SWANSON HYDROLOGY + GEOMORPHOLOGY

DRAFT Final Report

ESMERALDA CREEK RESTORATION AND STABILIZATION PLAN

for El Dorado Irrigation District

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1.0 INTRODUCTION

Swanson Hydrology + Geomorphology (SH+G) is working with the El Dorado Irrigation District (EID or District) to develop a Restoration/Stabilization Plan for Esmeralda Creek, a small tributary to the South Fork of the American River (SFAR) near Pollock Pines, California (Figure 1). The Restoration Plan is being developed to satisfy the requirements set forth in the Project 184 Settlement Agreement (EID, 2003), U.S. Forest Service 4(e) License Condition No. 36 (FS, 2003), and California State Water Resources Control Board Section 401 Clean Water Act Water Quality Certification Condition No. 7 (SWRCB, 2006). Restoration of Esmeralda Creek is needed to stabilize the channel and improve continuity of aquatic and riparian habitat along the creek corridor.

This report presents a plan for restoring/stabilizing the Esmeralda Creek channel. Section 1 provides an introduction and review of the project setting. Section 2 presents methods and results of field investigations and a discussion of site-specific hydrology. Section 3 discusses the principle factors contributing to instability of the channel and presents the plan for restoring/stabilizing the creek. References are provided in Section 4.

1.1 OBJECTIVES

Objectives for the project were established in the Rationale Report for Final Section 4(e) Conditions (FS, 2003). The primary objectives are as follows:

- Restore the original main channel that receives bypass flows from the District's diversion,
- Provide aquatic habitat continuity from upstream of the El Dorado Canal diversion to the mainstem SFAR.

These objectives have been used to guide the creek assessment and restoration planning process. The Restoration/Stabilization Plan described in Section 4 of this document is designed to achieve the objectives stated above.

1.2 LOCATION AND SETTING

Esmeralda Creek originates at elevation 4,500 feet and flows 2.0 miles to its confluence with the SFAR, at elevation 3,000 feet. The Esmeralda Creek watershed covers approximately 525 acres or 0.82 square miles (mi^2) (Figure 1). The drainage area at the project site is approximately 0.73 mi^2. The watershed lies entirely within El Dorado County. The watershed is predominately steep terrain (average slope ~ 15%) with dense forest cover. There is a network of dirt roads through the watershed used for local residential access and timber harvesting.

Approximately 3,000 feet upstream of the confluence with the SFAR the El Dorado Canal (canal) bisects Esmeralda Creek. The District operates and maintains a system which bypasses some flow in Esmeralda Creek over the canal and diverts a portion of the flow into the canal in accordance with FERC licensing conditions. The bypass/diversion system begins at a flashboard-controlled impoundment that raises the water surface to the entrance of the bypass/diversion flume. The bypass/diversion consists of a 196-foot-long, 5-foot-diameter Lennon flume (semi-circular steel) that crosses over the canal. Flap gates in the bottom of the flume are manually operated to divert water into the canal (Figures 2 and 3). The District is required to bypass 1 to 2 cfs, or natural flow, before they can begin to divert water[1].

After crossing over the canal the bypass flow spills from the flume into a network of channels. The channels are steep and eroding; the bed substrate consists of excavation spoils, which were believed to be placed during construction of the original canal and Esmeralda Tunnel. There is also a channel associated with a canal spillway (El Dorado Canal Spillway No. 30) that is used in emergency situations to control water levels in the canal (Figure 2 and 3). The spillway channel runs parallel to Esmeralda Creek and joins the main creek channel approximately 200 feet downstream of the canal. There is a wood flume in the upper portion of the spillway channel that conveys water down the steepest portion of the spillway channel. The wood spillway structure is in poor condition (wood rot, holes in bottom, etc.) and does not appear to serve its intended function.

For the purposes of this document the “study area” refers to Esmeralda Creek from the SFAR to approximately 500 feet upstream of the diversion impoundment. The limits of the “project area” extend from the District’s diversion impoundment to the downstream end of the unstable reach (see Section 2.2).

1.3 OWNERSHIP AND LANDUSE

Portions of Esmeralda Creek watershed are within the boundaries of the Eldorado National Forest (ENF), though much of the land within the watershed is privately held (Figure 1). Esmeralda Creek crosses the canal on property owned by Nina Poole. The FS owns land along Esmeralda Creek downstream of the Poole property and another parcel in the western portion of the watershed. Sierra Pacific Industries, a timber company, owns much of the upper watershed. Contemporary land uses in the watershed are predominately open space and forestry with some residential development and transportation. Review of historic aerial photos indicates that logging in the watershed has been significant. Highway 50, a major east-west transportation corridor in Northern California, crosses Esmeralda Creek in the lower portion of the watershed.

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[1] For March through May the bypass flow requirement is 2 cfs or natural flow i.e., if flow entering the diversion impoundment is greater than or equal to 2 cfs, then bypass flow must be 2 cfs. Flow exceeding 2 cfs may be diverted to the canal. If flow entering the diversion impoundment is less than 2 cfs then bypass flow is equal to the natural flow at the impoundment (i.e., no flow can be diverted to the canal). For June through February, the bypass flow must be 1 cfs or natural flow.

2.0 SITE CHARACTERIZATION AND ANALYSES

The site characterization included field-based assessments to determine the extent and causes of instability in the channel. Specifically, the field assessments included:

- Topographic survey;
- Reach delineation;
- Aquatic habitat assessment;
- Geomorphic characterization; and
- Geotechnical investigation of the excavation spoil piles

All of the field assessments were conducted in October 2007. The evaluation of site conditions also included a flood frequency analysis for the project site. The methods and results of these investigations are discussed in the following sub-sections.

2.1 TOPOGRAPHIC SURVEY

SH+G conducted a ground-based topographic survey of the project area. A local datum and assumed basis of bearings were established for vertical and horizontal control. A topographic map with 1-foot contours was developed in AutoCAD (Figure 3).

2.2 REACH DELINEATION AND DESCRIPTIONS

Reach delineation consists of identifying physical boundaries along the creek corridor based on landscape-scale variability in factors such as geology, channel and/or valley morphology (e.g., slope or confinement). Reaches were delineated beginning at the Esmeralda Creek-SFAR confluence and continued to the Plum Creek Road (ENF No. 10N40) crossing located approximately 500 feet upstream of the District’s diversion. A total of 8 reaches were delineated in the study area (Figure 4) and are described as follows:

> ***Reach 1- SFAR Confluence to Highway 50 (570 feet).*** Esmeralda Creek in this reach is extremely steep (~45% slope). An attempt was made to locate the confluence at the SFAR, but there are numerous drainage paths along the SFAR channel, making it difficult to discern Esmeralda Creek. From Highway 50 looking downstream the Esmeralda Creek alignment is again difficult to identify. The slope immediately below the road is composed of blast rock and fill from construction of the Highway 50 **(Photo 1)**. It appears that the Esmeralda Creek channel was buried during construction of the highway. Esmeralda Creek crosses underneath Highway 50 in a culvert; the culvert outlet could not be located. No riparian habitat was observed in the area immediately downstream of Highway 50, and due to the extreme slope, one would surmise that this portion of the creek does not provide valuable aquatic habitat.
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> ***Reach 2- Bridal Veil Falls (110 feet).*** Reach 2 is Bridal Veil Falls, a near vertical cascade approximately 150 feet in height. The falls is visible from Highway 50. This reach supports limited riparian habitat and is an obvious barrier to movement of aquatic species **(Photo 2 & Photo 3).**

Reach 3- Lower Gorge (515 feet). Above Bridal Veil Falls the channel continues to be a very steep (~50% slope) series of cascades **(Photo 4).** The channel is predominately bedrock with some gravel/cobble accumulating in the deeper pools. Large woody debris (LWD) is abundant throughout the reach. Mountain dogwood (*Cornus nuttallii*) and bigleaf maple (*Acer macrophyllum*) are dominant along the riparian corridor; the slopes of the gorge/canyon are dominated by mixed conifer forest.

Reach 4- Yew Trees (720 feet). In Reach 4, the channel and valley slope decreases (~20%). The channel is a mix of bedrock and large boulders with cobble substrate in the pools **(Photo 5).** The forest canopy in this reach is more open than in Reach 3, but still dense. A Pacific yew (*Taxus brevifolia*) tree, a FS sensitive species, marks the beginning of the reach. There are other yew trees spread throughout the reach along the riparian corridor. Near the upstream end of the reach there is a debris jam composed of 8 to 10, 24+ inch diameter logs **(Photo 6).** Gravel and fines have accumulated at the upstream end of the debris jam.

Reach 5- Big Trees (970 feet). In Reach 5 channel and valley slope continue to decrease (~10%). The channel is predominantly gravel/cobble alluvium with fewer bedrock exposures present. In this reach the channel is more sinuous and there is some development of floodplain surfaces **(Photo 7)**. The surrounding valley slopes are extremely steep in portions of the reach. Mountain dogwood thickets occlude portions of the channel. There are a few 8 to 10 foot diameter-at-breast-height (dbh) Douglas fir (*Pseudotsuga menziesii var. menziesii*) trees along the riparian corridor. Near the upstream end of the reach there is an active landslide on the left bank of the creek. The landslide toe, where groundwater seepage was observed, has been colonized by horsetail (*Equisetum* sp.) and ferns **(Photo 8).**

Reach 6- Below El Dorado Canal (280 ft). Reach 6 is the portion of the project area downstream of the canal and the location of the most significant channel instability/disturbance. There are three significant flow paths (i.e., channels) immediately downstream of the canal: the East, Central and West Channels, as shown on Figure 3. The channels are separated by embankment fill and spoils excavated from the Esmeralda Tunnel. Esmeralda Creek crosses the canal and flow spills from the bypass flume into a large pool **(Photo 9).**

From the large pool most of the flow goes into the East Channel that parallels an embankment near the toe of the hillslope. The embankment is constructed of fine-grained material and follows the alignment of the canal that existed prior to construction of the Esmeralda Tunnel. Approximately 130 feet downstream of the bypass flume the East Channel crosses through the embankment and connects with the Central Channel **(Photo 10).** Approximately 50 feet downstream of the East-Central Channel confluence there is a large, unstable headcut **(Photo 11).**

Approximately 120 feet downstream of the East-Central confluence, the Central Channel joins the West Channel, which emanates from the canal spillway **(Photo 12)**. This juncture is at the downstream end of the reach and the Esmeralda Creek channel is in good, functioning condition at this location. It is important note that throughout Reach 6 most of the stream flow goes subsurface, resurfacing at the downstream end. This is likely because the channel alignments have been highly altered and there has been a significant amount of porous fill material placed in this reach. A more thorough description of channel morphology is provided in Section 2.4**.**

Reach 7- El Dorado Canal to Diversion Impoundment (210 ft). Reach 7 is the portion of the project area upstream of the canal. The main channel in this reach is the bypass/diversion flume. To the east of the flume there is a concrete-lined diversion overflow channel. The ground between the bypass flume and overflow channel is highly compacted **(Photo 13).** The flashboard-controlled impoundment at the upstream end of the reach has collected a significant amount of sediment **(Photo 14)**. The flashboards also tend to leak water into the overflow channel. The District will address these issues as well as install a gaging station with the implementation of the restoration plan**.**

Reach 8- Diversion Impoundment to Plum Creek Road (510 ft). Upstream of the diversion impoundment, the channel quickly regains the character of a natural stream. The bed and banks are well defined and aquatic habitat is comprised of riffles and step-pools. Riparian vegetation is dense, dominated by mountain dogwood and cutleaf blackberry (*Rubus laciniatus,* non-native). White alder (*Alnus rhombifolia*) is present in this reach, which was not observed downstream of the diversion. White alder trees are indicators of perennial stream flow; their absence downstream of the diversion maybe due to historic dewatering of the creek prior to establishment of instream flow requirements. There is a moderate amount of LWD in the channel, most of which has been recruited locally from downed trees. Channel sinuosity and entrenchment increases near the upstream end of the reach. The streambanks are composed of fine-grained material, but dense vegetation cover protects them from mass erosion **(Photo 15).** At the upstream end of the reach the channel crosses under Plum Creek Road in a culvert constructed of a 36-inch corrugated metal pipe with a concrete headwall. The crossing is at grade with the streambed and appears to be functioning properly **(Photo 16).** Immediately upstream of the culvert the riparian cover is dense and the channel appears to be in good functioning condition. This marks the upstream limit of the channel inventory.

2.3 AQUATIC HABITAT ASSESSMENT

2.3.1 Approach

Aquatic habitat conditions were evaluated on Esmeralda Creek for Reaches 3, 4, 5 and 8. Reaches 1, 2, 6 and 7 were not applicable to the survey protocol because there was no channel identifiable in Reach 1, Reach 2 is a near-vertical cascade, Reach 6 was dry at the time of the survey and Reach 7 encompasses the flume structure (i.e., an artificial channel). The objectives of the assessment were to evaluate the overall quality of the habitat, provide a preliminary evaluation of potential limiting factors to fish abundance, assess presence/absence of fish within each reach through visual observations, and provide a dataset to evaluate habitat needs within the framework of the restoration efforts.

The primary habitat variables that affect production and rearing of salmonids in small mountainous stream systems are bed substrate, cover, and water depth. Bed substrate quality and quantity of the appropriate size affects spawning success. Cover habitat, referred to collectively as shelter habitat, consists of the habitat elements that provide protection to salmonids from predators or physical forces such as high winter flows. Habitat conditions that provide good cover for salmonids includes undercut banks, woody debris, terrestrial and aquatic vegetation, boulders and bedrock ledges. Water depth is often an indicator of habitat quality in that streams with larger pools can support larger fish and fish numbers. Streams that lack pools or only support shallow pools tend not to provide high quality rearing habitat for juvenile and adult fish.

Aquatic habitat conditions were evaluated using the Level III habitat typing procedure outlined in the California Salmonid Stream Habitat Restoration Manual (Flosi et al., 2002). Data collected for each habitat unit included a habitat unit number, habitat type, mean unit length, mean unit width, mean unit depth, and maximum depth of unit. For pool habitats data were collected on the depth of the pool tail crest, embeddedness of the substrate at the pool tail and the dominant substrate at the pool tail. Approximately 20 percent of the habitat units sampled were randomly selected to conduct a more detailed description of habitat conditions. The detailed habitat description included escape cover conditions, substrate composition, riparian canopy conditions, and bank material composition and vegetation densities.

2.3.2 Results

A total of 34 habitat units were measured on Esmeralda Creek with 6 habitat units selected for the detailed habitat descriptions (Figure 5). Reach 3 consists of a steep, bedrock dominated channel with cascade habitat comprising 80 percent of the available habitat and step-pools comprising the remaining habitat (Figures 5a and 5b). In Reach 4, gradient decreases slightly with fewer bedrock exposures. Step-pool was the dominate habitat type comprising 53 percent of the habitat with riffle habitat comprising 41 percent. Through Reach 5 the gradient decreases considerably with logs and log jams creating more structure and complexity in the valley bottom, dense vegetation provides cover habitat and flow obstructions, and habitat type diversity increases. Run habitat comprises 60 percent of Reach 5 with riffle and step-pool habitat comprising 18 and 14 percent of the reach, respectively. In Reach 8 the gradient decreases and the valley widens considerably. It appears that the channel through Reach 8 has slightly incised into debris flow material that has deposited at this location due to the depositional nature of the valley morphology. Riffle habitat dominates in Reach 8 with 41 percent of the reach length, most likely associated with small headcuts moving up through this reach and the more pronounced meander pattern of the channel due to the more alluvial nature of the reach. Step-pool and run habitat are subdominant through the reach with 30 and 23 percent, respectively.

The habitat assessment results suggest that Esmeralda Creek provides high quality, complex cover habitat with limited spawning habitat and a lack of deep pool habitat. Using a scale from 0 to 3, the lowest shelter rating assigned to any of the habitat units was a 2, with Reaches 5 and 8 providing the highest quality and most complex cover habitat available. The dominant bed substrate through all of the reaches consisted of bedrock, boulder, or large cobble suggesting an armored bed that lacked large pockets of available spawning gravel. Although gravel substrate for spawning was limited everywhere, some spawning habitat exists in Reaches 4, 5 and 8. Overall, pool habitat is limited in all reaches. Average maximum pool depths were less than 1 foot with only a few pools exceeding 1.5 feet of depth. The deepest pool encountered during the survey was 2 feet deep.

2.3.3 Discussion

Although comprehensive and quantitative assessments of the fish populations in Esmeralda Creek were not conducted as part of our habitat surveys, the presence of fish were noted. In summary, only a handful of fish were observed during the survey. Low light conditions made it difficult to observe fish, but despite the poor conditions, the number of fish observed suggests that the population occurs in low densities. Previous studies conducted by ECORP (2002) identified rainbow trout as being the only fish species present in lower Esmeralda Creek. Their work consisted of electrofishing two 100-meter segments of Esmeralda Creek located upstream and downstream of the canal and diversion in 2001 and 2002. In 2001, 2 rainbow trout were collected from the downstream sample area and 50 rainbow trout were collected from the upstream sample area. In 2002, 19 rainbow trout were collected from the downstream sample area and 69 rainbow trout were collected from the upstream sample area.

Overall low fish numbers are likely due to several factors. The primary factor for low fish densities is likely due to the lack of adequate spawning habitat throughout the study area. The steep nature of the channel, combined with high flow conditions creates a high energy environment where large patches of coarse gravel do not persist in the channel for any significant period of time. Even when spawning is successful, high flow conditions may return and wash out redds, which is most likely to occur in unprotected areas.

