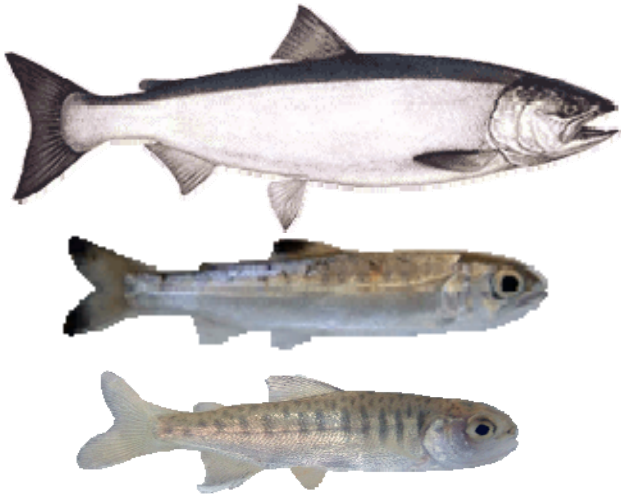
APPENDIX D

Draft 60% Complete Design Report – Dry Creek Habitat Enhancement Demonstration Projects: River Miles 6.2 to 7.3

Please note, the following 60% complete design report and drawings for the Dry Creek Habitat Enhancement Demonstration Project is in the process of being reviewed by various regulatory agencies and landowners within the project area. This report is a draft and is subject to change.



DRAFT

60% Complete Design Report

Dry Creek Habitat Enhancement Demonstration Projects: River Miles 6.2 to 7.3

Sonoma County, CA

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1 INTRODUCTION

Dry Creek flows 14 miles from the Warm Springs Dam (WSD) to the mouth of the Russian River in Sonoma County, California (*Figure 1*). WSD is operated by the Army Corps of Engineers to control floods, and by the Sonoma County Water Agency to supply potable water to 600,000 consumers in Sonoma and northern Marin Counties.

Dry Creek is home to native threatened and endangered fish, including coho salmon, Chinook salmon, and steelhead trout. The National Marine Fisheries Service has determined that the operation of Warm Springs Dam could threaten the survival of coho salmon and steelhead trout in Dry Creek, and in 2008 issued a Biological Opinion requiring improvements to their habitat. In particular, key goals identified for habitat enhancement in Dry Creek include development of rearing and refugia habitat for Central California Coast (CCC) coho salmon (*Onchorhynchus kisutch*) and CCC steelhead trout (*O. mykiss*).

Habitat enhancement in Dry Creek is seen as a significant opportunity for recovery of coho and steelhead in the region due to the relative abundance of cool water in the late summer months which is atypical of streams in the region. Late summer rearing conditions are considered a critical bottleneck for species recovery. Minimum habitat restoration goals are detailed more specifically in the Biological Opinion for Water Supply, Flood Control and Channel Maintenance Activities (RRBO: NMFS 2008).

The Biological Opinion lays out a timeline for the habitat work, which will ultimately result in over six miles of habitat enhancement in Dry Creek by 2020. A group of cooperating landowners in the Dry Creek Valley has come together with the Sonoma County Water Agency to begin planning the implementation of the first phase of these enhancements. This will be accomplished through a series of ‘demonstration’ projects within a 1.1 mile length of Dry Creek in the middle of the valley, extending from the mouth of Grape Creek to a point just downstream of the mouth of Crane Creek (Figure 1). Construction of the demonstration projects is scheduled to begin in 2012.

The following pages summarize the enhancement design development to date (60% Complete) for the 1.1 mile “Demonstration Reach” of Dry Creek.

2 SCOPE OF REPORT

The current report details design development to arrive at the present 60% Complete Enhancement Design. This draft design report is a ‘living’ document, which will be expanded as design development advances through the detailed design phase. As such, sections of the current report will be expanded with additional detail in future editions, and new sections will be added documenting further design development.

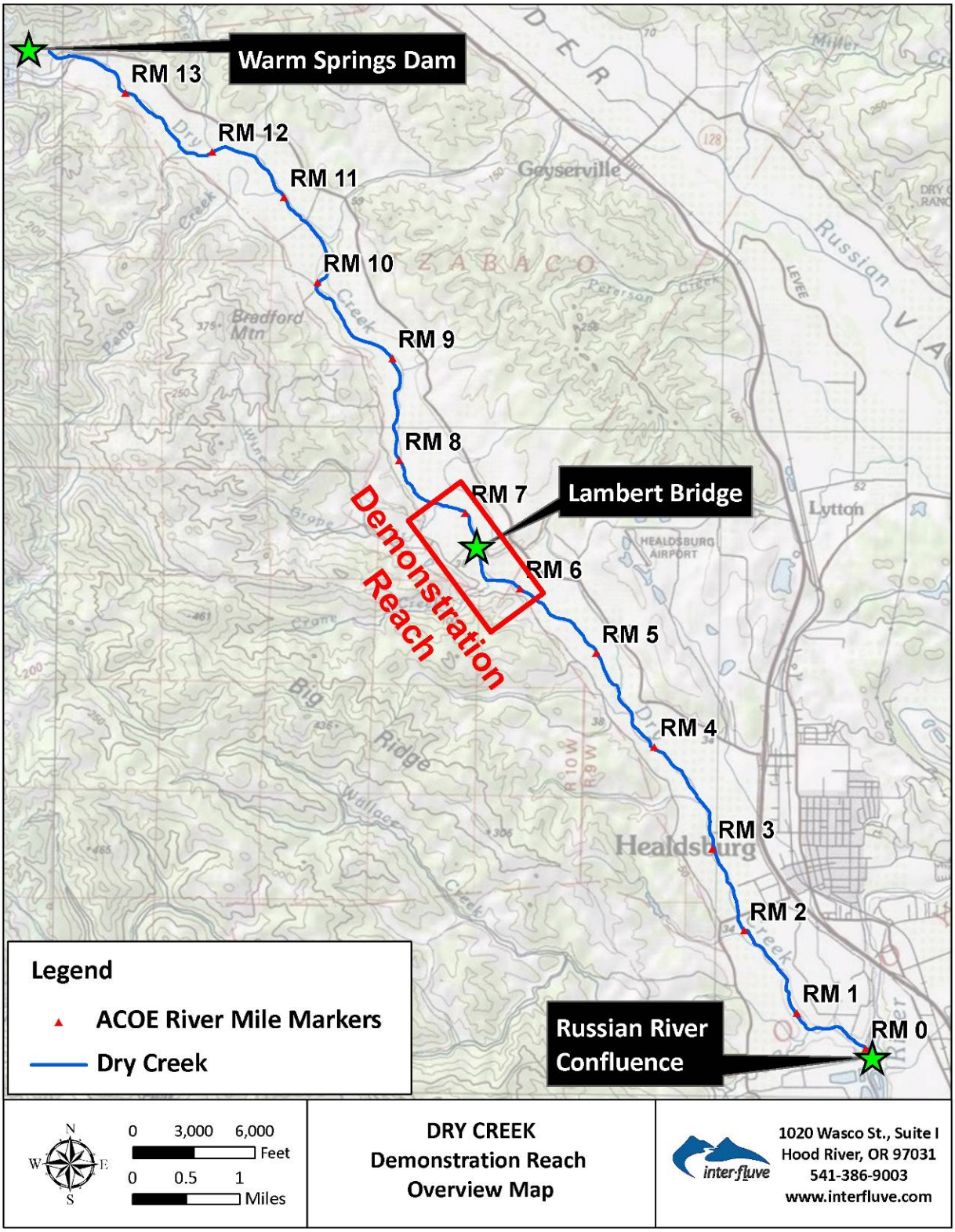


Figure 1: Map of Lower Dry Creek between Warm Springs Dam and the Russian River.

3 PREVIOUS STUDIES BY INTER-FLUVE

In addition to the detailed design of the Demonstration Projects, Inter-Fluve has been completing a feasibility study of fish habitat enhancement over the 13.9 mile length of Dry Creek between WSD and the Russian River. The feasibility study has resulted in two reports which provide a foundation for the demonstration project design. These reports are summarized below:

- *Final Current Conditions Report, Dry Creek from Warm Springs Dam to the Confluence with the Russian River* (Inter-Fluve 2010): This report includes a summary of watershed context and hydrology, an assessment of stream geomorphology based on available data and field observations, and a detailed summary of the fish habitat inventory completed in summer 2009.
- *Draft Habitat Enhancement Feasibility Study Report, Dry Creek from Warm Springs Dam to the Confluence with the Russian River* (Inter-Fluve 2011): This report includes additional quantitative assessment of stream geomorphology and trajectory, and assessment of the feasibility of fish habitat enhancement to meet the habitat goals of the RRBO on Dry Creek.

The following sections sample the key points from these studies as relevant to the demonstration project design. The reader is referred to the above reports for more detailed discussion.

4 DRY CREEK CURRENT CONDITIONS

4.1 Watershed Context

The Dry Creek watershed is located in the interior coast range of northern Sonoma and southern Mendocino counties, approximately 30 miles from the Pacific Ocean and 60 miles north of San Francisco Bay. Warm Springs Dam is located on Dry Creek at river mile 13.9, at the confluence of Dry and Warm Springs Creeks. The Dry Creek watershed lies within a region of Mediterranean climate, characterized by warm, dry summers and cool wet winters.

The characteristic pattern of the natural flow regime for Dry Creek prior to operation of the dam (before 1984) was seasonal with high flow events occurring in the winter and very low flow in the summer and early fall. Flow rates under natural conditions increased three orders of magnitude during the winter. After operation of the dam commenced in 1984, the flow regime changed to a perennial stream with much less variation in flow rates between summer and winter. Summers have consistent base flow while winter peak flows are reduced relative to natural flow conditions (Inter-Fluve 2010).

The present condition of lower Dry Creek expresses the legacy of management in the basin, which extends back to the settlement of the valley starting in the 1850s. Gravel mining began in the Russian River near Healdsburg about 1900, and continued in various locations within the mainstem until the late 1960s, and then shifted to the Russian River terraces below Healdsburg. The Potter Valley project was constructed in the early 1900s, which supplemented flow in the Russian River with water from the Eel River in northern California. Gravel mining also occurred along lower Dry Creek from the 1950s to the 1970s near the Mill Street bridge (approximately 2

miles above the creek mouth). In conjunction with the construction of Healdsburg (1952) and Coyote (1959) Dams on the Russian River which served to reduce downstream supplies of gravel, gravel mining and other activities resulted in a significant lowering of the base level for Dry Creek, which resulted in significant degradation in the main channel of lower Dry Creek, and subsequently in the tributaries (Army Corps of Engineers 1987).

4.2 Current Geomorphology of Dry Creek

The current geomorphology of lower Dry Creek is a result of the interaction of local geology, watershed characteristics, hydrology, and vegetative characteristics; the legacy of channel evolution and response to land management changes; and the ongoing influence of flow management. Lower Dry Creek is an incised, perennial, alluvial gravel bed stream that has responded to significant human induced hydrologic and geomorphic change over the past 150 years (Inter-Fluve 2010). The study reach is primarily composed of pool-riffle and plane-bed morphology (Montgomery and Buffington 1997) with an average channel gradient of 0.18%. The channel corridor is generally narrow relative to the active channel width, and relatively uniform in width over most of the study reach, with periodic wider reaches.

Widespread, systemic incision occurred historically in response to base-level lowering and other factors. Assessments completed in close proximity to the time of dam closure concluded that systemic degradation of lower Dry Creek had generally ceased by the time the dam came online (Harvey and Schumm 1985). The primary determinant of current geomorphic conditions is the influence of the dam, expressed through modified sediment supply, altered hydrology and the growth of riparian vegetation. Dam construction ceased delivery of bed material from the upper 60% of the watershed. The hydrologic regime has been converted from a seasonal runoff-based regime to a regime that combines moderate winter floods, year-round flows, and sustained, relatively high baseflow conditions. The change in hydrology has also resulted in increased growth of riparian trees that influence bank erosion rates (Inter-Fluve 2010, 2011)

The reduction in bedload supply is most noticeable in the reach between the dam and the confluence of Dutcher (RM 11.8) and Pena (RM 11) Creeks. The reduction in bed material supply is moderated by successive tributaries entering lower Dry Creek. The most significant of these in terms of bed material supply include Dutcher Creek (RM 11.8), Pena Creek (RM 11), Crane Creek (RM 6.3) and Mill Creek (RM 0.6). The reach between Pena Creek and Westside Bridge (RM 11 to RM 2) does not appear to be actively incising or aggrading, though there are selected areas of active channel adjustment. The reach between Westside Bridge and the confluence appeared to be the most alluvial reach, in which the channel position and shape are most readily shaped by fluvial forces (Inter-Fluve 2010, 2011)

Regulation has resulted in elevated summer baseflow conditions that when combined with the Mediterranean climate produces near ideal conditions for growth of riparian trees and shrubs. Regulation has also resulted in severe curtailment of major floods, which limits disturbance and removal of newly recruited and established vegetation. This combination of effects has resulted in extensive vegetative colonization of formerly active bar surfaces (Figure 2). Colonization of the bar surfaces serves to limit lateral migration of the active channel within the channel corridor, and has the effect of sequestering a reservoir of gravel within the system (Inter-Fluve 2010, 2011).

Vegetative colonization of bar surfaces has also led to an active channel that is efficient at moving gravel supplied to the stream despite the reduced flood flow hydrology. Mature vegetation and dense understory growth hydraulically roughen over bank areas and concentrate high flow velocities in the channel during high flow events. However, based on field observations, the combination of reduced bed material supply and reduced flood magnitudes and frequencies do not appear to have resulted in incremental systemic degradation or aggradation though areas of local adjustment and bed degradation are apparent, as observed by long-time Dry Creek landowners. Degradation is also kept in check by features which control the bed grade spaced periodically over the reach, such as bedrock exposures and grade control structures (Inter-Fluve 2010, 2011).

More detail regarding the current geomorphology of Dry Creek can be found in the Draft Feasibility Study Report (Inter-Fluve 2011).

Figure 2: Example of vegetative narrowing of channel corridor near Lambert Bridge (RM 6.6). Lambert Bridge is seen at lower right of each frame. Dry Creek flow is from top to bottom. Left frame is from 1976, right frame is from 2004. Light blue line is estimated limit of active fluvial features in 1976.

4.3 Fish Habitat in Dry Creek

A habitat inventory was conducted in 2009 to census aquatic habitat for coho salmon and steelhead trout in Dry Creek downstream of the Warm Springs Dam. Habitat conditions were documented at the summer steady-state operational discharge of approximately 100 cfs (Inter-Fluve 2010).

The inventory found that Dry Creek is composed of 26% riffles, 23% pools, 7% scour pools, 44% flatwaters and less than 1% cascades based on the relative frequency of mainstem habitats.

Pool depths generally decreased in the downstream direction, with a greater proportion of scour pools in the middle to upstream end of the survey area. Overall, there was far more flatwater than riffle habitat (44% of mainstem habitats by frequency versus 26% for riffles). Although Dry Creek is composed of 26% riffles by frequency, riffles represent only 12% of mainstem habitats by length. A total of 44 alcoves and 27 side channels were measured, with a relatively greater number of off-channel habitats in the lower half of the study reach (Inter-Fluve 2010).

Pebble counts were conducted at riffles in all surveyed reaches. The substrate sizes in these riffles meet coho and steelhead spawning requirements. The predominant substrate in riffles, flatwaters and pools was gravel. In side channel pools, dominant substrate was most often fine sediment, gravel, or sand. Instream woody debris (small, medium and large) totaled an average of 183 pieces of wood per mile in lower Dry Creek, with variability from reach to reach, ranging from 63 to 362 pieces per mile (Inter-Fluve 2010).

4.4 Habitat Enhancement Demonstration Reach Current Conditions

The Habitat Enhancement Demonstration Reach is located in survey reach 7 from the 2009 fish habitat and geomorphic inventory (Inter-Fluve 2010). Survey Reach 7 extends from below Crane Creek to about 1000 ft upstream of Grape Creek, while these important tributaries mark the upstream and downstream ends of the demonstration reach. These are deeply incised tributaries with exposed bedrock at their mouths. A mapped, unnamed tributary enters Dry Creek at river mile 6.6. A valley landmark, Lambert Bridge, crosses Dry Creek at river mile 6.6 (Figure 3).

Multiple bedrock outcrops are visible along the channel bed in this reach. Though the channel has narrowed as it has incised through this reach, there have been only minor amounts of channel migration since the 1940s (Figure 4). The channel is more sinuous than downstream, but the riparian corridor is narrow, and there is little room for substantial channel migration.

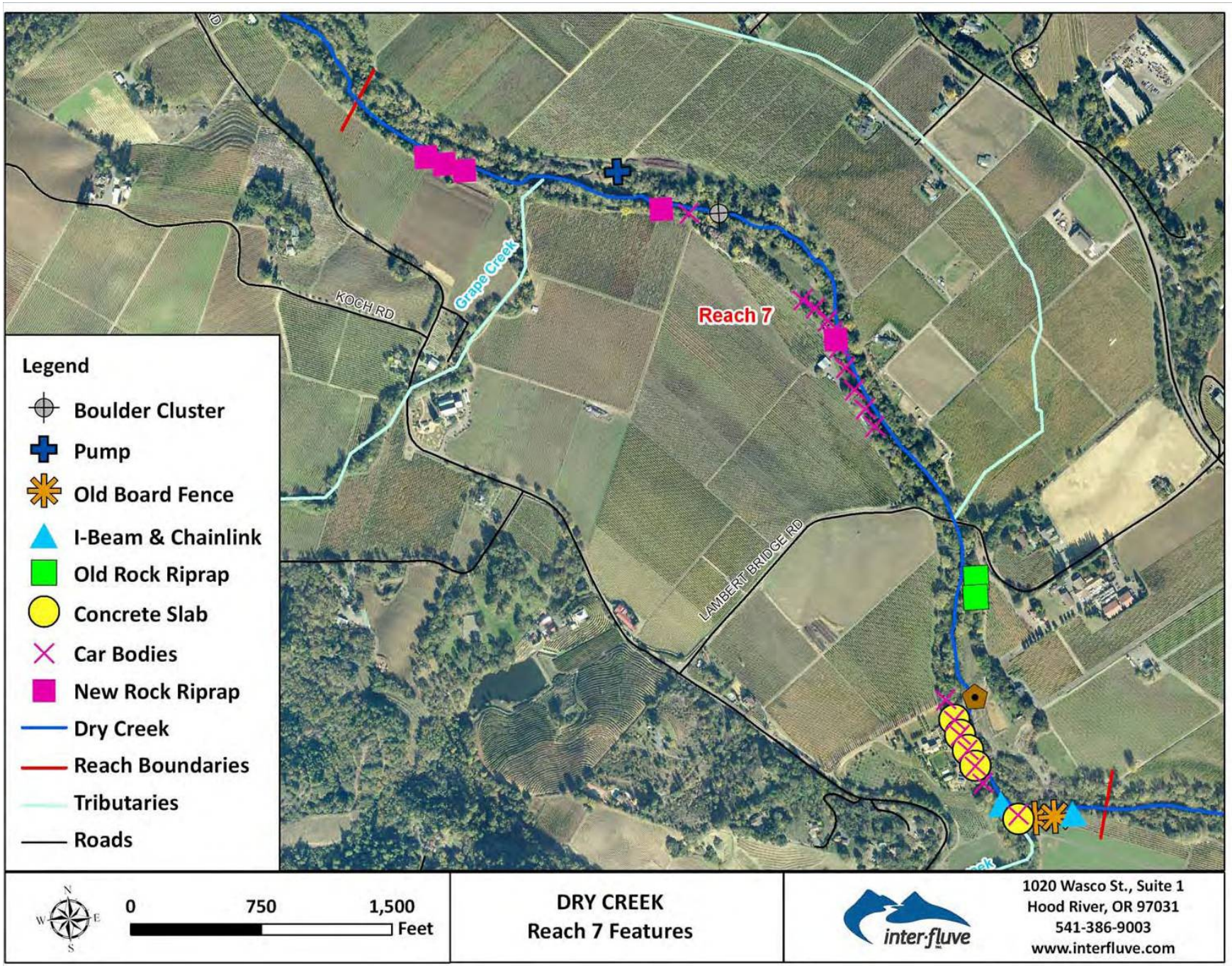


Figure 3: Existing features in Demonstration Reach (Inter-Fluve 2010).

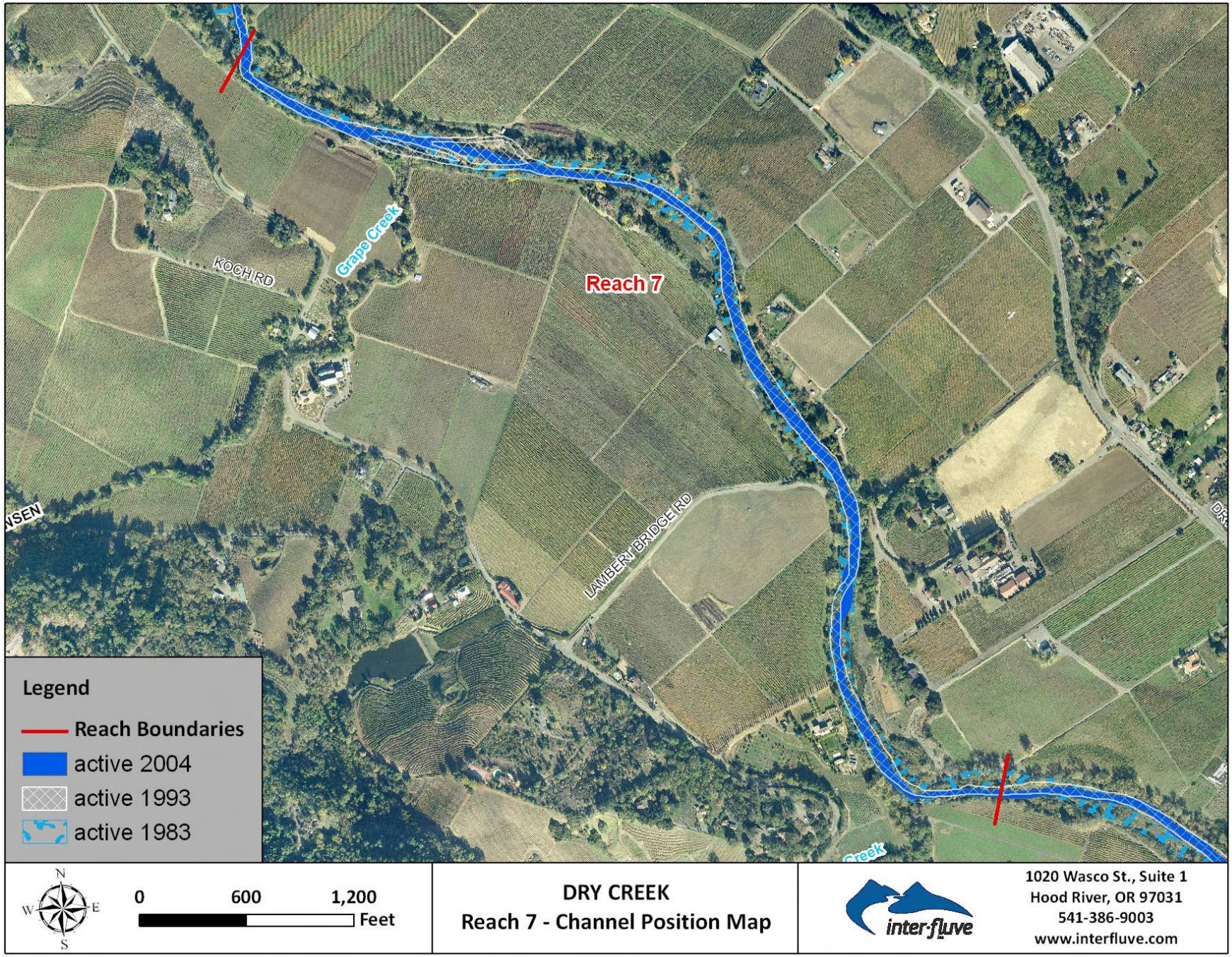


Figure 4: Channel position mapping for the post-dam period (Inter-Fluve 2010).

Figure 5: (upper left) cascade under Lambert Bridge, (upper right) mouth of Crane Creek, (lower left) bedrock outcrop, (lower right) riffle where Grape Creek enters Dry Creek.

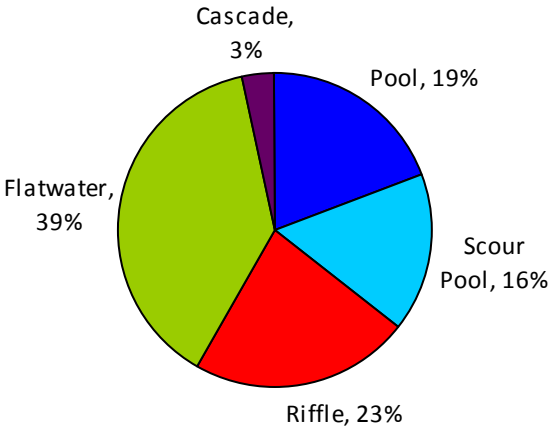
Substantial incision has occurred through this reach, but the bedrock outcrops have limited further widespread degradation. The most apparent bedrock outcrop is the bedrock cascade under the Lambert Bridge, but there are also outcrops at river mile 6.4 between the unnamed tributary and Crane Creek, at the mouth of Grape Creek and upstream of Grape Creek. These occasional bedrock outcrops provide cover for fish, influence pool formation, and control stream gradient. Despite the bedrock outcrops, the dominant substrate is gravel, followed by sand. Existing bank stabilization efforts in the reach include boulder riprap, old cars on the banks, concrete slabs, I-beam and chain link fence, and old board fence protecting banks just downstream of Crane Creek on the right bank.

Figure 6: (upper left) Failed I-beam and chainlink fence stabilization efforts, (upper right) car bodies in the banks, (lower left) erosion along an outside bend, (lower right) a triangular boulder cluster in Dry Creek.

4.5 Demonstration Reach Habitat Classification

At the time of the habitat inventory (2009), survey reach 7 contained 35% pool habitat, 39% flatwater, 23% riffle, and 3% cascade (under Lambert Bridge) by relative frequency (*Figure 7*). Riffles represent only 10% of the 1.3 miles of main channel on a length basis. There are a few side channels and alcoves, one cascade and seven riffles ranging in length from 50 to 60 ft (Figure 8).

Figure 7: Proportion of Habitat Types by Relative Frequency in Reach 7



The average wetted width during the survey was 48 ft and the active channel and flood prone widths are 58.5 and 81 ft respectively. The average active channel depth was 2.5 ft. Adjacent terraces are about 10 ft above the channel bed.

Pebble counts were conducted in four riffles in Reach 7. The median grain size of four sampled riffles ranged from 16 to 30 mm (Figure 9). Most samples were medium gravels through very coarse gravels. 80% of all samples were within desirable coho/steelhead spawning sediment

sizes, and 36% was within juvenile rearing size classes. 5% of the samples were fine sediments or sand (<2mm).

There were a total of 287 pieces of wood in Reach 7, with 193 pieces per mile in the mainstem. The highest densities of wood were found in pools and riffles, followed by flatwaters, then side-channels and alcoves. 5 out of the 8 large wood pieces (>20” diameter) observed were found in pools. Cover was provided by overhanging vegetation, terrestrial vegetation growing in the water, and small woody debris, and also by boulders, bedrock, and root masses. Edge habitat was present in 44% of the habitat units.

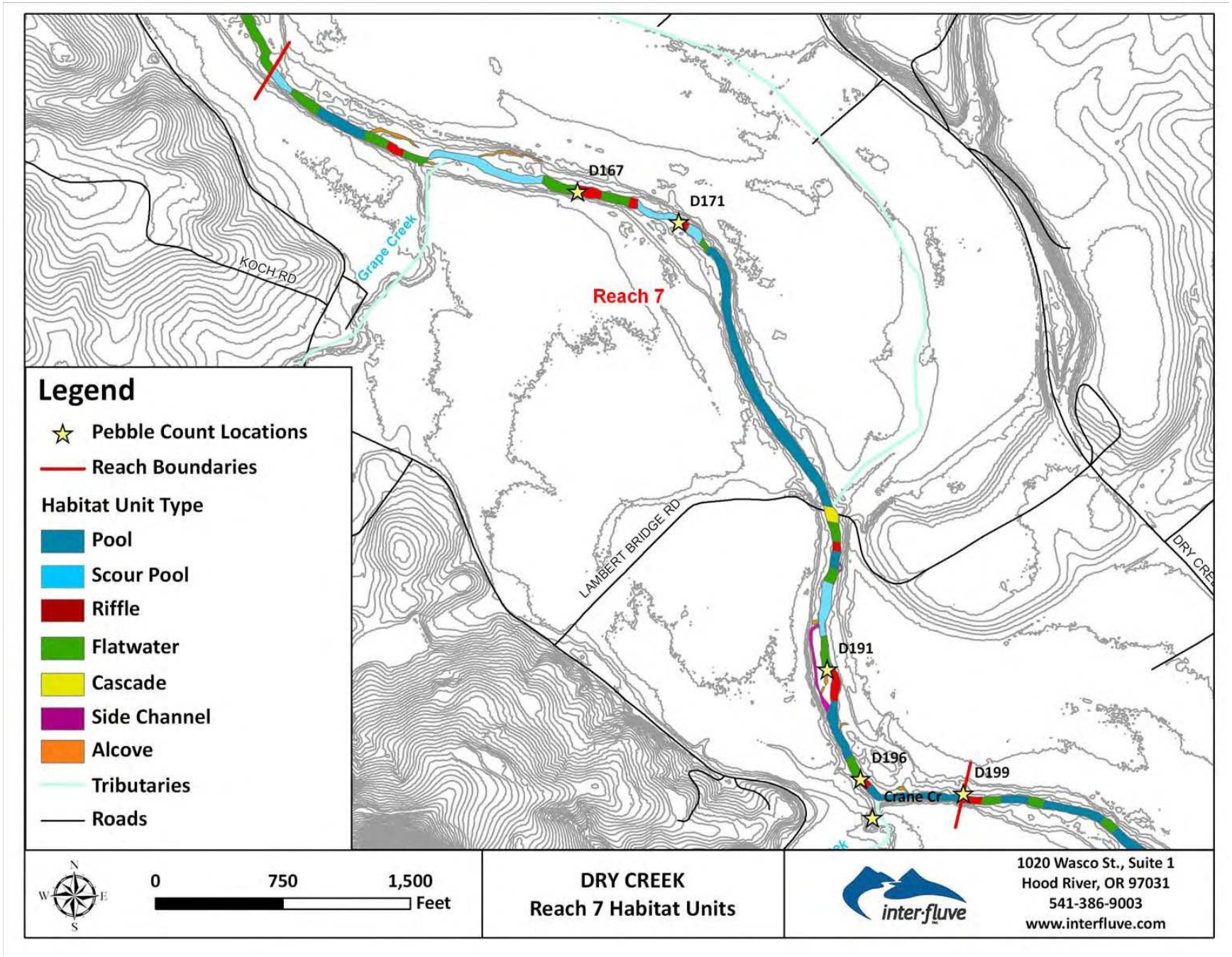
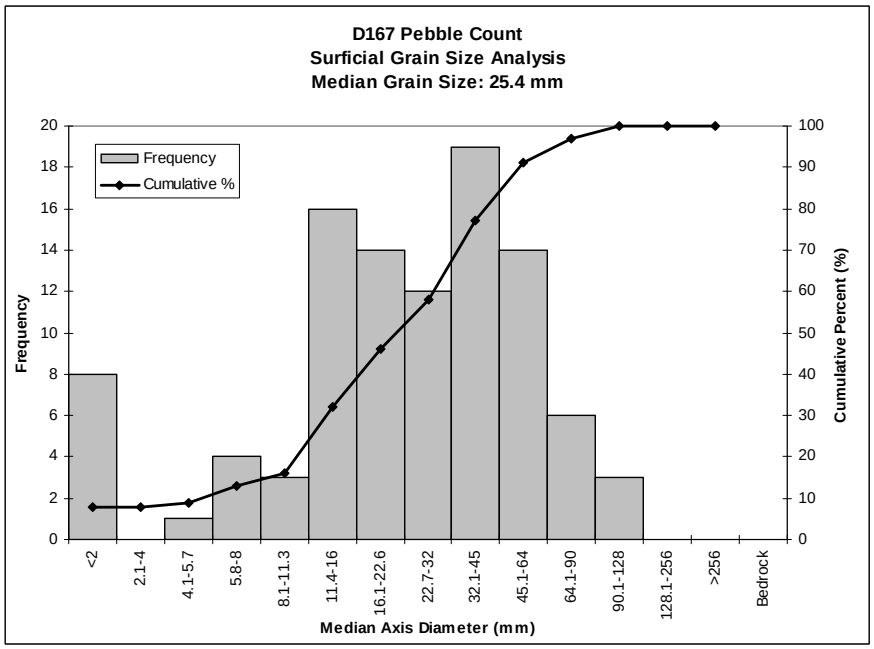


Figure 8: 2009 Habitat inventory results (Inter-Fluve 2010).

