BURKE CREEK RESTORATION PROJECT
ALTERNATIVES ANALYSIS REPORT
BURKE CREEK AT HIGHWAY 50
STATELINE, NEVADA

June 2009

Prepared for:

TAHOE REGIONAL PLANNING AGENCY

Prepared by:

WINZLER & KELLY

Michael Love & Associates
Hydrologic Solutions

McBain & Trush, Inc.

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Project No. 1118407001.11160

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Prepared for:

Tahoe Regional Planning Agency
128 Market Street
P.O. Box 5310
Stateline, Nevada 89449

REGISTERED PROFESSIONAL ENGINEER
STATE OF NEVADA
MICHAEL D. KINCAID
CIVIL
6-30-09
No. 5463

Prepared by:

Steven Allen, P.E.
Winzler & Kelly
633 Third Street
Eureka, CA 95501
(707) 443-8326

Michael Kincaid, P.E.
Winzler & Kelly
417 Montgomery Street
San Francisco, CA 94104
(415) 283-4970

Michael Love, P.E.
Michael Love & Assocaites
P.O. Box 4477
Arcata, CA 95518
(707) 476-8938

Geoffrey Hales, P.G.
McBain & Trush, Inc.
P.O. Box 663
Arcata, CA 95518
(707) 826-7794

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EXECUTIVE SUMMARY

The Burke Creek restoration project area includes the region immediately upstream and downstream of Highway 50, north of the Kahle and Highway intersection, and near the town of Stateline, NV (Figure). The Tahoe Regional Planning Agency (TRPA) along with Douglas County, Nevada Department of Transportation (NDOT), U.S. Fish and Wildlife (USFS), Nevada Department of State Lands (NDSL), and private property owners formed the Technical Advisory Committee (TAC) for the restoration project, which provided guidance and feedback to the project design team.

The project design team consists of Winzler & Kelly as the project lead; Michael Love & Associates, whose focus was the hydrologic and hydraulic analysis and channel design; and McBain & Trush, Inc., whose focus was the geomorphic conditions and botanical resources for both existing conditions and for restoration alternatives. The project team members were engaged in all aspects of the project.

At the October 2007 kick off meeting attended by TRPA, other TAC members and key project team members, several project objectives were discussed including the following:

- Improving fish passage conditions
- Improving flood flow conveyance
- Improving sediment transport
- Improving riparian corridor

The above objectives were recognized as being interrelated and the project is intended to explore restoration alternatives that have multiple ecological benefits.

Existing Conditions and Data Analysis

Following the project kick off meeting on October 2, 2007, the project team researched and obtained various applicable data, assembled and reviewed past studies and documents provided by the TAC, and collected and analyzed field data as described below.

Topographic and Bathymetric Surveying

In October 2007, Turner and Associates, Inc. was tasked with conducting a topographic and right-of-way survey of the project area. To supplement this topographic survey, McBain & Trush, Inc. conducted a channel longitudinal profile survey. This profile survey extended from the Lake Tahoe Shoreline to the upper meadow, approximately 2,300 feet upstream of Highway 50 (Figure).

Geomorphic Setting and Reach Designations

The survey and field reconnaissance data was utilized to determine the existing geomorphic setting (Section), selecting and analyzing reference reaches (Section), and analyzing existing hydrologic and hydraulic conditions (Sections and , respectively). For the geomorphic analysis, the creek was divided into three distinct reaches identified from upstream to downstream as the Upper Meadow Reach, the Upstream Reach, and the Downstream Reach.

Sediment Supply, Transport, and Deposition Analysis

The sediment supply, transport, and deposition analysis (Section) concluded that sediment load in the Burke Creek watershed is extremely low compared with other published values for other small Sierra Nevada streams.

Channel Stability Evaluation

The Burke Creek channel alignment within the project area has changed over time. Based on the evaluation of channel stability and review of prior development in the area, these changes appear to have occurred primarily related to development (Figure). The channel stability evaluation identified unstable areas in the Upper Meadow Reach, but head cutting is considered constrained by natural hardened features. The Upstream Reach appears to have adjusted from its reconfiguration over 30 years ago. The Downstream Reach appears to be very stable from the culvert to Rabe Meadow Pond. Downstream of the Rabe Meadow Pond, the channel experiences local bank erosion (with cut banks up to 3 feet high), but the risk of rapid lateral erosion or incision appears low, with potentially one exception. A 2.7 foot headcut currently exists at approximately station 46+50 (Figure), but the headcut appears to be currently stable.

Selection of Reference Reaches

Three reference reaches were selected as representative of conditions within the project area. Two of the reference reaches are upstream of Highway 50 and are designated as the Upstream Reference Reach and the Middle Reference Reach. One reference reach was selected downstream of the Rabe Meadow Pond and was designated as the Downstream Reference Reach. After evaluating the data including a summary of the hydraulic geometry of the reference reaches summarized in Table 3, the middle reference reach was selected to develop the conceptual alternatives.

Hydrologic Conditions and Design Flow

The following two approaches were used to quantify design flows for Burke Creek:

1) Large peak flows were determined using a USGS flood frequency analysis, and

2) Lower flows were estimated through direct comparison of measured flows in Burke Creek to flows in adjacent gaged streams.

For evaluating culvert hydraulic capacity and flooding, the potentially more conservative (higher) peak flow estimates derived from the USGS flow frequency values were utilized (Table).

Existing conditions were modeled using the Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). The model of Burke Creek was created and calibrated using information collected in the field and from the topographic surveys. Model results were used to quantify existing channel and culvert capacity and to evaluate present fish passage condition. The result of the existing conditions modeling indicates that the flow overtops the left bank dike at approximately 20 cfs, approximately 200 feet upstream of the culvert. The modeled 100-year flow event resulted in 75.4 cfs leaving the channel while 44.6 cfs remained. The model also showed that the culvert becomes submerged at 11.5 cfs. At approximately 25 cfs, the headwater depth is sufficient to begin overtopping Highway 50.

Existing Fish Passage Conditions

Another aspect of the modeling effort was to identify the existing fish passage conditions for relevant species. Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) are native to the Truckee Basin and historically resided in Lake Tahoe and its tributaries**.** LCT were listed as endangered species in 1970 and reclassified as threatened to facilitate management in 1975. Although LCT are now extirpated from Lake Tahoe and its tributaries, there have been efforts to reintroduce the fish. A stream survey identifying species abundance, distribution habitat suitability, location of existing migration barriers is recommended.

The existing fish passage conditions were assessed between the Rabe Meadow Pond and the upper meadow. The Burke Creek project reach is considered upstream of the historical and current limit for lake-run trout and is defined as a resident/ nursery reach (NDW, 1982). According to documents prepare by TRPA for Burke Creek and discussions that occurred at the kickoff TAC meeting for this project, fish passage and habitat enhancements for this project will focus on meeting the needs of adult resident and juvenile rainbow and Lahontan cutthroat trout.

Common criteria for juvenile salmonids and adult resident rainbow trout are listed in Table . The Table criteria were applied to the assessment of the existing 228-foot long corrugated metal culvert under Highway 50. The existing Highway 50 culvert could be classified as a barrier to the target fish at all flows. However, it is likely that stronger individual fish within the population can negotiate the culvert under certain flow conditions and therefore, this culvert should not be considered adequate as a barrier to block upstream migration of non-native fish.

Fish passage values summarized in Table were also utilized to evaluate the Upstream Reach and the Downstream Reach. Within the Upstream Reach there are 15 vertical drops that exceed the maximum drop height criterion of 0.67 feet for adult resident trout, with seven of them greater than 1 foot (Figure). The predominant channel slopes in the Upstream Reach are relatively steep, with approximately 230 feet of channel with slopes greater than 6%, and including a nearly 120 feet long reach with a slope of 11.8% (Figure). Although adult rainbow trout are known to migrate through channels with slopes exceeding those identified between Rabe Meadow and the Upper Meadow, it is unknown if they could ascend these steep channel segments due to the vertical drops within the channel and poor leaping conditions provided below them. It is also unclear if juvenile salmonids can ascend such steep sections of channel.

The Downstream Reach model results suggest that at the lower passage flow of 0.2 cfs, water depth in the downstream channel is inadequate for both juvenile salmonids and adult resident rainbow and LCT. At the high passage flow, adequate depth for juvenile salmonids is provided throughout most of the reach and the model predicted cross sectional averaged water velocities range between 0.2 and 2.4 ft/s. While water depth is less than ideal for both juvenile and resident adults, it does appear that these fish could negotiate this reach during periods of higher flow.

Vegetation Analysis

The final existing condition analysis included an evaluation of the existing vegetation (Section). A riparian botanist conducted the field inventory, which consisted of walking the length of Burke Creek from its confluence with Lake Tahoe up to the upper meadow and visiting each distinct cover type. Polygon boundaries were drawn in the field around discrete cover types and a cover attribute was assigned. Polygons were no smaller than 100 feet^2 and included all human disturbance (i.e., anthropogenic), riparian, wetland, and adjacent upland habitats (i.e., biological habitats) within the project area. Figure and Figure present the mapped vegetation analysis results.

Alternatives Analysis

Once the background data had been collected and analyzed the project team developed four preliminary alternatives which were submitted to the TAC on February 22, 2008 as a Technical Memorandum titled *"Burke Creek Restoration Project: Preliminary Development of Alternatives"* (Appendix A). On February 22, 2008, key members of the project team met with the TAC at the TRPA office to discuss the preliminary alternatives and answer questions from the TAC. TRPA compiled TAC comments and directed the project Team to further analyze and develop Alternatives A and B.

Alternative A

Alternative A has the following main features:

- 90-feet of modified channel upstream of Highway 50 within existing alignment (no parking lot encroachment)
- 100-foot long, 12-foot wide by 6.5-foot tall concrete box culvert crossing Highway 50 and effectively passing over the sewer line
- 345 feet of new channel constructed downstream of Highway 50
- 535 feet total of new channel length

Under Alternative A, 90-foot of the channel upstream of Highway 50 would be modified within its existing alignment, which is located on property owned by Sierra Colina LLC. The project area under Alternative A does not extend onto the adjacent commercial property to the south. The proposed channel bottom upstream of Highway 50 will be lower than the existing channel to allow for the installation of a larger culvert to pass higher flows. A deeper channel and existing dikes will contain the 100-year flows within the project area. Upstream of the project area, raising the existing dikes would be necessary in order to reduce current flooding potential on the adjacent commercial property.

The proposed culvert replacement under Alternative A is nearly perpendicular to the highway centerline. The culvert replacement for Alternative A is 100 feet in length and assumes the existing sewer line will not be relocated, and the new culvert would essentially pass over it and a portion of the sewer would be encased in concrete at the crossing. Downstream of the culvert, a new channel will be reconstructed connecting back to the existing willow channel approximately

345 feet downstream of the culvert outlet. Conceptual drawings for Alternative A are provide in Appendix J.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels. These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, provide channel and flow complexity that facilitates fish passage, and provide aquatic habitat.

The proposed channel alignment downstream of Highway 50 follows a swale defined by the hillslope to the north and a slight rise in the ground to the south. This alignment was chosen to match the proposed location of the culvert outlet and to utilize existing topography as much as practical to confine the floodplain.

Much of the downstream channel will require fill, as the channel thalweg is above the existing ground. It is believed that this portion of Rabe Meadow was lowered during excavation activities for the Jenning's Casino, which was never completed. Therefore, the fill proposed for the downstream channel can be part of a strategy to restore this area to pre-Jenning's Casino construction conditions.

Refer to Sections , , and for discussions on Alternative A geomorphic analysis, fish passage analysis, and revegetation options, respectively.

Alternative B

Alternative B has the following main features:

- 330-feet of channel upstream of Highway 50 similar to the historic channel profile with a ten foot encroachment into the parking lot
- 120-foot long, 12-foot wide by 6.5-foot tall concrete box culvert crossing Highway 50 with a relocated sewer line
- 400 feet of new channel constructed downstream of Highway 50
- 850 feet total of new channel length

The intent of proposed Alternative B is to construct a channel similar to the historical channel profile and morphology as much as possible, given the constraints imposed by the highway, land development, existing topography, and other changes in land use. Alternative B assumes the channel reach upstream of Highway 50 can be realigned to increase the available floodplain and riparian area while limiting flooding to adjacent infrastructure. Alternative B also assumes that the sewer line under the western shoulder of the highway can be relocated to allow for a continuous channel profile and avoid the need for fill in the downstream dry meadow.

Alternative B will create an 850-foot long channel that extends 330 feet upstream and 400 feet downstream of Highway 50. Upstream of Highway 50, the proposed channel will be realigned slightly to the south of the existing channel. The existing northern row of parking spaces within the commercial parking lot will be eliminated to facilitate realignment of the channel. The channel in this area will be confined by dikes and retaining walls. The lowered channel and raised dikes will contain the 100-year return flow with 2 feet of freeboard between the 100-year water surface elevation and top of dike.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels. These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, and provide channel and flow complexity that facilitates fish passage and provides aquatic habitat.

A new channel, approximately 400 feet long, will be constructed downstream of Highway 50. It joins the existing channel approximately 360 feet upstream of the Rabe Meadow Pond. The proposed channel alignment downstream of Highway 50 follows an existing swale. The existing channel from downstream of Highway 50 to the location where the relocated channel meets the existing channel will be abandoned. A small wetted swale, with a one-foot bottom constructed approximately 2-tenths of a foot below bankfull elevation provide limited water to help sustain a portion of the existing vegetation in the abandoned channel.

Upstream of Highway 50, floodplain widths of 4.0 to 7.5 feet are on either side of the channel. Dikes are proposed along the southern side of the channel at the edge of the floodplain. Retaining walls are necessary between approximate stations 63+75 and 65+60 along the edge of the commercial parking lot to allow construction of the channel, floodplain and dikes that will contain 100-year flows, while keeping within the defined project limits. The proposed retaining wall height varies from 2.2 to 5.5 feet.

Downstream of Highway 50, after flows expand out of the culvert and roadway embankment, excavation of 16 to 18-foot wide floodplains will be necessary to maintain the design bankfull channel dimensions and to tie into existing ground. Larger flow events will spread across the constructed floodplains onto existing ground, creating a much wider floodplain than what will be constructed.

Refer to Sections , , and for discussions on Alternative B geomorphic analysis, fish passage analysis, and revegetation options, respectively.

Alternative Comparison

To aid TRPA and the other TAC members in evaluating the proposed alternatives and to compare the alternatives to the existing conditions, criteria were selected, defined and then analyzed with respect to each alternative. The results of the alternative analysis are presented in the following table. A definition of each criterion is presented in Section as well as the terms used in the following table.

This comparison table is intended to aid the TAC in considering different alternatives. Upstream and downstream components are considered separately so that the different aspects of the project can be considered separately. The comparison table is intended to provide the TAC with a tool for discussion. The criteria are complex in nature and should be discussed. We have not attempted to weight the importance of any of the criteria. Ultimately the TAC need to discuss the various project criteria and determine the preferred alternative.

Alternative Analysis Matrix (Table 20 **Repeated)**

Category	Criterion	Existing		Alternatives A		Alternatives B	
		Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
Hydraulics	Flood flow conveyance	Poor	Moderate	Poor	Good	Good	Good
Fisheries	Fish passage	Poor	Poor	Poor	Good	Good	Good
Riparian	Impacts to existing vegetation	None	None	None	Moderate	Moderate	Moderate
Geo-morphology	Sediment management	Moderate	Poor	Good	Moderate	Good	Good
	Defined channel	Poor	Poor	Good		Good	
	Channel stability	Moderate	Moderate	Good		Good	
Construction	Temporary impacts	N/A	N/A	Moderate	Moderate	Moderate	Moderate
	Commercial parking lot permanent impacts	N/A	N/A	None		Moderate	
	Sewer line permanent impacts	N/A	N/A	Low/None		Moderate	
	Other utility permanent impacts	N/A	N/A	Good		Good	Good
	Opinion of probable cost	N/A	N/A	To be finalized		To be finalized	

<u>Color Definitions</u>
Red - Anticipated to be negative
Yellow - Anticipated to be neutral
Green - Anticipated to be positive

Outstanding Issues and Assumptions

During the conceptual design process, several assumptions were made to allow for alternatives to be developed. The assumptions are listed below as well along with their associated description. Collecting additional information and verifying the assumptions was beyond our scope of services, but verifying the assumptions is highly recommended prior to proceeding with the design of any alternative.

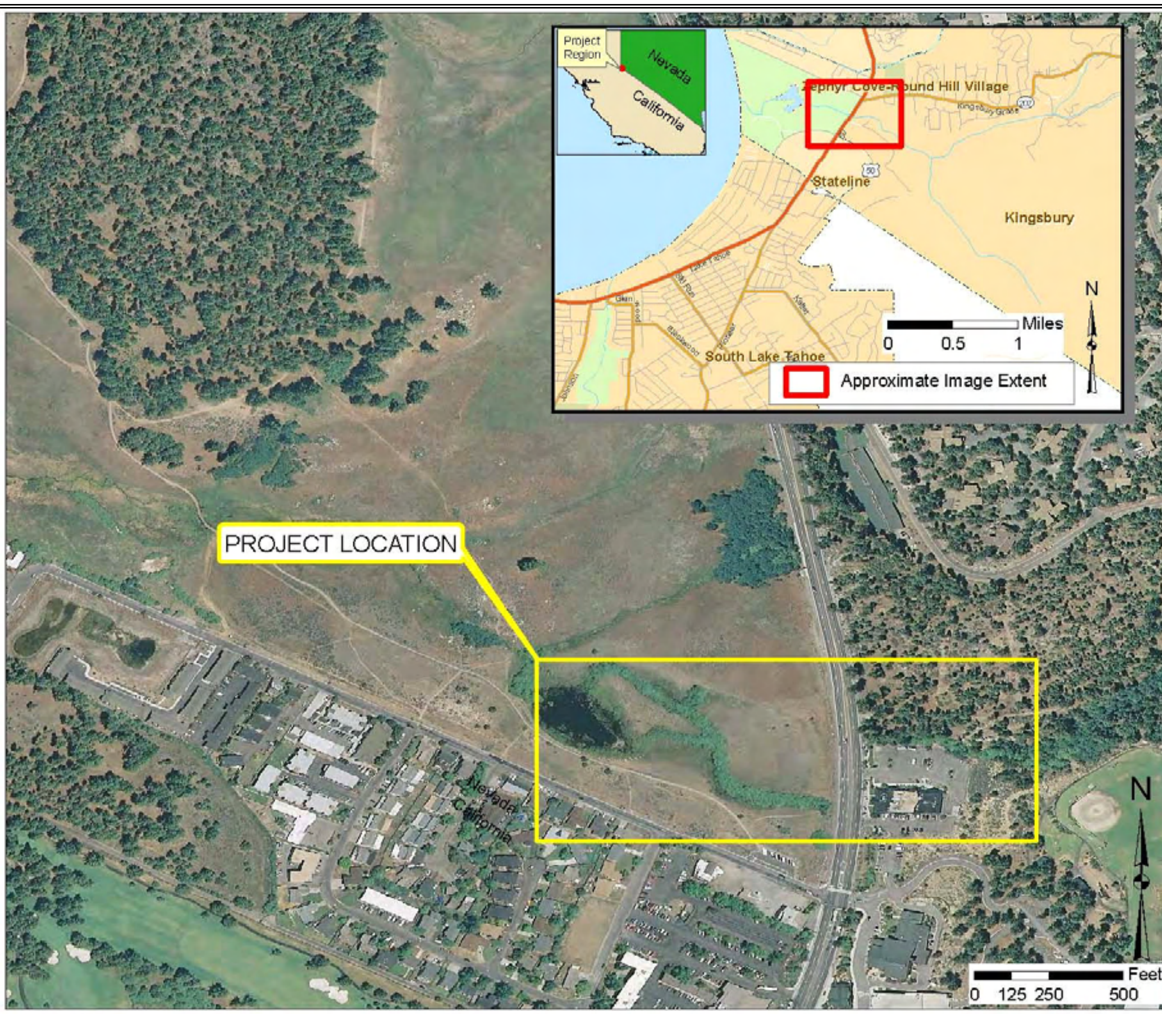
- Gravity sewer alignment
    - No potholing was conducted as part of this project. Sewer pipeline inverts and manhole cover elevations were collected as part of the survey. It was assumed that the sewer line follows a constant slope between manholes. Both alternatives impact this sewer alignment and potholing should be completed prior to any final design.
    - Further, a second map, created by JWA, for the sewer pipeline location and invert elevations was obtained (Appendix A). The JWA map invert elevations differ slightly from the survey results as does the difference between the inverts on either side of the proposed project crossing. Again, potholing should be conducted prior to any final design effort to determine the actual sewer line elevations in the anticipated project area.
- Sensitive species
    - Although field reconnaissance was conducted to identify vegetation within the project boundary, the reconnaissance was not intended to identify all species in the area. Prior to final design, additional seasonal appropriate surveys should be conducted to identify potential sensitive species within the project area.
- Streamside Environmental Zone Goals and Constraints
    - Actual SEZ boundaries were not mapped as part of this project. Additionally, SEZ guidelines are not clearly understood in relation to other restoration goals. They could be interpreted as a project goal or as a project constraint. This issue needs to be resolved in order to further develop project alternatives.
- Commercial parking lot
    - During the course of the conceptual design process, several alternatives were allowed to impact the commercial parking lot in order to explore project restoration goals. In order to better understand potentially feasible parking lot impacts, several potential layouts were discussed with the current owner of the property. There are several issues that may impact the owner's ability and willingness to allow the project to impact the parking lot. Currently it appears feasible that the owner could allow the project to impact the northerly row of existing parking stalls, and perhaps even more. Therefore, it was assumed that proceeding with an alternative that impacts only the northerly row of parking would be the most conservative approach and if more parking lot space were to become available later, the project could be designed to maximize the use of the available space to further develop the restoration goals.

- Groundwater
    - An analysis of groundwater conditions was beyond the scope of this project. It is recommended that groundwater monitoring be conducted in the project area. This information will be critical for developing appropriate planting approaches and minimizing construction impacts.
- Existing Culvert
    - The topographic survey obtained the invert locations of the existing culvert's inlet and outlet. It was assumed that the culvert extends linearly between the two recorded points. During the alternative development process, a figure created for an erosion control master plan for NDOT (Appendix A) was provided with a sketched culvert alignment showing the culvert paralleling Highway 50 towards the south until nearly even with the outlet. The sketch then shows the culvert crossing Highway 50 with a slight skew. Prior to final design, the existing culvert's actual alignment should be verified.
    - Based on the same sketch, it is currently assumed that some of the drainage inlets located in the commercial parking lot drain into the existing Burke Creek culvert. Prior to final design all drainage inlets that connect to the culvert should be identified.
- Upper Meadow Headcut
    - Fish passage through the project reach is a project objective. The alternatives developed do not remedy issues outside of the project area. Field work conducted as part of our efforts indicated that there may be fish passage barriers upstream of our project reach. It is recommended that the TAC consider this issue in case they would want to modify the project area to address this issue and to improve connectivity for migrating fish species.
- Property Ownership
    - The Turner Survey identified the property line along the northerly side of the commercial parking lot and the Highway 50 Right-Of-Way in the project. A question was raised at a TAC meeting regarding a potential small parcel just north of the culvert inlet and outside of our project area that may be under separate ownership. Prior to final design the property ownership in this area should be confirmed.
- Stream Length
    - The proposed alternatives both result in shortening the channel length. It is not known to what extent this may impact the permitting process. Prior to final design, potential permitting agencies should be contacted and engaged in the project so they can provide feedback on any potential issues with the proposed stream length as well as any other aspect of the alternatives.

1.0 INTRODUCTION

The Tahoe Regional Planning Agency (TRPA) along with Douglas County, Nevada Department of Transportation (NDOT), U.S. Fish and Wildlife (USFS), Nevada Department of State Lands (NDSL), and private property owners are seeking to make improvements and implement restoration efforts on a portion of Burke Creek in and around the U.S. 50 Highway crossing. A project location map is presented in Figure 1. The existing culvert crossing under Highway 50 is a known fish passage barrier and its replacement with a fish-friendly crossing is a driving force for this restoration project. It is recognized that providing a new fish-friendly crossing will also result in a crossing that provides increased hydraulic capacity, improved flood conveyance, improved sediment transport capabilities, and should therefore result in less maintenance requirements. Replacing the existing culvert with a new fish-friendly crossing will also necessitate modifications to the adjacent upstream and downstream channels.

Figure 1: Project Location



Burke Creek is a relatively small stream with a drainage area of approximately 4.5 square miles draining to Lake Tahoe. The stream has been historically modified and relocated in the project area to accommodate human developments such as the former Tahoe Nugget Casino, Highway 50 and other commercial developments upstream of the highway, including parking lots that have infringed upon the historical floodplain.

Burke Creek flows through at least four different property ownerships in the project area under consideration. From the upstream end of the project area, ownership starts with the USFS and the Lake Tahoe Basin Management Unit (LTBMU), then a mix of private ownership (for commercial and private use), followed by the Highway 50 crossing and right-of-way owned by NDOT, reverting back to USFS lands downstream of the highway crossing.

This report presents the development and analysis of the proposed alternatives for the Highway 50 crossing improvements and the adjacent Burke Creek channel. The alternatives analyzed were developed through coordination with TRPA and a Technical Advisory Committee (TAC). The report begins by reviewing background information and the project goals and constraints identified at a kickoff TAC meeting (Sections 2.0 and 3.0, respectively). This is followed by a summary of the field investigations completed that were necessary to develop the proposed alternatives (Section 4.0). An in-depth analysis of the existing condition topographic, hydrologic, geomorphic, biological, and hydraulic data analysis is then presented in Sections 4.1 through 4.7. From this information, four preliminary alternatives were developed and are summarized in Section 5.0. These four preliminary alternatives were submitted to the TAC and a summary of the TAC comments regarding the four preliminary alternatives are then presented. From these comments, two preferred alternatives were identified for further development and analysis. The development and analysis of these two alternatives are presented in Sections 6.0 through 8.0 and include project detail along with an analysis of how each alternative meets project goals. The final alternatives analysis is summarized in Section 9.0. Finally, recommendations and next project steps are presented in Section 10.0.

The project team that developed this report consists of Winzler and Kelly who provide the role of project management and engineering; Michael Love & Associates, who prepared the existing and proposed hydrologic and hydraulic analyses of the stream channel and culvert; and McBain and Trush, Inc., who assessed existing vegetation resources of the project area, prepared revegetation plans, and provided a geomorphic overview of the project. This report was prepared under the direction of TRPA, with input from a TAC committee that included representatives from TRPA, Douglas County, NDOT, USFS, NDSL, private property owners, and other interested parties.

2.0 REVIEW OF BACKGROUND INFORMATION

The project team gathered and reviewed relevant background information and data relating to the project area. This information included previously prepared reports and studies concerning Burke Creek, historical aerial photographs and maps, historical flow records for adjacent gaged streams, and 1996-1997 streamflow data for Burke Creek collected by Nevada Tahoe Conservation District (NTCD). The information has been referenced as part of this report and was used where relevant for assessment of existing conditions and preparation of alternatives.

3.0 TAC KICKOFF MEETING

Key members of the project team attended the project kickoff meeting with the TAC at the TRPA office on October 2, 2007. Meeting materials and other correspondence is included in Appendix A of this report. The meeting provided useful information on past and present projects that have, or could, affect current restoration efforts of Burke Creek near the Highway 50 crossing. Internally, TRPA refers to this project as EIP#161.

The project goal, as identified during the meeting, is to develop conceptual designs for a culvert replacement and stream channel modifications to restore ecological function and connectivity of Burke Creek within the project boundaries.

The following objectives were discussed by TRPA and the TAC:

- Improve fish passage
- Improve flood flow conveyance
- Improve sediment management
- Improve riparian corridor

The following constraints were discussed:

- There are multiple utilities located within or near the Highway 50 right-of-way.
- The project area spans multiple parcels under different ownership (public and private).
- Availability of space in commercial parking lot for restoration efforts appears likely but not definite.
- Construction within Highway 50 right-of-way may be challenging due to traffic control and limited construction window (construction after Labor Day Holiday preferred due to magnitude of summer traffic).

4.0 EXISTING CONDITIONS

4.1 Topographic and Longitudinal Profile Surveys

Topographic and right-of-way survey of the project area was conducted by Turner and Associates, Inc. in October 2007 as part of initial planning for this project. From the survey data, Turner and Associates developed a topographic base map with one-foot contours. This base map, along with a longitudinal profile of the stream channel bottom (thalweg) surveyed by the project team, was used by the project team when developing design alternatives.

The topographic and right-of-way survey utilized NDOT horizontal and vertical datums. A copy of the full survey has been provided to TRPA. The topographic base map is shown on the conceptual plans included in this report (Section 6.0).

A longitudinal channel profile was surveyed by the project team to supplement the Turner & Associates survey, which did not include a channel profile survey. The longitudinal profile survey was conducted from October 23 – 25, 2007 and included detailed characterization of the channel profile morphology. A Total Station survey instrument was used to map the channel bottom elevation (thalweg) and water surface elevations from the Lake Tahoe shoreline to the upper meadow (Figure 2), approximately 2,300 feet upstream of Highway 50. The total mapped channel length was approximately 8,800 feet

Additional bathymetric detail was collected in the sediment retention pond to help estimate sedimentation rates. This data was not included on the topographic basemap, but is discussed in Section4.2.3. All supplemental topographic mapping (longitudinal profile and pond bathymetry) was referenced to horizontal and vertical control established by Turner and Associates, Inc. and later converted to NDOT control. The extents of the project area investigated are show on Figure 2. The longitudinal profile near the project area is shown in Figure 3 and the full profile is included in Appendix B.

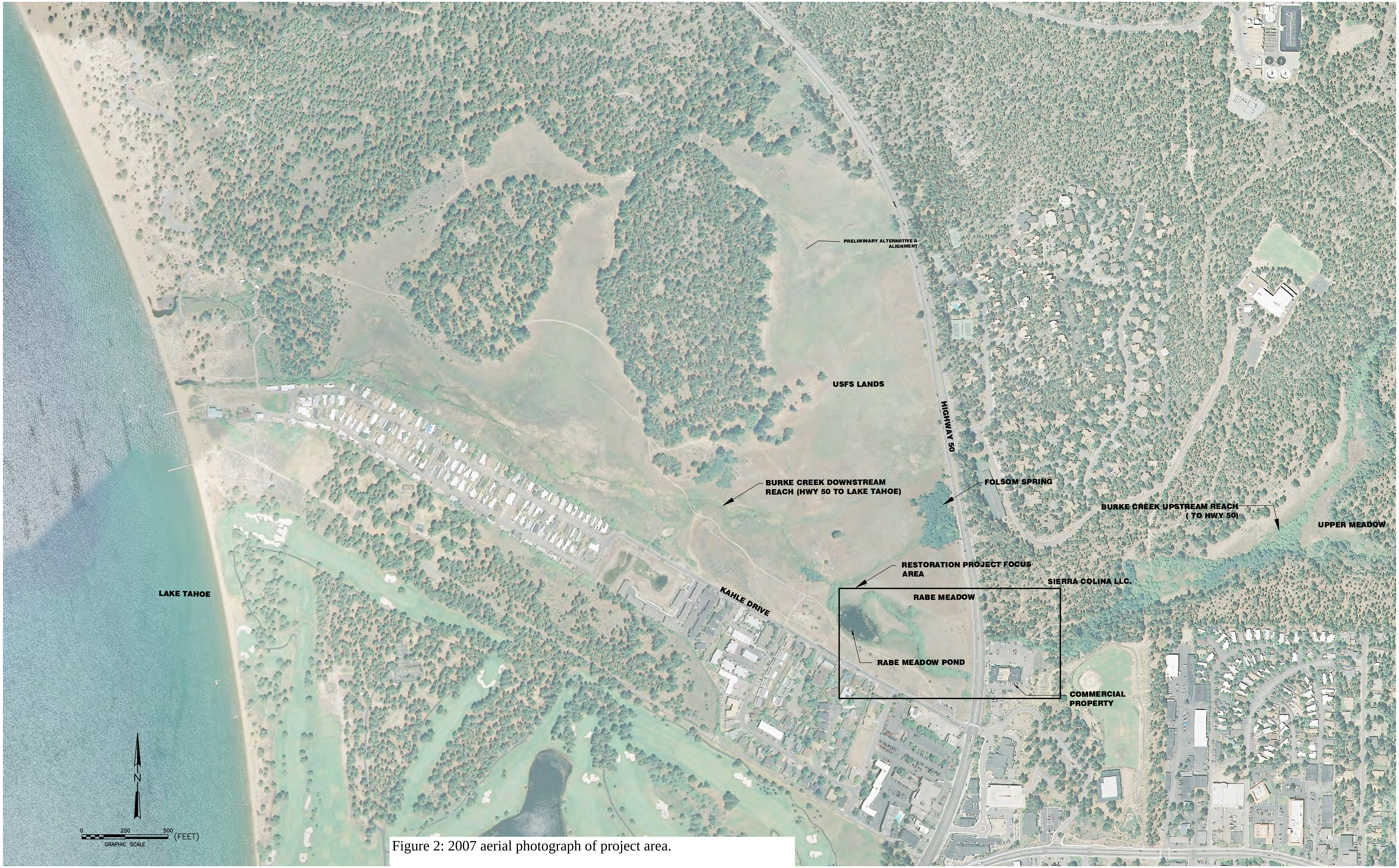


Figure 2: 2007 aerial photograph of project area.

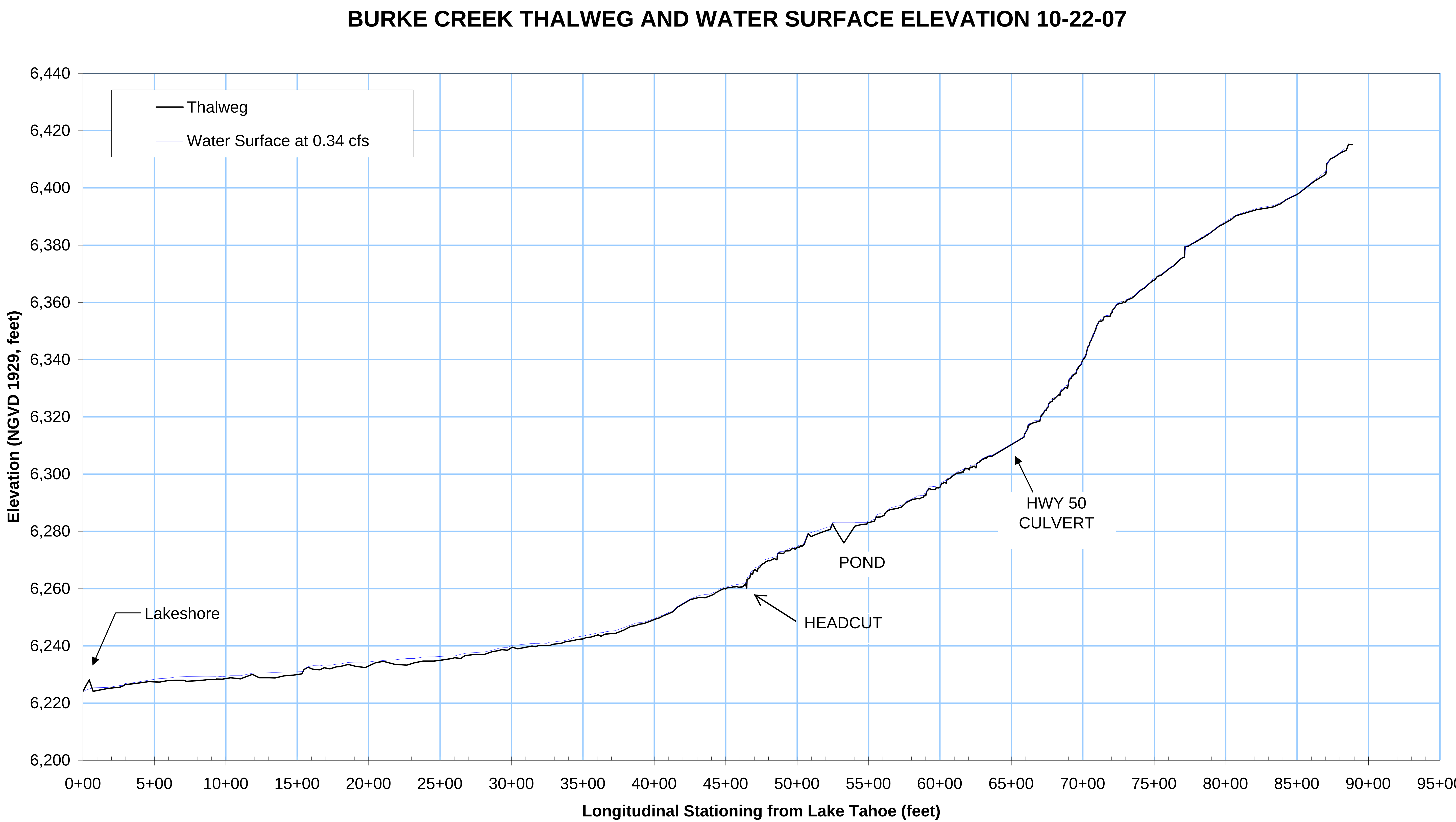


Figure 3: Surveyed longitudal profile of the Burke Creek Channel

4.2 Existing Condition Geomorphology

A geomorphic assessment was performed to help understand the physical processes and past management actions that have resulted in the present-day configuration of Burke Creek. Work consisted of evaluating contemporary channel geomorphic conditions and reviewing and interpreting historic channel conditions. The geomorphic assessment was performed to address three objectives: (1) document changes in channel planform morphology based on available aerial photographs; (2) qualitatively evaluate sediment supply, transport, and deposition in the proposed design reach; and (3) evaluate channel stability. These evaluations provided a basis for understanding existing geomorphic processes and were use for projecting potential geomorphic changes under design alternative scenarios.

4.2.1 Geomorphic Setting

Burke Creek is located on the southeastern side of the Lake Tahoe Basin (Figure 1). As described by the U.S. Forest Service (USFS), the majority of the upper watershed consists of gently rolling to very steep granitic rock outcrops and loamy coarse sand on granitic uplands, and the lower watershed consists of loamy coarse sands on alluvial fans and glacial outwash (USFS 1999).

Geomorphic investigations extended from the large meadow upstream of the project design area, downstream through a forested hillslope to the Highway 50 crossing, and then continued downstream through Rabe Meadow to Lake Tahoe (Figure 1), Based on the above USFS description and the observed geology and geomorphology, it is assumed that the project is located in an area described by the USFS as "lower watershed;" however, from the team's reconnaissance of this specific area, the project area has been subdivided beyond the USFS description into the following three reaches based on observed geomorphic characteristics:

Upper Meadow Reach (Existing Stations 71+00 to 89+00):

The Upper Meadow reach is defined by a valley expansion and apparent accumulation of glacial outwash. Investigation in this reach was limited to field reconnaissance of the lower half of the meadow (from approximately station 89+00 to station 71+00), primarily to contrast the geomorphic differences between this reach and the reaches downstream where the design effort was focused. The channel gradient through the surveyed portion of the Upper Meadow Reach is fairly uniform and averages approximately 3%. The channel bed contains almost exclusively coarse and fine sand (2 mm and finer) with occasional larger individual gravels.

Upstream Reach (Highway 50 to Existing Station 71+00):

As Burke Creek departs the Upper Meadow reach, channel gradients quickly steepen as the creek descends a steep forested hillslope at approximately station 71+00. At this transition, the channel steepens from an average gradient of approximately 3% to an average gradient of approximately 7%, with some segments reaching gradients of 10%. The lower half of this reach has been historically realigned and modified, and enters a culvert as it passes below Highway 50 at station 65+88.

Downstream Reach (Highway 50 to Lake Tahoe):

The Downstream Reach extends from Highway 50 to Lake Tahoe. In this reach, the channel exits the Highway 50 culvert at station 63+60 and flows through a constructed section of channel and into the Rabe Meadow Pond at approximately station 53+30. This reconstructed segment of channel occupies a former hotel casino construction site (a restoration project by the USFS in 1981). Downstream of the pond, Burke Creek meanders through Rabe Meadow until it reaches Lake Tahoe. Additional channel construction by the USFS has been performed in this lower segment (USFS 1999). Average channel gradients range from approximately 3% through the reconstructed segment to a lower gradient further downstream (approximately 0.5%).

The proposed design reach for Burke Creek improvements lies within the Upstream Reach and Downstream Reach.

4.2.2 Changes in Channel Location

To document changes in channel location, aerial photographs and historic topographic maps were reviewed. 1891 and 1893 topographic maps of the project area (U.S. Geological Survey Markleeville sheet, 1:125,000 scale) show Burke Creek as a blue-line stream (although unlabeled) flowing from the upland hillslopes, crossing a road (assumed to be approximately the future Highway 50 alignment) and continuing into an open area assumed to be Rabe Meadow. In this open area, the blue-line terminates in an area denoted with wet / marshy symbology, suggesting a wet meadow environment. It is not known if a defined channel existed between the blue-line mapping and Lake Tahoe. The mapped channel alignment roughly follows the channel delineated on the 1940 aerial photograph.

Historic digital aerial photographs were available for the following years: 1938, 1940, ca. 1950, 1969, ca. 1975, 1987, 2004, and 2007 (Appendix C). The channel centerlines were delineated and then digitized for the years 1940, 1969, ca. 1975, and 1987, and then compared with the 2007 surveyed channel centerline. These changes were then summarized on the 2007 aerial photograph showing contemporary land use and historic channel locations (Figure 4).

Figure 4: Historic and Current Channel Alignments of Burke Creek

A review of available historic topographic maps and aerial photographs reveals that the Burke Creek channel has changed location several times within the three project reaches (Upper Meadow, Upstream Reach, and Downstream Reach). The 1938 and 1940 aerial photographs show what is assumed to be the natural channel alignment for Burke Creek. In these photographs, the channel is in approximately the same location as it is today in the Upper Meadow Reach; however, at approximately station 71+00 (the present transition from the Upper Meadow Reach to the Upstream Reach), the channel continues west-southwest, exits the forested hillslope, and enters a meadow (presently occupied by the parking lot). Based solely on the photograph, it is assumed that at this location the channel gradient transitions from a steep 7%-10% slope to a slope more similar to the Upper Meadow and Rabe Meadow (approximately 3%). From this point, Burke Creek continues to the southwest, across a road presently occupied by Highway 50, and across the future location of Kahle Drive. At approximately 1,100 ft southwest of the road, Burke Creek turns northwest and continues northwest to Lake Tahoe, through the open meadow that today is occupied by the Tahoe Shores Mobile Home Park.

The next significant change to Burke Creek was observed on the 1969 aerial photograph. In this photograph, the channel has been moved to the north and a building and parking lot have been constructed. Highway 50 has been significantly widened and a culvert has been installed to route the channel below the highway. Rather than creating a perpendicular highway crossing, the culvert routes Burke Creek abruptly to the southwest, along the highway corridor, for approximately 250 feet On the south side of Highway 50, Kahle Drive had been constructed, which can be seen in the ca. 1950 aerial photograph, and by 1969 the area to the south of Kahle Drive had been developed (thereby reducing the size of Rabe Meadow). The culvert daylights on the south side of the highway, and Burke Creek was routed to the west, through Rabe Meadow on the north side of Kahle Drive, where it continued through the meadow to Lake Tahoe.

More significant change occurred in 1974 when construction began for a large hotel casino (Jennings Casino). In the aerial photograph, a large grading operation (estimated to be approximately 12 acres) had been completed in the portion of Rabe Meadow near the Highway 50 and Kahle Drive intersection. Construction appears to be in progress and large foundation elements are visible. Burke Creek was routed around the construction area into a concrete-lined ditch from the culvert outlet, south along Highway 50, and then west along Kahle Drive. The aerial photograph did not include the lower portion of the creek, so it is unknown how the channel was routed downstream of the construction area.

Construction of the hotel casino was never completed. In 1981, the USFS implemented a restoration project of the casino site by re-grading the construction area, breaking up and burying the casino foundations, re-routing Burke Creek back into Rabe Meadow, creating an in-channel sediment retention pond (the current Rabe Meadow Pond, (Figure 2), connecting the channel downstream of the pond with the Folsom Spring channel, and revegetating along the constructed channel (USFS 1999). The restoration project started at the Highway 50 culvert outlet and created a new section of channel flowing west into the constructed sediment retention pond. From the pond, the channel was routed into the existing Folsom Spring channel (which continues through Rabe Meadow to Lake Tahoe). It is likely the Folsom Spring channel did not have the hydraulic capacity to carry the additional flow contribution from Burke Creek, and has resulted in downstream adjustments (erosion) to accommodate the increased flows.

The 1987 aerial photograph shows no changes to the channel location since the 1981 photo. The Upstream Reach has remained in the same position since being relocated sometime between 1950 and 1969, and the Downstream Reach is in the same location following the 1981 USFS restoration. Similarly, the 2004 aerial photograph shows little change from 1987, with the exception of a secondary channel that has formed in the USFS restoration reach between the culvert outlet and the sediment retention pond. It is unclear whether this split channel was constructed or if it formed as a result of geomorphic processes. Lastly, the 2007 aerial photograph shows virtually no change since 2004.

Additional channel construction and rehabilitation was performed in 1991 and 1992 by the USFS in the lower portion of the Downstream Reach near Lake Tahoe, and some follow-up work was performed in 1998. This work included the Kahle Drive Erosion Control Project and the Burke Creek Channel Restoration project. Both of these projects are described in detail in the Burke Creek Stream Channel Restoration Monitoring Report 1990 – 1998 (USFS 1999). These projects are located downstream of the proposed design area and are unlikely to have an effect on the proposed design.

4.2.3 Sediment Supply, Transport, and Deposition

Our assessment of sediment dynamics in the Burke Creek study reach used a combination of aerial photograph interpretation, field observations, topographic mapping, and sediment sampling to better understand how sediments are stored and transported through the reach. Typically, natural/unregulated streams have a long-term balance between sediment supply and transport, such that the channel maintains itself over time via the erosion and transportation of sediments. Adjustments to either streamflow or sediment supply can disrupt the balance, and typically result in channel adjustments, including migration, incision, or aggradation. For example, where sediment supply exceeds sediment transport, the channel stores sediment; conversely, where sediment transport exceeds sediment supply, the channel has little sediment storage.

Certain management actions may decrease sediment transport potential, causing channel aggradation, decreasing channel capacity and increasing local flooding. Likewise, other actions may increase sediment transport potential, causing channel incision, increasing channel capacity and decreasing local flooding. It is important to understand the potential ramifications to altering sediment dynamics, including the related physical effects and how they are linked to hydrology. Assuming contemporary streamflow and sediment supply will remain largely the same post-project (i.e. proposed project activities will not alter either of these), our evaluation of potential project impacts is based on our observations of existing sediment dynamics.

From the aerial photographs, the 1940 channel appears to be in its natural position. As the channel transitioned from the steep hillside (7% - 10% slope) to Rabe Meadow (2% - 3% slope), the abrupt slope change likely created a depositional area, most likely in the form of an alluvial fan (although not discernable on the 1940 aerial photograph). This fan would represent an area where sediment deposited and accumulated as the channel's sediment transport capacity was reduced resulting from a decrease in slope and confinement.

Between 1940 and 1969 when the channel was relocated to the north side of the parking lot, the new channel continued at a 7% - 10% slope for approximately an additional 300 feet, until it entered the culvert, where the slope was abruptly reduced to 2% - 3% (based on the 2007 longitudinal profile survey and assuming negligible change in average slope). This downstream shift of the slope break transferred the former alluvial fan depositional zone downstream to this new location at the culvert entrance. As a result, the culvert entrance accumulates sediment and the culvert has a limited ability to transport the sediment downstream. Presently, the culvert is assumed to be partially to near-completely filled with sediment based on our observations at the culvert inlet and outlet

Downstream of the culvert outlet, the channel flows through a dense vegetation corridor until it reaches the Rabe Meadow Pond. In researching the USFS restoration project background for as-built construction details, Mr. Bill Johnson (retired USFS), who was in charge of the restoration project at the former hotel casino site, was contacted. Mr. Johnson did not have any as-built topographic information, nor did he think any was collected for the project. However, Mr. Johnson recalled the channel between the culvert and the pond was rock-lined, and that the pond was constructed approximately 8 to 10 feet deep. Field observations in this channel segment did not reveal any evidence of a rock-lined channel; rather, the channel bed is now covered primarily in granitic sand and is densely vegetated along its banks. This suggests sediments have been transported downstream of the culvert and into the pond.

To estimate the relative degree of sedimentation in the pond, a comparison of the October 2007 pond bathymetry and Mr. Johnson's estimated pond construction depth was conducted. Results of this comparison show overall pond depths have not changed (i.e. the pond is currently between 8 and 10 feet deep). Possible explanations for the apparent lack of sedimentation include: (1) sediment supply is naturally low, such that the pond is not significantly filling, (2) coarse sediment deposition is occurring above the pond at the culvert (which is currently plugged with sediment) and is not transported to the pond, and/or (3) channel maintenance is periodically performed at the culvert or in the pond to remove accumulated sediments.

To help evaluate these possibilities, sediment yield rates reported for Burke Creek by Northwest Hydraulic Consultants (NHC 2006) were reviewed. NHC reported rates for fine sediment to be 0.07 lb/ac/yr, which converts to 0.0224 tons/mi^2/yr (approximately 0.014 yd^3/mi^2, or approximately 0.066 yd^3/yr for the 4.5 mi^2 Burke Creek watershed area). Typically, the total sediment load transported by a stream can be separated into coarse and fine components (i.e. bedload and suspended load, respectively), and the fine component is commonly 75% to 90% greater by volume than the coarse component. Although NHC reports rates for fine sediment, the report does not define fine sediment. Because of this, an assumption was made that fine sediment as reported by NHC did not include the coarse sediment component, and an adjustment (increase) would be necessary to account for the total sediment load.

However, even if adjustments were made to increase the reported fine sediment yield to try and account for the total sediment load, the resulting estimates are extremely low compared with published values for other small Sierra Nevada streams. For example, Reid and Dunne (1992) report average annual sediment production estimates for small west slope Sierra Nevada streams of approximately 39 tons/mi^2. Moreover, NHC reported the predicted Burke Creek sediment yield is comparable to streams similar in size and disturbance in the Tahoe Basin (e.g. Lonely

Gulch Creek and McKinney Creek), and much less than other Tahoe Basin steams that are much more disturbed (e.g. Upper Truckee River and Blackwood Creek). For comparison to Burke Creek (0.0224 tons/mi^2), the estimated fine sediment supply from the Upper Truckee River is 42 tons/mi^2 (NHC 2006).

The rates reported by NHC, combined with the 2007 pond bathymetry, suggest the lack of sediment accumulation in the pond is reflective of naturally low sediment yield. However, the sediment accumulation observed at the culvert inlet and outlet suggests otherwise, so either Burke Creek has a more moderate sediment yield (i.e. greater than estimated by NHC, but still sufficiently low to not fill the pond), or the observed sediment was caused by infrequent episodic deposition (e.g. in response to a flood flow or quite possibly from observed slope failures that occurred downslope of the Kahle ball field and delivered sediment to Burke Creek).

The sediment currently stored in the culvert does not appear to be routing farther downstream into the pond. This may be due to maintenance at the culvert (periodic sediment removal) or due to low sediment transport capacity in the channel resulting in increased sediment storage. Without additional investigation to better understand the culvert sediment, it is conservatively assumed similar deposition to what is presently in the culvert can occur in proposed design reaches below the culvert outlet where channel conditions contain similar prominent slope breaks.

4.2.4 Channel Stability Evaluation

Channel streambed stability was evaluated as a part of the Fall 2007 field reconnaissance to identify unstable areas where channel adjustments are occurring. Unstable areas are defined as areas where eroding banks or headcuts are present. Headcut are over-steepened areas of the channel profile that are eroding headward, causing channel incision and associated bank erosion. The purpose of the investigation was to evaluate the causes of channel adjustments, and use this information to help assess risk to proposed design alternatives.

In the Upper Meadow Reach, unstable areas in the channel include local incision (up to approximately four feet deep), but head cutting is minimized from natural structures (boulders and/or roots) maintaining the elevation of the channel. Channel drops, such as one occurring at station 77+15, may have been head cuts in the past, but currently appear to have been stabilized due to abundant boulders and wood. Although assumed geomorphically stable, this drop (and others in the reach) present fish passage barriers. No significant bank erosion was observed, and channel migration appeared to be a low risk due to abundant vegetation roots and occasional boulders along the stream corridor.

In the Upstream Reach the channel appears to have adjusted to its reconfiguration from being relocated over 30 years ago. As a part of this relocation, a low berm was constructed along the south bank to prevent overbank flows into the downslope parking lot. The levee contains topographic low areas that have increased the risk of flow into the parking lot, and has been subsequently reshaped in the vicinity of station 69+00 as a part of an apparent geotechnical slope stability project in response to a slope failure on the south hillside below the Kahle Park ball field. It is unclear if levee modification was part of this slope stability project, but it appears heavy equipment was used in this vicinity, and some remnant geotextile fabric is present. Flood debris (large woody debris), assumed from 1997, is also present in the vicinity of station 69+00. The low-flow channel contains a series of step pools formed by roots and rocks and appears very stable. Adjacent banks are well vegetated (often densely) and the risk of channel migration appears low, with exception of levee breaching during a large flood event.

In the Downstream Reach, the channel appears very stable from the culvert outlet to the Rabe Meadow Pond. All evidence of a rock-lined channel (as reported to have been constructed by the USFS) has been overgrown with dense riparian vegetation and covered with granitic sand, which we assume has filled the interstitial spaces of the constructed rock channel and now sits as a veneer on the bed surface.

Downstream of the Rabe Meadow Pond, the channel continues at approximately a 2% - 3% slope to approximately station 38+00. In this reach, local bank erosion was observed, including localized areas with cut banks up to 3 feet high (Figure 5). Many of these localized active features appear to be confined by adjacent root and rock structures, so the risk of rapid lateral erosion or incision appears low. However, a 2.7-foot headcut at approximately station 46+50 may be actively migrating upstream, with no in-channel rock or wood elevation control (i.e. no evidence was observed that suggests this is a stable pool, such as a boulder or other feature that would prevent additional upstream incision). The channel banks downstream of this headcut are actively slumping and the channel has incised. The channel incision has dropped shallow ground water tables adjacent to the channel causing a notable shift in the wet meadow plant species composition on the left bank (Figure 6). The risk of additional upstream migration from this headcut appears high, but additional monitoring is needed to evaluate the cause (e.g. previous channel realignment effort), determine the upstream migration rate, and evaluate the risk to the upstream channel. Downstream of approximately station 38+00, the channel slope transitions into a flatter reach, averaging 0.5% for the remainder of its length.

Figure 5: Approximately 3 feet high cutbank eroding the north bank, in an aspen grove. Photograph taken at approximately station 50+00, view is facing upstream.

Figure 6: Headcut at Station 46+50 is actively migrating upstream. The channel banks downstream of this headcut are actively slumping and the channel has incised.

4.3 Reference Reach Analysis

To help guide the design of the project, three reference reach cross sections were surveyed on October 3, 2007. The purposed of the reference reach survey was to determine channel and floodplain hydraulic geometry and compute bankfull discharge based on channel characteristics. Each reference reach represents different channel types and slopes that may be encountered in the project reach.

4.3.1 Reference Reach Survey

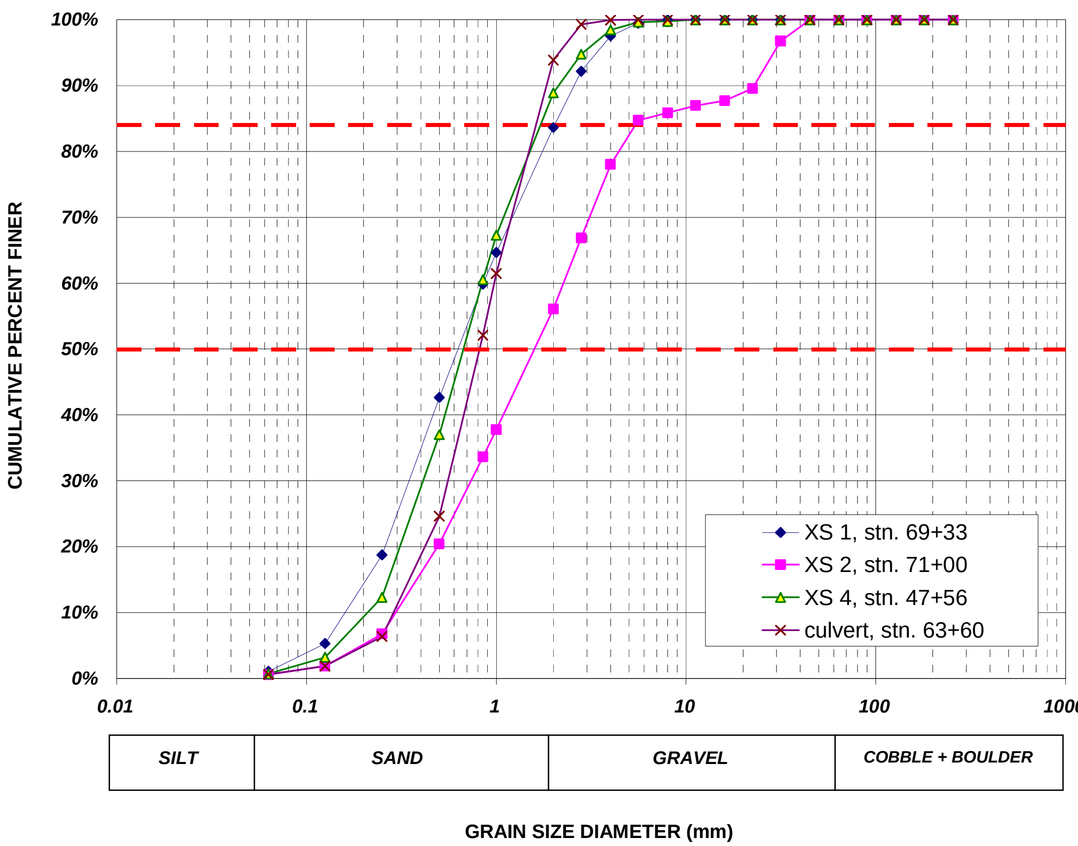
Three reference reaches (2 upstream of Highway 50 and 1 downstream of the pond) were surveyed and geomorphically characterized on October 3, 2007. This included surveying detailed channel cross sections and noting channel and floodplain characteristics. A bankfull water surface elevation was surveyed at each cross section, which was typically identified by a clear break in slope between the channel banks and adjacent overbank areas. Detailed longitudinal thalweg profiles within each reference reach were also surveyed to characterize channel and overbank slopes and channel profile morphology. Appendix E presents cross section and longitudinal profile surveys for each reference reach.

Four bulk streambed sediment samples were collected at selected representative locations and particle size analyses were performed. Sample locations and particle size parameters are shown in Table 1: Bulk Sample Locations and Corresponding D84 and D50 Particle Sizes. Table 1 and particle size distribution curves are summarized in Figure 7. The particle size distributions confirm our observations that Burke Creek is a sand- and fine gravel-bedded channel, which is consistent with the USFS description of loamy coarse sands. Particle size analysis data sheets for each sample are included in Appendix D.

Table 1: Bulk Sample Locations and Corresponding D_{84} and D_{50} Particle Sizes

Sample location name	Sample location (longitudinal station)	D_{84} (mm)	D_{50} (mm)
XS 1	69+33	2.0	0.6
XS 2	71+00	5.4	1.6
XS 4	47+56	1.7	0.7
Culvert	63+60	1.6	0.8

Figure 7: Cumulative particle size distribution for four bulk samples collected in Burke Creek study reach.



Note: Dashed horizontal red lines indicate 84% and 50%, denoting D84 and D50 particle sizes where curves are intersected.

Streamflow discharge measurement was made on Burke Creek in a reference reach upstream of Highway 50 for low-flow hydraulic reference. The stream flow measurement was conducted using standard USGS methods. Measured streamflow on October 26, 2007 was approximately 0.3 cfs. A data summary sheet for this discharge measurement is provided in Appendix G.

4.3.2 Reference Reach Descriptions

The following sections summarize each reference reach, bankfull flow computations, and hydraulic geometry. Appendix E presents cross section and longitudinal profile surveys for each reference reach.

Downstream Reference Reach

The most downstream reference reach is located in a steep grassy meadow downstream of constructed pond in Rabe Meadow and upstream of a headcut (Figure 8). The average channel slope within the reference reach is 6.1% and the bankfull channel width is 2.6 feet The bank and bed structure and channel stability is largely controlled by rhizomatous plant species. Overbank vegetation is generally sedges, grasses and low shrubs, with very few riparian trees. The channel is perched above the adjacent ground and when flows rise out of bank, they spread widely across the meadow. This reach of channel was once a tributary channel of Burke Creek. When the upstream pond was constructed in 1981, Burke Creek flows were diverted into this reach. Visual observations in 2009 at this cross section indicated that the present channel banks are undercut approximately 2 feet on either side, indicating substantial channel enlargement since the 2007 reference reach survey.

Figure 8: Lower reference reach in Rabe Meadow downstream of the constructed pond.

Note: Historically, Burke Creek was located on the other side of the rise, near the houses in the background.

Middle Reference Reach

The middle reference reach is located at the top of the cut slope associated with the parking lot of the commercial property, immediately upstream of the project area. This reach is characterized by dense riparian vegetation and a wood and boulder-controlled channel with small steps and narrow floodplains. The channel has a well-defined bankfull area formed within the native ground of the area (Figure 9). The bankfull width is 3.6 feet and the average channel slope within the reference reach is 6.9%. This channel was realigned approximately 150 feet to the north from its historical location to accommodate development of the commercial building and parking lot to the south. The channel floodplain width is limited within this reach by the steep bank along the north side of the channel and a dike along the south side of the channel There is ditch that enters the channel in this reach that once conveyed runoff from the sports complex located upstream of the reference reach.

Figure 9: The middle reference reach contains a well-defined bankfull channel and small floodplain.

Note: Contains a well defined bankfull channel and small floodplain. The reach is characterized by dense riparian vegetation and a wood controlled channel profile.

Upstream Reference

The most upstream reference reach is a constructed channel formed of small and large boulders. This reach is located approximately 524 feet upstream of the culvert inlet Like the other reference reaches, this reach has been altered from its natural geometry. The left valley wall is lined with rock slope protection associated with flood repairs resulting from runoff originating from the sports complex immediately upslope.

The bankfull channel width is 2.6 feet and the average slope of the reference reach channel is 9.4%. The channel banks are comprised of boulders ranging from 0.7 to 2.5 feet in diameter, which are covered with sand on the channel bottom. Boulders up to 5.0 feet in diameter are found in this section and form distinct drops and constrictions characteristic of a step pool channel. Adjacent to the bankfull channel is a moderately sized floodplain that contains aspen and grasses (Figure 10). The floodplain is also stabilized by large boulders placed during construction of the channel.

Figure 10: Reference reach in most upstream reach above Highway 50.

Note: This reach was characterized by small boulder steps and rock control of the channel profile. The reach is unconfined with a wide overbank area with wetland plants and a grove of aspens.

4.3.3 Bankfull Flow Computation

For each reference reach cross section, bankfull flow was computed to verify the hydrologic computations for frequent flows presented in Section 4.4. Bankfull flow has been found to be the “channel forming” flow, which shapes the active channel of a stream system. Bankfull flows have been found to commonly have a return period between 1.2- and 1.5-years (Leopold et al, 1964).

Calibration of Manning’s Roughness Coefficient

Bankfull flow was based on field measurements of channel cross section, bankfull elevation, water surface slope, and a field-calibrated Manning’s roughness coefficient (Manning’s n). The field calibrated Manning’s n was used for assessment of proposed condition low flow channel hydraulics, including fish passage design flows and bankfull flow hydraulics.

A low-flow Manning’s roughness coefficient was computed by conducting a flow measurement at one cross section (see Section 4.3.1). The measured streamflow was 0.3 cfs. On the same day, water surface elevations and water surface slopes within each reference reach were surveyed.

For each reference cross section, a Manning’s n was back calculated for 0.3 cfs using the field surveyed channel cross section and water surface slope. Table 2 presents a summary of the field-calibrated Manning’s n computed for each reference cross section. Field calibrated Manning’s n values were higher than expected in the upstream and middle reference reaches, though not atypical of shallow flow in steeply sloping channel reaches with large steps and pools. Mussetter (1989) evaluated Manning’s roughness coefficients for channels with slope between 4 and 10%

and found similar roughness coefficients for shallow flows. Therefore, the computed Manning's n coefficients were deemed appropriate for evaluating channel hydraulics for fish passage design and bankfull flows.

Table 2: Field calibrated Manning's roughness coefficients (Manning's n) and bankfull flows computed at reach reference reach cross section.

Reference Cross Section	Manning's n	Bankfull Flow
Upstream Reference Reach	0.247	0.47 cfs
Middle Reference Reach	0.205	2.5 cfs
Downstream Reference Reach	0.133	0.6 cfs

Note: Manning's n was calculated for a flow of 0.3 cfs. Computations were based on surveyed channel cross sections and water surface slope.

Computed Bankfull Flows

Using the field calibrated Manning's n coefficient, bankfull flow was calculated for each reference cross section (see Table 2). The computed bankfull flows ranged widely. However, this is not unexpected because the reference reach channels have been significantly altered in the past. The upstream reference reach was constructed with large rocks that are unable to adjust to channel forming flows. Additionally, out of bank flows were observed there during summer low flows, indicating that this reference reach is likely undersized for the bankfull discharge.

Burke Creek historically did not flow through the downstream reference reach. This reach of channel was once a tributary channel of Burke Creek, originating at Folsom Spring. When the pond was constructed, flows were diverted into this reach. It is theorized that the contemporary channel within this reference reach has not fully adjusted to the new flow regime of Burke Creek, possibly explaining the relatively low bankfull flow computed. A short distance downstream from this reference reach is an active headcut that may be a result of the increased flow regime caused by the routing of Burke Creek into this channel, indicating that channel adjustment is still occurring and the measured hydraulic geometry in this reach may not be typical of an equilibrium bankfull channel (See Section 4.2.2).

Though realigned, the middle reference reach is constructed within the native material of the project area and has likely adjusted to channel forming flows. The computed bankfull flow of 2.5 cfs is quite similar to the 2.2 cfs gaged in Burke Creek and estimated to have a 1.2-year return period (see Section 4.4).

Therefore, the middle reference reach and its bankfull geometry were used as the primary reference reach for the proposed channel design. However, both the upstream rock step pool and downstream meadow reaches exhibited channel and floodplain features that were valuable for designing channel and overbank morphology for the proposed channel.

4.3.4 Reference Reach Channel Geometry Applied to Design

Table 3 presents a summary of the hydraulic geometry of the reference reaches. Because the middle reference reach was found to convey a reasonable bankfull flow based on the limited Burke Creek streamflow record, and since the two other reaches appeared to be undersized, the bankfull hydraulic geometry of the middle reference reach was used to develop a bankfull channel for proposed conditions (see 4.3.3).

Table 3: Hydraulic geometry for reference reach bankfull channels.

Reference Cross Section	Slope	Bottom Width	Bankfull Width	Maximum Depth	Bankfull Area	Bankfull Width/ Depth Ratio	Floodplain Width
Upstream Reference Reach (XS2)	9.4%	1.5 ft	2.6 ft	0.39 ft	0.70 sf	9.5	~40 ft
Middle Reference Reach(XS1)	6.9%	2.2 ft	3.6 ft	0.74 ft	2.15 sf	6.3	~110 ft
Downstream Reference Reach (XS4)	6.1%	0.8 ft	1.6 ft	0.74 ft	0.84 sf	3.3	> 100 ft

4.4 Existing Hydrologic Conditions

The drainage area of Burke Creek at the Highway 50 crossing is 2.67 square miles. The contributing watershed elevation ranges between 8,440 feet at its highest peak, to the lake elevation of approximately 6,225 feet The watershed hydrology is characterized by snow, rain-on-snow, spring snowmelt, spring fed baseflow, and rainfall from monsoonal thunderstorms and warm late-fall Pacific storms. Rain-on-snow events typically create the largest peak flows, while spring snowmelt is characterized by a period of sustained high flow in mid spring.

The hydrologic characteristics for Burke Creek at the Highway 50 crossing were estimated using data collected at the site during multiple field visits by the project team, streamflow data collected by the Nevada Tahoe Conservation District (NTCD) and with a frequency analysis of nearby gaged streams within the Lake Tahoe Basin.

Two approaches were used to quantify design flows for Burke Creek: 1) Large peak flows were determined using a flood frequency analysis, and 2) Lower flows were estimated through direct comparison of measured flows in Burke Creek to flows in adjacent gaged streams.

4.4.1 High Flows

Flows used to estimate culvert and channel capacity were determined using a standard flood frequency analysis of five USGS stream gages located along the southeast shore of Lake Tahoe. All five are within close proximity to Burke Creek and have similar aspect ratios. A Log Pierson Type III distribution was applied to the annual maximum peak flow record for each gaging station using procedures outlined in Bulletin 17B (USGS, 1982) (see Table 4). The peak flow analysis for each gage is provided in Appendix G.

The predicted peak flows associated with various return periods were scaled by unit drainage area, and the average of the five sites was calculated. The average return flow per unit area was then scaled to the drainage area of Burke Creek at Highway 50. For the purpose of culvert sizing and evaluation of flood capacity, the 100-year return flow for Burke Creek was determined to be 120 cfs.

Table 4: Peak flow estimates for USGS gaging stations on small tributaries to Lake Tahoe within close proximity to Burke Creek.

			Peak Flow for Indicated Return Period (cfs)					
USGS Stream Gaging Station	**Period of Record**	**Drainage Area (mi2)**	**1.2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
10336760 Edgewood Ck at Stateline, NV	1993-2006	5.61	17	73	109	169	228	300
103367585 Edgewood Ck at Palisade Drive Nr Kingsbury, NV	1991-2001	3.13	8	34	50	77	102	133
10336735 North Logan House Ck at Hwy 50 Nr Glenbrook, NV	1991-2000	1.08	2	12	18	26	33	41
10336725 Glenbrook Ck at Old Hwy 50 Nr Glenbrook NV	1991-2000	3.75	8	37	55	87	117	153
10336730 Glenbrook Ck At Glenbrook, NV	1988-2006	4.11	19	60	84	125	164	212
Average flow per square mile (cfs/mi^2)			**3**	**12**	**17**	**27**	**35**	**45**
Estimated flood frequency determined from average unit discharge LPIII distribution of annual maximum flows.								
Burke Creek above Highway 50		**2.67**	**8**	**32**	**47**	**71**	**94**	**121**

4.4.2 Low Flows

Based on field visits, cross section analysis, and discussions with Tahoe Regional Planning Agency (TRPA) and US Forest Service personnel, it appears that peak flows in Burke Creek are uncharacteristically low relative to adjacent streams given its drainage area. This supposition is based on bankfull channel dimensions and flow data collected in Burke Creek.

The NTCD established a short-term streamflow gaging station on Burke Creek immediately upstream of the Highway 50 crossing. The station was in operation from April 26, 2006 through July 19, 2007 and recorded stage every 30 minutes. The gaging captured two years of spring snowmelt and baseflow over one complete summer (Figure 11). A stage-discharge rating curve was established by NTCD to relate stage to streamflow and a flow hydrograph was developed. This hydrograph is shown with flow records from three USGS gaged streams on Figure 12.

From Figure 12, it appears that the Burke Creek streamflow gaging station was established shortly before the peak of the 2006 spring snowmelt runoff. In Burke Creek, flows peaked at approximately 2.2 cfs on May 2, 2006. The spring snowmelt peak flow on two adjacent gaged streams was approximately equal to the 1.2-year return flow (see Table 5) and is very similar to the flow computed (2.5 cfs) for the existing bankfull channel at the middle reference reach (see Section 4.3.3). Therefore, it is reasonable to assume that the 1.2-year return flow on Burke Creek is approximately 2.2 cfs. For channel design and fish passage evaluation, this flow was assumed to approximate the "channel forming" or "bankfull" flow, which commonly has a return period between 1.2- and 1.5-years (Leopold et al, 1964). The 2007 snowpack was minimal and the peak flow associated with the spring snowmelt was much less than the 1.2-year return flow on all of the gaged streams in the Tahoe Basin.

The summer baseflow in Burke Creek appears to be relatively constant, indicating it is spring-fed during this period. The average baseflow in summer of 2006 between July 1 and September 13 was 0.22 cfs, with the lowest daily average flow being 0.19 cfs.

Figure 11: Daily average streamflow in Burke Creek immediately upstream of Highway 50.

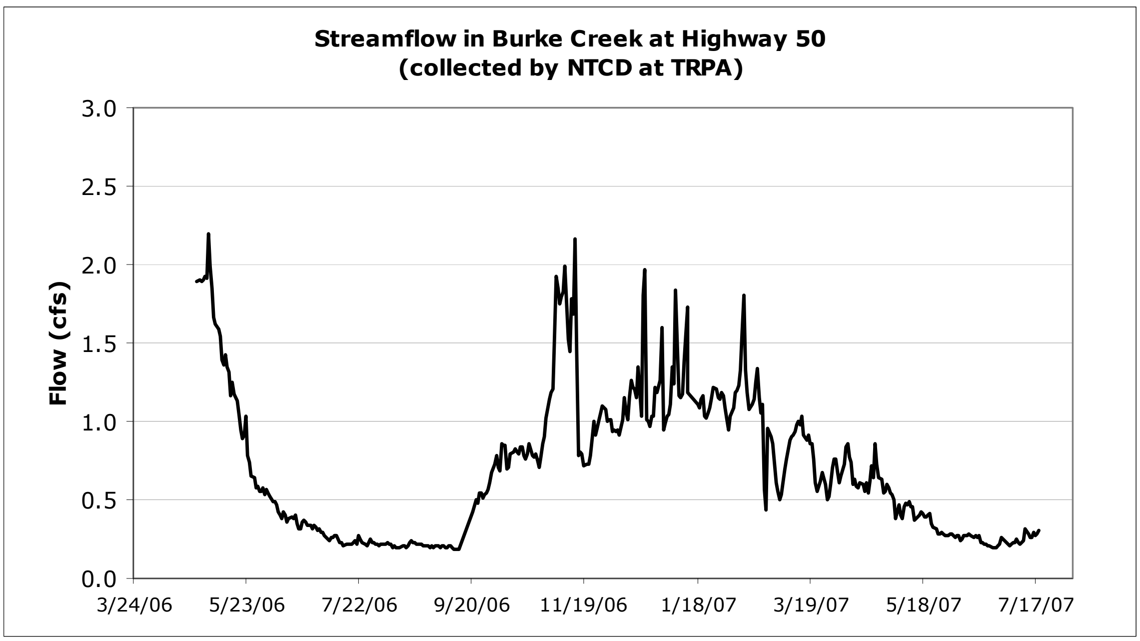


Figure 12: Hydrographs of three gaged streams near the project site including Burke Creek at Highway 50.

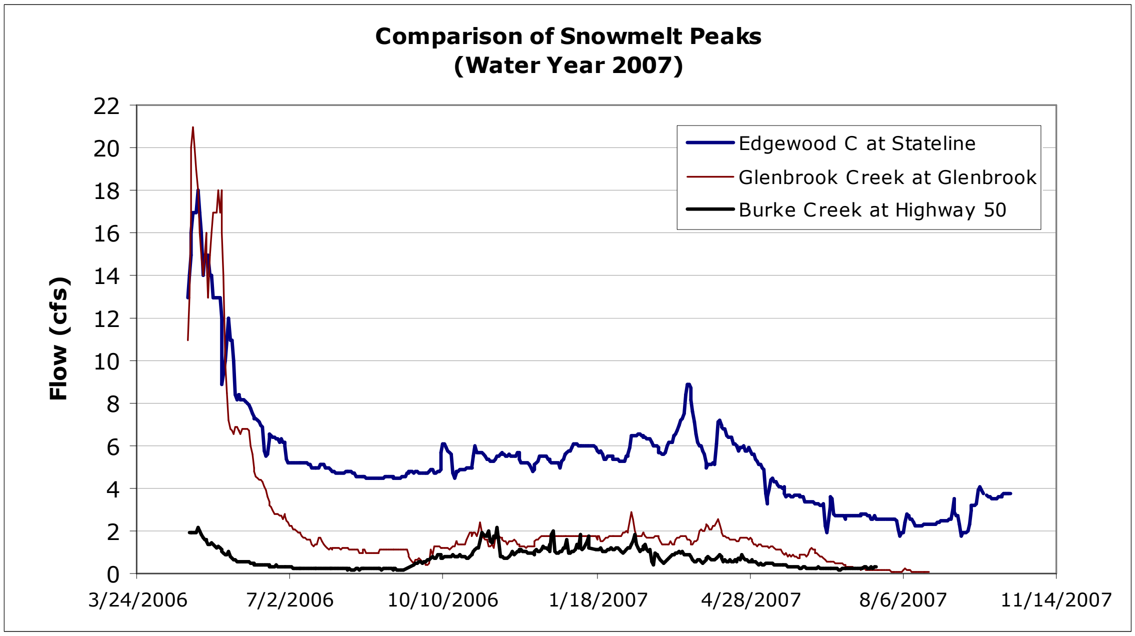


Table 5: Snowmelt peaks gaged at three streams near Burke Creek.

USGS Gage Number and Name	Drainage Area (mi²)	Date of Peak	Peak Flow	Approximate Return Period
10336760 Edgewood Cr. At Stateline, NV	5.61	5/3/2006	18 cfs	1.2-year
10336730 Glenbrook Ck. At Glenbrook, NV	4.11	4/30/2006	21 cfs	1.2-year
Burke Creek at Highway 50	2.67	5/2/2006	2.2 cfs	1.2-year*

* Assumed return period based on calculated return period of peaks on Edgewood and Glenbrook Creeks.

4.4.3 Comparison of Methods

Peak return flows for USGS gaging stations scaled to the drainage area of Burke Creek predict the 1.2-year flow for Burke Creek at Highway 50 to be 8 cfs (see Table 4), which is much greater than 2.2 cfs gaged (see Table 5) and the field measured bankfull channel capacity of 2.5 cfs (see Section 4.3.3). The flow gaging and field measurements of bankfull channel capacity suggest that actual flows in Burke Creek may be lower than those predicted using nearby USGS stream gages. However, because the flow gaging on Burke Creek was limited to the 2006-2007 NTCD gaging, this hypothesis is difficult to substantiate. Therefore, for evaluating culvert capacity and flooding, the potentially more conservative (higher) peak flow estimates derived from the USGS stream gages were utilized.

4.5 Existing Condition Hydraulic Analysis

4.5.1 Hydraulic Model Setup

Hydraulic modeling of the existing channel was conducted using the Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS), a one-dimensional steady-state open channel flow model. The model was constructed and calibrated using information collected in the field and from the topographic surveys. Model results were used to quantify existing channel and culvert capacity and to evaluate present condition fish passage.

The model was built using cross section and profile data from the topographic survey conducted by Turner Associates in October 2007. Georeferenced channel cross sections were created from the topographic basemap of the project area and entered into the hydraulic model. HEC-RAS cross sections were spaced approximately every 50 feet, and located at significant changes in channel geometry. Cross section numbering was based on alignment stationing for the existing channel. Cross section locations and geometry are shown in Appendix E.

The total modeled length of channel is 1,640 feet, with 1,032 feet downstream of Highway 50, 228 ft through the highway culvert, and extending upstream of the highway 380 feet The downstream end of the model is bounded by the constructed pond in Rabe Meadow and the downstream boundary condition was set to the surveyed pond water surface elevation. The channel within the willow thicket is ill defined and the entire width of the willow thicket, which ranges from 30 and 50 feet wide, is typically fully wetted. The upstream boundary condition was set to normal depth. A Manning's roughness coefficient of 0.20 was applied to the bankfull channel at the 1.2-year flow of 2.2 cfs. This was based on the back-calculated roughness coefficients in the reference reaches at a flow below bankfull (see Section 4.3.3). At higher flows, the Manning's roughness coefficient was assumed to be 0.15 for the channel, which is the upper end of roughness reported by Chow (1959) for steep mountain streams with complex channel bed structure. The overbank areas used a Manning roughness coefficient of 0.15 to account for the thick vegetation throughout the project reach.

The Highway 50 culvert was modeled as a 228 foot long, 2 foot diameter corrugated metal pipe at a 3.5% slope. The culvert alignment, dimensions and elevations were based on the 2007 Turner and Associates topographic survey. Culvert alignment information shown on the US 50 Erosion Control Master Plan (Appendix A) was not used because the culvert material and dimensions identified during the topographic survey information did not support it. However, there is the potential that the existing culvert alignment may be as shown in the Errosiohn Master Control Plan, with connection to drop inlets in the commercial parking lot upstream of Highway 50. A roughness coefficient of 0.024 was used for the CMP culvert. Ineffective flow areas near the crossing were defined as recommended in HEC-RAS (2008) to account for flow constriction associated with the culvert crossing. Levees were inserted where appropriate to properly simulate in-bank and overbank flows.

A lateral weir was defined along the upstream left bank where flow overtops the existing dike and enters the parking lot. The flow lost over the lateral weir was assumed to leave the modeled system. Another loss of flow from the model is associated with overtopping the culvert. Once the headwater elevation at the culvert inlet exceeds the elevation of the roadway inboard ditch, flows entering the highway inboard were assumed to leave the modeled system.

The existing conditions HEC-RAS model was run in the mixed flow regime mode for the 1.2-year and 100-year flows of 2.2 cfs and 120 cfs, respectively.

4.5.2 Results for Flood Flow Conditions

The HEC-RAS model results and field surveys were used to assess the existing conditions during high flows in the project reach. The high-flow analysis focused primarily on flooding and overtopping of the upstream channel banks. The HEC-RAS model predicts that flow just begins to overtop the left bank dike along the upstream reach at 20 cfs. At the estimated 100-year return flow of 120 cfs, the channel upstream of the Highway conveys 44.6 cfs with the remaining 75.4 cfs being diverted out of the channel through a low spot in the dike. The low spot in the dike is located approximately 200 feet upstream of the culvert inlet At this location, flow leaving the channel is directed into the commercial building parking lot and enters a drainage inlet that conveys water into the existing project culvert under Highway 50 (see Figure 13 and Figure 14). Members of the TAC indicated that this flooding has been observed to occur during moderate to large flow events.

When the culvert is flowing at capacity or when this drainage inlet becomes plugged, flow is directed towards the Highway 50 intersection with Kahle Drive and then down Kahle Drive before returning to Burke Creek well downstream of the Rabe Meadow pond. For this analysis, it was assumed that flows overtopping the dike along the upstream channel leave the system and are not conveyed within the downstream channel.

The hydraulic model predicts the current culvert flows are inlet controlled and the inlet becomes submerged by the headwater at 11.5 cfs. At approximately 25 cfs, the headwater depth is sufficient to begin overtopping the edge of the highway and diverting down the inboard side of the highway. This occurrence has been reported by the TAC to occur during larger flow events. During a spring rainfall event in 2009, flows in the inboard ditch exceeded the ditch and flooded the eastbound lanes of Highway 50. Overtopping flows are understood to be diverted to the Highway 50 intersection with Kahle Drive and then down Kahle Drive before returning to Burke Creek, well downstream of the constructed pond.

At the 100-year flow, approximately 25 cfs is conveyed through the existing culvert, with the remaining 19.5 cfs being diverted into the inboard ditch and out of the system. Based on these results, it appears that the largest flow reaching the downstream existing willow lined channel is only approximately 25 cfs (see Figure 15).

It is important to note that this flood modeling does not account for debris blockages caused by wood that may cause flow to be diverted out of the channel at lower flows, or for surface flow from the sports complex upslope of the parking lot that may be flowing directly into the parking lot or into the channel. The risk of this occurring in the current condition is high, but this risk should become significantly reduced with the proposed design alternatives.

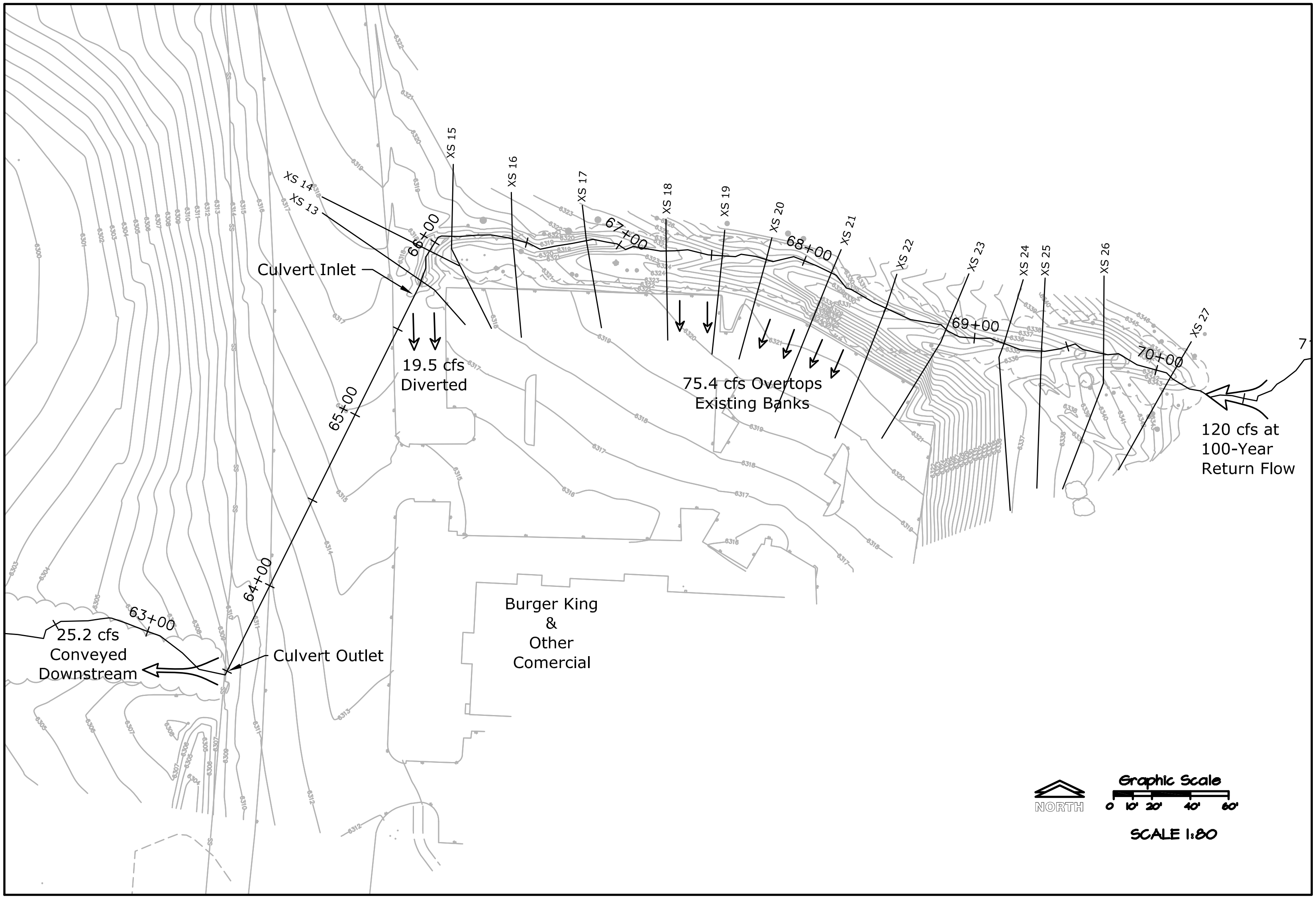
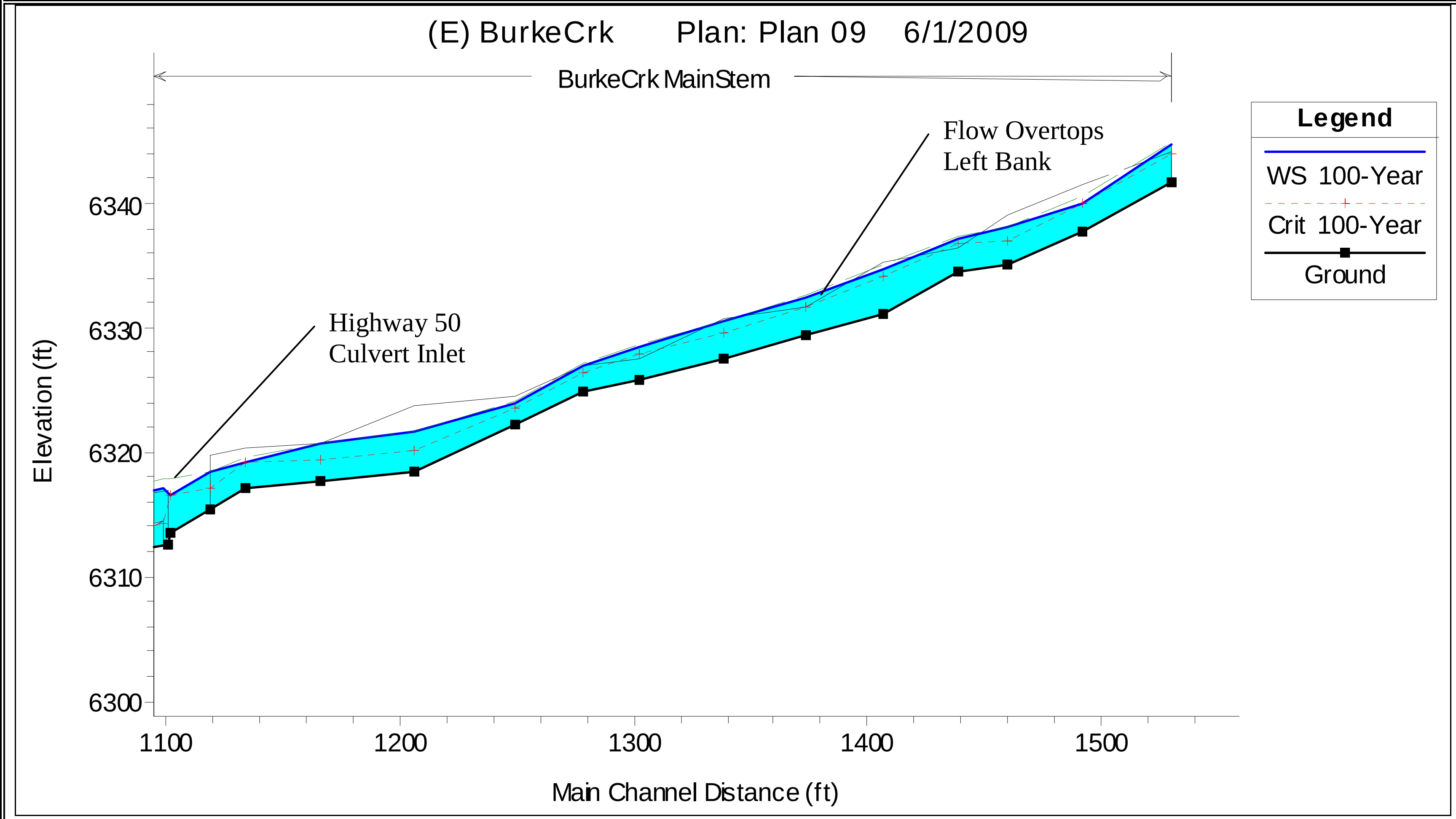


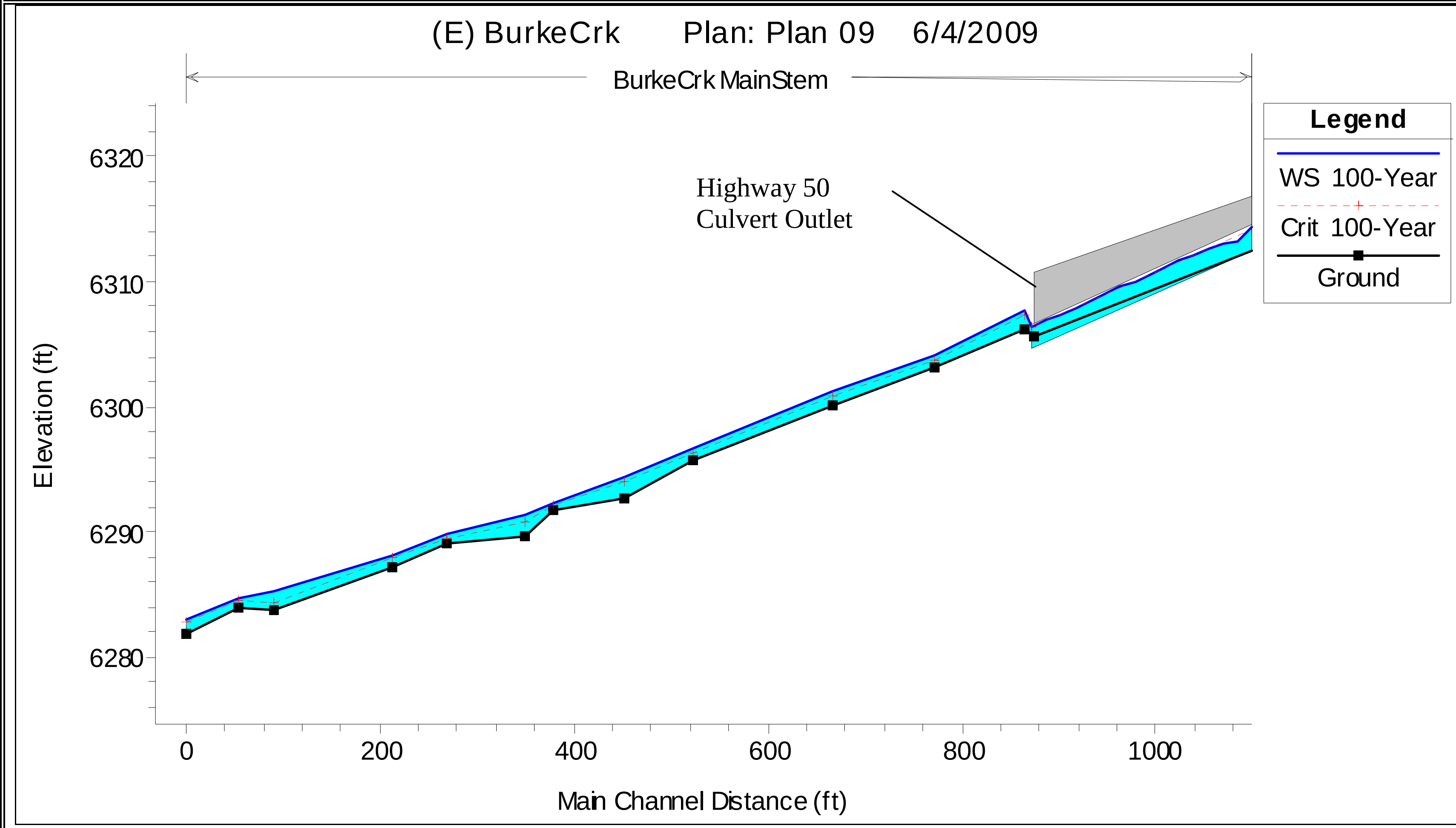
Figure 13: Location of cross sections used in HEC-RAS to determine upstream flooding locations for existing conditions.

Figure 14: Water surface profile for the 100-year flow of 120 cfs in the reach upstream of the Highway 50 culvert.



Note: The overbank of highway 50 flow was modeled using a lateral control structure, where flow that overtops the left bank dike is lost from the modeled system and I not conveyed downstream.

Figure 15: Profile of hydraulic model results for the 100-year flow of 120 cfs in the reach downstream of the Highway 50 culvert.



Note: Only 25 cfs is conveyed through the culvert and into the downstream channel reach, Overbank flow up[stream of the crossing is diverted and does not return to the modeled downstream channel.

4.6 Fisheries and Fish Passage

Improving fish passage within the channel and at the Highway 50 crossings is one of the project objectives. To evaluate existing fish passage conditions and establish design criteria for developing suitable project alternatives requires identifying target fish species and lifestages. These are not necessarily the species that currently reside in Burke Creek, but are the species and life stages that resource agencies wish to manage for now, or in the future. The following describes the proposed target fish species, proposed assessment and design criteria, and existing fish passage conditions. Proposed fish passage conditions for the alternatives are described later in the report.

4.6.1 Fishery Resources within Burke Creek

Lahontan cutthroat trout

Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) are native to the Truckee Basin and historically resided in Lake Tahoe and its tributaries**.** Lahontan cutthroat trout (LCT) can express both resident and migratory life histories, with resident forms using tributary habitats and migratory forms using both river and/or lake habitats in addition to tributaries (Sigler et al., 1983). LCT are obligatory stream spawners, and predominantly use tributary streams as spawning sites. Spawning typically occurs from April through July throughout the range of LCT (USFWS, 1995).

The Lake Tahoe LCT fishery disappeared in 1939 because of overfishing, introduction of predatory non-native fish species (i.e. lake trout, brook trout, and brown trout), hybridization with introduced rainbow trout, damage to spawning habitat, and migration barriers (USFWS, 1995). LCT were listed as endangered species in 1970 and reclassified as threatened to facilitate management in 1975. A recovery plan prepared by the US Fish and Wildlife Service for LCT was approved in 1995. Although LCT are now extirpated from Lake Tahoe and its tributaries, there have been efforts to reintroduce the fish.

Resident stream dwelling LCT commonly have a lifespan of less than 5 years and growth rates are fairly slow. Mean fork lengths for LCT in six Sierra Nevada streams were 3.5 inches, 4.5 inches, 8.0 inches, and 10.5 inches for ages 1-, 2-, 3-, and 4-years, respectively (Gerstung, 1986).

Nevada Division of Wildlife, when evaluating potential fisheries resources for Burke Creek, defined the lower 0.8 miles of Burke Creek (ending at the confluence with Folsom Spring) as being a “migratory fish section”, with a “resident/nursery section” of Burke Creek extending from 0.8 miles to 3.1 miles upstream from the lake shore (NDW, 1982).

Historical usage of Burke Creek as spawning and natal rearing habitats for LCT is uncertain due to limited records. Lacustrine life forms would have likely only used the more gently sloping lower 0.8 miles of Burke Creek for spawning after 1940 when the stream channel was modified and became steeper upstream of Highway 50. There is insufficient data to predict fish usage of Burke Creek before 1940, fish usage may have extended farther upstream when the steeper channel slope was located farther upstream (see Section 4.2.2). Farther upstream of the lower sloped reaches of Burke Creek, the steeper channel gradient and the very small channel size would have likely precluded use by the larger lacustrine LCT. However, in both Rabe Meadow and the upper meadow (upstream of Highway 50) Burke Creek may have historically provided habitat for both rearing juvenile LCT and adult resident LCT.

Current Fisheries and Fisheries Management

Fish surveys, conducted by Nevada Division of Wildlife in 1974 using electrofishing, found brook tout in the upper meadow. During field surveys as part of this project, salmonids (4 to 6 inches in size) were observed in Rabe Meadow and upper meadow reaches of Burke Creek. The species of fish were not determined. Others have documented observing "fish" in Burke Creek downstream of Highway 50, but species were not identified.

Following aquatic habitat rehabilitation at the former Jennings Casino site, a 1982 NDW file suggested planting rainbow trout fry or fingerling into Burke Creek. It is unknown if rainbow trout were subsequently planted.

A stream survey identifying species abundance, distribution habitat suitability, and location of existing migration barriers is recommended. The results of a migration barrier survey and assessing historical records can be used to identify whether existing barriers are natural barriers or manmade barriers, which then could guide actions on this and future projects.

4.6.2 Fish Passage

As part of this project, existing fish passage conditions were assessed between the Rabe Meadow Pond and the upper meadow. To assess fish passage conditions requires determining target fish species, life history and lifestages. For each target fish, the time of year, range of flows that passage should be provided, and the passage criteria must be identified. Lastly, the actual hydraulic conditions are compared to the fish passage criteria across the range of migration flows.

For the Highway 50 culvert, the fish passage assessment followed the US Forest Service National Inventory and Assessment Procedures for Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings (Clarkin, et al., 2005). In addition to assessing passage through the Highway 50 culvert, potential limiting factors to fish passage were evaluated in the upstream and downstream reaches because much of the channel has been manipulated, and does not resemble its historical morphology.

Target Species and Lifestages

The Burke Creek project reach is considered upstream of the historical and current limit for lake-run trout and is defined as a resident/ nursery reach (NDW, 1982). According to documents prepare by TRPA for Burke Creek and discussions that occurred at the kickoff TAC meeting for this project, fish passage and habitat enhancements should focus on meeting the needs of adult resident and juvenile rainbow and Lahontan cutthroat trout.

Migration Timing and Flows

The timing of spawning for adult rainbow trout in Lake Tahoe tributaries typically coincides with increased flows from spring snowmelt, from mid-April into June. If reintroduced, spawning by resident LCT would be expected to occur at the same time. LCT are known to use the same spawning habitat as rainbow trout (USFWS, 1995). During the spawning period, streamflows remain consistently high for a long duration due to the spring snowmelt (see Section 4.4.2). Therefore, to avoid an excessive migration delay due to high flow, the bankfull flow is often selected as the ***high fish passage flow*** for assessing passage of spring spawners in streams with a snowmelt hydrologic regime (Clarkin et al., 2005). Based on this, the estimated 1.2-year flow for Burke Creek of 2.2 cfs (see Section 4.4.2) was selected as the ***high fish passage flow*** for adult resident rainbow and Lahontan cutthroat trout.

During late summer, when flows are lowest in Burke Creek and adjacent tributaries, both adult and juvenile salmonids may need to move upstream or downstream to escape locally deteriorating habitat conditions arising from diminishing flow and/or water quality. As described in the Hydrology section (see Section 4.4.2)), it appears that Burke Creek at Highway 50 maintains a relatively consistent baseflow of about 0.2 cfs. Therefore, 0.2 cfs was selected as the ***low fish passage flow*** within the assessed reaches of Burke Creek for both adult resident and juvenile salmonids.

Fish Passage Criteria

To assess fish passage conditions through culverts and other artificial waterways, minimum water depths, maximum average cross sectional water velocity, and maximum water surface drops are typically established for each target species/lifestage. Nevada Division of Wildlife does not have specific assessment or design criteria for fish passage. Design criteria for adult rainbow trout and juvenile salmonids (the family to which both rainbow trout and LCT belong) have been widely established for fish passage assessments and migration barrier remediation projects throughout the western United States. However, there are no well-established assessment or design criteria for LCT. Given the physiological similarities between resident LCT and rainbow trout, it seems reasonable to apply both adult resident and juvenile salmonid passage criteria to both species.

Commonly criteria for juvenile salmonids and adult resident rainbow trout are listed in Table 6. These criteria were applied to the assessment of the existing 228-foot long corrugated metal culvert under Highway 50.

Table 6: Burke Creek fish passage flows and assessment criteria for juvenile salmonids and adult resident rainbow and Lahontan cutthroat trout.		
Criteria	Juvenile Salmonids	Adult Resident Rainbow Trout (also applied to resident LCT)
Fish Passage Flows	0.2 cfs to 2.2 cfs	0.2 cfs to 2.2 cfs
Minimum Water Depth	0.3 ft[1]	0.5 ft[2]
Maximum Water Velocity		
Length between Resting Areas	1 ft/s[3]	
Less than 100 ft		4 ft/s[2,4]
100 to 300 ft		3 ft/s[2,4]
Greater than 300 ft		2 ft/s[2,4]
Maximum Water Surface Drop	0.5 ft[1]	0.67 ft[1,2]

[1] California Dept. of Fish and Game Assessment Criteria (CDFG, 2002)

[2] California Dept. of Fish and Game Design Criteria (CDFG, 2002)

[3] Barber and Downs (1996)

[4] Washington Dept. of Fish and Wildlife (Bates, 2003)

Fish passage Assessment

Highway 50 Culvert

The existing culvert under Highway 50 is a 24 inch corrugated metal pipe (CMP), 228 feet in length and at a 3.5% slope. The culvert was evaluated using FishXing 3.0, the US Forest Service software designed for assessment and design of fish passage through culverts (USFS, 2008). The tailwater control was defined using the channel cross section immediately downstream of the culvert outlet A Manning's roughness coefficient of 0.2 was used to represent the willow-dominated channel downstream of the outlet at low flows.

The FishXing model results indicate that the culvert fails to meet fish passage requirements at all flows for either juvenile salmonids or adult resident rainbow and Lahontan cutthroat trout (see Table 7). Although the culvert outlet is backwatered by the aggraded downstream channel, the backwater effect only extends a short distance into the culvert before a hydraulic jump occurs and the flow becomes supercritical. At the low passage flow of 0.2 cfs, water velocities already exceed those suitable for juvenile salmonids. At the high fish passage flow of 2.2 cfs, water depth is still not sufficient and velocities exceed the 3 ft/s threshold for adult passage.

The Highway 50 culvert should be classified as a barrier to the target fish at all flows. However, it is likely that stronger individual fish within the population can negotiate the culvert under limited flow conditions by swimming through shallower than ideal depths and using the slower water velocities along the walls of the culvert. Therefore, this culvert should not be considered adequate for a barrier for use as a management tool to block upstream migration of non-native fish.

Table 7: Hydraulic conditions in the existing Highway 50 culvert at fish passage flows.

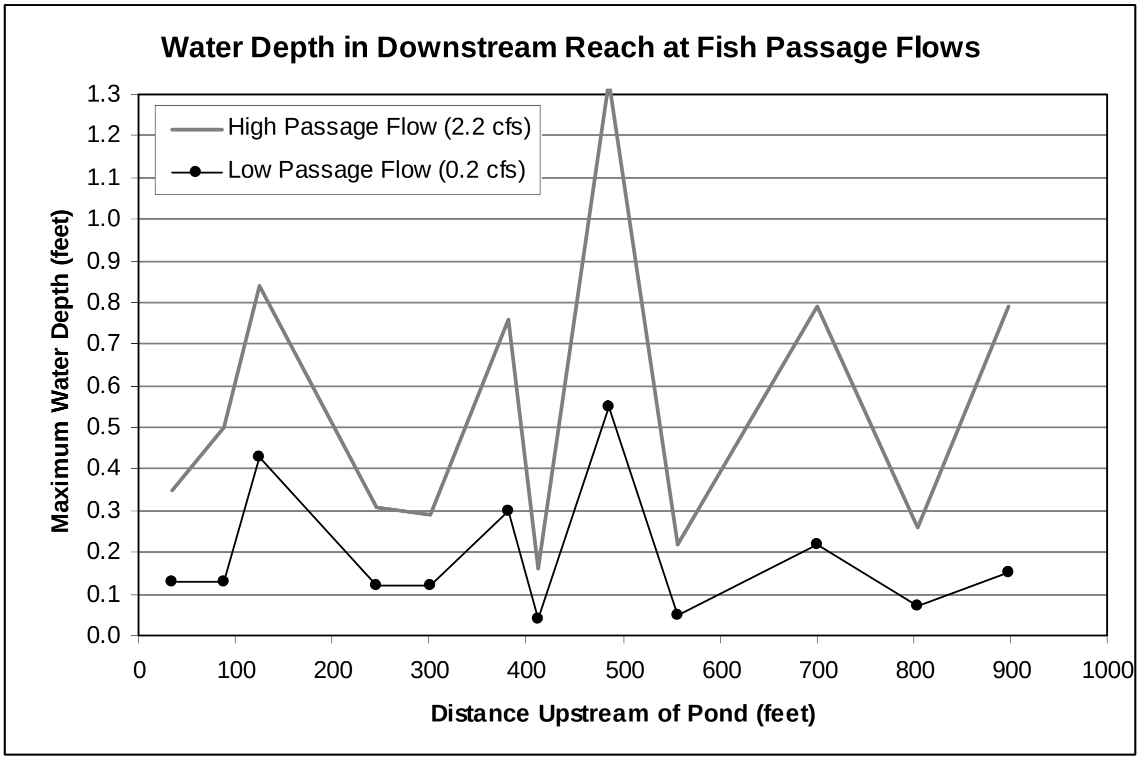
Parameter	Low Passage Flow	High Passage Flow
Flow	0.2 cfs	2.2 cfs
Water Depth	0.12 ft	0.39 ft
Water Velocity	2.5 ft/s	5.1 ft/s
Water Surface Drop	None	None

<u>Downstream Channel (Pond to Highway 50 Culvert Outlet)</u>

For the willow-lined reach between the Highway 50 culvert outlet and the Rabe Meadow Pond, the potentially limiting fish passage condition appears to be providing adequate water depth. The willow roots have densely covered the channel bottom, causing aggradation and channel widening. The result is a wide wetted area with little depth.

Predicted water depth was evaluated at fish passage flows within this reach using results from the existing conditions HEC-RAS model (see Figure 16). Model results suggest that at the lower passage flow of 0.2 cfs, water depth in the downstream channel is inadequate for both juvenile salmonids and adult resident rainbow and Lahontan cutthroat trout. At the high passage flow, adequate depth for juvenile salmonids is provided throughout most of the reach and the model predicted cross sectional averaged water velocities range between 0.2 and 2.4 ft/s. While water depth is less than ideal for both juvenile and resident adults, it does appear that these fish could negotiate this reach during periods of higher flow.

Figure 16: Model predicted maximum water depth within the channel reach between the constructed pond and the Highway 50 culvert outlet at the low and high fish passage flows.



Upstream (Highway 50 to Upper Meadow)

For the assessed channel reach upstream of Highway 50, vertical height of individual water surface drops were evaluated as is the channel slope. Because this channel reach is predominately a step-pool channel, water depths and velocities were not evaluated. Instead, it is assumed that the pools provide adequate depth for holding and resting, and that the primary conditions limiting fish passage are the height of individual drops, or steps, in the channel. Additionally, channel slope can serve as an indicator of the potential challenges a fish may have attempting to migrate upstream.

To evaluate drop heights and channel slope, the longitudinal profile of the channel thalweg and water surface were examined between the existing Highway 50 culvert inlet and the upper meadow. The analysis involved identifying:

- Individual drops in the water surface profile of 0.5 feet or greater over a maximum channel length of 6 feet or less

- Channel slopes over a minimum channel length of 35 feet

Water Surface Drops

Most of the water surface drops within this reach are at forced steps in the channel created by exposed roots from adjacent riparian trees. Others are created by riprap boulders placed in the channel. Additionally, there is one field-identified headcut with a 3.7 foot vertical face located at Station 77+15.

