R E P O R T

PERMANENTE CREEK LONG-TERM RESTORATION PLAN

Prepared for
Lehigh Southwest Cement Company
24001 Stevens Creek Boulevard
Cupertino, CA 95014

March 11, 2011

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Acronyms and Abbreviated Forms

Basin Plan	Water Quality Control Plan for the San Francisco Bay Basin
Board	San Francisco Bay Regional Water Quality Control Board
CAO	Cleanup and Abatement Order
Creek	Permanente Creek
CRLF	California red-legged frog
Facility	Permanente limestone quarry, aggregate plant and Portland cement plant
Operator	Hanson Permanente Cement, Inc. and Lehigh Southwest Cement Company
Plan	Long-term Restoration Plan
Quarry	Permanente limestone quarry
SWPPP	Stormwater Pollution Prevention Plan

USGS	United States Geological Survey
W/D	width/depth

1.1 INTRODUCTION

URS Corporation, on behalf of Lehigh Southwest Cement Company and Hanson Permanente Cement, Inc., has prepared this Permanente Creek Long-Term Creek Restoration Plan (Plan) to comply with the San Francisco Bay Regional Water Quality Control Board's ("Board") July 27, 1999 Cleanup and Abatement Order – 99-018 ("CAO"). Hanson Permanente Cement, Inc. is the owner of the property subject to the CAO, and Lehigh Southwest Cement Company (Operator) operates the facilities on the property. Both are sometimes collectively referred to as "Operator" herein, for convenience.

The CAO concerns the Permanente limestone quarry (Quarry), aggregate plant and Portland cement plant (collectively, the Facility). The limestone quarry and associated aggregate plant mining operation is in the western hillsides of unincorporated Santa Clara County to the west of the city of Cupertino. The Facility occupies a portion of approximately 3,600 contiguous acres owned by Hanson Permanente Cement, Inc. Mining activities began at the Quarry around 1903, and was acquired by Hanson Permanente Cement, Inc.'s predecessor, Kaiser Industries, in 1939. The Facility operates pursuant to regulatory authority from various governmental agencies, including the Board, Santa Clara County, the Bay Area Air Quality Management District, and the Santa Clara Valley Water District.

Hanson Permanente Cement, Inc.'s property is bisected by Permanente Creek (Creek). Figure 1-1 and Figure 1-2 show the existing facilities in relation to the Creek. The Creek's headwaters are in the higher elevations of the Coast Range and it flows northward until it reaches the floor of the Santa Clara Valley. Just south of the intersection of Miramonte Avenue and Eastwood Drive in Los Altos, California, the Creek flows are diverted via the Permanente Diversion Channel into Stevens Creek and from there continue to San Francisco Bay. As part of the normal Facility operations and subject to various regulatory requirements, a series of sedimentation basins, culverts, and channelized segments are used to controls sedimentation and manages non-point source discharges to the creek.

The Board issued the CAO to address sediment discharges into the Creek resulting from Facility operations. The CAO required interim and long-term corrective measures for sediment control, and included numerous requirements for investigating and mitigating sediment impacts to the Creek. The majority of the CAO requirements have been satisfied. The work performed in response to the CAO has included improving and maintaining existing sedimentation basins, construction of additional sedimentation basins, implementation of slope stability measures, revegetation efforts, the preparation of various reports and studies, and compliance with inspection and reporting requirements in the CAO. These efforts have largely been successful in reducing sediment loading into the Creek.

There is one CAO requirement that remains to be fulfilled. Item C-9, requires Lehigh to submit a proposal for long-term creek restoration to the Board. Under the terms of the CAO, this requirement would be completed in three phases. Item C-9 provides:

> *9.* ***By September 1, 2000*** *Hanson shall submit a technical report containing a proposal for a long term creek restoration plan (plan), acceptable to the Executive Officer, for all areas of the Creek area affected by the Facility. A creek restoration specialist must prepare the plan. This plan should build*

upon previous work including the tasks required above and be performed in three phases. The plan shall fully describe each phase, which should, at a minimum, include the following components:

Phase 1: A system wide field reconnaissance (fluvial geomorphology), that includes problem(s) identification (determine cause/mode of failure), and data collection and analysis (e.g., biological, geotechnical, hydraulics & hydrology, sedimentation, survey and mapping, etc.). Properly performed field reconnaissance and problem identification should result in a good qualitative understanding of erosion and bank stability problems on a watershed scale. The purpose of this reconnaissance is to identify sites along the Creek that would ideally require some form of stabilization and/or restoration;

Phase 2: Prioritization of candidate sites and a description of identified and potential solutions and design alternatives that incorporate information from Phase 1. Such a plan should consider appropriate fluvial geomorphologic design and the degree to which biotechnical measures and creek restoration design can be included as the solution; and,

Phase 3: Submittal of implementation schedules for candidate sites and their associated design alternative(s) and solutions from Phase 2.

Hanson Permanente Cement, Inc. completed the first of the three phases specified by Item C-9 on September 1, 2000 by submitting a document to the Board prepared by URS titled "Hanson Permanente Cement, Inc. Long-Term Restoration Plan" (URS 2000) (Phase 1 Report). This document focused on Phase 1 of Item C-9. It contained a study of existing biologic, geomorphic, and water-quality conditions within the Creek and listed candidate restoration sites. Phases 2 and 3 were not finalized in connection with this document but were left for future completion.

This Plan completes Item C-9 by fulfilling the Phase 2 and Phase 3 requirements. The Plan identifies candidate restoration sites along various reaches of the Creek, identifies optional restoration design alternatives, and contains implementation schedules. The Plan also updates aspects of the Phase 1 Report (URS 2000) with current field reconnaissance.

URS previously provided a conceptual outline of the Plan to the Board's staff on November 15, 2008 then a draft Plan was provided to the Board on July 31, 2009. The current Plan incorporates the comments received from Board staff in response to both the outline and the draft plan.

1.2 PURPOSE AND GOALS OF THE REPORT

The purpose of this Plan is to fulfill Item C-9, Phases 2 and 3, of the CAO. This Plan addresses these requirements by:

- Building on the Phase 1 Report with updated field reconnaissance
- Proposing feasible restoration activities for areas of the Creek affected by the Facility (CAO, Item C-9. Phase 2)
- Prioritizing a list of candidate restoration sites and activities (CAO, Item C-9. Phase 2)

- Developing an implementation schedule for the candidate sites (CAO, Item C-9. Phase 3)

This Plan has been developed in accordance with the beneficial uses identified for the Creek within the San Francisco Bay Basin Water Quality Control Plan ("Basin Plan") (SFRWQCB 2007). The beneficial uses for the Creek have been used to inform Plan goals. The Basin Plan defines the beneficial uses of the Creek as:

- cold freshwater habitat
- fish spawning
- wildlife habitat
- water contact recreation
- non-water contact recreation

1.3 SITE LOCATION

The Facility is in the Permanente Creek watershed on Stevens Creek Boulevard in Cupertino, California (see Figure 1-1). The Permanente Creek watershed is in the Santa Clara Basin near the cities of Cupertino and Mountain View. The Creek drains the eastern side of the Santa Cruz Mountains and is one of several drainages in the Santa Clara Basin that drain north into San Francisco Bay. Adjacent major drainages include San Francisquito Creek to the northwest and Stevens Creek to the east.

Off-site and downstream of the Facility, near Miramonte Avenue and Eastwood Drive in Los Altos, California, flows from the Creek are diverted to Stevens Creek via the Permanente Diversion Channel. The diversion channel is a concrete-lined, trapezoidal, flood-control channel, and it forms a barrier to fish migration for areas upstream of the diversion channel (including the Facility). The diversion channel is part of the Santa Clara Valley Water District flood damage reduction program, and it is not controlled by the Operator. As a result, restoration of anadromous fish passage to Creek reaches on the Facility cannot be accomplished by this Plan. However, the Plan endeavors to improve fish passage for resident fish populations.

1.4 PLAN LIMITATIONS

The following limitations apply to this Plan:

- The measures, recommendations, and schedules in this Plan apply to current conditions in or adjacent to the Creek. The Plan acknowledges that the Creek conditions will change over time as a result of future operations, future changes in creek morphology, or other constraints. Creek conditions would be reassessed and the Plan updated at the point of Facility closure and Plan implementation.

- This Plan assumes the Union Pacific railroad tracks currently serving the Quarry will be obsolete following Facility closure, and the rail grade will be available for restoration activities, as depicted in Figure 1-3 (Appendix A). However, the Operator cannot guarantee that Union Pacific will provide its holding for restoration actions.

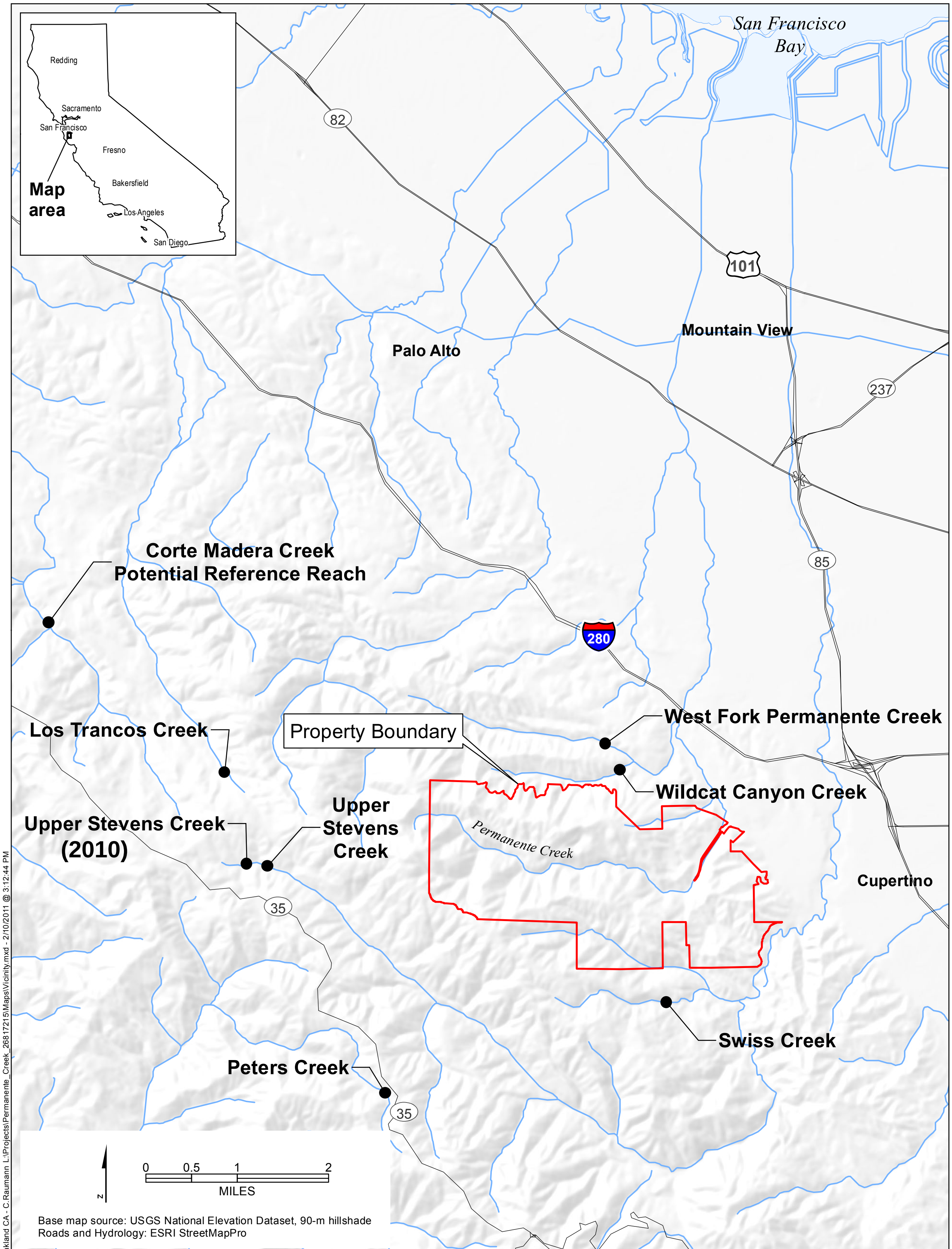
- This Plan includes actual or potential sediment inputs noted in the Phase 1 Report (September 2000) as well as new sediment sources identified in 2009. This Plan provides potential measures, recommendations, and schedules for some of these sediment sources resulting from daily Facility operations that are more appropriately addressed through the Stormwater Pollution Prevention Plan (SWPPP). This Plan focuses on the long-term removal of structures in and adjacent to the Creek and the restoration of the riparian zone of the creek. To fully address sediment sources, loading, and effectiveness of controls, a separate study will be conducted to provide recommendations to the SWPPP to facilitate better stormwater controls. Actual or potential sources of sediment that can be addressed by near-term SWPPP measures are not subject to this Plan. Such features, e.g. bank stabilization and floodplain creation, may nonetheless be mentioned within this Plan for reference or for other purposes.

1.5 PLANT AND ANIMAL COMMUNITIES

The Phase 1 Report provided a detailed description of biological resources in and immediately surrounding the Creek. This included specific descriptions of the various plant communities in and adjacent to the Creek, complete with species lists and locations of where such species were observed. The Phase 1 Report also presented a list of the birds, mammals, amphibians, fish, and invertebrates found during surveys of the Creek in the areas studied, and qualitative descriptions of the habitat characteristics in defined reaches (URS 2000). The sections of the Phase 1 Report described above have been excerpted and provided in Appendix B of this document.

In a few portions of Permanente Creek, notable changes in habitat have occurred since the Phase 1 Report was written. Pond 22 has filled with sediment and has been colonized by willows, and the creek currently flows through a shallow, meandering channel down the length of the pond. In Reach 8, the embankment below Screen Tower No. 4 was eroding and mostly unvegetated in 2000, but has since been colonized by upland plants and is now 95 percent stable. Reaches 9 and 10 (Stations 60+00 to 76+00), which had very little riparian vegetation and canopy at the time of the Phase 1 Report, have since been colonized by alders and now exhibit a moderate to dense canopy.

Since the Phase 1 Report, additional surveys and habitat studies for California red-legged frog (CRLF) have occurred on the Quarry property. Protocol level surveys in 2007 detected CRLF occurrences at Pond 14, 21, and 22 and successful breeding in Ponds 14 and 21 (Huffman-Broadway Group, Inc. 2008). Additionally, Pond 22 and the wetland area originating at Pond 21 have been classified as breeding habitat for this species, though the lack of deep, open pools may limit suitability (Jennings 2010). Suitable upland areas in the vicinity of Ponds 14, 21, and 22 may also be used by this species (Jennings 2010). Within Permanente Creek, no frogs have been sighted upstream of Pond 22 although Permanente Creek provides marginal habitat in pools and likely serves as a migration corridor between more suitable known breeding locations (Huffman-Broadway Group, Inc. 2008).



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Lehigh Southwest Cement Company
Permanente Creek Long-term Restoration Plan

Figure 1-1
Vicinity

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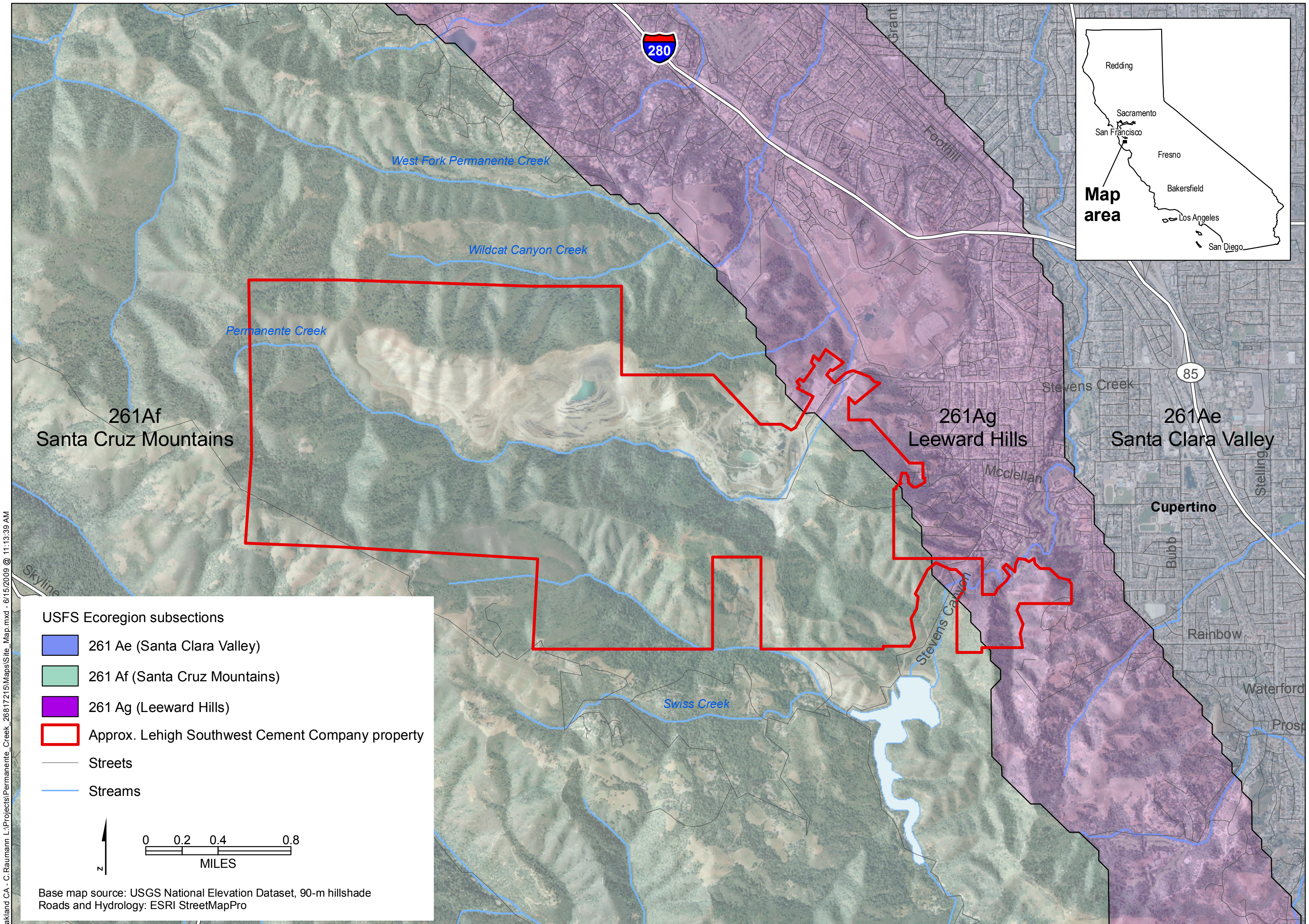

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Permanente Creek Long-term Restoration Plan

Figure 1-2
Site Map

1.6 UPDATES FROM THE PHASE 1 REPORT

The Phase 1 Report provided an assessment-level survey of the geomorphic characteristics on 3.7 miles of Creek within the area studied (Approximately 200 feet downstream of Station 0+00 to the most upstream end, Station 195+00) (see Appendix A). The Phase 1 Report also provided a classification of the various stream reaches using the Rosgen (1996) classification system, a discussion of the underlying geology, a description of existing land uses, an analysis of the prevailing hydrology, identification of possible erosion and potential sediment sources, and a reach-by-reach description of morphology and anthropogenic features.

In preparing this Plan, URS reviewed the information contained in the Phase 1 Report, and performed limited field studies to verify the current accuracy of that information. In general, the land-use, hydrologic, and geologic conditions in the Creek's watershed do not appear to have changed significantly since the Phase 1 Report. The 2009 observations indicate that many of the sediment sources identified in 2000 have stabilized or been resolved, and provide evidence that the Operator's efforts in response to the CAO have been successful in addressing sedimentation and turbidity in the Creek. Section 2.4 includes a discussion of locations where 2009 observations of the Creek's geomorphic conditions differ from conditions described in the Phase 1 Report.

As part of the 2009 assessment, the Creek was divided into 22 reaches for purposes of ascribing a reach classification and stability index to creek sections, and providing a unique identifier to engineered channels or culverts. The 22 reaches build upon the seven reaches and description of stream morphology contained in the Phase 1 Report and further refines the draft Phase 2 report nomenclature. Appendix C describes the location of the seven reaches from the Phase 1 Report and Draft Phase 2 report in relation to the reach classification used in this report.

Creek and Facility site visits associated with the progressive stages of Plan preparation occurred on: October 8, 2008; January 14, February 12, and March 5, 2009; and January 19, 2010. Observations of reference reaches occurred on March 5, April 28, 2009 and November 2010. Photos used in this report were taken during those site visits and assessments. Since the assessment took place during the spring, rainfall and runoff events often preceded assessment field days, and photos reflect water levels typical of high spring flows.

2.1 STREAM CLASSIFICATION

The Permanente Creek watershed has narrow, steep-sloping hillsides (as steep as 190 percent, but typically 50 to 75 percent) and steep to moderately sloping stream channels (slopes ranging from 1 to 13 percent). The narrowness of the valley floor limits the formation of a wide floodplain and terraces, and limits the stream's ability to meander. The stream channel, often with boulder or bedrock grade control, is typically connected to its small floodplain or bankfull benches. Bankfull is often described as the elevation above which the channel has access to an active floodplain.

Several different classification systems are available to describe the valley and stream characteristics. Rosgen describes a method of classifying rivers and streams in *A Classification of Natural Rivers* (Rosgen 1994). This method, which was used in the 2000 and 2009 assessments, is intended to provide a common language among practitioners when discussing various channels and to provide a structure for relating one channel to another. According to this method, a stream channel is classified by its entrenchment ratio, width/depth (W/D) ratio, sinuosity, slope, and channel material. For the 2009 assessment, these data were collected in each reach at a riffle cross-section location typical for that reach.

The Rosgen valley types and stream channel types and other Permanent Creek geomorphic factors are described below.

2.1.1 Valley Types

Valleys can be grouped into a series of types ranging from V-notched canyons (type I) to deltas (type XI). The valley of the upper portion of the project area (Station 40+00 and above) exhibits features typical of type II valleys. A type II valley is described as exhibiting moderate relief, being relatively stable, and having moderate side slope gradients. Valley slopes are typically less than 4 percent with soils developed from residual soils, colluvium, and alluvium. The dominant stream type is a B type (see Section 2.1.2 for description of stream types). While this valley does contain A-type reaches, these reaches result from debris, landslides, and Facility operations, which have straightened and steepened the channel.

The valley of the lower portion of the project area (Station 40+00 and below) transitions into a type VIII valley, which is generally described as being a broad valley with a gentle down-valley gradient, lateral terraces, soils developed from alluvium, and containing C- and E-type streams.

2.1.2 Stream Types

Stream types found in the project area are predominantly A and B types, 35 and 49 percent of project length, respectively, with smaller sections of D, F, and G types, 13, 1, and 3 percent, respectively. Downstream reaches immediately off site are C-type. The stream types are described below.

A-type streams are entrenched, step/pool or cascade system streams with channel slopes typically from 4 to 10 percent. W/D ratios and sinuosity are low. They have high sediment transport and low sediment storage capacities. Common features include relatively steep gradients, bedrock structural controls, debris constrictions, and scour pools.

B-type streams are moderately entrenched, rapids-dominated systems with step/pool formations transitioning to more frequent pool/riffle formations. Slopes typically range from 2 to 4 percent. Both the W/D ratio and sinuosity are considered to be low to moderate. Stream bank erosion is frequently low and typically little aggradation or degradation of the bed occurs.

C-type streams are meandering channels with riffle-pool complexes constructed in alluvial deposition, and they typically have well-developed floodplains. Slopes are typically less than 2 percent, and W/D ratio and sinuosity are moderate. Aggradation, degradation, and lateral extension processes are often active and dependent on stream bank stability, watershed conditions, and flow and sediment regimes.

D-type systems are braided with very high W/D ratios and channel slope commonly the same as the valley slope. They often occur in depositional fans, as is the case on the project site.

F-type streams are entrenched channels typically in the process of widening, and they may also be in the process of establishing bankfull benches inside the channel as a means of moving toward an equilibrium.

G-type streams are entrenched, incised systems with high bedload and suspended sediment transport capacities resulting in downcutting and bank erosion. They are moderate to steep channels with low W/D ratios.

The stream type assigned to each of the reaches is summarized with the reach descriptions in Section 2.4. Detailed data collected during field reconnaissance can be found in Appendix D.

2.1.3 Other Geomorphic Factors

A natural feature of Permanente Creek is the abundance of a conglomerate formation in the channel. Conglomerate generally consists of sand, gravel, silica, and a binding material such as calcium carbonate. Calcium carbonate, dissolved in the water, precipitates in many portions of the Creek where it encrusts stream gravel, leaves, branches, or other material in the water (Figure 2-1). Leaf and twig debris collects around boulders and other constrictions and become encrusted in calcium carbonate forming small, circular step-pools (Figure 2-2). In areas where the precipitate is concentrated, streambed gravels regularly inundated by water bind together, forming a conglomerate. This property armors the bed, limits transport of bed material, and reduces the quality of spawning gravels. Stream banks are similarly bound together by calcium carbonate precipitated by subsurface flow seeping from adjacent slopes. Portions of the stream channel have become incised where the precipitate has made banks resistant to erosion. Since much of the precipitate occurs on the southern banks and flows from seeps and tributaries on the southern side where there have not been mining or other industrial operations, the high calcium carbonate concentrations in the Creek are not a result of Facility operations.

Figure 2-1 Calcium carbonate-encrusted roots and rock steps (right) within the ordinary high water elevation of the Creek

Figure 2-2 Precipitate rock forming step pools

2.2 STREAM STABILITY INDEX

The *Stream Reach Inventory and Channel Stability Evaluation* (Pfankuch 1975) technique was used to assess the relative stability of the reaches during the 2009 assessment. The purpose of conducting the stability index was to systematically evaluate the stability of each reach and provide a common terminology when discussing the relative differences between reaches. The system was developed for mountain streams by Dale Pfankuch of the Lolo National Forest in Missoula, Montana. The system has been modified by David Rosgen to assign the reach stability condition using a combination of the Pfankuch numerical score and the reach classification. A table showing the relationship between score, stream type, and condition index can be found on the Pfankuch data sheets in Appendix D. The stream stability index assigned to each of the reaches is summarized with the reach descriptions in Section 2.4. Detailed data can be found in Appendix D.

2.3 STREAM CHARACTERISTICS

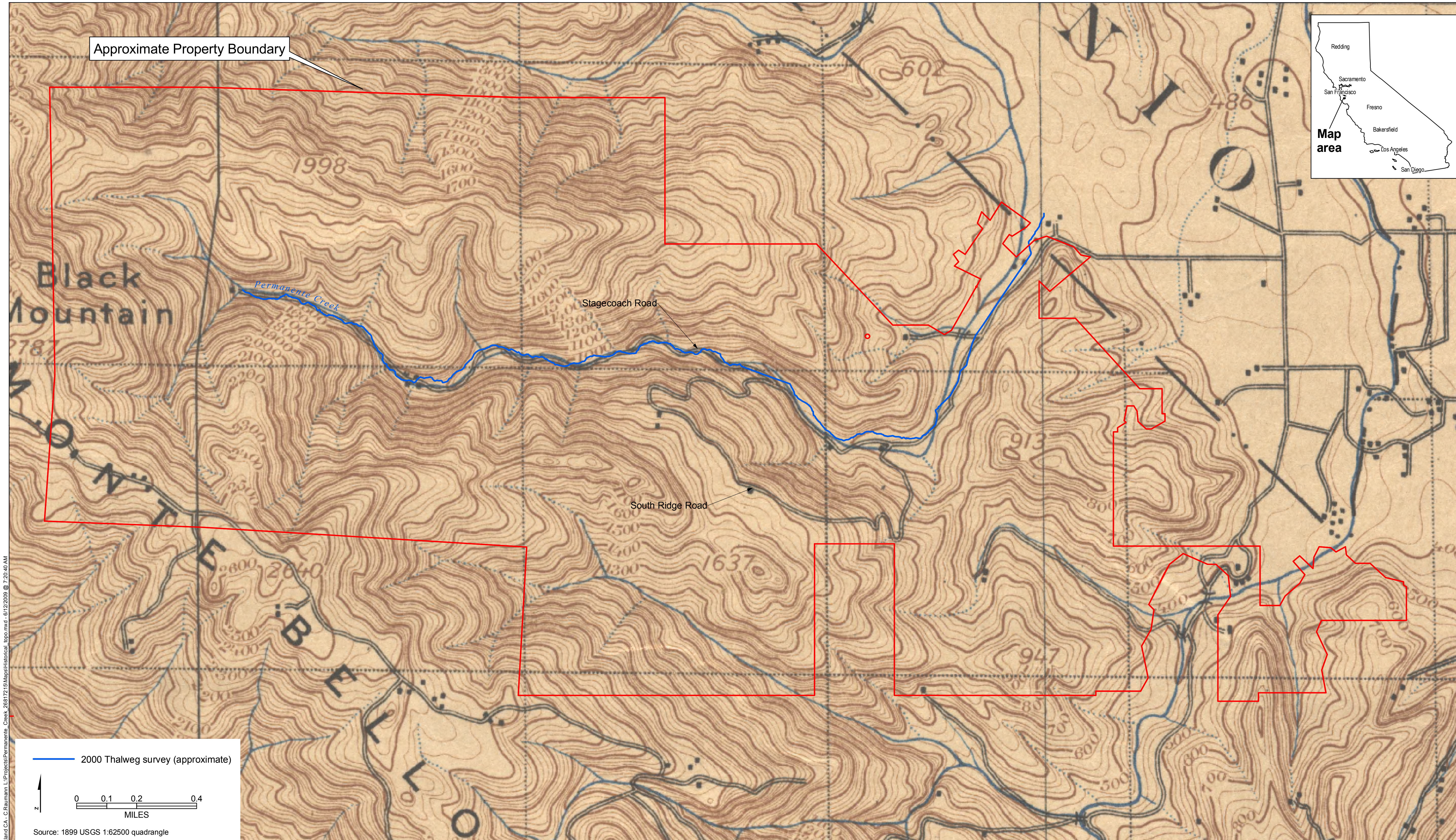
This section describes the stream geomorphic characteristics of Permanente Creek starting below the project area (approximately 200 feet below Station 0+00) to the most upstream end (Station 195+00) (see Figure 1-3 in Appendix A). This analysis of plan view geometry, creek profile, and cross section is based on observations made during the 2009 field reconnaissance.

2.3.1 Plan View Geometry

As described earlier, the Permanente Creek valley is narrow, with steep to moderately sloping hillsides and stream channels. The formation of floodplain and terrace and the stream's ability to meander is limited by the narrowness of the valley floor as well as the roads and other developments.

The 1899 Palo Alto United States Geological Survey (USGS) 15-minute topographic quadrangle (see Figure 2-3) provides the earliest topographic record of the area before the Quarry operations had a profound effect on the stream. In an effort to draw a comparison between the 1899 and 2000 plan view, the 1899 map was geo-rectified using three identifiable landscape features. While the maps did not overlay exactly, a relative comparison can be drawn between the stream alignments in 1899 and 2000. The overlay was used to compare the stream's position in the valley along the current railroad track alignment and near the full culvert. Both locations suggest that in 1899 the creek channel may have been positioned more to the center of the valley rather than against one side of the valley as the stream is currently.

A 1948 historical aerial photo comparison in Figure 2-4 confirms the shift in the channel alignment at the location of the full and half culvert (75+00 – 84+00). A similar shift in the channel alignment was observed in Reaches 17 – 19 (131+00 – 140+00) where debris slides and overburden material placed in and adjacent to the stream has pushed the stream to the south side of the valley likely at a higher elevation. No pre-development aerial imagery is available for the lower reaches of the Creek because by the time of the 1948 photo, the creek had already been realigned to accommodate the rail lines.



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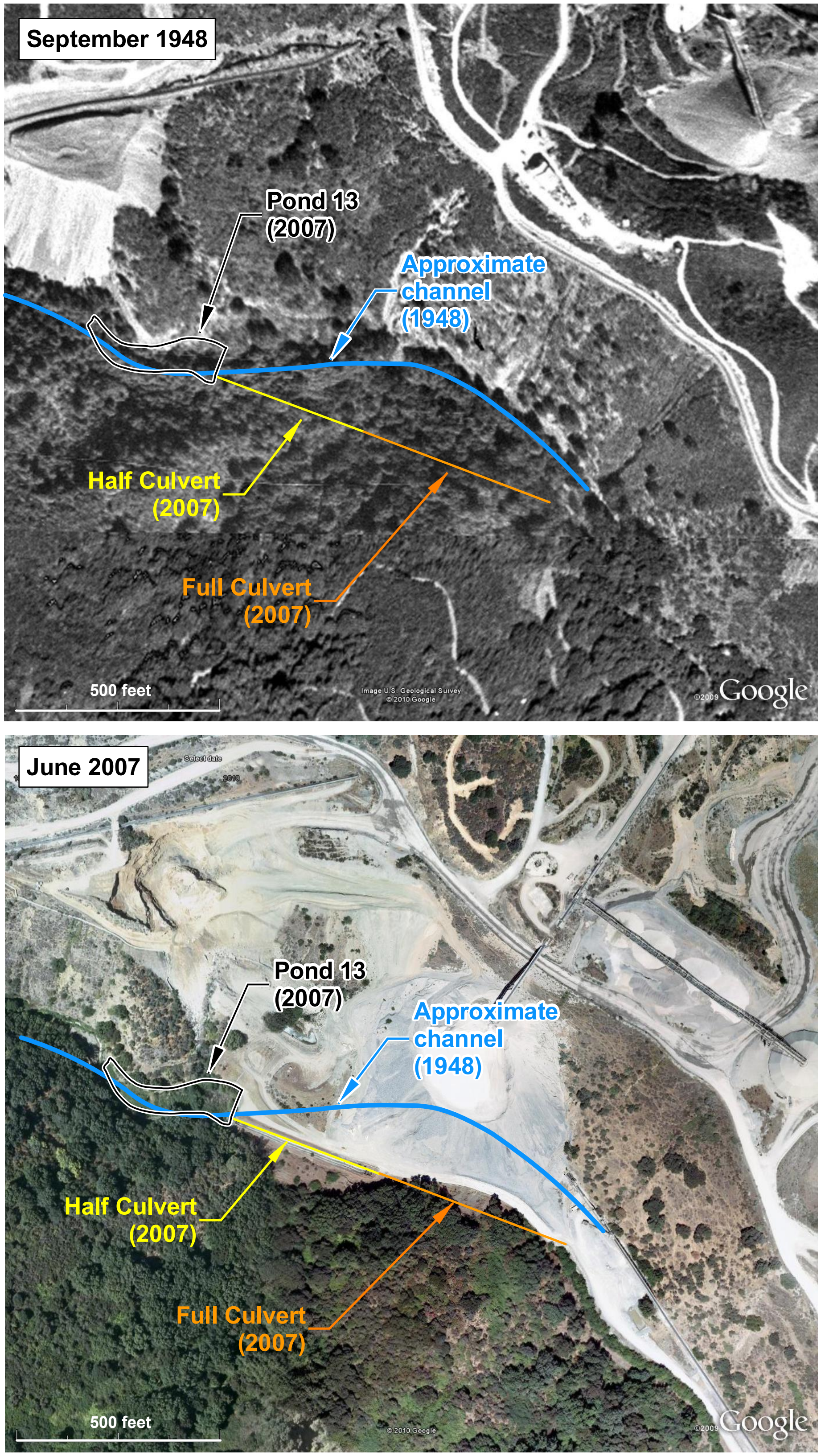
Permanente Creek Long-term Restoration Plan

Figure 3-2
1899 USGS Historical Topographic Map



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URS	Lehigh Southwest Cement Company Permanente Creek Long-term Restoration Plan	**Figure 2-2** Reaches 11 and 12 (full and half culverts), 1948 and 2007 channel alignment comparison

2.3.2 Profile

The thalweg of the Creek within the project area was surveyed for the Phase 1 Report. During the 2009 assessment, select portions of the project area were resurveyed to evaluate whether significant degradation or aggradation occurred in the intervening years. Areas that appeared to exhibit high potential for these processes were selected for the resurvey. The four reaches resurveyed in 2009 and a summary of the changes observed is provided in Table 2-1.