Figure 9: Grain size distribution for four riffles between Grape Creek and Crane Creek.D167 and D171 correspond to the habitat unit numbers in which the pebble counts were taken.



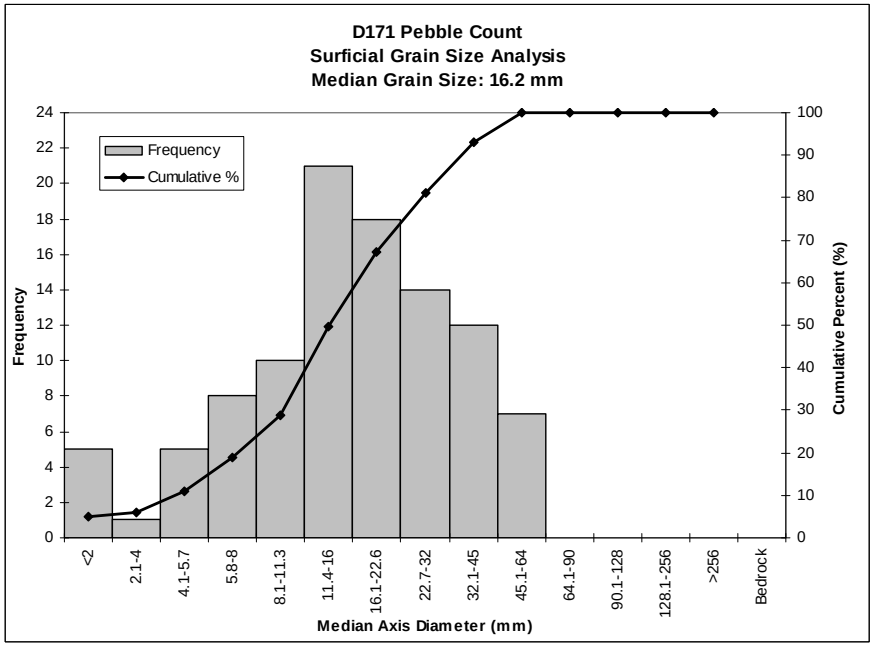
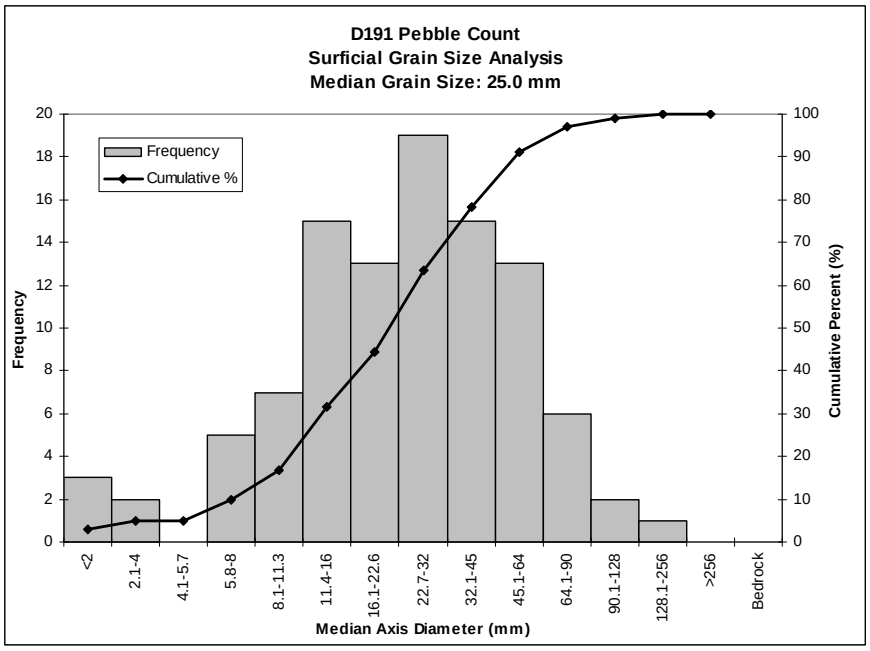
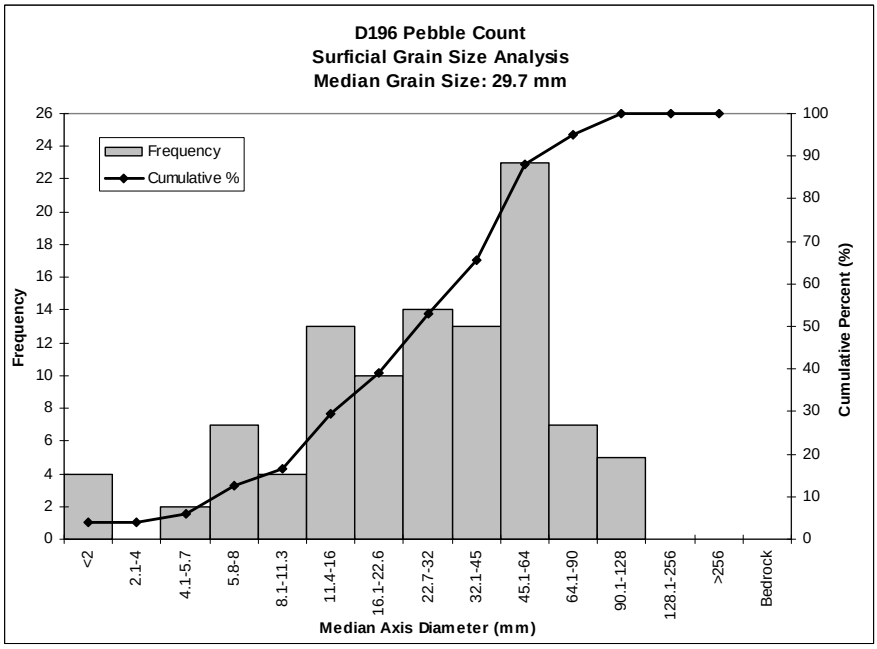


Figure 9, continued: Grain size distribution for four riffles between Grape Creek and Crane Creek. D191 and D196 correspond to the habitat unit numbers in which the pebble counts were taken.





5 DRY CREEK HYDROLOGY

Current hydrologic conditions in the project reach are regulated by WSD which became operational in 1984. Prior to dam construction and operation, Dry Creek had a natural flow regime typical of Mediterranean streams characterized by rapidly developing peak floods of relatively short duration occurring in conjunction with significant winter precipitation events, and very low summer period base flow. During major flood events, flow may have increased of 2-3 orders of magnitude over a short timeframe (Inter-Fluve 2010). The following section provides a summary of hydrologic characteristics germane to the enhancement design. More extensive discussion of Dry Creek hydrology is included in the Current Conditions and Feasibility Study Reports (Inter-Fluve 2010).

5.1 Flood Frequency Statistics

Peak flow hydrologic statistics (i.e., flood flows) were assessed for the project reach. Inter-Fluve (2011) reviewed the available data and estimated peak flows using corresponding methods. The available data consisted of peak flow estimates included in the Warm Springs Dam and Lake Sonoma Water Control Manual (WCM: Army Corps of Engineers 1984), and USGS gaging station data on Dry Creek (2 gages with 29 year records of relevant data) and Pena Creek (1 gage with a 12-year record). Table 1 reports the estimates derived from these two data sources. Because the estimates derived from the USGS streamflow data are based on observed streamflow conditions, those estimates have been accepted as the primary flood flow hydrology for the demonstration reach design.

Table 1: Peak discharge estimates for the Enhancement Demonstration Reach between Grape and Crane Creeks (Inter-Fluve 2011).

Flow Event	Discharge (cfs) Source: Extraploted from WCM	Discharge (cfs) Source: Estimated based on the available USGS gage data
1-year	2707	1392
2-year	4127	3795
5-year	6004	8444
10-year	7371	8743
25-year	9302	10152
50-year	10673	11127
100-year	12342	11214

5.2 Flow Duration Statistics

Flow duration statistics for Dry Creek were developed using daily average flow data from the USGS gaging station at Yoakim Bridge (USGS No. 11465200: (1) post-dam (1984-2008), and (2) pre-dam (1960-1983). The curves were developed for annual (January-December) and

winter-only (December-March) time periods. *Figure 10* presents flow-duration curves based on this analysis.

The magnitude and frequency of extreme high and low flows have shifted with regulation by Warm Springs Dam. Figure 10 shows that there were significantly more low flow days prior to construction of the dam. Post-dam flow duration curves for the two gages are similar with a majority of the flows in the 100 cfs range (80% of flows between 70 and 200 cfs below the dam) and no dry periods (Figure 10). The 50% excedence (median) flows at the dam outlet and at Yoakim Bridge for the post-dam period are 105 cfs and 110 cfs, respectively. This flow range corresponds closely with the steady state operational discharge maintained in Dry Creek in late spring, summer and fall.

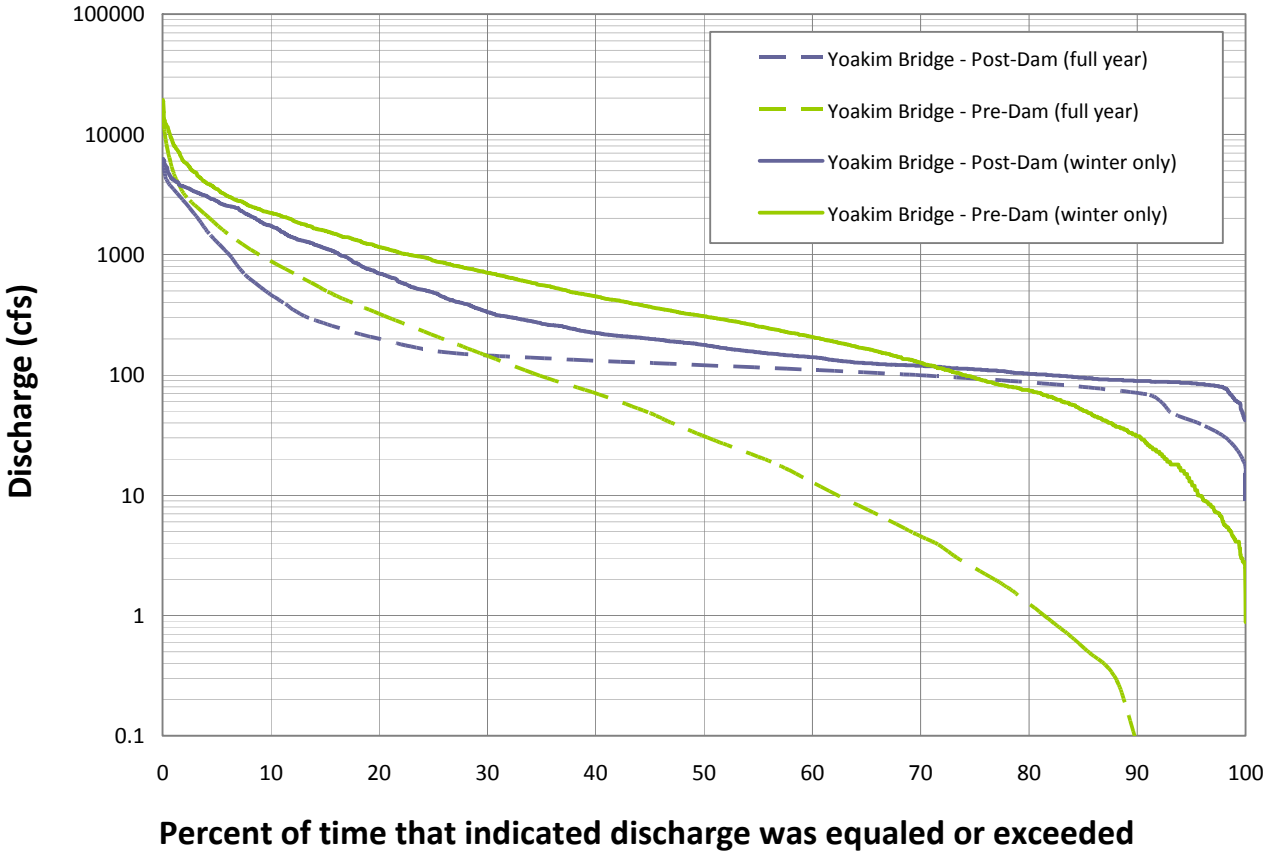


Figure 10: Flow duration curves for annual and winter (December-March) periods for Dry Creek at the USGS gage station at Yoakim Bridge (pre- and post-dam).

6 HYDRAULICS OF DRY CREEK

Existing hydraulic patterns were assessed to develop a baseline understanding of Dry Creek flow patterns through the study reach. The analysis was completed using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 4.1.0). HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program is one-dimensional, meaning that there is no direct modeling of the hydraulic effect of cross section shape changes, bends, and other two- and three-dimensional aspects of flow. The hydraulic model calculates channel and floodplain water velocities, depths and shear stresses for various input flows. The model geometry was developed using bathymetric, topographic and bridge data obtained as part of feasibility study and detailed design phases. The existing conditions model geometry includes 54 cross sections spaced over the 1.1 mile demonstration project reach.

Roughness coefficients (Manning's n values) applied at each model cross section were estimated from field observations, aerial photography and published methods (Arcement & Schneider 1989). Summarized in Table 2, the roughness values utilized fall within the range of values used in the 2006 FEMA study (Federal Emergency Management Agency 2006).

Table 2: Roughness coefficients used in the existing conditions model.

Description	**Manning's n values**
Channel, high roughness (bedrock, vegetation, LWD)	0.054 – 0.1
Channel, low roughness	0.03 – 0.04
Floodplain, heavily vegetated, LWD	0.12
Floodplain, mixed residential/lawns/landscape trees/minor structures	0.1
Floodplain, cleared surfaces and roads	0.04-0.09

The flood events utilized in the model include the 1.01-, 2-, 5-, 10-, 50- and 100-year estimates described above. Also simulated were the approximate steady state operational discharge (105 cfs) and the approximate flow (218 cfs) occurring during the original survey effort (May 2010) for comparison to observed water surface elevations. The simulations were executed for steady state flow conditions.

Model input parameters were adjusted so that simulated water surface elevations within the reach approximately match (+/- 0.04 to 0.7 ft, mean = 0.19 ft) observed water surface elevations measured during the May 2010 survey. Figure 11 shows the simulated water surface profiles under existing conditions for the range of simulated flows.

To examine the spatial patterns of surface water distribution in Dry Creek during the simulated flows for existing conditions, the ArcGIS extension HEC GeoRAS was utilized to prepare inundation maps for selected flow events (Figures 12-17). As can be seen, flow begins to spill out of the existing active channel at roughly the 2-year return period flood. The 100-year return period flow is contained within the creek corridor.

In addition, Inter-Fluve (2011) assessed select sediment transport characteristics of the demonstration reach. The analysis suggests that Dry Creek is capable of mobilizing the surface substrate on riffles in 2-year and 10-year return period floods. In many locations the surface substrate is also marginally mobile in the flow that is exceeded 20% of the time based on the winter flow duration curve, which is a flow that is exceeded relatively frequently and may occur for sustained duration. At the locations where subsurface substrate data were available, the analysis suggests that this material (which is assumed to approximate the actual bed material load during bedload transport events) can be transported at the three flow levels described above. Finally, based on evaluation of three locations within and immediately upstream of the demonstration reach, the effective discharge was estimated to occur in the range of 1000 to 3000 cfs, which is in the approximate 1-year to 2-year return period flood range. See Inter-Fluve 2011 for more detailed discussion.

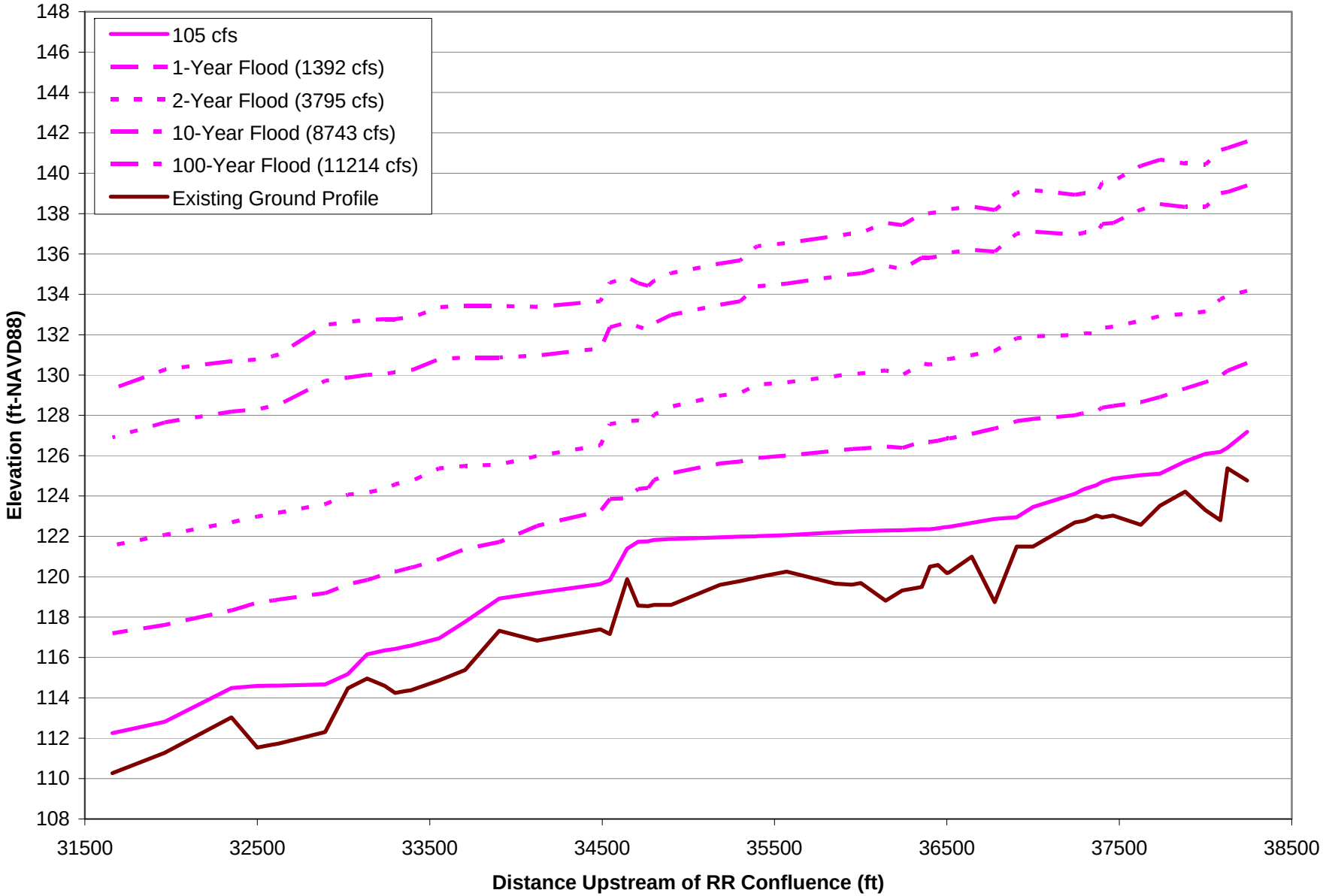


Figure 11. Simulated water surface profiles for existing conditions at base flow and a range of high flow events.

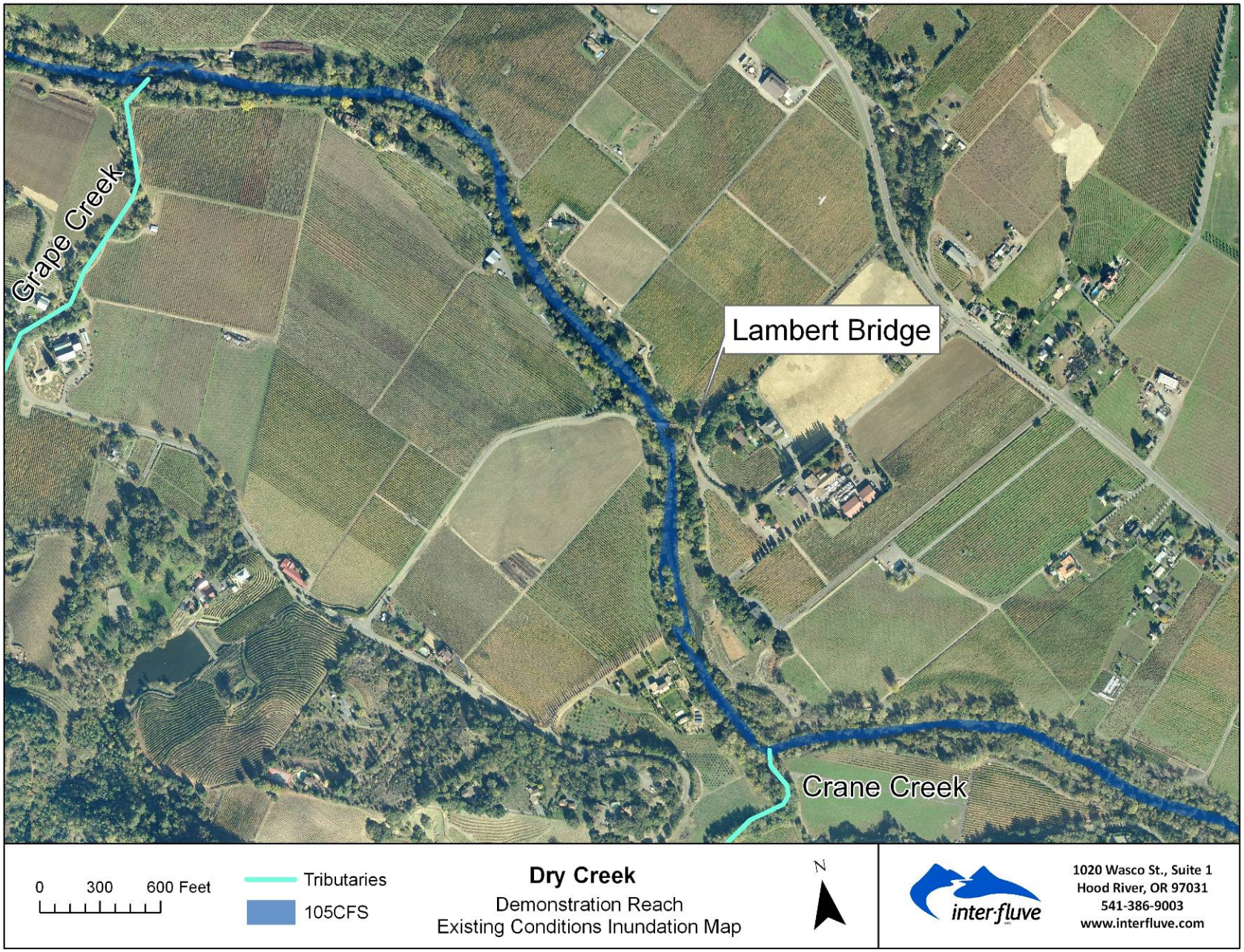


Figure 12. Inundation map based on existing conditions at 105 cfs.

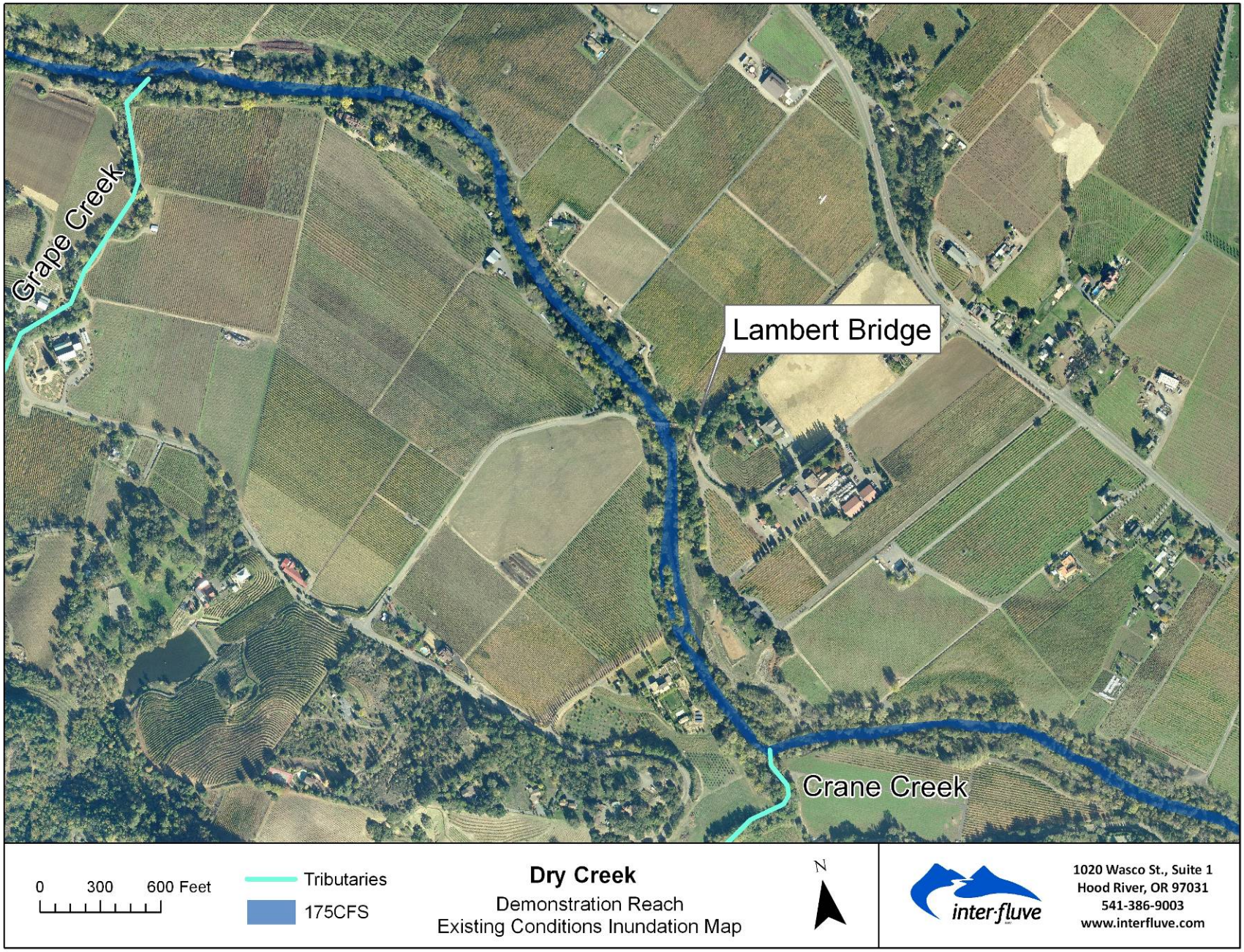


Figure 13. Inundation map based on existing conditions at 175 cfs.

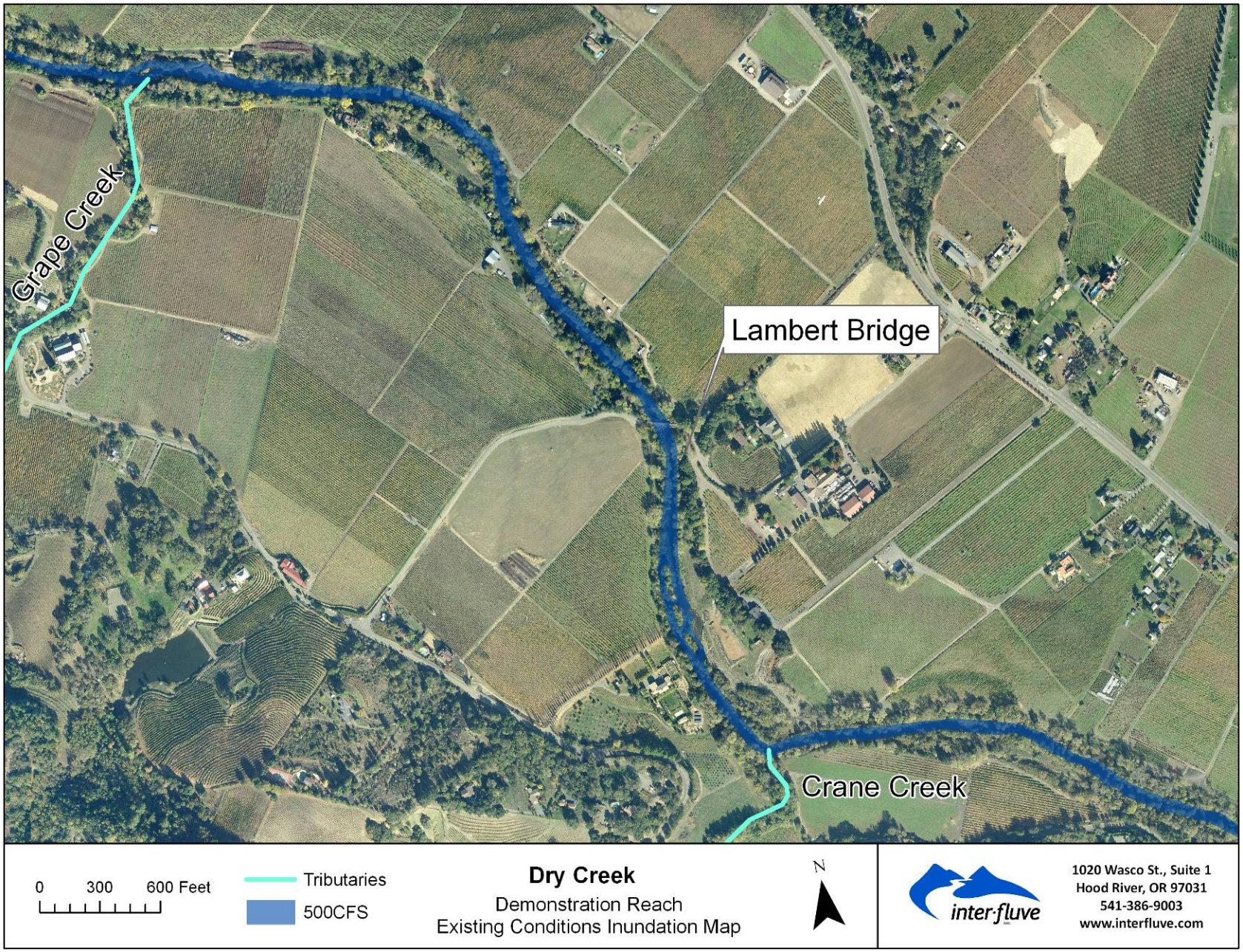


Figure 14. Inundation map based on existing conditions at 500 cfs.

