS WILL BE REQUIRED
3. SURVEYING WILL BE REQUIRED

REVISIONS:		DATE	INITIALS
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		DATE
DESIGN:	B. LAMBETH	11/15/2019
DRAWN:	A. BARENDT	11/15/2019
CHECKED:	B. LAMBETH	11/15/2019

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

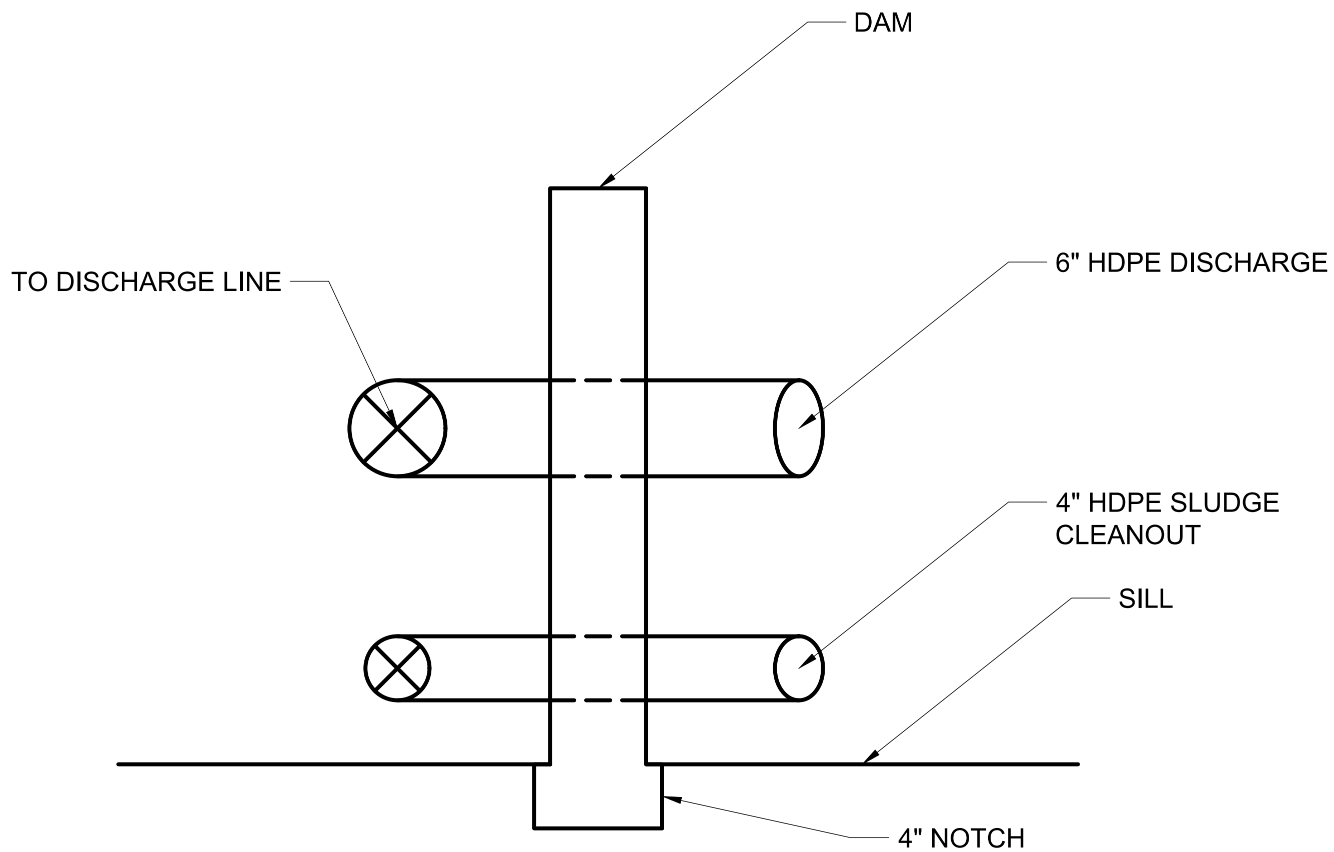
TITLE
BLUEBIRD MINE WETLAND TREATMENT SYSTEM

REVISION DATE
11/15/2019