The lack of poor spawning habitat availability is exacerbated by the degree to which individual habitat segments are isolated from each other due to natural passage barriers. Step-pools, short bedrock falls, and large woody debris jams are common throughout the study area, limiting free movement between habitat units and interaction amongst the low number of fish that do survive in this reach. During the low flow summer months, the small, shallow pools that hold fish during the dry season most likely are only able to support a single adult fish. Each pool may be isolated from adjacent habitat, limiting the ability of adult fish to reproduce.

In summary, the structural value of the habitat, in terms of providing food, shelter, and year-round habitat, is high. However, the overall quality of the habitat is limited by the steep channel conditions and the isolated nature of the habitat. It is likely that little to no spawning occurs in the study area. Fish present in the study area may have been spawned in higher quality habitat areas upstream and have moved into the study area to rear or were washed down by high flow conditions (usually during spring runoff).

2.4 CHANNEL MORPHOLOGY

2.4.1 Downstream of the Project Area (Reaches 1-5)

As mentioned in Section 2.2, channel gradient in the reaches downstream of the project area ranges from 10 to 95 percent. In the steepest reaches near Highway 50 the stream flows in bedrock, hence stability is high. Bankfull indicators are not well defined; the best indicators are scour of moss on bedrock and boulders, but bankfull width and depth vary greatly because channel slope fluctuates significantly within relatively short distances. The less steep portions of the channel are stable with no signs of degradation or disruption of fluvial processes; channel grade is held by shallow bedrock, boulders/large cobble and debris jams.

2.4.2 Project Area (Reaches 6-7)

The channel in Reach 6 (i.e., below the canal) is highly disturbed and there are multiple flow paths. Figure 6 provides cross-sections and profile of the valley and channel topography in this reach. The East and Central Channels have formed as a result of discharge associated with the Esmeralda Creek bypass/diversion. These channels flow through fill and tunnel spoils and lack morphology indicative of a natural stream (e.g., defined bed and bank, step-pool sequence, etc.). Valley morphology in the vicinity of the canal suggests that the West Channel was the alignment of Esmeralda Creek prior to construction of the canal and diversion; this hypothesis is supported by observations of coarse alluvium in the West Channel that is very similar in size and distribution to the natural channel immediately downstream of Reach 6.

Upstream of the canal (i.e., Reach 7) the main channel consists of the bypass/diversion flume. The diversion impoundment traps bedload from the upper watershed, which creates a discontinuity in sediment transport to reaches downstream of the canal. This does not appear to have resulted in degradation or significant “coarsening” of the channel downstream of the diversion. Sediment supply in reaches downstream of the project area is likely maintained by periodic landslides that enter the creek, such as that observed in Reach 5 (Photo 8); hence the supply of colluvial material minimizes the impacts of the sediment transport discontinuity created by the diversion impoundment.

2.4.3 Upstream of Project Area (Reaches 8)

The reach above the project area is the lowest gradient section of Esmeralda Creek in the study area. This area is a depositional section of the stream, as indicated by the fact that the banks are composed of fine-grained sediment that has been transported from the upper watershed. The channel is moderately sinuous and entrenched in some places. Channel entrenchment appears to be the result of the highly erodible bank material and possibly some effects of construction of the culvert crossing at Plum Creek Road. On a short temporal scale the channel appears stable, but the long-term geomorphic process in this reach is likely the accumulation of episodic debris flows, then the channel reforming in the deposit through lateral and vertical migration. This process in not controlled or influenced by the Project 184 operations, but may in part be dependent on the type and extent of silviculture practices in the upper watershed.

2.5 SUB-SURFACE INVESTIGATION OF TUNNEL SPOIL PILES

Observation of the area immediately downstream of the canal (i.e., Reach 6) suggests that fill material has been deposited in and around the Esmeralda Creek channel. The fill material was likely placed during construction of the canal and excavation of the Esmeralda Tunnel. A sub-surface investigation was conducted by Holdrege & Kull, a geotechnical engineering firm located in Truckee, California. The objective of the investigation was to characterize the extent and composition of fill material in the project area. This information is needed to understand the history of disturbance in the area and for design of channel restoration/stabilization measures. This sub-section summarizes the methods and result of the investigation. A complete report of the sub-surface investigation is provided in Appendix A.

The subsurface conditions at the site were investigated by observing cut streambanks and hand excavating several shallow exploratory test pits. Cut banks extended to heights of approximately 10 feet and test pits were excavated to about 2 feet below ground surface (bgs). Soil conditions exposed in the test pits were visually classified and bulk samples were collected for laboratory testing. The approximate locations of the test pits are shown on Figure 6a and in Appendix A.

The generalized soil conditions in the investigation area consist of a relatively thin layer of very silty sand with gravel, some cobbles and boulders overlying the Shoo Fly complex bedrock. The soil appears to be derived primarily from colluvium that has sloughed down the steep canyon walls. The site has been significantly graded, including the original canal construction and then the disposal of tunnel spoils on the site. The original canal construction appears to have involved excavation of a ditch in the native silty sand soil and placement of the excavated material in a levee embankment on the downhill side of the ditch (Figure 6a). The embankment material consists of very silty sand to sandy silt with some cobbles and small boulders. When nominally compacted this soil should have relatively low permeability. Due to the low plasticity, this soil may be prone to high erosion.

The tunnel spoils appear to have been placed in an elongated pile (Figure 6a). The tunnel spoils consist of coarse gravel and cobbles with a low percentage of fine grained material. The cobbles consist of strong angular clasts of sandstone and meta-volcanic or greenstone rock up to about 12 inches in diameter. Even when compacted, the material is expected to be highly permeable. The clasts have a relatively high specific gravity and due to their angularity, may interlock and not be prone to significant channel entrainment.

2.6 HYDROLOGY

Surface water hydrology in Esmeralda Creek is a function of natural hydrologic processes (e.g., rain, snowmelt and rain-on-snow events) and the diversion at the canal. Precipitation falls as rain or snow with over 90 percent occurring between October and April. The highest volume of runoff is generated by spring snowmelt in April through June. Warm winter rains that fall on snow typical of El Nino year storms can contribute the highest instantaneous peak runoff.

Mean monthly streamflow for Esmeralda Creek was studied during the relicensing process and is estimated to range from 0 to 4 cfs (FERC, 2003). Minimum flow requirements to support aquatic habitat downstream of the canal were established based on these data. The District is required to bypass 1 to 2 cfs, or natural flow, before they can begin to divert water. The District manually operates the diversion which consists of two flap gates on the bottom of the bypass flume, directly above the canal. When flows are high in the bypass flume, the gates are opened to allow discharge into the canal. A flashboard weir at the diversion impoundment controls the water surface elevation in the bypass. When flow exceeds the capacity of the bypass flume water can enter the concrete overflow channel that flows to the canal.

2.6.1 Flood frequency Analysis

Flood frequency analysis estimates the likely peak flow runoff rates from the watershed for several recurrence intervals. This information is useful for planning and designing channel restoration/stabilization measures. Since the period of record for flow monitoring on Esmeralda Creek is very brief (1999-2000), a flood frequency analysis was conducted on annual peak flow data from Alder Creek[2], which was gaged by USGS (Station 11440000) from 1923 to 1981. Alder Creek is a relatively large tributary of the SFAR, with a drainage area of 22.1 mi^2. The peak flows from Alder Creek were scaled to the drainage area of the Esmeralda Creek watershed at the project site (Figure 7) and the flood frequency was computed using the U.S. Army Corps of Engineers HEC-SSP software, which follows the USGS Bulletin 17B procedures. Table 1 provides the predicted discharge for various recurrence events and Figure 8 illustrates the resulting flood frequency curve for Esmeralda Creek.

Table 1. Flood frequency analysis for the Esmeralda Creek

Return Period (years)	**Flood Frequency Peak Flow** (cfs)
1	1
2	14
5	38
10	65
25	101
50	168
100	237

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[2] Alder Creek gaging data were used for flood frequency analysis to maintain consistency with previous studies that developed minimum flow requirements and because of the relatively long period of record. It is recognized that the drainage area of Alder Creek is disproportionately large compared to Esmeralda Creek. The peak flow values developed for this study are suitable for conceptual design. Hydrologic design criteria will be refined in later phases of the design process.

3.0 RESTORATION PLAN

3.1 PRINCIPLES FACTORS CAUSING CHANNEL INSTABILITY

Channel instability can largely be attributed to the construction and operation of the Project 184 facilities (i.e. the canal, diversion/bypass and tunnel). Historically, the channel likely flowed along the west side of the valley in the current alignment of the bypass flume upstream of the canal and the spillway flume downstream of the canal (Figure 3). Reach 7 was likely a gradual transition from the depositional zone upstream to the steeper gradient of Reach 6. When the canal was constructed in the late 1800s the alignment and continuity of the creek was disrupted. The area was further disturbed during construction of the tunnel and subsequent placement of spoils in the area downstream of the canal.

Over the years it is likely that there have been various methods used to divert Esmeralda Creek into the canal. The most significant problem with the contemporary structure is that the bypass flume discharges into highly erodible, permeable material. Discharge into highly erodible material has created a network of unstable channels that are actively headcutting and causing severe bank erosion. Stream discharge flows subsurface for most of the reach because the channels are formed in porous, unconsolidated material. This results in discontinuity of aquatic and riparian habitat. The diversion also has the potential to disrupt sediment transport from the upper watershed to reaches downstream of the canal, but this does not appear to have caused impacts that are typically associated with this type of disturbance (See Section 2.4.2).

3.2 RESTORATION/STABILIZATION PLAN

The two main objectives of the project are to 1) restore the original main channel that receives bypass flows from the District's diversion; and 2) provide aquatic habitat continuity from upstream of the El Dorado Canal diversion to the mainstem SFAR. Figure 9 presents a conceptual Restoration and Stabilization Plan that would achieve these objectives[3]. The conceptual plan proposes to create a new step-pool channel through Reach 6 (Figure 9). The new channel would start at the downstream end of the flume, then bend toward the alignment of the existing wood flume that is associated with the canal spillway. The wood flume would be removed and the spillway channel would be modified to accommodate a potential discharge of approximately 80 cfs.

Constructing the new step-pool and spillway channels would require excavation of fill and native material, removal of some large trees, and placement of large rock for channel stability. Access to the construction area would be achieved by placing temporary fill in the canal. Construction would occur in October when the canal is typically dewatered for maintenance activities.

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[3] It is important to note that "aquatic habitat continuity" often equates to fish passage. It is not practical or feasible to design a channel that would allow for fish passage in the project area; the valley slope is approximately 18 percent immediately downstream of the canal. Natural channels designs that meet the California Department of Fish and Game fish passage criteria have a maximum slope of approximately 5 to 8 percent. While the project would not provide fish passage, it would improve aquatic habitat continuity for organisms that are capable of movement in high gradient terrain (e.g. macroinvertebrates, reptiles, amphibians).

Once the alignment of Esmeralda Creek is restored, the existing Central and East channels would be stabilized to prevent further erosion and head cutting. Although the channels would no longer be preferential flow paths of Esmeralda Creek, they would be subject to erosion caused by overland flow during large storm events. The most efficient way to stabilize these channels would be to fill them with the tunnel spoils that are stockpiled between the channels. Filling the channels with the stockpiled spoils would accomplish two objectives: it would stabilize the channels and restore the valley morphology that is believed to have existed before the spoils were placed. There are approximately 2,500 cubic yards of tunnel spoils stockpiled on site. The preferred grading plan would balance the cut of the stockpile with the fill of the channels to minimize the need to import or remove material from the site. Grading the spoils pile would require removal of many small to medium sized trees (12 to 24 inch diameter). This temporary impact would be off-set with a revegetation plan for the restored area.

Under the proposed conceptual plan the existing impoundment, bypass/diversion and overflow channel in Reach 7 would remain intact. The existing impoundment would be cleared of sediment and the flashboards would be replaced so that they no longer leak into the overflow channel.

3.3 CONCLUSION

Condition No. 6 of the Settlement Agreement (EID , 2003) states that “Within 2 years of license issuance, the licensee shall survey the portion of the channel located on National Forest System lands and shall develop a plan that is approved by FS for restoration of the Esmeralda Creek channel.” This report constitutes the survey of the channel located on the National Forest System lands and the development of a restoration plan for Esmeralda Creek. The analysis of site conditions leads to the conclusion that the portion of Esmeralda Creek located on National Forest System lands has not be physically degraded or significantly adversely affected by the Project 184 operations. Channel morphology is stable on the National Forest System lands and the structural value of the aquatic habitat, in terms of providing food, shelter, and year-round habitat, is high. However, the overall quality of the habitat is limited by the steep channel conditions and the isolated nature of the habitat (i.e., many natural fish passage barriers).

The portion of Esmeralda Creek that has been significantly disturbed by the construction and operation of the Project 184 facilities lies on property owned by Nina Poole. The conceptual plan presented in this document would restore the original main channel of Esmeralda Creek downstream of the diversion and provide aquatic habitat continuity in this area. Providing aquatic habitat continuity along with establishment of minimum flows, as proposed, is likely to improve habitat conditions for fish and other aquatic organisms that inhabit Esmeralda Creek.

4.0 REFERENCES

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ESMERALDA CREEK
RESTORATION AND STABILIZATION PLAN

FIGURES

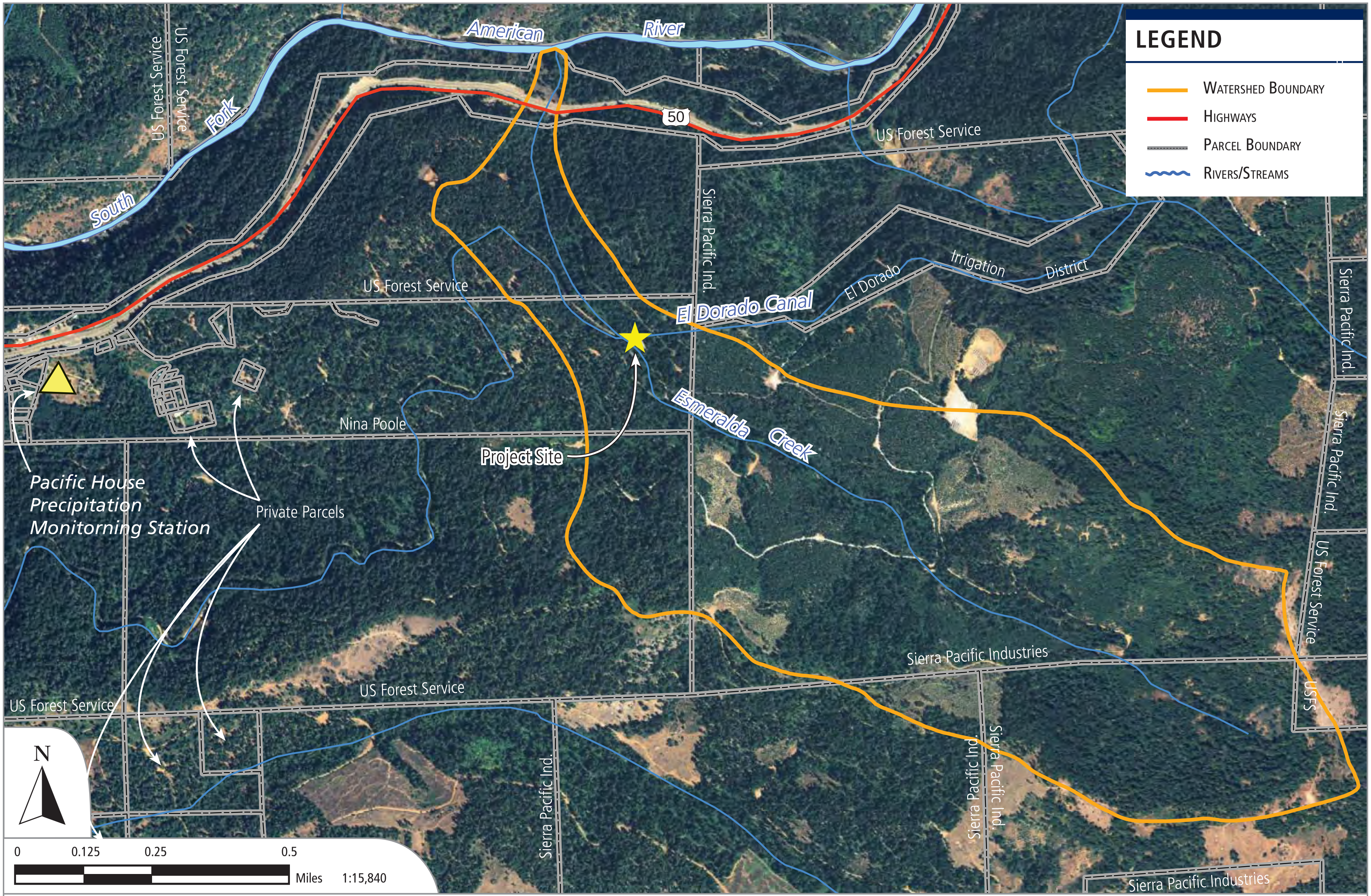

FIGURE 1: Map indicating Esmeralda Creek project location, watershed and land ownership.

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FIGURE 2a: Photo (top) of the El Dorado Canal, Esmeralda Creek diversion and bypass flume (looking upstream). Bypass flume outlet (bottom).

FIGURE 2b: Photo (top) of the bypass flume and flap gate diversion mechanism. Photo (bottom) of Canal Spillway No. 30.