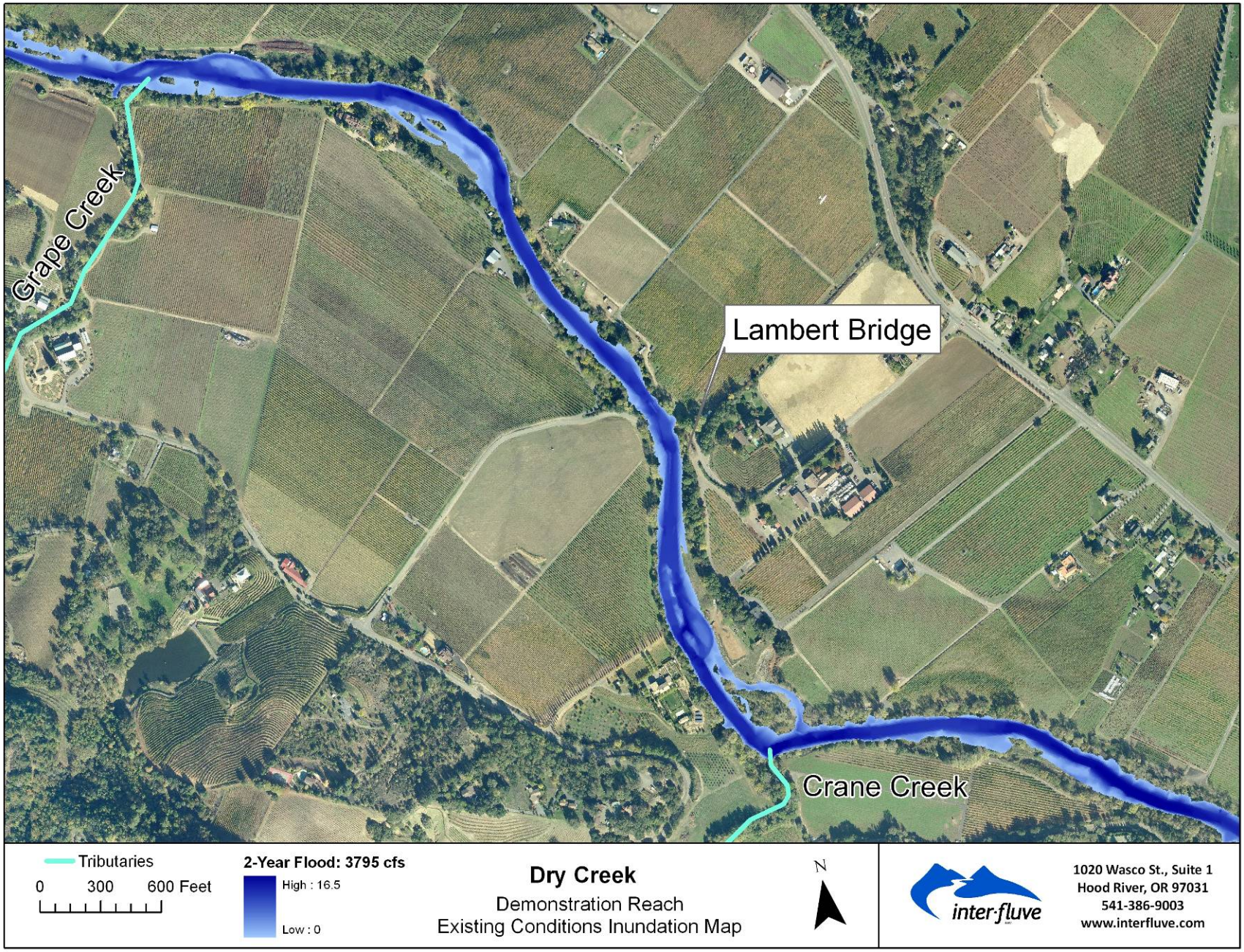


Figure 15. Inundation map based on existing conditions for 2-year return period flood (3795 cfs).

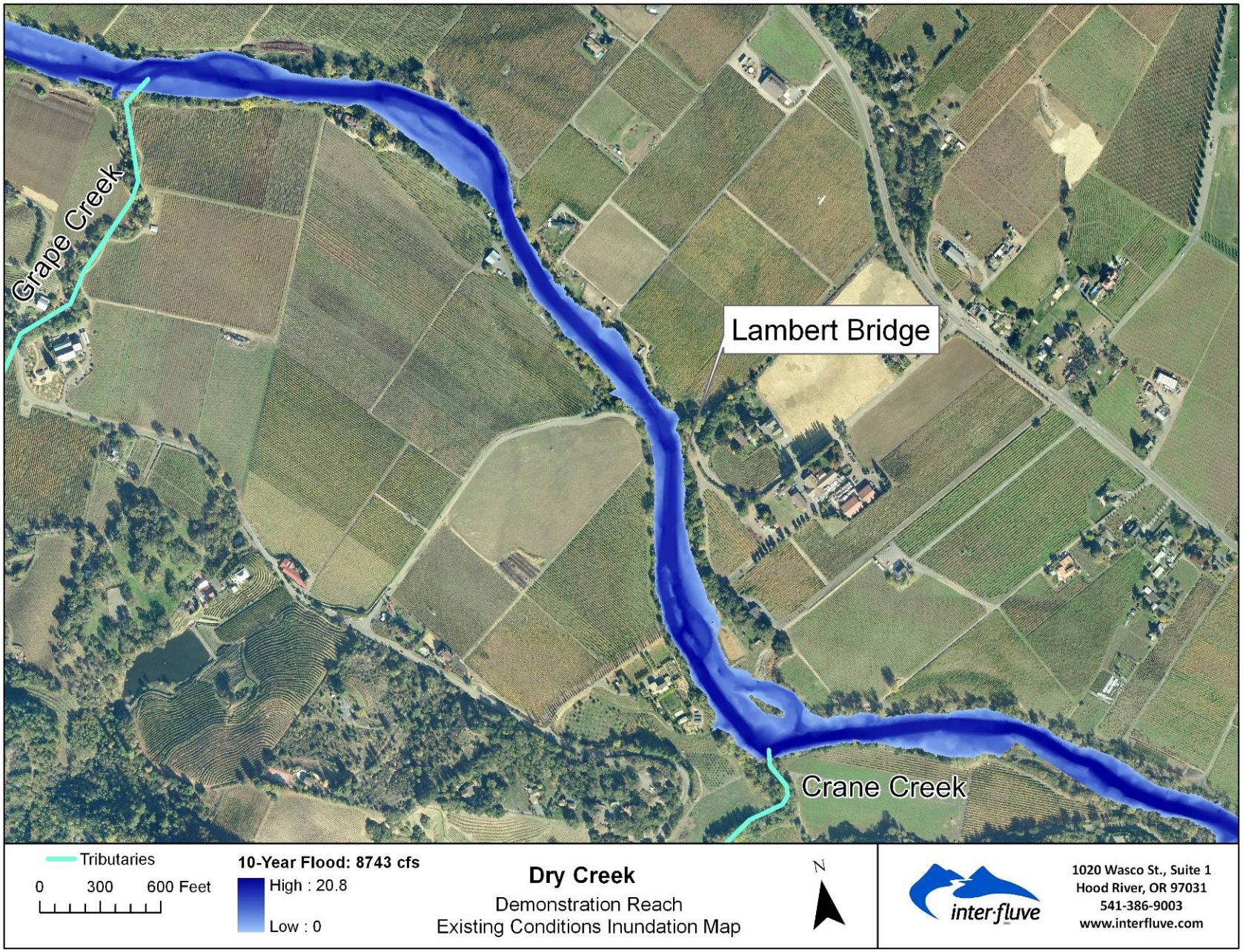


Figure 16. Inundation map based on existing conditions for 10-year return period flood (8743 cfs).

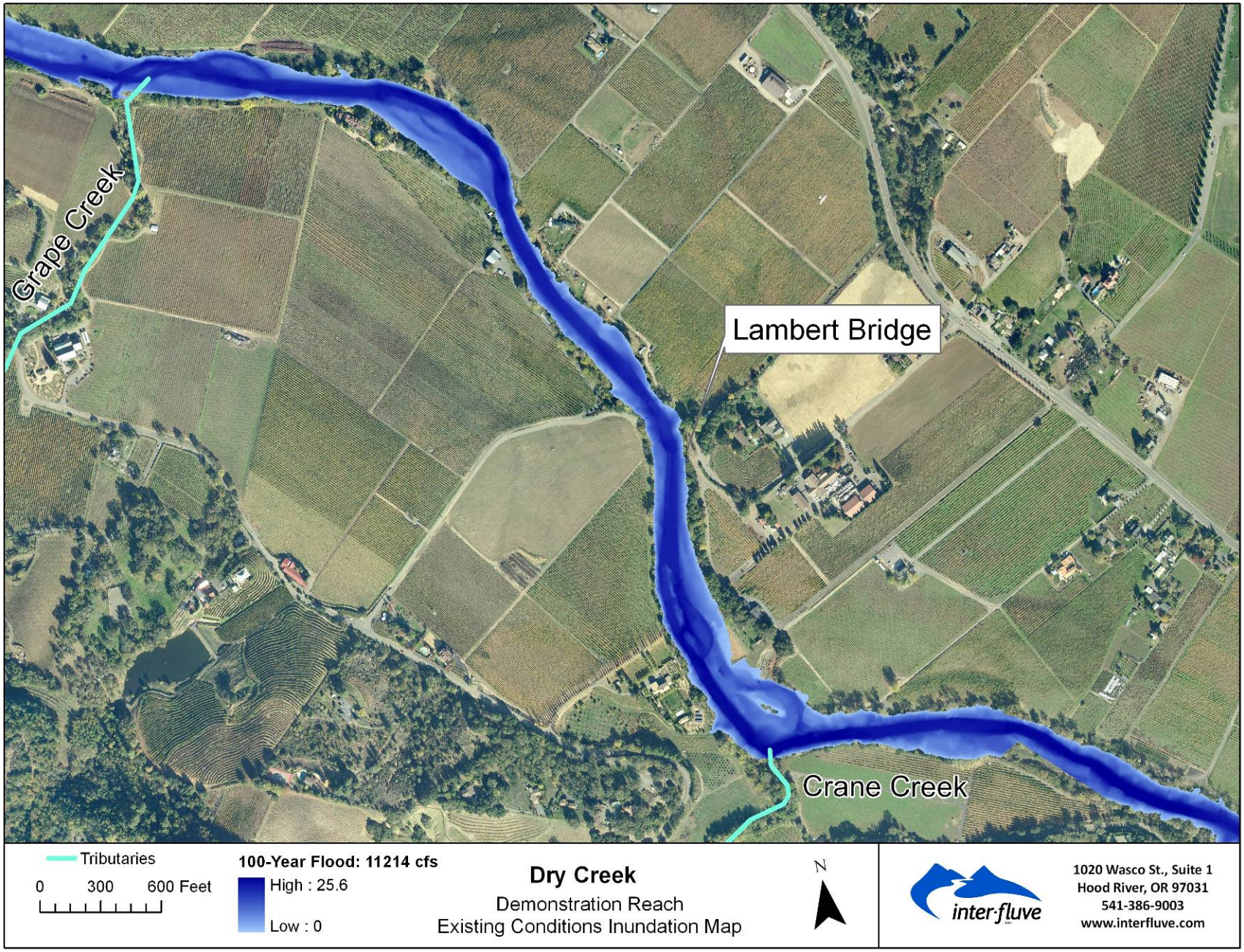


Figure 17. Inundation map based on existing conditions for 100-year return period flood (11214 cfs).

7 DEMONSTRATION PROJECTS GOALS, OBJECTIVES AND DESIGN CRITERIA

The goals and objectives for the Demonstration Reach enhancements include the following:

- Maximize the general ecological lift to the reach to the extent practicable within the current geomorphic and hydraulic function of the stream,
- Increase the availability of high quality summer rearing and winter refugia habitat for salmonids (specifically Coho and steelhead), given the current physical function of the system,
- Stabilize areas of problem erosion using techniques that also enhance habitat conditions for fish, and
- Demonstrate enhancement techniques that may be utilized elsewhere in Dry Creek in order to meet the habitat requirements of the Biological Opinion.

The RRBO lays out criteria which define high quality rearing habitat conditions for coho salmon and steelhead trout. These criteria were combined with additional considerations to constitute the design criteria for the project, summarized in Table 3. Although the RRBO is a 15 year guiding document, NMFS and CDFG will likely require the Water Agency to maintain functioning coho and steelhead habitat beyond this time frame. It is anticipated that the habitat enhancements will continue to provide habitat benefits and be maintained in approximately similar quantities for 25 years. The Water Agency, NMFS, and CDFG are engaged in an adaptive management planning process that will specify goals, objectives, and monitoring methods to verify the effectiveness and longevity of habitat enhancements (Wieckowski et al. 2010).

Table 3. Demonstration Project Design Criteria

Feature/Issue	Criteria	Remarks/Reference
Fish Habitat Design Criteria		
a. Target flow range	• 110 to 175 cfs	• Flow range outlined in RRBO
b. Pool Abundance	• 33% to 67% of all habitats	• RRBO
c. Pool:riffle ratio	• 1:2 to 2:1	• RRBO
d. Water depth	• 2 to 4 feet in pools	• RRBO
e. Velocity in rearing habitat	• < 0.2 ft/s • Reduced from present conditions to extent practicable	• RRBO • Primarily able to be met in off-channel habitats and shelter habitats associated with large woody debris • Local velocities in mainstem pool habitat
f. Cover	• >30% of habitat bottom obscured by cover	• RRBO • due to depth, surface turbulence, or presence of structures such as logs, debris piles, boulders, or overhanging banks and vegetation
g. Refugia habitat	• Should provide high quality shelter during high flow releases	• RRBO
h. Longevity of habitat	• 25 years in approximately similar quantities though adjustments will occur	• Water Agency
Large Woody Debris Stability		
i. Mobility of LWD	• 25 year event	• In most cases, stability requirements similar between Q2 and Q100-year events.
j. LWD Decay	• 15-25 year period	• Typical decay rates for coniferous species
Vertical Stability		
k. Design stability for riffles	• 25 year event	• In most cases, design substrate sizing is similar

Table 3. Demonstration Project Design Criteria

Feature/Issue	Criteria	Remarks/Reference
		between Q2 and Q100 events
Lateral Stability		
l. Stream boundaries constructed inside the channel corridor	• 5 year event	• Relatively deformable boundary construction
m. Stream boundaries constructed along margin of the channel corridor	• 50-year event	• Less deformable boundary construction
n. Stream boundary construction techniques	• Employ techniques that also provide margin shelter and riparian habitat	• Biotechnical techniques
Planform Stability		
o. Avulsion into off-channel habitat	• None within first 5 years following construction, notwithstanding extraordinary hydrologic events • Future avulsion is acceptable provided habitat criteria continue to be met	• Address risk of avulsion through design overbank roughness created with LWD
Riparian Vegetation		
p. Invasive species	• Endeavor to eliminate invasive vegetation	
q. Native revegetation	• Encourage diverse, less dense native community	
Construction Period		
r. Impacts to existing resources	• Minimal	
s. Impacts to adjacent operations	• Minimal	
t. Impacts to infrastructure	• None	

8 DEMONSTRATION PROJECTS ENHANCEMENT DESIGN

8.1 Enhancement Approaches

Enhancements in the Demonstration Reach will emphasize natural stream characteristics, or those which evolve through a given stream's geomorphology. By using enhancement practices that emulate natural geomorphic effects, the benefits provided to juvenile coho and steelhead will be optimized by increasing the amount of high quality rearing habitat. Because these approaches occur within a dynamic system, they should not be expected to be static through time. However, they should provide approximately similar quantities of habitat through time within the project reach, and the planned adaptive management approach will assist with this. The following paragraphs describe the primary enhancement approaches planned for the Demonstration Reach. Drawings representing each of these approaches are included in the 60% complete construction drawings included in Appendix A.

Backwater Channels & Ponds

Backwater channels, alcoves and ponds are areas off to the side of the stream that in summer connect to the main stream only at their downstream end. During this time, water backs into these areas, and has very low or no current. In addition to still water, logs that protrude into or float on the water, floating and submerged vegetation, and surrounding tall vegetation make these areas very attractive to juvenile fish. They use these areas to search for food, rest and to avoid predators. During winter periods, these areas will continue to have quiet water despite occasional high flows moving through them. This type of habitat provides the greatest opportunity in the Demonstration Reach to meet the target velocity criteria specified in the RRBO (Inter-Fluve 2011).

In the Demonstration Reach, this type of habitat is proposed in four areas, two each upstream and downstream of Lambert Bridge (Sheet 4 in Appendix A). Construction of these areas will entail excavation to achieve desired grades relative to the summer water surface elevation, and include placement of logs at appropriate locations, planting of aquatic vegetation and management of surrounding vegetation. The initial bottom grades for these areas have been set at 4 feet below the summer water surface elevation for the 60% design.

Based on repeat observations of backwater habitats in Dry Creek and assessment of the response of these habitats to high flow events, and monitoring of constructed side channels on other streams, Inter-Fluve (2011) developed guidelines to inform design of this habitat type on Dry Creek (Table 4). The primary challenges to the longevity of constructed backwater habitats are nuisance sedimentation and downstream changes in the main channel affecting the hydraulic control for the backwater habitat. Of the backwater channels reviewed on Dry Creek to date, those whose upstream ends were located a moderate distance from the active channel, and/or with a section of hydraulically rough floodplain between the upstream channel and the habitat were substantially less affected. These considerations will promote the longevity of the constructed habitat. Nevertheless, some degree of sedimentation in these areas may be unavoidable, and this issue should be tracked through the adaptive management program.

Table 4. Considerations for design of backwater channels on Dry Creek, based on field observations of similar habitats on Dry Creek, and observations of constructed side channel evolution on other project sites.

Consideration	Relevant Failure Mode
Outlets should not be located in depositional zones (e.g., riffles)	Nuisance sedimentation
Moderate distance from the active channel at the upstream end, and/or	Nuisance sedimentation
Hydraulically rough zone between active channel and upstream end	Nuisance sedimentation
A robust control on channel grade should be located downstream of the outlet (e.g., riffle)	Abandonment by loss of hydraulic control.

Substantial volumes of large woody debris will be installed in the backwater habitats. These installations will be overtopped by the full range of flood flows. In order to remain in the demonstration reach over a prolonged period to continue to provide habitat value, the large woody debris must either be large enough that it cannot be transported by the stream, or be ballasted to prevent its mobilization. Because it is not realistic to supply the size of large woody debris that would be self-stable in the reach (i.e., old growth logs), the large woody debris installed in Dry Creek will be ballasted to emulate the stability characteristics of much larger logs. Large woody debris will be ballasted through a range of techniques which will include partial burial, and cabling to other logs, existing mature trees, timber piles, snags, and/or boulders. Typical sections and details are included on the drawings (Sheets 35 to 40 in Appendix A), though it will be necessary to conform these typical approaches to the specifics of each installation location in real time during construction.

Riffle Construction

Riffles are areas where the streambed is steeper and the current is swift. Riffles play a key role in controlling the elevation of the streambed and releasing the stream's energy so that the current flowing through adjoining pools is slower during the summer period. They are also important for food production. Riffle habitat was found to be relatively lacking during the 2009 habitat inventory, which leads to long flatwater and pool habitat units with swifter than desired velocities and that lack complexity (Inter-Fluve 2010). Riffle habitat is lacking because Dry Creek has evolved to a condition where it is very efficient at transporting the sediment that is supplied to the stream downstream of WSD (Inter-Fluve 2011).

Construction of riffles in the Demonstration Reach is proposed in seven locations to provide key grade control for constructed backwater habitats and to improve the quality of the adjoining pools for fish (Sheet 4 in Appendix A). The riffles are designed to backwater the adjacent upstream pool in the summer operational discharge range, which will flatten the water surface through the pool and lead to reduced stream velocity. Although the riffles will reduce stream velocity through the existing pools, the primary locations in these habitats where the target velocity criteria specified in the RRBO will be met will be in shelter habitats associated with large woody debris and along the channel margins.

Riffles are constructed with a well-mixed layer of small boulders, cobbles, gravel and sand across the stream, and will entail excavation of portions of the existing streambed to prepare suitable subgrade conditions. The seven riffles planned for construction fall into two groups based on the anticipated hydraulic stresses applied to them following construction. Two of the

riffles (stations 32+590 and 34+990) are located in relatively more confined locations upstream of grade breaks in the stream, and consequently are estimated to be subjected to higher shear stresses during floods than the other five locations. Therefore, two riffle substrate gradations have been designed, with Type A applied to the higher shear stress locations and Type B applied to the remaining locations (Table 5). Riffle construction will include measures to prevent flanking.

Table 5: Constructed riffle substrate gradations.

Riffle Substrate Type	**A**		**B**	
Riffle Locations	**32+590, 34+990**		**All other locations**	
% Passing	**Median Diameter (in)**		**Median Diameter (in)**	
Weight Basis	**Min**	**Max**	**Min**	**Max**
100	14	16	6	8
84	11	13	5	7
50	9	10	4	5
16	1.8	2.0	0.8	0.9
5	0.3	0.4	0.1	0.2

Pool Enhancement

Pools are deeper areas of the stream which in a healthy stream provide key habitat for young fish because currents are slow, the flow patterns are diverse, and fish can hide beneath logs that project into the water. Proposed pool enhancement in the Demonstration Reach will act to increase the complexity and diversity of habitat for young fish, and create areas that have sheltered currents that young fish prefer. This will be accomplished with selected grading of existing pool features and the installation of large woody debris along the pool margins. Additionally, as described above, pool velocities will be reduced due to riffle construction.

Many of the pool enhancement locations are in relatively confined stream segments or next to tall banks leading from the stream up to the vineyard grade. In these locations, the large woody debris installations will be constructed tight to the banks to limit potential for flanking around the installations and damaging the banks. These installations will be overtopped by the full range of flood flows. Similar to the description above for large woody debris in backwater habitats, large woody debris will be ballasted through a range of techniques to enhance its longevity in the reach. Typical sections and details are included on the drawings (Sheets 35 to 40 in Appendix A), though it will be necessary to conform these typical approaches to the specifics of each installation location in real time during construction.

Log Jams

A log jam is an accumulation of logs that may be constructed in an area where it would be beneficial to initiate or stabilize the planform of the channel. The log jam serves to anchor the planform by being an immobile object along the streambank, acting similar to a bridge abutment or a natural bedrock outcrop. Deep pools may form next to the log jams through the interaction of the logs and flowing water, creating excellent fish habitat. To create a log jam, the area is excavated and then logs are stacked and knit together with boulders and “snags” (emulating

trunks of dead trees that remain standing vertical to the horizon). This combination stabilizes the log jam during large floods.

Similar to the descriptions above for large woody debris in backwater and pool habitats, large woody debris in log jams will be ballasted through a range of techniques to enhance its longevity in the reach. Typical sections and details are included on the drawings (Sheets 37 to 39 in Appendix A), though it will be necessary to conform these typical approaches to the specifics of each installation location in real time during construction.

Streambank Construction

Streambank Construction is proposed in multiple locations for varying objectives. Based on these characteristics, streambank construction techniques are divided into four categories. These are described below:

- Type 1 Bank – This bank construction technique is planned in multiple locations throughout the reach (Sheets 19 to 21 in Appendix A). These locations are characterized by low shear stress, but bank side slope that is steeper than 3 horizontal to 1 vertical. The construction technique includes grading, surface preparation, seeding, installation of coir biodegradable fabrics, and planting with riparian species. This approach will guard against erosion from streamflow and rill erosion due to direct rainfall,
- Type 2 Bank – This bank construction technique is planned at one location in the demonstration reach (Stations 334+25 to 336+30; Sheet 19 in Appendix A) where the planform will be adjusted within the larger channel corridor. This is a deformable bank boundary construction approach that consists of two or more layers of fabric encapsulated soil (FES) lifts. This technique involves wrapping soil and gravel materials in a double layer of biodegradable coir fabric, with live cuttings placed between the FES lifts. Over time, the fabric will degrade and established vegetation will provide the primary strength to the streambank.
- Type 3 Bank - This technique is planned at one location (Stations 333+50 to 337+25; Sheets 19 in Appendix A) to limit the creek from migrating into a high terrace along the channel corridor margin. With this approach, eroding materials will be excavated and the streambank will be rebuilt with a combination of logs, boulders, cobbles and soil. The area is then planted with native riparian vegetation. This forms a less deformable streambank which still provides habitat value. Large woody debris and rootwads protrude from the bank at elevations that are underwater during the summer period, providing shelter locations along the bank.
- Type 4 Bank - This technique is planned at one location (Stations 360+00 to 365+75; Sheets 21 in Appendix A) to limit the creek from migrating into a high terrace along the channel corridor margin and to stabilize a high eroding bank. Similar to the Type 3 approach, the eroding materials will be excavated and the streambank will be rebuilt with a combination of logs, boulders, cobbles and soil. The area is then planted with native riparian vegetation. The base of the streambank will be rebuilt using a log crib technique up to an elevation that matches the overbank elevation on the opposite side of the stream. The upper part of the streambank will be rebuilt with FES lifts as described for Type 2 Bank above. Native plants are seeded and planted in the upper bank. Large woody debris and rootwads protrude from the bank at elevations that are underwater during the summer period, providing shelter locations along the bank.

Riparian Vegetation Management

In general, the vegetation within the project area does not display the range of different successional classes indicative of a dynamic, properly functioning riparian system. Plant communities within intact riparian systems typically consist of a variety of vegetation communities that represent a range of different age classes and structural types. This pattern is largely a function of active floodplain evolution which is currently suppressed in the project reach.

Although there are small swaths of emergent wetland and shrub/scrub habitats within the project reach, the majority of the riparian community is comprised of mixed hardwood forest with differing levels of canopy closure and understory diversity. These hardwood forests are interspersed with areas that have been heavily impacted by human disturbance and are dominated by invasive species. Invasive species are found throughout the project area in varying densities. Dominant invasive species include Himalayan blackberry, English Ivy, thistle, periwinkle, and domestic grapes. Invasive densities range from small patches of individual species to large swaths of riparian area dominated solely by a single invasive species, typically Himalayan blackberry.

In order to increase plant species diversity, structural complexity, and overall habitat values, the riparian vegetation management plan will include the suppression and eradication of invasive species and planting of native vegetation. The area planned for riparian vegetation management is shown on Sheets 41 to 44 in Appendix A. A preliminary palette of native plants to be used in revegetation activities has been developed in consultation with the Sonoma County Stream Maintenance Program Manual (Horizon Water and Environment 2009), and is included on Sheet 45 in Appendix A.

When practicable, the proposed backwater habitats have been designed to support a wide range of plant species that vary along an elevation and hydrologic regime gradient. The goal for these areas is to maximize plant species diversity and provide vegetation and habitat types that are currently lacking in the project reach. The backwatered areas will support a vegetation gradient that transitions from emergent wetland aquatics and herbaceous wetland plants to a shrub/scrub plant community that will vegetate the interface between the wet and dry areas. The upper drier slopes will be planted with species that will mature into a multi-tiered, open canopy riparian forest.

Invasive species control methods will be further refined as the design progresses. The primary treatment focus will likely be restoration of areas that are so dominated by invasive species that almost all native species have been displaced and will not be able to re-colonize within the near future unless remedial actions are taken. Himalayan blackberry is the primary species responsible for this condition. In these areas, intensive chemical and mechanical land clearing treatments will be undertaken prior to the installation of a native plant community. Plant community types to be installed within these areas will depend on the existing communities adjacent to the treatment areas. A secondary, more labor intensive strategy will be the selected removal of invasive species from the understory. This type of invasive control is often more labor intensive due to hand removal methods that must be used in order to prevent damage to existing native plants.

Irrigation has been proven to increase the survival rates of newly planted vegetation and increase project success. The most cost effective method to irrigate enhancement areas is the installation of a temporary, above-ground irrigation system in locations where these provisions are unlikely to be destroyed by flood flows. These systems consist of PVC pipe laid in a grid throughout the enhancement area with simple impact sprinklers mounted on 3'-4' high risers. These systems can run on battery operated solenoid timers when plugged into an existing pressurized water source or from a single pump for well or direct withdrawal from surface waters. Alternate methods may be required in locations with frequent, swift overbank flows. Plants would be watered a total of 1" per week, preferably in a single watering depending on slope and soil characteristics. Irrigation would occur between the months of June and September for the first two years following plant installation.

8.2 Hydraulics of the 60% Complete Enhancement Design

The existing conditions HEC-RAS model (Section 6) was modified to simulate the future hydraulic conditions in the enhanced channel based on the 60% complete design. The 'design' hydraulic model was utilized to provide input into the preliminary design of stream channel bed and bank designs, to estimate the increased area of rearing habitat, and for assessment of the impact of the project on flood water surface profile elevations through the project reach. As with the existing conditions model, water surface profiles and inundation maps were produced for selected flows for the proposed enhancement design. It should be noted that the model results reported below are based on the 60% complete design. Predicted hydraulic conditions can be expected to be revised with ongoing design development in the coming months.

Figure 19 compares the predicted water surface profiles for selected flows for both existing and proposed conditions. At 105 and 175 cfs, the addition of rifles to the reach appears to achieve the goal of flattening the water surface (thereby reducing velocities) in the reach immediately upstream. Flood water surface profiles are similar between existing and proposed conditions, though slight increases are predicted in select locations, primarily in areas adjacent to proposed riffle construction. For the 100-year return period flood, increases in the water surface profile range from 0 to 1.0 feet, though the flood waters are still predicted to be contained in the creek corridor and within the project footprint. Though the design will be refined further in the coming months, Sonoma County requirements for documentation of predicted increases in the FEMA base flood profile should be reviewed at this time.

Simulated channel shear stresses through the project reach range from 0.2 to 2.0 lb/ft^2 at the 2-year return period flood discharge and from 0.3 to 2.9 lb/ft^2 at the 100-year discharge. The highest predicted values of shear stress are in the area of Lambert Bridge, where the flow is constricted and the channel bed drops over a bedrock outcrop. In general, predicted shear stresses are lower for the proposed case than the existing case, except in the vicinity of the proposed riffles, where increases are predicted.

Simulated flood inundation based on the proposed design are shown (Figures 20 to 25) to illustrate the effect of the project on the spatial pattern of surface water connection in Dry Creek following implementation. As compared to existing conditions, the area of inundation increases substantially at low to moderate discharge events (105 cfs up to the 2-year event), but is comparable at and above the 10-year flood event.