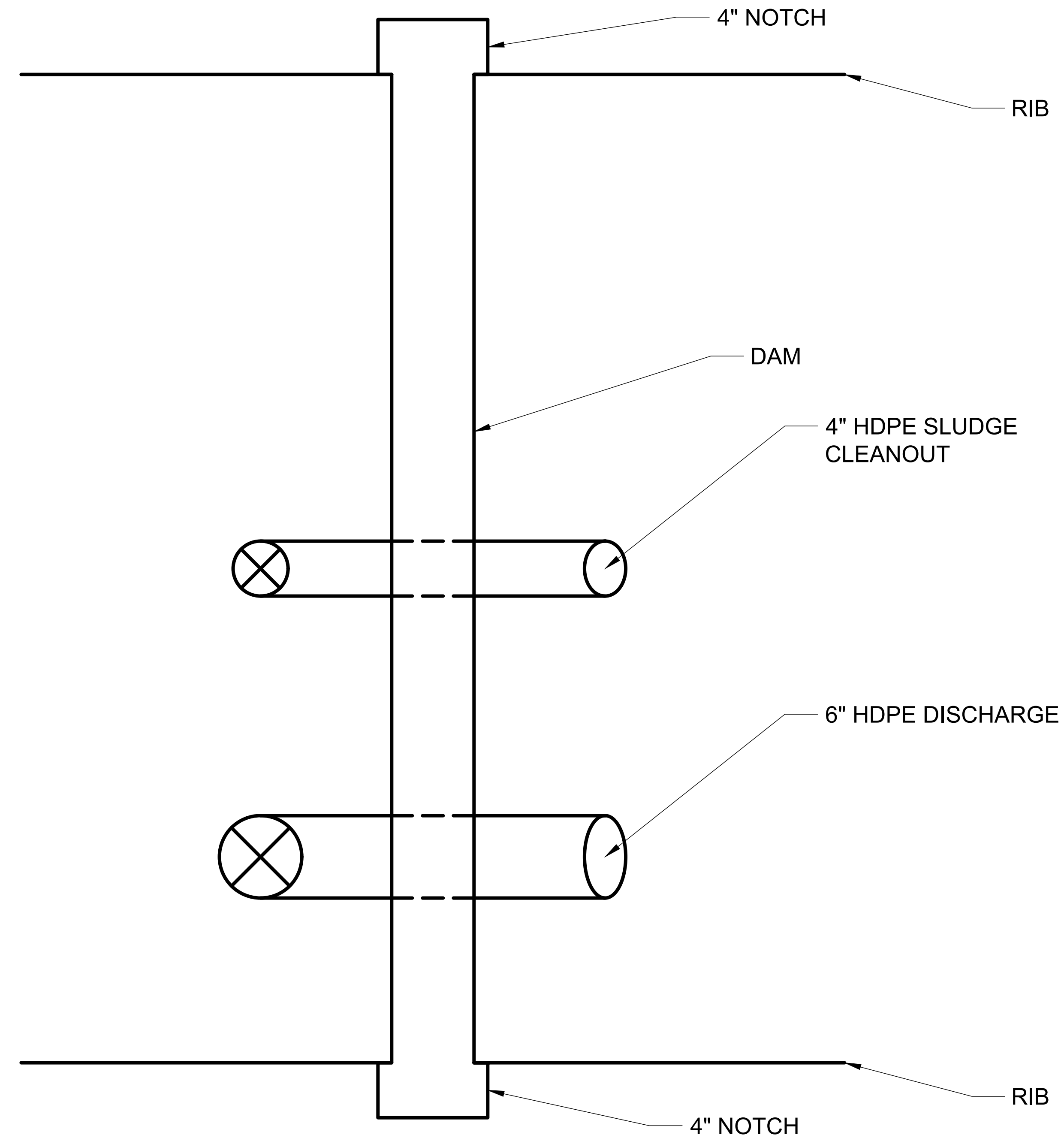
DRAWING NO.
18

SHEET
18 OF 23

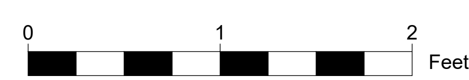
PROFILE VIEW



PLAN VIEW



NOTES:
1) SEE FIGURE 18 FOR LARGE SCALE LAYOUT
2) 4" SLUDGE CLEAN OUT IS DESIGNED TO WORK WITH A PUMP
3) DEBRIS SCREEN ON ALL INTAKES



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PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

