Design Memorandum

DATE: March 3, 2009

TO: Staci Belcastro, P.E.
City of Albany
333 Broadalbin Street SW
Albany, Oregon 97321

FROM: Scott Wright, P.E.
River Design Group, Inc.
311 SW Jefferson Avenue
Corvallis, Oregon 97333

SUBJECT: Streambank stabilization design at the Vine Street Water Treatment Plant.

Dear Ms. Belcastro,

Pursuant to your request, River Design Group, Inc. (RDG) developed two alternatives for stabilizing a streambank along the Calapooia River adjacent to City of Albany Water Treatment Plant (WTP) settling ponds. This report summarizes our methods and treatment approach, and outlines features, costs and benefits for each alternative.

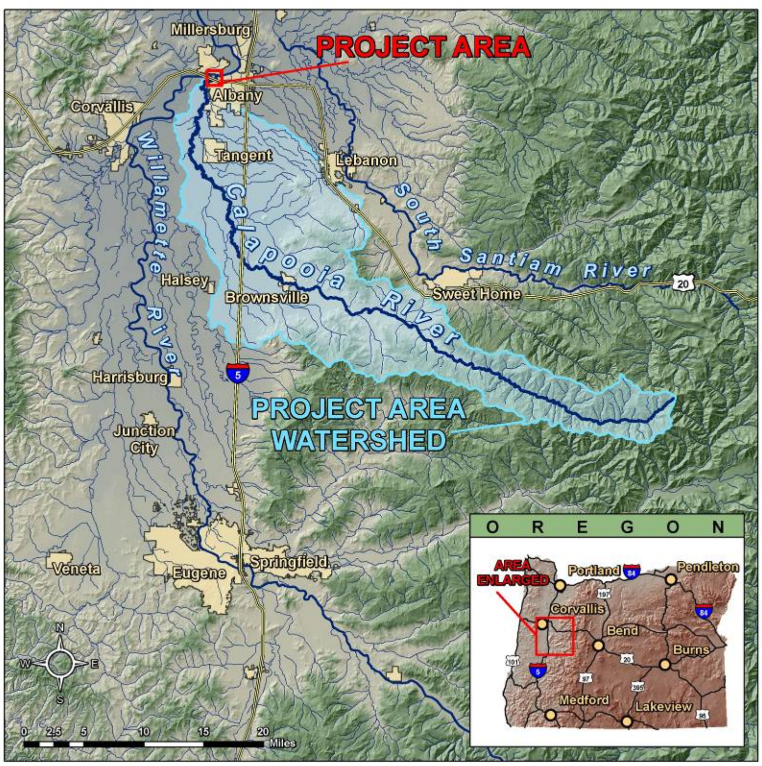

Figure 1. Vicinity map of Vine Street WTP in Albany, Oregon.

1 BACKGROUND

The Calapooia River bank adjacent to the Vine Street WTP has a history of documented failure extending back to 1974 (CH2M Hill 2005). In its current configuration, the bank is approximately 20 feet high and heavily vegetated with portions showing failed and oversteepened slopes as depicted in Figure 2. The bank soils consist of clayey silts and sandy silts of varying stiffness and plasticity, overlaying sandstone and siltstone (FEI 2008). The length of eroding bank is between 250 and 300 lineal feet.

Figure 2. View of existing bank failure at WTP on the Calapooia River, river-right streambank.

A geotechnical site characterization and slope stability analysis for the site was issued by Foundation Engineering, Inc. in June 2008. The existing slope was determined to be marginally stable and mechanisms of slope failure were discussed. Bank failure is likely due to a combination of scour and rapid drawdown after high-stage flows.

The project site was surveyed on July 2, 2008 using a Topcon GTS-211D total station. The survey was tied to an existing brass cap at the water control structure on the north settling pond, and to the top center of caps on monitoring wells installed during the geotechnical investigation. Survey control monuments were also installed on-site for reference during future surveying or construction.

The site survey was used to determine existing channel geometry for hydraulic modeling. Site geometry was generated using RiverCAD software, creating geometry suitable for 1-D hydraulic modeling in HEC-RAS v3.1.3.

Historically, the USGS maintained a gaging station on the Calapooia River near Albany, and gage statistics have been published. The drainage area contributing to the gage is estimated at 372 square miles and the area draining to the project site is estimated to be 374 square miles. Because of the proximity of the project site to the gage, and the comparable drainage area sizes, the USGS gage statistics can be used to estimate flows at the project site.