SURVEY NOTES

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 100.00' WAS ESTABLISHED FOR THE PURPOSES OF THE SURVEY AT CONTROL POINT #1, A 6" IRON SPIKE, SHOWN HEREON.

2. AN ASSUMED BASIS OF BEARINGS WAS ESTABLISHED FOR THE PURPOSES OF THE SURVEY, WITH N00'00'00"E BETWEEN POINTS #1 AND #2.

3. SURVEY PERFORMED BY SH+G ON OCTOBER 3 THROUGH 5, 2007.

4. CONTOUR INTERVAL IS ONE FOOT. ELEVATIONS AND DISTANCES SHOWN ARE IN DECIMAL FEET.

5. CONTROL POINTS ARE 6" IRON SPIKES SET IN GROUND AT EXISTING GRADE.

6. THIS IS NOT A BOUNDARY SURVEY. PROPERTY LINES ARE NOT SHOWN HEREON.

7. UNDERGROUND UTILITIES WERE NOT LOCATED.

TREE SURVEY NOTES

1. TREE DIMENSIONS: TRUNK DIAMETERS ARE SHOWN IN INCHES, MEASURED AT CHEST HEIGHT.

2. CAUTION SHOULD BE USED IN DESIGNING IMPROVEMENTS NEAR TREE TRUNKS. THERE ARE LIMITATIONS ON FIELD ACCURACY, DRAFTING ACCURACY, MEDIUM STRETCH AS WELL AS THE "SPREAD" OR "LEANING" OF TREES. REQUEST ADDITIONAL TOPOGRAPHIC DETAIL WHERE CLOSE TOLERANCES ARE EXPECTED.

3. TREES LESS THAN 12" IN DIAMETER ARE NOT SHOWN.

4. SPECIES ARE IDENTIFIED WHEN KNOWN. HOWEVER FINAL DETERMINATION SHOULD BE MADE BY A QUALIFIED BOTANIST.

5. SPECIES ABBREVIATIONS:

C=	CEDAR
CTW=	COTTONWOOD
F=	FIR
T=	UNIDENTIFIED

CONTROL POINTS

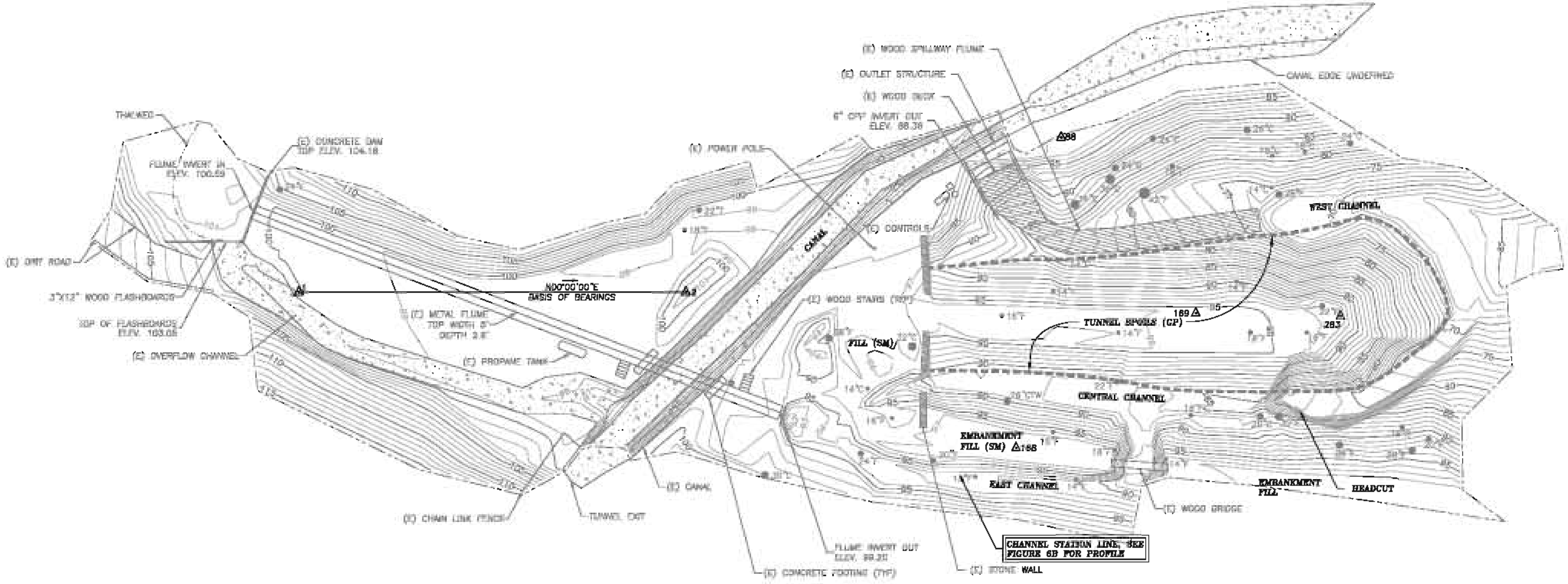
POINT	NORTHING	EASTING	ELEV.	DESC.
1	5000.00	5000.00	100.00	SPK
2	5134.67	5000.00	101.57	SPK
88	5265.27	4946.18	97.72	SPK
168	5249.62	5054.17	97.82	SPK
169	5312.15	5007.30	95.83	SPK
283	5362.40	5008.40	93.47	SPK

ABBREVIATIONS

CPP	CORRUGATED PLASTIC PIPE
DESC	DESCRIPTION
E	EASTING, EXISTING
ELEV	ELEVATION
N	NORTHING
TYP	TYPICAL

ASSUMED PROJECT NORTH

GRAPHIC SCALE: 1 INCH = 20 FEET



LEGEND

△	CONTROL POINT
▨	EXISTING CONCRETE
—85—	EXISTING GROUND MAJOR CONTOURS
—84—	EXISTING GROUND MINOR CONTOURS
▨	EXISTING STONE WALL
▨	EXISTING WOOD FLUME
— — —	LIMITS OF SURVEY
●	TREE

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EXISTING
CONDITIONS
TOPOGRAPHY

ESMERALDA CREEK
RESTORATION AND
STABILIZATION PLAN

DESIGNED BY:
DRAWN BY: C.M.R.
CHECKED BY:
DATE: 1/28/08
JOB NO.: 07-594

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIG. 3

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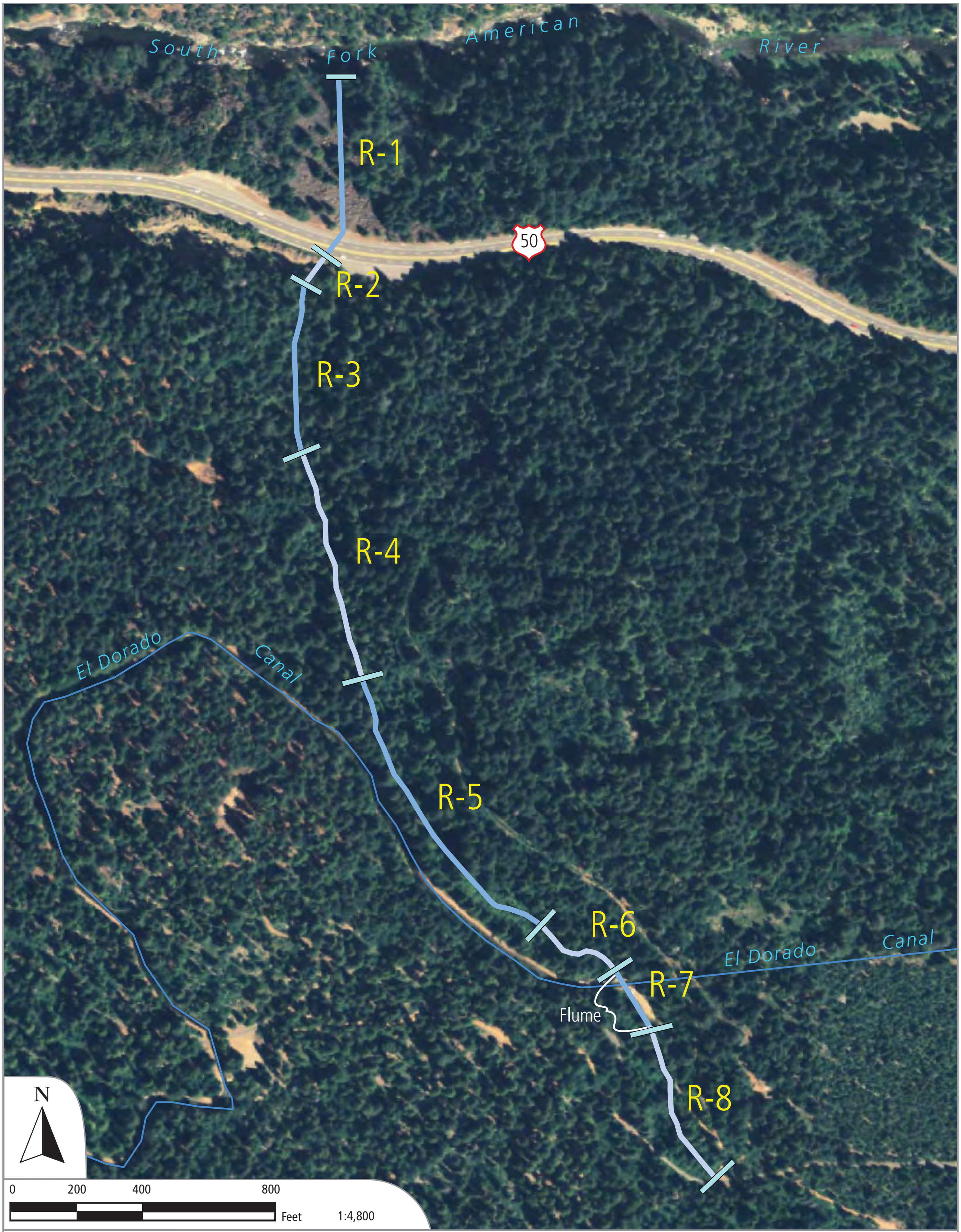

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FIGURE 4: Map indicating geomorphic reach delineations within the Esmeralda Creek study area.

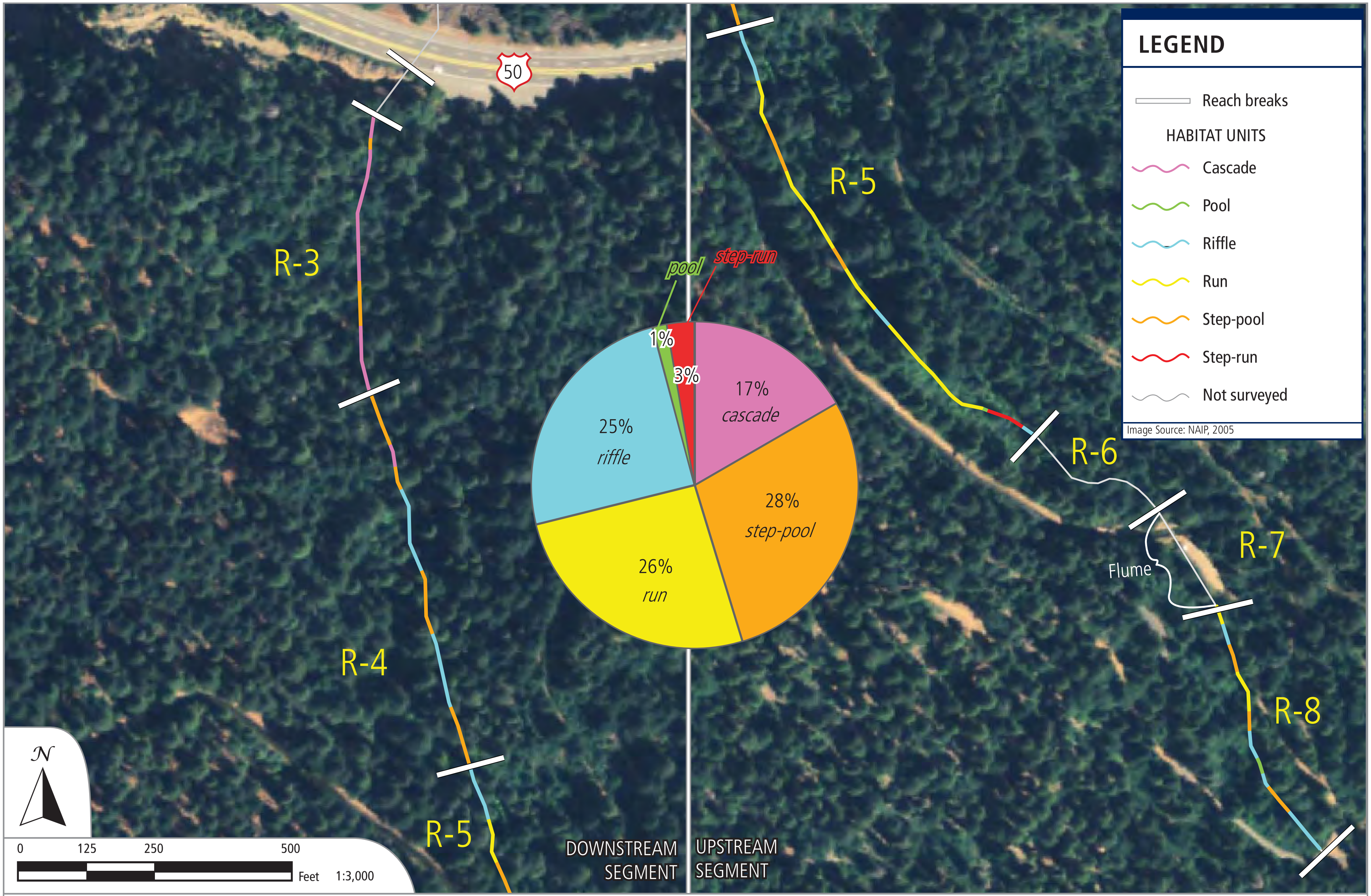
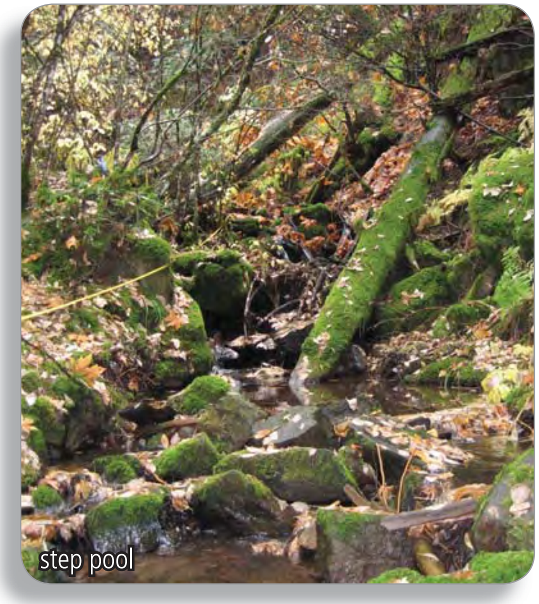


FIGURE 5a: Map indicating aquatic habitat units within the Esmeralda Creek study area.

Reach Summaries	REACH 3				REACH 4				REACH 5				REACH 8			
	Length		Area	Volume	Length		Area	Volume	Length		Area	Volume	Length		Area	Volume
Habitat Type	(ft)	%	(ft^2)	(ft^3)	(ft)	%	(ft^2)	(ft^3)	(ft)	%	(ft^2)	(ft^3)	(ft)	%	(ft^2)	(ft^3)
Cascade	440	80.1%	1985	522	44	5.6%	264	66								
Pool									10	0.9%	100	67	30	6.0%	150	37.5
Riffle					320	41.1%	2070	433	186	17.7%	1075	234	209	41.6%	1177	196.2
Run									628	59.6%	2672	676	115	22.9%	538	102.0
Step Pool	109	19.9%	436	138	415	53.3%	2335	900	151	14.3%	707	321	148	29.5%	628	172.0
Step Run									78	7.4%	390	65				
Total	**549**	**19.0%**	**2421**	**660**	**779**	**27.0%**	**4669**	**1398**	**1053**	**36.5%**	**4944**	**1363**	**502**	**17.4%**	**2493**	**508**



TOTALS				
	Length		Area	Volume
Habitat	(ft)	%	(ft^2)	(ft^3)
Cascade	484	16.8%	2249	588
Pool	40	1.4%	250	104
Riffle	715	24.8%	4322	863
Run	743	25.8%	3210	778
Step Pool	823	28.5%	4106	1531
Step Run	78	2.7%	390	65
Total	**2883**		**14527**	**3929**

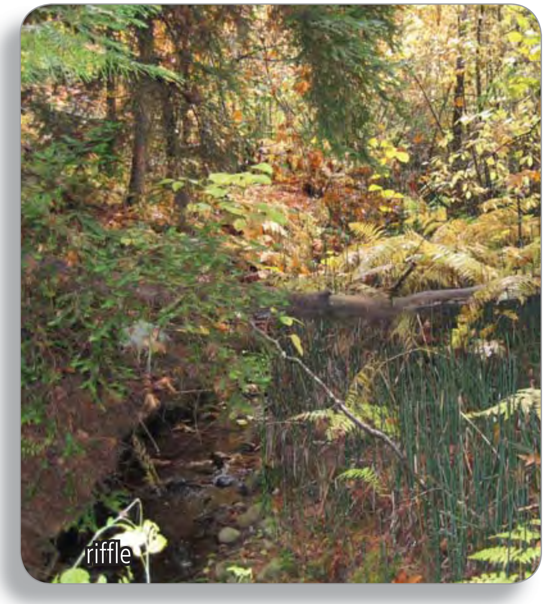


FIGURE 5b: Aquatic habitat assessment data by reach as well as cumulatively. Area and volume were calculated using mean unit width and mean unit depth, respectively.