Within this channel reach there are 15 vertical drops that exceed the maximum drop height criteria of 0.67 feet for adult resident trout, with seven of them greater than 1 foot (see Figure 17). Although adult resident rainbow trout are known to ascend drops of these heights by leaping, some of the drops have little to no plunge pool that the fish could use for acceleration, making leaping difficult.

If improvements are made to the channel within the realigned reach adjacent to the Commercial Building, there would remain at least eight drops greater 0.67 feet in height, including the 3.7-foot drop at the headcut at Station 77+15. To facilitate fish passage, at a minimum, measures should be taken to stabilize the headcut and reduce the drop heights for all eight drops.

<u>Channel Slopes</u>

Figure 18 shows the distribution of channel slopes and lengths between Highway 50 and the upper meadow. The predominant channel slopes in the reaches immediately upstream of Highway 50 are relatively steep, with approximately 230 feet of channel with slopes greater than 6%, and including a nearly 120 feet long reach with a slope of 11.8%. Upstream of this steep section, channel slopes decrease, ranging from 2.1 to 4%.

Although adult rainbow trout are known to migrate through channels with slopes exceeding those identified between Rabe Meadow and the upper meadow, it is unknown if they could ascend these steep channel segments due to the vertical drops within the channel and poor leaping conditions provided below them. It is also unclear if juvenile salmonids can ascend such steep sections of channel.

If improvements are made to the channel within the realigned reach adjacent to the commercial property, the steepest section (11.8%) of channel would still remain.

Figure 17: Water surface drops of 0.5 feet or greater in height within selected reaches of Burke Creek upstream of Highway 50.

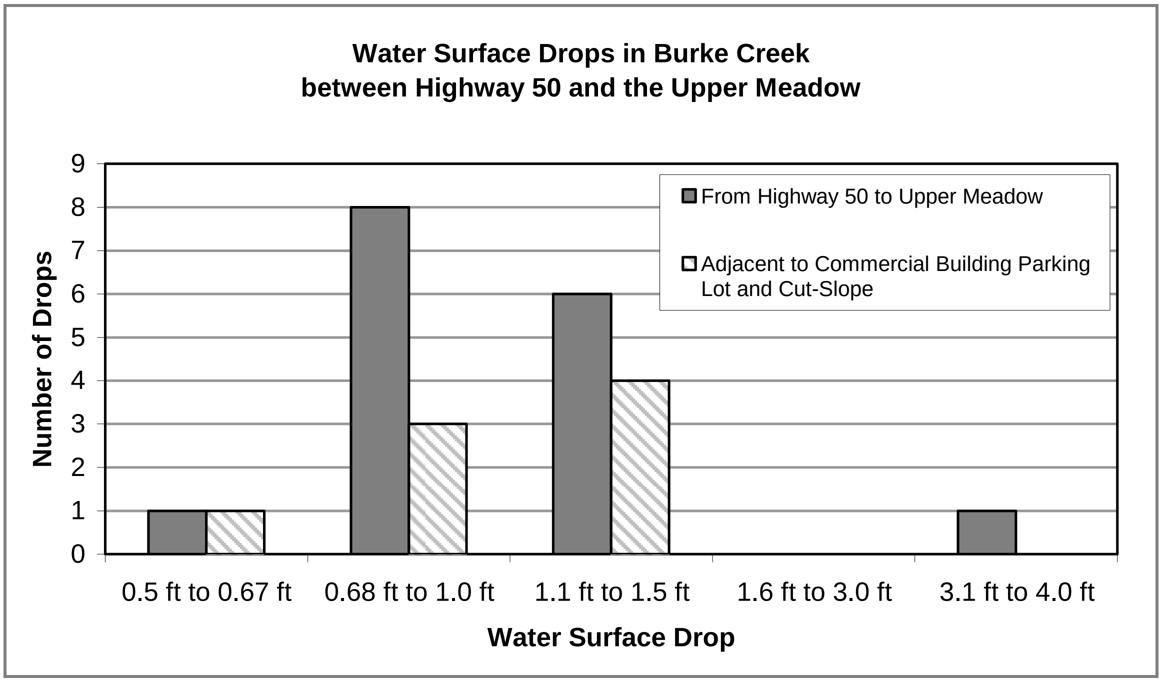
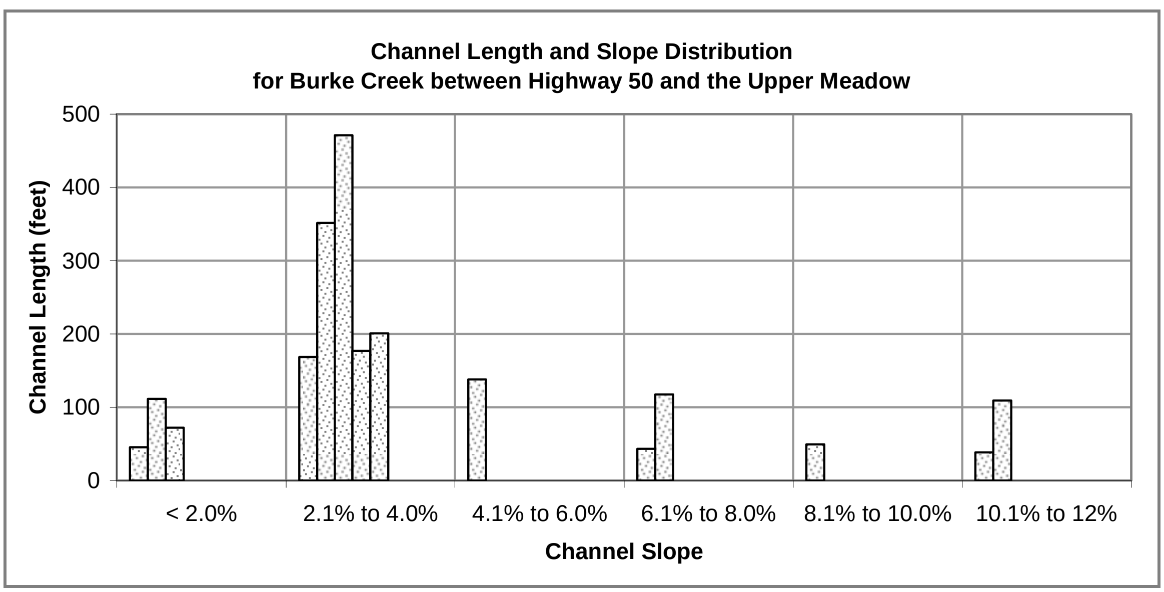


Figure 18: Channel length and slopes within selected reaches of Burke Creek upstream of Highway 50.



4.7 Existing Riparian Resources

4.7.1 Vegetation Description Methods

A detailed field-based vegetation inventory for the Burke Creek project area was conducted in October 2007. Riparian vegetation cover types were field mapped on orthorectified 2007 aerial photograph basemaps. The survey extended from the Lake Tahoe shoreline to the upper meadow approximately 2,300 feet upstream of Highway 50. Basemaps used for field mapping were scaled to 1 inch = 150 ft, plotted on 11 inch by 17 inch sheets and laminated for use in the field. All plant species observed during the survey can be found in Appendix H.

Vegetation is defined as "all the plant species in a region, and the way they are arranged" and usually appears as a mosaic of numerous, definable plant stand types (Sawyer and Keeler-Wolf 1995). The dominant plant species in the canopy defines the stand type, such that if there is a discernable shift in species dominance within the canopy, there is also a corresponding shift in stand type. A vegetation classification system utilizing stand types was used to assign cover attributes to mapped vegetated polygons during the inventory (Sawyer and Keeler-Wolf, 1995). Unvegetated polygons were assigned a cover attribute based on visible substrate and level of human disturbance. A cover attribute is the same as a cover type. Cover types include vegetated stand types and also unvegetated areas.

Cover types were mapped using an intensive field based site vegetation survey conducted during October 2007, to ensure a highly detailed and accurate vegetation map. A riparian botanist conducted the field inventory, which consisted of walking the length of Burke Creek from its confluence with Lake Tahoe up to the upper meadow, and visiting each distinct cover type. Polygon boundaries were drawn in the field around discrete cover types and a cover attribute was assigned. Individual trees were the smallest vegetation units mapped. Polygons were no smaller than 100 feet^2 and included all human disturbance (i.e. anthropogenic), riparian, wetland, and adjacent upland habitats (i.e. biological habitats) within the project area.

For purposes of analyzing impacts, an environmental study limit (ESL) was established around the project area where proposed alternatives are located (see Figure 19). The ESL included the proposed construction footprint for anticipated alternatives, as well as additional areas that may be indirectly affected by project alternatives. The ESL coincided with the vegetation analysis boundary. The term "project area" represents the total acreage within the ESL, which was 11.3 acres. Boundaries representing the impact area associated with each proposed alternative were drawn within the ESL.

Two maps were developed from the October 2007 field mapping (Figure 19 and Figure 20). A map of the vegetation was created using general biological habitat types, which illustrates the site vegetation at a coarser scale (Figure 19) and a second map using cover types (Figure 20). The cover type map shows vegetation patches, particularly riparian cover types, at a greater detail. The biological habitat map is useful for environmental regulatory compliance purposes, while the cover type map based on species dominance is useful for assessing vegetation quality and structure within the ESL, as well as developing conceptual revegetation designs for the alternatives.

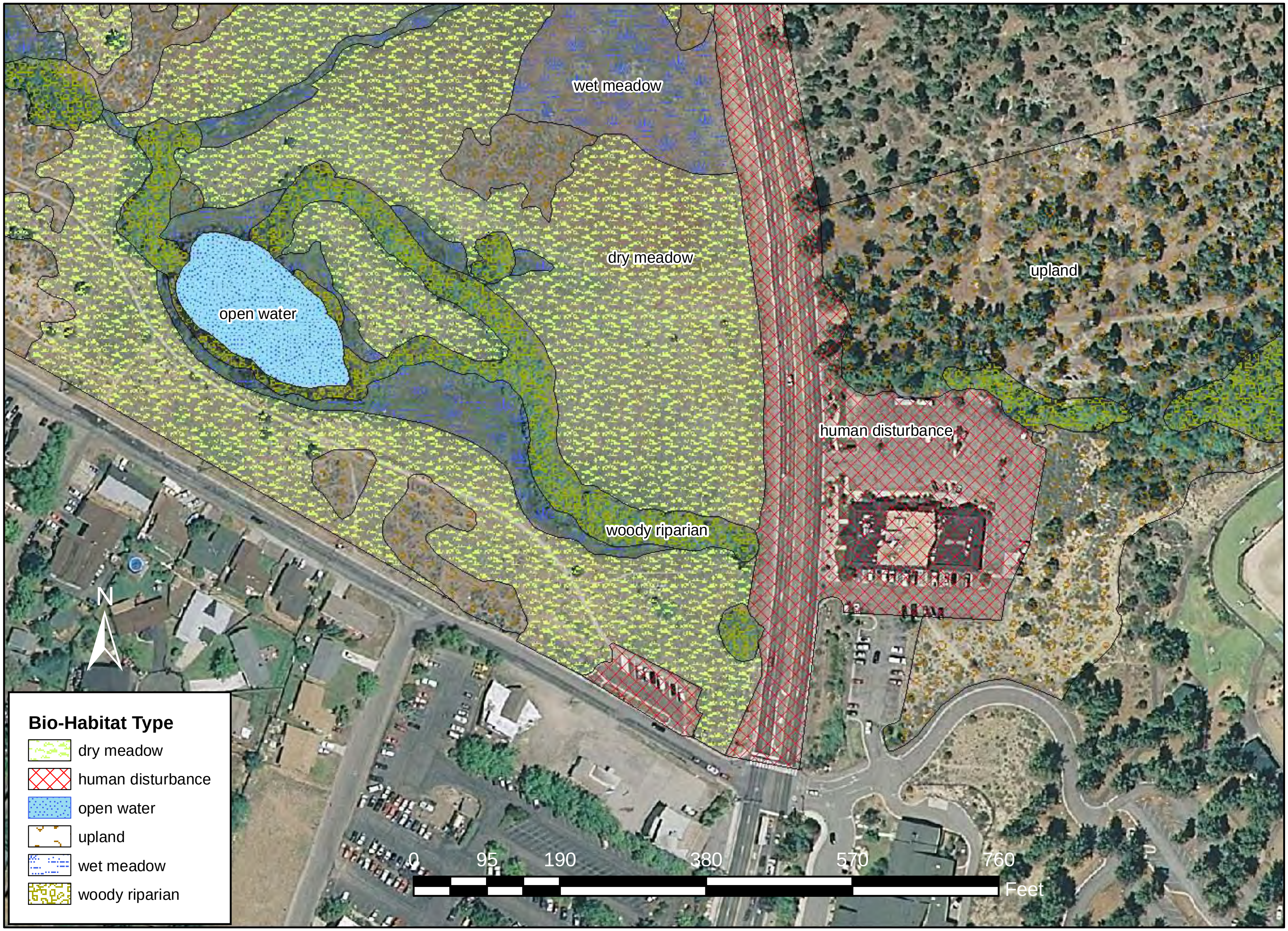


Figure 19: Inventory of biological habitats occurring within the Burke Creek Environmental Study Limit (ESL), mapped in October 2007.

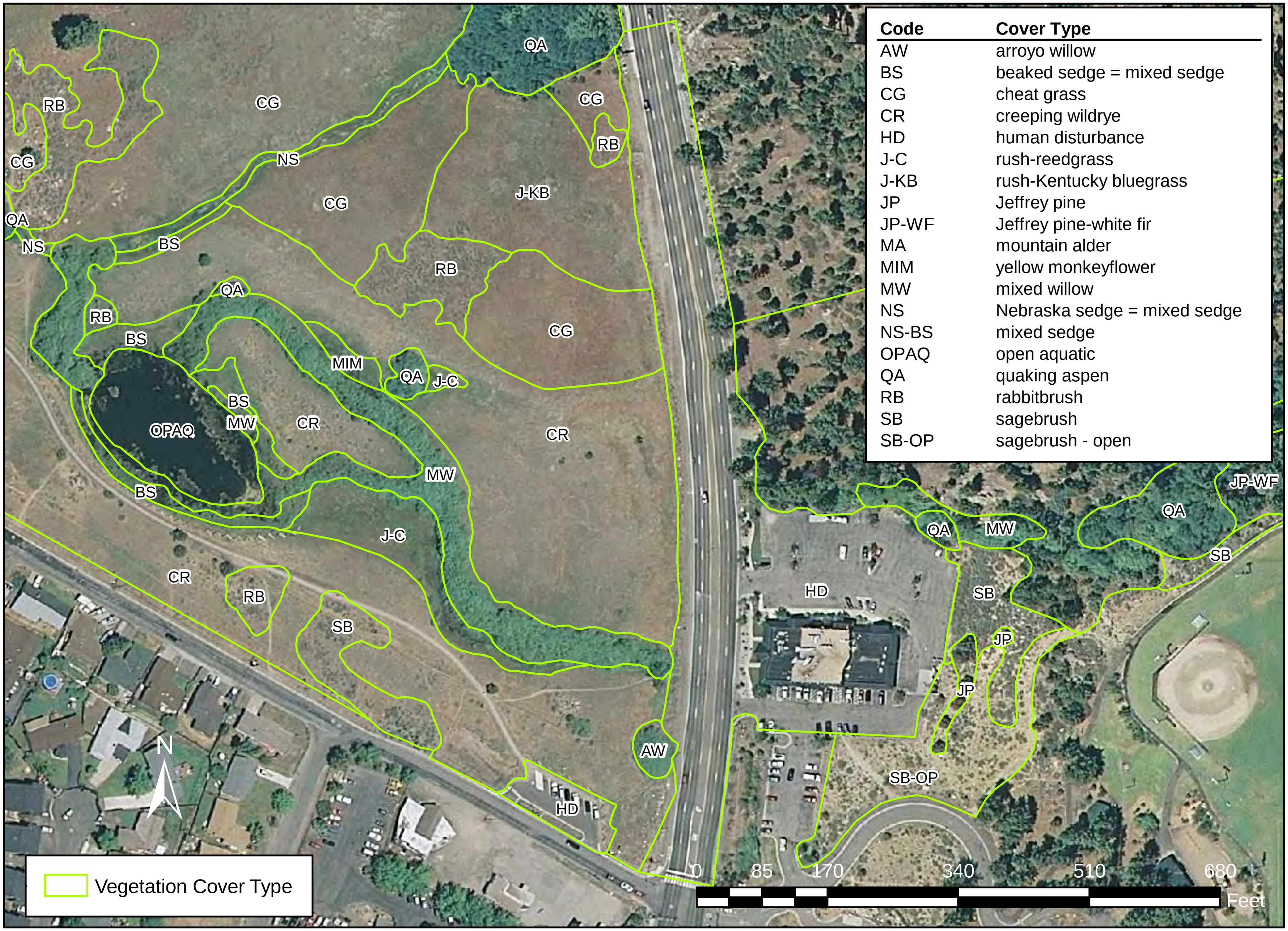


Figure 20: Inventory of vegetation cover types occurring within the Burke Creek Environmental Study Limit (ESL), mapped in October 2007.

4.7.2 Description of Existing Vegetation

Maps of fourteen cover types were created within the Burke Creek ESL in October 2007 (Figure 20). Mapped cover types were coarsely classified into five biological habitats: anthropogenic, wet meadow, dry meadow, woody riparian, and upland (see Figure 19 and Appendix H). Each habitat class and the related cover types are briefly described in the following sections.

Anthropogenic Habitats

These habitats include all human created or maintained cover types within the project area. The cover type classification is independent of hydrology and dependent on human land use patterns, both current and historic. We mapped one cover type within this habitat that makes up 13.2% of the ESL area (Figure 19).

Human Disturbance

Roads, trails, and access areas are all active human disturbances within the project area where plant cover has not returned. The most conspicuous human disturbances in the project area are the commercial development and associated parking lot upstream of Highway 50, as well as Highway 50, which bisects the ESL area (Figure 20).

Wet Meadow Habitats

Wet meadow habitats are herbaceous vegetated areas within the project area dependent on seasonal variation in surface and ground water hydrology (see Figure 21). They are a type of riparian habitat, which generally consist of obligate and facultative wetland indicator species. Groundwater is typically shallow and abundant in wet meadow cover types through most or all of the year. It is likely that soil type also contributes to the formation of wet meadows, although soil investigations were not conducted for this project. Obligate and facultative wetland indicator plants, especially sedges and rushes, are common in wet meadow habitats. Four cover types were mapped within this habitat and make up 4.2% of the ESL area (Figure 20):

Figure 21: Wet meadow habitat near the existing willow corridor downstream of Highway 50, looking downstream.

Mixed Sedge

Several different sedge habitats were mapped along the length of Burke Creek. Within the Environmental Study Limit, beaked sedge (*Carex utriculata*) dominates the mixed sedge cover type. Nebraska sedge (*C. nebrascensis*), Mexican rush (*Juncus mexicanus*), bigleaf avens (*Geum macrophyllum*), pull-up muhly, and slender cinquefoil are common associated species. Occasionally, young Lemmon's willows (*S. lemmonii*) occur in mixed sedge habitats. Mixed sedge does not occur in the construction footprint, but is within the ESL. It makes up a total of 3.2% of the ESL area (Figure 20).

Rush-Reedgrass

Mexican rush dominates this cover type, with shorthair reedgrass (*Calamagrostis breweri*) as a co-dominant species. Rush-reedgrass habitats are very species-rich. The most common associated species in the project area include pull-up muhly (*Muhlenbergia filiformis*), Kentucky bluegrass (*Poa pratensis*), yarrow (*Achillea millefolium*), tall tumblemustard (*Sisymbrium altissimum*), and pepperweed (*Lepidium virginicum* var. *virginicum*). Rush-reedgrass makes up a total of 0.3% of the ESL area (Figure 20).

Rush-Kentucky Bluegrass

Rush-Kentucky bluegrass is similar to the rush-reedgrass cover type, in that Mexican rush is a dominant species. However, Kentucky bluegrass replaces reedgrass as a codominant in this cover type. Other common species include mullein (*Verbascum blattaria*), slender cinquefoil (*Potentilla gracilis* var. *fastigiata*), yarrow, blue wildrye (*Elymus glaucus*), goat's beard (*Tragopogon dubius*), and slender tarweed (*Madia gracilis*). Rush-Kentucky bluegrass makes up less than 0.1% of the ESL area (Figure 20).

<u>Yellow Monkeyflower</u>

Yellow monkeyflower (*Mimulus guttatus*) dominates this cover type. The herb layer is very dense and species rich, including Mexican rush, brownhead rush (*J. phaeocephalus*), willowherb (*Epilobium ciliatum*), duckweed (*Lemna* sp.), slender cinquefoil, and cattail (*Typha latifolia*). Surface water is prevalent in yellow monkeyflower habitats within the project area. Occasional young willow sprouts occur (e.g., *Salix lemmonii, S. exigua, S. lucida, S. lasiolepis*), but they are neither dense enough nor tall enough to form a true shrub layer. Yellow monkeyflower makes up 0.6% of the ESL area (Figure 20).

Dry Meadow Habitats

Dry meadow habitats are herbaceous vegetated areas within the project area less dependent on ground water than wet meadows. Soils are typically coarser than wet meadows, although soil investigations were not conducted for this project. Grass species typically dominate dry meadow habitats, although numerous forbs also occur in these habitats. Two cover types were mapped within this habitat that make up 48.5% of the ESL area (Figure 19).

<u>Creeping Wildrye</u>

Creeping wildrye (*Leymus triticoides*) dominates this cover type. Other common species include Kentucky bluegrass, cheat grass (*Bromus tectorum*), smooth brome (*Bromus inermis*), slender tarweed, and Mexican rush. Creeping wild rye occurs only in the vicinity of the former Jenning's casino and makes up 42.5% of the ESL area (Figure 20).

<u>Cheat Grass</u>

Cheat grass, an invasive exotic grass, dominates this cover type. The herbaceous layer is dense and low compared to creeping wildrye. Other species found in cheat grass cover types include tall tumblemustard, goat's beard, and slender tarweed. Cheat grass is widespread throughout the length of lower Burke Creek and is the prevalent dry meadow cover type. Cheat grass makes up 6.1% of the ESL area (Figure 20).

Woody Riparian Habitats

Woody riparian habitats within the project area are similar to wet meadow habitats in that they are dependent on seasonal variation in surface and ground water hydrology. Woody riparian habitat along Burke Creek is currently more abundant than it was historically (based on aerial photographs), likely due to restoration of the former Jenning's casino site by the USFS (Section 4.2.2). Although shrubby willow habitat may not be a naturally occurring riparian cover type on Burke Creek downstream of Highway 50, it likely presently provides high quality habitat for migratory neo-tropical songbirds and other important wildlife. Two cover types were mapped within this habitat that make up 15.4% of the ESL area (Figure 19).

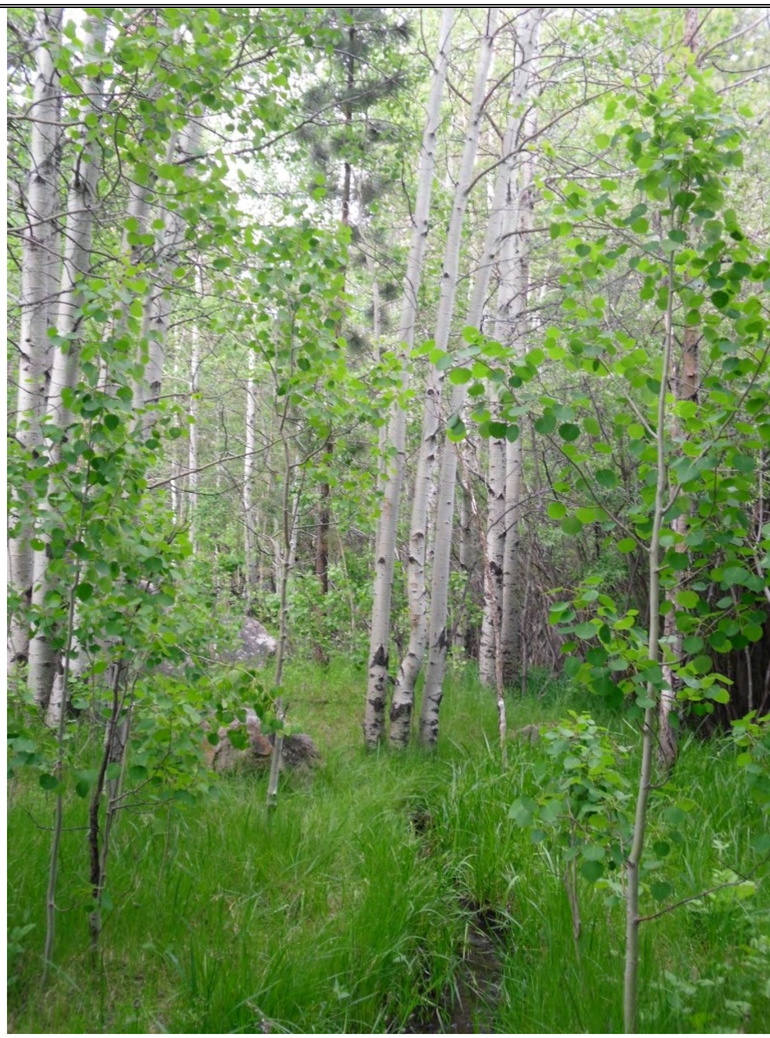
Mixed Willow

Three willow species co-dominate this cover type, including shiny willow (*Salix lucida*), Lemmon's willow, and arroyo willow. Shiny willow and Lemmon's willow are obligate wetland species and arroyo willow is a wet facultative wetland indicator species (Reed, 1988). The shrub layer is dense and may also include mountain alder (*Alnus incana*), young Jeffrey pine (*Pinus jeffreyi*) and mountain pink currant (*Ribes nevadense*)). The herb layer is also dense and composed mostly of Kentucky bluegrass, wintergreen (*Pyrola* sp.), mugwort (*Artemisia douglasiana*), and panicled bulrush (*Scirpus microcarpus*). The mixed willow cover type makes up 12.9% of the ESL area (Figure 20).

Quaking Aspen

Quaking aspen (*Populus tremuloides*) dominates this cover type. Quaking aspen is a facultative+ wetland indicator species (see Reed 1988). The tree layer is characteristically dense and also includes Jeffrey pine. Commonly occurring associates in this cover type are mountain pink currant, Lemmon's willow, Kentucky bluegrass, and meadowrue (*Thalictrum* sp.) (see Figure 22). The quaking aspen cover type makes up 2.4% of the ESL area (Figure 20).

Figure 22: Quaking aspen cover type upstream of Highway 50, looking upstream.



Upland Habitats

Upland habitats are vegetated cover types that are not reliant on surface and ground water in excess of that provided by precipitation alone. Typically, wetland indicator species are not found associated with upland habitats. Five cover types were mapped within this habitat making up 18.7% of the ESL area (Figure 19).

<u>Jeffrey Pine-White Fir</u>

Jeffrey pine and white fir (*Abies concolor*) co-dominate the tree layer of this cover type. The canopy is closed and the shrub and herb layers are correspondingly sparse. Species found within the Jeffrey pine-white fir cover type include mountain whitethorn (*Ceanothus cordulatus*), manzanita (*Arctostaphylos* sp.), mahala mat (*Ceanothus prostratus*), rabbitbrush (*Chrysothamnus nauseosus*), and blue wildrye (*Elymus glaucus*). Jeffrey pine-white fir occurs along the northern project boundary upstream of Highway 50. It makes up 9.5% of the total ESL area (Figure 20).

<u>Jeffrey Pine</u>

Jeffrey pine dominates the tree layer of this cover type. Within the project area, Jeffrey pine occurs as scattered trees near the interface between sagebrush and Jeffrey pine-white fir cover types, although it may form denser stands elsewhere. The canopy is open, the shrub layer is moderate to sparse, and the herb layer is low. Species found in the Jeffrey pine cover type include sagebrush (*Artemisia tridentata*), Kentucky bluegrass, and cheat grass. Jeffrey pine makes up less than 0.1% of the total ESL area (Figure 20).

<u>Rabbitbrush</u>

Rabbitbrush dominates this cover type and is the sole species in the sparse to dense shrub layer. The herb layer is typically sparse and low, consisting of cheat grass, Kentucky bluegrass, Douglas' sedge (*Carex douglasii*), and Mexican rush. Rabbitbrush makes up 0.3% of the total ESL area (Figure 20).

<u>Sagebrush</u>

Sagebrush dominates this shrubby cover type, although rabbitbrush occasionally occurs. The sagebrush cover type is very similar to rabbitbrush, with a sparse herb layer of cheat grass, Kentucky bluegrass, Douglas' sedge, and Mexican rush. Sagebrush makes up 1.5% of the total ESL area (Figure 20).

<u>Sagebrush-Open</u>

The sagebrush-open cover type is similar to sagebrush except that the shrub layer is sparse and individual sagebrush shrubs are separated by expanses of cheat grass, Kentucky bluegrass, and Douglas' sedge. Sagebrush-Open makes up 4.7% of the ESL area (Figure 20).

5.0 PRELIMINARY CONCEPTUAL ALTERNATIVES

The project team developed four preliminary conceptual alternatives for restoration of Burke Creek. The alternatives were developed to meet the project objectives and to fit within the site constrained identified at the TAC kickoff meeting.

Project objectives were to replace the existing undersized culvert conveying Burke Creek with a larger culvert that increased flow conveyance and sediment transport through the culvert and downstream. Additional objects were to create a stable, geomorphically functioning natural stream channel that provides fish rearing habitat and passage, and to create an ecologically functional riparian corridor.

Primary site constraints included private property constraints upstream of Highway 50 that limited the location and size of proposed channel and an existing gravity sanitary sewer line along Highway 50.

Using the information developed as part of the historical and existing condition assessments of the project area, four preliminary design alternatives were developed. Figure 23 shows the proposed channel alignments of the four preliminary alternatives and each alternative is summarized below and presented in more detail in Appendix I.

When the preliminary alternatives were developed, it was the project team's understands that the sanitary sewer line at Highway 50 could not be moved. Therefore, three of the four preliminary alternatives were developed assumed the sewer line to remain in place. A forth alternative (Alternative B), assumed that the sewer line could be moved.

Figure 23: Proposed channel centerline locations of Preliminary Alternatives A-D for the culvert replacement and restoration of Burke Creek.

5.1 Overview of Culvert Replacement and Preliminary Conceptual Alternatives

5.1.1 Proposed Replacement Culvert

For all four alternatives, the proposed replacement crossing structure is a concrete box culvert with a 12-foot width and 6.5-foot height with headwalls or wingwalls at the inlet and outlet The culvert bottom will be embedded 2.5 feet below the proposed channel bed. A stable streambed will be constructed within the culvert with similar bankfull channel dimensions as upstream and downstream, and include a small floodplain.

The culvert, accounting for embedment, is sized to convey the 100-year design flow of 120 cfs without overtopping the culvert inlet The actual alignment, slope, and length of the proposed culvert is dependent on the proposed alignment for each respective alternative. Further details on the culvert design are presented in Section 6.0.

5.1.2 Alternative A – Minimal Upstream Restoration (Sewer Line Remains)

Alternative A is considered the minimal alternative, creating 565 feet of new rock step-pool channel with 90 feet of channel improvements upstream of Highway 50. Upstream of Highway 50, this alternative keeps the upstream channel within its current alignment and avoids impacts to the existing parking lot to the south. Dikes along the south side of the channel will contain 100-year design flows. The proposed 100-foot replacement culvert will be constructed such that the existing sanitary sewer line can be encased in concrete within the embedded section of the culvert. Downstream of the culvert, a new channel will be reconstructed to meet the existing willow channel approximately 345 feet downstream of the culvert outlet Fill will be necessary to construct a channel profile within an area excavated for the Jennings Casino construction.

Refer to Appendix G for schematic plan view, channel profile, and cross sections for Alternative A.

5.1.3 Alternative B – Geomorphic Restoration (Moving Sewer Line)

Alternative B creates 790 feet of new boulder step pool and meadow channel. The objective of this alternative is to reconstruct the historical channel profile and morphology as much as possible, given constraints imposed by the highway, existing commercial property and other land uses.

Upstream of Highway 50, the existing channel will be moved slightly to the south, onto the parking lot of the commercial property. A new dike and retaining walls will be constructed to minimize impacts to the Parking lot. The top elevation of the dike was designed to provide two feet of freeboard above the predicted 100-year water surface elevation. This alternative assumes the existing sanitary sewer line at Highway 50 could be moved, allowing the proposed 120-foot replacement culvert outlet to be placed at a lower elevation. Downstream of Highway 50, a new channel will be constructed to meet the existing willow channel approximately 350 downstream of the culvert outfall.

Refer to Appendix I for schematic plan view, channel profile, and cross sections for Alternative B.

5.1.4 Alternative C – Geomorphic Restoration (Sewer Line Remains)

Alternative C creates 840 feet of new boulder step pool and meadow channel. Alternative C is similar to Alternative B, but moves the channel farther south, to increase the length of new channel and create a geomorphically stable channel slope without affecting the existing sanitary sewer line at Highway 50.

Upstream of Highway a 50, the proposed channel alignment is nearly identical to Alternative B, but extends further upstream. As with Alternative B, dikes and retaining walls will be necessary to minimize impacts to the existing parking lot on the commercial property to the south of the stream. The proposed 150-foot long culvert will be skewed to the roadway, with the inlet in the commercial parking lot. The proposed replacement culvert will be constructed such that the existing sanitary sewer line can be encased in concrete within the embedded section of the culvert. Downstream of Highway 50, the proposed channel flows through what is now open grasslands before rejoining the existing channel 380 feet downstream of the culvert outfall.

Refer to Appendix I for schematic plan view, channel profile, and cross sections for Alternative C.

5.1.5 Alternative D – Minimal Downstream Restoration (Sewer Line Remains)

Alternative D creates 590 feet of new boulder step pool channel. The objective of this alternative is to reconstruct the historical channel profile upstream of Highway 50 while tying into the existing downstream channel only 125 feet below the culvert outlet This option is intended to minimize downstream disturbance by preserving the existing downstream channel and riparian areas.

Upstream of Highway 50, the channel alignment is nearly identical to the alignment in Alternative B. Similar to Alternative B, dikes and retaining walls will be necessary to minimize impacts to the existing parking lot on the commercial property to the south of the stream. The culvert alignment is similar to Alternative C, but the culvert will be constructed at a less steep slope than Alternative C to allow it to tie into the existing channel closer to the culvert outfall. The low slope of the culvert relative to the upstream channel slope may create a sediment deposition area upstream of the culvert. The existing sanitary sewer line will be encased in concrete within the embedded section of the culvert. Downstream of the culvert, a new channel with meet the existing channel approximately 120 feet downstream of the culvert outlet

Refer to Appendix I for schematic plan view, channel profile, and cross sections for Alternative D.

5.2 TAC Preliminary Conceptual Alternatives Review

The preliminary conceptual alternatives presented in Section **Error! Reference source not found.** were submitted to the TAC on February 22, 2008 as a Technical Memorandum titled *"Burke Creek Restoration Project: Preliminary Development of Alternatives"* for review and comments (Appendix G). On February 22, 2008, key members of the project team met with the TAC at the TRPA office to discuss the preliminary alternatives and answer any questions from the TAC.

The TAC agreed to return comments to TRPA, and TRPA agreed to compile comments into a single set of comments to resolve any potential conflicting review comments and to provide clear direction to the project team on how to proceed with the project.

TRPA subsequently provided the project team with comments from TAC members and directed the project team to further analyze and develop Alternatives A and B. Appendix A contains meeting agendas and other correspondence related to this process.

6.0 CONCEPTUAL DESIGN OF ALTERNATIVES A & B

The two preliminary conceptual alternatives selected by the TAC for further conceptual design were Alternatives A and B. The conceptual designs were prepared based on the topographic survey prepared by Turner and Associates, Inc. in October 2007.

6.1 Alternative A

This section presents the Alternative A conceptual design. This includes a brief description, hydrology and hydraulic design features. Section 7.0 presents a discussion of the proposed geomorphic, vegetation and fish passage impacts associated with this Alternative.

Alternative A will create a 535-foot long channel. The alternative keeps the channel within its current alignment upstream of Highway 50, which is located on property owned by Sierra Colina LLC. The project area does not extend onto the adjacent commercial property to the south. The proposed channel bottom upstream of Highway 50 will be at a deeper elevation than the existing channel. A deeper channel and existing dikes will contain the 100-year flows within the project area. Upstream of the project area, raising the existing dikes will be necessary to reduce flooding potential on the adjacent commercial property.

The proposed culvert replacement is nearly perpendicular to the highway centerline. The culvert replacement for Alternative A is 100 feet in length and assumes the existing sewer line will not be relocated. Downstream of the culvert, a new channel will be reconstructed to meet the existing willow channel approximately 345 feet downstream of the culvert outlet Conceptual drawings for Alternative A are provide in Appendix J.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels (Montgomery & Buffington, 1997 and Grant et al., 1990). These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, and provide channel and flow complexity that facilitates fish passage and provides aquatic habitat.

The following sections present details on development of the proposed channel alignment, profile and cross sections. Section 6.3 presents a detailed discussion of the channel morphologic features. Section 6.4.2 presents the results of the hydraulic modeling used to verify channel capacity and to support the design of stable channel bed and banks and revegetation.

6.1.1 Proposed Channel Alignment

The proposed channel alignment of Alternative A follows the existing channel alignment for 90 feet upstream of Highway 50, differing only where the existing culvert crosses under Highway

50. The proposed culvert alignment is nearly perpendicular to the highway centerline to minimize the culvert length and maximize the culvert slope while accommodating the location of the existing sewer line along the west edge of the roadway.

The existing culvert will be plugged at the inlet but will remain in use. Inlet drainage from the commercial parking lot will continue to drain to the culvert and to the existing willow channel downstream of the culvert. The existing channel from downstream of Highway 50 to the location where the relocated channel meets the existing channel will no longer act as the main channel, but will still receive flow from the parking lot drainage.

Downstream of the outlet of the 100-foot long culvert, a new channel approximately 345 feet long will be constructed. It joins the existing channel approximately 400 feet upstream of the Rabe Meadow Pond. The proposed channel alignment downstream of Highway 50 follows a swale defined by the hillslope to the north and a slight rise in the ground to the south. This alignment was chosen to match the proposed location of the culvert outlet and to utilize existing topography as much as practical to confine the floodplain.

It should be noted that the former Jennings Casino construction effort, which was started but never completed, is understood to have resulted in excavation and lowering of the ground west of Highway 50 in the vicinity of the proposed downstream channel of Alternative A. While the exact difference between the current topographic relief is not known for certain, raising the downstream channel may closer approximate the historical topography in this area.

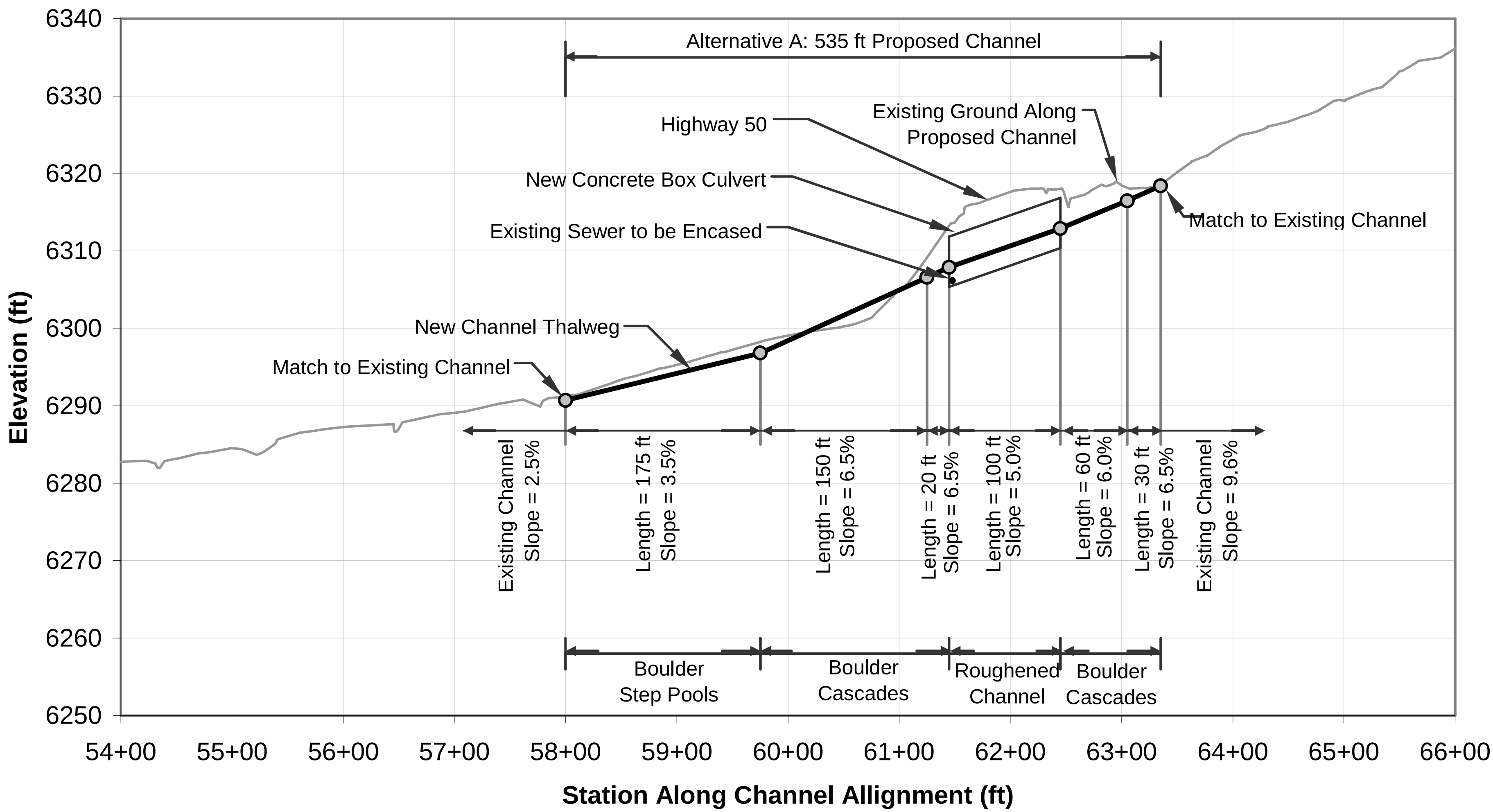
6.1.2 Proposed Channel Profile

Profile Design

The proposed channel profile was designed to allow for the creation of a stable, natural stream channel that facilitates fish passage and geomorphic processes, specifically transport of fine sediment. An opposing constraint was to design the proposed channel and culvert profile to accommodate the existing sewer line. The proposed profile was designed to fit within the slope ranges of the reference reaches surveyed for the project. The slope was limited to 6.5% and lower to facilitate channel stability and fish passage. At steeper slopes, spacing between boulder steps can become too small and/or drops over boulder steps can become too great to adequately dissipate flow energy and provide fish passage for smaller salmonids.

Sheet A1 of the Conceptual Drawings (Appendix J) and Figure 24 present Alternative A channel profile and overall channel slope segments. Upstream of the culvert, the proposed channel meets the existing channel at a 6.5% slope for 30 feet The channel profile then decreases to a 6% slope for the 60 feet upstream of the culvert, and decreases to a 5% slope through the proposed culvert. The intent of the design was to maintain a higher channel slope downstream through the culvert to avoid an abrupt slope break and promote transport of sediment to well downstream of the culvert outlet

Figure 24: Proposed channel profile for Alternative A.



The upstream channel slope and thalweg elevations of the channel were limited by the elevation of the existing sewer line near the downstream outlet of the culvert. The sewer line will pass through the embedded portion of the proposed culvert and will be encased in a concrete grade beam. The top of the concrete beam would be roughly flush with the channel thalweg and will be protected by the rock channel structures within the culvert.

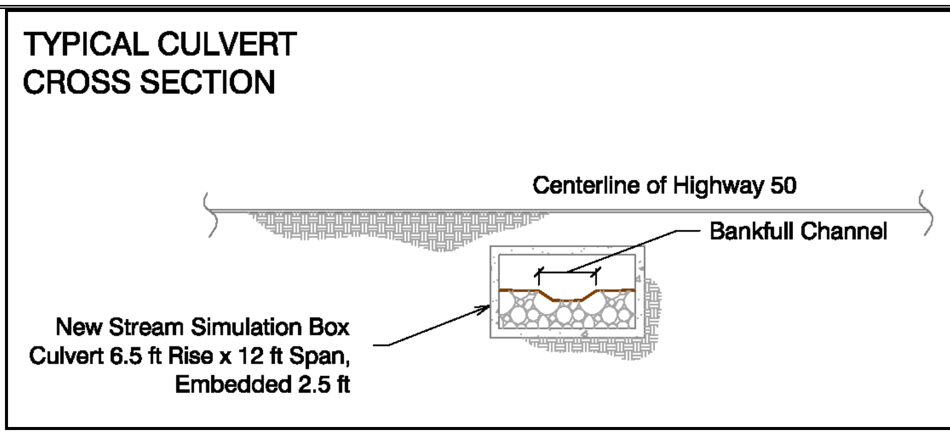
Due to the elevation of the sewer line, the culvert outlet is perched approximately 5.5 feet above the existing dry meadow immediately downstream. To minimize the amount of fill required within the dry meadow, the channel steepens to a 6.5% slope downstream of the culvert outlet This 6.5% sloping reach continues for 170 feet Downstream of the fill area, the channel slope decreases to a 3.5% slope to match the slope of the existing ground and tie into the existing channel. The abrupt drop in slopes from 6.5% to 3.5% was selected to minimize fill. It is expected that the slope transition area around station 60+00 will be characterized by sediment deposition because of the decrease in stream power, water velocities, and shear stress associated with the decreased channel slope.

Within each overall slope segment of the proposed channel, various profile control stabilization measures are proposed that are appropriate to steep channels. These include boulder cascades and pools and boulder step pools. See Section 6.3 for further discussion of channel morphology.

Replacement Culvert

A new concrete box culvert will be installed with the inlet at approximately the same location and elevation as the 24-inch existing culvert (Figure 25). The culvert will be placed perpendicular to the highway centerline, moving the outlet approximately 220 feet to the north of its current location. The relocation of the culvert outlet will allow for a steeper sloped culvert that will better facilitate sediment transport. A shorter culvert will also minimize the area of road disturbance and be beneficial for passage of fish and wildlife.

Figure 25: Typical Cross section of culvert



The proposed replacement culvert was designed in accordance with Stream Simulation methodology for steep channels (USFS, 2008). It will consist of a 100-foot long concrete box culvert with the invert set 2.5 feet below the thalweg elevation of the finished streambed and filled with streambed material to form the same cross sectional shape as the upstream channel. The constructed stream channel in the culvert will have a 4-foot wide bankfull channel and floodplain, and provide the necessary flow depths and suitable velocities for fish passage. The encased sewer line immediately inside the culvert outlet will be roughly flush with the constructed channel thalweg within the culvert.

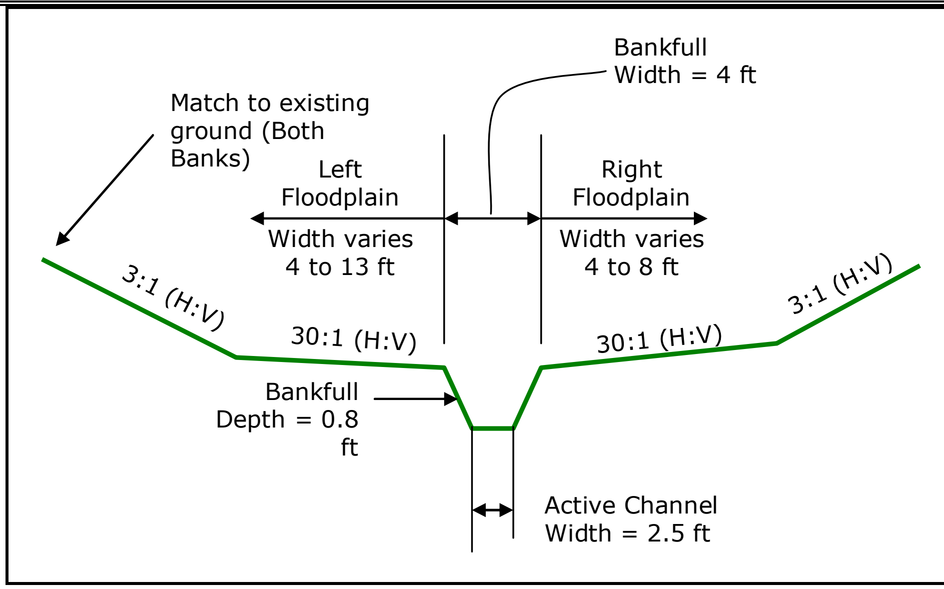
A 12-foot wide by 6.5-foot tall concrete box culvert was selected to maintain floodplain continuity and sufficient conveyance area for the 100-year flow event. The culvert slope matches the channel slope of 5%. To avoid pressurized flow that can compromise bed stability for a stream simulation channel, the proposed culvert was designed to convey the 100-year peak flow of 120 cfs without submerging the culvert inlet Allowing this freeboard also minimizes backwater effects to facilitate sediment transport and minimizes potential blockages by debris. Hydraulic modeling of the proposed culvert is discussed in detail in Section 6.4.

At the culvert inlet is a concrete headwall extending from both sides of the culvert. The headwall also extends vertically to meet the existing ground above the culvert inlet At the culvert outlet a concrete headwall will extend from both sides of the culvert and one foot above the top of the culvert. This will allow for re-establishment of the gentle embankment slope above and around the culvert outlet The headwalls also accommodate channel and floodplain grading immediately downstream of the culvert outlet, thus providing a geomorphically continuous stream channel into, through, and out of the culvert.

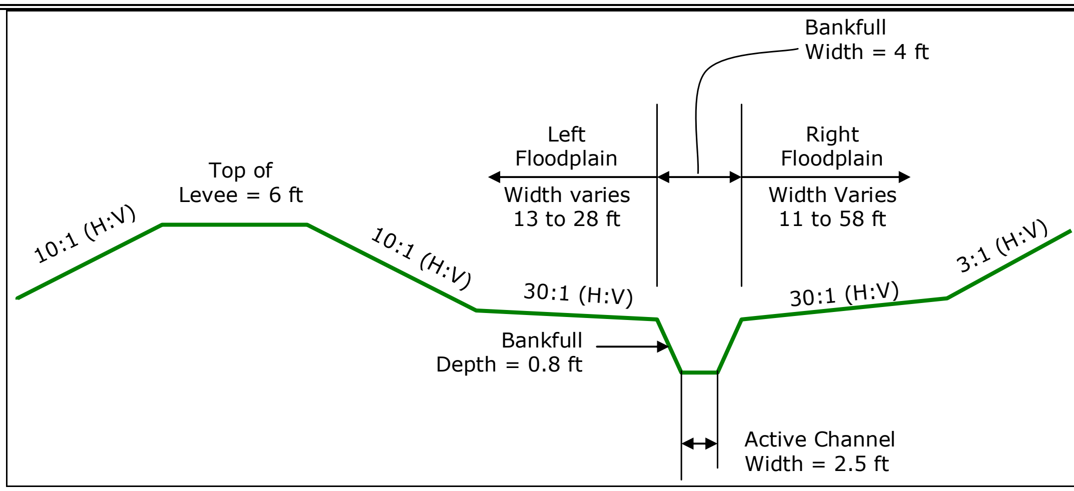
6.1.3 Proposed Cross Sections

The proposed channel cross sectional shape was designed to simulate reference conditions as best as possible. Channel bottom width, bottom cross slope, side slopes, bankfull width and depth, and floodplain width were matched to reference reach data within the constraints of the site. Figure 26 present typical cross sections for Alternative A upstream and downstream of Highway 50. The concept plans in Appendix J provide additional cross sections and show both existing and proposed ground surfaces.

Figure 26: Proposed typical cross sections for Alternative A upstream and downstream of Highway 50.

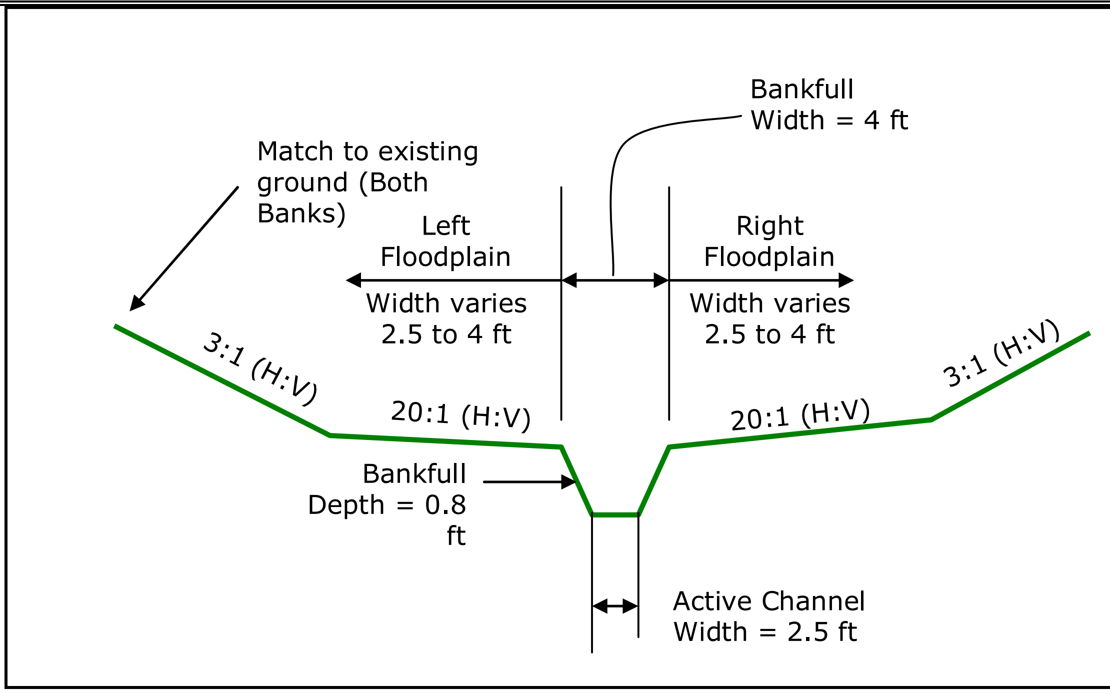


Typical cross section Stations 59+00 to 60+00 and 61+00 to 61+45.



Typical cross section Stations 60+00 to 61+00.

Figure 26: Proposed typical cross sections for Alternative A upstream and downstream of Highway 50.



c. Typical cross section Stations 62+45 to 62+62.

Bankfull Channel

A single bankfull cross section design was used for Alterative A, with varying floodplain widths to fit within site constraints. The proposed condition bankfull channel has a 2.5-foot wide bottom, 0.8 feet tall banks with 1H:1V side slopes, and a 4-foot top width. This channel conveys the 1.2-year flow, with water spreading out onto the adjacent floodplain at higher flows.

Floodplains

Small floodplains are a characteristic feature of the middle and upper reference reaches, despite their steep slope. They help reduce Burke Creek in-channel shear stresses, create areas of reduced velocity that fish can occupy during floods, and provide an area in which select riparian vegetation that need a high water table can become established. Small floodplains were included along the Alternative A channel alignment upstream of Highway 50. Floodplain widths increase downstream of Highway 50 as the slope decreases (Figure 26).

Upstream of Highway 50, floodplains of 2.5 to 4 feet can be created on either side of the channel. Wider floodplains are infeasible because of the adjacent hillslope with large trees to the north, and the property line of the commercial property to the south.

Downstream of Highway 50, after flows expand out of the culvert and roadway embankment, graded floodplain widths range from 12 to 39 feet, depending on location and whether the proposed channel will be excavated or created from fill material. Downstream of the culvert, between Stations 60+00 and 61+00, where the proposed channel requires fill to define the bankfull channel and floodplain, dikes are proposed 30 feet to the south of the proposed channel centerline. The dike height was set to contain the 100-year storm and dike side slopes of 10(H):1(V) will blend into the gentle hillslope of the project area. Constructing dikes in this area is necessary to prevent flows from rapidly expanding out of the culvert, potentially causing sediment deposition. The overbank floodplain width contained by the dike was established to create a fairly continuous floodplain width from the culvert to the downstream limits of the proposed channel.

6.2 Alternative B

This section presents the Alternative B conceptual design. This includes a brief description, hydrology and hydraulic design features. Section 7.0 presents a discussion of the proposed geomorphic, vegetation and fish passage impacts associated with this Alternative.

Alternative B, as developed in the following sections, differs slightly than the preliminary Alternative B discussed in Section 6.1.3. Specifically, the proposed alignment downstream of Highway 50 was adjusted slightly to the north to better use existing topography. The proposed channel profile and culvert profiles were steepened slightly to eliminate the need for fill downstream of Highway 50. Lastly, retaining walls were proposed to limit impacts to the commercial parking lot upstream of Highway 50.

The intent of proposed Alternative B is to construct a channel similar to the historical channel profile and morphology as much as possible, given the constraints imposed by the highway, land development, existing topography, and other changes in land use. Alternative B assumes the channel reach upstream of Highway 50 can be realigned to increase the available floodplain and riparian area while limiting flooding to adjacent infrastructure. Alternative B also assumes that the sewer line under the western shoulder of the highway can be relocated to allow for a continuous channel profile and avoid the need for fill in the downstream dry meadow. Conceptual drawings for Alternative B are provided in Appendix J.

Alternative B will create an 850-foot long channel that extends 330 feet upstream and 400 feet downstream of Highway 50. Upstream of Highway 50, the proposed channel will be realigned slightly to the south of the existing channel. The existing northern row of parking spaces within the commercial building parking lot will be eliminated to facilitate realignment of the channel. The channel in this area will be confined by dikes and retaining walls. The lowered channel and raised dikes will contain the 100-year return flow with 2 feet of freeboard between the 100-year water surface elevation and top of dike.

The proposed culvert replacement is nearly perpendicular to the Highway 50 centerline. The culvert replacement for Alternative B is 120 feet in length and assumes the existing sewer line will be relocated. Downstream of the culvert, a new channel will be reconstructed to meet the existing willow channel approximately 400 feet downstream of the culvert outlet

The existing culvert will be plugged at the inlet but will remain in use, presuming that the existing inlets in the commercial parking lot drain to the culvert, as shown on the US 50 Erosion Control Master Plan (Appendix A). The existing channel from downstream of Highway 50 to the location where the relocated channel meets the existing channel will no longer act as the main channel, but will still receive flow from the parking lot drainage.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels (Montgomery & Buffington, 1997 and Grant et al., 1990). These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, and provide channel and flow complexity that facilitates fish passage and provides aquatic habitat.

The following sections present details on development of the proposed channel alignment, profile and cross sections. Section 6.3 presents a detailed discussion of the channel morphologic features proposed for the project. Section 6.4 presents the results of the hydraulic modeling used to verify channel capacity and to support the design of stable channel bed and banks and revegetation.

6.2.1 Commercial Parking Lot Constraints

The parking lot located adjacent to the south of Burke Creek and east of Highway 50 will be impacted by Alternative B. Several parking lot layouts were discussed by the project team with the current parking lot owner. Proposed layouts presented to the landowner included:

- Removal of the middle row and adding more parking along the new edge,
- Keeping some of the middle parking but creating a one way lane to access the back, diagonal, parking stalls while still allowing access for motor homes or other larger vehicles,
- Removing just the north row and maintaining the existing 90 degree parking stalls.

After several discussions, it was clear that there were multiple issues that precluded this from being a simple matter that could be resolved in a timeframe conducive to the schedule available for this work effort. The parking lot owner has agreed in principle to give up the north row of parking spaces, approximately 26 spaces, for the benefit of this restoration effort, and possibly more. However, in the schedule available for this work effort, it was considered to be a conservative approach to developing Alternative B utilizing 20 feet of space on the north end of the parking lot (or approximately 26 parking spaces). Should the owner be willing to provide additional parking lot area, then the final design could be adjusted to utilize this area.

6.2.2 Proposed Channel Alignment

The proposed channel alignment of Alternative B is located to the south of the existing channel alignment for 330 feet upstream of Highway 50. The alignment was selected based on:

- The existing parking lot area available for project use, as approved by the existing owner,
- The desire to preserve existing large confers along the northern side of the channel that have roots extending into the existing channel bed, and
- To accommodate construction of a new dike along the south side of the channel to contain the 100-year return flow without the need for a retaining wall greater than 5.5 feet in height along the parking lot edge.

The proposed culvert crosses under Highway 50 at a slight skew to the highway centerline to create a smooth planform geometry between the upstream and downstream channels. The proposed culvert alignment attempts to minimize the culvert length.

Downstream of the culvert outlet a new channel approximately 400 feet long will be constructed. It joins the existing channel approximately 360 feet upstream of the Rabe Meadow Pond. The proposed channel alignment downstream of Highway 50 follows an existing swale. This alignment was chosen to match the proposed location of the culvert outlet and to utilize existing topography as much as practical to confine the floodplain and avoid the need for placement of fill to raise the existing ground. The existing channel from downstream of Highway 50 to the location where the relocated channel meets the existing channel will be abandoned. A small wetted swale, with a one-foot bottom constructed approximately 2-tenths of a foot below bankfull elevation provides limited water to help sustain a portion of the existing vegetation in the abandoned channel. The wetted swale will be located as show on the Sheet B-1 of the Conceptual Design Plans(Appendix J).

6.2.3 Proposed Channel Profile

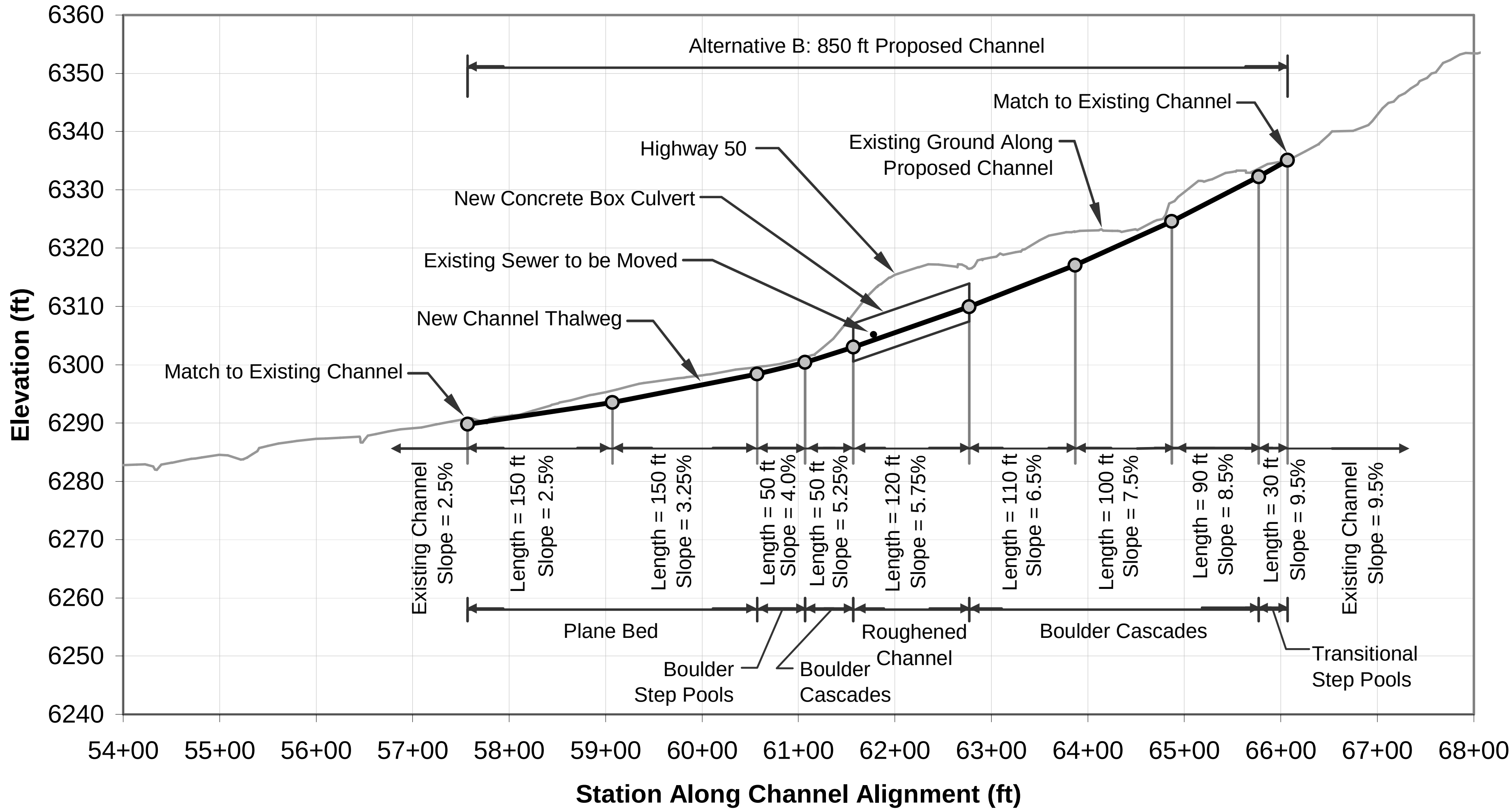
Profile Design

The overall objective in design of the project profile is to shifts the depositional area downstream from the location of the historical alluvial fan, which began at the head of the project area and extended through what is now the commercial property. The proposed channel profile was designed to allow for the creation of a stable, natural stream channel that facilitates fish passage and geomorphic processes; specifically transport of fine sediment. As a whole, the proposed channel profile for Alternative B is designed with continuously decreasing slopes in the downstream direction, avoiding abrupt slope breaks that can create an area prone to localized deposition and channel aggradation. Rather, the continuously decreasing profile promotes gradual sediment deposition, with most fine sediment being transported to well downstream of the culvert outlet

Design constraints included ensuring the 100-year water surface elevation upstream of Highway 50 remains at least 2-feet below the proposed top of dike, maintaining cover over the proposed culvert crossing without changing the roadway profile, and creating a channel and floodplain downstream Highway 50 that does not require fill within the dry meadow.

Sheet B1 of the Conceptual Drawings (Appendix J) and Figure 27 present Alternative B channel profile and overall channel slope segments. The proposed channel profile was designed to have continuously decreasing slopes in the downstream direction, matching existing channel elevations and slopes at the upstream and downstream extents of the project.

Figure 27: Proposed channel profile for Alternative B.



Within each overall slope segment of the proposed channel, various profile control stabilization measures are proposed that are appropriate to the channel slope. These include transitional step pools, boulder cascades and pools, boulder step pools, and a cobble plane-bed morphology. See Section 6.3 for further discussion of channel morphology.

Replacement Culvert

A new concrete box culvert will be installed with the inlet invert at approximately the same location but 5.1 feet lower in elevation than the existing 24-inch culvert. The inlet invert will be embedded 2.5 feet below the proposed channel thalweg. The culvert will be placed perpendicular to the highway centerline, moving the outlet approximately 220 feet to the north of its current location. The relocation of the culvert outlet will allow for a steeper culvert that will better facilitate sediment transport. A shorter culvert will also minimize the area of road disturbance and be beneficial for passage of fish and wildlife.

The proposed replacement culvert was designed in accordance with Stream Simulation methodology for steep channels (USFS, 2008). It will consist of a 120-foot long concrete box culvert with the invert set 2.5 feet below the thalweg elevation of the finished streambed and filled with streambed material to form the same cross sectional shape as the upstream channel. The constructed stream channel in the culvert will have a 4-foot wide bankfull channel and floodplain, and provide the necessary flow depths and suitable velocities for fish passage.

A 12-foot wide by 6.5-foot tall concrete box culvert was selected to maintain floodplain continuity and sufficient conveyance area for the 100-year flow event. The culvert slope fits within the proposed profile with a slope of 5.75%. To avoid pressurized flow that can compromise bed stability for a stream simulation channel, the proposed culvert was designed to convey the 100-year peak flow of 120 cfs without submerging the culvert inlet Allowing this freeboard also minimizes backwater effects to facilitate sediment transport and minimizes potential blockages by debris. Hydraulic modeling of the proposed culvert is discussed in detail in Section 6.4.

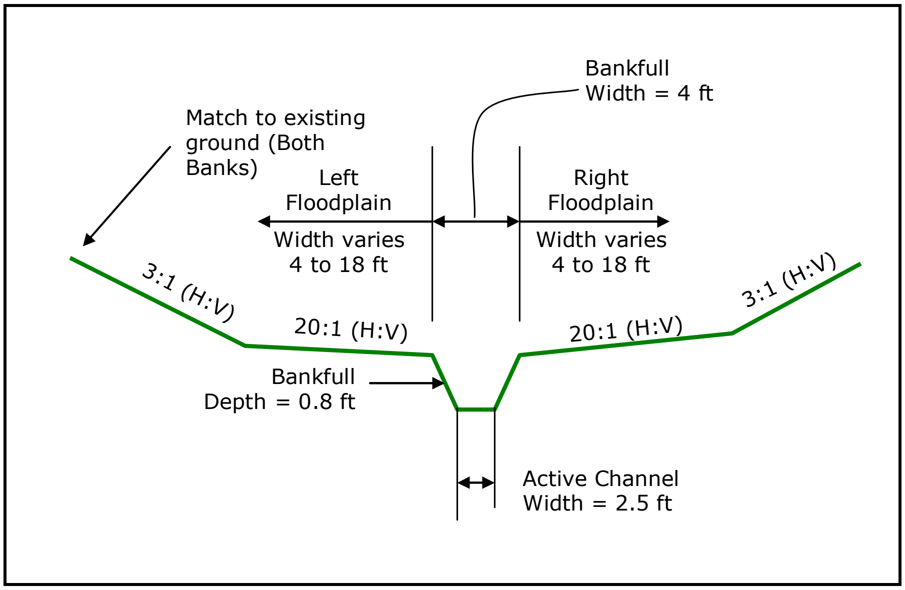
At the culvert inlet is a concrete headwall extending from both sides of the culvert. The headwall also extends vertically to meet the existing ground above the culvert inlet At the culvert outlet, a concrete headwall will extend from both sides of the culvert and one foot above the top of the culvert. This will allow for re-establishment of the gentle embankment slope above and around the culvert outlet The headwalls also accommodate channel and floodplain grading immediately downstream of the culvert outlet, thus providing a geomorphically continuous stream channel into, through, and out of the culvert.

6.2.4 Proposed Cross Sections

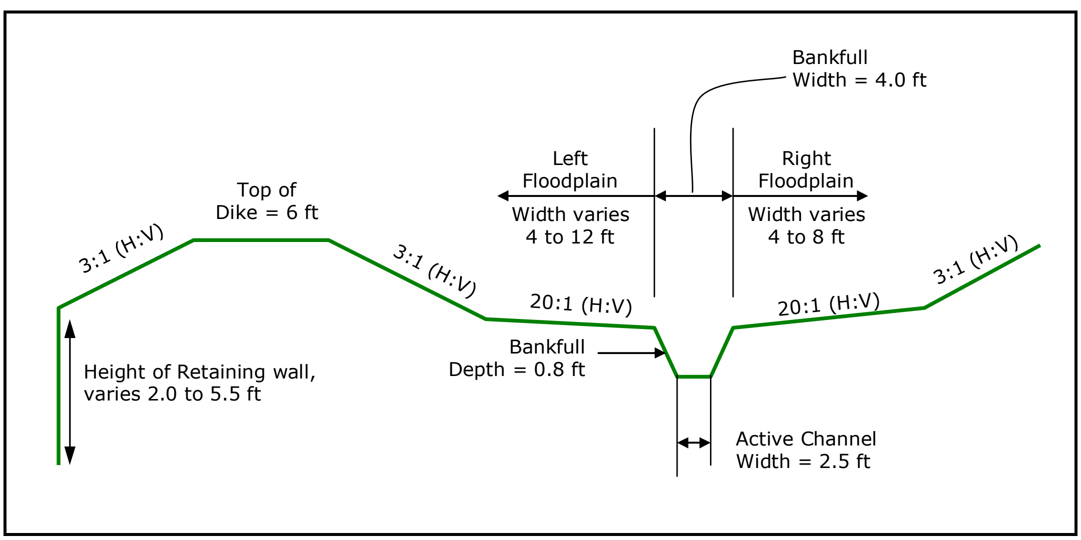
The proposed channel cross sectional shape was designed to simulate reference conditions as best as possible. Channel bottom width, bottom cross slope, side slopes, bankfull width and depth, and floodplain width were matched to reference reach data within the constraints of the site. Figure 28 present typical cross sections for Alternative

B upstream and downstream of Highway 50. The concept plans in Appendix J provide additional cross sections and show both existing and proposed ground surfaces.

Figure 28: Proposed typical cross sections for Alternative B upstream and downstream of Highway 50.



Typical cross section Stations 58+00 to 61+45.



Typical cross section Stations 62+77 to 66+00.

Bankfull Channel

A single bankfull cross section design was used for Alternative B, with varying floodplain widths to fit within site constraints. The proposed condition bankfull channel has a 2.5-foot wide bottom, 0.8 feet tall banks with 1H:1V side slopes, and a 4-foot top width. This channel conveys the 1.2-year flow, with water spreading out onto the adjacent floodplain at higher flows.

Floodplains

Small floodplains are a characteristic feature of the middle and upper reference reaches, despite their steep slope. They help reduce Burke Creek in-channel shear stresses, create areas of reduced velocity that fish can occupy during floods, and provide an area in which select riparian vegetation that need a high water table can become established. Small floodplains were included along the Alternative B channel alignment upstream of Highway 50. Floodplain widths increase downstream of Highway 50 as the slope decreases (Figure 28).

Upstream of Highway 50, floodplain widths of 4.0 to 7.5 feet are on either side of the channel. Dikes are proposed along the southern side of the channel at the edge of the floodplain. These dikes will rise at 3(H):1(V) slope to a 6-foot wide top, then fall at a 3(H):1(V) slope to meet existing ground or tie into a retaining wall. Retaining walls are necessary between approximate stations 63+75 and 65+60, along the edge of the commercial parking lot, to allow construction of the channel, floodplain and dikes that will contain 100-year flows, while keeping within the defined project limits. The proposed retaining wall height varies from 2.2 to 5.5 feet

Downstream of Highway 50, after flows expand out of the culvert and roadway embankment, excavation of 16 to 18-foot wide floodplains will be necessary to maintain the design bankfull channel dimensions and to tie into existing ground. Larger flow events will spread across the constructed floodplains onto existing ground, creating a much wider floodplain than what will be constructed. Additional information on floodplain widths is presented in Section 6.4

6.3 Proposed Channel Morphology for Alternatives A and B

Proposed channel bed morphology changes with changes in the channel slope. A total of four distinct channel types are proposed to address the wide variation in channel slope, from 2.5% to 9.5%. Each type is described in the following sections.

6.3.1 Boulder Cascades

Boulder cascades are proposed in channel reaches with overall slopes between 4 and 8.5% (Figure 29). Boulder cascades typically occur in steeper channels than step pools and the size and number of l rocks are larger to provide the necessary roughness to dissipate high energy flows (Montgomery and Buffington, 1997). Boulder cascades are a series of closely spaced steps and short pools forming a cascade with a complex flow pattern that create numerous pathways for fish passage. Flow energy is dissipated as it constricts around large rocks that partially block the flow area, then expands out into small pools. A larger pool exists at the bottom of each cascade, providing additional energy dissipation, and sufficient depth for fish to hold at low flows. A combination of one cascade and one pool forms a *cascade and pool sequence*, which conforms to the overall slope of the channel.

Individual step spacing, pool length, and overall lengths were designed in accordance with Grant, et al. (1990). Steps are formed with stable rock ranging in size from 1.3 to 3.0 feet Drop heights between steps of 0.3 feet will allow for fish passage through the cascade steps. The table in Figure 29 presents the range of dimensions for the proposed cascades and pools for Alternatives A and B.

The streambanks adjacent to the cascade/pool sequences will be comprised of boulder/cobble banklines. Banklines form the streambanks from the channel bottom up to the bankfull elevation. They are intended to resist erosion and confine the channel, similar to conditions in a naturally steep stream channel. Banklines should be constructed of rocks between 0.5 and 1.2 feet in size with smaller rocks and fine materials incorporated into the voids.

Floodplain sills are proposed to span the floodplain at the upstream limit of each cascade. The sills consist of large rock (1.2-3 feet in diameter) placed across the floodplain such that the top of each rock meets finished grade. The floodplain sills, in tandem with the vegetation stabilization (see Section 7.4), will help stabilize the floodplain during overbank flow events.

Random boulders are also proposed to be placed in the floodplain to create additional roughness to slow overbank flows, reducing the potential for erosion.

6.3.2 Boulder Step Pools

Boulder step pools are proposed in channel reaches with slopes ranging from 3.5% to 4%. Step pools are typical of moderately steep channels where the water plunging over individual steps dissipates flow energy. A sequence of one step and one pool forms one step pool unit. Drop between steps and step spacing conforms to the overall slope of the channel.

The proposed steps will consist of larger boulders (1.5-3 feet in diameter) that define the bankfull cross sectional shape of the channel bottom and banks. The boulder along the bottom of the channel will maintain the proposed channel bottom elevation. A large flat-sloped pool separates each step, providing energy dissipation, sufficient depth for leaping, as well as refuge and holding areas during the dry season.

The Figure 30 presents the range of dimensions for the proposed steps and pools proposed for Alternative A and B. Drop heights of 0.3 feet over each step will allow for full dissipation of energy in the pools associated with each drop and allow for passage of juvenile salmonids and other fish.

Between boulder steps, the channel bottom will consist of native materials, which is expected to be stream deposition from the historical alluvial fan in this location. The channel banks and floodplain will be stabilized using vegetation.

6.3.3 Transitional Step Pools

Transitional step pools are similar to the boulder step pools discussed in Section 6.3.2, but are located in steeper reaches of channel and will be characterized by 0.5 foot drops. Step pools with large drops are common in steep headwater streams with large boulders, often colluvium or glacial erratics, that jam in the channel, creating large steps and short pools (Grant, et al. 1990; and Montgomery and Buffington, 1997). Approximately 50 feet of transitional step pools are proposed between Stations 66+07 and 65+77 for Alternative B, where the proposed channel ties into an equally steep channel slope.

The proposed steps will consist of larger boulders (1.5-3 feet in diameter) that define the bankfull cross sectional shape of the channel bottom and banks. Because of the high energy of flows in the steep transmittal step pool reach, the pool bottoms will be lined with cobbles and boulders to limit pool scour, and the streambanks will be lined with bankline rock as described for Boulder Cascades in Section 6.3.1

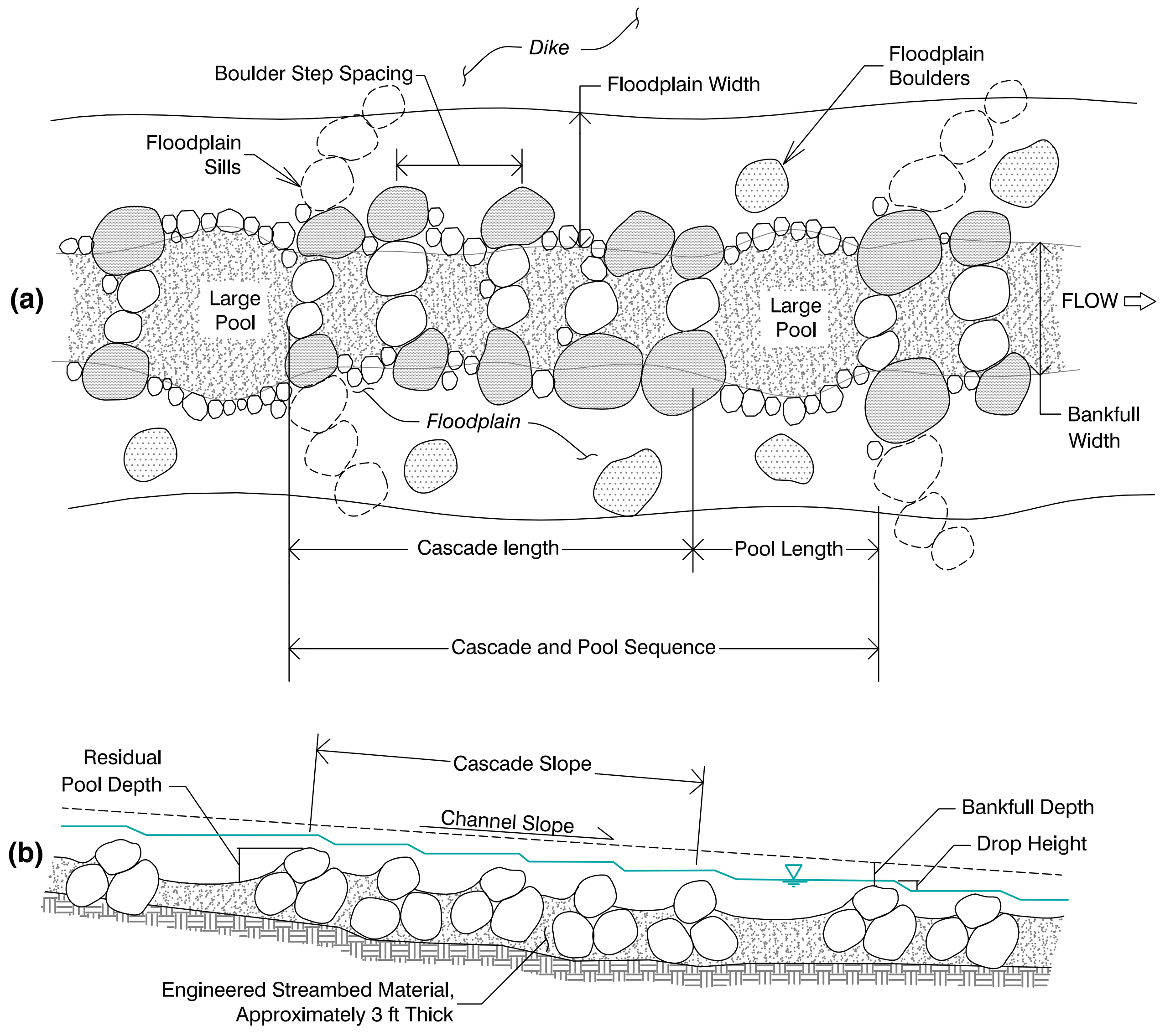
6.3.4 Plane Bed Channel

A Plane bed channel is proposed for Alternative B between Stations 57+57 and 60+57, where channel slope are less than 3.5%. Plane bed channels have been found to occur at slopes steeper than pool-riffle channels, but less steep than step pool channels (Montgomery & Buffington, 1997). Plane bed channels typically have coarser bed material, but lack repeating morphologic patterns characteristics of step pool and pool-riffle channels. The overall profile of a plane bed channel is of a uniform slope, with occasional flow perturbations where sediment sorting has formed small bedforms (Figure 31).

Within the plane bed channel, the channel bottom will consist of native materials mixed with imported cobbles and boulders (0.3 to 1.3 feet). The imported material will comprise about 50 percent of the streambed mixture, and will help stabilize the channel bottom. The larger material is expected to sort into occasional bedforms that will create channel and flow complexity. The channel banks and floodplain will be stabilized using vegetation and contain occasional large boulders. The bankline boulders help promote channel complexity and are characteristic of exposed erratics, which often characterize streams flowing through fine grain sediments within glaciated areas, such as Burke Creek.

6.3.5 Culvert Roughened Channel

For both Alternative A and B, a roughened channel will be constructed within the culvert. The channel will consist of a 4 foot wide bankfull channel flanked by 4-foot wide floodplains on each side (Figure 32). The 2.5-foot embedded depth of the proposed culvert does not provide sufficient depth of material to construct cascades or steps that will remain stable and pools with sufficient depth for energy dissipation. Therefore, the proposed channel within the culvert will be constructed at a uniform slope using engineered streambed material. The larger size fractions of the channel bed and bank material projects into the flow area, creating large-scale roughness that dissipates energy, maintains channel stability and provides diverse hydraulic conditions suitable for fish passage (Figure 32).



Typical Cascade and Pool Channel in (a) Plan and (b) Profile

Not To Scale

Alternative A

Station 59+75 to 61+45 and 62+45 to 63+35

Cascade and Pool Channel Dimensions

Dimension	Range
Channel Slope	6.0 to 6.5%
Cascade Slope	10.0%
Cascade Length	15 ft
Number of Steps per Cascade	5
Step Spacing	3.8 ft
Step Drop Height	0.3 ft
Boulder Size	1.2 to 3.0 ft
Large Pool Length	8.1 to 10.0 ft
Min Residual Pool Depth	1.0 ft
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Floodplain Width	2.5 to 39.0 ft

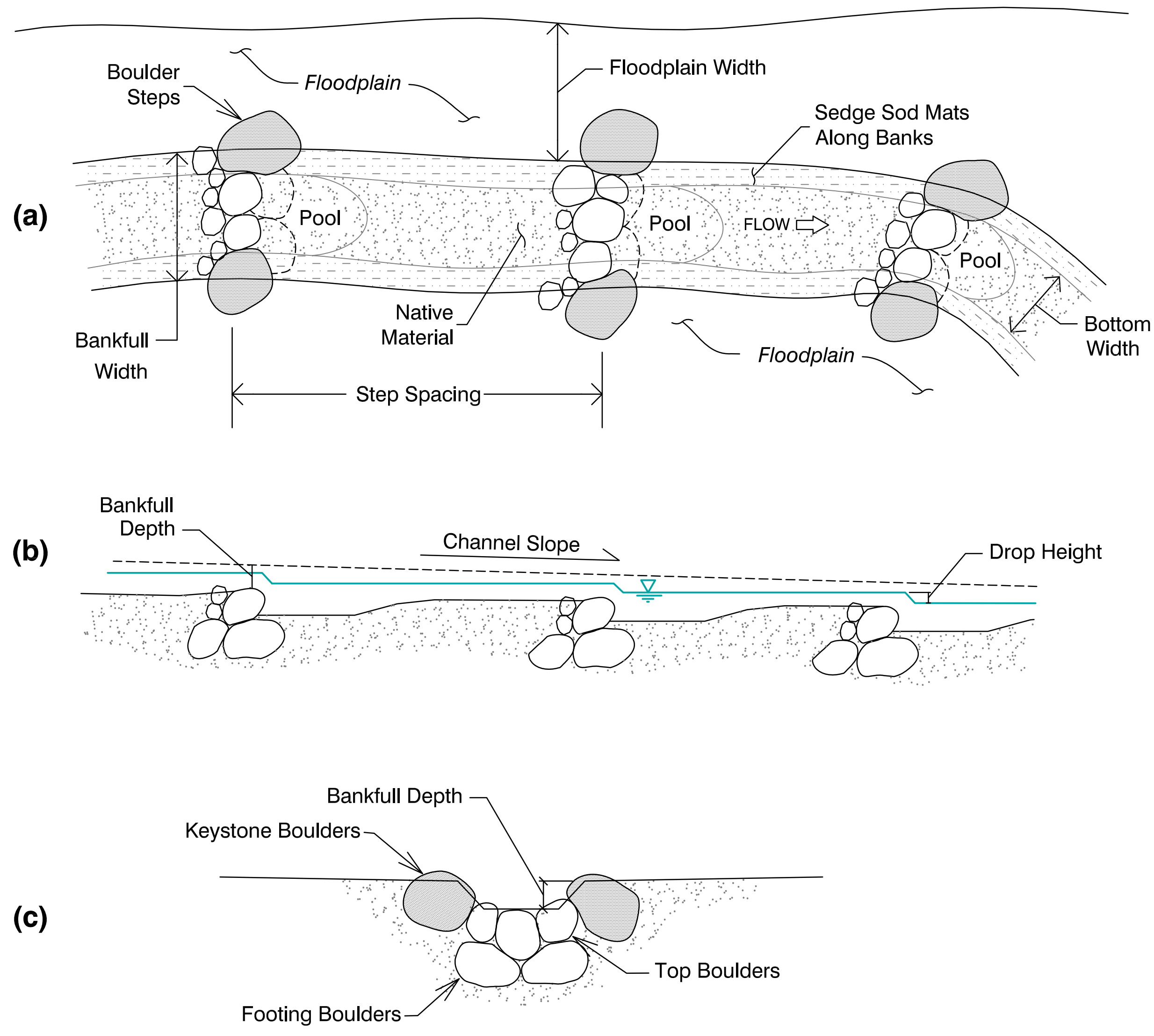
Alternative B

Station 61+07 to 61+57 and 62+77 to 65+77

Cascade and Pool Channel Dimensions

Dimension	Range
Channel Slope	5.25 to 8.5%
Cascade Slope	10.0 to 12.0%
Cascade Length	12.4 to 13.2 ft
Number of Steps per Cascade	4 to 5
Step Spacing	3.1 to 4.4 ft
Step Drop Height	0.3 ft
Boulder Size	1.2 to 3.0 ft
Large Pool Length	5.2 to 9.5 ft
Min Residual Pool Depth	1.0 ft
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Floodplain Width	4.0 to 7.5 ft

Figure 29: Typical boulder cascades: plan, profile, and section



Typical Boulder Step Pool Channel in (a) Plan, (b) Profile, and (c) Section

Not To Scale

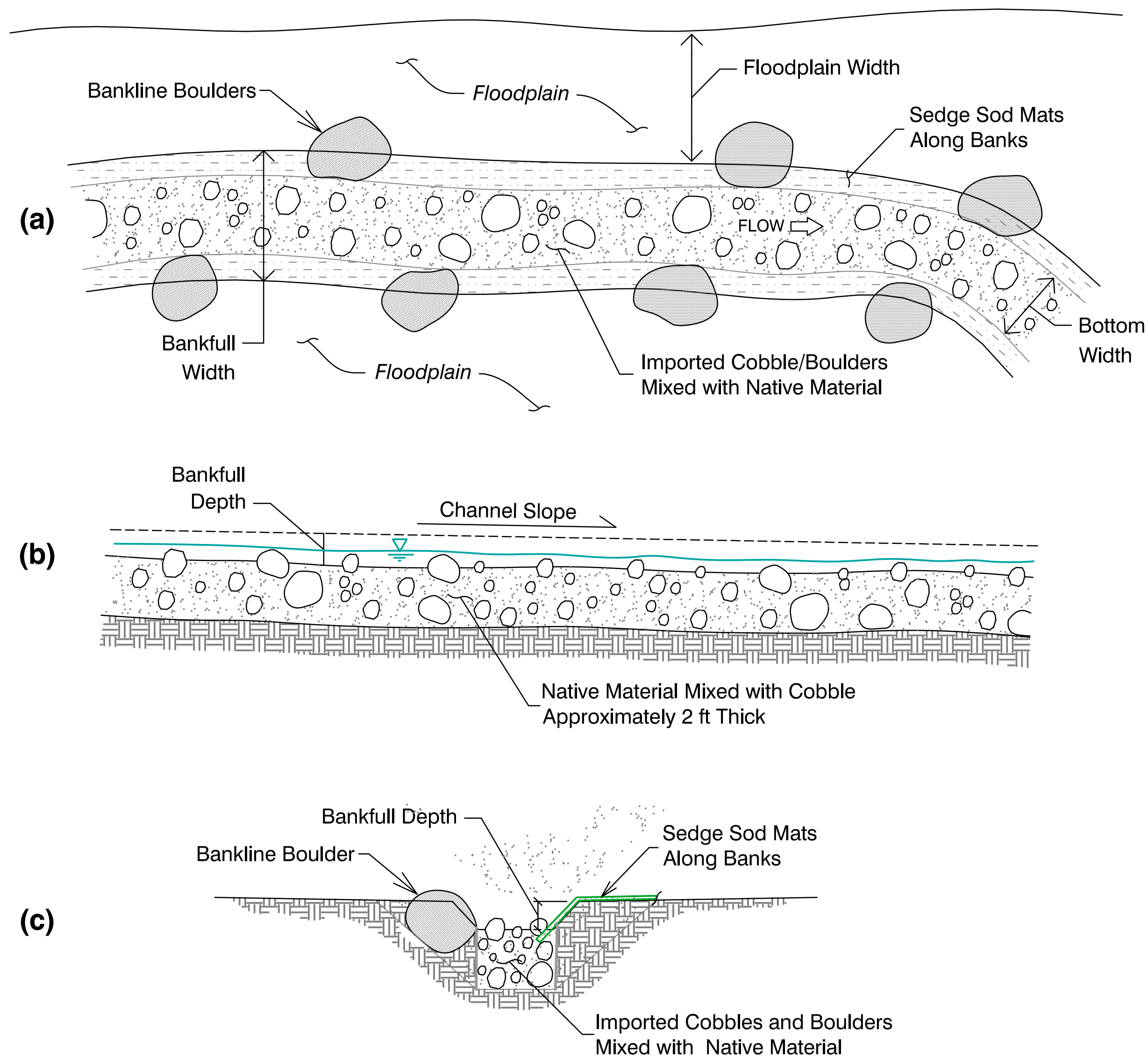
Alternative A
Station 58+00 to 59+75
Boulder Step Pool Channel Dimensions

Dimension	Range
Channel Slope	3.5%
Step Spacing	8.6 ft
Step Drop Height	0.3 ft
Boulder Size	0.5 to 2.0 ft
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Floodplain Width	8.0 to 13.0 ft

Alternative B
Station 60+57 to 61+07
Boulder Step Pool Channel Dimensions

Dimension	Range
Channel Slope	4.0%
Step Spacing	7.5 ft
Step Drop Height	0.3 ft
Boulder Size	0.5 to 2.0 ft
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Floodplain Width	2.0 to 13.0 ft

Figure 30: Typical boulder step pool channel: plan, profile, and section



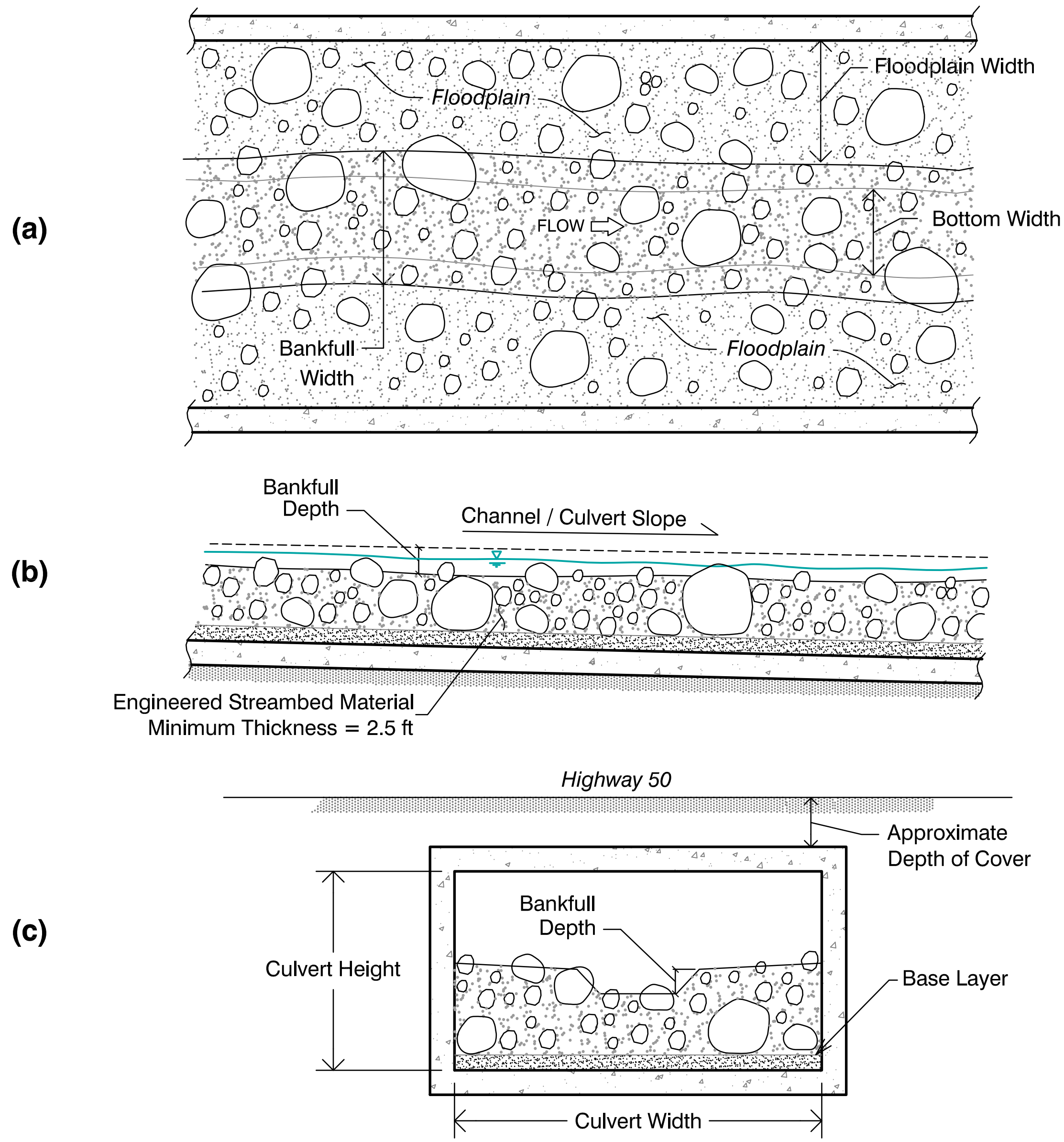
Typical Cobble Plane-Bed Channel in Plan (a) Profile (b), and (c) Section

Not To Scale

Alternative B
Station 57+57 to 60+57
Cobble Plane-Bed Channel Dimensions

Dimension	Range
Channel Slope	2.5 to 3.25%
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Cobble / Boulder Size	0.3 to 1.3 ft
Floodplain Width	16.0 to 78.0 ft

Figure 31: Typical cobble plane-bed channel: Plan, Profile, and Section



Typical Roughened Channel Through Culvert in (a) Plan, (b) Profile, and (c) Section

Not To Scale

Alternative A
Station 61+45 to 62+45
Culvert Channel Dimensions

Dimension	Range
Culvert Length	100 ft
Culvert Width / Height	12.0 ft / 6.5 ft
Depth of Cover	1.5 to 2.5 ft
Channel / Culvert Slope	5.0 %
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Rock Size (D50 to D100)	0.5 to 2.0 ft
Floodplain Width	4.0 ft

Alternative B
Station 61+57 to 62+77
Culvert Channel Dimensions

Dimension	Range
Culvert Length	120 ft
Culvert Width / Height	12.0 ft / 6.5 ft
Depth of Cover	3.0 to 5.0 ft
Channel / Culvert Slope	5.75 %
Bankfull Width	4.0 ft
Bankfull Depth	0.8 ft
Rock Size (D50 to D100)	0.5 to 2.2 ft
Floodplain Width	4.0 ft

Figure 32: Typical roughened channel through culvert: Plan, Profile, and Section

6.4 Hydraulic Analysis of Proposed Conditions for Alternatives A & B

Open channel flow modeling of the proposed channel and floodplain hydraulics for each Alternative was conducted using HEC-RAS in steady state. The modeling was used in an iterative process to refine the initial profile and cross section designs to ensure that project objectives were met The results of the model were used to obtain water surface elevations, slopes, water depths, water velocities, and channel shear stress at locations throughout the channel for various flows. These hydraulic parameters were then used to:

- Assess the capacity of the design channel and floodplain, and existing and proposed dikes upstream and downstream of Highway 50
- Determine the capacity of the proposed culvert
- Determine flow hydraulics to determine rock sizing for streambed and bankline design
- Assess flow hydraulics to evaluate channel and floodplain stabilization measures

The following sections present the HEC-RAS model setup for the proposed Alternatives, the results from the HEC-RAS model, and application of the results to project design.

6.4.1 HEC-RAS Model Setup

A proposed condition HEC-RAS hydraulic model was developed for Alternatives A and B using the proposed profile, planform and design cross sections developed for the Alternatives. Cross sections were located at 50-foot intervals along the proposed channel alignment, except at the Highway 50 culvert crossing. At the proposed culvert crossing, cross sections were located at the upstream and downstream faces of the proposed culvert, and the appropriate distance upstream and downstream to simulate the correct contraction and expansion reaches defined in HEC-RAS. Ineffective flow areas upstream and downstream of the proposed culvert were defined using standard protocols (ACOE, 2008). Cross section numbering is based on stationing along the proposed channel alignment, starting downstream and increasing in the upstream direction. Location of cross sections and model results are presented in Appendix K.

For Alternative A, cross sections extend upstream to station 65+00 and downstream to Station 59+00, creating a model 600 feet long. Upstream cross sections 63+50 to 65+00 model the existing channel outside the limits of the project area to assess the impact of the project on the existing dikes in that area.

For Alternative B, cross sections extend upstream to station 66+75, and downstream to Station 58+00, creating a model 875 feet long.

For both alternatives, the proposed culvert was modeled as a 12-foot wide, 4-foot high concrete box culvert to simulate the proposed 2.5-feet of embeddedness necessary to construct a roughened channel within the culvert. The slope and invert elevations of the proposed culvert matches the channel profile for each Alternative. The culvert bottom was assigned the same roughness as the channel and the culvert was assigned a roughness coefficient of 0.015. HEC-RAS does not allow for modeling the bankfull channel with floodplains inside a culvert. Therefore, to conservatively assess 100-year flow capacity, the proposed culvert was blocked using a one-foot high channel block, which effectively neglected conveyance within the bankfull channel. For the 1.2-year flow event, the model was run without a culvert because flows are fully contained within the constructed bankfull channel cross section within the culvert and the culvert has no influence on channel hydraulics.

Dikes were inserted where appropriate to properly simulate in-bank and overbank flows. For Alternative A, upstream of the project area the dike height was raised above the existing dike elevation at cross sections 64+00 through 65+00 to contain the 100-year flow and preventing loss of flow from the model. The assumption is that upstream improvements to the dike may happen in the future. Therefore, the new downstream culvert, channel and floodplain were designed to convey the total flow.

The model was run in mixed flow for a range of flows from 2.2 cfs to 120 cfs, simulating the 1.2-, 2- ,5-, 10-, 50-, and 100-year return flows. Upstream and downstream boundary conditions were set to normal depth using the existing local channel thalweg slope. Contraction and expansion coefficients were 0.1 and 0.3, respectively upstream of Highway 50. Within the flow contraction area of the proposed culvert and downstream Highway 50, contraction and expansion coefficients were 0.3 and 0.5 to simulate losses associated with a varying floodplain width.

Manning's roughness coefficients for the hydraulic model were derived from various sources. A Manning's coefficients of 0.15 was assigned to the channel for flows greater than the 1.2-year. This was based on estimates using Jarrett's equation (Jarrett, 1984), and is considered conservative when evaluating water surface elevations for flooding. The high roughness coefficient encapsulates the turbulence and energy loss associated with larger flow events in steeply sloping channel with steps and pools. A Manning's roughness coefficient of 0.2 was assigned to the bankfull channel for the 1.2-year flow. This value was computed from flow measurements within the existing channel (Section 4.3.3) and matches well with the roughness coefficients predicted using Jarrett's equation. The high roughness coefficient represents energy losses at lower flows from turbulence and flow separation generated by the constructed channel bed and bank morphology. A Manning's roughness coefficient of 0.15 was assigned to the overbank areas to simulate the proposed condition roughness of dense sedges, willow shrubs, and larger trees (Chow, 1959).

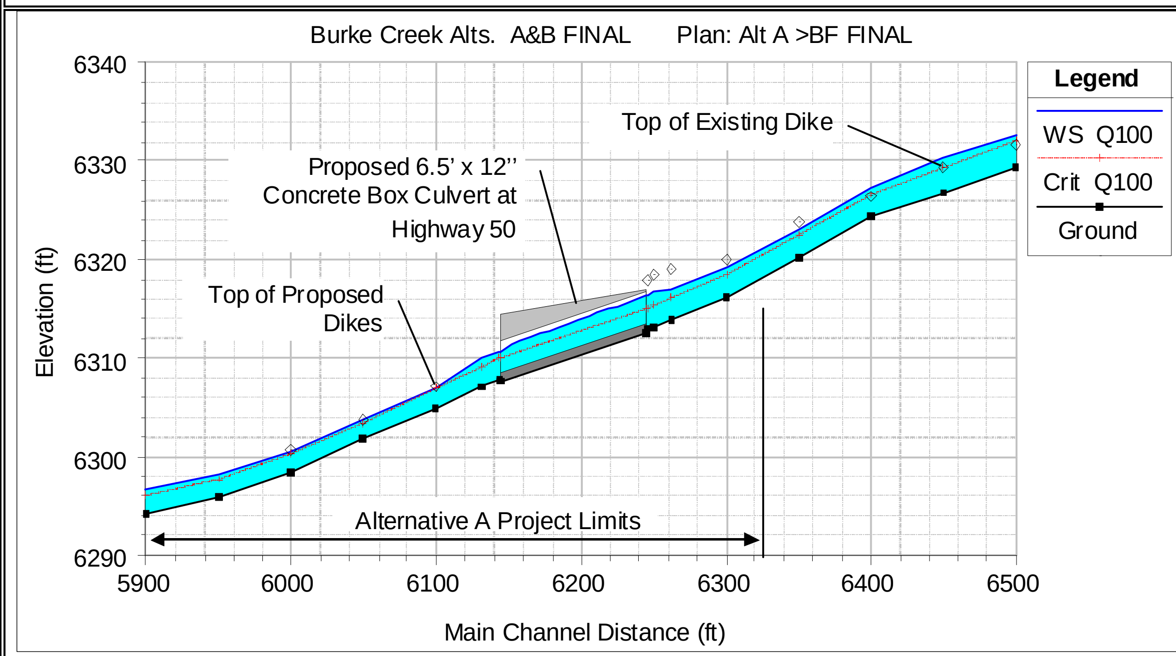
Currently, much of the flow from the Burke Creek watershed is diverted upstream by overtopping the existing berm adjacent to the commercial parking lot, or backing up due to the existing undersized culvert on Highway 50 and flowing to Kahle Drive (Section 4.5.2). The implementation of Alternative A or B will eliminate the current condition flow diversion, and all flows will remain within Burke Creek within the project area. Field observations of the existing pond indicate that there is little freeboard between the current pond water surface elevation and pond embankment. Routing all flows from the watershed through Burke Creek may compromise the existing pond storage and result in embankment overtopping flows, which will flow onto Kahle Drive into a residential area. The final design for the project should include evaluation of the Rabe Meadow Pond capacity and embankment stability and development of measures to address any potential issues.

6.4.2 HEC-RAS Modeling Results for Alternative A

100-Year Flow Capacity

Figure 33 presents a profile of the proposed channel bottom and culvert and 1.2-year and 100-year water surface elevations for Alternative A. Appendix K presents the results of the HEC-RAS modeling for Alternative A.

Figure 33: Profile of hydraulic model results for proposed conditions and a 100-year flow of 120 cfs.



The HEC-RAS model results indicate that the existing dikes upstream of the proposed project area are of insufficient height to contain the 100-year return flow. As a result, the commercial parking lot will likely continue to flood during large flow events unless the dikes are raised.

Within the project area upstream of Highway 50 the model predicts the existing dikes will be sufficient to contain the 100-year return flow. However, the existing dikes do not provide substantial freeboard above the predicted 100-year water surface elevation, and any debris jams or other flow obstructions that may occur in the channel may cause the dikes to be overtopped allowing floodwaters to flow into the adjacent parking lot. If heights of the existing dikes within the project reach are raised to increase the available freeboard, retaining walls will likely be necessary to prevent encroachment onto the commercial property.

Downstream of Highway 50, constructed dikes are necessary between Stations 60+00 and 61+00 to contain flows within a uniformly shaped floodplain. As designed, these dikes provide minimal freeboard above the 100-year water surface elevation. The height of these dikes can be raised to provide additional freeboard, but would require additional imported fill.

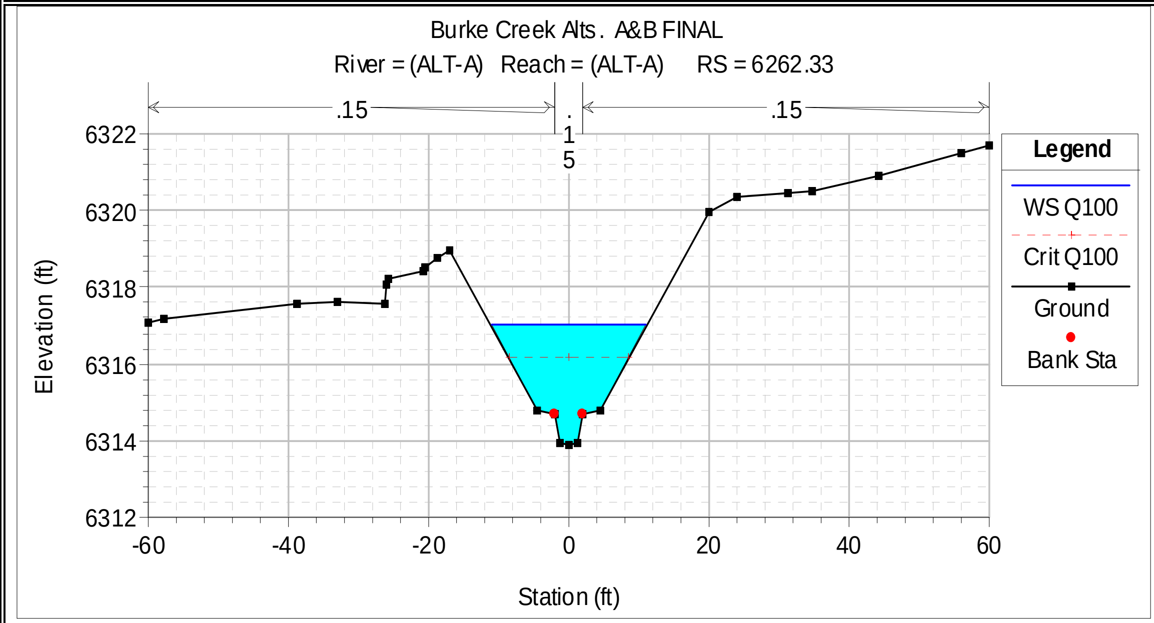
Culvert Capacity

Figure 33 also indicates that the proposed culvert for Alternative A conveys the 100-year return flow of 120 cfs without submerging the soffit of the culvert. At the 100-year return flow the headwater is 0.35 feet below the culvert soffit and the ratio of headwater-to-culvert height (HW/D) is 0.9.