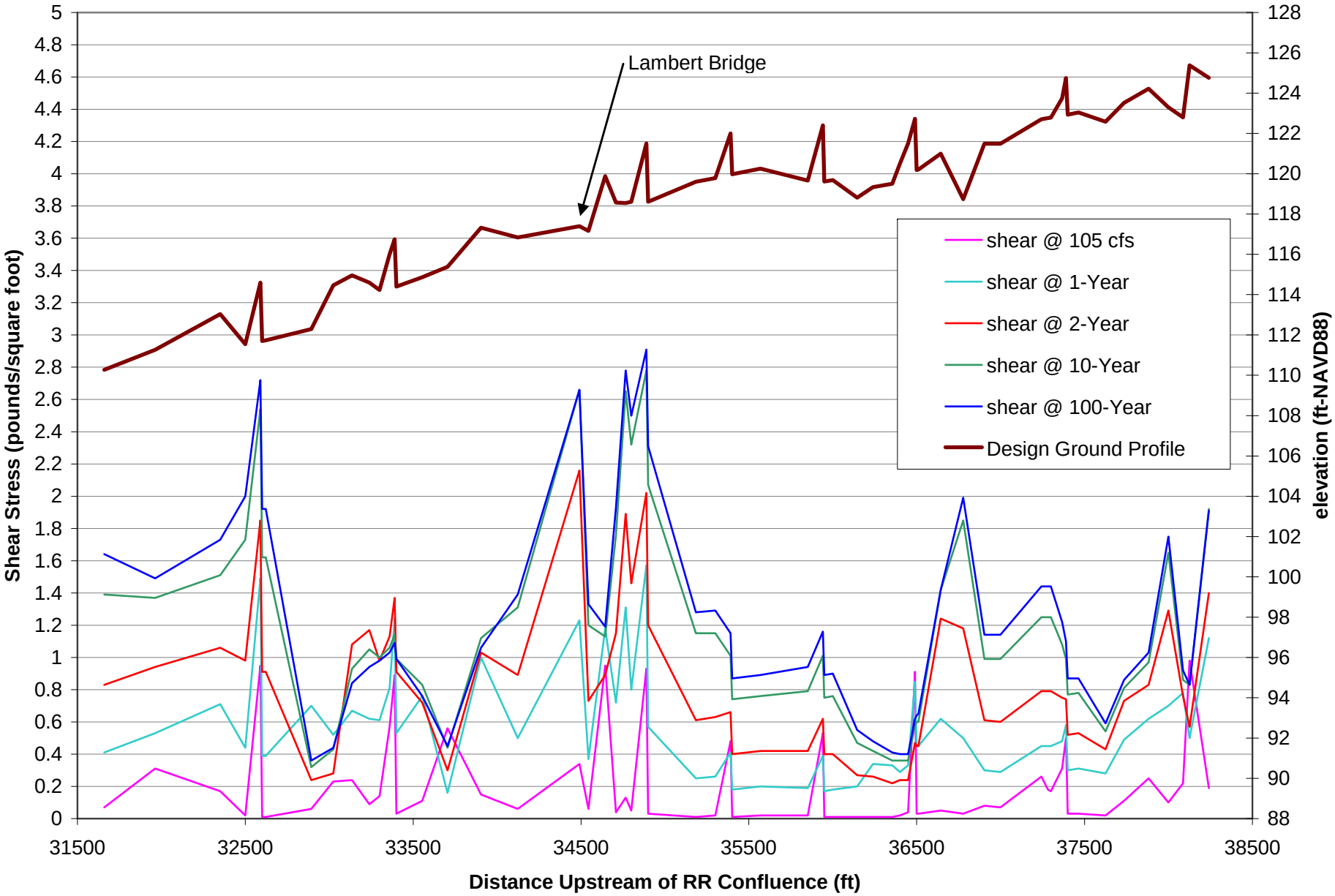


Figure 18. Simulated shear stress values associated with the proposed design for the Demonstration Reach.

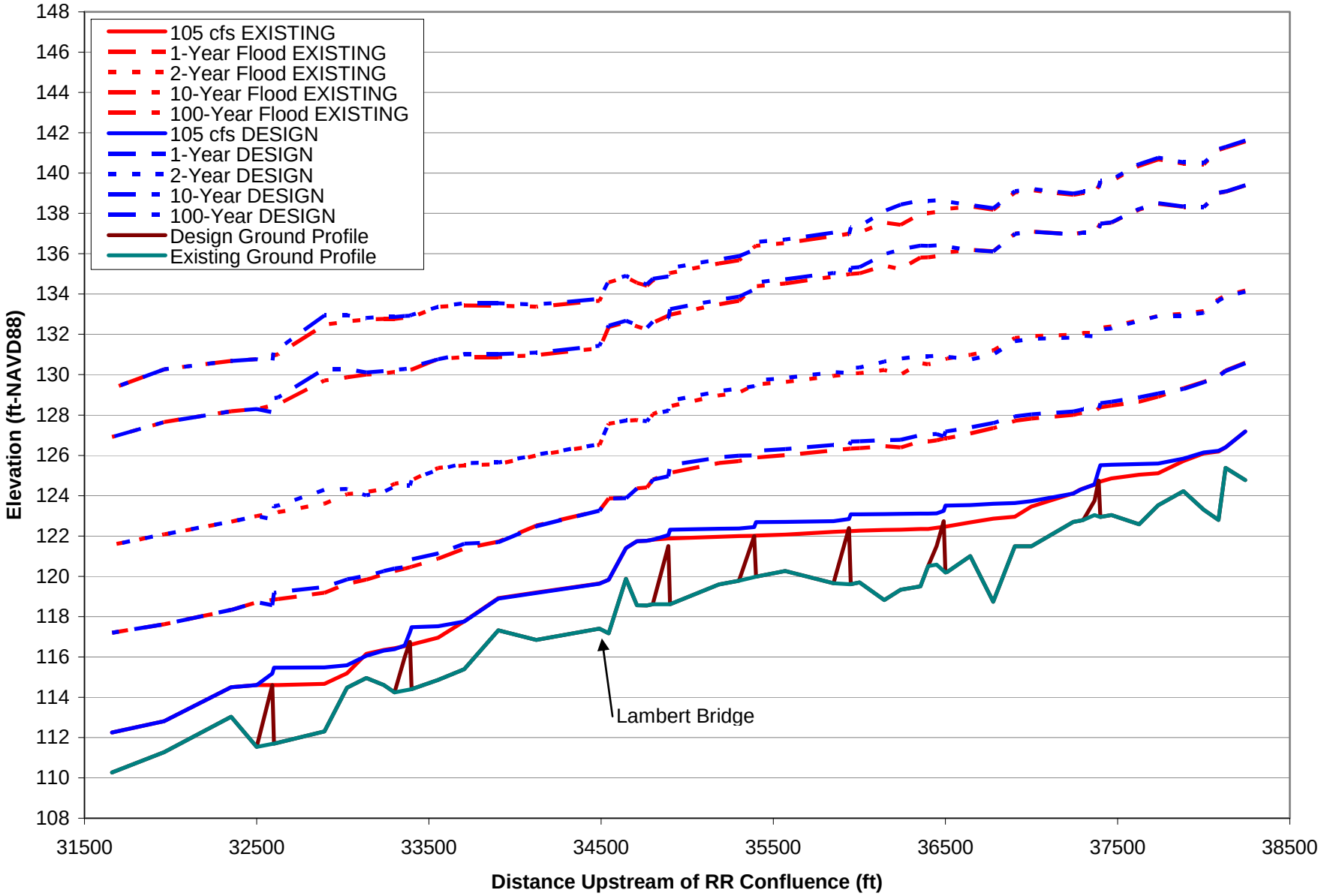


Figure 19. Simulated flood water surface profiles for existing conditions (red) and proposed conditions (blue) associated with the proposed design for the Demonstration Reach.

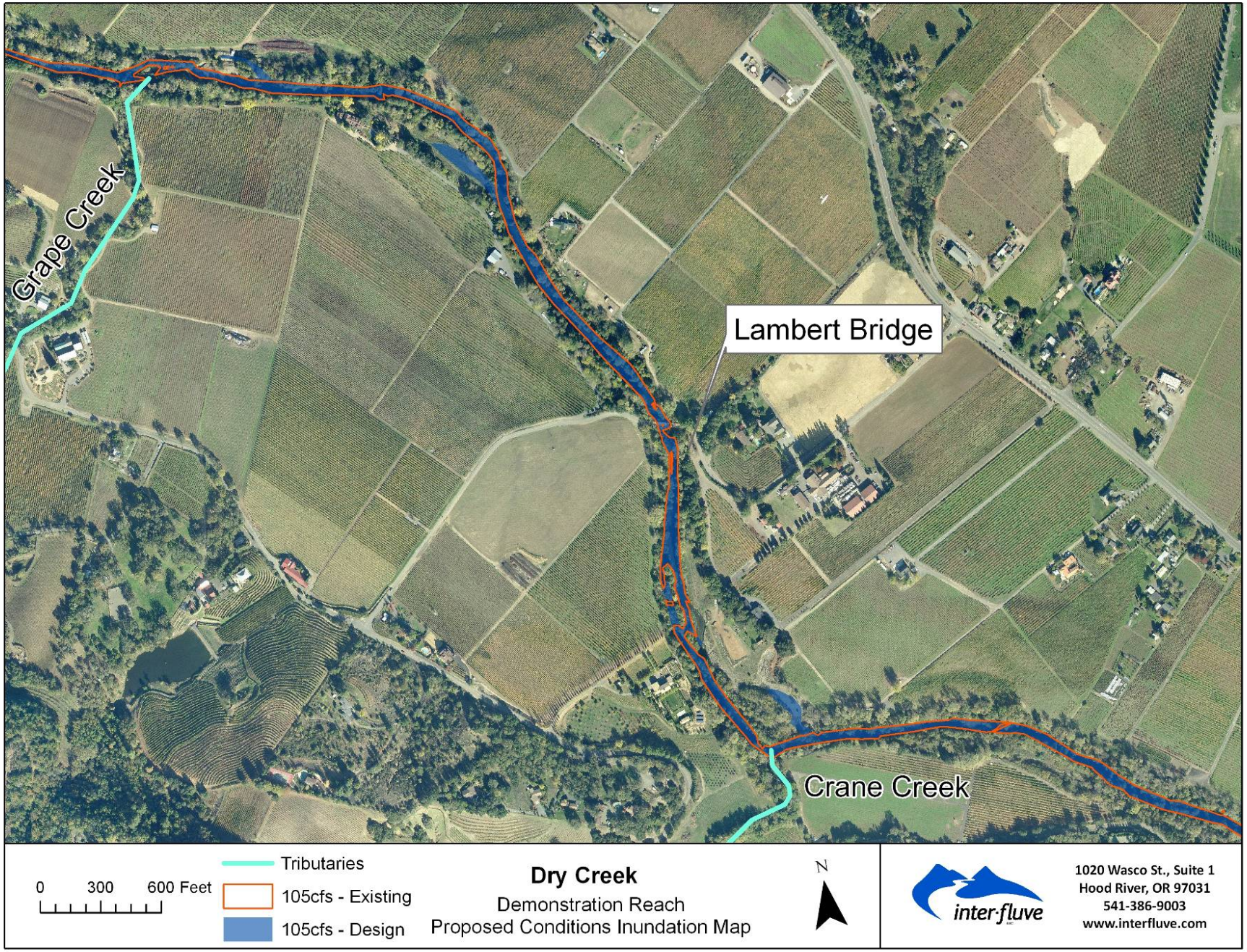


Figure 20. Inundation map based on design conditions at 105 cfs.

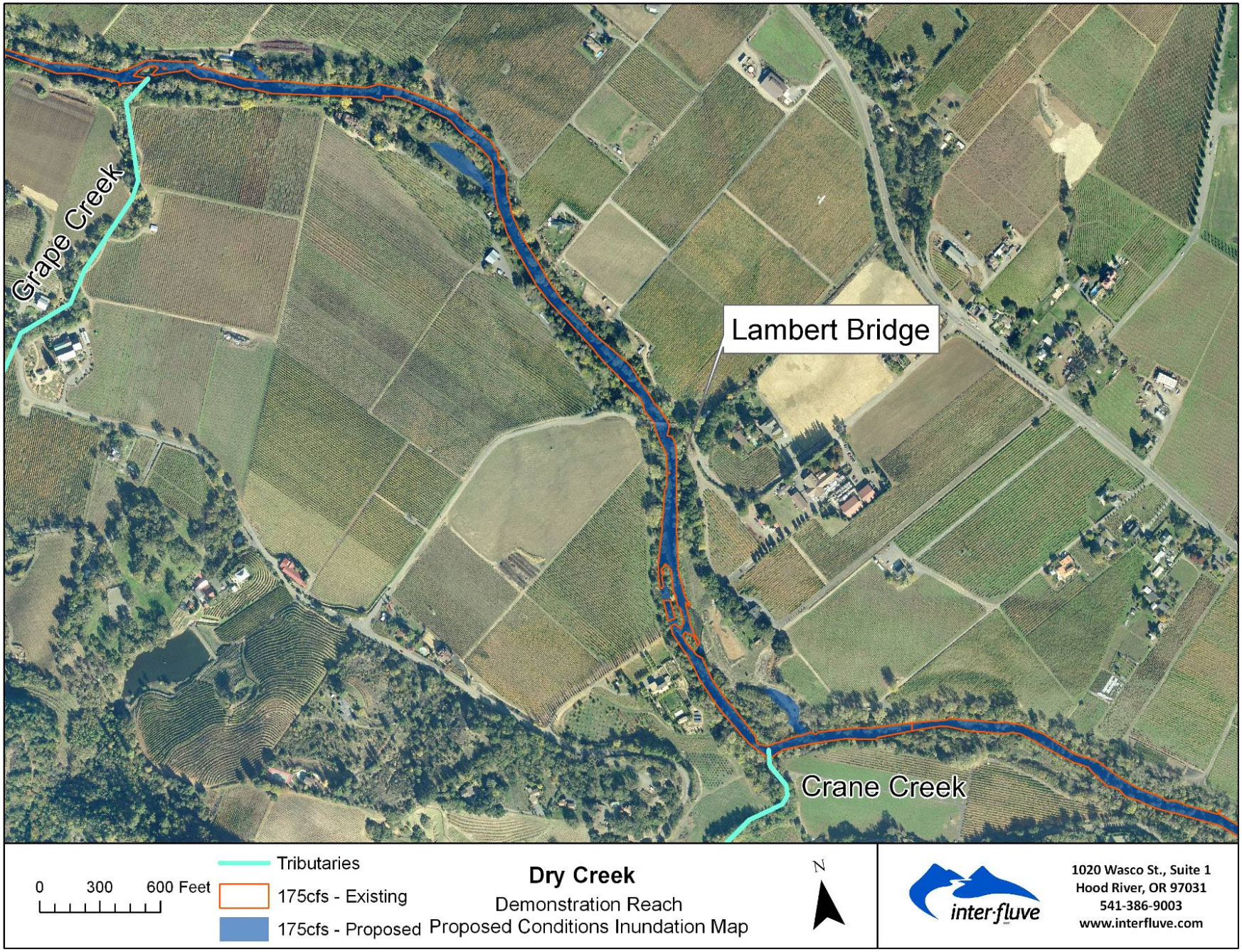


Figure 21. Inundation map based on design conditions at 175 cfs.

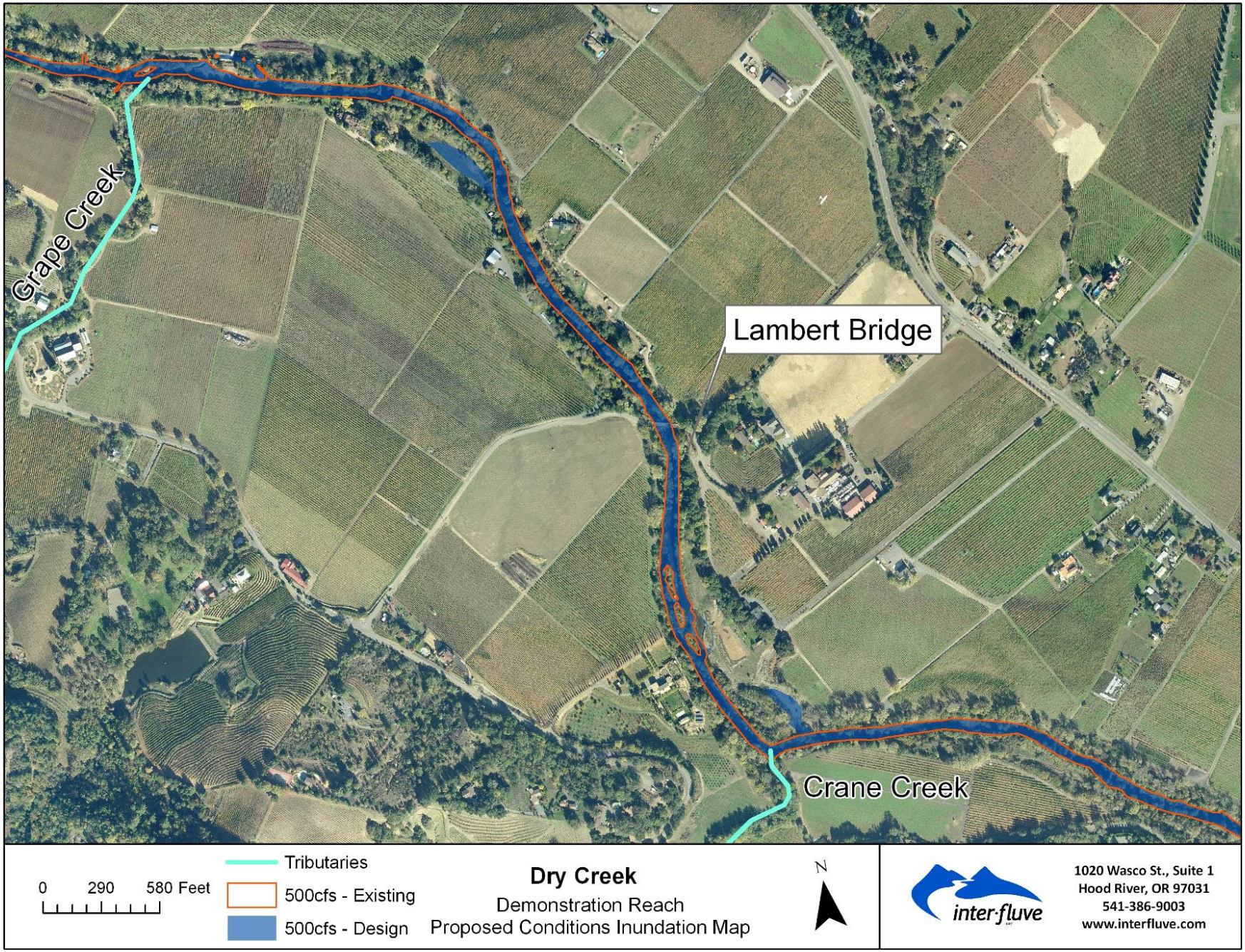


Figure 22. Inundation map based on design conditions at 500 cfs.

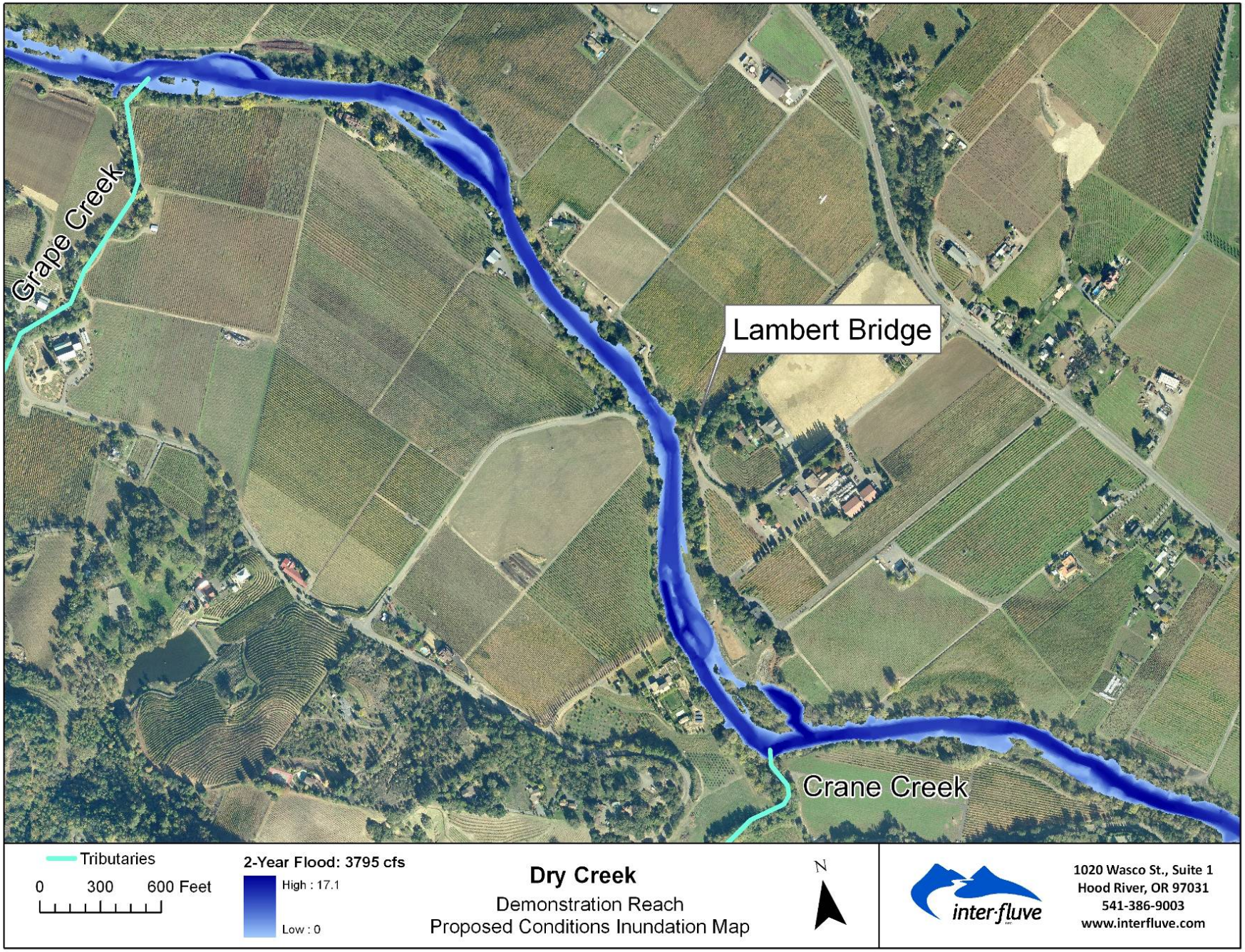


Figure 23. Inundation map based on design conditions for 2-year return period flood (3795 cfs).

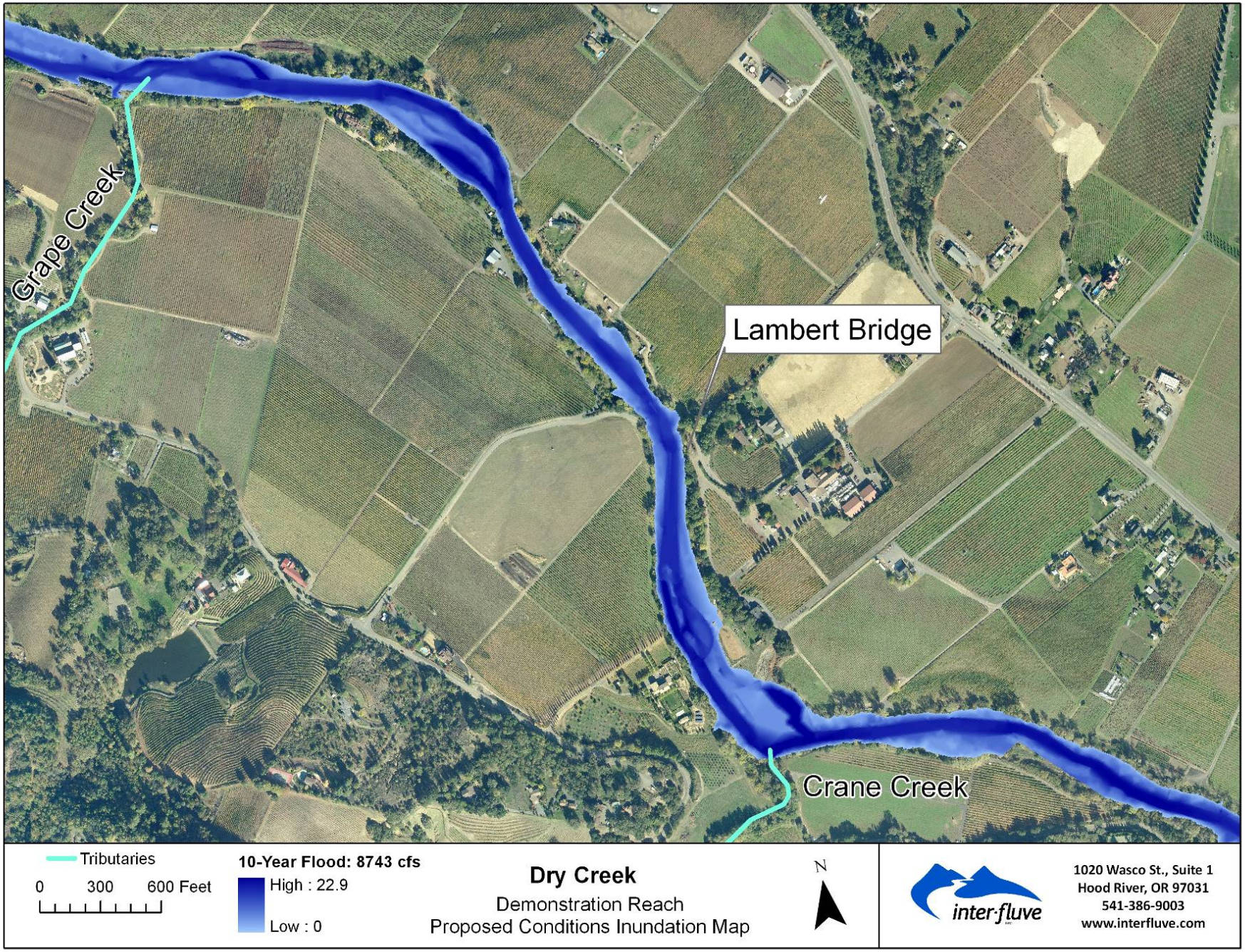


Figure 24. Inundation map based on design conditions for 10-year return period flood (8743 cfs).

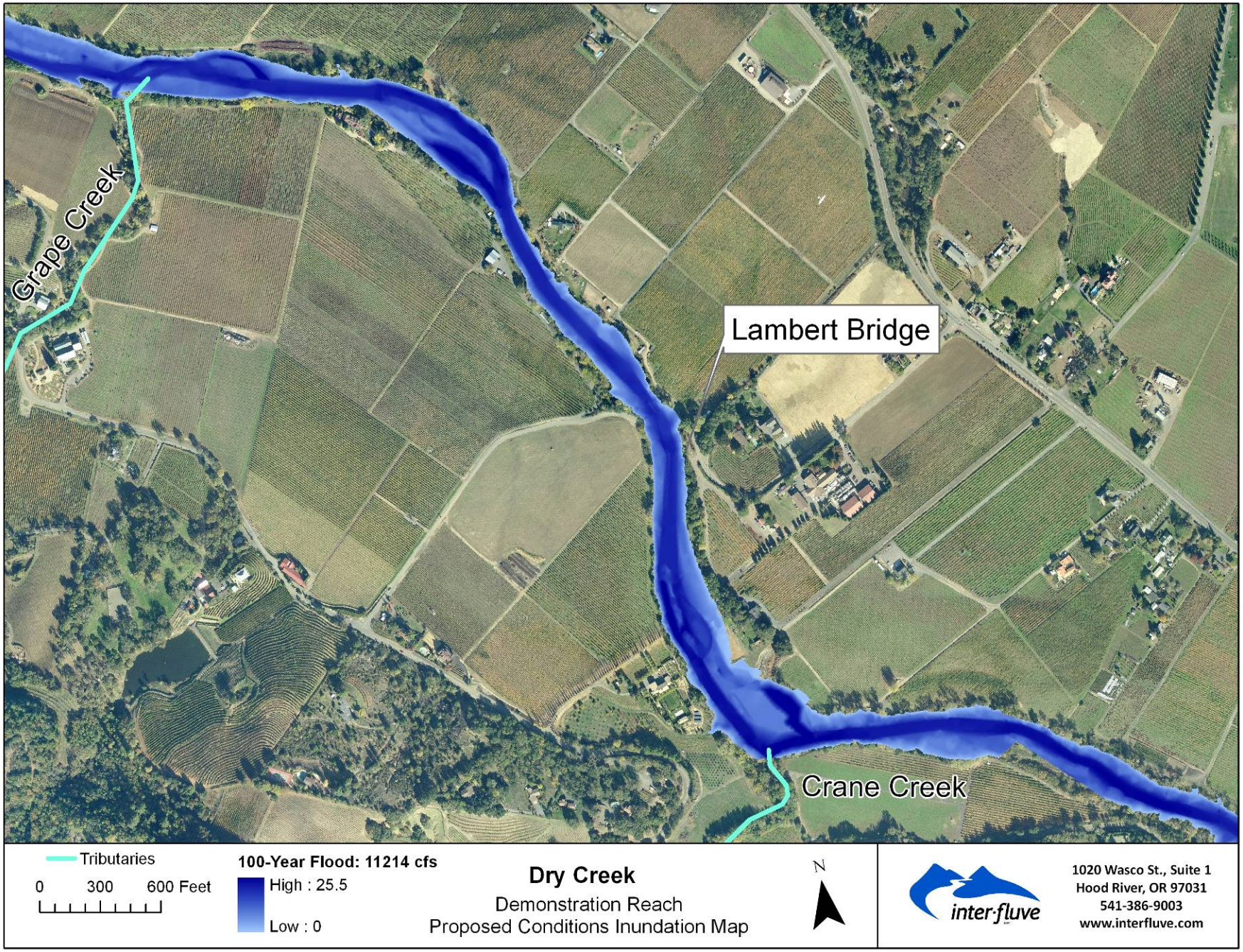


Figure 25. Inundation map based on design conditions for 100-year return period flood (11214 cfs).

9 ESTIMATED FUTURE HABITAT COMPOSITION AND ADDITIONAL REARING HABITAT

Included is a comparison of current and proposed stream habitat units for the Dry Creek Habitat Enhancement Demonstration Project. The baseline data source for this comparative assessment is the Summer 2009 habitat survey, which has been described in detail in the Draft Dry Creek Current Conditions Report (March 2010). The proposed habitat unit distribution is compiled from changes to stream features as provided in the 60% demonstration reach design. In addition, an analysis was performed to predict the additional potential juvenile coho rearing habitat resulting from the project. Figures 26-27 reflect habitat distribution by area and Figures 28-29 reflect habitat distribution by frequency, respectively. Figure 30a-b shows the spatial distribution of habitat units for existing and proposed conditions, while Table 6 summarizes habitat area by unit type for existing and proposed conditions.

The preliminary estimate of additional coho rearing habitat provided by the improvements to habitat outlined in the 60% design was calculated based on the area of proposed alcoves and also anticipated velocity refuge provided by large woody debris (LWD) placements. LWD placements will typically extend 2 to 4 feet into the channel (3 feet on average), with some protruding further and others flush with the bank. As a means of estimating this influence on increased juvenile coho rearing habitat area, we have assumed that the LWD features will provide a band of velocity refuge 3 feet wide over the length of the LWD placement. Adding together the area of created alcove with the area of LWD velocity refuge, our estimate results in an increase in potential coho rearing habitat of 84,406 ft^2 (7842 m^2, or 1.94 acres; Table 7). The spatial distribution of this additional coho rearing habitat is shown in Figure 30c. It should be noted that additional LWD placements are not included in the 60% design downstream of Lambert Bridge as a component of habitat enhancement, as existing margin and pool habitat was assessed to be sufficient. No instream improvements are currently proposed here except for the riffle construction depicted in Figures 30a and 30b.

It should also be noted that for this preliminary estimate of additional coho rearing area, we have elected to limit the estimate of additional rearing habitat to those areas with high predictability, i.e., area associated with alcoves and LWD placements only. Since the usability of the incremental pool margin areas is difficult to predict at the current stage of design development, (our modeling suggests that average pool velocity may be reduced by up to half) we have elected to not include them in the current analysis. For these reasons, the current preliminary estimate should be considered conservative. Additionally, the predicted composition of habitat units and additional rearing area may change with future design development and as feedback from stakeholders (such as landowners) is incorporated.