Site geometry was evaluated for both average monthly flows and peak flood events. Because this reach of the Calapooia River is backwatered by the Willamette River, the stage of the Willamette River influences water surface elevations in the project reach. Flows up to the 25-yr return interval event were evaluated to determine water velocities and shear stresses for bank stabilization design.

2 DESIGN

2.1 Alternatives

Four factors were considered in selecting treatments for slope stabilization: the ability of alternatives to be permitted, the ability of alternatives to provide scour protection, and the need for the alternatives to restore shallow and deep-seated slope stability.

Because portions of the work will occur below Ordinary High Water (OHW), treatment alternatives were selected to be permitted as easily as possible. OWH is a jurisdictional boundary, identified as the location on the stream bank where water ordinarily rises each year and where upland vegetation ends (ORS 274.005). Removal-Fill permits are required from the Oregon Division of State Lands (DSL) and the U.S. Army Corps of Engineers (USACE) when working below the OHW line. When endangered fish species are present in the project waterway, this permitting process also requires a biological opinion and consultation with the National Marine Fisheries Service (NMFS). Therefore, both treatment alternatives were selected to meet the criteria of a programmatic biological opinion, SLOPES IV. The programmatic biological opinion does not require individual consultation when specific criteria are met. This approach can save considerable time and expense in permitting, and will also guide the design project towards a bioengineering approach more beneficial to aquatic organisms.

Two alternatives were developed that meet SLOPES IV. Both treatment alternatives were designed to resist scour at the toe of the streambank. Toe scour can undermine slope stability by creating slopes that are steeper than the site soils can maintain over time. Preliminary results from our hydraulic modeling show shear stresses exceeding 4 pounds per square foot (psf) for flows beyond the 10-yr return interval flow. In-channel velocities also range from 9-12 feet per second (fps) at high flows. These high velocities and shear stresses exceed the ability of bare soil to resist erosion and scour (Fischenich 2001). Thus, materials other than bare soil are specified in each alternative to resist erosion and scour at high flows.

Both alternatives were also designed to address shallow and deep-seated slope failure by means of an engineered stable slope. In both cases, the existing streambank would be re-built at a more gradual slope throughout areas where the slope has previously failed. To reduce overall project cost, the stabilized slope would not be designed to address risk of liquefaction from earthquake loads as discussed in the geotechnical report.

Alternative 1 – Large Wood Toe and Vegetated Soil Lifts

The Calapooia River reach under consideration has significant amounts of large wood and vegetation along existing stable banks upstream and downstream of the site as illustrated in Figure 3.

Figure 3. View of existing large wood and vegetation on stable banks upstream of project site.

Alternative 1 involves reconstructing the streambank to address hydraulic and slope stability concerns in a manner that meets the SLOPES IV programmatic biological opinion. The streambank toe would be reinforced with large wood to resist scour, provide energy dissipation and provide aquatic habitat. The upper slope would be reconstructed to a stable slope utilizing vegetated soil lifts. The slope would be covered with a coir erosion control fabric and revegetated with a combination of grasses and dense willow plantings. The shaped slope incorporates a filter drain system to protect against excess pore pressures in the slope soil profile due to river level fluctuations. Long term bank stability is improved through establishment of vegetation and recruitment of additional large wood from the Calapooia River.

Alternative 2 – Engineered Large Wood Jams and Engineered Soil Lifts

Alternative 2 contains a similar approach as Alternative 1 that utilizes large wood and engineered soil lifts with vegetation. This alternative utilizes more distinct large wood structures placed in strategic locations to break up high velocities and dissipate energy. In between each log jam are continuous lifts of engineered soil and vegetation.

The two alternatives were discussed with City staff and it was determined that Alternative 2 was the preferred option. is the preferred alternative was further detailed for final design and is discussed in detail in the following sections.

2.2 Bank Stabilization

When looking at streambank stabilization projects it is important to evaluate both the geotechnical stability of the slope and fluvial processes leading to bank failure. Foundation Engineering, Inc. provided geotechnical sampling at the site, design and recommendations for stabilizing the slope. Their work is incorporated into the slope stability design shown on the plans.