Bankfull Channel Capacity

A flow of 2.2 cfs, the 1.2-year return flow, nearly fills the designed bankfull channel. Flows of 5 cfs, slightly higher than a 1.2-year return period bankfull flow, begin to spill out of the bankfull channel and fill the floodplain. Average flow velocities remain less than 2 ft/s within the bankfull channel for flows up to 5 cfs. Figure 34 shows the water surface elevation at cross section 63+62 (located 117 feet upstream of the proposed culvert inlet) at these two low flows. Additional cross section plots are available in Appendix K.

Figure 34: Alternative A HEC-RAS predicted water surface elevations for 2.2 cfs and 5 cfs at channel cross section 63+62, 117 feet upstream of the proposed culvert inlet



Floodplain Inundation

Figure 35 presents the floodplain inundation for 5- and 100-year return flows, which is 32 cfs and 120 cfs respectively. As designed, the proposed condition floodplain width is fairly uniform within the channel reaches upstream and reaches downstream of the Highway 50 culvert. Upstream of the culvert the width of inundation varies from approximately 10 feet wide at the 5-year return flow to 15-20 feet wide at the 100-year return flow. The inundated area in the culvert at both flow events is a total of 12-feet wide.

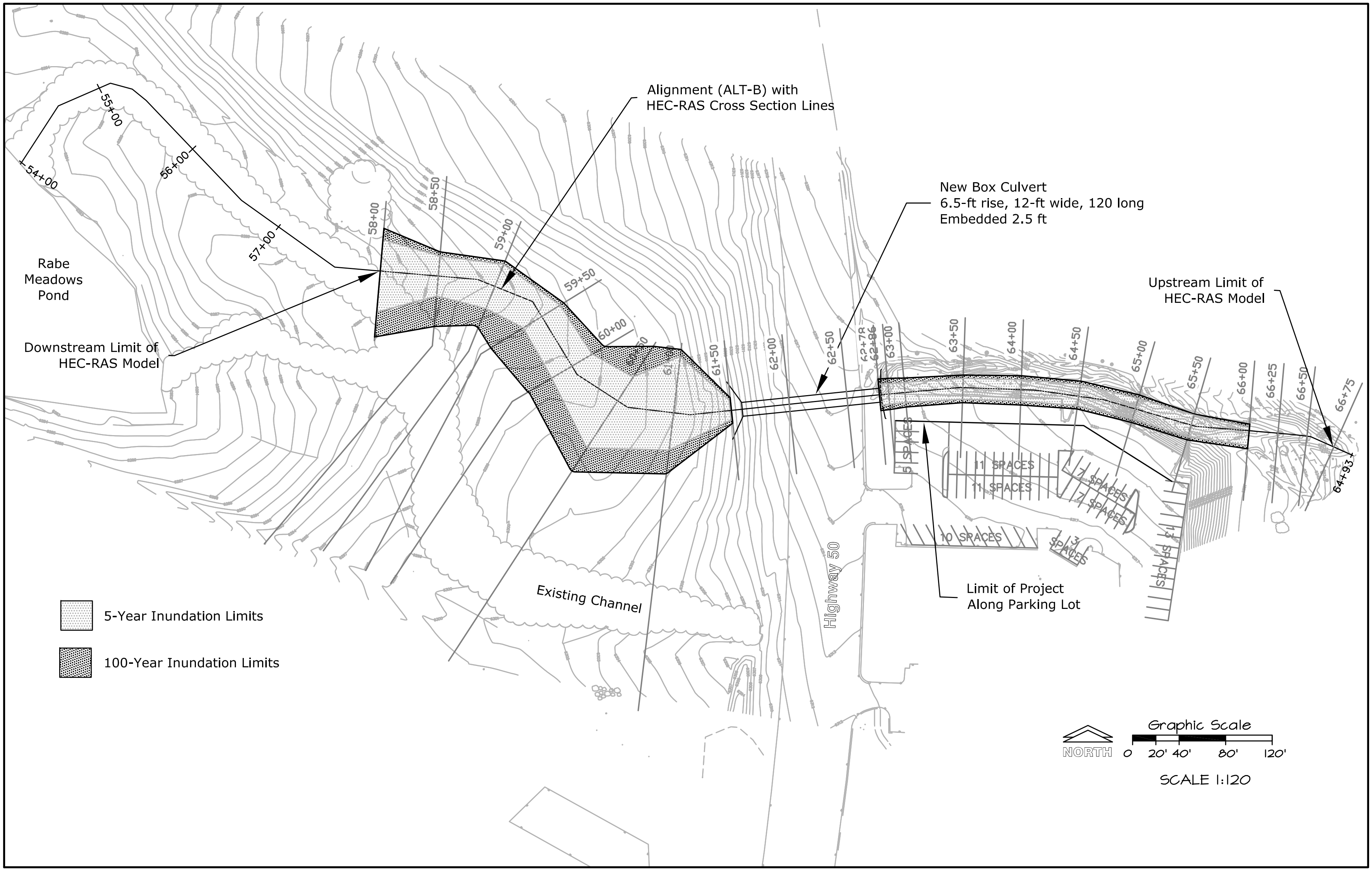


Figure 35: Alternative A floodplain inundation for 5 and 10 year return flows

Depth of flow on the floodplain upstream of Highway 50 is moderately shallow, and less than one foot at the 5-year flow. Though the proposed channel profile upstream of Highway 50 is steep, channel and floodplain velocities are typically less than 2 ft/s at the 5-year return flow, and only exceeding 5 ft/s in a couple locations at the 100-year return flow. Velocities in this range are suitable for being stabilized using riparian vegetation (see Section 4)

Downstream of the culvert, the floodplain increases substantially in width as flows leave the culvert and downstream roadway embankment. The total inundated width ranges from 37 to 53 feet during a 5-year return flow, and from 71 to 90 feet wide during a 100-year return flow.

Depth of flow on the floodplain downstream of Highway 50 are moderately shallow. They are less than one foot at the 5-year return flow and velocities on the floodplain are less than 2 ft/s during 5-year return flow, and rarely exceeding 3 ft/s at the 100-year return flow. Velocities in this range are suitable for use of riparian vegetation to stabilize the floodplain (Section 7.4).

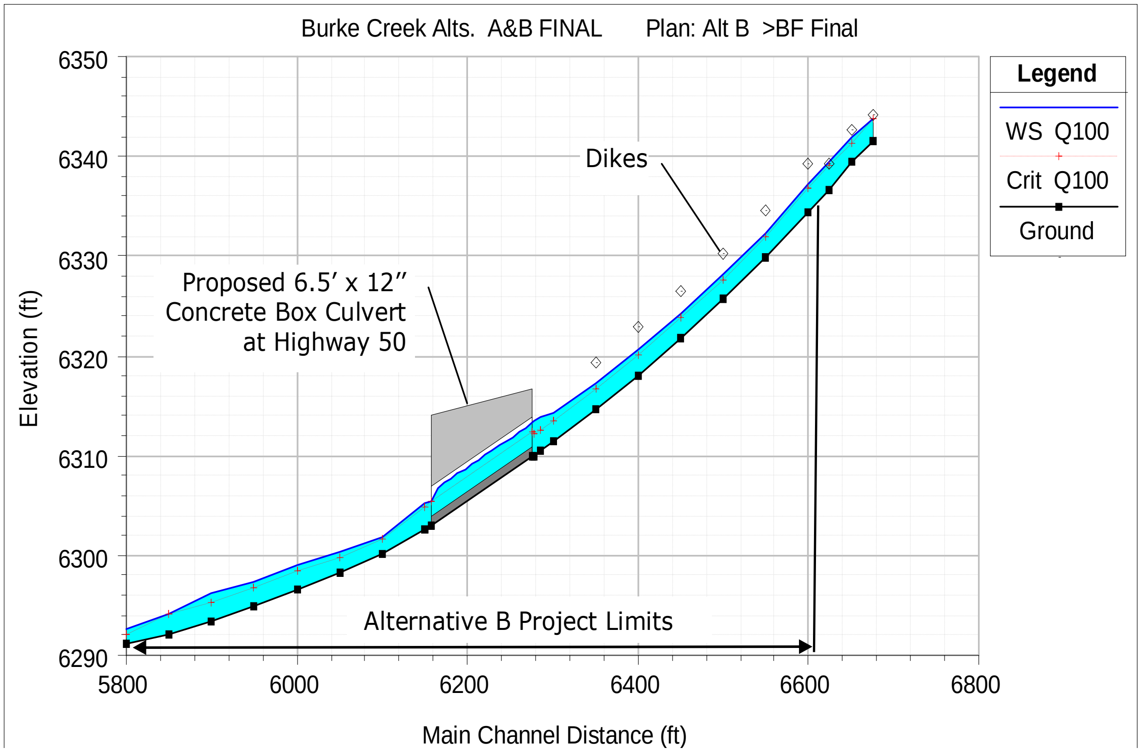
6.4.3 HEC-RAS Modeling Results for Alternative B

100-Year Flow Capacity

The profile of the proposed channel bottom and culvert along with the water surface profile for 100-year return flows of 120 cfs for Alternative B are shown in Figure 36. Results of the HEC-RAS modeling for Alternative B are provided in Appendix K.

The HEC-RAS model results indicate the proposed dikes upstream of Highway 50 provide a minimum of 2-feet of freeboard at the 100-year return flow within the project limits. The existing dikes upstream of the project limits contain the 100-year return flow, but with less freeboard. These dikes may need to be raised to provide flood protection consistent with the project reach upstream of Highway 50.

Figure 36: Profile of hydraulic model results for proposed conditions and a 100-year flow of 120 cfs.



Note: The ground elevation represents the proposed channel bottom. The open diamonds represent the top of the dike in the proposed channel upstream of Highway 50.

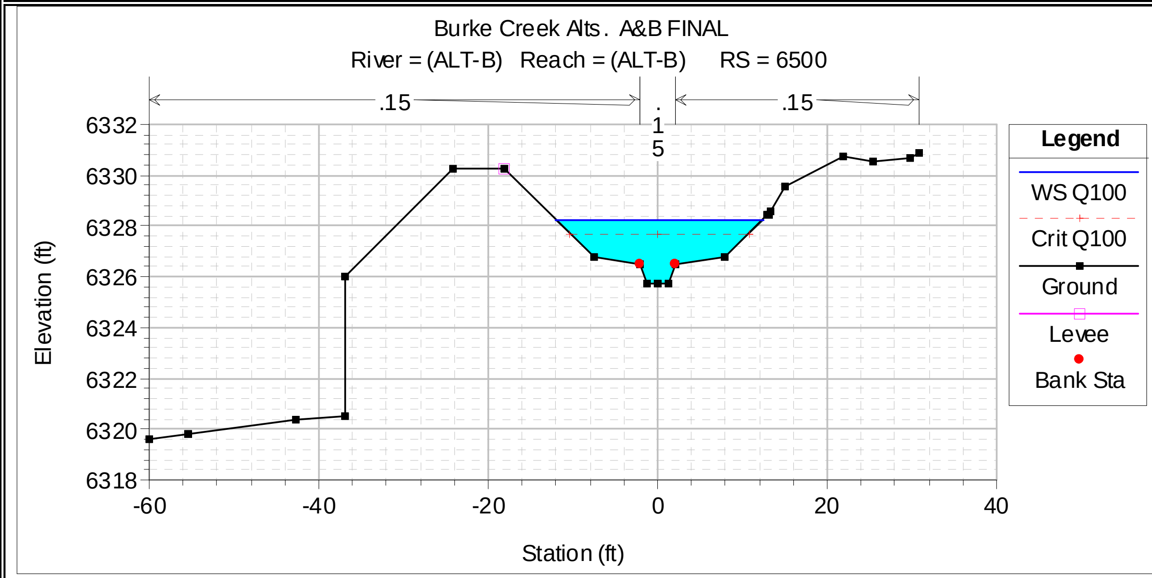
Culvert Capacity

The proposed culvert for Alternative B conveys the 100-year return flow of 120 cfs without submerging the culvert inlet At the 100-year return flow, the headwater is 0.6 feet below the culvert soffit and the ratio of headwater-to-culvert height (HW/D) is 0.8.

Bankfull Channel Capacity

A flow of 2.2 cfs, the 1.2-year return flow, nearly fills the designed bankfull channel. Flows of 5 cfs, slightly higher than a 1.2-year return period bankfull flow, spill out of the bankfull channel and fill much of the floodplain within the project reach upstream of Highway 50 (Figure 37). Average flow velocities remain less than 2 ft/s within the bankfull channel for flows up to 5 cfs.

Figure 37: Alternative B HEC-RAS predicted water surface elevations for 2.2 cfs and 5 cfs at channel cross section 64+00, 223 feet upstream of the proposed culvert inlet



Floodplain Inundation

Approximate floodplain inundation for 5- and 100-year return flows of 32 cfs and 120 cfs, respectively, are presented in Figure 38. As designed, the Alternative B area of inundation upstream of the Highway 50 culvert is nearly uniform, with the width of inundation being approximately 18 feet at the 5-year return flow to 23 to 27 feet at the 100-year return flow. The inundated area within the culvert at both flow events is 12 feet, which is the culvert width.

Depth of flow on the floodplain upstream of Highway 50 is moderately shallow, and less than one foot at the 5-year flow. Though the proposed channel profile upstream of Highway 50 is steep, velocities in the proposed channel are approximately 3 ft/sec at the 5-year return flow, and average less than 2 ft/s across the floodplain. Velocities in the proposed channel range from 4 to 5 ft/s at the 100-year return flow, and approximately 3 ft/s on the floodplain. Velocities in this range are suitable for being stabilized using riparian vegetation (see Section 7.4).

Downstream of the culvert, the floodplain increases substantially in width as flows leave the culvert and downstream roadway embankment. The inundated width is more variable than upstream because of the existing terrain, and ranges from 37 to 81 feet at the 5-year return flow, and from 59 to 128 feet wide at the 100-year return flow.

Depth of flow on the floodplain downstream of Highway 50 is moderately shallow. Maximum depth is less than one foot and average velocities across the floodplain are less than 2 ft/s at the 5-year return flow, and rarely exceeding 3 ft/s at the 100-year return flow. Velocities in this range are suitable for use of riparian vegetation to stabilize the floodplain (Section 7.4).

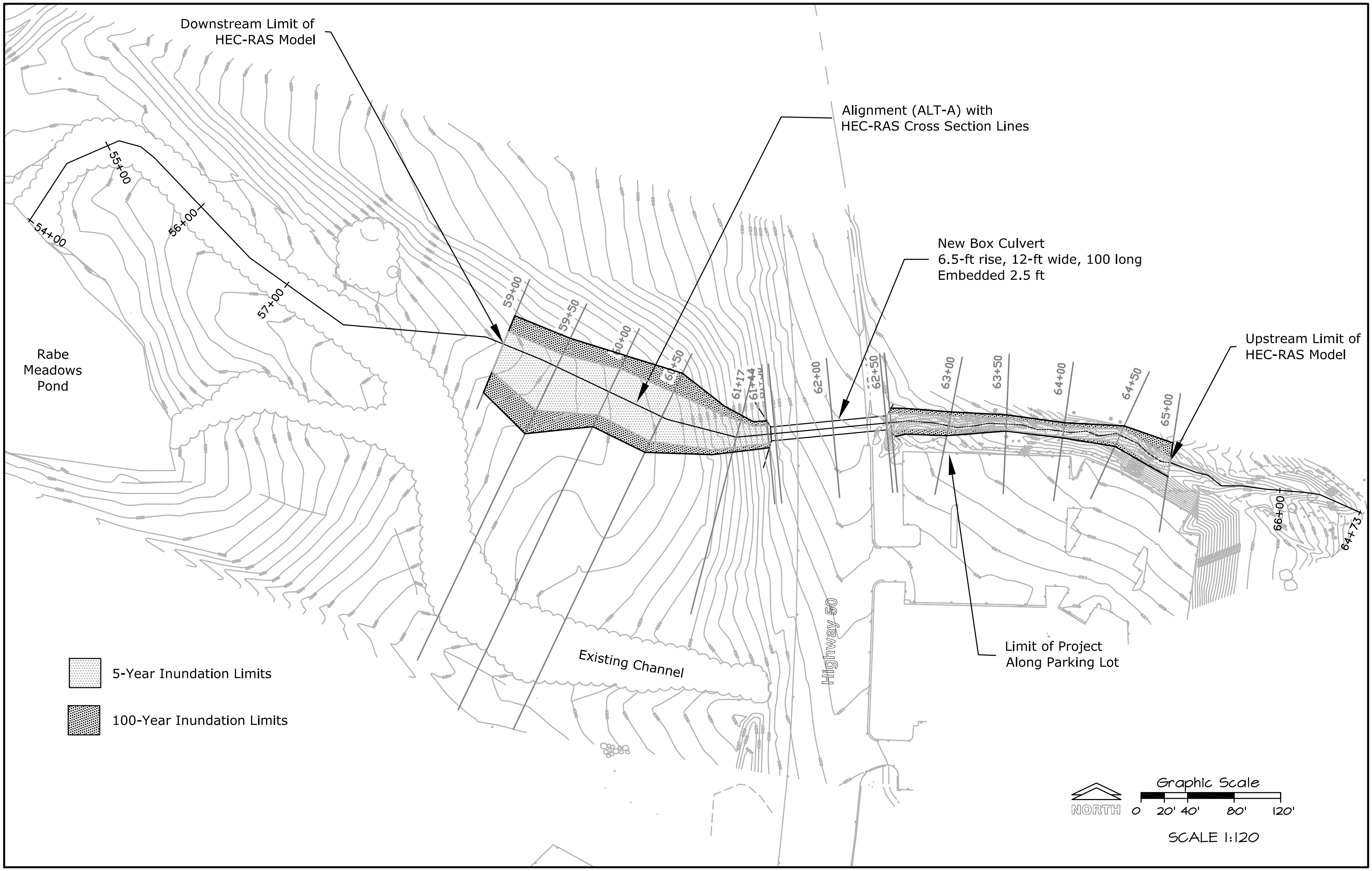


Figure 38: Plan view of proposed Alternative B showing 5-year and 100-year floodplain inundation extents

6.5 Rock Stabilization Design

6.5.1 Engineered Streambed Material Sizing

The proposed channel bed features (cascades, steps, plane bed) were designed to have an immobile bed constructed of large rocks intermixed with smaller material that controls porosity, similar to the gradation of material found in naturally steep stable channel reaches. The bed material is referred to as engineered streambed material (ESM), and the larger material within the mixture is designed to remain stable up to a 100-year flow event. The ESM gradation is designed to:

- Create the profile control and planform morphologic features within the channel
- Maintain stable bed and banks up to a structural bed design flow (100-year flow)
- Form a well compacted low-porosity bed to avoid subsurface flow
- Provide suitable flow resistance characteristics to create the desired velocity and depth conditions for fish passage

The ESM was designed using the methods presented in Love & Bates (2009) and Bates (2003). This method determines stable particle sizes for the larger rock component of ESM using US Army Corps of Engineers (ACOE) Steep Slope Riprap Design for the $D_{30\text{-}riprap}$ particle (ACOE, 1994), which predicts rock sizing based on the design unit discharge within the active channel and channel slope. The unit discharge within the bankfull channel at the 100-year flow for Alternative A were obtained from the HEC-RAS modeling (Section 6.4).

Riprap design guidelines yield relatively uniform rock sizes with large void spaces that result in a porous bed. Because this leads to subsurface flow, which is undesirable for fish passage and aquatic habitat, CDFG (2009) recommends specifying a broader range of rock sizes for the engineered streambed material, such that the ESM gradation mimics grain size distribution of natural steep channels. This is accomplished by using a D_{84} that is 1.5 times larger than the stable D_{30} particle size predicted using the ACOE method (*84% of the material in the ESM is smaller than the D_{84} partial size*). Once the D_{84} of the ESM is calculated, the D_{50} and D_{100} of the ESM can be defined using methods outlined in DFG (2009). The finest gradation component of the material, used to seal the streambed and control porosity is computed using a modified version of the Fuller-Thompson equations (USFS, 2008).

Computed gradations for the ESM based on location are presented for Alternatives A in Table 8 and for Alternative B in Table 9. The tables present ESM sizing by location and morphologic features within the channel. As the channel slope decreases and the floodplain widens in the downstream direction, the size of ESM necessary to stabilize the channel becomes smaller.

Table 8: Summary of proposed gradation for engineered streambed material (ESM) for Alternative A within the various proposed morphologic units of the channel.			
Location	Length	Morphological Unit	Engineered Streambed Material Gradation
Station 58+00 to 59+75	175 ft	Boulder Step Pools	D_{100}=1.5 ft D_{84}= 0.5 ft D_{50}=0.2 ft
Station 61+45 to 62+45	100 ft	Roughened Channel within Highway 50 Culvert	D_{100}=3.0 ft D_{84}= 1.2 ft D_{50}=0.5 ft
Station 62+45 to 63+35 Station 59+75 to 61+45	90 ft Upstream 170 ft Downstream	Boulder Cascades and Pools	D_{100}=3.0 ft D_{84}= 1.2 ft D_{50}=0.5 ft

Table 9: Summary of proposed gradation for engineered streambed material (ESM) for Alternative B within the various proposed morphologic units of the channel.			
Location	Length of Feature	Morphological Unit	Engineered Streambed Material Gradation
Stations 57+57 to 60+57	300 ft	Plane Bed	D_{100}=1.5 ft D_{84}= 0.5 ft D_{50}=0.2 ft
Station 60+57 to 61+07	50 ft	Boulder Step Pools	D_{100}=1.5 ft D_{84}= 0.5 ft D_{50}=0.2 ft
Station 61+57 to 62+77	120 ft	Roughened Channel within Highway 50 Culvert	D_{100}=2.2 ft D_{84}= 1.2 ft D_{50}=0.5 ft

Table 9: Summary of proposed gradation for engineered streambed material (ESM) for Alternative B within the various proposed morphologic units of the channel.			
Location	Length of Feature	Morphological Unit	Engineered Streambed Material Gradation
Station 61+07 to 61+57 Station 62+77 to 65+77	300 ft Upstream 50 ft Downstream	Boulder Cascades and Pools	D_{100}=3.0 ft D_{84}= 1.2 ft D_{50}=0.5 FT
Station 65+77 to 66+07	30 ft	Transitional Boulder Steps	D_{100}=3.0 ft D_{84}= 1.2 ft D_{50}=0.5 ft

6.5.2 Rock Sizing Used for Morphologic Features

The larger rocks (D_{84} to D_{100}) in the ESM are separated from the gradation and used to construct the structural features of the channel such as the boulder cascades, boulder step floodplain sills, and floodplain boulders. Therefore, the proposed cascades, step, floodplain sills and floodplain boulders are constructed of rock varying between 1.2 and 3 feet for channel slopes greater than 4% and 0.5 to 1.5 feet for channel slopes less than 4%. The remainder of the rock in the Engineered Streambed Material is used to construct the bottom of the stream channel and fill voids between the larger rock.

The banklines of the stream channel within cascade reaches and the transitional step reach will be constructed of separately furnished rock sized between the D_{50} and D_{84} of the ESM gradation. Therefore, the recommended rock size to construct the proposed banklines in the cascade and transitional step reaches should vary between 0.5 and 1.2 feet for both Alternatives. Smaller rocks and fine materials should be worked into the voids in the banklines to reduce porosity. For the lower slope step pool and plane-bed channel reaches, vegetation is used to stabilize the banks.

7.0 PROPOSED GEOMORPHIC, VEGETATION, AND FISH PASSAGE CONDITIONS

7.1 Anticipated Geomorphic Impacts Associated with Design Alternatives

Changes in channel geometry, hydraulics, and hydrology translate to changes in the channel's sediment transport dynamics. The following discussion of potential geomorphic impacts is based on our understanding of contemporary sediment dynamics in Burke Creek, and how these processes may change based on the proposed design alternatives.

Both proposed alternatives will create changes to channel hydraulics by modifying channel cross sectional shape and area, shortening the overall channel length, increasing channel slope, and decreasing sinuosity. Although these changes reduce geomorphic complexity, they are necessary to accommodate the steeper channel profile needed to pass Burke Creek below Highway 50 for both proposed alternative alignments. These changes will correspondingly change sediment transport and deposition patterns, most significantly by shifting the depositional zone from its present location at the culvert inlet (resulting from a change in slope from 7% - 10% in the Upstream Reach to 2% - 3% in the culvert and through the Downstream reach).

Both proposed alternative alignments will transfer the change in slope downstream of the new box culvert outlet, approximately 100 to 200 feet downstream of Highway 50 (depending on the design alternative). At this location, channel confinement will decrease as the floodplain widens and the channel slope drops from between 5% - 6% through the culvert to a slope that decreases gradually to between approximately 2.5% - 3.5% as it flows into Rabe Meadow before rejoining the existing channel just upstream of the sediment retention pond. By shifting the depositional setting to this location downstream of Highway 50, flow conveyance in the Upstream Reach will improve, and sediment deposition currently clogging the existing culvert will be eliminated, and sediments will now be routed through the culvert and deposited in the channel downstream.

In the Upstream Reach, both proposed alternatives increase channel capacity and improve the dike. A similar channel morphology will be constructed to accommodate the steep (7% - 10%) channel slope, creating a cascade and pool channel that uses large boulders to key into native ground, rock outcrops, and existing tree roots. Based on these proposed modifications, the sediment transport capacity in the Upstream Reach should be improved, and the improved sediment transport capacity should extend through the new culvert to the Downstream Reach.

In the Downstream reach, accommodating the anticipated shift in location of the sediment deposition area was a primary geomorphic design objective. How each of the proposed alternatives accommodates this and the differences between the alternatives is discussed in Section 7.1.1 for Alternative A and in Section 7.1.2 for Alternative B.

Because our assessment was largely qualitative, additional evaluations can be performed after a preferred alternative is selected. For example, changes in channel geometry, hydraulics, and hydrology translate to changes in sediment transport capacity; therefore, a sediment transport capacity analysis can be a useful predictive method for estimating future channel behavior. A stream's sediment transport rate can be estimated several ways; it can be modeled (e.g., Parker et al. 1982, Parker 1990), or it can be measured (e.g., Bunte and Abt 2001). Several models and measurement techniques have been developed, and each has its own pros and cons. For Burke Creek, modeling sediment transport capacity in the transitional reach between the culvert outlet and the point where construction ties into the existing channel would provide a basis to compare differences in transport capacity between the existing channel alignment and the preferred alternative for a range of hydrologic scenarios, and would help verify some of our assumptions.

7.1.1 Alternative A Geomorphic Analysis

Based on the Alternative A channel design, we assume the sediment transport capacity in the Upstream Reach will be improved, and assume this condition will extend through the new culvert to the Downstream Reach. With the Alternative A design, the proposed cascade and pool sequence recommends channel construction including boulders ranging from 1.2 ft to 3.0 ft diameter, which are as large or larger than the boulders in the existing channel. These boulders will be set within an engineered streambed and are expected to provide a very stable channel, with an assumed negligible risk of incision or lateral migration.

In the short-term, sediments routed into the Upstream Reach will fill in interstitial boulder spaces and may be stored temporarily in pools, but over time, the overall steep channel slope (> 6.0%) will facilitate sediment routing to the Downstream Reach, below the new culvert outlet Because the bedload transported by Burke Creek is granitic sand with occasional fine gravel and of low supply, we assume the potential of sediment deposition and any related changes in constructed channel morphology from channel aggradation is very low.

In the Downstream Reach, sediment deposition is expected to begin at approximately station 59+75, where the channel slope shifts from 6.0 to 6.5% below the culvert outlet to approximately 3.5% within a short distance. From this slope transition, the channel continues at approximately 3.5% until it connects with the existing channel at approximately station 58+00, where it's slope is further reduced to approximately 2.5 to 3.0%. In this short reach, increased sediment deposition is possible; however, the proposed design considers this possibility by increasing overbank channel width downstream of the culvert outlet to facilitate sediment deposition on the floodplain to help preserve channel capacity if some floodplain deposition occurs.

Similar to the channel design upstream of the culvert, channel sections in the Downstream Reach also include boulders. The boulders range from 0.5 ft to 3.0 ft diameter, which as proposed, are far more abundant and are larger than the few boulders observed in the existing channel. Based on this design, the proposed channel should be very stable and have a very low risk of incision or lateral migration. In addition, riparian vegetation planted on the floodplain following channel construction will facilitate "natural" floodplain building processes, by trapping fine sediments and increasing channel confinement, which can further increase channel stability (as well as provide riparian shade, cooling water temperatures, and providing increased terrestrial species habitat).

Additional geomorphic risks associated with Alternative A include increased sediment delivery to the sediment retention pond; however, estimated average sediment transport rates (NHC, 2006) combined with our field observations suggest the average annual sediment yield in Burke Creek is low, but that episodic events such as floods or landslides in the upstream portion of the watershed have the potential to deliver sediment to the study reach in volumes significantly greater than the estimated annual average supply rate (Section 4.2.3). Although these types of episodic events have occurred in the past and have supplied sediment to the study reach, (1) the pond volume (approximately

5,600 yd^3) is substantially larger than the volume of sediment currently stored in the channel, which may have been supplied from a similar event, and (2) our topographic surveys show no approximate change in pond volume since its construction. We therefore assume the risk to the pond filling with sediment at a rate which could reduce pond capacity and affect the Burke Creek channel is very low.

7.1.2 Alternative B Geomorphic Analysis

Based on the Alternative B channel design, we assume the sediment transport capacity in the Upstream Reach will be improved, and assume this condition will extend through the new culvert to the Downstream Reach. Similar to Alternative A, Alternative B proposes a cascade and pool sequence that recommends channel construction including boulders ranging from 1.2 ft to 3.0 ft diameter, which are as large or larger than the boulders in the existing channel. These boulders will be set within an engineered streambed material (specifics to be prescribed later) and are expected to provide a very stable channel, with an assumed negligible risk of incision or lateral migration.

As with Alternative A, sediments routed into this reach from upstream sources will fill in interstitial boulder spaces and may be stored temporarily in pools, but over time, the overall steep channel slope (5.25% - 8.5%) will facilitate sediment routing to the Downstream Reach, below the new culvert outlet Because the bedload transported by Burke Creek is granitic sand with occasional fine gravel and of low supply, we assume the potential of sediment deposition and any related changes in constructed channel morphology from channel aggradation is very low.

In the Downstream Reach, sediment deposition is expected to begin at approximately station 61+07, where the channel slope shifts from 5.75% as it exits the culvert to approximately 4.0%. From this location and continuing downstream, the channel gradually becomes less steep, eventually reaching a slope of 2.5 – 3.25% until it connects with the existing channel at approximately station 57+57 having a slope of approximately 2.5 – 3.0%. Unlike Alternative A, we expect a more gradual increase in sediment deposition as channel slope decreases, causing sediment deposition over a longer length of channel than Alternative A. Similar to Alternative A, the channel design from Alternative B increases overbank channel width downstream of the culvert to help preserve channel capacity if floodplain deposition occurs.

Channel cross sections in the Downstream Reach also include boulders (for boulder step pool, cascade and pool, and cobble plane bed channel morphologies). The boulders range from 0.3 ft to 3.0 ft diameter, which are significantly more abundant and are larger diameter than the few boulders observed in the existing channel. Based on this design, the proposed channel should be very stable and have a very low risk of incision or lateral migration. In addition, riparian vegetation planted on the floodplain following channel construction will facilitate “natural” floodplain building processes, buy trapping fine sediments and increasing channel confinement, which can further increase channel stability (as well as provide riparian shade, cooling water temperatures, and providing increased terrestrial species habitat).

Geomorphic risks associated with Alternative B include increased sediment delivery to the sediment retention pond; however, we assume the risk to the pond filling with sediment at a rate which could reduce pond capacity and affect the Burke Creek channel is very low. Other geomorphic risks with the Alternative B design include sediment deposition in the wetted swale (which starts at approximately station 60+57) , which could eventually fill (plug) the channel, reducing the swale capacity and possibly reducing subsurface flow that is designed to sustain certain vegetation.

7.2 Proposed Condition Fish Passage and Habitat

The proposed channel and floodplain in Alternatives A and B were both designed to create a stable, natural, geomorphically functional channel and floodplain. Channel features were designed to mimic natural channel bedforms while meeting fish passage requirements, as best as possible, for the target species and life stages of juvenile salmonids and adult resident rainbow and Lahontan cutthroat trout. Fish passage criteria listed in Section 4.6 was applied to the design, where appropriate. However, it is important to consider that fish passage criteria were generally developed for relatively uniform channels, culverts and technical fishways. These criteria do not account for the improved fish passage conditions provided by the hydraulic diversity created by complex channel morphology, as found in natural channels. This complexity is the reason that relatively small weaker swimming fish can ascend very steep channels.

The following section discus the fish passage and habitat considerations incorporated into the proposed the channel types for Alternative A and B.

7.2.1 Fish passage in the Proposed Cascades and Step Pool Reaches

The proposed cascade and step pool profiles for Alternative A and B are designed to provide adequate pool depth and low drop heights suitable for fish passage. The pools between drops provide slow velocities suitable for the target fish to hold and rest. Within boulder cascade and boulder step pool reaches, the proposed drop height across individual steps is 0.3 feet Due to the steep slope of the 30-foot long transitional step-pool reach in Alternative B, the drop between steps is designed at 0.5 feet Both satisfy the maximum water surface drop criteria of 0.5 feet for juvenile salmonids.

The boulder cascade and pool sequence and the transition step pool reach provide a minimum of 1-foot residual pool depths. In the boulder step pool reaches, the pools are allowed to self-scour within native materials (predominately sand) to their equilibrium depth. Saldi-Caromile et al. (2004) indicate that the pool depth should be a minimum of 1.25 times the drop height to provide the best hydraulic conditions for fish to leap. In the step pool and cascade reaches, pool depths will equal or exceed twice the drop height.

In pools that are more armored and less adjustable, such as in the cascade and transition step pool reaches, pools need to be designed to have adequate volume to dissipate the energy of the plunging flow without creating a fish passage barrier. Excessive turbulence can create blockages to migrating fish through disorientation and resulting fatigue (Bates, 2001). In self-scouring pools, such as in the boulder step-pool reaches, the pools generally enlarge to equilibrium condition that provides adequate volume to dissipating energy while maintaining fish passage (Love and Bates, 2009).

Turbulence is evaluated using the Energy Dissipation Factor (EDF), which is the rate energy is dissipated in the pool divided by the volume of the pool. The recommended maximum EDF for adult resident trout species is 3.0 ft-lb/s/ft^3 (Larinier, 1990). No criteria exist for juvenile salmonids. To satisfy the 3.0 ft-lb/s/ft^3 criteria at the high passage flow of 2.2 cfs, the volume of water in a pool below a 0.3 foot and 0.5 foot drop must be at least 13.7 ft^3 and 22.9 ft^3, respectively. The proposed pool spacing and depth for the cascade and transitional pool reaches appear to have adequate volume to meet these requirements, but the final pool volume should be further evaluated and modified as needed during final design.

7.2.2 Fish passage in the Proposed Plane-Bed Reach

Alternative B contains a reach of channel with a plane-bed morphology that extends for 150 feet at 3.25% and 150 feet for 2.5% before tying into the existing willow channel approximately 350 upstream of the constructed pond. Plane-bed channels generally lack bedforms but have larger bed material mixed with finer material that create hydraulic roughness and heterogeneity. Water depth and average cross-sectional water velocity were analyzed within the proposed plane-bed channel in Alternative B using the standard bankfull channel geometry and WinXSPro (USFS, 2005), a uniform flow cross section model. A Manning's roughness coefficient of 0.22 was used based on roughness predicted by Mussetter (1989), and based on values calculated in the upper two reference reaches (Section 4.3.3). Table 10 summarizes the results for the 3.25% sloped plane-bed reach.

Table 10: Average water depth and velocities at fish passage flows for the 3.25% sloped plane-bed reach in Alternative B.

Flow	Water Depth	Water Velocity	Note
0.2 cfs	0.2 ft	0.4 ft/s	Low Passage Flow
0.4 cfs	0.3 ft	0.5 ft/s	Juvenile Depth Criteria Satisfied
0.9 cfs	0.5 ft	0.6 ft/s	Adult Depth Criteria Satisfied
2.2 cfs	0.8 ft	0.8 ft/s	High Passage Flow

Water depths at the low passage flow are less than the depth requirements of 0.3 feet for juvenile salmonids and 0.5 feet for adult resident rainbow and Lahontan cutthroat trout. Even though the depth may not be adequate at lower flows, local micro-topography on the channel bed will undoubtedly form and provide pathways of deeper water that fish can use, similar to conditions in natural channel.

At the high passage flow, water depths and velocities are within criteria for both juvenile and adult resident trout. For juvenile salmonids, passage criteria for both depth and velocity are satisfied from 0.4 cfs up to and beyond the bankfull flow of 2.2 cfs. For adult rainbow and Lahontan cutthroat trout, depth and velocity passage criteria are satisfied from 0.9 cfs up to and beyond the bankfull flow. During flows above bankfull, there will be a slow velocity migration corridor along the channel and floodplain margins that fish can utilize.

7.2.3 Fish Passage in the Proposed Culvert

The constructed channel bed in the proposed culvert for both Alternative A and B consist of a 4 foot wide by 0.8 foot deep bankfull channel constructed of engineered streambed material that includes larger rocks to create channel stability and provide hydraulic roughness and diversity. The largest rocks, which exceed 2 feet in diameter, will also provide deeper, slower water suitable as holding and resting areas for fish.

Water depth and average cross-sectional water velocity were analyzed within the proposed culvert using the standard bankfull channel geometry and WinXSPro. A Manning's roughness coefficient of 0.22 was used based on roughness predicted by Mussetter (1989), and based on values calculated in the upper two reference reaches (4.3.3). Table 11 and Table 12 summarize the results for the 5.0% sloping roughened channel in Alternative A and 5.75% sloping roughened channel in Alternative B.

Fish Passage Flow	Alternative A		Note
	Water Depth	Water Velocity	
0.2 cfs	0.2 ft	0.5 ft/s	Low Passage Flow
0.5 cfs	0.3 ft	0.6 ft/s	Juvenile Depth Criteria Satisfied
1.2 cfs	0.5 ft	0.8 ft/s	Adult Depth Criteria Satisfied
2.2 cfs	0.7 ft	1.0 ft/s	High Passage Flow

Table 11: Average water depth and velocities at fish passage flows in the proposed roughened channel within the culvert crossing for Alternative A (5.0% slope).

Table 12: Average water depth and velocities at fish passage flows in the proposed roughened channel within the culvert crossing for Alternative B (5.75% slope).

Fish Passage Flow	Alternative B		Note
	Water Depth	Water Velocity	
0.2 cfs	0.2 Feet	0.3 ft/s	Low Passage Flow
0.5 cfs	0.3 ft	0.6 ft/s	Juvenile Depth Criteria Satisfied
1.2 cfs	0.5 ft	0.9 ft/s	Adult Depth Criteria Satisfied
2.2 cfs	0.7 Feet	1.0 ft/s	High Passage Flow

For both Alternatives A and B, water depths in the culvert at the low passage flow are less than the depth requirements of 0.3 feet for juvenile salmonids and 0.5 feet for adult resident rainbow and Lahontan cutthroat trout. Even though the depths may not be adequate at lower flows, local micro-topography on the channel bed will undoubtedly form and provide pathways of deeper water that fish can use, similar to conditions in a natural channel.

At the high passage flow, water depths and velocities are within criteria for both juvenile and adult resident trout. For juvenile salmonids, passage criteria for both depth and velocity are satisfied from 0.5 cfs up to the bankfull flow of 2.2 cfs for both Alternatives A and B. Channel velocities increase to greater than 1 ft/s during flows greater than bankfull, which may limit juvenile passage in the channel. However, shallow flows on the floodplain will create a slow velocity migration corridor along the channel and floodplain margins that fish can utilize during flows higher than bankfull.

For adult rainbow and Lahontan cutthroat trout, depth and velocity passage criteria are satisfied from 1.2 cfs up to and beyond the bankfull flow of 2.2 cfs for both Alternatives A and B.

7.3 Anticipated Vegetation Impacts Associated with Design Alternatives

Two types of vegetation impacts are associated with each of the proposed alternatives: direct impacts and indirect impacts. Direct impacts are associated with construction of the new channel and floodplain and may include vegetation removal and/or vegetation destruction due to access and/or staging areas. Direct impacts are measured within the construction footprint. Direct impacts assume that all vegetation within the construction footprint will be removed and/or impacted and will occur as a result of implementing Alternative A or B.

Indirect impacts are an associated outcome caused by the completed project rather than construction activities; examples include willow mortality and conversion of wet meadow to dry meadow resulting from channel realignment and de-watering. Indirect impacts are measured within the ESL. Indirect impacts may or may not occur as a result of implementing Alternative A or B. The following sections present both the direct and indirect impacts on vegetation associated with the proposed project.

7.3.1 Alternative A Vegetation Analysis

Alternative A assumes no change to existing conditions on Burke Creek upstream of Highway 50, but it would realign the channel downstream of Highway 50 to follow an existing swale and tie into the current channel approximately 100 feet below where the existing stream splits into two channels and flows into the existing pond (Figure 39). Burke Creek surface flow is delivered to the existing riparian corridor downstream of Highway 50 via the culvert that extends under Highway 50. Under Alternative A, the culvert would be realigned to deliver surface flow to a new channel located approximately 170 feet north of the existing channel.

For Alternative A, up to 1.91 acres of dry meadow, 0 acres of wet meadow, 0.08 acres of woody riparian, 0.04 acres of upland (Table 13), and 0.27 acres of human disturbance biohabitats would be directly impacted. An additional 0.48 acres of wet meadow and 0.65 acres of woody riparian habitat may be indirectly impacted through channel dewatering (Table 13).

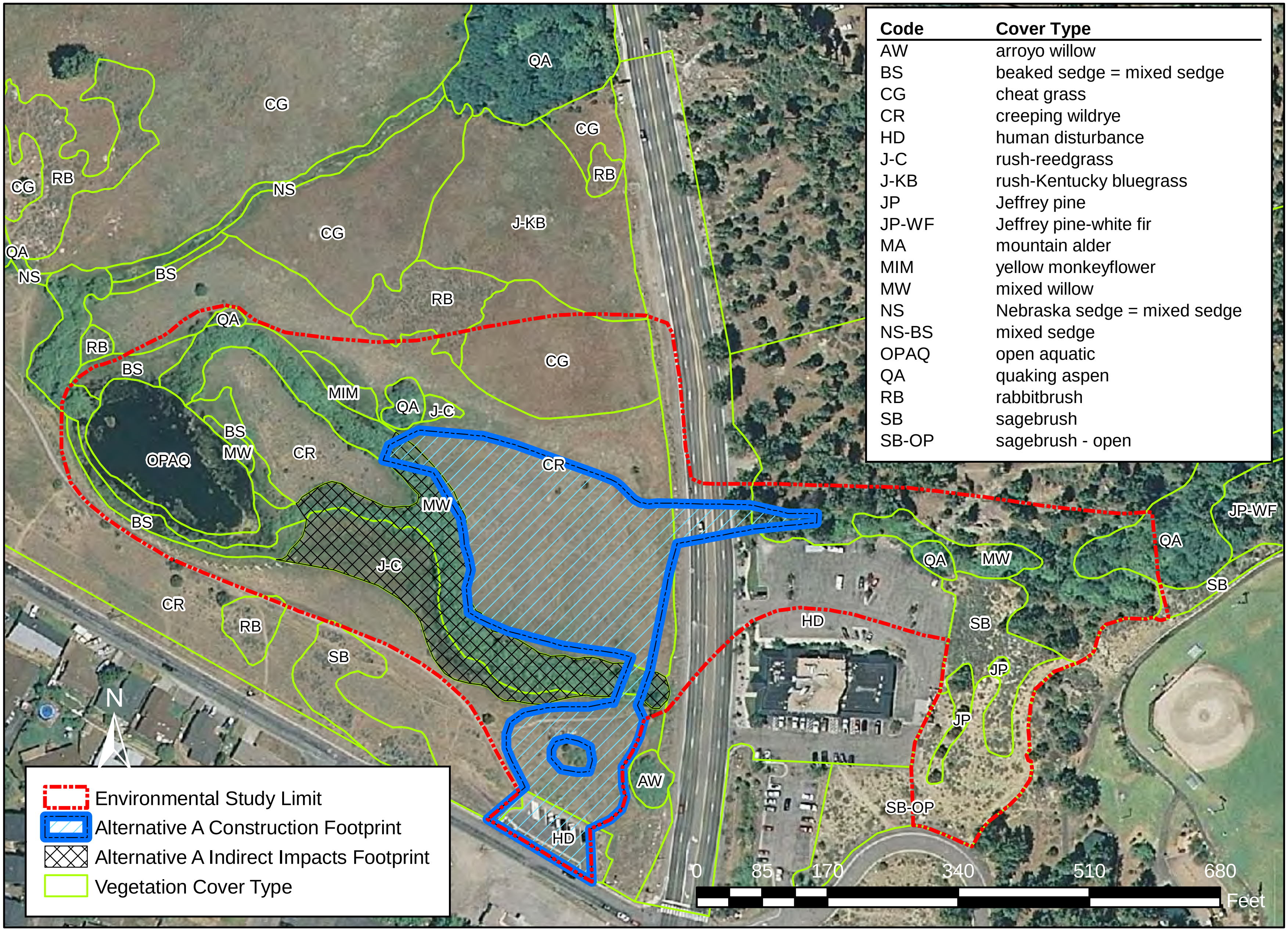


Figure 39: Channel design Alternative A construction footprint boundary, indirect impact boundary and mapped vegetation occurring within the Burke Creek Environmental Study Limit (ESL), mapped in October 2007.

Table 13: Anticipated Burke Creek impact areas for proposed channel design alternatives.					
	Existing Acres	Alternative A		Alternative B	
		Direct Impacts (ac)	Indirect Impacts (ac)	Direct Impacts (ac)	Indirect Impacts (ac)
Anthropogenic Total	1.41	0.27	-	0.61	-
Human Disturbance	1.41	0.27	-	0.61	-
Wet Meadow Total	0.93	None	0.48	None	0.35
Mixed Sedge	0.34	-	-	-	-
Rush-Kentucky Bluegrass	0.01	-	-	-	-
Rush-Reedgrass	0.51	-	0.48	-	0.35
Yellow Monkeyflower	0.07	-	-	-	-
Dry Meadow Total	4.70	1.91	-	1.89	-
Cheat Grass	0.65	-	-	-	-
Creeping Wildrye	4.05	1.91	-	1.89	-
Woody Riparian Total	1.64	0.08	0.65	0.22	0.40
Mixed Willow	1.38	0.08	0.65	0.18	0.40

Table 13: Anticipated Burke Creek impact areas for proposed channel design alternatives.					
	Existing Acres	Alternative A		Alternative B	
		Direct Impacts (ac)	Indirect Impacts (ac)	Direct Impacts (ac)	Indirect Impacts (ac)
Quaking Aspen	0.26	-	-	0.04	-
Upland Total	2.00	0.04	-	0.58	-
Jeffrey Pine	0.09	-	-	0.01	-
Jeffrey Pine-White Fir	1.01	0.04	-	0.09	-
Rabbitbrush	0.03	-	-	-	-
Sagebrush	0.38	-	-	0.23	-
Sagebrush-Open	0.50	-	-	0.25	-
Open Water	0.64	N/A	N/A	N/A	N/A
TOTAL	11.31	2.30	1.13	3.30	0.75

Note: Direct impacts occur within the construction footprint for each design alternative. Indirect impacts occur within the Environmental Study Limit (ESL) and are outside the construction footprint for each alternative. Indirect impacts may potentially occur as a result of implementing either alternative.

The new channel alignment will dewater approximately 500 feet of the existing channel. Increased distance to surface water (e.g., 170 ft), combined with coarse, well-drained soils, means that groundwater recharge is not likely to occur on the existing channel. Since storm water runoff is collected in an underground concrete pipe via drop inlets along Kahle Drive (JWA Consulting Engineers, 1991), surface flow will likely also be inadequate to recharge groundwater sufficiently. Reduced groundwater and lack of surface flows will likely result in dieback of the existing willows along the current channel.

7.3.2 Alternative B Vegetation Analysis

Alternative B would realign Burke Creek upstream of Highway 50 and also realign the channel downstream of Highway 50 to follow an existing swale and tie into the current channel approximately 100 feet below where the existing stream splits into two channels and flows into the existing pond (Figure 40). A wetted swale will split from the design channel at approximately station 60+50 and connect to the existing channel just upstream of the existing flow split (Sheet B-1 Appendix J).

Similar to Alternative A, Alternative B would also dewater a majority of the existing willow corridor. However, the wetted swale will deliver some surface flows to the existing channel at the current flow split, which would support continued growth of the existing willow corridor and surrounding wet meadow habitat.

For Alternative B, up to 0 acres of wet meadow, 1.89 acres of dry meadow, 0.22 acres of woody riparian, 0.58 acres of upland, and 0.61 acres of human disturbance biohabitats would be directly impacted. An additional 0.35 acres of wet meadow and 0.40 acres of woody riparian habitat may be indirectly impacted through channel dewatering (Table 13).

As discussed for Alternative A, realigning the channel under Alternative B would de-water the existing channel and cause willow dieback. However, the wetted swale would route flows into the existing channel further upstream than Alternative A, resulting in fewer indirect impacts. The southern fork of the existing split flow will therefore likely be maintained under Alternative B.

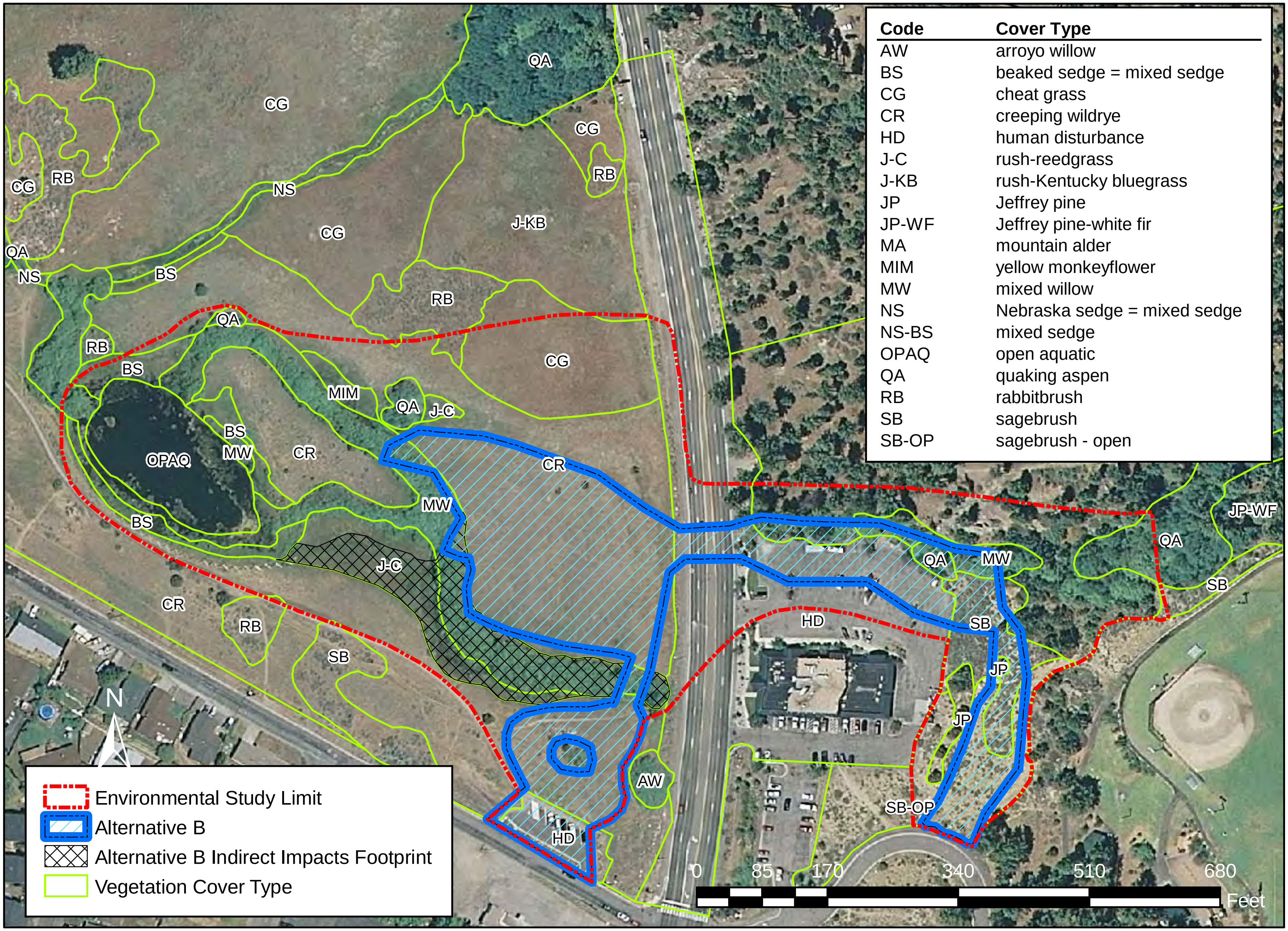


Figure 40: Channel design Alternative B construction footprint boundary, indirect impact boundary and mapped vegetation occurring within the Burke Creek Environmental Study Limit (ESL), mapped in October 2007.

7.4 Conceptual Revegetation Designs

7.4.1 Conceptual Revegetation Approach

There are two approaches to developing revegetation designs for Burke Creek. Both revegetation design approaches will establish different types of riparian vegetation within the Streamside Environmental Zone (SEZ). One revegetation approach seeks to restore conditions that were lost when the channel was presumably first relocated between 1950 and 1969. Another approach seeks to replace “in-kind” the habitat that will be lost directly or indirectly as a result of the project. The actual revegetation approach selected will be a decision of the TRPA, and will be the approach that is most congruous with their SEZ goals and objectives.

The first revegetation design approach for Alternative A and Alternative B relies on restoring historic riparian vegetation conditions to those that existed before the channel was first relocated. The “restoration” design approach relies on mimicking vegetation patterns shown in the 1940 aerial photograph (Figure 41). Historically, aspen, conifers, and sedges dominated the steeper upstream section of the creek along an assumed step-pool channel morphology. As the channel left this steeper upstream morphology, the step-pool channel morphology transitioned into a meadow morphology with a lower gradient meandering channel. This transition point was marked by an alluvial fan created by surface deposition and accumulation. In the 1940 aerial photograph, the transition in channel types occurred just upstream of the current parking lot, at approximately existing station 69+00. Because of infrastructure constraints and the need to account for channel slope, it is no longer possible to locate the channel transition zone in its historic location; rather, the current channel design under the proposed alternatives intends to extend the steeper step-pool channel morphology further downstream of Highway 50, where a transition in gradient and sediment transport dynamics will occur. At the transition point, the channel morphology will be similar to the meandering meadow stream type seen on the 1940 aerial photograph; the pool drop morphology would be revegetated with aspen and pines to the point where gradient lessens and sediment deposits (for a more detailed discussion of the stream gradient transition point and historical channel alignments, please refer to Sections 4.2.2, and 4.2.3). The lower gradient segment of stream could be revegetated with meadow or a willow thicket - though the meadow would be more reflective of the pre-disturbance condition.

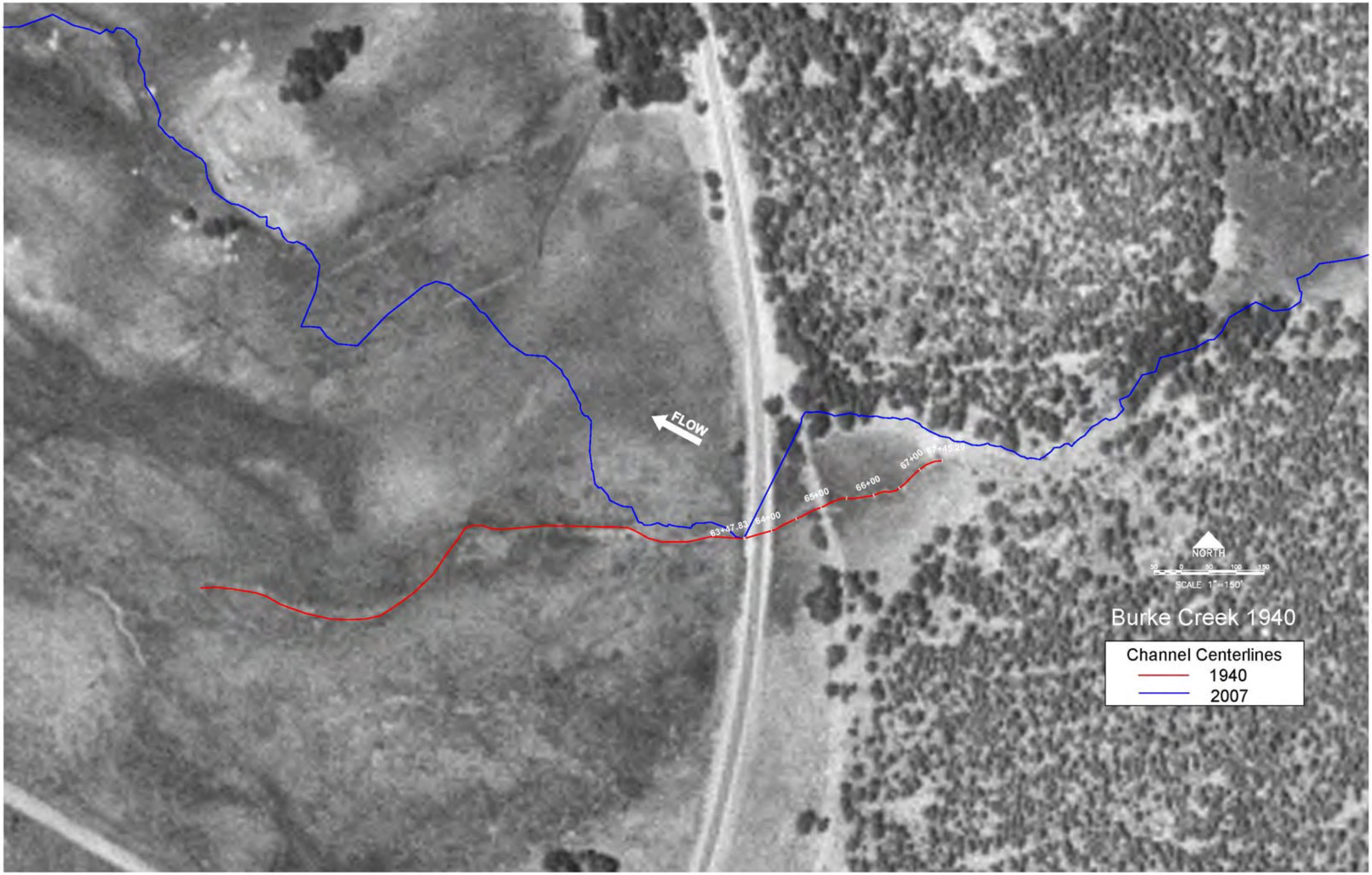


Figure 41: Aerial photograph from 1940, showing historical riparian vegetation in the project area and comparing the historical channel alignment from 1940 to the channel alignment in 2007.

A second design approach uses the existing conditions along the creek as a template upstream and downstream of Highway 50; therefore revegetation will replace the existing habitat that is directly or indirectly disturbed when the project is constructed (Figure 39 and Figure 40). The replacement approach would rely on recreating a willow thicket on the downstream side of Highway 50 and recreating either an aspen- or pine-dominated riparian zone on the upstream side of Highway 50. The replacement approach is one potential option for revegetating the constructed channel. Benefits of replacing existing habitat should be weighed against the benefits of restoring pre-disturbance vegetation patterns.

Conceptual revegetation designs have been developed for Alternatives A and B using the two revegetation design approaches. The objectives for the revegetation designs presented here are: 1) to preserve existing riparian vegetation and, where necessary and feasible, salvage existing vegetation; 2) to reduce exotic invasive plant species; 3) to reflect woody riparian vegetation patterns on less disturbed streams regionally; and 4) to create high quality habitat for fish and wildlife. Revegetation is therefore a combination of reducing impacts to existing vegetation while stacking the odds in favor of the plant species we want to recover through the restoration process.

The project area was divided into five revegetation zones: 1) the upstream zone, 2) the culvert zone, 3) the downstream zone, and 4) wetted swale (Figure 42 and Figure 43). The revegetation zones are defined by channel design slope and bedform. For each zone, one or two revegetation options were developed to reflect the different design approaches (i.e. restore historical conditions or replace existing conditions). Unless otherwise specified, the conceptual designs for each revegetation option are the same for both Alternative A and Alternative B.

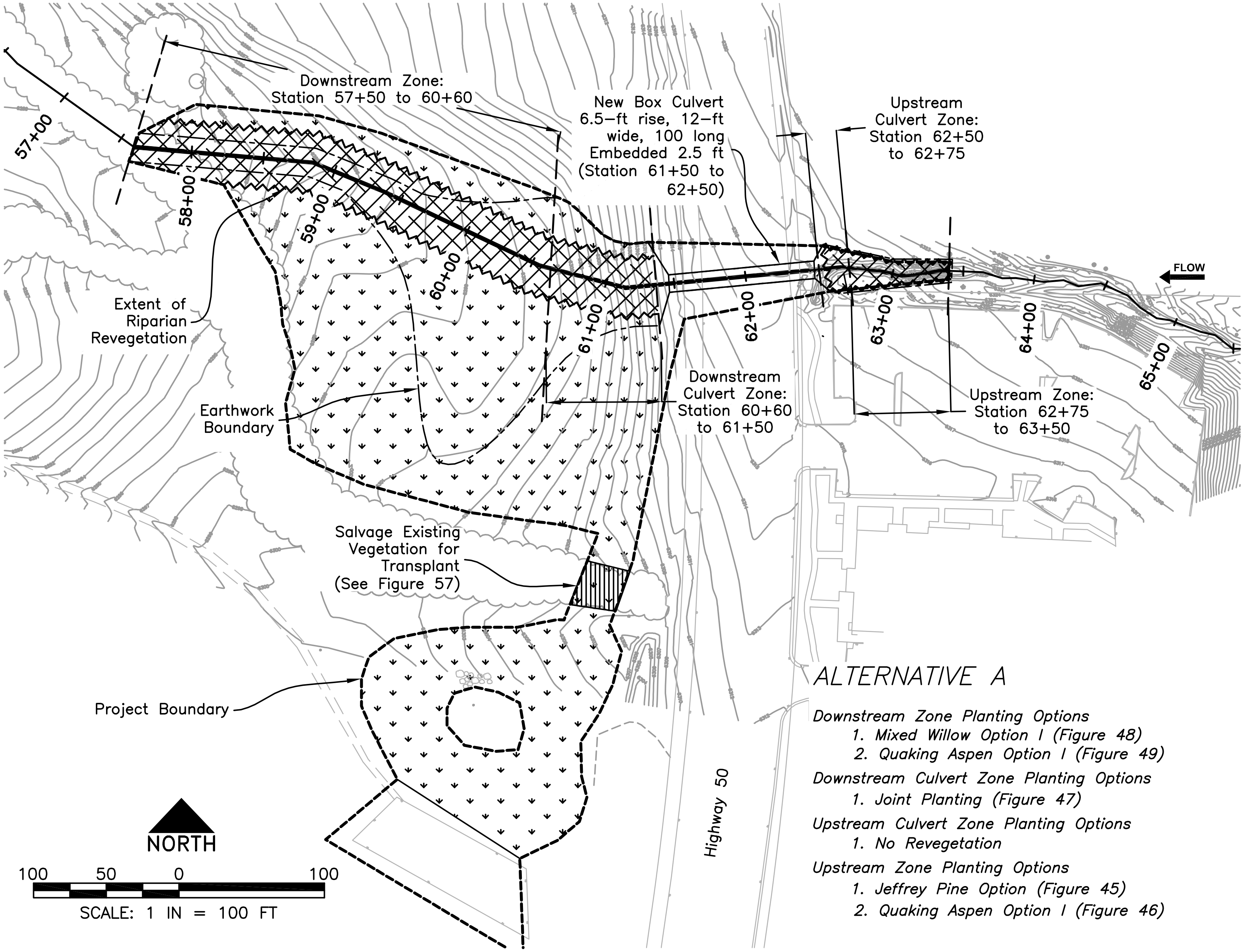


Figure 42: Overview of the Alternative A construction footprint and revegetation zones.

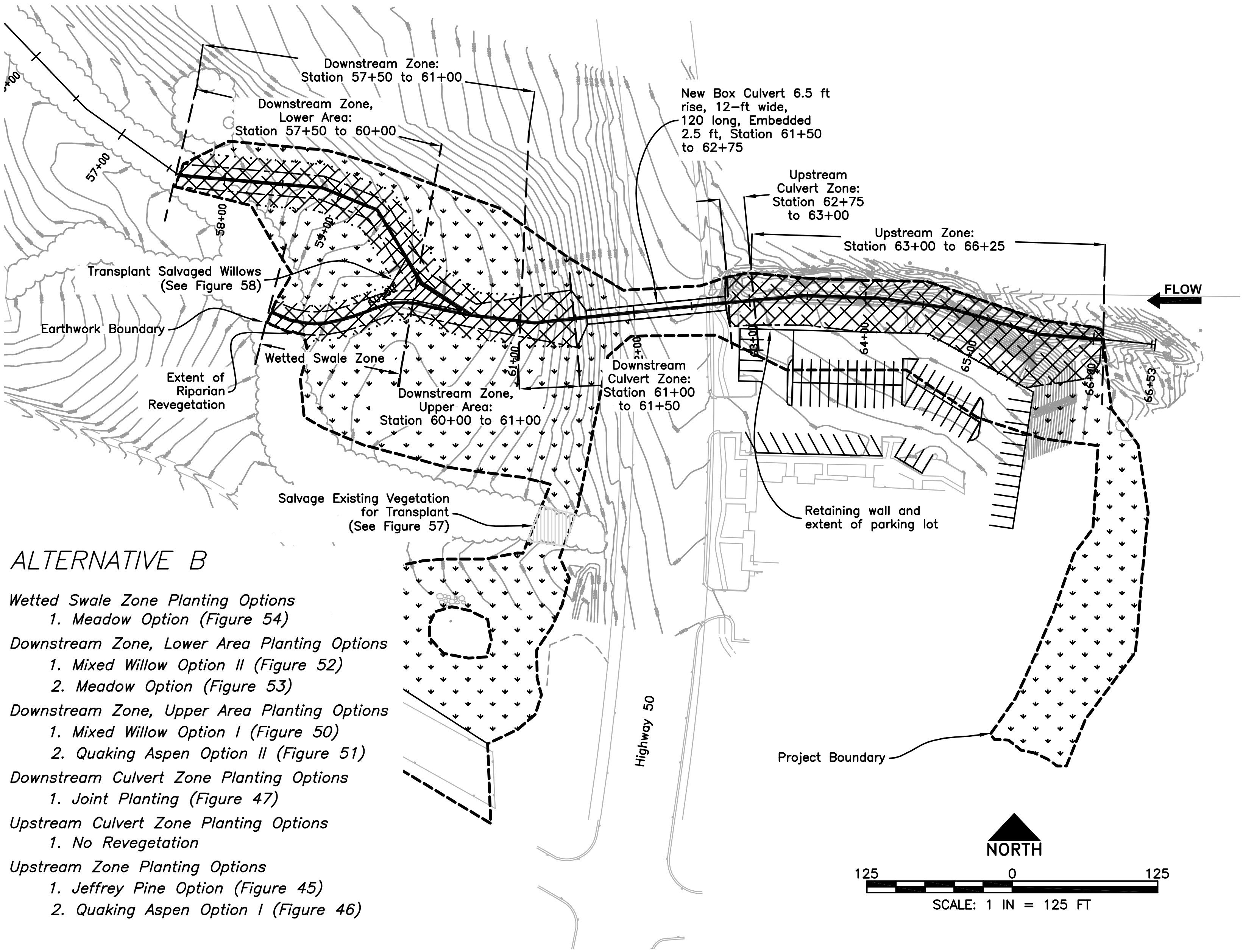


Figure 43: Overview of the Alternative B construction footprint and revegetation zones.

All species proposed in the revegetation designs are native to the Tahoe Basin, and most were observed on Burke Creek. Some species that are known to occur in the Tahoe Basin, but not observed on Burke Creek, and also known to be effective for erosion control (per Christopherson and Johnson, no date), have been recommended. The seventeen recommended species occur on the TRPA Recommended Plant List (Coburn et al. 2006) (Table 14).

Table 14: Revegetation species for use in the upstream, culvert, flow expansion, downstream, and high flow channel revegetation zones.

	Upstream Zone			
	Species	Common Name	Growth Form	Planting Methods
Woody Species	Pinus jeffreyi	Jeffrey pine	tree	bare root
	Populus tremuloides	quaking aspen	tree	pole
Sedges And Rushes	Carex douglasii	Douglas' sedge	sedge	plug
	Carex nebrascensis	Nebraska sedge	sedge	mat
	Carex utriculata	beaked sedge	sedge	plug
	Juncus mexicanus	Mexican rush	rush	mat
	Scirpus microcarpus	panicled bulrush	sedge	plug
Grasses	Elymus glaucus	blue wildrye	bunchgrass	seed
	Elymus trachycaulus	slender wheatgrass	bunchgrass	seed
	Festuca rubra	red fescue	sod grass	seed
	Leymus triticoides	creeping wildrye	bunchgrass	seed
	Leymus triticoides	creeping wildrye	bunchgrass	plug
Herbs	Artemisia douglasiana	Mugwort	herb	plug
	Culvert Zone			

Table 14: Revegetation species for use in the upstream, culvert, flow expansion, downstream, and high flow channel revegetation zones.

	Species	Common Name	Growth Form	Planting Methods
Woody Species	Salix exigua	narrowleaf willow	shrub	pole
	Salix geyeriana	Geyer's willow	shrub	pole
	Salix lasiolepis	arroyo willow	shrub	pole
	Salix lemmonii	Lemmon's willow	shrub	pole
	Flow Expansion Zone			
	Species	Common Name	Growth Form	Planting Methods
Woody Species	Salix exigua	narrowleaf willow	shrub	pole
	Salix geyeriana	Geyer's willow	shrub	pole
	Salix lasiolepis	arroyo willow	shrub	pole
	Salix lemmonii	Lemmon's willow	shrub	pole
	Salix lucida ssp. caudata	shiny willow	shrub	pole
	Populus tremuloides	quaking aspen	tree	pole
Sedges And Rushes	Carex douglasii	Douglas' sedge	sedge	plug
	Carex nebrascensis	Nebraska sedge	sedge	Mat
	Carex utriculata	beaked sedge	sedge	Plug
	Juncus mexicanus	Mexican rush	rush	Mat
grasses	Leymus triticoides	creeping wildrye	bunchgrass	Seed
	Leymus triticoides	creeping wildrye	bunchgrass	Plug
herbs	Artemisia douglasiana	mugwort	herb	Plug

Table 14: Revegetation species for use in the upstream, culvert, flow expansion, downstream, and high flow channel revegetation zones.

	Downstream Zone			
	Species	Common Name	Growth Form	Planting Methods
Woody Species	Salix lasiolepis	arroyo willow	shrub	Pole
	Salix lemmonii	Lemmon's willow	shrub	Pole
	Salix lucida ssp. caudata	shiny willow	shrub	Pole
	Populus tremuloides	quaking aspen	tree	Pole
Sedges And Rushes	Carex nebrascensis	Nebraska sedge	sedge	Mat
	Carex utriculata	beaked sedge	sedge	Mat
	Juncus mexicanus	Mexican rush	rush	Mat
Grasses	Leymus triticoides	creeping wildrye	bunchgrass	Seed
	Leymus triticoides	creeping wildrye	bunchgrass	plug
Herbs	Artemisia douglasiana	mugwort	herb	plug
	Wetted Swale			
	Species	Common Name	Growth Form	Planting Methods
Sedges And Rushes	Carex nebrascensis	Nebraska sedge	sedge	mat
	Carex utriculata	beaked sedge	sedge	mat
	Juncus mexicanus	Mexican rush	rush	mat
Grasses	Leymus triticoides	creeping wildrye	bunchgrass	seed
	Leymus triticoides	creeping wildrye	bunchgrass	plug

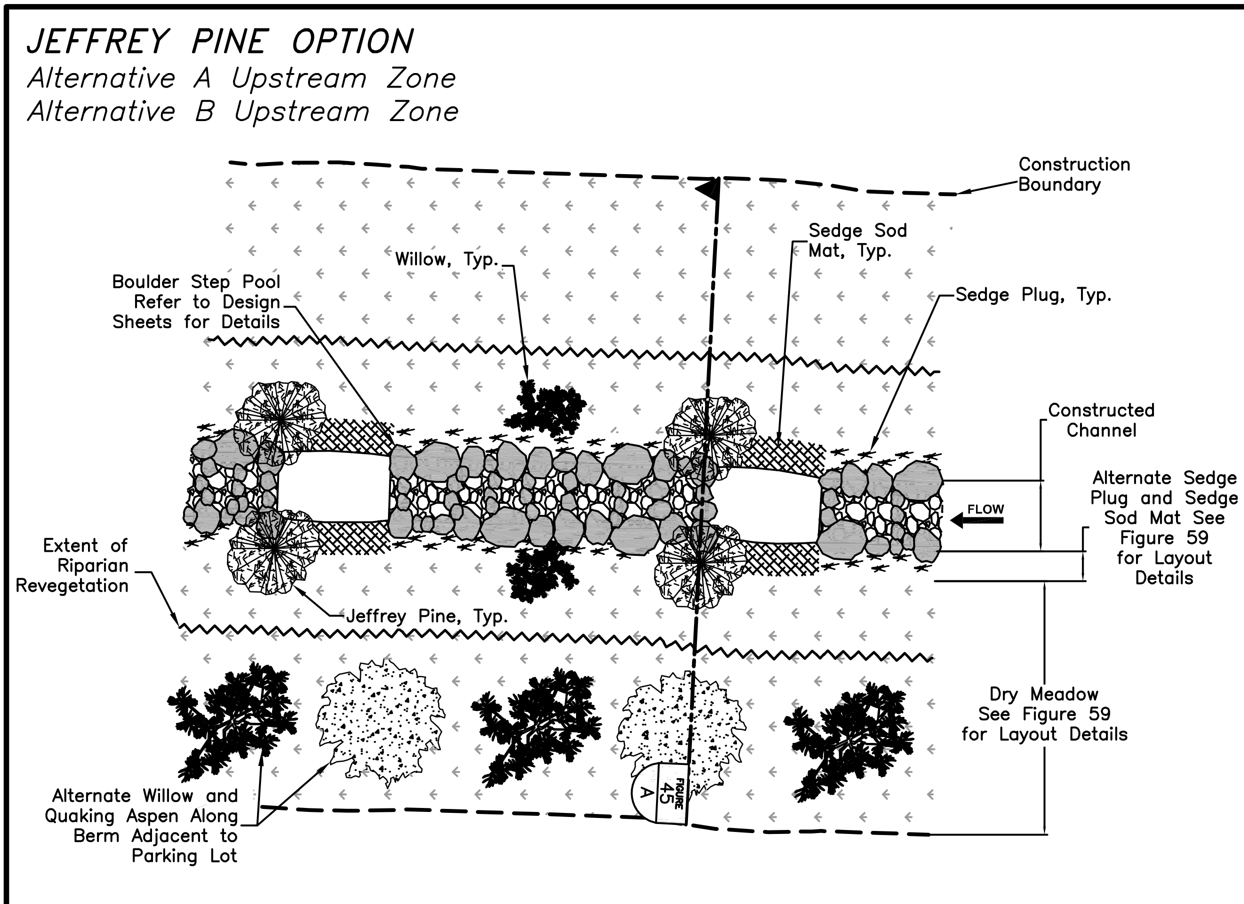
7.4.2 Upstream Revegetation Zone

The channel in the upstream revegetation zone flows directly through an existing Jeffrey pine-white fir forest as a result of the initial channel realignment. Narrow patches of mixed willow and quaking aspen cover types have grown up along the channel since realignment (Figure 44). Alternative B proposes to move the channel to the south and build a cascade step-pool sequence. Although Alternative A does not propose to move the existing channel in the upstream zone, the channel will be regraded to accommodate the new culvert and a cascade step-pool morphology will be built.

Figure 44: Photograph of existing upstream revegetation zone, showing mixed willow with Jeffrey pine-white fir.

Two different revegetation options could be potentially planted in the Alt B upstream zone: 1) a Jeffrey pine option and 2) quaking aspen #1 option (Figure 45 and Figure 46). Implementing the Jeffrey pine option would replace existing vegetation impacted during construction, whereas implementing the quaking aspen option would restore riparian vegetation to a condition similar to less disturbed regional stream of a similar gradient, substrate and size. Both revegetation designs establish tree species (either Jeffrey pine or quaking aspen, depending on the revegetation option) at the head of the cascade in the cascade step-pool progression so that their roots will ultimately provide the structure for the steps (Figure 45 and Figure 46). Lemmon’s willow will be planted toward the downstream end of the cascade to provide additional structure and stream shading.

Additionally, the designs will rely on native sedge species (e.g. Nebraska sedge, beaked sedge, and panicled bulrush) to displace non-native grasses (e.g. Kentucky bluegrass). Nebraska sedge sod mats will be planted along the pools, while clumping sedges (e.g. beaked sedge, panicled bulrush) will be planted along the cascade as an extra bank protection measure (Figure 45 and Figure 46). A combination of creeping wildrye plugs and a grass seed mix of creeping wildrye, blue wildrye (*Elymus glaucus*), and red fescue (*Festuca rubra*) will be planted outside the riparian corridor and mulched with straw to provide erosion control while the sedges and conifers or aspens become established.



Conceptualized Cross Section A for Alternatives A and B

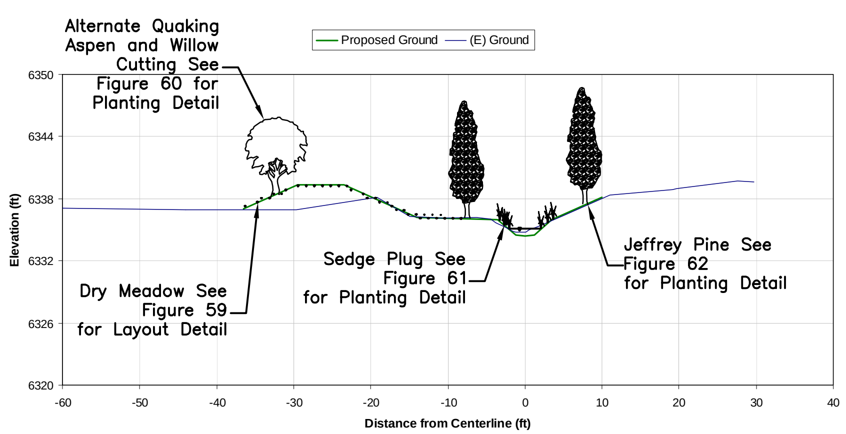


Figure 45: Jeffrey pine revegetation option for the upstream zone in Alternative A and Alternative B. Jeffrey pine represents the replacement revegetation option.

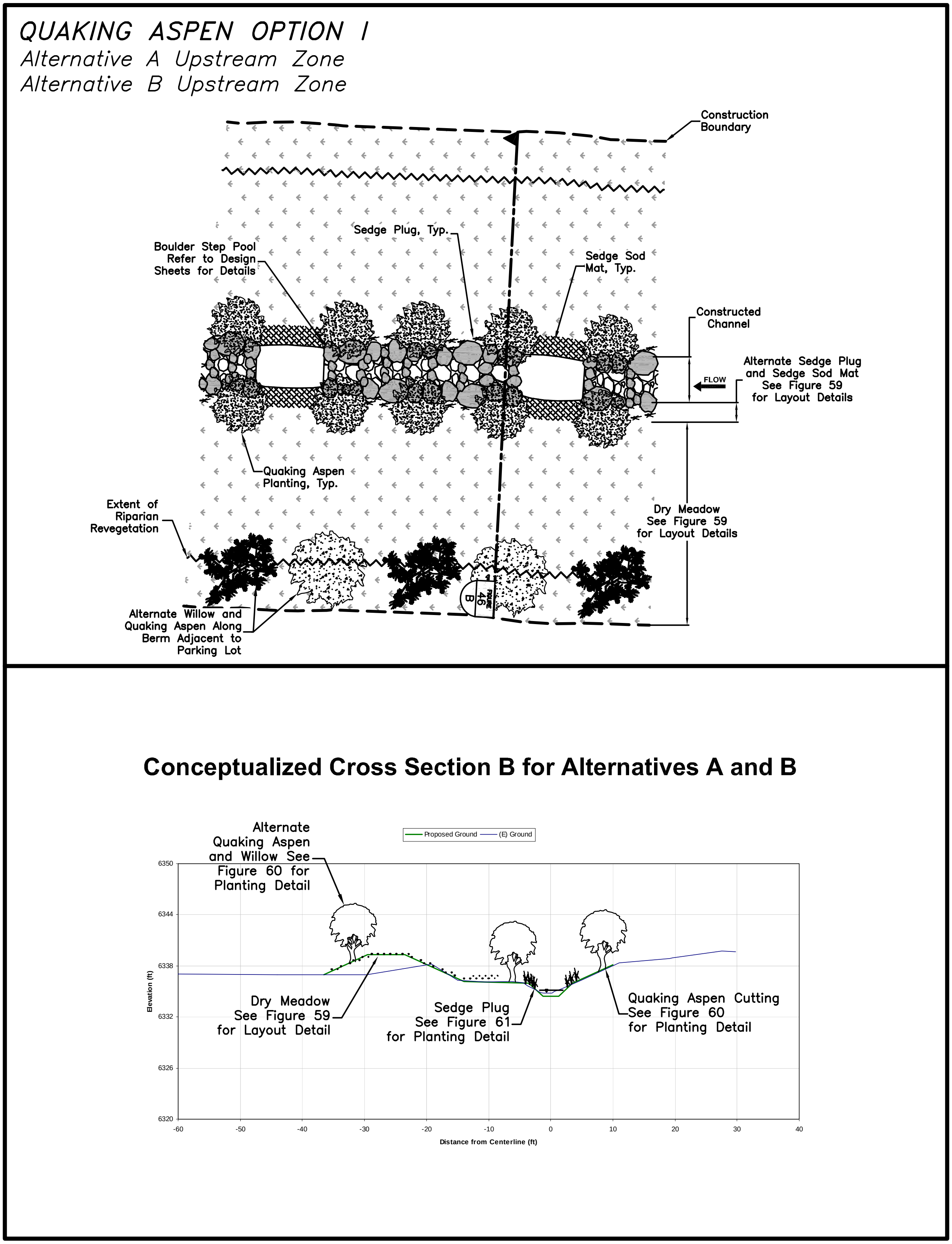
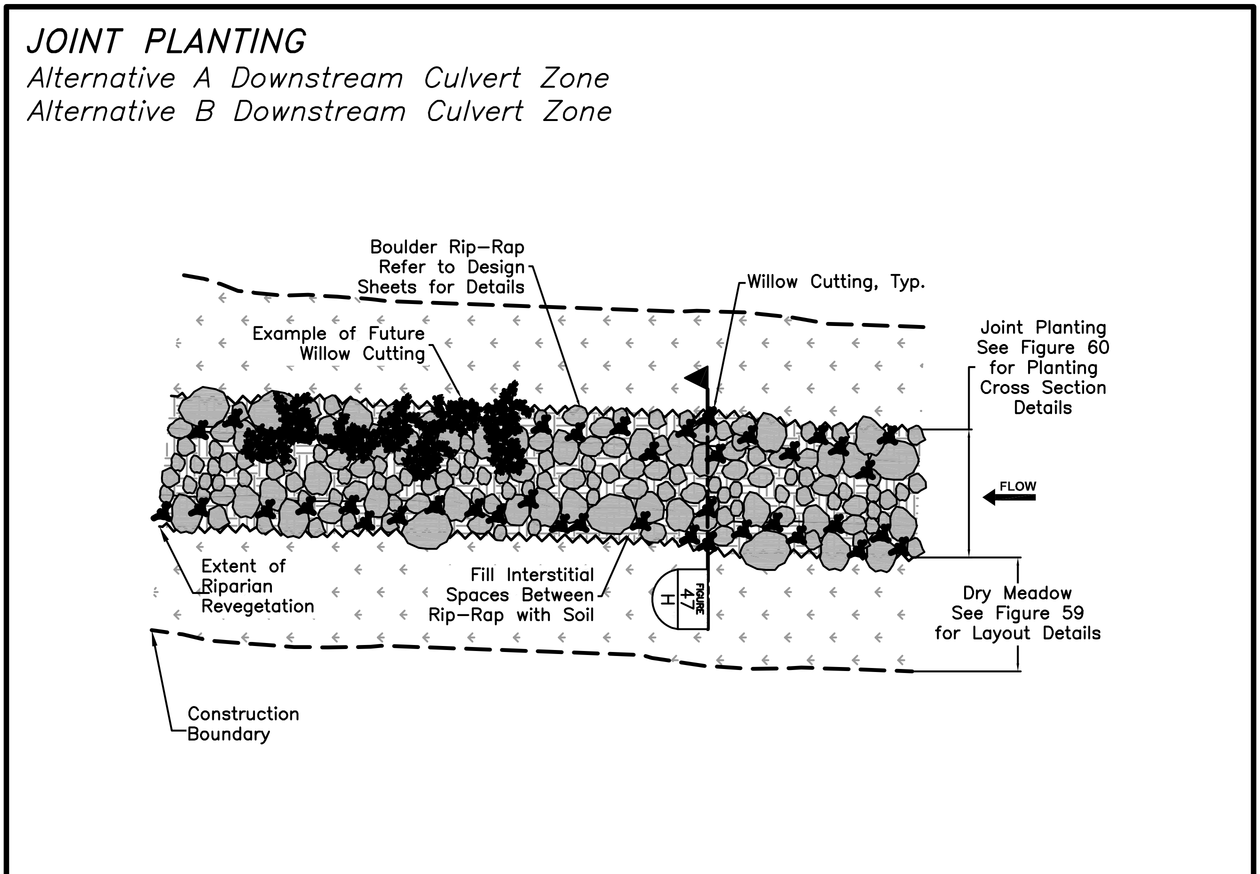


Figure 46: Quaking aspen revegetation option #1 for the upstream zone in Alternative A and Alternative B. Quaking aspen represents the restoration revegetation option.

7.4.3 Culvert Zone

The design channel in the culvert zone will be steep (5% slope). The culvert inlet downstream will be a cascade reach up to the face of the culvert, with a dirt overbank and rock sills. Due to differing channel performance needs, the culvert zone has been divided into upstream and downstream subzones. The upstream culvert zone occurs upstream of Highway 50 and should remain unvegetated to allow for culvert maintenance and flood flow conveyance.

The downstream culvert zone occurs downstream of Highway 50 and extends approximately 100 ft from the downstream edge of the culvert. The downstream culvert zone will be planted with willows (e.g. arroyo, Geyer's, and Lemmon's willows) in the joints between the placed rip-rap boulders (Figure 47). Only the replacement revegetation option was developed for the downstream culvert zone due to the steep channel gradient and construction materials.



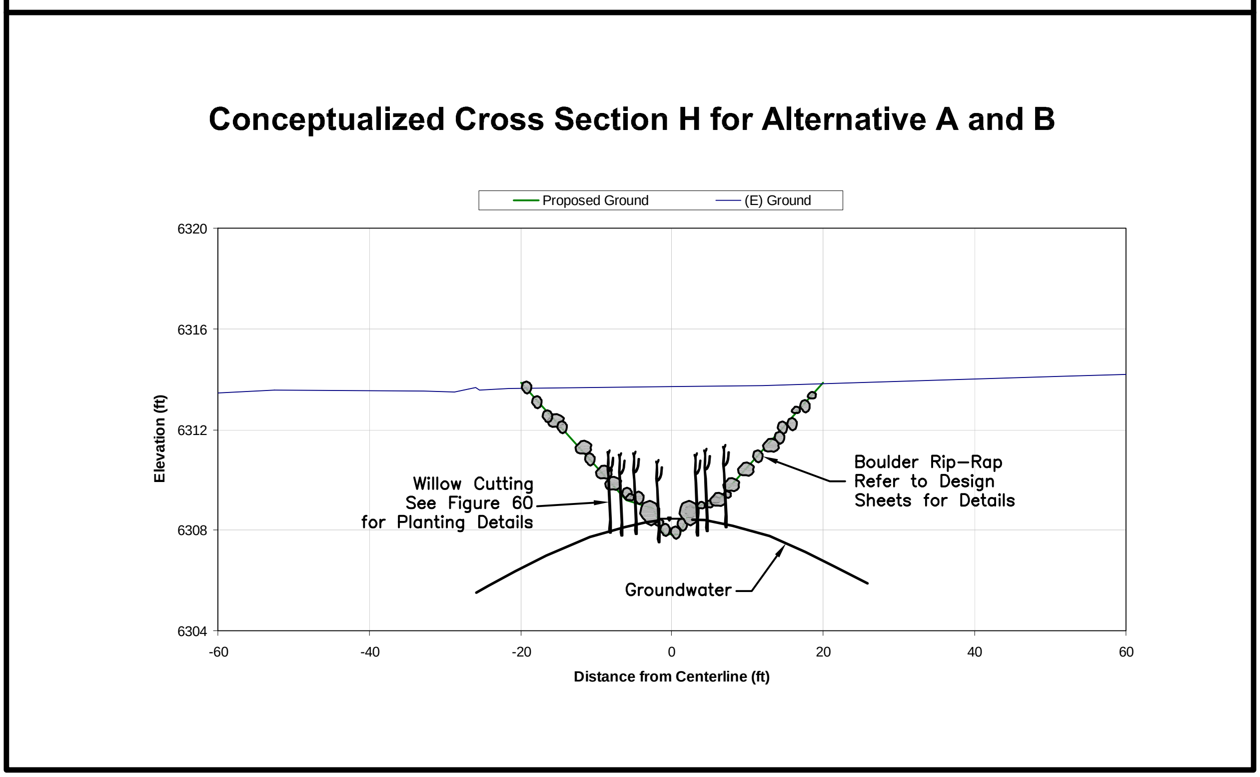


Figure 47: Mixed willow joint planting revegetation option for the downstream culvert zone in Alternative A and Alternative B.

7.4.4 Downstream Revegetation Zone

In the flow expansion zone, the existing channel flows through a well-developed willow corridor; the design channel will flow through an existing dry meadow. Alternative A and Alternative B have different alignments and channel designs through this zone and therefore will be discussed separately.

For Alternative A, the area of stream downstream of the culvert zone was treated as one zone (see next section) because of the steep channel slope stabilized with boulder cascades and step pools. Two revegetation options were developed for the Alternative A downstream zone: 1) mixed willow option #1 and 2) quaking aspen option #1 (Figure 48 and Figure 49). Quaking aspen option #1 is the same revegetation design for the upstream zone in Alternative B. It represents the restoration approach, even though aspens are not present in this area in the 1940 aerial photo; Alternative A effectively shifts the transition point between high gradient and low gradient stream to below the flow expansion/downstream zone. Since upstream channel slopes will be extended down through the flow expansion/downstream zone, it could be argued that the upstream vegetation should also be extended in this zone. Alternatively, mixed willow option #1 represents the replacement approach and will use a combination of dense willow plantings and sedge sod mats along the low flow channel to support channel and overbank stability throughout this steep gradient zone (Figure 49). For both revegetation options, a combination of creeping wildrye plugs and seeds will be planted to establish dry meadow outside the riparian corridor.

For Alternative B the area of stream downstream of the culvert zone was broken into two areas, an upper area and a lower area. The upper area in the downstream zone begins where the culvert zone ends and continues downstream another 100 feet The design channel will install boulder cascades and step pools in this steep section of the channel. Two revegetation options were developed for the upstream area in the downstream zone for Alternative B: mixed willow option #1 and quaking aspen option #2 (Figure 50 and Figure 51).Mixed willow option #1 is the same as discussed for Alternative A and represents the replacement approach. Quaking aspen option #2 is similar to quaking aspen option #1, except that aspens will be planted at alternate boulder weirs (Figure 51). This option may be closer to historical (i.e. pre-Jenning's casino site preparation) conditions than the mixed willow option because the channel will flow through predominantly wet meadow. For both revegetation options, a combination of creeping wildrye plugs and seeds will be planted to establish dry meadow outside the riparian corridor.

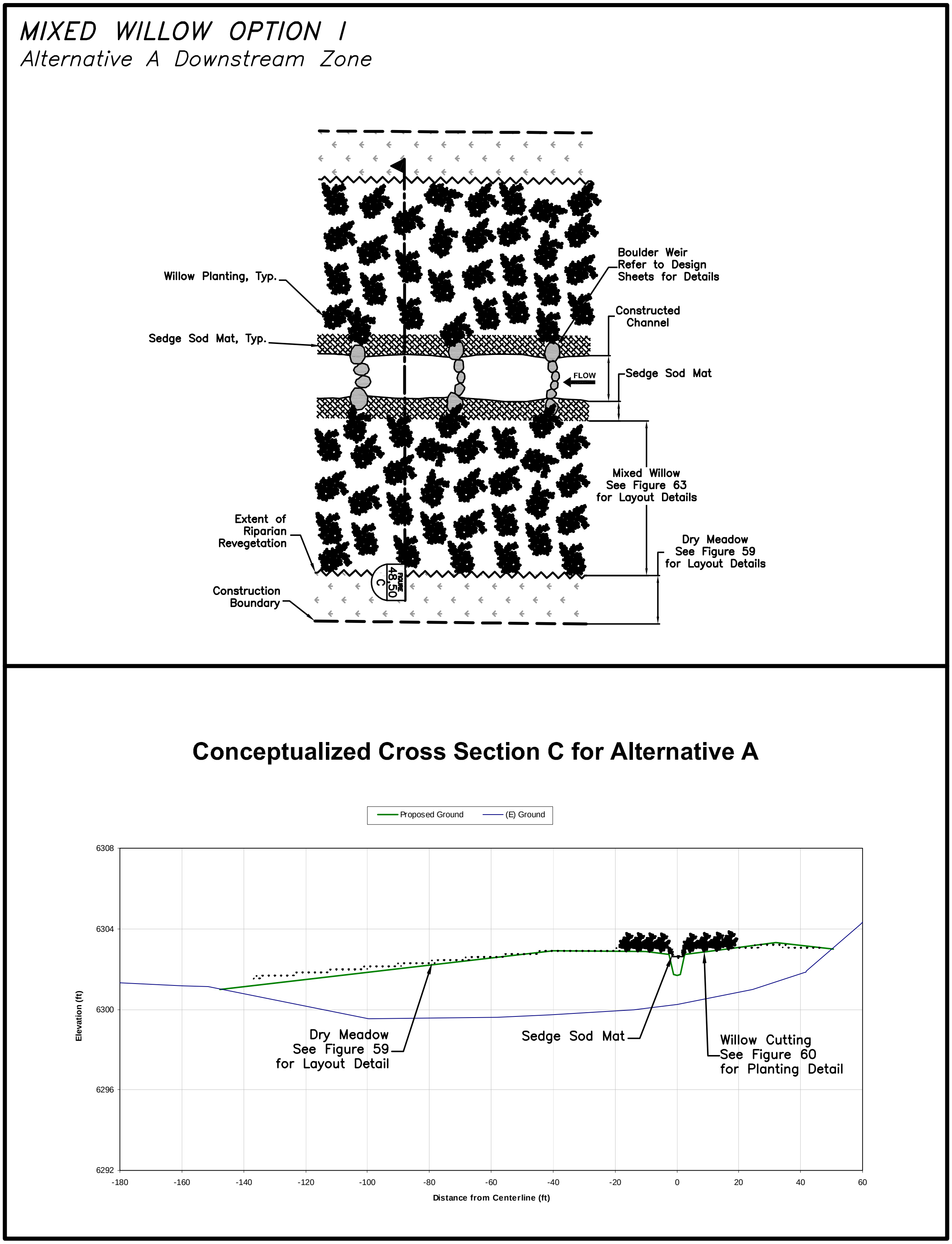


Figure 48: Mixed willow revegetation option #1 for the flow expansion/downstream zone in Alternative A. Mixed willow represents the replacement revegetation option.

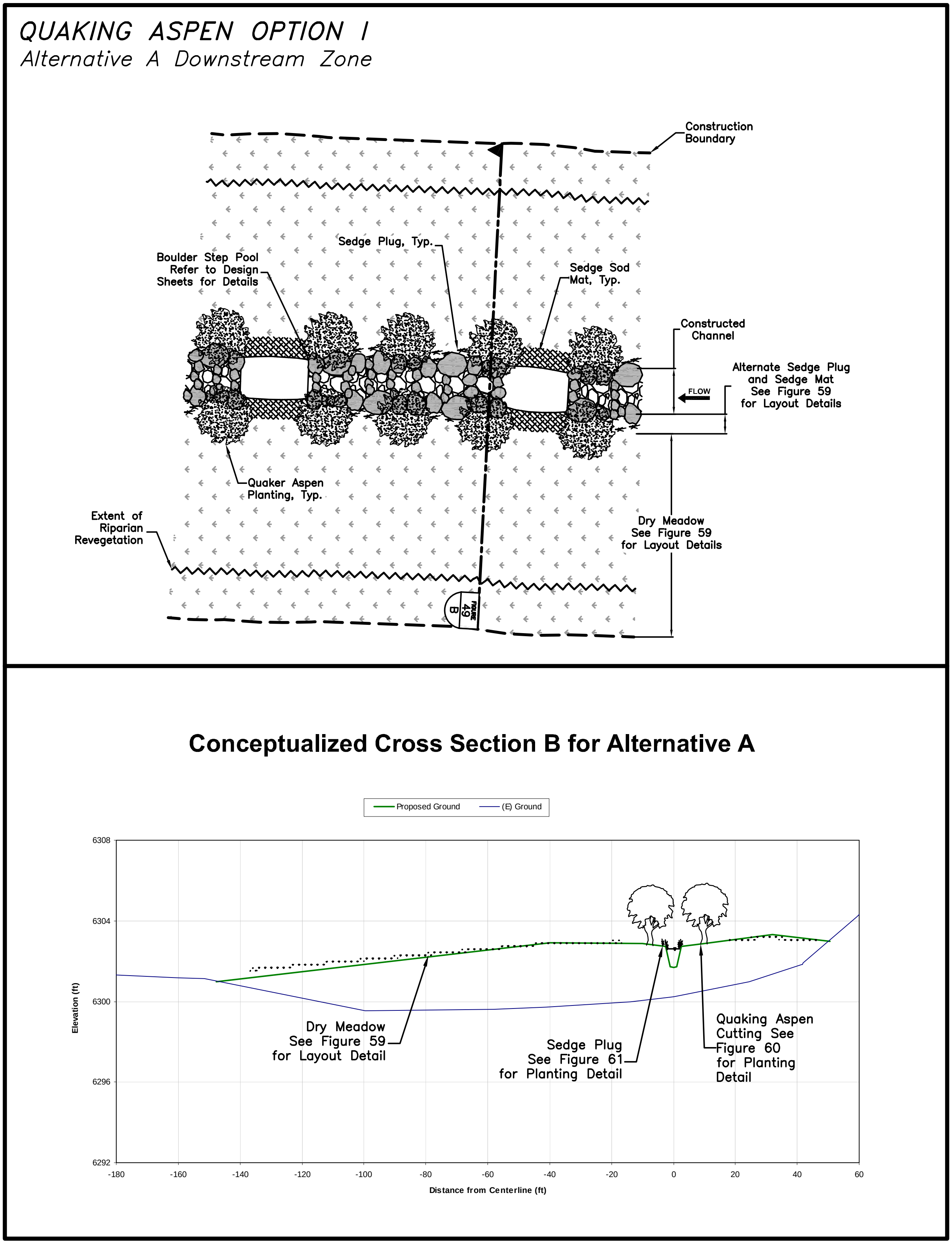


Figure 49: Quaking aspen revegetation option #1 for the flow expansion/downstream zone in Alternative A. Quaking aspen represents the replacement revegetation option.

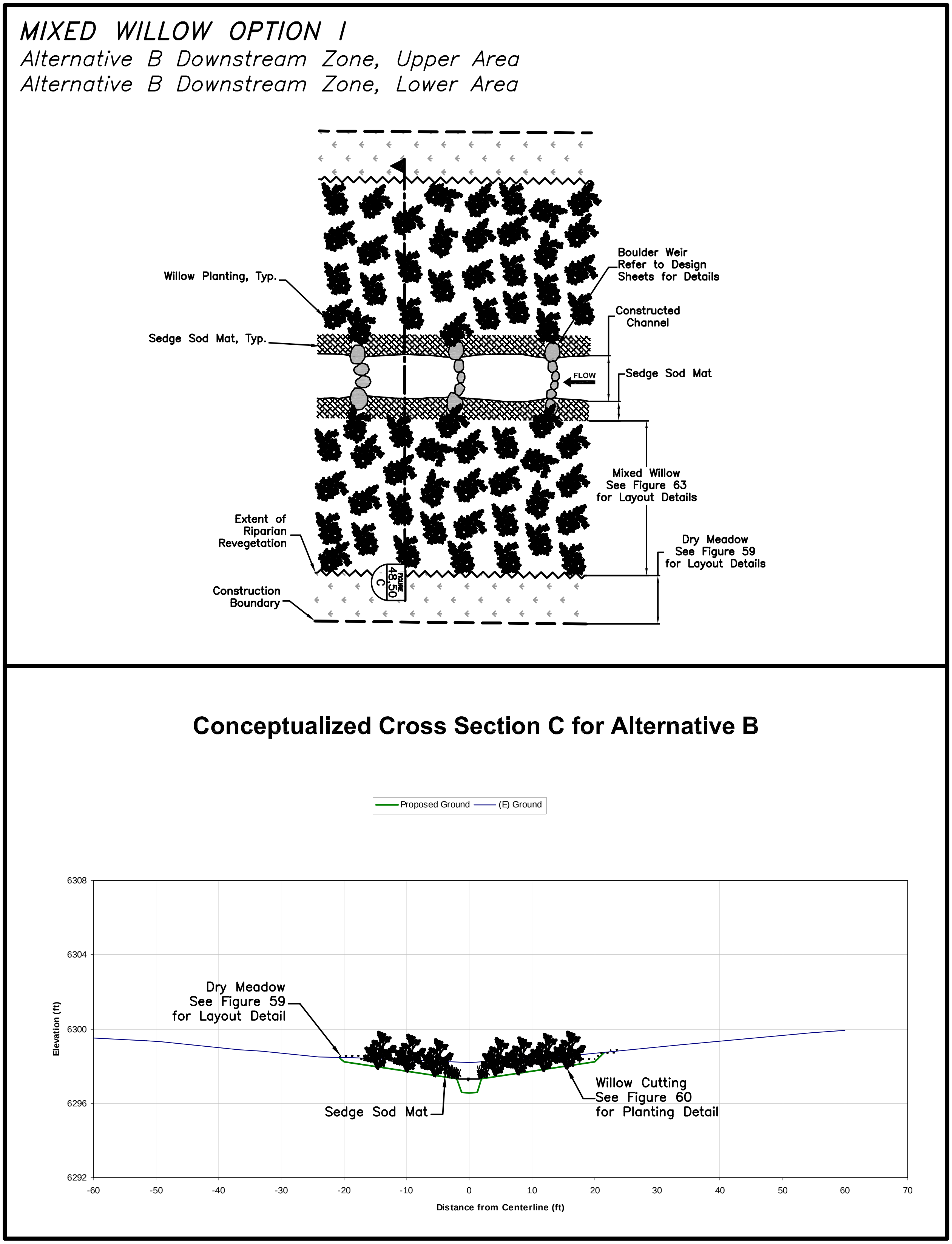


Figure 50: Mixed willow revegetation option #1 for the flow expansion zone and the downstream zone in Alternative B. Mixed willow represents the replacement revegetation option.

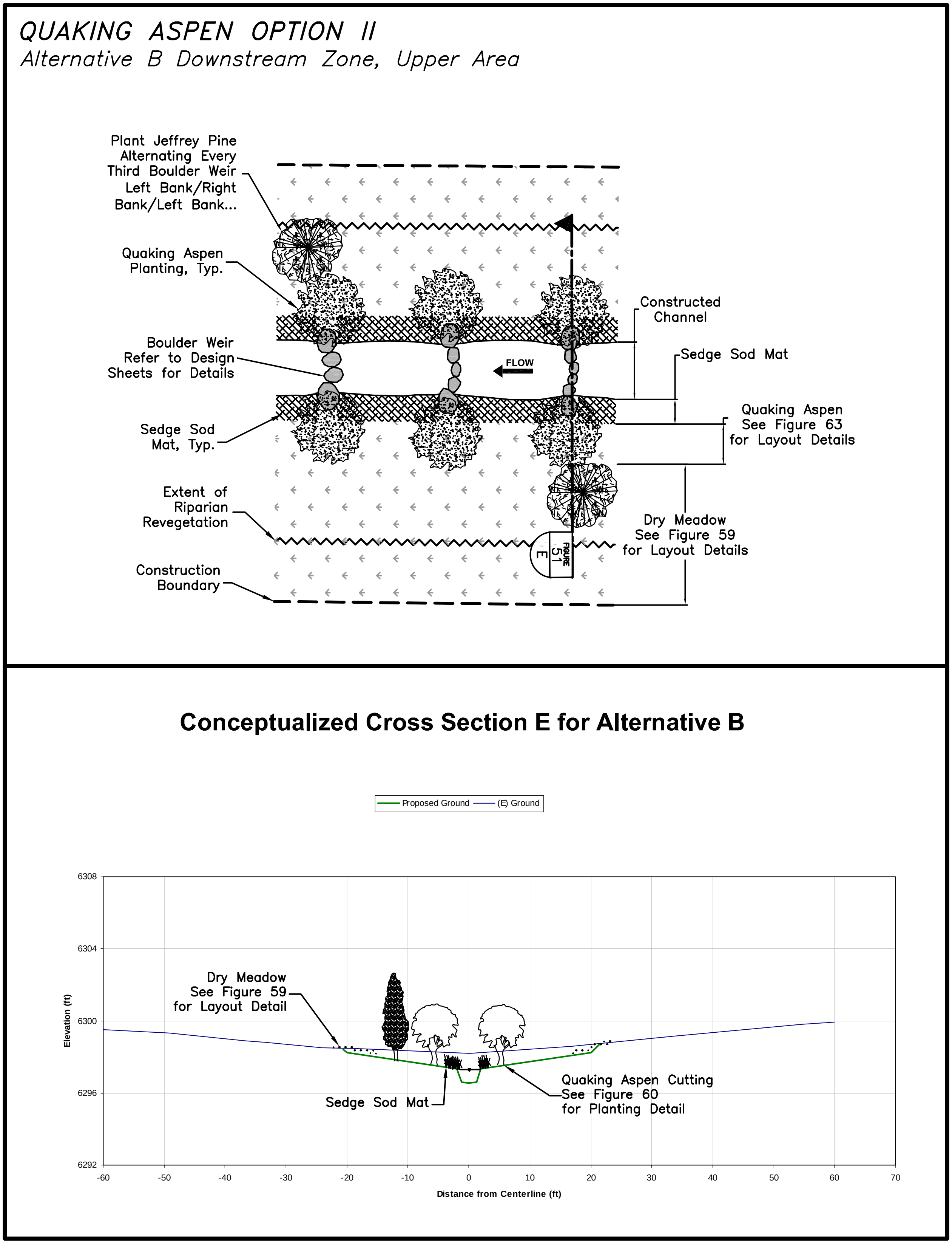
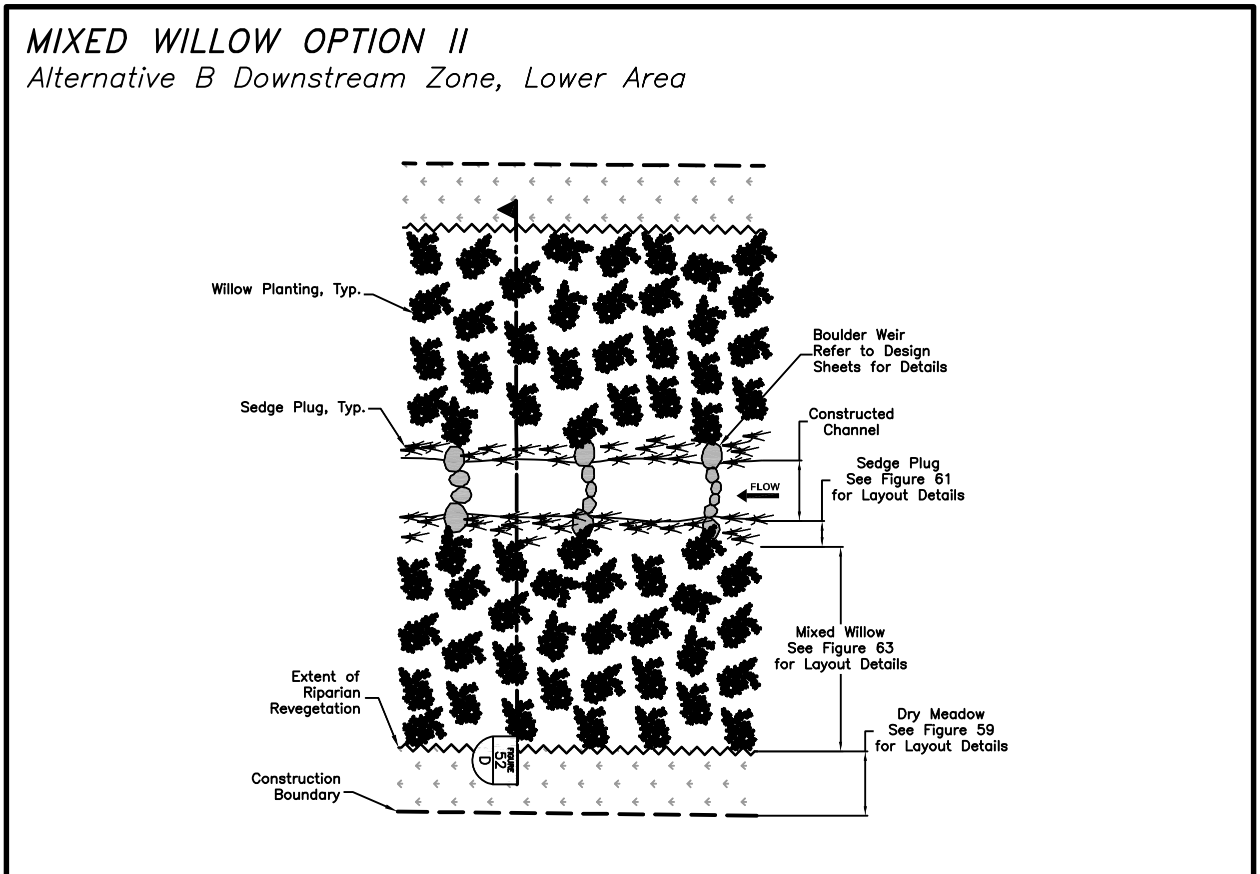


Figure 51: Quaking aspen revegetation option #2 for the flow expansion zone in Alternative B. Quaking aspen represents the restoration revegetation option.