Table 2-1 Summary of resurveyed reaches

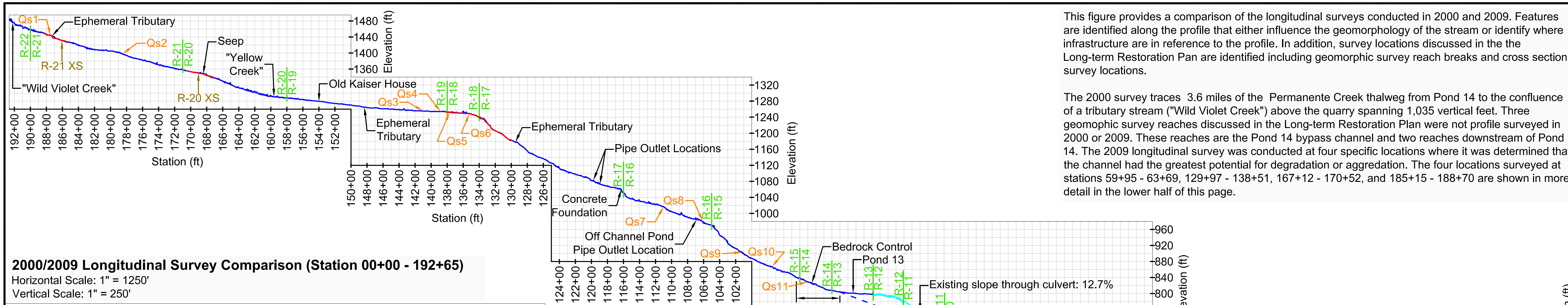
2009 Resurveyed Reach		
Stations	**Length (LF)**	**Change Between 2000 and 2009**
59+95 to 63+69	374	Entire reach: average 0.5 foot of degradation
129+97 to 138+51	854	135+50 to 138+40: 0.5 to 5 feet of degradation through fine sediment deposits
167+12 to 170+52	340	167+12 to 169+28: 0.5 to 1.2 feet of degradation
185+15 to 188+70	355	185+15 to 185+92: 1.4 feet of deposition from upstream Q_s1 material 186+79 to 187+31: 4.5 feet of degradation through Q_s1 material

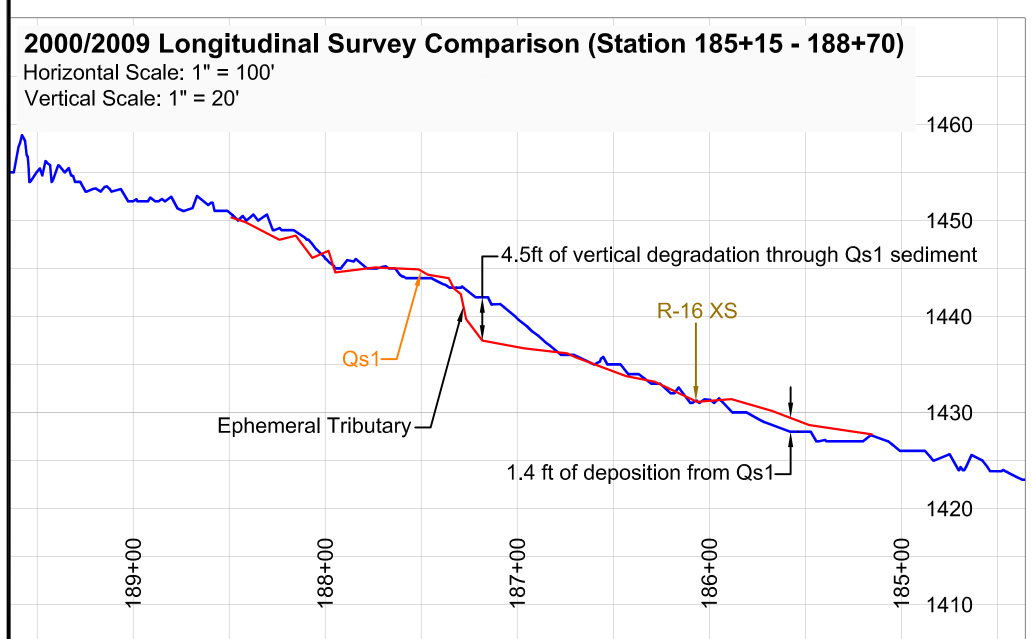
LF = linear feet

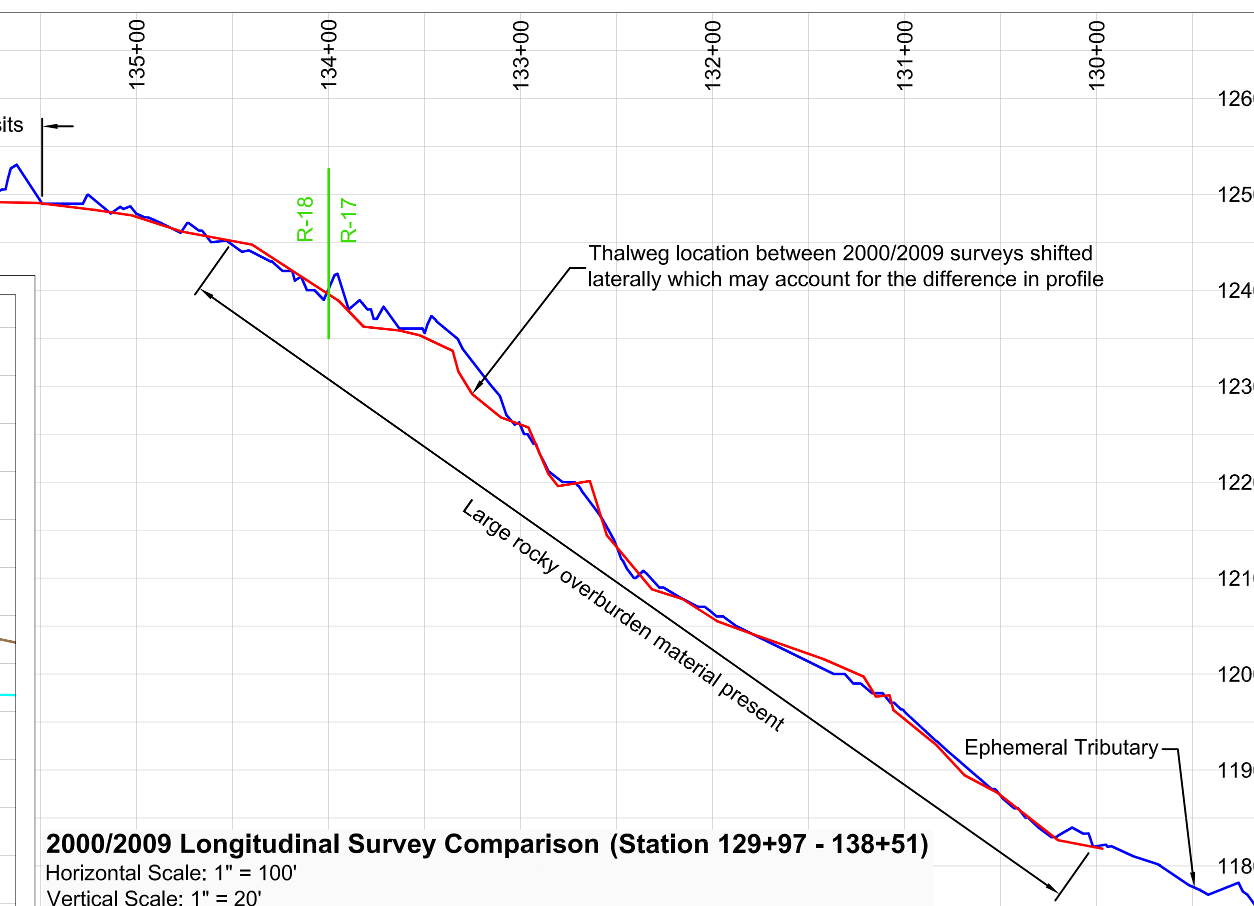
Figure 2-5 presents a comparative longitudinal profile of the stream thalweg showing 2000 and 2009 surveys. Predominantly, the resurveyed reaches experienced thalweg degradation of approximately 0.5 foot. In the reach from Stations 135+50 to 138+40, the 5 feet of degradation cited in the table occurs in two localized areas near Stations 135+63 and 136+00; the degradation does not occur over a long distance. The 4.5 feet (Stations 186+79 to 187+31) of degradation through Q_s1 deposits can be seen in Figure 2-6. Based on the profile and field observations, it appears that the material eroded from this area has deposited in the reach from Station 185+15 to 185+92.

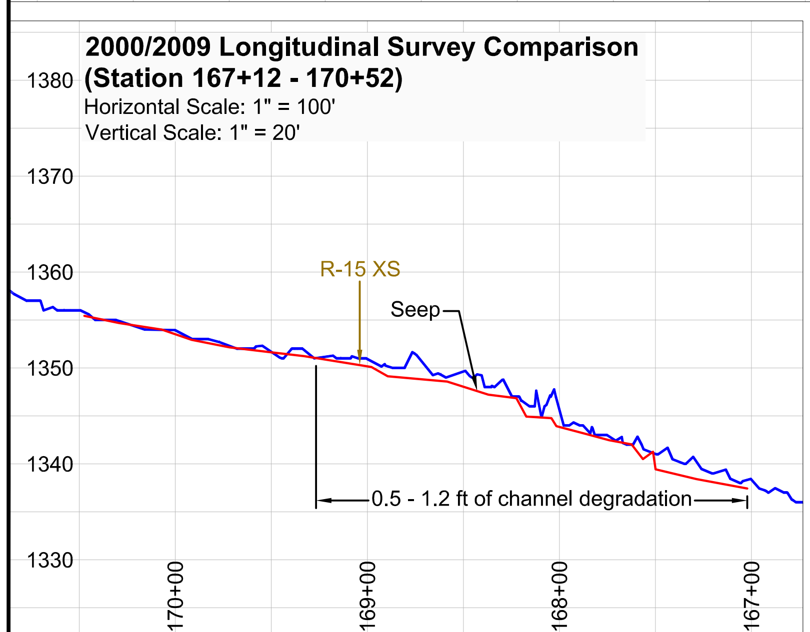
This figure provides a comparison of the longitudinal surveys conducted in 2000 and 2009. Features are identified along the profile that either influence the geomorphology of the stream or identify where infrastructure are in reference to the profile. In addition, survey locations discussed in the the Long-term Restoration Pan are identified including geomorphic survey reach breaks and cross section survey locations.

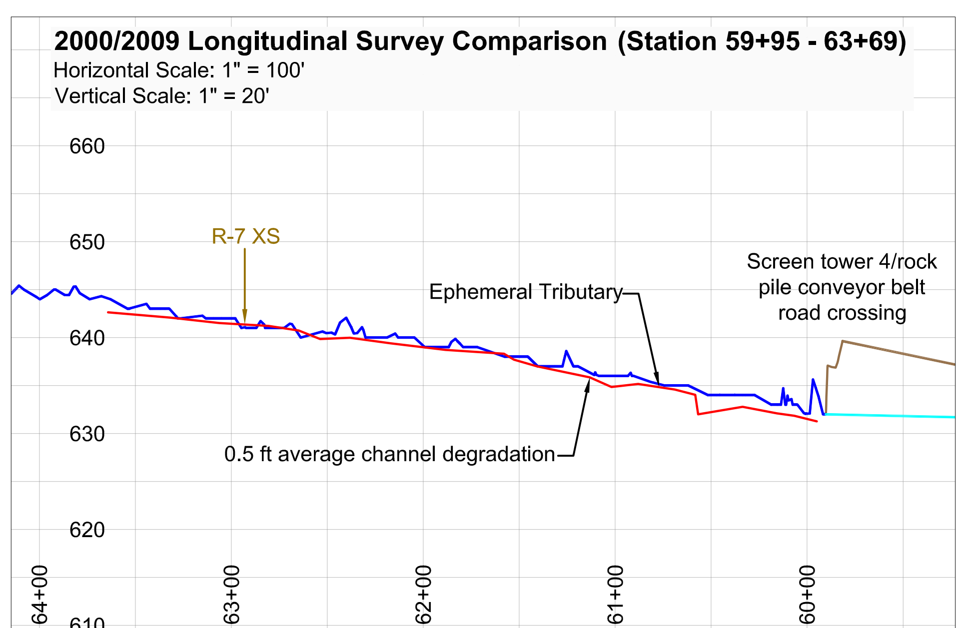
The 2000 survey traces 3.6 miles of the Permanente Creek thalweg from Pond 14 to the confluence of a tributary stream ("Wild Violet Creek") above the quarry spanning 1,035 vertical feet. Three geomophic survey reaches discussed in the Long-term Restoration Plan were not profile surveyed in 2000 or 2009. These reaches are the Pond 14 bypass channel and two reaches downstream of Pond 14. The 2009 longitudinal survey was conducted at four specific locations where it was determined that the channel had the greatest potential for degradation or aggredation. The four locations surveyed at stations 59+95 - 63+69, 129+97 - 138+51, 167+12 - 170+52, and 185+15 - 188+70 are shown in more detail in the lower half of this page.











2000 Thalweg Profile	Culverts (estimated from 2000 thalweg profile)
2009 Thalweg Profile	Road-Culvert Fill Profile (estimated from 2000 thalweg profile)
Proposed Step Pool Profile	Geomorphic Survey Reach Break

Qs1 Sediment Source

R-16 XS Reach Cross Section Survey Location

Vertical Datum: NGVD 29
(Surveyed from Santa Clara Valley Water District benchmarks)

URS

Project No.26817215

LEHIGH SOUTHWEST CEMENT COMPANY

Permanente Creek Long-term Restoration Plan
Pemanente Creek Longitudinal Profile

FIGURE 2-5

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Figure 2-6 Channel cut through Q_s1 material

In the remaining areas, where minor differences between the 2000 and 2009 thalwegs exist, they appear to be the result of differences in the selected locations of individual survey points. When boulders and large cobbles are present, different interpretations of the flow line of the channel can result in survey differences.

The stream profile through reaches 11 and 12 (the full and half culvert between stations 75+75 to 85+00) is straight and steep at 12.7 percent. The creek profile was recreated from the 1899 topographic map to determine if the profile through the culverted area has always been steep or was steepened by the Quarry operations. The 1899 profile indicates that the profile ranged from 6 to 32 percent between reaches 11 and 12, with an average slope of 11.7 percent (Figure 2-6). Given that the stream length was longer at that time and had not been straightened or culverted, the results indicate the likely presence of bedrock in the streambed that created a series of step pools, chutes, or falls.

Figure 2-7. 1899 longitudinal profile of Permanente Creek recreated from the 1899 USGS 15-minute topographic map.

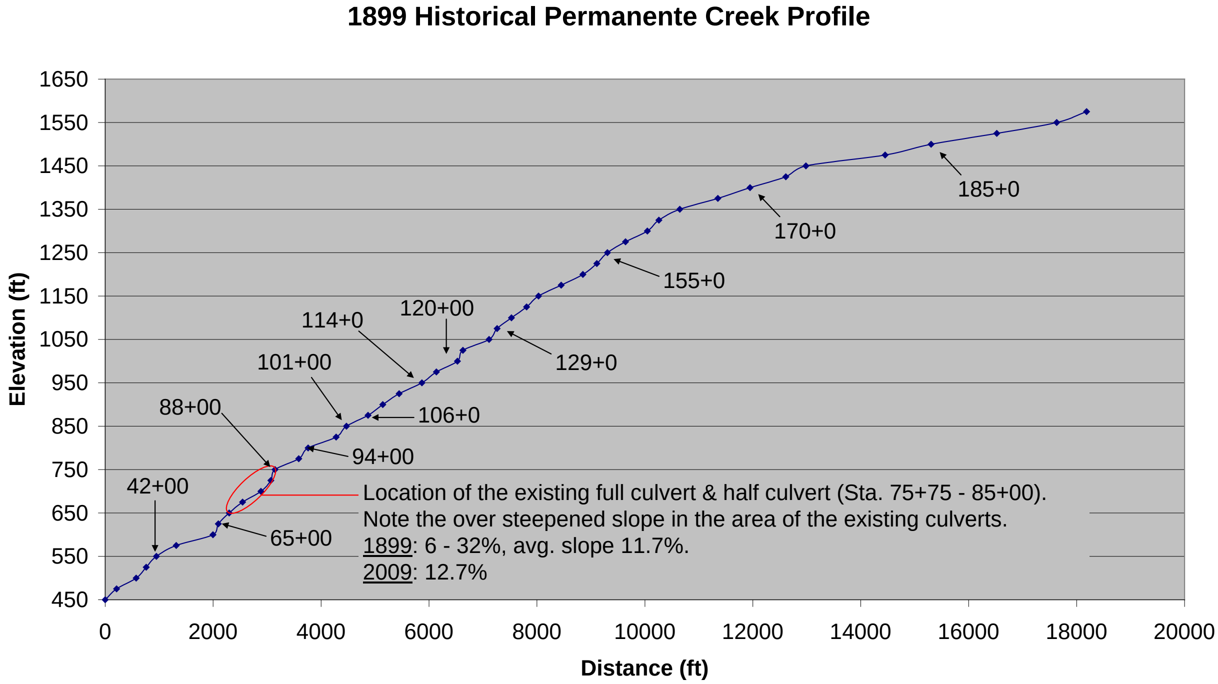

Figure 2-7 Historical Permanente Creek profile

2.3.3 Cross-Sections

Three cross-sections were surveyed during 2009 at Stations: 62+92, 169+03, and 185+95 (locations shown in Figures 2-5 and 3-1. The 2009 cross-sections were compared to cross-sections derived from the contours of the 2000 topographic survey (see Figure 2-8, Figure 2-9, and Figure 2-10. Bankfull data, such as area, width, and depth, were calculated for both the 2009 and the derived 2000 cross-sections using the 2009 bankfull elevations. Table 2-2 summarizes the comparison data.

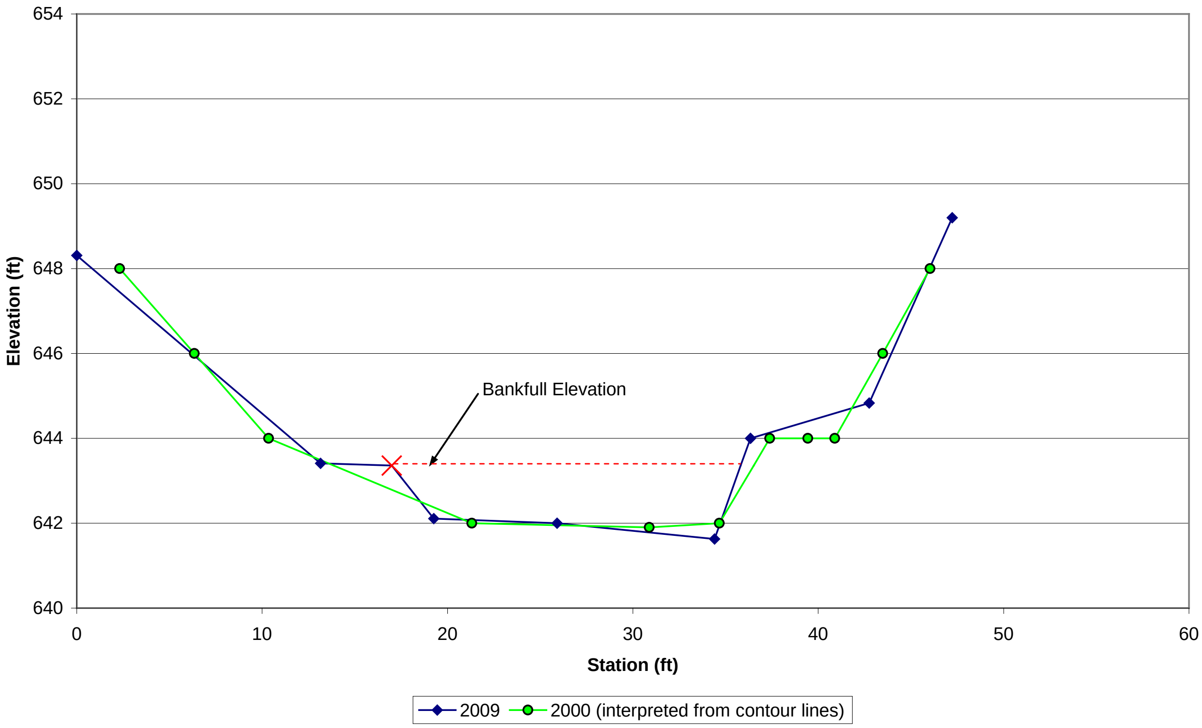

Figure 2-8 Station 62+92 (Reach 9) cross-section comparison

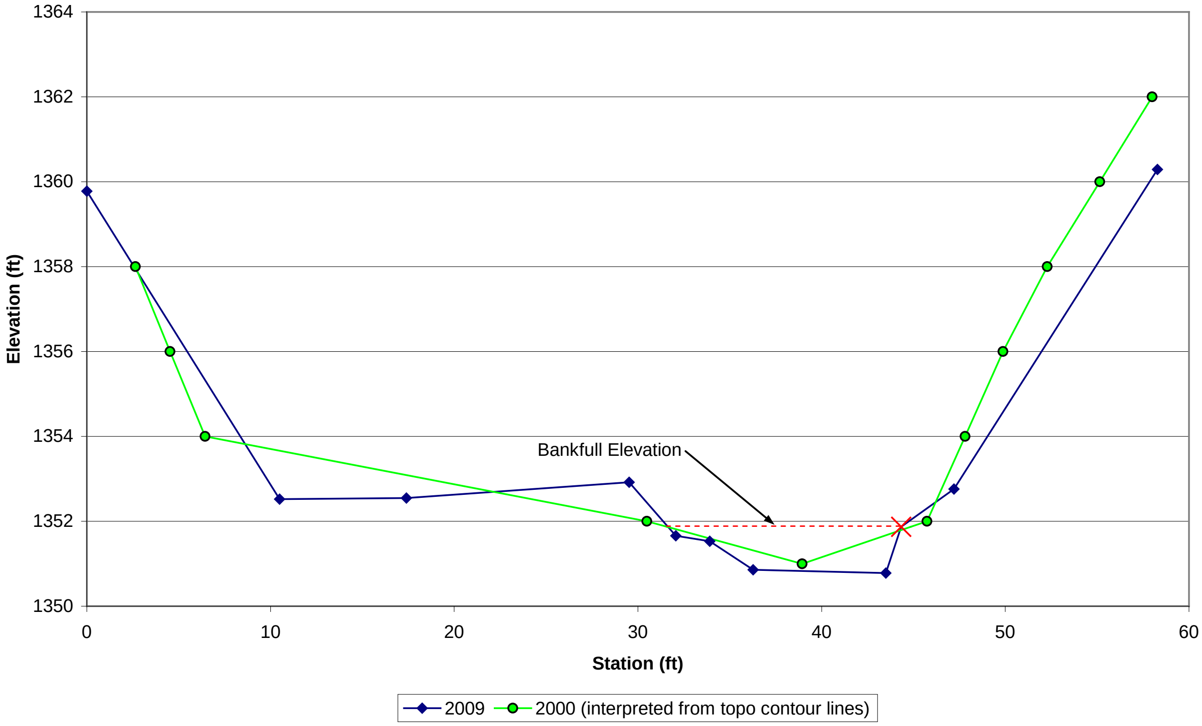

Figure 2-9 Station 169+03 (Reach 20) cross-section comparison

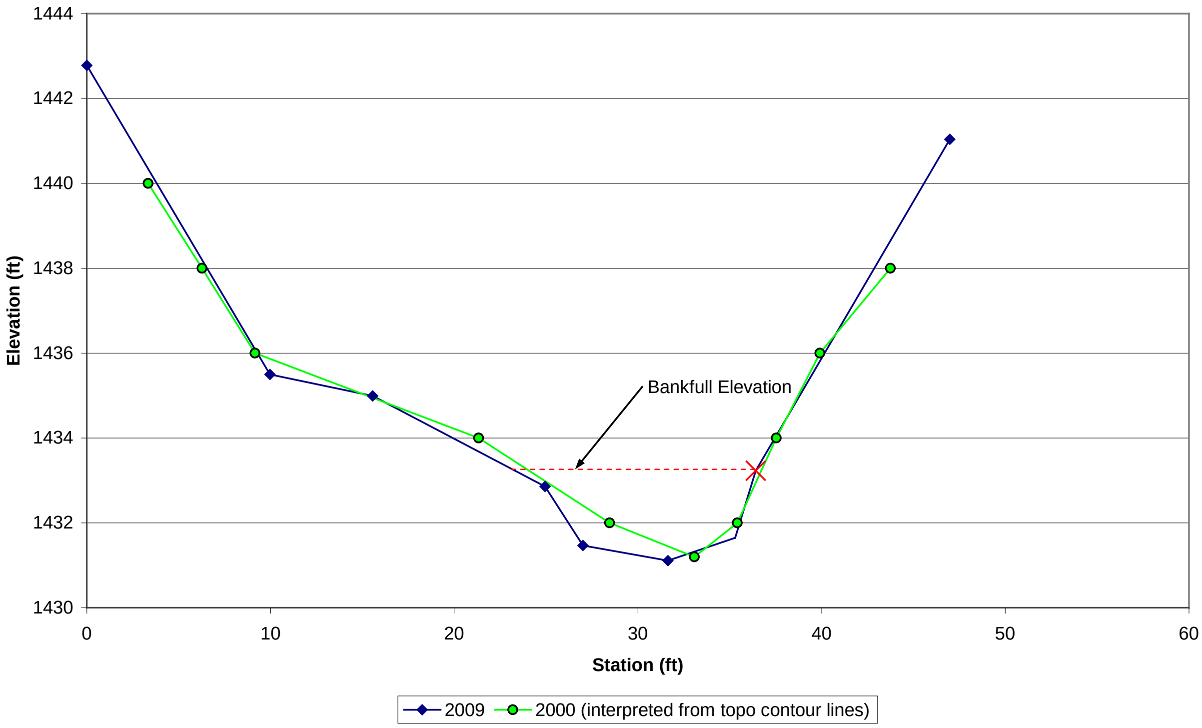

Figure 2-10 Station 185+95 (Reach 21) cross-section comparison

Table 2-2 Summary of cross-section data

Station	Year	BKF area cumulative		BKF width		BKF mean depth		BKF max depth		Width/depth ratio	
		(SF)	% Diff.	(ft)	% Diff.	(ft)	% Diff.	(ft)	% Diff.		% Diff.
62+92	2009	24.45	-3%	18.83	-17%	1.30	+17%	1.73	+27%	14.50	-29%
	2000	25.15		22.66		1.11		1.36		20.41	
169+03	2009	21.49	--	12.69	--	1.69	--	1.09	--	7.50	--
	2000	** insufficient survey data to interpolate BKF data **									
185+95	2009	19.14	+29%	13.10	+4%	1.46	+24%	2.12	+4%	8.97	-17%
	2000	14.83		12.64		1.17		2.03		10.77	

BKF = bankfull
ft – foot/feet
SF = square feet

The cross-section data show an insignificant decrease in cross-sectional area at Station 62+92. While the width and depth at Station 62+92 appear to show significant change, it is probable that little actual change has occurred and that the differences are a result of the lack of detail in the 2000 topographical data used for the comparison.

Bankfull data for the year 2000 could not be calculated for Station 169+03 because the 2000 topographical data is of insufficient resolution to discern the cross-section shape.

Station 185+95 has seen little change in bankfull width and depth, but cross-section shape has changed sufficiently to produce an increase in the bankfull cross-sectional area and mean depth. This is likely interrelated with the profile changes discussed in Section 2.3.2 and the stabilization of material deposited from Q_s1.

2.4 RESULTS OF GEOMORPHIC ASSESSMENT

This section describes the geomorphic characteristics within each of the 22 numbered and assessed stream reaches. Each reach is identified by a number, shown in brackets. Some reaches are culverts or engineered channels, lacking assessable geomorphic features typically used for classifying stream types, however they are labeled as reaches descriptive purposes. A full table of geomorphic data can be found in Appendix D.

[1] Offsite; Downstream of Outfall and Bypass Confluence (Stations N/A)

Length (ft)	Classi-fication	Pfankuch Rating
N/A	C4b	Good

This reach is offsite and was assessed to understand downstream conditions and their effect on restoration activities (see Figure 2-11). The channel appears to have downcut and become disconnected from its former floodplain. However, it has widened sufficiently to build benches within the channel, and it is moderately stable at its current elevation.

Figure 2-11 Looking downstream on Reach [1]

[2] Pond 14 Outfall Channel (Stations N/A)

Length (ft)	Classi-fication	Pfankuch Rating
100	G4	Poor

This reach is below the sluice-gate outfall of Pond 14. The pond's outfall channel runs for approximately 100 feet before it ties into the main channel. The channel includes a headcut approximately 8 feet high, a deep scour hole, vertical banks, and a 90° bend with undercut banks (Figure 2-12). The headcut is approximately 25 feet downstream of the sluice gate. A potential trigger for the headcut is likely the result of clear water discharge from Pond 14 flowing down an over-steepened hillside/bank that was not a former stream channel (thus lacked any sediment/gravel sorting or channel armoring). Combined with a nickpoint or break in slope between the pond outlet and the confluence with the main channel this flow could easily cause a headcut and channel degradation. Clear water discharge (lacking sediment and bedload) from the pond has a higher capacity to erode and carry away sediment than water transporting and replacing the full gradation of streambed particles that maintain the channel roughness and integrity. The headcut has potential to erode the Pond 14 weir if the four trees between the headcut and the weir are compromised by scour erosion or windfall.

Figure 2-12 Headcut downstream of the Pond 14 weir

[3a] Pond 14 (Station: 0+00 to 3+00)

This pond (see Figure 2-13) can be an offline pond or an online pond depending on how the overflow weir on Pond 22 is adjusted. During high flows, both Pond 14 and its bypass channel receive flow.

Figure 2-13 Looking downstream along Pond 14

[3b] Pond 14 Bypass Channel (Station: 0+00 to 3+00)

Length (ft)	Classi-fication	Pfankuch Rating
300	G4	Good

This reach has been confined to a narrow space between the hillside to the north and Pond 14 to the south. The channel is separated from Pond 14 by a narrow earthen berm. The channel is deep and straight with steep to vertical banks (see Figure 2-14).

Figure 2-14 Looking upstream at the confluence of Reaches [1] and [3b]

[4] Pond 22 **(Station: 3+00 to 5+25)**

This reach has been impounded by in-line Pond 22. The pond has become silted in with significant amounts of sediment, and the Creek has cut a low-flow channel across the pond's length. The bottom is highly vegetated and limits the ability to remove the sediments. A geomorphic assessment was not conducted on this reach because of its artificial nature and lack of a bankfull channel.

[5] Pond 22 to Railroad Crossing **(Station: 5+25 to 6+20)**

Length (ft)	Classi-fication	Pfankuch Rating
95	F4	Fair

This short reach connects the culverts under the railroad tracks to the upper end of Pond 22. The channel is entrenched due to the access road and railroad tracks and in a state of fluctuation due to what appears to be frequent events of sediment inundation in the active channel causing channel widening and braiding within the entrenched flood-prone area. Channel instability is caused by numerous factors: a sediment wedge that extends upstream from Pond 22, an inability of vegetation to become established along the active channel banks. The major sediment sources are likely from nearby upland areas and sediment ponds (e.g., the railroad tracks, Ponds 19, 20, and 21, upland drainage from the northwestern portion of the Facility, Pond 30, and deep hillslope rill erosion at the culvert outlet of Pond 30). Turbid stormwater runoff discharge to the Creek near Station 6+00 (Q_s14) was observed during moderate rainfall events in 2009 and 2010 (Figure 2-15). The level of sediment contribution from this source and other sources will be addressed in detail in the proposed sediment source study. Corrective actions to prevent or reduce the sediment contribution to the creek will be administered pursuant to the SWPPP.

Figure 2-15 Reach [4] near Station 6+20

Left: Looking upstream towards railroad crossing culverts above Reach [4] near Station 6+20 (2009). Right: Discharge outlet from Pond 30 and resulting rill erosion delivering sediment at station 6+20 (2010).

[6] Concrete Trapezoidal Channel **(Station: 6+20 to 37+00)**

This reach has been highly manipulated with a series of three culverted road crossings and concrete-lined trapezoidal channels. This reach also includes the culvert under the railroad tracks (Station 6+75 to 7+50). A geomorphic assessment of this reach was not conducted due to the lack of natural stream features. This reach is restricted by the location of Union Pacific property on the northern side and hill slopes on the southern side.

[7] Materials Storage Area to Road Upstream of Dinky Shed (Station: 37+00 to 41+75)

Length (ft)	Classi-fication	Pfankuch Rating
500	A4	Good

Due to its location at the Facility, directly adjacent to operations, this reach is channelized and does not have access to its original floodplain. This reach includes two culverted road crossings. However, the bed has stabilized in this position and the banks are stable and vegetated (see Figure 2-16). A short portion of this reach near the road crossing has widened and built a small, vegetated floodplain within the old channel.

Figure 2-16 View of Reach [7] near Station 37+50

[8] Road Upstream of Dinky Shed to Conveyor Crossing (Station: 41+75 to 59+00)

Length (ft)	Classi-fication	Pfankuch Rating
1,650	A4	Good

Due to its location at the Facility, directly adjacent to operations, this reach is slightly channelized in that it does not have access to its original floodplain and it is leveed off from the adjacent road. However, the bed has stabilized in this position and the banks are stable and vegetated. This reach runs along the embankment below Screen Tower No. 4, which was identified in the 2000 report as a problem area. The 2009 assessment indicates that the embankment is approximately 95 percent stable and the remaining area is stabilizing. The embankment no longer appears to be a significant sediment source. Pond 9 discharges into this reach, and during runoff events contributes to elevated turbidity in the channel (Q_s13).The level of sediment contribution from this source and other sources will be addressed in detail under the proposed sediment source study. Corrective actions to prevent or reduce the sediment contribution to the creek will be administered pursuant to the SWPPP.

[9] Conveyor Crossing to Parallel Buried Culvert (Station: 59+00 to 69+00)

Length (ft)	Classi-fication	Pfankuch Rating
900	B4c	Fair

This reach begins with the two culverts under the conveyor crossing. Bank erosion has been observed on the upstream side, and the banks are hardened by tractor-tire retaining walls. The right culvert is partially blocked at the upstream end, and fully blocked at the downstream end. The banks immediately downstream of the culverts are also vertical.

The reach upstream of the culverts has been confined to the southern side of the valley by roadway fill; however, the bed and banks are stabilizing in their new location and the channel has built bankfull benches at most locations (see Figure 2-17). The lower portion of this reach is influenced by a sediment fan (Q_s12) on the southern side of the channel. The geotechnical exploration roads in the upper watershed appeared to be the source of the sediment in 2009; however, a new larger fan of fine gravel was identified in 2010, extending from a storage area upstream along the tributary (Figure 2-18). The alluvial fan has expanded over the floodplain to begin delivering sediment and gravel to Permanente Creek during runoff events. The level of sediment contribution from this source and other sources will be addressed in detail under the proposed sediment source study. Corrective actions to prevent or reduce the sediment contribution to the creek will be administered pursuant to the SWPPP.

Figure 2-17 Looking upstream near Station 63+00

Figure 2-18 Looking downstream at an alluvial fan from an ephemeral drainage near Station 62+00

[10] Parallel Buried Culvert to Full Culvert (Station: 69+00 to 76+00)

Length (ft)	Classi-fication	Pfankuch Rating
700	A3	Good

A large culvert parallel to the channel is buried in the south slope along this reach. It appears that this reach may have been culverted in the past. However, no flow currently passes through the culvert, and the inlet appears to be buried under riprap near station 74+50. The Creek has completely bypassed the culvert and is stabilized in a new channel adjacent to the culvert (see Figure 2-19). Portions of the side of the buried culvert have been exposed in places; however, the culvert does not threaten the integrity of the channel. The channel has been confined along the south slope of the valley by the roadway fill, which contributes to a steeper channel slope. Concrete and riprap rubble have been placed at the outlet of the full culvert to increase the stability of the banks. The northern bank of the creek has been hardened with concrete riprap, and both banks of the creek have been colonized with alders since the 2000 assessment.

In the 2000 assessment, an eroded bank on the southern side of the Creek near Station 75+00 was identified. However, during the 2009 assessment, this bank was stable and vegetated. During a subsequent follow-up visit in January 2010, six small slumps (each less than 0.5 cubic yard) were observed on the steep bank on the southern side of the creek. Four of the slumps deposited directly into Permanente Creek, the other two slumped onto a bench above the channel. All of these slumps were natural in origin, not the result of the Facility operations (which occur on the northern side of the creek).

Figure 2-19 Looking downstream at Reach [9] from within the dry parallel culvert near Station 74+00

[11] Full Culvert, [12] Half-Culvert, and [13] Pond 13 (Station: 76+00 to 90+00)

These reaches are characterized by the full culvert, the half culvert, Pond 13, and the channel immediately upstream (a portion of which was once a part of Pond 13 prior to channel sedimentation). No geomorphic assessment was performed in this reach due to its manipulated nature. However, it should be noted that the Creek upstream of Pond 13 had been experienced a headcut initiated by excavation of the pond during sediment clearing (URS 2000), has built a stable, meandering channel with a floodplain (see Figure 2-20). Excavated side slopes along the access road (former stagecoach road) on the southern side of the creek remain steep and mostly unvegetated, but the Creek appears to be mostly unaffected by these side slopes. The relatively short slope (less than 15 feet long) and rocky soil contribute little sediment to the creek, thus are no longer a significant sediment source to the creek. The rock pile extends over the full culvert and lies adjacent to the half culvert.

Figure 2-20 Looking upstream of Pond 13 near Station 90+00

[14] Above Pond 13 **(Station: 90+00 to 94+00)**

Length (ft)	Classi-fication	Pfankuch Rating
400	A3	Good

This reach includes the "headcut" that was noted in the 2000 assessment. However, during the 2009 assessment, no headcut was found in the field, but the bedrock control in the channel was noted. The bedrock control, as noted in the 2000 assessment, is at a gully entering from the northern side of the channel near Station 93+00 (Q_s11). The gully is also controlled by bedrock at the confluence. It appears that the Creek has stabilized its bed around this bedrock control. Vertical stream banks between 1 and 3 feet high remain for short distances in a few locations. Most of the vertical banks are outside of the active channel, and thus are subject to less frequent erosive flows. No signs of recent erosion contributing significant sediment to the stream were observed in 2009 in this reach.

[15] Upstream of Primary Crusher **(Station: 94+00 to 105+00)**

Length (ft)	Classi-fication	Pfankuch Rating
1,100	B2a	Poor

This reach is affected by old debris slides and drainage from the primary crusher, which have coarsened the bed material and steepened the slope. Although this reach received a 'poor' Pfankuch rating, the channel is moderately stable and does not exhibit signs of degradation or aggradation. The 'poor' rating results from the low amount of vegetative cover on the old debris slopes, the steepness of the debris slopes, and the coarsened bed material, and it is unrelated to the channel form condition. The debris slopes appear to be stabilizing as fine sediment has washed away over the years and some vegetation has established.

An erosional drainage at Station 97+50 (Q_s10) is a problem area that was identified in 2000 as being of a somewhat more severe nature than it is currently. The old erosion is mostly stable due to a lack of run-on from the Quarry area and establishment of some vegetation. Upper portions of the gully are somewhat active as minor erosion and sloughing of loose bank material is evident. The alluvial fan noted in the 2000 assessment is no longer significant because it is stabilizing and vegetating. Only a minor amount of runoff has been observed from the gully during a heavy rain event, and much of the discharge was clear, with little or no sediment.

The old debris slide at Station 101+50 (Q_s9) is no longer a significant source because it has eroded to bedrock in most locations and some vegetation has become established in the bed and on the banks of the gully, providing some bank stabilization. In addition, the Facility installed measures to prevent runoff from entering the gully slope from the primary crusher. Runoff from the crusher area is redirected to off-channel pre-settlement pond 13A (Appendix A, Figure 1-3.8).