RDG's design focused on hydraulic forces caused by the river and creation of habitat conducive for aquatic species. In order to provide this combination, it was recommended that large wood be incorporated into the design along with engineered soil lifts to promote establishment of vegetation for long-term stability. The engineered soil lifts consist of reinforcement geotextile grids extending into the soil lift to enhance bank stability. Willows and other native vegetation are inserted into the engineered soil lift to help promote long term vegetation growth as illustrated in Figure 4.

Figure 4. Example of engineered soil lift used for bank stabilization and vegetation growth.

The intent of engineered soil lifts is to provide deformable, yet stable site conditions along the stream channel that are suitable for growing riparian vegetation. The soil lifts are able to withstand higher velocities and remain stable versus the existing soil slope that continues to recede due to excess pore pressure and instability. In the long-term, vegetation is able to dominate the bank area and provide stability as well as important riparian corridor processes. Soil lifts do not obstruct main channel flows and provide excellent fish habitat at all flow levels. The soil lifts are built on a cobble toe that include logs for additional roughness, near bank stress reduction, and habitat. Over a five to seven year period, the fabric will decompose and the rooting strength of established vegetation will maintain bank strength, hydraulic roughness, and reduced near bank shear stress.

2.3 Hydrology and Hydraulics

The site was surveyed using a total station and relative elevation benchmark. Temporary benchmarks were established on-site for future reference during construction. The topographic points were downloaded into AutoCAD 2007, and a topographic contour model was developed of the existing conditions as illustrated in attached Drawing 2.0.

The project site has a contributing runoff area of approximately 374 square miles. Peak flows were determined using regional regression equations applicable to the project area. The USGS StreamStats program (USGS 2008) was used to perform peak-flow hydrology calculations. StreamStats is a web-based GIS program that locates physical and climatic basin characteristics, delineates watershed areas based on digital elevation models, and predicts flood flows based on regionalized flood-frequency regression equations. Flows for selected return intervals are shown in Table 1.

Table 1. Predicted peak flows based on regional regression equations and contributing drainage area.

Return Interval (year)	Discharge (cfs)
2	10,300
5	15,300
10	18,900
25	23,500
50	27,000

A hydraulic model of the existing conditions was created using RiverCAD and HEC-RAS 3.1.3. HEC-RAS is a one-dimensional hydraulic model used for open-channel flow analysis in the river environment. The hydraulic model was used to evaluate various flows and determine hydraulic parameters for design. Figure 5 shows the hydraulic model wireframe used for the project design.

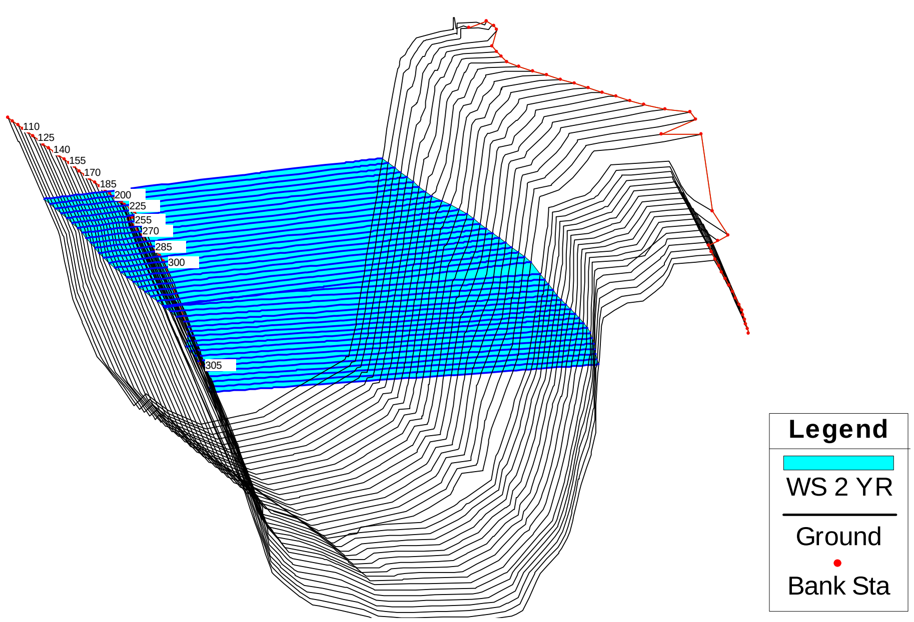

Figure 5. HEC-RAS hydraulic model of existing stream conditions under a 2-year flow event.