7.4.5 Lower Area for Alternative B

The lower area of the downstream revegetation zone extends approximately 100 ft downstream from theupper area where a transition to a plane bed form occurs. Channel banks will be stabilized with vegetation. For Alternative B, two revegetation options were developed for the lower area: 1) mixed willow option #2 and a 2) meadow option (Figure 52 and Figure 53). Mixed willow option #2 is similar to mixed willow option #1 with the exception that sedge clumps will be planted instead of sedge sod mats, since the channel slope will be less steep in this area (Figure 52). The meadow option relies on a mix of native sedge and rush mats to establish wet meadows along the channel margins (Figure 53). Meadows occurred in the downstream zone historically and therefore represent the restoration option. For both revegetation options, a combination of creeping wildrye plugs and seeds will be planted to establish dry meadow outside the riparian corridor.



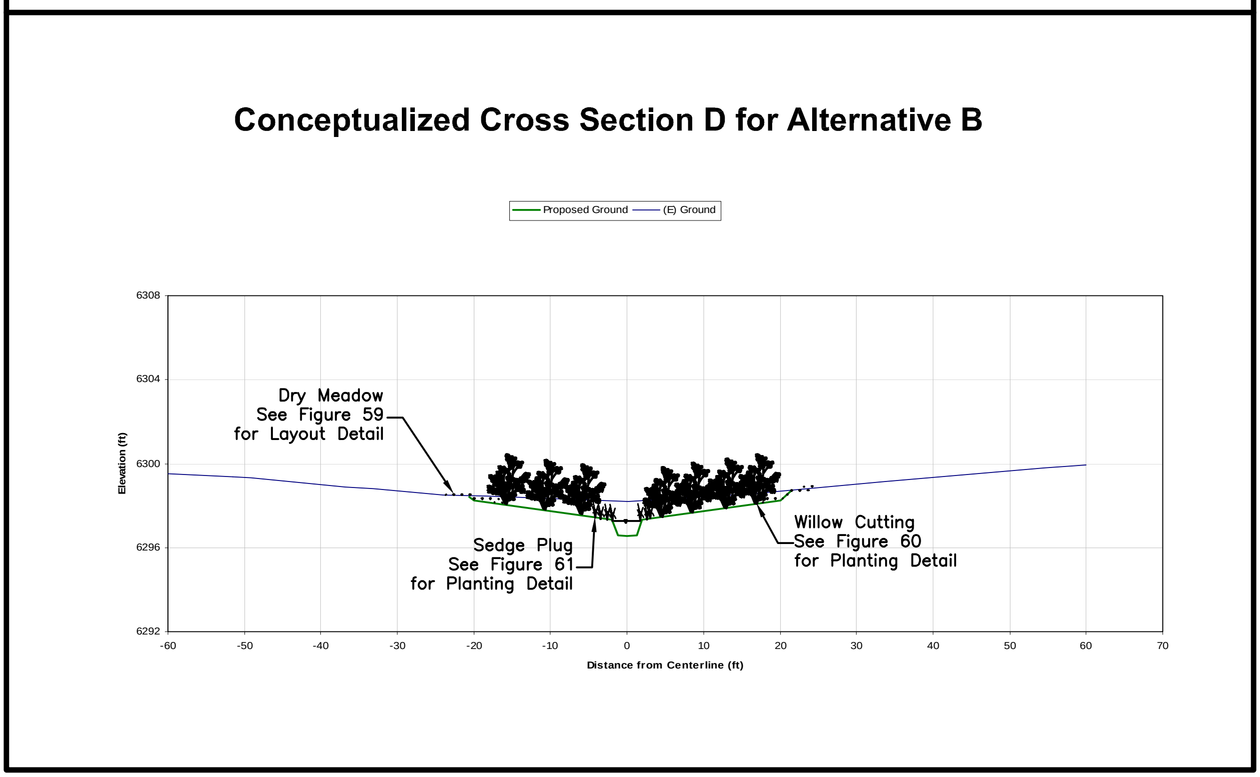


Figure 52: Mixed willow revegetation option #2 for the downstream zone in Alternative B. Mixed willow represents the replacement revegetation option.

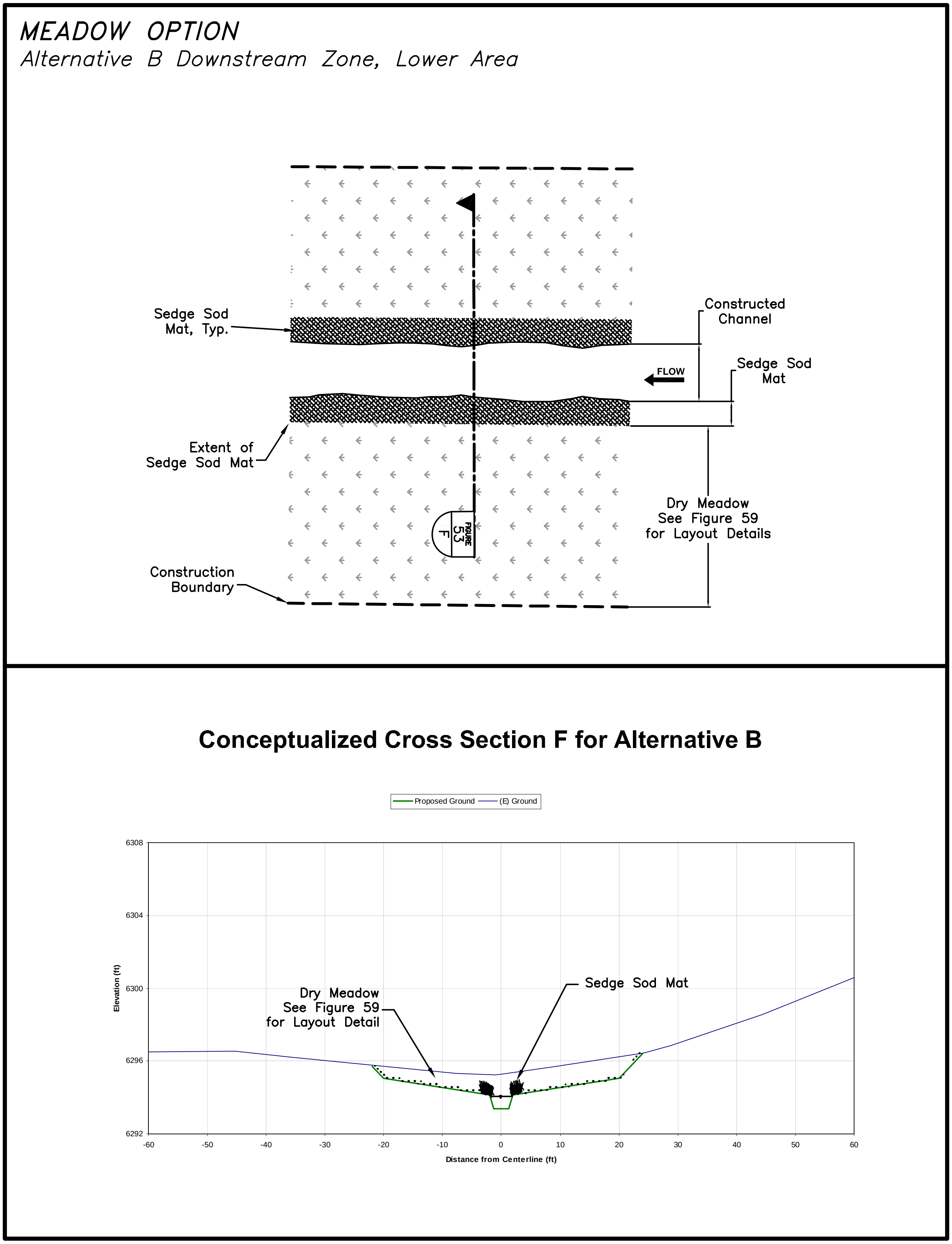


Figure 53: Meadow revegetation option for the downstream zone in Alternative B. Meadow represents the restoration revegetation option.

7.4.6 Wetted Swale Revegetation Zone

The wetted swale is approximately 140 ft long and only occurs in Alternative B. Only one revegetation option was developed for the wetted swale, the meadow option (Figure 54). The wetted swale will be revegetated with sedge sod mats placed across the entire channel and onto the streambanks (Figure 54). Since the wetted swale will be shallow, perennial flow is not expected. Instead, seasonal flows will be captured by the high flow channel, which will allow for some groundwater recharge and the development and maintenance of wet meadow habitat. A combination of creeping wildrye plugs and seeds will be planted to establish dry meadow outside the riparian corridor.

In addition to sedge sod mats lining the channel, willow clumps that are removed from the existing channel to provide construction access will be salvaged and planted just downstream of the confluence area of the high flow channel and the main channel (Figure 43). The salvaged willow clumps will provide immediate streambank stabilization and control for the downstream revegetation zone, as well as inhibit the high flow channel from capturing too much of the main channel flow.

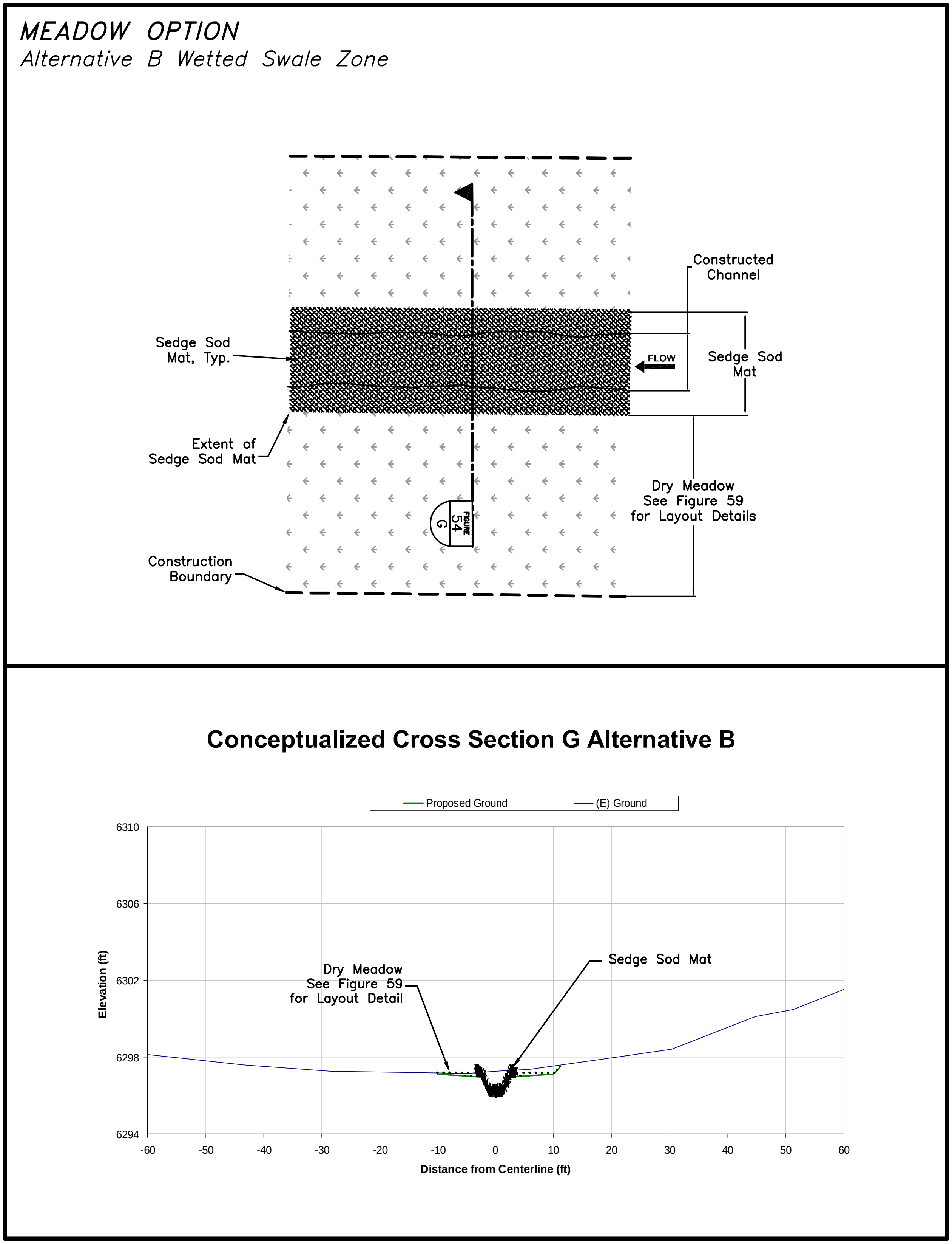


Figure 54: Meadow revegetation option for the wetted swale zone in Alternative B. Meadow represents the restoration revegetation option.

Comparison of Revegetated Area to Anticipated Impacts

One goal of revegetation is to reestablish vegetation in areas that construction directly impacts. Project revegetation should replace or increase the amount of vegetation associated with the SEZ. The proposed revegetation for both alternatives was designed to establish woody riparian or wet/dry meadows in an equal or greater amount than was directly disturbed through project construction (Table 15 and Table 16).

Table 15: Number of acres, cover type, and biohabitat type that will be revegetated following implementation of Alternative A.

Biohabitat	Directly Impacted (Acres)	Post Implementation Area (Acres)
Anthropogenic	0.27	0.29
Wet meadow	0	0
Dry Meadow	1.91	1.63
Woody Riparian	0.08	0.38 / 0.35
Upland	0.04	0 / 0.03
Total	2.30	2.30

Table 16: Number of acres, cover type, and biohabitat type that will be revegetated following implementation of Alternative B.

Biohabitat	Directly Impacted	Post Implementation Area (acres)
Anthropogenic	0.61	0.33
Wet meadow	0	0.29 / 0.08
Dry Meadow	1.89	1.98
Woody Riparian	0.22	0.70 / 0.58
Upland	0.58	0 / 0.33
Total	3.30	3.30

Alternative A proposes to impact 1.99 acres of woody riparian vegetation and dry meadow directly and another 1.13 acres of woody riparian vegetation and wet meadow indirectly (Table 15). Upland habitat and anthropogenic areas are not included in the area considered as part of the post implementation recovery. Alternative A revegetation barely increases woody riparian vegetation and dry meadow coverage over existing conditions within the project footprint. Depending on which revegetation options are selected for Alternative A, the amount of woody riparian and wet/dry meadow habitat replaced varies between 2.01 total acres and 1.98 total acres. The amount of woody riparian vegetation and wet/dry meadow revegetated area under Alternative A is equal to the direct impacts. Regardless of the revegetation options selected the area of proposed revegetation under Alternative A is not sufficient to compensate for losses that may occur through indirect impacts (i.e. long term dewatering of the existing channel associated with the project). The anthropogenic impacts within the construction foot print are about the same as pre-project under Alternative A.

Alternative B proposes to impact 2.11 acres of woody riparian vegetation and dry meadow directly and another 0.75 acres of woody riparian vegetation and wet meadow (Table 16). Upland habitat and anthropogenic areas are not included in the area considered as part of the post implementation recovery. Alternative B revegetation increases woody riparian vegetation and dry meadow coverage within the project footprint. Depending on which revegetation options are selected for Alternative B, the amount of woody riparian and wet/dry meadow habitat replaced under Alternative B varies between 2.97 acres and 2.64 acres. The amount of woody riparian vegetation and wet/dry meadow revegetated area under Alternative B is greater than the direct impacts alone.

Depending on which revegetation options are selected for Alternative B, the area of revegetation that is greater than the direct impacts may be enough to compensate for losses that may occur through indirect impacts (i.e. long term dewatering of the existing channel associated with the project). Furthermore, Alternative B revegetation reduces the remaining anthropogenic and upland habitats within the project footprint.

When indirect impacts and direct impacts are considered together, the overall vegetative cover of several biohabitats within the ESL changes substantially following the implementation of either alternative (Figure 55 and Figure 56). For instance, the acreage of dry meadow will increase as woody riparian (specifically mixed willow) and wet meadow habitats die back as a result of channel de-watering (Figure 55 and Figure 56). For Alternative A, wet meadow habitat within the ESL is likely to disappear completely, regardless of which revegetation option is selected (Figure 55). Quaking aspen, in contrast, will increase under the restoration option for Alternative A.

Similar patterns occur for Alternative B revegetation options. Cover of dry meadow will increase as mixed willow and wet meadow die back following channel de-watering (Figure 56). However, there will be less overall loss of wet meadow habitats for Alternative B because this biohabitat will be planted as part of the revegetation. Cover of sagebrush-rabbitbrush upland types will decrease under Alternative B as a result of accessing the upstream part of the project.

As for Alternative A, cover of quaking aspen will increase under the restoration option for Alternative B.

The above discussion assumes that, for each alternative, either the restoration revegetation options or the replacement revegetation options are chosen; it does not account for mixing and matching between revegetation options. To account for the selection of options from both revegetation strategies, acreages for each cover type in each revegetation zone were calculated (Table 17 and Table 18).

The revegetated cover type depends on the revegetation option that is selected. For instance, the restoration option for Alternative A will create 0.27 acres of quaking aspen in the flow expansion/downstream zone, whereas the replacement option will create 0.27 acres of mixed willow. In either case, the same amount of woody riparian habitat is created (Table 17). However, the same biohabitat is not always created. For instance, the restoration option for Alternative B in the upstream zone will create 0.33 acres of quaking aspen (woody riparian), whereas the replacement option will create 0.33 acres of Jeffrey pine (upland) (Table 18).

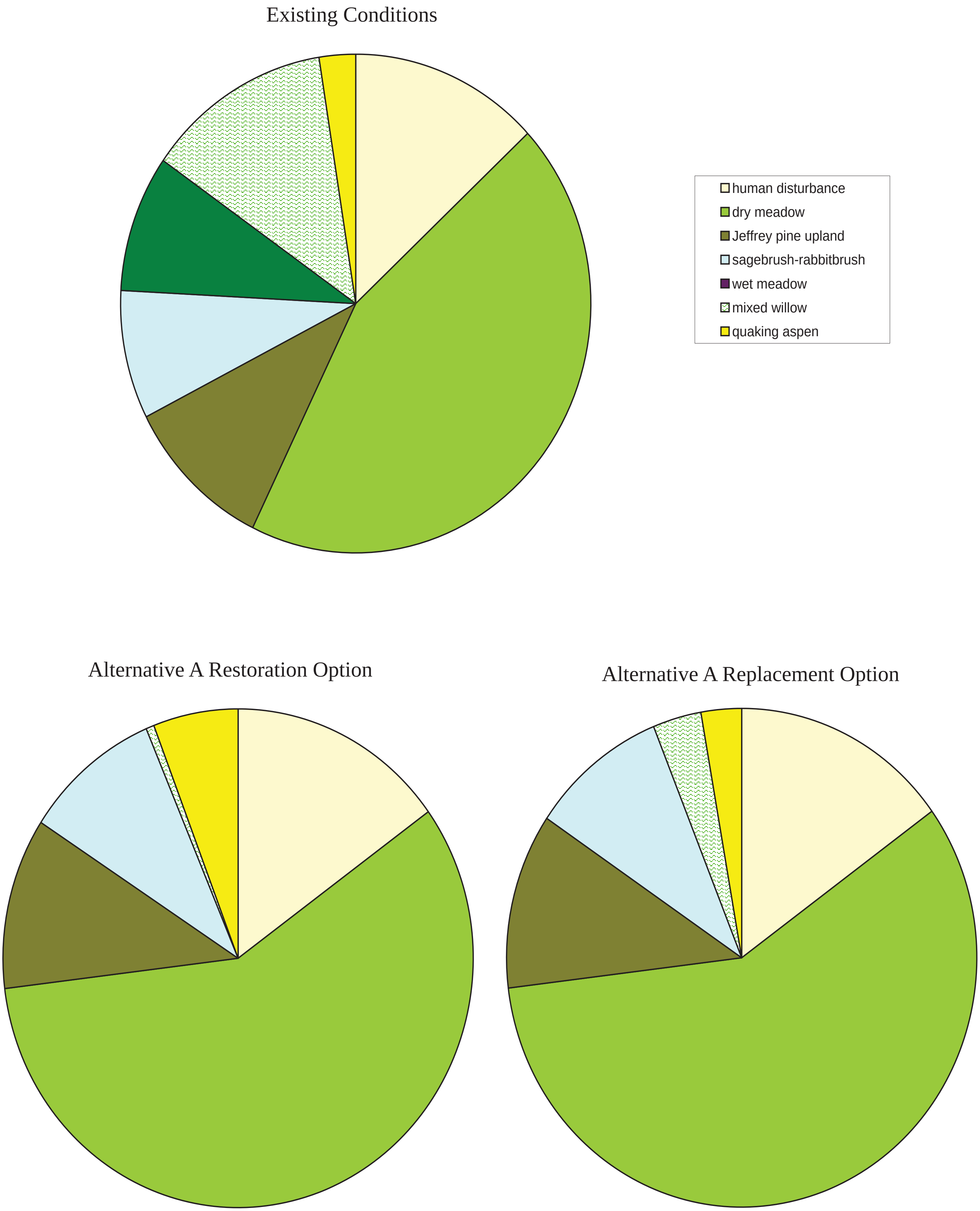


Figure 55: Comparison of total percent cover of biohabitats within the Environmental Study Limit (ESL) between existing conditions and Alternative A revegetation options.

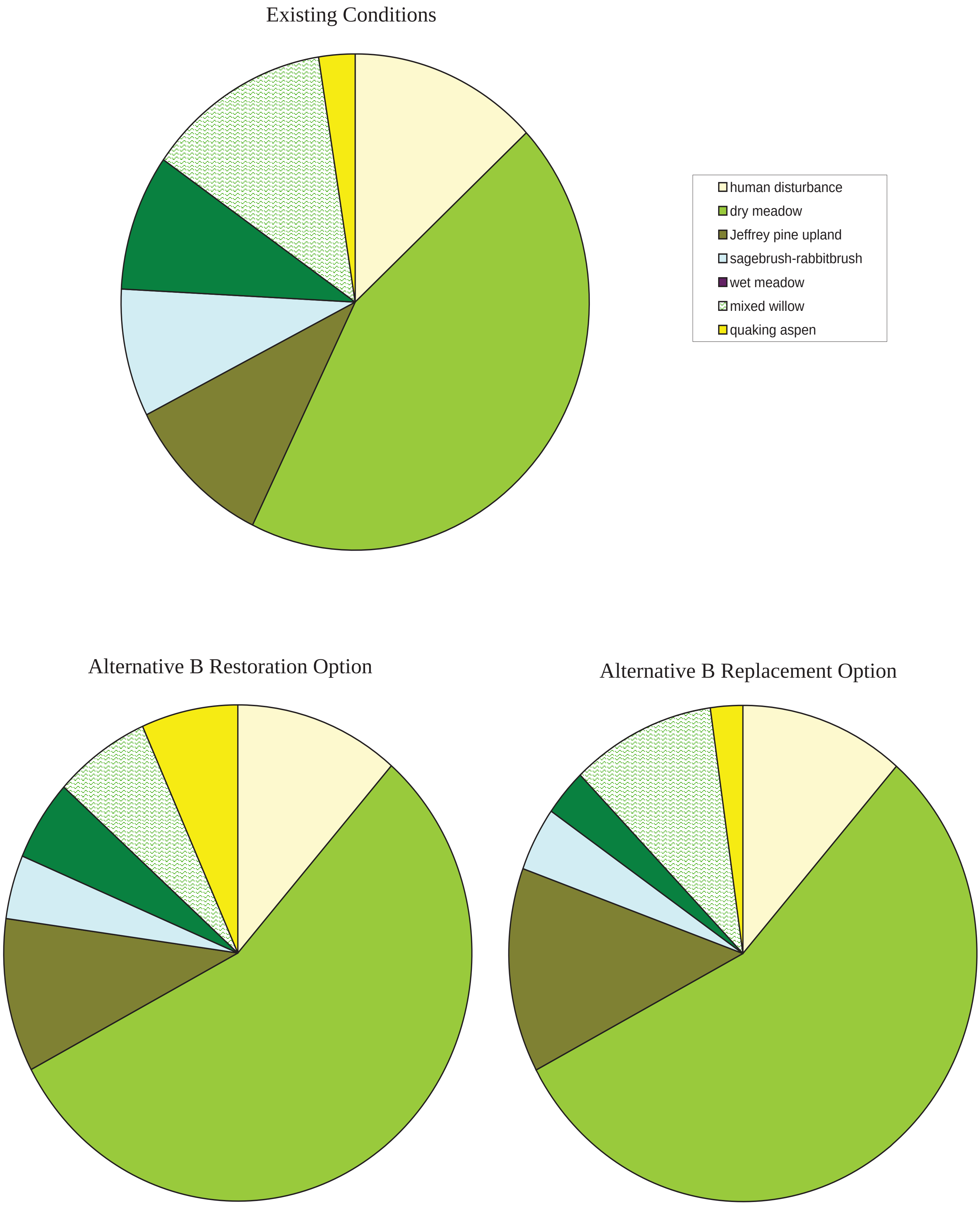


Figure 56: Comparison of total percent cover of biohabitats within the Environmental Study Limit (ESL) between existing conditions and Alternative B revegetation options.

Table 17: Comparison between revegetation options of cover type acreages within each revegetation zone for Alternative A.				
Area	Revegetation Zone	Restoration Option	Replacement Option	Total Acres
SEZ	Upstream	Quaking aspen	Jeffrey pine	0.03
	Upstream Culvert	Human disturbance	Human disturbance	0.01
	Downstream Culvert	Mixed willow	Mixed willow	0.07
	Flow Expansion/Downstream	Quaking aspen	Mixed Willow	0.27
Other	Staging areas and other human disturbance Existing human disturbance	Dry meadow N/A	Dry meadow N/A	1.63 0.29
			Total	2.30

Table 18: Comparison between revegetation options of cover type acreages within each revegetation zone for Alternative B.				
Area	Revegetation Zone	Restoration	Replacement	Total Acres
SEZ	Upstream	Quaking aspen	Jeffrey pine	0.33
	Upstream Culvert	Human disturbance	Human disturbance	0.02
	Downstream Culvert	Mixed willow	Mixed willow	0.05
	Flow Expansion	Quaking aspen	Mixed willow	0.1
	Downstream	Wet meadow	Mixed willow	0.21
	High Flow Channel	Wet meadow	Wet meadow	0.08
Other	Staging areas and other human disturbance	Dry meadow	Dry meadow	1.98
	Slope of dike along parking lot	Mixed willow	Mixed willow	0.22
	Existing human disturbance	N/A	N/A	0.31
			Total	3.30

7.4.7 Revegetation Installment and Planting Details

Different types of plant material should be installed differently. Dormant hardwood cuttings may be installed in holes dug using a WaterJet Stinger, and salvage willow clumps may be planted in holes dug with an excavator (Figure 57, Figure 58, and Figure 59). Herbaceous sedges and rushes will need to be grown in a nursery and planted as plugs or mats, depending on the species (Figure 60). Grass species may be planted as plugs and be sown in the fall as a seed mix. Seeded areas should be mulched.

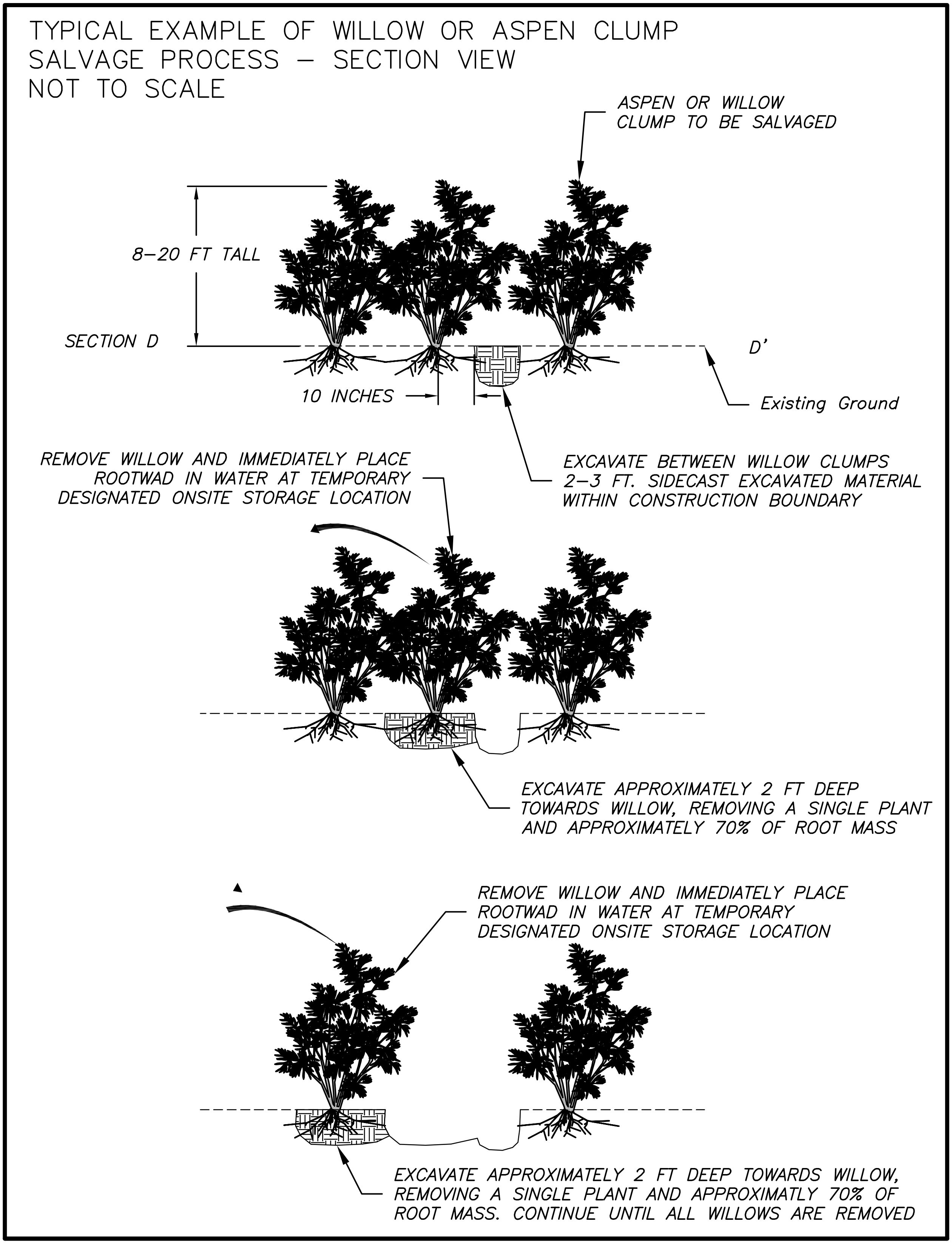
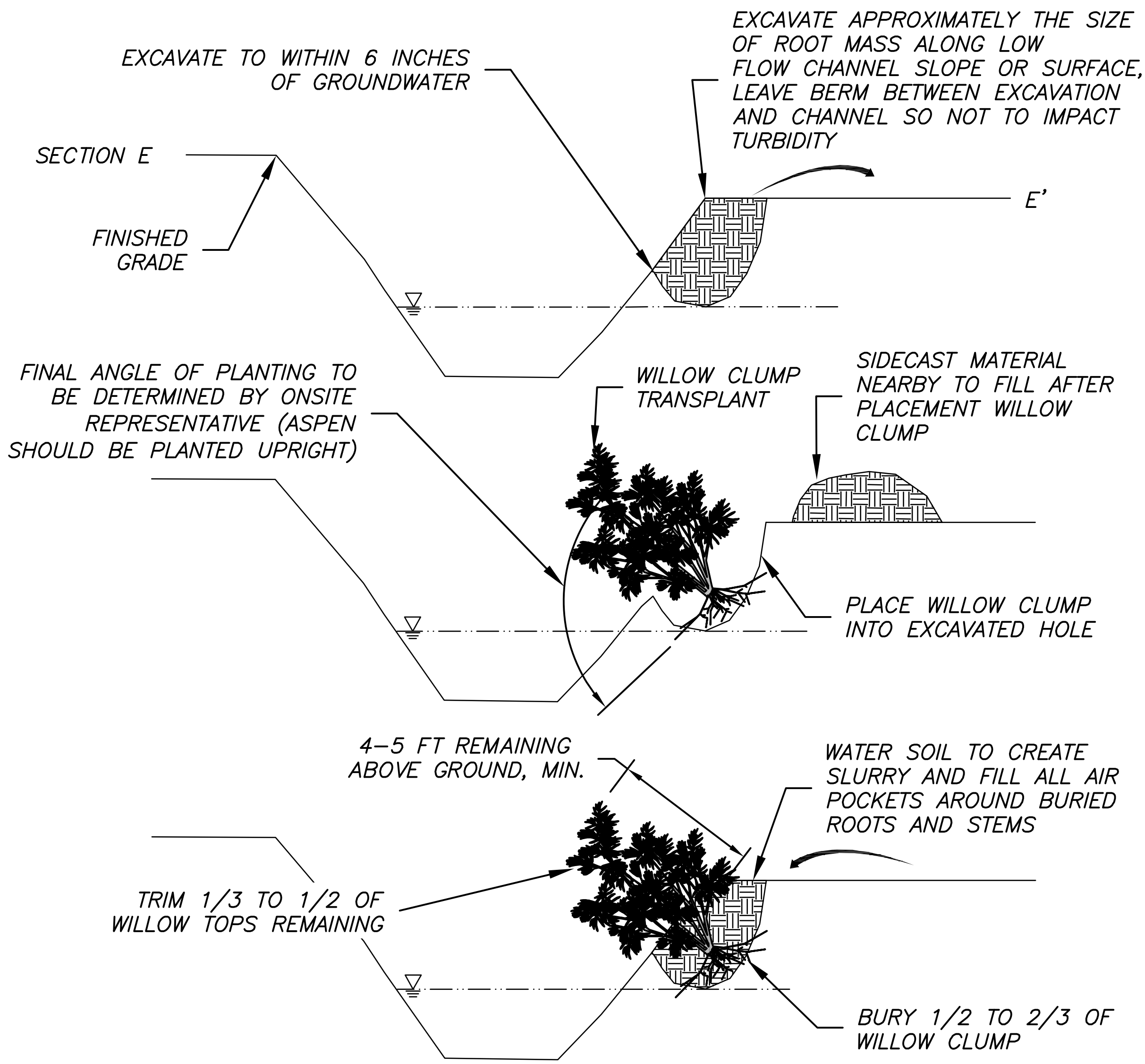


Figure 57: Typical example of the salvage process for salvaged willow or aspen clumps.

EXAMPLE OF WILLOW CLUMP PLANTING ALONG CHANNEL, TYP.
FOR EXAMPLE OF ASPEN CLUMP PLANTING SUBSITUE ASPEN FOR WILLOW, TYP.
SECTION VIEW NOT TO SCALE



NOTES

1. An onsite representative will flag willows within construction boundary to be salvaged for clump plantings.
2. An onsite representative will specify the temporary storage location for extracted willow clumps.
3. An onsite representative will specify the locations where clump plantings shall be placed.
4. Clump plantings shall be planted as quickly as feasible after removal from designated storage site.
5. Excavate hole approximately the size of the rootwad along the low flow channel slope or surface. Leave berm between excavation and channel so not to impact turbidity.
6. Place one clump planting in hole burying 1/2 to 2/3 of willow clump. Trim 1/3 to 1/2 of willow tops remaining.
7. Backfill around rootwad with sediment removed from hole, water soil to create slurry and fill in all air pockets around buried roots and stems.
8. Upon completion of backfill, regrade area around planting as necessary so that finished surface is no more than 1 ft above grade.

Figure 58: Typical example of the planting process for willow or aspen clumps.

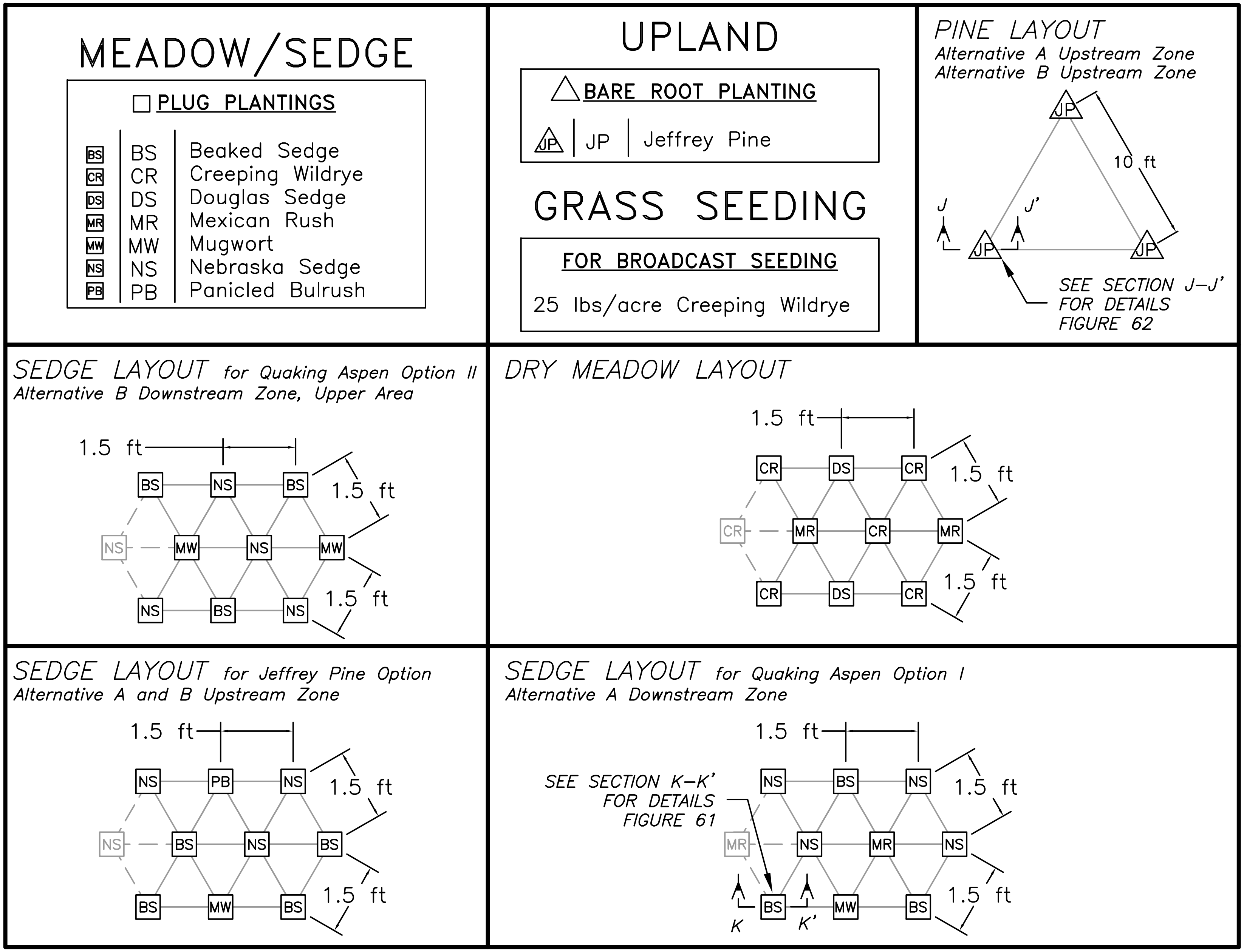


Figure 59. Typical layouts for sedge clump plantings, dry meadow plantings, upland Jeffrey pine plantings, and grass seeding.

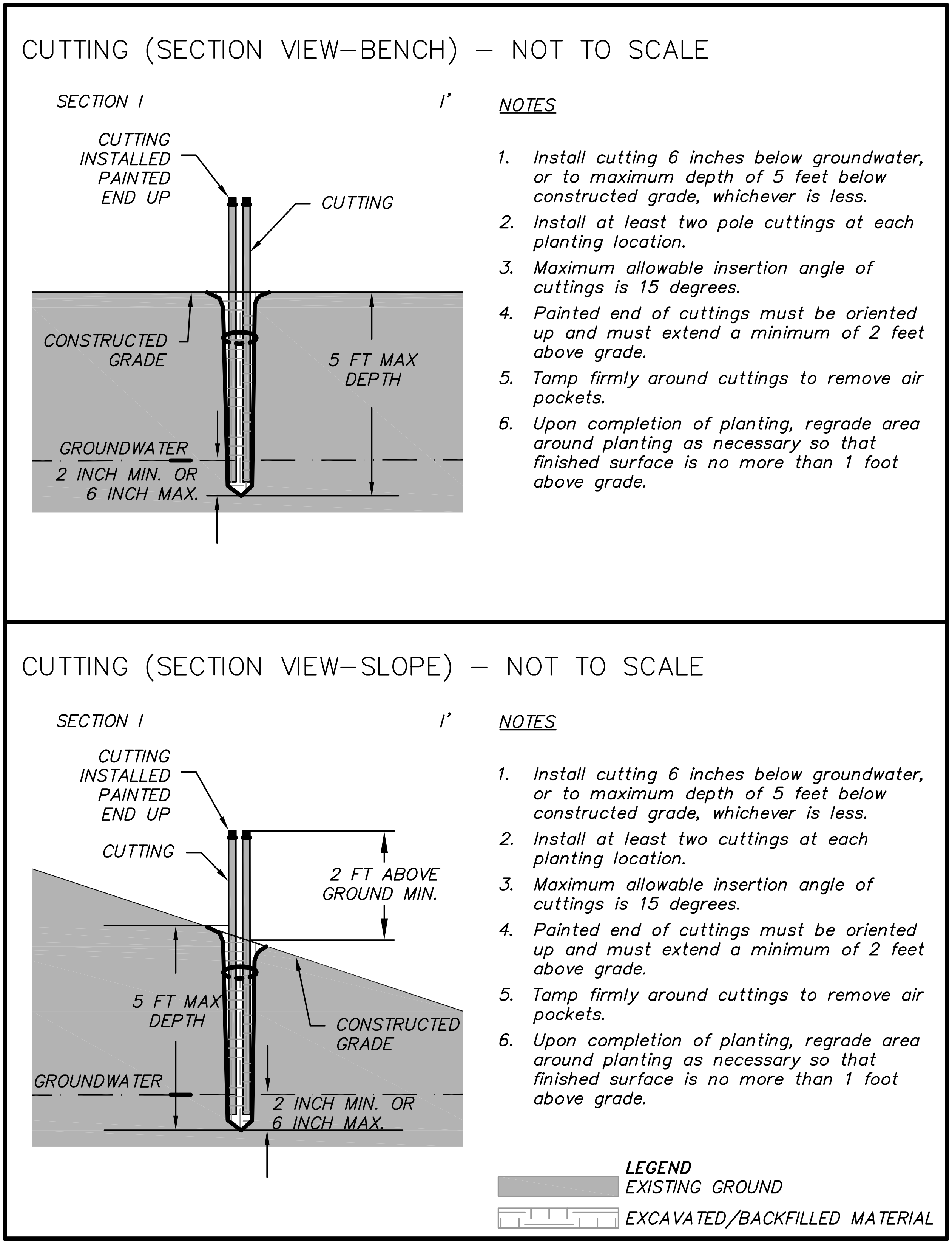


Figure 60: Typical example of the planting process for riparian hardwood cuttings.

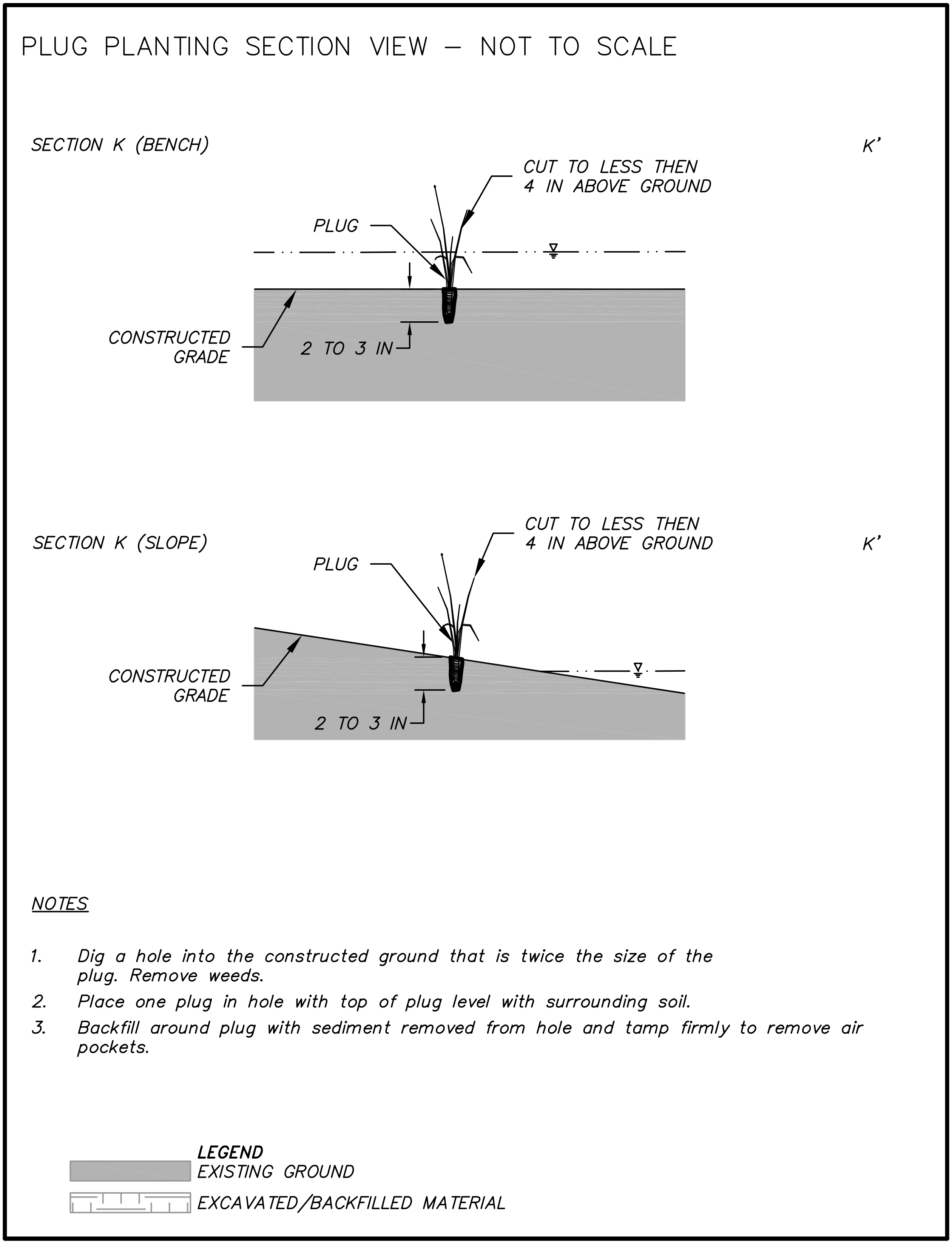


Figure 61: Typical example of the planting process for herbaceous plugs.

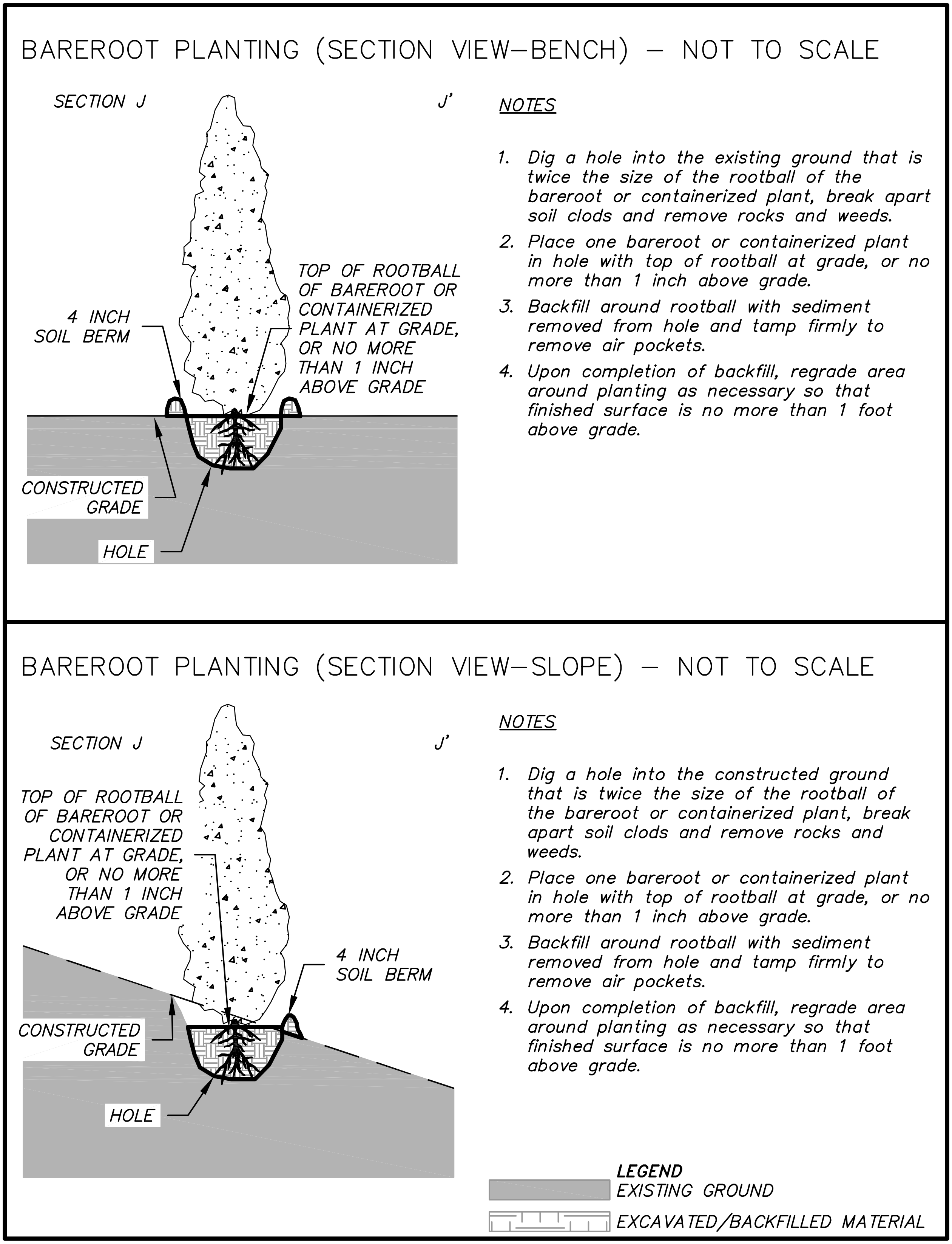


Figure 62: Typical example of the planting process for bare-root plants.

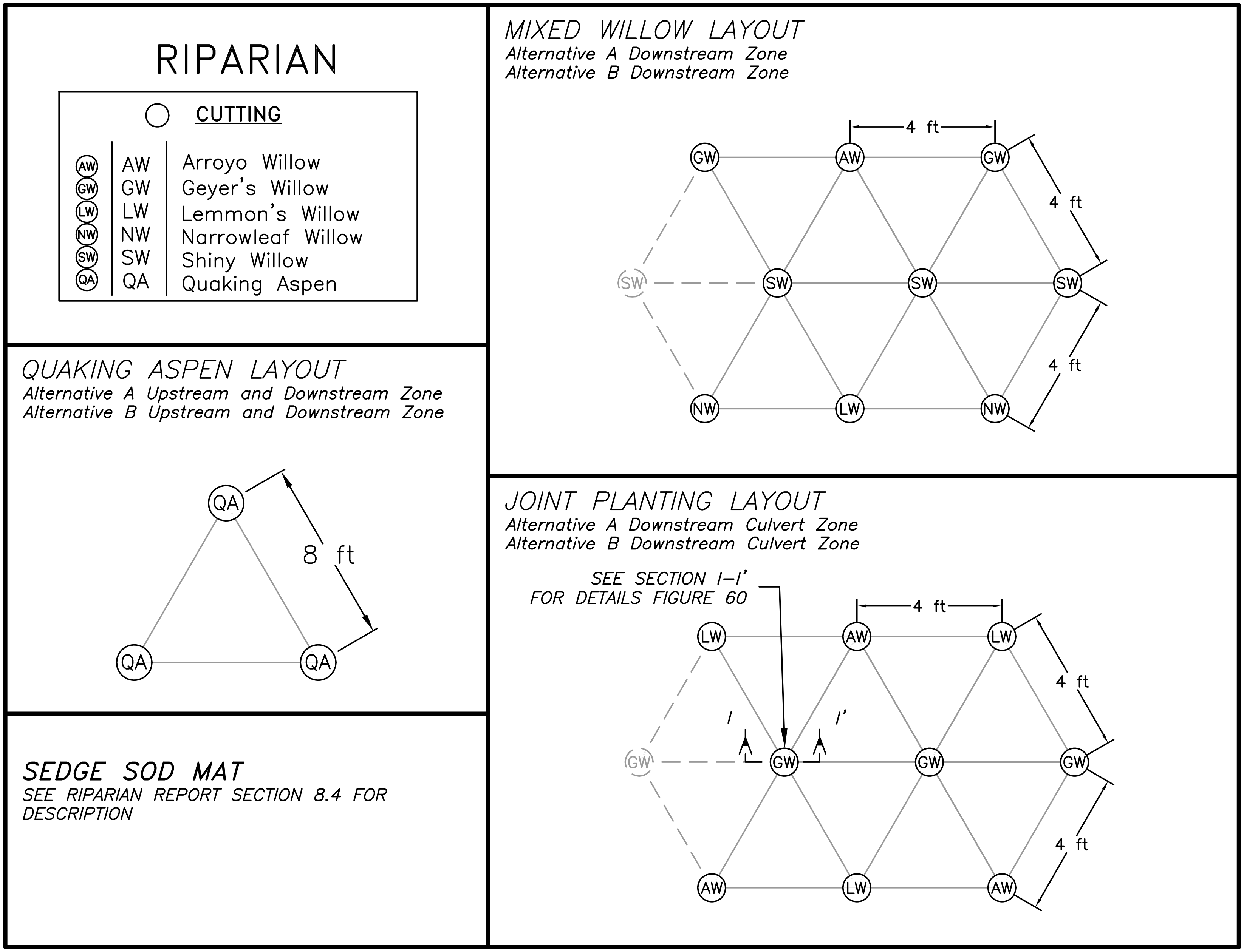


Figure 63: Typical layouts for woody riparian layouts (e.g., mixed willow, quaking aspen).

8.0 CONSTRUCTION AND PERMITTING CONSIDERATIONS

This section discusses the general construction considerations identified through this conceptual design process and is intended to be useful for moving into the next level of design and ultimately to construction. The opinion of probable construction cost is then presented for each of the two developed conceptual alternatives.

8.1 Construction Considerations

The conceptual alternatives developed have incorporated concepts that are considered constructible using commonly available materials. As with any construction project, there are aspects of the project that will be more straight forward than others. We offer the following thoughts based on the conceptual level of design development completed so far.

8.1.1 Construction Access

Site access is generally good, but does present challenges. Highway 50 is a key access route and during the summer months experiences a large volume of traffic. For this reason, construction is anticipated to occur after the Labor Day Holiday weekend. Once construction has begun, Highway 50 may be reduced to two lanes of traffic (one lane each way) as necessary. A detailed traffic control plan should be developed as part of the final design process or as a contractor submittal prior to construction commencing.

A temporary access road will be required to construct the channel downstream of Highway 50. This access is currently anticipated to occur from Kahle Drive, and it will require crossing the existing Burke Creek channel, impacting the existing riparian corridor. This approach appears preferable compared to accessing the downstream channel directly from Highway 50 due to traffic volumes and the steep embankment adjacent to the highway.

Accessing the channel upstream of Highway 50 for Alternative A will likely occur from either the adjacent commercial parking lot and/or the Highway 50 shoulder area just north of the upstream channel. Accessing the upstream channel for Alternative B channel work could utilize space east of the commercial parking lot and west of the sports complex off of Kingsbury Grade (see Sheet B-1 of the conceptual designs for location). No discussions occurred with specific landowners regarding construction access as part of this effort.

The adjacent commercial property's parking lot would be also impacted if Alternative B is pursued. The current concept design would affect the most northerly parking row and the north half of the middle parking row. Impacts could be temporary for access to the upstream channel construction and for the permanent construction of retaining walls along the northerly side of the parking lot. These issues need to be worked out during the final design process.

8.1.2 Culvert Replacement and Gravity Sanitary Sewer Relocation

Both alternatives include the construction of a new culvert crossing of Highway 50, although the precise location and depths differ between the two alternatives. It is currently envisioned that a pre-cast concrete culvert would be utilized in order to decrease the amount of construction time necessary and potentially to reduce project costs as well.

Currently, a gravity sewer runs parallel to Highway 50 and is located west of the highway. Sources differ on the exact size of the sewer pipe, with 8 inch and 10 inch designations being made. The survey conducted for this conceptual design was used for the location of the pipe and to determine the slope. The existing pipe's slope was calculated to be 1.15%. A more detailed investigation of the pipe size, horizontal and vertical locations must be conducted as part of the final design. We recommend potholing to locate the sewer pipe in the vicinity of the planned culvert crossing. We also recommend other utilities in the area be identified and potholed during the design process to accurately locate them. This effort would allow the design process to minimize impacts to the existing utilities, potentially saving time and money during construction.

The culverts proposed for both alternatives affect this sewer main, but to differing degrees. Alternative A does not require the sewer main to be relocated but the sewer will need to be protected. We currently envision encasing the existing sewer pipe in concrete as it will be buried within the engineered streambed material but still above the culvert invert. This could be accomplished at a joint in the precast culvert sections, or by special ordering and casting a section of the culvert that allows for a cast-in-place encasement of the sewer pipe. Regarding the encased sewer pipe in the channel itself, it is anticipated that the encasement would be slightly below the finish channel elevation, and it would also serve as an added structural element for channel stability. It is possible that other cross channel stability concrete sections may be added as part of the final channel design concept.

The horizontal and vertical position of the Alternative B proposed culvert requires the sewer main to be relocated. Three options have been considered for this conceptual design effort to determine if relocating the sewer line is feasible (Figure 64). The options considered have not been fully designed, and all focus on utilizing gravity options, as opposed to other options such as siphons and pump stations. Non-gravity options would require additional operational and maintenance costs and it is recommended that all gravity options be exhausted prior to considering other solutions.

Gravity Option 1 considers installing a new pipe between the two existing manholes located north and south of the proposed culvert. The pipe would be designed to accommodate accepted manufacturer installed deflection for a 10 inch PVC pipe and could, theoretically, be installed by open trench or directionally drilled, although subsurface conditions are not known at this time and may render this option infeasible or undesirable. This option crosses all lanes of traffic and would impact Highway 50 traffic and require significant traffic control. The pipeline slope would decrease due to the additional length to approximately 0.84%.

Gravity Option 2 considers the installation of new pipe originating from the existing northern manhole and terminating at a new manhole located near the upstream end of the proposed culvert. Another pipe would then be installed to cross back under Highway 50 to the existing southern manhole. Like Option 1, this option could significantly affect Highway 50 traffic and unknown subsurface conditions could render this option infeasible or undesirable. The pipeline slope would decrease due to the additional length to approximately 0.84%.

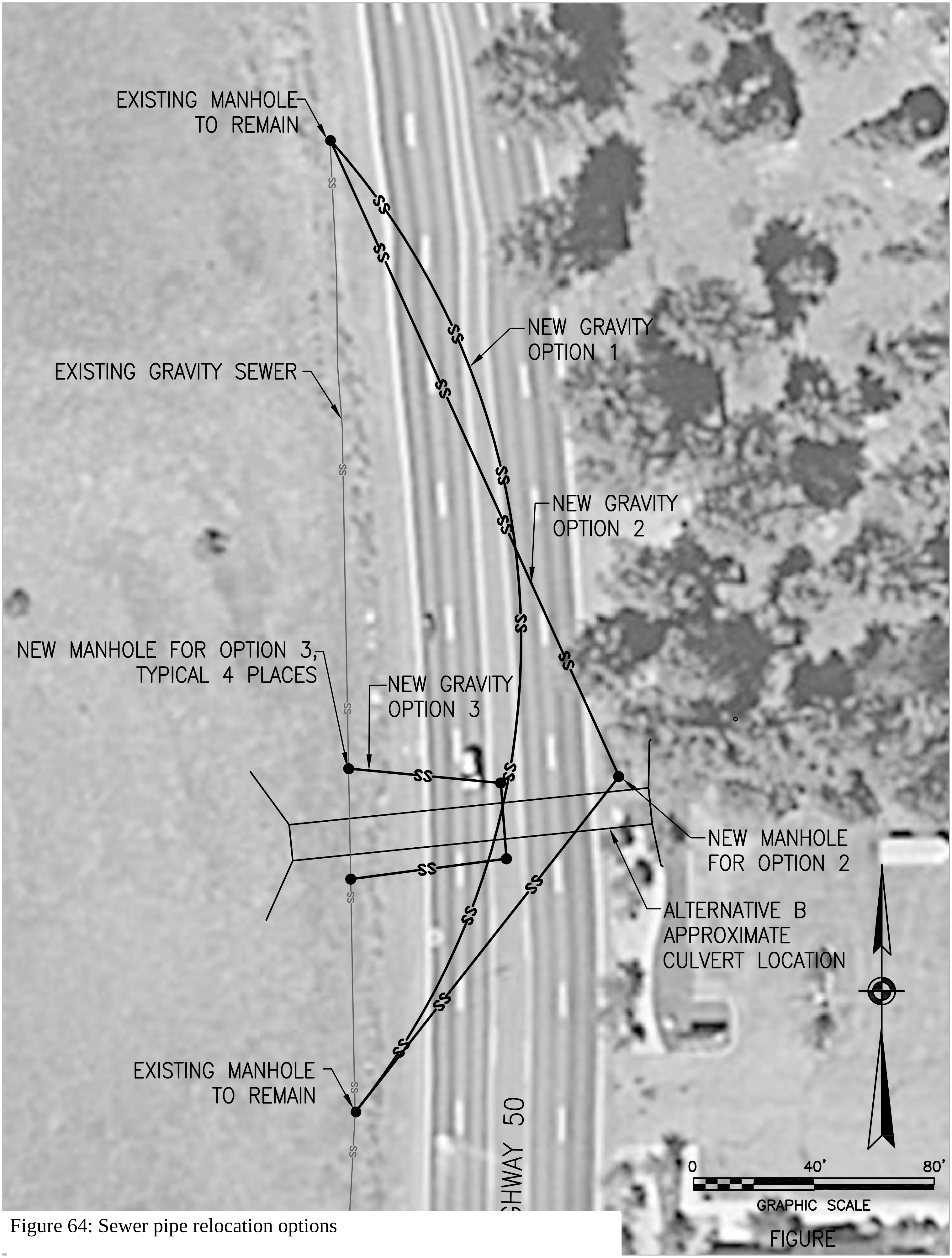


Figure 64: Sewer pipe relocation options

Gravity Option 3 is, of the three gravity options considered, the one that would impact Highway 50 traffic the least and is located within the required excavation footprint of the Alternative B culvert location. It also requires less new pipe but more manholes. Option 3 proposes a new manhole located near the downstream end of the culvert and the installation of a new pipe section to a new manhole located in the turn lane of Highway 50. Another new manhole would be installed on the south side of the culvert and the section of pipe connecting the two would travel through the culvert and would be encased, similar to Alternative A. A fourth, and final, new manhole would be installed near the downstream end of the culvert, on the south side. This manhole would connect the new sewer pipe to the existing one. This option's slope would be approximately 0.3%. If this is the preferred option, we suggest the existing sewer line be potholed near the tie in points and the slopes be carefully analyzed during final design. Obviously there are combinations of these alternatives that should be considered. Our goal was to consider this issue to avoid a potential fatal flaw and to aid in the development of constructible alternatives.

8.1.3 Retaining Walls

Alternative B also requires a new retaining wall to be constructed along the north end of the parking lot. The design of the retaining wall will be part of the final design process. This design element requires a geotechnical investigation be conducted prior to the final design phase. The geotechnical investigation is also needed to provide recommendations for the sewer and culvert crossing under Highway 50, downstream soil conditions and fill recommendations, and upstream channel fill recommendations for Alternative B.

The final design process should endeavor to balance cut and fill quantities as much as possible, and the subsurface characterization of materials from the geotechnical investigation will be useful in this respect. The rock work and actual channel construction requires some skill and understanding of the design process to obtain a functioning final product; a contractor with in-stream construction experience is recommended. It is also recommended that the project team be involved during construction. Construction of the channel in the culvert itself is a little more challenging, and has been accomplished successfully many times in the past. This can be accomplished section by section, or by more specialized equipment once the entire culvert is in place. The preferred construction approach will depend upon the final design.

Temporary construction impacts can be planned for and managed to avoid offsite impacts to the environment. Appropriate techniques to manage air and storm water pollution should be developed as part of the final design and implemented during construction. The desired vegetation restoration concept will impact how to best approach temporary erosion control methodologies. Likewise, the preferred alternative that is fully developed will help determine the best way to deal with water management of any flow in the existing Burke Creek channel. It is not anticipated that much flow will be present after Labor Day, so this should not present a significant challenge or cost for the project.

8.2 Opinion of Probable Cost

A planning level opinion of probable construction cost was completed based on the current conceptual designs. The opinion of probable cost for Alternative A is $1,990,800 and $2,796,000 for Alternative B. Appendix L includes a table detailing line item costs and quantities. An estimating contingency was included in the opinion of probable cost which accounts for material and construction cost volatility and uncertainties associated with the current conceptual level of this project. The opinion of probable unit costs attempts to reflect the challenges associated with construction equipment access constraints and traffic control considerations during construction. Additional construction constraints may be determined during the geotechnical investigation and the final design development.

9.0 ALTERNATIVES ANALYSIS

To benefit the TAC in analyzing the two developed alternatives, project criteria were identified. The project criteria are presented in Table 19 and a definition of each criterion is presented below.

Section **Error! Reference source not found.** presents an alternatives comparison matrix (Table 20) and briefly discusses Alternatives A and B with respect to each of the project criterion. Table 20 also includes existing conditions for additional comparison of the alternatives and to help identify project benefits.

9.1 Alternative Comparison Criteria

9.1.1 Hydraulics: Flood Flow Conveyance

Improving flood flow conveyance is a project objective. This criterion evaluates the channel's ability to convey flows up to the 100 year return flow event based on the modeling approaches presented Sections 4.5 and 6.4. In Table 20 a channel configuration that fully contains the 100 year flow event is rated good. A rating of moderate or poor indicates that out of channel flow is possible or likely, respectively.

9.1.2 Fisheries: Fish Passage

Fish passage is a project objective. This criterion evaluates the channel's ability to provide conditions favorable for fish passage based on physical and hydraulic properties (velocity, water depth, and drop heights) established in Section 4.6. In Table 20 a rating of good indicates that favorable fish passage conditions are expected. A rating of moderate or poor indicates that fish passage conditions are less than ideal or that fish passage is unlikely, respectively.

9.1.3 Riparian: Impacts Existing Vegetation

This criterion qualitatively considers the extent of impact on existing vegetation, giving higher weight to impacts on wetland vegetation, mature conifers and riparian trees. In Table 20 a rating of none indicates that no impacts are expected to the existing vegetation. A rating of moderate indicates that some impacts are expected, but that the impacts are less than significant or are mitigated as part of the design. A rating of poor indicates that no mitigation is possible for the potentially significant existing vegetation impacts.

Table 19: Project Criteria	
Category	**Criterion**
Hydraulics	Flood flow conveyance
Fisheries	Fish passage
Riparian	Impacts to existing vegetation
Geomorphology	Sediment management
	Defined channel
	Channel stability
Construction	Temporary impacts
	Commercial parking lot permanent impacts
	Sewer line permanent impacts
	Other utility permanent impacts
	Opinion of probable cost

9.1.4 Geomorphic: Sediment Management

Improving sediment management is a project objective. This criterion qualitatively evaluates the channel configuration's ability to manage sediment. In Table 20 a rating of good indicates that sediment is not expected to settle within the culvert and any aggradation within the project reach will not result in negative impacts such as increased flooding potential or avulsion. A rating of moderate indicates that aggradation may occur and may increase the possibility for flooding in the long term, but avulsion is unlikely as is aggradation within the culvert. A rating of poor indicates that either avulsion, aggradation within the culvert, and/or long-term flooding due to aggradation is likely.

9.1.5 Geomorphic: Defined Bankfull Channel

This criterion evaluates the channel's physical configuration with respect to the bankfull channel over time. In Table 20 a rating of good indicates that currently or at the time of project completion and into the foreseeable future, the bankfull channel is anticipated to remain functioning. This includes future impacts related to aggradation and the channel's response to flow events up to the 100 year flow. A rating of moderate indicates that the channel may suffer from current or future aggradation or may succumb to hydraulic forces from flow events less than the 100 year event that result in a loss of function, but that the loss of function does not result in significant fish passage concerns, avulsion, or loss of channel geometry definition. A rating of poor indicates that the channel currently is or is anticipated to lose over time the bankfull channel functionality due to aggradation, incision, or hydraulic forces from storm events much less than the 100 year flow event.

9.1.6 Geomorphic: Channel Stability

This criterion qualitatively evaluates the channel's long-term stability. Primarily, this criterion focuses on the channel's response to high flow conditions and the potential for avulsion or grade control issues such as the formation of a new head cut within the project reach. In Table 20 a rating of good indicates that the channel is expected to remain stable within the foreseeable future. A rating of moderate indicates that the channel may succumb to forces, but neither sediment management nor fish passage would be affected to a significant level. A rating of poor indicates that the channel is considered unstable.

9.1.7 Construction: Temporary Impacts

This criterion qualitatively evaluates the magnitude of temporary impacts due to construction activities. Potential impacted areas include Highway 50 and the surrounding intersections and streets, Rabe Meadow trailhead parking lot, and existing utilities, which may include loss of service for periods of time. In Table 20 a rating of good indicates that there is little or no temporary impacts expected during construction. A rating of moderate indicates that some impacts may be expected, but that through proper planning the impacts will manageable. A rating of poor indicates that impacts could be significant, which means potentially long traffic delays and extended utility outages.

9.1.8 Construction: Permanent Commercial Parking Lot Impacts

This criterion evaluates the permanent impacts to the commercial parking lot, especially with respect to loss of parking spaces. In Table 20 a rating of good indicates that no permanent loss of parking spaces are expected. A rating of moderate indicates that less than 40 parking spaces are anticipated to be removed and a rating of poor indicates that more than 40 parking spaces are anticipated to be removed.

9.1.9 Construction: Permanent Sewer Line Impacts

This criterion evaluates permanent impacts to the existing sewer line that parallels the western edge of Highway 50. In Table 20 a rating of good indicates that little or no impacts are expected, the sewer line would remain in place or any new alignment would result in a slope similar to existing conditions. A rating of moderate indicates that permanent impacts are expected (e.g. new alignment) and that the slope will be decreased, but not lower than currently accepted minimum design values. A rating of poor indicates that permanent impacts are expected and that either the new alignment's slope is less than an accepted design criterion or fluids will need to be moved through the project area via a pump, siphon, or similar technology.

9.1.10 Construction: Other Utility Impacts

This criterion evaluates permanent impacts to utilities other than the sewer pipeline. In Table 20 a rating of good indicates that no permanent impacts are expected with respect to these utilities. A rating of moderate indicates that some permanent impacts are expected, but that the impacts will not greatly affect the end users. A poor rating indicates that permanent impacts are expected and that the end user will be impacted or the utility owner will be affected negatively.

9.1.11 Construction: Potential Cost

This criterion evaluates the potential cost relative to each other. In Table 20 a rating of moderate indicates a cost less than the cost associated with other alternatives evaluated. A rating of moderate/expensive indicates a higher cost relative to the other alternatives evaluated. Although this measurement is qualitative, a dollar value of the opinion of probable cost is included presented in Section 8.2.

Table 20: Alternative Analysis Matrix

Category	Criterion	Existing		Alternatives			
				A		B	
		Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
Hydraulics	Flood flow conveyance	Poor	Moderate	Poor	Good	Good	Good
Fisheries	Fish passage	Poor	Poor	Poor	Good	Good	Good
Riparian	Impacts to existing vegetation	None	None	None	Moderate	Moderate	Moderate
Geo-morphology	Sediment management	Moderate	Poor	Good	Moderate	Good	Good
	Defined channel	Poor	Poor	Good		Good	
	Channel stability	Moderate	Moderate	Good		Good	
Construction	Temporary impacts	N/A	N/A	Moderate	Moderate	Moderate	Moderate
	Commercial parking lot permanent impacts	N/A	N/A	None		Moderate	
	Sewer line permanent impacts	N/A	N/A	Low/None		Moderate	
	Other utility permanent impacts	N/A	N/A	Good		Good	Good
	Opinion of probable cost	N/A	N/A	Moderate		Moderate/Expensive	

Color Definitions

Red - Anticipated to be negative

Yellow - Anticipated to be neutral

Green - Anticipated to be positive

10.0 SUMMARY

The Burke Creek restoration project area includes the region immediately upstream and downstream of Highway 50, north of the Kahle and Highway intersection, and near the town of Stateline, NV (Figure 1). The Tahoe Regional Planning Agency (TRPA) along with Douglas County, Nevada Department of Transportation (NDOT), U.S. Fish and Wildlife (USFS), Nevada Department of State Lands (NDSL), and private property owners formed the Technical Advisory Committee (TAC) for the restoration project, which provided guidance and feedback to the project design team.

The project design team consists of Winzler & Kelly as the project lead; Michael Love & Associates, whose focus was the hydrologic and hydraulic analysis and channel design; and McBain & Trush, Inc., whose focus was the geomorphic conditions and botanical resources for both existing conditions and for restoration alternatives. The project team members were engaged in all aspects of the project.

At the October 2007 kick off meeting attended by TRPA, other TAC members and key project team members, several project objectives were discussed including the following:

- Improving fish passage conditions
- Improving flood flow conveyance
- Improving sediment transport
- Improving riparian corridor

The above objectives were recognized as being interrelated and the project is intended to explore restoration alternatives that have multiple ecological benefits. There was not a single driving objective identified and it was recognized that there may be some restoration alternatives developed that may appear to benefit one objective more than another. The design team is tasked with exploring constraints and objectives and developing restoration alternatives for consideration. The TAC is tasked with providing input and direction to the design team, and ultimately to select the preferred restoration approach.

10.1 Existing Conditions and Data Analysis

Following the project kick off meeting on October 2, 2007, the project team researched and obtained various applicable data, assembled and reviewed past studies and documents provided by the TAC, and collected and analyzed field data as described below.

10.1.1 Topographic and Bathymetric Surveying

In October 2007, Turner and Associates, Inc. was tasked with conducting a topographic and right-of-way survey of the project area.

To supplement this topographic survey, McBain & Trush, Inc. conducted a channel longitudinal profile survey. This profile survey extended from the Lake Tahoe Shoreline to the upper meadow, approximately 2,300 feet upstream of Highway 50 (Figure 2). The profile total length was approximately 8,800 feet and utilized the same datum as the topographic survey.

10.1.2 Geomorphic Setting and Reach Designations

The survey and field reconnaissance data was utilized to determine the existing geomorphic setting (Section 4.2), selecting and analyzing reference reaches (Section 4.3), and analyzing existing hydrologic and hydraulic conditions (Sections 4.4 and 4.5, respectively). For the geomorphic analysis, the creek was divided into three distinct reaches identified from upstream to downstream as the Upper Meadow Reach, the Upstream Reach, and the Downstream Reach.

The Upper Meadow Reach is defined by a valley expansion and apparent accumulation of glacial outwash. The channel gradient through this reach is approximately 3% and the channel bed contains almost exclusively coarse and fine sand with occasional larger individual gravels.

The Upstream Reach is much steeper than the Upper Meadow Reach. The channel's average gradient within this reach is 7%, with segments within the reach approaching 10%. The lower half of this reach has been realigned and modified in the past. This reach terminates as it enters a culvert at the Highway 50 crossing.

The Downstream Reach extends from the culvert exit from under Highway 50 to Lake Tahoe. Burke Creek enters Rabe Meadow Pond immediately downstream of Highway 50. This pond was constructed in 1981 to trap sediment from Burke Creek. After the pond, Burke Creek meanders through Rabe Meadow until reaching Lake Tahoe. The average gradient in the Downstream Reach ranges from 3% to approximately 0.5%.

The Burke Creek Restoration Project area encompasses a portion of the Upstream Reach, the Highway 50 crossing, and a portion of the Downstream Reach, all centered around the Highway 50 crossing. The Upper Meadow Reach is outside of the scope of this project.

10.1.3 Sediment Supply, Transport, and Deposition Analysis

The sediment supply, transport, and deposition analysis (Section 4.2.3) concluded that sediment load in the Burke Creek watershed is extremely low compared with other published values for other small Sierra Nevada streams. The typically higher sediment loads in Sierra Nevada streams could have lead the USFS to conclude that the construction in 1981 of what is now known as Rabe Meadow Pond would tangibly reduce the sediment into Lake Tahoe. However, what has been found through the sediment supply, transport, and deposition analysis completed for this study is that the level of accumulated sediment in Rabe Meadow pond is quite low. This low level of sedimentation could be caused by a number of factors including the following possibilities:

(1) The sediment supply in Burke Creek is naturally low such that the Rabe Meadow Pond is not significantly filling, and/or

(2) Coarse sediment deposition is occurring above the pond at the culvert (which is currently partially filled with sediment) and is not transported to the pond, and/or

(3) Channel maintenance is periodically performed at the culvert or in the pond to remove accumulated sediments.

Whatever the factor(s), it appears that relatively low levels of sediment transport in Burke Creek are to be expected in the future, barring significant changes in the watershed or in maintenance practices.

10.1.4 Channel Stability Evaluation

The Burke Creek channel alignment within the project area has changed over time. Based on the evaluation of channel stability and review of prior development in the area, these changes appear to have occurred primarily related to development (Figure 4).

The channel stability evaluation identified unstable areas in the Upper Meadow Reach but head cutting is considered constrained by natural hardened features. The Upstream Reach appears to have adjusted from its reconfiguration over 30 years ago. The Downstream Reach appears to be very stable from the culvert to Rabe Meadow Pond. Downstream of the Rabe Meadow Pond, the channel experiences local bank erosion (with cut banks up to 3 feet high), but the risk of rapid lateral erosion or incision appears low, with potentially one exception. A 2.7 foot headcut currently exists at approximately station 46+50 (Figure 3), but the headcut appears to be currently stable.

10.1.5 Selection of Reference Reaches

Three reference reaches were selected as representative of conditions within the project area and to allow for the establishment of design parameters to assist in the development of conceptual alternatives. Two of the reference reaches are upstream of Highway 50 and are designated as the Upstream Reference Reach and the Middle Reference Reach. One reference reach was selected downstream of the Rabe Meadow Pond and was designated as the Downstream Reference Reach. The three reference reaches varied in bankfull flow volumes and roughness (Table 2). The reference reaches also differed in geometry (Table 3).

After evaluating the data including a summary of the hydraulic geometry of the reference reaches summarized in Table 3, the middle reference reach was selected to develop the conceptual alternatives. The middle reference reach was found to convey a reasonable bankfull flow based on the limited Burke Creek streamflow record, and since the two other reaches appeared to be undersized, the bankfull hydraulic geometry of the middle reference reach was used to develop a bankfull channel for the proposed conditions. The middle reference reach has the following geometry characteristics: slope 6.9%, bottom width 2.2 ft, bankfull width 3.6 ft, maximum depth, 0.74 ft, bankfull area 2.15 ft^2, bankfull depth /depth ratio 6.3, and floodplain width approximately 110 ft.

10.1.6 Hydrologic Conditions and Design Flow

The existing hydrologic conditions (Section 4.4) identified that the Burke Creek drainage area at the Highway 50 crossing is 2.67 square miles. The highest point within the drainage area is 8,440 ft (the lake elevation downstream is 6,225 ft). The watershed hydrology is characterized by snow, rain-on-snow, spring snowmelt, spring fed baseflow, and rainfall from monsoonal thunderstorms warm late-fall Pacific storms. Rain-on-snow events typically create the largest peak flows, while spring snowmelt is characterized by a period of sustained high flow in mid spring.

The following two approaches were used to quantify design flows for Burke Creek:

1) Large peak flows were determined using a USGS flood frequency analysis, and

2) Lower flows were estimated through direct comparison of measured flows in Burke Creek to flows in adjacent gaged streams.

For evaluating culvert hydraulic capacity and flooding, the potentially more conservative (higher) peak flow estimates derived from the USGS flow frequency values were utilized (Table 433).

Existing conditions were modeled using the Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS), which is a one-dimensional steady-state open channel flow model. A model of Burke Creek was created and calibrated using information collected in the field and from the topographic surveys. Model results were used to quantify existing channel and culvert capacity and to evaluate present fish passage condition.

The model was created using the project topographic survey. A Manning's roughness coefficient of 0.2 was applied to the 2.2 cfs, 1.2-year flow event. A Manning's roughness coefficient of 0.15 was used for the 120 cfs, 100-year flow event.

The result of the modeling of the existing conditions indicates that the flow overtops the left bank dike at approximately 20 cfs, approximately 200 feet upstream of the culvert. The modeled 100-year flow event resulted in 75.4 cfs leaving the channel while 44.6 cfs remained.

Under modeled existing conditions, the culvert becomes submerged at 11.5 cfs. At approximately 25 cfs, the headwater depth is sufficient to begin overtopping Highway 50. Based on the modeling results, it appears that the largest flow reaching the existing willow lined channel downstream is approximately 25 cfs.

10.1.7 Existing Fish Passage Conditions

Another aspect of the modeling effort was to identify the existing fish passage conditions for relevant species. Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) are native to the Truckee Basin and historically resided in Lake Tahoe and its tributaries**.** Lahontan cutthroat trout (LCT) can express both resident and migratory life histories, with resident forms using tributary habitats and migratory forms using both river and/or lake habitats in addition to tributaries (Sigler et al., 1983). LCT are obligatory stream spawners, and predominantly use tributary streams as spawning sites. Spawning typically occurs from April through July throughout the range of LCT (USFWS, 1995).

LCT were listed as endangered species in 1970 and reclassified as threatened to facilitate management in 1975. A recovery plan prepared by the US Fish and Wildlife Service for LCT was approved in 1995. Although LCT are now extirpated from Lake Tahoe and its tributaries, there have been efforts to reintroduce the fish. A stream survey identifying species abundance, distribution habitat suitability, location of existing migration barriers is recommended.

The existing fish passage conditions were assessed between the Rabe Meadow Pond and the upper meadow. Assessing fish passage conditions requires first determining target fish species, life history and lifestages. For each target fish, the time of year, range of flows that passage should be provided, and the passage criteria must be identified. Lastly, the actual hydraulic conditions are compared to the fish passage criteria across the range of migration flows.

The Burke Creek project reach is considered upstream of the historical and current limit for lake-run trout and is defined as a resident/ nursery reach (NDW, 1982). According to documents prepare by TRPA for Burke Creek and discussions that occurred at the kickoff TAC meeting for this project, fish passage and habitat enhancements for this project will focus on meeting the needs of adult resident and juvenile rainbow and Lahontan cutthroat trout.

Common criteria for juvenile salmonids and adult resident rainbow trout are listed in Table 6. The Table 6 criteria were applied to the assessment of the existing 228-foot long corrugated metal culvert under Highway 50.

The existing Highway 50 culvert could be classified as a barrier to the target fish at all flows. However, it is likely that stronger individual fish within the population can negotiate the culvert under certain flow conditions by swimming through shallower than ideal depths and using the slower water velocities along the walls of the culvert. Therefore, this culvert should not be considered adequate as a barrier to block upstream migration of non-native fish.

Fish passage values summarized in Table 6 were also utilized to evaluate the Upstream Reach and the Downstream Reach.

For the Upstream Reach, vertical height of individual water surface drops were evaluated as well as channel slope. Because this channel reach is predominately a step-pool channel, water depths and velocities were not evaluated. Instead, it is assumed that the pools provide adequate depth for holding and resting, and that the primary factor limiting fish passage is the height of individual drops, or steps, in the channel. Additionally, channel slope can serve as an indicator of the potential challenges a fish may have while attempting to migrate upstream.

Within the Upstream Reach there are 15 vertical drops that exceed the maximum drop height criterion of 0.67 feet for adult resident trout, with seven of them greater than 1 foot (Figure 17). Although adult resident rainbow trout are known to ascend drops of these heights by leaping, some of the drops have little to no plunge pool that the fish can use for acceleration, making leaping difficult.

The predominant channel slopes in the Upstream Reach are relatively steep, with approximately 230 feet of channel with slopes greater than 6%, and including a nearly 120 feet long reach with a slope of 11.8% (Figure 18). Upstream of this steep section of channel, slopes decrease, ranging from 2.1 to 4%.

Although adult rainbow trout are known to migrate through channels with slopes exceeding those identified between Rabe Meadow and the Upper Meadow, it is unknown if they could ascend these steep channel segments due to the vertical drops within the channel and poor leaping conditions provided below them. It is also unclear if juvenile salmonids can ascend such steep sections of channel.

The Downstream Reach model results suggest that at the lower passage flow of 0.2 cfs, water depth in the downstream channel is inadequate for both juvenile salmonids and adult resident rainbow and LCT. At the high passage flow, adequate depth for juvenile salmonids is provided throughout most of the reach and the model predicted cross sectional averaged water velocities range between 0.2 and 2.4 ft/s. While water depth is less than ideal for both juvenile and resident adults, it does appear that these fish could negotiate this reach during periods of higher flow.

10.1.8 Vegetation Analysis

The final existing condition analysis included an evaluation of the existing vegetation (Section 4.7). A riparian botanist conducted the field inventory, which consisted of walking the length of Burke Creek from its confluence with Lake Tahoe up to the upper meadow and visiting each distinct cover type. Polygon boundaries were drawn in the field around discrete cover types and a cover attribute was assigned. Individual trees were the smallest vegetation units mapped. Polygons were no smaller than 100 feet^2 and included all human disturbance (i.e. anthropogenic), riparian, wetland, and adjacent upland habitats (i.e. biological habitats) within the project area.

Figure 19 and Figure 20 present the mapped vegetation analysis results. In all, 14 cover types were identified in the field inventory. These cover types were grouped as follows:

- Anthropogenic
  - Human Disturbance
- Wet meadow habitats
  - Mixed Sedge
  - Rush-Reedgrass
  - Rush-Kentucky Bluegrass
  - Yellow Monkeyflower
- Dry meadow habitat
  - Creeping Wildrye
  - Cheat Grass
  - Woody Riparian Habitats
  - Mixed Willow
  - Quacking Aspen
- Upland habitats
  - Jeffrey Pine-White Fir
  - Jeffrey Pine
  - Rabbitbrush
  - Sagebrush
  - Sagebrush-Open

10.2 Selection of Conceptual Alternatives

Once the background data had been collected and analyzed, the project team developed four preliminary alternatives which were submitted to the TAC on February 22, 2008, as a Technical Memorandum titled *"Burke Creek Restoration Project: Preliminary Development of Alternatives"* for review and comments (Appendix A). On February 22, 2008 key members of the project team met with the TAC at the TRPA office to discuss the preliminary alternatives and answer questions from the TAC.

TRPA compiled TAC comments and directed the project team to further analyze and develop Alternatives A and B. Appendix A contains meeting agendas and other correspondence related to this process.

10.3 Conceptual Design Alternatives

The following sections summarize the two conceptual alternatives developed for this project as directed. Much more detail is presented in Sections 6.0 and 7.0 of this report. Prior to summarizing each alternative the outstanding issues and assumptions for the project are presented.

10.3.1 Outstanding Issues and Assumptions

During the conceptual design process, several assumptions were made to allow for alternatives to be developed. The assumptions are listed below along with associated descriptions. Collecting additional information and verifying the assumptions was beyond our scope of services, but verifying the assumptions is highly recommended prior to proceeding with the final design of any alternative.

- Gravity sewer alignment
  - No potholing was conducted as part of this project. Sewer pipeline inverts and manhole cover elevations were collected as part of the survey. It was assumed that the sewer line follows a constant slope between manholes. Both alternatives impact this sewer alignment and potholing should be completed prior to any final design.
  - Further, a second map, created by JWA, for the sewer pipeline location and invert elevations was obtained (Appendix A). The JWA map invert elevations differ slightly from the survey results, as does the difference between the inverts on either side of the proposed project crossing. Again, potholing should be conducted prior to any final design effort to determine the actual sewer line elevations in the anticipated project area.
- Sensitive species
  - Although field reconnaissance was conducted to identify vegetation within the project boundary, the reconnaissance was not intended to identify all species in the area. Prior to final design, additional seasonal appropriate surveys should be conducted to identify potential sensitive species within the project area.
- Streamside Environmental Zone (SEZ) Goals and Constraints
  - Actual SEZ boundaries were not mapped as part of this project. Additionally, SEZ guidelines are not clearly understood in relation to other restoration goals. They could be interpreted as a project goal or as a project constraint. This issue needs to be resolved in order to further develop project alternatives.

- Commercial parking lot
    - During the course of the conceptual design process, several alternatives were allowed to impact the commercial parking lot in order to explore project restoration goals. In order to better understand potentially feasible parking lot impacts, several potential layouts were discussed with the current owner of the property. There are several issues that may impact the owner's ability and willingness to allow the project to impact the parking lot. Currently it appears feasible that the owner could allow the project to impact the northerly row of existing parking stalls, and perhaps even more. Therefore, it was assumed that proceeding with an alternative that impacts only the northerly row of parking would be the most conservative approach, and if more parking lot space were to become available later, the project could be designed to maximize the use of the available space to further develop the restoration goals.
- Groundwater
    - An analysis of groundwater conditions was beyond the scope of this project. It is recommended that groundwater monitoring be conducted in the project area. This information will be critical for developing appropriate planting approaches and minimizing construction impacts.
- Existing Culvert
    - The topographic survey obtained the invert locations of the existing culvert's inlet and outlet. It was assumed that the culvert extends linearly between the two recorded points. During the alternative development process, a figure created for an erosion control master plan for NDOT (Appendix A) was provided with a sketched culvert alignment showing the culvert paralleling Highway 50 towards the south until nearly even with the outlet. The sketch then shows the culvert crossing Highway 50 with a slight skew. Prior to final design, the existing culvert's actual alignment should be verified.
    - Based on the same sketch, it is currently assumed that some of the drainage inlets located in the commercial parking lot drain into the existing Burke Creek culvert. Prior to final design all drainage inlets that connect to the culvert should be identified.
- Upper Meadow Headcut
    - Fish passage through the project reach is a project objective. The alternatives developed do not remedy issues outside of the project area. Field work conducted as part of these efforts indicated that there may be fish passage barriers upstream of the project reach. It is recommended that the TAC consider this issue in case they would want to modify the project area to address this issue and to improve connectivity for migrating fish species.
- Property Ownership
    - The Turner Survey identified the property line along the northerly side of the commercial parking lot and the Highway 50 Right-Of-Way in the project area. A question was raised at a TAC meeting regarding a potential small parcel just north

of the culvert inlet and outside of our project area that may be under separate ownership. Prior to final design the property ownership in this area should be confirmed.

- Stream Length
    - The proposed alternatives both result in shortening the channel length. It is not known to what extent this may impact the permitting process. Prior to final design, potential permitting agencies should be contacted and engaged in the project so they can provide feedback on any potential issues with the proposed stream length as well as any other aspect of the alternatives.

10.3.2 Alternative A

Alternative A has the following main features:

- 90-feet of modified channel upstream of Highway 50 within existing alignment (no parking lot encroachment)
- 100-foot long, 12-foot wide by 6.5-foot tall concrete box culvert crossing Highway 50, effectively passing over the sewer line
- 345 feet of new channel constructed downstream of Highway 50
- 535 feet total of new channel length

Under Alternative A, 90-feet of the channel upstream of Highway 50 would be modified within its existing alignment, which is located on property owned by Sierra Colina, LLC. The project area under Alternative A does not extend onto the adjacent commercial property to the south. The proposed channel bottom upstream of Highway 50 will be lower than the existing channel to allow for the installation of a larger culvert to pass higher flows. A deeper channel and existing dikes will contain the 100-year flows within the project area. Upstream of the project area, raising the existing dikes would be necessary in order to reduce current flooding potential on the adjacent commercial property.

The proposed culvert replacement under Alternative A is nearly perpendicular to the highway centerline. The culvert replacement for Alternative A is 100 feet in length and assumes the existing sewer line will not be relocated, and the new culvert would essentially pass over it and a portion of the sewer would be encased in concrete at the crossing. Downstream of the culvert, a new channel will be reconstructed connecting back to the existing willow channel approximately 345 feet downstream of the culvert outlet. Conceptual drawings for Alternative A are provide in Appendix J.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels (Montgomery & Buffington, 1997 and Grant et al., 1990). These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, provide channel and flow complexity that facilitates fish passage, and provide aquatic habitat.

The proposed channel alignment downstream of Highway 50 follows a swale defined by the hillslope to the north and a slight rise in the ground to the south. This alignment was chosen to match the proposed location of the culvert outlet and to utilize existing topography as much as practical to confine the floodplain.

Much of the downstream channel will require fill, as the channel thalweg is above the existing ground. It is believed that this portion of Rabe Meadow was lowered during excavation activities for the Jenning's Casino, which was never completed. Therefore, the fill proposed for the downstream channel can be part of a strategy to restore this area to pre-Jenning's Casino construction condition.

The proposed channel profile was developed to allow for the creation of a stable, natural stream channel that facilitates fish passage and geomorphic processes, specifically transport of fine sediment.

A challenging constraint is the existing sewer line. The proposed profile was designed to fit within the slope ranges of the reference reaches surveyed for the project while avoiding the existing sewer as much as possible. The slope was limited to 6.5% and lower to facilitate channel stability and fish passage.

Upstream of the culvert, the proposed channel meets the existing channel at a 6.5% slope for 30 feet. The channel profile then decreases to a 6% slope for the 60 feet upstream of the culvert, and decreases to a 5% slope through the proposed culvert. The intent of the design was to maintain a higher channel slope downstream through the culvert to avoid an abrupt slope break and promote transport of sediment to well downstream of the culvert outlet.

A new 100 feet long by 12-foot wide by 6.5-foot tall concrete box culvert will be installed with the inlet at approximately the same location and elevation as the existing 24-inch culvert (Figure 25). The culvert will be placed perpendicular to the highway centerline, moving the outlet approximately 220 feet to the north of its current location. This culvert was selected to maintain floodplain continuity and sufficient conveyance area for the 100-year flow event. The culvert slope matches the channel slope of 5%.

The proposed replacement culvert was designed in accordance with Stream Simulation methodology for steep channels (USFS, 2008). The culvert invert is imbedded 2.5 feet below the thalweg elevation of the finished streambed and filled with streambed material to form the same cross sectional shape as the upstream channel. The constructed stream channel in the culvert will have a 4-foot wide bankfull channel and floodplain, and provide the necessary flow depths and suitable velocities for fish passage. The encased sewer line immediately inside the culvert outlet will be roughly flush with the constructed channel thalweg within the culvert.

At the culvert inlet is a concrete headwall extending from both sides of the culvert. The headwall also extends vertically to meet the existing ground above the culvert inlet. At the culvert outlet a concrete headwall will extend from both sides of the culvert and one foot above the top of the culvert. This will allow for re-establishment of the gentle embankment slope above and around the culvert outlet. The headwalls also accommodate channel and floodplain grading immediately downstream of the culvert outlet, thus providing a geomorphically continuous stream channel into, through, and out of the culvert.

Figure 26 presents typical cross-sections for this alternative. Alternative A utilizes the same bankfull geometry throughout the project reach, but the flood plain widths vary depending on physical constraints. The bankfull geometry is: width 2.5 feet, 0.8 feet tall banks sloped at 1H:1V, and a top width of 4 feet.

Refer to Sections 7.1.1, 7.2, and 7.3.1 for discussions on Alternative A geomorphic analysis, fish passage analysis, and revegetation options, respectively.

10.3.3 Alternative B

Alternative B has the following main features:

- 330-feet of channel upstream of Highway 50 similar to the historic channel profile with a ten foot encroachment into the parking lot
- 120-foot long, 12-foot wide by 6.5-foot tall concrete box culvert crossing Highway 50, requiring a relocated sewer line
- 400 feet of new channel constructed downstream of Highway 50
- 850 feet total of new channel length

The intent of proposed Alternative B is to construct a channel similar to the historical channel profile and morphology as much as possible given the constraints imposed by the highway, land development, existing topography, and other changes in land use. Alternative B assumes the channel reach upstream of Highway 50 can be realigned to increase the available floodplain and riparian area while limiting flooding to adjacent infrastructure. Alternative B also assumes that the sewer line under the western shoulder of the highway can be relocated to allow for a continuous channel profile and avoid the need for fill in the downstream dry meadow.

Alternative B will create an 850-foot long channel that extends 330 feet upstream and 400 feet downstream of Highway 50. Upstream of Highway 50, the proposed channel will be realigned slightly to the south of the existing channel. The existing northern row of parking spaces within the commercial parking lot will be eliminated to facilitate realignment of the channel. The channel in this area will be confined by dikes and retaining walls. The lowered channel and raised dikes will contain the 100-year return flow with 2 feet of freeboard between the 100-year water surface elevation and top of dike.

The proposed channel was designed as a boulder-stabilized channel with profile and planimetric morphologic features appropriate to steep channels (Montgomery & Buffington, 1997 and Grant et al., 1990). These morphologic features create a stable channel bed up to a 100-year flow, provide the channel bed and bank roughness necessary to dissipate energy, and provide channel and flow complexity that facilitates fish passage and provides aquatic habitat.

A new channel, approximately 400 feet long, will be constructed downstream of Highway 50. It joins the existing channel approximately 360 feet upstream of the Rabe Meadow Pond. The proposed channel alignment downstream of Highway 50 follows an existing swale. This alignment was chosen to match the proposed location of the culvert outlet and to utilize existing topography as much as practical to confine the floodplain and avoid the need for placement of fill to raise the existing ground. The existing channel from downstream of Highway 50 to the location where the relocated channel meets the existing channel will be abandoned.

A small wetted swale, with a one-foot bottom constructed approximately 2-tenths of a foot below bankfull elevation, provides limited water to help sustain a portion of the existing vegetation in the abandoned channel.

As a whole, the proposed channel profile for Alternative B is designed with continuously decreasing slopes in the downstream direction, avoiding abrupt slope breaks that can create an area prone to localized deposition and channel aggradation. Rather, the continuously decreasing profile promotes gradual sediment deposition, with most fine sediment being transported to well downstream of the culvert outlet.

A new 120 feet long by 12-foot wide by 6.5-foot tall concrete box culvert will be installed with the inlet invert at approximately the same location, but 5.1 feet lower in elevation, than the existing 24-inch culvert. The inlet invert will be embedded 2.5 feet below the proposed channel thalweg. The culvert will be placed perpendicular to the highway centerline, moving the outlet approximately 220 feet to the north of its current location. The relocation of the culvert outlet will allow for a steeper culvert that will better facilitate sediment transport, which is currently a problem. A shorter culvert will also minimize the area of road disturbance and be beneficial for passage of fish and wildlife.

The culvert slope fits within the proposed profile with a slope of 5.75%. To avoid pressurized flow that can compromise bed stability for a stream simulation channel, the proposed culvert was designed to convey the 100-year peak flow of 120 cfs without submerging the culvert inlet. Allowing this freeboard also minimizes backwater effects to facilitate sediment transport and minimizes potential blockages by debris.

At the culvert inlet is a concrete headwall extending from both sides of the culvert. The headwall also extends vertically to meet the existing ground above the culvert inlet. At the culvert outlet a concrete headwall will extend from both sides of the culvert and one foot above the top of the culvert. This will allow for re-establishment of the gentle embankment slope above and around the culvert outlet. The headwalls also accommodate channel and floodplain grading immediately downstream of the culvert outlet, thus providing a geomorphically continuous stream channel into, through, and out of the culvert.

Figure 27 presents the typical cross-sections for Alternative B. The proposed channel cross sectional shape was designed to simulate reference conditions as best as possible. Channel bottom width, bottom cross slope, side slopes, bankfull width and depth, and floodplain width were matched to reference reach data within the constraints of the site.

A single bankfull cross section design was used for Alternative B, with varying floodplain widths to fit within site constraints. The proposed condition bankfull channel has a 2.5-foot wide bottom, 0.8 feet tall banks with 1H:1V side slopes, and a 4-foot top width. This channel conveys the 1.2-year flow, with water spreading out onto the adjacent floodplain at higher flows.

Upstream of Highway 50, floodplain widths of 4.0 to 7.5 feet are on either side of the channel. Dikes are proposed along the southern side of the channel at the edge of the floodplain. These dikes will rise at 3(H):1(V) slope to a 6-foot wide top, then fall at a 3(H):1(V) slope to meet existing ground or tie into a retaining wall. Retaining walls are necessary between approximate stations 63+75 and 65+60 along the edge of the commercial parking lot to allow construction of the channel, floodplain and dikes that will contain 100-year flows, while keeping within the defined project limits. The proposed retaining wall height varies from 2.2 to 5.5 feet.

Downstream of Highway 50, after flows expand out of the culvert and roadway embankment, excavation of 16 to 18-foot wide floodplains will be necessary to maintain the design bankfull channel dimensions and to tie into existing ground. Larger flow events will spread across the constructed floodplains onto existing ground, creating a much wider floodplain than what will be constructed.

Refer to Sections 7.1.2, 7.2, and 7.3.2 for discussions on Alternative B geomorphic analysis, fish passage analysis, and revegetation options, respectively.

10.3.4 Alternative Comparison

To aid TRPA and the other TAC members in evaluating the proposed alternatives and to compare the alternatives to the existing conditions, criteria were selected, defined and then analyzed with respect to each alternative. The results of the alternative analysis are presented in Table 21. A definition of each criterion is presented in Section 9.1 as well as the terms used in Table 21.

This comparison table is intended to aid the TAC in considering different alternatives. Upstream and downstream components are considered separately so that the different aspects of the project can be considered separately. Color coding has been added as a graphic aid. The comparison table is intended to provide the TAC with a tool for discussion. The criteria are complex in nature and should be discussed. We have not attempted to weight the importance of any of the criteria. Ultimately the TAC need to discuss the various project criteria and determine the preferred alternative.

Table 21: Alternative Analysis Matrix (Table 20 Repeated)

Category	Criterion	Existing		Alternatives A		Alternatives B	
		Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
Hydraulics	Flood flow conveyance	Poor	Moderate	Poor	Good	Good	Good
Fisheries	Fish passage	Poor	Poor	Poor	Good	Good	Good
Riparian	Impacts to existing vegetation	None	None	None	Moderate	Moderate	Moderate
Geo-morphology	Sediment management	Moderate	Poor	Good	Moderate	Good	Good
	Defined channel	Poor	Poor	Good		Good	
	Channel stability	Moderate	Moderate	Good		Good	
Construction	Temporary impacts	N/A	N/A	Moderate	Moderate	Moderate	Moderate
	Commercial parking lot permanent impacts	N/A	N/A	None		Moderate	
	Sewer line permanent impacts	N/A	N/A	Low/None		Moderate	
	Other utility permanent impacts	N/A	N/A	Good		Good	Good
	Opinion of probable cost	N/A	N/A	Moderate		Moderate/Expensive	

Color Definitions
Red - Anticipated to be negative
Yellow - Anticipated to be neutral
Green - Anticipated to be positive

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Appendix A
Correspondence

Burke Creek
Restoration Project
EIP # 161
TAC Meeting
October 2, 2007
10:00-12:00am
TRPA Alpine Room

Agenda

- Introductions
- Project schedule and scope review : goals, objectives, constraints
- Background data, reports and studies
- Field data collection
- Next steps

Burke Creek
Restoration Project
EIP # 161
TAC Meeting
February 27, 2008
9:00-12:00am
TRPA Library

Agenda

- Introductions and project overview to date - Mike Elam
- Project goals and objectives review, project constraints - Steve Allen and design team
- Existing conditions analyses – Steve Allen and team
- Formulation of alternatives, technical memorandum review – Steve Allen and team
- Evaluation of alternatives - TAC discussion
- Moving forward - TAC technical memorandum review and comments, development of draft preferred alternatives report, next TAC meeting.

Burke Creek TAC
EIP # 161
February 27, 2008

Sign In

Name	Agency	Phone	E-mail
Mike Elam	TRPA	775-589-5308	melam@trpa.org
GEOFF HALES	McBAIN & TRUSH, INC.	(707) 826-7794	geoff@mcbaintrush.com
MICHAEL LOVE	LOVE & ASSOCIATES	707-476-8938	mlove@h2odesigns.com
STEVEN ALLEN	WINZLER & KELLY	707-443-8326	steveallen@w-and-k.com
RON ROMAN	DOUGLAS COUNTY	775.782.6239	RROMAN@CO.DOUGLAS.NV.US
Jason Drew	NCE - Sierra Collina	775-588-2505	jdrew@NCE.Reno.NV.US
El Harrison	NDSL	775-684-2736	elharrison@lands.nv.gov
CHAD SMITTKAMP	NUGGET BLDG	775-815-8111	
Craig Oehrli	USFS	530-543-2681	coehrli@fs
David P. Catalano	NDOW	775-684-2742	dcatalano@ndow.org

Steve Allen

From:	Elizabeth Harrison [EHarrison@lands.nv.gov]
Sent:	Thursday, March 13, 2008 5:03 PM
To:	Mike Elam; Ron Roman; Gallo, Vanessa A; Craig Oehrli
Cc:	Tim Hagan
Subject:	Burke Creek Comments
Follow Up Flag:	Follow up
Flag Status:	Flagged
Attachments:	Burke Creek Photo003.pdf

Existing Conditions Analysis

1. During the geomorphic reconnaissance, was there any quantification of the amount of erosion that occurred?
2. Since vegetation mapping was done late in the season last year, is there a need to collect more data?
3. There is a need to complete biological/wildlife and archeological surveys this season to put together an existing conditions analysis and to evaluate alternatives.
4. It should be documented in the ECAM the types of flooding events that occur at the highway and give a general description of the cause.
5. It seems like we need to have more details on what the objective "improve sediment transport" is actually getting at. That is are we lessening or increasing the sediment transport and what does that mean to downstream reaches? Are we changing how sediment is transported and what may be stored in floodplains?
6. Also it seems like maybe we could define more as to what is meant by "improve the riparian corridor".
7. Don't understand the word "connectivity" in the Goal statement. Are we talking about connectivity to a flood plain or other types of connectivity (improved conveyance via a box culvert?).
8. Should include details as to what "reference reaches" are in terms of how they were selected (e.g. represent historic conditions and/or are stable).
9. Need to pothole now to ensure utility location and location of the NDOT culvert. Also to determine whether any private lines tie into the NDOT culvert (likely just the Burger King property).
10. Also it seems we should determine exactly what is meant by "Flood flow conveyance". Should this be documented in terms of flood impacts to private property? I just think it should be clear that we want to protect private property but we also want to encourage "natural" flood events to occur which will have multiple environmental benefits.

-Objectives/Constraints

11. Another constraint may be "slope of highway grade". That is to get the two portions of Burke Creek to connect and flow properly we must consider the shallow slope across the highway which in many way constrains the design possibilities.
12. I think one of the objectives on the project should be to increase overbank events to increase the connectivity with the floodplain. (Rather than just flood flow conveyance).
13. Should we have an objective that discusses protecting private property and public health and safety (maybe just in terms of flood conveyance)?
14. I think we have decided as a group that the sewer line relocation would not be possible. Therefore the constraints section could be added to specify this. We really need the sewer district (KGID or Tahoe Douglas Sewer) at the table to discuss all options that are being developed and to inform of us of other issues that need to be considered.

15. I believe folks mentioned previously that there is head cut below the highway that would preclude some fish passage. Also, I am wondering whether the channel above the basin itself (and below the highway) impedes fish passage considering it is not a well defined channel (e.g. is there sufficient water depths within this section to allow fish passage in normal water years?)

-Hwy 50-NDOT culvert

1. It is questionable as to what facilities are actually located within the NDOT ROW (based NDOT initial review). Also there does not appear to be existing easements for maintenance on the outlet. NDOT does inspect and cleans the inlet to these pipes on a yearly basis. They informed me that they do not have any issues with this pipe in terms of highway flooding even though the outlet of the pipe is mostly filled in with sediment. Are the flooding issues discussed at the meeting associated within the Burger King parking lot DI? NDOT mapped the system (attached document) and it shows that the pipe does parallel the highway south of the Burger King parking lot and then crosses the highway at the location of the creek downstream.
2. We need to be sure that easements are secured at the inlet and outlet for NDOT maintenance.
3. Please have Winzler and Kelly contact Vanessa Gallo of NDOT (775-888-7799) to discuss this pipe in more detail and to determine what design considerations need to be.