[16] Upstream of Primary Crusher to Old Crusher Foundation(Station: 105+00 to 116+00)

Length (ft)	Classi-fication	Pfankuch Rating
1,100	B3	Fair

This reach is affected by the outfall from an off-line sedimentation pond. This reach is relatively stable (see Figure 2-21) and the old overburden slopes are stabilizing as most of the fine sediment has washed away in years past and some vegetation has become established on the slope. The old debris slides at Stations 106+00 (Q_s8) and 111+00 (Q_s7) are no longer significant sources since the gullies have eroded to bedrock in most locations and some vegetation has become established in the bed and on the banks, stabilizing portions of the gully. In 2009, new debris slides were observed near station 106+00. This debris slide formed after sheet piles at the top of the slope failed, releasing unconsolidated soil and rock down slope.

Figure 2-21 Stabilizing channel over old debris flow near Station 106+00

[17] Old Crusher Foundation to Downstream End of Unconsolidated Fill (Station: 116+00 to 134+00)

Length (ft)	Classi-fication	Pfankuch Rating
1,800	B3/B3a	Good

This area is characterized by historic overburden material, large rock piles, and steep, partially unvegetated slopes along the northern side. The ground cover conditions have limited vegetation to sparse populations of drought-resistant plant species. Despite the lack of vegetation and significant fill in the valley, the Creek appears to have predominantly stabilized with alternating sections of steeper and shallower gradients. A 150-foot portion of this reach (Station: 131+44 to 132+94) is experiencing some upstream migration. As discussed above, this slope has migrated approximately 4 feet upstream since the 2000 assessment. Despite the large amounts of overburden in the creek bottom, much of the fine sediment has washed downstream, leaving a surface protected from further erosion by the larger remaining rock (Figure 2-22).

Creek flow is mainly subsurface through this reach. During the lower flows (approximately 10 percent of bankfull) observed in October 2008, the Creek had flow in the channel above and below this reach, but this reach was dry. However, after a 4-inch rain event on February 16, 2009, and with flows at approximately 50 percent of bankfull, this reach was flowing with approximately the same flow as the upper and lower reaches (see Figure 2-22).

Figure 2-22 Looking downstream along Reach [17] near Station 122+50

[18] Downstream End to Upstream End of Unconsolidated Fill(Station: 134+00 to 138+00)

Length (ft)	Classi-fication	Pfankuch Rating
400	B4c	Fair

This reach is characterized by the overburden slope, which has narrowed the valley sufficiently to straighten the channel (see Figure 2-23). The valley fill acts as a sediment plug and grade control for upstream areas. The channel has low, vegetated bankfull benches on both sides. The overburden slope is unvegetated and a potential sediment source for the Creek. Potions of the slope near station 135+00 consist of small gravel mixed with a smaller fraction of fine sediment that sloughs down towards the creek or is mobilized when rainfall is intense enough to generate surface flow (Figure 2-23). The coarse bed material is embedded with finer materials from upstream. The old debris slides at Stations 135+00 (Q_s6) and 138+00 (Q_s5) are no longer significant sources of sediment because runoff from the Quarry operation no longer drains to the gullies or the slope. Vegetation has also become established in the gully and on the banks at Q_s5, helping stabilize remaining overburden material.

Figure 2-23 Looking downstream through Reach [18] near Station 135+00

[19] Upstream End of Unconsolidated Fill to Kaiser House (Station: 138+00 to 158+00)

Length (ft)	Classi-fication	Pfankuch Rating
1,900	D4/6	Poor

This reach is characterized by a wide valley flat with approximately 20-year-old woody vegetation and trees. Evidence shows that this area was previously inundated with sediment, but conditions appear to have stabilized as the area revegetated with willows, blackberries, nettles, and other vegetation. The stream is a low gradient, shallow, wetland-type drainage (see Figure 2-24), but it is developing a gravel substrate in some areas and these areas may become riffles. The reach rates as ‘poor’ due to its braided nature. The stability of the channel will likely improve in time as large flows scour sediments and form a single bankfull channel. The old debris slide at Station 139+00 (Q_s4) noted in the Phase 1 Report is stabilizing and is no longer a significant sediment source. The old debris slide at Station 141+20 (Q_s3) still appears to be a source of sediment to the Creek. The sediment is the result of a slump of loose material that had been pushed over the hillside. Surface flow is causing additional rills carrying sediment to the floodplain (Figure 2-25). The level of sediment contribution from this source and other sources will be addressed in detail under the proposed sediment source study. Corrective actions to prevent or reduce the sediment contribution to the creek will be administered pursuant to the SWPPP.

Figure 2-24 Reach [19] near Station 140+00

Figure 2-25 Sediment source near Station 141+20 (Q_s3)

[20]Kaiser House to Debris Slide Area **(Station: 158+00 to 171+00)**

Length (ft)	Classi-fication	Pfankuch Rating
1,400	A4	Fair

This reach is building bankfull benches within its floodplain. The reach appears to have been previously affected by sediment from upstream debris slides, and terraces of this material as well as an old stagecoach road. The channel is stabilizing (see Figure 2-26). A gully that starts below the upper portion of the Kaiser house road drains to a sediment basin at the base of the Kaiser house road. This gully was eroded by runoff diverted from the upper Quarry Road, however, it no longer conveys sediment or runoff from the Facility to the creek. The sediment basin was lined with grass and contained no sediment or water after a 2-year storm event. The pond discharges to the inside of the road near a turnaround where any flow would spread over the turnaround and filter through the floodplain before entering the creek. This gully was not identified in 2000.

Figure 2-26 View near Station 169+00 on Reach [20]

[21]Debris Slide Area **(Station: 171+00 to 190+00)**

Length (ft)	Classi-fication	Pfankuch Rating
1,900	B4	Fair

This reach is characterized by several debris slides adjacent to the Creek. Most of the material within the valley bottom has been redistributed, and is stabilized in place (see Figure 2-27). The exception is the area starting near the base of the debris slide at Station 187+50 (Q_s1) and continuing for approximately 355 feet downstream (Station: 185+15 to 188+70). As discussed in Section 2.3.2, the profile has downcut from 0.1 to 1.1 feet over the length of this reach, and the slope of the steepest portion at the base of Q_s1 has migrated approximately 12 feet upstream. The old debris slide at Station 178+50 (Q_s2) is still active along the upper slope, but it is no longer a significant source of sediment to the Creek, as most of the fines have already washed away and portions of the slope have begun to revegetate. The old debris slide at Station 187+50 (Q_s1) is no longer a significant source of sediment, as most of the fine-grained material has eroded away and vegetation has become established, stabilizing the slide. Small amounts of sediment may be dislodged as the stream continues to adjust its profile through the debris slide material in the streambed. Most of the down cutting has already occurred; however, the vertical banks will eventually erode to a more stable angle of repose.

Figure 2-27 View near Station 186+00 on Reach [21]

[22]Above Debris Slide Area to End of Reach (Station: 190+00 to 195+00)

Length (ft)	Classi-fication	Pfankuch Rating
500	A4/A1	Fair

This reach is predominantly stable, with some inputs of very large boulders that likely have rolled down from the Upper Quarry Road. Unlike the lower reaches, this reach does not receive sediment from debris slides from the overburden areas, and it is considered to essentially be in reference condition considering the geology of the region (see Figure 2-28). Evidence of natural landslides and treefall appears along both sides of the Creek. These processes are typical hillslope processes in the Santa Cruz Mountains, but they cause this otherwise reference condition system to receive a Pfankuch rating of “fair.”

Figure 2-28 View on Reach [22] near Station 195+00

3.1 INTRODUCTION

The restoration of stream systems involves numerous complex and interrelated processes (e.g., hydrologic, hydraulic, geomorphic, and ecological) and cannot be solely supported by traditional engineering techniques and equations. As a consequence, the future design should use reference reaches from nearby streams, in conjunction with equations and models, to develop, inform, and validate the restoration design.

A reference reach is ideally a stream in dynamic equilibrium with its watershed and land use conditions. Typically, the channel neither aggrades nor degrades, and it maintains its cross-sectional shape, slope, and meander pattern. The stream should also be in good ecological condition (e.g., riparian vegetation, aquatic macroinvertebrate, and fisheries communities), be in the same hydrogeophysical province (i.e., similar rainfall pattern, geologic setting, vegetation communities and geomorphology), and have stream and valley types comparable to the restored system.

Because the ideal reference reach already exhibits the conditions desired for the restored reach and is in a very similar setting and in relatively close proximity to the Creek, it can provide valuable design data (such as pool spacing, glide slopes, step-pool dimensions, etc.). This section provides descriptions of a number of potential reference reaches that have been explored for guidance in restoration design.

3.2 ECOREGIONS

The ecoregions were developed as a tool for ecosystem management, providing a framework for planning and comparing ecological units. The U.S. Forest Service and the Natural Resource Conservation Service have defined and described ecoregions and subregions across the United States (Bailey et al. 1994). The framework begins on a large landscape scale and maps progressively smaller units. The units have increasingly similar biotic and environmental characteristics as the scale becomes finer. Permanente Creek lies in the Central California Coast Section 261A. This section has 12 subsections and the Creek on the Operator's property is predominantly in Subsection 261Af Santa Cruz Mountains. The downstream-most portion of the Creek is in Subsection 261Ag Leeward Hills. Ecoregions were used as a guide in the selection of the reference reaches.

3.3 FIELD OBSERVATIONS

URS conducted field reconnaissance on June 26, 2000, on three nearby creeks. Observations were made on Ohlone Creek to the north, Swiss Creek to the south, and Stevens Creek just south of Swiss Creek. These reaches were revisited in March and April of 2009 and an additional reach on Upper Stevens Creek was added to the review. In November 2010 three additional streams were visited (one surveyed) for a potential reference to Reaches 11 – 13 of Permanente Creek, suspected to be a steep bedrock or cobble/bedrock channel (locations shown on Figure 1-1). Like the Facility site, the reaches examined on these reference creeks (Figure 1-1) are also in Subsection 261Af Santa Cruz Mountains. The following sections update the Phase 1 Report with respect to each stream's characteristics as they relate to their suitability for use as reference areas.

3.3.1 West Fork Permanente Creek (formerly Ohlone Creek)

2000 Observations

West Fork Permanente Creek is just north of the Creek in the Rancho San Antonio Open Space Preserve. West Fork Permanente Creek is a small, ephemeral stream, which at the time of the reconnaissance had very low flow and was dry in places. The creek and its watershed are smaller than Permanente Creek and watershed. The stream corridor was heavily vegetated, thick in places, with little access. The bed material was loose and not bound as observed in Permanente Creek. A large amount of silt was also present. The characteristics of West Fork Permanente Creek were different than those observed along Permanente Creek.

2009 Observations

During the 2009 assessment, two creeks were observed in the Rancho San Antonio Open Space Preserve: one along the Rogue Valley Trail (West Fork Permanente Creek) and one along the Wildcat Loop and Upper Wildcat Canyon Trails (Wildcat Canyon Creek).

Length (ft)	Classi-fication	Pfankuch Rating
N/A	G4	Good

During the observations, West Fork Permanente Creek appeared to be intermittent because it contained flow throughout the observed reach, yet no precipitation had occurred in the 2 weeks prior to the assessment. In comparison to Permanente Creek, West Fork Permanente Creek does not exhibit the calcium carbonate conglomerate, the gravel substrate is a much smaller size, it has a lower gradient and wider valley, and it has an abandoned floodplain terrace approximately 3 feet above bankfull (see Figure 3-1). The reach exhibited small and partially formed bankfull benches within the channel. Due to the variation from the nature of Permanente Creek, this reach is not recommended for use as a reference.

Figure 3-1 Looking upstream along West Fork Permanente Creek

Length (ft)	Classi-fication	Pfankuch Rating
N/A	B4	Fair

Wildcat Canyon Creek appeared to be intermittent because it contained flow throughout the assessed reach and no precipitation had occurred in the 2 weeks prior to the assessment. In comparison to Permanente Creek, Wildcat Canyon Creek does not exhibit the calcium carbonate conglomerate, the gravel substrate is a much smaller size, the gradient is similar, and landslides are typical on the riparian slopes. The trail is right next to the reach, and it is apparent that trail protection measures have somewhat confined the creek in its current location. Several trail bridges and culverts were observed near the assessed reach. Due to the altered and confined nature of the reach, Wildcat Canyon Creek is not recommended for use as a reference reach.

3.3.2 Swiss Creek

2000 Observations

Swiss Creek was observed off of Peacock Court and Swiss Creek Lane. This stream had similar properties to those of Permanente Creek and resembles a Rosgen class “A” or “B” stream type. The channel was narrow and incised. Swiss Creek exhibited similar channel geometry, bed material binding, and exposed conglomerate as Permanente Creek. The cobble and boulder bed material was armored, and transport was limited. The dominant trees forming the riparian woodland canopy consisted of bay, alder, oak, and big leaf maple. The understory layer dominants included poison oak, stinging nettle, and horsetail. Aquatic invertebrates that were observed included water striders, mayflies, and caddis flies, and there were filamentous algae in the stream. The characteristics of Swiss Creek closely match those observed along Permanente Creek.

2009 Observations

Length (ft)	Classi-fication	Pfankuch Rating
N/A	B3a/A3	Fair/Poor

Swiss Creek was observed approximately 500 feet above the Peacock Court crossing because the channel was downcut at the crossing. In comparison to Permanente Creek, Swiss Creek also exhibited the calcium carbonate conglomerate, the channel was also shaped by debris flows and landslides from natural hillside processes, and the valley was similarly narrow and steep, but the sediment composition is somewhat coarser than that of Permanente Creek (see Figure 3-2). Due to the landslides and debris flows, this location of Swiss Creek is not in reference condition. However, it does demonstrate that landslides are characteristic of the area.

Swiss Creek was also observed above and along Stevens Creek Road where the channel was found to be incised, have eroded banks and low bank vegetation, and be impacted by the close proximity of the road (see Figure 3-3).

Neither observed reach is recommended for use as a reference reach.

Figure 3-2 Looking upstream along Swiss Creek above Peacock Court

Figure 3-3 Looking downstream along Swiss Creek near Stevens Creek Road

3.3.3 Stevens Creek

2000 Observations

Middle Stevens Creek is south of Swiss Creek, upstream of the Canyon Picnic Area, and upstream of Stevens Canyon Road. Middle Stevens Creek is significantly different from Permanente Creek. The first reach observed had a higher flow rate, a flatter slope, and is wider than Permanente Creek. The flatter slopes yielded more runs (as opposed to pools and riffles). The bed material consisted mostly of sand and gravel. The bed material was loose and did not indicate signs of binding as observed in Permanente Creek and Swiss Creek. Alternatively, there was iron-colored staining on the rocks in the creek. There was plenty of sediment in the stream, which is available for downstream transport. Moving upstream to steeper reaches, the bed material transitioned from mostly sands and gravel to more cobbles and boulders. The material did not exhibit any binding.

The stream banks were vegetated with little bank erosion or channel incision. The dominant riparian woodland tree species were bay, big leaf maple, alder, and oak. Trout, stonefly larva, aquatic beetles, and cased caddis flies were observed. The characteristics of Middle Stevens Creek were different from those observed along Permanente Creek.

2009 Observations

Length (ft)	Classi-fication	Pfankuch Rating
N/A	B4	Fair

A different location along Stevens Creek was chosen for observation during the 2009 assessment because a smaller and less developed watershed than the Middle Stevens Creek location was desired. Upper Stevens Creek, west of Permanente Creek, was observed in the Monte Bello Open Space Preserve near the junction of the Stevens Creek Nature Trail and the White Oak Trail. The assessed portion of Upper Stevens Creek, upstream of a bridge trail crossing, was in excellent condition with significant newt and aquatic vegetation populations in the channel. In comparison to Permanente Creek, Upper Stevens Creek exhibits similar hillslope and landslide processes, has similar bed material of cobbles and boulders interspersed with some small amounts of sand and silt, has similar riparian vegetation communities, and has steep canyon walls like Permanente Creek, but it does not contain the calcium carbonate conglomerate (see Figure 3-4 and Figure 3-5). Upper Stevens Creek, while being affected by landslides and debris flows, remains in dynamic equilibrium and has been able to accommodate or adjust to the sediment inputs quickly. The trail bridge limits lateral channel adjustment, which has caused some bank scouring both upstream and downstream of the crossing, but the erosion is localized.

The channel scores a 'fair' stability rating due to its steep upper slopes and landslide potential, but these features are necessary for a reference reach to be applicable to Permanente Creek.

If the channel exhibited the calcium carbonate conglomerate, it would be an ideal reference for Permanente Creek. Despite the absence of the conglomerate, the Upper Stevens Creek provides the most appropriate reference reaches because of its exceptional condition and its similarities to Permanente Creek.

Figure 3-4 Looking downstream along Upper Stevens Creek

Figure 3-5 Looking upstream along Upper Stevens Creek

2010 Observations

Length (ft)	Classi-fication	Pfankuch Rating
400	F1b/F3b	Good

Approximately a half mile upstream of the B4 reference reach identified in 2009, a third location on Stevens Creek was surveyed for reference conditions. This reach is located less than a tenth of a mile downstream of where White Oak Trail crosses Stevens Creek. The location was chosen due to the bedrock apparent in the streambed and stable banks and relatively high sinuosity (1.3) for a stream located in a confined canyon. The bed slope at 2.2 percent is lower than the desired 4 – 10 percent slope desired for a reference stream for Reaches 11 – 13 of Permanente Creek.

The channel scores a 'good' bordering a 'fair' stability rating due to its steep upper slopes and landslide and channel debris potential. The active channel is stable with moss growing on boulders and cobble, adequate vegetation and rooting in the banks, and little cutting and deposition. The channel classified as an F-type stream with a slightly steeper slope lending characteristics of a B-type stream, hence the F1b/F3b designation. The morphology suggests that the stream was scoured out by debris flows transitioning from a G1/3 to F1b/F3b which in time will shift to a stable B1/B3. While this reach is not an ideal reference for the purpose intended, in the time frame of the Facility closure it may become a potential candidate as a future reference for other portions of Permanente Creek.

3.3.4 Other Creeks

Three other Creeks were investigated in 2010 in a search to find additional reference reaches: Los Trancos; Peters Creek; and Corte Madera Creek.

The upper reaches of Los Trancos Creek where walked in the Los Trancos Open Space Preserve. Most of the stream was an A or B stream type with portions of the channel having exposed bedrock. While a portion of the stream and a minor tributary shared similar limestone geology with calcium carbonate precipitate present, the banks of the stream where unstable and did not lend itself as a reference.

A small segment of Peters Creek was walked along Peters Creek Trail in the Long Ridge Open Space Preserve near Long Ridge Trailhead 10. This segment of stream was not steep enough with any bedrock channel to be suitable as a reference for Reaches 11 – 13 of Permanente Creek.

A portion of Corte Madera Creek was scoped from Alpine Road driving up the creek to the end of the road from Portola Valley. While there was not enough time left in the day to walk up Corte Madera Creek into the Coal Creek Open Space Preserve, preliminary observations indicate that this stream may be a promising location to search for an A1/3 or B1/3 reference stream for Reaches 11 – 13 of Permanente Creek.

3.4 CONCLUSIONS

Both Swiss Creek and Upper Stevens Creek have similar geomorphology, watershed characteristics, landscape positions, and vegetative communities to Permanente Creek. However, Swiss Creek appears impacted by natural landslides, while Upper Stevens Creek appears to have adjusted to landslides occurring on its upper and riparian slopes. West Fork Permanente Creek, Wildcat Canyon Creek, and Middle Stevens Creek should not be used as reference reaches because their geomorphologies are dissimilar to Permanente Creek. Based on the current knowledge of reference areas and the fact that the calcium carbonate conglomerate found in Permanente Creek will not be available initially but develop over time in the restored reaches, Upper Stevens Creek is recommended for use as a reference reach.

An effort was made to identify a steep cobble/bedrock reference stream for Reaches 11 – 13 of Permanente Creek in 2010. While this one day survey did not result in finding a suitable A1/3 or B1/3 reference stream, Corte Madera Creek in the Coal Creek Open Space Preserve may serve as a starting point for future surveys once a timeframe has been established for the restoration of Reaches 11 – 13 of Permanente Creek. These reaches of Permanente Creek represent a small percentage of the overall restoration area that is buried under deep fill material. It is assumed from the slope changes of the impacted area that an A1/3 or B1/3 reference stream would be appropriate, however this is speculative until the buried stream channel is unearthed. It is believed that when the time arrives for this Plan to be put to action that an appropriate reference stream will be identified suitable to this small segment of Permanente Creek.

This Plan describes a conceptual creek restoration plan to satisfy Item C-9, Phases 2 and 3, of the Order. Section 4 discusses the issues, preferred and alternate restoration recommendations for each of the 22 Permanente Creek reaches on the Facility. Recommendations incorporate a combination of broad scale and localized restoration techniques, creating a design to achieve restoration goals and implement the objectives. General Recommendations are presented for 3 common creek impairment categories: channel modification, sediment sources, and in-stream infrastructure. A short design overview and detailed recommendations for each of the 22 specific reaches follows. Section 4 concludes with a discussion of implementation prioritization protocols and selection criteria and an implementation schedule.

4.1 RESTORATION GOALS AND OBJECTIVES

The restoration plan goals and objectives were developed based on the Order and on the beneficial uses for Permanente Creek listed in the Basin Plan.

Restoration Goal

The Long-Term Restoration goal is to develop and apply feasible restoration activities on specific anthropogenic conditions that will improve the ecological and hydrological function of the Creek.

Restoration Objectives

The following objectives were used to guide the development of the Plan. As implementation will generally occur in the future, restoration recommendations will be designed based on conditions and constraints in existence at that time.

- Restore stream structure and substrate where affected by anthropogenic conditions.
- Maintain or improve hydrologic and biological functions by improving channel morphology and bank stability in areas affected by anthropogenic conditions.
- Establish stream conditions that can naturally adjust over time reaching a state of dynamic equilibrium.
- Stabilize and limit stream-side anthropogenic sources of sediment where access is possible.
- Minimize creation of sediment sources by avoiding disturbance of steep slopes, stable and vegetated areas, or areas in the process of stabilizing and vegetating.
- Promote establishment of riparian corridor comprised of multiple strata of native riparian vegetation.

This plan provides restoration alternatives intended to best achieve the above objectives. At some point in time when these alternatives must move towards a design a discussion will need to occur among the stakeholders to prioritize and decide on the most suited ecological objectives to meet for particular reaches of the stream. For instance in reaches 11 – 13 (full culvert, half culvert, and Pond 13) there may be a large bedrock outcrop that historically inhibited fish passage. If this is discovered to be the case, a decision will need to be made as to whether the restoration design should return the stream to a pre-disturbance condition or utilize existing valley fill to provide fish passage.

4.2 TYPES OF RESTORATION TECHNIQUES

Restoration options are grouped into six categories based on their primary stream benefits. Restoration designs include a combination of broad scale and localized techniques that meet the restoration goal and implement the objectives discussed above. Restoration categories are comprised of multiple techniques available for implementation, as discussed below. The techniques are listed in Table 4-1 and are described in detail and illustrated in Appendix E. Technique selection is based on restoration objectives and site conditions.

Table 4-1 Summary of restoration techniques detailed in Appendix E listed by category

Type	Technique	
Natural channel design	E.1	Channel restoration/realignment
	E.2	Floodplain/bankfull bench creation
In-stream structures	E.3	Cross vanes
	E.4	Step-pools
	E.5	J-hook vanes
Fish habitat structures	E.3	Cross vanes
	E.4	Step pools
	E.5	J-hook vanes
	E.6	Native material revetments
	E.7	Boulder clusters
Fish passage	E.3	Cross vanes
	E.4	Step pools
	E.8	Culvert modification/replacement
Bioengineered bank stabilization	E.3	Cross vanes
	E.5	J-hook vanes
	E.6	Native material revetments
	E.9	Fascines
	E.10	Live pole cuttings/stakes
	E.11	Vegetated rock riprap
	E.12	Native revegetation
Slope stabilization	E.12	Native revegetation
	E.13	Terracing
	E.14	Slope drains
	E.15	Hydroseeding with hydromulching
	E.16	Erosion control mat
	E.17	Geo-cellular confinement system

- *Natural channel design* – Methods use native materials and mimic naturally occurring geomorphic structures (e.g., pools, logs, overhanging roots) to provide in-stream habitat and encourage appropriate riparian habitat. The methods involve designing the stream dimension (cross-section), pattern (meander), and profile (slope) to attain dynamic equilibrium with its water and sediment loads. The method uses reference condition streams as models for the design.

- *In-stream structures* – Stream stabilization techniques use in-stream structures to provide grade control, redirect flow, modify channel slope, and/or modify channel cross-section.
- *Fish habitat structures* – These techniques primarily provide fish spawning and rearing habitat by diversifying flow and providing shelter, shading, and resting areas.
- *Fish barrier removal/fish passage* – Techniques involve removing barriers to fish passage by creating in-stream structures or by demolition of man-made barriers. While fish passage for resident fish populations can be restored on the Facility, fish migration for anadromous populations is currently blocked downstream and off-site by the Permanente Diversion Channel (Cleugh and McKnight 2002).
- *Bioengineered bank stabilization* – These techniques use the natural bank stabilization potential of vegetation and rooted systems to assist with the structural integrity of slopes during vegetation establishment.
- *Slope stabilization* – These are bioengineered bank techniques and erosion controls designed for use on upland rather than riparian slopes.

4.3 GENERAL RECOMMENDATIONS BY TYPE OF IMPAIRMENT

The Phase 1 Report described three primary types of conditions affecting the creek: channel modification, sediment sources, and in-stream infrastructure. This section describes the general approach to restoring these 3 conditions.

Channel Modification

The creek channel has been altered and destabilized by a combination of Facility structures, deposition, and erosion. This Plan recommends natural channel design as the preferred method of restoring hydrological and biological function to disturbed areas. This often involves designing the stream dimension (cross section), pattern, (meander) and profile (slope) to attain dynamic equilibrium with its water and sediment loads. This technique uses native materials and mimics naturally occurring geomorphic structures to provide in-stream habitat and encourage riparian growth, when appropriate. This method uses reference condition streams as models for the design. The removal of infrastructure, such as railroad tracks, access roads, and material storage areas from the valley and floodplain of the creek would facilitate this design method by increasing the area available for channel design.

Sediment Sources

The long-term planning horizon focused on here is generally inconsistent with the need to address sediment sources on a near-term basis. Accordingly, sediment sources will, as noted in Table 4-2, be investigated and analyzed as a part of a sediment source study separate from the Plan and the 99-018 CAO. The sediment study will provide near-term recommendations for reducing sediment loads to the creek. The sediment management recommendations will be implemented as stormwater management controls pursuant to the SWPPP. While this Plan focuses on long-term stabilization of slopes and banks along the creek through the creation or enhancement of riparian vegetation and channel design, it does identify potential solutions to some of the sediment sources that would be addressed in the sediment source study and SWPPP.

In-stream Infrastructure

Removal or improvement of these structures will aid fish passage. In-stream structures include in-line sedimentation ponds, culverts, bridges, and concrete-lined channels. Typically, the structures are recommended for post-closure removal; however, the feasibility of removal is dependent on site constraints (e.g., property ownership, future land use, access requirements, special status species, costs, benefits, and impacts); these will be evaluated during the design phase. In cases where crossings are essential post-closure, installation of natural bottom culverts or bridge crossings are recommended.

Some inline sedimentation ponds may provide habitat for certain special-status species such as CRLF, but the ponds greatly alter the channel hydraulics and sediment transport capacity of the Creek. At Facility closure, removal of the inline ponds may depend on the presence and use by special-status species.

It is recommended that at Facility closure, non-essential creek crossings be removed and a free-flowing channel be constructed using a natural channel design approach. The channel may be realigned to the plan view dimensions that are most appropriate for the stream and valley type at specific locations. Channel dimensions should be relative to the appropriate reference reach dimensions and/or based on empirical relationships derived from South Bay regional curve data and analytical modeling. In-stream habitat and grade control structures (e.g., rock cross vanes) should be placed at the downstream and upstream ends of the areas requiring channel profile adjustment to stabilize the streambed and banks while vegetation becomes established.

Restoration activities are not advised for all conditions. Equipment access is very limited in many locations and creating access to specific creek restoration reaches could disrupt the riparian corridor and outweigh the potential benefit of restoration measures. These locations include reaches within the tight confines of the canyon such as the reaches above Pond 13 (Stations 92+00 to 120+00) and the reaches above the old Kaiser House (Stations 158+00 to 192+64). In many of these areas the creek has begun to adjust to changes that occurred in the past. For example, former debris flow material deposited in the confines of the canyon between stations 92+00 and 120+00 (above Pond 13) has developed a stable stream cross-sectional dimension. In these areas, the Creek has cut through some of the debris sediment to reestablish a new channel dimension or calcium carbonate deposits have helped stabilize the material in place while new vegetation has established along the banks.

4.4 DESIGN OVERVIEW

Conceptual planform dimensions would typically be derived from either historical photographs (circa 1948), map interpretation (dating back to 1899), or from reference reach measurements. The historical photograph and map search provided limited results, including the following observations based on the 1948 aerials:

- The lower portion of the creek near the railroad tracks had already been altered to the current location.
- Upstream of Reach 8 the creek is relatively undisturbed, however canopy cover in the canyon bottom obscures much of the creek making it difficult to determine the precise alignment.

- The historical channel alignment through Reaches 11 and 12 was located where the rock pile is located today. The proposed realignment of the creek in Figure 1-3 takes the estimated historical alignment into account.

The earliest maps are not of a sufficient scale to indicate signs of meandering planform geometry in the lower reaches of the Creek before they were affected by land use practices. The 1899 Palo Alto USGS 15-minute topographic quadrangle (Figure 2-3) indicates that the Creek was located in the middle of the valley where the railroad tracks currently reside and that it was located on the northern side of the valley where the rock pile is currently located. The reference reach search found a B-type reference stream for the upper reaches of the project area, however no streams were identified in the vicinity with an unaltered C-type channel in a low gradient wide bottomed valley such as occurs along the railroad tracks.

As a result of the historical and reference reach investigations, the conceptual planform dimensions shown on Figure 1-3 were estimated using three empirical relations derived by Leopold (1964, 1994) using the meander wavelengths, amplitudes, and radii of curvature from numerous streams. These relationships indicate that stream geometric parameters (e.g., meander wavelength and amplitude) form a near linear relationship with bankfull width. It is important to emphasize that the conceptual planform shown is for graphical purposes only. The analysis conducted to generate the conceptual planform is not intended to take precedence over additional engineering techniques (e.g., hydraulic modeling) that will be implemented during design. The final planform should be determined during the design phase.

4.5 REACH-SPECIFIC RECOMMENDATIONS

Recommended restoration activities are based on the conditions observed in 2000 and 2009 (Section 2) and may need updating as site and watershed conditions change, prior to preparation of detailed designs and construction drawings. The Plan assumes that, at the time of Facility closure, railroad structures in or adjacent to the creek may be removed to accommodate the restoration. For example, the Plan assumes that the area owned by Union Pacific (downstream of the Dinky Shed) will not be essential infrastructure after Facility closure and restoration of a meandering channel typical of a valley stream is recommended for the reach that includes Union Pacific properties. It is likely that Facility closure may likely occur in stages in which case portions of the land (e.g. Union Pacific property) may not be available for restoration at the same time.

The following subsections describe restoration alternatives and recommended actions on a reach-by-reach basis.

[1] Offsite; Downstream of Outfall and Bypass Confluence (No Stationing Designated)

This reach lies outside of the Facility property and does not require modifications to stabilize the upstream channel. No recommendations are made for this reach.

[2] Pond 14 Outfall Channel (No Stationing Designated)

Summary of Issues

An 8 foot deep headcut has formed just downstream of the Pond 14 weir that has potential to threaten the integrity of the pond outlet structure. The headcut is relatively unstable with little vegetation cover, low rooting density, and cohesive soils. The channel downstream of the headcut is mostly vertical with a sharp 90 degree bend and undercut banks. Several large trees that stabilize the Pond 14 weir are threatened by the headcut. Potential presence of special status species will influence final selection of restoration goals and techniques.

Alternative Actions

In the near term, installation of rock or log check dams would protect the headcut from further erosion, provided they are sloped appropriately and keyed into the bank to avoid having the construction exacerbate erosion.

Alternatively, step pools could be installed to protect the pond weir from erosion. Tree removal may be necessary to install the step pools, to add channel length or construction access.

Preferred Action

Measures should be taken to stabilize the pond outfall in the near term, cognizant of the restoration goals at closure. Large rock riprap could be placed in the outfall channel to dissipate flow and stabilize the bed and banks in the near-term. Where possible the vertical banks should be reshaped to a more stable angle and native vegetation including willows, blackberries, and elderberry shrubs, installed.

In the long-term, if pond 14 is left in place, the concrete weir at the pond outfall could be replaced with an armored earthen spillway. Armament could include a geo-cellular confinement system protecting the pond berm from scour during high flow events while allowing herbaceous vegetation to grow in the membrane’s cells. The spillway outfall should have a small armored stilling basin (rock or geo-cellular material) to reduce flow velocities prior to discharging to the downstream channel. The downstream channel should be reshaped to an appropriate size for the designed discharge volumes. Step pools would be installed along the channel if necessary to reduce the stream gradient and provide scour pool habitat. Rock would be placed to armor the channel, stabilizing it under clear-water discharge conditions. The streambanks and disturbed areas would be revegetated with native vegetation such as willows, alders, elderberries, blackberries, rushes, and sedges. Willow fascines could be incorporated along the edges of banks and spillway where high bank shear stress is expected.

[3a] Pond 14 (Station: 0+00 to 3+00)

Summary of Issues

Water flow from Pond 22 either diverted down the bypass channel or into Pond 14 to capture sediment. This requires periodic dredging to regain pond capacity affecting existing pond vegetation that provides habitat for the CRLF. The weir controlling the discharge of pond water has caused excess downstream scour and channel degradation.

Alternative Actions

Remove Pond 14 and re-create a lengthened channel in place. This would reduce the gradient (below that of the existing bypass channel) provide a greater area for fish habitat and a more expansive floodplain. However, this would remove a known breeding location for CRLF, and the creation of other off-channel ponds would likely be needed to mitigate.

Preferred Action

Pond 14 would be left in place for CRLF use. The Pond 14 bypass channel would be modified to become the main channel (see below). A cross vane with a high-water overflow would be installed in the bypass, diverting high water flows into Pond 14 to maintain CRLF breeding habitat. The concrete weir would be removed and replaced with an armored spillway (described above). To reduce the need to engineer a new pond embankment; the new pond spillway crest would be rebuilt at the elevation of the bottom of the concrete weir that is to be removed. This will reduce pond volume and area, but is not anticipated to reduce its CRLF habitat value.

[3b] Pond 14 Bypass Channel (Station: 0+00 to 3+00)

Summary of Issues

The Pond 14 bypass channel is relatively straight, incised, entrenched and confined against the hillside by fill material surrounding Pond 14. The channel only conveys water when water is diverted around Pond 14. This diversion structure is a potential barrier to fish passage. It is suspected that this is the approximate location of the historic channel as there is no evidence of relic channel morphology immediately down valley of Pond 14.

Alternative Actions

Abandon the bypass channel, remove pond 14, and re-create the channel through the Pond 14 footprint. This would allow greater lengthening of the channel and provide a greater area for fish habitat. However, this would remove a known breeding location for CRLF, and the creation of other off-channel ponds would likely be needed to provide mitigation.

Preferred Action

The preferred action is to make the by-pass channel the primary flow path by removing the Pond 22 outlet stream diversion structure and removing the culverts that convey flow to Pond 14. A rock cross vane would divert a small portion of flows exceeding bankfull stage to Pond 14. A bankfull bench would be excavated into the steep banks of the existing channel to provide flood relief. The streambed and banks would be stabilized with rock cross vane step pools to control drop, improve fish passage and habitat.

[4] Pond 22 (Station: 3+00 to 5+25)

Summary of Issues

Pond 22 is full of sediment. The creek has cut a low-flow channel in the sediment prism. The sediment prism is now vegetated, making removal of the sediment difficult without disturbing willows. In addition, the Pond 22 outfall diversion is a barrier to fish passage. Pond 22 may provide habitat for CRLF.

Alternative Actions

Pond 22 vegetation could be cleared and the sediment removed to create an in-stream pond. The concrete outlet diversion structure could be replaced with an earthen berm and armored rock or geo-cellular membrane lined spillway. The restored pond would likely provide CRLF habitat for some time, however, the pond would fill in and revert to its present form. This would require the removal of riparian vegetation, and the solution is not ideal in the long-term. Without a series of fishway weirs or step-pools the pond outlet would be a fish passage barrier. Fish passage with such structures would be limited to when the pond is full and spilling.

Preferred Action

The preferred solution for this reach involves the removal of Pond 22 and the concrete and steel water diversion structure at the pond outlet. Though Pond 22 may provide habitat for CRLF, it is not a likely breeding location considering that Pond 14 would 1) provide much better breeding habitat and 2) is in close proximity. Restoration of the pond to a meandering channel with riparian vegetation would still provide aestivation and dispersal habitat for CRLF. Much of the sediment within Pond 22 could remain in place and become the floodplain area at this location, though some sediment removal would be needed to create a smooth transitioning channel profile from the reach upstream to the bypass channel downstream of Pond 22. The installation of step pools or rock vanes would create fish habitat within this reach and stabilize the streambanks and fill material.

[5] Pond 22 to Railroad Crossing (Station: 5+25 to 6+20)

Summary of Issues

Sediment input from various sources causes this reach to be unstable, with a fluctuating channel resulting from aggradation. The discharge from Pond 30, serving the east materials storage area northwest of the creek, is causing hillslope and streambank erosion upstream of Pond 22. The reduction of sediment input into this reach will be addressed in the SWPPP.

Alternative Actions

The installation of a slope drain for Pond 30 discharge would prevent further bank erosion, however, it may become another abandoned structure requiring removal and hillslope revegetation in the future. Culverts typically require periodic maintenance to prevent clogging, separation, or failure. Permanente Creek could be revegetated with bunch grasses such as rushes and sedges to stabilize the existing channel alignment in place allowing stormflows to shape a more stable cross section as sediment loads decrease. This option does not take into account the adjustments to the channel profile that may occur as a result of upstream or downstream restoration.