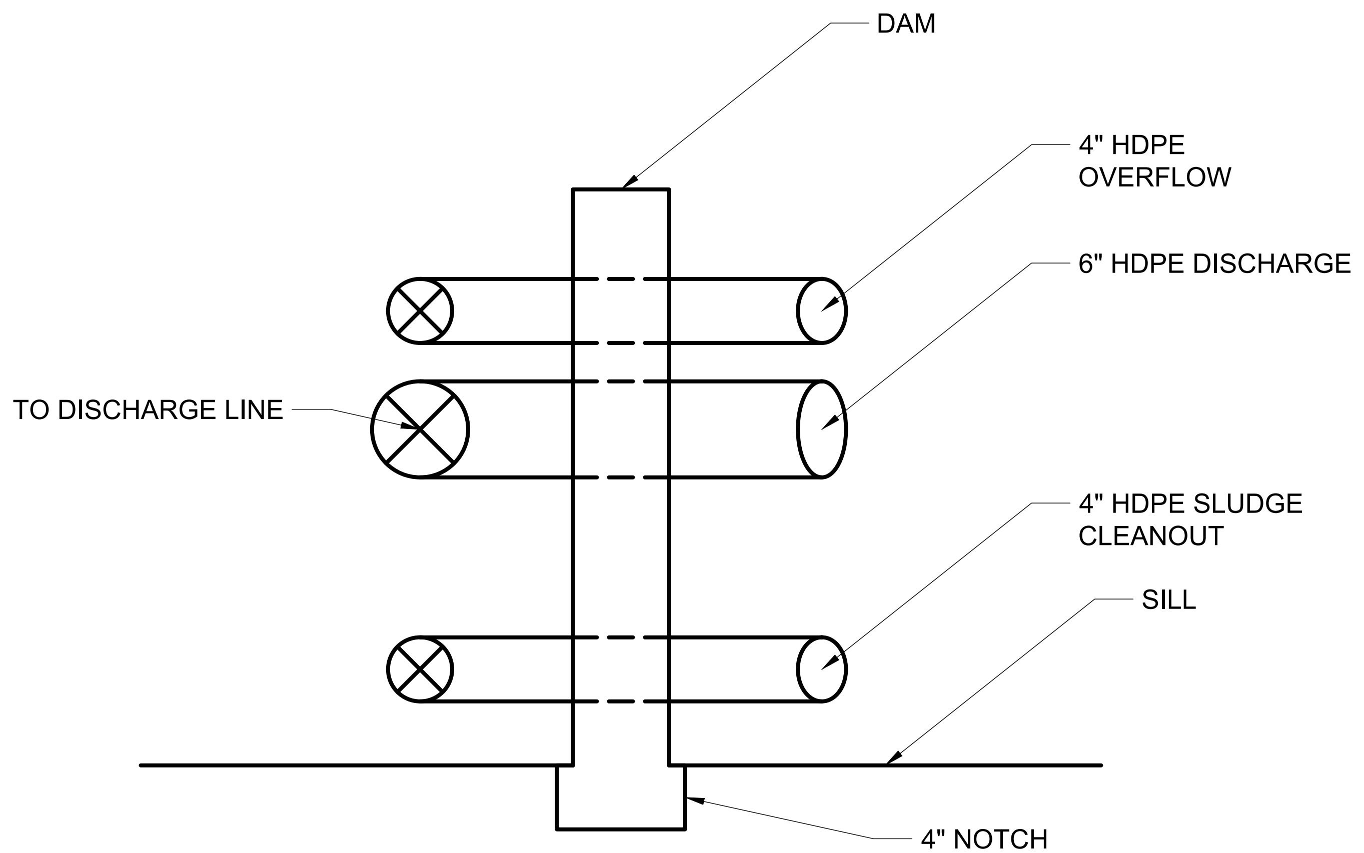
TITLE
NEW LOWER BLACKJACK ADIT DAMS

REVISION DATE
11/15/2019

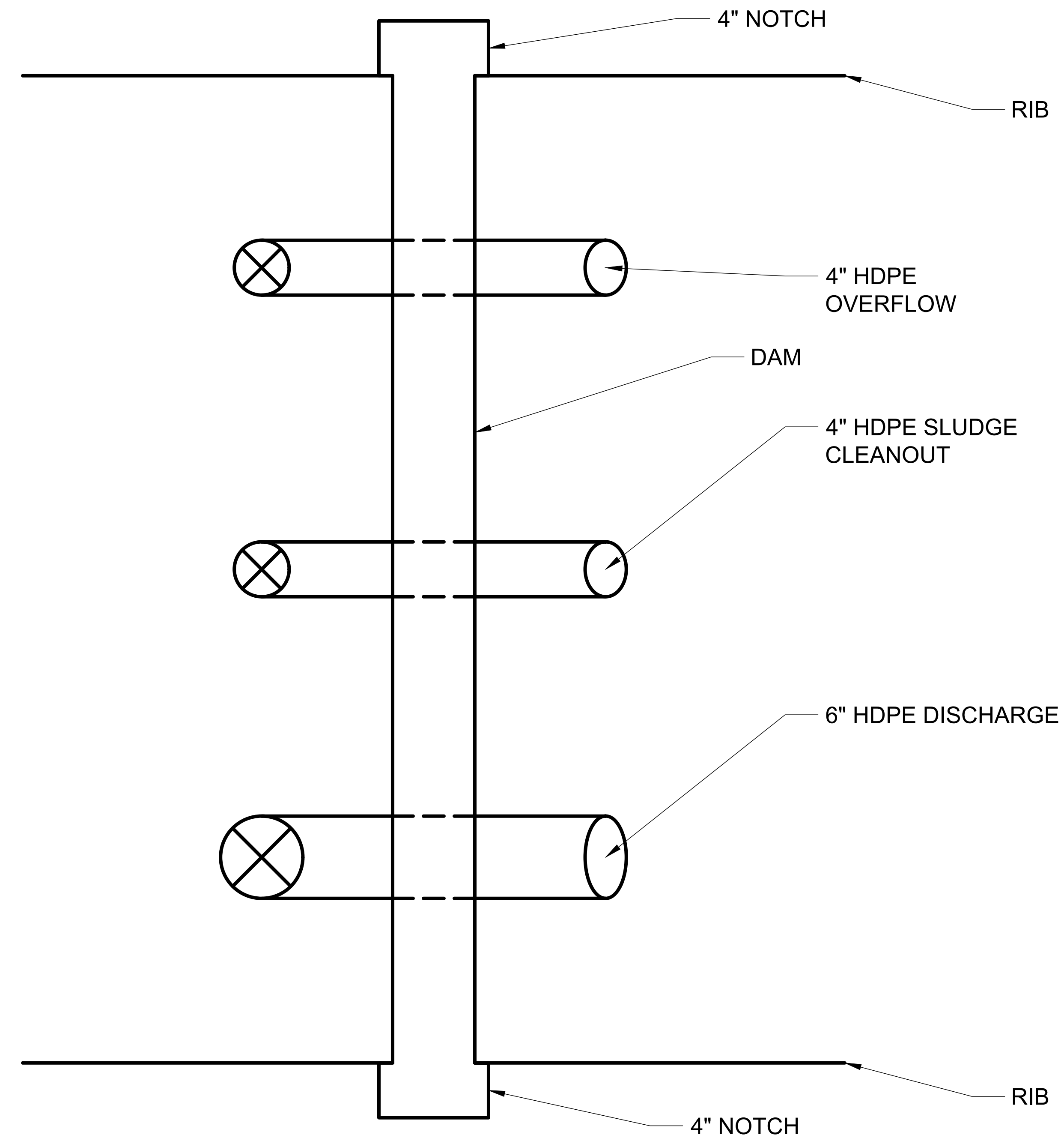
DRAWING NO.
19

SHEET
19 OF 23

PROFILE VIEW



PLAN VIEW



NOTES:
1) SEE FIGURE 18 FOR LARGE SCALE LAYOUT
2) 4" OVERFLOW LINE SHOULD BE OPEN EXCEPT OF MAINTENANCE
3) 4" SLUDGE CLEAN OUT IS DESIGNED TO WORK WITH A PUMP
4) DEBRIS SCREEN ON ALL INTAKES

0 1 2 Feet

REVISIONS:

No.		DATE	INITIALS
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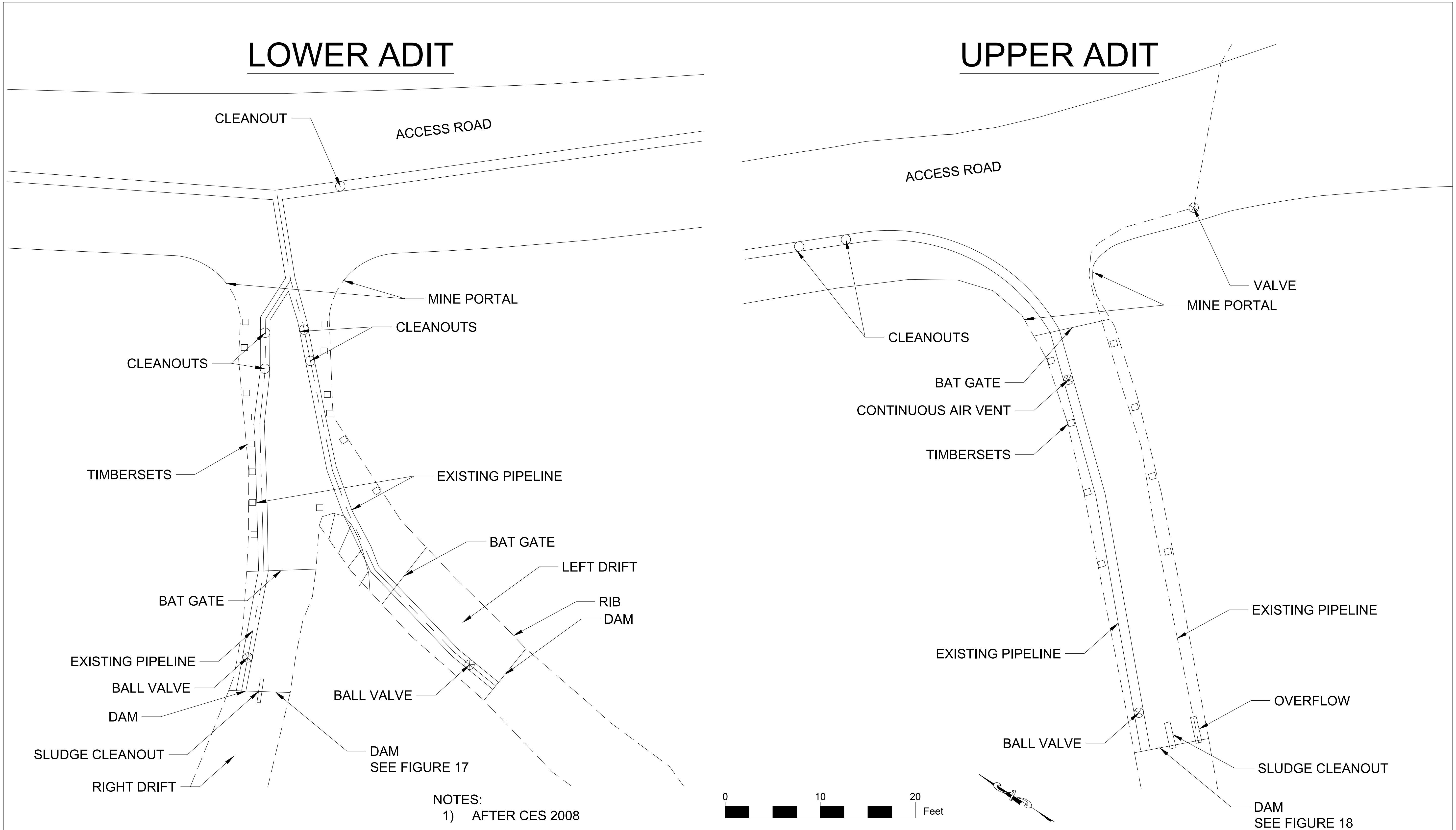
PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
NEW UPPER BLACKJACK ADIT DAMS

REVISION DATE
11/15/2019

DRAWING NO.
20

SHEET
20 OF 23



NOTES:
1) AFTER CES 2008

REVISIONS:

No.		DATE	INITIALS
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CHECKED:	B. LAMBETH	11/15/2019