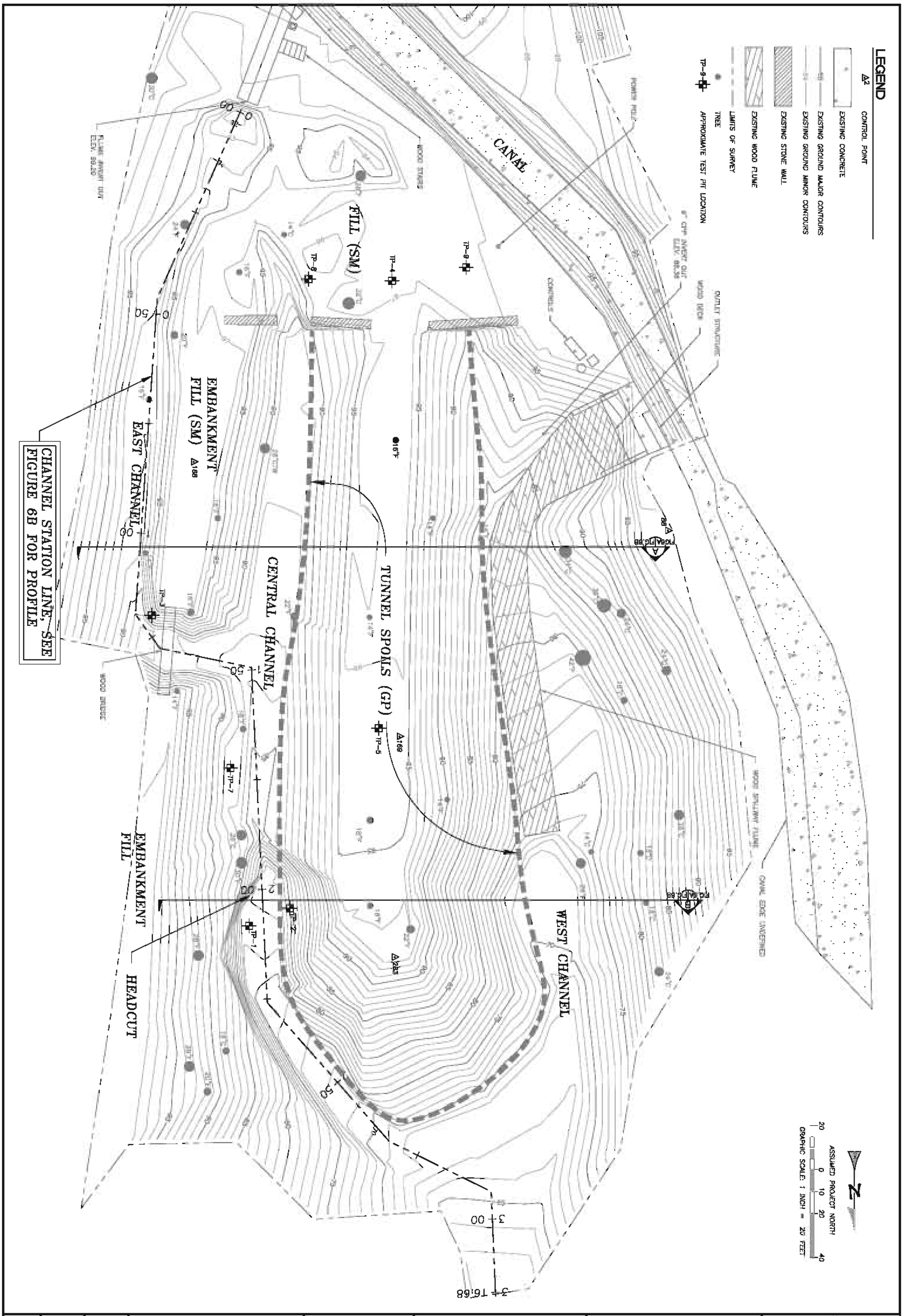


FIG. 6A

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

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DRAWN BY:
CHECKED BY: C.M.R.
DATE: 1/28/08
JOB NO.: 07-594

ESMERALDA CREEK
RESTORATION AND
STABILIZATION PLAN

PLAN VIEW
REACH 6

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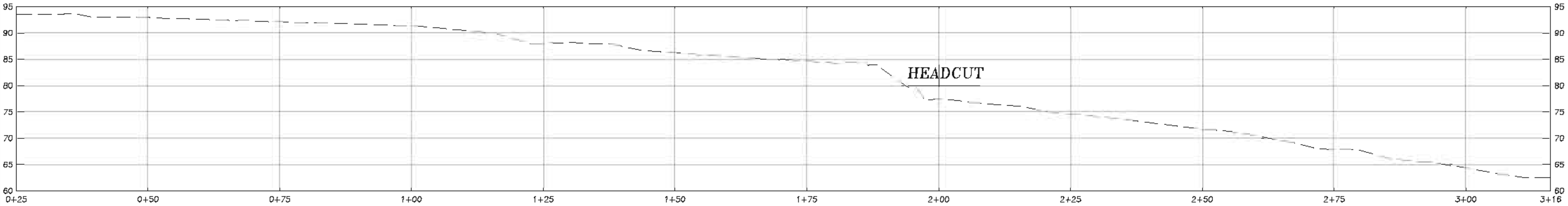
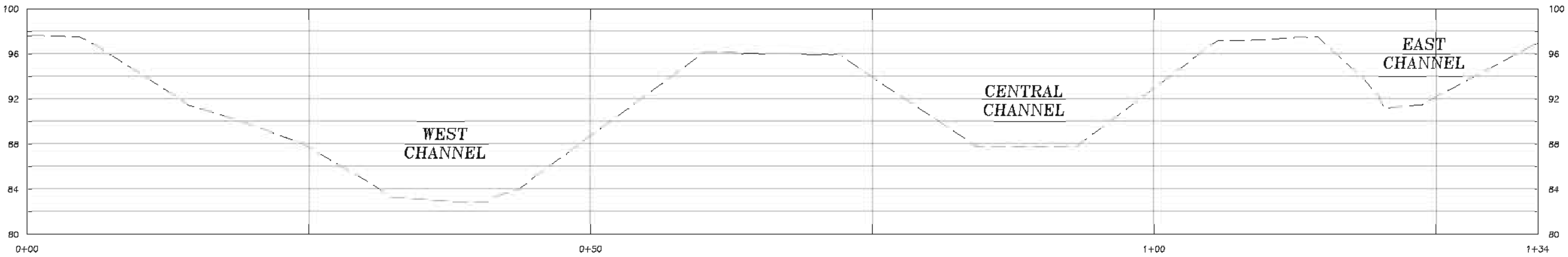
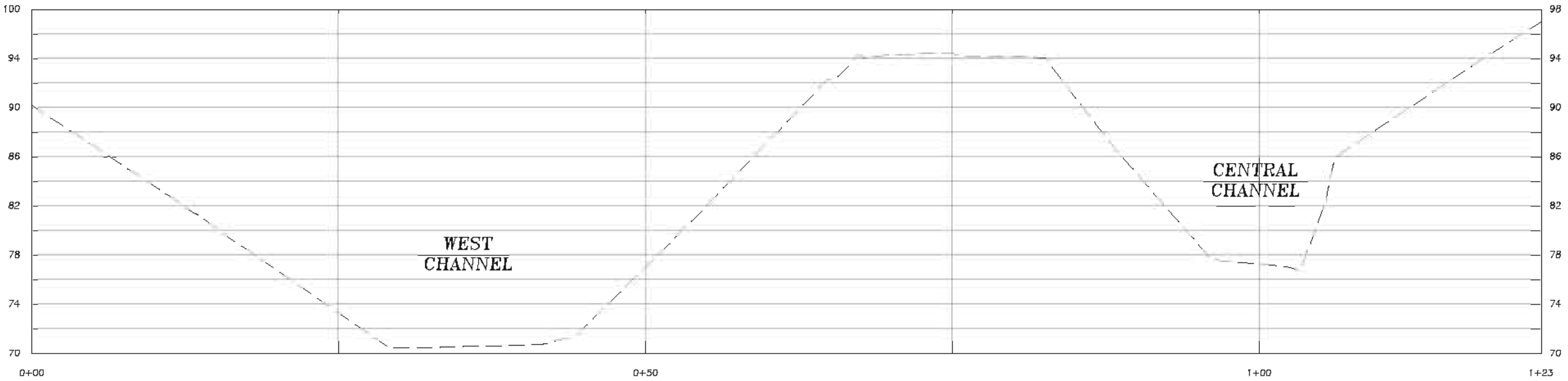


PROFILE
SCALE: 1"=10'



CROSS SECTION (A) FIG 6A FIG 6B
SCALE: 1"=5'



CROSS SECTION (B) FIG 6A FIG 6B
SCALE: 1"=5'

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CROSS SECTIONS AND CHANNEL PROFILE IN REACH 6

ESMERALDA CREEK RESTORATION AND STABILIZATION PLAN

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CHECKED BY:
DATE: 1/28/08
JOB NO.: 07-594

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0 1"

FIG. 6B

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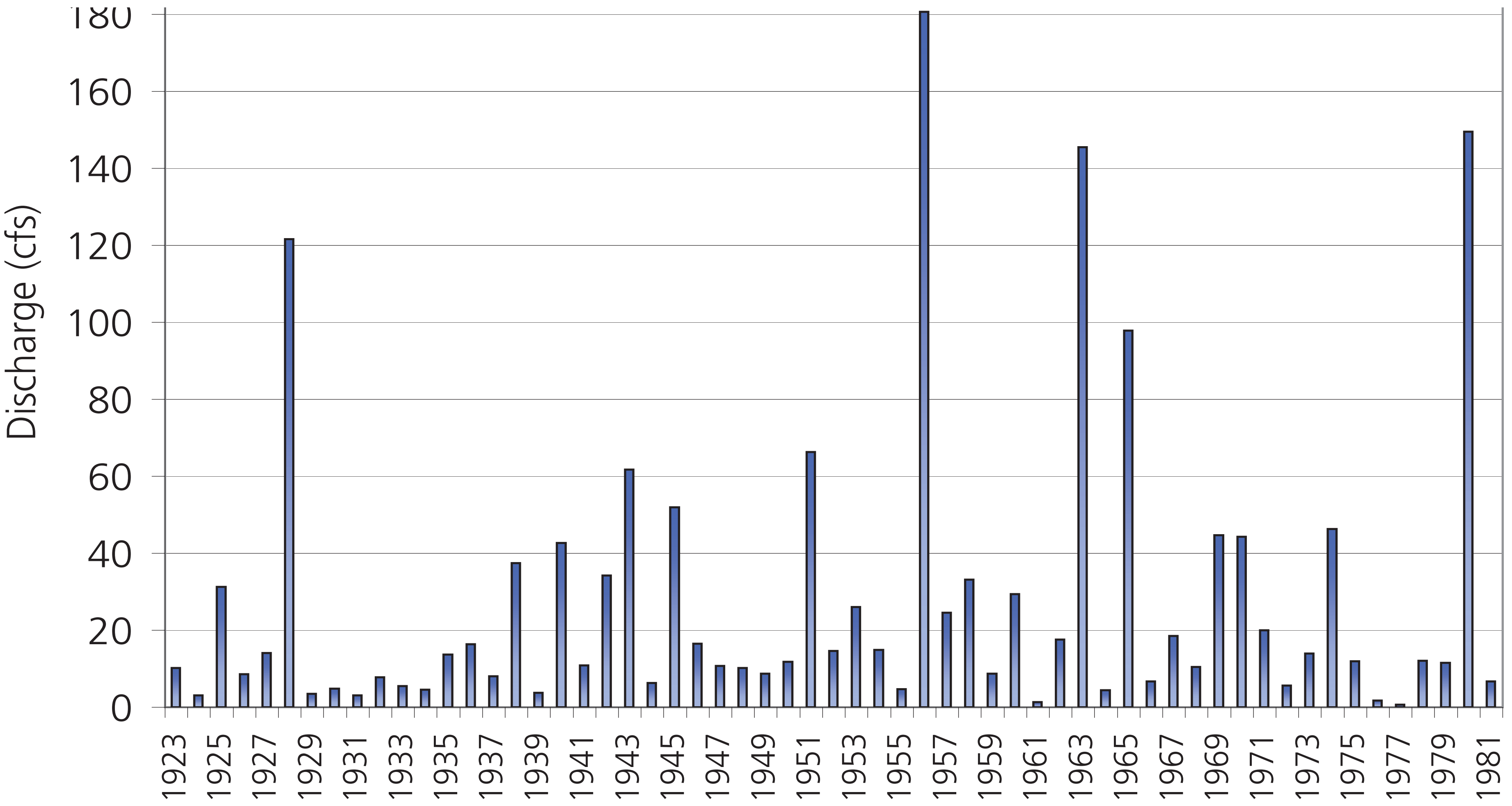


FIGURE 7: Annual peak discharge at Esmeralda Creek based on the peak flow record at Alder Creek near Whitehall (USGS gage # 11440000) and scaled by drainage area (Alder Creek - 22.1 square miles versus 0.73 square miles at the Esmeralda Creek project site).