Preferred Action

In the near-term, the SWPPP and sediment study should address the effectiveness of Pond 30 and implement erosion control measures. Installation of vegetated rock riprap at the off-channel pond outfall is more practical, and would not require maintenance following Facility closure. Additionally, the vegetated riprap would continue to provide bank stabilization and streambank vegetation even if discharge from the pond ceases. In any case, access to the outfall location would require vegetation removal. Permanente Creek would be restored to an appropriate bankfull dimension, plan, and profile to match upstream and downstream desired future conditions. Depending on the future profile, sediment may need to be excavated or fill placed in the active channel to recreate floodplain at an appropriate elevation. Rock grade control structures or cross vanes would be installed to add channel stability and habitat until native vegetation becomes established.

[6] Concrete Trapezoidal Channel (Station: 6+20 to 37+00)

Summary of Issues

This reach is comprised of engineered culverts and concrete lined channels that are potential fish barriers and provide minimal habitat. Lehigh does not own all the land required to implement the preferred actions. One incentive for Union Pacific to participate is the potential for them to obtain riparian mitigation credits for track removal and creek restoration. Approximately 6.9 acres of the Union Pacific property (3,800 linear feet) is located within the proposed floodplain creation area, as shown in Figures 1-3.1 to 1-3.4.

Alternative Actions

If the railroad tracks cannot be removed following Facility closure, the culvert crossings in this reach would be replaced with either a bridge or stream simulation type culvert with vegetated riprap armoring on the inlet and outlet slopes. The concrete channel could be removed and replaced with a confined channel with vegetated riprap banks. This option would improve fish passage and habitat, however would limit the reach to a sediment transporting reach limiting sediment deposition and channel morphology. Where enough space is available (e.g. where the access road can be removed southeast of the channel) a bankfull bench could be incorporated to provide flood relief, reduce flood velocities, and allow an area for sediment deposition. The streambanks would be planted with willows and other riparian species.

A second alternative would be to retrofit the existing concrete channel with concrete baffles or fishway weirs to improve fish passage. The upper banks could be planted with large shade trees to help moderate water temperatures.

Preferred Action

A more complete restoration of this reach requires removal of the concrete trapezoidal channel, culvert crossings, and adjacent railroad tracks. Creating a stable channel and floodplain in this location would likely require the excavation of large quantities of fill. Creation of an unrestricted channel is also dependant on the removal of the Facility roads and Union Pacific rail tracks within the valley. The creation of a meandering channel with a floodplain would improve sediment storage in this reach, improve fish habitat, and create riparian habitat. Numerous rock cross vanes and J-hook vanes would be installed in this reach to provide fish habitat, maintain sediment competence, and stabilize the bed and banks. Since an appropriate reference channel has not been identified for this reach an analytical approach to channel design may be necessary to develop a stable channel dimension based on hydraulic and sediment modeling. The planform geometry may be determined using empirical equations as described in Section 4.4 or from a historical photo analysis of local streams before human alteration with a similar valley type, vegetation, and geology.

[7] Materials Storage Area to Road Upstream of Dinky Shed (Station: 37+00 to 41+75)

Summary of Issues

This reach has been channelized and contains two culverts, these structures limit fish habitat and are potential fish passage barriers. These culverts also constrict flood flows. While the channelization has steepened this reach to an A4 stream type, the bed and bank of the stream are stable due to the establishment of vegetation, lack of recent channel/bank disturbance, and/or sufficient rock armoring of the channel in the past.

Alternative Actions

Remove all infrastructure and excavate fill material to reestablish the approximate historic valley width. Realign the stream channel adding sinuosity to decrease the overall slope to obtain a transition from a B to a C stream type. Additional stream length and meanders will provide additional pool-riffle habitat for fish. Grade control structures such as cross vanes and J-hooks would provide bed and bank stabilization for the new channel. Channel realignment would require abandonment of a stable channel for a restored channel. The restored channel would require time to adjust to a state of equilibrium and for newly planted vegetation to become established.

Preferred Action

In the near-term, the effectiveness of Ponds 16 and 17 should be analyzed as part of the sediment plan and addressed in the SWPPP. Following the end of operations, the removal of culverts, settling ponds, rail line, and other non-essential infrastructure will allow the excavation of fill soil to reestablish a floodplain. Excavation work would minimize disturbance to existing trees along the channel to the extent possible, however some vegetation including trees growing higher on the existing banks would need to be removed to reconnect the channel to an appropriate floodplain elevation. Rock cross vanes or step pools would be installed as a grade control upstream and downstream of where the culvert is removed or where channel work may alter the profile of the stream. The new floodplain area would be revegetated with native riparian species. Overall, these actions would provide a floodplain for the stream to adjust over time to a more appropriate dimension without negatively impacting the existing stable channel dimension. In the long-term, this alternative would provide the same benefits of the alternative without the initial channel disturbance. Dependent on stormflows following the project restoration, this alternative may allow time for vegetation in the floodplain to become established before flood flows alter the channel alignment.

[8] Road Upstream of Dinky Shed to Conveyor Crossing (Station: 41+75 to 59+00)

Summary of Issues

This reach is leveed off from the adjacent road and does not have access to a floodplain. Fill placed in or adjacent to the stream in the past has caused the reach to be relatively straight and steep (A4 stream type) for the slope of the valley. The stream in this valley position would have been more likely a B4 stream type before the stream was confined by past Facility operations. Since the reach has not been disturbed in recent time, vegetation has become well established allowing the reach to attain a stable state. There is a 96 inch diameter culvert road crossing that spurred off from the main Lower Quarry road that no longer supports vehicle traffic.

Alternative Actions

If the 96" culvert is deemed essential, it could be replaced with either a bridge or stream simulation type culvert with vegetated riprap armoring.

Similar to the alternative in Reach 7, the channel could be restored with a more sinuous pattern and lower slope to mimic a B4 stream type. This alternative would require abandoning an existing stable stream channel for a newly excavated channel.

Preferred Action

As in previous reaches, settling ponds should be evaluated in the near-term, as part of the sediment study and SWPPP to determine effectiveness. If deemed non-essential, the 96" culvert may be removed prior to Facility closure. Rock cross vane grade control structures will be installed where changes in streambed slope occur as a result of the culvert removal. Culvert removal will improve fish passage, reduce debris jam potential, improve flood capacity, and reduce scour at the culvert outfall. Following Facility closure, the removal or narrowing of the road and removal of the culvert adjacent to the raw materials storage area would provide area for floodplain restoration, improving riparian habitat and channel stability. Similar to the preferred alternative for Reach 7, a new floodplain would be excavated around the existing channel maintaining the current channel alignment. The floodplain would be revegetated in anticipation of future natural channel adjustment/realignment.

[9] Culvert under Conveyor Crossing to Parallel Buried Culvert(Station: 59+00 to 69+00)

Summary of Issues

Two of the culverts under the conveyor crossing road are fully or partially blocked causing an impediment to fish passage, reduction of flood capacity, and the culvert outfall is a source of bank erosion. The banks immediately downstream of the culverts are vertical. Upstream of the culverts, the banks have been hardened by the placement of tractor-tire retaining walls. In the remainder of the reach, the channel is confined to the southern side of the valley by the road fill and levees.

Alternative Actions

Replace road culvert crossing adjacent to the conveyor belt with stream simulation type culvert(s). The culverts could be replaced in the near-term, however future floodplain restoration would require removal of the culvert(s) disturbing the channel requiring subsequent channel restoration and likely installation of grade control structure(s). Removal of the culvert would improve storm capacity and fish passage within this reach.

After Facility closure the fill that confines the stream to the south side of the valley could be removed. A new meandering B3/4 channel could be reconstructed within the restored valley floor and floodplain. Similar to the Reach 7 and 8 alternatives, this method requires abandonment of an existing channel that is relatively stable.

Preferred Action

Replace road culvert crossing adjacent to the conveyor belt with a bridge. Installation of a bridge would reduce the amount of disturbance to the stream channel at closure. Bridge superstructure and abutments would need to be removed, however the channel should not require disturbance.

The alluvial fan of small gravel deposited on the floodplain located upstream of the culvert crossing in 2010 will be removed pursuant to the SWPPP. Additional gravel pushed into the ephemeral drainage from a storage area would be removed from the channel and banks to prevent further material from reaching Permanente Creek. The floodplain and ephemeral channel would be revegetated with native vegetation. Temporary disturbance resulting from equipment access to the alluvial fan from across the creek would be restored and revegetated.

After Facility closure the removal or narrowing of the road in this reach would increase the valley width, allowing excavation of a bankfull bench and/or floodplain. This alternative may require removal of some native vegetation (including trees) growing above the bankfull elevation. The floodplain and disturbed area above it would be revegetated in anticipation of future natural channel adjustment/realignment. This alternative retains the relatively steep channel slope anticipating that the stream may seek an alternate more sinuous alignment within the reestablished floodplain.

[10] Parallel Buried Culvert to Full Culvert (Station: 69+00 to 76+00)

Summary of Issues

The buried and abandoned culvert within this reach artificially straightens the channel by hardening the southern bank. The channel is confined to the south slope of the valley by the roadway. Portions of the northern bank and the outlet of the full culvert are covered in riprap, reducing habitat value in this reach. As the buried parallel culvert lies on the opposite side of the creek from the road, disturbance to the creek for access may be needed.

Alternative Actions

After Facility closure the riprap and fill that confines the stream could be removed. A new meandering B3/B4 channel could be reconstructed within the restored valley floor and floodplain to match the historical alignment as closely as discernable from the 1948 aerial photograph. Similar to the Reach 7 and 8 alternatives, this method requires abandonment of a relatively stable existing channel. A new channel may immediately increase fish habitat from additional pool-riffle structures, as compared with the current steep rocky channel.

A second alternative may be to retain some of the valley fill and alter the channel alignment to create the smoothest transition in the profile from upstream to down stream reaches optimizing potential for fish passage and increasing length of stream habitat. This approach may result in streamflow infiltrating into the valley fill material leaving the channel dry during periods of baseflow and/or low to moderate flow events. Over-excavation and recompaction of suitable fill material may mitigate the effects of unwanted subsurface flow.

Preferred Action

The riprap placed along the channel in this reach is needed to protect the adjacent roadway. Without the riprap, high flows may undercut the road, causing sedimentation in the creek. Once operations cease and the road is no longer needed, the riprap may be removed. Additionally, natural recruitment of alders within the riprap has improved habitat somewhat. For these reasons, removal of the riprap is not proposed until operations have ceased. At Facility closure concrete riprap would be removed from the channel banks and replaced with riparian vegetation, boulders or cobble to add sufficient bank roughness to replace what was removed. The floodplain would be revegetated in anticipation of future natural channel adjustment/realignment.

Removal of the entire buried culvert may not be possible without excessive disturbance to vegetated areas and the hillslope lengthening the recovery time. Removal of the end segments, filling the bore with rock, and crushing the inlet may be more appropriate. Full culvert removal should occur unless the center portions of the culvert are found to be buried under mature trees or stable hillslope vegetation that may become unstable with the excavation. Any associated concrete riprap would be completely removed from the south side of the creek, followed by the creation of a bankfull bench. Channel restoration techniques could include rock cross vanes or step pool structures to step down the channel gradient where channel is disturbed from the culvert removal. This will improve riparian habitat, in-stream habitat, and improve runoff filtering.

Short term recommendations for this reach address the sediment fan and stormwater controls related to recent activities at a storage area and geotechnical exploration on the southern ridge.

[11] Full Culvert and [12] Half-Culvert (Station 76+00 to 85+00)

Summary of Issues

This reach contains two long, steep culverts, totaling 900 feet in length. These culverts are fish barriers, have no riparian habitat and provide minimal aquatic habitat. The presence of these culverts also restricts stream processes in the above and below reaches. The steep slope within this reach complicates restoration efforts (Figure 2-5). The bottom of the valley in this reach has also been filled with significant amounts of overburden, including a large gravel pile. Much of this material is aggregate material that will be removed prior to Facility closure, though significant excavation will likely be needed to create a stable and coherent channel. Due to the steepness of this reach, careful design of the channel is needed to prevent potential headcutting if there is no bedrock control in the channel bottom of the restored valley.

The configuration of this reach prior to the installation of the culverts is not known. Based on the historic topographic map (Figure 2-3) and aerial imagery (Figure 2-4), it is likely that this reach always had a high gradient and may have been a natural fish passage barrier.

Alternative Actions

The presence of bedrock below the valley fill may have historically limited fish passage. During reference reach surveys in nearby streams several streams were observed to have bedrock outcrops in the streambed creating a chute with slopes commonly exceeding a 15 percent. If a large bedrock outcrop is identified in Reach 12, it is possible that a relic channel carved in the bedrock may be unearthed, restoring the channel to its former elevation.

Preferred Action

The exact location of the full culvert in Reach 11 is not known. It may be less damaging to existing vegetation on the north facing slope to leave the culvert, or portions of it, in place instead of removing it. If the culvert is not removed, the ends will be located, plugged, and/or crushed to prevent future entrapment of the creek into the abandoned culvert.

The preferred approach to restoration is to grade the valley slope to achieve a smooth profile from the upstream to downstream reach minimizing to the gradient to an extent possible without placing fill in the valley downstream of the reach. The channel planview would be made to mimic the alignment estimated from the1948 aerial photograph (Figure 2-4), wherever practical. This approach may encounter bedrock, particularly in the upper portion of the reach, which may need to be shaped to an appropriate A1 or B1 stream channel cross sectional dimension if not already present. A meandering step pool channel of a similar alignment estimated from historical photo analysis would be built to provide fish passage to upstream areas. [This makes the assumption that providing anadromous fish access to areas where they did not historically have access is ecologically appropriate; however it may result in stranding where there is insufficient summer water.] Numerous rock cross vanes or step pool structures would be necessary to achieve a stable channel passable to fish without excessive drop heights. A bankfull bench or floodplain would be excavated where appropriate for the channel type. Since there may be some unconsolidated fill remaining in the valley below the channel with this alternative, it is possible that channel flow (or at least low flows) may infiltrate the unconsolidated fill and resurface downstream leaving the channel dry until the valley fill is fully saturated (similar to the condition observed currently in Reach 17).

[13] Pond 13 and Pond 13 over-excavation (Station: 85+00 to 90+00)

Summary of Issues

Pond 13 and its outlet structure obstruct stream flow preventing bedload from replenishing downstream reaches. Over-excavation of the upstream end of Pond 13 resulted in vertical banks that are a minor source of sediment and limit the development of riparian vegetation.

Alternative Actions

Retain a portion of Pond 13 by removing the concrete outlet structure and allowing the pond to drain at a slightly lower elevation than current. The outlet would be armored with riprap to prevent degradation or head cutting of the channel down to the bottom elevation of the pond. The pond would provide CRLF habitat until the pond fills with sediment at which point a new channel would develop over the pond sediments.

Preferred Action

In this location it is preferable to re-grade the vertical banks, create a bankfull bench, and revegetate with species native to the watershed. It is also preferred that Pond 13 would be removed following Facility closure. It is unlikely that this pond would remain open, in the long term without periodic sediment removal, which may not be possible following Facility closure. The valley slope through Pond 13 would be matched to the downstream reach and a meandering B4 to a B3/A3 channel would likely be most appropriate as the valley slope increases. Grade control structures would be incorporated in to the channel to facilitate habitat development and sediment conveyance. The slope of this reach presents design challenges similar to that of the downstream reach. The gradient may limit the potential for fish passage.

[14] Above Pond 13 (Station: 90+00 to 94+00)

Summary of Issues

This reach is affected by minor hillside erosion from rain/runoff. The effected slope is very steep and rocky.

Alternative Actions

Topsoil could be imported and used to create revegetation areas on the affected slopes. However, access for restoration efforts would be extremely difficult and result in further damage to vegetation on the steep slope, and may cause further erosion.

Preferred Action

Revegetation would require the importation of topsoil to an inaccessible slope, therefore no action is recommended.

[15] Upstream of Primary Crusher (Station: 94+00 to 105+00)

Summary of Issues

Runoff from the quarry that was causing erosion and affecting this reach has been diverted. The affected slopes are very steep and have little or no topsoil for revegetation.

Alternative Actions

Topsoil could be used to create revegetation areas on the affected slopes. However, access for restoration efforts would be extremely difficult and result in further damage to vegetation on the steep slope, and may cause further erosion.

Preferred Action

As any revegetation effort would require the conveyance of topsoil to an inaccessible slope, no action is recommended.

[16] Upstream of Primary Crusher to Old Crusher Foundation(Station: 105+00 to 116+00)

Summary of Issues

This reach was affected by Quarry debris slides where sheet-piles placed to prevent debris from sliding into the creek have failed. A boulder pile in this channel reach constricts flows and may be a fish passage barrier.

Alternative Actions

Due to the limited equipment access, removing the in-stream boulder pile would also require vegetation removal. As an alternative, the boulder pile could be left in place.

Preferred Action

In the short term, the damaged sheet pile could be repaired, overburden removed from the top of the slope, and erosion controls installed to stabilize loose material at the top of the slope. In this reach, equipment access to the creek is limited. Removal of the in-stream boulder pile would improve fish passage, remove a flow constriction, improve the slope profile transition through upstream reaches, and aid in sediment redistribution. The creation of an access route to remove the boulder pile would disturb mature vegetation and stable banks.

[17] Old Crusher Foundation to Downstream End of Unconsolidated Fill(Station: 116+00 to 134+00)

Summary of Issues

Historic overburden material fills the creek bottom in this reach. During lower flows, this reach is dry due to infiltration through the overburden material. The overburden material is predominantly cobble and boulder, and the lack of soil limits the development of riparian vegetation. The old crusher foundation constricts flows and may be a fish passage barrier.

Alternative Actions

This reach could be retained as an intermittent reach since the existing channel is stable. Topsoil could be placed atop the overburden to provide soil to establish vegetation suited to well-draining areas, such as sycamore. This alternative would only provide seasonal fish passage, at best.

If the old crusher foundation cannot be removed, it may be possible to modify it so that it presents less of a constriction or potential passage barrier.

A second alternative is to attempt to remove all the overburden material until the buried valley floor is reached and restore the channel to it former elevation. This costly alternative would involve extensive excavation and loss of existing vegetation that has established in the valley. Geotechnical borings may be necessary to map the valley floor and determine the depth of excavation and feasibility of the approach. This alternative would involve the installation of a new step pool channel with grade control structures and total revegetation of the valley. The approach may improve flows for fish as water may not be running subsurface with this alternative.

Preferred Action

It is suspected that the placement of overburden material within and on the north side of the creek forced the channel to the south side of the valley at a higher elevation than occurred pre-disturbance. The 1948 aerial photograph indicates that the channel may have been located as much as 200 feet further north at one point than the current alignment in Reaches 18 and 19. While Reach 17 had already been disturbed by the mining operations in 1948, it is not unreasonable to suspect that the channel was located further north of the current alignment and at a lower elevation. However, it is unlikely that the overburden is the single reason for the sharp profile change at the upstream end of the Reach 17 into Reach 18. Bedrock from the ridge to the south likely controlled the stream profile in these reaches creating a bench or distinct change in the streambed profile. If restoring surface flow within this reach is a primary goal, a geotechnical and groundwater investigation may be warranted to ensure success by mapping the valley topography beneath the overburden material. If surface flows can be restored to this reach, it may be possible to provide fish passage. Extensive earthwork is needed to remove overburden for the creation of a stable bankfull bench and floodplain and resurface creek flow. Additionally, removal of material may be needed up through Reach 19 to prevent an excessively steep channel slope. Topsoil would need to be imported to revegetate the valley unless a buried topsoil horizon is identified from borings or during excavation. The old crusher foundation should be removed, provided it can be done without effecting mature vegetation or destabilizing the stream banks. Another concrete structure near 128+50 would also be removed from the valley slope.

[18] Downstream End to Upstream End of Unconsolidated Fill(Station: 134+00 to 138+00)

Summary of Issues

The overburden on the north slope has narrowed the valley sufficiently to straighten the creek, creating a pinch point that constrains the channel. The valley fill acts as a sediment plug and grade control for the upstream reach. Loose sediment on the overburden slope continues to enter the creek zone during large rain events. Currently, this reach is only sparsely vegetated with native species.

Alternative Actions

Regrade the overburden slope enough to prevent overburden material from eroding and falling in the creek. Import topsoil to revegetate the slope adjacent to the stream channel. This alternative will reduce sediment from reaching the creek but does not provide additional floodplain or address the vertical profile of the creek.

A second alternative is to totally remove all overburden material in the valley as described in the Reach 17 second alternative. The channel would be relocated to the pre-disturbance alignment estimated from the 1948 aerial photograph or from other geotechnical subsurface analysis.

Preferred Action

Remove the excess overburden material and lay back the slope to increase the floodplain area. Import topsoil to effectively revegetate the slope adjacent to the stream channel. Reestablish the stream channel at a lower elevation to reduce the sharp break in channel slope that occurs in Reach 17. Install step pool grade control structures to reduce the gradient and facilitate fish passage. Apply revegetation measures to the slope and floodplain for erosion control, shade, and to provide riparian habitat. Some sparse vegetation will likely be removed during excavation and slope grading.

[19] Upstream End of Unconsolidated Fill to Kaiser House (Station: 138+00 to 158+00)

Summary of Issues

This lower gradient reach is a braided channel in many locations reducing sediment competence and limiting fish habitat. The channel appears to be slowly stabilizing, but receives sediment from loose material pushed over the top of the bank. Severe erosion of mine tailings in the past filled this reach with fine sediments, which has the potential to headcut or experience excessive scour during storm events. The deposition of fines in this reach is partly due to impoundment by overburden in the downstream reach.

Alternative Actions

Numerous willows and smaller vegetation have revegetated the large area of consolidated sediment since the 2000 surveys. While the channel rates as a “poor” in the modified Pfankuch channel stability rating, there is evidence that the channel is slowing improving. One alternative is to let the channel continue to stabilize without further interference. This approach would not help increase surface flows to downstream reaches that are subterranean much of the year, but would not impact the riparian corridor that has reestablished since 2000.

A second alternative is to continue the valley excavation of overburden and quarry related sediment from the reach as described as a second alternative in Reaches 17 and 18. In order for equipment to access this reach from the quarry road, the creation of a graded access road would be necessary from the downstream end of the reach. Heavy equipment could be used to remove the old consolidated sediment deposited throughout the reach and more recent overburden material deposition at Qs3. A new floodplain at or near the historic channel elevation could be reestablished. This alternative may increase surface flows to the downstream reaches, however would require removal of most of the existing mature willows that have since stabilized the sediment in place.

Preferred Action

The preferred action for this reach is a continuation of the preferred approach from Reaches 17 and 18 by removing some of the valley sediment adjacent to the channel to improve the transition of the channel slope through the reaches. Excavation may need to continue up through half of Reach 19 to achieve a desired gradient that may improve flow duration, fish passage and habitat. Step pools or rock cross vanes would be used to restabilize the restored channel and banks and facilitate fish passage. A new bankfull bench or floodplain would be incorporated into the lowered channel. The width of the valley excavation and thus vegetation removal would be limited to the extent necessary to contain the expected belt width of the restored B channel.

The debris slide at Qs3 should be stabilized by removing as much of the excess material as possible without removing any of the large trees growing on the slope. Work could begin at the top of the slope and work down in the near term recontouring the hill to it pre-disturbance slope. Erosion control materials should be installed. Native trees and shrubs should be planted by importing topsoil into each of the planting basins to improve planting success. At Facility closure if overburden material is still impacting the creek at the toe of the slope the material should be removed and revegetated as done at the top of the slope.

[20]Kaiser House to Debris Slide Area (Station: 158+00 to 171+00)

Summary of Issues

This reach was previously affected by gully erosion from quarry runoff. Though the gully is no longer active, it is not vegetated and has steep and or undercut banks.

Alternative Actions

Access for equipment to the gully is limited by steep slopes populated by mature trees. The vertical slope of the gully could be recontoured to allow vegetation to be planted or naturally recruit. Work would be done with hand tools due to the steep slope and mature trees. Gully bank reshaping would be limited by any trees growing close to the gully that should not be disturbed. Rock or coir logs and durable erosion control fabric would need to be placed in the gully bottom to prevent subsequent erosion of the gully bank fill. This technique may reduce soil loss in the long term as the gully bank would eventually erode to a more stable angle of repose. The work may also increase soil loss due to limited success of revegetation efforts the result of dense tree canopies and allelopathic properties of oak leaf litter.

Preferred Action

The preferred action at this gully is to revegetate the invert of the gully and other bare areas along the gully where possible with shade tolerant species. Vegetation success may be low, however there would be little risk for increased erosion that might occur with the alternative approach.

[21]Debris Slide Area (Station: 171+00 to 190+00)

Summary of Issues

This reach is affected by several old debris slides, which have mostly stabilized. The creek is downcutting the toe of some of the slides in this reach, creating some vertically cut, unstable banks. Fish passage in this reach may be limited by vertical drops formed by the downcut.

Alternative Actions

Debris slide material in the creek could be completely removed from the active channel and placed at toe of the hill slope or hauled offsite with the use of an excavator winched down the hillslope from the road above. Equipment use would allow total removal of the sediment as opposed to hand removal but would require disturbance of hillslope and some riparian vegetation to bring in and maneuver the excavator.

Preferred Action

The preferred actions in this reach are designed to add stability to the debris slides and improve fish habitat. This includes stabilizing portions of the slope that may be eroding or removing loose material that may fall to the creek. Hillslope terracing may be an acceptable method for preventing loose material from reaching the creek while providing a bench for vegetation to be planted. Any remaining bare areas on the slopes should be covered with erosion control fabric and revegetated. Revegetation should include placement of topsoil in the planning basins to help vegetation get established. Creek restoration shall include cutting back the vertical banks on the debris slide at Qs1 to create a bankfull bench, and creating rock step pools from native rock. As there are no routes for equipment to access this reach, restoration actions within this reach limited to tasks that can be competed with hand tools. Rock materials would be limited to what is naturally available at the site.

[22]Above Debris Slide Area to End of Reach (Station: 190+00 to 195+00)

Summary of Issues

This reach is mostly stable and upstream of the quarry overburden. This reach is also well vegetated. No restoration actions are warranted for this reach.

4.6 SITE-SPECIFIC RECOMMENDATIONS

Table 4-2 lists the preferred site-specific recommendations based on the conditions identified in each of the 22 reaches during the 2009 assessment that are subject to this Plan. This provides further detail for the recommendations made in Sections 4.5. For each condition, the impact on the Creek is summarized, recommended alternatives to address those impacts are provided, and the anticipated benefits of the recommendations are discussed. Appendix A depicts the location of many of the items listed in Table 4-2 and provides a conceptual plan view of the restoration of middle reaches of the Creek. All potential restoration measures are subject to site constraints (e.g., special-status species, future land use, property ownership, etc.), and a feasibility analysis will be conducted during the design phase to evaluate contemporary appropriateness of the recommendations.

4.7 PRIORITIZATION PROTOCOL AND CRITERIA

The CAO requires that candidate sites for restoration be prioritized. The prioritization protocol was developed as a means to assist in determining the order and schedule of the implementation of restoration activities. The recommendations provided in Table 4-2 are prioritized into five categories:

Category (I) – These recommendations should be implemented in the near term because they represent active erosion or other sediment sources to the Creek, have the potential to threaten site infrastructure (e.g., roads), and may be implemented without interfering with Facility operations. As previously mentioned, a sediment source survey outside the scope of the 99-018 CAO will analyze sediment sources and recommend corrective actions to be addressed as stormwater management controls under the SWPPP.

Category (II) – These recommendations are contingent upon the ability to remove infrastructure, and, therefore, they should not be implemented until site closure.

Category (III) – These recommendations may result in creek improvements but are of such significant cost or may have significant concerns about additional disturbance that they should only be implemented if additional studies show they are warranted. Such studies might include post-closure fisheries monitoring that show migrating fish pooling at the base of an obstacle (e.g., overburden material) in the Creek; migrating fish may only occur in the future after an off-site action occurs at the Permanente Diversion Channel related to migration barrier removal.

Category (IV) – These recommendations may result in improvements to the Creek but are cost-prohibitive or may cause more ecological damage to hillslopes or the Creek itself (due to disturbance for access or excavation) than benefits realized in the Creek.

No Action – These items were included in Table 4-2 to provide a comprehensive list of in-stream features and potential sediment sources associated with previous reports and studies. These items include sediment sources that were noted in earlier investigations but have since stabilized and been colonized by plants.

4.8 SCHEDULE

The recommendations are proposed to be implemented on the following schedule:

Category (I) – Within 5 years of final Plan approval

Category (II) – Upon closure of the Facility

Category (III) – Only as warranted by post-closure monitoring

Category (IV) – Not recommended for implementation

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 2 – Pond 14 Outfall Channel (Q_s15)	Figure 1-3.1 Station –1+00 to 0+00	2009	• Headcut and bank erosion sediment source. Potential threat to Pond 14 stability	• Stabilize headcut with large rock rip rap (E.11)	I
				• Reestablish bankfull bench at outfall structure location (E.2) • Revegetate riparian corridor with willow fascines (E.9), stakes (E.10), and native vegetation (E.12)	II
Reach 3a – Pond 14	Figure 1-3.1 Station -1+00 to 3+00	2000 and 2009	• Barrier to fish passage	• Retain Pond 14 as CRLF habitat. • Install in-stream rock cross vane in bypass channel to divert overflow into the pond(E.3) • Remove concrete weir and install armored earthen spillway and stilling basin (E.17). If needed, Install in-stream step-pools (E.4) or Cross vanes (E.3)	II
Reach 4 – Pond 22 Outfall Diversion Structure	Figure 1-3.1 Station 3+00	2000 and 2009	• Barrier to fish passage	• Remove outfall diversion structure • Install in-stream rock cross vanes (E.3) or step pools (E.4) as grade control • Reestablish bankfull bench at outfall structure location (E.2) • Revegetate riparian corridor (E.9, E.10 &, E.12)	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 4 – Pond 22	Figure 1-3.1 Station 3+00 to 5+25	2000 and 2009	• Lack of a defined channel/bed habitat features (e.g., riffle, run, pool, and glide) • Sediment pond full. Fine sediment conveyed to downstream reaches or trapped in Pond 14 (depending on diversion structure)	• Remove ponds and sediment • Restore stream channel profile and cross section (E.1) • Install in-stream rock cross vanes (E.3) or step pools (E.4) as grade control • Reestablish floodplain or bankfull bench (E.2) • Revegetate riparian corridor (E.9, E.10 &, E.12)	II
Reach 5 –Pond 30 discharge (Q_s14)	Figure 1-3.1 Station 6+00	2010	• Sediment source • Causing erosion of slope and bank at pond outfall	• Implement erosion control measures in sediment source areas pursuant to SWPPP (E.16) • Analyze pond effectiveness and sizing in the sediment study • Install energy dissipation structure at outfall, such as vegetated rock riprap (E.11)	I
Reach 6 – Culvert under rail tracks	Figure 1-3.1 Station 6+75 to 7+50	2000 and 2009	• Potential fish passage barrier	• Remove culvert and fill prism • Restore stream channel profile and cross section (E.1) • Install in-stream rock cross vanes (E.3) or step pools (E.4) as grade control • Reestablish floodplain or bankfull bench (E.2) • Revegetate riparian corridor (E.9, E.10, & E.12)	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 6 – Trapezoidal concrete channel	Figure 1-3.1 to Figure 1-3.3 Station 7+50 to 31+00	2000 and 2009	• No current habitat value • Potential fish passage barrier • Existing channel stable	• Remove concrete channel • Remove rail lines, riprap, asphalt, and other non-essential utilities • Reconstruct valley floor • Construct natural meandering channel using entire floodplain (E.1 & E.2) • Install in-stream structures (E.3, E.4, E.5, and E.7) to protect banks, convey sediment, and create pools/riffles • Revegetate riparian corridor (E.9, E.10 &, E.12)	II
Reach 6 – Culverts adjacent to raw materials storage area (3 culverts)	Figure 1-3.3 Stations: 28+00 to 29+00 31+00 to 32+00 34+00 to 37+00	2000 and 2009	• Potential fish passage barrier • Constriction of flood flows	• Remove culvert, rail lines, and other non-essential utilities • Reconstruct valley floor • Construct natural meandering channel using entire floodplain (E.1 & E.2) • Install in-stream structures (E.3, E.4, E.5, and E.7) to protect banks, convey sediment, and create pools/riffles • Revegetate riparian corridor (E.9, E.10 &, E.12)	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 7 – Bridge adjacent to raw materials storage area (1 bridge)	Figure 1-3.3 to Figure 1-3.4 Stations: 38+25 to 39+00	2000 and 2009	• Constriction of flood flows	• Remove bridge, rail lines, and other non-essential utilities • Reconstruct valley floor and floodplain (E.2) • Install in-stream structures (E.3, E.4, E.5, and E.7) to protect banks, convey sediment, and create pools/riffles • Revegetate riparian corridor (E.9, E.10 &, E.12)	II
Reach 7/8 – Ponds 16/17 Discharge	Figure 1-3.3 to Figure 1-3.4 Pond 16/17 Discharge at: Station 37+50	2000 (Screen Tower No. 4 overland flow) and 2010	• Sediment source (when Pond 17 full of sediment or during rainstorms)	• SWPPP to address Pond 17 cleanout maintenance • Evaluate the effectiveness of Pond 17 • Install vegetated swales, filter strips, sediment basins as needed	I
				• Remove unnecessary infrastructure within 150 ft of stream channel	II
Reach 8 – Culvert adjacent to raw materials storage area	Figure 1-3.4 Stations: 41+75 to 42+50	2000	• Potential fish passage barrier • Constriction of flood flows	• Remove culvert and other non-essential utilities • Reconstruct valley floor and floodplain (E.2) • Install in-stream structures (E.3, E.4, E.5, and E.7) to protect banks, convey sediment, and create pools/riffles • Revegetate riparian corridor (E.9, E.10 &, E.12)	II
Reach 8 – Screen Tower No. 4 embankment	Figure 1-3.4 to Figure 1-3.5	2000	• Area approximately 95% stable with remaining areas stabilizing	• Remove unnecessary infrastructure within 150 ft of stream channel	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
	Station 42+50 to 59+00			• Restore bankfull bench/floodplain (E.2) on left bank of the stream (where road exists) • Revegetate riparian corridor (E.9, E.10, & E.12) • Use the sediment study to evaluate and treat runoff from roads and facilities	
Reach 8 – Pond 9 Discharge (Q_s13)	Figure 1-3.4 Station 44+90	2009	• Source of fine sediment	• Update the SWPPP to improve stormwater controls upstream of Pond 9 • SWPPP to address Pond 9 cleanout maintenance/improvements • Reduce contributing drainage area • Use the sediment study to evaluate and improve trapping sediment runoff from roads and facilities	I
Reach 8 – 96" culvert without road crossing	Figure 1-3.4 Station 48+50 to 48+75	2009	• Potential fish passage barrier • Constriction of flood flows • Source of bank erosion	• Remove crossing if deemed non-essential to operations • Restore bankfull channel and bench/floodplain (E.1 & E.2) • Revegetate riparian corridor (E.9, E.10 &, E.12)	I

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 9 – Culvert under conveyor crossing	Figure 1-3.5 Station 59+00 to 60+00	2009	• Potential fish passage barrier • Constriction of flood flows • Source of bank erosion	• Remove culvert crossing, if non-essential • Restore bankfull channel and bench/floodplain (E.1 & E.2) • Revegetate riparian corridor (E.9, E.10 &, E.12) • Replace culvert with a bridge or stream simulation-type culvert (E.8) and armor banks with vegetated riprap (E.11), if road crossing is essential	II
Reach 9 – Sediment fan (Q_s12) and South Ridge Geotechnical Exploration Roads	Figure 1-3.5 Station 60+00	2009 and 2010	• Sediment source from material storage area adjacent to tributary	• Remove gravel from tributary drainage and storage area • Remove sediment fan from floodplain • Revegetate sediment fan area and slopes of tributary as necessary (E.12) • Update the SWPPP to repair road erosion and provide stormwater controls	I
Reach 9 – Creek between conveyor crossing and full culvert	Figure 1-3.5 Station 60+00 to 69+00	2000 and 2009	• Creek pushed to southern side of valley by road fill and levees	• Remove road if non-essential, or reduce road width to that necessary for one-way access • Restore bankfull channel and bench/floodplain (E.1 & E.2) • Revegetate riparian corridor (E.9, E.10 &, E.12)	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 10 – Parallel buried culvert	Figure 1-3.6 Station 69+00 to unknown extent	2009	• Artificially straightens reach by hardening southern bank	• Remove culvert or culvert end sections and crush inlet to prevent flow from entering the culvert, as appropriate • Install in-stream rock cross vanes (E.3) or other structures as a grade control • Stabilize and restore bank slope (E.9, E.10,, and E.12) • Revegetate riparian corridor (E.10 & E.12)	I
Reach 10 – West bank below full culvert	Figure 1-3.6 Station 75+00	2000 and 2010	• Small slumps that may contribute sediment were observed in 2010	• If slumping continues or worsens, consider removal of colluvial sediment and revegetate or hydroseed bare soil scarps (E.12 and E.15)	IV
Reach 10 – Concrete and riprap on eastern bank	Figure 1-3.6 Station 75+00	2000 and 2009	• No habitat	• Remove riprap and install step pool channel (E.4) with a bankfull bench (E.2) • Realign stream channel to add length, if necessary (E.1) • Revegetate riparian corridor (E.9, E.10, and E.12)	II
Reach 11 – Full culvert	Figure 1-3.6 Station 76+00 to 81+00	2000 and 2009	• Potential fish passage barrier • No habitat	• Remove culvert, road, and artificial valley fill • Realign stream channel to add length reducing stream to match upstream and downstream gradient, if necessary (E.1. • Install step pool channel (E.4) with a bankfull bench/floodplain (E.2) • Revegetate riparian corridor (E.9, E.10, and E.12)	II