The estimated flow at the project site during fieldwork was used to calibrate the HEC-RAS hydraulic model and determine realistic roughness coefficients. A Manning's roughness value of 0.033 was used with an out of bank roughness value of 0.08. The average slope for the site is 0.005 ft/ft and the model was run in a subcritical flow condition. Results for the 2-yr flow conditions are provided in Table 2.

Table 2. HEC-RAS hydraulic model output for 2-yr discharge.

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude
305	2 YR	12500	169.68	185.59	186.77	0.003564	8.71	1434.46	113.02	0.43
300	2 YR	12500	169.67	185.56	186.75	0.003768	8.77	1425.42	112.49	0.43
295	2 YR	12500	169.66	185.52	186.73	0.003668	8.82	1416.7	112.14	0.44
290	2 YR	12500	169.65	185.49	186.71	0.003728	8.88	1408.43	112	0.44
285	2 YR	12500	169.64	185.46	186.69	0.003827	8.92	1401.05	112.31	0.45
280	2 YR	12500	169.63	185.43	186.67	0.003969	8.95	1396.39	113.28	0.45
275	2 YR	12500	169.61	185.4	186.65	0.004098	8.97	1393.5	114.07	0.45
270	2 YR	12500	169.61	185.36	186.63	0.004306	9.05	1381.8	114.38	0.46
265	2 YR	12500	169.6	185.33	186.61	0.004435	9.08	1376.24	114.61	0.46
260	2 YR	12500	169.6	185.29	186.59	0.004574	9.15	1365.8	114.36	0.47
255	2 YR	12500	169.57	185.23	186.56	0.004694	9.28	1346.91	112.99	0.47
250	2 YR	12500	169.5	185.16	186.53	0.004767	9.39	1330.88	111.46	0.48
245	2 YR	12500	169.43	185.11	186.51	0.004818	9.49	1317.04	109.98	0.48
240	2 YR	12500	169.35	185.05	186.48	0.004893	9.58	1304.36	108.88	0.49
235	2 YR	12500	169.28	185	186.45	0.005016	9.67	1293.05	108.35	0.49
230	2 YR	12500	169.21	184.98	186.42	0.005091	9.61	1301.38	109.48	0.49
225	2 YR	12500	169.13	184.97	186.39	0.005023	9.56	1306.97	110.11	0.49
220	2 YR	12500	169.06	184.95	186.36	0.004946	9.51	1313.8	110.71	0.49
215	2 YR	12500	169	184.94	186.33	0.004822	9.44	1324.1	111.03	0.48
210	2 YR	12500	168.99	184.92	186.3	0.00482	9.41	1328.24	111.44	0.48
205	2 YR	12500	168.97	184.89	186.28	0.00489	9.44	1324.12	111.43	0.48
200	2 YR	12500	168.96	184.86	186.25	0.005189	9.47	1319.29	111.36	0.49
195	2 YR	12500	168.94	184.82	186.23	0.004987	9.51	1314.65	111.26	0.49
190	2 YR	12500	168.92	184.79	186.2	0.00503	9.54	1309.78	111.15	0.49
185	2 YR	12500	168.9	184.76	186.18	0.005069	9.58	1305.06	111.03	0.49
180	2 YR	12500	168.88	184.72	186.16	0.005109	9.61	1300.38	110.91	0.49
175	2 YR	12500	168.86	184.69	186.13	0.005147	9.65	1295.76	110.77	0.5
170	2 YR	12500	168.84	184.65	186.11	0.005184	9.68	1291.19	110.62	0.5
165	2 YR	12500	168.82	184.62	186.08	0.005216	9.72	1286.61	110.42	0.5
160	2 YR	12500	168.8	184.58	186.06	0.00523	9.75	1282.22	110.09	0.5
155	2 YR	12500	168.78	184.55	186.03	0.005182	9.78	1277.67	109.12	0.5
150	2 YR	12500	168.76	184.51	186.01	0.005102	9.82	1273.36	107.83	0.5
145	2 YR	12500	168.74	184.48	185.99	0.005013	9.85	1269.2	106.49	0.5
140	2 YR	12500	168.72	184.45	185.96	0.004861	9.88	1265.52	104.63	0.5
135	2 YR	12500	168.7	184.42	185.94	0.004821	9.9	1262.17	104.01	0.5
130	2 YR	12500	168.68	184.38	185.92	0.004816	9.93	1258.37	103.64	0.5
125	2 YR	12500	168.66	184.35	185.89	0.004836	9.97	1254.19	103.43	0.5
120	2 YR	12500	168.64	184.32	185.87	0.00486	10	1249.9	103.24	0.51
115	2 YR	12500	168.62	184.28	185.85	0.004887	10.04	1245.32	103.06	0.51
110	2 YR	12500	168.6	184.25	185.82	0.004924	10.08	1240.18	102.89	0.51
105	2 YR	12500	168.58	184.21	185.8	0.004962	10.12	1234.8	102.7	0.51
100	2 YR	12500	168.56	184.17	185.77	0.005002	10.17	1229.45	102.54	0.52