Table 6: Habitat area by unit type for existing and proposed conditions.

	Existing Habitat		Proposed Habitat	
	Area (ft^2)	**#**	**Area (ft^2)**	**#**
Alcove	7969	6	67047	9
Cascade	6552	1	6552	1
Flatwater	62044	10	44082	8
Pool	211622	9	184956	13
Riffle	30075	6	65500	12

Table 7. Additional coho rearing habitat provided by new alcoves and LWD placements.

Habitat Type	**(ft^2)**	**(m^2)**
Alcove	63118	5864
LWD-Margin Habitat	21288	1978
Total	**84406**	**7842**

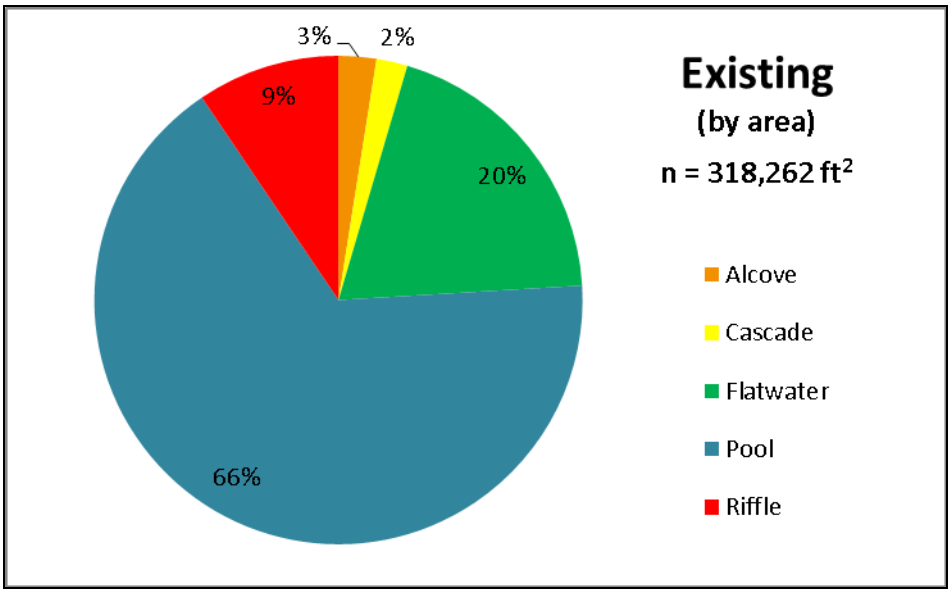


Figure 26. Existing habitat units in the Demonstration Reach, by area.

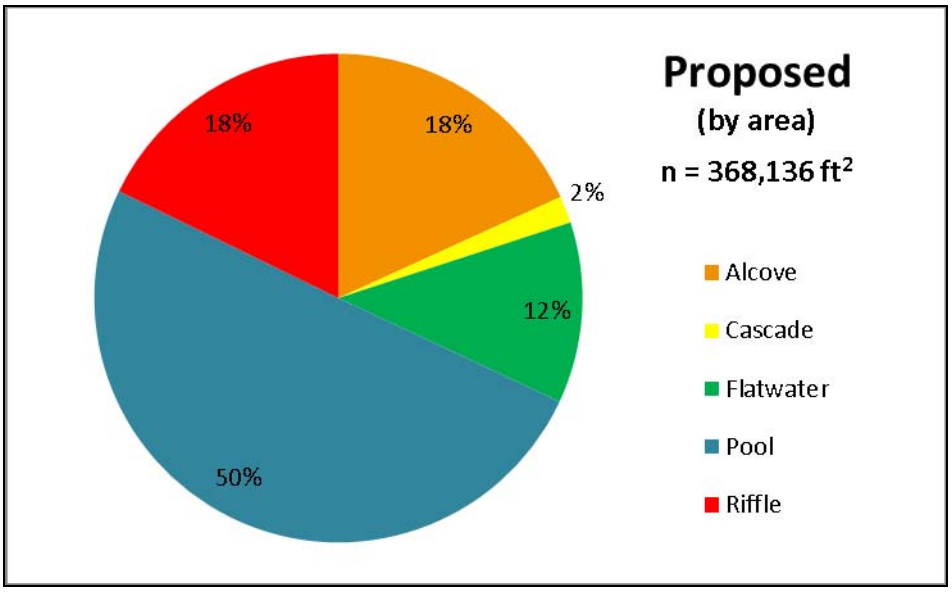


Figure 27. Future habitat units in the Demonstration Reach based on the 60% design, by area.

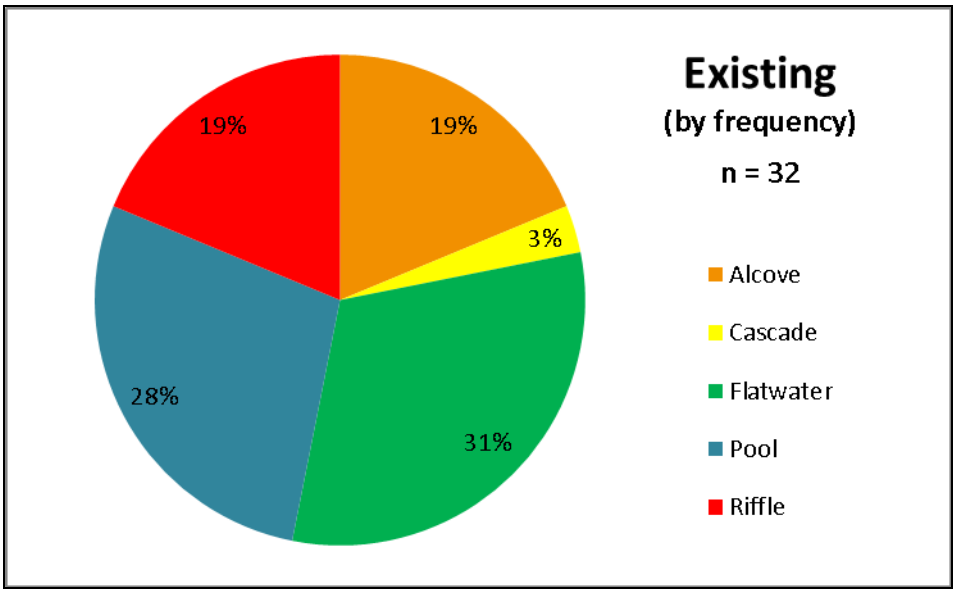


Figure 28. Existing habitat units in the Demonstration Reach, by frequency.

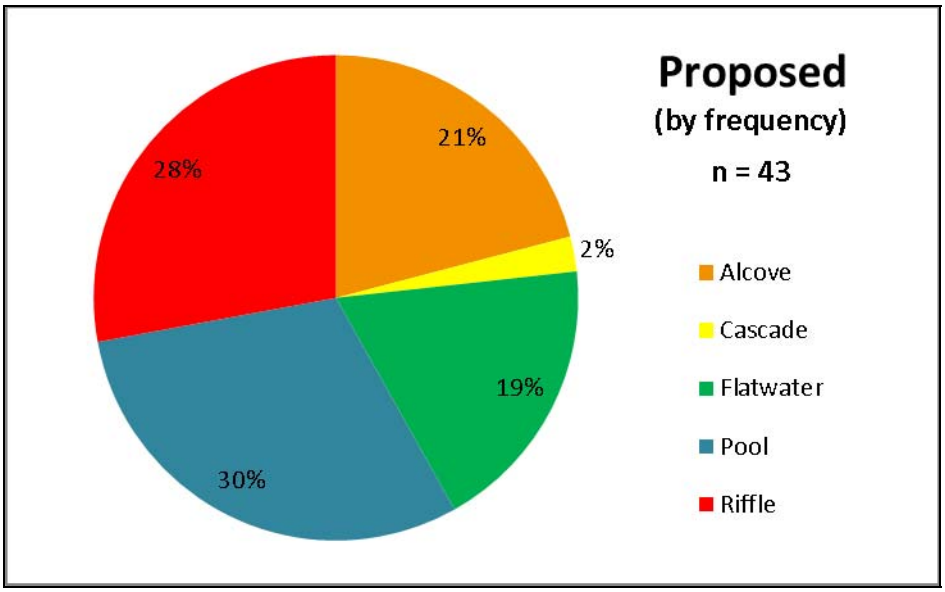


Figure 29. Future habitat units in the Demonstration Reach based on the 60% design, by frequency.

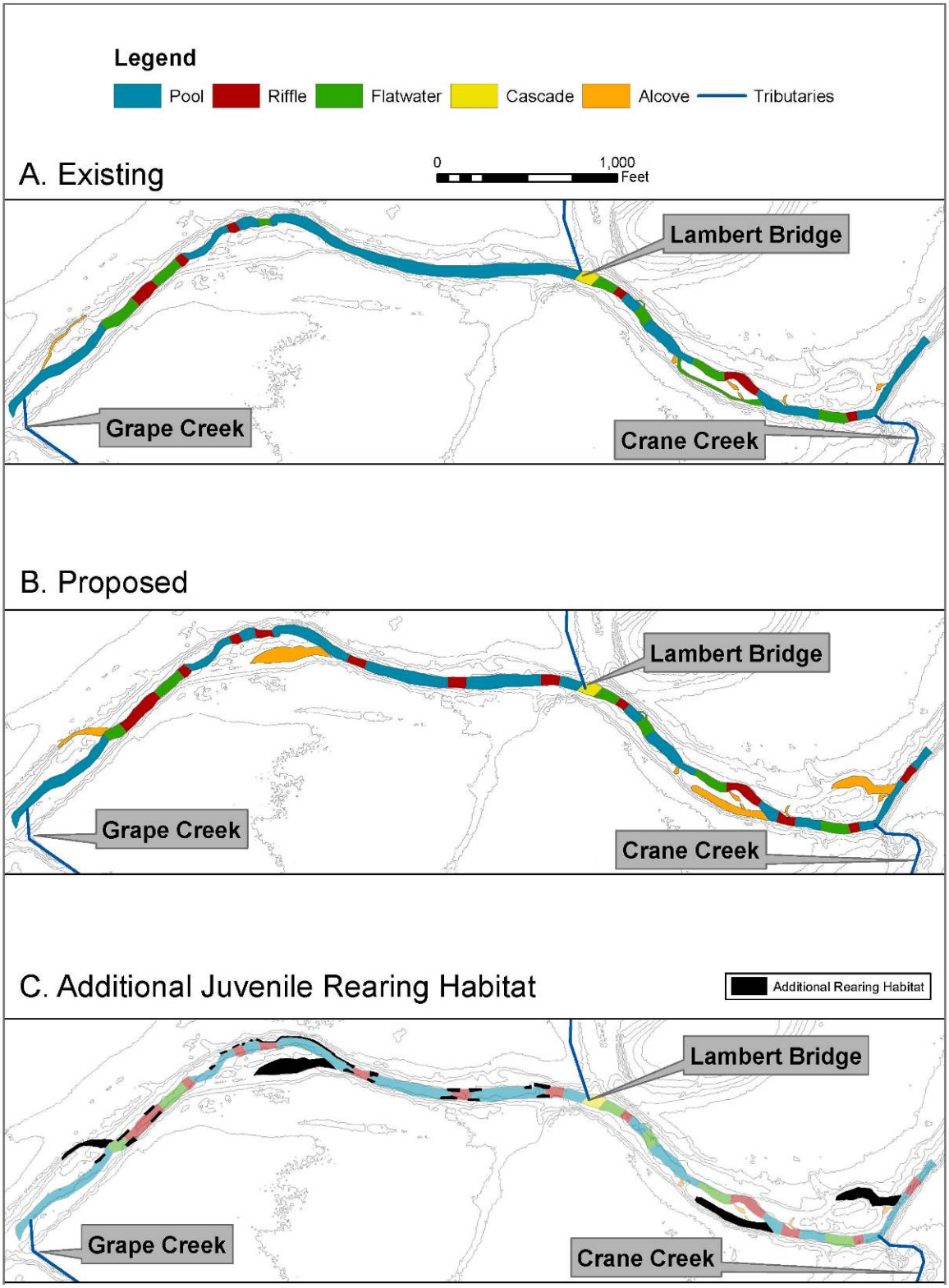


Figure 30. Existing (a) and proposed (b) spatial distribution of habitat units for the Dry Creek Demonstration Reach. Additional juvenile rearing habitat is shown in (c), associated with LWD placement, LWD protruding from bank stabilization, and new alcove habitats.

10 DEMONSTRATION PROJECT CONSTRUCTION CONSIDERATIONS

The nature of land use and infrastructure constraints in the Demonstration Reach present logistical challenges for constructing the enhancements, discussed below.

10.1 Access and Staging

The narrow, incised creek corridor and proximity to vineyard operations limit available access corridors and staging areas. Proposed alignments of ingress/egress, access corridors and staging areas are shown on the 60% complete drawings. These proposed corridors will need to be reviewed by the Agency and the landowners to verify consistency with vineyard operations. In select locations, it may be necessary to clear vegetation and grade access ramps down to the stream corridor in order to construct the work. These areas will need to be restored following construction.

10.2 Timing and Duration of Construction

The in-water work period for Dry Creek is typically June 15 to October 15. If necessary, this period could be potentially extended for two weeks on either end, dependent on year and circumstances of the work. In order to maximize the available construction window within the in-water work period, mobilization and site preparation efforts may commence around or before June 1. Following review of the 60% complete design, it will be necessary to identify whether there are periods between May and October during which construction work would adversely impact vineyard operations, such as the autumn crush period. If necessary, the available work window will be further constrained to accommodate vineyard operations. The anticipated total duration of construction ranges from 3 to 4 months, but could be shortened through mobilization of multiple work crews and expanded working hours (see below).

10.3 Stream Diversion and Dewatering

The steady state operational discharge maintained by the Water Agency during the allowable in-water work period is typically 105 cfs but may be as high as 140 cfs for multiple periods of several days if the work is constructed during a dry hydrologic year.. In order to satisfactorily construct the enhancements and prevent excessive turbidity to the active flowing stream, it will be necessary to divert the stream around active work zones and dewater active work areas. Based on test pit sampling conducted as part of the geotechnical subsurface exploration program (Appendix B), the subsurface materials become compromised quickly during excavation under water, leading to caving of excavation zones and limited control on excavation precision.

105 to 140 cfs is a substantial volume of water to divert in a stream with the physical characteristics such as Dry Creek, including relatively narrow and deeply incised stream corridor, high value adjacent land use and a primary traffic corridor (Lambert Bridge Road) bisecting the work zone. Stream diversion options include gravity-driven and pumped systems. Two alternative approaches have been developed for consideration and discussion with regulatory entities, and are reflected in the drawings (Appendix A). Additionally, alternate

project cost opinions based on utilization of each of these alternatives are included in Section 11 below.

Following review of these alternatives, the preferred general approach will be selected and reflected in the construction drawings, though it will presented as a non-binding approach. Ultimately, the construction contractor will be responsible for final design and implementation of stream diversion and dewatering, constrained by the requirements set forth by the project permits and other limitations described in the project construction specifications. The construction contractor will submit their design for diversion and dewatering for review and concurrence by the Project Engineer. The two alternative approaches are described below:

Pumped Diversion Alternative (Sheets 8 to 10 in Appendix A)

A pumped diversion system provides the benefits of moving the water out of the creek corridor, and maximizes the available work space in the corridor, which will facilitate efficient and competent completion of the work, including concurrent completion of work at multiple sites within the reach. Due to the logistics of installing a pumped system to convey 105-140 cfs, it is most practical to bypass the entire project reach with a single system.

The preliminary design of the system includes six to eight 250 horsepower electric pumps, conveying bypass flows through four to five 24-inch discharge lines running in parallel. A preliminary alignment for the temporary bypass system is shown in the plans on the east side of the creek. The discharge lines would be typically placed on the existing ground surface, but the alignment will require the discharge lines to be either temporarily trenched through Lambert Bridge Road, or passed beneath the east end of Lambert Bridge. A variation on the potential alignment is shown on the Rued property. The feasibility of these alternate routes will need to be verified with the landowner.

Electric pumps may be more economical in terms of energy costs and rental fees than diesel pumps, and may provide a quieter environment while the work is being constructed. To power an electrical system, a temporary extension of the existing electrical system in the area would be considered. Alternatively, power could be supplied by diesel generator sets equipped with sound muffling equipment.

The primary limitations to the pumped diversion alternative include high cost, potential interaction with vineyard operations at select locations, relatively inflexibility once installed, substantial fish relocation effort, and temporary impacts to biota associated with drying up the entire project reach over the complete project construction period.

Gravity Diversion Alternative (Sheets 11 to 14 in Appendix A)

The gravity diversion alternative provides a more surgical approach to stream diversion. Due to the high transmissivity of the alluvium that comprises the substrate materials in Dry Creek, a gravity-driven system will require containing the flow in either pipes or a lined open bypass channel, supplemented with well points to draw down the local water table in excavation zones. Either piped or open-channel gravity systems require space within the channel corridor to convey the bypass flows, which is only available in a subset of the project reach.

This alternative includes two separate gravity diversion zones, each approximately 1300 feet in length. The first (Sheet 12) would enable sequenced construction of off-channel enhancement areas A and B, in addition to the associated riffles, bank construction and log jams in this zone. The second bypass zone (Sheet 13) would enable construction of off channel enhancement area C, the Type 4 Bank, and associated riffles and log jams. These gravity bypass systems would be supplemented with a network of well points used at critical sequencing junctures to complete the work. The remainder of the work included in the demonstration reach would be constructed using a variety of local coffer dam, well point and other dewatering approaches (Sheets 12 to 14 in Appendix A).

Because this alternative relies more heavily on local dewatering from well points and open excavations, it will be necessary to handle substantial volumes of water to ensure that water is not discharged back to Dry Creek in a sediment-laden condition, and within acceptable water quality standards. Water pumped from the subsurface from well points should be clean once the well points are in place because it is the same water as is flowing down Dry Creek. However, some minimal treatment may be necessary including running the water through sedimentation facilities (Baker tanks, filter bags, or settling basins) and periodic testing of water quality. This will require space in order to be accomplished. In addition to small areas within the creek corridor itself, currently fallow vineyard lands on the Seghesio, Dry Creek Vineyard, and Farrow properties may provide opportunities to handle this water.

The primary benefits associated with the gravity diversion relative to the pumped diversion include lower cost, greater flexibility in sequencing work between different areas of the project reach, reduced fish relocation requirements, reduced impact to areas not being enhanced by the project, and limited interaction with vineyard operations. The primary drawbacks to this approach include increased need to work in the active flowing stream while the system is installed in each location, more day to day management of the system, greater complexity, greater need to manage local dewatering outflow, and more disturbance of non-enahacement areas and areas within the enhancement zones which will require reconstruction to a condition at least as sound as the pre-project condition.

10.4 Shoring of Excavations

Based on the results of the subsurface geotechnical exploration (Appendix B), it is estimated that excavation shoring may be required along select portions of the excavation required to construct the Type 4 Bank (Stations 360+00 to 365+75) in order to avoid impacting the adjacent vineyard rows. Shoring is not anticipated to be required for other enhancement areas.Determination of the need for, design of and installation of shoring measures will ultimately be the responsibility of the construction contractor through a performance-based specification.

10.5 Interaction with Existing Features

The design endeavors to avoid interactions with existing features to the extent possible. However, iteractions were unavoidable in select locations. At the Type 4 Bank Construction (Stations 360+00 to 365+75), a fenced horse paddock and a fenced sheep pen are within the limits of the construction footprint as currently drawn at the upstream and downstream ends,

respectively. Additionally, the vineyard road adjacent to the the streambank at this location is within the construction footprint. These features will need to be modified to complete the work, but can be replaced following construction.

In addition, a pump intake and a storm drain outflow fall within the construction footprint at off-channel enhancement areas A (Sheet 19 in Appendix A) and D (Sheet 22 in Appendix A), respectively. It is proposed that these features will be modified at the time of construction. For the pump intake, it is proposed to convert the surface intake to a subsurface Ranney collector-type intake buried in the streambed. At the storm drain outfall, measures will be installed to limit potential for underming and dissipate enrgey from the outfall.

10.6 Right-of-Way Considerations

For purposes of determining limits for right-of-way determinations, in areas where off-channel enhancement is planned, it is recommended to include the full width of the channel corridor in order to anticipate potential future channel adjustments. For isolated riffles and logs jams enhancement, a margin of 50 feet upstream and downstream and 20 feet on each side of the planned enhancements is recommended. It should be noted that the locations of enhancement features may be adjusted to fit field conditions at the time of construction, thus flexibility in determining final right-of-way boundaries is recommended is this can be accommodated within necessary protocol.

10.7 Fish Screening and Relocation

If selected, a pumped diversion system will require screening to prevent aquatic life from entering the system. It is anticipated that a large perimeter screen will enclose the pump intake zone to allow approach water velocities to be within criteria established by the National Marine Fisheries Service. Screen mesh will meet established criteria.

Once the stream diversion commences in each work zone, it will be necessary to relocate aquatic life from the project reach to adjacent reaches, in particular ESA-listed salmonids. Fish relocation will require a significant effort, accomplished through a combination of methods using nets and electrofishing techniques.

10.8 Working Hours

The Water Agency and landowners may wish to consider extended working hours to maximize the daily rate of production, to minimize the overall duration of construction and project cost. If feasible, expanded working hours that allow two shifts per day during the extended summer daylight hours will reduce overall project cost and impact. The available working hours are also likely to be constrained by local ordinances.

11 Opinions of Probable Construction Costs

Two alternate Opinions of Probable Construction Costs (OPC) based on the 60% complete design are found in Table 8a-b below. The first OPC (Table 8a) assumes pumped diversion of the stream around the full project reach. The second OPC (Table 8b) assumes gravity diversion and the site specific approaches discusses above. The cost opinions have been developed based on review of construction costs for similar items in past projects, consultation with construction contractors and material suppliers, and applicable reference cost data. The actual cost of implementation of the project may vary from the cost opinions due to heavy construction market and other unforeseen factors. To account in part for this, a 15% construction cost contingency has been included in the cost opinions.

Table 8a. Engineer's Opinion of Probable Construction Costs - 60% Complete Submittal. Alternative A. Pumped Diversion

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal	design and quantity assumptions
General - Project Initiation						
1	Mobilization	LS	$336,361	1	$336,361	5% of Items 2-20
2	Temporary Access Road Improvements	LS	$100,000	1	$100,000	Temporary ditch crossings, misc road upgrades
3	Temporary Traffic Control & Flagging	LS	$75,000	1	$75,000	misc
4	Dust Control	LS	$100,000	1	$100,000	16 weeks x 5 days x 8 hours x $150
Erosion Prevention, Environmental Protection and Sediment Control						
5	Fish Relocation	LS	$20,000	1	$20,000	Placeholder estimate
6	Stream Diversion					100 cfs system - six electric/diesel pumps, 4 24" HDPE discharge lines, 3 diesel backup
a.	fixed startup and teardown costs	LS	$800,000	1	$800,000	freight, assembly, power delivery improvements, diversion dam
b.	monthly cost	EA	$380,000	3	$1,140,000	equipment rental, power
7	Dewatering	LS	$50,000	1	$50,000	local dewatering
8	Erosion Control BMPs	LS	$200,000	1	$200,000	placeholder estimate
Earthwork						
9	Clearing and Grubbing	LS	$25,000	1	$25,000	limited
10	Common Excavation					
a.	Off Channel Area A: Wallace-Farrow	CY	$20	12,000	$240,000	Based on 041511 volume estimate
b.	Off Channel Area B: Wallace-Lipton	CY	$20	1,600	$32,000	Based on 041511 volume estimate
c.	Off Channel Area C: Van Alyea	CY	$20	11,500	$230,000	Based on 041511 volume estimate
d.	Off Channel Area D: Seghesio	CY	$20	1,500	$30,000	Based on 041511 volume estimate
Large Woody Debris Installation						
11	Floodplain Roughness Logs					
a.	logs	EA	$1,000	72	$72,000	furnish and install
b.	logs with rootwads	EA	$1,500	48	$72,000	furnish and install
c.	boulders	TN	$100	120	$12,000	estimate 1 ton per log
12	Backwater Habitat Logs					
a.	logs	EA	$1,000	117	$117,000	furnish and install
b.	logs with rootwads	EA	$1,500	78	$117,000	furnish and install
c.	boulders	TN	$100	195	$19,500	estimate 1 ton per log
12	Pool Enhancment Logs					
a.	logs	EA	$1,000	71	$71,000	furnish and install
b.	logs with rootwads	EA	$1,500	46	$69,000	furnish and install
c.	boulders	TN	$100	117	$11,700	estimate 1 ton per log
13	Log Jams & Misc Placements					
a.	logs	EA	$1,000	420	$420,000	furnish and install
b.	logs with rootwads	EA	$1,500	260	$390,000	furnish and install
c.	boulders	TN	$100	680	$68,000	estimate 1 ton per log
Bank stabilization						
14	Type 1 Bank - Farrow & Van Alyea	SY	$15	3,400	$51,000	fabric treatment on slope, includes stakes, seed and wastage
15	Type 2 Bank - Wallace	Face Foot	$32	900	$28,800	ps
16	Type 3 Bank - Wallace					
a.	Logs	EA	$1,000	180	$180,000	furnish and install
b.	Logs with Rootwads	EA	$1,500	80	$120,000	furnish and install
c.	Riprap Scour Protection and Granular Backfill	CY	$70	550	$38,500	18"-0
d.	Fabric Encapsulated Lift	Face Foot	$32	425	$13,600	includes stakes, seed and wastage
17	Type 4 Bank - Mascherini					Upstream and Downstream Locations Combined
a.	Logs	EA	$1,000	162	$162,000	furnish and install
b.	Logs with Rootwads	EA	$1,500	54	$81,000	furnish and install
c.	Earthwork	CY	$18	12,690	$228,420	subgrade cut / crib & lift common backfill, disposal of excess
d.	Riprap Scour Protection and Granular Backfill	CY	$70	2,565	$179,550	18"-0
e.	Aggregate Filter Material	CY	$50	338	$16,875	
f.	Geotextile Fabric	SY	$9	2,430	$21,870	
g.	Fabric Encapsulated Lift	Face Foot	$32	6,075	$194,400	includes stakes, seed and wastage
Riffle Installation						
18	Riffle Material	CY	$120	3,900	$468,000	Assume imported river material, assumes subgrade cut, reuse and disposal of excess
Vegetation Management						
19	Clearing of Invasive Vegetation and Selected Revegetation	AC	$20,000	15.5	$310,000	
Site Restoration						
20	Misc Restoration	LS	$100,000	1.0	$100,000	
21	2" A.C. Overlay	SY	$20	2,600	$52,000	Post Construction, Van Alyea Driveway
	Construction Subtotal				$7,063,576	
	15% Contingency				$1,059,536	
	Project Total				$8,123,112	

Additive Items

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal	design and quantity assumptions
A1	Increase Diversion Capacity from 105 to 140 cfs	LS	$776,000	1	$776,000	increase pumped diversion system capacity from 105 to 140 cfs for dry year conditions

Table 8b. Engineer's Opinion of Probable Construction Costs - 60% Complete Submittal. Alternative B. Gravity Diversion

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal	design and quantity assumptions
General - Project Initiation						
1	Mobilization	LS	$298,361	1	$298,361	5% of Items 2-20
2	Temporary Access Road Improvements	LS	$100,000	1	$100,000	Temporary ditch crossings, misc road upgrades
3	Temporary Traffic Control & Flagging	LS	$75,000	1	$75,000	misc
4	Dust Control	LS	$100,000	1	$100,000	16 weeks x 5 days x 8 hours x $150
Erosion Prevention, Environmental Protection and Sediment Control						
5	Fish Relocation	LS	$20,000	1	$20,000	Placeholder estimate
6	Stream Diversion					Systems capable of handling 140 cfs. 2 large gravity bypass locations (60" pipe), site specific treatments including coffer damming and dewatering wells
a.	gravity bypass system	EA	$325,000	2	$650,000	2 sites @ ~ 1400 LF persite. 60" dia HDPE (not welded), excavation, decomission, coffer dams, misc restoration
b.	isolated riffle/LWD sites	EA	$100,000	3	$300,000	per detail on plans
c.	dewatering wells	EA	$3,500	30	$105,000	misc placements sitewide, 24" casing, 4" pump, 2 weeks operation
	Misc coffer dams	EA	$25,000	5	$125,000	Assume steel sheet piling, 70 LF each @350LF
7	Dewatering	LS	$50,000	1	$50,000	local dewatering
8	Erosion Control BMPs	LS	$200,000	1	$200,000	placeholder estimate
Earthwork						
9	Clearing and Grubbing	LS	$25,000	1	$25,000	limited
10	Common Excavation					
a.	Off Channel Area A: Wallace-Farrow	CY	$20	12,000	$240,000	Based on 041511 volume estimate
b.	Off Channel Area B: Wallace-Lipton	CY	$20	1,600	$32,000	Based on 041511 volume estimate
c.	Off Channel Area C: Van Alyea	CY	$20	11,500	$230,000	Based on 041511 volume estimate
d.	Off Channel Area D: Seghesio	CY	$20	1,500	$30,000	Based on 041511 volume estimate
Large Woody Debris Installation						
11	Floodplain Roughness Logs					
a.	logs	EA	$1,000	72	$72,000	furnish and install
b.	logs with rootwads	EA	$1,500	48	$72,000	furnish and install
c.	boulders	TN	$100	120	$12,000	estimate 1 ton per log
12	Backwater Habitat Logs					
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12	Pool Enhancment Logs					
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c.	boulders	TN	$100	117	$11,700	estimate 1 ton per log
13	Log Jams & Misc Placements					
a.	logs	EA	$1,000	420	$420,000	furnish and install
b.	logs with rootwads	EA	$1,500	260	$390,000	furnish and install
c.	boulders	TN	$100	680	$68,000	estimate 1 ton per log
Bank stabilization						
14	Type 1 Bank - Farrow & Van Alyea	SY	$15	3,400	$51,000	fabric treatment on slope, includes stakes, seed and wastage
15	Type 2 Bank - Wallace	Face Foot	$32	900	$28,800	ps
16	Type 3 Bank - Wallace					
a.	Logs	EA	$1,000	180	$180,000	furnish and install
b.	Logs with Rootwads	EA	$1,500	80	$120,000	furnish and install
c.	Riprap Scour Protection and Granular Backfill	CY	$70	550	$38,500	18"-0
d.	Fabric Encapsulated Lift	Face Foot	$32	425	$13,600	includes stakes, seed and wastage
17	Type 4 Bank - Mascherini					Upstream and Downstream Locations Combined
a.	Logs	EA	$1,000	162	$162,000	furnish and install
b.	Logs with Rootwads	EA	$1,500	54	$81,000	furnish and install
c.	Earthwork	CY	$18	12,690	$228,420	subgrade cut / crib & lift common backfill, disposal of excess
d.	Riprap Scour Protection and Granular Backfill	CY	$70	2,565	$179,550	18"-0
e.	Aggregate Filter Material	CY	$50	338	$16,875	
f.	Geotextile Fabric	SY	$9	2,430	$21,870	
g.	Fabric Encapsulated Lift	Face Foot	$32	6,075	$194,400	includes stakes, seed and wastage
Riffle Installation						
18	Riffle Material	CY	$120	3,900	$468,000	Assume imported river material, assumes subgrade cut, reuse and disposal of excess
Vegetation Management						
19	Clearing of Invasive Vegetation and Selected Revegetation	AC	$20,000	15.5	$310,000	
Site Restoration						
20	Misc Restoration	LS	$100,000	1.0	$100,000	
21	2" A.C. Overlay	SY	$20	2,600	$52,000	Post Construction, Van Alyea Driveway
	Construction Subtotal				$6,265,576	
	15% Contingency				$939,836	
	Project Total				$7,205,412	

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13 APPENDIX A – 60% COMPLETE ENHANCEMENT DESIGN DRAWINGS

14 APPENDIX B – DRAFT GEOTECHNICAL REPORT

SANDERS & ASSOCIATES GEOSTRUCTURAL ENGINEERING

SAGE

INTEGRATING EARTH & STRUCTURE

DRAFT

Geotechnical Investigation Report

Dry Creek Habitat Enhancement Demonstration Projects - Phase 3

Sonoma County, California

SAGE Project No. 07-082.02

Prepared for:

Inter-fluve Inc.
1020 Wasco Street
Suite 1
Hood River, OR 97031

March 11, 2011

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SANDERS & ASSOCIATES GEOSTRUCTURAL ENGINEERING

SAGE

INTEGRATING EARTH & STRUCTURE

March 11, 2011
Project No. 07-082.02 3.02

Mr. Michael Burke
Inter-Fluve, Inc.
1020 Wasco St., Ste. 1
Hood River, OR 97031

RE: Revised Draft Geotechnical Investigation Report
Dry Creek Habitat Enhancement Demonstration Projects
Station 325+00 to 383+00
Sonoma County, California

Dear Mr. Burke:

Sanders & Associates Geostructural Engineering, Inc. (SAGE) is pleased to submit this revised draft report presenting the results of our geotechnical investigation for the proposed habitat enhancements in Dry Creek, a major tributary to the Russian River in Sonoma County, California. Specifically, this investigation was focused on the first phase of enhancements along an approximately 1.1 mile length of Dry Creek, referred to as the Demonstration Reach, which extends from the mouth of Grape Creek downstream to the mouth of Crane Creek (station 325+00 to 383+00). We are submitting one (1) copy of this draft report for your review.