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 12 – Half Culvert	Figure 1-3.6 to Figure 1-3.7 Station 81+00 to 85+00	2000 and 2009	• Potential fish passage barrier • No habitat • Potential temperature increase	• Remove culvert, road, and artificial valley fill • Realign stream channel to add length reducing stream to match upstream and downstream gradient, if necessary (E.1) • Install step pool channel (E.4) with a bankfull bench/floodplain (E.2) • Revegetate riparian corridor (E.9, E.10, and E.12)	II
Reach 13 – Pond 13	Figure 1-3.7 Station 85+00 to 87+50	2000 and 2009	• Barrier to fish passage • Vertical/unstable banks continuing sediment source	• Remove pond, pond infrastructure, and sediment to match historic upstream to downstream valley topography • Install step pool stream channel (E.4) with bankfull bench (E.2) • Revegetate riparian corridor (E.9, E.10, and E.12)	II
Reach 13 – Pond 13 over-excavation	Figure 1-3.7 Station 87+50 to 90+00	2000 and 2009	• 1-3 foot vertical banks a minor contributing sediment source	• Regrade a bankfull bench to remove cut banks (E.2) • Revegetate riparian areas (E.9, E.10, and E.12)	II
Reach 14 – Gully (Qs11)	Figure 1-3.7 Station 93+00	2000 and 2009	• Minor erosion associated with infrequent slump or raindrop slash erosion of raw gully banks • Erosion impacts hillside vegetation	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	IV

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 15 – Primary Crusher Drainage (Qs10)	Figure 1-3.8 Station 97+50	2000 and 2009	• Insignificant hillslope erosion as the gully no longer has source water to further erode banks • Gully appears to be revegetating	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	IV
Reach 15 – Debris slide (Qs9)	Figure 1-3.8 Station 101+50	2000 and 2010	• Insignificant hillslope erosion as the gully no longer has source water to further erode banks • Gully appears to be revegetating	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	IV
Reach 16 – Debris slide (Qs8)	Figure 1-3.8 Station 106+00	2000 and 2010	• Hillside sediment source to the creek from overland flow and material pushed over hill by recent grading operations	• Sediment reduction measures to be addressed in the SWPPP • Remove sheet pile or bend upright • Remove overburden sediment source • Hydromulch bare slope (E.15) • Install erosion control matting (E.16) • Revegetate hillslope with native vegetation (E.12)	I
Reach 16 – Debris slide (Qs7)	Figure 1-3.8 Station 111+00	2000 and 2010	• Insignificant hillslope erosion as the gully no longer has source water to further erode banks • Gully appears to be revegetating	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	No Action
Reach 16 – In-stream boulder pile	Figure 1-3.9 Station 115+75 to 116+25	2009	• Flow constriction • Potential fish passage barrier	• Remove excess in-stream boulders • Reestablish a bankfull bench (E.2)	III or IV

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 17 – Old crusher foundation	Figure 1-3.9 Station 116+25	2000 and 2009	• Flow constriction • Potential fish passage barrier	• Remove concrete structure • Reestablish a bankfull bench (E.2)	III or IV
Reaches 17 and 18 – Overburden material valley fill	Figure 1-3.9 to Figure 1-3.10 Station 116+00 to 138+00	2000 and 2009	• Sediment source • Minimal riparian habitat • Flows subsurface during low flow periods • Fish migration barrier when reach goes dry	• Remove overburden material in creek • Recreate a stable profile and "daylight" channel flow (E.1), geotechnical and groundwater investigations may be needed • Establish new bankfull bench/floodplain (E.2) • Install step pools to stabilize streambed (E.4) • Remove sediment source from quarry bottom water discharge • Revegetate riparian areas (E.9, E.10, and E.12) • Regrade, stabilize, and revegetate hillslope erosion (E.12, E.15, and E.16)	III or IV
Reach 18 – Unconsolidated Fill	Figure 1-3.10 Station 134+00 to 137+00	2000 and 2009	• Loose gravel and sediment dislodging and running off into the stream from the over-steepened overburden slope • Overburden slope confining the stream floodplain	• Remove excess overburden material away from the channel and layback slope to increase floodplain area (E.2) • Stabilize fill slope (E.15, E.16) • Revegetate slope and floodplain (E.12)	I
Reach 18 - Debris slide (Qs6)	Figure 1-3.10 Station 135+00	2000	• No longer a source. This feature naturally stabilized	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	No Action
Reach 18 – Debris slide (Qs5)	Figure 1-3.10 Station 138+00	2000	• No longer a source. This feature naturally stabilized	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	No Action

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 19 – Deposition of sediment	Figure 1-3.10 Station 138+00 to 157+00	2000 and 2009	• Deposition of fine material • Creek becomes wide and shallow with limited pools	• Remove sediment to transition stream profile through the former overburden stockpile area (E.1) • Install step pool structures (E.4) and bankfull bench (E.2) to facilitate competence and prevent headcutting • Revegetate riparian areas (E.9, E.10, and E.12)	III
Reach 19 – Debris slide (Qs4)	Figure 1-3.10 Station 139+00	2000	• No longer a source. This feature naturally stabilized	• None recommended • Sediment study to ensure that no Facility runoff enters the gully	No Action
Reach 19 – Debris slide (Qs3)	Figure 1-3.11 Station 141+20		• Sediment source • Debris flows impacting hillside vegetation • Gully erosion on upper slope threatening road	• Revegetate hillslope (E.12)	I
				• Remove sedimentation from riparian areas • Stabilize gully and hillslope erosion, recontrouring the hillside as needed (E.13, E.15 and/or E.16)	III
Reach 20 – Gully at Kaiser House road	Figure 1-3.12 Station 158+00 to 160+00	2009	• Erosion impacting hillside vegetation • Currently not a sediment source to the creek (no inflow from the Quarry)	• Revegetate invert of gully and hillslope along gully banks	III
Reach 21 – Debris slide (Qs2)	Figure 1-3.13 Station 178+50	2000 and 2009	• Upper slope of debris slide contributing minor amounts of sediment to the creek	• Stabilize gully and hillslope erosion (E.13, E.15, and E.16) • Revegetate hillslope (E.12)	III

Table 4-2 Summary of Permanente Creek recommended actions

Reach/ Location Description	Figure #/ Station	Year Identified	Effects on Creek	Preferred Restoration Measures and Selected Techniques*	Restoration Prioritization Category
Reach 21 – Debris slide (Qs1) and Hillslope Erosion	Figure 1-3.14 Station 187+50	2000 and 2009	• Channel incised through the debris flow material • May limit fish passage • Minor sediment input as stream adjusts profile through the debris flow material	• Hand remove sediment debris along the banks of the stream to reestablish a bankfull bench (E.2) • Install step pools with nearby rock (E.4) • Revegetate riparian area (E.12)	I
			• Hillslope erosion • Erosion impacting hillside vegetation • Gully erosion on upper slope threatens road	• Stabilize gully and hillslope erosion (E.13, E.15, and E.16) • Revegetate hillslope (E.12)	III

*The selected techniques, E.1 through E.16, are listed in Table 4-1 and fully described in Appendix E.

Acronyms and Abbreviations:

CRLF = California red-legged frog

SWPPP = Storm Water Pollution Prevention Plan

To best meet project goals and derive the greatest ecological benefit from the restoration, some activities listed in Table 4-2 should be implemented in conjunction with each other due to spatial proximity and interrelated effects between reaches. Simultaneous construction of the recommendations in these groupings contributes to increased ecological benefits by extending the restoration length of each implementation project. All the Category (I) activities may be implemented as stand-alone projects (shown as an "X" in the priority grouping column in Table 4-3). Table 4-3 indicates the recommended grouping of proposed restoration actions (described in Table 4-2) that should be implemented at the same time to provide the most ecological benefit and least environmental disturbance.

Table 4-3 Restoration priorities and groupings

Prioritization Category	Priority Grouping*	Reach/Location Description	Figure #	Station
I	X	Reach 2 – Pond 14 outfall channel	Figure 1-3.1	–1+00 to 0+00
I	X	Reach 5 – Pond 30 discharge (Q_s14)	Figure 1-3.1	6+00
I	X	Reach 8 – Pond 9 discharge (Q_s13)	Figure 1-3.4	44+90
I	X	Reach 8 – 96" culvert without road crossing	Figure 1-3.4	48+50 to 48+75
I	X	Reach 9 – Sediment fan (Q_s12) and south ridge geotechnical exploration roads	Figure 1-3.5	60+00
I	X	Reach 14 – Gully (Qs11)	Figure 1-3.7	93+00
I	X	Reach 15 – Primary crusher drainage (Qs10)	Figure 1-3.7	97+50
I	X	Reach 21 – Debris slide (Qs2)	Figure 1-3.13	178+50
I or II	X or C	Reach 10 – Parallel buried culvert	Figure 1-3.6	69+00 to unknown extent
Stormwater controls – I, Infrastructure Removal – II	X, B	Reach 8 – Screen Tower No. 4 overland flow	Figure 1-3.4 to Figure 1-3.5	42+50 to 59+00
II	A	Reach 3b – Pond 14 bypass channel	Figure 1.3-1	0+00 to 3+00
II	A	Reach 4 – Pond 22 outfall diversion Structure	Figure 1-3.1	3+00
II	A	Reach 4 – Pond 22	Figure 1-3.1	3+00 to 5+25
II	A	Reach 5 – Culvert under rail tracks	Figure 1-3.1	6+75 to 7+50
II	A	Reach 6 – Trapezoidal concrete channel	Figure 1-3.1 to Figure 1-3.3	7+50 to 31+00
II	A	Reach 6 – Culverts adjacent to raw materials storage area (3 culverts)	Figure 1-3.3	28+00 to 29+00, 31+00 to 32+00, 34+00 to 37+00,
II	A	Reach 7 – Culverts adjacent to raw materials storage area (2 culverts)	Figure 1-3.3 to Figure 1-3.4	38+50 to 39+00, 42+00 to 42+50
II	B	Reach 8 – Screen Tower No. 4 embankment	Figure 1-3.4 to Figure 1-3.5	42+50 to 59+00
II	B	Reach 9 – Culvert under conveyor crossing	Figure 1-3.5	59+00 to 60+00
II	C	Reach 9 – Creek between conveyor crossing and full culvert	Figure 1-3.5	60+00 to 69+00
II	D	Reach 10 – Concrete and riprap on eastern bank	Figure 1-3.6	75+00
II	D	Reach 11 – Full culvert	Figure 1-3.6	76+00 to 81+00
II	D	Reaches 11 and 12 – Rock pile north of Creek	Figure 1-3.6	76+00 to 82+00

Table 4-3 Restoration priorities and groupings

Prioritization Category	Priority Grouping*	Reach/Location Description	Figure #	Station
II	D	Reach 12 – Half culvert	Figure 1-3.6 to Figure 1-3.7	81+00 to 85+00
II	D	Reach 13 – Pond 13	Figure 1-3.7	85+00 to 87+50
II	D	Reach 13 – Pond 13 over-excavation	Figure 1-3.7	87+50 to 90+00
II	A	Reach 3a – Pond 14	Figure 1-3.1	0+00 to 3+00
III	F	Reaches 17 and 18 – Overburden material valley fill	Figure 1-3.9 to Figure 1-3.10	116+00 to 138+00
III or IV	E	Reach 16 – In-stream boulder pile	Figure 1-3.9	115+75 to 116+25
III or IV	E	Reach 17 – Old crusher foundation	Figure 1-3.9	116+25
IV	F	Reach 18 – Unconsolidated Fill	Figure 1-3.10	134+00 to 138+00
IV	F	Reach 19 – Depositional reach	Figure 1-3.10	138+00 to 157+00
IV	G	Reach 10 – West bank below full culvert	Figure 1-3.6	75+00
IV	G	Reach 15 – Debris slide (Qs9)	Figure 1-3.8	101+50
IV	G	Reach 16 – Debris slide (Qs8)	Figure 1-3.8	106+00
IV	G	Reach 16 – Debris slide (Qs7)	Figure 1-3.8	111+00
IV	G	Reach 19 – Debris slide (Qs3)	Figure 1-3.11	141+20
IV	G	Reach 20 – Gully at Kaiser House road	Figure 1-3.12	158+00 to 160+00
No Action	—	Reach 18 – Debris slide (Qs6)	Figure 1-3.10	135+00
No Action	—	Reach 18 – Debris slide (Qs5)	Figure 1-3.10	138+00
No Action	—	Reach 19 – Debris slide (Qs4)	Figure 1-3.10	139+00
No Action	—	Reach 21 – Debris slide (Qs1)	Figure 1-3.14	187+50

*Activities designated with a priority grouping of "X" are considered as stand alone activities, thus do not need to be implemented along with other project locations.

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Appendix A

Figure 1-3.1 Through 1-3.14

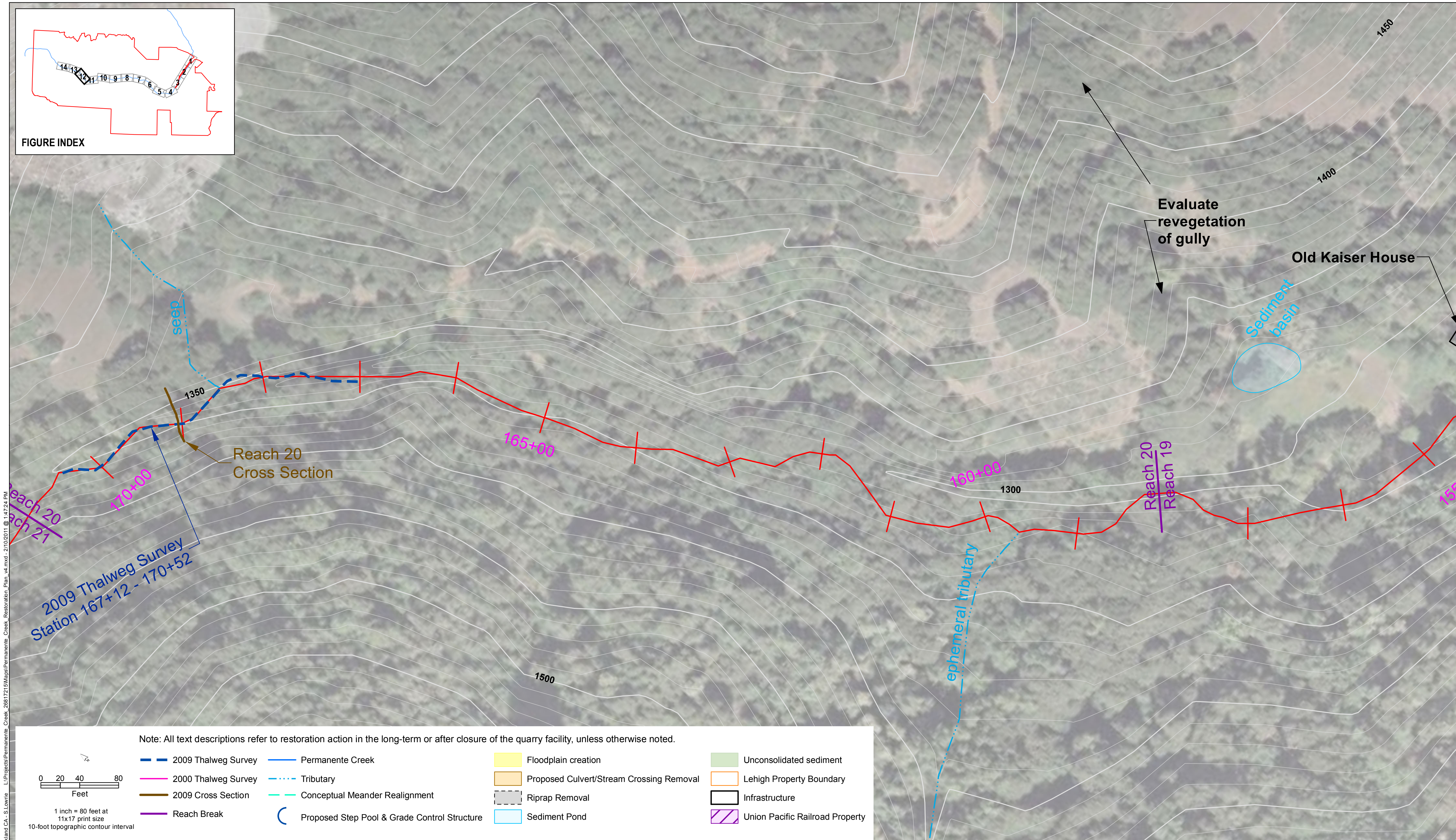

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Figure 1-3.12

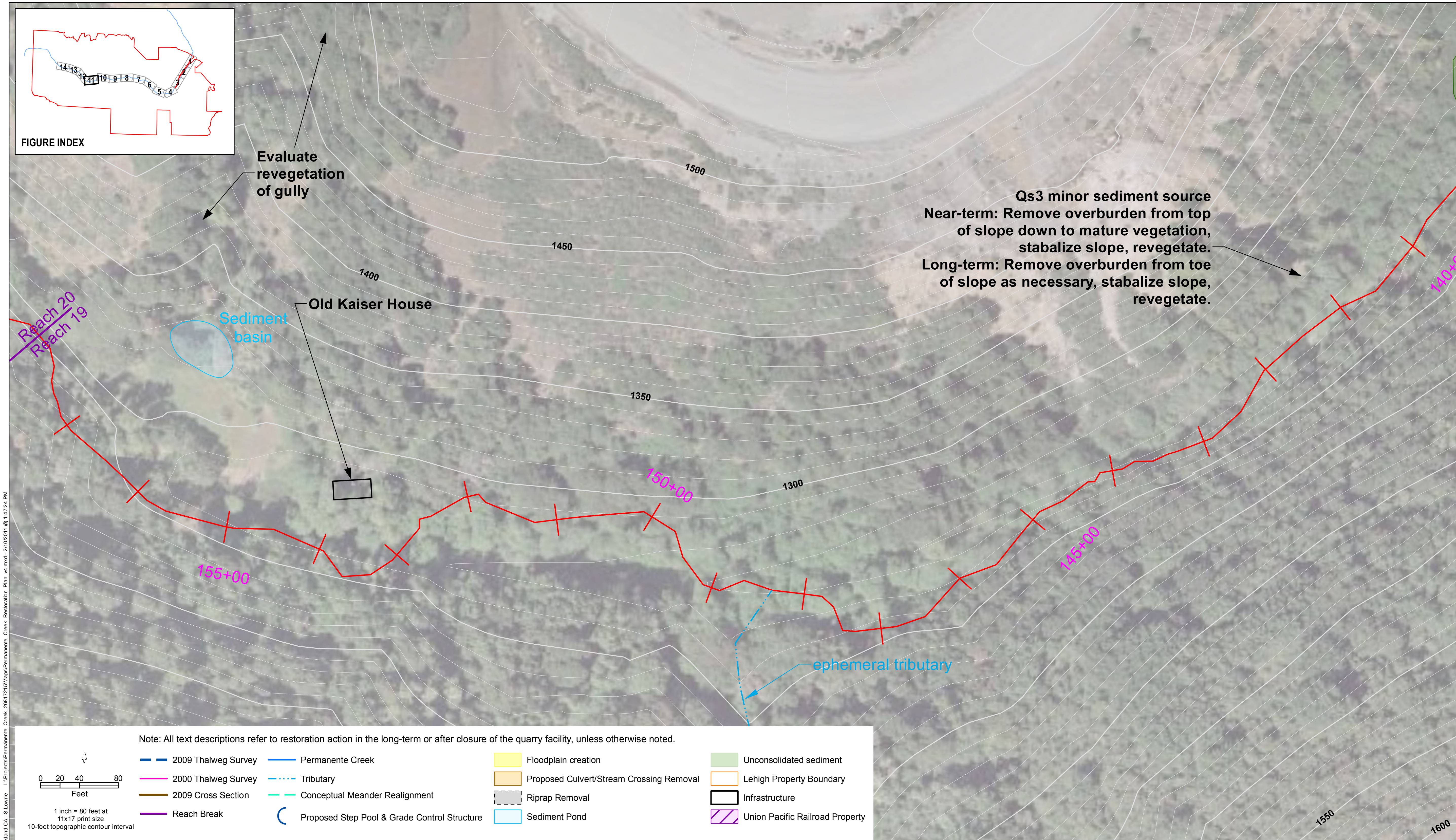

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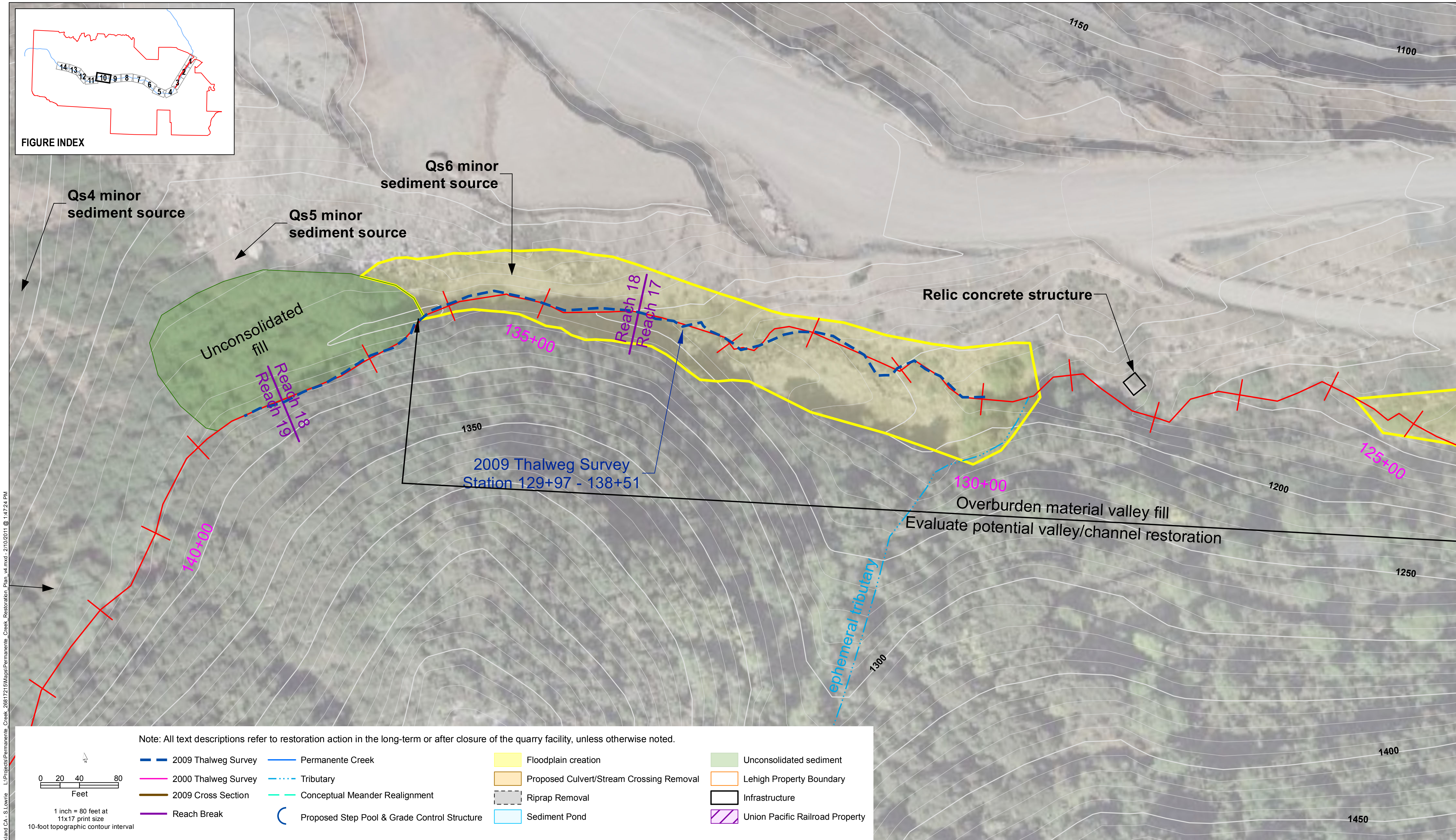
Figure 1-3.11



Note: All text descriptions refer to restoration action in the long-term or after closure of the quarry facility, unless otherwise noted.

0 20 40 80 Feet

1 inch = 80 feet at 11x17 print size

10-foot topographic contour interval

- 2009 Thalweg Survey
- 2000 Thalweg Survey
- 2009 Cross Section
- Reach Break
- Permanente Creek
- Tributary
- Conceptual Meander Realignment
- Proposed Step Pool & Grade Control Structure
- Floodplain creation
- Proposed Culvert/Stream Crossing Removal
- Riprap Removal
- Sediment Pond
- Unconsolidated sediment
- Lehigh Property Boundary
- Infrastructure
- Union Pacific Railroad Property