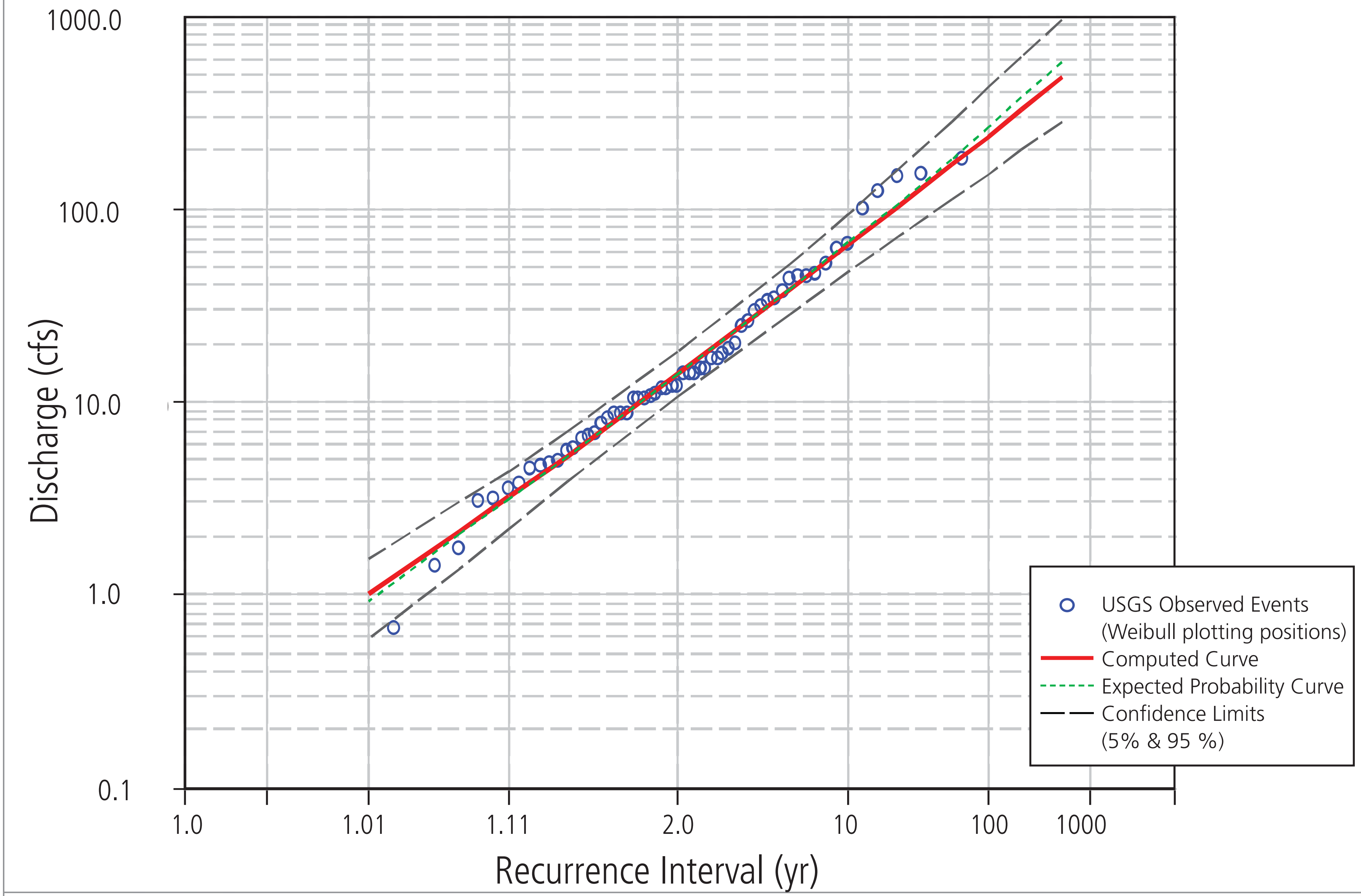
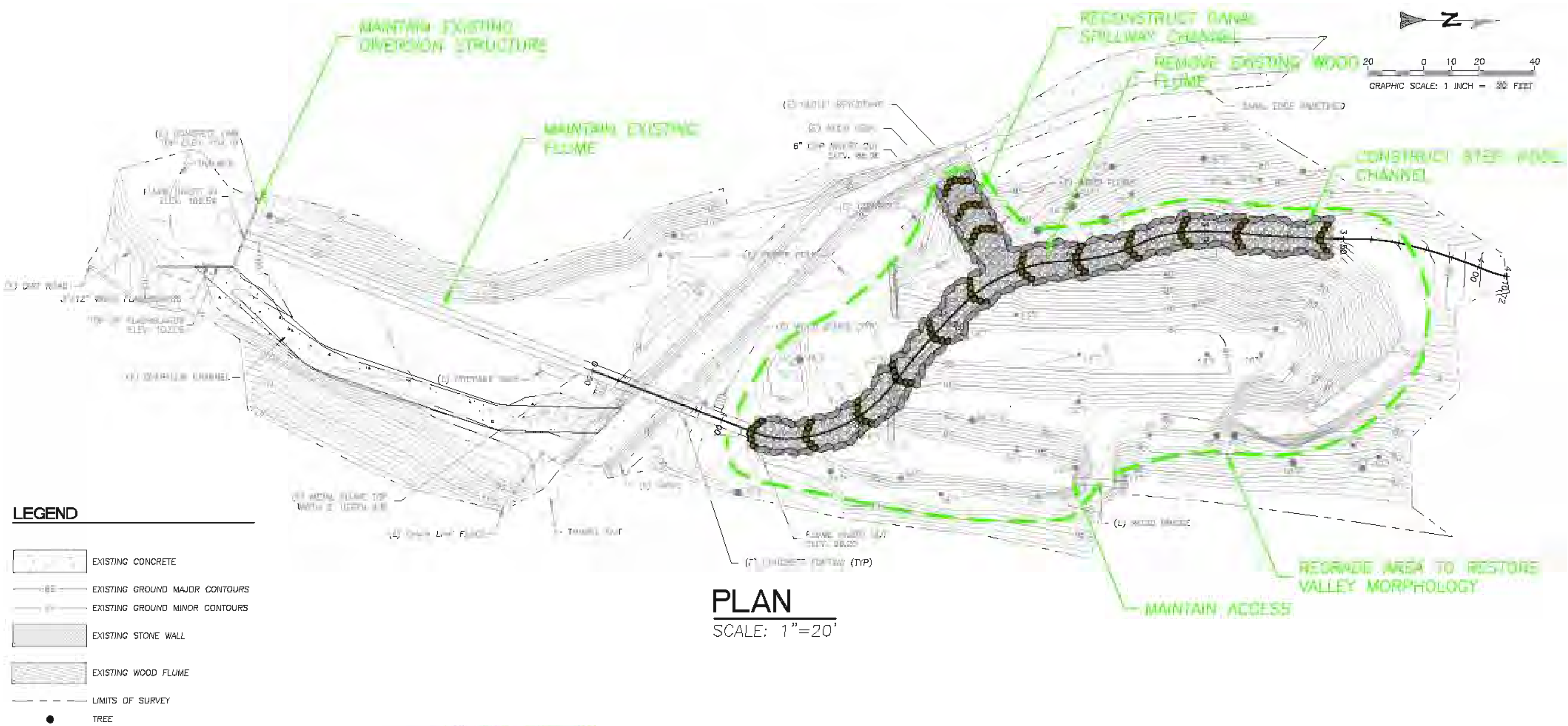
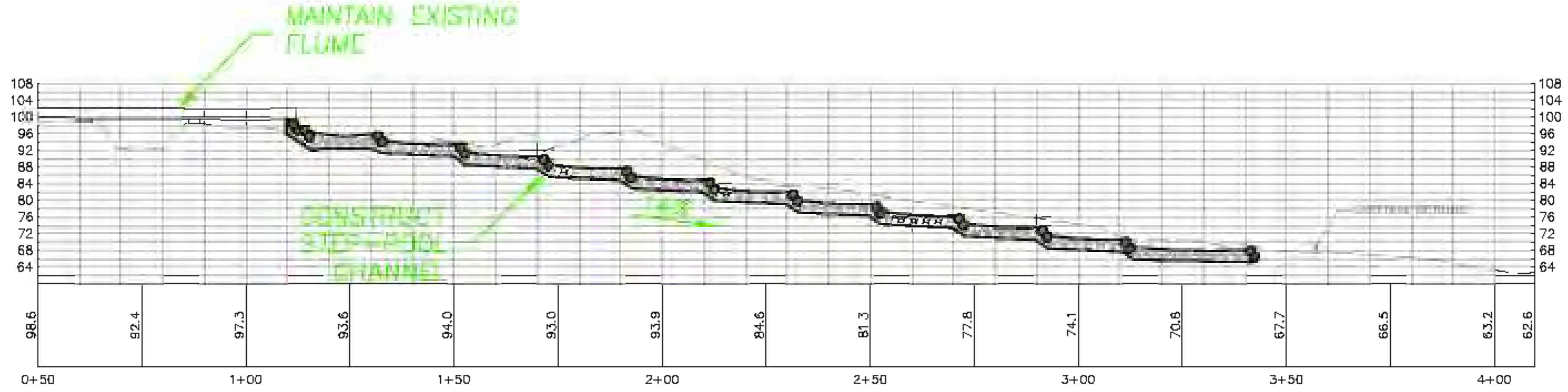


FIGURE 8: A flood frequency curve for Esmeralda Creek was developed using the peak flood record (1923 to 1981) and scaled by drainage area (Alder Creek - 22.1 square miles versus 0.73 square miles at the Esmeralda Creek project site).



PLAN
SCALE: 1"=20'



PROFILE
SCALE: 1"=20'

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CONCEPTUAL RESTORATION/ STABILIZATION PLAN

ESMERALDA CREEK RESTORATION AND STABILIZATION PLAN

DESIGNED BY:
DRAWN BY: C.M.R.
CHECKED BY:
DATE:
JOB NO.: 07-594

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0 1"

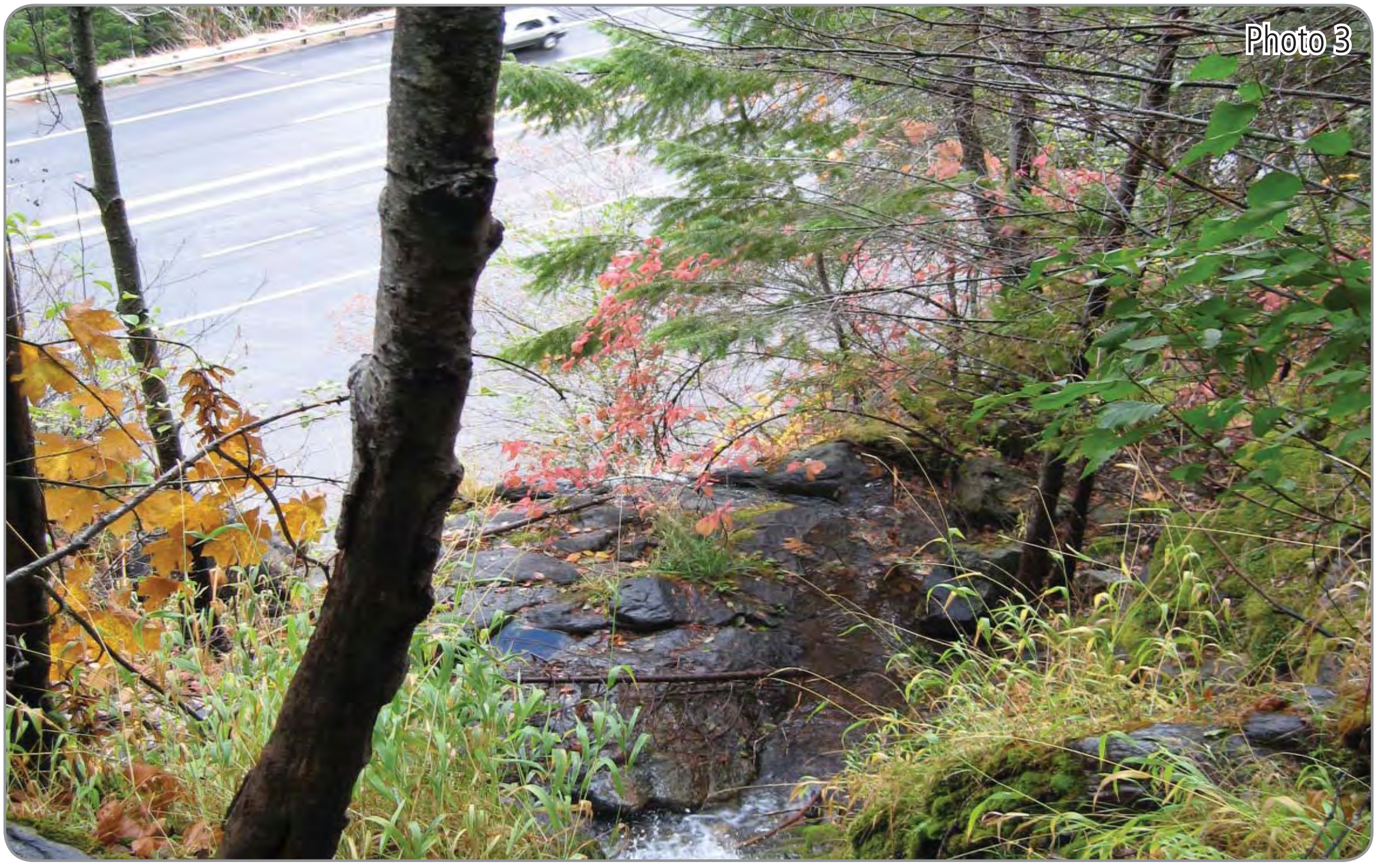
FIG. 9

ESMERALDA CREEK
RESTORATION AND STABILIZATION PLAN

PHOTOGRAPHS

PHOTO 1: From Highway 50 looking downstream at the Esmeralda Creek alignment (Reach 1).

PHOTO 2: Bridal Veil Falls (approximately 150 vertical ft) adjacent to Highway 50 (Reach 2).



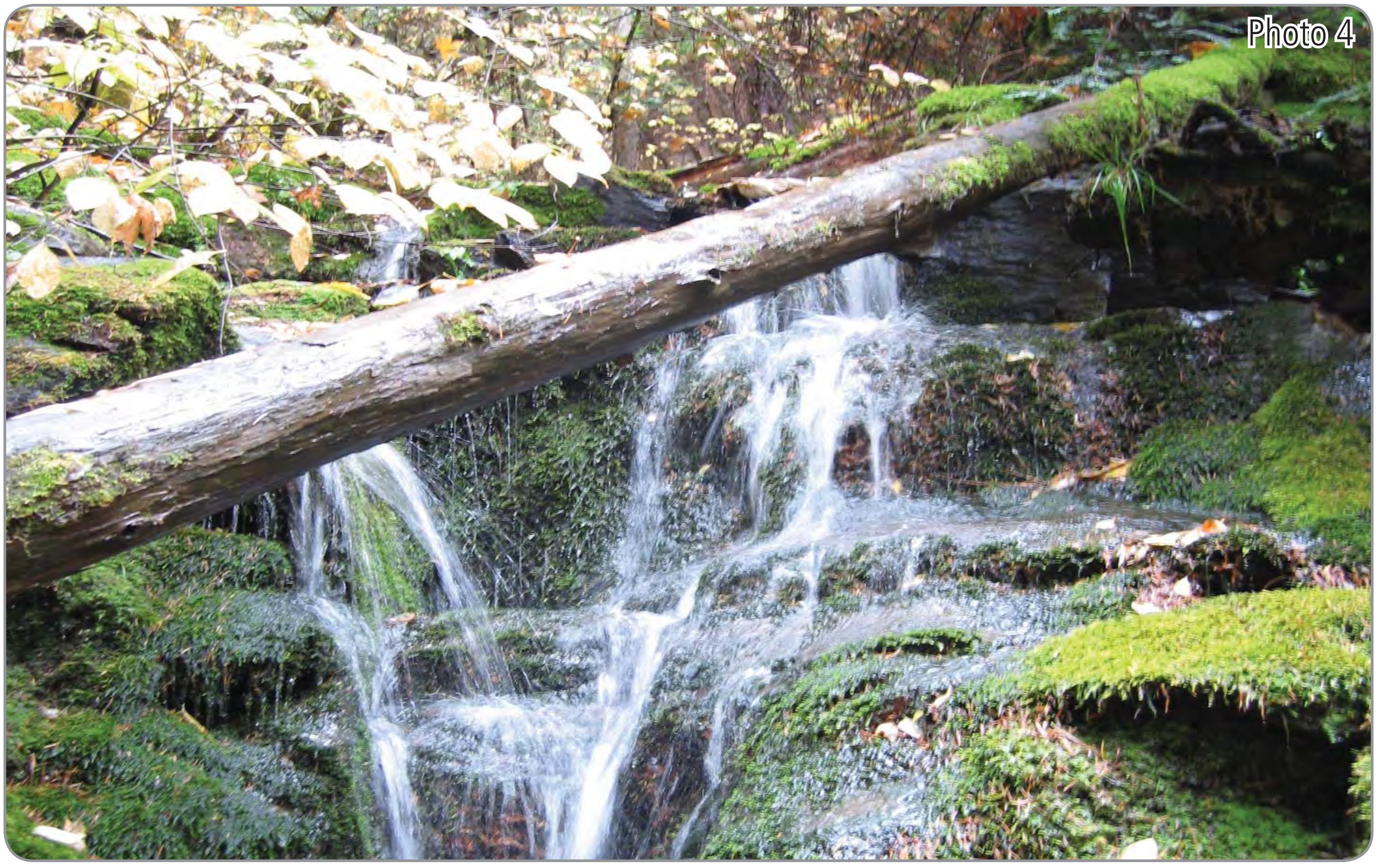


PHOTO 3: Looking down Bridal Veil Falls to Highway 50 (Reach 2).

PHOTO 4: Bedrock cascades and large woody debris upstream of Bridal Veil Falls (Reach 3).

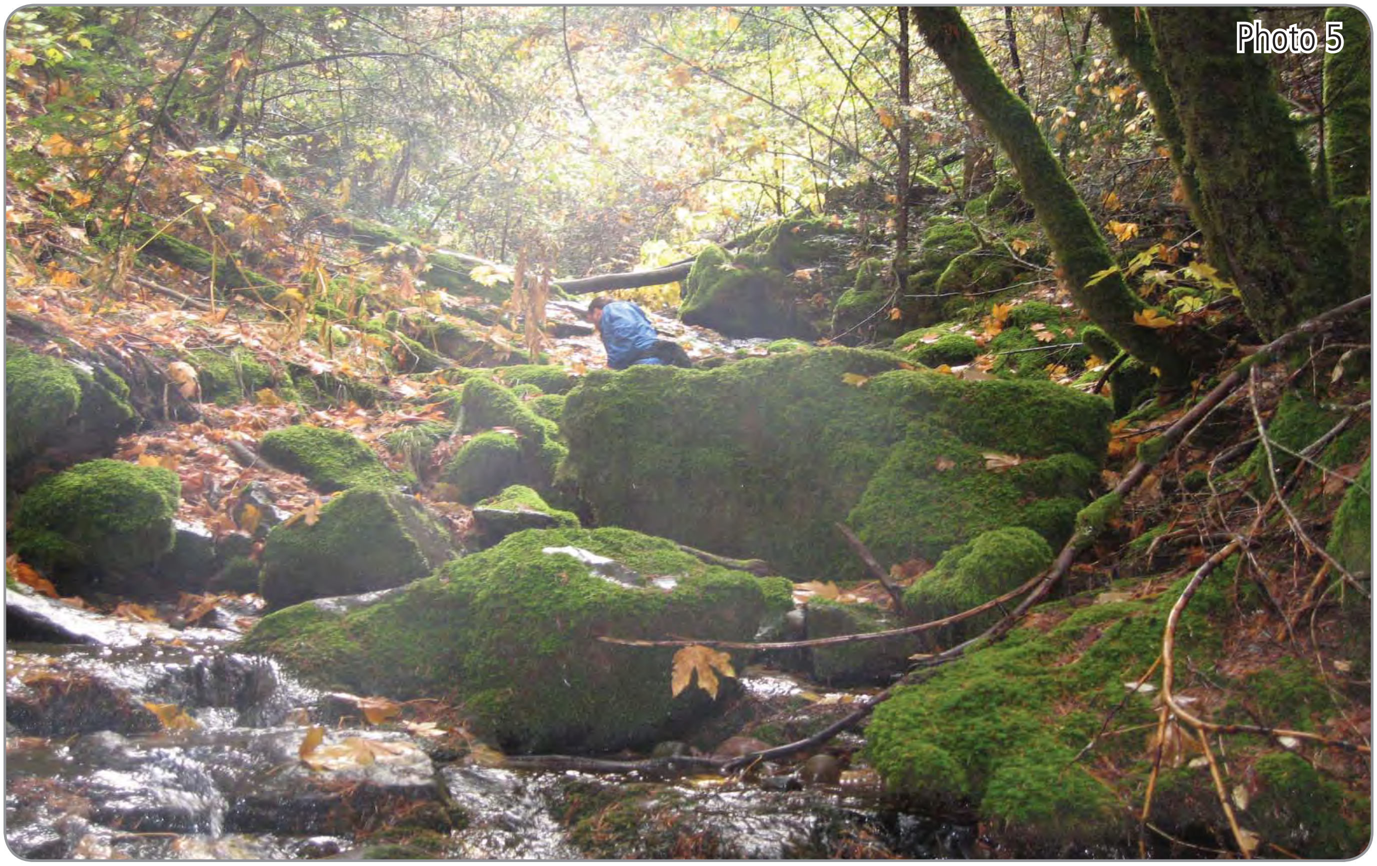


PHOTO 5: The Reach 4 channel (~20% slope) consists of bedrock and large boulders.