We explored the subsurface conditions at selected off channel enhancement sites and a bank stabilization site by excavating eight (8) test pits and drilling two (2) small-diameter borings (Figure 2). In addition, NORCAL Geophysical Consultants performed a geophysical survey at an off channel enhancement site which could not be accessed by conventional mechanized equipment.

In general, we encountered alluvial soils consisting of mixtures of gravel and sand with interbedded layers of finer material. The material ranged from loose to dense, with the least dense materials generally near the ground surface. Saturated materials were very loose upon excavation and could not maintain excavation cuts or slopes.

Based on the results of the geophysical survey, the depth to bedrock at Off-Channel Enhancement Area D is estimated between 2 and 9 feet on the northwest and southeast ends of a seismic refraction line performed at this site, respectively. The recorded velocities suggest the rock is rippable to moderately rippable with a CAT 9L bulldozer. Bedrock was not encountered in any of the test pits excavated at the site.

DRAFT

The report submitted herewith contains recommendations regarding site grading, temporary and permanent slopes, slope stability, and bearing capacity. These recommendations are based on limited subsurface exploration and laboratory testing. Consequently, variations between expected and actual soil conditions may be found during construction. SAGE should be retained to observe the earthwork to evaluate actual conditions encountered for conformance with the geotechnical aspects of the plans and specifications.

Please call us should you have questions.

Sincerely yours,
Sanders & Associates Geostructural Engineering, Inc.

Darren A. Mack
Geotechnical Engineer

Drew G. Kennedy
Engineering Geologist

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Figure 2 Subsurface Exploration Map

APPENDICES

Appendix A – Field Exploration Program

Figure A-1 Soil Classification Chart

Figures A-2 through A-3 Logs of Soil Borings B1 and B2

Figure A-4 Logs of Test Pits TP1 through TP8

Appendix B – Laboratory Test Results

Appendix C – Geophysical Survey Report

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INTEGRATING EARTH & STRUCTURE

REVISED DRAFTGEOTECHNICAL INVESTIGATION REPORT
Dry Creek Habitat Enhancement Demonstration Projects
Station 325+00 to 385+00
Sonoma County, California

1.0 INTRODUCTION

Sanders & Associates Geostructural Engineering, Inc. (SAGE) is pleased to submit this revised draft report presenting the results of our geotechnical investigation for habitat enhancements in Dry Creek, a major tributary to the Russian River in Sonoma County, California. Specifically, this investigation was focused on the first phase of enhancements along an approximately 1.1 mile length of Dry Creek, referred to as the Demonstration Reach, which extends from the mouth of Grape Creek downstream to the mouth of Crane Creek (STA 325+00 to 383+00).[1]

The purpose of the proposed habitat enhancements is to develop summer rearing and winter refugia habitat for local fish species, specifically coho salmon and steelhead trout. Based on our review of the 30% Dry Creek Habitat Enhancement Demonstration Projects plans, we understand this will be achieved using a combination of enhancement approaches, including backwater ponds and channels for the fish to inhabit. The backwater ponds and channels will require excavation in stream terraces adjacent to the active stream channel. Slope inclinations for channel regarding are expected to be on the order of 2H:1V or flatter, with cuts up to 15 feet. In channel enhancement measures will include new riffle areas, deepening of existing pools, and construction of artificial log jams.

In addition, stabilization of the creek banks will be locally required to retain property and to enhance the habitat characteristics along the edge of Dry Creek. Anticipated bank stabilization measures will include: (1) flattening the existing slopes and covering with biodegradable fabrics; (2) bank reconstruction using log cribs with live willow cuttings; and (3) bank reconstruction using fabric encapsulated soil with live willow cuttings. The log cribs will have nominal widths (perpendicular to slope) of 20 to 25 feet, and will be underlain at the toe by 3- to 4-foot-wide by 5- to 8-foot-deep pads of 18-inch-minus rock. Backcuts for taller stabilization efforts are expected to consist of temporary slopes, although shoring may be required locally where layback space is limited by the presence of existing vineyards.

The approximate project location is shown on the Site Location Map (Figure 1). The important project features are shown on the Subsurface Exploration Map (Figure 2).

[1] Project stations (STA) are based on the 30% Dry Creek Habitat Enhancement Demonstration Projects plans prepared by Inter-Fluve, dated October 1, 2010.

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2.0 SCOPE OF SERVICES

We performed a subsurface investigation in support of the proposed habitat enhancements for the Demonstration Reach. We have summarized the observations and results of our investigation in this geotechnical report, which provides recommendations and conclusions for developing the habitat enhancement design. Specifically, our investigation consisted of:

- Conducting a site reconnaissance to review selected locations for subsurface exploration;
- Obtaining the necessary drilling permits and coordinating our subsurface exploration program;
- Retaining the services of a private utility locator to clear investigation locations for possible underground utilities and/or buried objects;
- Performing a subsurface exploration program including eight (8) test pits and two (2) soil borings;
- Performing a geophysical survey at an off channel enhancement site which could not be accessed by conventional mechanized equipment;
- Collecting representative samples of the soil encountered in the test pits and soil borings;
- Performing laboratory testing on selected soil samples; and
- Preparing this geotechnical report.

3.0 SITE CONDITIONS

Dry Creek is an incised stream with flows regulated by the upstream Warm Springs Dam. Flow regulation has reduced the frequency and severity of major floods while providing a continuous baseflow during the summer months. This has resulted in the rapid growth of dense riparian vegetation and shrubs along the channel banks and formerly active bar surfaces since the dam was put into service in 1984. Where visible through the dense vegetation, the channel banks are generally steep to very steep and locally subject to erosion. Alluvial terraces are locally preserved along the Demonstration Reach, and are positioned above the active stream channel. These terrace surfaces, including a prominent terrace at Off Channel Enhancement Area C (Figure 2), are relatively flat benches with areas of dense vegetation to open grassy meadows.

4.0 GEOLOGIC CONDITIONS

4.1 Regional Geologic Setting

The Demonstration Reach is located in the Dry Creek drainage valley within the Coast Ranges geomorphic province of California. The Coast Ranges province is generally characterized by northwest-trending mountain ranges and intervening valleys that are controlled by right-lateral strike-slip faulting along the San Andreas fault system.

Review of available geologic mapping and literature sources indicate that the Dry Creek drainage valley is a structurally-controlled valley that generally lies on the boundary between sedimentary units

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of the Great Valley Complex to the east and various fault bounded lenses of the Coast Range ophiolite and metamorphic rock units of the Franciscan Complex to the west (Blake, Graymer, and Stamski, 2002). However, sandstone, siltstone, and shale units belonging to the Great Valley Complex are also mapped along the western margin of the valley adjacent to the Demonstration Reach. The valley is filled with stream channel and floodplain deposits associated with Dry Creek and include up to three terrace deposits, the oldest of which appears to be approximately 1,000 years old (Harvey and Schumm, 1985).

4.2 Site Geology

Geologic conditions at the site are generally similar to those depicted by Huffman and Armstrong (1980) and Blake, Graymer, and Stamski (2002). In general, the Demonstration Reach is underlain by alluvial deposits of varying age. The deposits are comprised of clay, silt, sand, gravel, and cobble mixtures of varying rock types derived from tributaries extending into the adjacent Coast Range ophiolite, Great Valley Complex, and Franciscan Complex. The youngest alluvium is found within the active stream channel and low-lying gravel bars that are seasonally inundated.

Alluvial terraces are preserved along the length of the Demonstration Reach, and are comprised of older alluvial deposits. The position of these terraces relative to the active stream channel varies along the reach. In general, terraces positioned higher than the active stream channel are well vegetated, particularly the prominent terrace at Off Channel Enhancement Area C (Figure 2). Shallow slope failures are locally present along the active channel and terraces banks in areas where the banks are actively being undercut.

Bedrock outcrops observed along the active stream channel are generally limited to Grape and Crane Creeks near the confluence with Dry Creek, and within the Dry Creek channel below and immediately downstream of Lambert Bridge. The exposures are comprised of interbedded layers of weak siltstone and somewhat stronger, thicker beds of sandstone that appear to be consistent with descriptions of the siltstone, sandstone, and shale units of the Great Valley Complex. In general, the siltstone and sandstone exposures can easily be broken with a rock hammer, and are expected to be excavatable using conventional grading equipment. At Grape Creek, the bedrock is locally folded along a west-southwest plunging axis approximately parallel to the apparent syncline evident in the mapped Great Valley Complex units exposed on the western flank of the valley.

5.0 SUBSURFACE CONDITIONS

We explored the subsurface conditions at selected off channel enhancement sites and bank stabilization site by excavating eight (8) test pits and drilling two (2) small-diameter borings (Figure 2). In addition, NORCAL Geophysical Consultants (NORCAL) performed a geophysical survey at an off channel enhancement site which could not be accessed by conventional mechanized equipment. Table 1 summarizes the subsurface exploration performed. A description of our field exploration program, as well as the test pit and borings logs, is presented in Appendix A. The results of laboratory testing are presented in Appendix B.

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TABLE 1
SUMMARY OF EXPLORATION LOCATIONS

Enhancement Site*	Property Owner(s)	Subsurface Exploration
Off Channel Enhancement Area A Bank Stabilization (STA 334+00 – 337+70)	Wallace & Farrow	Test pits (TP5 to TP8)
Off Channel Enhancement Area C	Van Alyea	Test pits (TP1 thru TP4)
Bank Stabilization (STA 360+00 – 363+55, STA 365+10 – 365+80)	Mascherini	Soil borings (B1, B2)
Off Channel Enhancement Area D	Seghesio	Geophysical survey

TP1 through TP4 were excavated at Off Channel Enhancement Area C. The upper 6 to 12 inches of TP1 through TP3 were composed of loose to medium dense gravelly silt and silty gravel with organic material. TP4 exposed four feet of medium stiff gravelly clay at the surface of the excavation. Below the surficial layer, we encountered easily excavatable loose to medium dense sand and gravel mixtures. Groundwater was encountered around Elevation 122 feet in each test pit.

Soils encountered in TP5 through TP9 generally comprised sandy gravel with trace fines and cobbles up to 10 inches. Localized layers of sand and clayey sand were also encountered. The subsurface material was loose to medium dense and could be easily excavated. Groundwater was encountered between Elevation 115 and 118 feet.

The soils encountered in B1 and B2 indicate that the upper 13 to 15 feet of the creek bank is variable. In B1, we encountered loose to medium dense silty sand and sand. In B2, we encountered medium stiff to stiff clay with some silty sand. Below 15 feet, we encountered sand and gravel with varying silt and clay content. Groundwater was between 21 and 23 feet below existing grade, which corresponds to between Elevation 121 and 122 feet.

The water level in Dry Creek was measured adjacent to TP-1 and TP-5. At these two locations, the measured groundwater elevations in the test pits were approximately the same as the adjacent water surface elevation in Dry Creek. Although not measured in the field, we would expect similar results for the remaining test pits.

The test pit side slopes were marginally stable in dry to moist conditions. However, rapid caving or sloughing generally occurred below the water table, particularly where active seepage was encountered, which limited the depth of the test pits.

Although bedrock of the Great Valley Complex is visible in Grape and Crane Creeks near the confluence with Dry Creek, and within Dry Creek below and immediately downstream of Lambert Bridge, bedrock was not encountered in the test pits and borings. At Off Channel Enhancement Area D, the results of the NORCAL survey suggest the depth to sedimentary bedrock is between 2 and 9 feet below existing grades on the northwest and southeast ends of the seismic refraction line,

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respectively. The recorded velocities suggest the rock is rippable to moderately rippable with a CAT 9L bulldozer. The approximate location of the seismic line is shown on Figure 2, and the full geophysical report is presented in Appendix C.

6.0 SEISMICITY

6.1 Regional Seismicity

Seismicity is defined as the geographical and historical distribution of earthquakes, or more simply, earthquake activity. The potential for ground shaking at the site is related to earthquake activity that might occur along nearby or distant faults. Based on historical earthquake activity and fault hazard mapping, the Sonoma County region is considered to have a relatively high potential for seismic activity related to the San Andreas fault system.

The 2002 Working Group on California Earthquake Probabilities (WGCEP) suggests the overall probability of one or more $M_W \geq 6.7$ earthquakes occurring in the San Francisco Bay region during the period from 2002 to 2032 is 62 percent (WGCEP, 2003). The highest probability of 27 percent was assigned to the Hayward/Rodgers Creek fault zone.

The closest active faults in this system are the Maacama and Rodgers Creek faults, which are mapped approximately 6 miles northeast and 8 miles southeast of the site, respectively. The San Andreas fault is mapped approximately 20 miles southwest of the site.

Regional fault maps and databases (Jennings et al., 2010; USGS, 2010) and a fault evaluation report (Bryant, 1982) show several strands of the Healdsburg fault within and adjacent to the Dry Creek drainage valley. No strands are mapped as crossing or projecting towards the Demonstration Reach. Seismically, the Healdsburg fault comprises an approximately one mile wide system of northwest trending, right-lateral strike-slip fault strands. These strands appear to be a northwest extension of the Rodgers Creek fault and define part of a complex seismic stepover with the Maacama fault to the north (McLaughlin and Sarna-Wojcicki, 2003). Both the Rodgers Creek and Maacama fault systems are zoned as active[2] under the State of California Alquist-Priolo (AP) Earthquake Fault Zoning Act (Bryant and Hart, 2007).

Although not currently zoned as active under the AP Act, workers mapping in the surrounding region considered some traces of the Healdsburg fault to be "recently active" (Huffman and Armstrong, 1980) or "Quaternary active" (Blake, Graymer, and Stamski, 2002). Based on available paleoseismic studies for the region and the structural relationship of the Healdsburg fault with the active Rodgers Creek and Maacama fault systems, the Healdsburg fault should be considered potentially active[3].

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[2] Active faults are defined as those exhibiting either surface ruptures, topographic features created by faulting, surface displacements of Holocene (younger than about 11,000 years old) deposits, tectonic creep along fault lines, and/or close proximity to linear concentrations or trends of earthquake epicenters.

[3] Potentially active faults displace geologic deposits of Pleistocene age (about 2 million to 11,000 years old).

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6.2 Seismic Hazards

Based on the close proximity of the site to the Maacama, Rodgers Creek, and other major active faults in the area, there is a high potential for the site to experience moderate to very strong ground shaking during a major earthquake on one of these faults. The intensity of earthquake ground motion at the site will depend on the characteristics of the generating fault, the distance to the earthquake epicenter, the magnitude and duration of the earthquake, and specific site geologic conditions.

In addition, given the sandy nature of the materials and high elevation of the groundwater table encountered during the subsurface excavation, liquefaction may occur. It is possible that liquefaction or ground shaking may damage the bank stabilization structures due to lateral spreading. However, damage caused by lateral spreading should not cause a safety hazard for the local population since the improvements are for the remediation of an existing habitat and are not infrastructure related. Therefore, recommendations regarding liquefaction and liquefaction mitigation were not included in our scope of work.

6.3 Fault Rupture

Given the structural relationship of the Healdsburg fault with the active Rodgers Creek and Maacama faults, there is a reasonable chance of ground surface rupture along traces of the Healdsburg fault during a major earthquake on either of the active faults. Stereoscopic analysis of aerial photos and digital imagery suggests that one or more low sinuosity reaches of Dry Creek upstream/downstream of the Demonstration Reach may be structurally controlled along unmapped traces of the Healdsburg fault or other lineaments that may be associated with the fault. However, the Demonstration Reach is a higher sinuosity reach that does appear to be structural controlled. In addition, given the nature of the proposed habitat enhancements, any potential fault offset would be unlikely to have any significant impacts to the long term performance.

7.0 RECOMMENDATIONS

We believe the proposed construction is feasible from a geotechnical standpoint provided our geotechnical recommendations are incorporated into project design and construction. The primary geotechnical considerations for the site are the excavatability of the native subsurface material and stability of temporary and permanent slopes. In accordance with our scope of services, the following subsections present our recommendations for site grading, temporary and permanent slopes, and excavations.

7.1 Demolition & Clearing

Site demolition is expected to be minimal, but could include the removal of existing below-grade improvements, if any, that will interfere with the proposed construction. These could include utilities, culverts, and abandoned auto bodies.

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Where utilities are to be abandoned and removed, they should be capped or plugged with grout at the Right-of-Way (ROW). Where it is feasible to abandon utilities in-place, utilities greater than three inches in diameter should be completely filled with flowable cement grout over their entire length. Where abandoned utilities are perpendicular to an excavation, they should be filled with grout to the nearest manhole or valve. It may be necessary to pothole utilities in several locations to facilitate and/or verify grouting. Utilities less than or equal to three inches in diameter can be plugged with concrete at the sides of the excavation. Existing utility lines, where encountered, should be addressed on a case-by-case basis.

Any demolition requiring excavation should be properly backfilled with engineered fill according to the recommendations provided later in this section.

7.2 Fill Material and Compaction Requirements

On-site soil will be acceptable for use as general site fill provided it is free of organic material and contains no rocks or lumps larger than four inches in greatest dimension. Rock fragments larger than four inches can be reused in the fill provided they are broken down to less than four inches in diameter.

If imported fill is required, it should be free of organic matter or other deleterious material, contain no rocks or lumps larger than four inches in greatest dimension, and have a relatively low expansion potential (defined by liquid limit less than 40 and a plasticity index lower than 15).

All fill material, including on-site fill, should be submitted to the Geotechnical Engineer for approval at least 72 hours before it is to be used on site. Where imported fill is required, the grading subcontractor should provide analytical test results or other suitable environmental documentation at least three days before use at the site indicating the proposed fill material is free of hazardous materials.

Where fill is required, the exposed subgrade should be scarified to a depth of eight inches, moisture-conditioned to at least two percent above optimum moisture content, and compacted to at least 90 percent relative compaction.[4] However, 85 percent relative compaction is acceptable where vegetation or replanting is planned. Where the thickness of the fill layer will be five feet or greater, the soil should be placed in eight-inch loose lifts and compacted to above optimum moisture content.

7.3 Aeration

If wet subgrade conditions are encountered at the site, or the base of excavations or backfill areas become soft, unstable and/or disturbed by construction equipment, it may be necessary to stabilize the base of the excavation prior to fill placement. For granular soils, particularly gravels, installation

[4] Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same material, as determined by ASTM D1557-00 laboratory compaction procedure.

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of sumps to locally lower the water level will likely be sufficient to stabilize the material provided the pumps are large enough to keep up with infiltration. For clayey soils, the least costly stabilization measure typically consists of aeration (drying) of the wet soil to reduce its moisture content to a compactable level. However, depending on climatic conditions, several days to several weeks of relatively warm, dry weather may be required to dry the soil to an acceptable level. In addition, it is often necessary to turn the material several times a day to promote uniform drying. The soil will be deemed sufficiently aerated when the required degree of compaction can be achieved and/or the resulting subgrade surface is firm and unyielding.

7.4 Excavatability

Based on the results of our borings and test pits, we believe standard construction equipment, such as a hydraulic excavator, should be able to complete the excavations required for the proposed habitat improvements. The encountered materials were generally loose to medium dense and were easily excavated. No cemented soils or bedrock was encountered in our borings or test pits.

Based on the preliminary results of the seismic refraction line performed at Area D, bedrock appears to be about 2 to 9 feet below existing grade. The reported seismic velocities range from about 1,000 feet per second in overburden materials to over 6,800 feet per second in bedrock, which suggests the bedrock is rippable to marginally rippable using a CAT D9L bulldozer. We expect bedrock encountered at Crane Creek, Grape Creek, and Lambert Bridge will be similar.

7.5 Temporary Slopes

Temporary slopes are expected to be cut for bank stability construction in areas B and C. All temporary slopes should be excavated in accordance with the latest edition of the CAL-OSHA excavation and trench safety standards as a minimum (CCR, 2005). We understand some top-of-cut setback limitations may exist in these areas due to the proximity of an existing vineyard.

Test borings B1 and B2 were drilled through the proposed backslope materials for Area C. In boring B1, the upper 20 feet of the materials encountered consist of loose to medium dense sand, silty sand, and silty sandy gravel. Because this is a layered system, the maximum slope inclination is controlled by the least stable layer, in this case, the sand. At this location, it is our opinion that the soil should be preliminarily classified as Type C according to the CAL-OSHA classification system. The maximum allowable slope for Type C soil is 1.5H:1V. Vertical benches should not be cut into the base of temporary excavations.Type C should also be assumed for Areas B, where access limitations did not allow for site specific exploration to be performed.

At the location of boring B2, however, the upper 11 feet of the embankment consists of medium stiff to stiff sandy clay, which in our opinion can be preliminarily classified as a Type B soil. The maximum allowable slope for Type B soil is 1H:1V. Below this depth, the soil is classified as silty sand and gravel, and a direct shear test in the silty gravel indicates the material has some apparent cohesion. The silty sand and gravel is transitional between Type B and C soil and will require on-site classification during excavation to determine the CAL-OSHA soil type. Because OSHA does not

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allow layered systems with upper slopes steeper than lower slopes, we recommend cuts taller than 11 feet in the vicinity of boring B2 have an assumed inclination of 1.5H:1V for preliminary planning purposes.

The contractor should be responsible for all temporary slopes excavated at the site, and should designate one of their on-site employees as a "competent person" who is responsible for trench and excavation safety. The competent person should be responsible for determination of the correct CAL-OSHA soil type and should direct the excavation crews to use shallower slopes than presented above if appropriate. The competent person should also be prepared to flatten slopes if seepage is observed within the excavation.

If there is insufficient space to construct temporary slopes, temporary shoring may be required. Given the medium dense nature of the sands and gravels encountered at the site, we anticipate steel sheet piles, installed using a vibratory hammer mounted to a hydraulic excavator, are the most likely method of shoring to be used at the site. For design of temporary shoring, and assuming granular slope deposits, we recommend using active pressures of 35 and 65 pounds per cubic foot (pcf) for level backslope conditions and a maximum backslope of 1.5H:1V, respectively. Passive resistance should be computed using allowable passive pressures of 300 and 145 pcf above and below the groundwater table, respectively. These passive pressures include a factor of safety of 1.5 to limit sheet pile deflections.

7.6 Permanent Slopes

Permanent slopes are expected to be cut for channel regarding. They will generally be excavated in gravelly sands and sandy gravels with no appreciable cohesion. All permanent slopes should have a maximum finished slope of 2H:1V. Permanent slopes should be revegetated and/or be covered in biodegradable fabrics as shown in the final construction plan set.

7.7 Slope Stability and Bearing Capacity

We understand bank stabilization will be performed at Off Channel Enhancement Area B and C. For evaluation of slope stability at these locations, a cohesion of 250 psf and a friction angle of 24 degrees can be used for native soils to remain or recompacted native soil. If imported soil meeting the requirements presented in section 7.2 is used, a friction angle of 32 degrees (no cohesion) can be used.

The proposed log crib structures may bear on underlying soils at two points. An average bearing pressure may be imposed over the width of the overall crib structure, which is estimated to be on the order of 20 to 25 feet. However, pressures may be imposed locally on the 18-inch-minus rock streambed substrate (toe rock) buried beneath the toe of the wall. If it is necessary to evaluate the bearing capacity at these two points, we recommend using the allowable dead load bearing capacities presented in Table 2.

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TABLE 2
ALLOWABLE DEAD LOAD BEARING CAPACITY

Structure	Min. Width, ft	Min. Embedment*, ft	Allowable Dead Load Bearing Pressure, psf
Log crib (overall structure)	20	None required	4,000
Toe Rock	3	5	3,000

*Measured vertically from creek bed to bottom of improvement

These values assume fully saturated (submerged) soil conditions and a factor of safety of at least 3 for dead load conditions. The toe pressures are provided as a check to ensure that excessive toe pressures at not imposed, which could cause the bank stabilization system to settle and/or rotate toward the channel.

8.0 SERVICES DURING CONSTRUCTION

The recommendations provided in this report are based on the assumption that SAGE will be retained to provide plan review and observation and testing services during construction in order to evaluate compliance with our recommendations. Prior to construction, we should review the excavation and/or shoring plans prepared by the contractor. During construction, we should periodically check the materials exposed due to excavation of temporary and permanent slopes. These observations will allow us compare the subsurface conditions observed during construction with those encountered during our investigation and allow us to assess the contractor's work with respect to the project plans and specifications and the recommendations presented herein. If SAGE is not retained for these services, we cannot assume responsibility for any and all potential claims that may arise during or after construction as a result of misuse or misinterpretation of SAGE's report by others.

9.0 LIMITATIONS

This report has been prepared for the sole use of Sonoma County Water Agency and their agents specifically for the design of the Dry Creek Habitat Enhancement Demonstration Projects described herein. The opinions, conclusions, and recommendations contained in this report are based upon the information obtained from our site subsurface exploration, our engineering studies, experience, and engineering judgment, and have been formulated in accordance with generally accepted geotechnical engineering practices that exist at the time this report was prepared. No other warranty, expressed or implied, is made or should be inferred. In addition, the recommendations presented in this report are based on the subsurface conditions encountered in a limited number of test pits and borings. Actual conditions may vary. If subsurface conditions encountered in the field differ from those described in this report, we should be consulted to determine if changes to our conclusions or supplemental recommendations are required.

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The opinions presented in this report are valid as of the date of this report for the property being evaluated. Changes in the condition of a property can occur with the passage of time, whether due to natural processes or the works of man. If site conditions vary from those described herein, we should be consulted to evaluate the impact of the changes, if any. In addition, changes in applicable standard of practice can occur, whether from legislation or the broadening of knowledge. Accordingly, the opinions presented in this report may be invalidated, wholly or partially, by changes outside of SAGE's control. In any case, this report should not be relied upon after a period of three years without prior review and approval by SAGE.