Alternatives

16. Alternative A is not preferred. It should be documented that this option actually decreases the flow path of the stream (decreases the length of the NDOT culvert and as a shorter channel length to the basin.) Also I do not support the idea of a installing hard structures such as retaining walls (hard structure) for a restoration project. This design also includes a substantial amount of fill in the meadow which I would not support. Lastly, this design is said to contain high flows so the project would not have connectivity to the floodplain or overbank sediment deposition.
17. Alternative B should be excluded due to the need to relocate the sewer line.
18. Alternative C seems favorable over B in that it reduces the amount of fill in the SEZ, has more potential to avoid conflicts with the sewer (and maybe other utilities?) and also provides a greater channel length below the highway (at least it appears so). This design could allow for more opportunities for overbank events and potential biogeochemical reactions along the bed and banks of the creek. In addition the "middle reach" has a slightly shallower slope that Alternative B as well which should help in the transition across Highway 50.
19. Alternative D drawbacks are the possible sediment deposition at the inlet of the culvert. This could become a maintenance issue for NDOT so it not preferable if it is felt to be a risk. This alternative may be favorable to some considering downstream alterations are minimal. This alternative likely should be kept as an alternative for consideration based on feedback from the USFS.
20. Overall designs should limit the amount of disturbance and fill in the meadow and the 100-year floodplain.

General Planning

4. The "next steps" information on page 14 does not refer to the development of the existing conditions analysis. I know the development of the work is currently being discussed with TRPA. Collection of additional information for the existing conditions analysis should be done early this season to identify impacts to the FS property (to fully disclose impacts in a special use permit), any changes in flow volume through the NDOT ROW (for a ROW NDOT permit) and to satisfy NEPA.
21. A determination needs to be made as to who is the NEPA lead on this project. The Forest Service, BOR or the Army Corps would be the potential candidates. Through coordination with TRPA and the NEPA lead, a determination of the environmental documentation for this project can be determined.
5. Ensure that flow volumes etc. are understood in terms of their effect on downstream reaches. There is

an EIS that was generated for the Tahoe Beach Club project that should be consulted in terms of their final selected design alternative. To my knowledge, the preferred alternative will fill an existing ditch which will alter flows in Burke Creek as well groundwater levels in the vicinity of the creek. In addition, the preferred alternative included conveyance of treated stormwater to the meadow system within the upper 40 inches.

6. Considering flows from the Burger King parking lot are directly conveyed to the creek, we should work with Chad Smittkamp to get his BMPs installed for the property (maybe based on a modified parking lot design).

Please let me know if I can clarify any of these comments. Thanks!

Elizabeth Harrison
Environmental Scientist III
Nevada Tahoe Resource Team
Nevada State Lands
901 South Stewart Street, Suite 5003
Carson City, NV 89701
eharrison@lands.nv.gov
phone (775) 684-2736
fax (775) 684-2721

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ALL STATIONS ARE IN METERS

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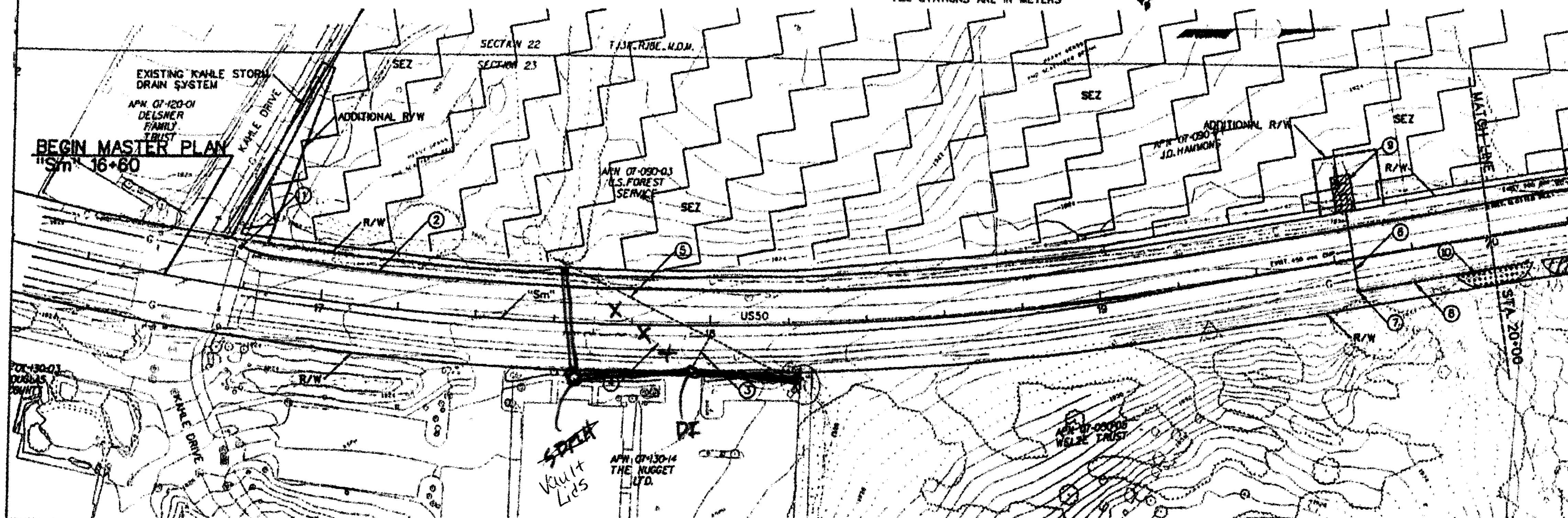

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② 16+78 LT. TO 33+23 LT. CONSTRUCT TYPE 8 CURB AND GUTTER, CONNECT TO EXISTING VERTICAL CURB AND GUTTER AT 16+78 LT.

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DEPARTMENT OF TRANSPORTATION

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STA. 16+60 TO STA. 20+00

Steve Allen

From: Ron Roman [rroman@co.douglas.nv.us]
Sent: Saturday, March 01, 2008 8:34 AM
To: Mike Elam
Subject: RE: Burke Creek Technical Memorandum File
Follow Up Flag: Follow up
Flag Status: Flagged

Mike,

Here are my comments on the February 22, 2008 Technical Memorandum:

1. Relocation/protection of the sewer line is a potential stumbling block. The consultant should talk with DCSID No. 1 about the concept of constructing a concrete grade beam around the sewer line. If this is not acceptable to DCSID No. 1, then the sewer line will need to be relocated. Relocation/lowering of the sewer line will most likely require that the line be extended down Kahle Drive where they can pick up the additional depth needed to lower the line at the Burke Creek crossing. This will impact the project cost.
2. The consultant should prepare parking lot layouts and striping plans for the alternatives that impact the parking lot. This will help determine the impact on parking spaces and whether or not the remaining parking lot area is usable.
3. Overlay the APN's on the drawings.
4. Several alternatives include construction of an embankment and raising the flowline of Burke Creek. While the consultant is providing two (2) feet of freeboard, they also need to look at the impacts to property if the embankment were to breach in the vicinity of the commercial building. This type of analysis will most likely be required by the County to assess public health and safety.
5. The project objectives to improve the riparian corridor and fish passage seem potentially contradict.
6. Constructability of the box culvert and the stable rock bed need to be considered. Can the rock bed material be easily placed during construction, and if it did move in a large storm event, can it be maintained/repaired?
7. Confirm that no underground storm drains from the commercial property connect to the existing 24-inch CMP. If there are connections, these need to be considered in the alternatives and design.
8. I did find aerial photographs of the project area taken on June 24, 1981 in our files. It looks like the pond had just been constructed and Burke Creek has just been reconstructed through the old casino pad. Let me know if you would like to borrow the aerial contact print.

Ron Roman
Senior Civil Engineer
Douglas County Community Development
P.O. Box 218
Minden, NV 89423
775-782-6239
775-782-6297 (Fax)

-----Original Message-----
From: Mike Elam [mailto:melam@trpa.org]
Sent: Tuesday, February 26, 2008 8:16 AM
To: Charlie Donohue; Cooke, Steve M; Craig Oehrli; David Catalano; Drew Jack; Elizabeth Harrison;

Myrnie Mayville; Paul Nielsen; Roman, Ron; Ted Thayer
Cc: bwolfe@nhc-sac.com; JDrew@nce.reno.nv.us; chad smittkamp; Steve Kenninger
Subject: FW: Burke Creek Technical Memorandum File

From: Steve Allen [mailto:steveallen@w-and-k.com]
Sent: Sunday, February 24, 2008 5:56 PM
To: Mike Elam
Cc: mlove@h2odesigns.com; Geoff Hales
Subject: Burke Creek Technical Memorandum File

Mike,
Attached to this email is the 8 meg PDF file I mentioned below.

From: Steve Allen
Sent: Sunday, February 24, 2008 5:53 PM
To: 'Mike Elam'
Cc: 'mlove@h2odesigns.com'; Geoff Hales
Subject: Burke Creek Technical Memorandum Deliverable

Mike,
Below is a link that you and the TAC can easily use to download our Burke Creek Technical Memorandum. I will send a second email to you with the attachment but it is an 8 meg file so I wanted to make sure everyone could receive it. The download link is:

http://h2odesigns.com/BurkeCreek/Burke_Creek_TM_022208.zip

I will also bring eight hardcopies of the technical memorandum with me to the meeting this Wednesday.

We look forward to meeting with everyone soon,

Steven A. Allen, P.E.
Senior Project Manager
Winzler & Kelly Consulting Engineers
633 Third Street
Eureka, CA 95501
Phone: (707) 443-8326 ext 163
Fax: (707) 444-8330
Email: steveallen@w-and-k.com
Web: http://www.w-and-k.com

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Engineering and Environmental Services
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MEMORANDUM

TO: Mike Elam – TRPA

FROM: Sierra Colina LLC. Nichols Consulting Engineers and nhc

DATE: 3/24/08

SUBJECT: Comments on Draft Technical Memorandum for the Burke Creek Restoration Project: Preliminary Development of Alterantives Winzler & Kelly Dated February 22, 2008

Sierra Colina LLC, NCE and nhc submit the following comments based on our review of the Feb. 22, 2008 technical memorandum.

***Sierra Colina LLC*:**

1. Sierra Colina remains supportive of assisting TRPA to implement a feasible alternative to adequately address the goals and objectives of the Burke Creek Restoration Project (WQIP). It is important that the project be practical and efficient to construct and maintain while recognizing that any improvements which may impact or reside on private property, including the Sierra Colina property and the adjacent commercial center property, need to resolve any potential conflicts, construction, maintenance and/or liability related issues arising from their design.

2. With respect to the issue of whether any WQIP facilities constructed on the Sierra Colina parcel will affect the base allowable coverage on the parcel, because the residential project proposed by Sierra Colina is anticipated to utilize all of the base allowable coverage on the parcel, it is important that (i) any non-SEZ land capability areas used for these facilities maintain their existing land capability status so as not to reduce the base allowable land coverage on the Sierra Colina parcel; and (ii) to the extent that any WQIP facilities constructed on the Sierra Colina parcel constitute new "coverage", such new coverage be mitigated by the WQIP transferring in an equal amount of coverage onto the Sierra Colina parcel.

3. Sierra Colina remains open to considering granting necessary temporary right of entry and maintenance easements to WQIP to construct and maintain any facilities of the project located on the Sierra Colina parcel,

with appropriate indemnity and related agreements to adequately protect all parties.

4. Based on a review of the Draft Technical Memorandum, it appears that none of the possible Project Alternatives either conflicts with the proposed Sierra Colina Village project (including its storm water treatment and retention plans) or adversely its ability to comply with any anticipated subsequent conditions of project approval which TRPA may later impose on the Sierra Colina project. Any such potential conflicts which arise during the design phase of this WQIP would need to be resolved to the mutual satisfaction of all parties.

***Nichols Consulting Engineers*:**

General Comments

1. How was the project boundary selected or delineated? It would be good to include documentation about how the project boundary was selected. See nhc comments below on this subject.
2. Since the project has done an excellent job of collecting all the available information related to Burke Creek in this area, it would be helpful to post all of the studies, reports, hydrologic data, survey data and other information on an ftp site or other web based access point.

Goals and Objectives:

1. It would be helpful to define how decisions will be made on the project. Is the decision process consensus based, information sharing, etc.?
2. It is important to include a goal for Stakeholder involvement. Particularly important to document the role of landowners.

Alternatives:

1. During the next iteration it will be important to define exactly what the potential impacts, benefits and drawbacks will be for each alternative. This is particularly important to the project landowners, including Sierra Colina.
2. Since the channel alignment and thus the floodplain boundaries will be changing for some of the alternatives, a flood plain analysis will be required by Douglas County. It will be important to engage the County on this issue as soon as appropriate.
3. How will TRPA be defining new SEZ Boundaries and Setbacks for the proposed channel as part of each alternative or the project?

Northwest Hydraulic Consultants:

The following comments are provided as input to a combined comment letter to be submitted by Sierra Colina to TRPA, and will be augmented by NCE and Sierra Colina. The comments are made based on review of the *Burke Creek*

Restoration Project: Preliminary Development of Alternatives (dated February 22, 2008 and produced by Winzler & Kelley).

Comments

1. The study area for stream restoration improvements is narrower than we anticipated. The technical memorandum does not describe the rationale or basis for delineating the project area boundary, which is used to bound the development of alternatives to the reaches of Burke Creek in the immediate vicinity of Highway 50 (see Figure G-1 in the memorandum). If the rationale or basis for the delineated project area is documented elsewhere, please provide that reference.

2. There appears to be potential for restoration work outside the project boundary.

    a. Please see the report previously provided to TRPA: *Burke Creek Restoration Potential and Design Concepts* (nhc, 2006). While based on a limited assessment, nhc identified a few reaches above the proposed project area (within the Sierra Colina parcel and the USFS Upper Meadow) with a high potential for restoration that could potentially meet some of the project's objectives (e.g., improved sediment transport, improved riparian corridor, etc.).

    b. The technical memorandum states that geomorphic field work and riparian field work were conducted from the Lake Tahoe shoreline to the upper meadow. What are the conclusions from that work and what are the project team's opinions of the restoration potential for the reaches surveyed upstream of the current project area?

3. More comprehensive restoration planning appears to be beneficial, even if only a portion of planned improvements can be constructed in the near term. The Burke Creek Restoration Project will likely to be the only collaborative effort to study and plan improvements for the creek for quite some time. Any future restoration activities upstream of the proposed project area may affect the improvements implemented in the project area, especially with regard to sediment transport and water quality. Can the project develop a more comprehensive restoration plan covering the stream through the Upper Meadow? This seems like the best approach to protect improvements implemented by any near term project while guiding the approach for potential future restoration improvements upstream of this project.

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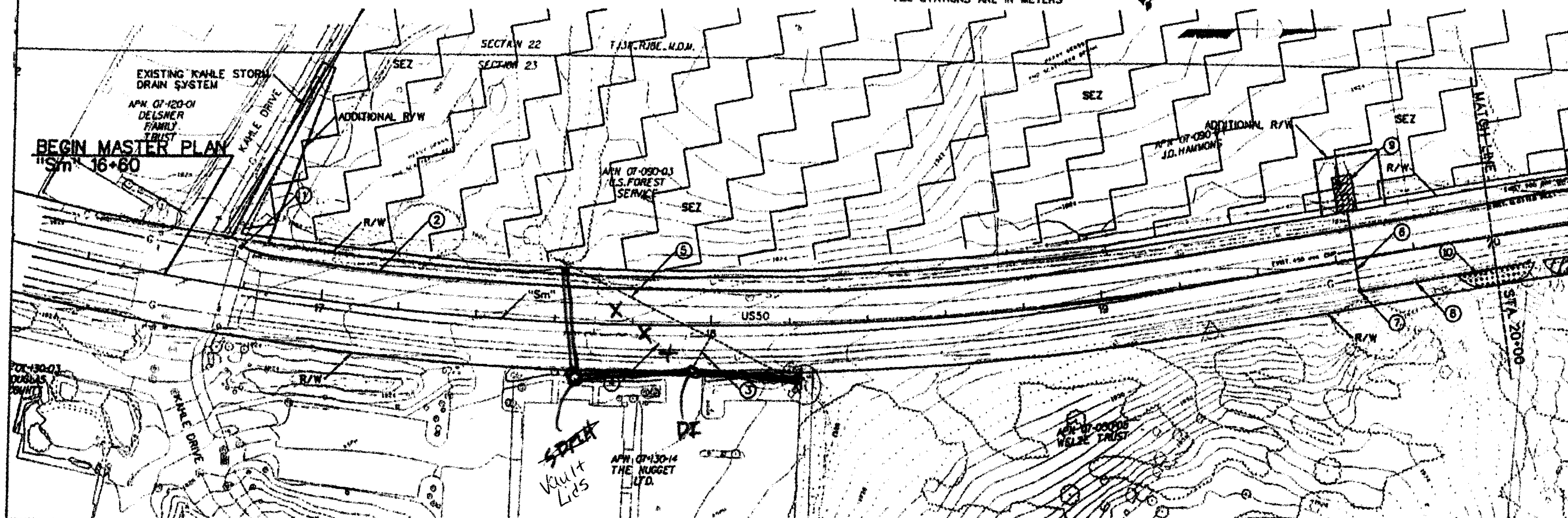

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WINZLER & KELLY

MEMORANDUM

TO: Mike Elam, TRPA

FROM: Steven Allen

DATE: July 9, 2008

RE: **Burke Creek Project Questions**

JOB #: 1118407001-11100

Mike,
Thank you for providing several TAC review comments on April 1, 2008 regarding our Preliminary Development of Alternatives Draft Technical Memorandum. We have been following up on some items that we were tasked with since then and we were expecting additional information from you as well. We are now planning our next steps for this project and we have some questions for you to help us clarify how best to proceed.

Following are some of the key issues and action items from my meeting notes from our February 27, 2008 TAC meeting summarizing our understanding of how the project would proceed:

1) A request was made (Mike Elam, Elizabeth Harrison, others) to prepare a separate document titled an "Existing Conditions Report" based on regulatory requirements (and not part of our current scope of services).

2) The project schedule is currently behind based on the final contractual start date and scheduling the TAC review meeting. Mike Elam noted we can revise the schedule and end date as needed to proceed with the project.

3) One of the pivotal constraints to our preliminary alternatives was the location and depth of utilities. Mike Elam agreed to take the lead on pursuing utility potholing in vicinity of proposed alternatives across Highway 50.

4) A second pivotal constraint to our preliminary alternatives was the parking lot at the commercial property, regarding how much of the parking lot may be used to relocate the channel. Steve Allen agreed to take the lead on working with Chad Smittkamp to resolve this issue.

5) Following our meeting, Mike Elam agreed to collect TAC review comments, review and resolve any potentially conflicting comments and then summarize key comments to be

addressed by design team. Based on the comments, Mike would provide W&K clear direction as to which alternatives are to be developed in the next task.

We are not currently clear of the outcome of all the above issues. Based on the list above, we have the following questions:

1) Do you we need to prepare an "Existing Conditions Report?" If so,
    a. What is the timeline (i.e., does this need to be done concurrently with out current work?)
    b. Can you please provide us with the details required to be included in the report?

2) Regardless of whether or not our scope of services is expanded to include an "Existing Conditions Report," can we prepare an updated schedule and corresponding contract amendment to modify the final completion date (current contract completion date is September 5, 2008)?

3) Were you successful in coordinating utility potholing? If so, can you provide us with an update?

4) Regarding the commercial parking lot, I have left several messages with Chad Smittkamp at (775) 815-8111 with no response to date. I have no other contact information for him. You and I discussed this problem on the phone and you noted that you have also had limited success in having your calls returned. Have you been able to reach him? Can you provide me with an update or suggestions on how to resolve these issues so we can move ahead? If I had an address for him I could send him a brief memo and site map as he requested at the meeting and request a response that way. We need to understand what he needs regarding parking for his tenants before we can proceed with developing any alternative that affects parking.

5) We need clear direction from you to clarify and resolve potentially conflicting TAC review comments. Following are some of the individual comments that we need clarification on:

    Comments from Elizabeth Harrison (headings and numbers from her list in her email):

    Regarding Existing Conditions Analysis

    3. Confirm that biological/wildlife/archeological surveys and related existing conditions analysis are not in our current scope. Clarify if you would like us to add these items to our scope.

    4. Relates to existing conditions analysis. Clarify if you would like us to add these items to our scope and if so what the requirements are documenting flooding.

6. Clarify what is meant by "improve riparian corridor." We have the same question as it relates to the upstream and downstream channels. There are different ways of looking at this and we need direction, eg in the lower channel is the goal to restore a meadow riparian corridor or maintain the existing willow corridor? Perhaps Tim Hagen could provide input? We need direction as to what the preferred goals are for riparian corridor.

9. Need for potholing utilities. Same as our meeting notes. Please clarify.

<u>Alternatives</u>

16-19. Please confirm which alternatives you want us to develop

20. Clarify if limiting fill in the meadow and floodplain is a driver or general recommendation.

<u>General Planning</u>

5. Please clarify relevance of the project and comment regarding EIS for the Tahoe Beach Club. If it relates to us evaluating that project's impacts on this project, that is beyond our scope. If the comment relates to a related issue we would be interested to receive a copy of the EIS.

Comments from Nichols Consulting Engineers (headings and numbers from their letter):

<u>Northwest Hydraulic Consultants comments</u>

2. Confirm that our project boundary is acceptable and we should not be considering additional work and assessment outside of the boundary. Their comment seems valid, but outside of our scope of services.
3. Confirm that their suggestion is outside of our scope of services.

Comments from Ron Roman, Douglas County (numbers from his email):

5. Clarify how to address his comment regarding potential contradiction between project objectives to improve riparian corridor and improve fish passage.

I understand that these questions need to be answered before TRPA can recommend which alternatives should be developed. We are currently on hold with this project until we get clarification on the above items. We look forward hearing from you soon. Please feel free to contact me should you have any questions.

c: Mike Love, Geoff Hales

MEMORANDUM

TO: Mike Elam, TRPA

FROM: Steven Allen

DATE: May 13, 2009

RE: **Burke Creek Project Clarifications**

JOB #: 1118407001-11100

Mike,
This memo is to clarify our understanding of direction we have received for proceeding with this project. This is a follow up to our July 9, 2008 memo to you requesting clarification on project direction after receiving TAC review comments on our February 22, 2008 Preliminary Development of Alternatives Draft Technical Memorandum. We have received various information regarding project details and how to proceed. The following is our understanding of direction provided to us. Please notify us in writing immediately if our understanding is not correct, as we now do not have much time to complete our work.

1) Schedule: we have received a contract amendment extending the project completion date to June 30, 2009, which we understand is a grant related deadline which can not be moved. Therefore all work must be complete by June 30, and the final invoice for work completed by June 30 must be provided in July. In order to complete our remaining work, we propose the following schedule updates:
    a. We are currently developing our alternatives analysis.
    b. TAC Conference call update: 1:00 pm Thursday May 21 (W&K to provide draft agenda and conference call-in information) to review what has transpired since the TAC reviewed our last transmittal and provide opportunity for the TAC and consultant team to ask clarification questions so we can complete our alternatives analysis.
    c. Monday June 8: Provide Draft Alternatives Analysis Report to TRPA for transmittal to TAC.
    d. Thursday June 11, 9am: sit down meeting at TRPA office with TAC so consultant team can discuss analysis, have a joint discussion, and answer questions.
    e. Thursday June 18: TRPA provided consultant team with a single set of comments and clear direction on how to finalize the alternatives analysis.
    f. Tuesday June 30: Submittal of final Alternatives Analysis Report, our final contract deliverable.

633 Third Street, Eureka California 95501-0417
tel 707.443.8326 fax 707.444.8330
eka@w-and-k.com
www.w-and-k.com

2) We are not being asked to prepare a separate document titled an "Existing Conditions Report" as it is not part of our existing scope.

3) We understand that locating utility depths by potholing in vicinity of proposed alternatives across Highway 50 as we requested was not feasible to be completed by TRPA. Therefore have been directed to proceed with our conceptual designs essentially ignoring potential utility conflicts with the understanding that the utilities should be able to be moved and should not be a fatal flaw to the design at this point. This includes the sewer line, previously identified as a potential major constraint, and affects all alternative alignments.

4) We have been in contact with Chad Smittkamp, the current property owner, regarding the parking lot at the commercial property. Based on information provided by Mr. Smittkamp, he may only be able to forego the back line of parking stalls (those located on the north side of the parking lot.

5) Earlier this spring we were directed by TRPA to develop Alternatives C and D, which reflected the general feedback and preference of the TAC, as noted in some of their comments to our preliminary development of alternatives report. Recently we have been directed by TRPA to develop Alternatives A and B in our alternatives analysis.

6) Based on feedback from Mr. Smittkamp regarding available space in the commercial parking lot, we have been directed by TRPA to modify the upstream portion of Alternative B to accommodate the likely available space (i.e., approximately 20 feet of the north end of the parking lot). This adjustment will require the addition of a retaining wall to still allow for some channel improvements (i.e., greater channel cross section to improve sediment transport and reduce frequency of flooding). This adjustment will also result in reduced area upstream of Hwy 50 that could be considered new SEZ compared to our previously developed Alternative B. This revised approach is also a departure from the previous direction provided which was to focus on a design that could infringe on the parking lot as needed in order to maximize various ecological benefits.

7) We are still not clear on what the project design objectives are. What is desired regarding changes or improvements to the riparian corridor or increasing potential SEZ areas? We have the same question as it relates to the upstream and downstream channels. There are different ways of looking at this and we need direction. Pursuing Alternatives A and B will both remove water from the existing willow and wetland corridor downstream of Highway 50. There may be enough surface water and groundwater to maintain some or all of the willows in the abandoned reach, but there could potentially be a loss of wetlands. Perhaps Tim Hagen could provide input? We need direction as to what the preferred goals are for the new riparian corridor. Clarify if limiting fill in the meadow and floodplain is a driver or general recommendation. Encouraging wetland development in a

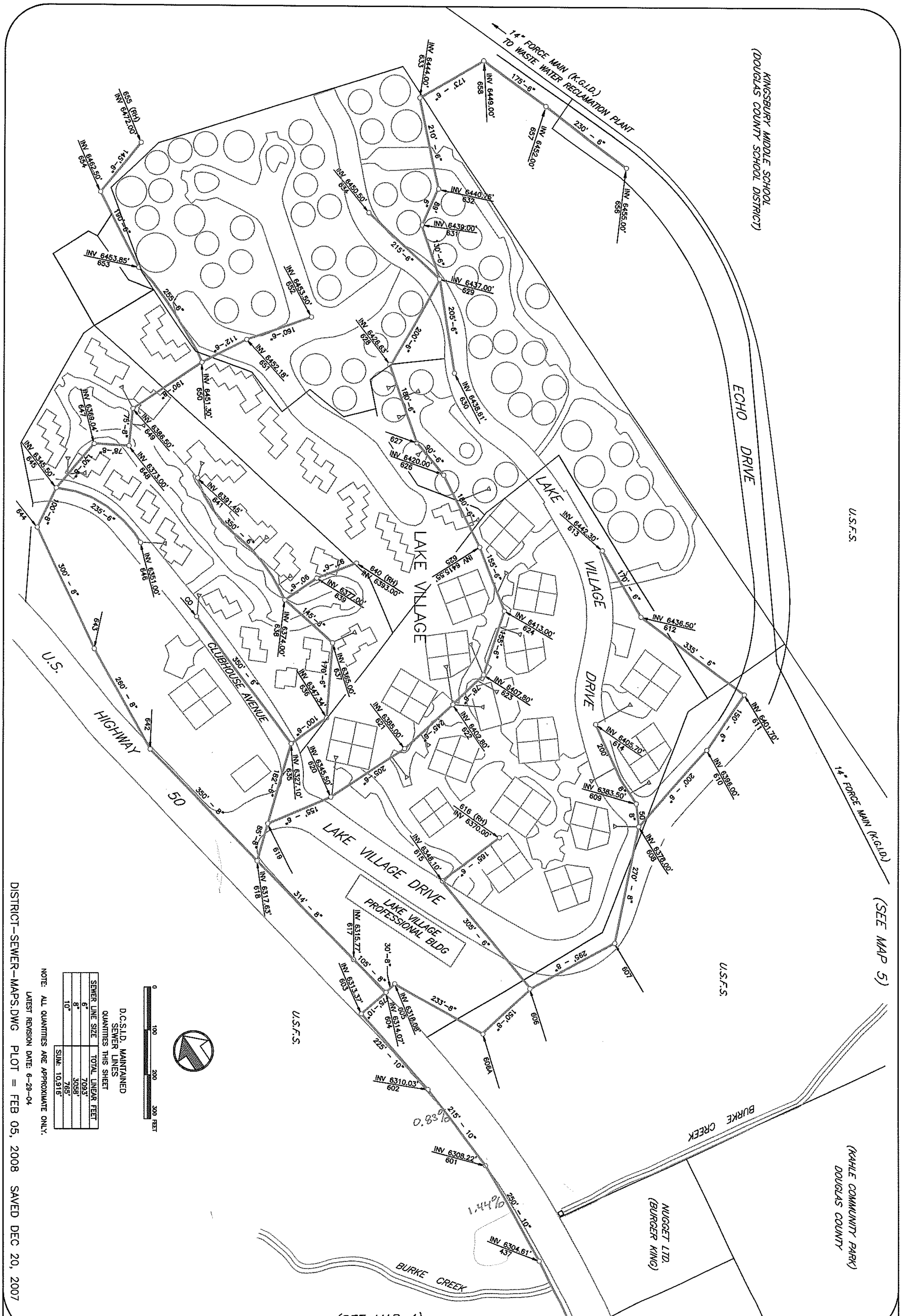
new downstream channel could limit fish passage and sediment transport capabilities. Encouraging fish passage and sediment transport could limit new wetland development. We are concerned the project could result in a net loss of wetland, and potentially require wetland mitigation.

8) Regarding comments received from Nichols Consulting Engineers (February 2008), we understand that our project boundary is acceptable and we should not be considering additional work and assessment outside of the boundary. Therefore there is nothing for us to address from their comments.

9) Regarding February 2008 comments received from Ron Roman, Douglas County, we are not sure how to address his comment regarding potential contradiction between project objectives to improve riparian corridor and improve fish passage. The historical, current and proposed channel steepness upstream of Highway 50 and the shallow flow depth in the willow dominated channel downstream of Highway 50 suggest that fish passage opportunities will be, and may have always been, limited.

We are proceeding based on the above understanding, and need additional clarification on item number seven above. Please feel free to contact me should you have any questions, and contact me immediately if any part of our understanding is not correct.

c: Mike Love, Geoff Hales



JWA

DOUGLAS COUNTY SEWER IMPROVEMENT DISTRICT NO. 1 – SEWER LINE LOCATION MAP

LAKE VILLAGE AREA

MAP 6

WINZLER & KELLY

Burke Creek TAC EIP #161

AGENDA

Conference Call Project Update

Tuesday, May 21, 2009, 1:00 pm

Dial In - 877-326-2337 Conference ID - 6507634

Project Update

- **Summary Update; Mike Elam**
  - Feb 22, 2008 Submittal of Burke Creek Preliminary Development of Alternatives
  - Feb 27, 2008 Last TAC meeting
  - March 2008 Receive review comments from individual TAC members
  - July 9, 2008 W&K submits Memo to TRPA regarding project questions & how to proceed
  - Spring 2009 W&K Coordination with Chad Smittkamp regarding parking lot requirements/options
  - Spring 2009 TRPA provides direction to Design Team
    - Develop Alternatives A & B for Alternatives Analysis Report
    - Utilities not located; therefore proceed with design development essentially ignoring potential utility conflicts with the understanding that the utilities should be able to be moved and should not be a fatal flaw to the design at this point.
    - Modify the upstream portion of Alternative B to accommodate the likely available space (i.e., approximately a 20 foot encroachment from the north end of the parking lot). This adjustment will require a retaining wall to still allow for some channel improvements (i.e., greater channel cross section to improve sediment transport and reduce frequency of flooding) rather than a 4:1 slope as shown on earlier conceptual drawings.

- **Tasks In-Progress; Mike Elam/Design Team**
  - Alternatives Analysis (Alternatives A and B only)
    - Alternative A is being developed to cross over the sewer line as there may be limited practical options to move the sewer line to accommodate a lower crossing elevation with this alternative.
    - Alternative B is being developed with a lower crossing that minimizes fill requirements in the downstream channel, but requires the gravity sewer line to be moved towards the east side of Highway 50.
  - Development of Alternatives Analysis Draft Report

633 Third Street, Eureka California 95501-0417
tel 707.443.8326 fax 707.444.8330
eka@w-and-k.com
www.w-and-k.com

- **Proposed Schedule for Completion; Mike Elam/Design Team**
  - Monday June 8: Submit Draft Alternatives Analysis Report to TRPA for transmittal to TAC (proposed submittal as PDF file available for download).
  - Thursday June 11, 9am: Sit down meeting at TRPA office with TAC so design team can present analysis, have a joint discussion, and answer questions.
  - Friday June 12 – Wednesday June 17: TAC prepares comments for TRPA.
  - Thursday June 18: TRPA provides design team with a single set of comments and clear direction on how to finalize the alternatives analysis.
  - Tuesday June 30: Submittal of final Alternatives Analysis Report to TRPA, the final contract deliverable.

- **Questions, Concerns and/or Comments**
  - TAC members
  - TRPA
  - Design Team: Winzler & Kelly, Michael Love & Associates, McBain & Trush, Inc.
    - We are still not clear on what the project design objectives are. What is desired regarding changes or improvements to the riparian corridor or increasing potential SEZ areas? We have the same question as it relates to the upstream and downstream channels. There are different ways of looking at this and we need direction. Both Alternatives A and B have the potential to de-water the existing willow and wetland corridor downstream of Highway 50. There may be enough residual surface water and groundwater to maintain some or all of the willows in the abandoned reach, but there could potentially be a loss of adjacent wetlands. Perhaps Tim Hagen could provide input? We need direction as to what the preferred goals are for the new riparian corridor. Clarify if limiting fill in the meadow and floodplain is a driver or general recommendation. We are concerned the project could result in a net loss of SEZ area, including wetland habitats, and potentially require wetland mitigation.
    - Are there suggestions for where the contractor staging area should be located for this project? We ask as access to the downstream channel is very limited. Utilizing the parking lot near Kahle Drive could be preferred staging area for safe ingress/egress to Highway 50, but would require a temporary roadway through the existing downstream channel willow corridor to access the new downstream channel construction area.
    - We understand fish passage is not a primary objective of the project, but any improvements should improve fish passage conditions. It should be

noted that the existing and proposed upstream channel slopes upstream of Highway 50 are very steep, likely greatly limiting fish passage. Also, the existing willow-channel downstream of Highway 50 produces wide shallow flow that limits fish passage, and if a new channel design utilizes a similar willow riparian corridor, the same limitations for fish passage could occur through time.

- We will need to receive one set of TAC comments from TRPA by June 18 in order for us to finalize the Alternatives Analysis by June 30th.

Steve Allen

From: Mike Elam [melam@trpa.org]
Sent: Thursday, June 18, 2009 2:50 PM
To: Steve Allen
Subject: Burke Creek
Attachments: RE: Burke Creek project; RE: Burke Creek project

Steve,

Attached are the comments received from E. Harrison and M. Azad. These are the only comments. Responses to Ms. Harrison's concerns:

1. General question
2. Not that I know of. This may be another project that might affect the outcome of the final Burke design.
3. It was concluded that the rate of sediment deposition in the pond (that may result in maintenance issues) is not significant as discussed on page 75.
4. Can the headcut be stabilized to reduce the desired heights for fish passage?
5. Can we include Alts. C and D as she requests, in the opinion of probable costs, they are discussed on page 53. We are attempting to come up with a best case scenario for ecological enhancement based on channel improvements, with the associated constraints, in the project area, and all alternatives or combinations are still on the table, we are simply persuing Alt. B as being the most viable alternative for ecological improvement. Is this true? There are other proposed projects in the area that may ultimately influence the final design alternative such as the bike path alignment coming from the north through the meadow and the Douglas County redevelopement for lower Kingsbury to name a few.
6. She is right.
7. Is a better word "define" the floodplain, rather than confine - is that what is meant?
8. Episodic events are unpredictable and always present a problem. Sediment transport is not the only reason for replacement the culvert.
9. Please add to the discussion
10. Please add to the discussion
11. There can be no reduction in SEZ area from existing; accurate SEZ delineation still needs to be completed. There is no issue in creating more "dry meadow" per se, we just cannot reduce the SEZ. Can this be accomplished with this alternative?
12. Please advise.

Please continue the process with Alt. B as discussed in the TAC meeting with consideration of the attached comments and my response. Please let me know if you have questions. Please leave a voice mail message if you need immediate assistance as I will be out of the office until Tuesday AM on the 23rd, I will check my messages in the morning and afternoon on Friday and Monday. Thanks.

Mike Elam
TRPA
Environmental Planner II
775-589-5308

Steve Allen

From: Azad, Mahmood [MAzad@co.douglas.nv.us]
Sent: Tuesday, June 16, 2009 2:10 PM
To: Mike Elam
Subject: RE: Burke Creek project
Follow Up Flag: Follow up
Flag Status: Flagged

Mike;
At this time we have only one comment: "Please proceed". We would like confirmation from US Fish & Wildlife on the fish passage velocities for LCT.

Mahmood Azad, PE
Douglas County Engineer
775.782.9063

-----Original Message-----
From: Mike Elam [mailto:melam@trpa.org]
Sent: Tuesday, June 16, 2009 11:04 AM
To: Azad, Mahmood; Craig Oehrli; Myrnie Mayville; chad smittkamp; Elizabeth Harrison; mnussbaumer@dot.state.nv.us.
Subject: Burke Creek project

Hello All,

Reminder: Burke Creek DRAFT Alternatives Analysis Comments due to me June 17 by 5pm. Please e-mail or call with your comments. Thanks.

Mike Elam
TRPA
775-589-5308

Steve Allen

From: Elizabeth Harrison [EHarrison@lands.nv.gov]
Sent: Wednesday, June 17, 2009 7:14 AM
To: Mike Elam; mazad@co.douglas.nv.us; Craig Oehrli; Myrnie Mayville; chad smittkamp; mnussbaumer@dot.state.nv.us.
Subject: RE: Burke Creek project
Follow Up Flag: Follow up
Flag Status: Flagged

Mike,
Here are my comments on the draft report.

1. Pg 11. Does the fact that the "blue-line terminates in an area denoted with wet/marshy symbology" indicate that there was not a defined channel below this point?
2. Pg 15. Are there plans that show the relocation of Kahle Drive that could be included?
3. Pg 18. It seems possible that the maintenance needs for sediment removal could be transported downslope either to the large slope break or in the pond. This may be okay but perhaps it should be discussed?
4. Pg 25. It sounds as if the "Upstream" reach will be impassable by adult and juvenile fish (for the most part) due to slope. Therefore, even with the proposed improvements, fish could not make it to upper reaches. This is very important considering the replacement of the culvert was originally intended as primarily a fish passage improvement.
5. Pg 53. Although Alt C and D were not fully developed like A and B, is there any way to include them (in a ball-park fashion) in the table of approximating impacts and costs? It still appears to me that one of these alternatives maybe should be still considered.
6. Pg 56. Section 11.1.1-Should more discussion be included in the 2nd paragraph where it discusses the "shortening the overall channel length, increasing channel slope and decreasing sinuosity"? The reason being is that these are modifications we generally are trying to avoid rather than encourage in project design. Some additional discussion may be warranted.
7. Pg 58-Section 11.2.1.- I am unsure why you would want to confine water in the floodplain.
8. Pg 60-The slope transition could cause channel avulsion or impede fish passage due to deposition of sediment. Although it is discussed that not much sediment is carried through the reach, in episodic events, there could be issues. Also there is a lot of sediment that clogs the culverts every year (from previous discussions). If it is found that sediment transport is still very low, we should also consider that sediment transport may not be a huge reason to replace the culvert.
9. Pg 75. I don't recall seeing any previous discussions on the high flow channel. What are the benefits and drawbacks and what is its exact purpose?
10. Pg 87. What event produces a 5 c.f.s flow?
11. Figures 56 and 57-So it appears there is more dry meadow created for both alternatives and both revegetation scenarios than the existing condition. Is this an issue for TRPA in terms of SEZ determinations?
12. Plan Drawing A-3-For the channel cross section F- I wasn't clear why there is excavation shown in this section when I thought the culvert was perched above the existing ground.
13. I sent this onto Janet Murphy of Tahoe Douglas Sewer District. I think I told her Thursday for comments instead of Wednesday however. IF I hear anything, I will let you all know.

Thanks for the opportunity to comment.

Elizabeth Harrison
Water Quality Program Manager
Nevada Tahoe Resource Team
Nevada Division of State Lands
901 S Stewart Street, Suite 5003
Carson City, NV 89701
(775) 684-2736
fax: 684-2721

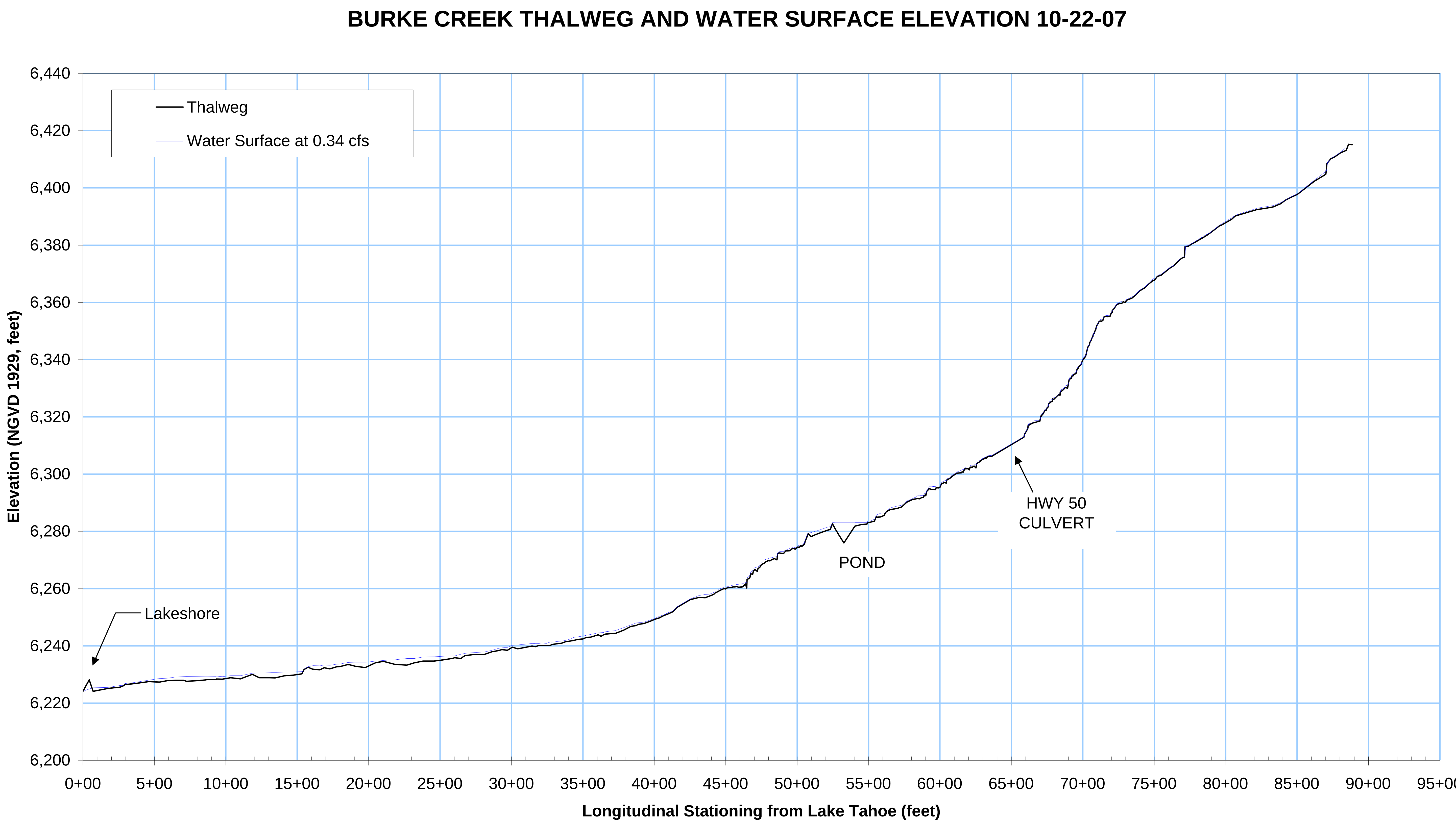
From: Mike Elam [mailto:melam@trpa.org]
Sent: Tuesday, June 16, 2009 11:04 AM
To: mazad@co.douglas.nv.us; Craig Oehrli; Myrnie Mayville; chad smittkamp; Elizabeth A. Harrison; mnussbaumer@dot.state.nv.us.
Subject: Burke Creek project

Hello All,

Reminder: Burke Creek DRAFT Alternatives Analysis Comments due to me June 17 by 5pm. Please e-mail or call with your comments. Thanks.

Mike Elam
TRPA
775-589-5308

Appendix B
Full Channel Profile


BURKE CREEK THALWEG AND WATER SURFACE ELEVATION 10-22-07
Thalweg
Water Surface at 0.34 cfs
Elevation (NGVD 1929, feet)
6,440
6,420
6,400
6,380
6,360
6,340
6,320
6,300
6,280
6,260
6,240
6,220
6,200
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
40+00
45+00
50+00
55+00
60+00
65+00
70+00
75+00
80+00
85+00
90+00
95+00
Longitudinal Stationing from Lake Tahoe (feet)
Lakeshore
POND
HWY 50
CULVERT

Appendix C
Aerial Photographs

FLOW
63+47.83
64+00
65+00
66+00
67+00
67+45.29
NORTH
50 0 50 100 150
SCALE 1"=150'
Burke Creek 1940
Channel Centerlines
1940
2007

FLOW
?
?
NORTH
50 0 50 100 150
SCALE 1"=150'
Burke Creek 1969
Channel Centerlines
1969
2007


FLOW
NORTH
SCALE 1"=150'
Burke Creek
Mid-Late 1970's
Channel Centerlines
1970's
2007


FLOW
NORTH
Burke Creek 1987
Channel Centerlines
1987
2007


FLOW
NORTH
50 0 50 100 150
SCALE 1"=150'
Burke Creek 2004
Channel Centerline
2007


FLOW
NORTH
50 0 50 100 150
SCALE 1"=150'
Burke Creek 2007
Channel Centerline
2007

Appendix D
Existing Condition
Geomorphic Assessment Data

BULK SAMPLE: PARTICLE SIZE ANALYSIS

River:	**Burke Creek**	**Sample #**	**Burke XS1**
Location:	**MLA XS1**	**Date Collected:**	**10/26/2007**
Crew:	**B. Powell**	**Method of Collection:**	**grab**
Description		**Surface/Sub-surface**	**mixed**
Sampler	**Powell**	**Bag # of #**	**1 of 1**

Date Processed: **12/10/2007**
Processed by: **BC, DM**

UNITS **G**

------------------- WEIGHT ------------

Sieve	Finer than	Final Net		%	Cum%<
256		0.0		**0.0%**	**100.0%**
180	256	0.0		**0.0%**	**100.0%**
128	180	0.0		**0.0%**	**100.0%**
90	128	0.0		**0.0%**	**100.0%**
64	90	0.0		**0.0%**	**100.0%**
45	64	0.0		**0.0%**	**100.0%**
31.5	45	0.0		**0.0%**	**100.0%**
22.4	31.5	0.0		**0.0%**	**100.0%**
16	22.4	0.0		**0.0%**	**100.0%**
11.2	16	0.0		**0.0%**	**100.0%**
8	11.2	0.0		**0.0%**	**100.0%**
5.6	8	13.8		**0.5%**	**100.0%**
4	5.6	50.4		**1.9%**	**99.5%**
2.8	4	140.6		**5.4%**	**97.6%**
2	2.8	224.3		**8.5%**	**92.2%**
1	2	498.9		**19.0%**	**83.7%**
0.85	1	126.0		**4.8%**	**64.7%**
0.5	0.85	451.8		**17.2%**	**59.9%**
0.25	0.5	627.3		**23.9%**	**42.7%**
0.125	0.25	353.5		**13.5%**	**18.8%**
0.063	0.125	111.3		**4.2%**	**5.3%**
Pan	0.063	28.4		**1.1%**	**1.1%**
TOTAL:					

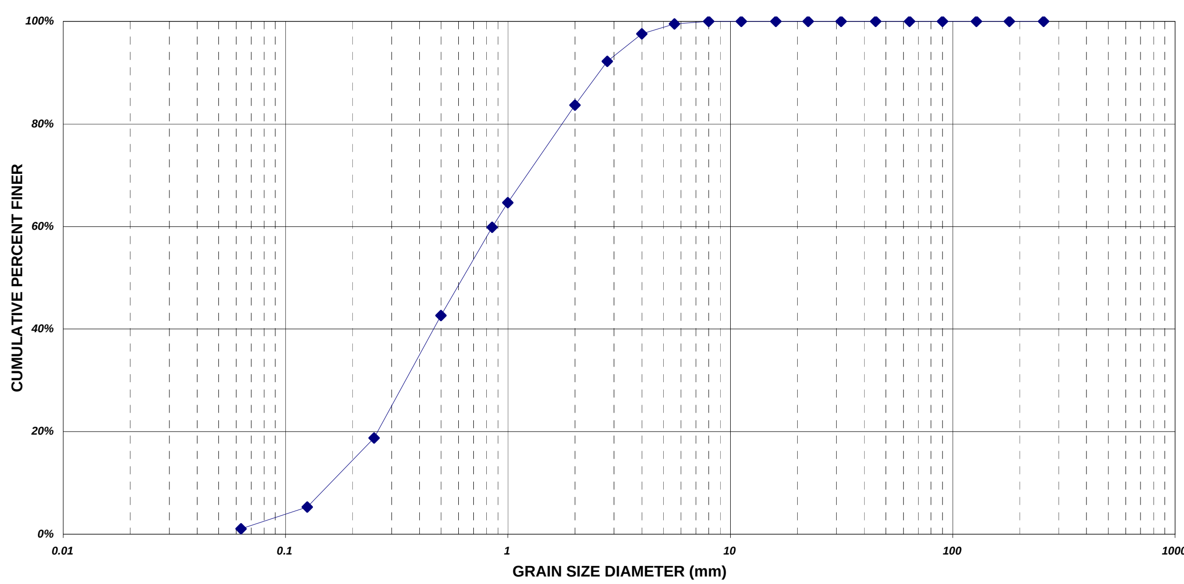
SIZE PARAMETERS

D5	**0.1 mm**
D16	**0.2 mm**
D25	**0.3 mm**
D35	**0.4 mm**
D50	**0.6 mm**
D65	**1.0 mm**
D75	**1.5 mm**
D84	**2.0 mm**
D90	**2.6 mm**
dg	**0.7 mm**
FREDLE	**0.3 mm**
T&B STEELHEAD SURVIVAL	
T&B CHINOOK SURVIVAL	
% LESS THAN 2 mm	**83.7%**
% LESS THAN 0.85 mm	**59.9%**

ADDITIONAL NOTES:

Dmax= 0.0 mm
Dmax mass= 0 g

Sample Dry Wt **2612** - Total Processed Wt 2626 = Net Loss: -14.3
% of Sample: -0.55%



BULK SAMPLE: PARTICLE SIZE ANALYSIS

River:	**Burke Creek**	**Sample #**	**Burke XS2**
Location:	**MLA XS2**	**Date Collected:**	**10/26/2007**
Crew:	**B. Powell**	**Method of Collection:**	**grab**
Description		**Surface/Sub-surface**	**mixed**
Sampler	**Powell**	**Bag # of #**	**1 of 1**

Date Processed: **12/10/2007**
Processed by: **DM**

UNITS **G**

------------------- **WEIGHT** ------------

Sieve	Finer than	Final Net	%	Cum%<
256		0.0	**0.0%**	**100.0%**
180	256	0.0	**0.0%**	**100.0%**
128	180	0.0	**0.0%**	**100.0%**
90	128	0.0	**0.0%**	**100.0%**
64	90	0.0	**0.0%**	**100.0%**
45	64	0.0	**0.0%**	**100.0%**
31.5	45	98.5	**3.2%**	**100.0%**
22.4	31.5	219.5	**7.2%**	**96.8%**
16	22.4	55.5	**1.8%**	**89.6%**
11.2	16	23.0	**0.8%**	**87.7%**
8	11.2	34.2	**1.1%**	**87.0%**
5.6	8	33.8	**1.1%**	**85.9%**
4	5.6	204.4	**6.7%**	**84.7%**
2.8	4	339.8	**11.2%**	**78.0%**
2	2.8	328.0	**10.8%**	**66.9%**
1	2	558.5	**18.3%**	**56.1%**
0.85	1	126.3	**4.1%**	**37.8%**
0.5	0.85	402.2	**13.2%**	**33.6%**
0.25	0.5	415.3	**13.6%**	**20.4%**
0.125	0.25	149.7	**4.9%**	**6.8%**
0.063	0.125	39.1	**1.3%**	**1.9%**
Pan	0.063	18.2	**0.6%**	**0.6%**
TOTAL:				

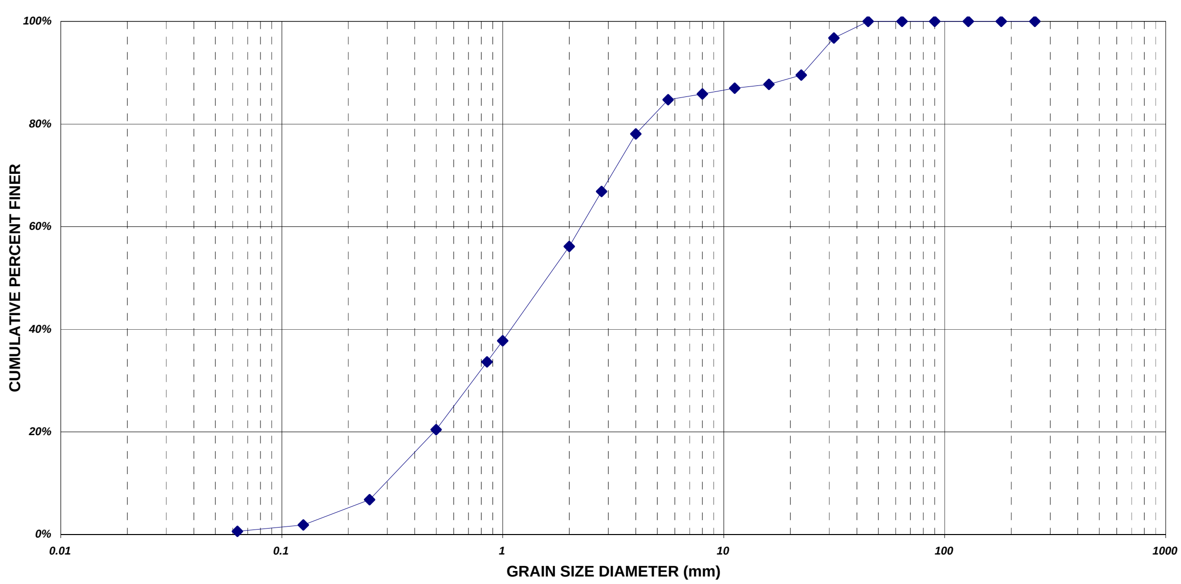
SIZE PARAMETERS

D5	**0.2 mm**
D16	**0.4 mm**
D25	**0.6 mm**
D35	**0.9 mm**
D50	**1.6 mm**
D65	**2.6 mm**
D75	**3.6 mm**
D84	**5.4 mm**
D90	**22.9 mm**
dg	**1.8 mm**
FREDLE	**0.7 mm**
T&B STEELHEAD SURVIVAL	
T&B CHINOOK SURVIVAL	
% LESS THAN 2 mm	**56.1%**
% LESS THAN 0.85 mm	**33.6%**

ADDITIONAL NOTES:

Dmax= 0.0 mm
Dmax mass= 0 g

Sample Dry Wt **3035.5** - Total Processed Wt 3046 = Net Loss: -10.4
% of Sample: -0.34%



BULK SAMPLE: PARTICLE SIZE ANALYSIS

River:	Burke Creek	Sample #	Burke XS4
Location:	MLA XS4	Date Collected:	10/26/2007
Crew:	B. Powell	Method of Collection:	grab
Description		Surface/Sub-surface	mixed
Sampler	Powell	Bag # of #	1 of 1

Date Processed: 12/18/2007
Processed by: BC

UNITS G

------------------- WEIGHT ------------

Sieve	Finer than	Final Net	%	Cum%<
256		0.0	0.0%	100.0%
180	256	0.0	0.0%	100.0%
128	180	0.0	0.0%	100.0%
90	128	0.0	0.0%	100.0%
64	90	0.0	0.0%	100.0%
45	64	0.0	0.0%	100.0%
31.5	45	0.0	0.0%	100.0%
22.4	31.5	0.0	0.0%	100.0%
16	22.4	0.0	0.0%	100.0%
11.2	16	0.0	0.0%	100.0%
8	11.2	6.0	0.2%	100.0%
5.6	8	4.0	0.1%	99.8%
4	5.6	32.3	1.2%	99.6%
2.8	4	100.9	3.7%	98.5%
2	2.8	161.4	5.9%	94.8%
1	2	593.1	21.6%	88.9%
0.85	1	185.6	6.8%	67.3%
0.5	0.85	645.5	23.5%	60.5%
0.25	0.5	677.8	24.7%	37.0%
0.125	0.25	250.1	9.1%	12.3%
0.063	0.125	68.6	2.5%	3.2%
Pan	0.063	20.2	0.7%	0.7%
TOTAL:				

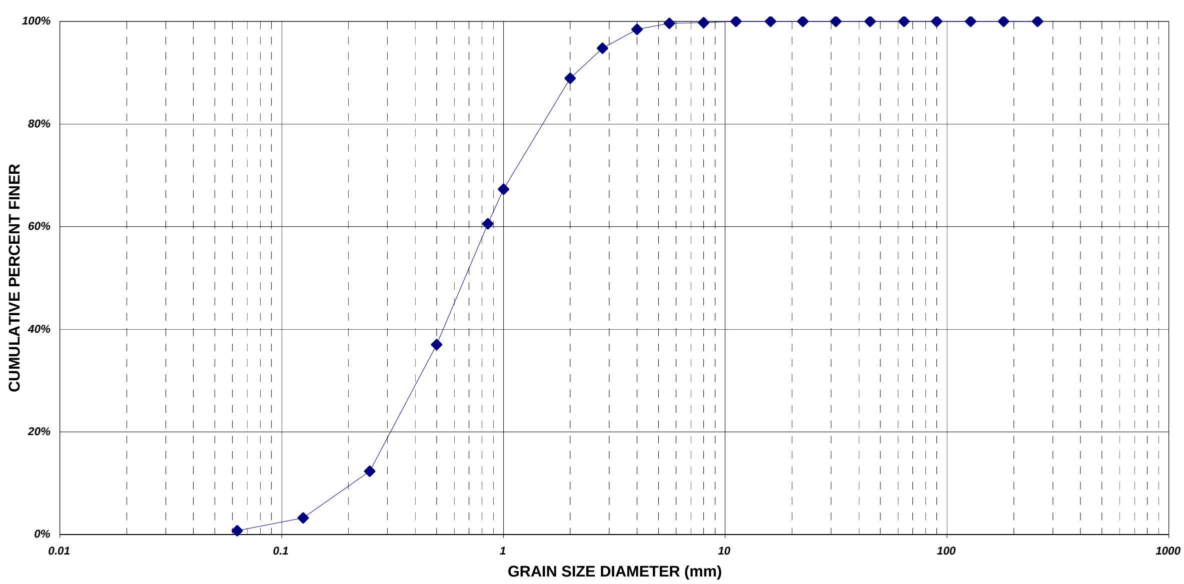
SIZE PARAMETERS

D5	0.1 mm
D16	0.3 mm
D25	0.4 mm
D35	0.5 mm
D50	0.7 mm
D65	0.9 mm
D75	1.3 mm
D84	1.7 mm
D90	2.1 mm
dg	0.7 mm
FREDLE	0.4 mm
T&B STEELHEAD SURVIVAL	
T&B CHINOOK SURVIVAL	
% LESS THAN 2 mm	88.9%
% LESS THAN 0.85 mm	60.5%

ADDITIONAL NOTES:

Dmax= 0.0 mm
Dmax mass= 0 g

Sample Dry Wt 2761.5 - Total Processed Wt 2745 = Net Loss: 16.1
% of Sample: 0.58%



BULK SAMPLE: PARTICLE SIZE ANALYSIS

River:	Burke Creek	Sample #	Burke Culvert
Location:	HWY 50 Culvert @ downstream invert	Date Collected:	10/26/2007
Crew:	B. Powell	Method of Collection:	grab
Description		Surface/Sub-surface	mixed
Sampler	Powell	Bag # of #	1 of 1

Date Processed: 12/18/2007
Processed by: BC

UNITS G

------------------- WEIGHT ------------

Sieve	Finer than	Final Net	%	Cum%<
256		0.0	0.0%	100.0%
180	256	0.0	0.0%	100.0%
128	180	0.0	0.0%	100.0%
90	128	0.0	0.0%	100.0%
64	90	0.0	0.0%	100.0%
45	64	0.0	0.0%	100.0%
31.5	45	0.0	0.0%	100.0%
22.4	31.5	0.0	0.0%	100.0%
16	22.4	0.0	0.0%	100.0%
11.2	16	0.0	0.0%	100.0%
8	11.2	0.0	0.0%	100.0%
5.6	8	0.0	0.0%	100.0%
4	5.6	1.6	0.0%	100.0%
2.8	4	21.2	0.6%	100.0%
2	2.8	179.1	5.4%	99.3%
1	2	1066.3	32.4%	93.9%
0.85	1	309.3	9.4%	61.5%
0.5	0.85	903.5	27.4%	52.1%
0.25	0.5	602.4	18.3%	24.7%
0.125	0.25	148.1	4.5%	6.4%
0.063	0.125	40.7	1.2%	1.9%
Pan	0.063	21.2	0.6%	0.6%
TOTAL:				

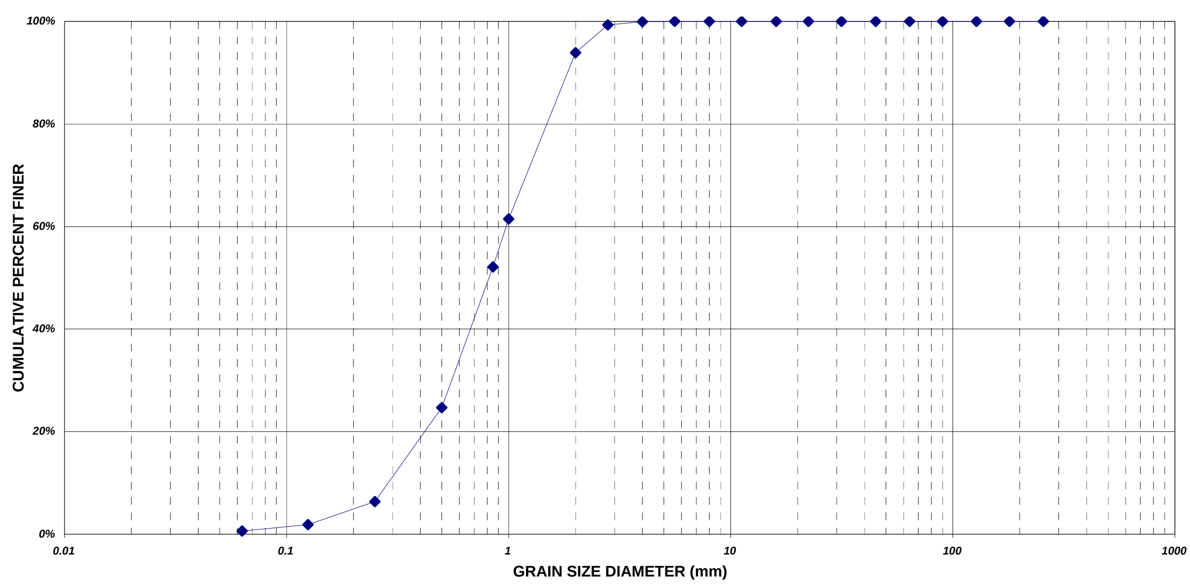
SIZE PARAMETERS

D5	0.2 mm
D16	0.4 mm
D25	0.5 mm
D35	0.6 mm
D50	0.8 mm
D65	1.1 mm
D75	1.3 mm
D84	1.6 mm
D90	1.8 mm
dg	0.8 mm
FREDLE	0.5 mm
T&B STEELHEAD SURVIVAL	
T&B CHINOOK SURVIVAL	
% LESS THAN 2 mm	93.9%
% LESS THAN 0.85 mm	52.1%

ADDITIONAL NOTES:

Dmax= 0.0 mm
Dmax mass= 0 g

Sample Dry Wt 3313 - Total Processed Wt 3293 = Net Loss: 19.5
% of Sample: 0.59%



DISCHARGE MEASUREMENT COMPUTATION SHEET, BURKE CREEK, NV

[Version 1.1 updated 09-07-05 by GH & BP]

		Date
Entered by:	BP	11/5/2007
Checked by:		

Personnel:	BP	**Begin Time:**	10/26/07 09:44	**Meter:**	PYGMY std2
Date:	10/26/07 09:44	**End Time:**	10/26/07 10:00	**Meter ID:**	0-00B
Location:	Burke Creek	**Begin Gage Height:**	NA	**SpinTest (preQ):**	
Site:	MLA-XS2	**End Gage Height:**	NA	**SpinTest (postQ):**	
Measurement No:	1	**Accuracy Rating:**	Fair		
AquaCalc GID	10/26/07 09:42	**Water Temperature:**		**Rating No:**	
Comp Sheet by:	BP	**Air Temperature:**		**Percent Diff:**	

Summary Data:

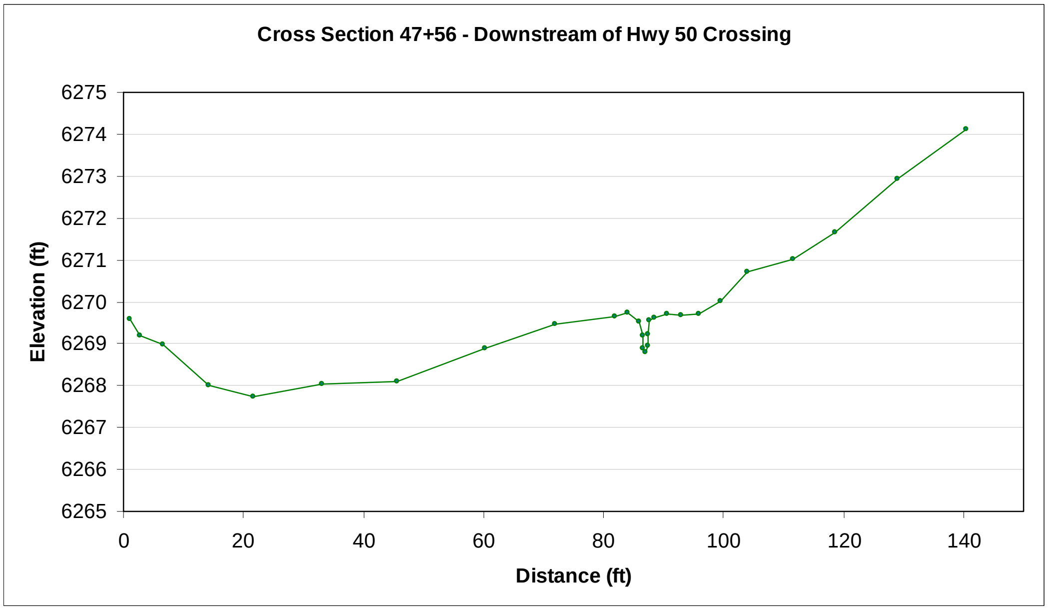
Discharge:	**0.34**	**cfs**
Width:	**2.3**	**ft**
Area:	**0.57**	**ft^2**
Mean Depth:	**0.25**	**ft**
Mean Velocity:	**0.60**	**fps**
No Verticles:	**10**	
Max % Flow:	**26.5%**	**ft**
Wetted Perimeter	**2.48**	**ft**
Hydraulic Radius	**0.23**	**ft**

Section:	Mike Love and Associates reference cross section #2, upstream of HWY 50
Flow Conditions:	low flow
Weather:	Clear and sunny
Control:	Downstream riffle crest / clear
Remarks:	A few leaves floating downstream may have interfered with a couple of verticles, unavoidable due to time of year

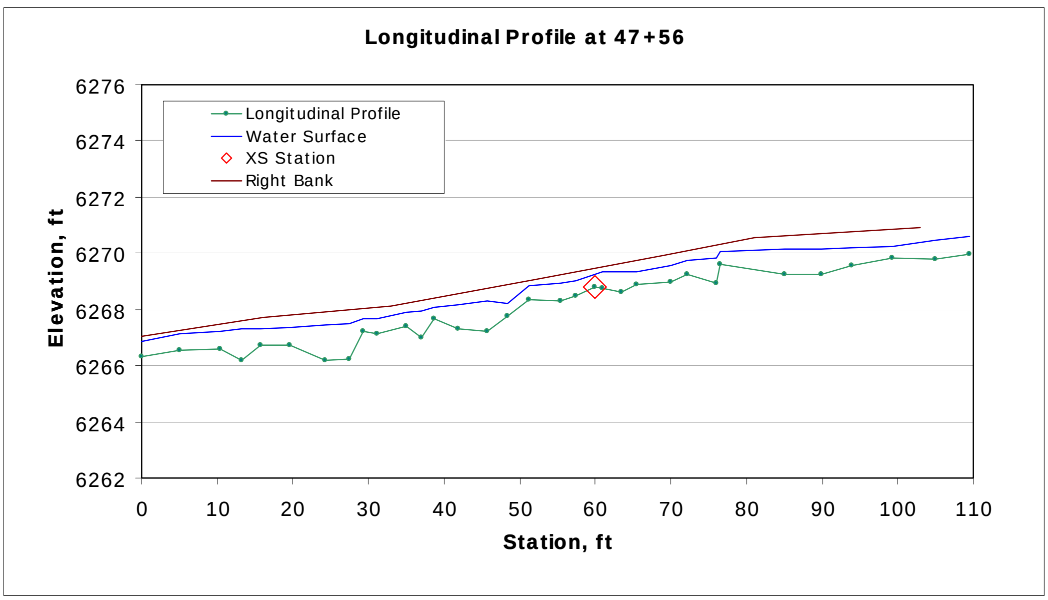
Appendix E
Existing Condition
Reference Reach Data

Downstream Reference Reach (XS4: Existing Condition Station 47+56)

- Latitude: N38° 58.380’
- Longitude: W119° 56.317’
- 1,592 feet downstream of the existing Highway 50 culvert outlet.



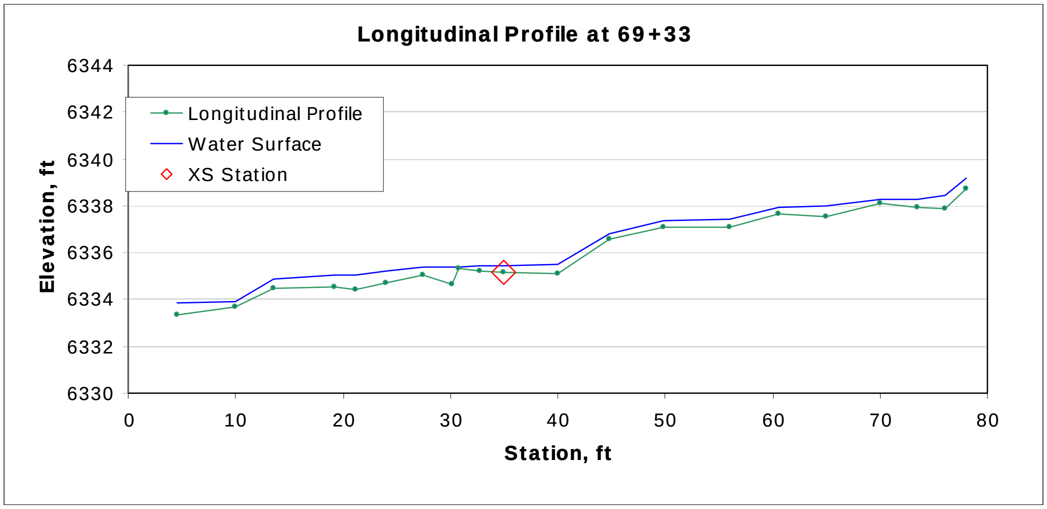
Surveyed cross section of the reference reach with vertical exaggeration.



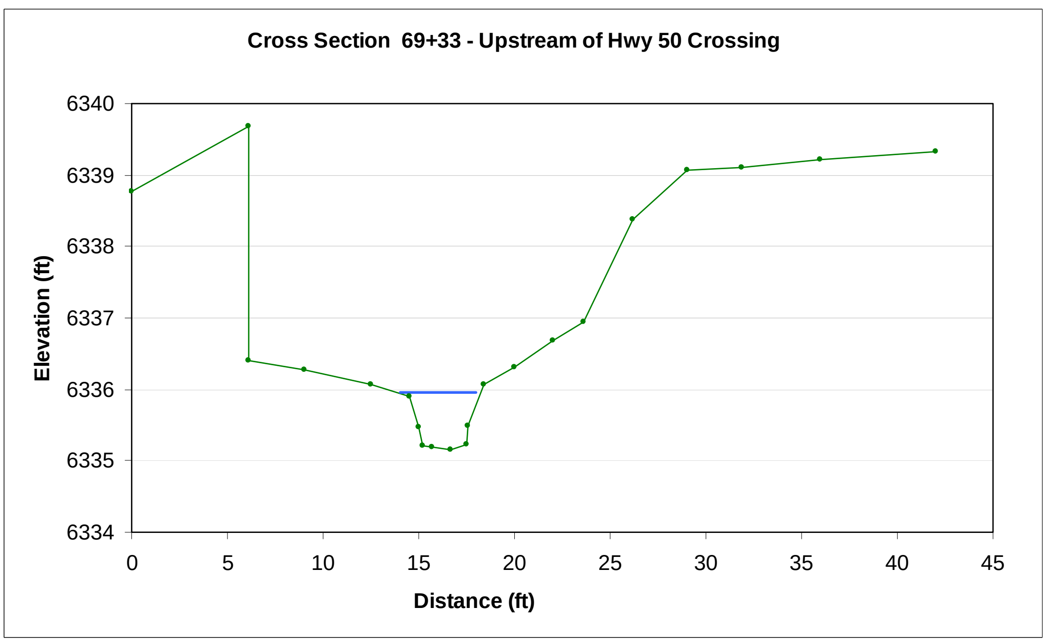
Longitudinal profile of the channel thalweg and water surface in the vicinity of the reference reach cross section.

Middle Reference Reach (XS1: Existing Station 69+33)

- Latitude: N38^o 58.370'
- Longitude: W119^o 56.023'
- 357 feet upstream of the Highway 50 culvert inlet.



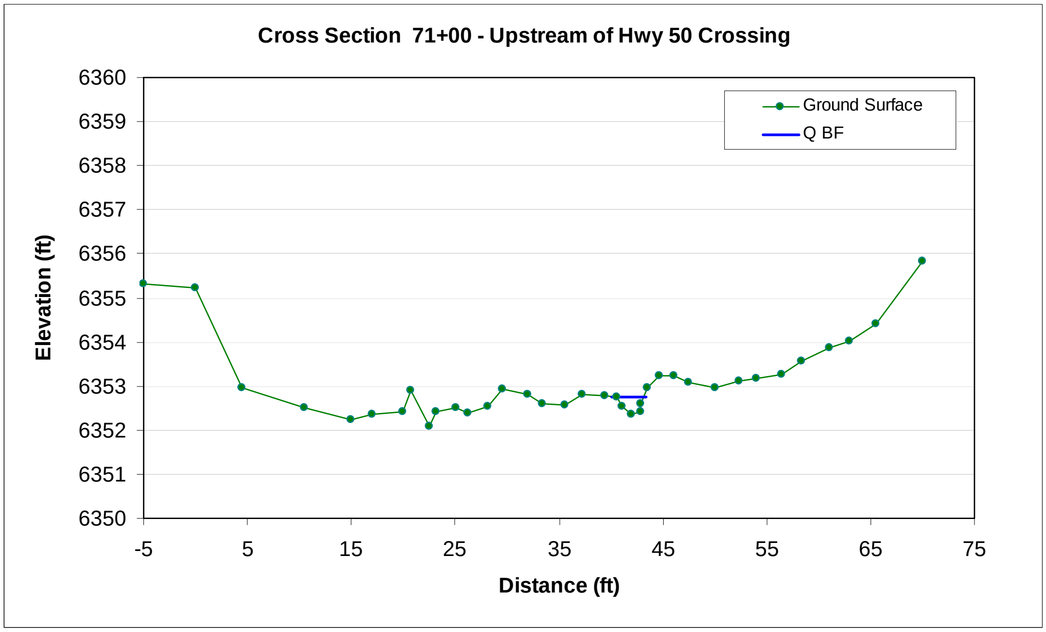
Surveyed cross section of the reference reach with vertical exaggeration.



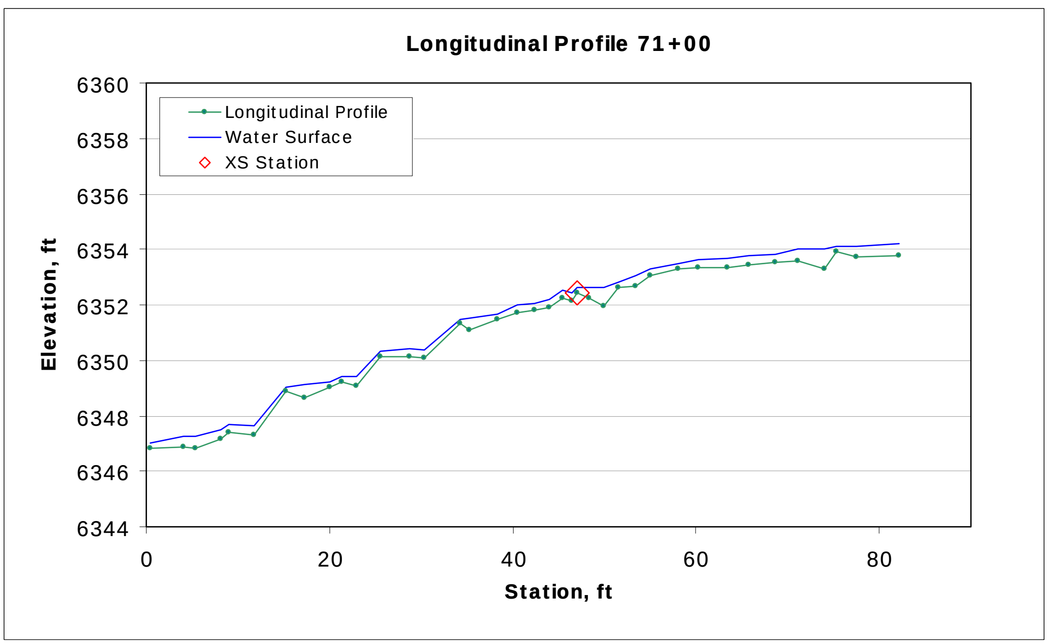
Longitudinal profile of the channel thalweg and water surface in the vicinity of the reference reach cross section.

Upstream Reference Section 2: Existing Station 71+00)

- Latitude: N38° 58.296'
- Longitude: W119° 55.990'
- 524 feet upstream of the Highway 50 culvert inlet.



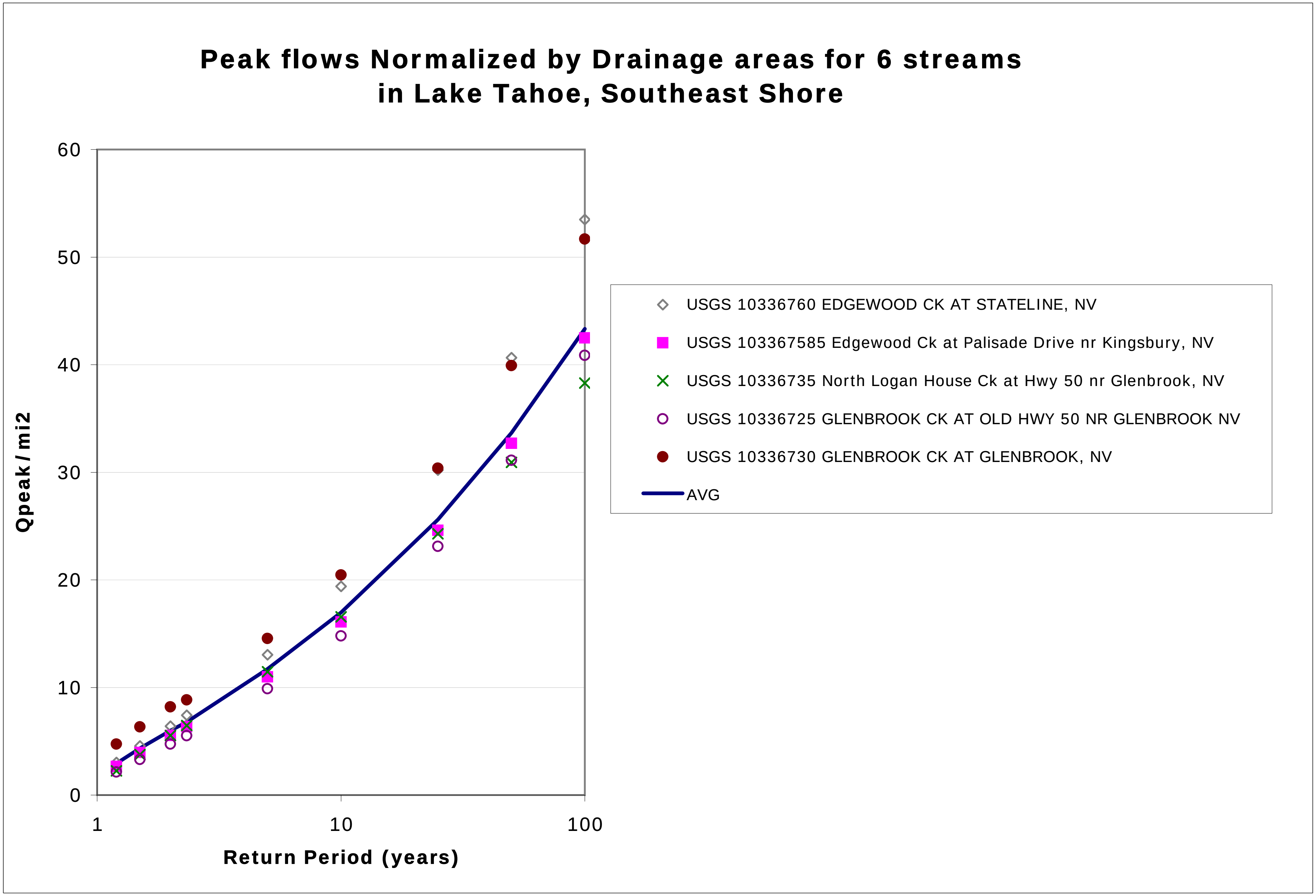
Surveyed cross section of the reference reach with vertical exaggeration.



Longitudinal profile of the channel thalweg and water surface in the vicinity of the reference reach cross section.

Appendix F

Existing Condition
Hydrologic Assessment Data



Peak flows Normalized by Drainage areas for 6 streams
in Lake Tahoe, Southeast Shore
Qpeak / mi2
0
10
20
30
40
50
60
1
10
100
Return Period (years)
USGS 10336760 EDGEWOOD CK AT STATELINE, NV
USGS 103367585 Edgewood Ck at Palisade Drive nr Kingsbury, NV
USGS 10336735 North Logan House Ck at Hwy 50 nr Glenbrook, NV
USGS 10336725 GLENBROOK CK AT OLD HWY 50 NR GLENBROOK NV
USGS 10336730 GLENBROOK CK AT GLENBROOK, NV
AVG

Flood Frequency based on Annual Maximum Series

USGS 10336725 GLENBROOK CK AT OLD HWY 50 NR GLENBROOK NV

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)
1991	5/17/1991	0.83
1992	1992	6.52
1993	1993-06	6.71
1994	4/7/1994	0.58
1995	5/4/1995	16.2
1996	5/16/1996	46.8
1997	1/2/1997	70
1998	6/7/1998	25
1999	1999-05	18
2000	2000-05	12.5

RANK	Recurrence Interval (years)	Gumbel Reduced Variate	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1	11.00	1.38	70	2	1.85
2	5.50	0.80	46.8	1	1.67
3	3.67	0.44	25	1	1.40
4	2.75	0.17	18	1	1.26
5	2.20	-0.06	16.2	0	1.21
6	1.83	-0.26	12.5	0	1.10
7	1.57	-0.46	6.71	0	0.83
8	1.38	-0.65	6.52	0	0.81
9	1.22	-0.87	0.83	0	-0.08
10	1.10	-1.13	0.58	0	-0.24

Sample Size, n =	10		
Skewness =	1.45	1.45	0.33
Mean=	25	1	1.26
Std Dev=	22	1	0.37

Flow Frequency

From USGS Data

Generalized Skew=	**0.20**	A=	-0.30394
Station Skewness (log Q)=	0.33	B=	0.85529
Station Mean (log Q)=	1.26	MSE (station skew) =	0.49667
Station Std Dev (log Q)=	0.37		
Weighted Skewness (G_W)=	**0.25**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**
1.2	0.833	-0.98486	8
1.5	0.667	-0.46552	12
2.0	0.500	-0.04118	18
2.33	0.429	0.13686	21
5.0	0.200	0.82727	37
10	0.100	1.30500	55
25	0.040	1.83275	87
50	0.020	2.18383	117
100	0.010	2.50649	153

Values From K-Table for Linear interpolation

Weighted Skewness =	0.20	0.30	0.25
P	K	K	K
0.9	-1.25824	-1.24516	-1.25202
0.8	-0.84986	-0.85285	-0.85128
0.7	-0.54757	-0.55839	-0.55272
0.6	-0.28403	-0.29897	-0.29114
0.500	-0.03325	-0.04993	-0.04118
0.429	0.14472	0.12820	0.13686
0.200	0.83044	0.82377	0.82727
0.100	1.30105	1.30936	1.30500
0.040	1.81756	1.84949	1.83275
0.020	2.15935	2.21081	2.18383
0.010	2.47226	2.54421	2.50649

Flood Frequency based on Annual Maximum Series

USGS 10336735 North Logan House Ck at Hwy 50 nr Glenbrook, NV

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Gumbel Reduced Variate	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1991	5/7/1991	1.1	1	11.00	1.38	15.7	0	1.20
1992	4/2/1992	1.2	2	5.50	0.80	11.2	0	1.05
1993	5/19/1993	2.88	3	3.67	0.44	10.6	0	1.03
1994	4/6/1994	0.87	4	2.75	0.17	10.4	0	1.02
1995	1995-05	11.2	5	2.20	-0.06	6.46	0	0.81
1996	1996-04	6.46	6	1.83	-0.26	3.14	0	0.50
1997	1/2/1997	15.7	7	1.57	-0.46	2.88	0	0.46
1998	1998-06	10.4	8	1.38	-0.65	1.2	0	0.08
1999	1999-05	10.6	9	1.22	-0.87	1.1	0	0.04
2000	4/4/2000	3.14	10	1.10	-1.13	0.87	0	-0.06

Sample Size, n =	10		
Skewness =	0.17	0.17	-0.80
Mean=	8	0	0.77
Std Dev=	5	0	0.38

Flow Frequency

From USGS Data

Generalized Skew=	**0.20**	A=	-0.26603
Station Skewness (log Q)=	-0.80	B=	0.73210
Station Mean (log Q)=	0.77	MSE (station skew) =	0.54196
Station Std Dev (log Q)=	0.38		
Weighted Skewness (G_W)=	**-0.16**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**
1.2	0.833	-0.98768	2
1.5	0.667	-0.41260	4
2.0	0.500	0.02621	6
2.33	0.429	0.20254	7
5.0	0.200	0.84827	12
10	0.100	1.26337	18
25	0.040	1.69514	26
50	0.020	1.96815	33
100	0.010	2.20978	41

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.20	-0.10	-0.16
P	K	K	K
0.9	-1.30105	-1.29178	-1.29713
0.8	-0.83044	-0.83639	-0.83296
0.7	-0.49927	-0.51207	-0.50469
0.6	-0.22168	-0.23763	-0.22843
0.500	0.03325	0.01662	0.02621
0.429	0.20925	0.19339	0.20254
0.200	0.84986	0.84611	0.84827
0.100	1.25824	1.27037	1.26337
0.040	1.67999	1.71580	1.69514
0.020	1.94499	1.99973	1.96815
0.010	2.17840	2.25258	2.20978

Flood Frequency based on Annual Maximum Series

USGS 103367585 Edgewood Ck at Palisade Drive nr Kingsbury, NV

Annual Maxima Series								
WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Gumbel Reduced Variate	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1991	8/14/1991	57	1	12.00	1.45	57.0	2	1.76
1992	10/26/1991	4.5	2	6.00	0.88	51.0	1	1.71
1993	4/21/1993	7.8	3	4.00	0.52	21.0	1	1.32
1994	4/17/1994	1.7	4	3.00	0.25	21.0	1	1.32
1995	5/1/1995	11	5	2.40	0.03	14.0	0	1.15
1996	5/16/1996	21	6	2.00	-0.16	11.0	0	1.04
1997	1/2/1997	51	7	1.71	-0.35	7.8	0	0.89
1998	3/24/1998	21	8	1.50	-0.52	7.1	0	0.85
1999	5/12/1999	14	9	1.33	-0.70	4.5	0	0.65
2000	4/13/2000	7.1	10	1.20	-0.90	3.4	0	0.53
2001	3/28/2001	3.4	11	1.09	-1.16	1.7	0	0.23

Sample Size, n =	11		
Skewness =	1.17	1.17	0.45
Mean=	24	1	1.25
Std Dev=	19	1	0.34

Flow Frequency

From USGS Data

Generalized Skew=	**0.20**	A=	-0.29381
Station Skewness (log Q)=	0.45	B=	0.82237
Station Mean (log Q)=	1.25	MSE (station skew) =	0.47006
Station Std Dev (log Q)=	0.34		
Weighted Skewness (G w)=	**0.30**		

Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Predicicted Discharge (cfs)
1.2	0.833	-0.98366	8
1.5	0.667	-0.47177	12
2.0	0.500	-0.04972	17
2.33	0.429	0.12841	20
5.0	0.200	0.82386	34
10	0.100	1.30927	50
25	0.040	1.84910	77
50	0.020	2.21017	102
100	0.010	2.54331	133

Values From K-Table for Linear interpolation

Weighted Skewn	0.30	0.40	0.30
P	K	K	K
0.9	-1.24516	-1.23114	-1.24534
0.8	-0.85285	-0.85508	-0.85282
0.7	-0.55839	-0.56867	-0.55826
0.6	-0.29897	-0.31362	-0.29879
0.500	-0.04993	-0.06651	-0.04972
0.429	0.12820	0.11154	0.12841
0.200	0.82377	0.81638	0.82386
0.100	1.30936	1.31671	1.30927
0.040	1.84949	1.88039	1.84910
0.020	2.21081	2.26133	2.21017
0.010	2.54421	2.61539	2.54331

Flood Frequency based on Annual Maximum Series

USGS 10336760 EDGEWOOD CK AT STATELINE, NV

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Gumbel Reduced Variate	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1993	5/3/1993	11	1	15.00	1.63	136	4	2.13
1994	1/4/1994	6.4	2	7.50	1.07	86	2	1.93
1995	5/1/1995	31	3	5.00	0.72	67	2	1.83
1996	12/12/1995	32	4	3.75	0.46	32	1	1.51
1997	1/2/1997	136	5	3.00	0.25	31	1	1.49
1998	3/24/1998	67	6	2.50	0.07	20	1	1.30
1999	5/13/1999	20	7	2.14	-0.09	17	0	1.23
2000	2/17/2000	14	8	1.88	-0.24	15	0	1.18
2001	5/30/2001	12	9	1.67	-0.38	14	0	1.15
2002	4/11/2002	15	10	1.50	-0.52	13	0	1.11
2003	11/11/2002	17	11	1.36	-0.67	12	0	1.08
2004	3/22/2004	13	12	1.25	-0.82	12	0	1.08
2005	5/16/2005	12	13	1.15	-1.00	11	0	1.04
2006	12/31/2005	86	14	1.07	-1.23	6.4	0	0.81

Sample Size, n =	14		
Skewness =	1.33	1.33	0.48
Mean=	51	1	1.57
Std Dev=	43	1	0.35

Flow Frequency

From USGS Data

Generalized Skew=	**0.20**	A=	-0.29124
Station Skewness (log Q)=	0.48	B=	0.81404
Station Mean (log Q)=	1.57	MSE (station skew) =	0.38887
Station Std Dev (log Q)=	0.35		
Weighted Skewness (G_w)=	**0.32**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**
1.2	0.833	-0.98284	17
1.5	0.667	-0.47477	26
2.0	0.500	-0.05397	36
2.33	0.429	0.12414	42
5.0	0.200	0.82197	73
10	0.100	1.31115	109
25	0.040	1.85701	169
50	0.020	2.22311	228
100	0.010	2.56154	300

Values From K-Table for Linear interpolation

Weighted Skewnes	0.30	0.40	0.32
P	K	K	K
0.9	-1.24516	-1.23114	-1.24175
0.8	-0.85285	-0.85508	-0.85339
0.7	-0.55839	-0.56867	-0.56089
0.6	-0.29897	-0.31362	-0.30254
0.500	-0.04993	-0.06651	-0.05397
0.429	0.12820	0.11154	0.12414
0.200	0.82377	0.81638	0.82197
0.100	1.30936	1.31671	1.31115
0.040	1.84949	1.88039	1.85701
0.020	2.21081	2.26133	2.22311
0.010	2.54421	2.61539	2.56154

Flood Frequency based on Annual Maximum Series

USGS 10336730 GLENBROOK CK AT GLENBROOK, NV

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Gumbel Reduced Variate	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1988	4/14/1988	1.4	1	20.00	1.87	144	4	2.16
1989	3/8/1989	5.7	2	10.00	1.30	42	1	1.62
1990	9/26/1990	2.9	3	6.67	0.97	40	1	1.60
1991	3/4/1991	5	4	5.00	0.72	37	1	1.57
1992	10/26/1991	6.2	5	4.00	0.52	31	1	1.49
1993	3/17/1993	7.4	6	3.33	0.35	25	1	1.40
1994	5/8/1994	2	7	2.86	0.21	24	1	1.38
1995	5/4/1995	25	8	2.50	0.07	17	0	1.23
1996	5/16/1996	37	9	2.22	-0.05	11	0	1.04
1997	1/2/1997	144	10	2.00	-0.16	7.4	0	0.87
1998	6/7/1998	40	11	1.82	-0.27	7.3	0	0.86
1999	5/26/1999	31	12	1.67	-0.38	6.2	0	0.79
2000	5/24/2000	17	13	1.54	-0.49	5.7	0	0.76
2001	5/19/2001	2.3	14	1.43	-0.59	5	0	0.70
2002	11/24/2001	11	15	1.33	-0.70	4.3	0	0.63
2003	1/23/2003	4.3	16	1.25	-0.82	2.9	0	0.46
2004	3/18/2004	7.3	17	1.18	-0.95	2.3	0	0.36
2005	5/20/2005	24	18	1.11	-1.10	2	0	0.30
2006	12/31/2005	42	19	1.05	-1.31	1.4	0	0.15

Sample Size, n =	19		
Skewness =	2.58	2.58	1.57
Mean=	45	1	1.56
Std Dev=	41	1	0.28

Flow Frequency

From USGS Data

Generalized Skew=	**0.20**	A=	-0.05021
Station Skewness (log Q)=	1.57	B=	0.55000
Station Mean (log Q)=	1.56	MSE (station skew) =	0.62586
Station Std Dev (log Q)=	0.28		
Weighted Skewness (G_W)=	**0.64**		

Log Pearson Type III Distribution

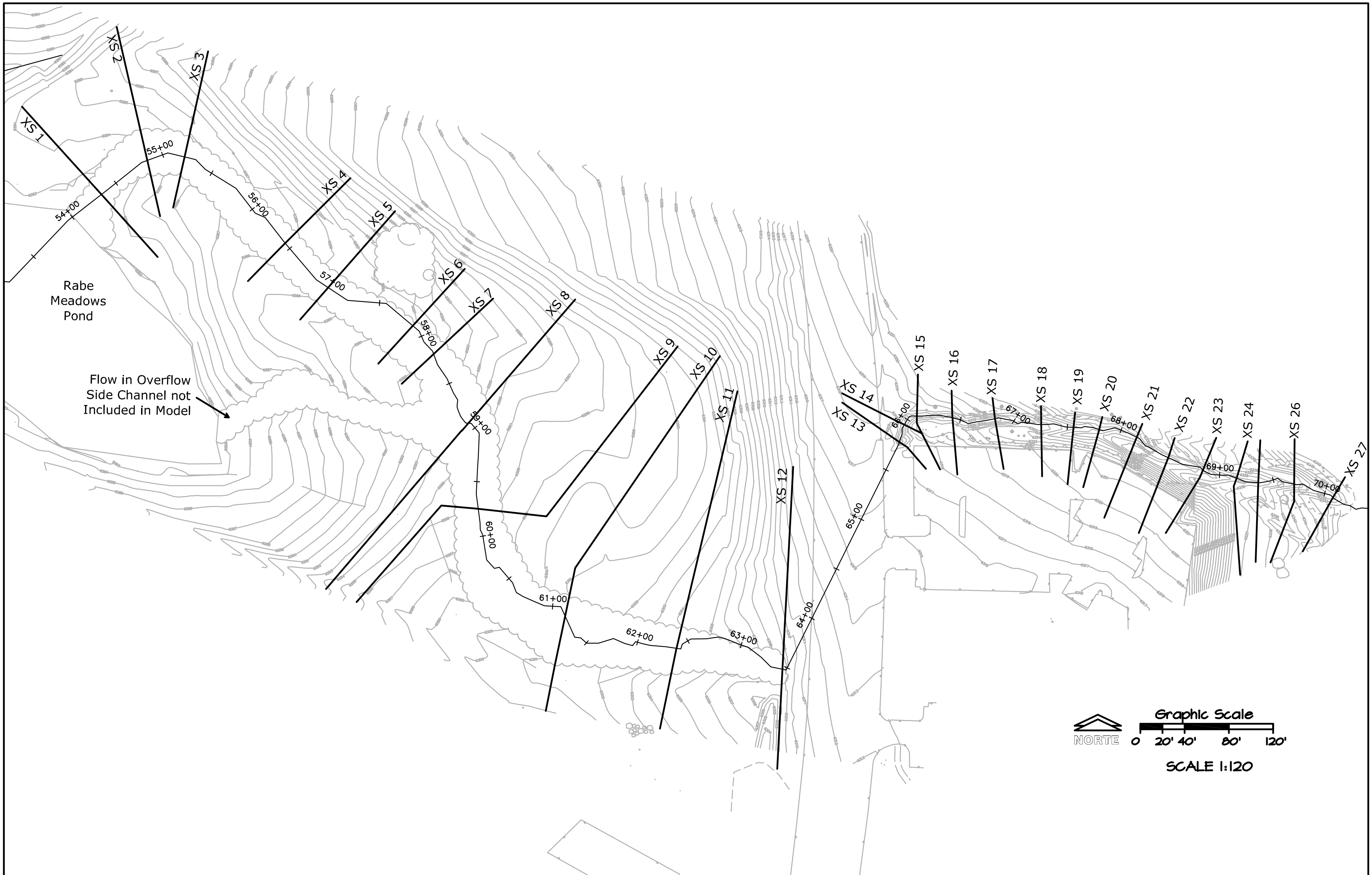
Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**
1.2	0.833	-0.96900	19
1.5	0.667	-0.51029	26
2.0	0.500	-0.10673	34
2.33	0.429	0.01597	36
5.0	0.200	0.79536	60
10	0.100	1.33048	84
25	0.040	1.95129	125
50	0.020	2.38044	164
100	0.010	2.78567	212

Values From K-Table for Linear interpolation

Weighted Skewness =	0.60	0.70	0.64
P	K	K	K
0.9	-1.20028	-1.18347	-1.19278
0.8	-0.85718	-0.85703	-0.85711
0.7	-0.58757	-0.59615	-0.59140
0.6	-0.34198	-0.35565	-0.34808
0.500	-0.09945	-0.11578	-0.10673
0.429	0.07791	-0.06097	0.01597
0.200	0.79950	0.79022	0.79536
0.100	1.32850	1.33294	1.33048
0.040	1.93896	1.96660	1.95129
0.020	2.35931	2.40670	2.38044
0.010	2.75514	2.82359	2.78567

Appendix G

Existing Condition Hydraulic Assessment

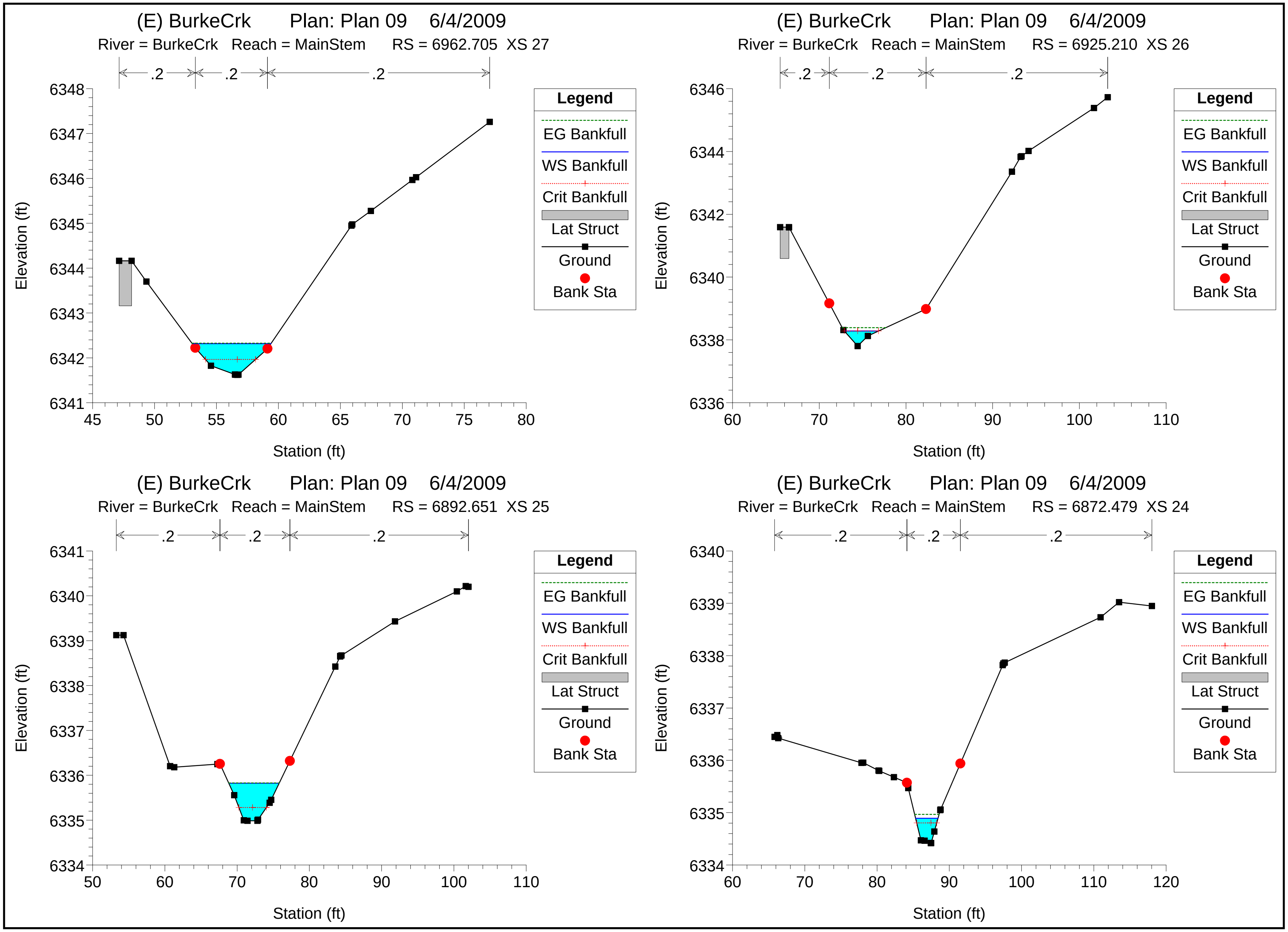


Existing Conditions

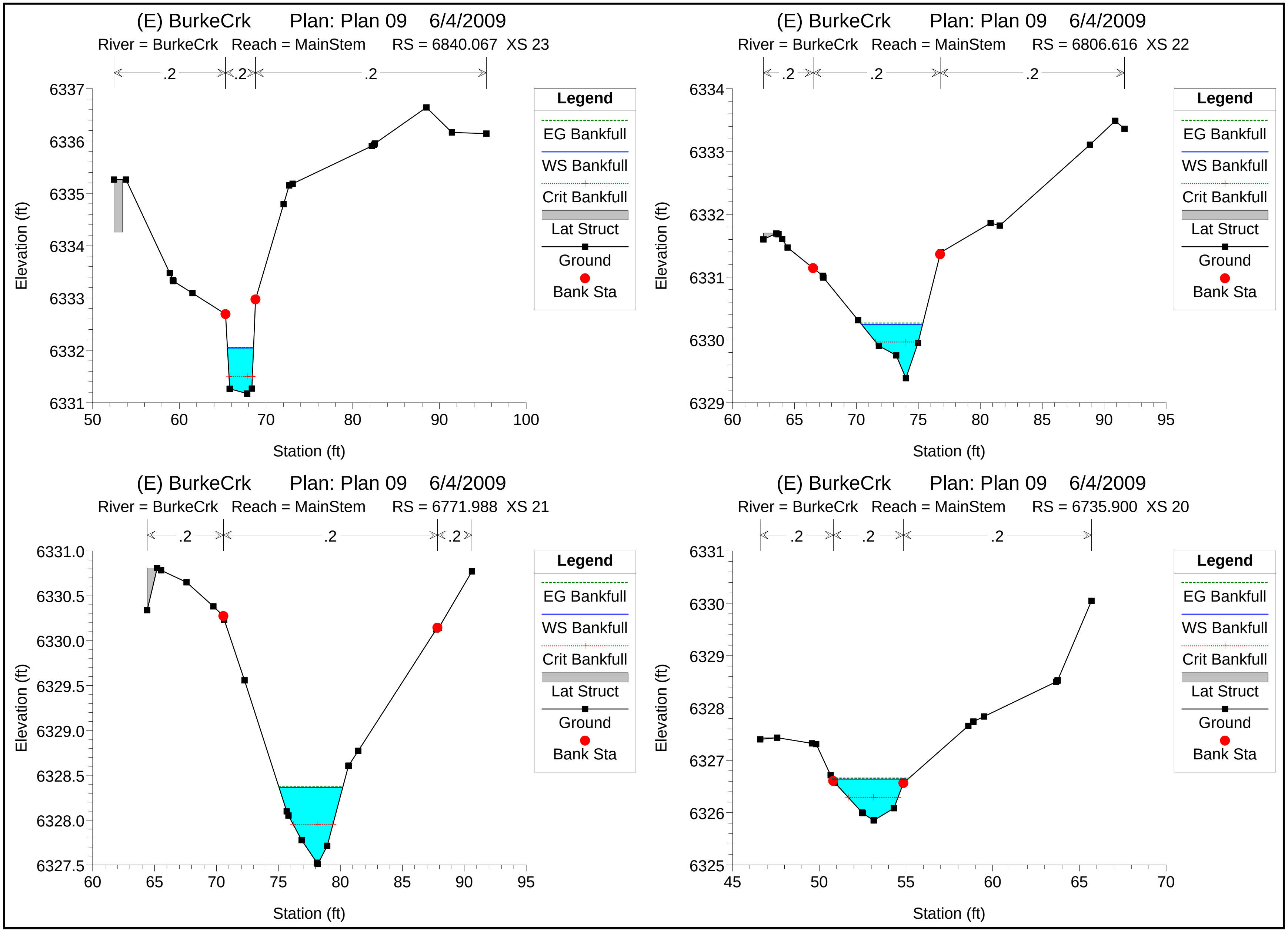
HEC-RAS Alignment and Cross Sections

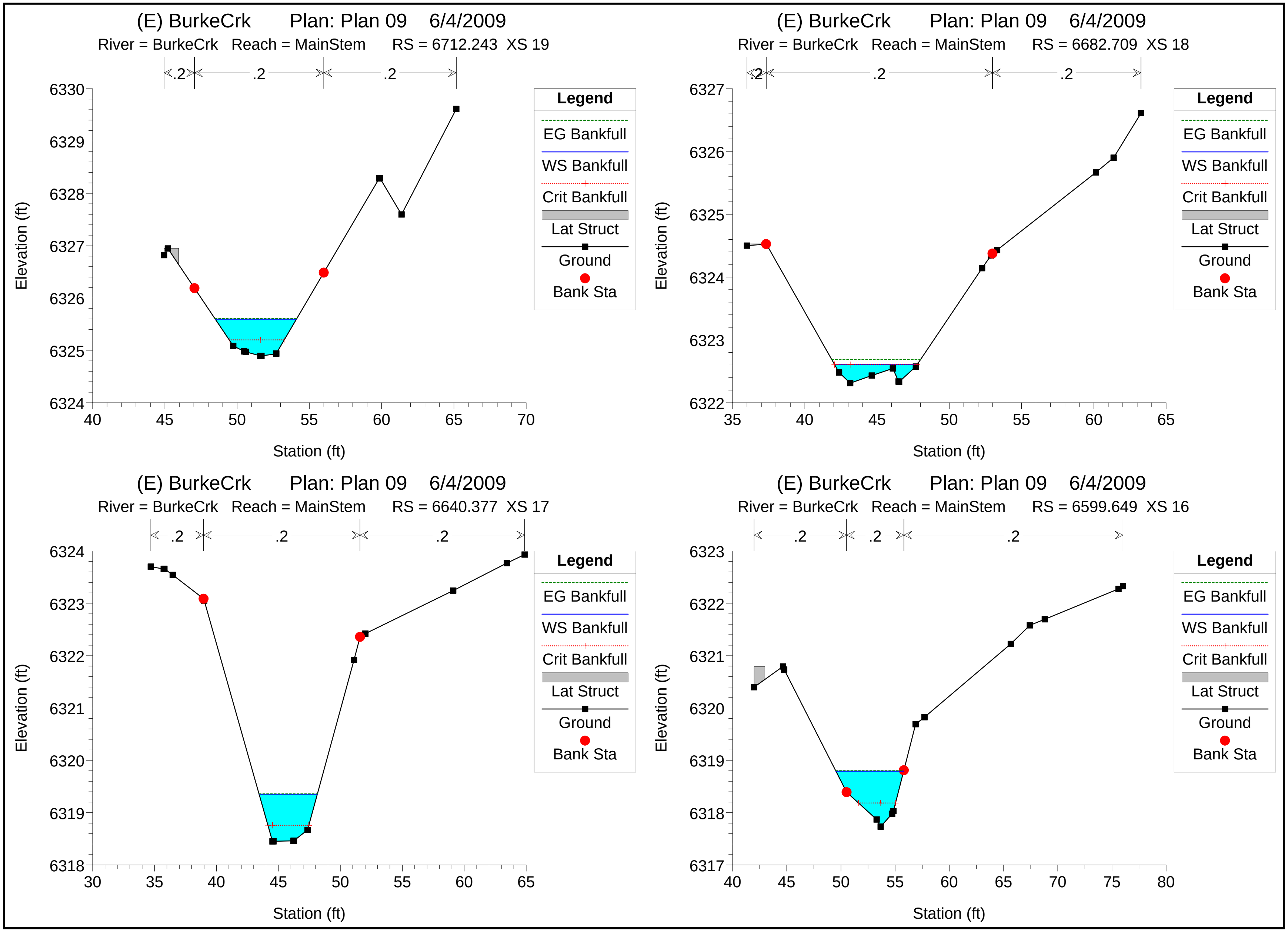
Bankfull Flow Existing Condition HEC-RAS Model