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
BLACKJACK ADIT DAMS

REVISION DATE
11/15/2019

DRAWING NO.
21

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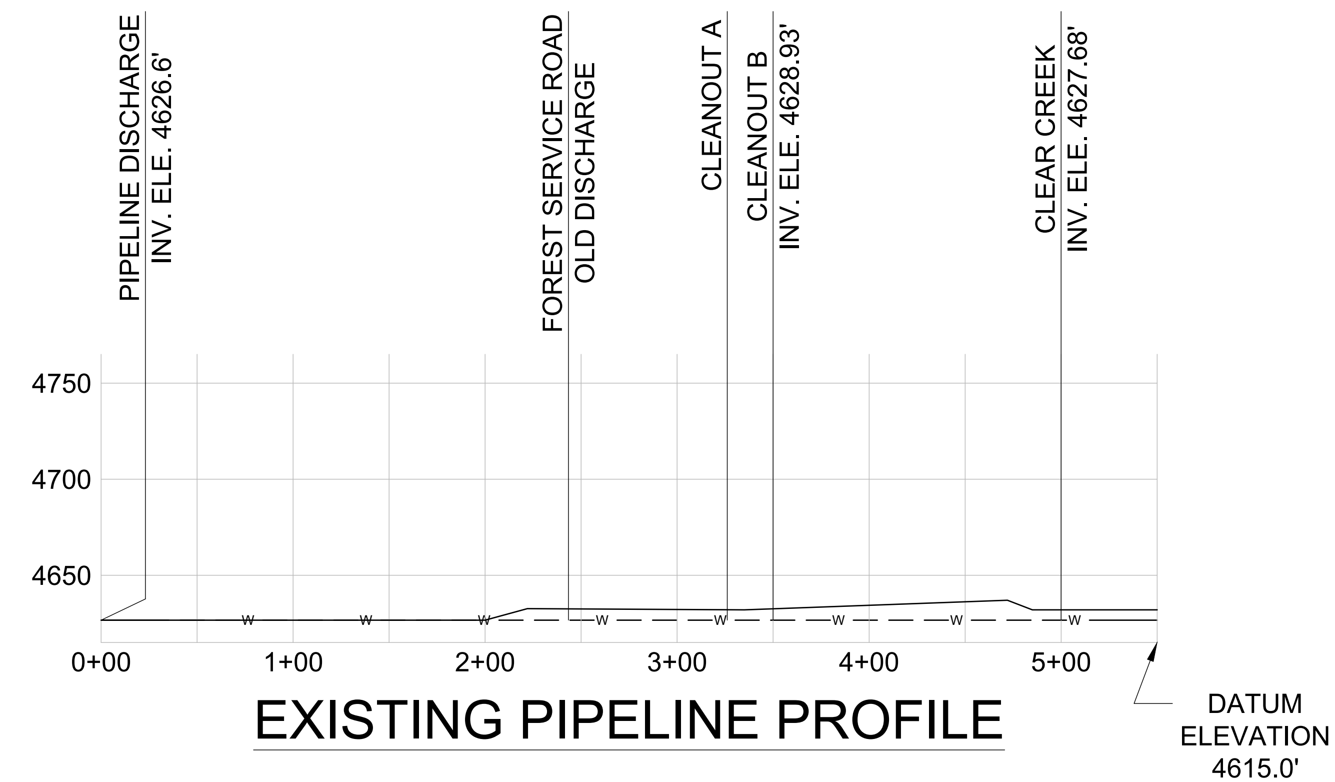