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FIGURES

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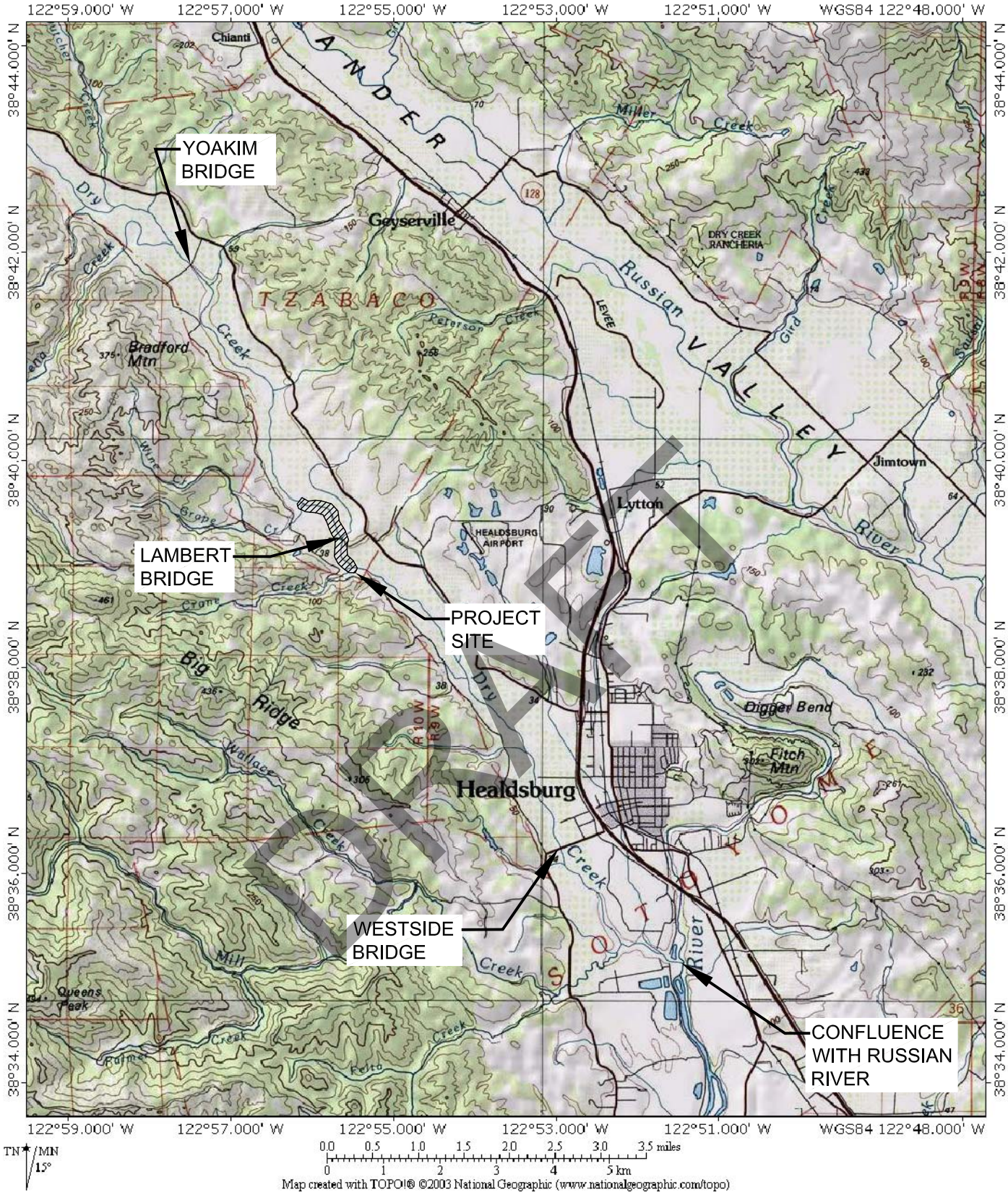

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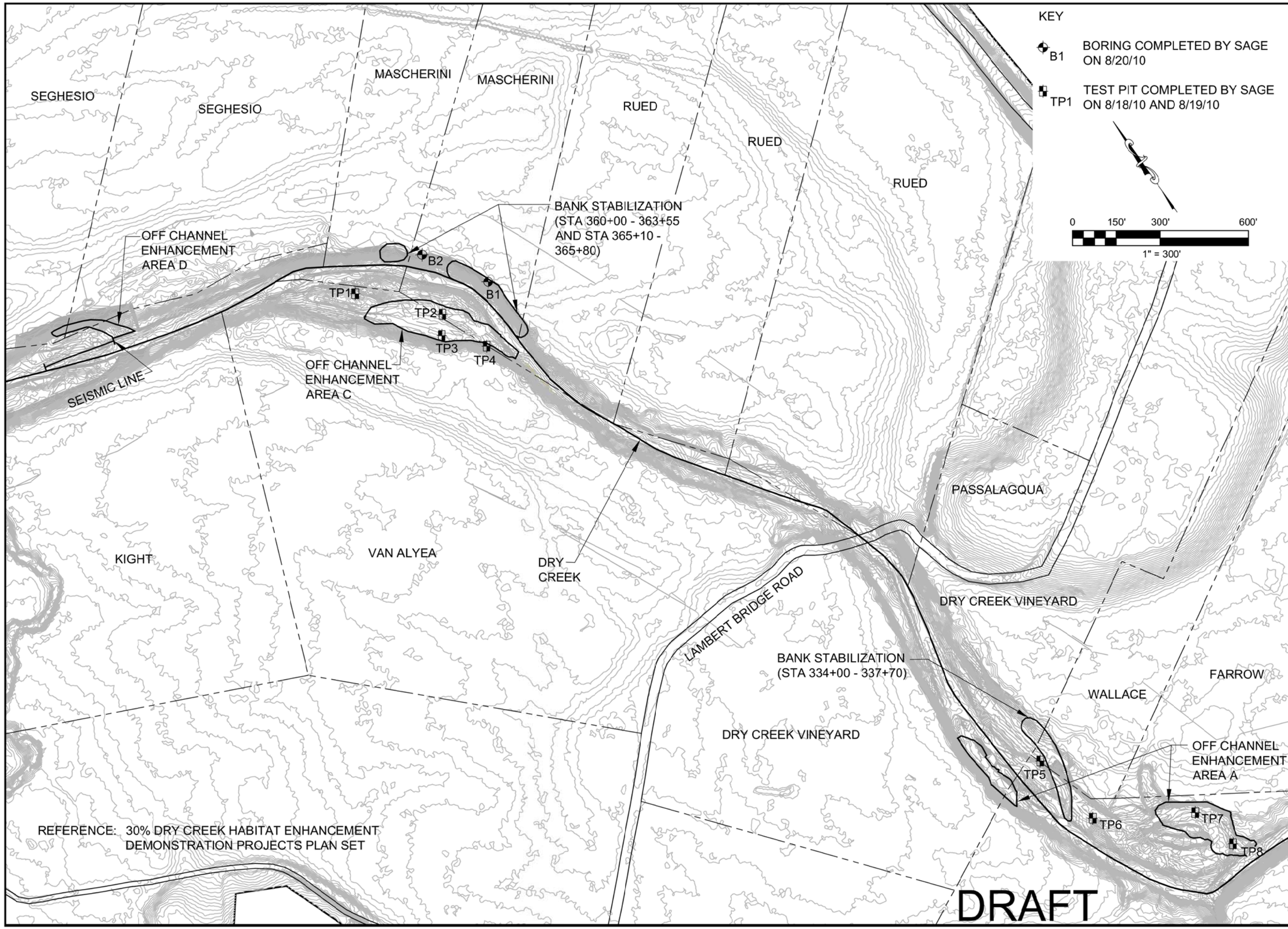
DRY CREEK HABITAT ENHANCEMENT DEMONSTRATION PROJECTS

SONOMA COUNTY — SITE LOCATION MAP — CALIFORNIA

FIG 1

DATE: 03/11/11	FILE: 07-082.02	SCALE: NONE	JOB NO.: 07-082.02

F:\1-PROJECTS\2007\07-082 Dry Creek Habitat Restoration\2 - Demonstration Reach Geotechnical Invest. (Phase 3 - Task 3.02)\DRAWINGS\IFI_DRY_CR_BASE_100110.dwg, 2011-03-11 5:41:29 PM, rabernathy, Letter, 1:1



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SUBSURFACE EXPLORATION MAP

DRY CREEK HABITAT ENHANCEMENT DEMONSTRATION PROJECTS

COUNTY OF SONOMA CALIFORNIA

REV	BY	DATE	DESCRIPTION
1	-	-	-

DATE: 03/11/11
SCALE: 1" = 300'
DESIGNED BY: RMA
DRAFTED BY: RMA
CHECKED BY: DGK
JOB NO.: 07-082.02
FILE: 07-082.00

FIG 2

F:\1-PROJECTS\2007\07-082 Dry Creek Habitat Restoration\2 - Demonstration Reach Geotechnical Invest. (Phase 3 - Task 3.02)\DRAWINGS\IFI_DRY_CR_BASE_100110.dwg, 2011-03-11 5:46:27 PM, rabernathy, Tabloid, 1:1

APPENDIX A
Field Exploration Program

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A.1 Field Exploration Program

Our field exploration program consisted of excavating eight (8) test pits and drilling two (2) small-diameter soil borings. The approximate test pit and boring locations, designated TP1 through TP8 and B1 through B2, respectively, are presented on Figure 2.

Prior to the start of drilling, SAGE obtained a drilling permit from the Sonoma County Permit and Resource Management Department (PRMD) and notified Underground Service Alert (USA) at least 48 hours prior to the start of work. Furthermore, all borings and test pits were cleared by a private utility locator.

The test pits were excavated by Luce Backhoe Excavation of Santa Rosa, California. Test pits TP1 through TP4 were excavated on August 18, 2010 using a CAT 416C rubber-tire backhoe equipped with a 24-inch bucket. Test pits TP5 through TP8 were excavated on August 19, 2010 using a CAT 315L track-mounted excavator equipped with a 42-inch bucket. The test pit depths were limited to 13.5 feet or less due to caving conditions below groundwater.

Borings B1 and B2 were drilled on August 20, 2010 by Clear Heart Drilling of Santa Rosa, California. The borings were drilled using a truck-mounted DR5K1 drill rig equipped with seven-inch-diameter hollow stem augers. B1 and B2 were advanced to a depth of 41.5 feet below the existing ground surface, which corresponds to 21.3 and 23.2 feet below the existing channel bed invert, respectively.

During excavation of the test pits and drilling of the borings, our geologist logged the materials encountered and obtained representative samples for visual classification and laboratory testing. The materials encountered were classified in general accordance with the Unified Soil Classification System (USCS) as summarized on Figure A-1. Logs of the borings and test pits are presented as Figures A-2 through A-3 and Figure A-4, respectively.

Representative soil samples were recovered during drilling using the following sampler types:

- Modified California (MCA) split-barrel sampler with a 3.0-inch-outside diameter fitted with 2.43-inch-inside-diameter, six-inch-long brass or stainless steel liners;
- Standard Penetration Test (SPT) split-barrel sampler with a 2.0-inch-outside diameter, without liners; and

Both split-barrel samplers were driven with a 140-pound, safety (rope and cathead) hammer falling 30 inches. The blow counts required to drive the samplers over a standard 18-inch-drive were recorded in six-inch increments in the field. Where refusal was encountered, defined as greater than 50 blows over any six-inch increment, drive lengths less than 12 inches were also recorded. The final 12-inches of the drive (less in the case of refusal) were added to develop the reported blow count. The blow counts for the MCA sampler were corrected for the effects of sampler size and converted to SPT N-values using a conversion factor of 0.6. The final, corrected values for each drive are presented on the boring logs and represent N_{60} values.

Due to the proximity of the borings to Dry Creek, grout migration through the coarse grained alluvial deposits and into the creek was a concern. To mitigate this, our geologist obtained verbal

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approval from the on-site Sonoma County PRMD inspector to backfill the borings with soil cuttings to 15 feet, and top off with neat cement grout. The remaining cuttings were spread out on the ground surface adjacent to the boring.

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UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions		Symbols	Typical Names
Coarse-Grained Soils (more than holf of soil > No. 200 sieve size)	Gravels (More than half of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	Sands (More than half of coarse fraction > No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils (more than holf of soil < No. 200 sieve size)	Silts and Clays LL = < 50	ML	Inorganic silts and clayey silts of low plasticity, sandy silts, gravelly silts
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	Silts and Clays LL = > 50	MH	Inorganic silts of high plasticity
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic silts and clays of high plasticity
Highly Organic Soils		PT	Peat and other highly organic soils

GRAIN SIZE CHART

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size in Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel		
coarse	3" to No.4	76.2 to 4.76
fine	3" to 3/4"	76.2 to 19.1
	3/4" to No. 4	19.1 to 4.76
Sand		
coarse	No. 4 to No. 200	4.76 to 0.074
medium	No. 4 to No. 10	4.76 to 2.00
fine	No. 10 to No. 40	2.00 to 0.420
	No. 40 to No. 200	0.420 to 0.074
Silt and Clay	Below No. 200	Below 0.074

TYPES OF STRENGTH TESTS

PP	Pocket Penetrometer
TV	Field Torvane
LVS	Laboratory Vane Shear
UC	Unconfined Compression
TXUU	Triaxial, unconsolidated, undrained
DS	Direct Shear

Unstabilized (initial) groundwater level

Stabilized groundwater level

SAMPLER TYPE

C — Core barrel

O — Osterberg piston sampler using 3.0-inch outside diameter, thin-walled Shelby tube

PT — Pitcher tube sampler using 3.0-inch outside diameter, thin-walled Shelby tube

ST — Shelby tube (3.0-inch outside diameter, thin-walled tube) advanced with hydraulic pressure

BULK — Disturbed grab sample

CA — California split-barrel sampler with 2.5-inch outside diameter and 1.93-inch inside diameter

MCA — Modified California split-barrel sampler with 3.0-inch outside diameter and 2.5-inch inside diameter

SPT — Standard Penetration Test (SPT) split-barrel sampler with a 2.0-inch outside diameter and a 1.5-inch inside diameter

Sampling attempted without recovery

DRY CREEK HABITAT ENHANCEMENT DEMONSTRATION PROJECTS

Sonoma County California

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SOIL CLASSIFICATION CHART

Project No. 07-082.02

Date 10/29/10 Figure A-1

PROJECT: Dry Creek Demonstration Reach, Sonoma County, CA	**LOG OF BORING** B1	Sheet 1 of 2
BORING LOCATION: See Figure 2	**DRILLING SUBCONTRACTOR:** Clear Heart Drilling	
DATE STARTED: 8/20/2010 **DATE FINISHED:** 8/20/2010	**DRILL RIG:** DR5KI Truck Mounted	
LOGGED BY: D. Kennedy	**DRILLING METHOD:** 7-inch hollow stem auger	
ELEVATION (FT): 144.2 **DATUM:** NAVD 88		
GW DEPTH (FT): 22.7 **GW DATE:** 8/20/2010	**HAMMER TYPE:** Rope and cathead (safety)	
CASING NOTES: N/A	**HAMMER WT (LBS):** 140 **HAMMER DROP (IN):** 30	
BACKFILL MATERIAL: Soil cuttings & neat cement	**SAMPLERS:** MCA, SPT	

DEPTH (FT)	ELEV. (FT)	SAMPLE TYPE	SAMPLE	SPT N60 VALUE	LITHOLOGY	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	FINES (%)	TYPE of TEST	UNCONFINED STRENGTH (tsf)	SHEAR STRENGTH (ksf)	PLASTICITY LL	PLASTICITY PI
						LABORATORY TEST DATA								
1	143				SM	SILTY SAND (SM) yellow brown, loose, moist, fine grained sand								
2	142													
3	141	MCA		7										
4	140													
5	139													
6	138	MCA		12	SP	SAND (SP) brown, medium dense, moist, fine grained sand, trace silt, locally grades to medium grained sand								
7	137													
8	136	MCA		8		loose, with SILTY SAND (SM) interbeds								
9	135													
10	134													
11	133	MCA		12	SM	SILTY SAND (SM) brown, medium dense, moist, fine grained sand, approximately 25% fines								
12	132													
13	131					gravel at 13.5 based on change in drilling								
14	130				GM	SILTY SANDY GRAVEL (GM) brown, medium dense, moist, fine gravel with some coarse gravel, medium to coarse sand, trace fines								
15	129													
16	128	SPT		25										
17	127													
18	126													
19	125					GRAVEL WITH SILT AND SAND (GW-GM)								

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MCA and SPT blow counts converted to SPT N60 values using conversion factors of 0.6 and 1.0, respectively.

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Project No: 07-082.02
Figure: A-2

PROJECT: Dry Creek Demonstration Reach
Sonoma County, CA

LOG OF BORING B1

DEPTH (FT)	ELEV. (FT)	SAMPLE TYPE	SAMPLE	SPT N60 VALUE	LITHOLOGY	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	FINES (%)	TYPE of TEST	UNCONFINED STRENGTH (tsf)	SHEAR STRENGTH (ksf)	PLASTICITY LL	PLASTICITY PI
						LABORATORY TEST DATA								
21	123	MCA		18		brown, medium dense, moist, primarily fine gravel with coarse sand, medium grained sand lenses locally			6.6					
						GRAVEL WITH SILT AND SAND (GW-GM) (Con't)								
22	122					**Approximate elevation of channel bed invert**								
						8/20/2010								
23	121				GW-GM	softer drilling below 22.7', groundwater encountered								
24	120													
25	119					gravel size increases, fine to coarse gravel, decreased sand content locally, wet								
26	118	MCA		17										
27	117													
28	116					GRAVELLY SILTY SAND (SW) brown gray, medium dense, wet, medium to coarse grained sand, fine to coarse gravel (1/4" to 1"), some silt								
29	115													
30	114													
31	113	MCA		16										
32	112													
33	111													
34	110													
35	109				SW	dense, coarse grained sand, gravels up to 2.5"								
36	108	MCA		31										
37	107													
38	106													
39	105													
40	104					medium to coarse grained sand, reduced gravel content, with some clay locally								
41	103	SPT		36										
42	102													
43	101													

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Boring terminated at a depth of 41.5 feet below existing ground surface.
MCA and SPT blow counts converted to SPT N60 values using conversion factors of 0.6 and 1.0, respectively.

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Project No: 07-082.02
Figure: A-2

PROJECT: Dry Creek Demonstration Reach, Sonoma County, CA	**LOG OF BORING** B2	Sheet 1 of 2
BORING LOCATION: See Figure 2	**DRILLING SUBCONTRACTOR:** Clear Heart Drilling	
DATE STARTED: 8/20/2010 **DATE FINISHED:** 8/20/2010	**DRILL RIG:** DR5KI Truck Mounted	
LOGGED BY: D. Kennedy	**DRILLING METHOD:** 7-inch hollow stem auger	
ELEVATION (FT): 142.3 **DATUM:** NAVD 88		
GW DEPTH (FT): 20.0 **GW DATE:** 8/20/2010	**HAMMER TYPE:** Rope and cathead (safety)	
CASING NOTES: N/A	**HAMMER WT (LBS):** 140 **HAMMER DROP (IN):** 30	
BACKFILL MATERIAL: Soil cuttings and neat cement	**SAMPLERS:** MCA, SPT	

DEPTH (FT)	ELEV. (FT)	SAMPLE TYPE	SAMPLE	SPT N60 VALUE	LITHOLOGY	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	FINES (%)	TYPE of TEST	UNCONFINED STRENGTH (tsf)	SHEAR STRENGTH (ksf)	PLASTICITY LL	PLASTICITY PI
						SANDY CLAY (CL) brown, medium stiff to stiff, moist, fine grained sand								
1	141													
2	140													
3	139													
4	138													
5	137				CL									
6	136	MCA		6		silty sand lense			64.6					
7	135													
8	134	MCA	○	6										
9	133													
10	132													
11	131	MCA		6		SILTY SAND (SM) brown, loose, moist, fine grained sand DSDC: Ø=24°, c=250psf; See Appendix B	20.8	88						
12	130													
13	129				SM									
14	128													
15	127					GRAVELLY SILTY SAND (SM) brown, medium dense to dense, moist, medium to coarse sand, fine gravel, trace fines, weakly cemented locally								
16	126	MCA		26										
17	125													
18	124					**Approximate elevation of channel bed invert**								
19	123				8/20/2010									

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MCA and SPT blow counts converted to SPT N60 values using conversion factors of 0.6 and 1.0, respectively.

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Project No: 07-082.02
Figure: A-3

PROJECT: Dry Creek Demonstration Reach
Sonoma County, CA

LOG OF BORING B2

DEPTH (FT)	ELEV. (FT)	SAMPLE TYPE	SAMPLE	SPT N60 VALUE	LITHOLOGY	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	FINES (%)	TYPE of TEST	UNCONFINED STRENGTH (tsf)	SHEAR STRENGTH (ksf)	PLASTICITY LL	PLASTICITY PI
					SM	GRAVELLY SILTY SAND (SM) (Con't) some clay								
21	121	SPT		24										
22	120													
23	119													
24	118													
25	117													
26	116	MCA		6	SC	CLAYEY SAND (SC) gray, loose, wet, fine grained sand, marsh or overbank deposit								
27	115	SPT		28	SM	GRAVELLY SILTY SAND (SM) brown, medium dense to dense, wet, medium to coarse sand, fine gravel with some coarse gravel, with thin clay lenses								
28	114													
29	113				SP	SAND (SP) gray, loose to medium dense, wet, medium grained sand, trace fines								
30	112	MCA		17		GRAVELLY SILTY SAND (SM) brown, medium dense, wet, medium to coarse grained sand, fine gravel with some coarse gravel								
31	111													
32	110				SM									
33	109													
34	108													
35	107	MCA		30		SILTY SANDY GRAVEL (GM) brown to yellow brown, dense, wet, with locally clean gravel lenses								
36	106													
37	105													
38	104				GM									
39	103													
40	102	SPT		25		little to no coarse gravel								
41	101													
42	100													
43	99													

LABORATORY TEST DATA

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Boring terminated at a depth of 41.5 feet below existing ground surface.
MCA and SPT blow counts converted to SPT N60 values using conversion factors of 0.6 and 1.0, respectively.

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Figure: A-3

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FIGURE A-4 – LOGS OF TEST PITS TP1 THROUGH TP8

Test Pit Number	Depth (feet)	Soil Classification	Soil Description
TP1 (El. 126.0)	0' – 1'	SILTY GRAVEL (GM)	brown, loose to medium dense, dry with some sand, fine to coarse gravel, with organics
	1' – 6'	SANDY GRAVEL (GW)	brown, loose, moist to 3.5', wet below 3.5', primarily fine gravel with some coarse gravel, medium to coarse sand, with fines; Laboratory Gradation: 64.3% gravel, 35.4% sand, 0.3% fines Groundwater encountered at El. 122.8'
TP2 (El. 128.3)	0' – 0.5'	SILTY GRAVEL (GM)	brown, loose to medium dense, dry, with some sand, fine to coarse gravel, with organics
	0.5' – 3.5'	SANDY GRAVEL (GW – GM)	brown, loose, dry to moist, primarily fine gravel with some coarse gravel, medium to coarse sand, trace fines, clean gravel interbeds locally, estimate 50% gravel (40% fine, 10% coarse), 45% sand, 5% fines
	3.5' – 10'	GRAVELLY SAND (SW)	brown gray, medium dense, moist to 6.5', wet below 6.5', medium to coarse grained sand, gravel primarily fine with some coarse, trace fines; Laboratory Gradation: 37.7% gravels, 61.7% sand, 0.6% fines Groundwater encountered at El. 121.8'
TP3 (El. 131.1)	0' – 0.5'	GRAVELLY SILT (ML)	brown, soft to medium stiff, dry, with some sand, fine to coarse gravel, with organics
	0' – 3.0'	SANDY GRAVEL (GW – GM)	brown, loose to medium dense, dry, primarily fine gravel with some coarse gravel, medium to coarse sand, trace fines, clean gravel interbeds locally ,estimate 60% gravel (50% fine, 10% coarse), 35% sand, 5% fines
	3.0' – 4.5'	SAND WITH GRAVEL (SP)	brown, loose, dry to moist, medium grained sand, with fine to coarse gravel, some organics/roots, estimate 70% sand, 30% gravel
	4.5' – 12'	GRAVELLY SAND (SW)	brown gray, medium dense, moist to 8.5', wet below 8.5', medium to coarse grained sand, fine to coarse gravel, trace fines, estimate 60% sand, 35% gravel (25% fine, 10% coarse), 5% fines Groundwater encountered at El. 122.6'

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TP4 (El. 126.6)	0' – 4'	GRAVELLY CLAY (CL)	brown, medium stiff, dry to moist, with some sand, fine to coarse gravel, with organics
	4' – 11'	SANDY GRAVEL (GW – GM)	brown gray, medium dense, moist to 4.4', wet below 4.4', primarily coarse grained sand with medium grained sand, fine to coarse gravel, trace fines, estimate 35% sand, 55% gravel (35% fine, 20% coarse), 10% fines, trace cobble Groundwater encountered at El. 122.2'
TP5 (El. 119.2)	0' – 10'	SANDY GRAVEL (GW –GM)	brown gray, loose to medium dense, moist, wet below 2.5', fine to coarse gravel, medium to coarse sand, trace cobbles (up to 6"), traces fines, estimate 60% gravel (40% fine, 20% coarse), 30% sand, 5% cobbles, 5% fines Groundwater encountered at El. 117.6'
TP6 (El. 118.5)	0' – 10.5'	SANDY GRAVEL (GW – GM)	brown gray, loose to medium dense, moist, wet below 2.4', fine to coarse gravel, medium to coarse sand, trace cobbles (up to 10"), trace fines; Laboratory Gradation: 64.4% gravel, 35.1% sand, 0.5% fines CLAYEY SAND (SC) interbed at ~10', medium grained, increased clay content locally, estimate interbed is less than 0.5' thick Groundwater encountered at El. 115.9'
TP7 (El. 121.4)	0' – 3.8'	SANDY GRAVEL (GW)	brown gray, loose to medium dense, moist, fine to coarse gravel, medium to coarse sand, trace fines, estimate 60% gravel (40% fine, 20% coarse), 35% sand, 5% fines
	3.8' – 5.5'	SAND (SP)	olive brown, loose to medium dense, moist, medium grained sand, trace coarse grained sand and fine gravel
	5.5' – 13.5'	SANDY GRAVEL (GW – GM)	brown gray, loose to medium dense, moist, wet below 6', fine to coarse gravel, medium to coarse sand, trace fines, trace cobbles, cobbles up to 6", estimate: 50% gravel (30% fine, 20%), 40% sand, 5% cobbles, 5% fines Groundwater encountered at El. 115.5'
TP8 (El. 118.0)	0' – 9'	SANDY GRAVEL (GW)	brown gray, loose to medium dense, dry in upper 1.5', moist 1.5' – 3.1', wet below 3.1', fine to coarse gravel, medium to coarse sand, trace fines (<5%), no cobbles observed, thin (~3") clean gravel (fine) lenses visible in upper 3' where pit can be safely accessed, increased sand content locally, estimate 50% gravel (30% fine, 20% coarse), 45+% sand, <5% fines Groundwater encountered at El. 114.9'

APPENDIX B
Laboratory Test Results

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B.1 Laboratory Testing

Representative soil samples obtained from the borings were reviewed in our office to confirm field classifications. Representative samples were selected and submitted for laboratory testing. Samples were selected based on how representative they were of surrounding materials. Laboratory testing was performed to determine the following properties:

- Percent Passing the No. 200 sieve (Fines Content) per ASTM D1140;
- Consolidated-Drained Direct Shear (DSCD) per ASTM D3080;
- Particle Size Analysis per ASTM D422;

LABORATORY TESTING SUMMARY

Boring/Test Pit	Laboratory Test	Approximate Samp Depth (ft)
B1	Percent Passing No. 200	21
B2	Percent Passing No. 200	5.5
B2	Direct Shear	11
TP1	Particle Size Analysis	3
TP2	Particle Size Analysis	5.5
TP6	Particle Size Analysis	6.5

The laboratory reporting sheets for the laboratory testing follow. Note that there are two Direct Shear result sheets because the test was run twice with two different normal loads on the sample. A minimum of two different normal loads are required in order to calculate cohesion and internal friction.

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GRAIN SIZE ANALYSIS – WASH

Project	Sage Project No. 07-082.02	Job No.	110033		
Project Name	Dry Creek Phase 3	Boring No.	B1	Sample No.	6
Tested By	RD	Depth of Sample	21.0 ft		
Reviewed By	PF	Date of Testing	9/10/10		

Before Wash		**After Wash**	
Wt. of dry sample + Container (g)	941.6	Wt. of dry sample + Container (g)	889.3
Wt. of Container (g)	143.6	Wt. of Container (g)	143.6
Wt. of dry sample (g)	798.0	Wt. of dry sample(g)	745.7

Sieve analysis and grain shape

Sieve No.	Diam. (mm)	Wt. Retained	% Retained	% Passing
#200	0.075	745.7	93.4	6.6

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GRAIN SIZE ANALYSIS – WASH

Project	Sage Project No. 07-082.02	Job No.	110033		
Project Name	Dry Creek Phase 3	Boring No.	B2	Sample No.	1
Tested By	RD	Depth of Sample	5.5 ft		
Reviewed By	PF	Date of Testing	9/13/10		

Before Wash		**After Wash**	
Wt. of dry sample + Container (g)	785.5	Wt. of dry sample + Container (g)	359.2
Wt. of Container (g)	125.2	Wt. of Container (g)	125.2
Wt. of dry sample (g)	660.3	Wt. of dry sample(g)	234.0

Sieve analysis and grain shape

Sieve No.	Diam. (mm)	Wt. Retained	% Retained	% Passing
#200	0.075	234.0	35.4	64.6

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DIRECT SHEAR TEST RESULT

(ASTM D3080)

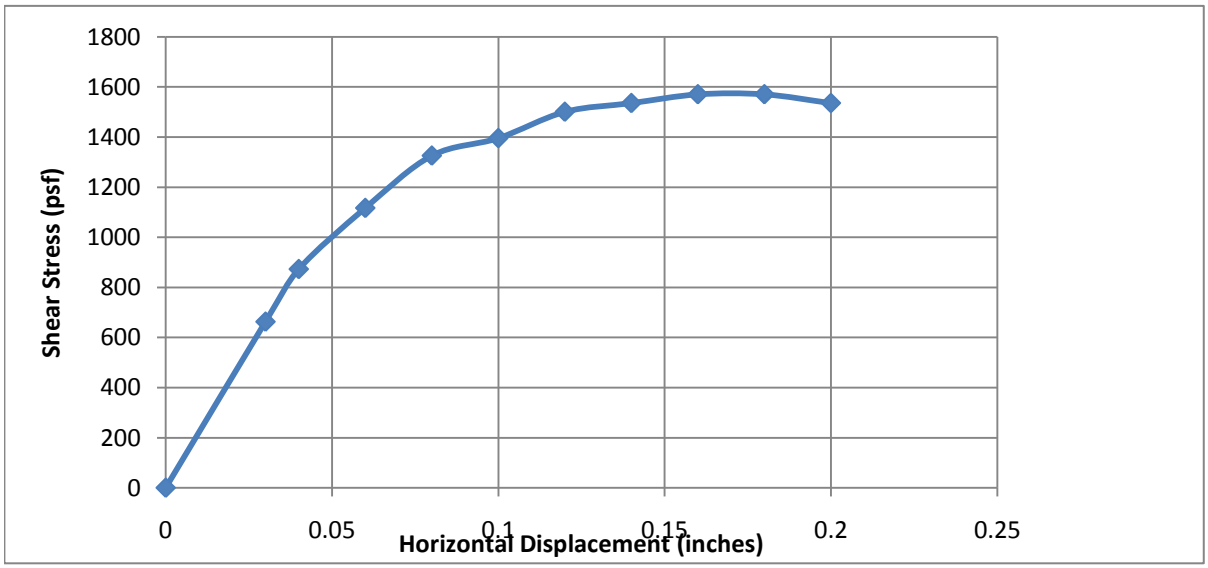
Horizontal Displacement (inches)	Shear Stress (psf)
0	0
0.03	663
0.04	873
0.06	1117
0.08	1326
0.1	1396
0.12	1501
0.14	1536
0.16	1571
0.18	1571
0.2	1536

Client: SAGE P.N. 110033
Date: 9-15-10
Sample No: B2-2 @ 11 ft.
Initial water content: 20.8 %
Final water content: 24.6 %
Dry density: 87 pcf

Sample sheared at strain rate = 0.031 in/min
Sample submerged, unconsolidated

Maximum Vert. Displacement: 0.173 inches

Normal Load = 3000 psf



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DIRECT SHEAR TEST RESULTS

(ASTM D3080)

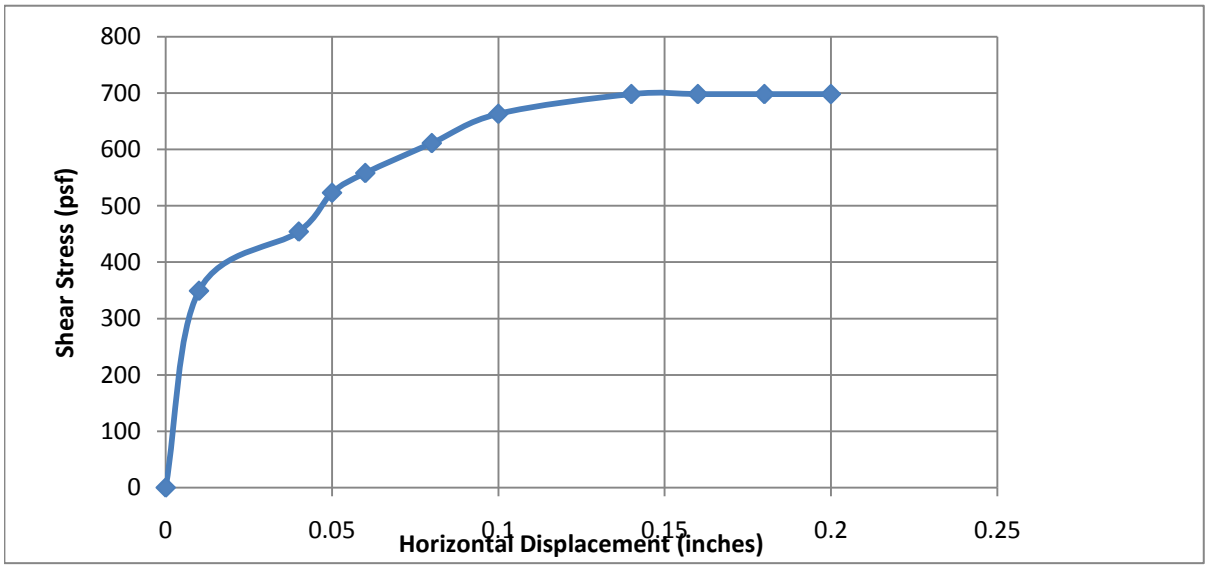
Horizontal Displacement (inches)	Shear Stress (psf)
0	0
0.01	349
0.04	454
0.05	523
0.06	558
0.08	611
0.1	663
0.14	698
0.16	698
0.18	698
0.2	698

Client: SAGE P.N. 110033
Date: 9-15-10
Sample No: B2-2 @ 11 ft.
Initial water content: 20.8 %
Final water content: 27.7%
Dry density: 88 pcf

Sample sheared at strain rate = 0.031 in/min
Sample submerged, unconsolidated

Maximum Vert. Displacement: 0.12 inches

Normal Load = 1000 psf



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GRAIN SIZE ANALYSIS – MECHANICAL

Project	Sage Project No. 07-082.02	Job No.	110033		
Project Name	Dry Creek Phase 3	Boring No.	TP1	Sample No.	1
Tested By	RD	Depth of Sample	3 ft		
Reviewed By	PF	Date of Testing	9/9/10		