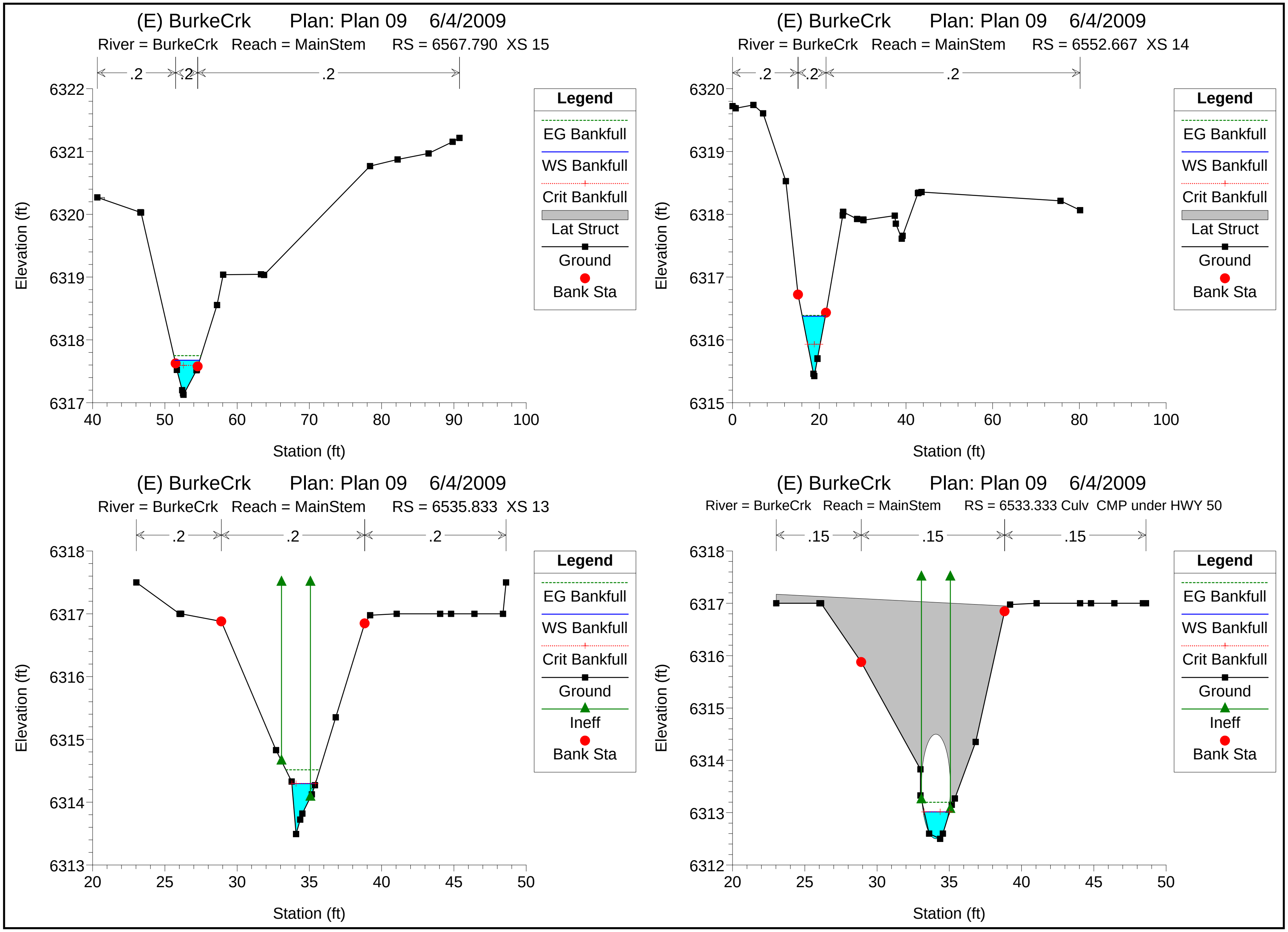
HEC-RAS Plan: Plan 07 River: BurkeCrk Reach: MainStem Profile: Bankfull													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
MainStem	6962.7	Bankfull	2.2	6341.6	6342.3	6342.0	6342.3	0.03661	0.83	2.68	6.36	0.22	1.01
MainStem	6962.0		Lat Struct										
MainStem	6925.2	Bankfull	2.2	6337.8	6338.3	6338.3	6338.4	1.03880	2.63	0.84	3.95	1.01	13.31
MainStem	6892.7	Bankfull	2.2	6335.0	6335.8	6335.3	6335.8	0.01483	0.58	3.76	6.98	0.14	0.48
MainStem	6872.5	Bankfull	2.2	6334.4	6334.9	6334.8	6335.0	0.42663	2.19	1.01	3.10	0.68	8.06
MainStem	6840.1	Bankfull	2.2	6331.2	6332.1	6331.5	6332.1	0.03737	0.96	2.29	3.01	0.19	1.28
MainStem	6806.6	Bankfull	2.2	6329.4	6330.3	6330.0	6330.3	0.08399	1.11	1.98	4.94	0.31	1.95
MainStem	6772.0	Bankfull	2.2	6327.5	6328.4	6328.0	6328.4	0.03803	0.87	2.53	5.15	0.22	1.10
MainStem	6735.9	Bankfull	2.2	6325.9	6326.6	6326.3	6326.7	0.06153	1.10	2.02	4.36	0.27	1.76
MainStem	6712.2	Bankfull	2.2	6324.9	6325.6	6325.2	6325.6	0.03419	0.82	2.69	5.62	0.21	0.98
MainStem	6682.7	Bankfull	2.2	6322.3	6322.6	6322.6	6322.7	1.08032	2.31	0.95	5.72	0.99	11.00
MainStem	6640.4	Bankfull	2.2	6318.5	6319.4	6318.8	6319.4	0.01736	0.69	3.17	4.70	0.15	0.65
MainStem	6599.6	Bankfull	2.2	6317.7	6318.8	6318.2	6318.8	0.01113	0.59	3.86	6.26	0.12	0.45
MainStem	6567.8	Bankfull	2.2	6317.1	6317.7	6317.6	6317.8	0.40459	2.18	1.02	3.42	0.67	7.90
MainStem	6552.7	Bankfull	2.2	6315.4	6316.4	6315.9	6316.4	0.03767	0.85	2.58	5.32	0.22	1.07
MainStem	6535.8	Bankfull	2.2	6313.5	6314.3	6314.3	6314.5	1.32512	3.75	0.59	1.62	0.98	24.05
MainStem	6533.3		Culvert										
MainStem	6297.5	Bankfull	2.2	6306.3	6307.1	6306.7	6307.1	0.02390	0.61	3.60	9.15	0.17	0.58
MainStem	6204.9	Bankfull	2.2	6303.2	6303.5	6303.4	6303.5	0.07343	0.63	3.51	20.19	0.26	0.80
MainStem	6100.3	Bankfull	2.2	6300.0	6300.8	6300.5	6300.8	0.01262	0.29	7.49	35.35	0.11	0.16
MainStem	5957.1	Bankfull	2.2	6295.7	6296.0	6295.9	6296.0	0.26453	1.16	1.89	11.28	0.50	2.77
MainStem	5885.2	Bankfull	2.2	6292.7	6294.0	6293.1	6294.0	0.00980	0.38	5.82	15.43	0.11	0.23
MainStem	5812.9	Bankfull	2.2	6291.8	6292.0	6292.0	6292.0	0.24345	0.72	3.08	37.01	0.43	1.33
MainStem	5782.5	Bankfull	2.2	6289.7	6290.5	6290.0	6290.5	0.02085	0.63	3.48	7.52	0.16	0.59
MainStem	5702.0	Bankfull	2.2	6289.1	6289.4	6289.2	6289.4	0.00989	0.26	9.22	55.91	0.10	0.13
MainStem	5645.6	Bankfull	2.2	6287.1	6287.4	6287.4	6287.5	1.10608	2.39	0.92	5.41	1.02	11.66
MainStem	5524.5	Bankfull	2.2	6283.7	6284.6	6284.0	6284.6	0.00193	0.21	10.63	20.93	0.05	0.06
MainStem	5487.9	Bankfull	2.2	6283.9	6284.2	6284.2	6284.3	1.02366	2.15	1.02	6.65	0.97	9.77
MainStem	5433.6	Bankfull	2.2	6281.8	6283.0	6282.2	6283.0	0.00107	0.20	13.39	37.64	0.04	0.05



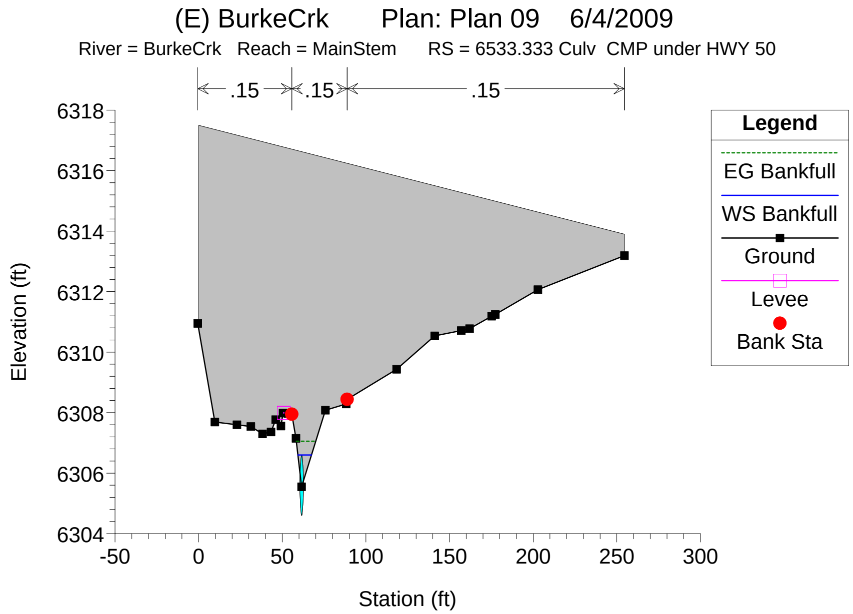
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6962.705 XS 27
.2
.2
.2
Elevation (ft)
Station (ft)
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6925.210 XS 26
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6892.651 XS 25
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6872.479 XS 24

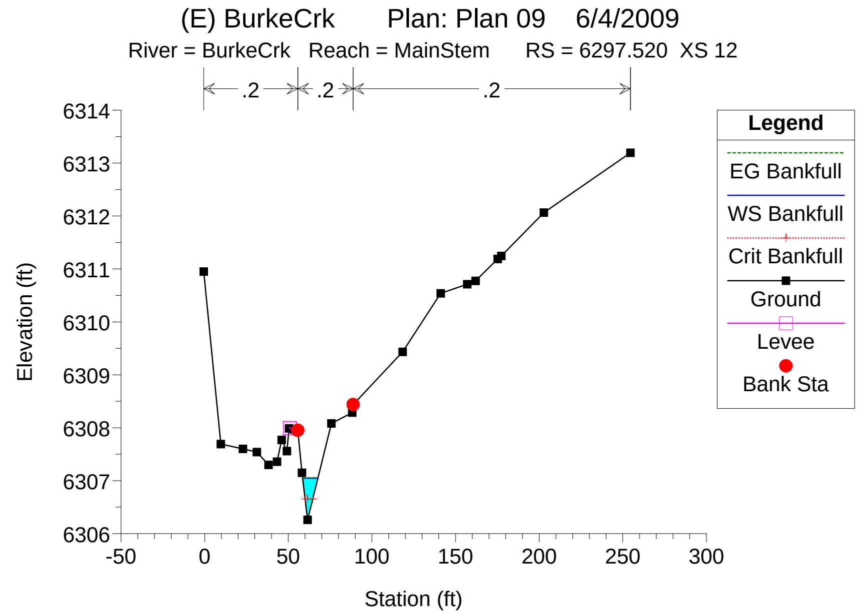

(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6840.067 XS 23
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6337
6336
6335
6334
6333
6332
6331
50
60
70
80
90
100
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6806.616 XS 22
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6334
6333
6332
6331
6330
6329
60
65
70
75
80
85
90
95
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6771.988 XS 21
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6331.0
6330.5
6330.0
6329.5
6329.0
6328.5
6328.0
6327.5
60
65
70
75
80
85
90
95
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6735.900 XS 20
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6331
6330
6329
6328
6327
6326
6325
45
50
55
60
65
70

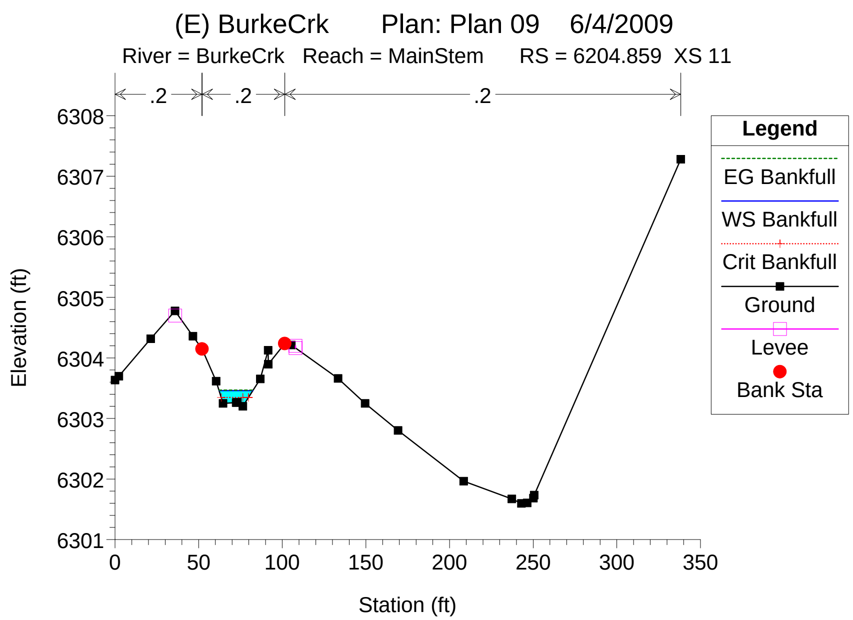

(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6712.243 XS 19
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6682.709 XS 18
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6640.377 XS 17
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6599.649 XS 16

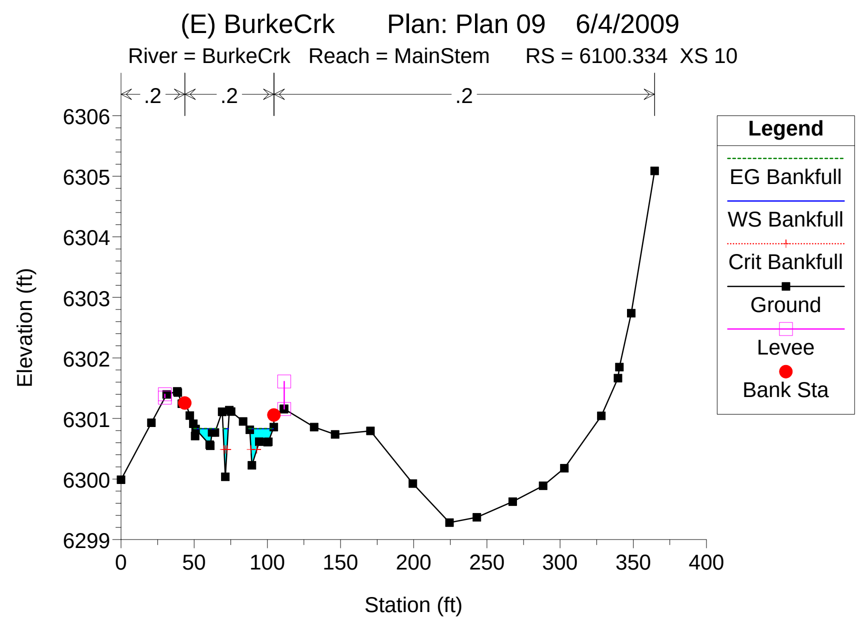


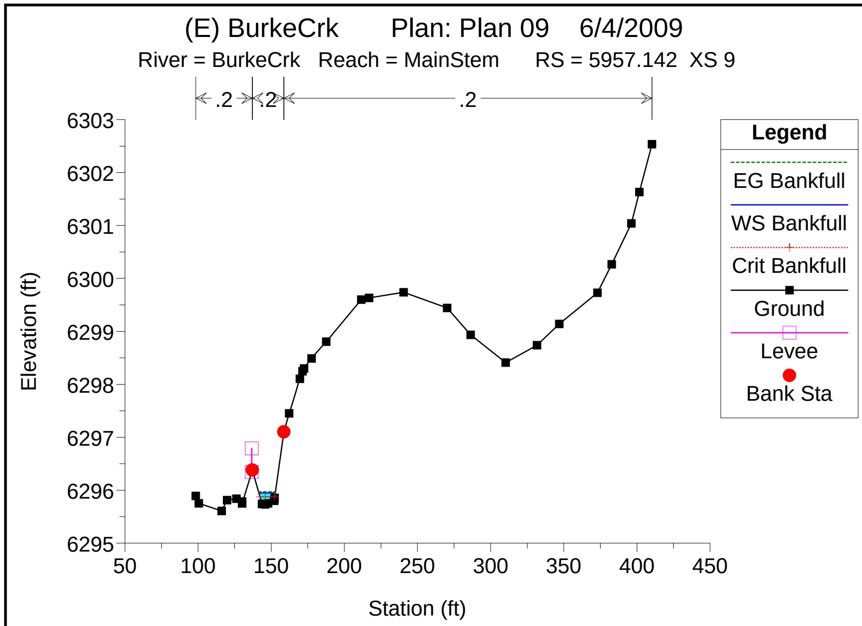
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6567.790 XS 15
.2 .2 .2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6552.667 XS 14
.2 .2 .2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6535.833 XS 13
.2 .2 .2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6533.333 Culv CMP under HWY 50
.15 .15 .15
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6533.333 Culv CMP under HWY 50
.15
.15
.15
Legend
EG Bankfull
WS Bankfull
Ground
Levee
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
6304
Station (ft)
-50
0
50
100
150
200
250
300

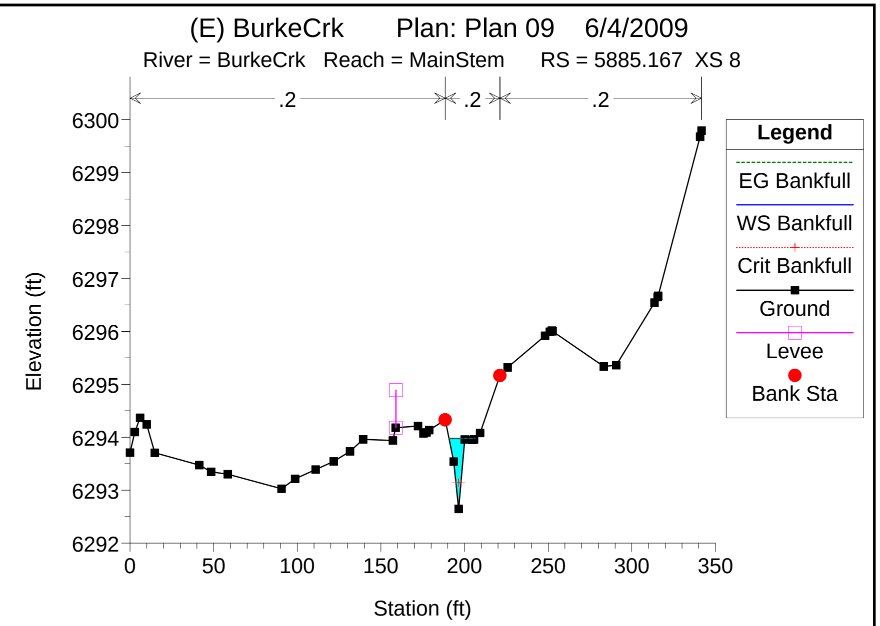

(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6297.520 XS 12
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
Elevation (ft)
6314
6313
6312
6311
6310
6309
6308
6307
6306
Station (ft)
-50
0
50
100
150
200
250
300


(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6204.859 XS 11
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
Elevation (ft)
6308
6307
6306
6305
6304
6303
6302
6301
Station (ft)
0
50
100
150
200
250
300
350

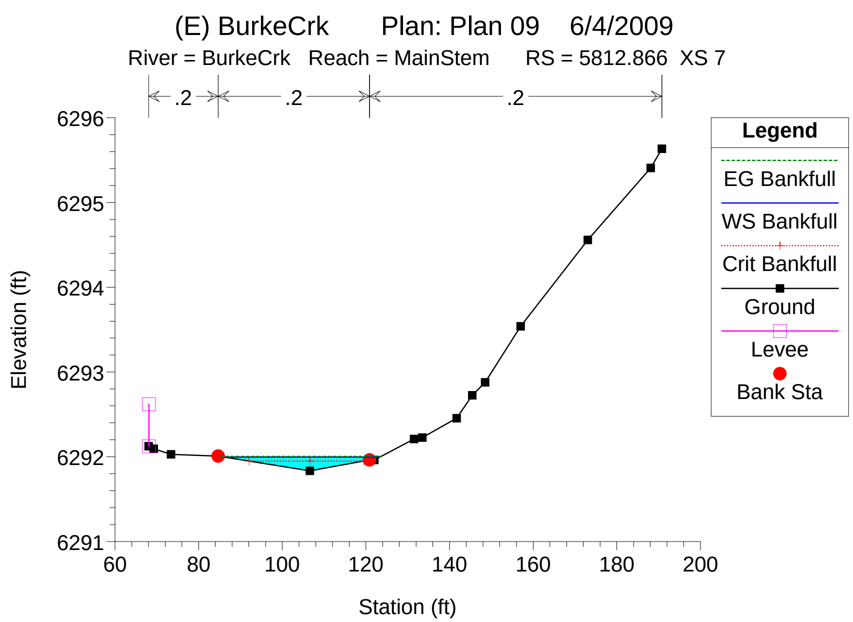

(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6100.334 XS 10
.2
.2
.2
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
Elevation (ft)
6306
6305
6304
6303
6302
6301
6300
6299
Station (ft)
0
50
100
150
200
250
300
350
400



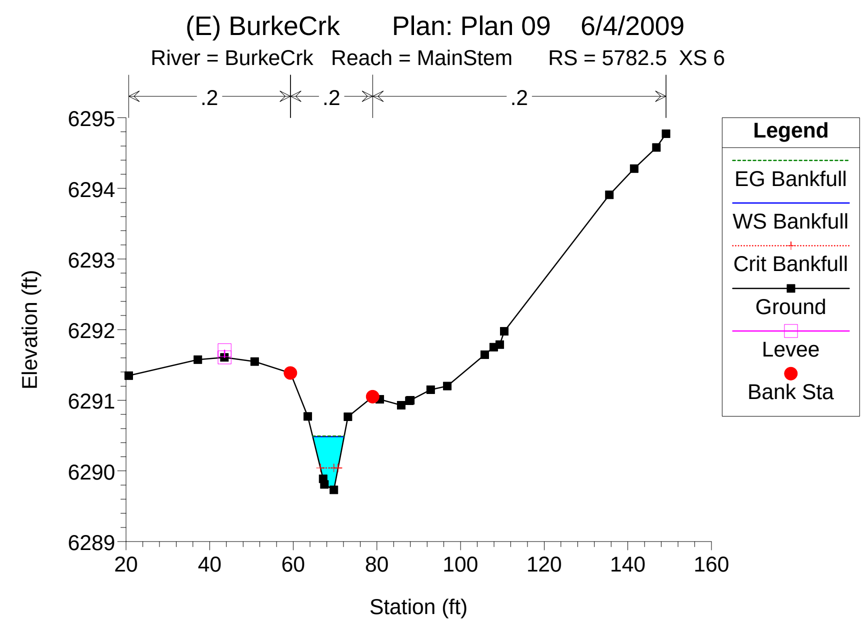
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5957.142 XS 9
.2
.2
.2
Elevation (ft)
6295
6296
6297
6298
6299
6300
6301
6302
6303
Station (ft)
50
100
150
200
250
300
350
400
450
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta



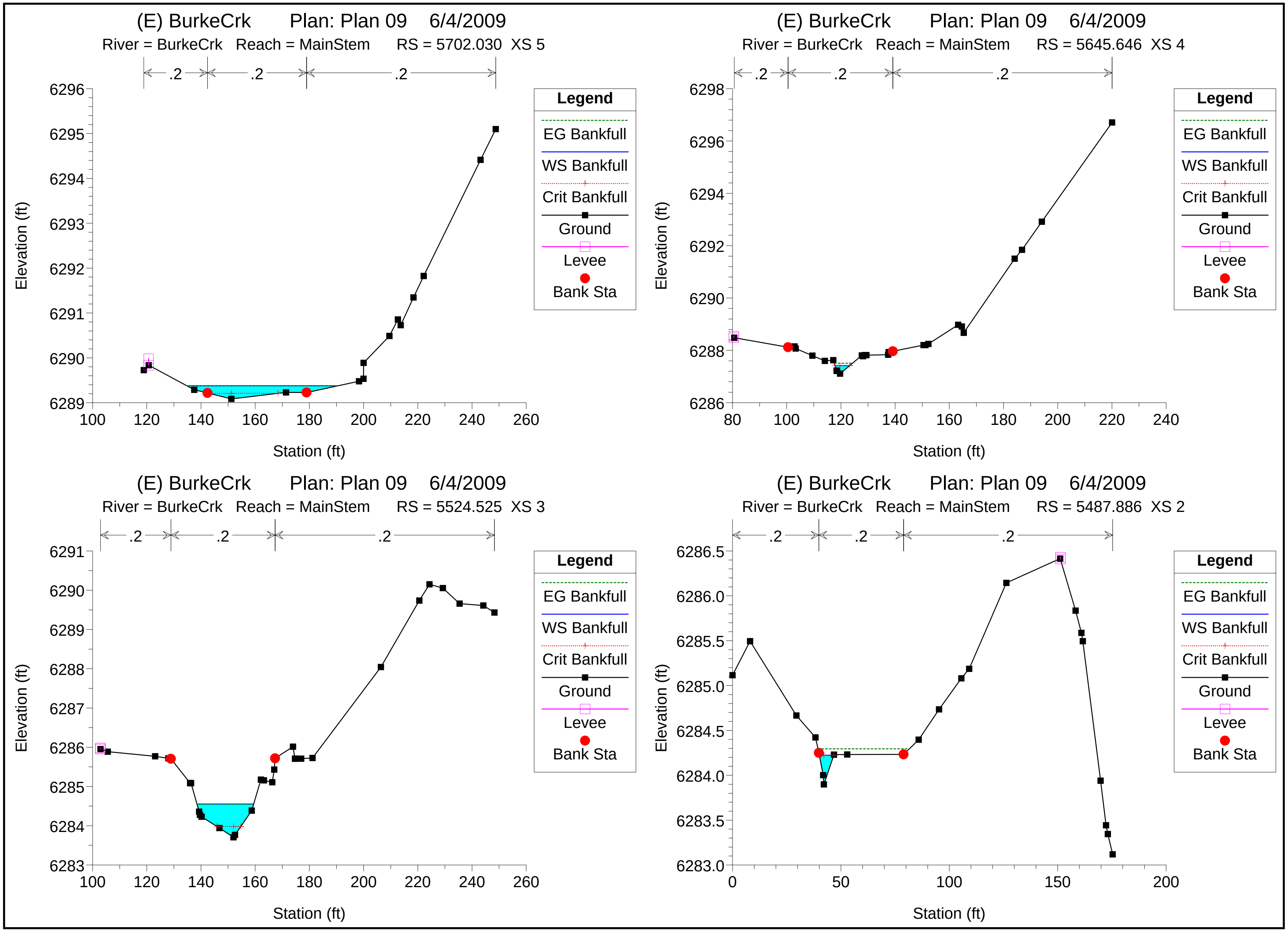
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5885.167 XS 8
.2
.2
.2
Elevation (ft)
6292
6293
6294
6295
6296
6297
6298
6299
6300
Station (ft)
0
50
100
150
200
250
300
350
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta

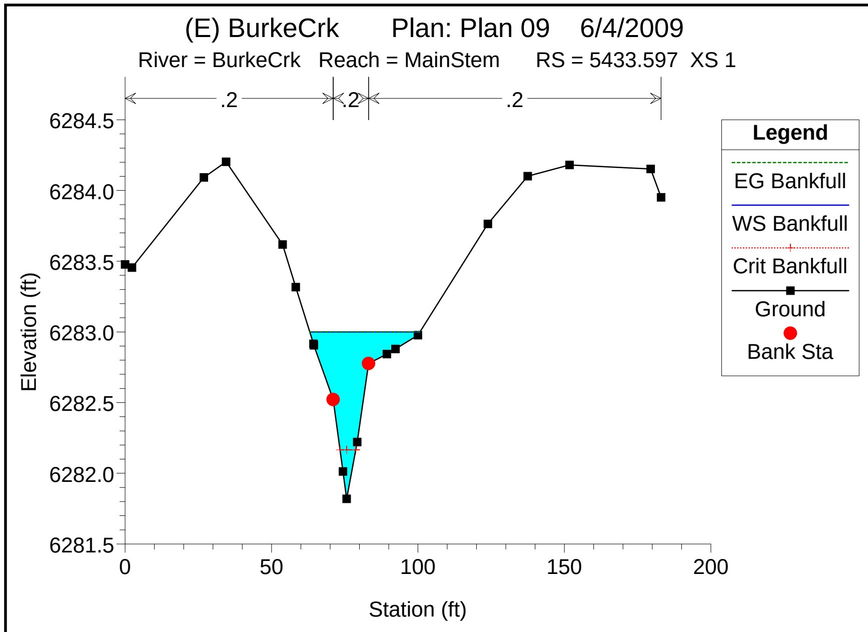


(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5812.866 XS 7
.2
.2
.2
Elevation (ft)
6291
6292
6293
6294
6295
6296
Station (ft)
60
80
100
120
140
160
180
200
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta



(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5782.5 XS 6
.2
.2
.2
Elevation (ft)
6289
6290
6291
6292
6293
6294
6295
Station (ft)
20
40
60
80
100
120
140
160
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta

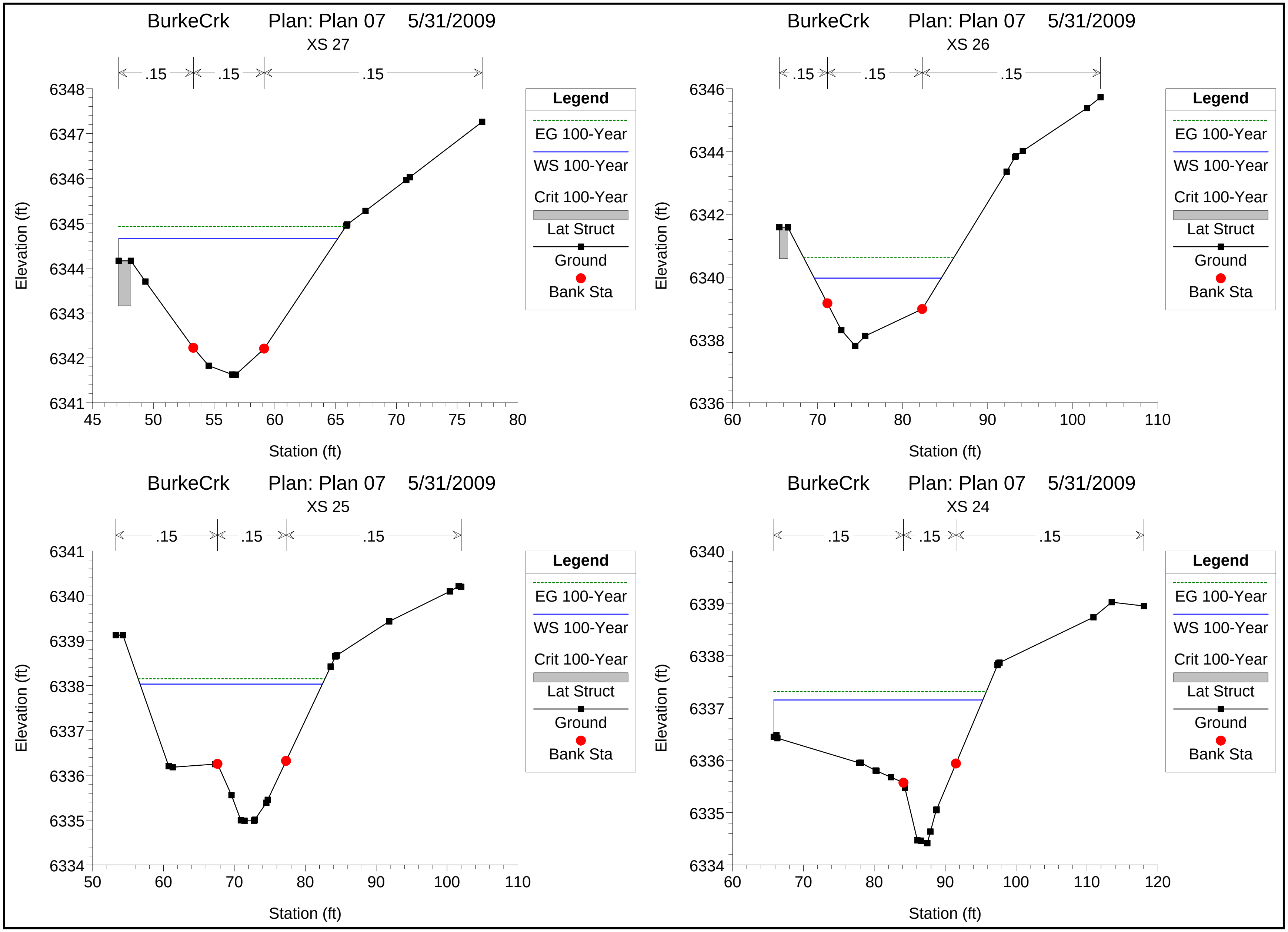

(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5702.030 XS 5
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5645.646 XS 4
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5524.525 XS 3
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5487.886 XS 2
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Levee
Bank Sta


(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5433.597 XS 1
.2
.2
.2
Elevation (ft)
6284.5
6284.0
6283.5
6283.0
6282.5
6282.0
6281.5
Station (ft)
0
50
100
150
200
Legend
EG Bankfull
WS Bankfull
Crit Bankfull
Ground
Bank Sta

100-Year Existing Condition HEC-RAS Model

HEC-RAS Plan: Plan 07 River: BurkeCrk Reach: MainStem Profile: 100-Year													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
MainStem	6962.7	100-Year	120	6341.6	6344.7	6343.9	6344.9	0.0620	4.8	31.7	18.02	0.51	10.56
MainStem	6962.0		Lat Struct										
MainStem	6925.2	100-Year	117.77	6337.8	6340.0	6340.0	6340.6	0.2690	6.7	18.7	14.93	0.95	24.72
MainStem	6892.7	100-Year	117.77	6335.0	6338.0	6337.0	6338.2	0.0300	3.1	45.1	25.71	0.34	4.54
MainStem	6872.5	100-Year	113.70	6334.4	6337.2	6336.7	6337.3	0.0594	3.8	38.1	29.49	0.46	7.27
MainStem	6840.1	100-Year	103.97	6331.2	6334.8		6335.0	0.0847	4.5	27.5	16.62	0.44	10.40
MainStem	6806.6	100-Year	94.60	6329.4	6332.4		6332.6	0.0595	3.7	29.6	22.32	0.46	7.13
MainStem	6772.0	100-Year	83.54	6327.5	6330.5		6330.6	0.0526	3.0	28.2	20.83	0.42	5.00
MainStem	6735.9	100-Year	62.22	6325.9	6328.5		6328.6	0.0601	4.0	21.0	16.71	0.47	7.98
MainStem	6712.2	100-Year	44.64	6324.9	6326.9		6327.1	0.0749	3.4	13.9	11.71	0.49	6.41
MainStem	6682.7	100-Year	44.64	6322.3	6323.9	6323.6	6324.1	0.1472	3.7	12.2	12.41	0.65	8.65
MainStem	6640.4	100-Year	44.64	6318.5	6321.6		6321.7	0.0293	2.3	19.3	9.90	0.29	2.91
MainStem	6599.6	100-Year	44.64	6317.7	6320.7		6320.8	0.0167	2.3	25.0	19.81	0.25	2.52
MainStem	6567.8	100-Year	44.64	6317.1	6319.1	6319.1	6319.5	0.1647	5.7	11.2	15.92	0.75	17.29
MainStem	6552.7	100-Year	44.64	6315.4	6318.5	6317.2	6318.5	0.0121	1.9	40.1	67.79	0.21	1.75
MainStem	6535.8	100-Year	44.64	6313.5	6316.6	6316.6	6317.8	0.3731	8.9	5.0	9.03	0.99	41.40
MainStem	6533.3		Culvert*										
MainStem	6297.5	100-Year	25.15	6306.26	6307.80	6307.3	6307.9	0.0500	1.9	13.6	17.37	0.37	2.39
MainStem	6204.9	100-Year	25.15	6303.20	6304.06	6303.7	6304.1	0.0336	1.2	21.7	42.48	0.29	1.07
MainStem	6100.3	100-Year	25.15	6300.04	6301.25	6300.9	6301.3	0.0221	0.9	29.1	67.46	0.23	0.64
MainStem	5957.1	100-Year	25.15	6295.73	6296.71	6296.3	6296.8	0.0482	1.8	14.4	19.98	0.36	2.18
MainStem	5885.2	100-Year	25.15	6292.65	6294.49	6294.1	6294.5	0.0234	1.1	25.7	54.76	0.25	0.95
MainStem	5812.9	100-Year	25.15	6291.84	6292.36	6292.2	6292.4	0.0354	1.1	25.5	70.30	0.29	1.00
MainStem	5782.5	100-Year	25.15	6289.73	6291.32	6290.8	6291.4	0.0326	1.5	19.7	39.47	0.30	1.52
MainStem	5702.0	100-Year	25.15	6289.09	6289.76	6289.4	6289.8	0.0131	0.8	35.7	76.96	0.18	0.48
MainStem	5645.6	100-Year	25.15	6287.11	6288.09	6287.9	6288.1	0.1104	1.8	14.5	41.97	0.50	2.70
MainStem	5524.5	100-Year	25.15	6283.71	6285.26	6284.4	6285.3	0.0100	0.9	28.2	32.58	0.17	0.53
MainStem	5487.9	100-Year	25.15	6283.90	6284.79	6284.4	6284.8	0.0166	0.9	31.5	70.72	0.21	0.61
MainStem	5433.6	100-Year	25.15	6281.82	6283.00	6282.8	6283.1	0.0789	2.3	13.4	37.64	0.47	3.75

**Note, flow that overtops the road is diverted away from the downstream channel and does not return to the system.*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XS 27
.15 .15 .15
Elevation (ft)
Station (ft)
6341 6342 6343 6344 6345 6346 6347 6348
45 50 55 60 65 70 75 80
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 26
.15 .15 .15
Elevation (ft)
Station (ft)
6336 6338 6340 6342 6344 6346
60 70 80 90 100 110
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 25
.15 .15 .15
Elevation (ft)
Station (ft)
6334 6335 6336 6337 6338 6339 6340 6341
50 60 70 80 90 100 110
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 24
.15 .15 .15
Elevation (ft)
Station (ft)
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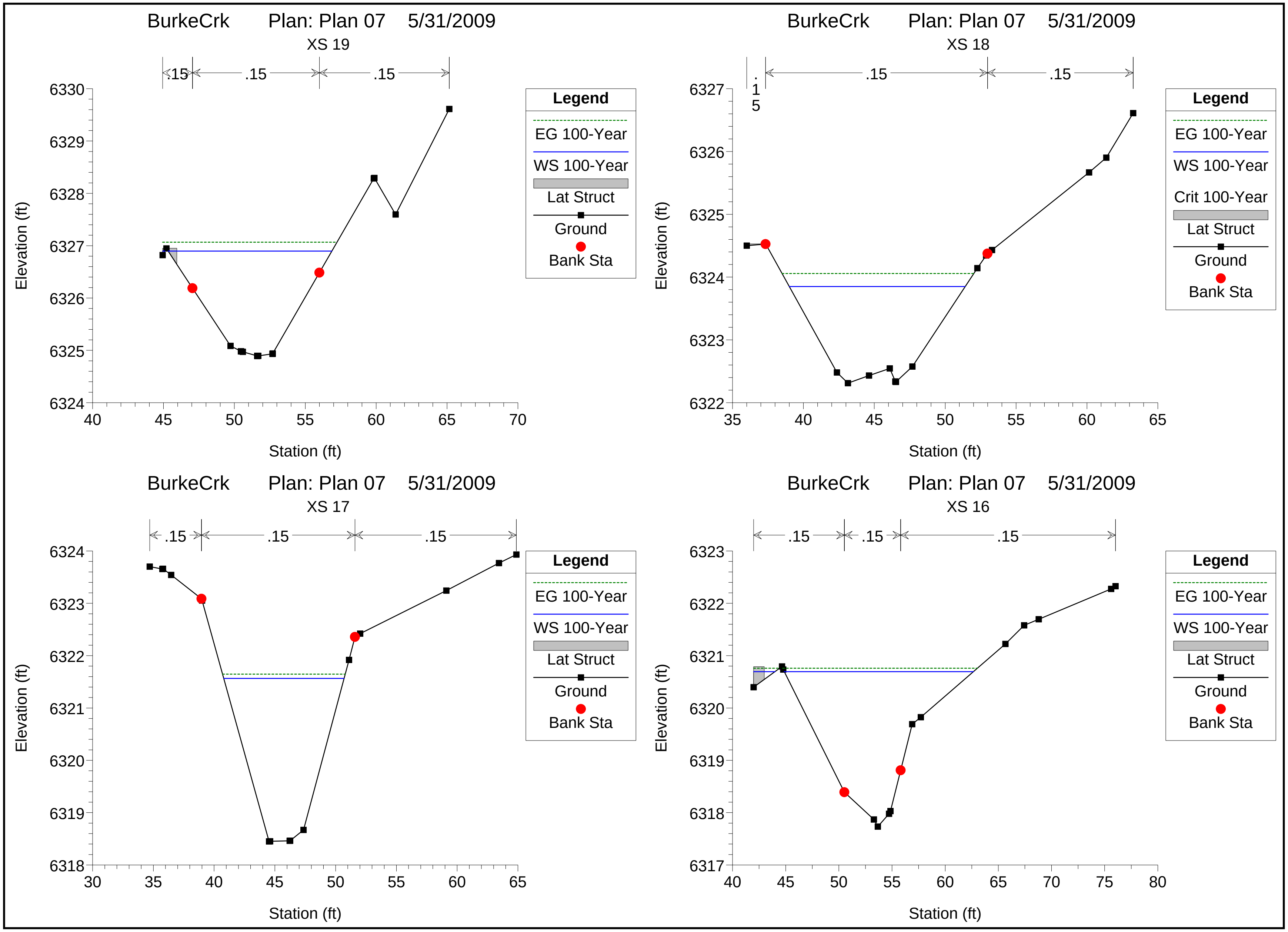
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta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Station (ft)
Legend
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WS 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 18
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.15
.15
Elevation (ft)
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 17
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.15
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Elevation (ft)
Station (ft)
Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta
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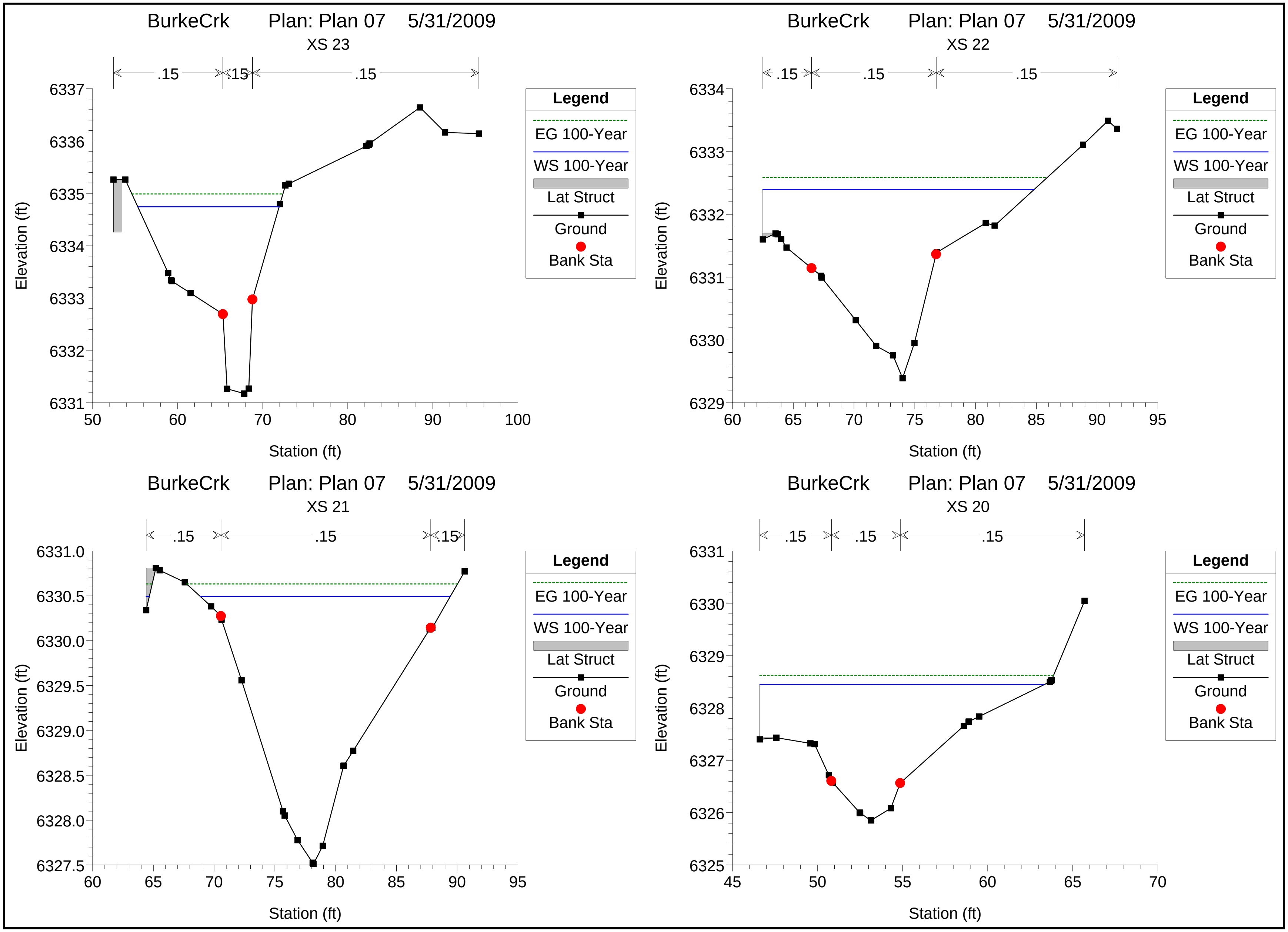
Elevation (ft)
Station (ft)
Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta



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XS 23
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Elevation (ft)
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Station (ft)
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Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 22
.15 .15 .15
Elevation (ft)
6334 6333 6332 6331 6330 6329
Station (ft)
60 65 70 75 80 85 90 95
Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 21
.15 .15 .15
Elevation (ft)
6331.0 6330.5 6330.0 6329.5 6329.0 6328.5 6328.0 6327.5
Station (ft)
60 65 70 75 80 85 90 95
Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta
BurkeCrk Plan: Plan 07 5/31/2009
XS 20
.15 .15 .15
Elevation (ft)
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Station (ft)
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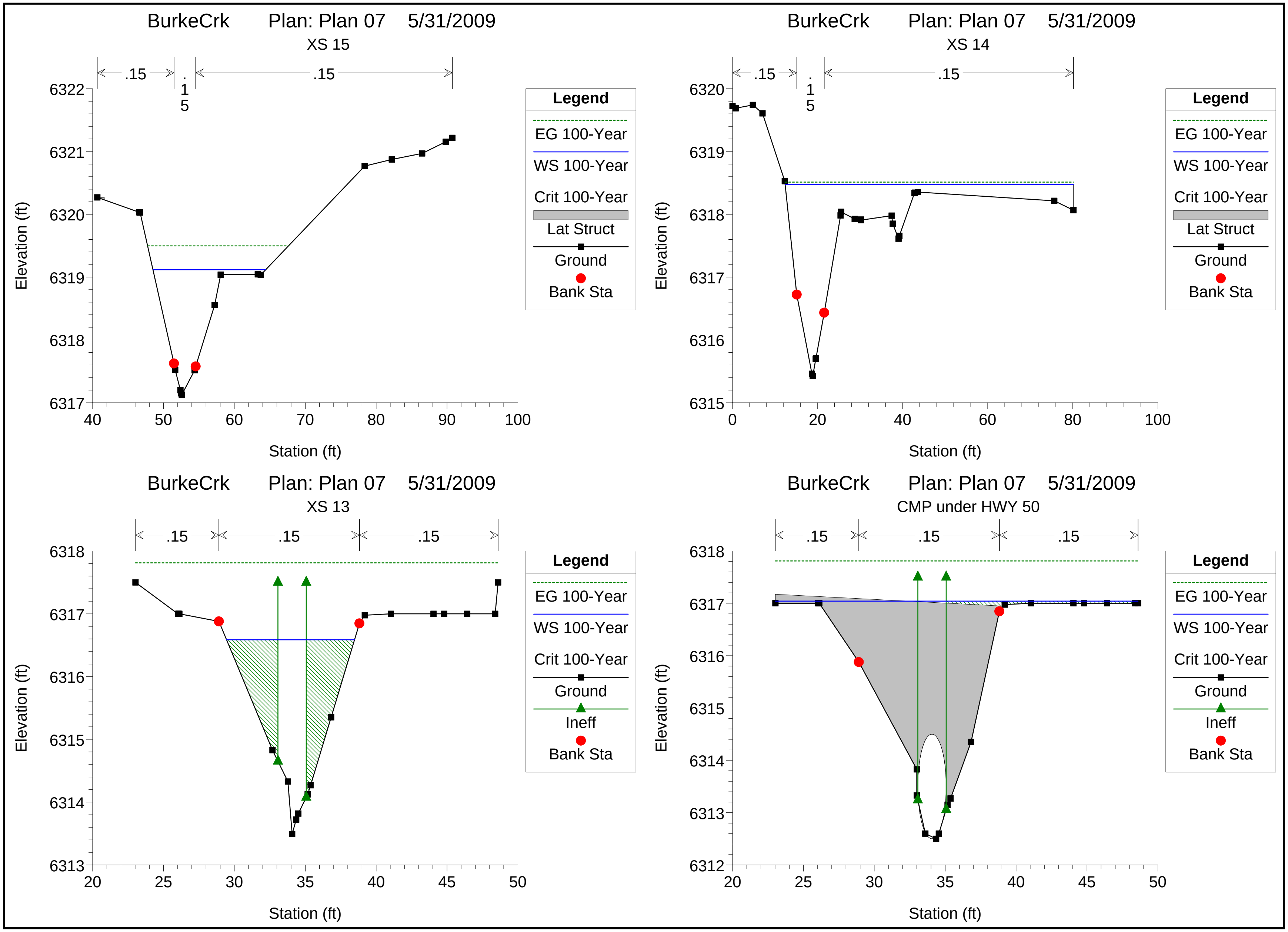
Legend
EG 100-Year
WS 100-Year
Lat Struct
Ground
Bank Sta



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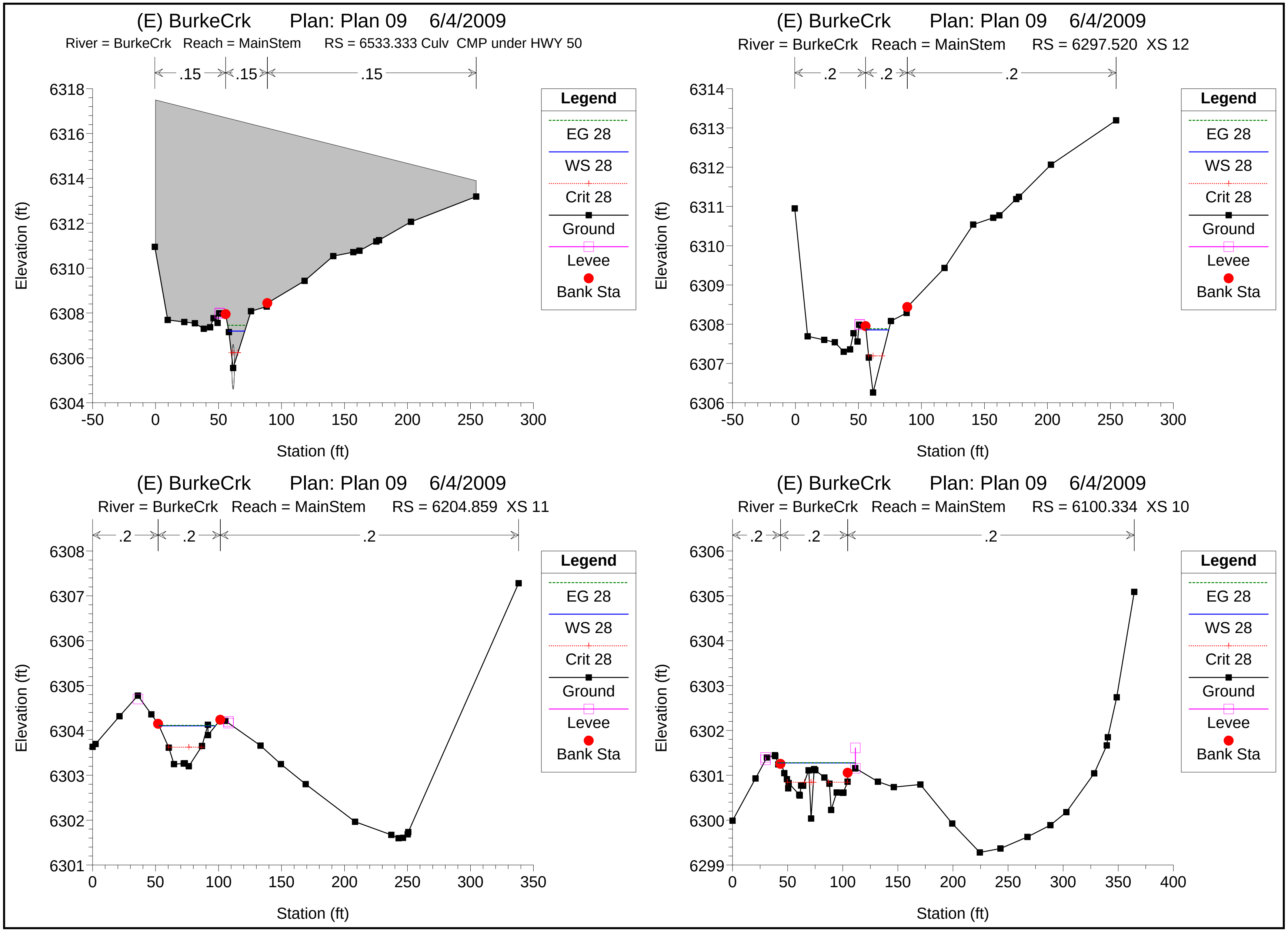
XS 15
.15
.15
.15
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6317
6318
6319
6320
6321
6322
40
50
60
70
80
90
100
BurkeCrk Plan: Plan 07 5/31/2009
XS 14
.15
.15
.15
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Lat Struct
Ground
Bank Sta
Elevation (ft)
Station (ft)
6315
6316
6317
6318
6319
6320
0
20
40
60
80
100
BurkeCrk Plan: Plan 07 5/31/2009
XS 13
.15
.15
.15
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
6313
6314
6315
6316
6317
6318
20
25
30
35
40
45
50
BurkeCrk Plan: Plan 07 5/31/2009
CMP under HWY 50
.15
.15
.15
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
6312
6313
6314
6315
6316
6317
6318
20
25
30
35
40
45
50



(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6533.333 Culv CMP under HWY 50
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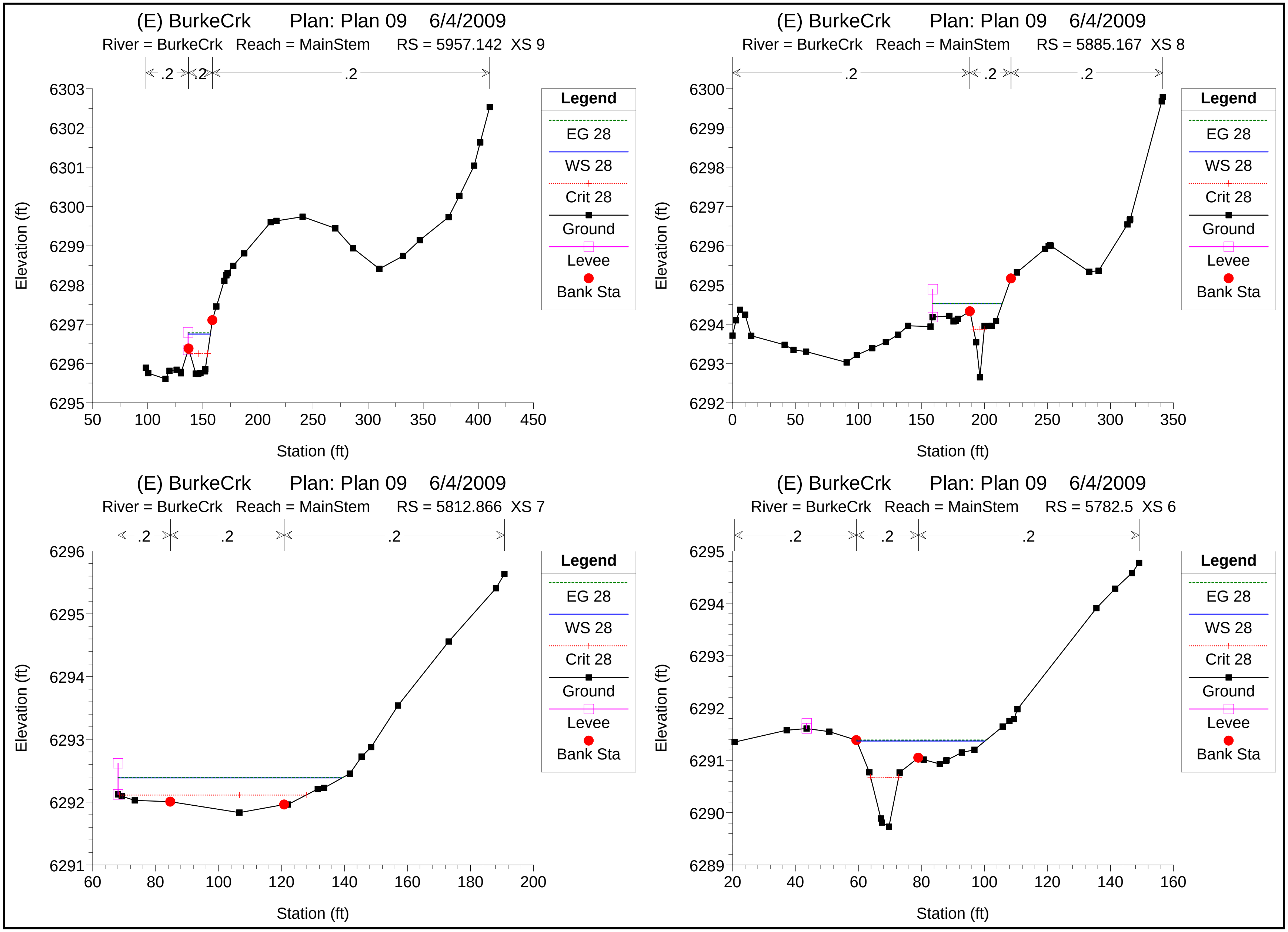
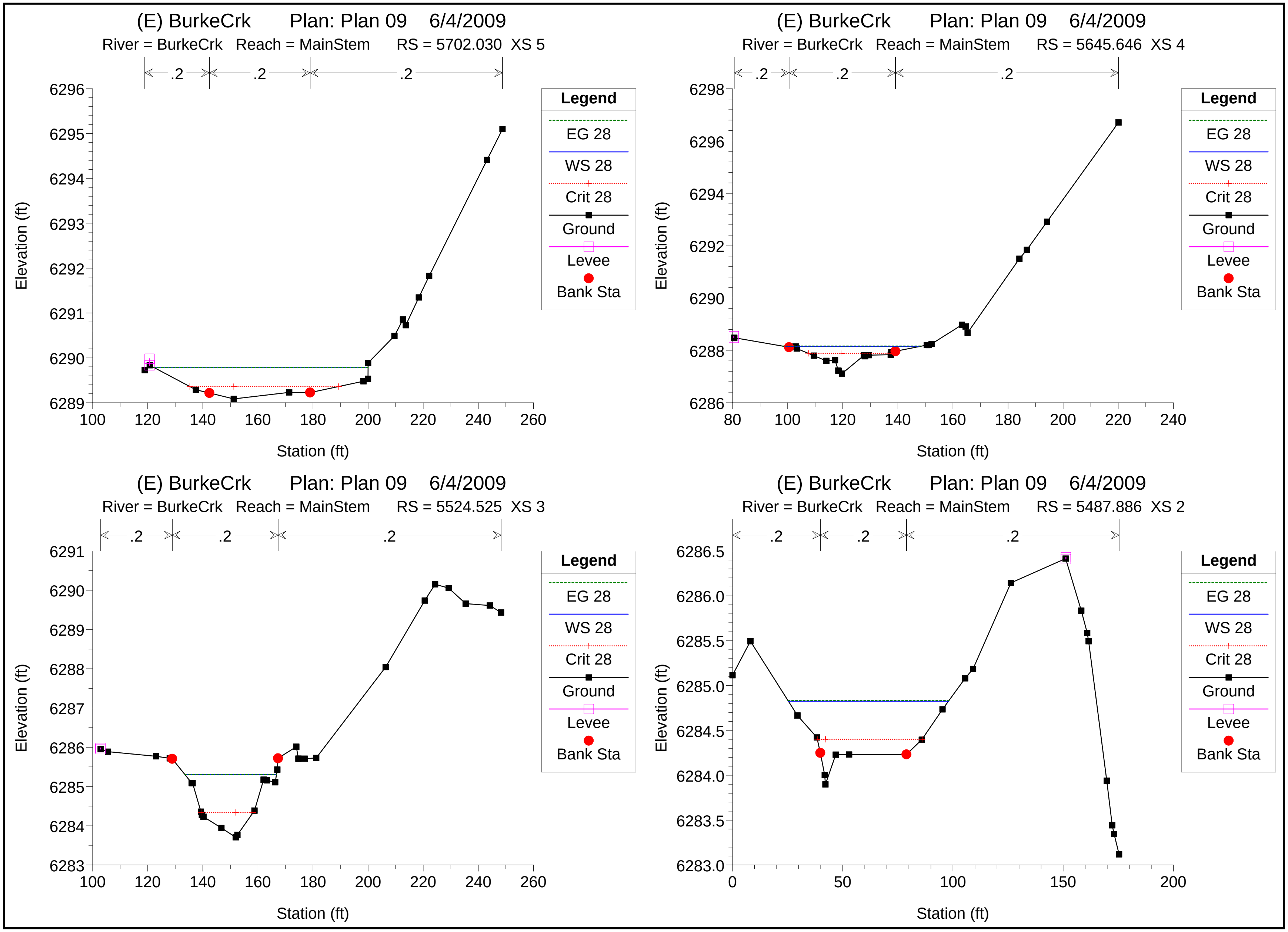
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6297.520 XS 12
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6204.859 XS 11
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 6100.334 XS 10
.2 .2 .2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta



(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5957.142 XS 9
.2
.2
.2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5885.167 XS 8
.2
.2
.2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5812.866 XS 7
.2
.2
.2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5782.5 XS 6
.2
.2
.2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta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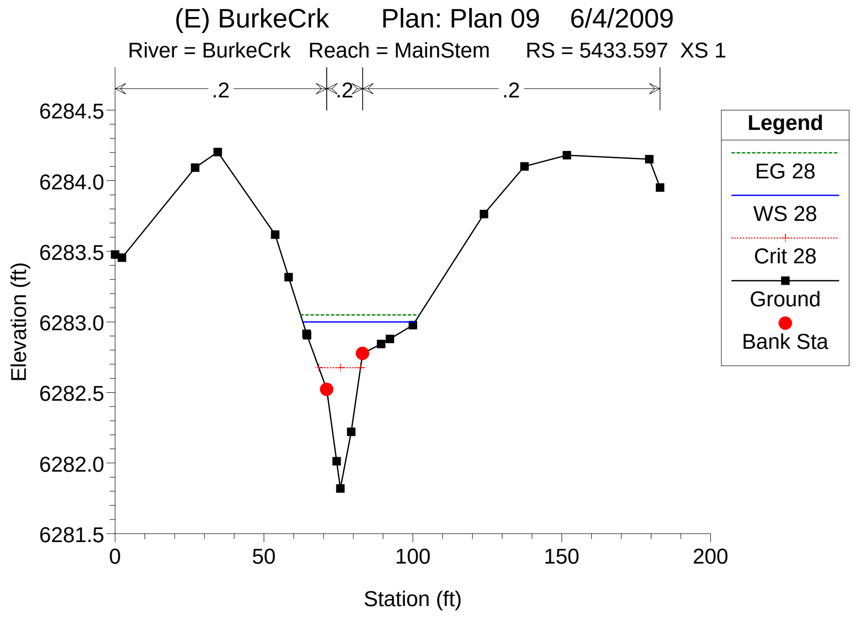
River = BurkeCrk Reach = MainStem RS = 5702.030 XS 5
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5645.646 XS 4
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5524.525 XS 3
(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5487.886 XS 2
Elevation (ft)
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Levee
Bank Sta



(E) BurkeCrk Plan: Plan 09 6/4/2009
River = BurkeCrk Reach = MainStem RS = 5433.597 XS 1
.2
.2
.2
Elevation (ft)
6284.5
6284.0
6283.5
6283.0
6282.5
6282.0
6281.5
0
50
100
150
200
Station (ft)
Legend
EG 28
WS 28
Crit 28
Ground
Bank Sta

Appendix H
Existing Condition
Vegetation Assessment Data

Table 1. October 2007 mapped biohabitat and cover types within the Burke Creek Environmental Study Limit (ESL) including the dominant and commonly associated plant species. Red species are non-native invasive species.

Biohabitat Type	Cover Type	Species	Common Name
Anthropogenic	Human Disturbance	N/A	
Dry Meadow	Cheat Grass	*Bromus tectorum*	cheat grass
		Madia gracilis	slender tarweed
		Sisymbrium altissimum	tall tumblemustard
		Tragopogon dubius	goat's beard
		Purshia tridentata	bitterbrush
	Creeping Wildrye	*Leymus triticoides*	creeping wildrye
		Juncus mexicanus	Mexican rush
		Bromus tectorum	cheat grass
		Bromus inerme	smooth brome
		Madia gracilis	slender tarweed
		Poa pratensis	Kentucky bluegrass
Wet Meadow	Mixed Sedge	*Carex nebrascensis*	Nebraska sedge
		Carex utriculata	beaked sedge
		Juncus mexicanus	Mexican rush
		Muhlenbergia filiformis	pull-up muhly
		Poa pratensis	Kentucky bluegrass
		Geum macrophyllum	bigleaf avens
		Salix lemmonii	Lemmon's willow
		Potentilla gracilis var. *fastigiata*	slender cinquefoil
	Rush-Reedgrass	*Juncus mexicanus*	Mexican rush
		Calamagrostis breweri	shorthair reedgrass
		Achillea millefolium	yarrow
		Lepidium virginicum var. *virginicum*	pepperweed
		Muhlenbergia filiformis	pull-up muhly
		Poa pratensis	Kentucky bluegrass
		Sisymbrium altissimum	tall tumblemustard
	Rush-Kentucky Bluegrass	*Juncus mexicanus*	Mexican rush
		Poa pratensis	Kentucky bluegrass
		Achillea millefolium	yarrow
		Elymus glaucus	blue wildrye
		Muhlenbergia filiformis	pull-up muhly
		Potentilla gracilis var. *fastigiata*	slender cinquefoil
		Tragopogon dubius	goat's beard
		Verbascum blattaria	mullein
	Yellow Monkeyflower	*Mimulus guttatus*	yellow monkeyflower
		Juncus phaeocephalus	brownhead rush
		Lemna sp.	duckweed
		Epilobium ciliatum	willowherb
		Juncus mexicanus	Mexican rush
		Salix exigua	narrowleaf willow
		Salix lasiolepis	arroyo willow
		Salix lemmonii	Lemmon's willow
		Salix lucida ssp. *caudata*	shiny willow
		Poa pratensis	Kentucky bluegrass
		Potentilla gracilis var. *fastigiata*	slender cinquefoil
		Typha latifolia	cattail

Table 1. October 2007 mapped biohabitat and cover types within the Burke Creek Environmental Study Limit (ESL) including the dominant and commonly associated plant species. Red species are non-native invasive species.

Biohabitat Type	Cover Type	Species	Common Name
Woody Riparian	Mixed Willow	*Salix exigua*	narrowleaf willow
		Salix lasiolepis	arroyo willow
		Salix lemmonii	Lemmon's willow
		Salix lucida ssp. *caudata*	shiny willow
		Ribes nevadense	mountain pink currant
		Artemesia douglasiana	mugwort
		Carex nebrascensis	Nebraska sedge
		Carex utriculata	beaked sedge
		Poa pratensis	Kentucky bluegrass
		Alnus incana	mountain alder
		Pinus jeffreyi	Jeffrey pine
		Populus tremuloides	quaking aspen
		Pyrola sp.	wintergreen
		Scirpus microcarpus	panicled bulrush
	Arroyo Willow	*Salix lasiolepis*	arroyo willow
	Quaking Aspen	*Populus tremuloides*	quaking aspen
		Ribes nevadense	mountain pink currant
		Salix lemmonii	Lemmon's willow
		Salix lucida ssp. *caudata*	shiny willow
		Poa pratensis	Kentucky bluegrass
		Thalictrum sp.	meadowrue
		Pinus jeffreyi	Jeffrey pine
Upland	Jeffrey Pine	*Pinus jeffreyi*	Jeffrey pine
		Artemesia tridendata	sagebrush
		Bromus tectorum	cheat grass
		Carex douglasii	Douglas' sedge
		Poa pratensis	Kentucky bluegrass
	Jeffrey Pine-White Fir	*Pinus jeffreyi*	Jeffrey pine
		Abies concolor	white fir
		Arctostaphylos sp.	manzanita
		Ceanothus cordulatus	mountain whitethorn
		Chrysothamnus nauseosus	rabbitbrush
		Ceanothus prostratus	mahala mat
		Bromus tectorum	cheat grass
		Elymus glaucus	blue wildrye
	Rabbitbrush	*Chrysothamnus nauseosus*	rabbitbrush
		Bromus tectorum	cheat grass
		Carex douglasii	Douglas' sedge
		Juncus mexicanus	Mexican rush
		Poa pratensis	Kentucky bluegrass
	Sagebrush	*Artemesia tridendata*	sagebrush
		Chrysothamnus nauseosus	rabbitbrush
		Bromus tectorum	cheat grass
		Carex douglasii	Douglas' sedge
		Juncus mexicanus	Mexican rush
		Poa pratensis	Kentucky bluegrass
	Sagebrush-Open	*Artemesia tridendata*	sagebrush
		Bromus tectorum	cheat grass
		Carex douglasii	Douglas' sedge
		Poa pratensis	Kentucky bluegrass

Appendix I

Preliminary Development of Alternatives A, B, C, and D

PLAN VIEW OF OVERALL PROJECT AREA

0 250 500
GRAPHIC SCALE (FEET)

PRELIMINARY
NOT FOR CONSTRUCTION
FEBRUARY 2008 SUBMITTAL

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
CONSULTING ENGINEERS
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
(707) 476-8938

McBain & Trush, Inc.

DES AL/ML | DRN PTJ
SUPV SAA | CHK SAA

SEE SCALE BAR

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
AT HIGHWAY 50 CROSSING
CIVIL
PLAN VIEW OF
OVERALL PROJECT AREA

SEAL

JOB NUMBER 0101607001
SHEET 1 OF 11
G-1

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P:\2005 & Beyond\11184 TahoeRegionalPlanningAgency\11184-07-001 BurkeCreekRestorationProject\CAD 1118407001 Burke\dwg

D

C

B

A

REVISIONS

SYM | DESCRIPTION | DATE | APPROVED

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CONSULTING ENGINEERS
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
(707) 476-8938

McBain & Trush, Inc.

DES AL/ML
DRN PTJ
SUPV SAA
CHK SAA

SEE SCALE BAR

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
AT HIGHWAY 50 CROSSING
CIVIL
HISTORIC AND CURRENT
CHANNEL ALIGNMENTS

JOB NUMBER 0101607001
SHEET 2 OF 11
G-2

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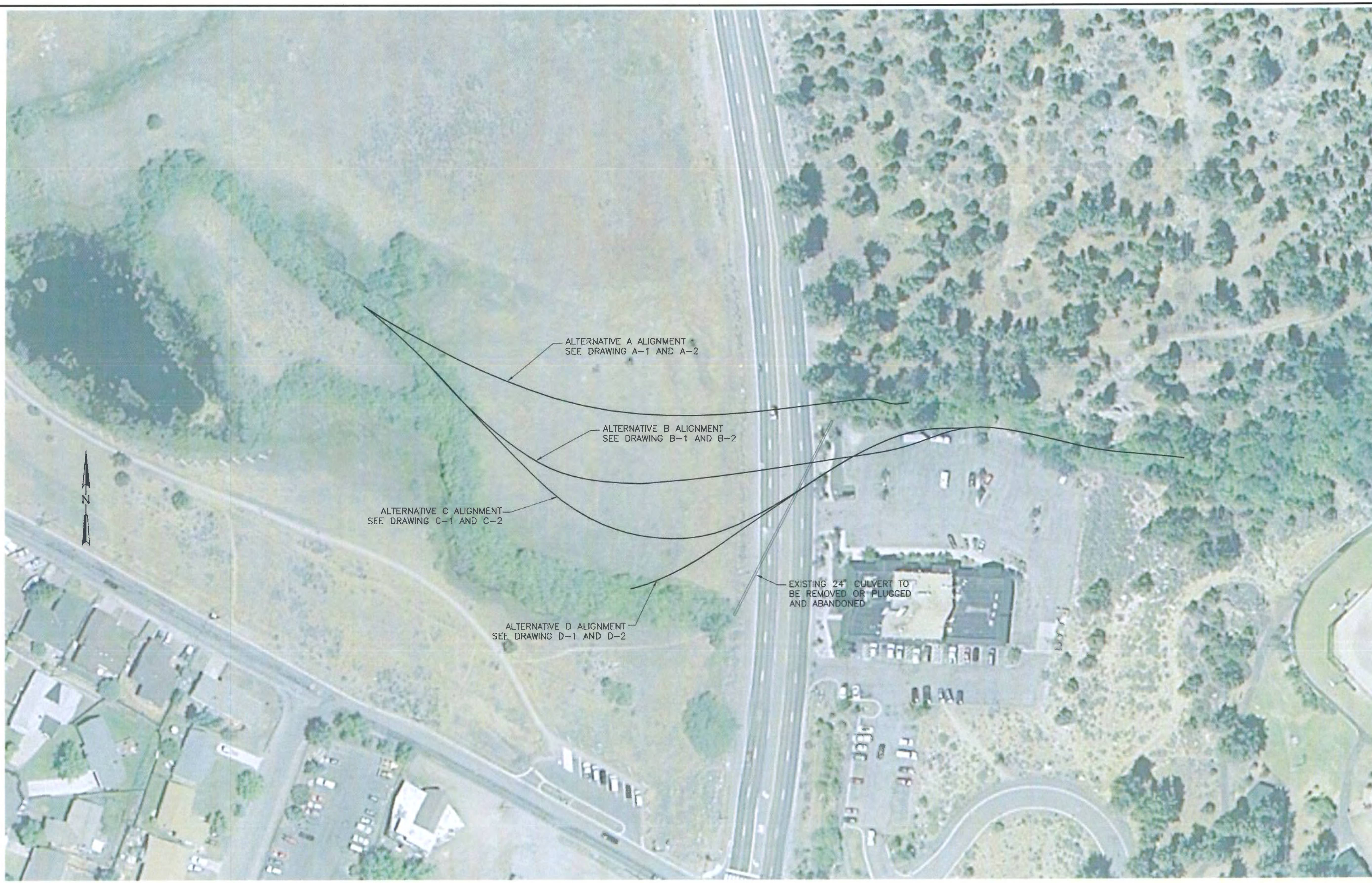

PLAN VIEW OF ALL ALTERNATIVE ALIGNMENTS

0 50 100
GRAPHIC SCALE
(FEET)

PRELIMINARY
NOT FOR CONSTRUCTION
FEBRUARY 2008 SUBMITTAL

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

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CONSULTING ENGINEERS
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
(707) 476-8938

McBain & Trush, Inc.

DES AL/ML
DRN PTJ
SUPV SAA
CHK SAA

SEE SCALE BAR

SEAL

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
AT HIGHWAY 50 CROSSING
CIVIL
PLAN VIEW OF
ALL ALTERNATIVE ALIGNMENTS

JOB NUMBER 0101607001
SHEET 3 OF 11
G-3

D
C
B
A

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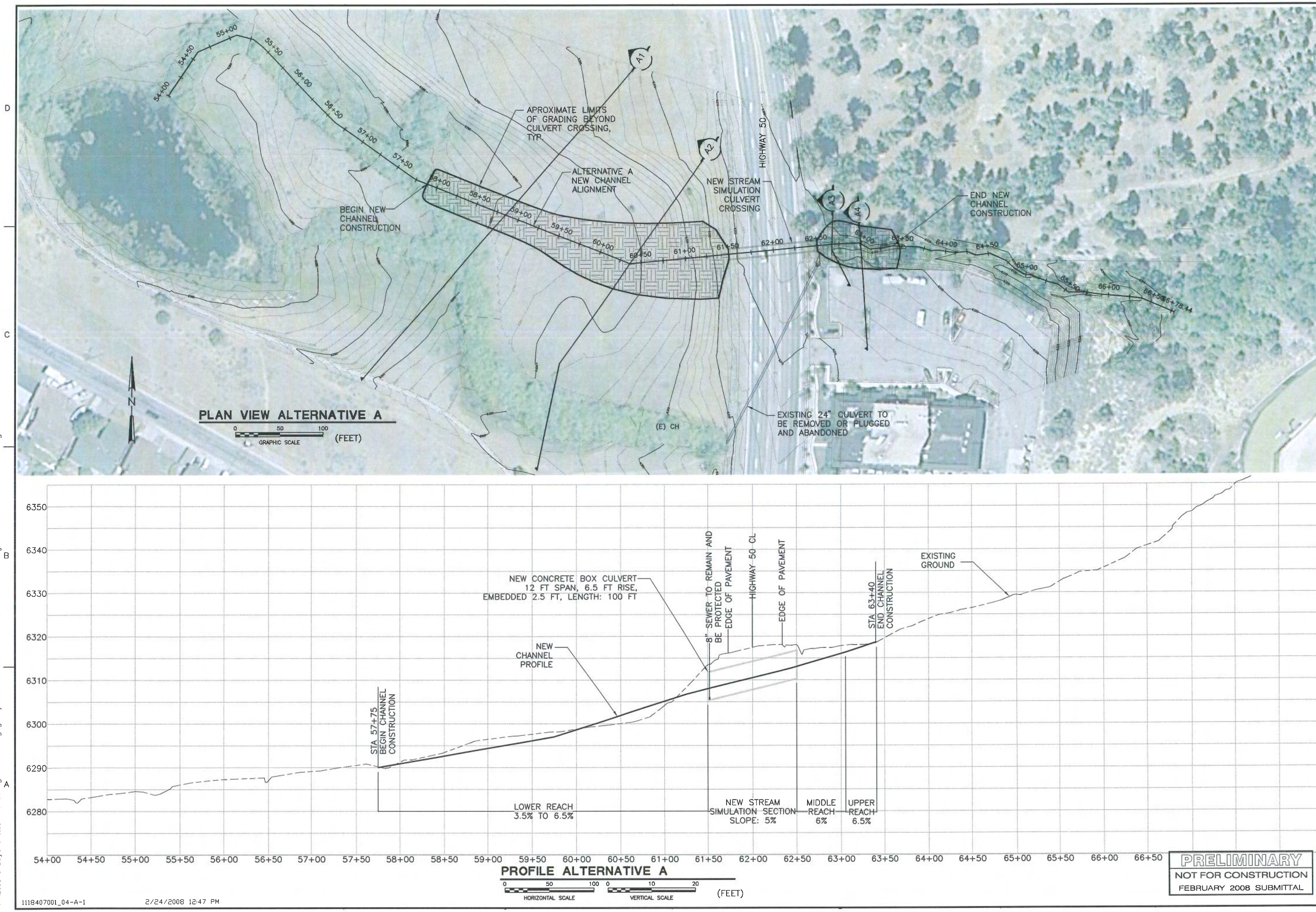

PRELIMINARY
NOT FOR CONSTRUCTION
FEBRUARY 2008 SUBMITTAL

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REVISIONS

DESCRIPTION | DATE | APPROVED | SYM.

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633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
(707) 476-8938
McBain & Trush, Inc.

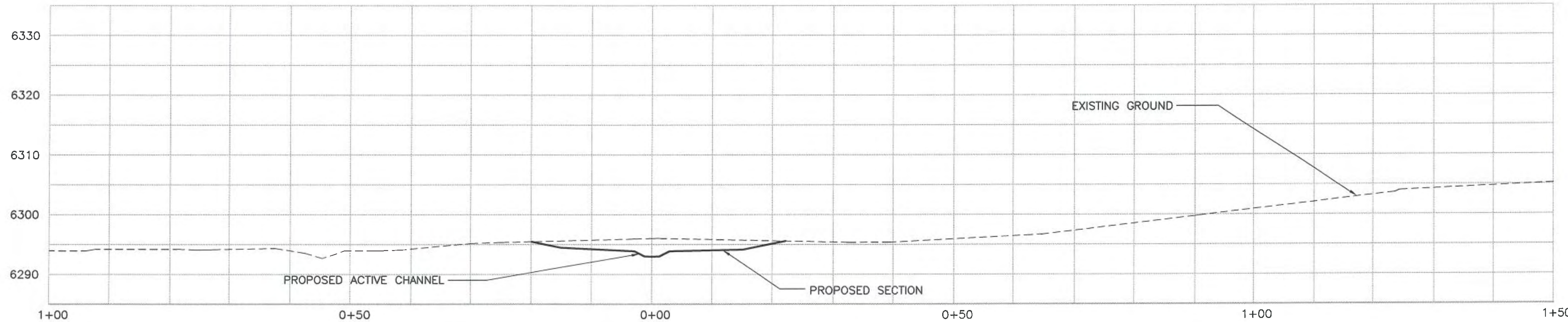
DES AL/ML | DRN PTJ | SUPV SAA | CHK SAA

SEE SCALE BAR

SEAL

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT AT HIGHWAY 50 CROSSING
CIVIL
PLAN AND PROFILE ALTERVATIVE A

JOB NUMBER 0101607001
SHEET 4 OF 11
A-1



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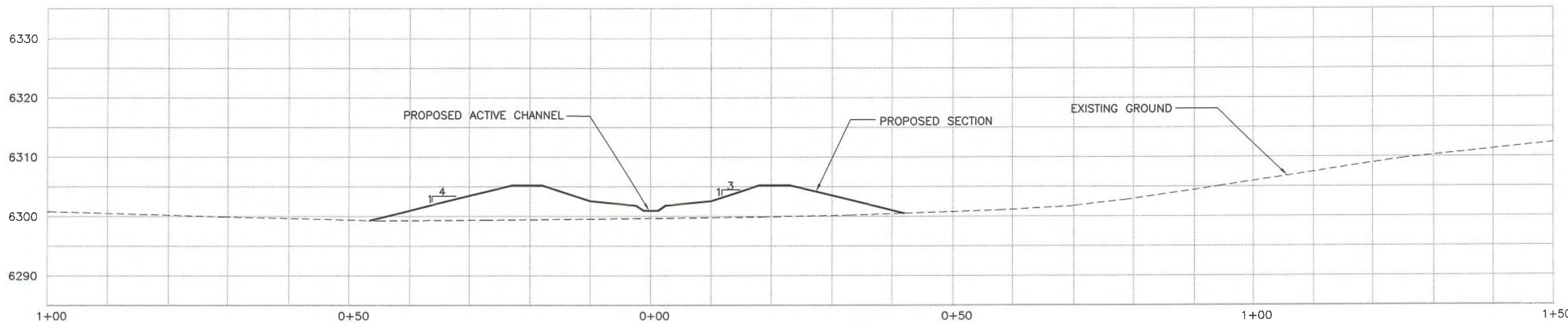

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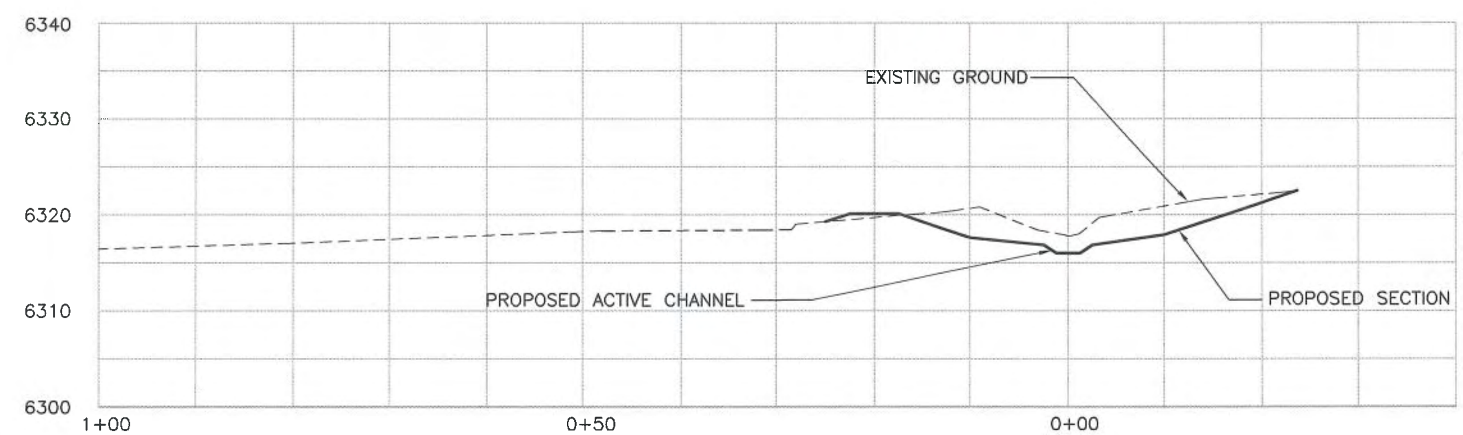

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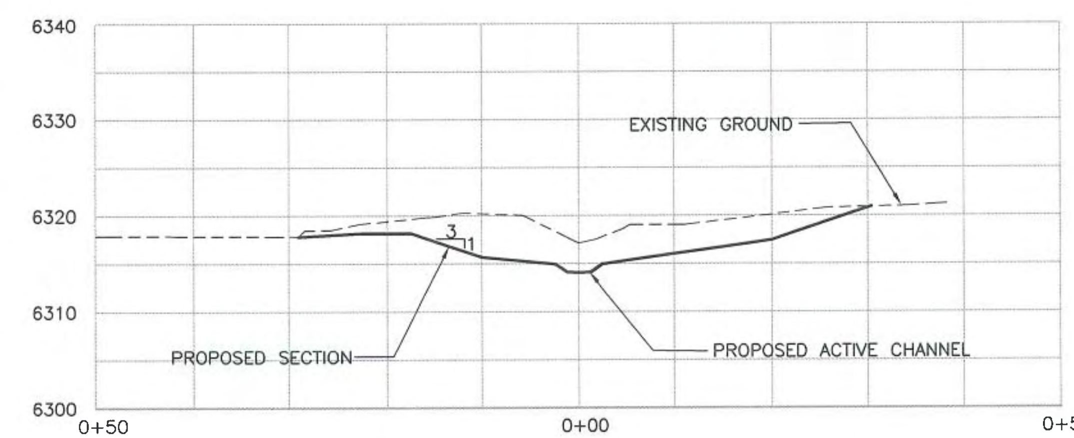

A4 ALTERNATIVE A XS-4

0 10 20 GRAPHIC SCALE (FEET)

PRELIMINARY
NOT FOR CONSTRUCTION
FEBRUARY 2008 SUBMITTAL

REVISIONS

SYM. DESCRIPTION DATE APPROVED

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CONSULTING ENGINEERS
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

McBain & Trush, Inc.

SUBCONSULTANT
Michael Love & Associates
(707) 476-8938

DES AL/ML DRN PTJ
SUPV SAA CHK SAA

SEE SCALE BAR

SEAL

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
AT HIGHWAY 50 CROSSING
CIVIL
ALTERNATIVE A
CROSS SECTIONS

JOB NUMBER 0101607001

SHEET 5 OF 11

A-2

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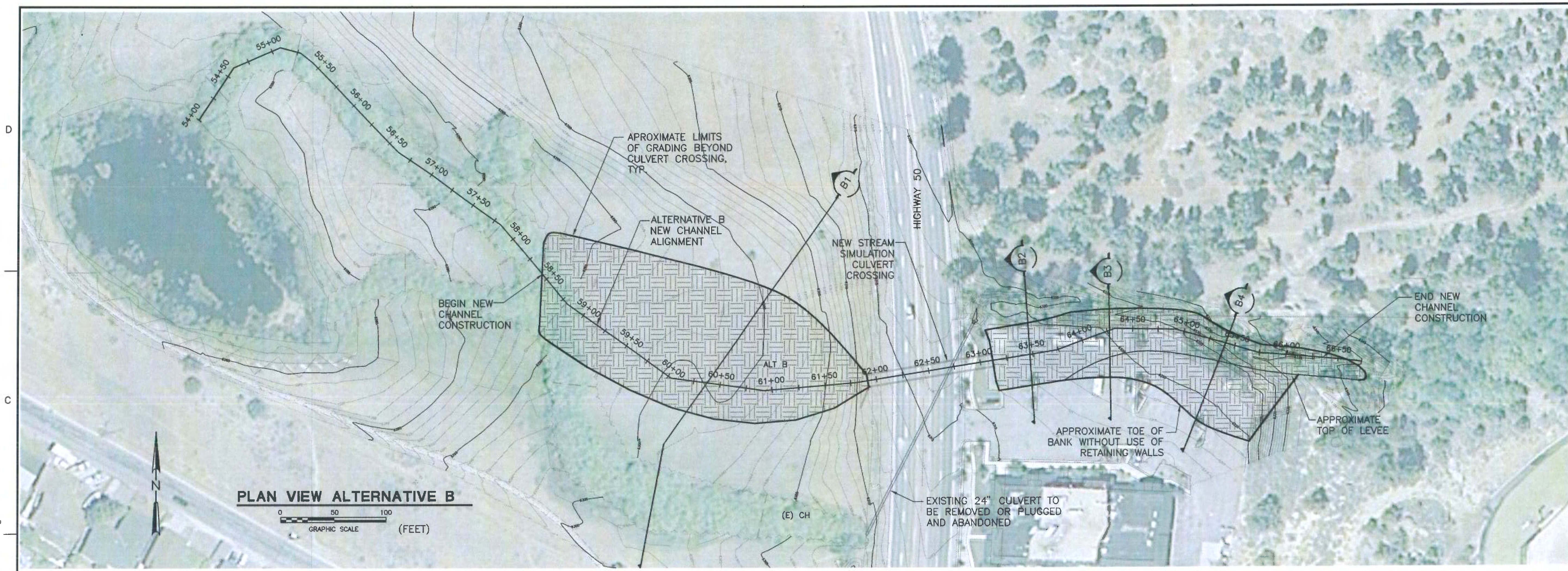

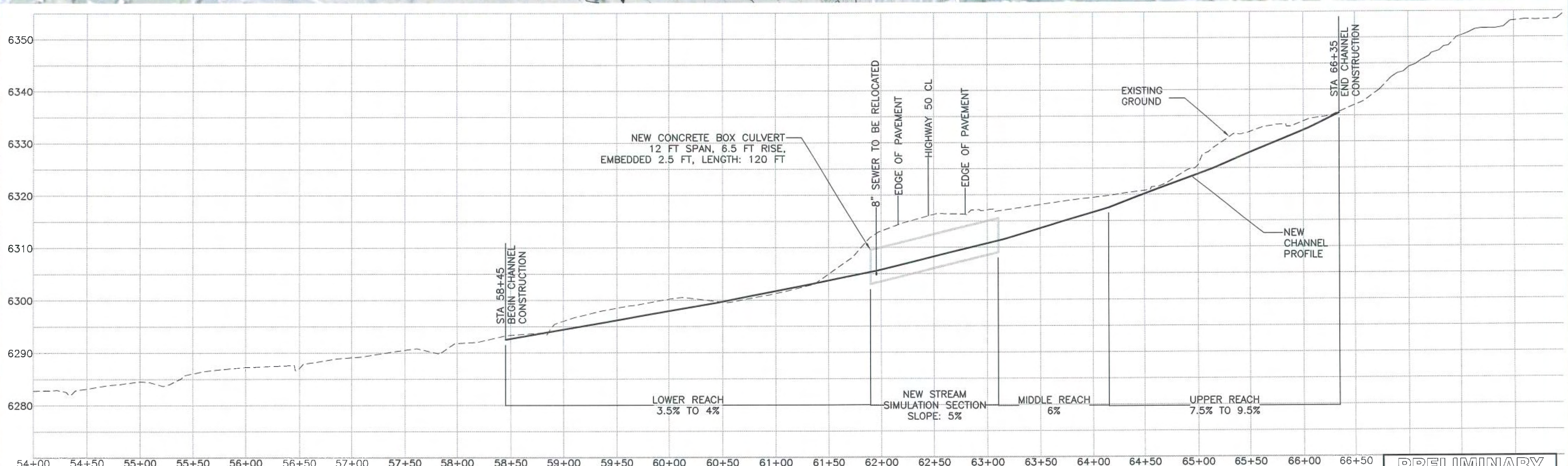

PROFILE ALTERNATIVE B

0 50 100 HORIZONTAL SCALE — 0 10 20 VERTICAL SCALE (FEET)

PRELIMINARY
NOT FOR CONSTRUCTION
FEBRUARY 2008 SUBMITTAL

REVISIONS — SYM. DESCRIPTION DATE APPROVED

WINZLER & KELLY CONSULTING ENGINEERS
633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330

SUBCONSULTANT: Michael Love & Associates (707) 476-8938
McBain & Trush, Inc.

DES AL/ML — DRN PTJ — SUPV SAA — CHK SAA — SEE SCALE BAR

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BURKE CREEK RESTORATION PROJECT AT HIGHWAY 50 CROSSING
CIVIL
PLAN AND PROFILE ALTERVATIVE B

JOB NUMBER 0101607001
SHEET 6 OF 11
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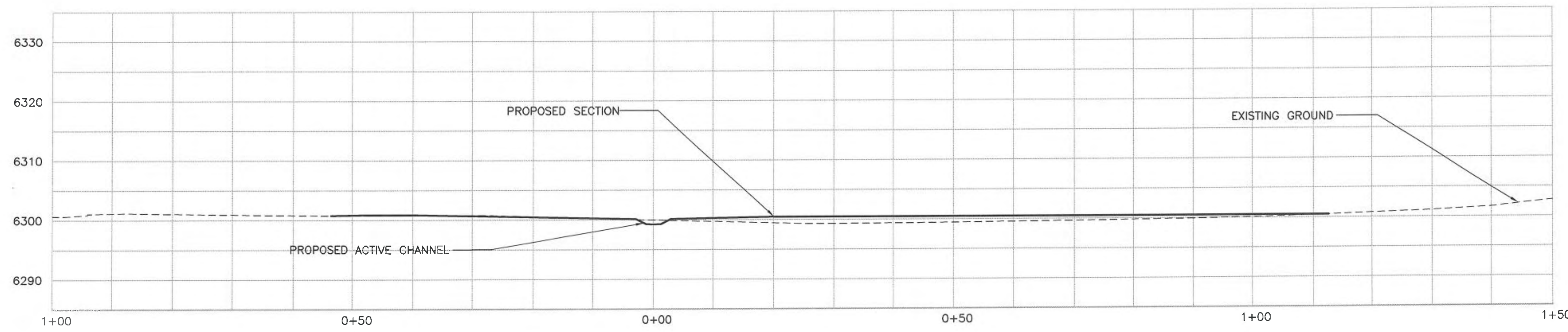

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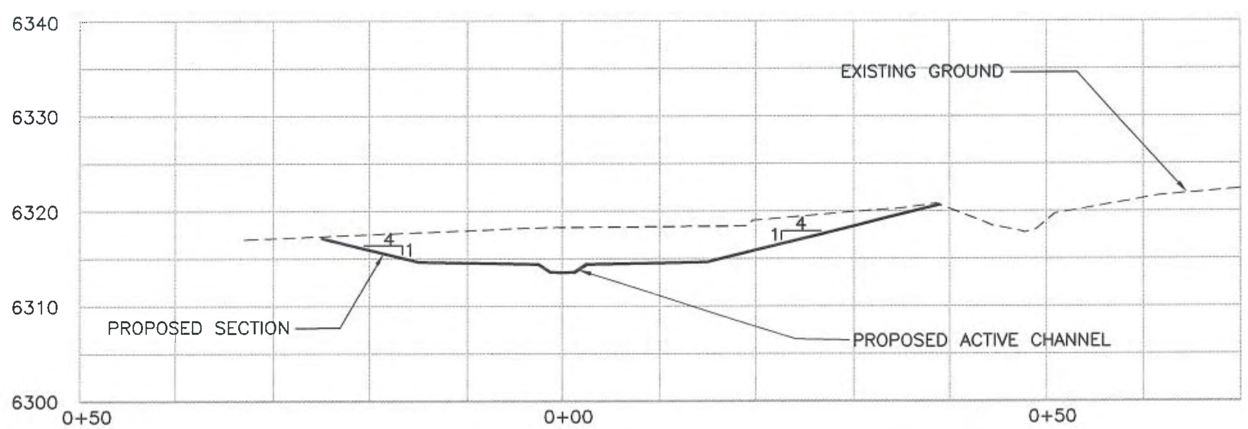

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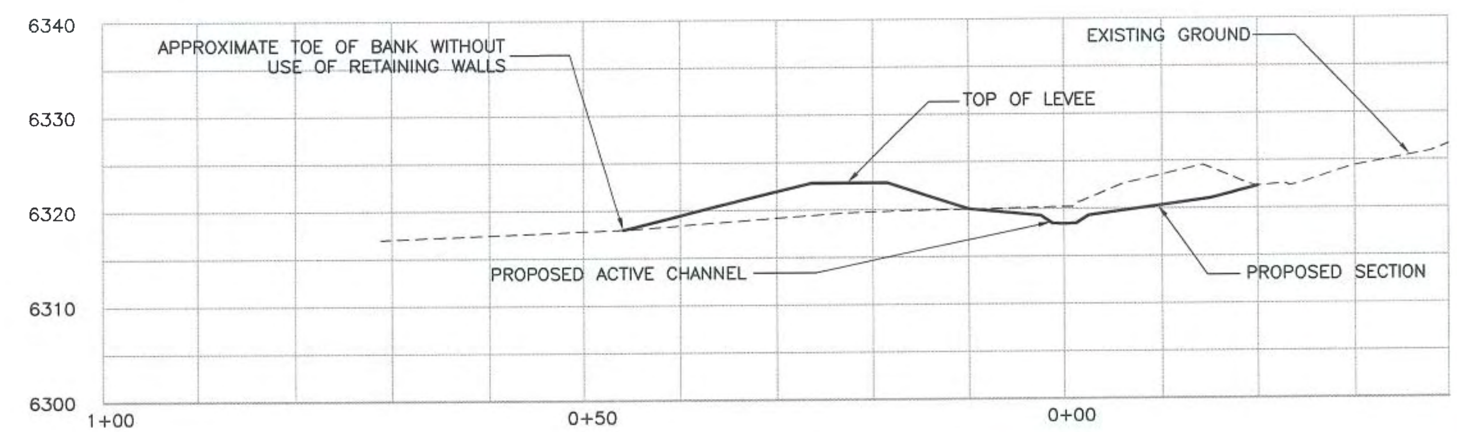

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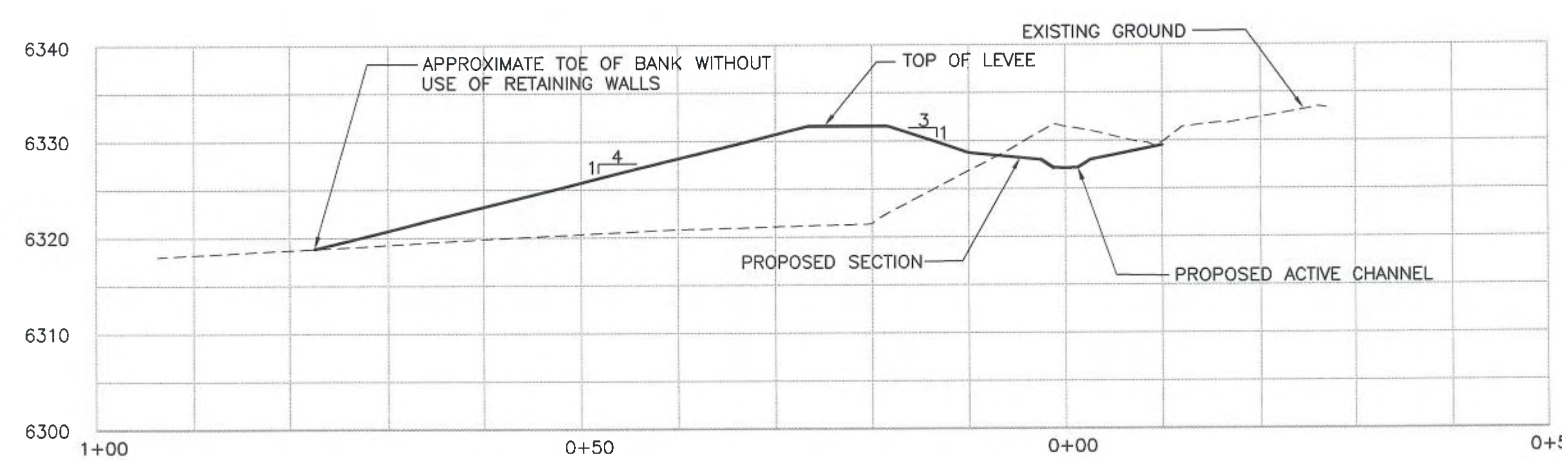

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SUBCONSULTANT
Michael Love & Associates (707) 476-8938

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BURKE CREEK RESTORATION PROJECT
AT HIGHWAY 50 CROSSING
CIVIL
ALTERNATIVE B
CROSS SECTIONS

JOB NUMBER 0101607001
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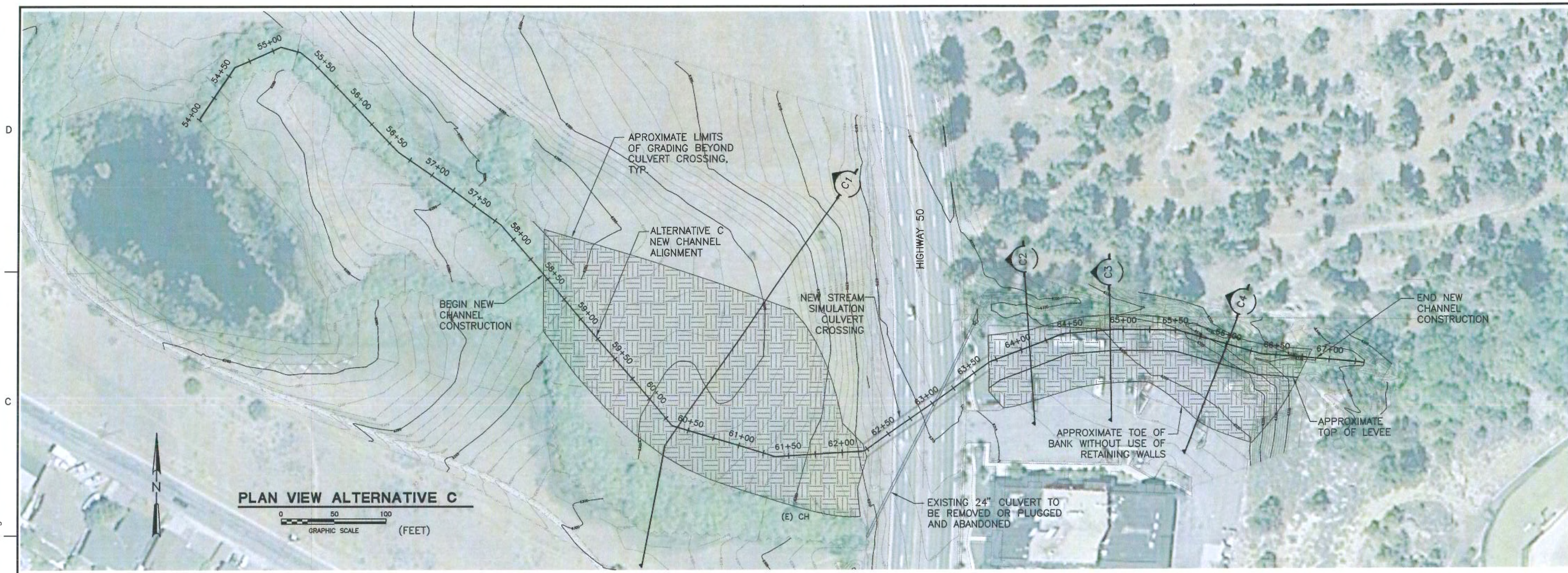

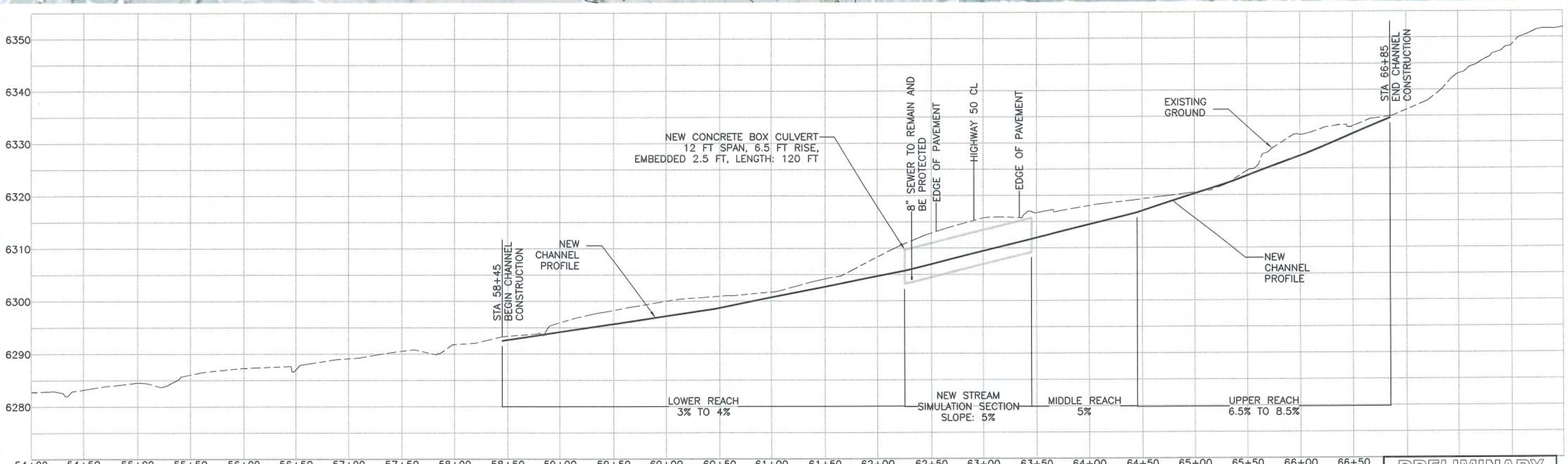

PROFILE ALTERNATIVE C

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FEBRUARY 2008 SUBMITTAL

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633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates (707) 476-8938

McBain & Trush, Inc.