PHOTO 6: Debris jam in Reach 4 composed of 8 to 10 large logs.

PHOTO 7: Reach 5 (~10% slope) consists of predominantly gravel/cobble alluvium.

PHOTO 8: Horsetail and ferns have colonized the landslide toe near the upstream end of Reach 5.


Photo 9

10.03.2007 13:59


Photo 10

10.03.2007 13:56

PHOTO 9: Downstream end of the Esmeralda Creek bypass flume (Reach 6).

PHOTO 10: Confluence of the East and Central Channels (Reach 6).

PHOTO 11: Large unstable headcut approximately 50 ft downstream of the confluence of the East and Central Channels.

PHOTO 12: Downstream end of the wood flume in the canal spillway channel (Reach 6).

PHOTO 13: Bypass flume (Reach 7) crossing over the El Dorado Canal (right) and the overflow channel (left).

PHOTO 14: Flashboard-controlled impoundment upstream of the bypass flume (Reach 7).

PHOTO 15: The fine-grained streambanks of Reach 8 are densely vegetated, while providing erosion protection.

PHOTO 16: The upstream end of Reach 8, where Esmeralda Creek passes under Plum Creek Rd through a 36-inch corrugated metal pipe.

ESMERALDA CREEK
RESTORATION AND STABILIZATION PLAN

APPENDIX A:
GEOTECHNICAL INVESTIGATION

HOLDREGE & KULL
CONSULTING ENGINEERS • GEOLOGISTS

January 23, 2008
Project No: 41011-01

Swanson Hydrology + Geomorphology
500 Seabright Avenue, Suite 202
Santa Cruz, California 95062

Attention: Mr. Kevin Fisher

Reference: ***Esmeralda Creek Feasibility Study***
El Dorado County, California

Subject: **Geotechnical Engineering Material Investigation**

This letter report presents the results of our subsurface investigation completed at the referenced project on October 5, 2007. The purpose of our investigation was to explore subsurface conditions and classify soil in the area of proposed improvements to Esmeralda Creek. Our test pit logs and laboratory test results are attached at the end of this report.

Site Description

Esmeralda Creek is a tributary of the South Fork American River, located south of the American River and Highway 50 about 5 miles east of Pollock Pines in El Dorado County, California. The project site is located about ¾- mile south (up-stream) of the confluence with Esmeralda Creek and the American River, at the intersection of Esmeralda Creek and the El Dorado Ditch/Canal. The site location is in the Northeast ¼ Section 35, Township 11 N., Range 13 E. (1950 edition of the Riverton, California 7.5-minute topographic map published by the United States Geological Survey, (USGS)). The site elevation is approximately 3,840 feet above mean sea level (MSL). The site generally slopes moderately down from south to north. The approximate location of the site is shown on Figure 1, Site Vicinity Map.

The project site consists of the Esmeralda Creek channel flowing down from the south to the north and the El Dorado Ditch/Canal flowing from east to west/northwest. A tunnel was constructed that by-passes a portion of the El Dorado Ditch and outlets at the project site immediately up-stream of Esmeralda Creek. Esmeralda Creek crosses the new tunnel ditch in a metal flume and discharges down-slope of the ditch into the old El Dorado Ditch. The creek flows north in the old canal for about 80 feet and then cuts through the embankment into an incised channel downstream of the El Dorado ditch. There is an existing stone wall that crosses the location of the original Esmeralda Creek channel that may have acted as a small dam or weir prior to construction of the tunnel. The stone wall is located on the downhill side of the original El Dorado Ditch.

Vegetation at the site consists of moderately dense brush and conifer trees. A plan view of the project area is shown on Figure 2, Test Pit Location Plan.

PROJECT DESCRIPTION

Information about the proposed improvements was obtained from our site visit, and conversations with Kevin Fisher and Matt Weld of Swanson Hydrology + Geomorphology. As currently proposed, the project consists of construction of a naturalized stream channel for Esmeralda Creek to bypass the El Dorado Ditch/Canal and stabilize severe erosion of the creek channel at the site. A section of the El Dorado Ditch was bypassed via a tunnel in approximately 1930 that exits immediately upstream of the intersection of Esmeralda Creek and El Dorado Ditch. The site area has been significantly altered due to the El Dorado Ditch construction, the tunnel construction and subsequent erosion by Esmeralda Creek. Appurtenant construction may include construction of a rock wall or rock slope protection adjacent to a portion of the Esmeralda Creek channel.

FIELD EXPLORATION

We reviewed portions of a consulting engineering report prepared by Carlton Engineering, "Landslide Potential Along the El Dorado Canal", dated September 5, 2002 with attached Geologic and Landslide map. The geologic map indicates that the site is underlain by the Shoo Fly complex, consisting of undifferentiated Paleozoic age rocks. Based on our observations at the site, the underlying rock appears to be moderately fractured sandstone and greenstone.

The subsurface conditions at the site were investigated on October 5, 2007 by logging the existing stream banks and hand excavating several shallow exploratory test pits. Stream cut banks extended to heights of approximately 10 feet and test pits were excavated to about 2 feet below the ground surface (bgs).

A geologist from our firm logged the soil conditions exposed in the test pits, visually classified soil, and collected bulk samples for laboratory testing. Soil samples were packaged in the field to reduce moisture loss and were returned to our laboratory for testing. The approximate locations of the test pits are shown on Figure 2, Test Pit Location Plan. The logs of the test pits are included at the end of this report.

SUBSURFACE SOIL CONDITIONS

The generalized soil conditions in the site area consist of a relatively thin layer of very silty sand with gravel, some cobbles and boulders overlying the Shoo Fly complex bedrock. The soil appears to be derived primarily from colluvium that has sloughed down the steep canyon walls. As previously stated, the site has been significantly graded, including the original canal construction and then the disposal of tunnel spoils on the site. The original canal construction appears to have involved excavation of a ditch in the native silty sand soil and placement of the excavated material in a levee embankment on the downhill side of the ditch. The embankment material consists of very silty sand to sandy silt with some cobbles and small boulders (see Test Pit TP-3).

The tunnel spoils appear to have been placed north of the rock wall in a elongated pile down the original creek channel. The tunnel spoils consist of coarse gravel and cobbles with a low percentage of fine grained material. The cobbles appear to consist of strong angular clasts of sandstone and meta-volcanic or greenstone rock up to about 12 inches in diameter. The soil material south of the rock wall is similar to the ditch embankment material and consists of silty sand fill derived from native soil.

There are some stream channel deposits in the existing channel of Esmeralda Creek consisting of sand and gravel. Esmeralda creek channel is located east of the tunnel spoil pile.

LABORATORY TEST RESULTS

We performed laboratory tests on bulk soil samples collected from the exploratory test pits to help evaluate site soil engineering properties. The following laboratory tests were performed:

- Sieve Analysis (ASTM D422)
- Atterberg Limits (ASTM D4318)

Sieve analysis data resulted in a Unified Soil Classification System (USCS) classification of sandy Silt (ML) to very silty Sand with gravel (SM). More specific soil classification and laboratory test data is included in Appendix B. USCS classifications are summarized below:

Sample Number	Depth (feet)	USCS Classification
TP-3	5	Silty Sand (SM) to Sandy Silt (ML)
TP-6	4	Silty Gravel with Sand (GM)
TP-7	1	Poorly graded Sand with Silt & Gravel (SP)

The USCS divides soil into groups based on relative grain sizes. Coarse gravel consists of particles ranging from ¾ to 3 inches in size, cobbles consist of particles ranging from 3 to 12 inches in size, and boulders consist of particles greater than 12 inches in size. Particles smaller than ¾-inch are classified as fine gravel, sand, and fines (clay or silt). The following table summarizes the estimated percentage of particle types contained in the laboratory samples listed above:

Sample Number	Depth (feet)	Cobbles (%)*	Coarse Gravel (%)*	Fine Gravel, Sand, and Fines (%)*
TP-3	5	est <5	est <5	>90
TP-6	4	est 10%	est 10	>80
TP-7	1	0	11	89

*Percent by weight, sieve run on samples with particles less than 6 inch size.

COBBLE DESCRIPTIONS

Based on the subsurface conditions exposed in our test pits and site observations, it appears that the soil pile north of the rock wall consists of poorly graded coarse gravel and cobbles. The cobbles are strong, angular sandstone, a relatively high specific gravity. The size of material is predominately 2 inches to 6 inches with an estimated 20 percent to 40 percent ranging from 6 to 12 inches.

GROUNDWATER CONDITIONS

Groundwater was not encountered in any of our test pits. Our field work was preformed prior to seasonal precipitation. However, we expect that seasonal groundwater will be perched on top of the bedrock and generally correlate with the stream flow.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are based on our field observations, laboratory test results, and our experience in the project area.

The existing ditch levee embankment and undisturbed native soil consists of very silty sand to sandy silt of low plasticity. This soil contains some cobbles and boulders. When nominally compacted this soil should have relatively low permeability. Due to the low plasticity, this soil may be prone to high erosion.

The large pile of soil material north of the rock wall appears to consist of tunnel spoils. The rock clasts are coarse open graded material with a low percentage of fines. Even when compacted, the material is expected to be highly permeable. The clasts appear to have a relatively high specific gravity and due to their angularity, may interlock and not be prone to significant channel entrainment. The clasts are strong but may be prone to abraision.

CLOSING

We have prepared this letter for your exclusive use in accordance with the generally accepted geotechnical engineering practice as it exists in the site area at the time of our services. No warranty is expressed or implied. We appreciate the opportunity to provide assistance on this project. If you have any questions regarding this letter or we may be of further assistance, please contact the undersigned.

Sincerely,

Holdrege & Kull

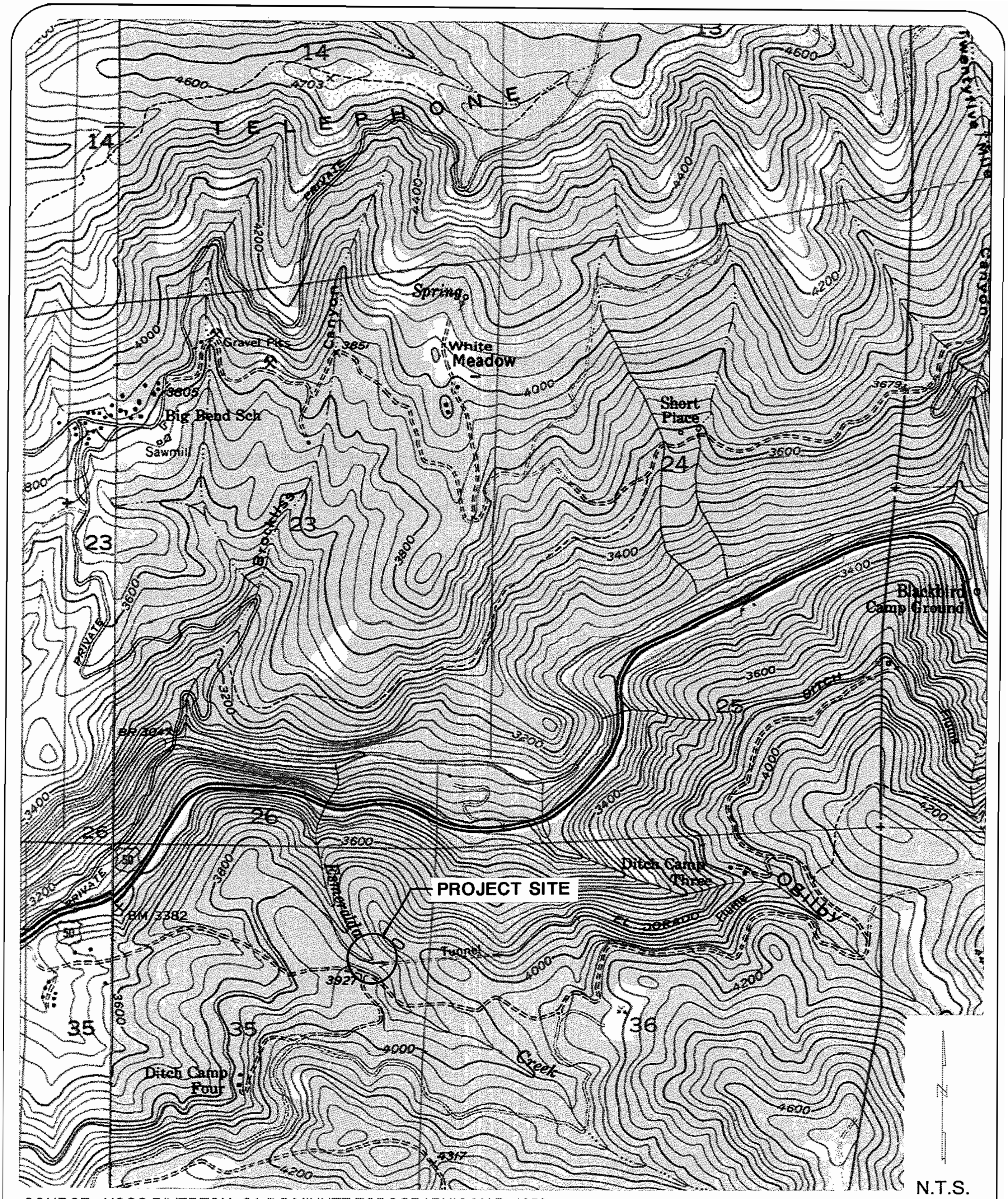
John K. Hudson

John K. Hudson, P.E., C.E.G.
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
JOHN K. HUDSON
No. C 050923
Exp. 9-30-09
CIVIL
STATE OF CALIFORNIA

Attachments:

Figure 1 - Site Vicinity Map
Figure 2 - Test Pit Location Plan
Appendix A - Logs of Test Pits
Appendix B – Laboratory test Results



SOURCE: USGS RIVERTON, CA 7.5 MINUTE TOPOGRAPHIC MAP, 1950

HOLDREGE & KULL

CONSULTING ENGINEERS • GEOLOGISTS

HK

10775 PIONEER TRAIL
SUITE 213
TRUCKEE, CA 96161
(530) 587-5156

SITE VICINITY MAP
ESMERALDA CREEK
FEASIBILITY STUDY
EL DORADO COUNTY, CALIFORNIA

PROJECT NO.: 41011-01

DATE: JANUARY 2008

FIGURE NO.: 1

SURVEY NOTES

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 100.00' WAS ESTABLISHED FOR THE PURPOSES OF THE SURVEY AT CONTROL POINT #1, A 6" IRON SPIKE, SHOWN HEREON.

2. AN ASSUMED BASIS OF BEARINGS WAS ESTABLISHED FOR THE PURPOSES OF THE SURVEY, WITH N00°00'00"E BETWEEN POINTS #1 AND #2.

3. SURVEY PERFORMED BY SH+G ON OCTOBER 3 THROUGH 5, 2007.

4. CONTOUR INTERVAL IS ONE FOOT. ELEVATIONS AND DISTANCES SHOWN ARE IN DECIMAL FEET.

5. CONTROL POINTS ARE 6" IRON SPIKES SET IN GROUND AT EXISTING GRADE.

6. THIS IS NOT A BOUNDARY SURVEY. PROPERTY LINES ARE NOT SHOWN HEREON.

7. UNDERGROUND UTILITIES WERE NOT LOCATED.

TREE SURVEY NOTES

1. TREE DIMENSIONS: TRUNK DIAMETERS ARE SHOWN IN INCHES, MEASURED AT CHEST HEIGHT.

2. CAUTION SHOULD BE USED IN DESIGNING IMPROVEMENTS NEAR TREE TRUNKS. THERE ARE LIMITATIONS ON FIELD ACCURACY, DRAFTING ACCURACY, MEDIUM STRETCH AS WELL AS THE "SPREAD" OR "LEANING" OF TREES. REQUEST ADDITIONAL TOPOGRAPHIC DETAIL WHERE CLOSE TOLERANCES ARE EXPECTED.