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Figure 1-3.10

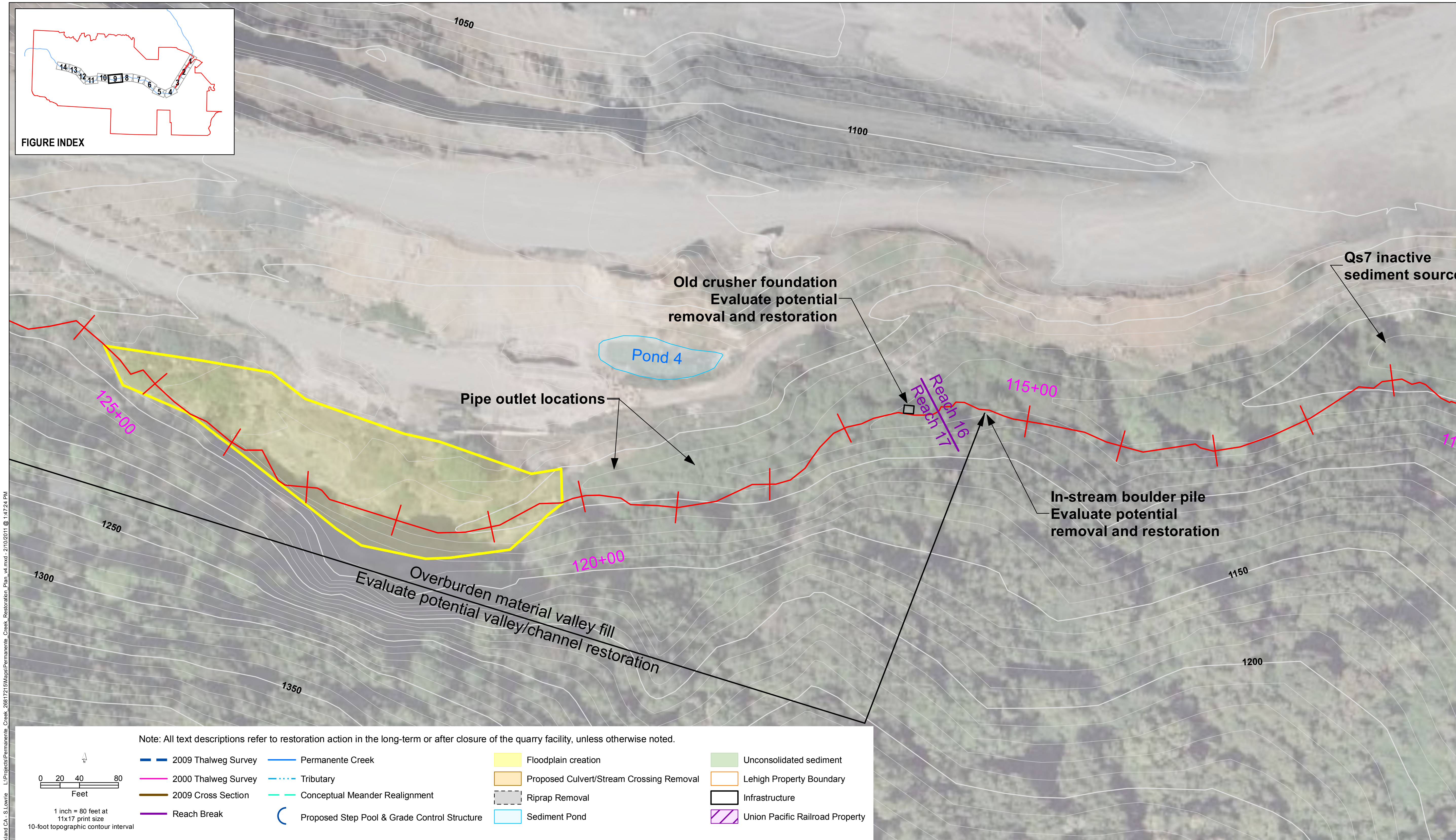

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Figure 1-3.9

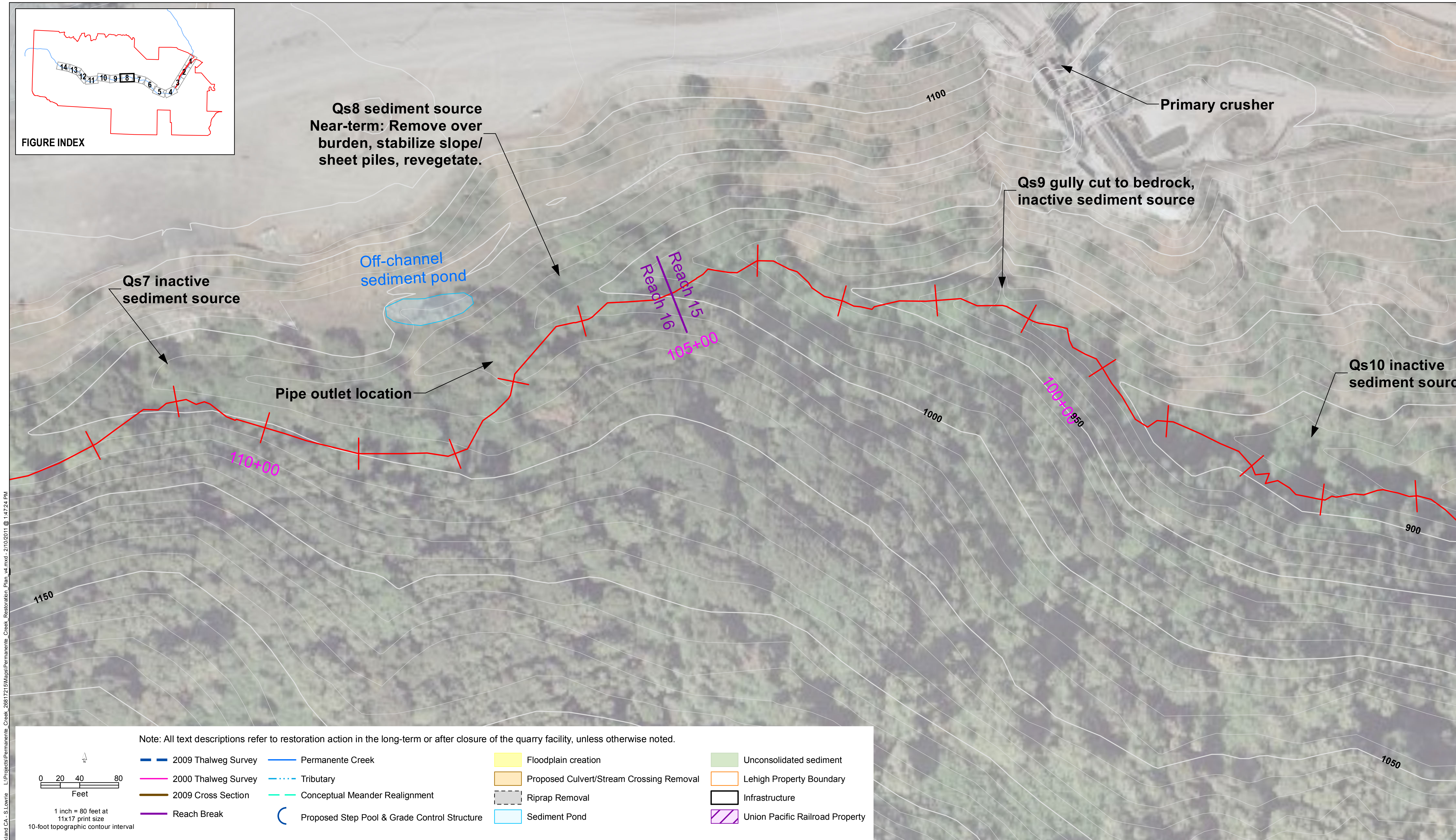

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Figure 1-3.8

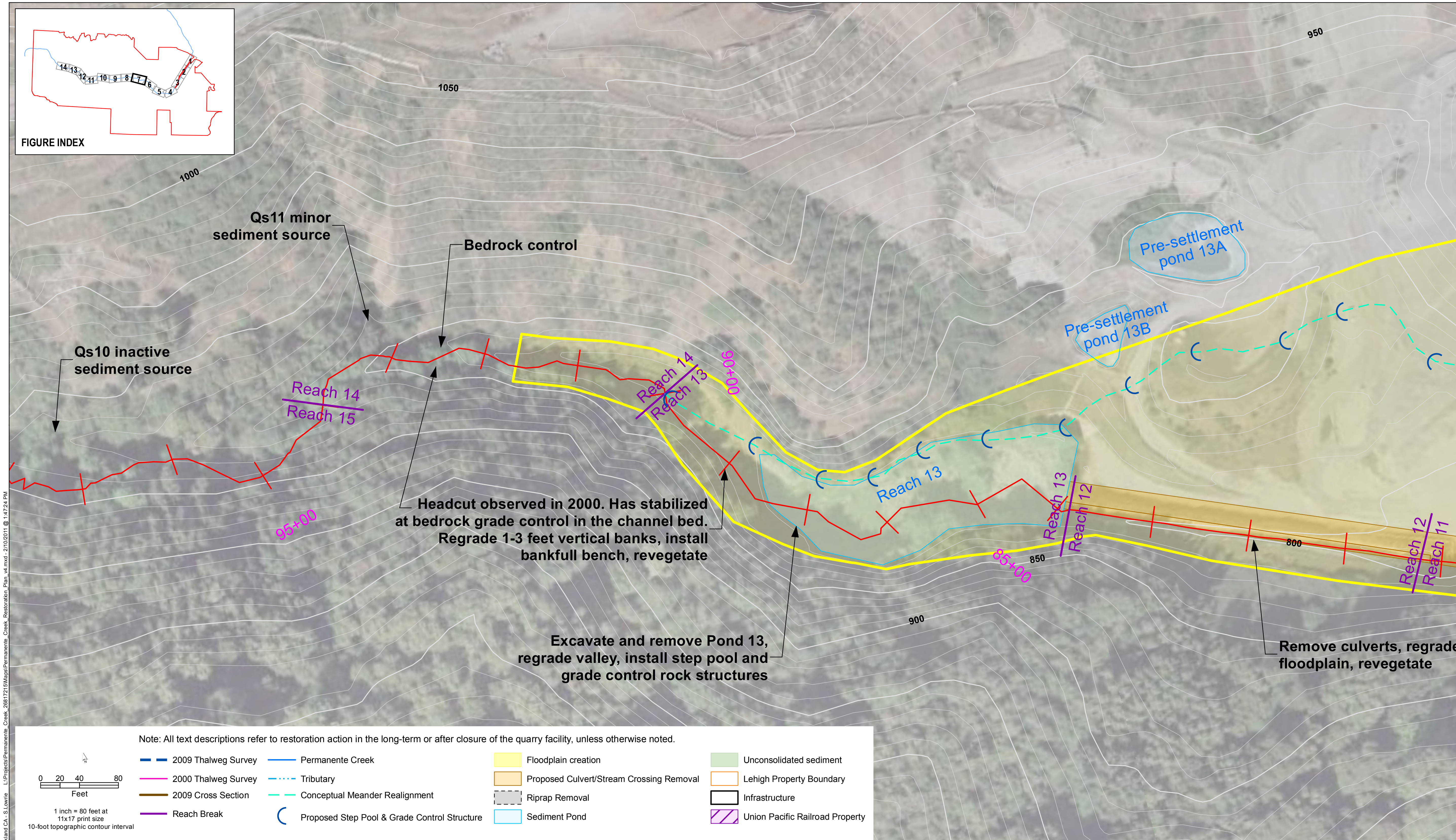

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Figure 1-3.7

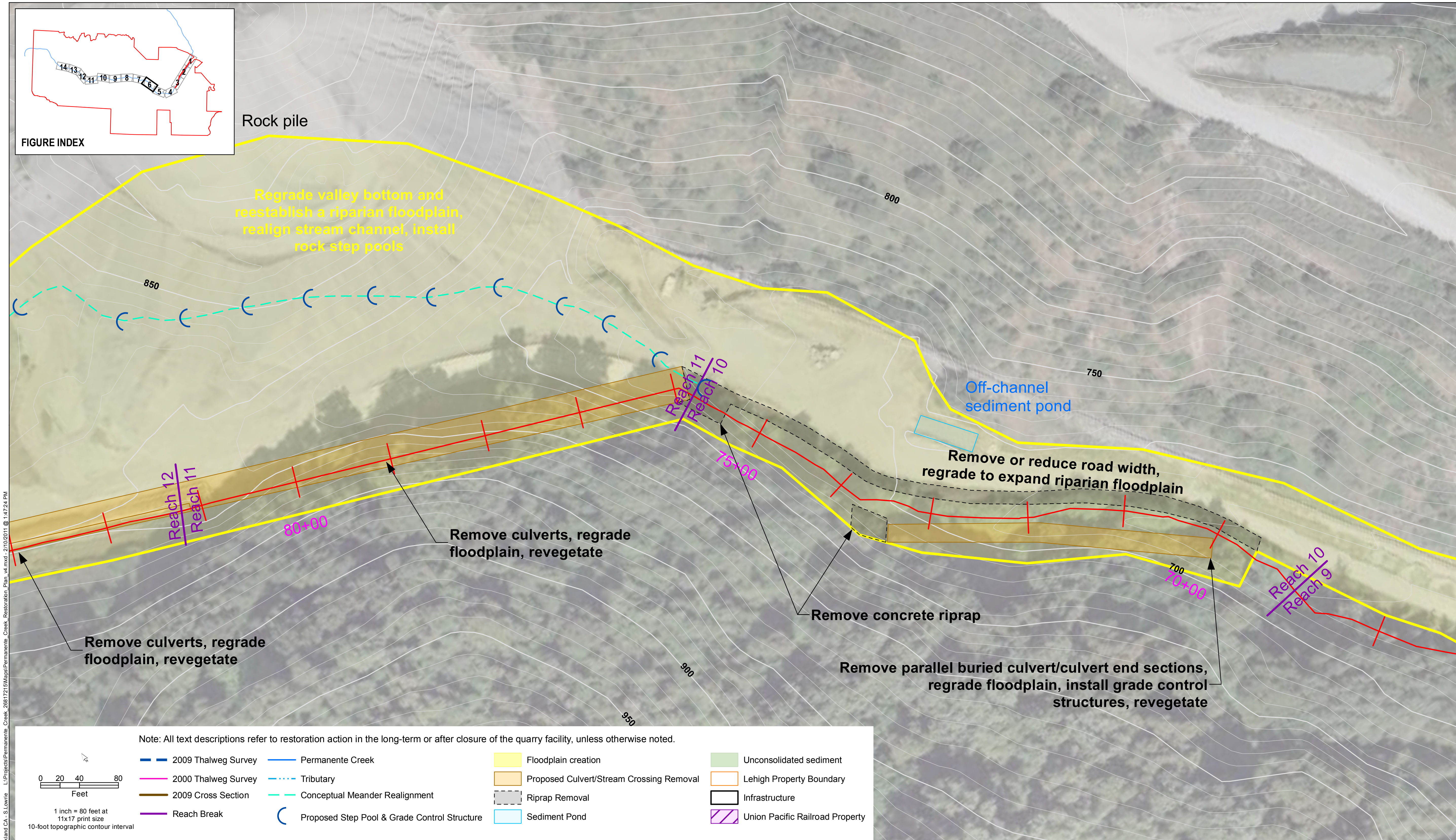

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Figure 1-3.6

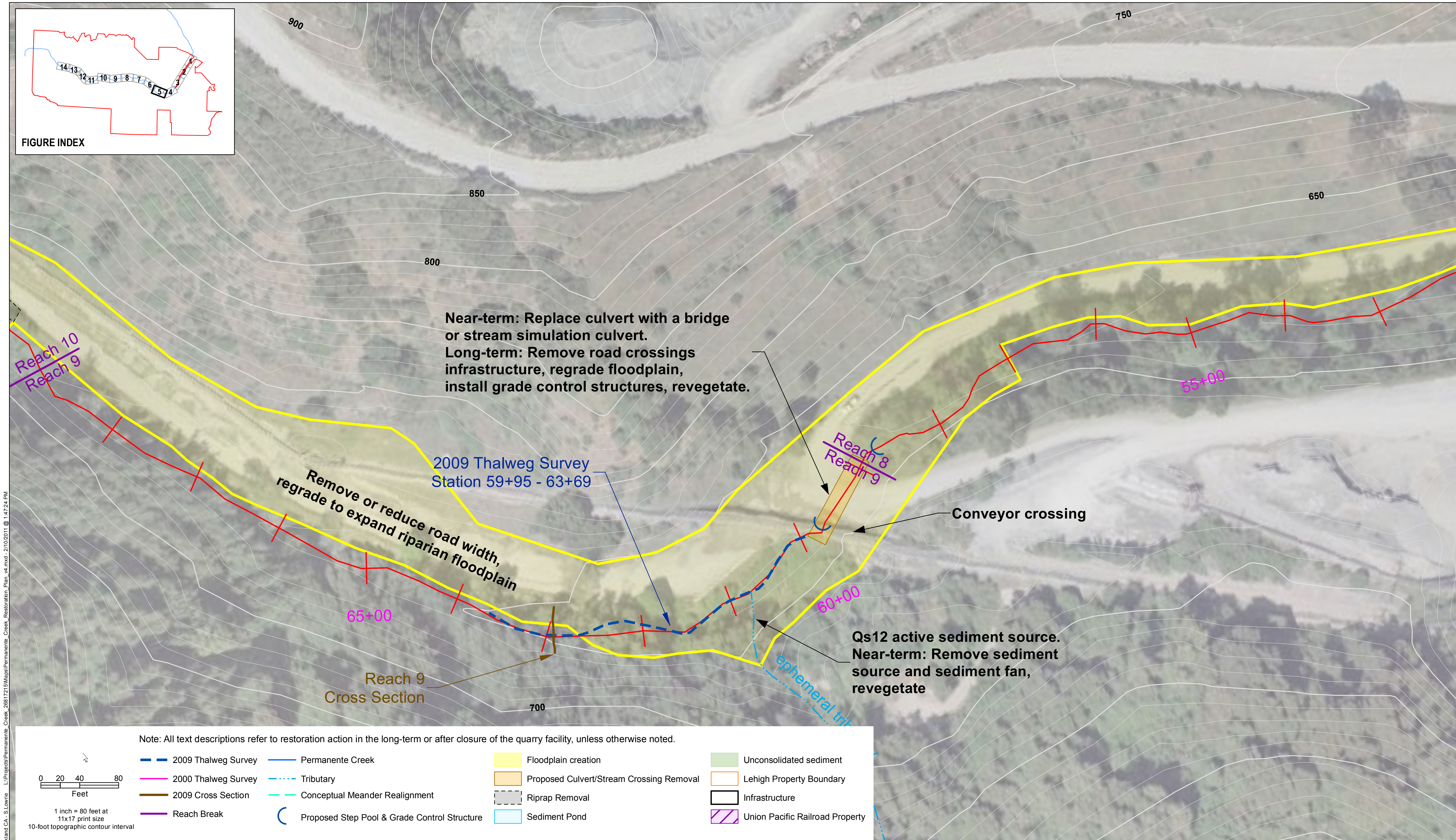

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Figure 1-3.5

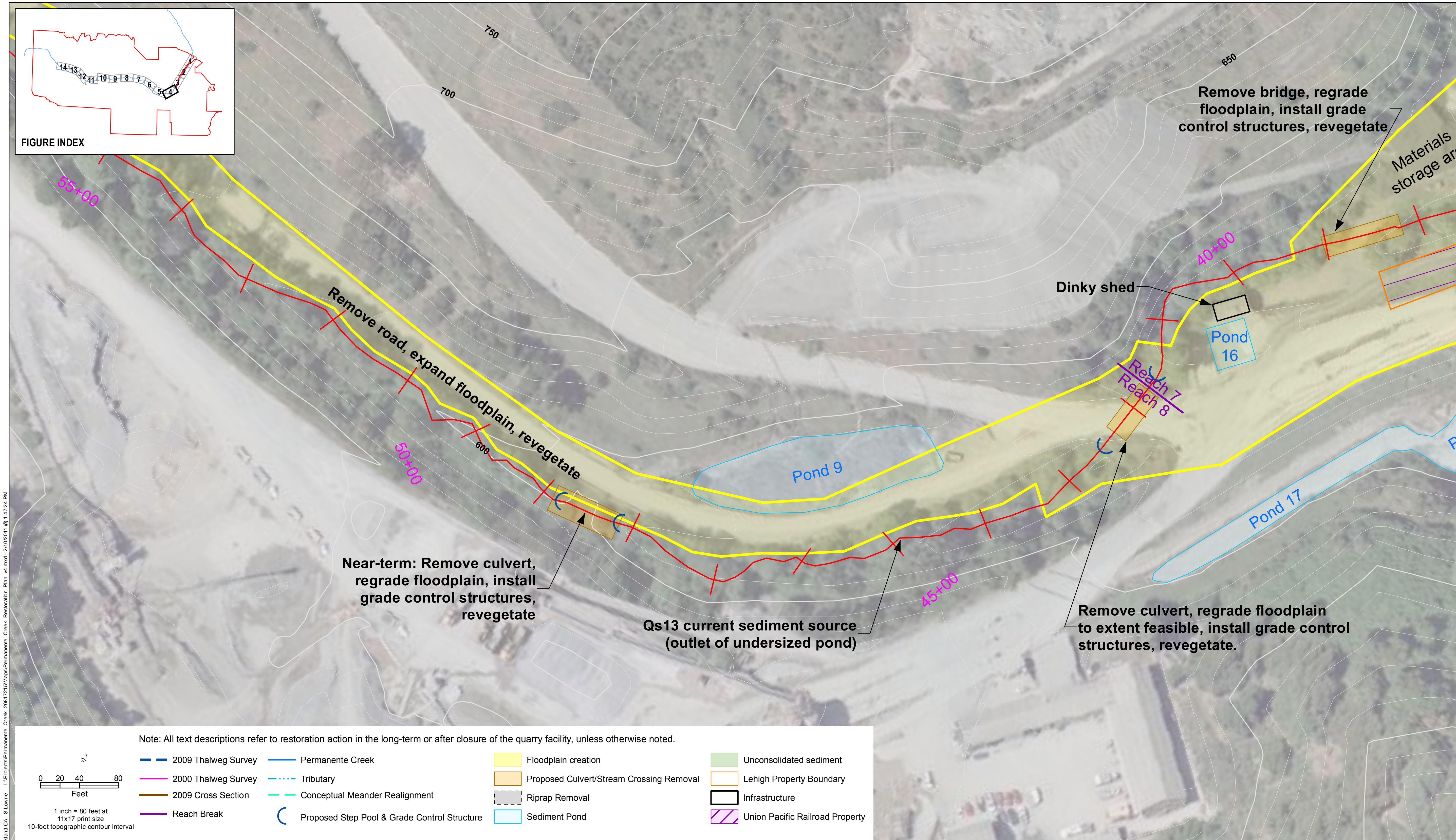

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Figure 1-3.4

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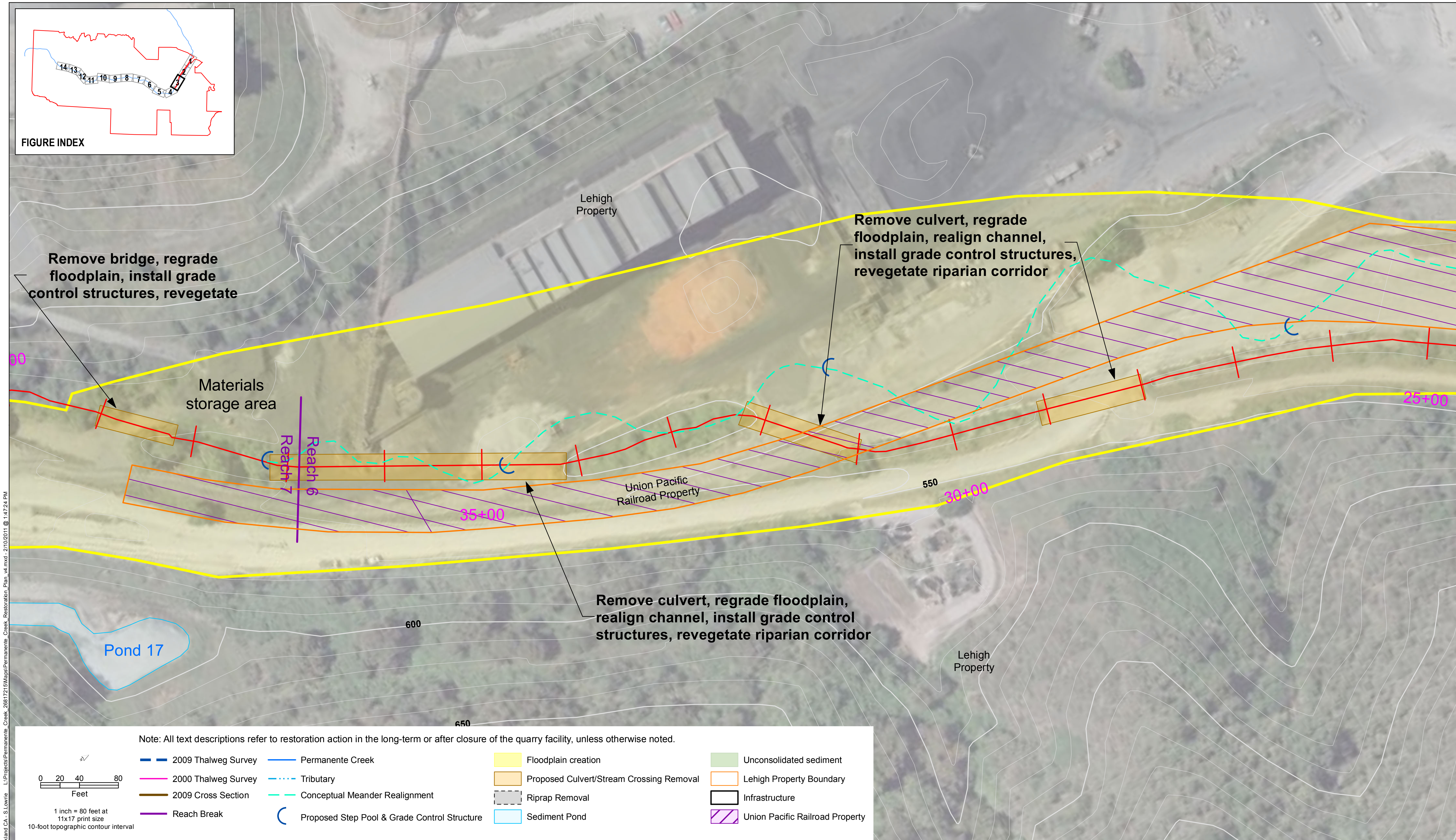

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Figure 1-3.3

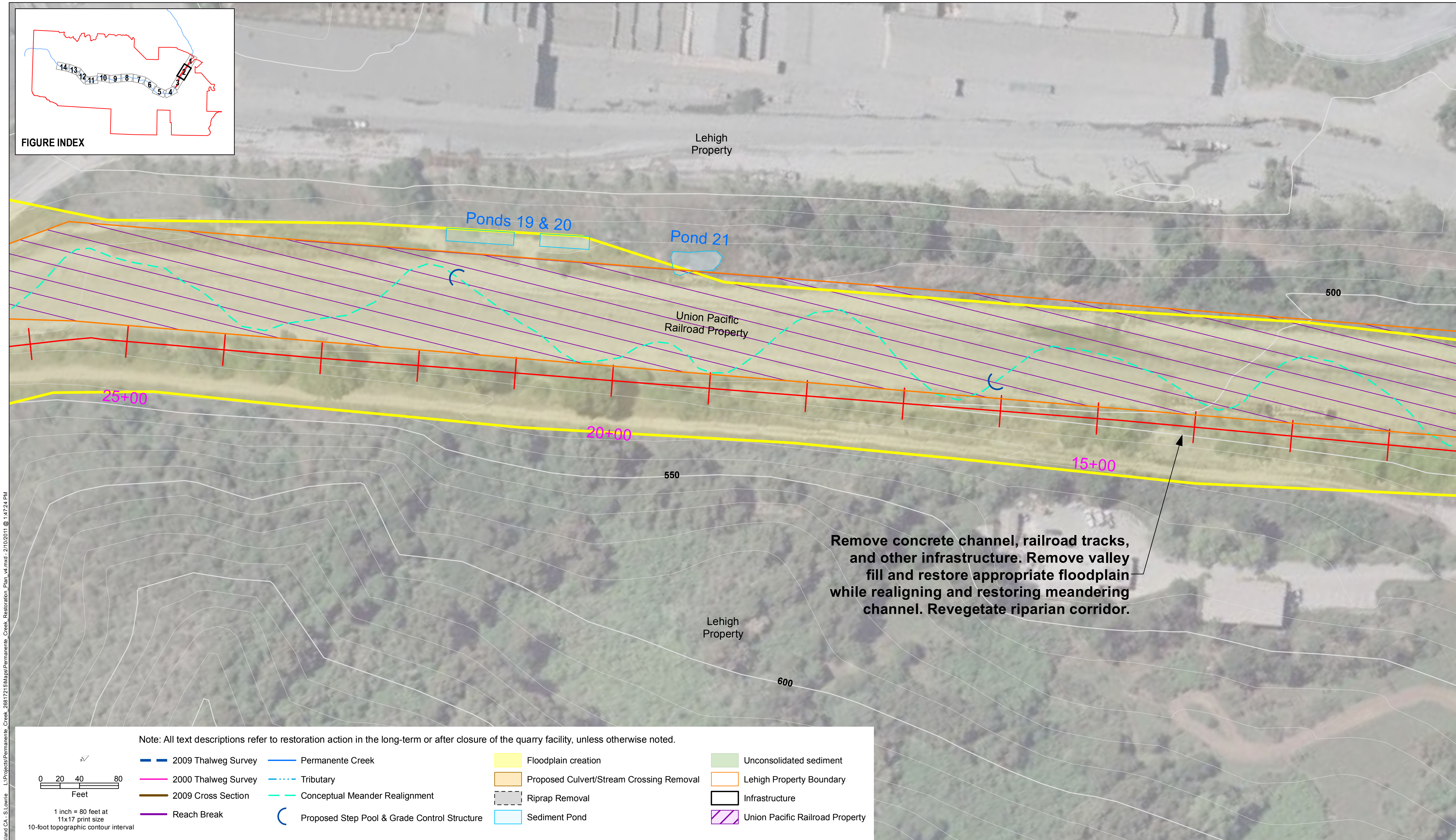

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Figure 1-3.2

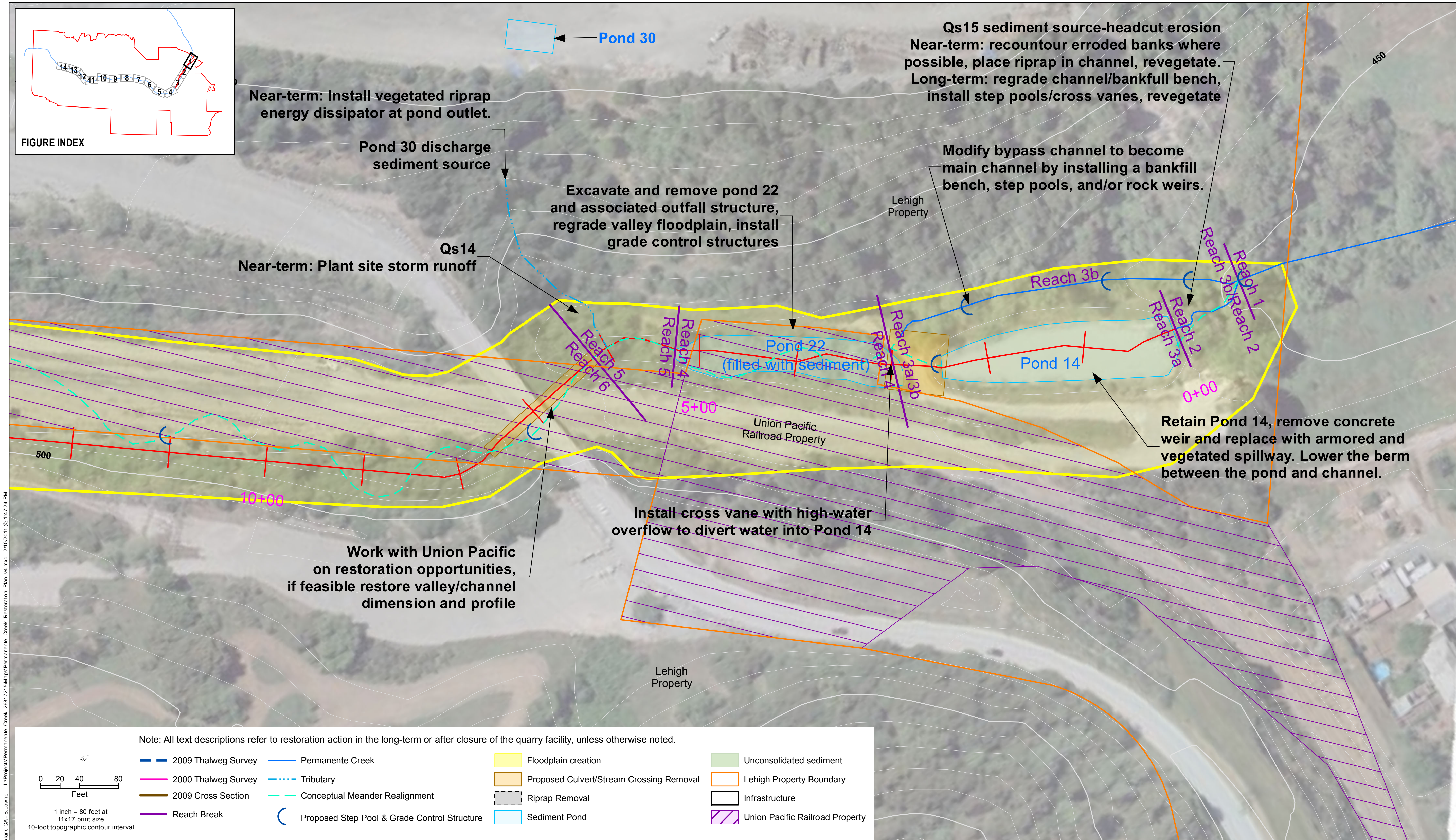

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Figure 1-3.1

Appendix B

Phase I Report - Plant and Animal Communities

This section describes the biological surveys conducted on Permanente Creek during Spring and Summer 2000, including vegetation, bird, animal, fish, and invertebrate surveys. All surveys conducted were qualitative, with the exception of the fish survey.

2.1 PLANT COMMUNITIES

A vegetation survey was conducted on June 28, 2000, to identify and characterize plant communities along Permanente Creek on the Hanson Permanente Cement property. A list of dominant plant species found was compiled subsequent to the survey and is provided in Table 2-1. This list identifies each plant's common scientific name and categorizes each plant by native/nonnative status, vegetation layer, habit, vegetation community, and location within the watershed (stream reach or instream pond). A discussion of the vegetation survey methodology and description of the plant communities is provided in the following sections.

2.1.1 Methods

Dominant plant communities found along Permanente Creek watershed were divided into five broad community types: aquatic, wetland, riparian woodland, human-made pond bank, and mixed evergreen/deciduous forest. Dominant plant species identified in each community type were further divided by habit and vegetation layer. Habit describes the form in which the plants grow (i.e., submergent refers to leaves of the plant growing in submerged conditions). Plants were categorized into four vegetation layers determined by their growth form: tree, shrub (small tree), herbaceous, and vine.

2.1.2 Plant Community Descriptions

Dominant plant communities along Permanente Creek on Hanson Permanente Cement property are described below:

- *Aquatic* - The main aquatic plant communities found along the Creek and instream sedimentation basins (instream ponds) were submergent and floating habits. Dominant submergent plants included parrot's feather (*Myriophyllum aquaticum*) and various species of algae. Submergent plants were found primarily in aquatic communities of the instream ponds and to a lesser extent in some reaches of the creek. Watercress (*Rorippa* sp.) was the dominant floating plant found in aquatic communities in the instream ponds. Dominant submergent and floating plants were all found in the herbaceous layer.

- *Wetland* - Wetland plant communities were found primarily in instream ponds along Permanente Creek. The emergent habit predominated among wetland plant communities. All dominant wetland plants were found in the herbaceous layer. Dominant plants found along edges of the human-made ponds include cattail (*Typha* spp.), common horsetail

Table 2-1
Plant Species List and Locations

Common Name	Scientific Name	Native	Vegetation Layer	Vegetation Community	Reach G and Up-stream	Pond 13	Reach E	Reaches D & C	Reach B	Reach A	Pond 14/22
Alder	*Alnus rhombifolia*	Yes	tree	riparian woodland				X	X		X
Annual bluegrass	*Poa annua*	No	herbaceous	many	X		X		X		
Barley	*Hordeum vulgare*	No	grass	many							X
Big leaf maple	*Acer macrophyllum*	Yes	tree	riparian woodland	X	X					
Black mustard	*Brassica nigra*	No	herbaceous	many		X	X	X		X	X
Blue elderberry	*Sambucus mexicana*	Yes	tree	riparian woodland				X	X		
Bristly ox-tongue	*Picris echioides*	No	herbaceous	pond bank							X
Buckeye	*Aesculus californica*	Yes	tree	riparian woodland	X						
Bull thistle	*Cirsium vulgare*	No	herbaceous	pond bank/ disturbed		X					
Bush monkey flower	*Mimulus aurantiacus*	Yes	shrub	chaparral	X						
California bay	*Umbellularia californica*	Yes	tree	upland forest	X	X	X				
California blackberry	*Rubus ursinus*	Yes	vine	riparian woodland/ pond bank	X	X		X	X		
California buckwheat	*Eriogonum fasciculatum*	Yes	shrub	chaparral	X						
California figwort	*Scrophulana californica*	Yes	herbaceous	riparian woodland				X	X		
California man-root	*Marah fabaceus*	Yes	vine	riparian woodland	X						
California sagebrush	*Artemisia californica*	Yes	shrub	coastal sage scrub						X	X
California wild grape	*Vitis californica*	Yes	vine	riparian woodland							
California wild rose	*Rosa californica*	Yes	shrub	riparian				X			

Table 2-1 (continued)

Common Name	Scientific Name	Native	Vegetation Layer	Vegetation Community	Reach G and Up-stream	Pond 13	Reach E	Reaches D & C	Reach B	Reach A	Pond 14/22
				woodland							
Cattail	*Typha* sp.	Yes	emergent	wetland/ riparian	X	X					X
Chamise	*Adenostoma fasciculatum*	Yes	shrub	chaparral	X						
Coast live oak	*Quercus agrifolia*	Yes	tree	riparian/ upland forest	X	X	X		X	X	
Coffeeberry	*Rhamnus californica*	Yes	tree	riparian woodland							
Cow parsnip	*Heracleum lanatum*	Yes	herbaceous	riparian woodland	X						
Coyote brush	*Baccharis pilularis* var. *consanguinea*	Yes	shrub	chaparral	X			X		X	
Cudweed	*Gnaphalium luteo-album*	No	herbaceous	riparian/ disturbed	X						
Deerweed	*Lotus scoparius*	Yes	shrub	chaparral	X						
Dock	*Rumex* sp.	No	herbaceous	many				X	X		
Fennel	*Foeniculum vulgare*	No	herbaceous	pond bank							X
Gooseberry	*Ribes californicum*	Yes	shrub	upland forest	X		X				
Honeysuckle	*Lonicera hispidula*	Yes	vine	riparian/ chaparral	X						
Horsemint	*Agastache urticifolia*	Yes	herbaceous	riparian woodland	X	X					
Horsetail	*Equisetum arvense*	Yes	wetland	wetland/ riparian		X	X	X	X		
Iris-leaved rush	*Juncus xiphioides*	Yes	wetland	wetland/ riparian	X						
Italian ryegrass	*Lolium multiflorum*	No	herbaceous	pond bank		X	X	X			X
Italian thistle	*Carduus pycnocephalus*	No	herbaceous	pond bank	X	X		X	X	X	X
Licorice fern	*Polypodium glycyrrhiza*	Yes	herbaceous	riparian/ upland forest	X						X

Table 2-1 (continued)

Common Name	Scientific Name	Native	Vegetation Layer	Vegetation Community	Reach G and Up-stream	Pond 13	Reach E	Reaches D & C	Reach B	Reach A	Pond 14/22
Mariposa tulip	*Calochortus* sp.	Yes	herbaceous	upland forest	X						
Mugwort	*Arlemesia douglasiana*	Yes	herbaceous	riparian woodland	X				X		
Northern California black walnut	*Juglans hindsii*	depends	tree	riparian woodland	X				X		
Nutsedge	*Cyperus* sp.	species depende nt	wetland	wetland/ riparian	X			X			
Oceanspray	*Holodiscus discolor*	Yes	shrub	upland forest		X		X			
Pacific madrone	*Arbutus menziesii*	Yes	tree	chaparral		X					
Pampas grass	*Cortaderia selloana*	No	herbaceous	chaparral	X						
Parrot's feather	*Myriophyllum aquaticum*	No	herbaceous	submergent aquatic	X						
Pipestems	*Clematis lasiantha*	Yes	vine	riparian woodland	X						
Poison oak	*Toxicodendron diversilobum*	Yes	variable	riparian/ upland forest	X		X	X	X	X	
Prickly lettuce	*Lactuca serriola*	No	herbaceous	pond bank				X			X
Rabbit's foot grass	*Polypogon monspeliensis*	No	herbaceous	riparian woodland	X	X	X		X		X
Ripgut brome	*Bromus diandrus*	No	herbaceous	pond bank					X		X
Scarlet monkey flower	*Mimulus cardinalis*	Yes	herbaceous	riparian woodland	X		X	X			
Scotch broom	*Cytisus scoparius*	No	shrub	chaparral	X						
Snowberry	*Symphoricarpos mollis*	Yes	shrub	upland forest		X					
Sourclover	*Melilotus indica*	No	herbaceous	wetland/ riparian						X	X
Stinging nettle	*Urtica dioica*	Yes	herbaceous	wetland/ riparian	X			X	X		
Subteranean clover	*Trifolium subteraneum*	No	herbaceous	riparian woodland				X			X

Table 2-1 (continued)

Common Name	Scientific Name	Native	Vegetation Layer	Vegetation Community	Reach G and Up-stream	Pond 13	Reach E	Reaches D & C	Reach B	Reach A	Pond 14/22
Sword fern	*Polystichum dudleyi*	Yes	herbaceous	riparian woodland	X						
Telegraph weed	*Heterotheca grandiflora*	Yes	herbaceous	riparian/ disturbed				X			
Toyon	*Heteromeles arbutifolia*	Yes	tree	chaparral	X						
Vetch	*Vicia* sp.	species depen-dent	vine	disturbed				X			
Watercress	*Rorippa* sp.	Yes	wetland	wetland/ riparian		X			X		
Western sycamore	*Platanus racemosa*	yes	tree	riparian woodland				X			
White everlast	*Gnaphalium canescens* ssp. *microcephalum*	Yes	herbaceous	riparian/ disturbed	X			X			
Wild oat	*Avena fatua*	No	herbaceous	pond bank/ disturbed					X		
Willow	*Salix* sp.	Yes	tree	riparian woodland	X		X	X	X	X	X
Willow herb	*Epilobium ciliatum* ssp. *ciliatum*	Yes	herbaceous	wetland/ riparian	X				X		X
Yarrow	*Achillea millefolium*	Yes	herbaceous	many	X			X			
Yellow star thistle	*Centaurea solstitialis*	No	herbaceous	pond bank				X			X

X = Tree species as seedlings/saplings

(*Equisetum arvense*), rabbit's foot grass (*Polypogon monspeliensis*), and willow herb (*Epilobium ciliatum* ssp *ciliatum*).

- *Riparian Woodland* - Riparian woodland plant communities, or plants associated with the banks of the creek, consisted of emergent plants found within the stream channel (wetted width) and plants found growing in the floodplains of the creek. Dominant emergent plants found in riparian woodland communities along Permanente Creek were all in the herbaceous vegetation layer and include cattail (*Typha* spp.), horsemint (*Agastache urticifolia*), iris-leafed sedge (*Juncus xiphioides*), nutsedge (*Cyperus eragrostis*), stinging nettle (*Urtica dioica*), watercress (*Rorippa* sp.), and willow herb (*Epilobium ciliatum* ssp *ciliatum*).

  The floodplain of Permanente Creek was composed of plant species from all vegetation layers. Dominant plant species in the tree layer were blue elderberry (*Sambucus mexicana*), big leaf maple (*Acer macrophyllum*), California buckeye (*Aesculus californica*), coast live oak (*Quercus agrifolia*), coffeeberry (*Rhamnus californica*), Northern California black walnut (*Juglans californica* var. *hindsii*), western sycamore (*Platanus racemosa*), white alder (*Alnus rhombifolia*), and willow (*Salix* spp.). The floodplain shrub layer is dominated by saplings of blue elderberry, coast live oak, Northern California black walnut, white alder, and willow and California sagebrush (*Artemisia californica*), California wild rose (Rosa californica), coyote brush (*Baccharis pilularis*), and poison oak (*Toxicodendron diversilobum*). The herbaceous vegetation layer was comprised primarily of the following dominant species: annual bluegrass (*Poa annua*), black mustard (*Brassica nigra*), California figwort (*Scrophularia californica*), cow parsnip (*Heracleum lanatum*), cudweed (*Gnaphalium luteo-album*), dock (*Rumex* sp.), horsetail, horsemint, Italian thistle, scarlet monkey flower (*Mimulus cardinalis*), mugwort (*Artemisia douglasiana*), poison oak, rabbit-foot grass, ripgut brome (*Bromus diandrus*), sourclover, stinging nettle, and seedlings of tree and shrub species (especially willow). Dominant plant species in the vine layer include California blackberry (*Rubus ursinus*), California man-root (*Marah fabaceus*), honeysuckle (*Lonicera hispidula* var. *vacillans*), pipestems (*Clematis lasiantha*), and poison oak.

- *Instream Ponds and Streambank* - Both the banks of the instream ponds and channelized streambanks exhibit similar plant communities. A few scattered shrubs and many weedy herbaceous plants and grasses are found in these areas. Dominant shrubs include California sagebrush, coyote brush, scotch broom (*Cytisus scoparius*), and occasional willow/coast live oak/alder saplings and seedlings. The herbaceous layer is dominated by barley (*Hordeum vulgare*), black mustard, bristly ox-tongue (*Picris echioides*), fennel, Italian rye grass, Italian thistle, poison oak, and sourclover (*Melilotus indica*).

- *Mixed Evergreen/Deciduous Forest* - The north-facing slope of Permanente Creek canyon consists of a mixed evergreen/deciduous forest. Dominant tree species in this community are big leaf maple, California bay (*Umbellularia californica*), California black walnut, and coast live oak. Shrubs found in this community include gooseberry (*Ribes californicum*), oceanspray (*Holodiscus discolor*), and snowberry (*Symphoricarpos mollis*). The herbaceous layer consists of licorice fern (*Polypodium glycyrrhiza*), mariposa tulip (*Calachortus* sp.), poison oak, sword fern (*Polystichum dudleyi*), and several grass species.

- *Chaparral* - Chaparral plant communities were found on the south-facing side of the canyon on the banks below Hanson Permanente Cement operations. This community consisted of shrubs, bunchgrasses, and annual, nonnative grasses. The shrub layer contained primarily California buckwheat (*Eriogonum fasciculatum*), California sagebrush (*Artemisia californica*), chamise (*Adenostoma fasciculatum*), coyote brush (*Baccharis pilularis*), deerweed (*Lotus scoparius*), scotch broom, and an occasional small tree, Pacific madrone (Arbutus menziesii). Plants that dominated the herbaceous layer included black mustard, pampas grass (Cortaderia selloana), white everlast (*Gnaphalium canescens* ssp. *microcephalum*), wild oat (*Avena fatua*), and yellow star thistle (*Centaurea solstitialis*).

2.2 ANIMALS

Qualitative animal surveys were conducted during Spring and Summer 2000. A list of birds, mammals, amphibians, fish and invertebrates found during these surveys is presented in Table 2-2. A description of the survey methodology and the results of the habitat survey are discussed below in the following sections. In addition, a separate discussion of the California Red Legged Frog is presented in Section 2.2.5.

2.2.1 Description of Survey Methods

Habitat surveys were conducted on July 14 and July 21, 2000, using an abbreviated version of the *California Salmonid Stream Habitat Assessment* (Flossi and Reynolds 1998). The habitat survey included the measurement of stream segments and different habitat conditions and detailed description of discreet habitat units. During the electrofishing survey it was determined that rainbow trout (*Oncorhynchus mykiss*) were present in the stream and that most trout were found in pools. Other habitat types were generally too shallow to provide suitable habitat conditions. Therefore, pools were fully described in terms of shelter components, substrate, and other habitat components. Non-pool habitats were not further classified, but length of non-pool habitat units was recorded as were mean width, mean depth, maximum depth, substrate dominant and subdominant size classes, area of potential spawning habitat, spawning substrate condition, and canopy cover. Permanente Creek was divided into nine discreet stream reaches based on habitat characteristics as summarized in Table 2-3.

Fish sampling using electrofishing and visual observation was conducted on May 11 and May 22, 2000. Electrofishing was completed using a single-pass, reconnaissance survey method. Due to the small size of the stream and good visibility, it is likely that almost all the trout in the sampled sections were either captured or seen. Areas sampled and results of the survey are presented in Table 2-4. The electrofishing was conducted in reaches that are subsections of the nine discreet habitat survey stream reaches. The electrofishing reaches are displayed on Figure 2-1.

Additional information on fish inhabiting Pond 22 and Pond 13 was collected during fish removal in preparation for de-silting operations at both ponds. Fish removal was conducted on August 18 and 21, 2000.