EXISTING PIPELINE PROFILE

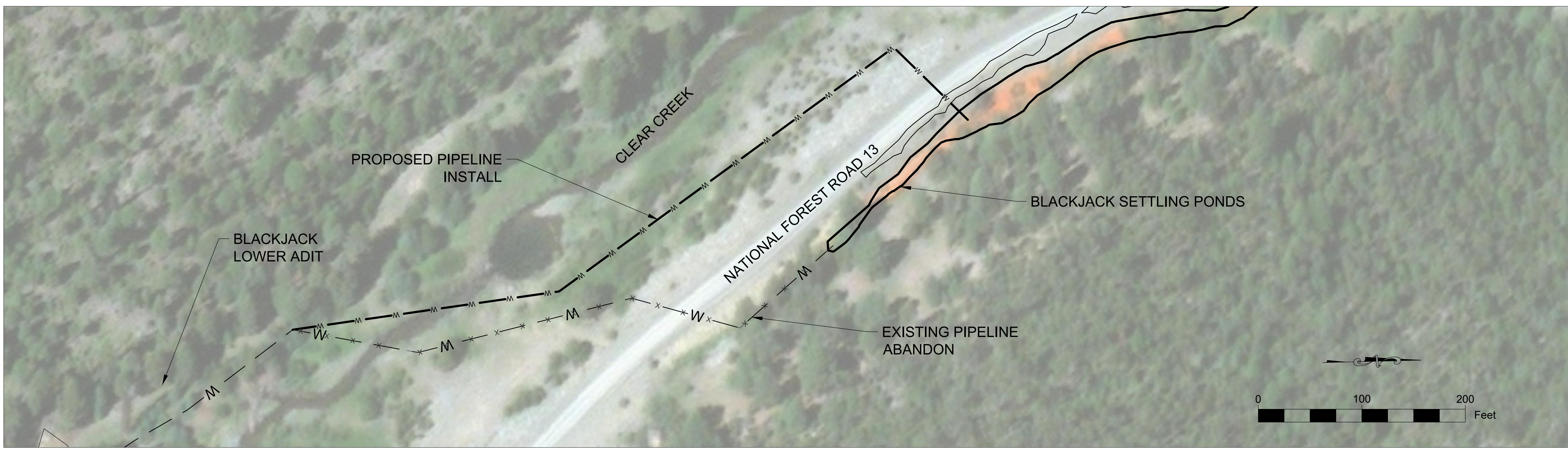
NOTES:

CURRENT PIPELINE PROFILE (LEFT):

1. PROFILE AFTER CES 2008
2. EXISTING DISCHARGE PIPELINE IS FLAT FROM CLEAR CREEK TO OUTFALL.
3. BASELINE ELEVATIONS DIFFER BETWEEN CES PROFILE AND PLAN VIEWS (PROFILE ELEVATION USED)

PROPOSED PIPELINE RELOCATION (BELOW):

1. NEW ROUTE WILL CREATE A RECOMMENDED GRADE OF APPROXIMATELY 0.01 INCH/FOOT
2. NEW LOCATION WILL WORK WITH EXISTING SETTLING PONDS
3. ROUTE WILL ADD APPROXIMATELY 350 FEET OF LINE
4. LOCATIONS SHOWN IN FIGURE ARE ESTIMATES. SURVEY WILL BE REQUIRED,
5. EXISTING PIPELINE SHOWN AFTER CES, 2013



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DESIGN:	B. LAMBETH	11/15/2019 DATE
DRAWN:	A. BARENDT	11/15/2019 DATE
CHECKED:	B. LAMBETH	11/15/2019 DATE