3. TREES LESS THAN 12" IN DIAMETER ARE NOT SHOWN.

4. SPECIES ARE IDENTIFIED WHEN KNOWN. HOWEVER FINAL DETERMINATION SHOULD BE MADE BY A QUALIFIED BOTANIST.

5. SPECIES ABBREVIATIONS:

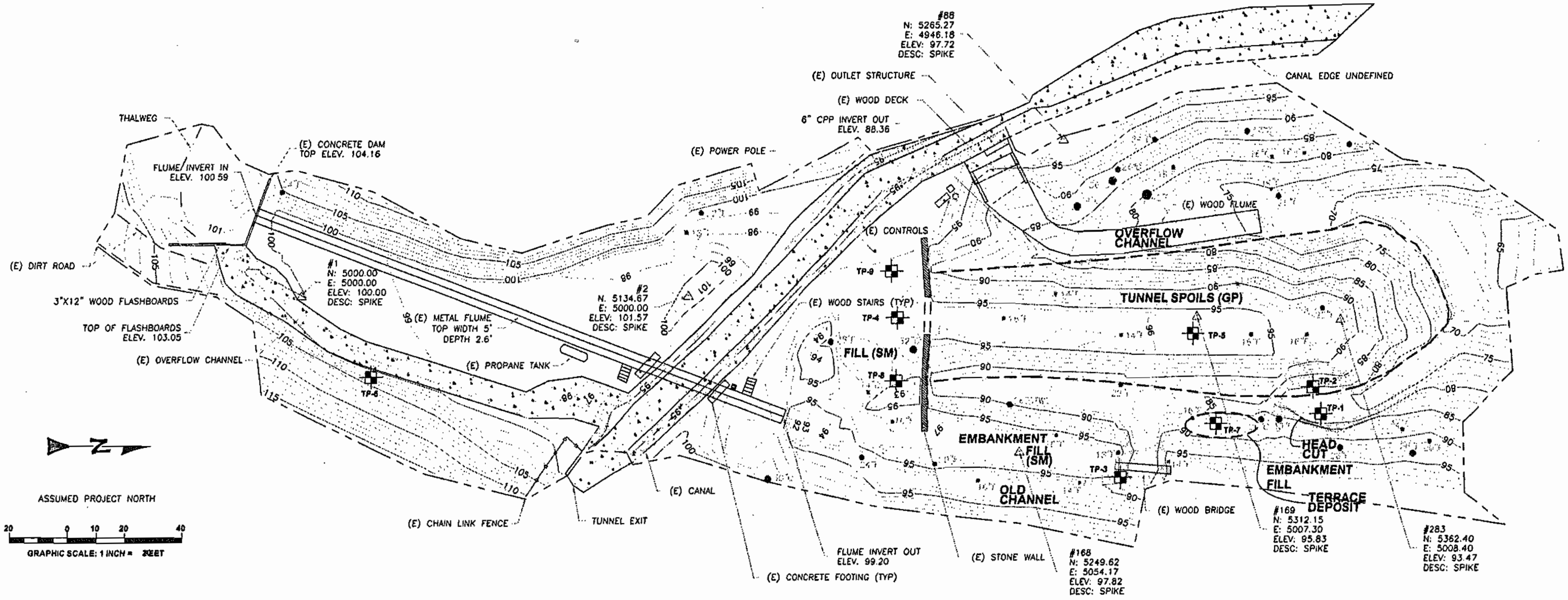
C=	CEDAR
CTW=	COTTONWOOD
F=	FIR
T=	UNIDENTIFIED

ABBREVIATIONS

CPP	CORRUGATED PLASTIC PIPE
DESC	DESCRIPTION
E	EASTING, EXISTING
ELEV	ELEVATION
N	NORTHING
TYP	TYPICAL

LEGEND

⊞ TP-9	APPROXIMATE TEST PIT LOCATION
△	POINT NUMBER NORTHING EASTING ELEVATION DESCRIPTION } CONTROL POINT
⁘	EXISTING CONCRETE
------------	EXISTING DIRT ROAD
–o–o–o–	EXISTING FENCE
—85—	EXISTING GROUND MAJOR CONTOURS
—84—	EXISTING GROUND MINOR CONTOURS
▨	EXISTING STONE WALL
— – – —	LIMITS OF SURVEY
●	TREE



DRAWING MODIFIED FROM TOPOGRAPHIC MAP PROVIDED BY SWANSON HYDROLOGY + GEOMORPHOLOGY

HK HOLDREGE & KULL
CONSULTING ENGINEERS • GEOLOGISTS
10775 PIONEER TRAIL, SUITE 213
TRUCKEE, CA 96161
(530) 587-5156 FAX 587-5196

TEST PIT LOCATION PLAN
ESMERALDA CREEK FEASIBILITY STUDY
EL DORADO COUNTY, CALIFORNIA

DRAWN BY: WSY
CHECKED BY: JKH
PROJECT NO.: 41011-01
DATE: JANUARY 2008
FIGURE NO.: 2

APPENDIX A Test Pit Logs

TEST PIT NO. 1

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011-01	ESMERALDA CREEK	–	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
STREAM CUT BANK	BULK	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
			1		FILL SM	FILL - BROWN TO RED BROWN SILTY SAND (SM): SLIGHTLY MOIST, LOOSE, FINE TO COARSE SAND AND GRAVEL WITH SOME COBBLES AND TRACE OF BOULDERS UP TO ABOUT 18 INCHES
			2		SM	GRAY BROWN SILTY SAND (SM): DRY TO SLIGHTLY MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE SAND AND GRAVEL WITH TRACE OF COBBLES AND BOULDERS (ORIGINAL GROUND)
			3			
			4			LIGHT RED BROWN SILTY SAND (SM): DRY TO SLIGHTLY MOIST, MEDIUM DENSE, FINE TO COARSE SAND WITH SOME FINE TO COARSE GRAVEL AND OCCASIONAL COBBLES
			5			
			6		SM	
			7			NOTE: NUMEROUS ROOTS IN THE TOP 3 FEET
			8			
			9	☒		
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

TEST PIT NO. 2

PROJECT NO. 41011-01	PROJECT NAME ESMERALDA CREEK	APPROX. ELEVATION -	DATE 10/5/2007	PAGE 1 OF 1

EXCAVATING METHOD STREAM CUT BANK HAND EXCAVATION	SAMPLING METHOD BULK	GROUNDWATER ENCOUNTERED NO	CAVED NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
			1			LIGHT YELLOW BROWN SILTY GRAVEL TO COBBLE RUBBLE (GP): MOIST, LOOSE, SILT AND FINE SAND ON SURFACE, ANGULAR CLASTS OF COARSE GRAVEL AND COBBLES UP TO 12 INCHES VISUAL ESTIMATION 60%-80% <6 INCHES IN SIZE
			2			
			3			
			4			MATERIAL APPEARS TO BE TUNNEL SPOILS
			5		GP	
			6			
			7			
			8			
			9			
			10			SAMPLE OBTAINED FROM BOTTOM OF TAILINGS EMBANKMENT
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

TEST PIT NO. 3

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011-01	ESMERALDA CREEK	–	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
STREAM CUT BANK HAND EXCAVATED	BULK	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
			1		SM/ ML	DARK RED TO RED BROWN SILTY SAND (SM) TO SANDY SILT (ML): MOIST, MEDIUM DENSE, FINE TO COARSE SAND WITH OCCASIONAL COBBLES AND BOULDER NUMEROUS ROOTS IN TOP 2 TO 3 FEET
			2			
			3			
			4			
			5			
	54.2	13		☒		
			6			
			7		RX	OLIVE SANDSTONE ROCK: MODERATELY WEATHERED, CLOSELY TO MODERATELY FRACTURED, STRONG
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

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TEST PIT NO. 4

PROJECT NO. 41011-01

PROJECT NAME ESMERALDA CREEK

APPROX. ELEVATION –

DATE 10/5/2007

PAGE 1 OF 1

EXCAVATING METHOD HAND EXCAVATED

SAMPLING METHOD NONE

GROUNDWATER ENCOUNTERED NO

CAVED NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
					GP	GRAY TO YELLOW BROWN SANDY GRAVEL (GP-GM)
			1		SM	RED BROWN SILTY SAND (SM): MOIST, MEDIUM DENSE, FINE TO COARSE SAND
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

TEST PIT NO. 5

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011–01	ESMERALDA CREEK	–	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
HAND EXCAVATED	BULK	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)			USCS	DESCRIPTIONS/REMARKS
			1	☒	▨	GP	GRAY TO YELLOW BROWN SILTY GRAVEL (GP): MOIST, LOOSE, TRACE TO SOME FINE SAND, COBBLES UP TO ABOUT 8 INCHES APPEARS TO BE TUNNEL SPOILS
			2		▨		
			3				
			4				
			5				
			6				
			7				
			8				
			9				
			10				
			11				
			12				
			13				
			14				
			15				
			16				
			17				
			18				
			19				
			20				

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TEST PIT NO. 6

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011-01	ESMERALDA CREEK	–	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
STREAM CUT BANK	BULK	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)			USCS	DESCRIPTIONS/REMARKS
			1	☒			RED BROWN SILTY GRAVEL WITH SAND (GM): MOIST, LOOSE, FINE TO COARSE SAND WITH SOME COBBLES AND TRACE BOULDER UP TO ABOUT 18 INCHES NUMEROUS ROOTS IN TOP 2 FEET BECOMES MEDIUM DENSE BELOW ABOUT 2.5 FEET
			2				
			3			GM	
	22.1	7	4	☒			
			5				
			6				
			7				
			8				
			9				
			10				
			11				
			12				
			13				
			14				
			15				
			16				
			17				
			18				
			19				
			20				

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TEST PIT NO. 7

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011-01	ESMERALDA CREEK	-	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
HAND EXCAVATED	NONE	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
			1		SP	GRAY BROWN TO RED BROWN POORLY GRADED SAND WITH SILT AND GRAVEL (SP): MOIST, LOOSE, FINE TO COARSE SAND AND GRAVEL UP TO ABOUT 1-INCH IN SIZE
	9.1		2	☒		
			3			RECENT STREAM TERRACE DEPOSIT IN EXISTING CHANNEL
			4			
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

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TEST PIT NO. 8

PROJECT NO. 41011-01	PROJECT NAME ESMERALDA CREEK	APPROX. ELEVATION –	DATE 10/5/2007	PAGE 1 OF 1

EXCAVATING METHOD STREAM CUT BANK	SAMPLING METHOD NONE	GROUNDWATER ENCOUNTERED NO	CAVED NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
				▨	SM	DARK RED TO RED BROWN SILTY SAND (SM): MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE SAND
			1	▨		
			2	▨		
			3	▨		
			4			
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

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TEST PIT NO. 9

PROJECT NO.	PROJECT NAME	APPROX. ELEVATION	DATE	PAGE
41011-01	ESMERALDA CREEK	–	10/5/2007	1 OF 1

EXCAVATING METHOD	SAMPLING METHOD	GROUNDWATER ENCOUNTERED	CAVED
HAND EXCAVATED	NONE	NO	NO

SAMPLE NO.	PERCENT PASSING #200 SIEVE	PLASTICITY INDEX	DEPTH (FT)		USCS	DESCRIPTIONS/REMARKS
				▨	SM	DARK RED SILTY SAND (SM): MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE SAND
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			

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APPENDIX B Laboratory Test Results

Atterberg Indices

ASTM D4318

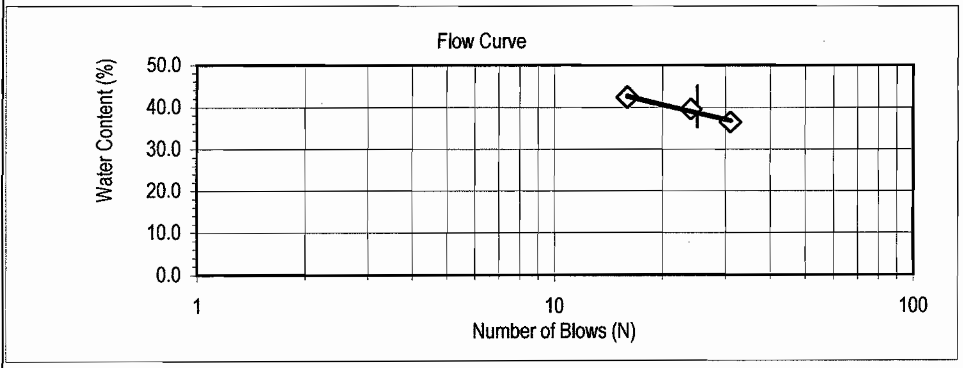
Project No.:	**41011-01**	Project Name:	**Esmeralda Creek Feasibility Study**	Date:	**10/25/2007**
Sample No.:	**TP-3**	Boring/Trench: **N/I**	Depth, (ft.): **5**	Tested By:	**MLH/BLP**
Description:	**Dark Red (2.5YR 3/6) Sandy Silt/Silty Sand**			Checked By:	**JKH**
Sample Location:				Lab. No.:	**7-853**

Estimated % of Sample Retained on No. 40 Sieve: ______ Sample Air Dried: yes

Test Method A or B: A

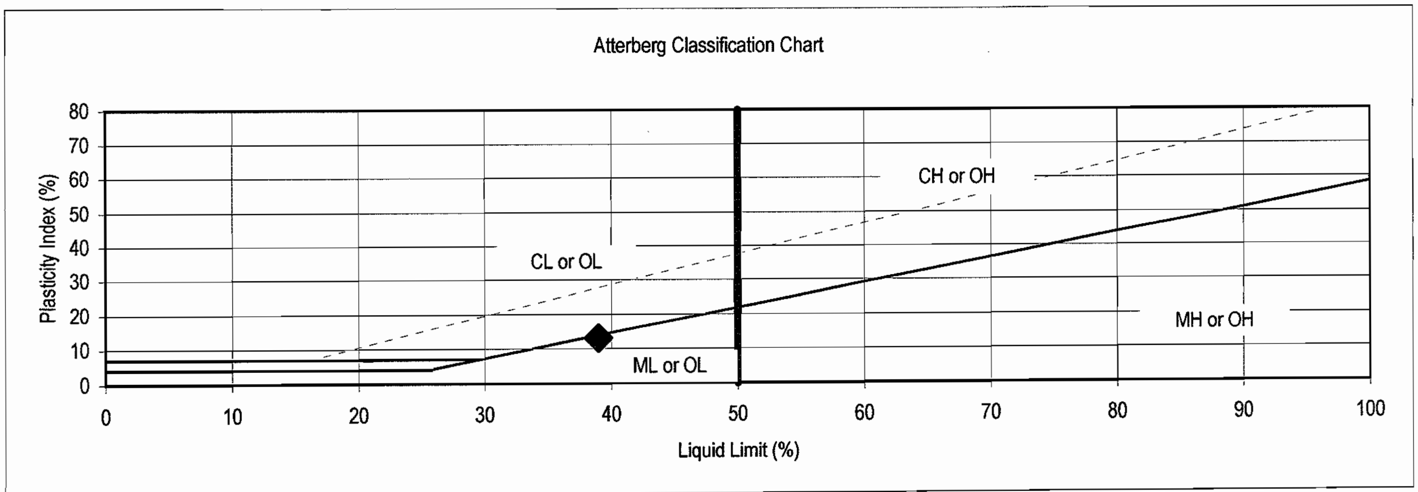
	LIQUID LIMIT:					PLASTIC LIMIT:		
Sample No.:	1	2	3	4	5	1	2	3
Pan ID:	AT	Z5	LLF			Q	BB	
Wt. Pan (gr)	15.25	15.28	15.11			11.08	11.15	
Wt. Wet Soil + Pan (gr)	26.30	28.27	30.41			14.24	14.16	
Wt. Dry Soil + Pan (gr)	23.01	24.59	26.33			13.58	13.53	
Wt. Water (gr)	3.29	3.68	4.08			0.66	0.63	
Wt. Dry Soil (gr)	7.76	9.31	11.22			2.50	2.38	
Water Content (%)	42.4	39.5	36.4			26.4	26.5	
Number of Blows, N	16	24	31					

LIQUID LIMIT = 39 PLASTIC LIMIT = 26



Plasticity Index = 13

Group Symbol = CL



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41011-01 lab# 7-853.xlsatterberg TP-3

Particle Size Distribution

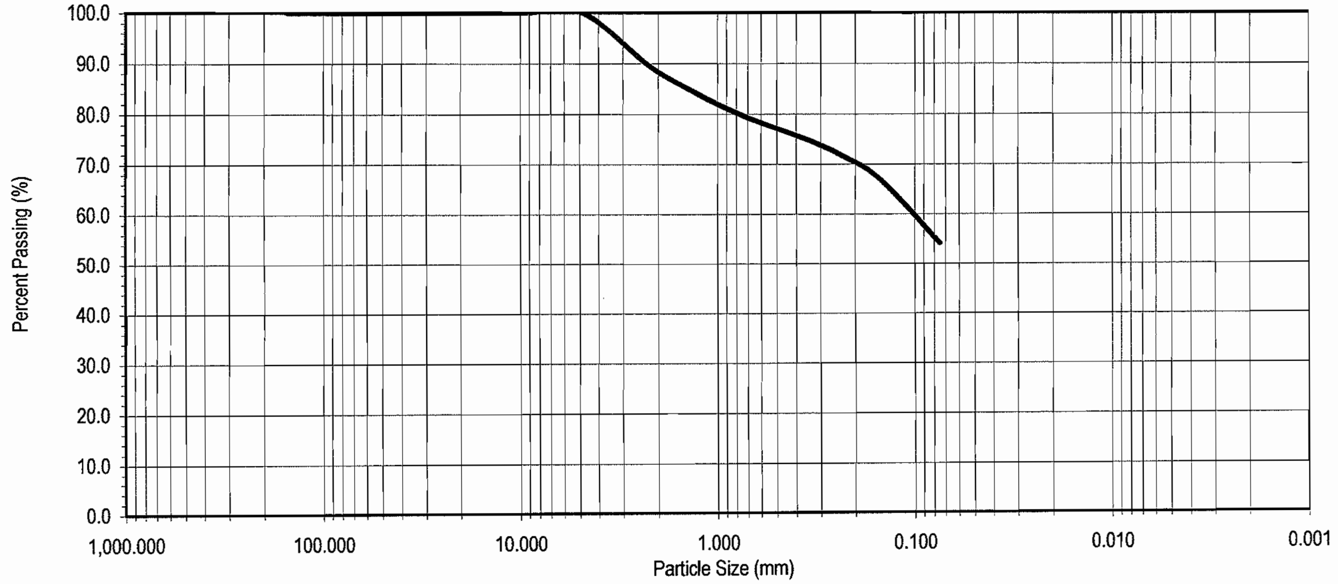
ASTM D422

Project No.: **41011-01** Project Name: **Esmeralda Creek Feasibility Study** Date: **10/25/2007**
Sample No.: **TP-3** Boring/Trench: **N/I** Depth, (ft.): **5** Tested By: **MLH/BLP**
Description: **Dark Red (2.5YR 3/6) Sandy Lean Clay** Checked By: **JKH**
Sample Location: Lab. No.: **7-853**