2.4 Design

Water surfaces and velocities for the 5-year and 10-year peak flows are shown in Figure 6. Maximum velocities in the project area are approximately 11 fps for the 25-year peak flow, and corresponding shear stresses range from 4.4 to 5.4 psf (Figure 7). In order to effectively compensate for these stresses, a coir fabric is incorporated into the vegetated soil lift design that is able to withstand a shear stress of 8 psf and water velocities of 18 fps. High density coir logs will be placed within the coir fabric to provide a streambank face. The coir logs provide the bank shape, provide additional shear resistance, and retain moisture to enhance riparian vegetation growth. Native willow and shrub vegetation will be incorporated into the stream banks in order to provide long-term soil stability and natural riparian functions. A set of drawings and specifications are attached that outline the proposed bank stabilization techniques and necessary construction sequencing.

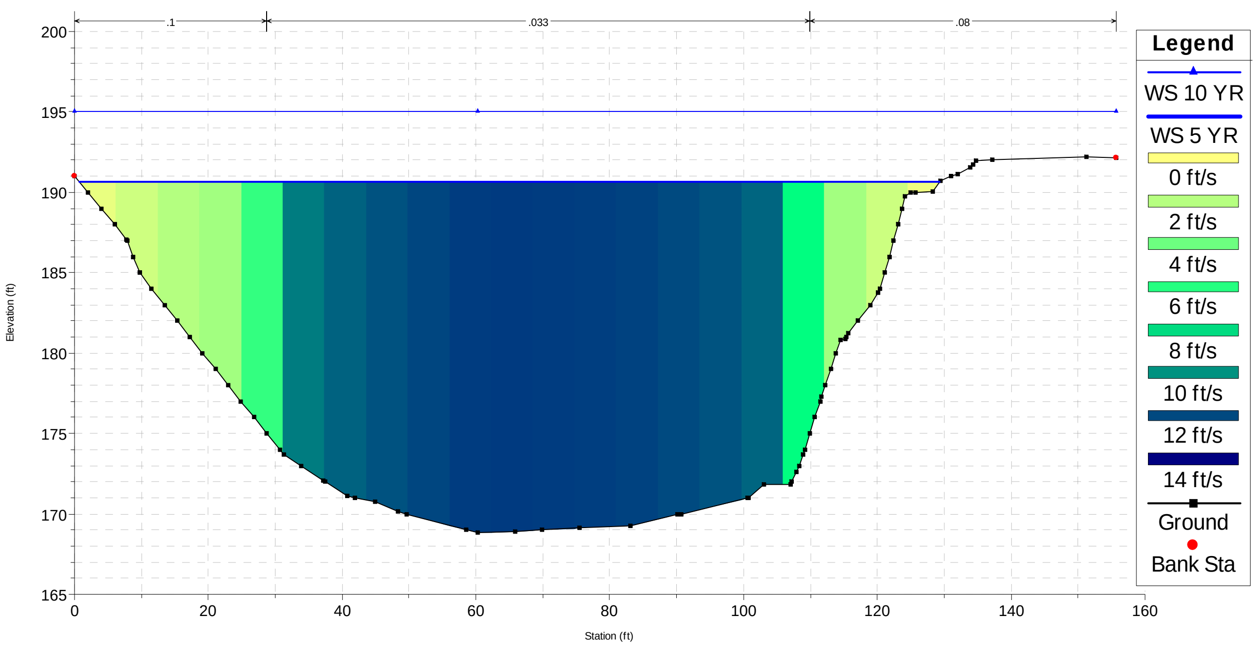

Figure 6. Water surfaces for 5-yr and 10-yr peak flows, and water velocities for 5-yr peak flows in the project vicinity.