PROJECT NAME
BLUEBIRD/BLACKJACK EE/CA

TITLE
REPLACE/REROUTE BLACKJACK MINE PIPELINE

REVISION DATE
11/15/2019

DRAWING NO.
22

SHEET
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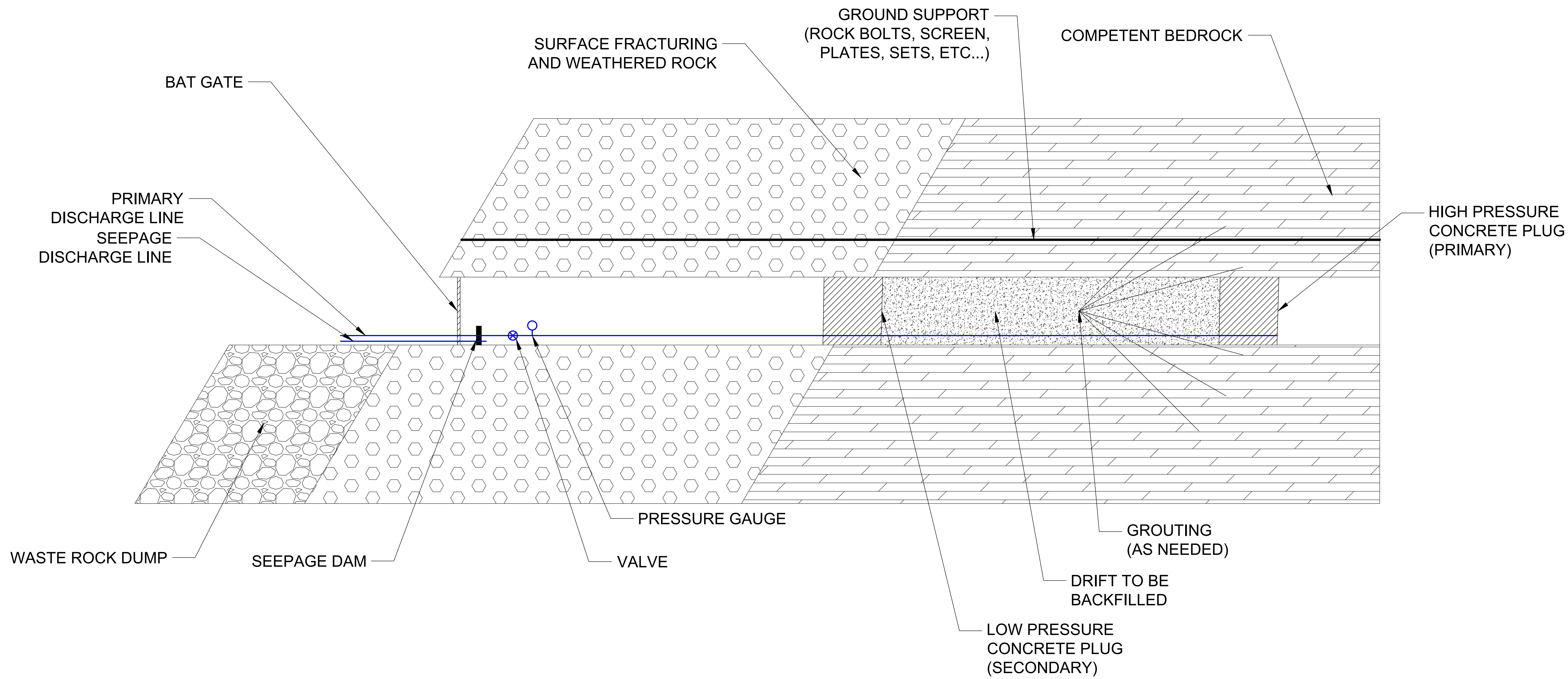

NOTES:

1) FIGURE IS CONCEPTUAL. NO SCALE.
2) DEPTH TO PLUG IS SITE-SPECIFIC AND DEPENDS ON FRACTURING, WEATHERING DEPTH, FAULTS, ROCK COMPETENCY, AND PROJECTED HYDROSTATIC AND LITHOSTATIC LOAD DIFFERENCES.
3) PLUG DESIGN WILL BE BASED ON ANTICIPATED HYDROSTATIC LOAD, ROCK COMPETENCY, AND WATER CHEMISTRY.
4) CONCRETE MUST BE NON-SHRINKING, IMPERMEABLE, AND USUALLY SULFATE RESISTANT.
5) REBAR IS USUALLY STAINLESS STEEL.
6) REBAR CAGE IS USUALLY ANCHORED TO DYWIDAG BOLTS IN BEDROCK.
7) MULTIPLE "GROUT RINGS" ARE USUALLY NECESSARY.
8) SEEPAGE SHOULD DISCHARGE TO INFILTRATION SYSTEM
9) A STANDBY INFILTRATION/TREATMENT SYSTEM SHOULD BE AVAILABLE TO "DE-PRESSURE" THE SYSTEM.

REVISIONS:		DATE	INITIALS
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		DATE
DESIGN:	B. LAMBETH	11/15/2019
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CHECKED:	B. LAMBETH	11/15/2019

PROJECT NAME: **BLUEBIRD/BLACKJACK EE/CA**

TITLE: **CONCEPTUAL BLACKJACK ADIT PLUG PROFILE**

REVISION DATE: **11/15/2019**

DRAWING NO. **23**

SHEET **23** OF **23**

APPENDIX 1

Summary of Previous Investigations and Historical Data Tables

APPENDIX 2

Site Photographs

APPENDIX 3

Laboratory Reports

APPENDIX 4

Data Gaps Report

APPENDIX 5

Quality Assurance / Quality Control

APPENDIX 6

Sludge Volume Calculations

APPENDIX 7

Screening Level Human Health Risk Assessment

APPENDIX 8

Streamlined Ecological Risk Assessment

APPENDIX 9

Potential Applicable or Relevant and Appropriate Requirements

APPENDIX 10

Wetland Treatment Conceptual Design Documents

APPENDIX 11

Detailed Cost Summary of Proposed Alternatives