Sieve Size	Particle Diameter		Dry Weight on Sieve			Percent
	Inches	Millimeter	Retained On Sieve	Accumulated On Sieve	Passing Sieve	Passing
(U.S. Standard)	(in.)	(mm)	(gm)	(gm)	(gm)	(%)
6 Inch	6.0000	152.4	0.00	0.0	1,042.0	**100.0**
3 Inch	3.0000	76.2	0.00	0.0	1,042.0	**100.0**
2 Inch	2.0000	50.8	0.00	0.0	1,042.0	**100.0**
1.5 Inch	1.5000	38.1	0.00	0.0	1,042.0	**100.0**
1.0 Inch	1.0000	25.4	0.00	0.0	1,042.0	**100.0**
3/4 Inch	0.7500	19.1	0.00	0.0	1,042.0	**100.0**
1/2 Inch	0.5000	12.7	0.00	0.0	1,042.0	**100.0**
3/8 Inch	0.3750	9.5	0.00	0.0	1,042.0	**100.0**
#4	0.1870	4.7500	0.98	1.0	1,041.0	**99.9**
#10	0.0787	2.0000	121.15	122.1	919.9	**88.3**
#20	0.0335	0.8500	78.87	201.0	841.0	**80.7**
#40	0.0167	0.4250	47.86	248.9	793.2	**76.1**
#60	0.0098	0.2500	39.95	288.8	753.2	**72.3**
#100	0.0059	0.1500	55.75	344.6	697.5	**66.9**
#200	0.0030	0.0750	132.36	476.9	565.1	**54.2**

Boulders	Cobble	Gravel		Sand			Silt	Clay
		Coarse	Fine	Coarse	Medium	Fine		

Particle Size Gradation



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Atterberg Indices

ASTM D4318

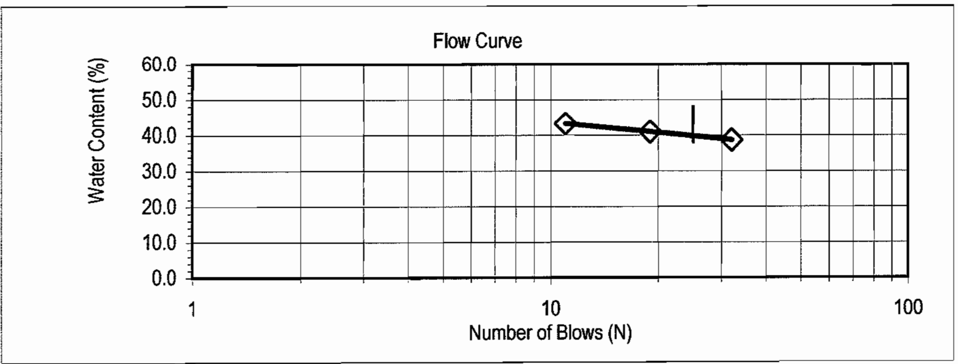
Project No.: **41011-01** Project Name: **Esmeralda Creek Feasibility Study** Date: **10/25/2007**
Sample No.: **TP-6** Boring/Trench: **N/I** Depth, (ft.): **4** Tested By: **MLH/BLP**
Description: **Dark Red (2.5YR 3/6) Silty Gravel with Sand** Checked By: **JKH**
Sample Location: Lab. No.: **7-853**

Estimated % of Sample Retained on No. 40 Sieve: Sample Air Dried: yes
Test Method A or B: A

	LIQUID LIMIT:					PLASTIC LIMIT:		
Sample No.:	1	2	3	4	5	1	2	3
Pan ID:	LB	HK	MBE			LF	I	
Wt. Pan (gr)	15.23	14.92	15.19			10.82	11.27	
Wt. Wet Soil + Pan (gr)	27.63	29.38	29.41			14.76	15.29	
Wt. Dry Soil + Pan (gr)	23.89	25.18	25.44			13.76	14.26	
Wt. Water (gr)	3.74	4.20	3.97			1.00	1.03	
Wt. Dry Soil (gr)	8.66	10.26	10.25			2.94	2.99	
Water Content (%)	43.2	40.9	38.7			34.0	34.4	
Number of Blows, N	11	19	32					

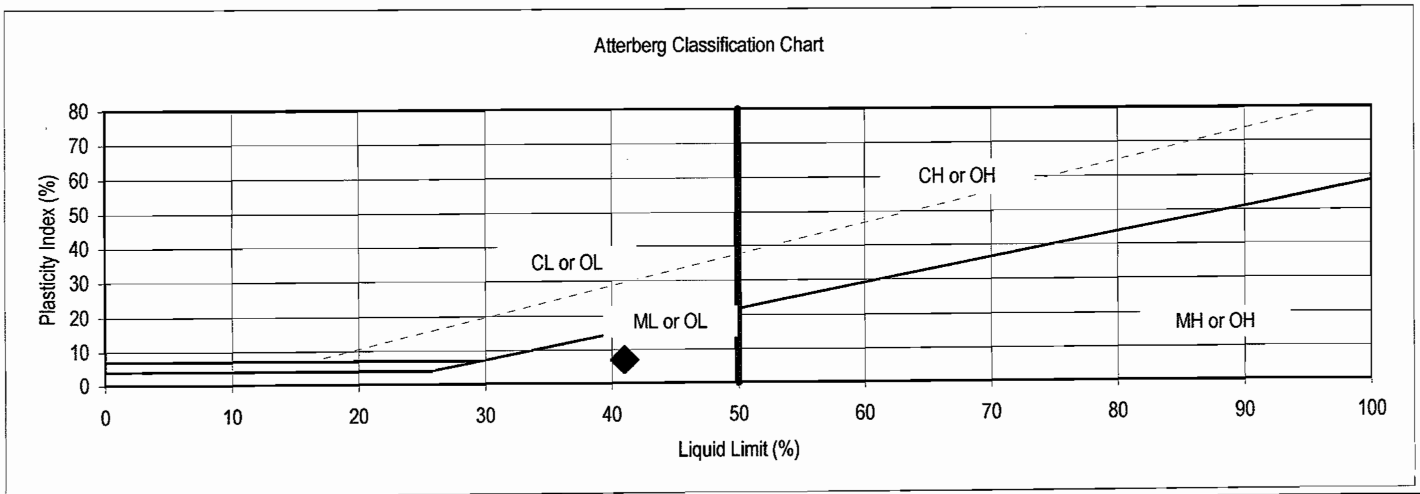
LIQUID LIMIT = 41

PLASTIC LIMIT = 34



Plasticity Index = 7

Group Symbol = ML



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41011-01 lab# 7-853.xlsatterberg TP-6

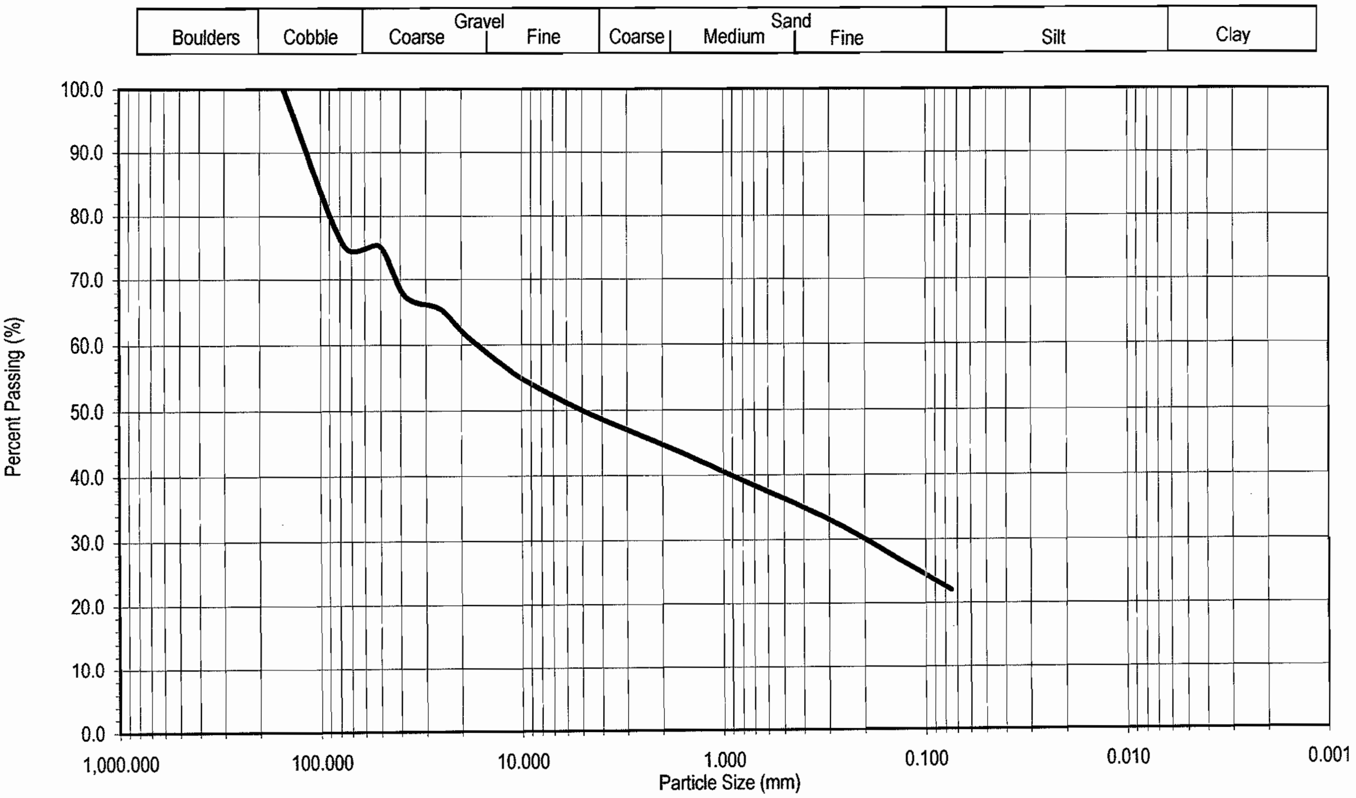
Particle Size Distribution

ASTM D422

Project No.: **41011-01** Project Name: **Esmeralda Creek Feasibility Study** Date: **10/25/2007**
Sample No.: **TP-6** Boring/Trench: **N/I** Depth, (ft.): **4** Tested By: **MLH/BLP**
Description: **Dark Red (2.5YR 3/6) Silty Gravel with Sand** Checked By: **JKH**
Sample Location: Lab. No.: **7-853**

Sieve Size	Particle Diameter		Dry Weight on Sieve			Percent
	Inches	Millimeter	Retained On Sieve	Accumulated On Sieve	Passing Sieve	Passing
(U.S. Standard)	(in.)	(mm)	(gm)	(gm)	(gm)	(%)
6 Inch	6.0000	152.4	0.00	0.0	2,459.5	**100.0**
3 Inch	3.0000	76.2	607.02	607.0	1,852.5	**75.3**
2 Inch	2.0000	50.8	0.00	607.0	1,852.5	**75.3**
1.5 Inch	1.5000	38.1	191.63	798.7	1,660.9	**67.5**
1.0 Inch	1.0000	25.4	48.28	846.9	1,612.6	**65.6**
3/4 Inch	0.7500	19.1	101.03	948.0	1,511.5	**61.5**
1/2 Inch	0.5000	12.7	104.06	1,052.0	1,407.5	**57.2**
3/8 Inch	0.3750	9.5	67.22	1,119.2	1,340.3	**54.5**
#4	0.1870	4.7500	118.68	1,237.9	1,221.6	**49.7**
#10	0.0787	2.0000	120.19	1,358.1	1,101.4	**44.8**
#20	0.0335	0.8500	127.91	1,486.0	973.5	**39.6**
#40	0.0167	0.4250	102.97	1,589.0	870.5	**35.4**
#60	0.0098	0.2500	87.43	1,676.4	783.1	**31.8**
#100	0.0059	0.1500	99.37	1,775.8	683.7	**27.8**
#200	0.0030	0.0750	141.23	1,917.0	542.5	**22.1**

Particle Size Gradation



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Particle Size Distribution

ASTM D422

Project No.: **41011-01** Project Name: **Esmeralda Creek Feasibility Study** Date: **10/25/2007**

Sample No.: **TP-7** Boring/Trench: **N/I** Depth, (ft.): **1** Tested By: **MLH/BLP**

Description: **Dark Reddish Brown (5YR3/3) Poorly Graded Sand with Silt and Gravel** Checked By: **JKH**

Sample Location: Lab. No.: **7-853**

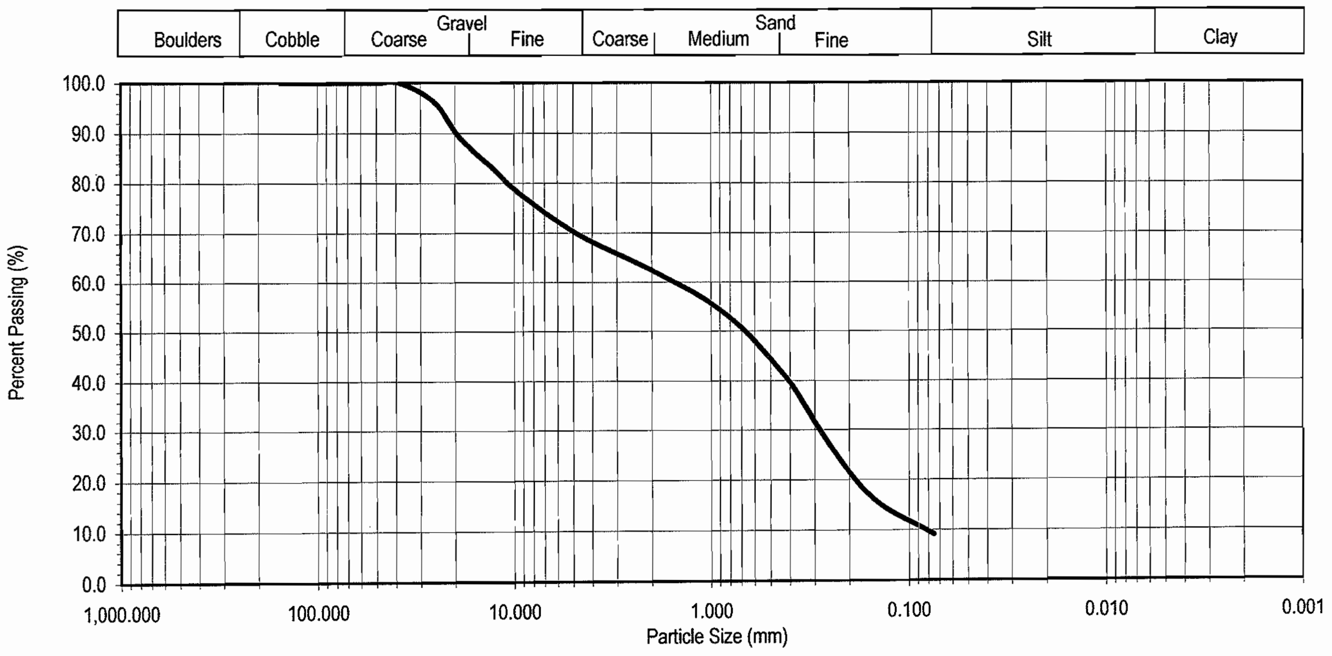
Sieve Size	Particle Diameter		Dry Weight on Sieve			Percent
	Inches	Millimeter	Retained On Sieve	Accumulated On Sieve	Passing Sieve	Passing
(U.S. Standard)	(in.)	(mm)	(gm)	(gm)	(gm)	(%)
6 Inch	6.0000	152.4	0.00	0.0	986.8	**100.0**
3 Inch	3.0000	76.2	0.00	0.0	986.8	**100.0**
2 Inch	2.0000	50.8	0.00	0.0	986.8	**100.0**
1.5 Inch	1.5000	38.1	0.00	0.0	986.8	**100.0**
1.0 Inch	1.0000	25.4	37.66	37.7	949.2	**96.2**
3/4 Inch	0.7500	19.1	67.33	105.0	881.9	**89.4**
1/2 Inch	0.5000	12.7	63.50	168.5	818.4	**82.9**
3/8 Inch	0.3750	9.5	47.00	215.5	771.4	**78.2**
#4	0.1870	4.7500	82.78	298.3	688.6	**69.8**
#10	0.0787	2.0000	71.77	370.0	616.8	**62.5**
#20	0.0335	0.8500	86.77	456.8	530.0	**53.7**
#40	0.0167	0.4250	124.59	581.4	405.4	**41.1**
#60	0.0098	0.2500	140.34	721.7	265.1	**26.9**
#100	0.0059	0.1500	106.17	827.9	158.9	**16.1**
#200	0.0030	0.0750	68.74	896.7	90.2	**9.1**

Cc = 0.58

Cu = 17.78

D60	D30	D10
1.6	0.29	0.09

Particle Size Gradation



HOLDREGE & KULL

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