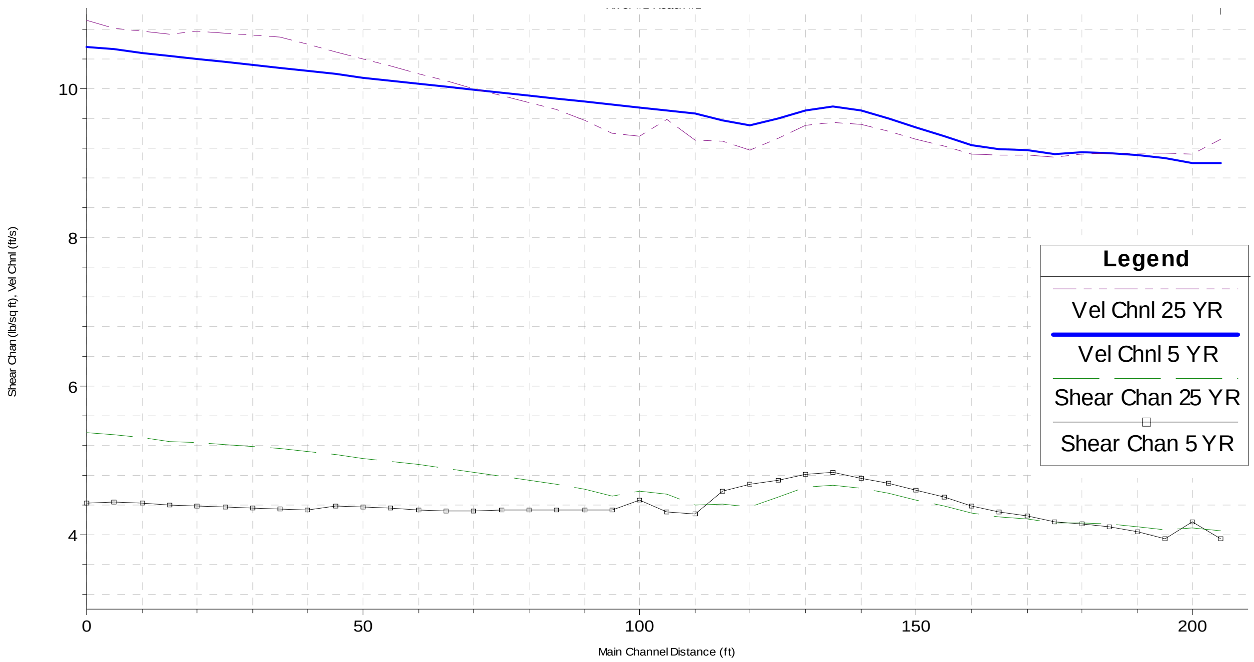

Figure 7. Velocity and shear stress plot for 5-yr and 25-yr peak flows in the project vicinity.

In summary, based on our site visit and hydraulic modeling, we recommend 1) constructing large wood structures in strategic locations to break up high velocities and dissipate energy, 2) building a stable slope with engineered soil lifts per the geotechnical reommendations, and 3) establishing vegetation for long-term slope stability and fisheries habitat.

3 PERMITS

Constructing engineered large wood jams and the vegetated soil lift will require excavation, fill, and grading of the slope below ordinary high water (OHW). Due to the extent of the removal and fill in the project area, a joint USACE and DSL permit is required. Because fish species listed under the Endangered Species Act may be present, consultation with the National Marine Fisheries Service is also required. The USACE has consulted with NMFS and adopted a programmatic biological opinion for streambank restoration (SLOPES IV 2008). The USACE has also issued Nationwide Permit (NWP) 13 for bank stabilization. The project design meets the intent of SLOPES IV and should be permitted under the NWP 13 and programmatic biological opinion.

This project will likely qualify for the NWP 13 permit and should only require a preconstruction notification to the district engineer. In addition, the project has been designed to minimize adverse impacts and meet the intent of the recently adopted Standard Local Operating Procedures for Endangered Species (SLOPES IV 2008) that allows provisions for streambank restoration if the project incorporates bioengineering and large wood.

Due to the inherent variability and dynamic nature of rivers, it is suggested that a representative from River Design Group be present during construction to review existing conditions and ensure proper implementation of the design intent. An experienced representative will be able to make necessary field adjustments for the site conditions at the time of construction.

4 REFERENCES

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