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BURKE CREEK RESTORATION PROJECT AT HIGHWAY 50 CROSSING

CIVIL
PLAN AND PROFILE
ALTERVATIVE C

JOB NUMBER 0101607001

SHEET 8 OF 11

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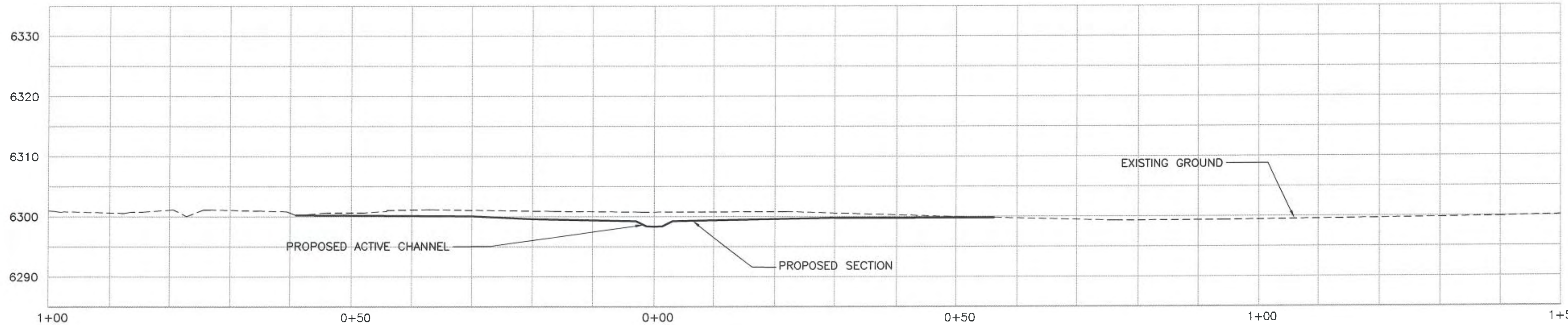

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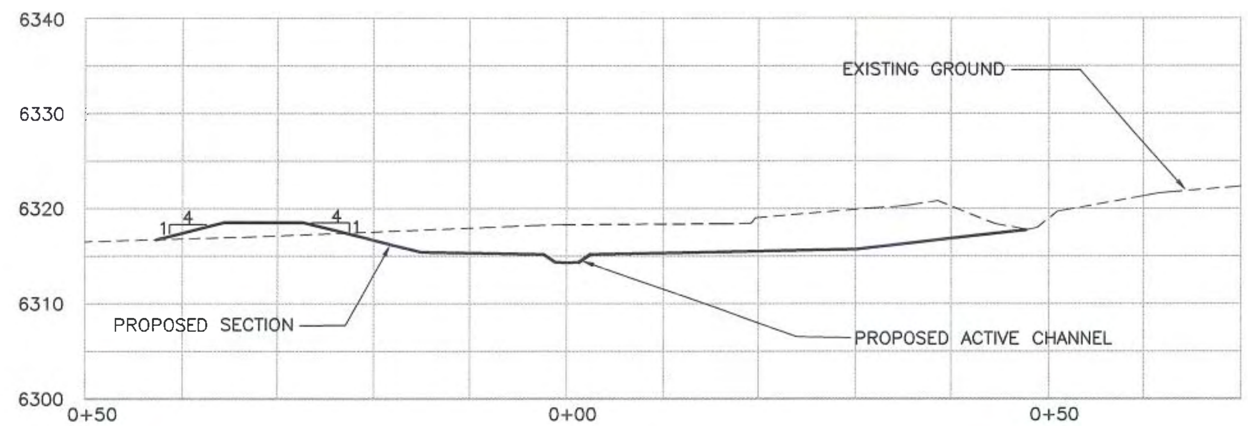

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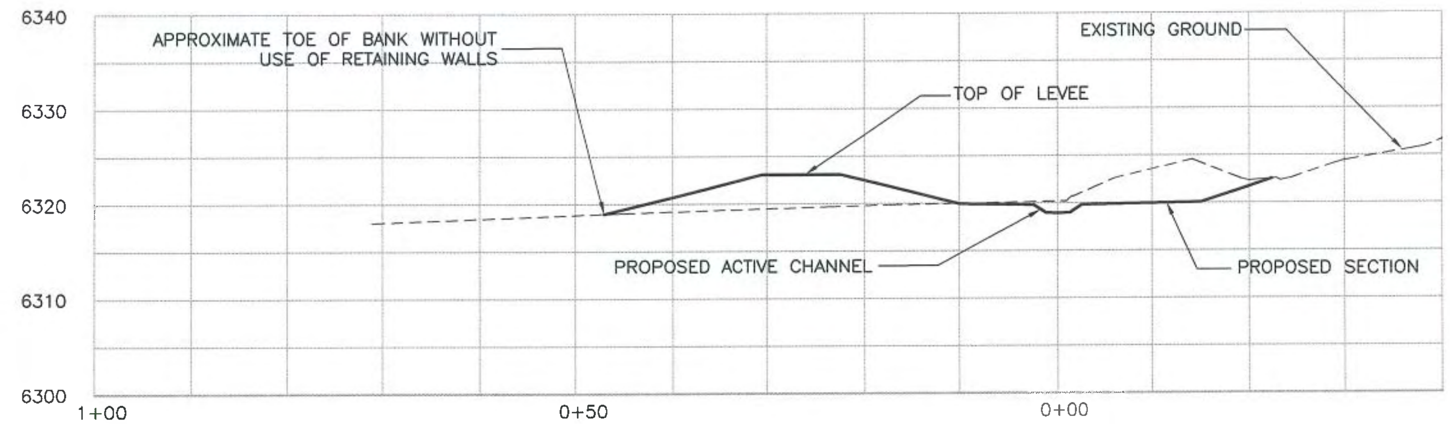

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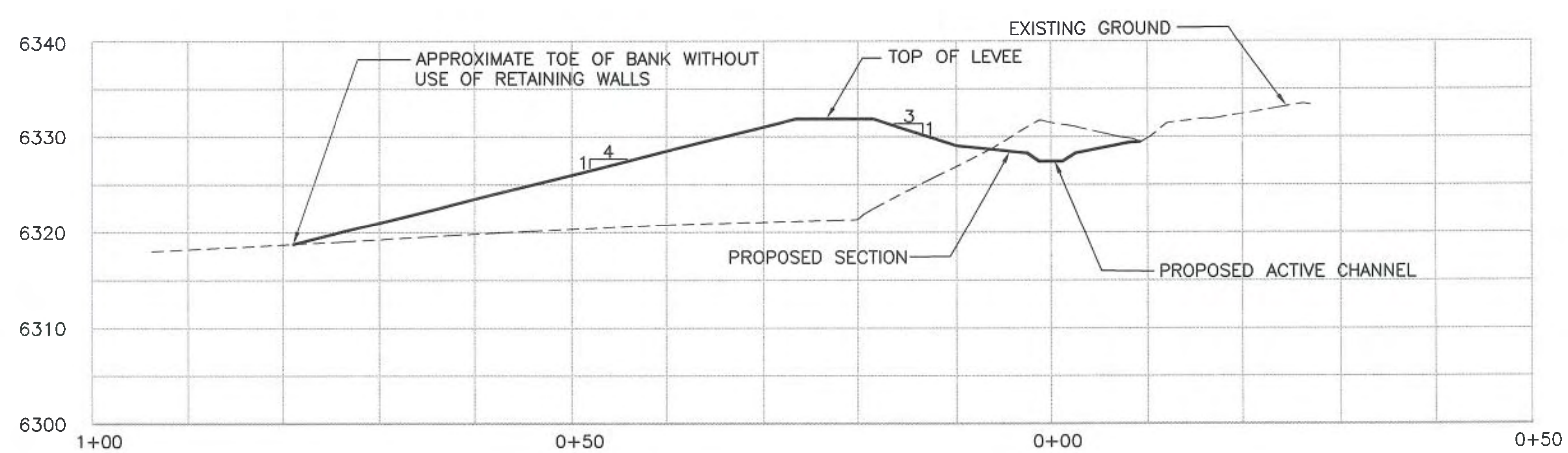

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633 THIRD STREET
EUREKA, CA 95501-0417
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FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
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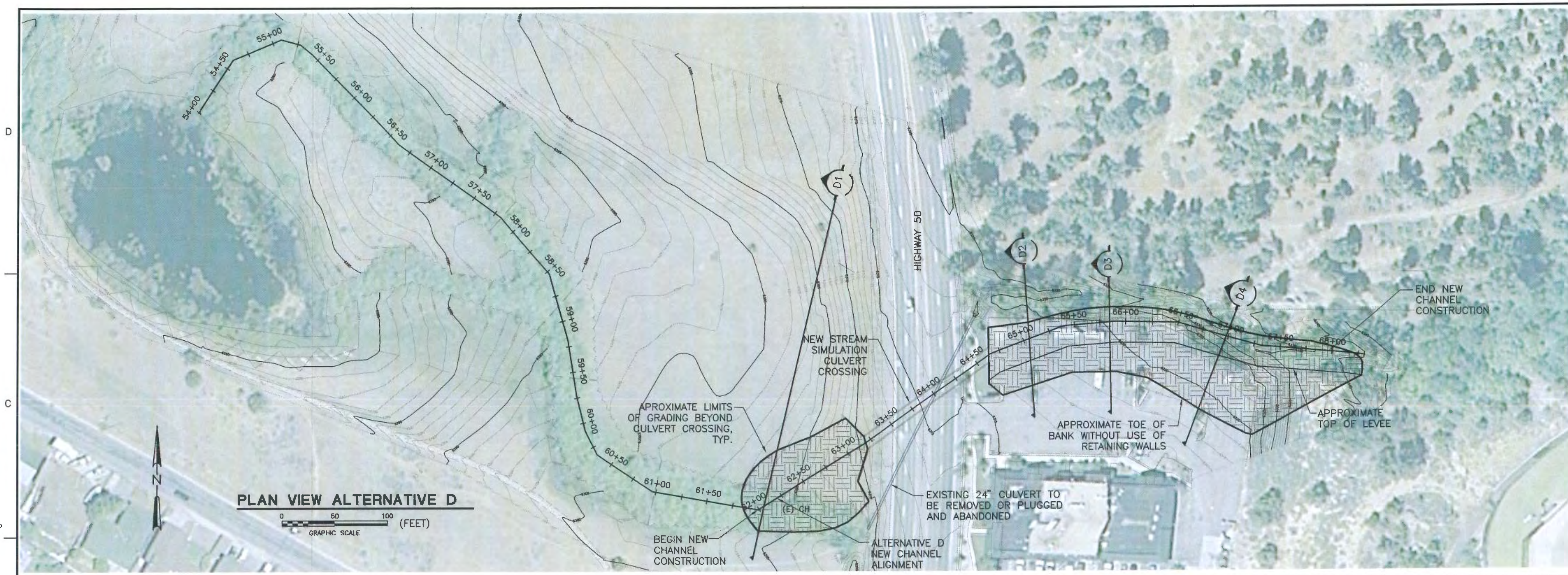

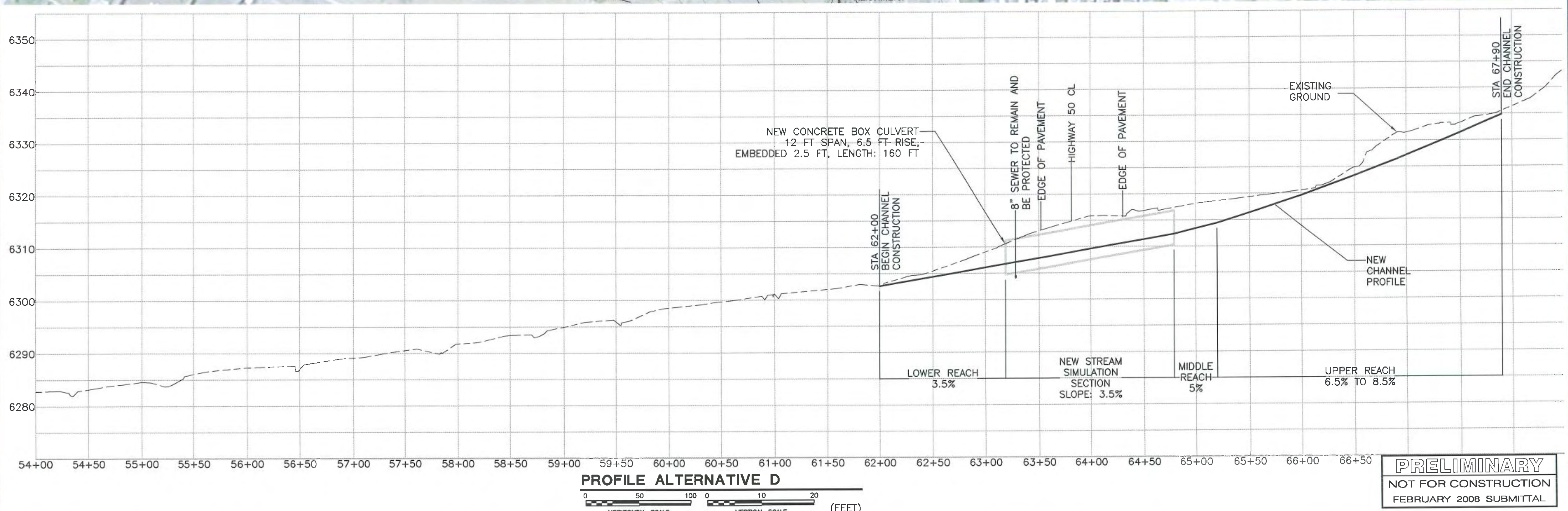

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BURKE CREEK RESTORATION PROJECT AT HIGHWAY 50 CROSSING
CIVIL
PLAN AND PROFILE ALTERVATIVE D

JOB NUMBER 0101607001
SHEET 10 OF 11
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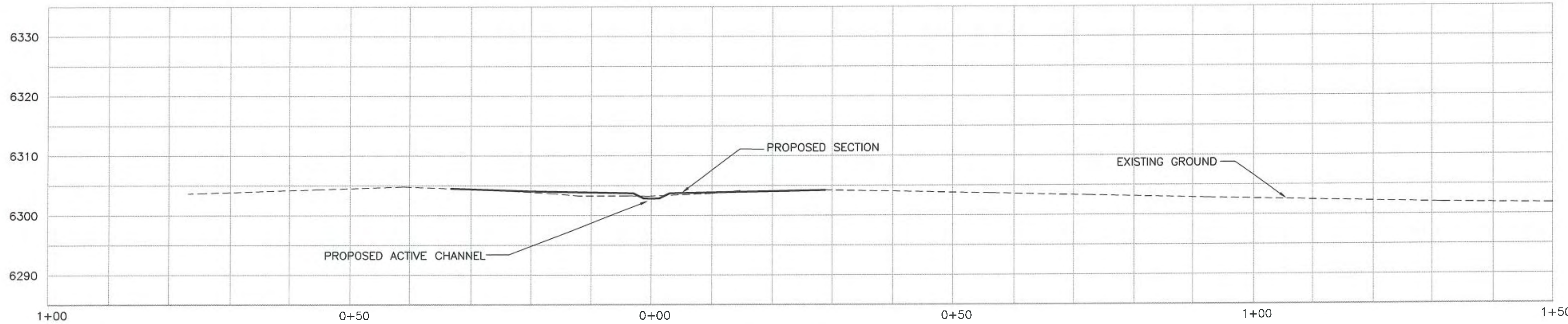

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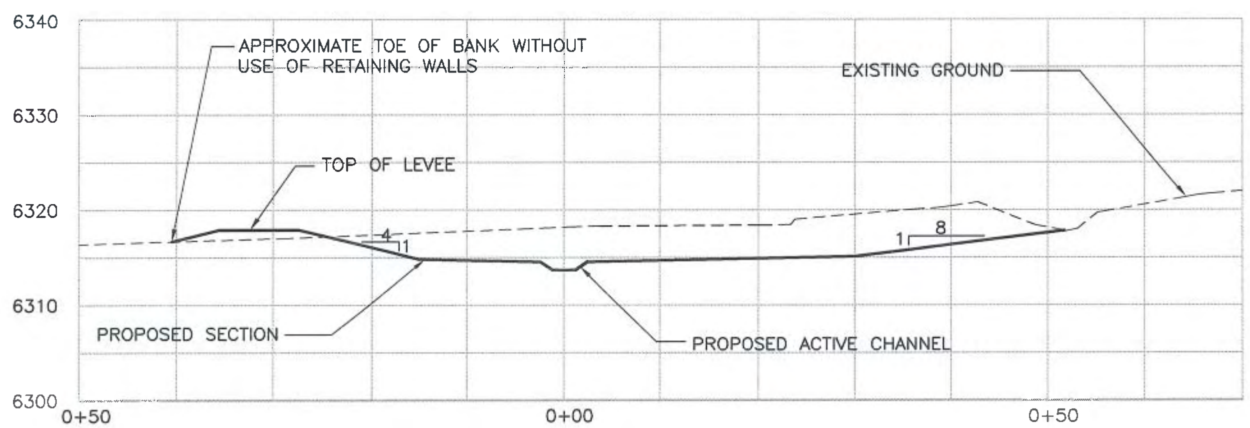

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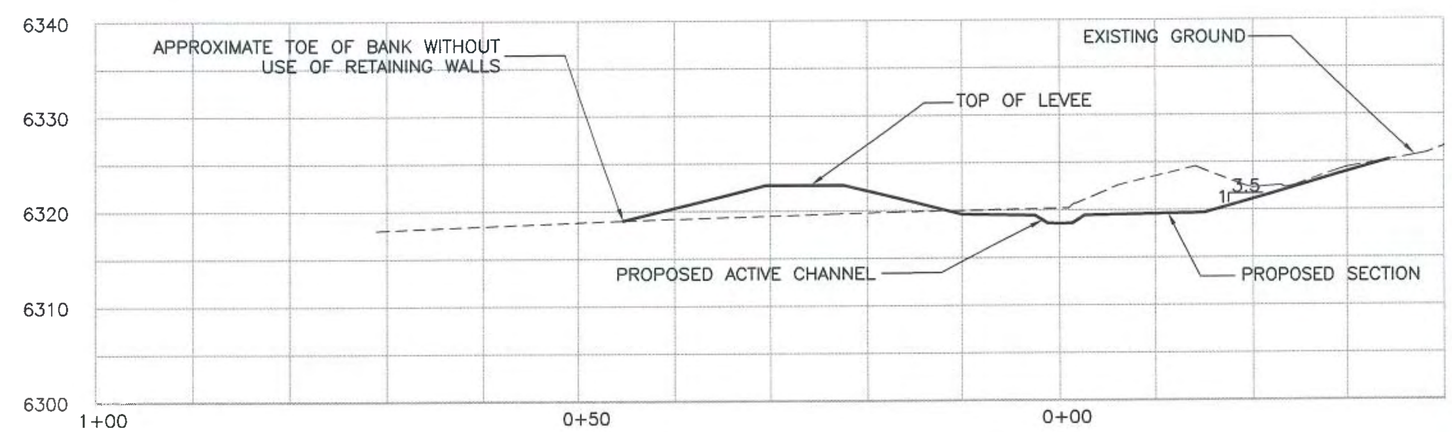

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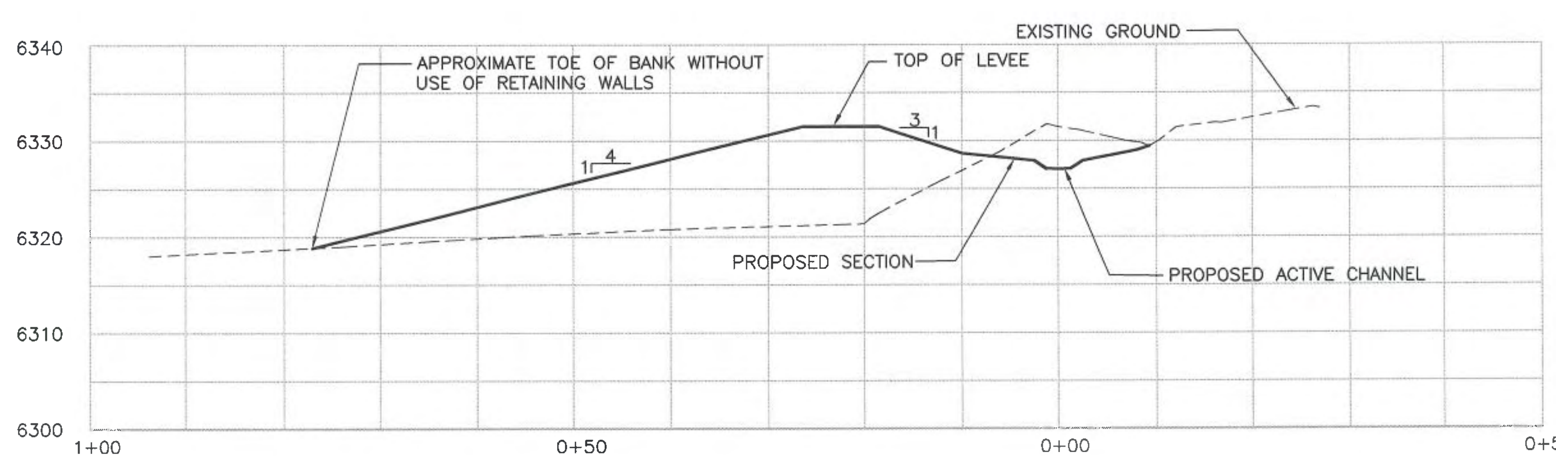

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McBain & Trush, Inc.

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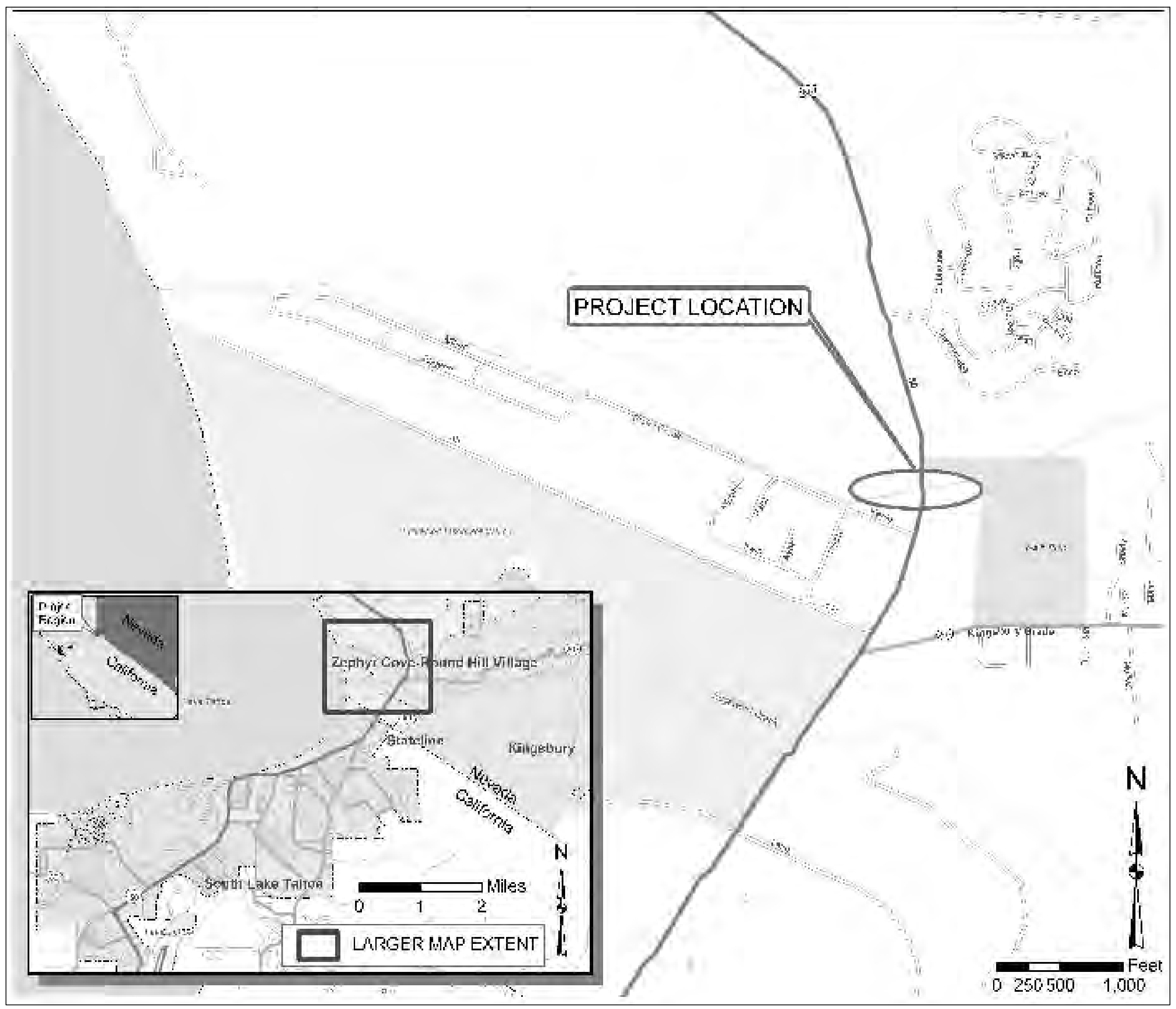
Appendix J
Proposed Alternatives A and B
Conceptual Design

TAHOE REGIONAL PLANNING AGENCY
IN COOPERATION WITH
DOUGLAS COUNTY

BURKE CREEK RESTORATION PROJECT
CONCEPTUAL ALTERNATIVE DESIGN PLANS
STATELINE, NEVADA

JUNE 2009



VICINITY MAP

SHEET INDEX

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WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
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DES ML/TL/RS
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SUPV ML/SA
CHK ML/SA
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TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
CONCEPTUAL ALTERNATIVE DESIGN PLANS
GENERAL
COVER SHEET

JOB NUMBER 11184-07-001
SHEET 1 OF 11

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SYMBOLS:

GENERAL:

- ⌀ DIAMETER
- ± APPROXIMATE
- @ AT
- △ DELTA
- WATER SURFACE

A / G2 | T2
- SECTION OR DETAIL DESIGNATION (LETTER INDICATES SECTION, NO. INDICATES DETAIL)
- SHEET WHERE SECTION OR DETAIL SHOWN
- SHEET FROM WHICH SECTION OR DETAIL WAS CUT

TOPOGRAPHIC:

NEW — EXISTING

- LIMITS OF DISTURBANCE
- ROAD CENTER
- SD — STORM DRAIN/CULVERT PIPE
- X — FENCE
- EXISTING THALWEG
- DRAINAGE/IRRIGATRION DITCH/SWALE
- 10+50, 10+60 — NEW DESIGN FLOWLINE
- CH — APPROX. EDGE OF CHANNEL (NOT SURVEYED)
- AC PAVEMENT
- ROADSIDE GUARDRAIL
- TEMPORARY 1/8" MESH FISH SCREEN
- 10, 12 — CONTOUR LINE
- TOP OF BANK
- TOE OF BANK
- BRUSH/VEGETATION LINE
- CONCRETE
- NEW TERRACE FLOODPLAIN
- POOL-GLIDE
- ROUGHENED CHUTE
- ROCK BAND/SILL
- LARGE WOOD FEATURE
- TREE
- OBSERVED STANDING WATER & SATURATED SOILS
- TP B — TEST PIT BORING
- TBM — TEMPORARY BENCH MARK
- +104.7 — SURVEY ELEVATION POINT

UTILITIES:

- PP — UTILITY POLE (PP=POWER), (TP=TELEPHONE), (JP=JOINT POLE)
- E OHD — OVERHEAD ELECTRICAL LINE

ABBREVIATIONS:

AB	ANCHOR BOLT
AB	AGGREGATE BASE
AC	ASPHALT CONCRETE
AGG	AGGREGATE
AVG	AVERAGE
@	AT
B-	BORING
BC	BEGIN CURVE
BM	BENCH MARK
BO	BLOW OFF
BOT	BOTTOM
BVC	BEGIN VERTICAL CURVE
CL, ℄	CENTERLINE
CLR	CLEAR, CLEARANCE
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CONC	CONCRETE
CONT	CONTINUOUS
CONT'D	CONTINUED
COORD	COORDINATE
COR	CORNER
CU	CUBIC
d	PENNY (NAIL SIZE)
DIA, ⌀	DIAMETER
DTL	DETAIL
DI	DROP (DRAINAGE) INLET
DF	DOUGLAS FIR
DWG	DRAWING
(E)	EXISTING
E	EAST
EA	EACH
EC	END CURVE
EF	EACH FACE
EP	EDGE PAVING
EQ	EQUAL
ER	EDGE ROAD
EL/ELEV	ELEVATION
ENGR	ENGINEER
EVC	END VERTICAL CURVE
EW	EACH WAY
FIN	FINISH
FF	FINISH FLOOR
FG	FINISH GRADE
FL, FL	FLOW LINE
FLR	FLOOR
FS	FINISHED SURFACE
FT	FOOT OR FEET
FTG	FOOTING
GAL	GALLON
GALV	GALVANIZED
GR	GRADE
GRD	GROUND
HORZ	HORIZONTAL
HWY	HIGHWAY
IP	IRON PIPE
INV	INVERT
JCT	JUNCTION
L	LENGTH
LAC	LEFT ACTIVE CHANNEL
LT	LEFT
LWD	LARGE WOODY DEBRIS
MAX	MAXIMUM
MFR	MANUFACTURER
MH	MAN HOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MG	MILLION GALLON
N	NORTH
(N)	NEW
NIC	NOT IN CONTRACT
NO	NUMBER
NTS	NOT TO SCALE
OC	ON CENTERS
OPNG	OPENING
PCC	PORTLAND CONCRETE CEMENT
PE	POLYETHYLENE
PL	PLATE
P/L, PL	PROPERTY LINE
PLCS	PLACES
PLWD	PLYWOOD
POC	POINT OF CONNECTION
PP	POWER POLE
PSI	POUNDS PER SQUARE INCH
PT	PRESSURE TREATED
PVC	POLYVINYL CHLORIDE PLASTIC PIPE
R, RAD	RADIUS
RAC	RIGHT ACTIVE CHANNEL
RC	RELATIVE COMPACTION
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
RDWD	REDWOOD
REQ'D	REQUIRED
REQ'T	REQUIREMENT
RSP	ROCK SLOPE PROTECTION
RT	RIGHT
R/W	RIGHT-OF-WAY
S	SLOPE
SAT	SATURATED
SCH, SCHED	SCHEDULE
SD	STORM DRAIN
SDMH	STORM DRAIN MANHOLE
SHT	SHEET
SIM	SIMILAR
SO	SOUTH
S STL	STAINLESS STEEL
STA	STATION
STD	STANDARD
STL	STEEL
TBD	TO BE DETERMINED
THK	THICK
TG	TOP GRATE
TP	TEST PIT
TS	TOP OF SLAB
TW	TOP OF WALL
TYP	TYPICAL
UBC	UNIFORM BUILDING CODE
UNO	UNLESS OTHERWISE NOTED
VERT	VERTICAL
W/	WITH
WD	WIDE
XING	CROSSING
YD	YARD

NOTE: CONTACT ENGINEER FOR ABBREVIATIONS NOT LISTED.

GENERAL NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH ALL PROJECT PERMITS.
2. PRIOR TO COMMENCING ANY EXCAVATION OR DEMOLITION WORK, THE TEMPORARY FISH SCREENS AND COFFER DAMS MUST BE INSTALLED AND FISH REMOVED FROM THE PROJECT AREA. CONTRACTOR SHALL COORDINATE WITH FISHERIES BIOLOGIST RESPONSIBLE FOR REMOVING FISH FOR SCHEDULING PLACEMENT OF FISH SCREENS, COFFER DAM AND DEWATERING PLAN. FISHERIES BIOLOGIST IS RESPONSIBLE FOR SITING THE BEST LOCATION FOR FISH SCREENS.
3. EXISTING VEGETATION SHALL BE PROTECTED AND LEFT UNDISTURBED AS MUCH AS PRACTICAL.
4. NATIVE TOPSOIL THAT IS EXCAVATED TO BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE AFTER ROUGH GRADING IS COMPLETE.
5. NATIVE STREAMBED MATERIAL THAT IS EXCAVATED SHALL BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE IN CHANNEL REGRADING.
6. UNSUITABLE EXCAVATED MATERIAL REMOVED FROM SITE SHALL BE DISPOSED OF IN A MANNER CONSISTENT WITH APPLICABLE REGULATIONS SUCH AS COUNTY GRADING ORDINANCES. CONTRACTOR IS RESPONSIBLE FOR LEGAL PROPER DISPOSAL OF UNSUITABLE MATERIALS TAKEN FROM SITE.
7. ANY PUMPS USED ON-SITE (DEWATERING ETC) SHALL BE PLACED ON ABSORBENT PADS. THE CONTRACTOR SHALL HAVE SPILL CONTAINMENT MATERIALS LOCATED AT THE SITE, WITH OPERATORS TRAINED IN SPILL CONTROL PROCEDURES.
8. ALL LARGE WOODY DEBRIS FOUND IN PROJECT AREA SHALL BE STOCKPILED ON SITE FOR RE-USE AS DIRECTED BY THE ENGINEER.
9. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER UPON DISCOVERING SIGNIFICANT DISCREPANCIES, ERRORS OR OMISSIONS IN THE PLANS PRIOR TO PROCEEDING.
10. IN THE EVENT CULTURAL RESOURCES (I.E., HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES, AND HUMAN REMAINS) ARE DISCOVERED DURING GRADING OR OTHER CONSTRUCTION ACTIVITIES, WORK SHALL BE HALTED WITHIN A 100 FOOT RADIUS OF THE FIND. A QUALIFIED ARCHEOLOGIST SHALL BE CONSULTED FOR AN ON-SITE EVALUATION. ADDITIONAL MITIGATION MAY BE REQUIRED BY THE COUNTY PER THE ARCHEOLOGIST'S RECOMMENDATIONS. IF HUMAN BURIALS OR HUMAN REMAINS ARE ENCOUNTERED, THE CONTRACTOR SHALL NOTIFY THE COUNTY CORONER IMMEDIATELY AND CEASE WORK.
11. SHOULD GRADING OPERATIONS ENCOUNTER HAZARDOUS MATERIALS, OR WHAT APPEAR TO BE HAZARDOUS MATERIALS, STOP WORK IN THE AFFECTED AREA IMMEDIATELY AND CONTACT 911 OR THE APPROPRIATE AGENCY FOR FURTHER INSTRUCTION.

EROSION & SEDIMENT CONTROL NOTES:

1. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO MINIMIZE EROSION AND PREVENT THE TRANSPORT OF SEDIMENT TO THE ADJACENT STREAM AND SENSITIVE AREAS.
2. IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO FIX ANY DEFICIENCIES INDICATED BY THE OWNER OR THE OWNERS REPRESENTATIVE.
3. PRIOR TO FINAL ACCEPTANCE ALL AREAS OF THE SITE WILL BE VEGETATED OR PERMANENTLY STABILIZED AND ALL TEMPORARY SEDIMENT CONTROL MEASURES SHALL BE REMOVED.
4. PRESERVATION OF EXISTING VEGETATION SHALL OCCUR TO THE MAXIMUM EXTENT PRACTICABLE.
5. DISCHARGES OF POTENTIAL POLLUTANTS FROM CONSTRUCTION SITES SHALL BE PREVENTED USING SOURCE CONTROLS TO THE MAXIMUM EXTENT PRACTICABLE. POTENTIAL POLLUTANTS INCLUDE BUT ARE NOT LIMITED TO: SEDIMENT, TRASH, NUTRIENTS, PATHOGENS, PETROLEUM HYDROCARBONS, METALS, CONCRETE, CEMENT, ASPHALT, LIME, PAINT, STAINS, GLUES, WOOD PRODUCTS, PESTICIDES, HERBICIDES, CHEMICALS, HAZARDOUS WASTE, SANITARY WASTE, VEHICLE OR EQUIPMENT WASH WATER AND CHLORINATED WATER.
6. WHENEVER IT IS NOT POSSIBLE TO UTILIZE EROSION PREVENTION MEASURES, EXPOSED SLOPES SHALL EMPLOY SEDIMENT CONTROL DEVICES, SUCH AS FIBER ROLLS AND SILT FENCES. FIBER ROLLS AND SILT FENCES SHALL BE TRENCHED AND KEYED INTO THE SOIL AND INSTALLED ON CONTOUR. SILT FENCES SHALL BE INSTALLED APPROXIMATELY 2 TO 5 FEET FROM TOE OF SLOPE.
7. SOIL AND MATERIAL STOCKPILES SHALL BE PROPERLY PROTECTED TO MINIMIZE SEDIMENT AND POLLUTANT TRANSPORT FROM THE CONSTRUCTION SITE.
8. SOLID WASTE, SUCH AS TRASH, AND DEBRIS, SHALL BE PLACED IN DESIGNATED COLLECTION AREAS OR CONTAINERS. THE CONSTRUCTION SITE SHALL BE CLEARED OF SOLID WASTE DAILY, OR AS NECESSARY, AND REGULAR REMOVAL AND PROPER DISPOSAL SHALL BE ARRANGED.
9. A CONCRETE WASHOUT AREA, SUCH AS A TEMPORARY PIT, SHALL BE DESIGNATED TO CLEAN CONCRETE TRUCKS AND TOOLS. AT NO TIME SHALL CONCRETE PRODUCTS AND WASTE BE ALLOWED TO ENTER COUNTY WATERWAYS SUCH AS CREEKS OR STORM DRAINS.
10. PROPER APPLICATION, CLEANING AND STORAGE OF POTENTIALLY HAZARDOUS MATERIALS, SUCH AS PAINTS AND CHEMICALS, SHALL BE CONDUCTED TO PREVENT THE DISCHARGE OF POLLUTANTS.
11. WHEN UTILIZED, TEMPORARY RESTROOMS AND SANITARY FACILITIES SHALL BE LOCATED AND MAINTAINED TO PREVENT THE DISCHARGE OF POLLUTANTS.
12. APPROPRIATE VEHICLE STORAGE, FUELING, MAINTENANCE AND CLEANING AREAS SHALL BE DESIGNATED AND MAINTAINED TO PREVENT DISCHARGE OF POLLUTANTS.

SURVEY:

1. TOPOGRAPHIC DATA IS BASED ON A FIELD SURVEY CONDUCTED BY TURNER & ASSOCIATES, INC. IN OCTOBER 2007.
2. ALL UTILITIES SHOWN (IF ANY) WERE LOCATED FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED FOR THIS SITE. NOTIFY UNDERGROUND SERVICE ALERT PRIOR TO ANY GRADING OR EXCAVATION WITHIN THE SITE AT 1-800-227-2600.
3. AERIAL IMAGE USED AS BACKGROUND IMAGE DATED 2007

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TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
CONCEPTUAL ALTERNATIVE DESIGN PLANS
GENERAL
GENERAL NOTES, SYMBOLS & ABBREVIATIONS

JOB NUMBER 11184-07-001
SHEET 2 OF 11
G-2

NOTE:
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PRELIMINARY
NOT FOR CONSTRUCTION
JUNE 2009

REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
(707) 476-8938
McBain & Trush, Inc.

DES TL/RS/ML
DRN TL/TJ
SUPV SAA/ML
CHK SAA/ML
SEE SCALE BAR
SEAL

TAHOE REGIONAL PLANNING AGENCY
BURKE CREEK RESTORATION PROJECT
CONCEPTUAL ALTERNATIVE DESIGN PLANS
GENERAL
EXISTING CONDITIONS
1 OF 3

JOB NUMBER 11184-07-001
SHEET 3 OF 11
G-3

\\ekasvr3\projects\2005 & Beyond\11184 TahoeRegionalPlanningAgency\11184-07-001 BurkeCreekRestorationProject\CAD 1118407001 Burke\dwg\2ndGenerationDwgs
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2 OF 3

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11184-07-001

SHEET 4 OF 11

G-4

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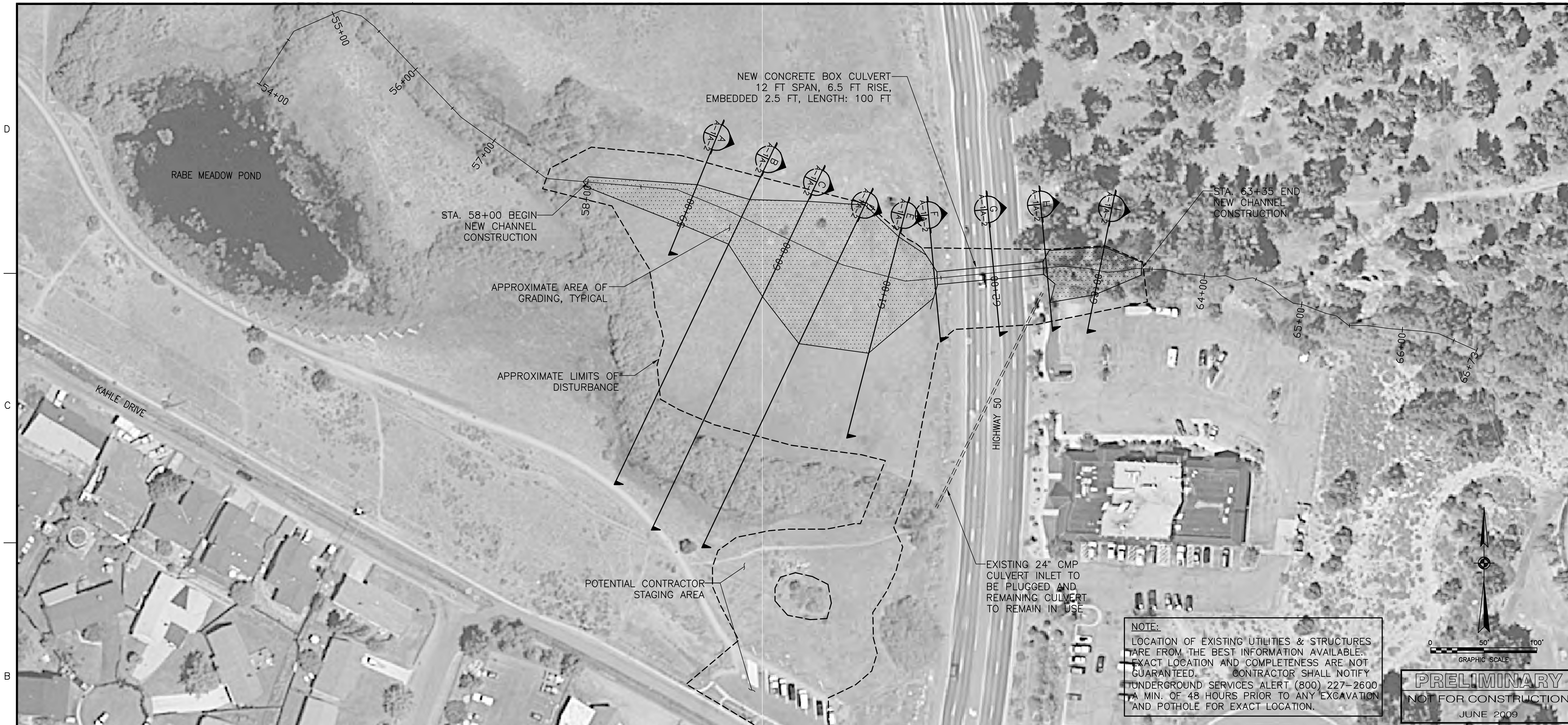
GENERAL

EXISTING CONDITIONS 3 OF 3

JOB NUMBER 11184-07-001
SHEET 5 OF 11
G-5



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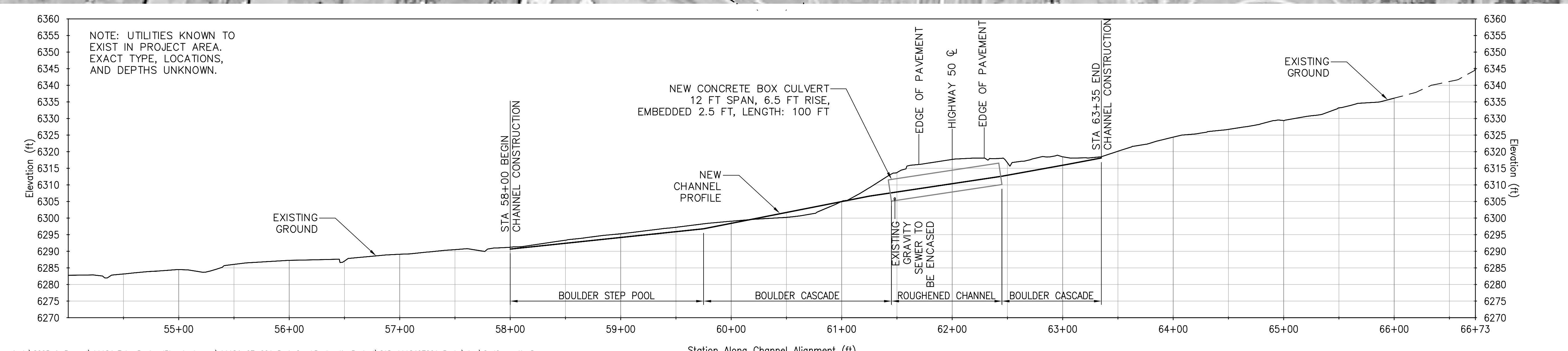

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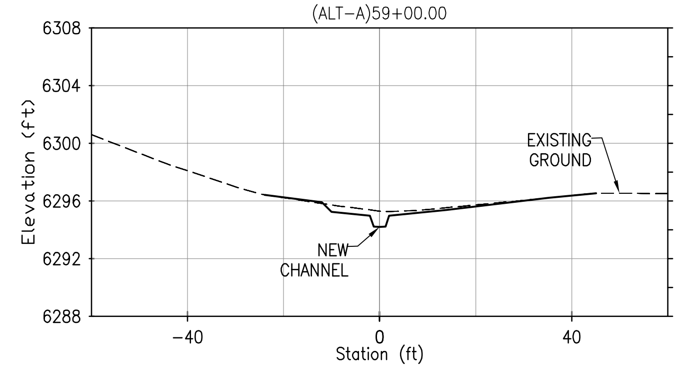
CONCEPTUAL ALTERNATIVE DESIGN PLANS
CIVIL
ALTERNATIVE A
PLAN AND PROFILE

JOB NUMBER 11184-07-001
SHEET 6 OF 11
A-1



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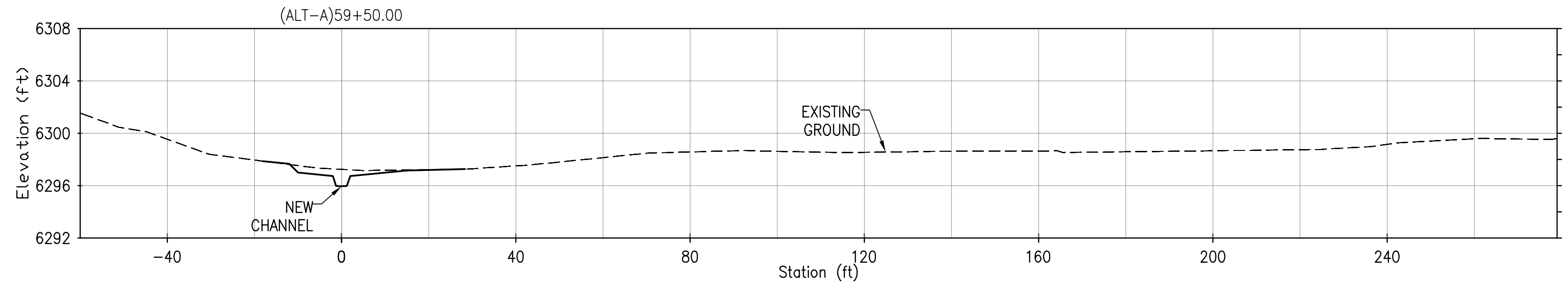

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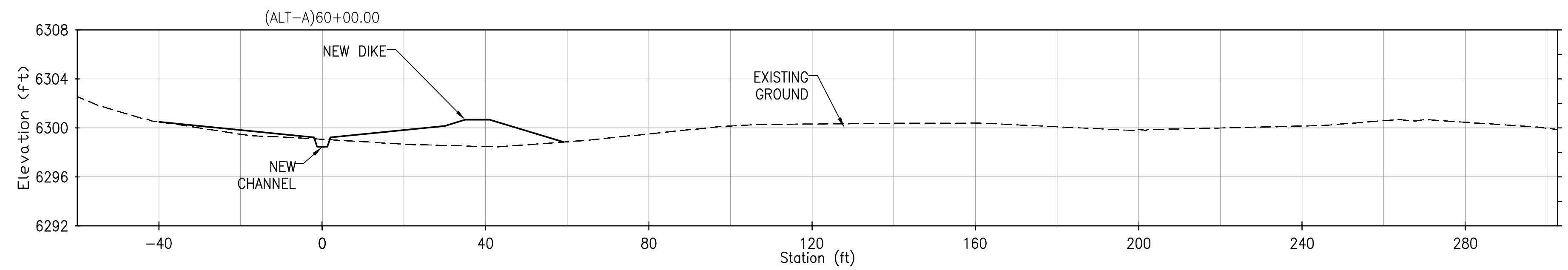

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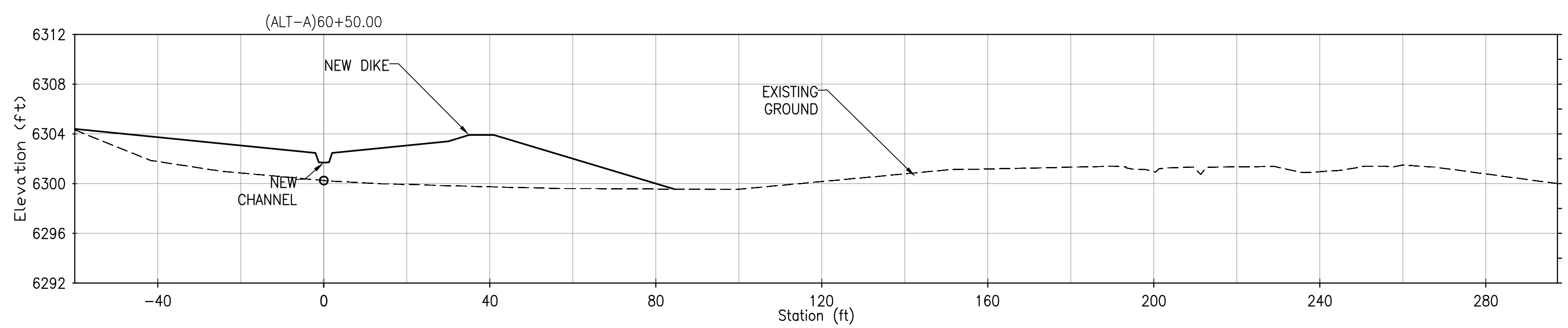

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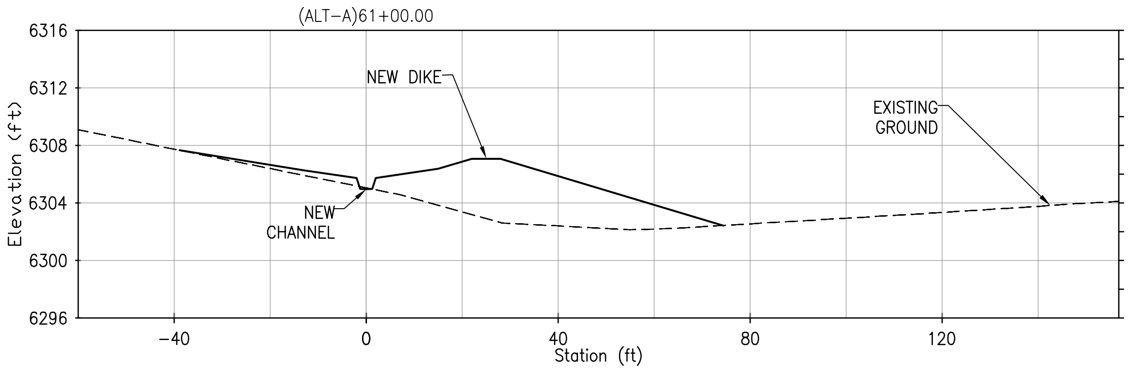
CROSS-SECTIONS 1 OF 2

JOB NUMBER 11184-07-001
SHEET 7 OF 11
A-2



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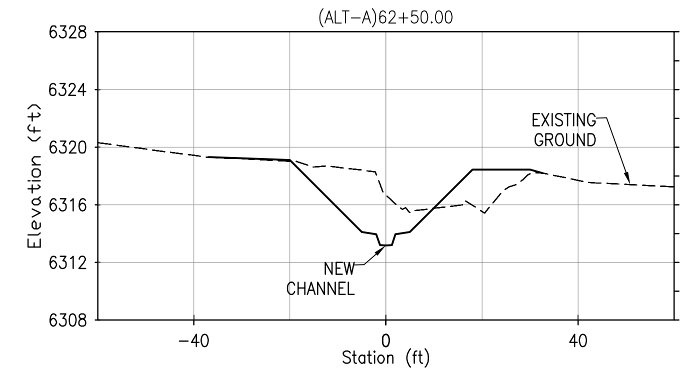

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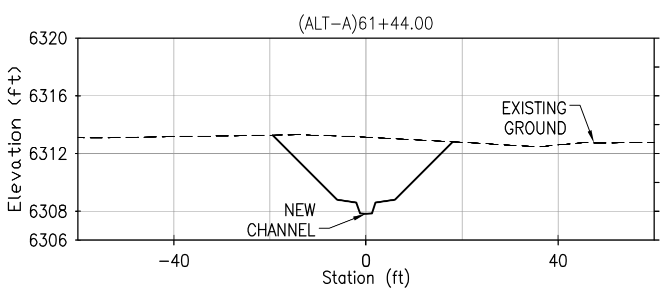

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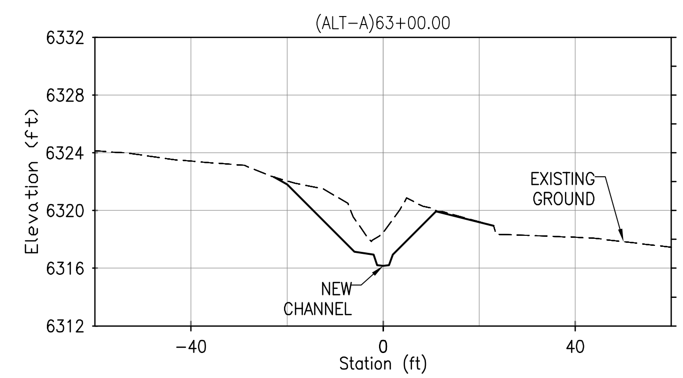

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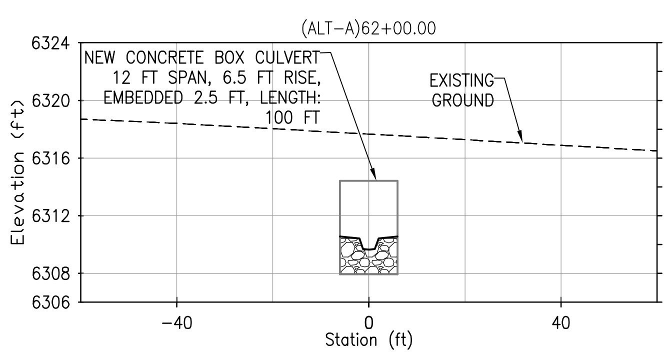

G B-1 B-3 CHANNEL CROSS-SECTION STA. 62+00

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633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330
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JOB NUMBER 11184-07-001
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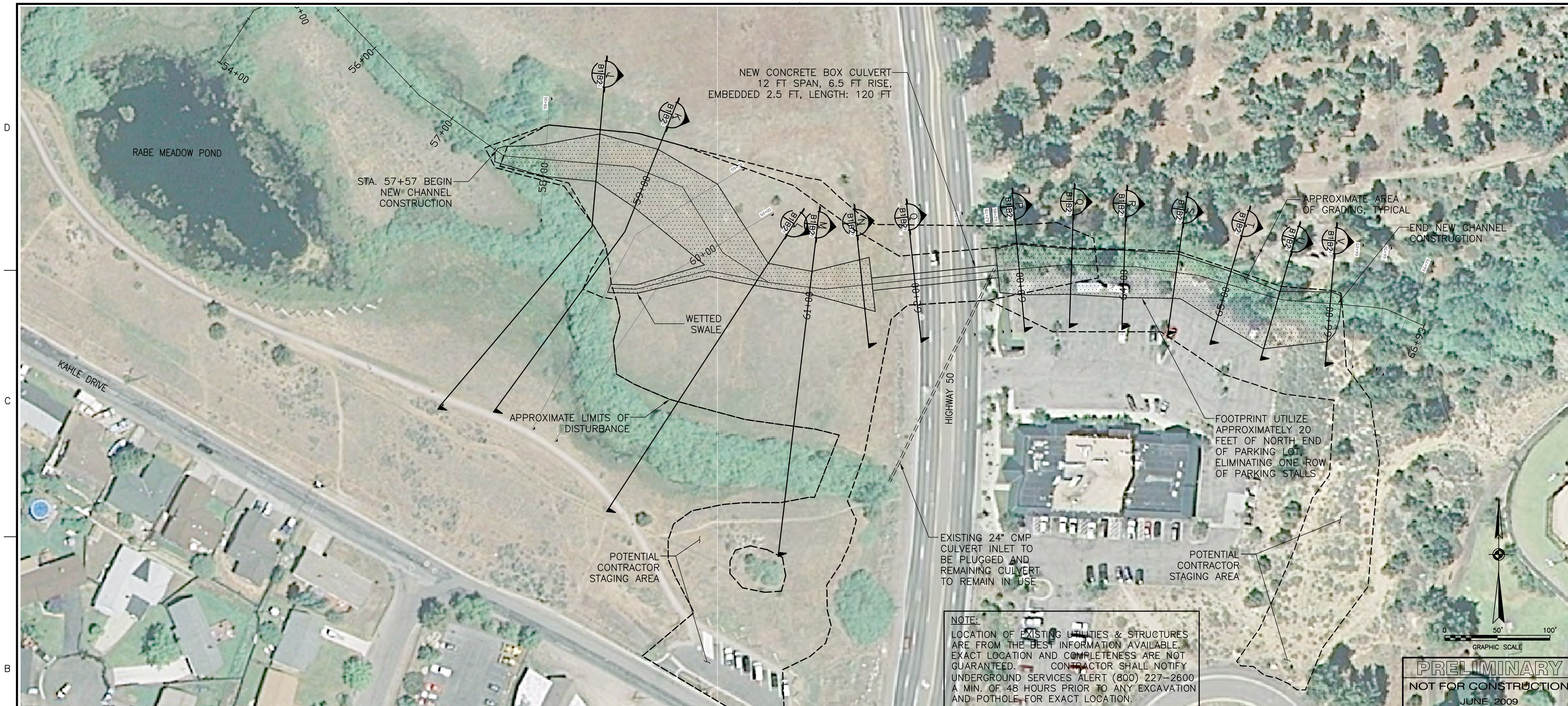
A-3



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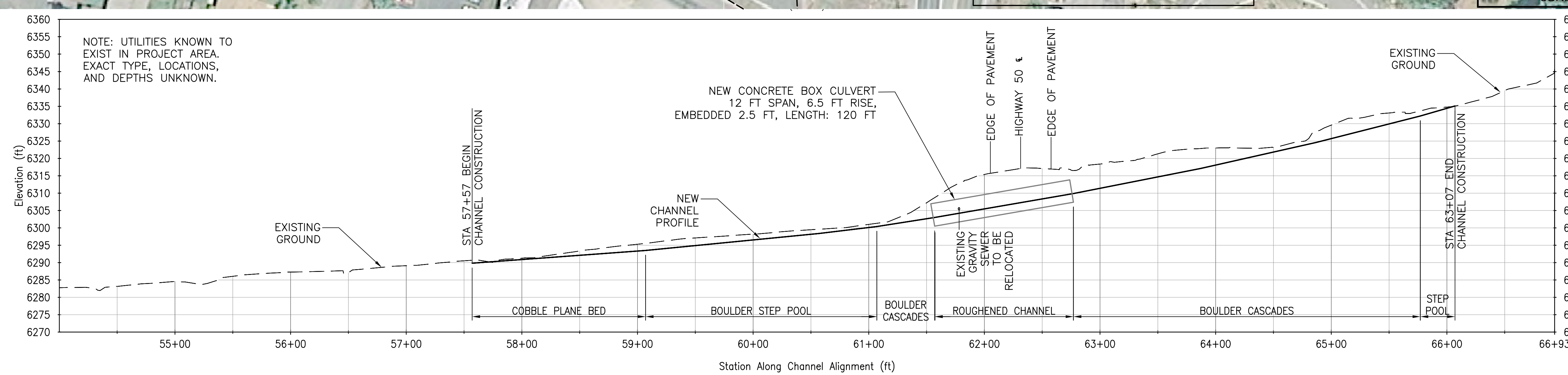

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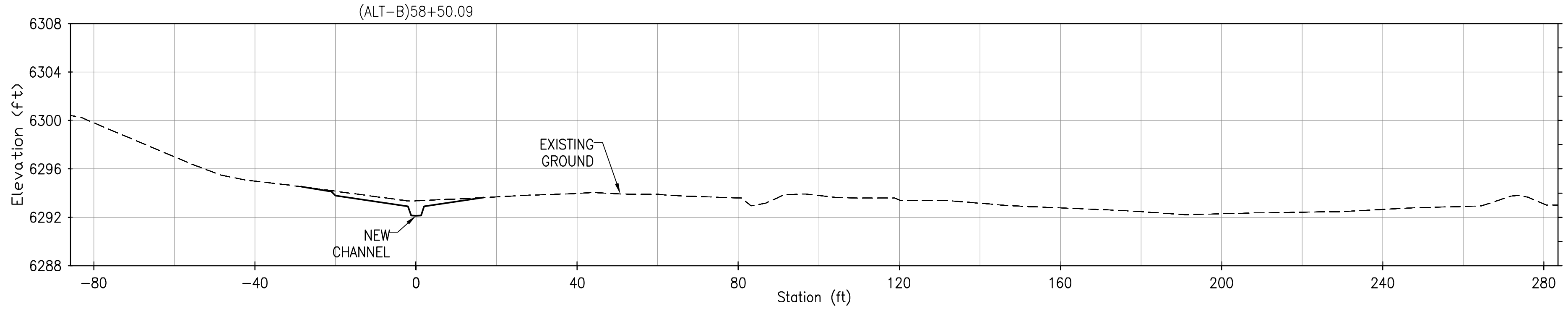
JOB NUMBER 11184-07-001
SHEET 9 OF 11

B-1



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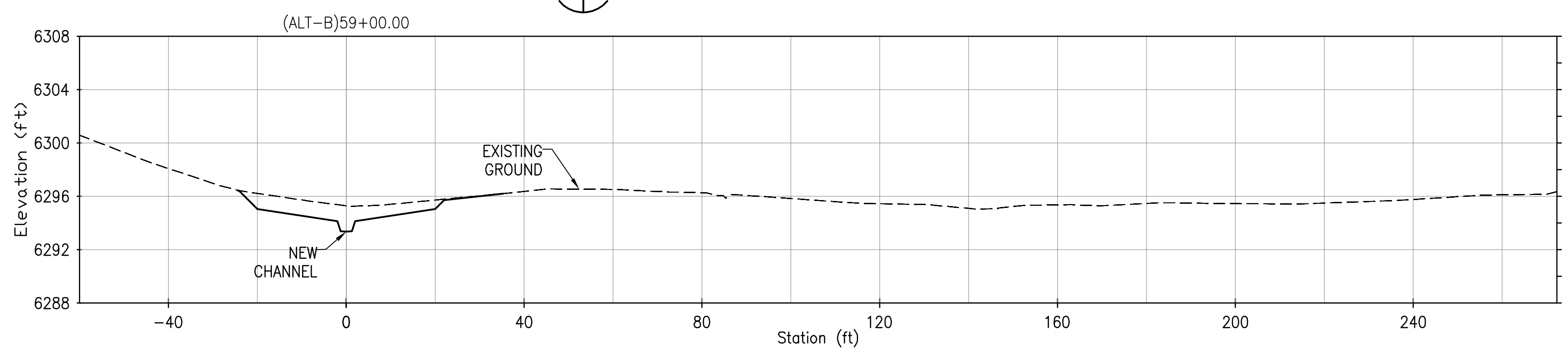

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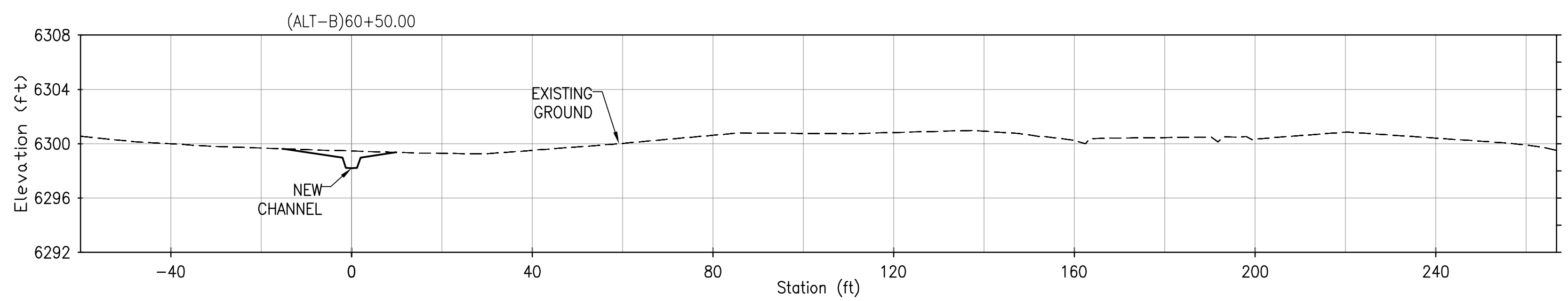

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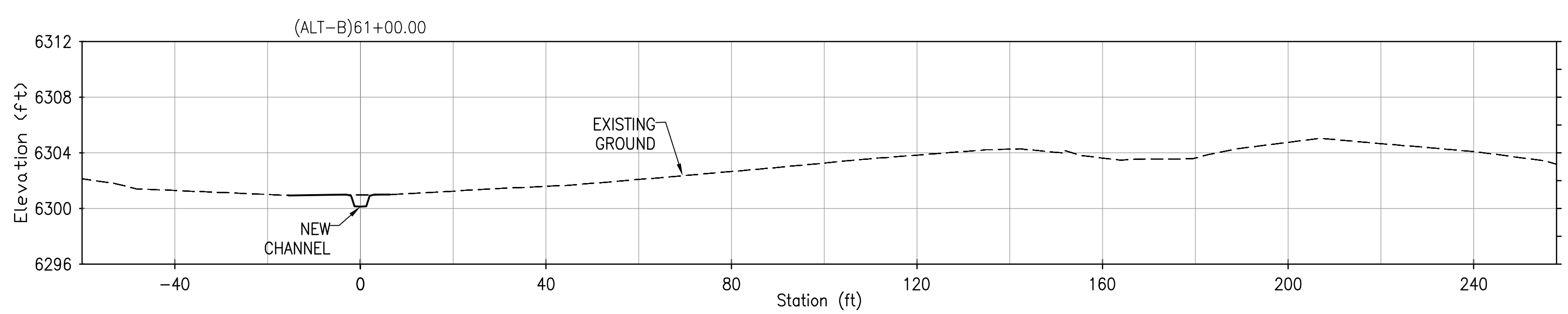

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SCALE: N.T.S.

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JOB NUMBER 11184-07-001
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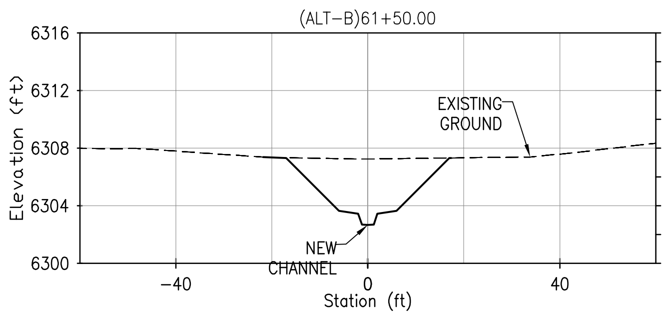
B-2



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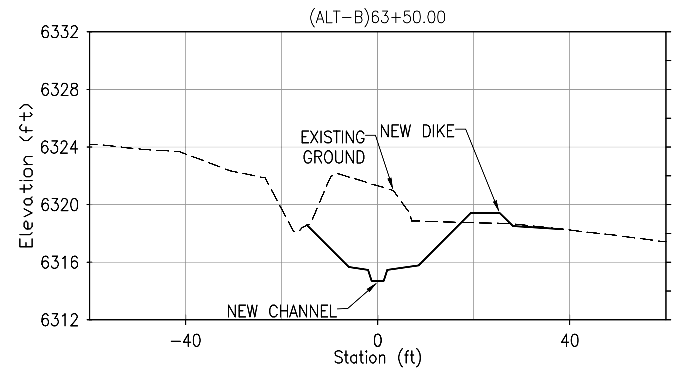

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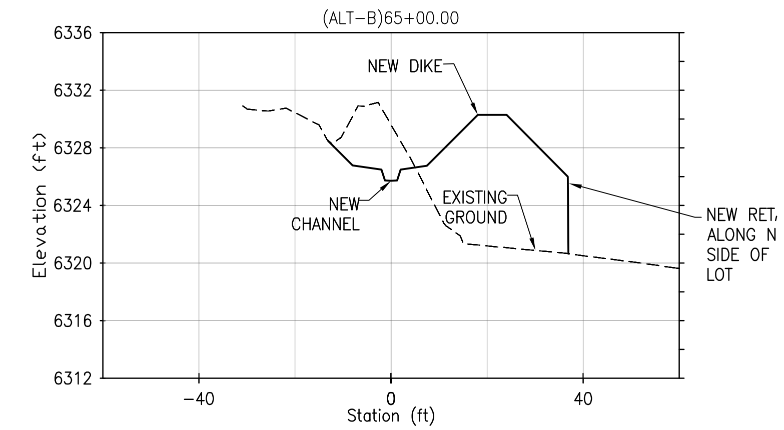

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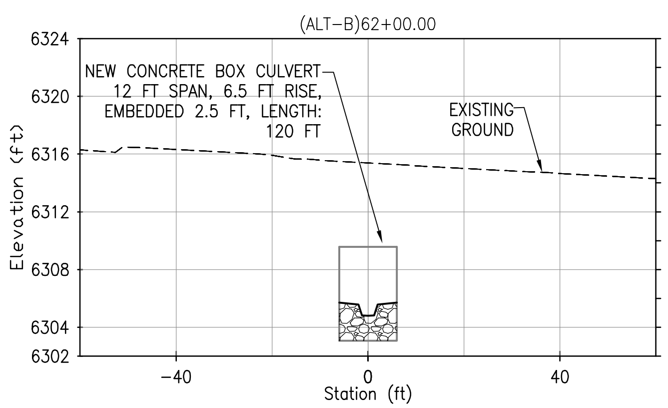

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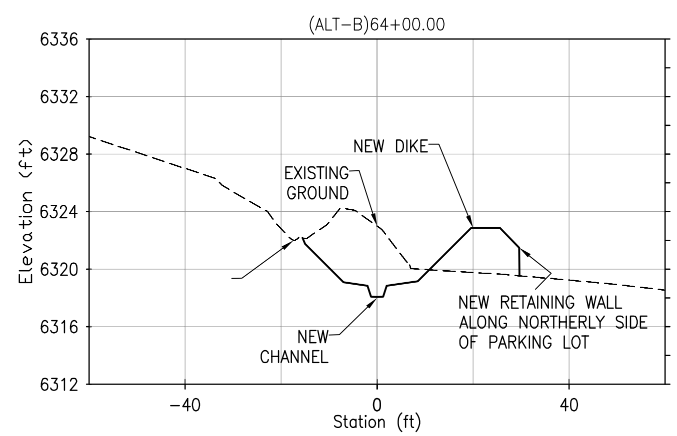

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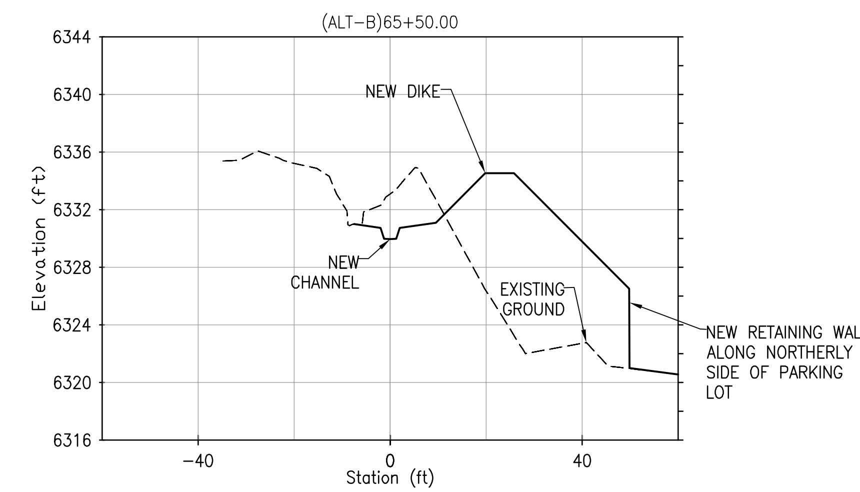

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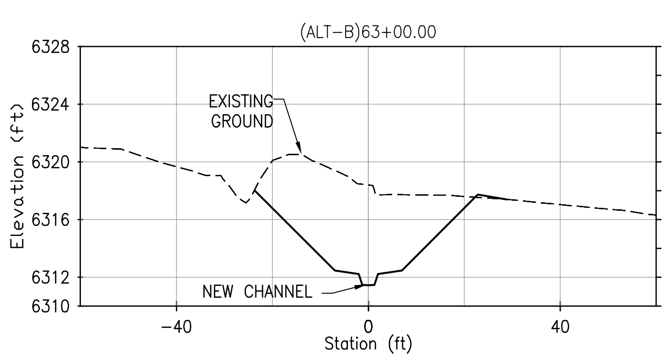

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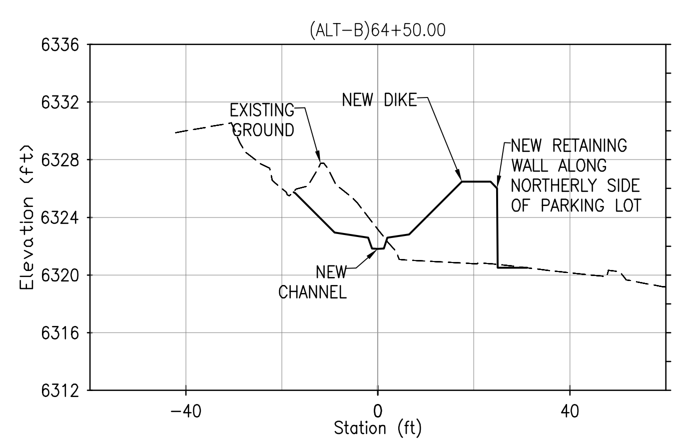

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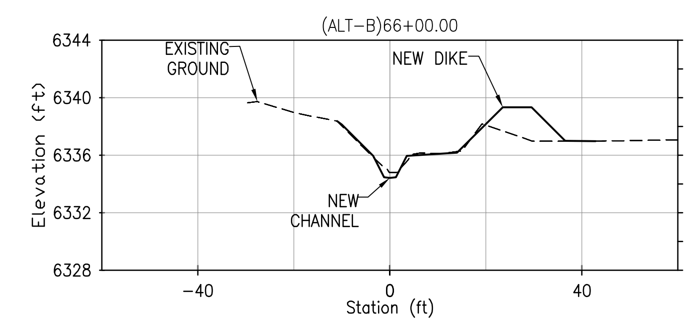

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CROSS–SECTIONS 2 OF 2

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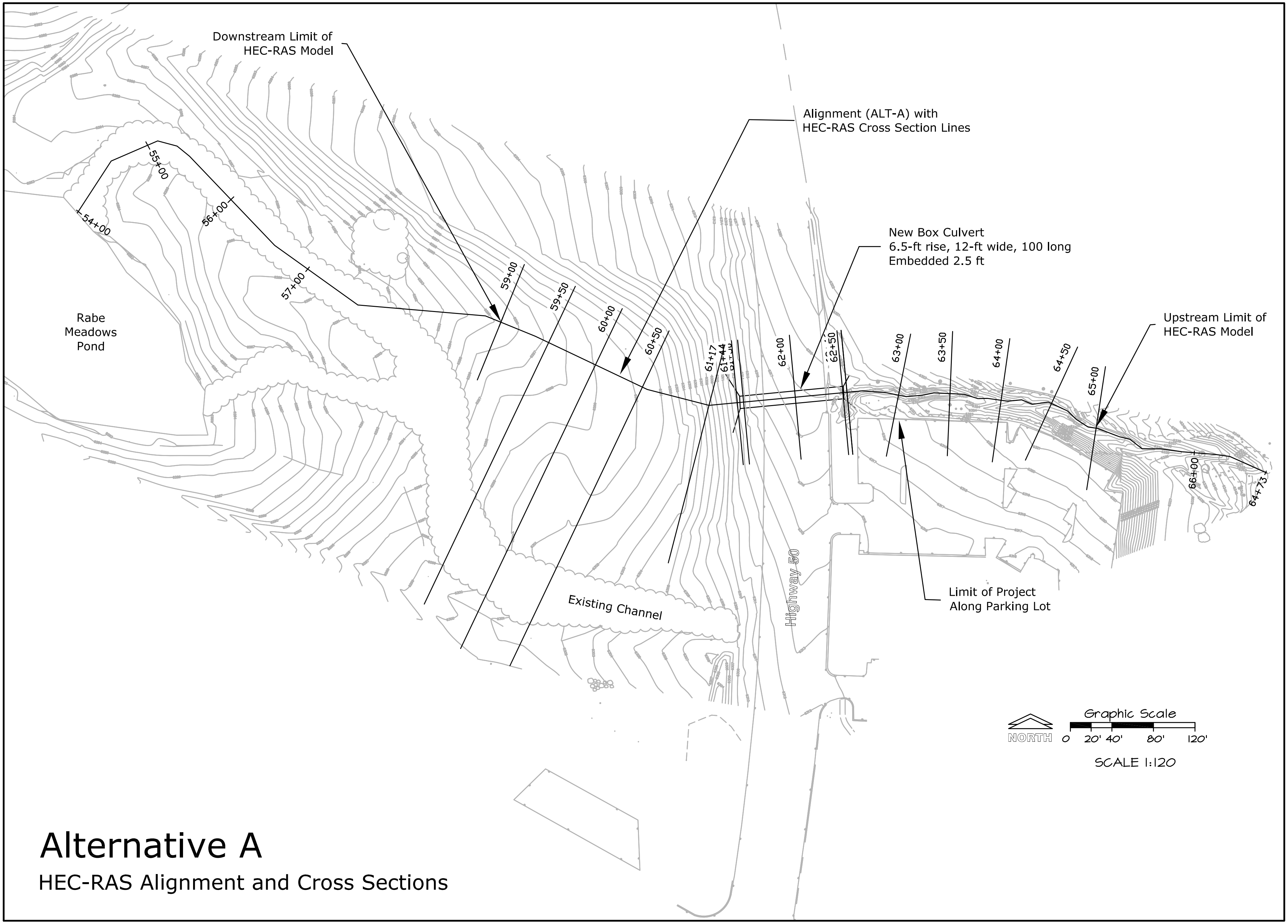
SHEET 11 OF 11

B–3

Appendix K

Proposed Condition Hydraulic Analysis for Alternatives A &B



Alternative A

HEC-RAS Alignment and Cross Sections

HEC-RAS Plan: A >BF FINAL River: (ALT-A) Reach: (ALT-A)

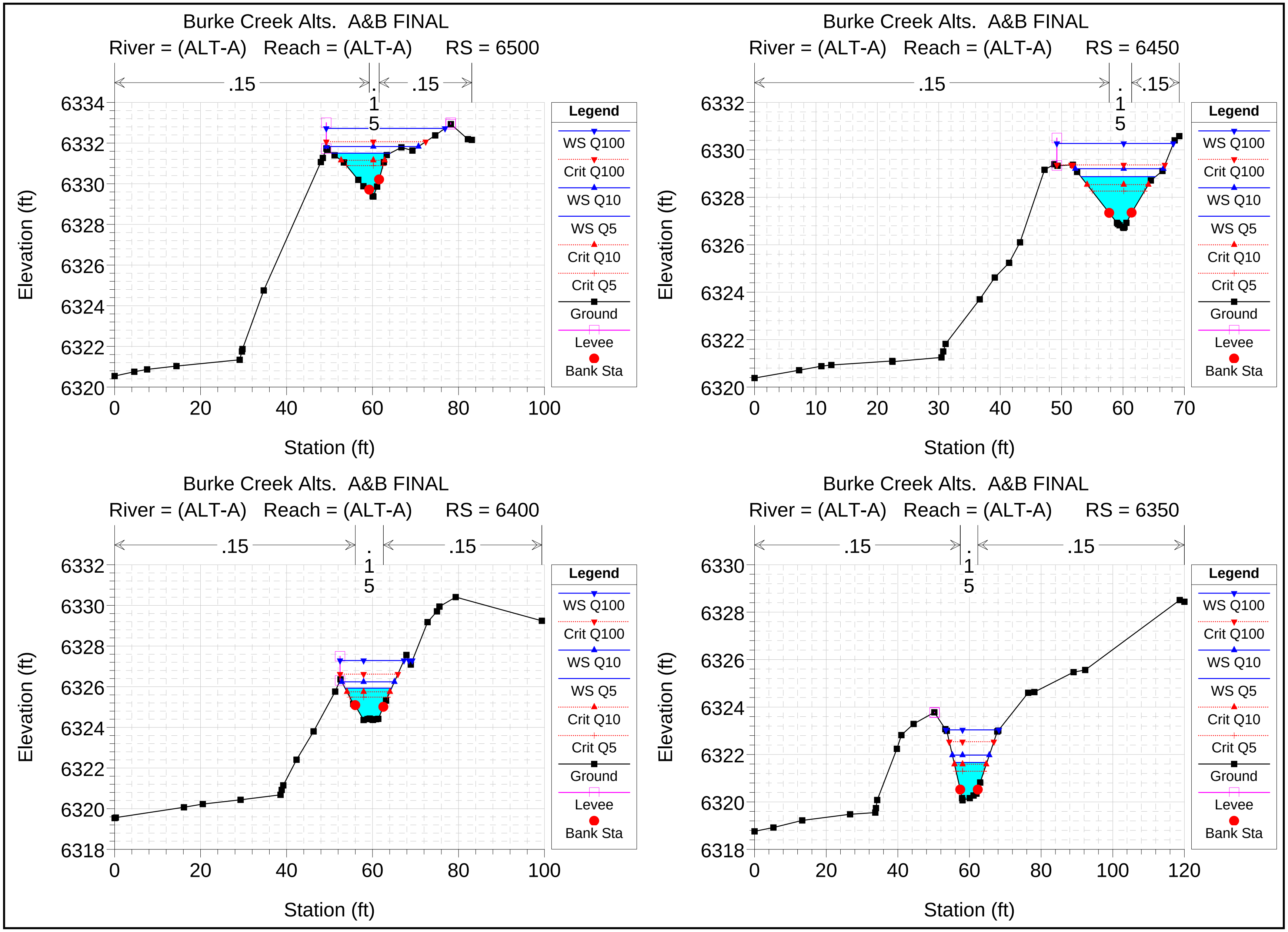
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-A)	6500	Q5	32.00	6329.37	6331.50	6330.89	6331.61	0.058518	3.29	13.05	13.59	0.43
(ALT-A)	6500	Q10	47.00	6329.37	6331.83	6331.16	6331.96	0.056158	3.59	18.68	21.45	0.43
(ALT-A)	6500	Q100	121.00	6329.37	6332.72	6332.07	6332.89	0.049209	4.24	40.67	27.61	0.43
(ALT-A)	6450	Q5	32.00	6326.71	6328.87	6328.26	6328.99	0.047298	3.14	13.07	12.16	0.40
(ALT-A)	6450	Q10	47.00	6326.71	6329.21	6328.54	6329.35	0.048393	3.55	17.56	14.36	0.42
(ALT-A)	6450	Q100	121.00	6326.71	6330.27	6329.37	6330.48	0.047008	4.54	36.51	18.97	0.44
(ALT-A)	6400	Q5	32.00	6324.36	6325.93	6325.49	6326.08	0.073127	3.22	10.97	10.81	0.48
(ALT-A)	6400	Q10	47.00	6324.36	6326.24	6325.75	6326.43	0.072046	3.67	14.59	12.25	0.50
(ALT-A)	6400	Q100	121.00	6324.36	6327.29	6326.62	6327.61	0.071066	5.02	29.01	15.65	0.54
(ALT-A)	6350	Q5	32.00	6320.07	6321.66	6321.30	6321.87	0.097567	3.85	9.50	9.15	0.57
(ALT-A)	6350	Q10	47.00	6320.07	6321.98	6321.59	6322.23	0.098180	4.40	12.55	10.32	0.59
(ALT-A)	6350	Q100	121.00	6320.07	6323.04	6322.54	6323.47	0.096799	6.00	25.68	14.78	0.63
(ALT-A)	6300	Q5	32.00	6316.18	6317.99	6317.55	6318.10	0.058861	3.05	13.06	13.64	0.42
(ALT-A)	6300	Q10	47.00	6316.18	6318.28	6317.76	6318.42	0.059766	3.43	17.31	15.39	0.43
(ALT-A)	6300	Q100	121.00	6316.18	6319.18	6318.51	6319.42	0.067190	4.69	33.61	20.80	0.49
(ALT-A)	6262.33	Q5	32.00	6313.90	6315.63	6315.23	6315.75	0.065171	3.11	12.89	14.01	0.44
(ALT-A)	6262.33	Q10	47.00	6313.90	6315.92	6315.44	6316.06	0.064439	3.46	17.20	15.74	0.45
(ALT-A)	6262.33	Q100	121.00	6313.90	6317.00	6316.16	6317.18	0.051320	4.19	37.70	22.23	0.43
(ALT-A)	6250	Q5	32.00	6313.18	6314.98	6314.50	6315.07	0.048193	2.76	14.68	15.30	0.38
(ALT-A)	6250	Q10	47.00	6313.18	6315.31	6314.68	6315.41	0.044308	2.98	20.06	17.28	0.37
(ALT-A)	6250	Q100	121.00	6313.18	6316.60	6315.38	6316.71	0.028588	3.35	47.26	25.00	0.33
(ALT-A)	6246	Q5	32.00	6312.94	6314.83	6314.25	6314.90	0.034590	2.42	15.10	17.52	0.32
(ALT-A)	6246	Q10	47.00	6312.94	6315.16	6314.41	6315.25	0.035333	2.74	19.01	19.47	0.34
(ALT-A)	6246	Q100	121.00	6312.94	6316.38	6315.07	6316.58	0.035588	3.75	33.65	26.79	0.36
(ALT-A)	6201		Culvert									
(ALT-A)	6144	Q5	32.00	6307.81	6309.47	6309.12	6309.59	0.067356	3.06	12.26	16.09	0.44
(ALT-A)	6144	Q10	47.00	6307.81	6309.74	6309.30	6309.89	0.069160	3.46	15.46	17.69	0.46
(ALT-A)	6144	Q100	121.00	6307.81	6310.64	6309.96	6310.97	0.080442	4.91	26.31	23.12	0.53

HEC-RAS Plan: A >BF FINAL   River: (ALT-A)   Reach: (ALT-A) (Continued)

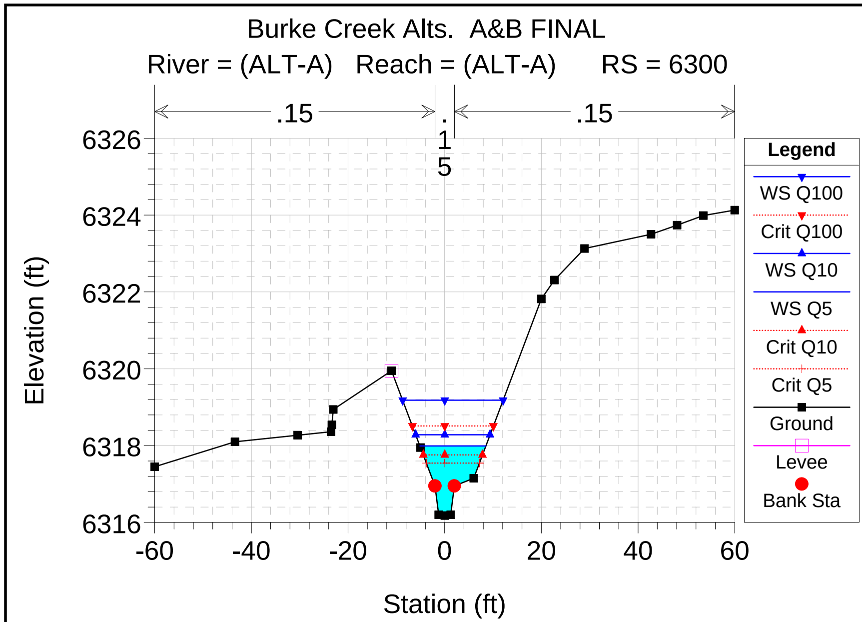
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-A)	6132.41	Q5	32.00	6307.03	6308.70	6308.35	6308.80	0.062831	2.97	13.79	16.15	0.43
(ALT-A)	6132.41	Q10	47.00	6307.03	6308.95	6308.54	6309.07	0.065584	3.35	17.92	17.62	0.45
(ALT-A)	6132.41	Q100	121.00	6307.03	6309.99	6309.16	6310.15	0.048355	3.93	39.65	23.91	0.41
(ALT-A)	6100	Q5	32.00	6304.95	6306.49	6306.29	6306.59	0.076490	3.08	15.92	31.26	0.46
(ALT-A)	6100	Q10	47.00	6304.95	6306.66	6306.47	6306.76	0.079033	3.38	21.57	36.41	0.48
(ALT-A)	6100	Q100	121.00	6304.95	6306.88	6306.88	6307.21	0.226764	6.25	30.17	43.09	0.83
(ALT-A)	6050	Q5	32.00	6301.70	6303.19	6302.98	6303.25	0.058459	2.63	20.38	46.59	0.40
(ALT-A)	6050	Q10	47.00	6301.70	6303.35	6303.12	6303.41	0.057050	2.79	28.42	56.02	0.40
(ALT-A)	6050	Q100	121.00	6301.70	6303.79	6303.47	6303.87	0.057928	3.36	57.92	75.18	0.43
(ALT-A)	6000	Q5	32.00	6298.45	6299.90	6299.73	6299.97	0.073477	2.88	18.48	44.10	0.45
(ALT-A)	6000	Q10	47.00	6298.45	6300.04	6299.87	6300.12	0.076352	3.15	25.20	52.49	0.46
(ALT-A)	6000	Q100	121.00	6298.45	6300.47	6300.21	6300.57	0.075401	3.73	52.56	72.36	0.48
(ALT-A)	5950	Q5	32.00	6295.95	6297.54	6297.28	6297.57	0.033504	2.09	25.43	53.03	0.31
(ALT-A)	5950	Q10	47.00	6295.95	6297.71	6297.38	6297.75	0.031806	2.19	35.35	60.84	0.31
(ALT-A)	5950	Q100	121.00	6295.95	6298.25	6297.70	6298.30	0.029715	2.58	76.59	90.72	0.31
(ALT-A)	5900	Q5	32.00	6294.20	6295.82	6295.48	6295.86	0.035009	2.17	22.25	37.09	0.32
(ALT-A)	5900	Q10	47.00	6294.20	6296.03	6295.60	6296.08	0.035042	2.37	30.80	45.58	0.32
(ALT-A)	5900	Q100	121.00	6294.20	6296.62	6296.02	6296.68	0.035058	2.90	66.17	71.32	0.34

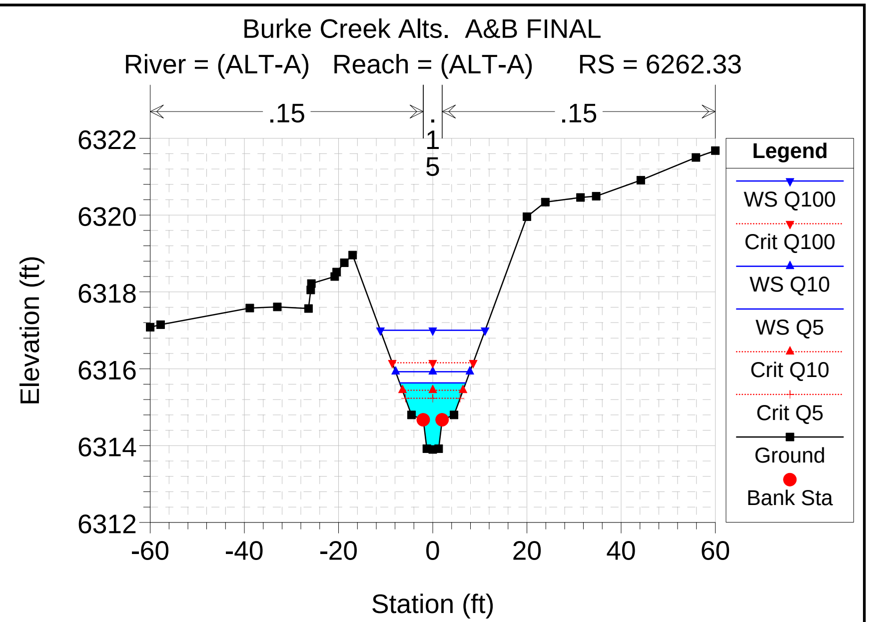
HEC-RAS Plan: A BF FINAL River: (ALT-A) Reach: (ALT-A) Profile: Q 2.2 cfs

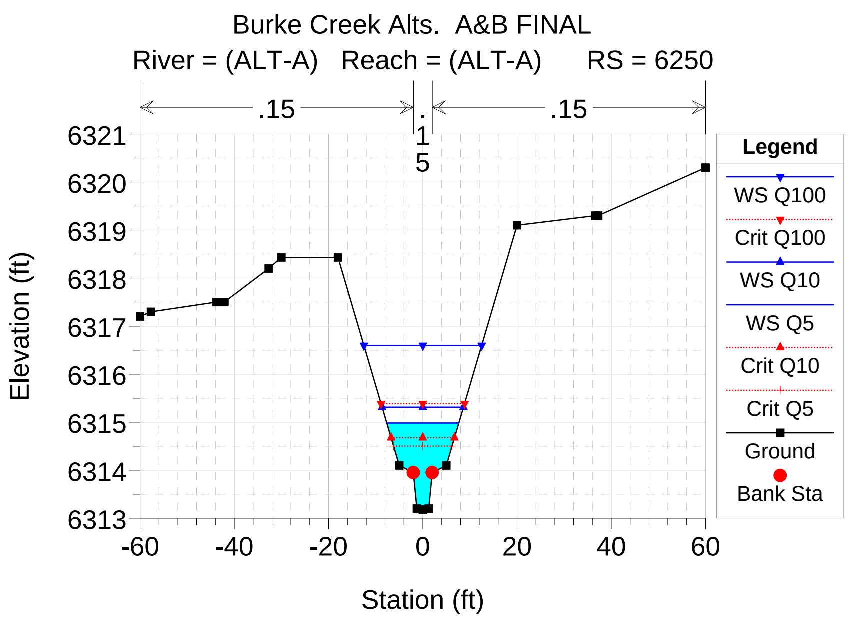
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-A)	6500	Q 2.2 cfs	2.20	6329.37	6330.21	6329.93	6330.23	0.067460	1.07	2.02	4.93	0.26
(ALT-A)	6450	Q 2.2 cfs	2.20	6326.71	6327.60	6327.19	6327.62	0.041432	0.95	2.41	5.02	0.21
(ALT-A)	6400	Q 2.2 cfs	2.20	6324.36	6324.89	6324.61	6324.90	0.074185	0.97	2.28	5.79	0.27
(ALT-A)	6350	Q 2.2 cfs	2.20	6320.07	6320.62	6320.39	6320.64	0.099669	1.12	1.97	5.26	0.31
(ALT-A)	6300	Q 2.2 cfs	2.20	6316.18	6316.87	6316.47	6316.89	0.058502	1.02	2.16	3.85	0.24
(ALT-A)	6262.33	Q 2.2 cfs	2.20	6313.90	6314.58	6314.19	6314.60	0.062271	1.04	2.12	3.82	0.25
(ALT-A)	6250	Q 2.2 cfs	2.20	6313.18	6313.89	6313.47	6313.91	0.053828	0.99	2.23	3.88	0.23
(ALT-A)	6246	Q 2.2 cfs	2.20	6312.94	6313.71	6313.23	6313.72	0.041147	0.90	2.45	3.99	0.20
(ALT-A)	6144	Q 2.2 cfs	2.20	6307.81	6308.49	6308.11	6308.51	0.065406	1.06	2.08	3.80	0.25
(ALT-A)	6132.41	Q 2.2 cfs	2.20	6307.03	6307.71	6307.32	6307.73	0.063866	1.05	2.10	3.81	0.25
(ALT-A)	6100	Q 2.2 cfs	2.20	6304.95	6305.63	6305.25	6305.64	0.066246	1.06	2.07	3.79	0.25
(ALT-A)	6050	Q 2.2 cfs	2.20	6301.70	6302.39	6302.00	6302.40	0.063124	1.05	2.10	3.81	0.25
(ALT-A)	6000	Q 2.2 cfs	2.20	6298.45	6299.12	6298.75	6299.14	0.067793	1.07	2.05	3.78	0.26
(ALT-A)	5950	Q 2.2 cfs	2.20	6295.95	6296.76	6296.25	6296.77	0.034784	0.85	2.60	5.55	0.19
(ALT-A)	5900	Q 2.2 cfs	2.20	6294.20	6295.00	6294.50	6295.02	0.035058	0.86	2.59	5.45	0.19

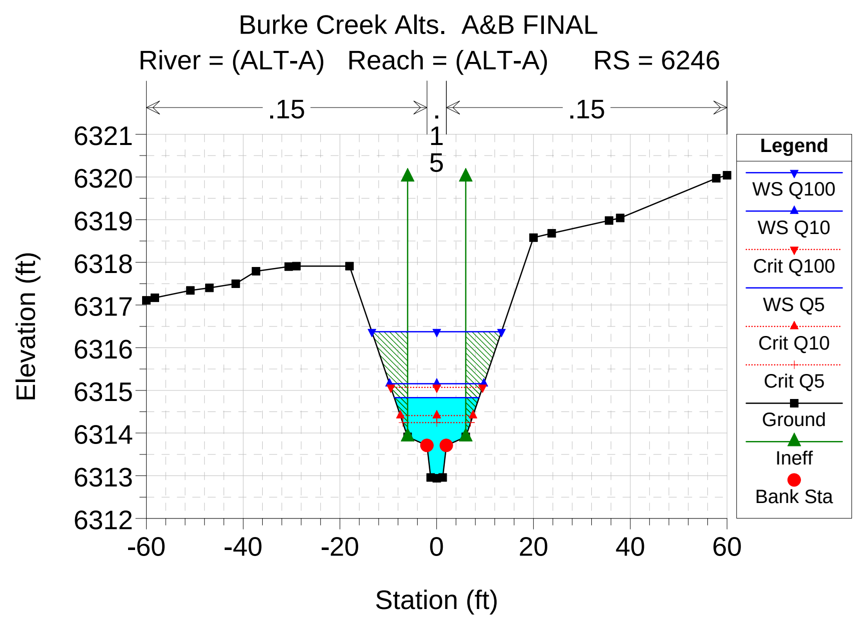


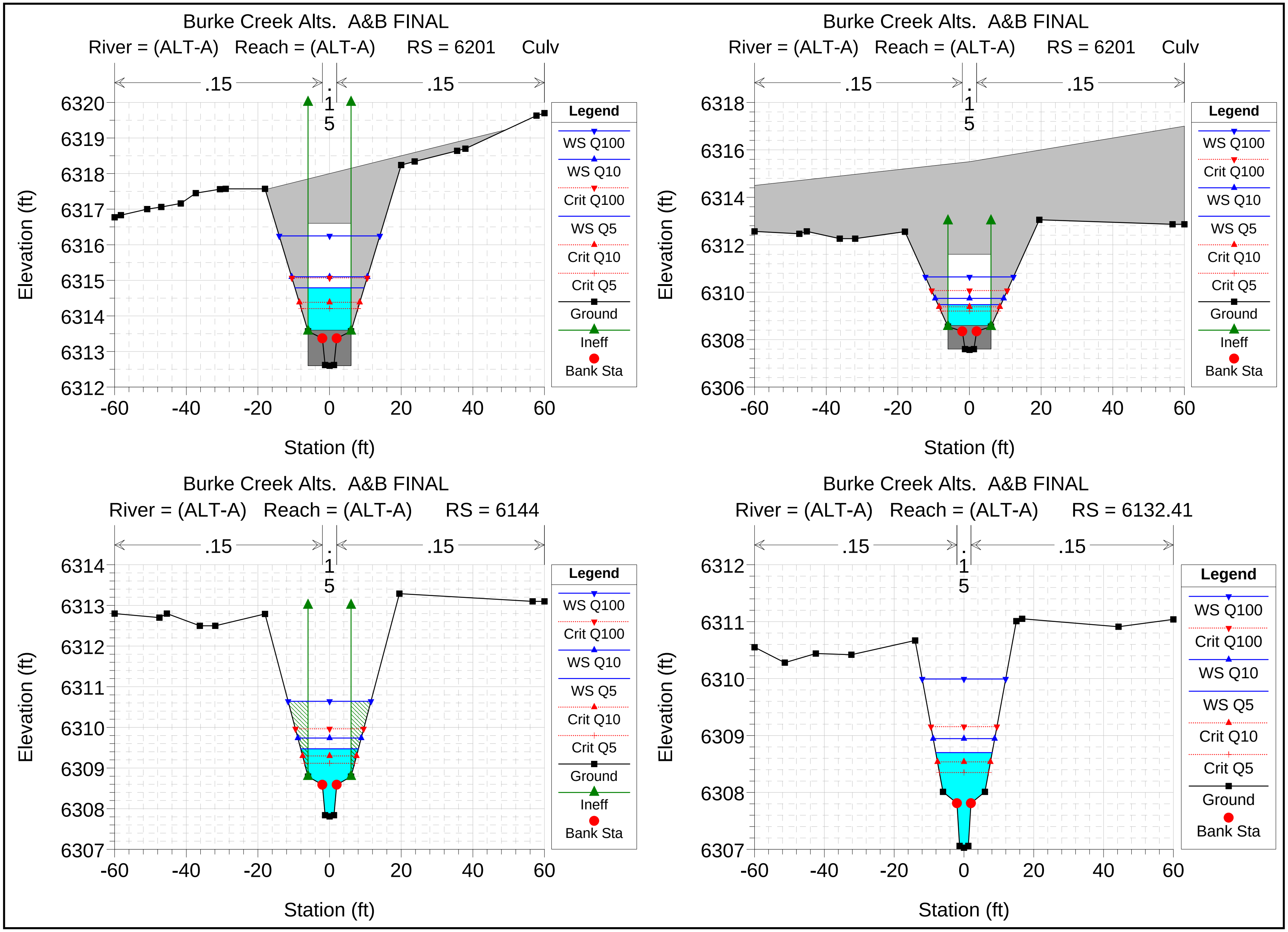
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6500
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6450
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6400
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6350

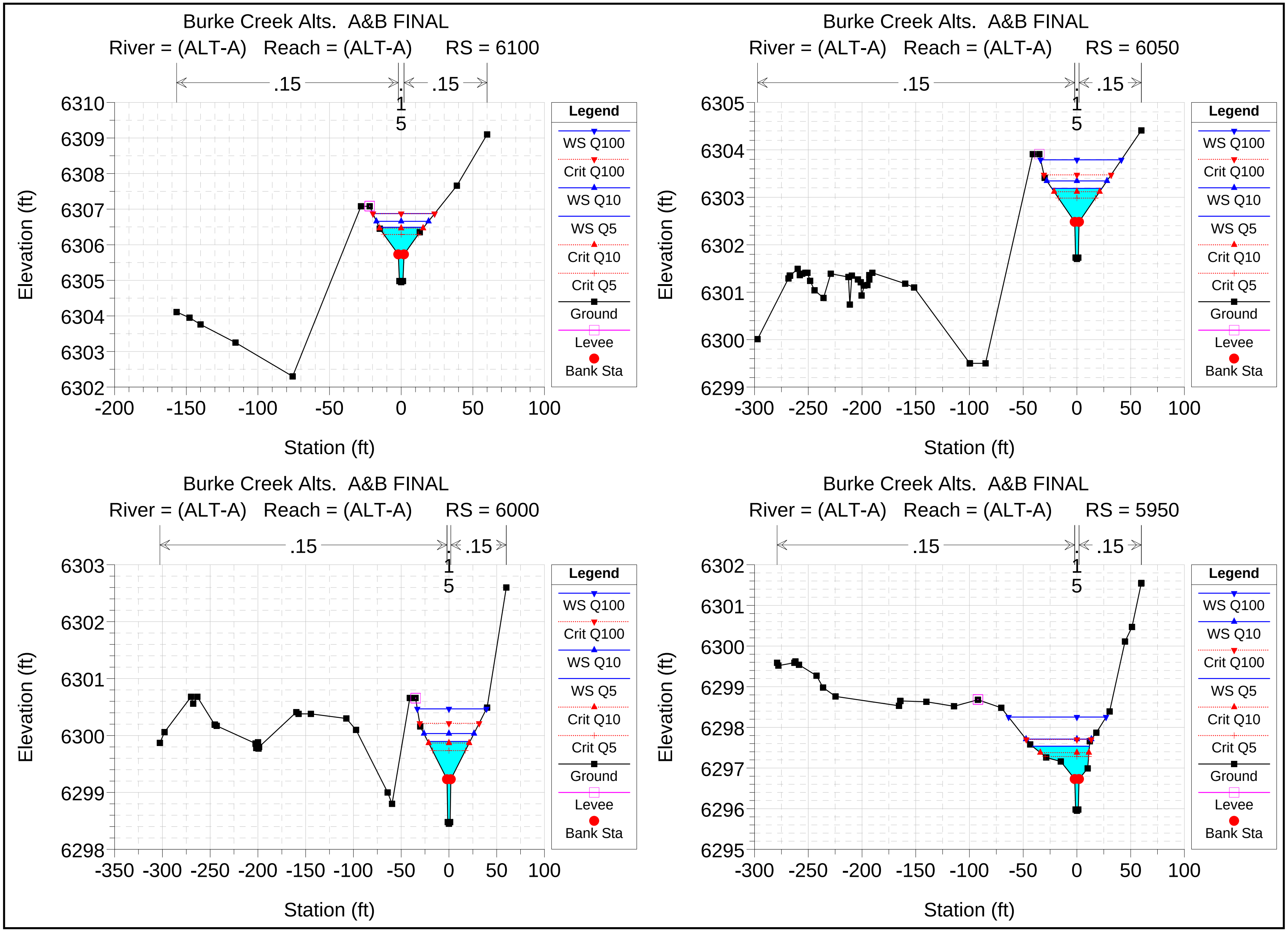

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6300
.15
.15
.15
Elevation (ft)
6326
6324
6322
6320
6318
6316
-60
-40
-20
0
20
40
60
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

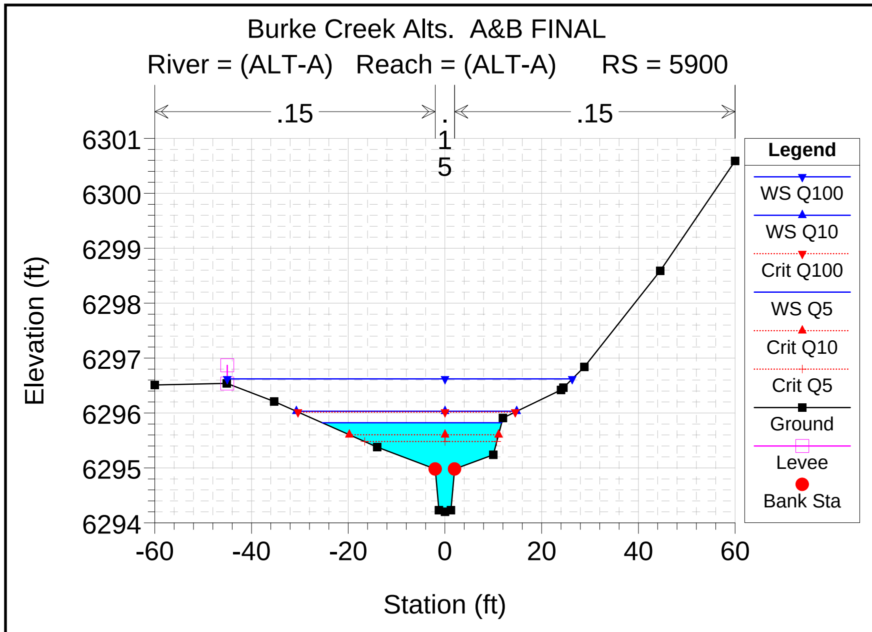

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6262.33
.15
.15
.15
Elevation (ft)
6322
6320
6318
6316
6314
6312
-60
-40
-20
0
20
40
60
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6250
.15
.15
.15
Elevation (ft)
6321
6320
6319
6318
6317
6316
6315
6314
6313
-60
-40
-20
0
20
40
60
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Bank Sta