Table 2-2
Animal Species List, Permanente Creek

Common Name	Scientific Name
Birds	
American crow	*Corvus brachyrhynchos*
Black phoebe	*Sayornis nigricans*
Green heron	*Butorides virescens*
House finch	*Carpodacus mexicanus*
Mourning dove	*Zenaida macroura*
Red-tailed hawk	*Buteo jamaicensis*
Rufous-sided towhee	*Pipilo erythrophthamus*
Rock dove	*Columba livia*
Steller's jay	*Cyanocitta stelleri*
Tree swallow	*Tachycineta bicolor*
Violet green swallow	*Tachycineta thalassina*
Woodpecker	(heard only)
Mammals	
Coyote	*Canus latrans*
Mule deer	*Odocoileus hemionus*
Amphibians	
Rough-skinned newt	*Taricha granulosa*
Pacific tree frog	*Hyla regilla*
Fish	
Rainbow trout	*Oncorhynchus mykiss*
Stickleback	*Gasterosteus aculeatus*
Invertebrates	
Aquatic beetles	*Coleoptera*
Aquatic worms	*Oligochaetes*
Banana slug	*Ariolimax* spp.
Caddis fly	*Trichoptera*
Damsel fly	*Zygoptera*
Hellgrammite	*Corydalidae*
Mayfly	*Ephemeroptera*
Midges	*Tendipedidae*
Stonefly	*Plecoptera*
Water striders	*Gerridae*

Table 2-3
Permanente Creek Habitat Survey Summary

Station Location	Reach	Habitat Components by Length (ft)							Mapped Habitat Components (%)						Average % Canopy	Mean Depth of Pools (ft)	Maximum Depth of Pools (ft)	Mean Depth Riffle/Run/Glide (ft)	Maximum Depth Riffle/Run/Glide (ft)	Spawning Gravel Area (ft^2)
		Pools	Riffle/Run/Glide	Silt Pond	Culvert / Concrete Channel	Dry	Not Surveyed	Total Measured	Pools	Riffle/Run/Glide	Silt Pond	Culvert / Concrete Channel	Dry	Total						
5-35	Pond 22 to first open creek section just downstream of "Dinky shed"	63	168	73	3,038	0	0	3,342	2	5	2	91	0	100	13	1.1	1.8	0.2	0.3	4
35-42	Open section from downstream of "Dinky Shed" to culvert under main road	57	423	0	80	0	5	560	10	76	0	14	0	100	44	0.8	1.3	0.3	0.6	8
42-59	Culvert upstream of "Dinky Shed" to conveyor belt crossing	203	1,402	0	93	0	0	1,698	12	83	0	5	0	100	59	0.8	1.3	0.3	0.6	23
59-75	Conveyor belt crossing to culvert under "rockpile"	83	1,367	0	0	0	92	1,450	6	94	0	0	0	100	2	1.0	1.7	0.3	0.8	0
75-90	Culvert under "rockpile" through Pond 13 and disturbed area above	0	256	262	0	0	0	518	0	49	51	0	0	100	0	NA	NA	0.2	0.6	0
90-115	Natural section above Pond 13 until dry section at old overburden deposit area	307.5	1,069	0	0	0	1,205	1,376.50	22	78	0	0	0	100	57	0.8	1.5	0.4	0.9	8
115-132	Dry section along old overburden deposit area	0	0	0	0	2,338	0	2,338	0	0	0	0	100	100	0	NA	NA	NA	NA	NA
132-157	Upstream of old overburden deposit area to "Yellow" Creek	8	1,963	0	0	0	0	1,971	0	100	0	0	0	100	70	NA	NA	NA	NA	420
157-END	Upstream of "Yellow" Creek	152	1,092	0	0	0	161	1,244	12	88	0	0	0	100	84	0.8	1.3	NA	NA	103
	Total	874	7,740	335	3,211	2,338	1,463	14,498	6	53	2	22	16	100						

NA = not available

Table 2-4. Permanente Creek Fish Sampling Results

Electofishing Reach	Station	Description	Length Sampled	Effort (seconds)	Number of Trout Captured	Trout Size Range (inches)	Other Trout Observed	Other Aquatic Organisms Present	Habitat Conditions	Water Temperature (°C)	Air Temperature (°C)
X	0-2	Permanente Creek from outlet of Pond 14 upstream to Pond 22		287	0		0	None observed	Good riparian canopy, stream is small but fairly frequent small pools, looks like it would hold trout	17.5	21.5
A	32-34	Open steep-banked section between first main road crossing and bridge near Dinky shed.		560	7	6 to 7		Mayfly larvae, other fly larvae		16	19
B	34-40	Upstream of bridge near Dinky shed			3	1 to 1.5		Numerous large mayfly larvae			
C	40-48	Upstream from second main road crossing		1,300	3	6, 7.5, 10.5		One rough-skined newt, four Pacific tree frog tadpoles in confluence pool below tributary culvert; mayfly larvae, stonefly larvae, midge larvae		16	23
D	50-58	Just upstream from Screen Tower No. 4	about 490 feet	1,430	4	1.5, 7, 7, 10		Two Pacific giant salamander larvae: caddis fly larvae, diptera larvae, mayfly larvae, helgramite larvae, annelids		14	21
E.	59-67	Open section along south side of road below conveyor belt	about 430 feet	932	0			One Pacific giant salamander larva	Long riffle section, no pools, no riparian growth, heavily cemented substrate	17	26
F	88-100	Upstream of Pond 13	about 220 feet	818	8	1 to 8	Three to four 6- to 7-inch trout in upper part of Pond 13; missed two fish during electrofishing- 1 young-of-year and one 5- to 5.5-inch	One Pacific giant salamander larva	Steep gradient, overhanging riparian growth, cemented substrate	15	28
G	118-132	Upstream from Pond 4		893	7	4 to 6	Missed three trout (one 7- to 8-inch and two 4- to 5-inch)	Two Pacific giant salamander larvae, caddis fly larvae, Gerridae	Steep gradient section, below landslide. No riparian growth, large boulders. Filamentous algae present. This section went dry by late June.	25	33
H	135-155	From landslide and debris flow areas upstream past cabin and south side tributary	Visual observation only				Trout throughout section including young-of-year in depositional areas downstream of cabin. Depression in sandy depositional area below cabin looked like a trout redd.		Low gradient area with lots of deposition of sand and gravel. Poor pool development, good riparian growth.	15.5	22

2.2.2 Results of Habitat Survey

Habitat conditions varied widely in different reaches of Permanente Creek. Based on differences in habitat conditions and on the presence of barriers to fish movement between sections, nine discreet reaches were identified. These reaches are described in detail in the following sections and summarized in Table 2-3. The first reach begins at Pond 22 and subsequent reaches proceed in order upstream (Figure 2-1).

Reach A (Station 5+00 to 35+00). This reach begins at Pond 22 and extends upstream through a short section of natural stream channel followed by a long section of concrete-lined channel and then alternating sections of culvert and concrete lined channel. The reach ends at a short section of natural channel beginning just downstream from the "Dinky Shed." Only about 4 percent of the reach provides potential habitat for trout. Pond 22 supports a large number of trout ranging from about 4 to 12 inches in size. The concrete channel section presents a barrier to upstream migration of trout. Fish that move downstream, presumably during high-flow conditions, are prevented from returning upstream due to the steepness and smoothness of the concrete channel. A very small amount of potential spawning habitat occurs in the short natural section just upstream of Pond 22 but no evidence of recent reproduction is apparent. Canopy is thin in the natural creek sections, ranging from 10 to 35 percent.

Reach B (Station 35+00 to 42+00). This relatively short reach is composed primarily of unlined stream channel and it extends upstream to the culvert a short distance upstream from the "Dinky Shed". The relatively small amount of pool habitat in this reach held a few trout during the electrofishing survey (Table 2-2). Three young-of-year trout were found adjacent to the "Dinky Shed," indicating some possible successful spawning in this reach. The Fry may have originated in upstream reaches. Habitat for trout was limited to the few, small pools but these pools had relatively good shelter components and moderate canopy cover. The substrate was primarily gravel and small cobble that was not compacted or bound but had a relatively high component of fine sediments.

Reach C (Station 42+00 to 59+00). This section of unlined stream channel has the best conditions for trout downstream of Pond 13. Pools comprise 17 percent of the length of this reach and many of these, though small, support up to 10.5-inch trout. Trout are not abundant, averaging one per 160 feet of stream. Because smaller size classes were not represented in electrofishing surveys, the fish identified may have migrated from upstream areas. Although one young-of-year trout was captured, the trout population in this reach does not appear to be self-sustaining. These fish are cut off from upstream reaches by the steep culvert downstream of Pond 13. Potential spawning habitat is scarce but the substrate was generally not bound or was only lightly bound and was not compacted. Canopy cover was generally good although a few sections were open. Water temperature appeared to be suitable for trout, maintaining at 21°C at mid-day with air temperature at 28°C.

Reach D (Station 59+00 to 75+00). Beginning just under the conveyor belt crossing, this reach is nearly devoid of pools and contains homogenous sections of very shallow riffle/run type habitat. Most of the riparian area had been cleared of vegetation and canopy cover was very light. Water temperature was 22°C at 3:00 PM when air temperature was 24°C. Binding of the substrate increased in this reach to moderate and high levels and the substrate was compacted. A small amount of habitat for trout occurred in the upper third of this reach where the channel became steeper and boulders formed small scour pockets. A few trout in the 6- to 8-inch range were seen at the extreme upper end of the reach just below the outlet of the steep culvert that is located under the rockpile and downstream from Pond 13.

Reach E (Station 75+00 to 90+00). This reach consists of the long, steep culvert and half culvert section below Pond 13, including the graded section at its upper end. The only habitat for trout in this section appears to be in Pond 13 itself. Although the pond was very shallow and open at the time of the survey, a few trout in the 6- to 10-inch range were observed. Trout were also captured during fish relocation activities in the spill basin immediately below the weir and just upstream of the half culvert.

Reach F (Station 90+00 to 115+00). This reach contains relatively pristine natural stream channel and extends upstream to a dry section beginning downstream of the former overburden disposal site. It had the highest incidence of pools of all the reaches surveyed and some of the non-pool habitats contained habitat for trout. Canopy cover was generally moderate to high and temperature conditions were excellent, ranging from 14.5 to 15.5°C through mid-day. Numerous trout of all size classes were seen throughout the reach. During the electrofishing survey in the extreme lower end of the reach, trout were captured with a frequency of about one fish per 22 feet; this rate was higher than other locations but would still not be regarded as densely populated. The substrate in Reach F was moderately too highly bound and compacted.

Reach G (Station 115+00 to 132+00). This reach was dry during the habitat survey but had supported a few trout in mid-May when electrofishing was conducted. Canopy cover was very light in this reach and the riparian vegetation was limited to grasses and small scrub. High bedrock outcrops occur in places on the south side of the creek and overburden banks occur in places on the north side. Overburden appears to have entered the creek channel within this reach.

Reach I (Station 132+00 to 157+00). This reach begins in the low gradient section upstream of the old overburden disposal area. Large amounts of sand and small gravel had accumulated in this reach and very little pool development was noticeable. On the other hand, most of the area identified as good for spawning occurred in this reach. In some areas, binding of the substrate was light and the substrate was not compacted. Although no electrofishing surveys were conducted in this reach, young-of-year trout (as well as some older fish) were observed in this section during reconnaissance surveys.

Reach J (Station 157+00 to 192+00). This reach begins a short distance downstream of "Yellow Creek" and upstream of a debris flow area on the north side of the creek. The habitat in this reach is relatively pristine and supports multiple age classes of trout throughout its length. Stickleback were also observed in this reach during the habitat survey. Although pools made up a relatively small amount of the habitat, trout in this reach also used nonpool habitats. Canopy was relatively dense and temperatures were low, ranging from 14.5° to 15.5°C through mid-day with air temperature up to 23°C. Relatively high amounts of potential spawning habitat occurred in this reach (compared to other reaches of Permanente Creek), binding of the substrate ranged from light to moderate, and the substrate was not compacted in some areas. Gravel and sand were the dominant substrate components.

2.2.3 Results of Fish Survey

Rainbow trout were present throughout Permanente Creek from above the long concrete channel section (Station 25+00) upstream. Later observations revealed trout in Pond 22 and in the stream adjacent to Pond 14. Fish may have moved into these areas after the May sampling period, since electrofishing in this section in May did not produce any fish.

The majority of trout captured downstream of Pond 13 were larger than 6 inches. These fish would be at least in their second or third year of growth. Two of these fish, at 10 and 10.5 inches, would be even older. Trout in the reach downstream of Pond 13 averaged about one trout per 100 feet in stream sections surveyed. They were found almost exclusively in the relatively infrequent small pools with generally one trout in each pool.

The presence of relatively few fish without representation by younger age classes suggests a transient or marginal population made up of older fish that likely migrated into the reach from upstream areas (numerous barriers to upstream migration occur within this reach). They appeared to be relatively healthy and appeared to have abundant food resources but fish present downstream of Pond 13 cannot be regarded as part of a healthy, self-sustaining population. Capture of three young-of-year trout in this reach indicates possible successful spawning in the reach. The low numbers raises questions concerning survival rates to hatching and the consistency of spawning success. Sufficient successful reproduction does not appear to be sufficient to sustain a population in this reach.

Upstream of Pond 13, trout are more numerous and are represented by a greater diversity of age groups. This appears to be a relatively healthy self-sustaining population but it may be somewhat limited by the small size of the stream, both in terms of the population size and growth potential of individual fish. The trout population upstream of Pond 13 may be the source of individuals in the reach downstream of Pond 13.

In-line sediment ponds provided additional habitat for rainbow trout. Pond 22 supported a large number of trout in August. A total of 42 trout were removed from the pond in late August in advance of de-silting operations. Trout ranged from 90 to 301 mm (3.5 to 12 inches). The majority (about 65%) were between 200 and 260 mm (8-10 inches). All trout appeared to be in good condition. Pond 13 also supported a few trout. One 223 mm (8.8 inches) fish was captured in the pond itself and 6 additional fish ranging from 109-201 mm (4-8 inches) were captured in the spill basin immediately below the weir.

2.2.4 Summary of Findings

Permanente Creek on the Hanson Permanente property is a small, steep gradient, headwater stream. It supports a small but self-sustaining population of resident rainbow trout, presumably of native coastal stock. Except for a few stickleback, no other fish species are present. During sampling periods in 2000, the stream had relatively cool temperatures in most locations and has sufficient habitat to hold fish up to 10-12 inches over the summer. Sections of the Creek upstream of the Kaiser cabin (around station 150+00) and between Pond 13 and the old crusher foundation (Station 105+00-110+00) appear to have relatively pristine habitat conditions with high amounts of riparian canopy and more frequent pools. Sections with steeper gradient have more pools, larger pools, and greater depth and provide habitat for younger trout even outside of pools. In addition to the small stream size, the following factors may limit trout production in the stream:

- Sections of stream that have been straightened concrete lined, or placed in culverts and are no longer available to trout. This is a characteristic of Reaches A and E (Table 2-4).
- There are several potential barriers to upstream migration of trout including concrete-lined sections, some culverts, in-channel sediment ponds (14, 22, and 13), and the steep section upstream of Pond 4 consisting of overburden material in the creek. Older trout that move downstream past these barriers into reaches without spawning habitat are effectively lost to the upstream population in terms of reproductive potential. Some of the culverts and concrete-lined sections, however, may be passable under certain flow conditions (Table 2-5).
- Suitable size substrate for spawning (0.5 to 2.5 inch) is lacking in parts of the stream. Much of the substrate is bound by mineral deposits that appear to be natural in the watershed, as it was observed in a southern tributary and in Swiss Creek, a neighboring drainage to the south. The natural deposits fill voids between the gravel and cobble substrate and make them difficult for trout to dislodge in preparation for spawning.
- Pools are small and pool habitat is infrequent. All of the older trout were present in pools and the small size and low frequency of pools limits the ability of the creek to support adult trout over the summer low-flow period. In some cases, lack of pools can be attributed to lack of pool-forming structures (boulders, logs, stumps, roots, bedrock outcrops, etc.). This appears to be the case in Reach D, downstream of Pond 13, where removal of riparian growth has occurred in some areas and where the creek channel has been constrained due to the close proximity of the road. In other cases, pools may have been filled-in by fine sediments, as is the case in the reach between Pond 4 and the cabin (Reach H) where debris flows have entered the creek and the stream gradient is not very steep.
- Riparian vegetation is thin or lacking in some areas, minimizing canopy coverage. This condition is most notable along the road next to the conveyor belt (Reach D) and upstream of Pond 4 where large amounts of overburden are present in the channel (Reach G). The result is increased water temperature, most notably in the section just above Pond 4. In addition, large woody debris can be an important factor in pool formation; where the riparian growth has been cleared, few pools exist.

2.2.5 Red-legged Frogs (Rana aurora draytonii)

U.S. Fish and Wildlife Service (Service) guidance documents for the California red-legged frog recommend conducting a combination of site assessments and field surveys. According to the Natural Diversity Data Base there are known populations of the California red-legged frog on Permanente Creek. Results of a red-legged frog site assessment and field survey by biologists trained in these surveys found no California red-legged frogs within ponds 13 and 22 (Radian International 1997). The only red-legged frog population found was located in a small pool (10 feet by 5 feet) approximately 30 yards downstream of Pond 14, downstream of Hanson's plant operations (Radian International 1997). The report described the deep waters of Pond 13 as potential adult red-legged frog habitat and emergent vegetation and shallow water along the banks as breeding habitat for the frogs (Radian International 1997). On August 21, 2000, there was a possible California red-legged frog sighted (a flash of red was seen on the frog as it leapt away) during a fish relocation effort (personal communication, Mr. Jeff Hagar). However, there was no positive identification on the frog seen and the field biologist who sighted the frog was not trained in California red-legged frog identification.

The California red-legged frog (*Rana aurora draytonii*) requires a combination of various habitat types in which to live; a freshwater aquatic breeding area surrounded by a mixture of riparian and upland dispersal habitats is essential. These frogs breed from December through April in the following areas: pools and backwaters along streams and creeks; natural and man-made ponds (e.g. stock ponds); sag ponds; dune ponds; and lagoons. This subspecies of red-legged frog occurs from sea level to approximately 5,000 feet in elevation from Marin County, California south to northern Baja California, Mexico. The California red-legged frog is federally listed as threatened under the Endangered Species Act of 1973 (61 *Federal Register* 25813).

Pond maintenance on the Hanson Permanente property may enhance the California red-legged frog habitat if done properly, at the right time, and with proper supervision. The California red-legged frog requires aquatic habitat for breeding between December and April and for development between April and August. By late August most of the frogs have completed their transformation from tadpoles to juvenile frogs. Adult frogs use deepwater habitats (greater than 3 feet) outside of the breeding season to escape predators. However, the California red-legged frogs have evolved in the Mediterranean-type climate of California with markedly wet winters and springs and dry summers and falls. During the dry summers and falls when deep-water aquatic areas are scarce, the California red-legged frog escapes predators by congregating in burrows of other animals, old dug wells, deep holes in drying streams, and around springs.

The Draft Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*) outlines guidelines for proper pond management for the benefit of the California red-legged frog (U.S. Fish and Wildlife Service 2000). In these guidelines, they recommend to manage ponds so as to mimic the natural water cycle of the Mediterranean-type climate. Therefore, URS believes that the proposed pond clean-out at the Hanson Permanente property in September 2000 will not impact the California red-legged frog habitat but may even enhance the frog's habitat. Pond clean-out in September avoids the frog's critical aquatic-based breeding and transformation period from December to late August; mimics the dry summer/fall Mediterranean-type climate; and will provide deeper aquatic habitats required for the frog late this year and in following years. URS recommends having a biologist qualified in California red-legged frog identification on-site during pond clean-up to monitor frog habitat and activity.

Table 2-5
Permanente Creek, Barriers to Fish Migration

Barrier Type	Distance from Pond 22 (feet)	Nature of Barrier	Length (feet)	Gradient (percent)	Height (feet)	Depth of Jump Pool (feet)	Culvert Type and Condition
Culvert	304	Shallow depth at low flow, high velocity at high flow	130	3.5			Double 6-foot CMP
Concrete-Lined	437	Shallow depth at low flow, high velocity at high flow	2,016	19 for 4 feet; 5 for 170 feet			
Culvert	2,453	Shallow depth at low flow, high velocity at high flow	118	2			Double 4-foot CMP
Concrete-Lined	2,571	Shallow depth at low flow, high velocity at high flow	188				
Culvert	2,759	Shallow depth at low flow, high velocity at high flow	106	1.5			Double 5-foot CMP
Concrete-Lined	2,865	Shallow depth at low flow, high velocity at high flow	207				
Culvert	3,072	Shallow depth at low flow, high velocity at high flow	270	U			Double 6-foot CMP
Cascade	3,472	Requires jump	NA	NA	5	1.4	
Culvert	3,827	Shallow depth at low flow, high velocity at high flow	80	3			6-foot CMP, natural substrate
Culvert	5,512	Shallow depth at low flow, high velocity at high flow	93				6-foot CMP, gravel on bottom
Culvert	7,147	Shallow depth at low flow, high velocity at high flow					

CMP = corrugated metal pipe

Appendix C

Phase 1 and Phase 2 Reach Designations

Phase 1 and Phase 2 Reach Designation Summary

Phase II Final Report (December 3, 2010)[a]					Phase II Draft Report (July 31, 2009)[b]			Phase I Final Report (August 2000)[c]	
Phase II Reach (2010)	2010 Stationing Start	2010 Stationing End	Figure #	Phase II Reach Name (2009 and 2010)	Phase II Reach (2009)[d]	2009 Stationing	Table 4-2 Restoration Locations	Phase I Reach[e]	Phase I Station
1	NSD[f]- East of Reach 1(offsite)		1-3.1	Downstream of outfall and bypass confluence	2	NSD[f]	-	NRD	NSD[f]
2	NSD - East of Pond 14		1-3.1	Pond 14 outfall channel	1	NSD	-	NRD	NSD
3a	0+00	3+00	1-3.1	Pond 14 (parallels bypass channel, reach 3b)	NRD	0+00 to 3+00	A	NRD	NSD
3b	0+00	3+00	1-3.1	Pond 14 bypass channel	3	0+00 to 3+00	B	NRD	NSD
4	3+00	5+25	1-3.1	Pond 22	NRD	3+00 to 5+25	C and D	NRD	NSD
5	5+25	6+25	1-3.1	Pond 22 to RR crossing	4	5+25 to 6+20	-	A	5+00 to 35+00
6	6+25	37+00	1-3.1 to 1-3.3	Trapezoidal Channel	NRD	6+20 to 37+00	E and F	A	5+00 to 35+00
7	37+00	41+75	1-3.3 to 1-3.4	Coke pile to road upstream of Dinky Shed	5	37+00 to 42+00	G	B	35+00 to 42+00
8	41+75	59+00	1-3.4 to 1-3.5	Road upstream of Dinky Shed to conveyor crossing	6	42+50 to 59+00	H	C	42+00 to 59+00
			1-3.5	Culvert under conveyor crossing[g]	NRD	59+00 to 60+00	I	-	-
9[g]	59+00	69+00	1-3.5	Conveyor crossing to parallel buried culvert	7	60+00 to 69+00	J	D	59+00 to 75+00
10	69+00	76+00	1-3.6	Parallel buried culvert to full culvert	8	69+00 to 76+00	J, K, and L	D	59+00 to 75+00
11	76+00	81+00	1-3.6	Full Culvert	NRD	76+00 to 90+00	M	E	75+00 to 90+00
12	81+00	85+00	1-3.6 to 1-3.7	Half Culvert	NRD	76+00 to 90+00	N	E	75+00 to 90+00
13	85+00	90+00	1-3.7	Pond 13	NRD	76+00 to 90+00	O and P	E	75+00 to 90+00
14	90+00	94+00	1-3.7	Pond 13 to erosional drainage	9	90+00 to 94+00	-	F	90+00 to 115+00

Phase II Final Report (December 3, 2010)[a]					Phase II Draft Report (July 31, 2009)[b]			Phase I Final Report (August 2000)[c]	
Phase II Reach (2010)	2010 Stationing Start	End	Figure #	Phase II Reach Name (2009 and 2010)	Phase II Reach (2009)[d]	2009 Stationing	Table 4-2 Restoration Locations	Phase I Reach[e]	Phase I Station
15	94+00	105+00	1-3.7 to 1-3.8	Erosional drainage to upstream of primary crusher	10	94+00 to 105+00	-	F	90+00 to 115+00
16	105+00	116+00	1-3.8 to 1-3.9	Upstream of primary crusher to old crusher foundation	11	105+00 to 116+00	Q	F	90+00 to 115+00
17	116+00	134+00	1-3.9 to 1-3.10	Old crusher to downstream end of Unconsolidated Fill	12	116+00 to 134+00	R	G	115+00 to 132+00
18	134+00	138+00	1-3.10	Downstream end to upstream end of Unconsolidated Fill	13	134+00 to 138+00	-	I[1]	132+00 to 157+00
19	138+00	158+00	1-3.10 to 1-3.11	Upstream end of Unconsolidated Fill to Kaiser House	14	138+00 to 157+00	-	I	132+00 to 157+00
20	158+00	171+00	1-3.12 to 1-3.13	Kaiser House to debris slide area	15	157+00 to 171+00	-	J	157+00 to 192+00
21	171+00	190+00	1-3.13 to 1-3.14	Debris slide area	16	171+00 to 190+00	-	J	157+00 to 192+00
22	190+00	192+64.83	1-3.14	Debris slide area to end of reach	17	190+00 to 195+00	-	J	157+00 to 192+00

Notes

[a] URS (URS Corporation). 2010. Permanente Creek Long-Term Restoration Plan, Final Report. Oakland, California. December 2010.
[b] URS (URS Corporation). 2009. Permanente Creek Long-Term Restoration Plan, Draft Report. Oakland, California. July 31, 2009.
[c] URS (URS Corporation). 2000. Hanson Permanente Cement Company, Inc., Long-Term Restoration Plan. Oakland, California. August 25, 2000.
[d] NRD-No reach designation. The Phase II Draft Report did not include reach designations for culverted or impounded sections of the creek.
[e] NRD-No reach designation. These portions of the creek not given a reach designation in the Phase I Final Report.
[f] NSD-No stationing designated for this reach, or this reach is east of station 0+00.
[g] The culvert under the conveyor crossing is included in reach 9 of the Phase II Final Report.

Appendix D

Stream Data Forms

Rosgen Stream Classification

Reach ID	Reach Description	Station DS	Station US	Reach Length (LF)	Wbkf (FT)	Dmax (FT)	Abkf (SF)	Dbkf (FT)	W/D	Wfpa (FT)	ER	D50 (Size class)	Slope	Sinuosity	Stream Type
[1]	Offsite; DS of Outfall and Bypass Confluence	na	-1+00	na	13.0	2.6	26.0	2.0	6.5	38.0	2.9	Gravel	3.0%	1.1-1.2	C4b
[2]	Pond 14 Outfall Channel	-1+00	0+00	100	7.5	2.6	18.8	2.5	3.0	13.0	1.7	Cobble	5.0%	1.5	G4
[3a]	Pond 14[!]	0+00	3+00	300	-	-	-	-	-	-	-	-	-	-	Pond
[3b]	Pond 14 Bypass Channel	0+00	3+00	300	6.4	2.1	10.9	1.7	3.8	13.0	2.0	Gravel	5.0%	1.1	G4
[4]	Pond 22[!]	3+00	5+25	225	-	-	-	-	-	-	-	-	-	-	Pond
[5]	Pond 22 to RR Xing*	5+25	7+50	225	22.0	2.0	22.0	1.0	22.0	26.0	1.2	Gravel	1.5%	1.2	F4
[6]	Trapazoidal Channel[!]	7+50	37+00	2950	-	-	-	-	-	-	-	-	-	-	Concrete
[7]	Coke Pile to Road US of Dinky Shed	37+00	42+50	550	12.0	1.7	16.2	1.4	8.6	15.0	1.3	Gravel	2.5%	1.05	A4
[8]	Road US of Dinky Shed to Conveyor Xing	42+50	59+00	1650	11.0	1.8	16.7	1.5	7.3	12.5	1.1	Gravel	3.0%	1.20	A4
[9]	Conveyor Xing to Parallel Buried Culvert	59+00	69+00	1000	18.0	1.7	24.9	1.4	12.9	28.0	1.6	Gravel	1.5%	1.1	B4c
[10]	Parallel Buried Culvert to Full Culvert	69+00	76+00	700	12.5	2.7	16.9	1.4	8.9	33.5	2.7	Cobble	3.0%	1.1	A3
[11]	Full Culvert[!]	76+00	81+00	500	-	-	-	-	-	-	-	-	-	-	Culvert
[12]	Half Culvert[!]	81+00	84+00	300	-	-	-	-	-	-	-	-	-	-	Culvert
[13]	Pond 13[!]	84+00	90+00	600	-	-	-	-	-	-	-	-	-	-	Pond
[14]	Pond 13 to the Erosional Drainage	90+00	94+00	400	11.0	1.7	15.7	1.4	7.9	13.0	1.2	Cobble	6.0%	1.3	A3
[15]	Erosional Drainage to US of Primary Crusher	94+00	105+00	1100	12.5	1.7	10.6	0.9	13.9	19.0	1.5	Boulder	11.5%	1.2	B2a
[16]	US of Primary Crusher to Old Crusher Foundation	105+00	116+00	1100	15.0	2.1	15.8	1.1	13.6	27.0	1.8	Cobble	3.5%	1.1-1.2	B3
[17]	Old Crusher Foundation to DS End of Pinch Point ("Utah")	116+00	134+00	1800	16.0	1.4	11.2	0.7	22.9	37.0	2.3	Cobble	4.0%	1.1-1.2	B3/B3a
[18]	DS End to US End of Pinch Point	134+00	138+00	400	14.0	1.3	12.0	0.9	15.6	19.0	1.4	Gravel	1.5%	1.1	B4c
[19]	US End of Pinch Point to Kaiser House	138+00	158+00	2000	85.0	1.0	45.0	0.5	170.0	95.0	1.1	Silt/Gravel	1.0%	1.1	D4/6
[20]	Kaiser House to Debris Slide Area	158+00	171+00	1300	8.7	1.5	11.4	1.3	6.7	14.5	1.7	Gravel	4.0%	1.1	A4
[21]	Debris Slide Area to Above Qs1	171+00	190+00	1900	10.5	1.1	9.4	0.9	11.7	14.5	1.4	Gravel	2.0%	1.2	B4
[22]	Above Qs1 to End of Reach	190+00	192+65	265	3.5	1.3	4.6	1.3	2.7	6.5	1.9	Gravel/Bedrock	7.5%	1.0	A4/A1
Reference	West Fork Permanente Creek (@ Rogue Valley & Wildcat Loop Trails)	na	na	na	9.2	1.4	10.6	1.2	7.7	14.5	1.6	Gravel (sm)	1.5%	1.4-1.5	G4
Reference	Wildcat Canyon Creek (on Wildcat Loop Trail)	na	na	na	9.0	1.0	6.3	0.7	12.9	12.5	1.4	Gravel (sm)	3.5%	1.2	B4
Reference	Swiss Creek (above Peacock Ct Xing)	na	na	na	11.0	1.9	12.9	1.2	9.2	24.0	2.2	Cobble	8.0%	1.1-1.2	B3a/A3
Reference	Upper Stevens Creek (@ Stevens Cr Nature Trail & White Oak Trail)	na	na	na	20.0	1.7	28.1	1.4	14.3	34.0	1.7	Gravel (lg)/Cobble	1.8%	1.4-1.5	B4
			Total **	19265											

[!]These reaches have highly modified channels and cannot be rated using the Rosgen Classification.

* This reach includes 130 feet of culvert that is not included in the stream classification.

Length by Type *		%
A	4865	25%
B	7300	38%
D	2000	10%
F	95	0%
G	400	2%
Culv/Conc	4605	24%
		100%

** Does not include Reference Reaches.

Modified Pfankuch Channel Stability Rating

Reach ID	Reach Description	Station		Reach Length	Rating Summary			
		DS	US	(LF)	Total	Existing Stream Type	Potential Stream Type	Modified Rating
[1]	Offsite; DS of Outfall and Bypass Confluence	na	na	na	83	C4b	C4b	Good
[2]	Pond 14 Outfall Channel	na	na	100	116	G4	C4	Poor
[3a]	Pond 14[!]	0+00	3+00	300	-	-	-	-
[3b]	Pond 14 Bypass Channel	0+00	3+00	300	85	G4	C4b	Good
[4]	Pond 22[!]	3+00	5+25	225	-	-	-	-
[5]	Pond 22 to RR Xing*	5+25	7+50	225	110	F4	C4b	Fair
[6]	Trapazoidal Channel[!]	7+50	37+00	2950	-	-	-	-
[7]	Coke Pile to Road US of Dinky Shed	37+00	42+50	550	60	A4	A4	Good
[8]	Road US of Dinky Shed to Conveyor Xing	42+50	59+00	1650	67	A4	A4	Good
[9]	Conveyor Xing to Parallel Buried Culvert	59+00	69+00	1000	73	B4c	B4c	Fair
[10]	Parallel Buried Culvert to Full Culvert	69+00	76+00	700	57	A3	A3/B4	Good
[11]	Full Culvert[!]	76+00	81+00	500	-	-	-	-
[12]	Half Culvert[!]	81+00	84+00	300	-	-	-	-
[13]	Pond 13[!]	84+00	90+00	600	-	-	-	-
[14]	Pond 13 to the Erosional Drainage	90+00	94+00	400	59	A3	A3	Good
[15]	Erosional Drainage to US of Primary Crusher	94+00	105+00	1100	67	B2a	B2a	Poor
[16]	US of Primary Crusher to Old Crusher Foundation	105+00	116+00	1100	72	B3	B3	Fair
[17]	Old Crusher Foundation to DS End of Pinch Point ("Utah")	116+00	134+00	1800	59	B3/B3a	B3	Good
[18]	DS End to US End of Pinch Point	134+00	138+00	400	77	B4c	B3	Fair
[19]	US End of Pinch Point to Kaiser House	138+00	158+00	2000	106	D4/6	B3	Poor
[20]	Kaiser House to Debris Slide Area	158+00	171+00	1300	80	A4	B4	Fair
[21]	Debris Slide Area to Above Qs1	171+00	190+00	1900	80	B4	B4	Fair
[22]	Above Qs1 to End of Reach	190+00	192+65	265	121	A4/A1	A4/A1	Fair
Reference	West Fork Permanente Creek (@ Rogue Valley & Wildcat Loop Trails)	na	na	na	79	G4	C4	Good
Reference	Wildcat Canyon Creek (on Wildcat Loop Trail)	na	na	na	79	B4	B4	Fair
Reference	Swiss Creek (above Peacock Ct Xing)	na	na	na	95	B3a/A3	B3a/A3	Poor/Fair
Reference	Upper Stevens Creek (@ Stevens Cr Nature Trail & White Oak Trail)	na	na	na	69	B4	B4	Fair

[!] These reaches have highly modified channels and cannot be rated using the Pfankuch Channel Stability Rating.

* This reach includes 130 feet of culvert that is not included in the stream classification.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Pond 14 Outfall Channel** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16	y	16
	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8	y	8
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16	y	16
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24	y	24
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			7	Good total =			12	Fair total =			9	Poor total =			88

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	116
Existing stream type =	G4
* Potential stream type =	C4

Modified channel stability rating
Poor

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Offsite; DS of Outfall and Bypass Confluence** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			1	Good total =			60	Fair total =			6	Poor total =			16

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	83
Existing stream type =	C4b
* Potential stream type =	C4b
Modified channel stability rating	
Good	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr Location: **Pond 14 Bypass Channel** Valley Type: Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6	y	6	<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18	y	18	More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			5	Good total =			40	Fair total =			24	Poor total =			16

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	85
Existing stream type =	G4
* Potential stream type =	C4b
Modified channel stability rating	
Good	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Pond 22 to RR Xing*** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent: Description	Rating			Good: Description	Rating			Fair: Description	Rating			Poor: Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6	y	6	<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16	y	16
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16	y	16
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24	y	24
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3	y	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4		
			Excellent total =			5	Good total =			22	Fair total =			15	Poor total =			68

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	110
Existing stream type =	F4
* Potential stream type =	C4b

Modified channel stability rating
Fair

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr Location: **Coke Pile to Road US of Dinky Shed** Valley Type: Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3	y	3	Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =	22			Good total =	24			Fair total =	6			Poor total =	8		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	60
Existing stream type =	A4
* Potential stream type =	A4
Modified channel stability rating	
Good	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Road US of Dinky Shed to Conveyor Xing** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3	y	3	Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3	y	3	70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =	19			Good total =	26			Fair total =	6			Poor total =	16		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	67
Existing stream type =	A4
* Potential stream type =	A4

Modified channel stability rating

Good

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Conveyor Xing to Parallel Buried Culvert** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent				Good				Fair				Poor			
			Description	Rating			Description	Rating			Description	Rating			Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2	y	2	Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			15	Good total =			30	Fair total =			12	Poor total =			16

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	73
Existing stream type =	B4c
* Potential stream type =	B4c
Modified channel stability rating	Fair

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr   Location: **Parallel Buried Culvert to Full Culvert**   Valley Type: Observers: **SL & JP**

Location	Key	Category	Excellent Description	Excellent Rating			Good Description	Good Rating			Fair Description	Fair Rating			Poor Description	Poor Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3	y	3	Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2	y	2	Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9	y	9	<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			28	Good total =			6	Fair total =			15	Poor total =			8

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	57
Existing stream type =	A3
* Potential stream type =	A3/B4
Modified channel stability rating	Good

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Pond 13 to the Erosional Drainage** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9	y	9	<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2	y	2	Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3	y	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4		
			Excellent total =			25	Good total =			12	Fair total =			18	Poor total =			4

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	59
Existing stream type =	A3
* Potential stream type =	A3
Modified channel stability rating	Good

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Erosional Drainage to US of Primary Crusher** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2	y	2	Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			25	Good total =			8	Fair total =			6	Poor total =			28

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	67
Existing stream type =	B2a
* Potential stream type =	B2a
Modified channel stability rating	
Poor	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **US of Primary Crusher to Old Crusher Foundation** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2	y	2	Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			23	Good total =			6	Fair total =			15	Poor total =			28

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	72
Existing stream type =	B3
* Potential stream type =	B3
Modified channel stability rating	
Fair	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Old Crusher Foundation to DS End of Pinch Point ("Utah")** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2	y	2	Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2	y	2	40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2	y	2	Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4

Excellent total = 27 | Good total = 12 | Fair total = 0 | Poor total = 20

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	59
Existing stream type =	B3/B3a
* Potential stream type =	B3
Modified channel stability rating	Good

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **DS End to US End of Pinch Point** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2	y	2	Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			20	Good total =			8	Fair total =			21	Poor total =			28

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	77
Existing stream type =	B4c
* Potential stream type =	B3
Modified channel stability rating	Fair

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **US End of Pinch Point to Kaiser House** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3	y	3	70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1			Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4	y	4
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8	y	8
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12	y	12	Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16	y	16
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18	y	18	More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =	8			Good total =	6			Fair total =	48			Poor total =	44		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	106
Existing stream type =	D4/6
* Potential stream type =	B3
Modified channel stability rating	
Poor	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr Location: **Kaiser House to Debris Slide Area** Valley Type: Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2	y	2	Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			10	Good total =			36	Fair total =			6	Poor total =			28

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	80
Existing stream type =	A4
* Potential stream type =	B4
Modified channel stability rating	
Fair	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Debris Slide Area to Above Qs1** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent				Good				Fair				Poor			
			Description	Rating			Description	Rating			Description	Rating			Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2	y	2	Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3	y	3	Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9	y	9	<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			11	Good total =			32	Fair total =			21	Poor total =			16

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	80
Existing stream type =	B4
* Potential stream type =	B4
Modified channel stability rating	
Fair	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **2/18/2009**

Stream: Permanente Cr | Location: **Above Qs1 to End of Reach** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Excellent Rating			Good Description	Good Rating			Fair Description	Fair Rating			Poor Description	Poor Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6			Bank slope gradient >60%	8	y	8
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6	y	6	<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16	y	16
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8	y	8
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16	y	16
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18	y	18	More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =			2	Good total =			12	Fair total =			39	Poor total =			68

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Grand Total =	121
Existing stream type =	A4/A1
* Potential stream type =	A4/A1
Modified channel stability rating	Fair

* Rating should be adjusted to potential stream type, not existing.