Wt. of dry sample + Container (g)	2329.0
Wt. of Container (g)	363.0
Wt. of dry sample (g)	1966.0

Sieve analysis and grain shape

Sieve No.	Diam. (mm)	Wt. Retained	% Retained	% Passing
3”	75.0	0	0	100.0
2”	50.0	0	0	100.0
1 ½”	37.5	0	0	100.0
1”	25.0	103	5.2	94.8
¾”	19.0	356	18.1	81.9
½”	12.7	645	32.8	67.2
3/8”	9.5	838	42.6	57.4
#4	4.75	1265	64.3	35.7
#10	2.0	1628	82.8	17.2
#20	0.850	1836	93.4	6.6
#40	0.425	1896	96.4	3.6
#60	0.250	1934	98.4	1.6
#140	0.106	1957	99.5	0.5
#200	0.075	1960	99.7	0.3
PAN		1966	100	0.0

% passing = 100 - ∑% retained

% Cobbles >3”	**% Gravel** <3” to >#4	**% Sand** <#4 to >#200	**% Silt & Clay** <#200
0	64.3	35.4	0.3

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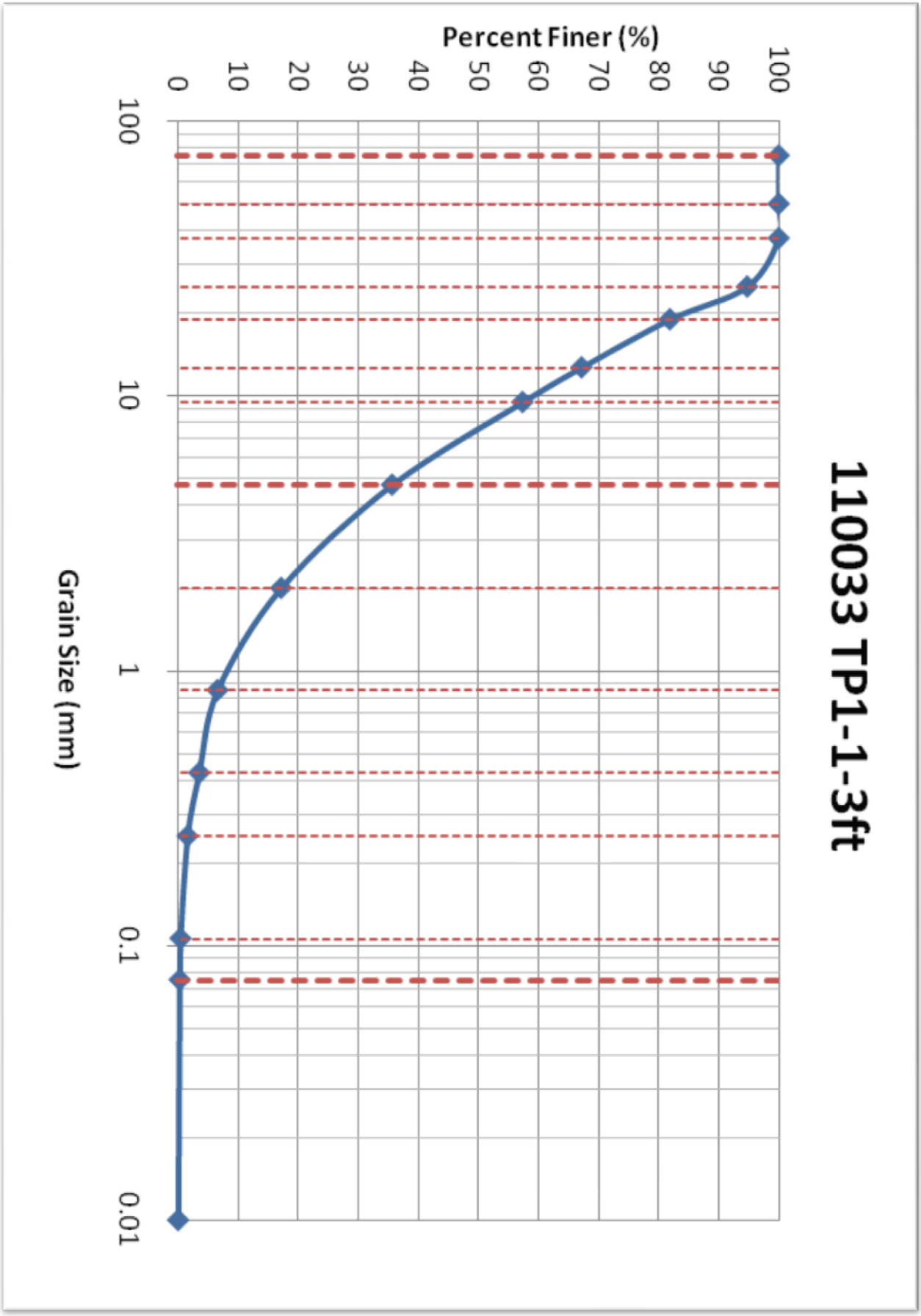
110033 TP1-1-3ft
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
Grain Size (mm)

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GRAIN SIZE ANALYSIS – MECHANICAL

Project	Sage Project No. 07-082.02	Job No.	110033		
Project Name	Dry Creek Phase 3	Boring No.	TP2	Sample No.	1
Tested By	RD	Depth of Sample	5.5 ft		
Reviewed By	PF	Date of Testing	9/9/10		

Wt. of dry sample + Container (g)	3156.0
Wt. of Container (g)	363.0
Wt. of dry sample (g)	2793.0

Sieve analysis and grain shape

Sieve No.	Diam. (mm)	Wt. Retained	% Retained	% Passing
3”	75.0	0	0	100.0
2”	50.0	0	0	100.0
1 ½”	37.5	0	0	100.0
1”	25.0	0	0	100.0
¾”	19.0	145	5.2	94.8
½”	12.7	320	11.4	88.5
3/8”	9.5	519	18.6	81.4
#4	4.75	1052	37.7	62.3
#10	2.0	1743	62.8	37.2
#20	0.850	2225	79.7	20.3
#40	0.425	2458	88.0	12.0
#60	0.250	2617	93.7	6.3
#140	0.106	2758	98.7	1.3
#200	0.075	2776	99.4	0.6
PAN		2792	100.0	0.0

% passing = 100 - ∑% retained

% Cobbles >3”	**% Gravel** <3” to >#4	**% Sand** <#4 to >#200	**% Silt & Clay** <#200
0	37.7	61.7	0.6

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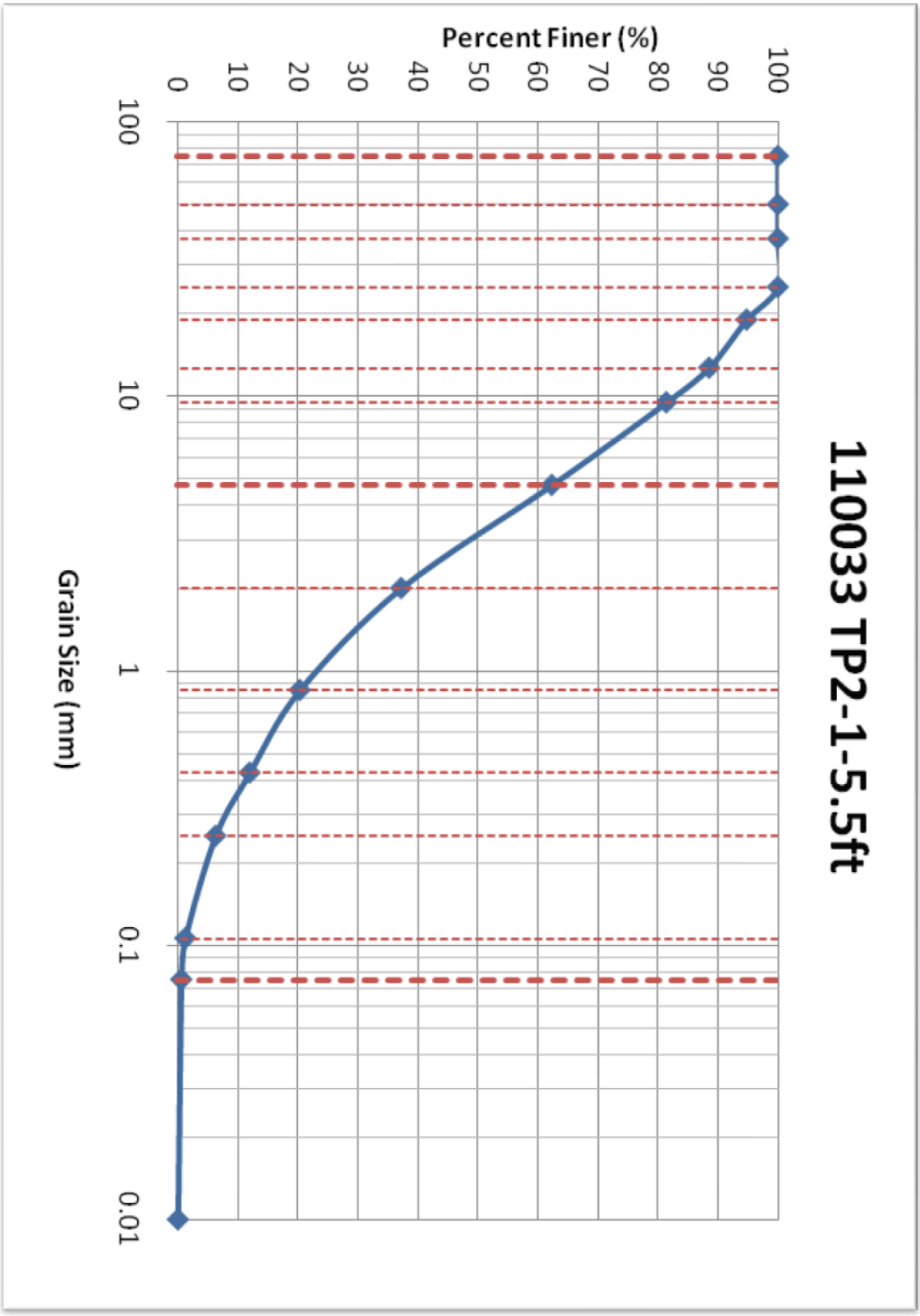
110033 TP2-1-5.5ft
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
Grain Size (mm)

EARTHTEC, Inc.
GEOTECHNICAL ENGINEERS • SPECIAL INSPECTORS
GEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

GRAIN SIZE ANALYSIS – MECHANICAL

Project	Sage Project No. 07-082.02	Job No.	110033		
Project Name	Dry Creek Phase 3	Boring No.	TP6	Sample No.	1
Tested By	RD	Depth of Sample	6.5 ft		
Reviewed By	PF	Date of Testing	9/8/10		

Wt. of dry sample + Container (g)	3339.0
Wt. of Container (g)	947.0
Wt. of dry sample (g)	2392.0

Sieve analysis and grain shape

Sieve No.	Diam. (mm)	Wt. Retained	% Retained	% Passing
3”	75.0	0	0.0	100.0
2”	50.0	0	0.0	100.0
1 ½”	37.5	159	6.6	93.4
1”	25.0	303	12.7	87.3
¾”	19.0	497	20.8	79.2
½”	12.7	807	33.7	66.3
3/8”	9.5	1044	43.6	56.4
#4	4.75	1540	64.4	35.6
#10	2.0	1957	81.8	18.2
#20	0.850	2174	90.9	9.1
#40	0.425	2285	95.5	4.5
#60	0.250	2342	97.9	2.1
#140	0.106	2372	99.2	0.8
#200	0.075	2379	99.5	0.5
PAN		2392	100.0	0.0

% passing = 100 - ∑% retained

% Cobbles >3”	**% Gravel** <3” to >#4	**% Sand** <#4 to >#200	**% Silt & Clay** <#200
0	64.4	35.1	0.5

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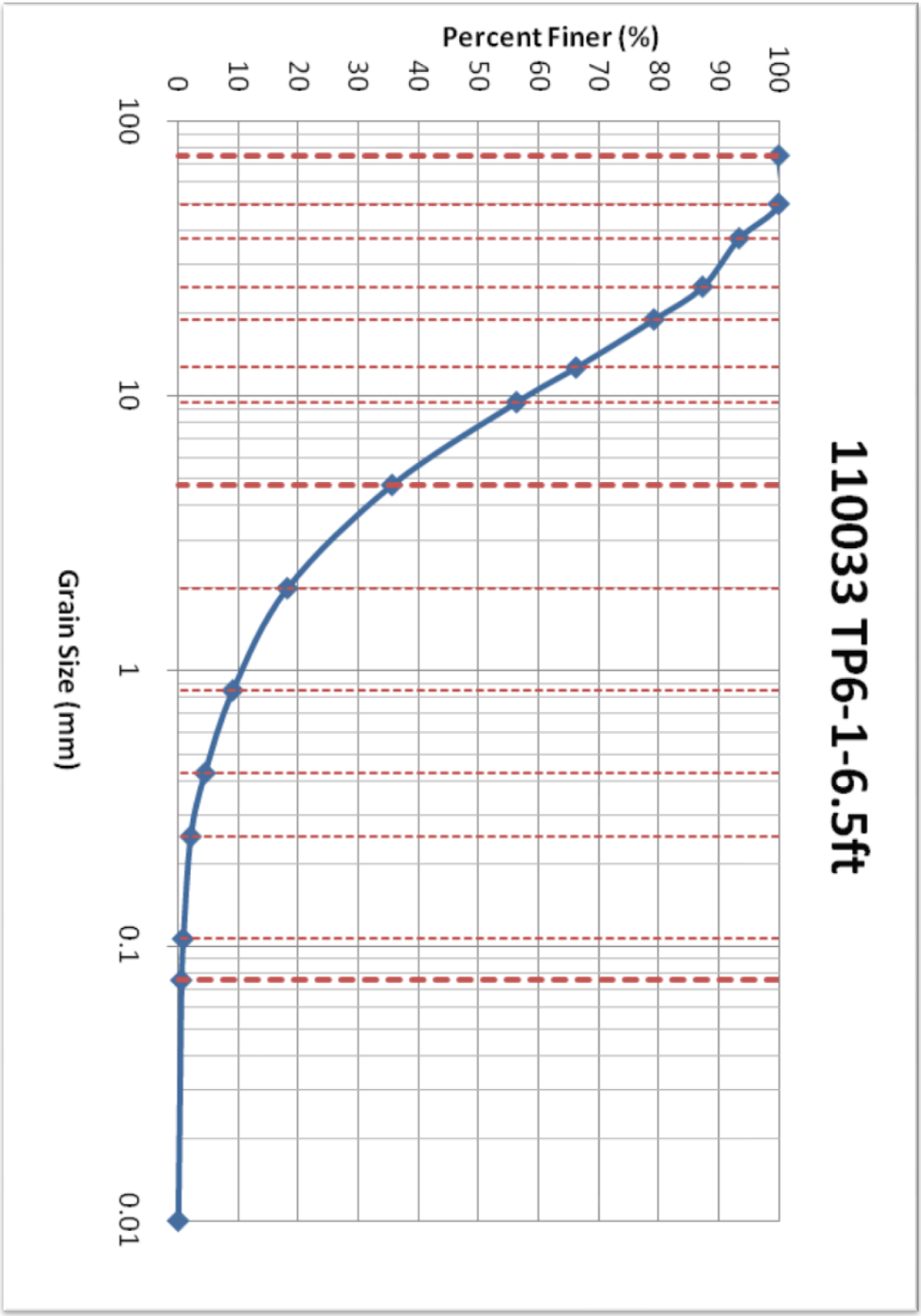

110033 TP6-1-6.5ft
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
Grain Size (mm)

APPENDIX C
Geophysical Survey Report

DRAFT

SANDERS & ASSOCIATES GEOSTRUCTURAL ENGINEERING
sage
INTEGRATING EARTH & STRUCTURE

NORCAL GEOPHYSICAL CONSULTANTS, INC.

November 09, 2010

Mr. Drew G. Kennedy
Sanders & Associates Geostructural Engineering
4180 Douglas Blvd., Ste. 100
Granite Bay, CA 95746

Subject: Seismic Refraction Survey
Dry Creek Habitat Enhancement Demonstration Project
Off Channel Enhancement Area D, Demonstration Reach
Sonoma County, California
NORCAL Job # 10-916.04

Dear Mr. Kennedy:

This report presents the findings of a seismic refraction (SR) survey performed by NORCAL Geophysical Consultants, Inc. along Dry Creek in Sonoma County, CA. The survey was performed on October 20, 2010 by NORCAL Professional Geophysicists William E. Black and Donald J. Kirker, and geophysical technician David Spaulding. Logistical support was provided by Drew Kennedy of Sanders & Associates Geostructural Engineering (SAGE).

1.0 SITE DESCRIPTION AND PURPOSE

The geophysical survey was conducted in the "Off Channel Enhancement Area D" of the Demonstration Reach of Dry Creek. It is located approximately 6 miles downstream of the Warm Springs Dam on the Seghesio Parcel. The site comprises a relatively flat river cut terrace that is heavily vegetated. The parcel is accessed by a gravel/dirt road from an adjacent vineyard north of the creek.

The local geology, as indicated by SAGE, consists of alluvium (interbedded clays, silt, sand, and gravel) over Great Valley Complex sedimentary bedrock (sandstone, siltstone, and shale).

The seismic refraction survey was conducted along one line, as shown on Plate 1. It is designated as Line 1-1 and trends along the north bank of Dry Creek. Surface elevations along Line 1-1 range from 127- to 131-ft above mean sea level (msl).

The purpose of the SR survey was to obtain seismic refraction data to aid in evaluating the thickness of overburden and the depth and excavation characteristics (rippability) of the bedrock. We understand that this information will be used in conjunction with other geotechnical investigations to plan for the construction of backwater ponds and channels associated with habitat enhancements along the creek.

321A BLODGETT STREET • COTATI, CA 94931 • TELEPHONE (707) 796-7170 • FAX (707) 796-7175
www.norcalgeophysical.com

2.0 METHODOLOGY

The SR method is used to determine the compressional velocity of subsurface materials. The seismic velocity of fill, sediments, and rock are dependent on physical properties such as compaction, density, hardness, and induration. However, other factors such as bedding, fracturing, and saturation also affect seismic velocity. Typically, low velocities are indicative of loose soil, poorly compacted fill material, poorly to semi-consolidated sediments, and deeply weathered and highly fractured rock. Moderate velocities are usually indicative of dense and highly compacted sediments and fill, and/or moderately weathered and moderately fractured rock. High velocities are indicative of slightly weathered to unweathered rock with little fracturing. It should be noted that apparent velocities can be affected by the orientation of bedding planes with respect to the direction of the seismic profile. Apparent velocities of rock are typically slower when measured along lines oriented perpendicular to bedding planes of steeply dipping rock, than those measured along lines oriented parallel. A more detailed description of the SR methodology is provided in Appendix A.

3.0 FIELD INVESTIGATIONS

We obtained seismic refraction data along a single transect, designated as Line 1-1 on Plate 1. The line is 246 feet long and is located along the north bank of Dry Creek. It consists of two overlapping spreads that each comprises 24 geophones and three shot points distributed in a collinear array. The geophones were coupled to the ground surface at 6 foot intervals. Two of the shot points were located 6 feet beyond the end geophones of each spread. The third shot point was positioned in the center of the spread.

The SR data were recorded using a Geometrics ***Geode***, 24-bit digital seismic recording system and Oyo Geospace digital-grade geophones with a natural frequency of 10-Hz. We produced seismic energy at each shot point by striking an aluminum plate, placed on the ground surface, with a 16-pound sledge hammer. An accelerometer attached to the hammer transmitted a triggering pulse to the seismograph each time the plate was struck. The resulting travel time data were recorded on a seismograph and processed to generate seismic velocity cross-sections. A more detailed description of data acquisition and analysis procedures are also provided in Appendix A.

4.0 RESULTS

The results of the seismic refraction survey are illustrated by the seismic velocity profile shown on Plate 2. The vertical axis represents elevation (above mean sea level) and the horizontal axis represents distance. The solid line along the top of the profile depicts the ground surface. The color contours represent seismic velocities according to the color scale shown at the bottom of the section.

The profile shown on Plate 2 indicates seismic velocities that range from about 1,000- to over 6,800-ft/s. Since ground truth from borings is not available for comparison to the detected seismic

velocities shown along Line 1, our interpretation of these velocities is based on our observations of local geological conditions evident from nearby rock outcrops and our experience from past seismic surveys. Therefore, we interpret velocities ranging from 1,000 to about 3,000 ft/s (purple to dark blue) as representing surficial soils and unconsolidated sediments. Velocities ranging from 3,000 to 5,000 ft/s (green) are consistent with semi-consolidated sediments, saturated alluvium, and/or highly weathered/fractured bedrock. Velocities of over 5,000 ft/s represent moderately weathered and/or fractured rock. Plate 2 shows that the bedrock is very shallow at the northwest end (less than 2 ft deep) and increases to a depth of about 9-ft at the southeast end.

5.0 EXCAVATION CHARACTERISTICS (Rippability)

The interpreted bedrock exhibits velocities that range from 5,000 to over 6,800 ft/s. Seismic velocity charts relating seismic velocity and excavation characteristics have been developed from field tests by others. These charts list the seismic velocity of various types of rock and their relative ease of excavation using different types of rippers. Caterpillar Tractor Company publishes a performance manual that lists ripper performance charts for the D8L, D9L, and D11L tractors. The following information in Table A was obtained from a performance chart for a D9L Ripper:

Table A: D9L Ripper Performance Chart

PERFORMANCE	ROCK TYPE	VELOCITY RANGE (ft/s)
Rippable	Sedimentary	< 6,400 to 7,800
	Igneous	< 6,700 to 7,600
	Metamorphic	< 7,200 to 7,300
Marginally Rippable	Sedimentary	6,400 to 9,700
	Igneous	6,700 to 8,600
	Metamorphic	7,200 to 9,200
Non-rippable	Sedimentary	> 8,600 to 9,700
	Igneous	> 8,000 to 8,700
	Metamorphic	> 9,000 to 9,200

According to the D9L Ripper Performance chart above, velocities of 5,000 to 6,800 ft/s are consistent with rock that is rippable to marginally rippable. This information should only be used as a general guide, however, as many other factors should also be considered. These factors include rock jointing and fracture patterns, the experience of the equipment operator, and the equipment and excavation methods selected. Also, the computed velocities measured along each profile are an average for each layer, and that the data analysis routine assumes that the velocity of subsurface

materials increase with depth. Therefore, there may be localized zones within each layer where the velocities may be higher or lower than indicated. This is especially true in areas where bedrock is highly bedded and steeply dipping. Also, if a layer has velocities that are slower than those of the material above it, the slower layer will not be resolved. Since the accuracy of our findings is subject to these limitations, it should be noted that subsurface conditions may vary slightly from those depicted in the final results. A more detailed discussion of the limitations with regard to the seismic refraction method is presented in Appendix A.

6.0 STANDARD OF CARE

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate having the opportunity to provide you with this information.

Respectfully,

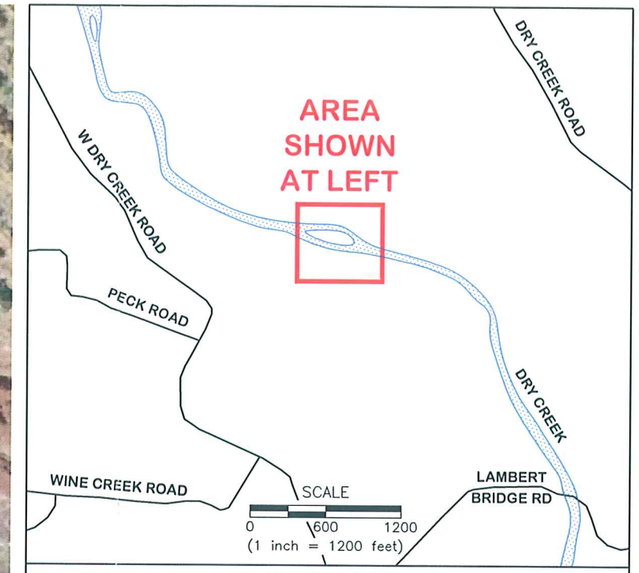
NORCAL Geophysical Consultants, Inc.

Donald J. Kirker

Donald J. Kirker
Professional Geophysicist, PGp-997

DJK/tt

Enclosures: Plates 1 and 2
Appendix A Seismic Refraction Survey



VICINITY MAP

SCALE
0 30 60 120
(1 inch = 60 feet)

LEGEND	
	SEISMIC REFRACTION PROFILE LOCATION

NORCAL

SITE LOCATION MAP
OFF CHANNEL ENHANCEMENT AREA D
DEMONSTRATION REACH – SEGHESIO PARCEL

LOCATION: DRY CREEK, HEALDSBURG, CALIFORNIA

CLIENT: SAGE

NORCAL GEOPHYSICAL CONSULTANTS INC.

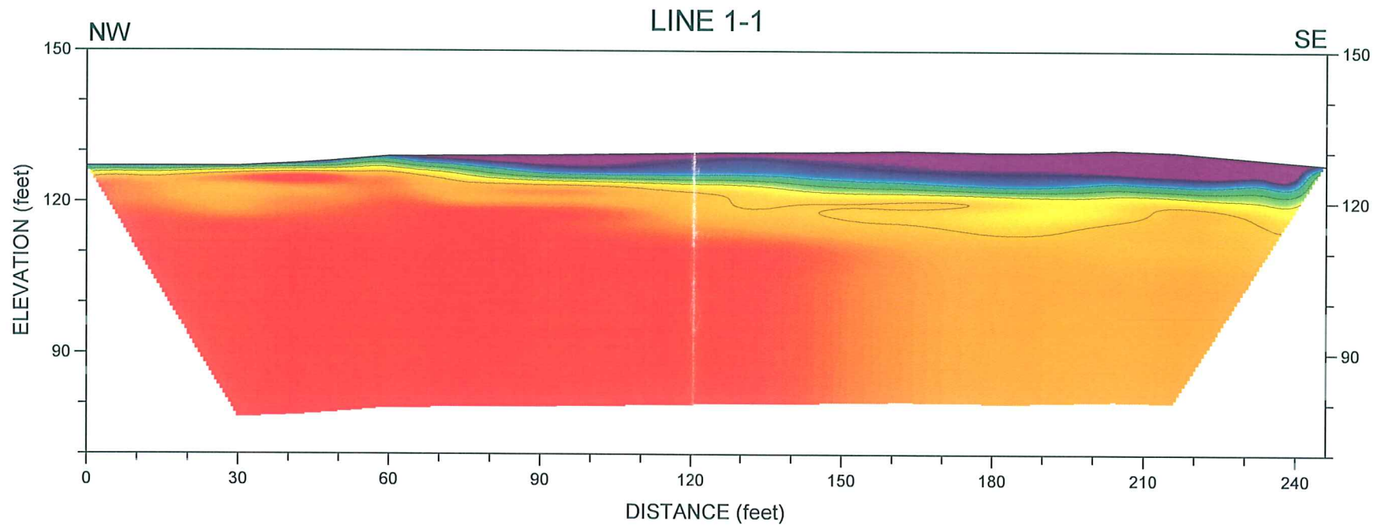
JOB #: 10-916.04

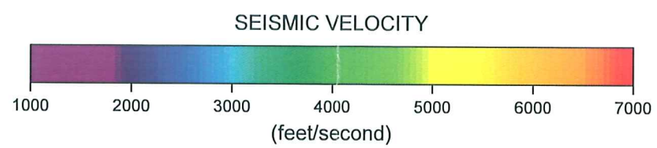
DATE: NOV. 2010

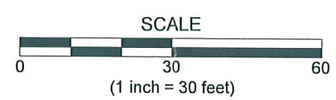
DRAWN BY: G.RANDALL

APPROVED BY: DJK

PLATE 1







NORCAL

SEISMIC REFRACTION PROFILE - LINE 1-1
OFF CHANNEL ENHANCEMENT AREA D
DEMONSTRATION REACH - SEGHESIO PARCEL

LOCATION: DRY CREEK, HEALDSBURG, CALIFORNIA

CLIENT: SAGE

JOB #: 10-916.04

NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: NOV. 2010

DRAWN BY: G.RANDALL

APPROVED BY: DJK

PLATE 2

Appendix A

SEISMIC REFRACTION SURVEY

Appendix A

SEISMIC REFRACTION (SR)

Methodology

The seismic refraction method provides information regarding the seismic velocity structure of the subsurface. An impulsive (mechanical or explosive) source is used to produce compressional (P) wave seismic energy. The P-waves propagate into the earth and are refracted along interfaces caused by an increase in velocity. A portion of the P-wave energy is refracted back to the surface where it is detected by sensors (geophones) that are coupled to the ground surface in a collinear array (spread). The detected signals are recorded on a multi-channel seismograph and are analyzed to determine the shot point-to-geophone travel times. These data can be used along with the corresponding shot point-to-geophone distances to determine the depth, thickness, and velocity of subsurface seismic layers.

The seismic refraction technique is based on several assumptions. Paramount among these are:

1) that seismic velocity increases with depth, and,
2) that the velocity of each seismic layer is uniform over the length of the given spread.

In cases where these assumptions do not hold, the accuracy of the technique decreases. For example, if a low velocity layer occurs between two layers of higher velocity, the low velocity layer will not be detected and the depth to the underlying high velocity layer will be erroneously large. Also, if the velocity of a seismic layer varies laterally within a spread, those variations will be interpreted as fluctuations in the elevation of the underlying seismic layer.

Instrumentation

Data acquisition is initiated along each SR line by producing seismic energy using a mechanical source. Mechanical sources produce energy by impacting a metal strike plate on the ground surface with either a 12-16 pound sledge hammer or an elastic-band driven weight drop. The resulting seismic wave forms are recorded using a Geometrics 24-channel engineering seismograph and Mark Products geophones with a natural frequency of 10 Hz. The data are recorded on hard copy records (seismograms) as well as on computer disks for future processing. The seismograms display the amount of time it takes for a compression (P) wave to travel from a given shot point to each geophone in a spread.

Data Analysis

The seismic data are downloaded to a computer and processed using the program ***Seisimager*** by Geometrics, Inc. This is an interactive program that is used to determine the shot point to geophone travel times, and to compute a 2D model based on those times. Once the travel times for a given line are determined, the programs time-term algorithm is used to compute a preliminary 2D seismic model. This model is then used as input for the programs tomographic routine. Using this procedure, the program divides the starting model into a network of cells and assigns velocities to those cells based on the starting model. The program then traces the refracted seismic travel paths through

those cells and computes the associated travel times. It then compares the computed travel times with the measured times and adjusts the velocities of the appropriate cells to improve the fit. The software is programmed to continue this procedure for twenty iterations. Typically, at the end of the twenty iterations the travel times associated with the computed model match the observed travel times to an accuracy of one milli-second (mS) or better. Once a satisfactory model is computed, the software contours the model velocities to produce seismic velocity vs. depth and distance cross-sections (profiles).

Limitations

In general, there are limitations unique to the SR method. These limitations are primarily based on assumptions that are made by the data analysis routine. First, the data analysis routine assumes that the velocities along the length of each spread are uniform. If there are localized zones within each layer where the velocities are higher or lower than indicated, the analysis routine will interpret these zones as changes in the surface topography of the underlying layer. A zone of higher velocity material would be interpreted as a low in the surface of the underlying layer. Zones of lower velocity material would be interpreted as a high in the underlying layer.

Second, the data analysis routine assumes that the velocity of subsurface materials increase with depth. Therefore, if a layer exhibits velocities that are slower than those of the material above it, the slower layer will not be resolved. Also, a velocity layer may simply be too thin to be detected. Due to these and other limitations inherent to the SR method, the results of the SR survey should be considered only as approximations of the subsurface conditions. The actual conditions may vary locally.