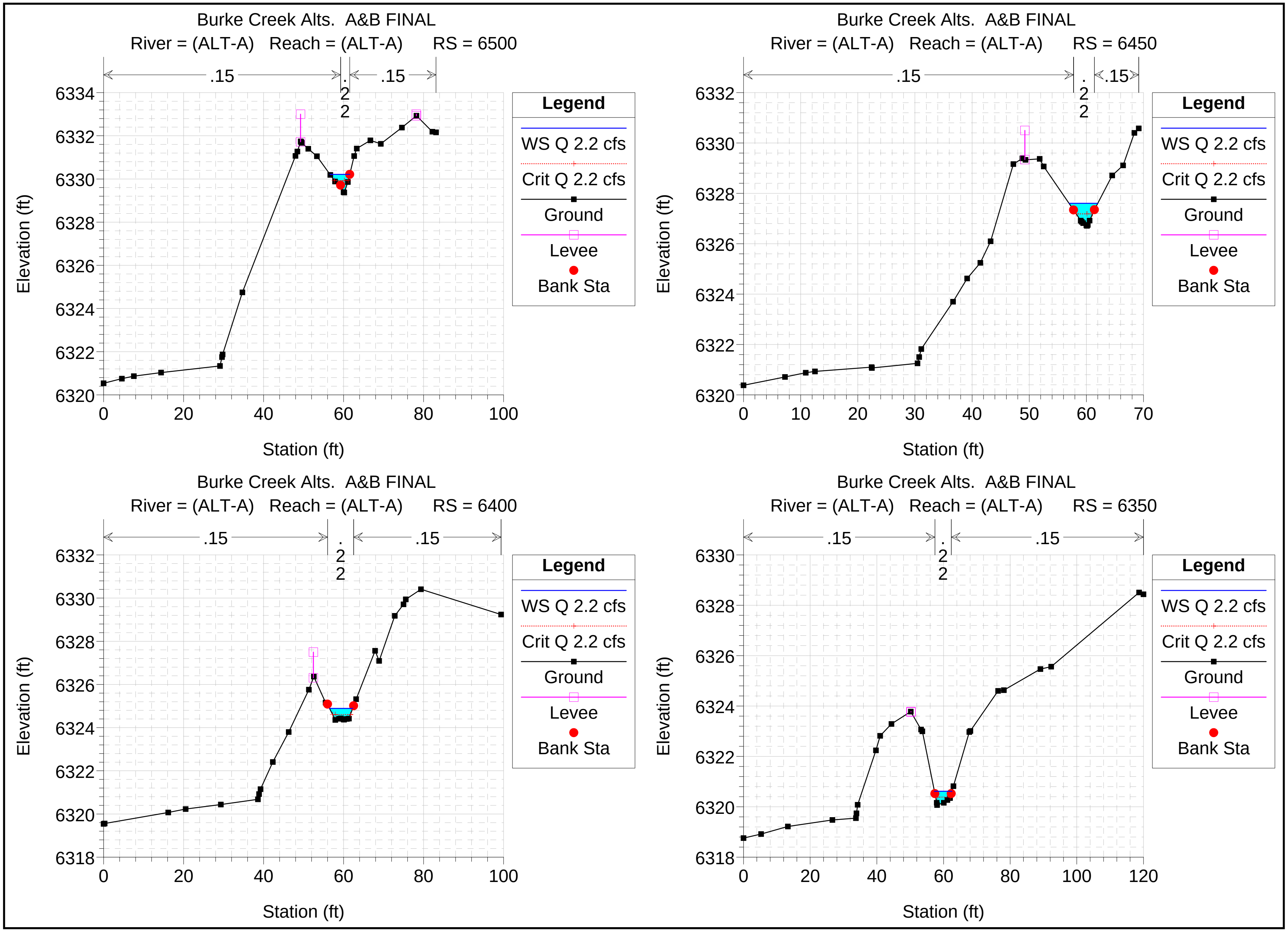

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6246
.15
.15
.15
Elevation (ft)
6321
6320
6319
6318
6317
6316
6315
6314
6313
6312
-60
-40
-20
0
20
40
60
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta

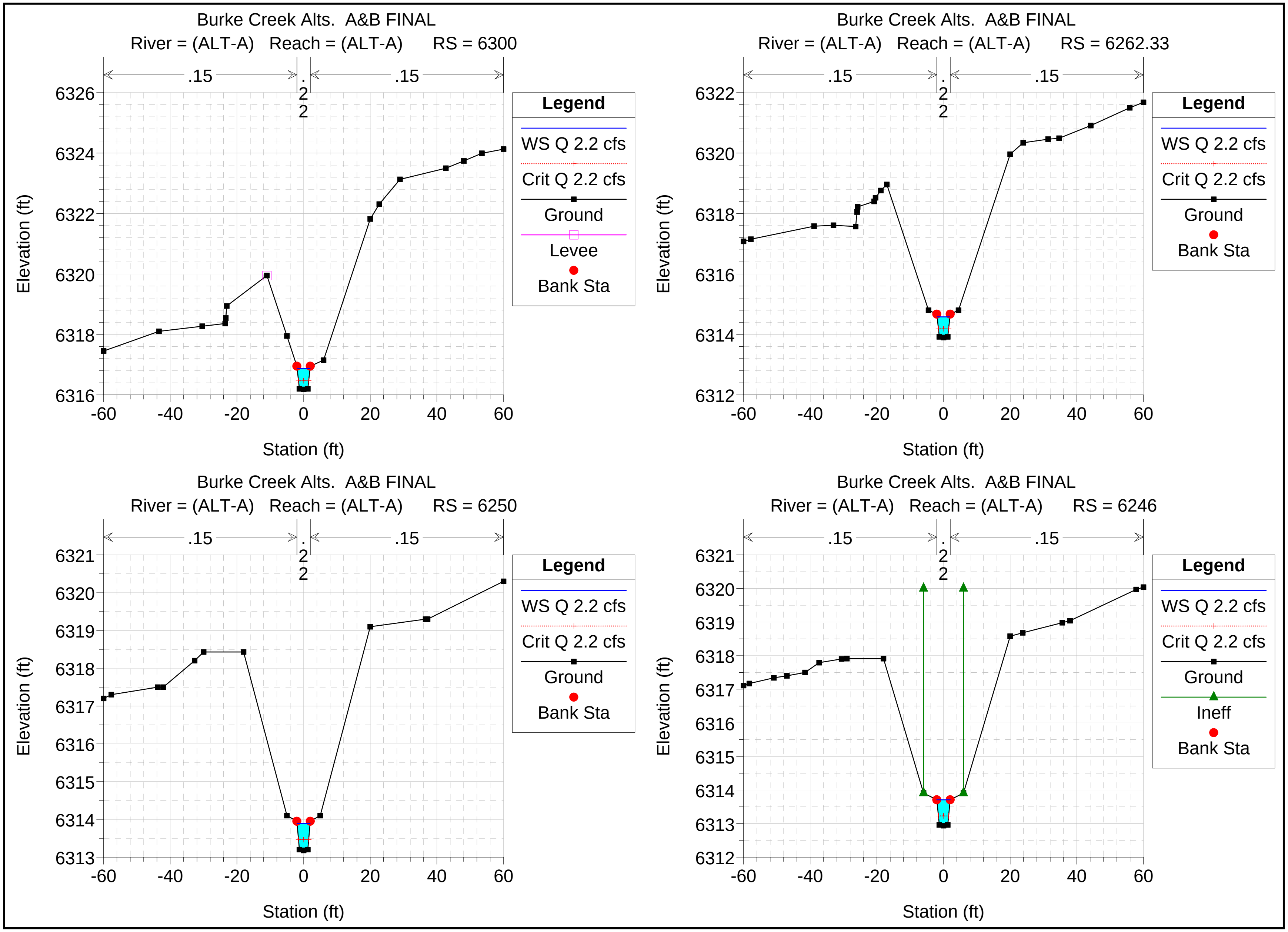

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6201 Culv
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6201 Culv
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6144
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6132.41
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Bank Sta

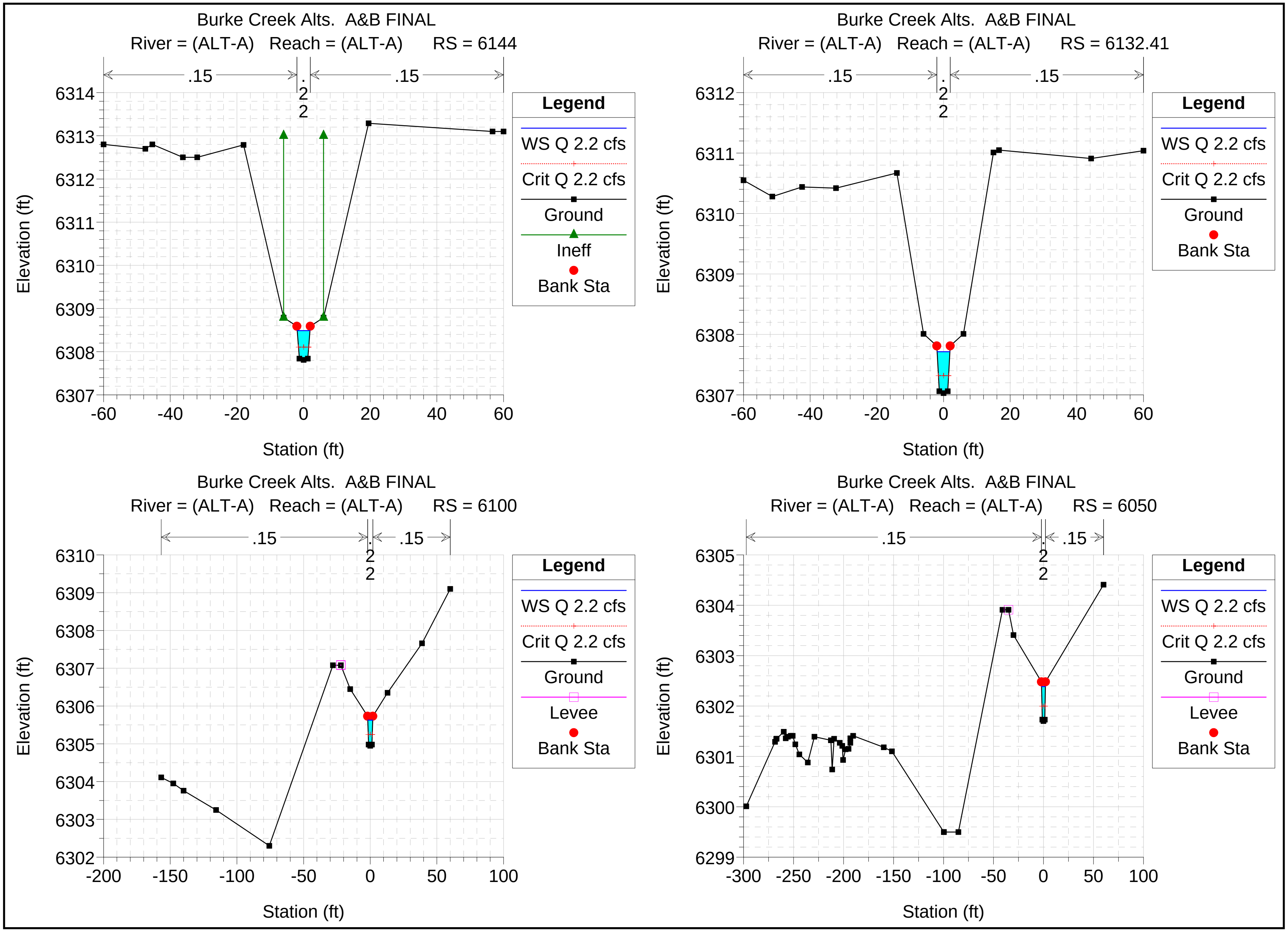

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6100
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6050
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6000
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 5950
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

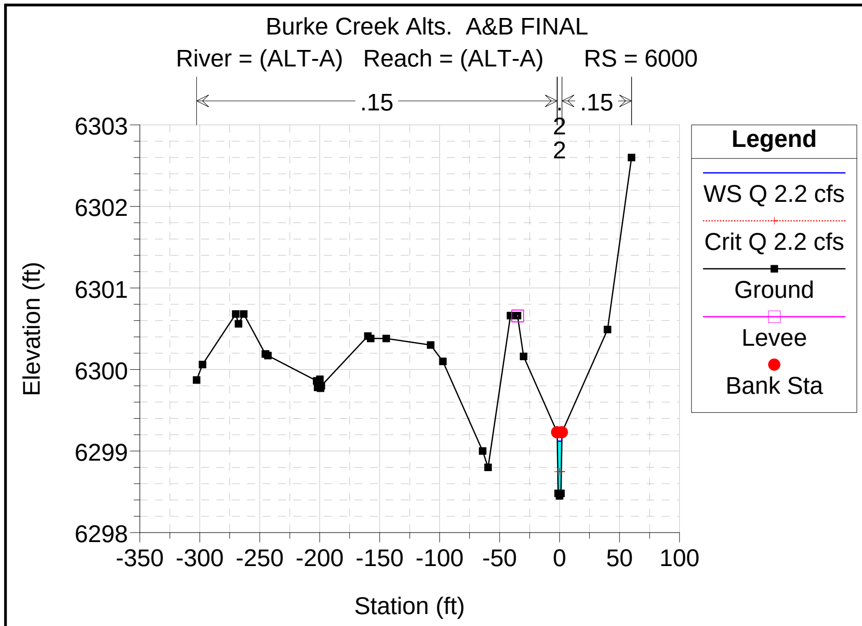


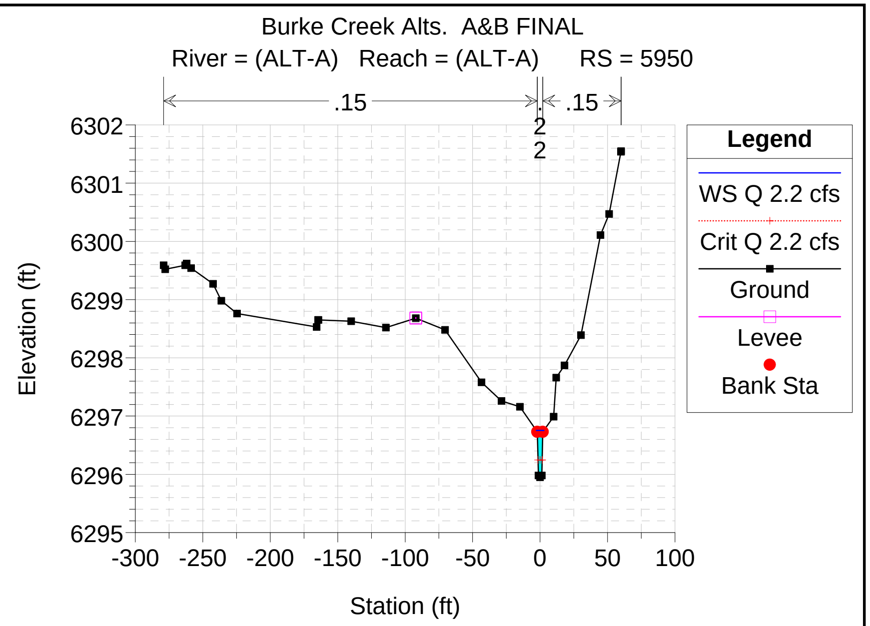
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 5900
.15
.15
.
1
5
Elevation (ft)
6301
6300
6299
6298
6297
6296
6295
6294
-60
-40
-20
0
20
40
60
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

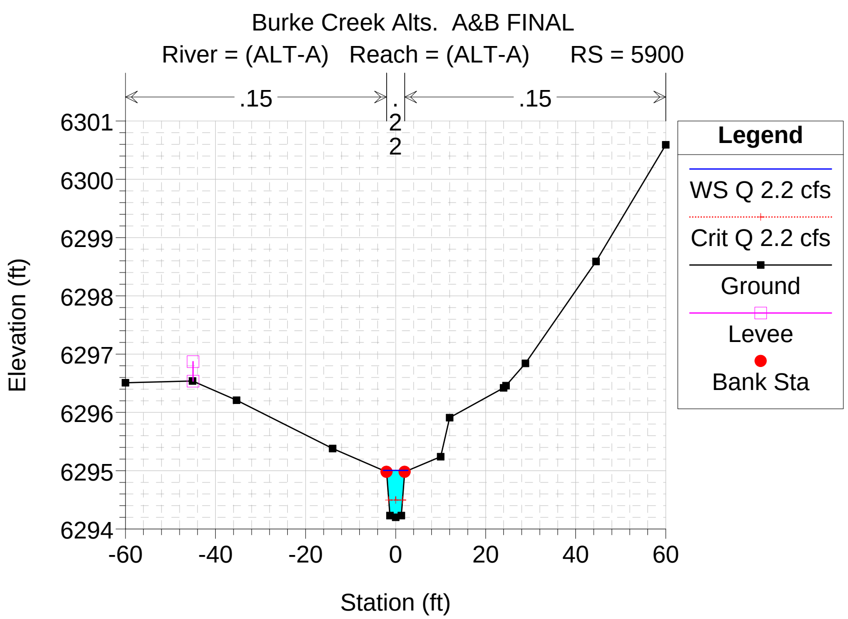

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6500
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6450
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6400
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6350
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta

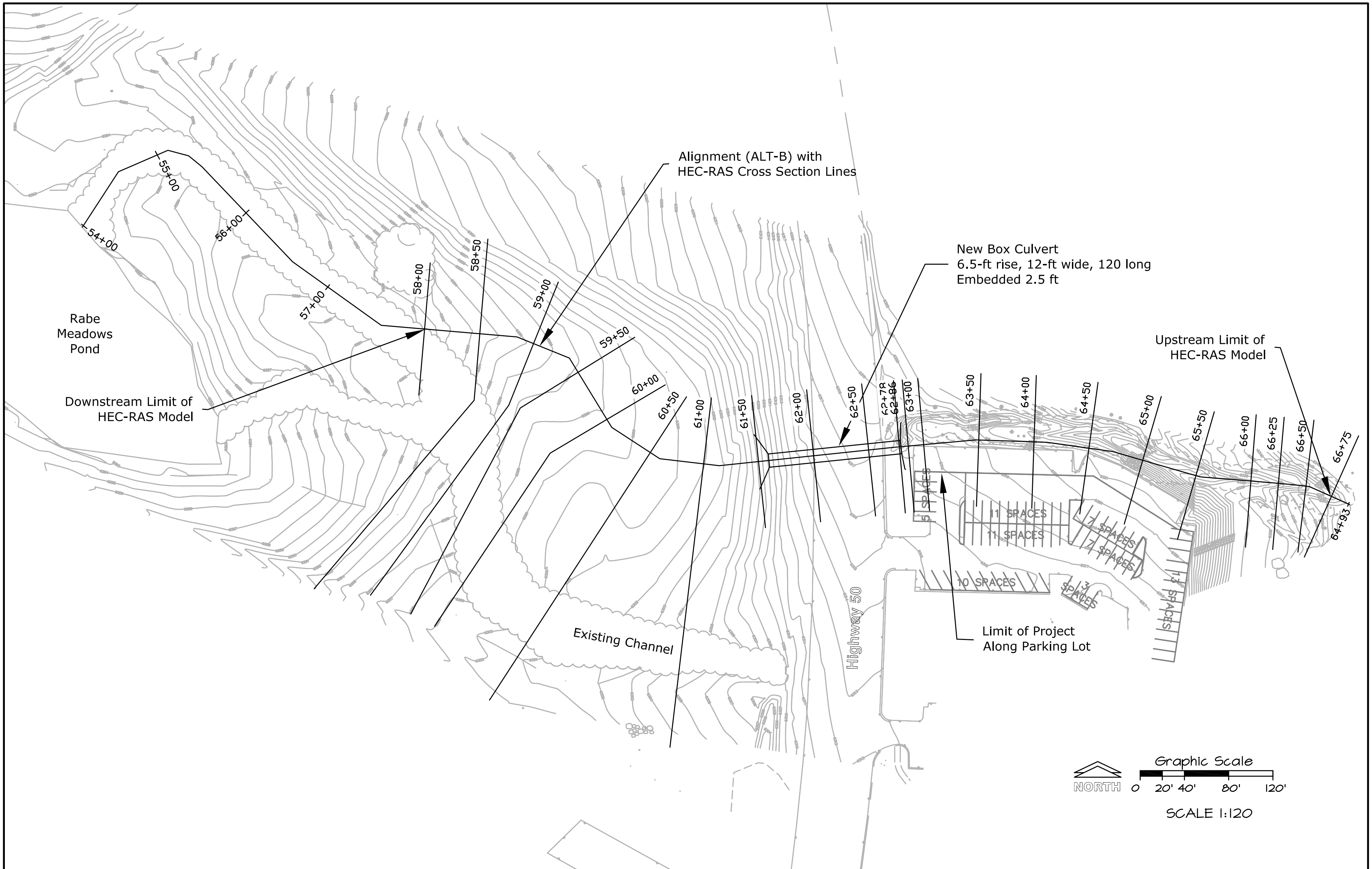

Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6300
.15
.2 2
.15
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Elevation (ft)
6326
6324
6322
6320
6318
6316
-60
-40
-20
0
20
40
60
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6262.33
.15
.2 2
.15
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Elevation (ft)
6322
6320
6318
6316
6314
6312
-60
-40
-20
0
20
40
60
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6250
.15
.2 2
.15
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Elevation (ft)
6321
6320
6319
6318
6317
6316
6315
6314
6313
-60
-40
-20
0
20
40
60
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6246
.15
.2 2
.15
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta
Elevation (ft)
6321
6320
6319
6318
6317
6316
6315
6314
6313
6312
-60
-40
-20
0
20
40
60
Station (ft)


Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6144
.15
.022
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6132.41
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6100
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6050
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 6000
.15
.022
.15
Elevation (ft)
Station (ft)
6303
6302
6301
6300
6299
6298
-350 -300 -250 -200 -150 -100 -50 0 50 100
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 5950
.15
.022
.15
Elevation (ft)
Station (ft)
6302
6301
6300
6299
6298
6297
6296
6295
-300 -250 -200 -150 -100 -50 0 50 100
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-A) Reach = (ALT-A) RS = 5900
.15
.022
.15
Elevation (ft)
Station (ft)
6301
6300
6299
6298
6297
6296
6295
6294
-60 -40 -20 0 20 40 60
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta



Alternative B

HEC-RAS Alignment and Cross Sections

HEC-RAS Plan: B > BF FINAL River: (ALT-B) Reach: (ALT-B)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-B)	6675	Q5	32.00	6341.51	6343.18	6342.69	6343.30	0.081271	2.78	11.50	11.17	0.48
(ALT-B)	6675	Q10	47.00	6341.51	6343.47	6342.93	6343.62	0.088005	3.16	14.89	12.70	0.51
(ALT-B)	6675	Q100	121.00	6341.51	6343.75	6343.75	6344.40	0.316356	6.46	18.74	14.24	0.99
(ALT-B)	6650	Q5	32.00	6339.49	6340.72	6340.42	6340.89	0.116541	3.27	9.94	11.34	0.58
(ALT-B)	6650	Q10	47.00	6339.49	6341.00	6340.63	6341.20	0.106249	3.69	13.27	12.67	0.58
(ALT-B)	6650	Q100	121.00	6339.49	6341.90	6341.44	6342.27	0.096957	5.05	26.73	17.02	0.61
(ALT-B)	6625	Q5	32.00	6336.58	6338.40	6337.95	6338.57	0.075670	3.41	10.80	11.03	0.50
(ALT-B)	6625	Q10	47.00	6336.58	6338.69	6338.24	6338.90	0.081214	3.98	14.30	13.76	0.53
(ALT-B)	6625	Q100	121.00	6336.58	6339.52	6339.16	6339.88	0.094278	5.55	27.75	17.53	0.61
(ALT-B)	6600	Q5	32.00	6334.43	6336.20	6335.76	6336.38	0.102560	3.43	10.54	18.37	0.54
(ALT-B)	6600	Q10	47.00	6334.43	6336.43	6336.22	6336.63	0.102013	3.82	14.89	19.74	0.55
(ALT-B)	6600	Q100	121.00	6334.43	6337.16	6336.85	6337.45	0.098892	4.90	30.91	24.12	0.58
(ALT-B)	6550	Q5	32.00	6329.95	6331.45	6331.27	6331.56	0.090261	3.29	13.14	19.43	0.50
(ALT-B)	6550	Q10	47.00	6329.95	6331.64	6331.41	6331.78	0.091802	3.63	17.07	20.07	0.52
(ALT-B)	6550	Q100	121.00	6329.95	6332.35	6331.91	6332.59	0.094683	4.75	32.31	23.08	0.56
(ALT-B)	6500	Q5	32.00	6325.70	6327.24	6327.02	6327.35	0.079041	3.14	13.42	18.38	0.47
(ALT-B)	6500	Q10	47.00	6325.70	6327.47	6327.16	6327.60	0.076872	3.44	17.82	19.76	0.48
(ALT-B)	6500	Q100	121.00	6325.70	6328.27	6327.71	6328.47	0.072187	4.35	35.53	24.56	0.49
(ALT-B)	6450	Q5	32.00	6321.82	6323.37	6323.14	6323.48	0.076096	3.10	13.60	18.46	0.46
(ALT-B)	6450	Q10	47.00	6321.82	6323.59	6323.29	6323.71	0.078713	3.47	17.67	19.74	0.48
(ALT-B)	6450	Q100	121.00	6321.82	6324.30	6323.83	6324.53	0.086140	4.64	33.37	24.05	0.54
(ALT-B)	6400	Q5	32.00	6318.07	6319.63	6319.37	6319.73	0.073755	3.07	13.76	18.50	0.46
(ALT-B)	6400	Q10	47.00	6318.07	6319.87	6319.54	6319.99	0.070459	3.33	18.37	19.94	0.46
(ALT-B)	6400	Q100	121.00	6318.07	6320.73	6320.08	6320.90	0.061107	4.10	37.69	25.08	0.46
(ALT-B)	6350	Q5	32.00	6314.69	6316.32	6316.00	6316.41	0.060143	2.86	14.58	18.08	0.41
(ALT-B)	6350	Q10	47.00	6314.69	6316.55	6316.15	6316.66	0.063221	3.23	18.83	19.44	0.44
(ALT-B)	6350	Q100	121.00	6314.69	6317.27	6316.74	6317.48	0.076863	4.50	34.39	23.77	0.51
(ALT-B)	6300	Q5	32.00	6311.44	6313.03	6312.76	6313.13	0.071470	3.06	13.60	17.40	0.45
(ALT-B)	6300	Q10	47.00	6311.44	6313.28	6312.91	6313.40	0.067495	3.31	18.27	18.94	0.45

HEC-RAS Plan: B > BF FINAL   River: (ALT-B)   Reach: (ALT-B) (Continued)

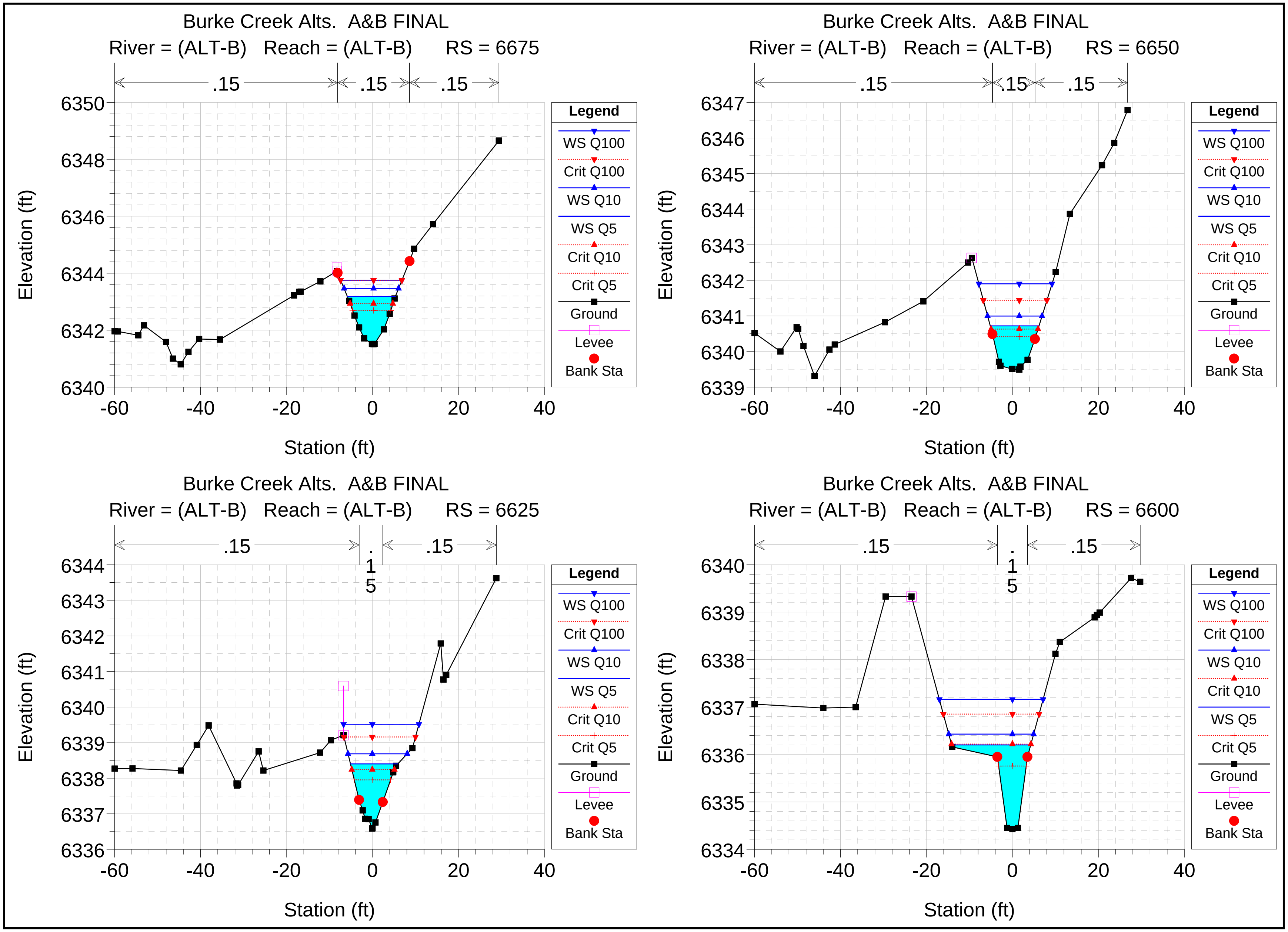
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-B)	6300	Q100	121.00	6311.44	6314.28	6313.49	6314.44	0.048982	3.85	40.22	24.94	0.41
(ALT-B)	6286	Q5	32.00	6310.53	6312.30	6311.83	6312.37	0.042420	2.55	16.14	17.60	0.35
(ALT-B)	6286	Q10	47.00	6310.53	6312.62	6312.02	6312.70	0.037830	2.72	22.14	19.54	0.34
(ALT-B)	6286	Q100	121.00	6310.53	6313.84	6312.61	6313.94	0.025444	3.09	50.52	26.88	0.31
(ALT-B)	6278	Q5	32.00	6310.01	6312.06	6311.32	6312.11	0.023629	2.12	16.99	18.46	0.27
(ALT-B)	6278	Q10	47.00	6310.01	6312.36	6311.48	6312.45	0.026917	2.50	20.66	20.30	0.30
(ALT-B)	6278	Q100	121.00	6310.01	6313.50	6312.16	6313.70	0.033207	3.66	34.36	27.15	0.35
(ALT-B)	6200		Culvert									
(ALT-B)	6150	Q5	32.00	6302.67	6304.24	6303.99	6304.38	0.092107	3.42	11.09	15.52	0.51
(ALT-B)	6150	Q10	47.00	6302.67	6304.49	6304.16	6304.67	0.092073	3.82	14.15	17.05	0.52
(ALT-B)	6150	Q100	121.00	6302.67	6305.32	6304.82	6305.71	0.107683	5.42	24.08	22.02	0.61
(ALT-B)	6100	Q5	32.00	6300.14	6301.48	6301.28	6301.50	0.038107	1.96	29.56	81.26	0.32
(ALT-B)	6100	Q10	47.00	6300.14	6301.57	6301.36	6301.61	0.041936	2.17	37.95	88.88	0.34
(ALT-B)	6100	Q100	121.00	6300.14	6301.89	6301.60	6301.95	0.051389	2.79	69.47	107.74	0.39
(ALT-B)	6050	Q5	32.00	6298.19	6299.73	6299.50	6299.76	0.031764	1.99	29.44	73.19	0.30
(ALT-B)	6050	Q10	47.00	6298.19	6299.89	6299.58	6299.92	0.027866	2.01	42.63	89.98	0.28
(ALT-B)	6050	Q100	121.00	6298.19	6300.40	6299.87	6300.43	0.019849	2.05	99.38	128.63	0.25
(ALT-B)	6000	Q5	32.00	6296.56	6298.32	6297.90	6298.35	0.025323	1.96	25.47	40.47	0.27
(ALT-B)	6000	Q10	47.00	6296.56	6298.51	6298.04	6298.55	0.026883	2.17	33.20	44.62	0.29
(ALT-B)	6000	Q100	121.00	6296.56	6299.11	6298.44	6299.17	0.032944	2.92	68.41	75.33	0.33
(ALT-B)	5950	Q5	32.00	6294.94	6296.54	6296.28	6296.60	0.050374	2.58	19.58	37.23	0.38
(ALT-B)	5950	Q10	47.00	6294.94	6296.72	6296.43	6296.79	0.047456	2.71	26.75	40.66	0.37
(ALT-B)	5950	Q100	121.00	6294.94	6297.39	6296.79	6297.46	0.035620	2.96	71.20	98.96	0.34
(ALT-B)	5900	Q5	32.00	6293.37	6295.22	6294.71	6295.24	0.016704	1.65	29.40	41.06	0.22
(ALT-B)	5900	Q10	47.00	6293.37	6295.43	6294.86	6295.45	0.016681	1.78	38.12	42.31	0.23
(ALT-B)	5900	Q100	121.00	6293.37	6296.22	6295.25	6296.27	0.016791	2.26	76.82	59.26	0.24
(ALT-B)	5850	Q5	32.00	6292.12	6293.66	6293.45	6293.74	0.067553	2.90	17.28	34.67	0.43
(ALT-B)	5850	Q10	47.00	6292.12	6293.83	6293.61	6293.92	0.071493	3.23	24.59	49.81	0.46

HEC-RAS Plan: B > BF FINAL   River: (ALT-B)   Reach: (ALT-B) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-B)	5850	Q100	121.00	6292.12	6294.06	6294.06	6294.29	0.165518	5.39	38.13	64.36	0.71
(ALT-B)	5800	Q5	32.00	6291.20	6292.01	6291.59	6292.03	0.020014	1.16	35.79	78.24	0.24
(ALT-B)	5800	Q10	47.00	6291.20	6292.15	6291.68	6292.17	0.019994	1.30	47.66	89.29	0.24
(ALT-B)	5800	Q100	121.00	6291.20	6292.60	6292.00	6292.63	0.020000	1.71	92.76	109.37	0.26

HEC-RAS Plan: B BF FINAL River: (ALT-B) Reach: (ALT-B) Profile: Q 2.2 cfs

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
(ALT-B)	6675	Q 2.2 cfs	2.20	6341.51	6342.12	6341.85	6342.14	0.073204	0.95	2.32	6.07	0.27
(ALT-B)	6650	Q 2.2 cfs	2.20	6339.49	6339.90	6339.73	6339.91	0.110652	0.99	2.21	7.41	0.32
(ALT-B)	6625	Q 2.2 cfs	2.20	6336.58	6337.30	6337.03	6337.32	0.097829	1.09	2.01	5.17	0.31
(ALT-B)	6600	Q 2.2 cfs	2.20	6334.43	6335.03	6334.71	6335.05	0.084076	1.12	1.97	4.23	0.29
(ALT-B)	6550	Q 2.2 cfs	2.20	6329.95	6330.55	6330.24	6330.58	0.095141	1.20	1.83	3.67	0.30
(ALT-B)	6500	Q 2.2 cfs	2.20	6325.70	6326.35	6325.99	6326.37	0.075193	1.11	1.98	3.75	0.27
(ALT-B)	6450	Q 2.2 cfs	2.20	6321.82	6322.45	6322.11	6322.47	0.080828	1.14	1.93	3.73	0.28
(ALT-B)	6400	Q 2.2 cfs	2.20	6318.07	6318.73	6318.36	6318.75	0.069145	1.08	2.04	3.78	0.26
(ALT-B)	6350	Q 2.2 cfs	2.20	6314.69	6315.36	6314.98	6315.38	0.065846	1.06	2.08	3.80	0.25
(ALT-B)	6300	Q 2.2 cfs	2.20	6311.44	6312.12	6311.73	6312.13	0.064027	1.05	2.10	3.81	0.25
(ALT-B)	6286	Q 2.2 cfs	2.20	6310.53	6311.20	6310.82	6311.22	0.067038	1.07	2.06	3.79	0.25
(ALT-B)	6278	Q 2.2 cfs	2.20	6310.01	6310.72	6310.30	6310.73	0.054353	0.99	2.22	3.88	0.23
(ALT-B)	6150	Q 2.2 cfs	2.20	6302.67	6303.36	6302.96	6303.38	0.060734	1.03	2.13	3.83	0.24
(ALT-B)	6100	Q 2.2 cfs	2.20	6300.14	6300.91	6300.43	6300.92	0.040504	0.89	2.46	4.00	0.20
(ALT-B)	6050	Q 2.2 cfs	2.20	6298.19	6298.98	6298.48	6298.99	0.036667	0.87	2.54	4.74	0.19
(ALT-B)	6000	Q 2.2 cfs	2.20	6296.56	6297.41	6296.86	6297.42	0.026964	0.79	2.87	6.93	0.17
(ALT-B)	5950	Q 2.2 cfs	2.20	6294.94	6295.69	6295.23	6295.70	0.045393	0.93	2.37	3.95	0.21
(ALT-B)	5900	Q 2.2 cfs	2.20	6293.37	6294.28	6293.66	6294.29	0.019118	0.70	3.39	9.49	0.14
(ALT-B)	5850	Q 2.2 cfs	2.20	6292.12	6292.87	6292.41	6292.88	0.045079	0.93	2.37	3.95	0.21
(ALT-B)	5800	Q 2.2 cfs	2.20	6291.20	6291.43	6291.28	6291.43	0.020015	0.29	5.58	30.66	0.13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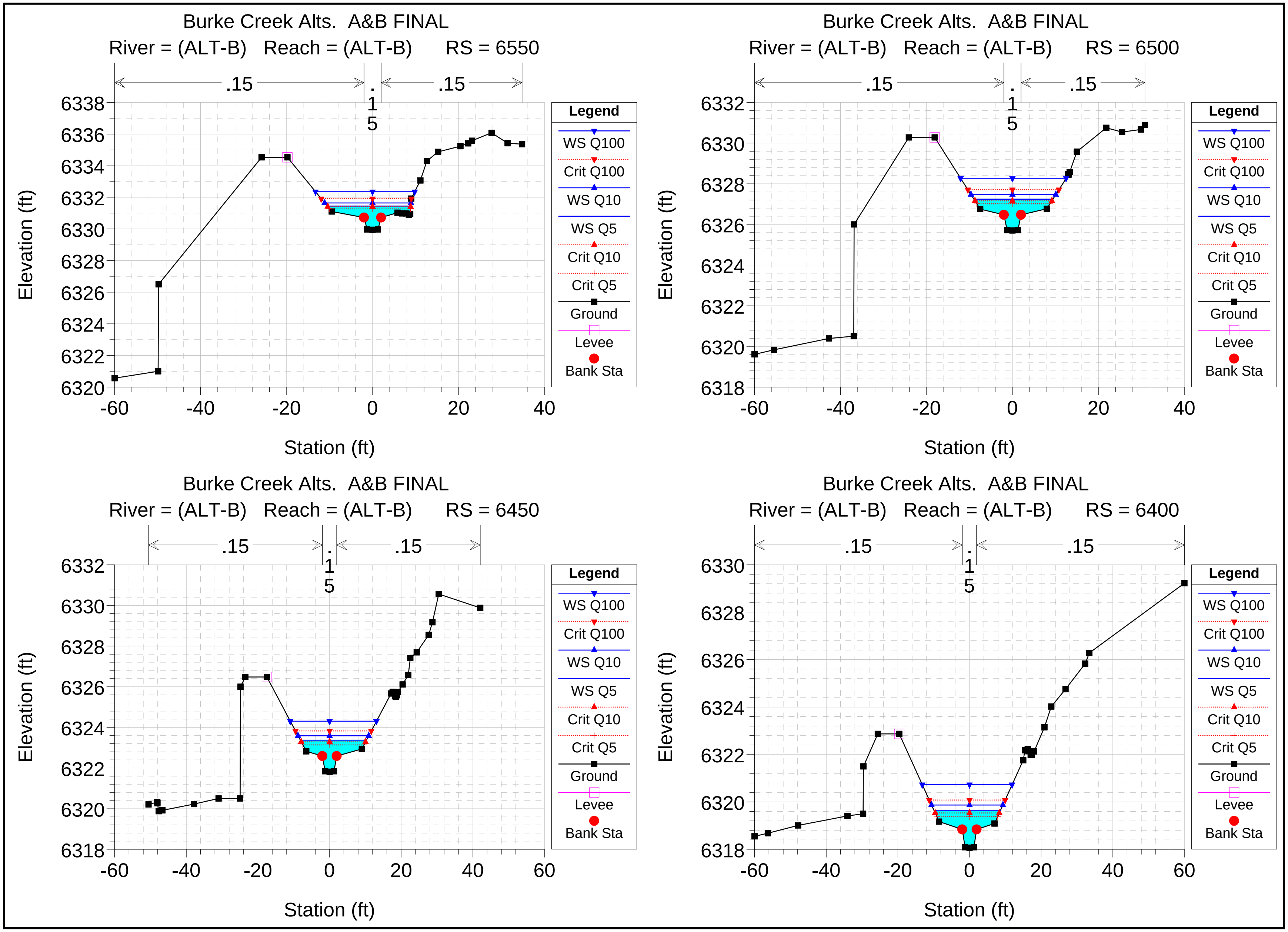
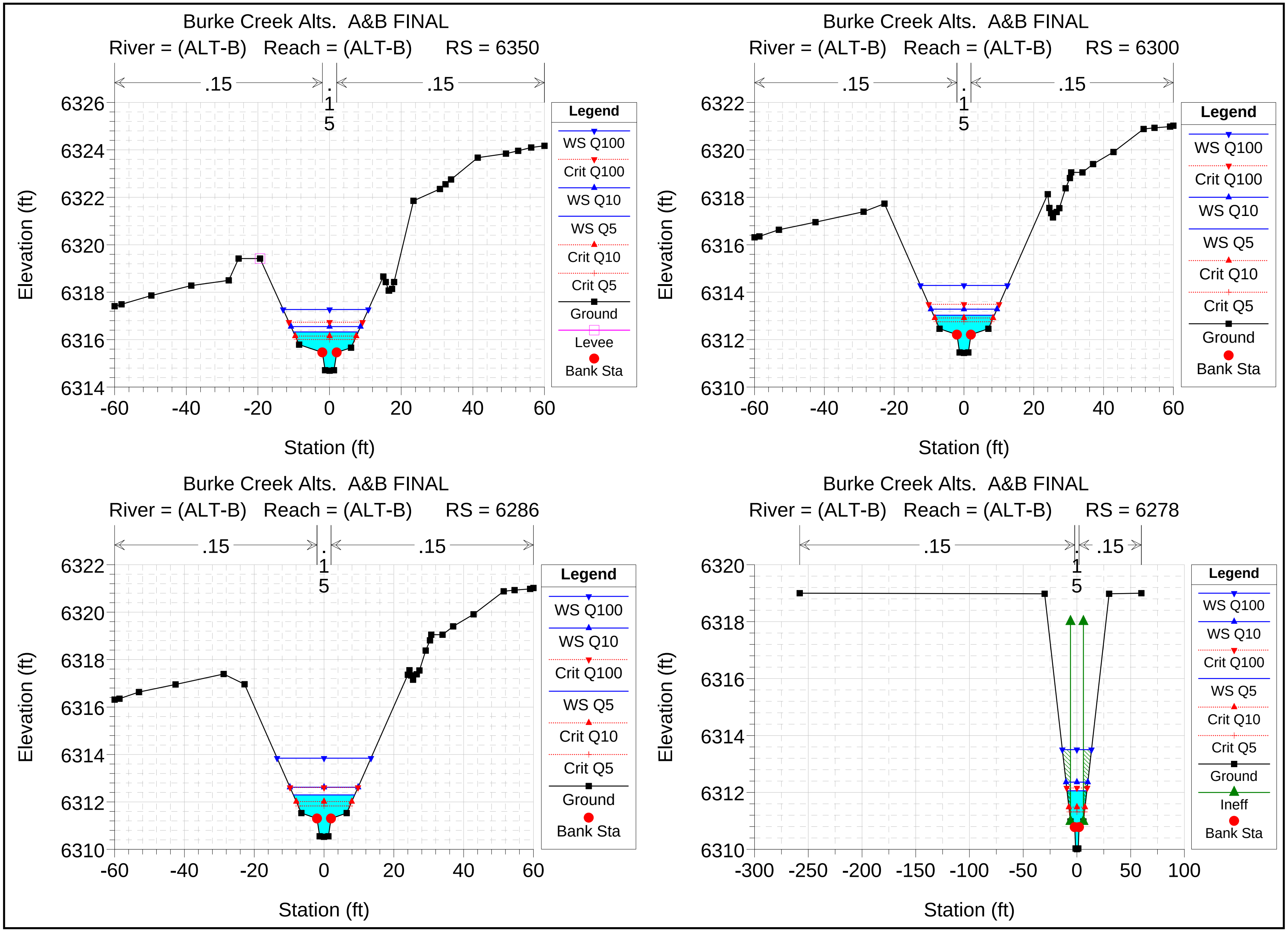
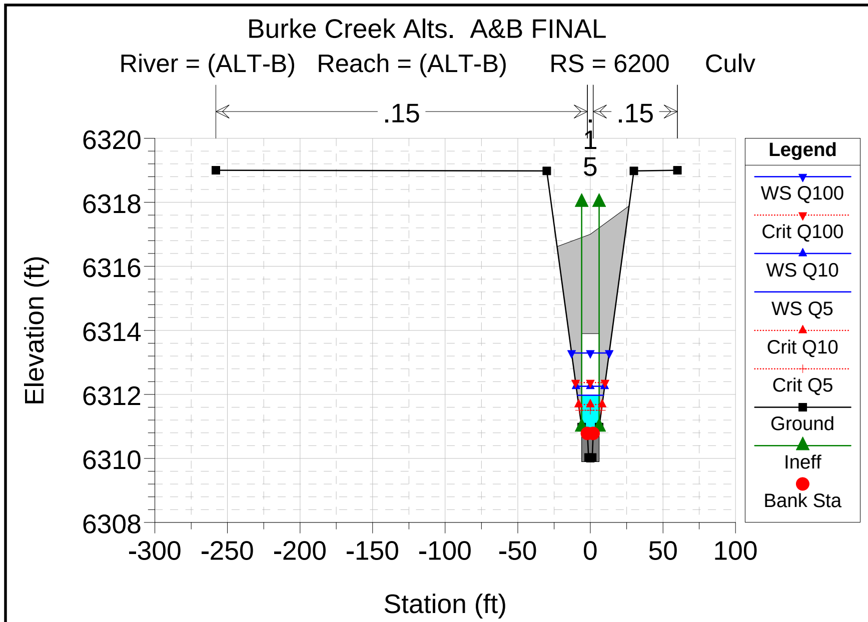
River = (ALT-B) Reach = (ALT-B) RS = 6675
.15 .15 .15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6650
.15 .15 .15
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6625
.15 .15 .15
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6600
.15 .15 .15
Elevation (ft)
Station (ft)



Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6550
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6500
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6450
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6400



Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6350
.15
.15
.15
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6300
.15
.15
.15
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6286
.15
.15
.15
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6278
.15
.15
.15
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6200 Culv
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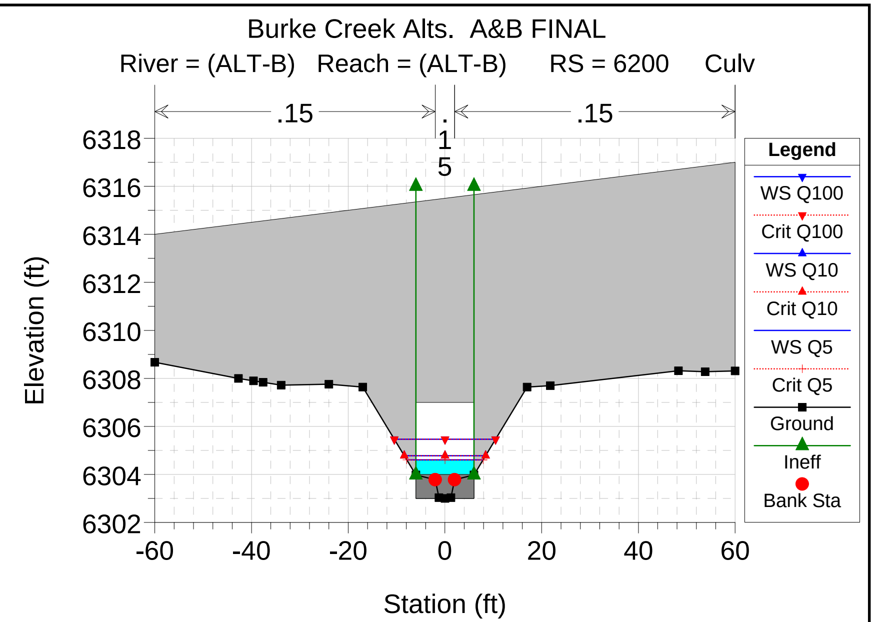
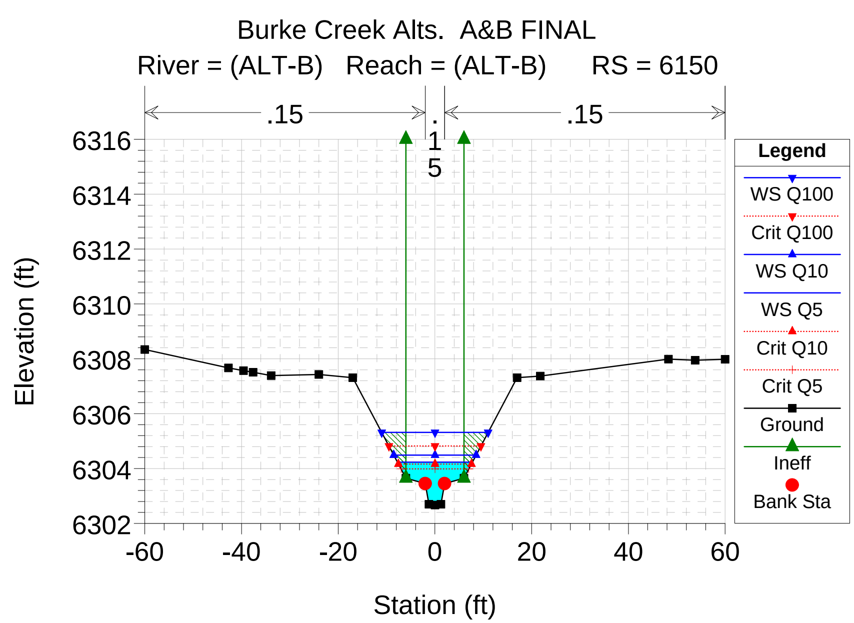
.15
.15
Elevation (ft)
Station (ft)
6320
6318
6316
6314
6312
6310
6308
-300
-250
-200
-150
-100
-50
0
50
100
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6200 Culv
.15
.15
.15
Elevation (ft)
Station (ft)
6318
6316
6314
6312
6310
6308
6306
6304
6302
-60
-40
-20
0
20
40
60
Legend
WS Q100
Crit Q100
WS Q10
Crit Q10
WS Q5
Crit Q5
Ground
Ineff
Bank Sta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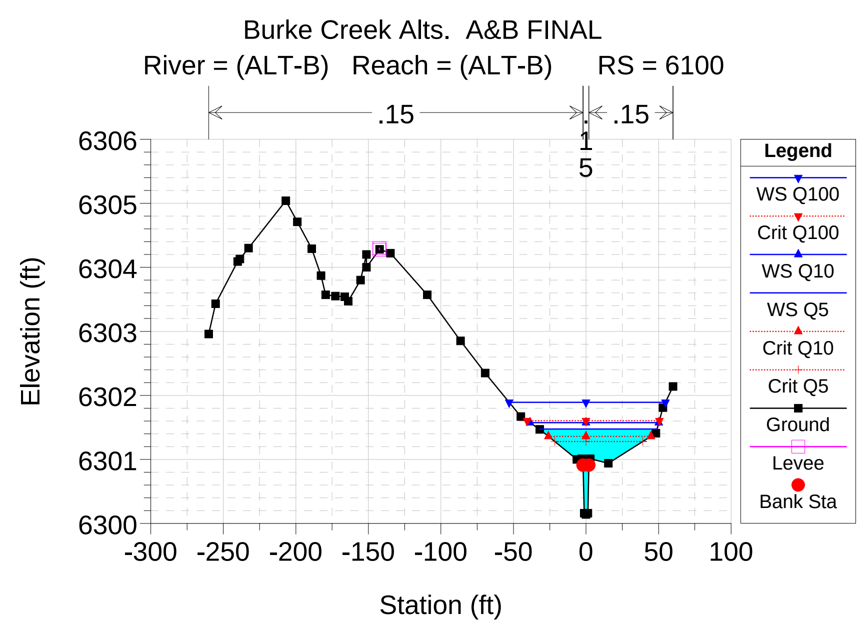
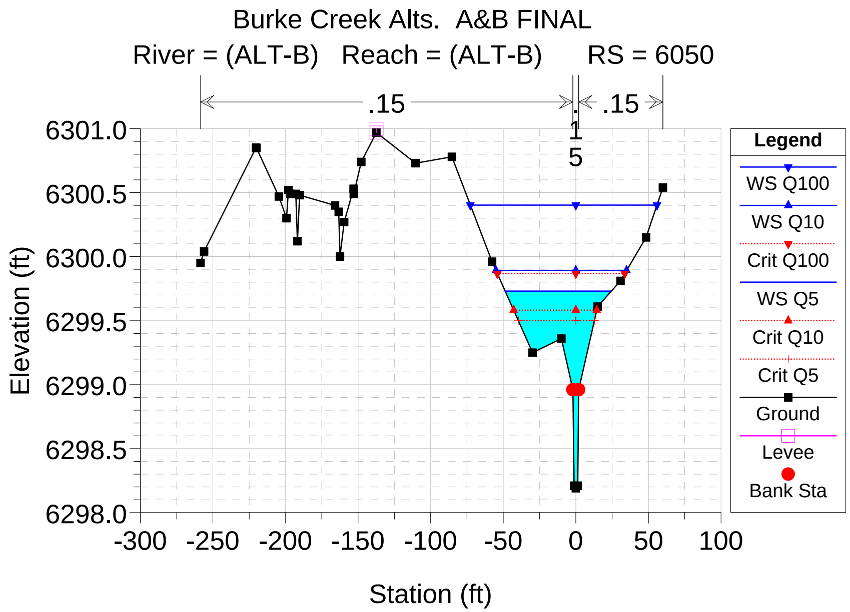
River = (ALT-B) Reach = (ALT-B) RS = 6150
.15
.15
.15
Elevation (ft)
Station (ft)
6316
6314
6312
6310
6308
6306
6304
6302
-60
-40
-20
0
20
40
60
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Ineff
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6100
.15
.15
.15
Elevation (ft)
Station (ft)
6306
6305
6304
6303
6302
6301
6300
-300
-250
-200
-150
-100
-50
0
50
100
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta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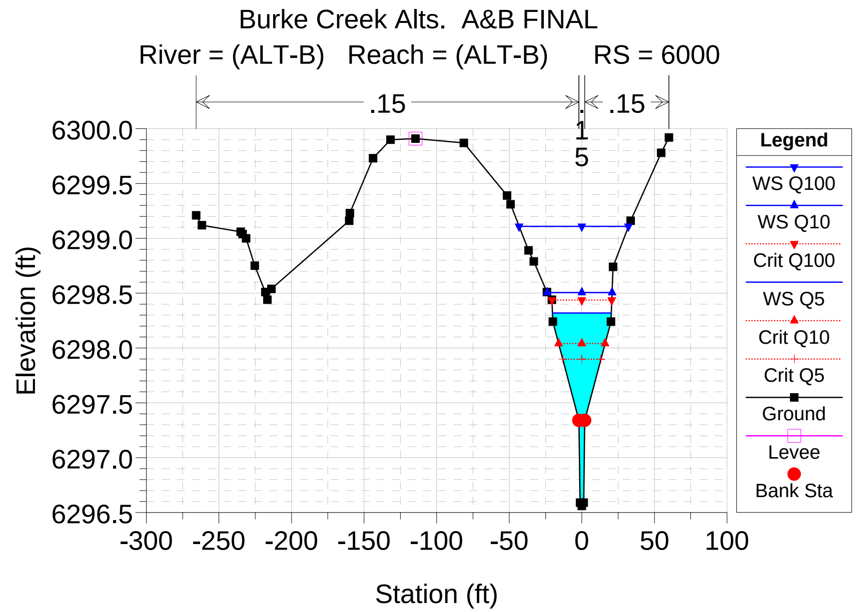
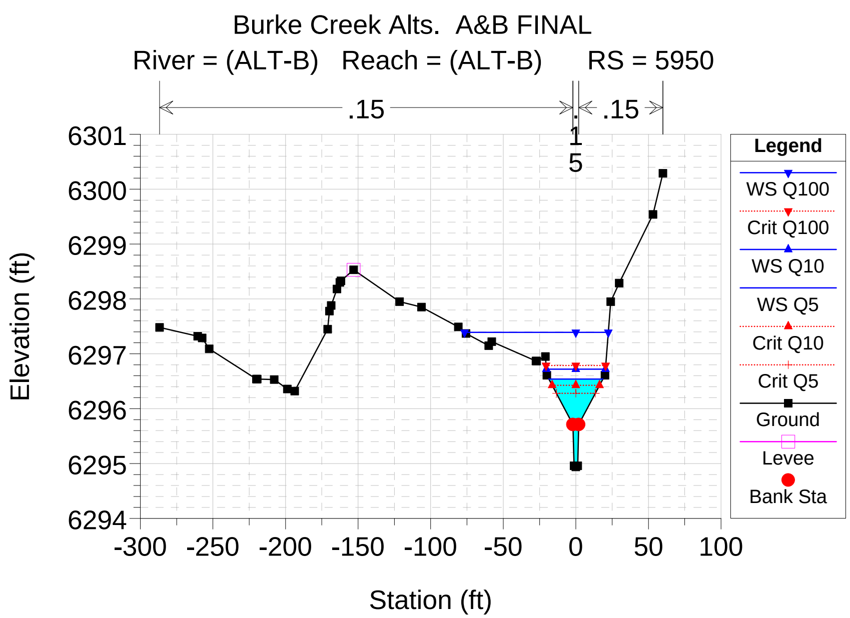
River = (ALT-B) Reach = (ALT-B) RS = 6050
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6000
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5950
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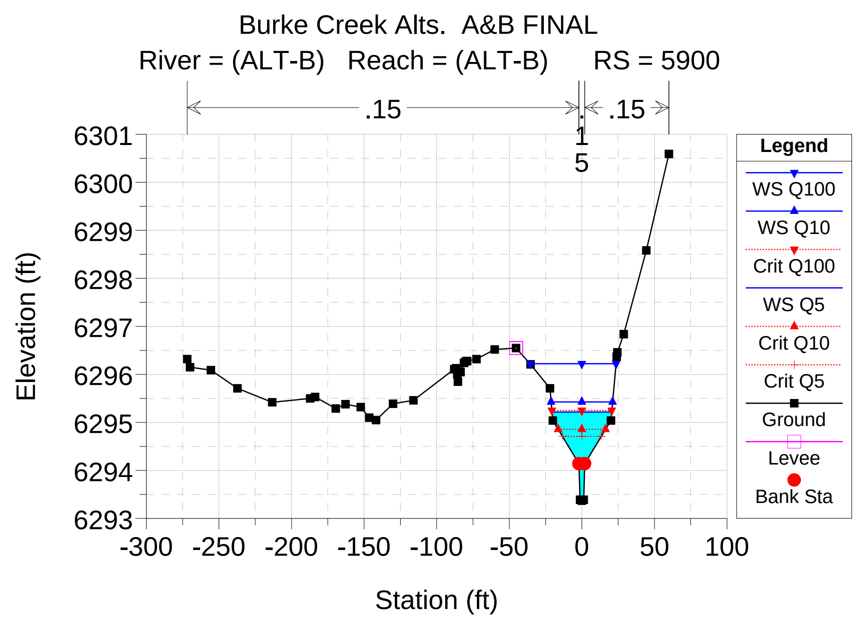
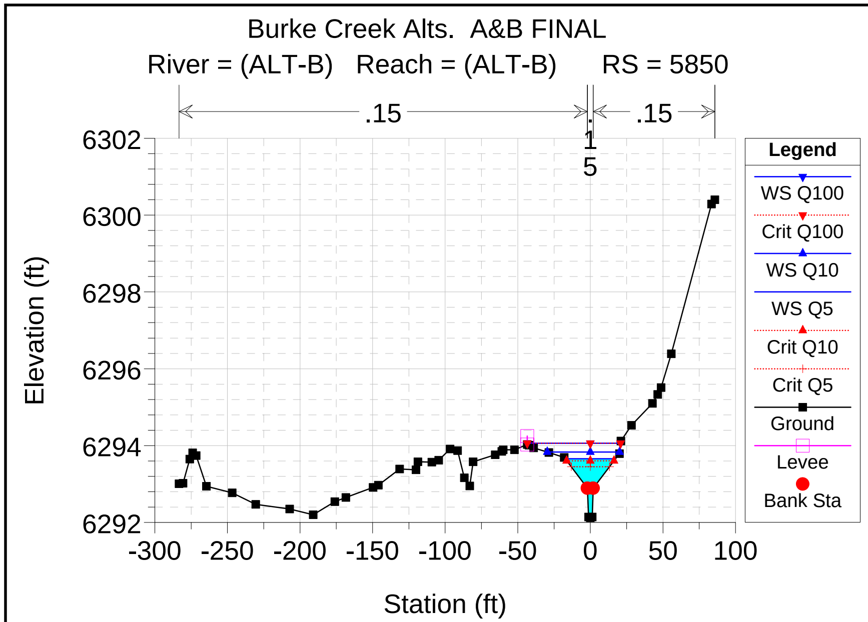
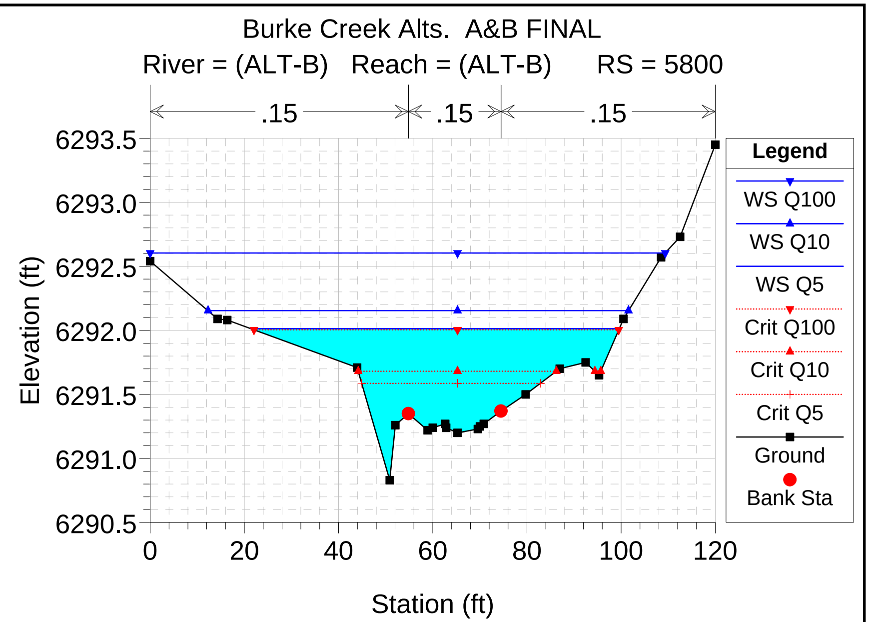
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

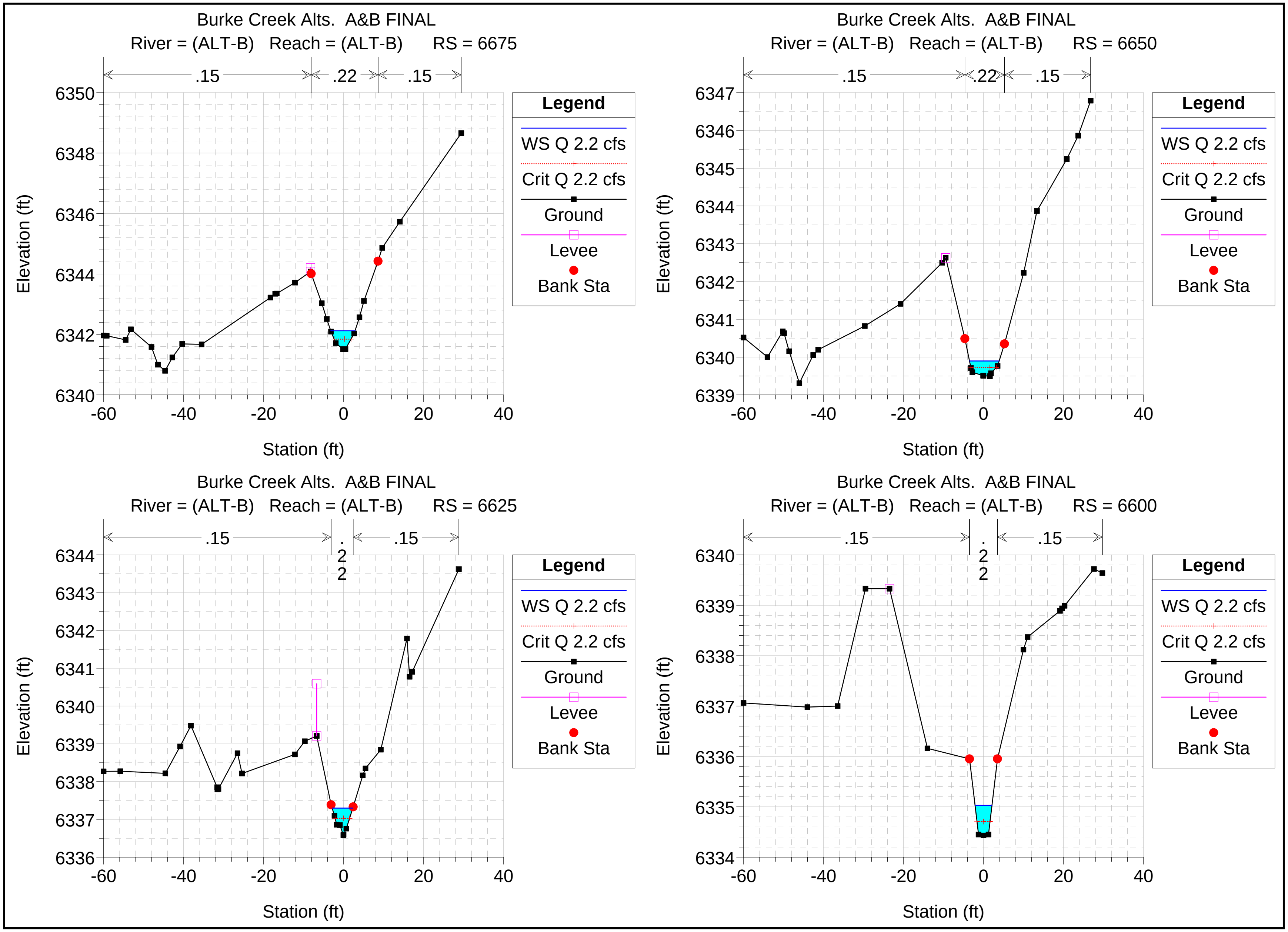

Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5900
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
Crit Q100
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

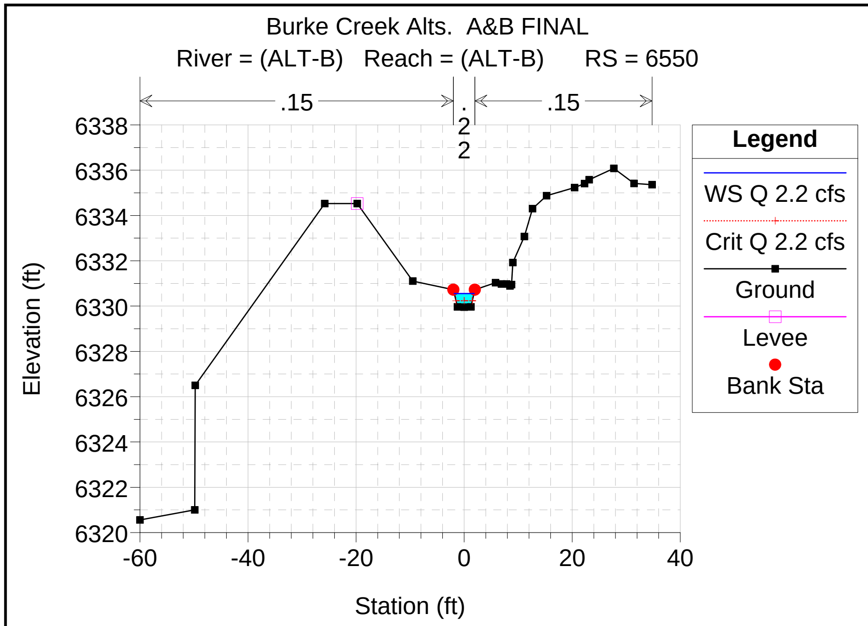


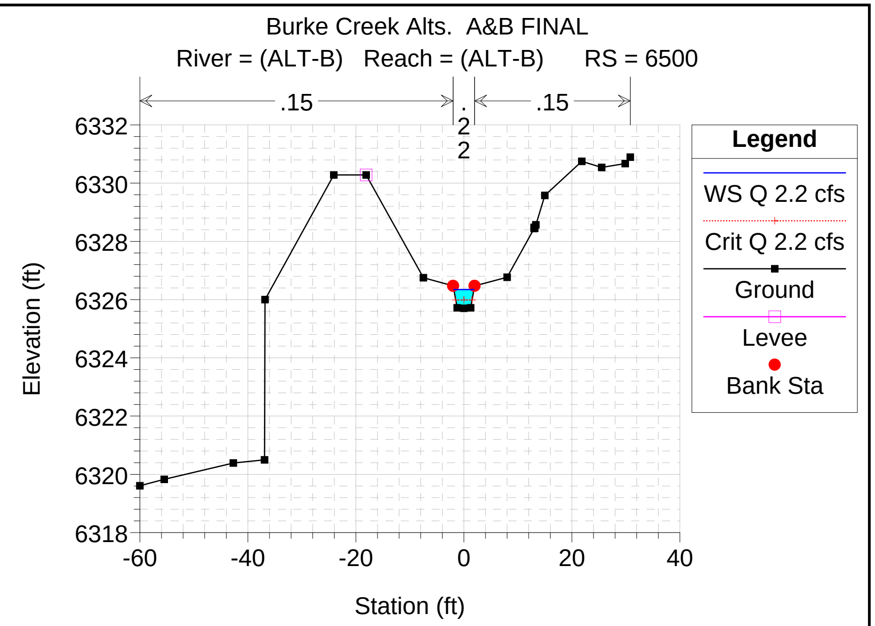
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5850
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
Crit Q100
WS Q10
WS Q5
Crit Q10
Crit Q5
Ground
Levee
Bank Sta

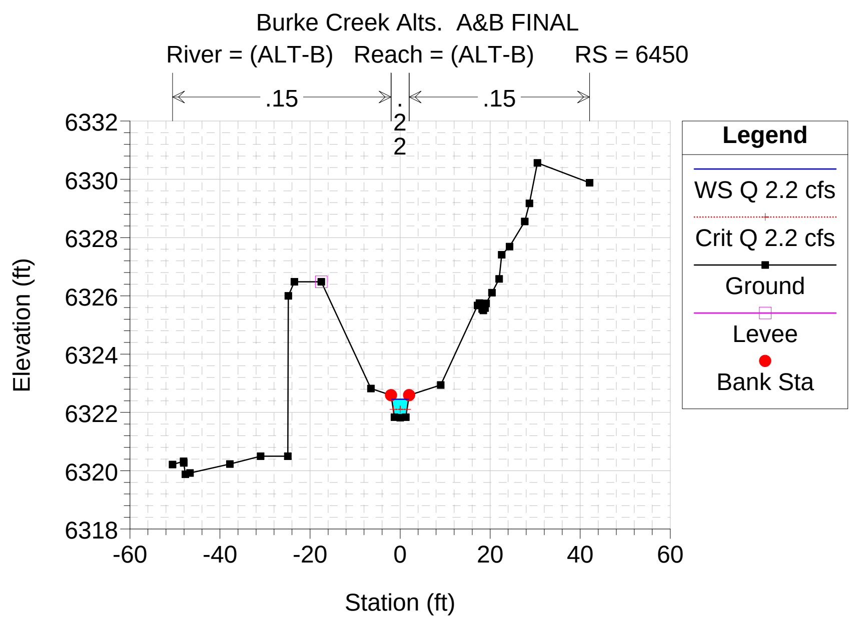


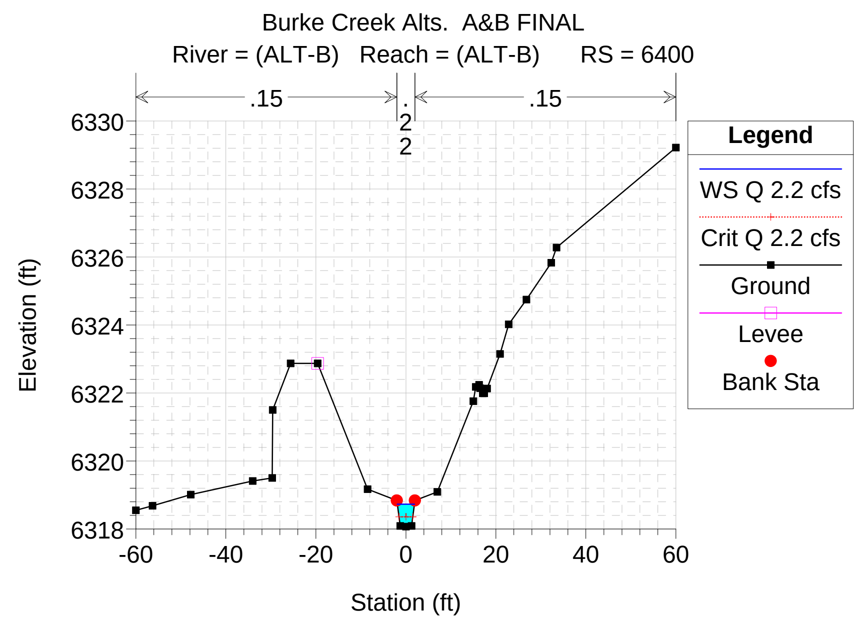
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5800
.15
.15
.15
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q10
WS Q5
Crit Q100
Crit Q10
Crit Q5
Ground
Bank Sta

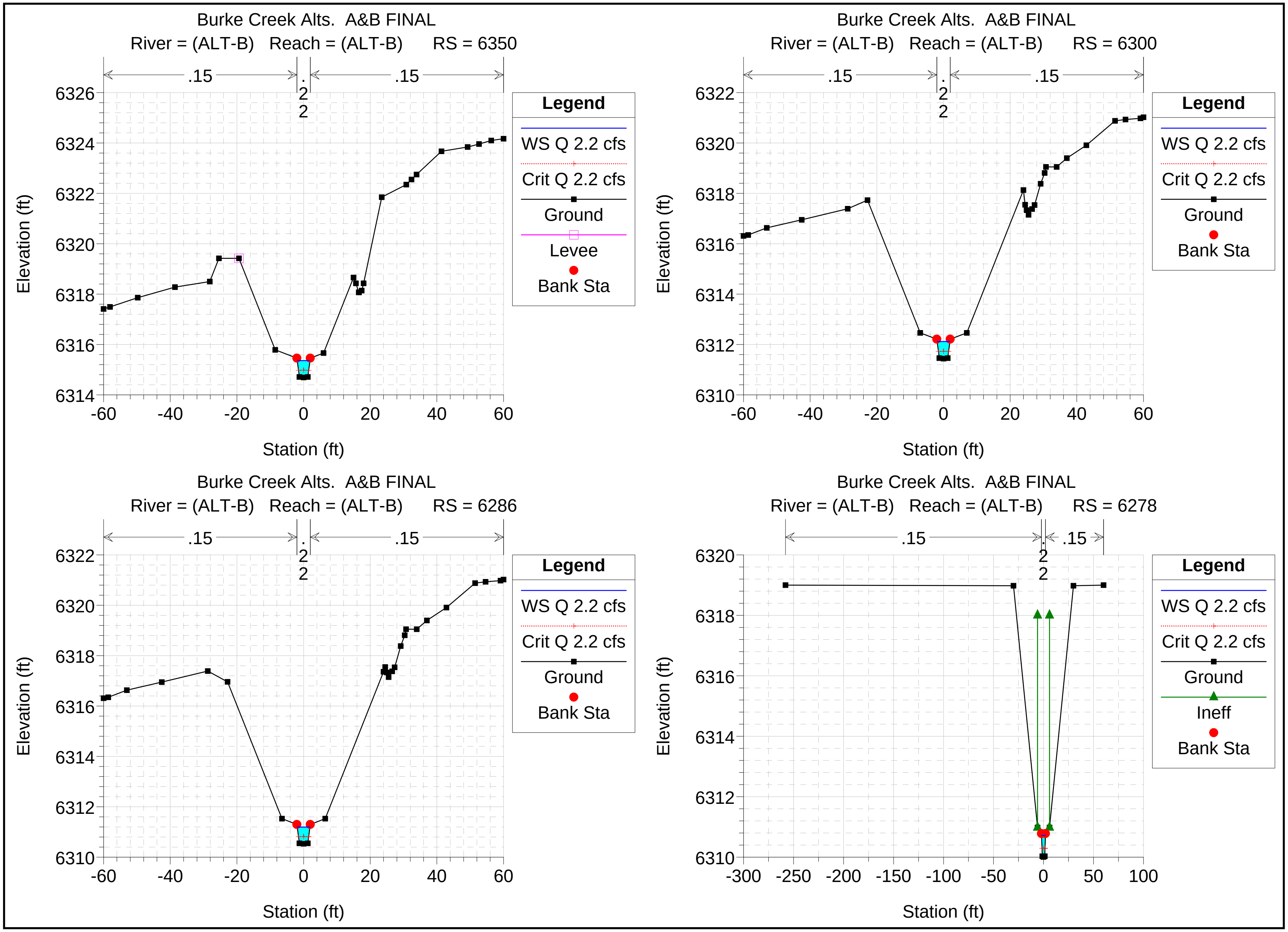

Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6675
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6650
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6625
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6600
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6550
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6500
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6450
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6400
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6350
.15
.2 2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6300
.15
.2 2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6286
.15
.2 2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6278
.15
.2 2
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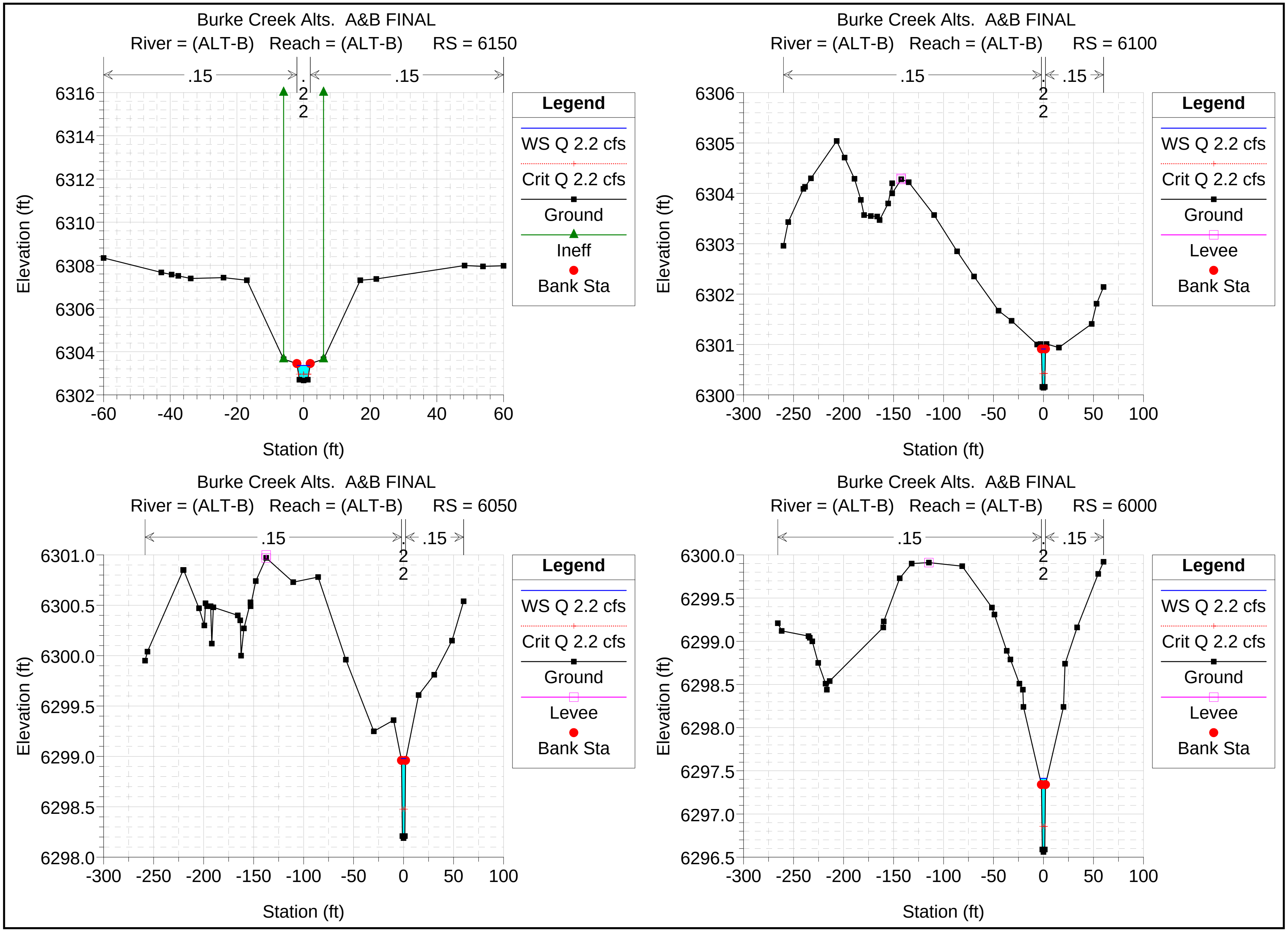
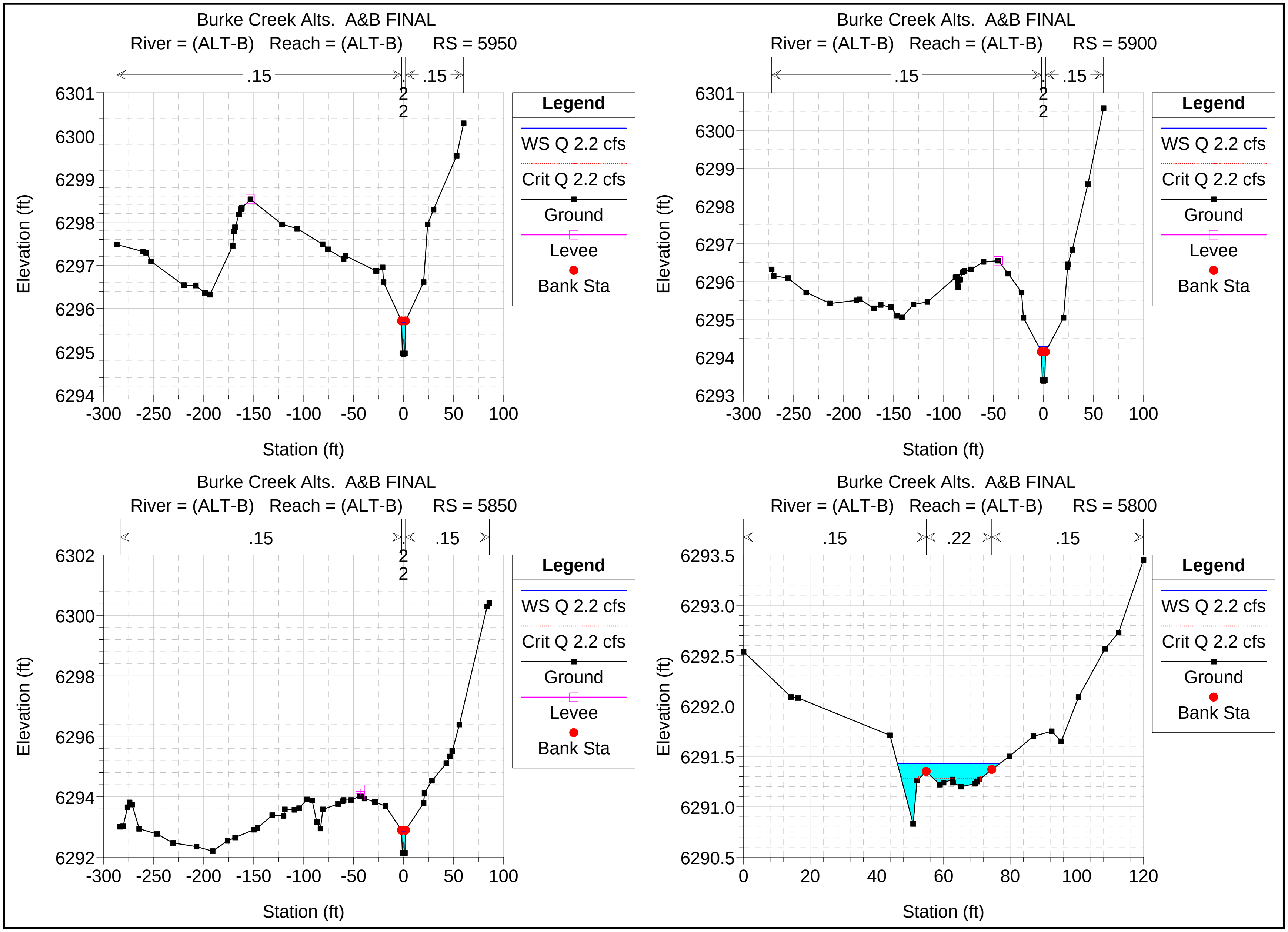
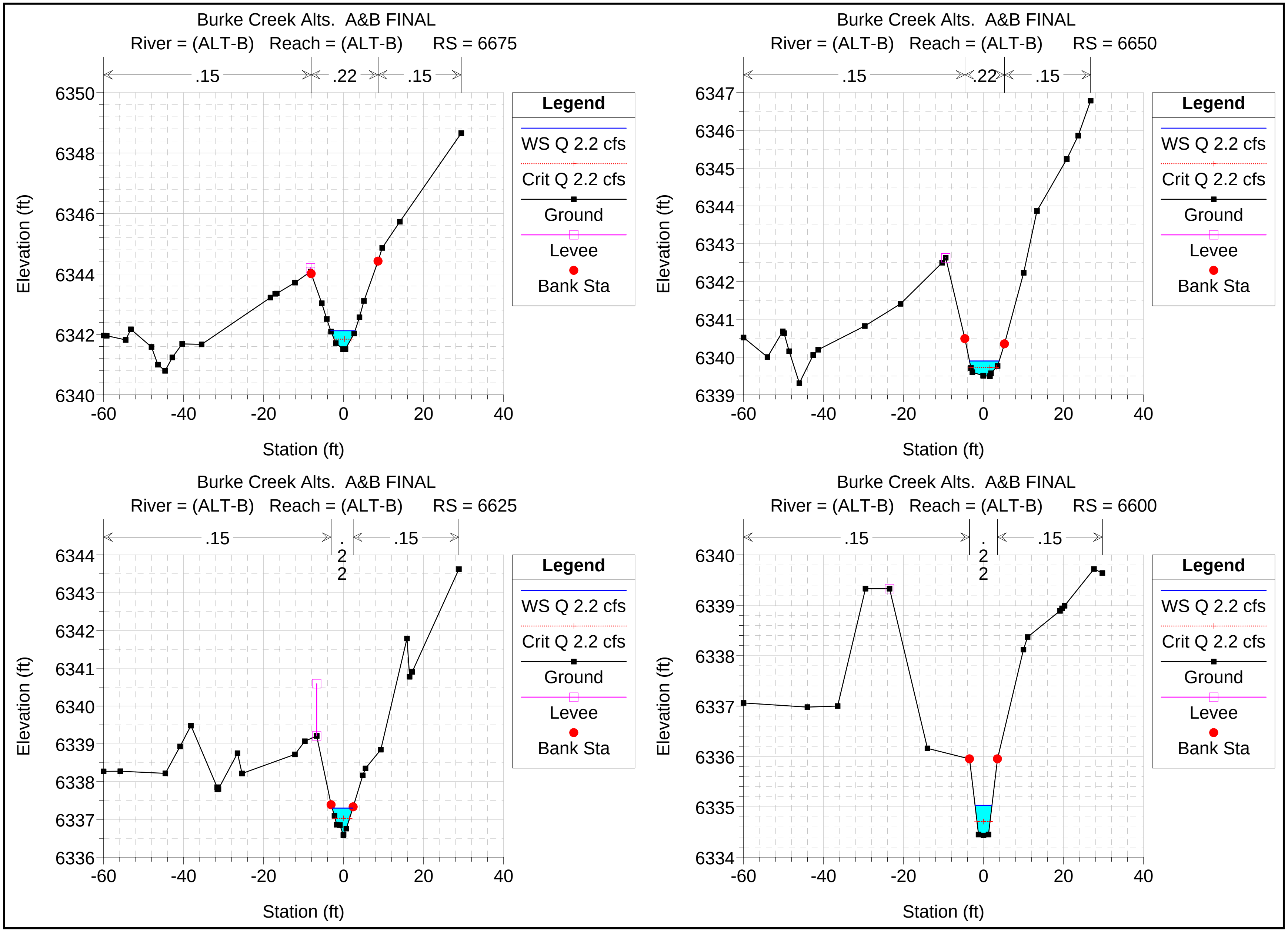
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta

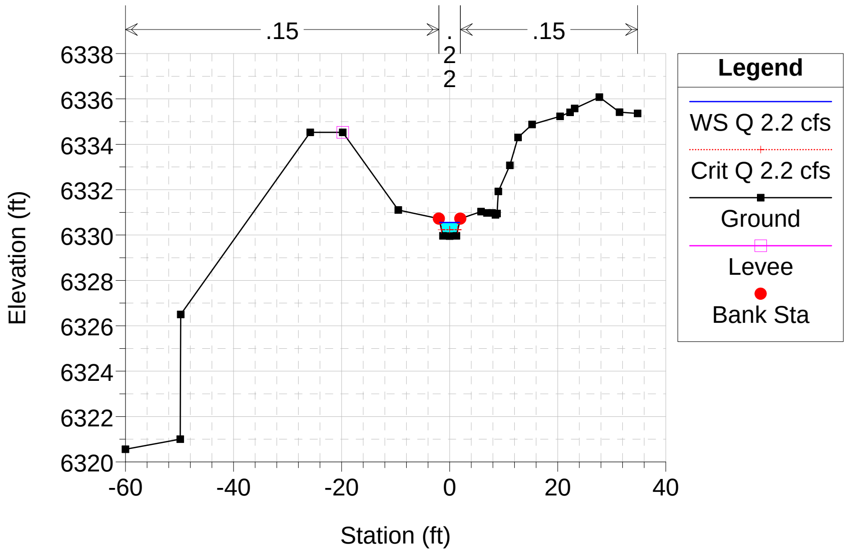


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6150
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6100
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6050
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6000
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta

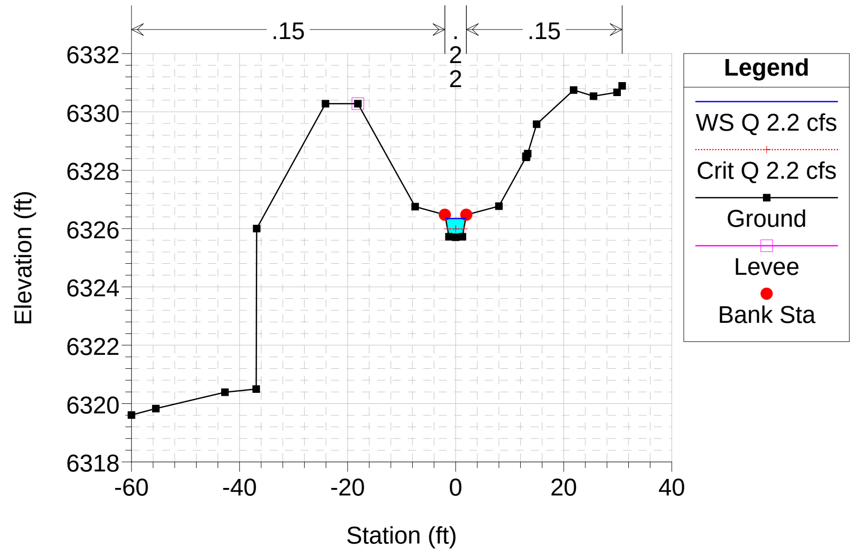

Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5950
.15
.15
2
2
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5900
.15
.15
2
2
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5850
.15
.15
2
2
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5800
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6675
.15
.22
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6650
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6625
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6600

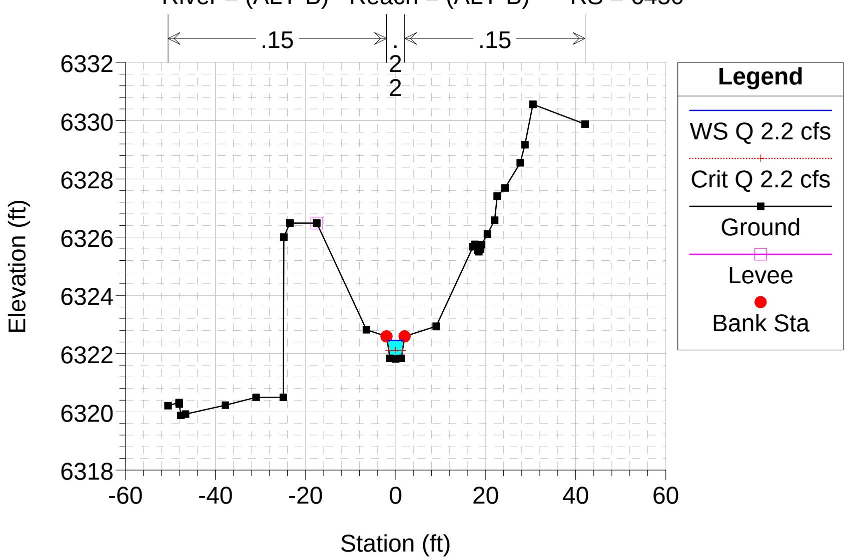
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6550



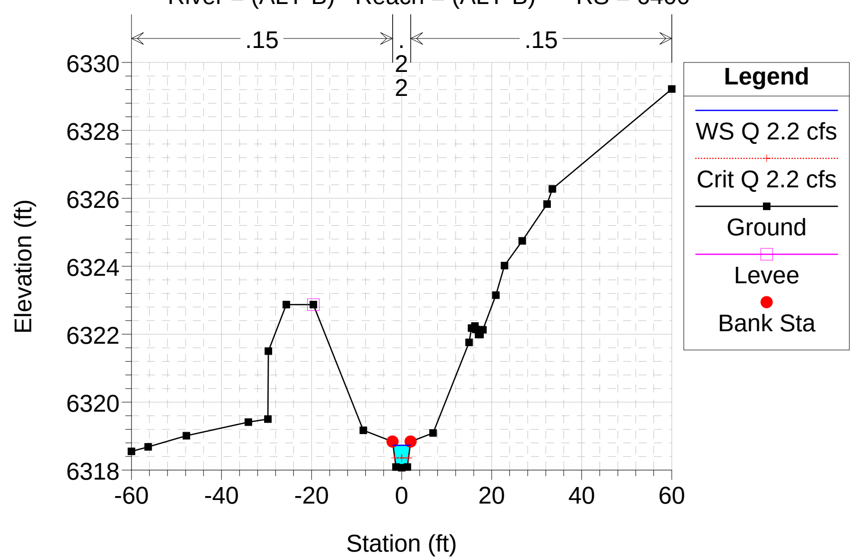
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6500

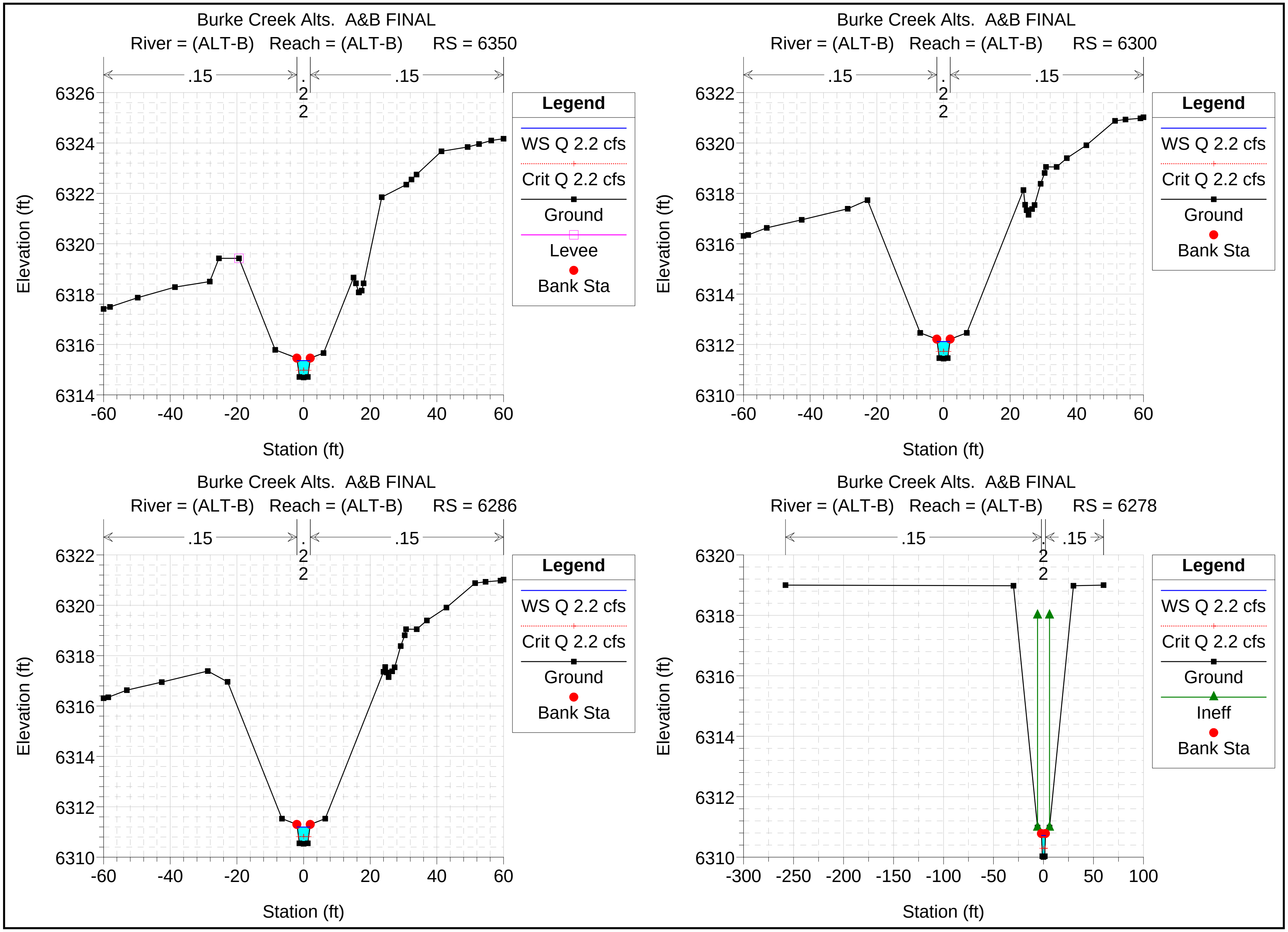


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6450

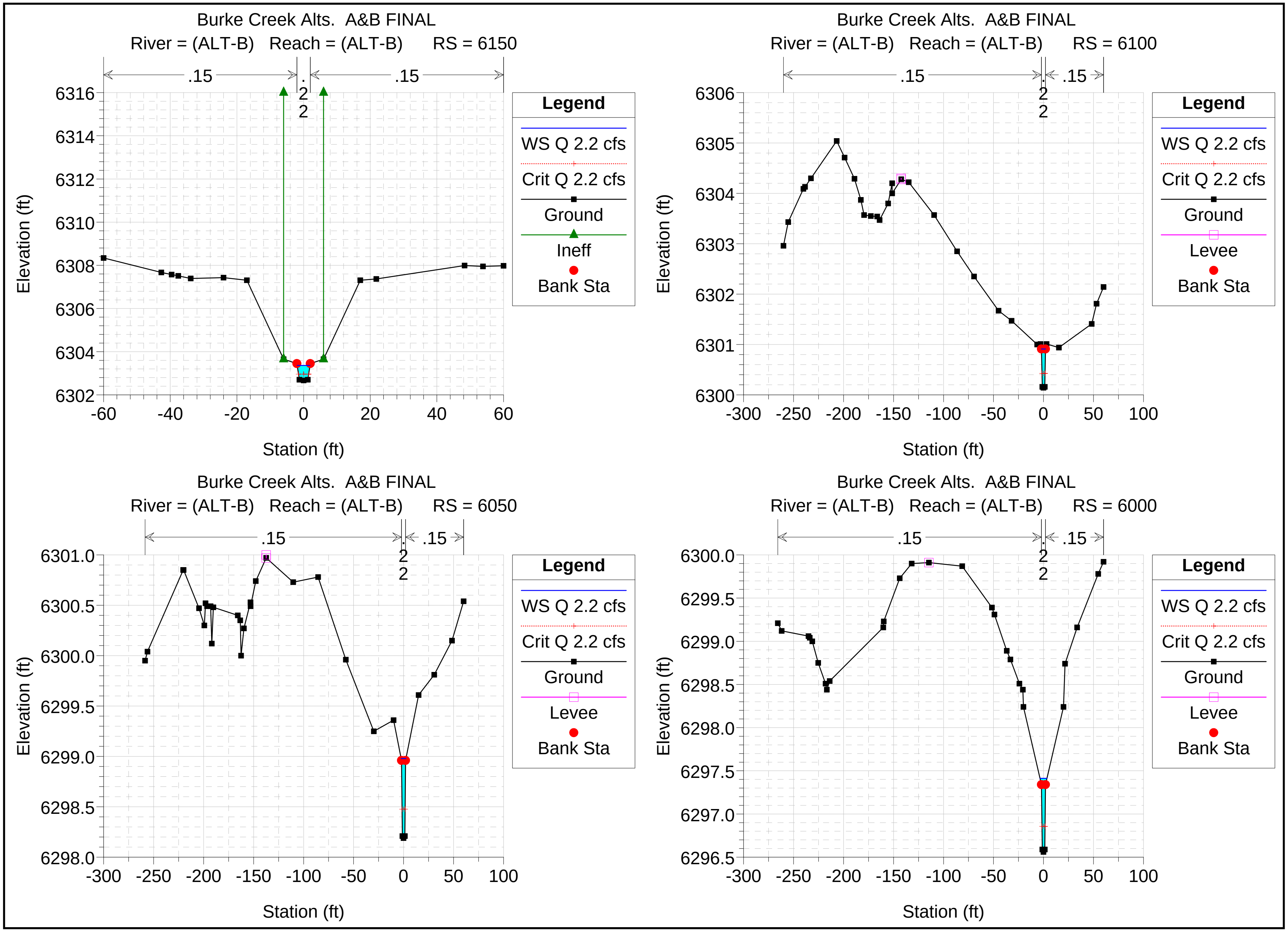


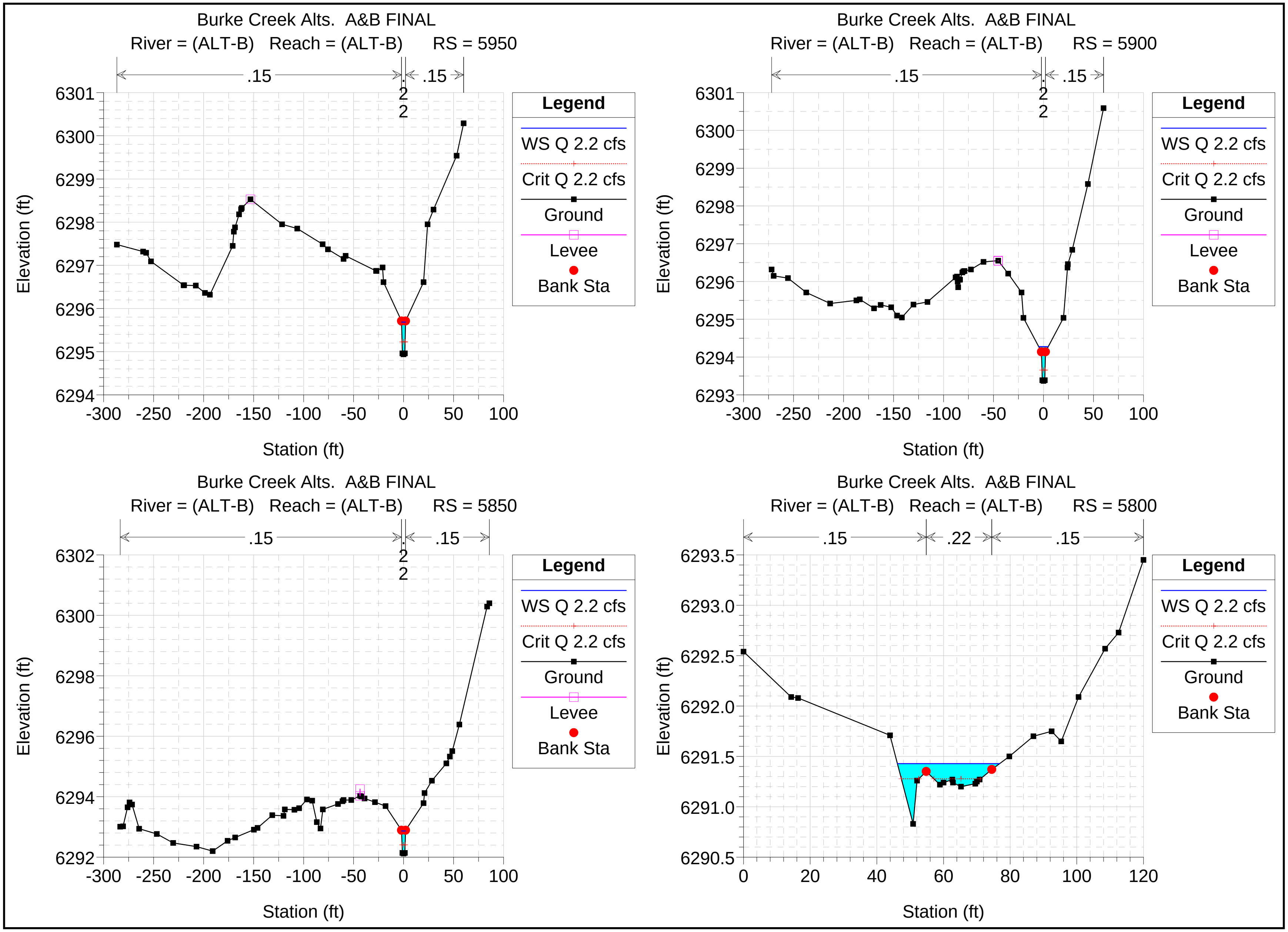
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6400





Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6350
.15
.022
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6300
.15
.022
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6286
.15
.022
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6278
.15
.022
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta


Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6150
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Ineff
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6100
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6050
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 6000
.15
.2
.15
Elevation (ft)
Station (ft)
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta



Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5950
.15
.15
2
2
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5900
.15
.15
2
2
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5850
.15
.15
2
2
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Burke Creek Alts. A&B FINAL
River = (ALT-B) Reach = (ALT-B) RS = 5800
.15
.22
.15
Legend
WS Q 2.2 cfs
Crit Q 2.2 cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

Appendix L
Opinion Probable Construction Costs

Burke Creek Restoration Project
Order of Magnitude Opinion of Probable Construction Cost - Based on June 2009 Conceptual Drawings
Prepared for: Tahoe Regional Planning Agency
Project # 1118407001-11110

				Alternative A		***Alternative B***	
Item No	***Item Description***	***Unit***	***Unit Cost***	***Quantity***	***Total***	***Quantity***	***Total***
1	Mobilization and Demobilization (Approx. 5% of line items 2-21)	LS	Variable	1	$73,000	1	$102,000
2	Project Signs	LS	$5,000	1	$5,000	1	$5,000
3	Water Management	LS	Variable	1	$125,000	1	$175,000
4	Traffic Control	LS	$150,000	1	$150,000	1	$150,000
5	Clearing and Grubbing	LS	Variable	1	$75,000	1	$125,000
6	Channel Excavation and Disposal	CY	$50	800	$40,000	1,900	$95,000
7	Channel Compacted Import Backfill	CY	$75	1,600	$120,000	1,800	$135,000
8	Engineered Streambed Material	CY	$85	320	$27,200	360	$30,600
9	Cast In Place Retaining Wall (In Parking Lot)	SF	$140	0	$0	825	$115,500
10	Roadway and Base Grinding/Excavation	CY	$125	90	$11,250	90	$11,250
11	Culvert Excavation	CY	$25	1,600	$40,000	1900	$47,500
12	Culvert Bedding	CY	$125	70	$8,750	80	$10,000
13	Culvert (12'x6.5' ID)	LF	$1,200	100	$120,000	120	$144,000
14	Cast In Place Concrete Wingwalls	SF	$140	750	$105,000	750	$105,000
15	Culvert Backfill	CY	$75	1,300	$97,500	1,500	$112,500
16	Road Base	Ton	$60	280	$16,800	280	$16,800
17	AC Paving	Ton	$200	80	$16,000	80	$16,000
18	Striping	LS	$10,000	1	$10,000	1	$10,000
19	Sewer Pipe encasement at crossing	LS	$15,000	1	$15,000	1	$15,000
20	Sewer pipeline relocation	LS	$80,000	0	$0	1	$80,000
21	Revegetation	LS	Variable	1	$250,000	1	$325,000
22	Irrigation	LS	Variable	1	$125,000	1	$175,000
23	Erosion and Sediment Control	LS	Variable	1	$100,000	1	$150,000
			Subtotal:		$1,530,500		$2,151,150
			Estimating Contingency @ 30%:		$459,150		$645,345
			Order of Magnitude Opinion of Probable Construction Cost (Rounded)		**$1,990,000**		**$2,796,000**