Notes:

4 Bare soils, steep slopes

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **4/28/2009**

Stream: Reference: West Fork Permanente Cr | Location: **West Fork Permanente Creek (@ Rogue Valley & Wildcat Loop Trails)** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent				Good				Fair				Poor			
			Description	Rating			Description	Rating			Description	Rating			Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6	y	6	Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8	y	8
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8	y	8	Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2	y	2	Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2	y	2	Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4		
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8	y	8
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4	y	4	Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =	7			Good total =	46			Fair total =	6			Poor total =	20		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

2 slump US healing over

Grand Total =	79
Existing stream type =	G4
* Potential stream type =	C4
Modified channel stability rating	
Good	

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **4/28/2009**

Stream: Reference: Wilcat Canyon Creek — Location: **Wildcat Canyon Creek (on Wildcat Loop Trail)** — Valley Type: — Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3	y	3	Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9			Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4	y	4	Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6			Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9	y	9	<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6	y	6	<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4	y	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6			Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3	y	3	Predominantly bright, >65%, exposed ir scoured surfaces	4		
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4			Mostly losse asortment with no apparent overlap	6	y	6	No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8			Moderate change in sizes. Stable materials 20-50%	12	y	12	Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
			Excellent total =	13			Good total =	20			Fair total =	42			Poor total =	4		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	79
Existing stream type =	B4
* Potential stream type =	B4
Modified channel stability rating	Fair

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **3/5/2009**

Stream: Reference: Swiss Creek | Location: **Swiss Creek (above Peacock Ct Xing)** | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Excellent Rating			Good Description	Good Rating			Fair Description	Fair Rating			Poor Description	Poor Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6			50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12	y	12
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4			20-40% Most in the 3-6" range	6	y	6	<20% rock fragments of gravel sizes 1-3" or less	8		
	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2			Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4	y	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
	9	Deposition	Little or no enlargement of channel or point bars	4			Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12	y	12	Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1	y	1	Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3			Well rounded in all dimensions, surfaces snooth	4		
	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3			Predominantly bright, >65%, exposed ir scoured surfaces	4	y	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6			5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12	y	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1			Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4	y	4
					Excellent total =	2			Good total =	34			Fair total =	39			Poor total =	20

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:

Grand Total =	95
Existing stream type =	B3a/A3
* Potential stream type =	B3a/A3
Modified channel stability rating	Poor/Fair

* Rating should be adjusted to potential stream type, not existing.

Modified Pfankuch Channel Stability Rating Procedure (as modified by D. Rosgen)

Date: **4/28/2009**

Stream: Reference: Upper Stevens Creek | Location: **Upper Stevens Creek** (@ Stevens Cr Nature Trail & White Oak Trail) | Valley Type: | Observers: **SL & JP**

Location	Key	Category	Excellent Description	Rating			Good Description	Rating			Fair Description	Rating			Poor Description	Rating		
Upper Banks	1	Landform Slope	Bank slope gradient <30%	2			Bank slope gradient 30-40%	4			Bank slope gradient 40-60%	6	y	6	Bank slope gradient >60%	8		
Upper Banks	2	Mass Erosion	No evidence of past or future mass erosion	3			Infrequent. Mostly healed over. Low future potential	6			Frequency and magnitude aggravated by normal high water. Subsequent undercutting of unstable areas with increased sedimentation	9	y	9	Frequent or large causing sediment nearly yearlong or intermittent danger of same	12		
Upper Banks	3	Debris Jam Potential	Essentially absent from immediate channel area	2			Present, but mostly small twigs and limbs	4			Noticeable accumulation of all sizes.Stream can float it away at certain times, decreasing bank protection and increasing DS debris jam potential	6	y	6	Moderate to heavy amounts, predominantly larger sizes	8		
Upper Banks	4	Vegetative Bank Protection	>90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass	3			70-90% density. Fewer species or less vigor suggest less dense or deep root mass	6	y	6	50-70% density. Lower vigor and fewer species form a shallow discontinuous root mass	9			<50% deensity plus fewer species & less vigor indicating poorm discontinuous and shallow root mass	12		
Lower Banks	5	Channel Capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0 Bank-height ratio (BHR) = 1.0	1	y	1	Bank stage is contained within banks. Width/depth ratio depature from reference W/D ratio = 1.0-1.2. BHR = 1.0-1.1	2			Bankfull stage is not contained. Width/depth ratio departure from reference W/D ratio = 1.2-1.4. BHR = 1.1-1.3	3			Bankfull stage is not contained, overbank flows are common with flows less than bankfull. W/D ratio departure from reference W/D ratio >1.4. BHR > 1.3	4		
Lower Banks	6	Bank Rock Content	>65% with large angular boulders 12"+ common	2			40-65% mostly boulders and small cobbles. 6-12"	4	y	4	20-40% Most in the 3-6" range	6			<20% rock fragments of gravel sizes 1-3" or less	8		
Lower Banks	7	Obstruction to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed	2	y	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm	4			Moderately frequent, unstable obstructions move with high flows causing bank cutting and poo, filling	6			Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full. Channel migration occurring	8		
Lower Banks	8	Cutting	Little or none. Infrequent raw banks <6"	4			Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6	y	6	Significant cuts 12-24" high. Root mat overhangs and sloughing evident	12			Almost continuous cuts, some over 24" high. Failure of overhangs frequent	16		
Lower Banks	9	Deposition	Little or no enlargement of channel or point bars	4	y	4	Some new bar increase, mostly from course gravel	8			Moderate deposition of new gravel and coarse sand on old some new bars	12			Extensive deposit of predominantly fine particles, Accelrated bar development	16		
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfacces rough	1			Rounded corners and edges. Surfaces smooth and flat	2			Corners and edges well rounded in 2 dimensions	3	y	3	Well rounded in all dimensions, surfaces snooth	4		
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright	1			Mostly dull, but may have <35% bright surfaces	2			Mixture dull and bright, i.e. 35-65% mixture range	3	y	3	Predominantly bright, >65%, exposed ir scoured surfaces	4		
Bottom	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping	2			Moderately packed with some overlapping	4	y	4	Mostly losse asortment with no apparent overlap	6			No apcking evident. Losse assortment, easily moved	8		
Bottom	13	Bottom Size Distribution	No size change evident. Stable material 80-100%	4			Distribution shift light. Stable material 50-80%	8	y	8	Moderate change in sizes. Stable materials 20-50%	12			Marked distribution change, Stable materials 0-20%	16		
Bottom	14	Scouring & Deposition	<5% of bottom affected by scour or deposition	6	y	6	5-30% affected. Scour at constrictions and wheere grades steepen. Some deposition in pools	12			30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools	18			More than 50% of the bottom in a state of flux or change nearly yearlong	24		
Bottom	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too	1	y	1	Common. Algae in low velocity and pool areas. Moss here, too	2			Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick	3			Perennial types scarce or absent. Yellow-green, short-term bloom may be present	4		
			Excellent total =	14			Good total =	28			Fair total =	27			Poor total =	0		

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3
Good (stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107
Fair (mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132
Poor (unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+

Stream Type	D4	D5	D6	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2
Good (stable)	85-107	85-107	67-98	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60
Fair (mod. unstable)	108-132	108-132	99-125	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78
Poor (unstable)	133+	133+	126+	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+

Stream Type	G3	G4	G5	G6
Good (stable)	85-107	85-107	90-112	85-107
Fair (mod. unstable)	108-120	108-120	113-125	108-120
Poor (unstable)	121+	121+	126+	121+

Notes:
Bottom and lower banks in excellent stability.
2 rated fair due to future potential
14 dusting of fine sediment

Grand Total =	69
Existing stream type =	B4
* Potential stream type =	B4
Modified channel stability rating	Fair

* Rating should be adjusted to potential stream type, not existing.

Appendix E

Restoration Technique Descriptions

Table E-1 lists, by restoration type, the individual techniques that may be appropriate for use in the Permanente Creek restoration. The subsequent sections describe each technique.

Table E-1 Summary of Restoration Techniques by Type

Type	Technique	
Natural channel design	E.1	Channel restoration/realignment
	E.2	Floodplain/bankfull bench creation
In-stream structures	E.3	Cross vanes
	E.4	Step-pools
	E.5	J-hook vanes
Fish habitat structures	E.3	Cross vanes
	E.4	Step pools
	E.5	J-hook vanes
	E.6	Native material revetments
	E.7	Boulder clusters
Fish passage	E.3	Cross vanes
	E.4	Step pools
	E.8	Culvert modification/replacement
Bioengineered bank stabilization	E.3	Cross vanes
	E.5	J-hook vanes
	E.6	Native material revetments
	E.9	Fascines
	E.10	Live pole cuttings/stakes
	E.11	Vegetated rock riprap
	E.12	Native revegetation
Slope stabilization	E.12	Native revegetation
	E.13	Terracing
	E.14	Slope drains
	E.15	Hydroseeding with Hydromulching
	E.16	Erosion control mat
	E.17	Geo-cellular Confinement System

Sources:

Short ID — Full citation

CalTrans: Caltrans, 2003. *Storm Water Quality Handbooks: Construction Site Best Management Practices (BMPs) Manual*, California Department of Transportation, March 2003

CSSHRM: Flosi, 1998. Gary Flosi et al, *California Salmonid Stream Habitat Restoration Manual*, California Department of Fish and Game, January, 1998.

NEH650: NRCS, 2007. *National Engineering Field Handbook*, National Engineering Handbook Part 650, Natural Resources Conservation Service, April, 1975

NEH654: NRCS, 2007. *Stream Restoration Design*, National Engineering Handbook Part 654, Natural Resources Conservation Service, August, 2007.

TS-14: NRCS, 2007. *Technical Supplements for Stream Restoration Design*, National

Engineering Handbook Part 654, Natural Resources Conservation Service, August, 2007.

E.1 CHANNEL RESTORATION/REALIGNMENT

Source: NEH654 11

This natural channel design technique is based on the morphological and morphometric qualities of the Rosgen classification system. The essence for this design approach is based on measured morphological relations associated with bankfull flow, geomorphic valley type, and geomorphic stream type. This channel design technique involves a combination of hydraulic geometry, analytical calculation, regionalized validated relationships, and analogy in a precise series of steps.

River restoration based on the principles of the Rosgen geomorphic channel design approach is most commonly accomplished by restoring the dimension, pattern, and profile of a disturbed river system by emulating the natural, stable river. Restoring rivers involves securing their physical stability and biological function, rather than the unlikely ability to return the river to a pristine state. Any river restoration design must first identify the multiple specific objectives, desires, and benefits of the proposed restoration. The causes and consequences of stream channel problems must then be assessed.

Natural channel design using the Rosgen geomorphic channel design approach incorporates a combination of analog, empirical, and analytical methods for assessment and design. Because all rivers within a wide range of valley types do not exhibit similar morphological, sedimentological, hydraulic, or biological characteristics, it is necessary to group rivers of similar characteristics into discreet stream types. Such characteristics are obtained from stable reference reach locations by discreet valley types, and then are converted to dimensionless ratios for extrapolation to disturbed stream reaches of various sizes.

Figure E-1 Natural channel design installation with channel realignment.

E.2 FLOODPLAIN/BANKFULL BENCH CREATION

In areas where incised channels or vertical banks occur, the addition of a bankfull bench can relieve bank erosion and slow velocities during high flows by providing an area of overbank flooding. Bankfull benches are ideal locations to install riparian vegetation to stabilize banks, provide wildlife habitat and channel shading, and reduce water temperatures.

The building of a bankfull bench in most cases requires additional excavation from existing streambanks, however in some cases fill soil may be necessary to establish a bench at the appropriate bankfull elevation. The width of the bankfull bench can vary depending on stream size, available space, design considerations and constraints, cost, and access. Where bank erosion is to be addressed, sizing should be based on the maximum overbank flow and velocity desired.

Figure E-2 Natural channel design installation with bankfull bench creation.

E.3 CROSS VANES

Sources: NEH654 11, TS-14G, and TS-14H

Cross vanes are structures constructed in the stream designed to redirect flow by changing the rotational eddies normally associated with streamflow. They are used extensively as part of natural stream restoration efforts to provide grade stabilization and improve instream habitat through adding pools and velocity variation. Cross vanes can be constructed from rock, logs, or both.

Cross vanes are typically oriented upstream 20 to 30 degrees to the bank tangent. However, the angle may vary as they work around the curve. Design of cross vanes is based on bankfull depth. The length typically extends to one third of the bankfull width, and the height at the bank is a third of the bankfull depth. The weir slope is 2 to 7 degrees up towards bank. The required stone size for vanes is often very large. The top layer of stones is underlain by footer stones, with the depth of the footer foundation being adjusted to the estimated depth of scour. A pool is excavated within the downstream legs of the structure and may be maintained by the flow turbulence. The cross vane structures are tied back into the bank to prevent flanking.

Figure E-3.1 Rock cross vane installation.

Figure E-3.2 Log cross vane installation.

E.4 STEP-POOLS

Sources: NEH654 TS-14G

A series of step-pools can be used individually for small vertical grade changes or can be grouped in a series, effectively providing a greater drop height than a single structure, for larger vertical grade changes or for steep slope areas. The series of step-pools then provides a degree of conservatism in the design, as one element may reduce stress on the upstream element. Loss of one element may not mean loss of function for the total treatment. The structures must be spaced close enough that channel degradation above one does not undermine the upstream structure.

The use of step-pools as fish passage features is a viable option in stream systems with large cobble to boulder channel beds. Use of rock emulates natural step-pool sequences, cascades, riffles, rock aprons, and log sills that fish naturally migrate past. They are typically more visually appealing than concrete and, in some cases, may be more cost effective. To maintain fish passage step or drop heights typically should not exceed one foot from the top of the rock at the apex of the structure to the pool water surface for adult fish and six inches for juvenile fish. The distance between structures depends on the size and slope of the channel. Sufficient space must be left to form a scour pool to dissipate energy preventing excess scour on the downstream structure.

Figure E-4 Step-pool installation.

E.5 J-HOOK VANES

Sources: NEH654 11, TS-14G, and TS-14H

J-hook vanes are structures constructed in the stream designed to redirect flow by changing the rotational eddies normally associated with streamflow. Although primarily developed for bank stabilization, the application shown extends across the low-flow stream and may act as a grade control structure. Cross vanes can be constructed from rock, logs, or both.

J-hook vanes are typically oriented upstream 20 to 30 degrees to the bank tangent. However, the angle may vary as they work around the curve. Design of J-hook vanes is based on bankfull depth. The length typically extends to one third of the bankfull width, and the height at the bank is a third of the bankfull depth. The weir slope is 2 to 7 degrees up towards bank. The required stone size for vanes is often very large. As shown, the flow is between stones placed near the center of the stream. The J-hook vane structures are tied back into the bank to prevent flanking.

Figure E-5 Installation of a log/rock J-hook vane.

E.6 NATIVE MATERIAL REVETMENTS

Sources: CSSHRM and NEH654 TS-14I and TS-14J

Native material revetments are alternatives to boulder riprap armoring and crib wall type structures. By combining boulders, logs, and live plant material to armor a stream bank fish habitat is enhanced, in addition to creating a natural looking bank stabilization structure. Native material revetments can provide toe protection for slides or eroding banks and can also be used to reestablish natural stream channel dimensions.

A backhoe or excavator is essential in construction of the revetment. The material sizes needed vary depending on the stream size and hydrological factors. Logs, preferably redwood with root wads attached, boulders and live plant materials are placed in sequence to ensure stability and proper function of the structure. Logs without root wads (footer logs) are set in a toe trench below the thalweg line, with the channel end pointed downstream and the butt end angled 45 to 60 degrees upstream. A second log with a root wad is set on top of the footer log diagonally, forming an "X." The root wad end is set pointing upstream and the butt end lying downstream 45 to 60 degrees. The apex of the logs are anchored with threaded rebar. Large boulders are secured in the spaces between the logs, at each apex. Normally, earth, large rock or cables, and earth anchors are used to stabilize the woody elements.

Various shrub and tree plantings are incorporated into the bank and flood plain areas. Since rootwads themselves will not last indefinitely, this treatment depends on a complementary strategy to replant the bank or to allow a healthy riparian corridor plant community to develop in the overbank zone. After all the logs and boulders have been set in place, any live plant material disturbed from the site along with recruited willows are placed within the spaces of the structure, behind the boulders. Once this has been done the excavated gravel and streambed materials can be placed over the bank-end portion of the revetment.

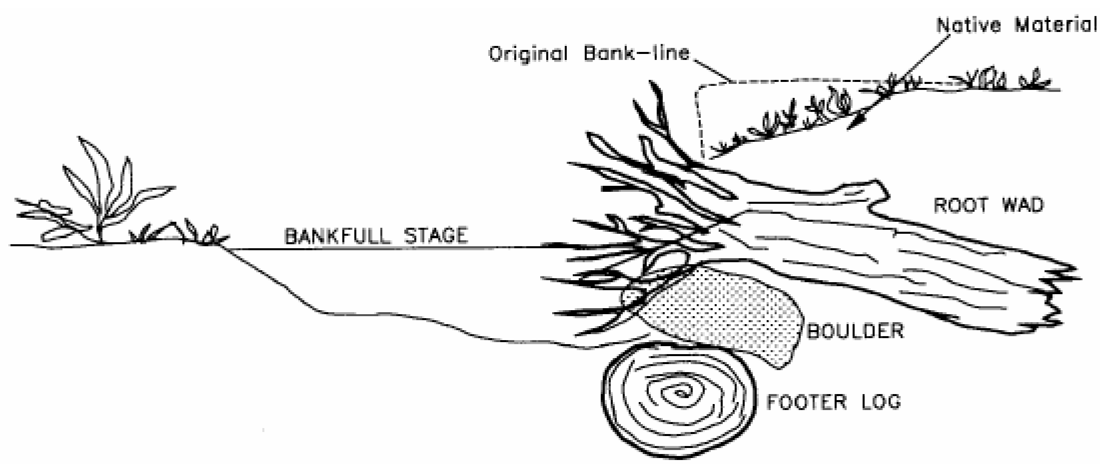

Figure E-6 Typical rootwad revetment.

(Source: CSSHRM)

E.7 BOULDER CLUSTERS

Source: CSSHRM

Boulder clusters are used to create scour pockets around boulders, to provide rearing habitat for juvenile salmonids, to build quiet water resting areas for upstream migrating spawners, and to sort spawning gravel.

Generally, clusters are located in straight, stable, moderately to well confined, low gradient riffles (0.5 to 1 percent slope) for spawning gravel enhancement; they are also placed in higher gradient riffles (1 to 4 percent slope) to improve rearing habitat and provide cover. At least 3 to 5 foot diameter boulders are recommended, except in very small streams. To be effective in creating scour pockets and habitat niches around individual boulders, the correct distance between adjacent boulders and the configuration of the boulder clusters must be determined. In general, adjacent boulders should be 0.5 to 1 foot apart. The best configuration for boulders is usually a triangle of three boulders. Several of these clusters may be aggregated to increase scour area and create greater habitat complexity.

If large angular quarry boulders are available, a single boulder can create good cover for juvenile and adult fish. Place the boulder within the middle two quarters of channel width, and not in a deposition zone. If the boulder is placed on a sand or silt bar, it may disappear into the bar. Do not use boulders that are so big that they divert the stream from its channel, or into soft stream banks.

Operation and maintenance requirements for boulder clusters are minimal. Clusters should be inspected annually to determine stability. Boulders that have dislodged and moved a few feet need not be relocated unless they are causing stability problems. More significant movement is indicative of design deficiencies, and harvesting and relocating boulders into zones of lower velocity should be considered. Shifts in the channel thalweg that cause boulders to perch during low flow conditions should also be regarded as an inducement to relocate boulders.

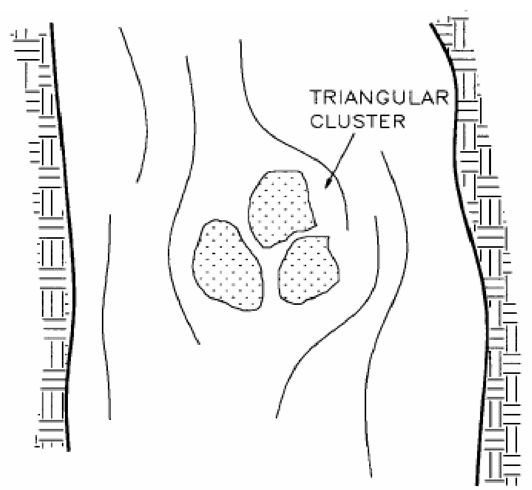

Figure E-7 Typical boulder cluster placement.

(Source: CSSHRM)

E.8 CULVERT MODIFICATION/REPLACEMENT

Source: NEH654 TS-14N

This approach would be used to create or maintain natural stream processes within the barrel of a culvert thus simulating the stream within the culvert. Applying the stream simulation approach requires a working knowledge of the stability (both vertical and horizontal) of a prospective work site. The target stream channel must be stable within a range that can be accommodated by the planned culvert. Channels suitable for stream simulation culverts must be in equilibrium, meaning that the quantity and size of sediment delivered to the reach is roughly equivalent to the quantity and size transported out. Downstream grade controls are necessary to ensure degradation will not lead to a perched culvert.

Stream simulation culverts are sized wider than the active channel and filled with a mix of bed material that will promote natural sediment transport dynamics through the road crossing. Stream simulation culverts are most often applied at slopes between 3 percent and 6 percent, although installations have occurred in gradients up to 8 percent.

This method involves either placing a bottomless arch (precast concrete, structural steel plate) over the entire width of the channel or countersinking an oversized round culvert or flat-bottomed pipe (pipe arch, precast concrete). The most basic stream simulation culvert is a bottomless arch placed over an undisturbed natural channel, allowing the streambed to remain intact and decreasing chances of geomorphic instability.

Round, corrugated metal or concrete box culverts are preferred over pipe arches. A round pipe with a diameter roughly equal to a given pipe arch span affords a greater fill depth for the same bed and crown elevations, thus providing a vertical erosion buffer before the pipe bottom is exposed. Costs are very similar, but assembly and installation of a round pipe is easier than for a similarly sized pipe arch. Regardless of which culvert shape is used, it must be sufficiently wide and embedded deep enough (30 to 50% of culvert height) to allow natural stream processes (scour, deposition, and thalweg migration) to occur within the enclosed channel.

Properly embedding a stream simulation culvert raises the stream channel to the widest part of the pipe and creates deeper fill which can withstand greater vertical and lateral channel adjustments. The channel bed within a stream simulation culvert should be based on channel composition in reaches adjacent to the crossing. Stream simulation design culverts are easiest to install where channel slope and bed material match culvert slope and bed material.

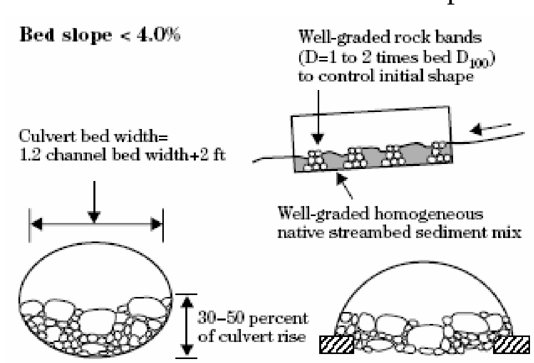

Figure E-8 Culvert replacement with stream simulation method. **(Source: NEH654 TS-14N)**

E.9 FASCINES

Source: NEH654 TS-14I

A fascine is a long bundle of live cuttings bound together into rope or sausage-like bundles. The structure provides immediate protection for the bank toe. Since this is a surface treatment, it is important to avoid sites that will be too wet or too dry. The technique uses live cuttings (3/4 to 2 inches in diameter, 5 to 15 feet long), natural fiber cord or small-gauge, nongalvanized wire, dead stout stakes (2 to 3 feet long depending on soil conditions), and require minimal tools for installation.

For the installation, live cuttings are collected then soaked for 14 days, or they are installed the day they are harvested. Side branches of the cuttings are left intact. The cuttings, with varying orientations, are staggered into a uniform bundle built to a length of about 8 feet. Bundles can be easily spliced together to create a fascine long enough to fit the particular project site. Bundles are tied with twine so that they are 6 to 24 inches in diameter, depending on the application. Installation begins at a stable point at the upstream end of the eroding bank. A trench (half to three-quarters the diameter of the bundle) is excavated into the bed of the stream, where the bank meets the bed. The bundle is placed in the trench and staked directly through the bundle. To improve depth of reinforcement and rooting, live stakes (2 to 3 ft in length) are installed just below (downslope) and in between the previously installed dead stout stakes. The fascine is covered with soil, ensuring good soil to stem contact, and washed with water. Some portion remains exposed to sunlight to promote sprouting. Erosion control fabric can be used to hold the soil adjacent to and in between the fascine bundles, especially in wet climates. When using erosion control fabric between the fascine bundles, the fabric is first placed in the bottom of the trench, an inch of soil is placed on top and up the sides of the trench and erosion control fabric, and the fascine bundle is then placed in the trench and staked down.

Figure E-9 Fascine installation.

(Source: NEH654 TS-14I)

E.10 LIVE POLE CUTTINGS/STAKES

Source: NEH654 TS-14I

Live pole cuttings are dormant stems, branches, or trunks of live, woody plant material inserted into the ground so that they will sprout and grow. Live stakes are generally shorter material that are also used as stakes to secure other soil bioengineering treatments such as fascines, brush mattresses, erosion control fabric, and coir fascines. However, the terms live stakes and live pole cuttings are often used interchangeably. Both live poles and live cuttings can be used as anchoring stakes. They are live material so they will also root and sprout. Live pole cuttings are 3 to 10 feet long, and 3/4 to 3 inches in diameter. These cuttings typically do not provide immediate reinforcement of soil layers, as they normally do not extend beyond a failure plane.

Over time, they provide reinforcement to the soil mantle, as well as surface protection and roughness to the streambank and some control of internal seepage. They assist in quickly reestablishing riparian vegetation and cause sediment deposition in the treated area.

Figure E-10 Live stake installation after one growing season.

(Source: NEH654 TS-14I)

E.11 VEGETATED ROCK RIPRAP

Source: NEH654 TS-14I

Rock riprap is one of the most common and effective forms of streambank protection. Rock can settle and conform if some scour should occur. Conventional riprap placement, however, does not increase wildlife habitat nor is it aesthetically pleasing. It often takes many years for riprap to become vegetated if revegetation is not planned in advance and integrated with construction. Woody vegetation establishment will prevent soil loss (piping) from behind the structures and increase pullout resistance. Vegetated riprap techniques should be considered with projects in streams with fishery resources.

Joint plantings or vegetated riprap utilize cuttings of live, woody plant material inserted between the joints or voids of riprap and into the ground below the rock. Joint planting cuttings are 30 to 48 inches long, and from 3/4 to 2 inches in diameter. These live cuttings typically do not provide immediate reinforcement of soil layers, as they normally do not extend beyond the failure plane. The live cuttings are intended to root and develop top growth providing several adjunctive benefits to the riprap. Over time, these installations provide reinforcement to the soil on which the riprap has been placed, as well as providing roughness (top growth) that typically causes sediment deposition in the treated area. Some control of internal seepage is also provided. These joint planting installations assist in quickly reestablishing riparian vegetation. Joint plantings are frequently used on the lower part of the bank.

Figure E-11 Vegetated riprap installation

(Source: NEH654 TS-14I)

E.12 NATIVE REVEGETAION

Native plants form an integral part of the foundation for the ecological functioning of riparian and other natural areas. Native vegetation affects soil conservation, wildlife habitat, plant communities, invasive species, and water quality. Establishing locally-adapted, self-sustaining plant communities is key to the successful integration of disturbed areas back into natural open spaces.

Native revegetation involves planting native vegetation species that are locally-appropriate and are adaptable to the varying site conditions (e.g. slope gradient, slope aspect, soil type and productivity).

The following guidelines will be considered when revegetation occurs:

- Plant installation should follow (not precede) establishment of the appropriate hydrogeomorphic alignment, structure, or cross section.
- Having a sufficient topsoil layer is critical in this rocky, thin soil environment. Therefore, if rocks or cover are removed, the soil should be evaluated and potentially replenished prior to planting.
- Riparian revegetation will be accomplished using species and cultivars native to the Permanente Creek watershed.
- Seeds and other propagules should be collected from the watershed and either be planted, treated and stored, or be nursery grown and then installed.
- Successful establishment of riparian vegetation must integrate three sources of variability: vertical, horizontal, and temporal.
  - Vertical strata include: trees, shrubs, herbaceous and grass species.
  - Horizontal variation is related to creek cross section features, e.g. channel, bars (willow), bankfull (alders), first flood plain terrace (oaks), and upslope from there (bay).
  - Temporal: shade intolerant early colonizers (chemise) and shade tolerant species (ferns), often the climax community species.
- Slope, aspect, and soils are critical plant selection factors to inform species placement. Example plant communities by aspect are provided below:
  - Coast live oak community is common on the north to northeast side of the mountains.
  - Chamise series and manzanita shrublands are common on shallow soils and on south-facing slopes.
  - California bay series on north-facing slopes.
  - Interior live oak, coast live oak, scrub oak, and blue oak communities on south-facing slopes.
- Most of the plants will require supplemental watering during a 3-5 year establishment period.

Figure E-12.1 Example of current riparian conditions (Reach 17).

Figure E-12.2 Riparian area showing an example revegation scheme (Reach 17).

E.13 TERRACING

Source: NEH 650 8

Terraces are constructed to reduce erosion by shortening the length of a slope and conducting the runoff water on a nonerosive grade to a stable outlet. Terracing is one of the best mechanical erosion control practices. Terraces that are properly located, constructed and maintained reduce runoff and soil losses and prevent the forming of rills and gullies. They assist in reclaiming badly gullied slopes by intercepting the runoff before it becomes concentrated and attains an eroding velocity. Terraces prevent the loss of costly seed and plant materials. To be effective, they must be used in combination with other practices, such as slope drains, revegetation, and erosion control matting.

Figure E-13 Typical terrace application.

(Source: NEH650 8)

E.14 SLOPE DRAINS

Source: Caltrans SS-11.

A slope drain is a pipe that intercepts runoff or groundwater and directs it to an adequate channel or a sedimentation basin or trap. Slope drains are used in combination with earth dikes and vegetated swales, which intercept and direct surface flow away from slope areas, to protect cut or fill slopes. Slope drains are suitable where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion, where terraces are used to stabilize long, steep slopes, and where water accumulates at the top of cut and fill slopes.

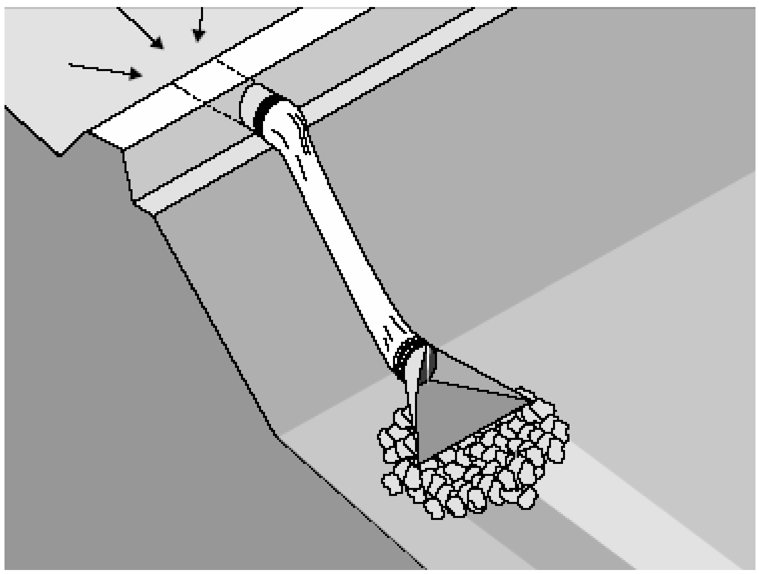

Figure E-14 Typical slope drain installation.

(Source: Caltrans SS-11)

E.15 HYDROSEEDING WITH HYDROMULCHING

Source: Caltrans SS-3 and SS-4.

Hydroseeding typically consists of applying a mixture of wood fiber, seed, fertilizer, and stabilizing emulsion with hydromulch equipment, to temporarily protect exposed soils from erosion by water and wind. In this case the seed with fertilizer and tackifier is applied first to ensure maximum contact of the seed with the soil surface. Then the wood fiber and stabilizing emulsion is sprayed during a second application to the slope. The second application protects the seed from raindrop splash and wind erosion, lowers seed predation, and increases soil moisture retention.

Steep slopes are difficult to protect with hydroseeding and hydromulching alone. Other slope stabilization and runoff redirection methods should be used in conjunction with this technique. Seeding should not be implemented during the annual dry season without supplemental irrigation. Prior to application, the area to be seeded should be roughen with furrows trending along the contours. To ensure plant vigor and habitat compatibility, only native and site-appropriate plant species should be included in the seed mixture.

E.16 EROSION CONTROL MAT

Sources: CalTrans SS-8 and NEH654 TS-14D

Erosion control blankets are used to temporarily stabilize and protect disturbed soil from raindrop impact and surface erosion, to increase infiltration, decrease compaction and soil crusting, and to conserve soil moisture. Mulching with erosion control blankets will increase the germination rates for grasses and legumes and promote vegetation establishment. Erosion control blankets also protect seeds from predators, reduce desiccation and evaporation by insulating the soil and seed environment. Erosion control blankets and mats can be used with biotechnical techniques such as grass plug planting, willow staking, fascines etc.

Erosion control blankets are generally a machine produced mat of organic, biodegradable mulch such as straw, curled wood fiber (excelsior), coconut fiber or a combination thereof, evenly distributed on or between photodegradable polypropylene or biodegradable natural fiber netting. Synthetic erosion control blankets are a machine produced mat of ultraviolet stabilized synthetic fibers and filaments. The netting and mulch material are stitched to ensure integrity and the blankets are provided in rolls for ease of handling and installation.

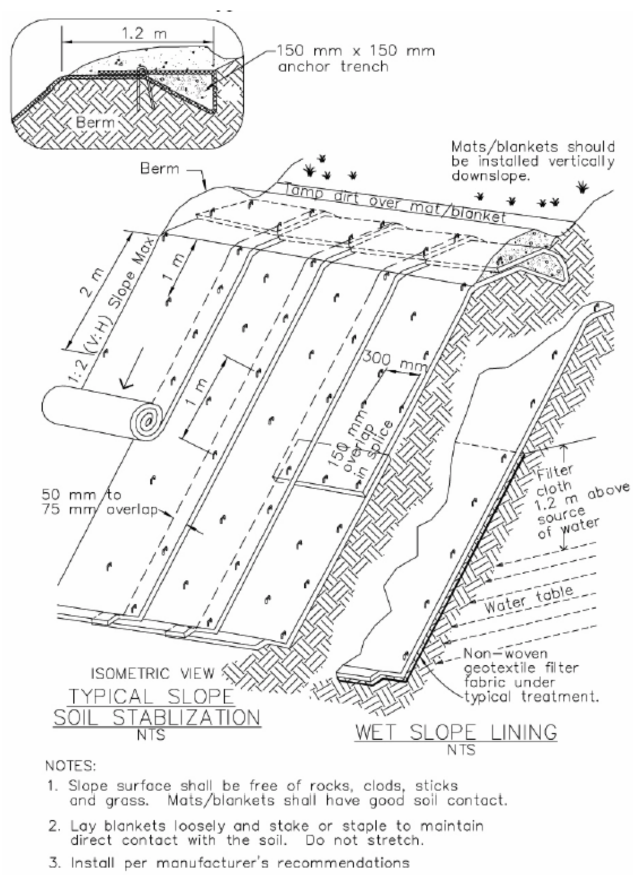

Figure E-16 Erosion control blanket installation detail.

(Source: CalTrans)

E.16 GEO-CELLULAR CONFINMENT SYSTEM

Sources: CalTrans SS-7, NS-4 and NEH654 TS-14D

Geo-cellular confinement systems are commonly used to permanently stabilize steep slopes and channels. The matting is flexible conforming to changes in slope such as a creek cross-section. A typical geo-cellular mat section is shown on Figure E-17. Because geo-cellular mats provide horizontal and vertical reinforcement by confining fill material in a series of connected cells the material can be used as a substitute for riprap to prevent erosion from streamflow. The cell thickness typically ranges between four and eight inches allowing soil and rock to be placed in the cells to grow vegetation. The panels act as large mats, distributing load over a larger area, while also increasing the bearing capacity of the soil. The subgrade below the mats should be sufficiently compacted, and a geo-textile liner will be placed directly on the compacted subgrade prior to placing the geo-cellular panels. Mats can be placed end-to-end to cover the area of reinforcement, and connected to adjacent mats by heavy-duty stapling. The geo-cellular mat is secured in place using hook shaped rebar anchors.

For the use in a channel or spillway, the matting should line the side slopes up to the design storm water surface elevation (e.g. 100-year flood level). Soil and gravel mixture (3:2 ratio by volume) should be placed within the cells of the confinement matting along with native grass seed or plugs. Geo-cellular matting used in a pond spillway application should include a stilling basin lined in the matting to reduce flow velocities and erosion.

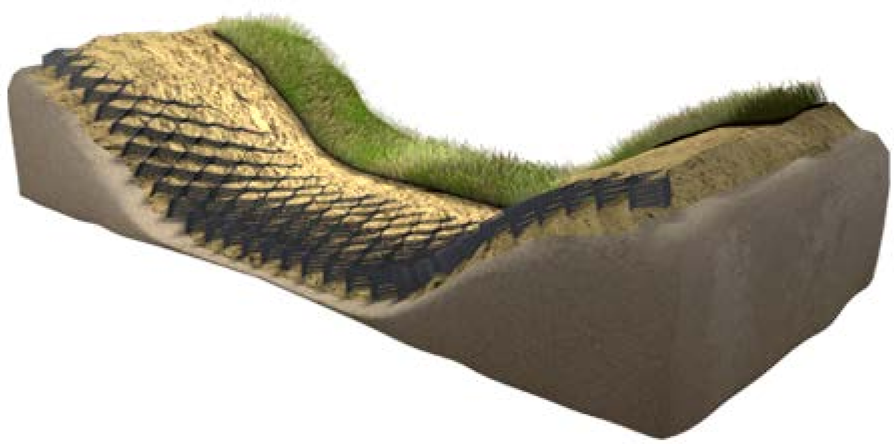

Figure E-17. Typical Geo-cellular Mat

(source: www.geoproducts.org)