

PUBLIC UTILITY DISTRICT NO. 1 *of* CHELAN COUNTY
P.O. Box 1231, Wenatchee, WA 98807-1231 • 327 N. Wenatchee Ave., Wenatchee, WA 98801
(509) 663-8121 • Toll free 1-888-663-8121 • www.chelanpud.org

December 28, 2011

VIA ELECTRONIC FILING

Honorable Kimberly D. Bose, Secretary, and
Nathanial J. Davis, Sr., Deputy Secretary
ATTN: OEP/DHAC
FEDERAL ENERGY REGULATORY COMMISSION
888 First Street, NE
Washington, DC 20426

Re: **Rocky Reach Hydroelectric Project No. 2145-102**
License Article 406 – Entiatqua Trail Feasibility Study

Dear Secretary Bose and Deputy Secretary Davis:

On October 12, 2010, the Federal Energy Regulatory Commission (Commission) issued the "*Order Modifying and Approving Revised Recreation Management Plan*"[1] for the Rocky Reach Hydroelectric Project (Project). Ordering Paragraph (B) requested that, within 1 year of the date of issuance of this order, the licensee shall complete the proposed Entiatqua Trail Feasibility Study and file the results with the Commission along with documentation of agency consultation. Subsequently, on September 14, 2011, the Public Utility District No. 1 of Chelan County, Washington (Chelan PUD or licensee) requested an extension of time to complete the proposed study and file the study results with the Commission to December 31, 2011.

In accordance with the above Order, Chelan PUD hereby files the study and the results along with the consultation. Below is a summary of the submittal.

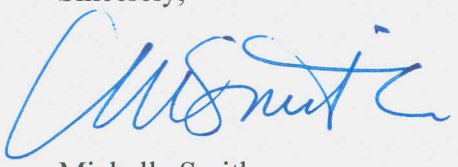
- Entiatqua Trail Feasibility Study (Includes proposed development information for the trail, as well as a description of soil erosion and sediment control measures to be used where ground-disturbing activities are proposed, a discussion of how the needs of the disabled were considered in the planning and design of the trail, a provision for trash clean-up and removal, and identification of the entity(ies) responsible for construction, operation, and maintenance of the trail.)
- Appendix A – Commission Order issued October 12, 2010
- Appendix B – Preliminary Design Drawings

[1] 133 FERC ¶ 62,040 (2010)

- Appendix C – Geotechnical Analysis
- Appendix D – Consultation

Please contact me if you have any questions regarding this filing or requests for additional information.

Sincerely,



Michelle Smith
Licensing and Compliance Manager
michelle.smith@chelanpud.org
(888)663-8121, Ext. 4180

Attachments

ENTIATQUA TRAIL FEASIBILITY STUDY
December 28, 2011

Introduction

The Federal Energy Regulatory Commission (FERC or Commission) issued an Order Modifying and Approving Revised Recreation Management Plan to Chelan County PUD on October 12, 2010 (see Appendix A). The Order directed Chelan County PUD to complete the Entiatqua Trail Feasibility Study and file the study results with the Commission along with documentation of agency consultation.

Chelan County PUD has completed a feasibility study of the trail and determined it can be built. The study involved engineering analyses of the proposed project site; development of preliminary design drawings and cost estimates; and consultation with all agencies identified in the Order and agencies responsible for environmental permitting of the proposed project. This feasibility study provides development information for the trail and assessments regarding environmental permitting, site conditions, accessibility constraints, and the trail's proximity to a major transportation corridor, including highways and bridges.

Project Description

The proposed Entiatqua Trail is a bike and pedestrian path located at the confluence of the Entiat and Columbia rivers as illustrated in Figure 1: Entiatqua Trail Conceptual Plan and Figure 2: Proposed Project Layout. The trail site parallels the Rocky Reach Reservoir and the Entiat River along an existing earth embankment which supports the Cascade and Columbia Railroad and State Highway 97A.

Trail features are illustrated in detail in drawings contained in Appendix B – Preliminary Design Drawing. Features include:

- Trail Dimensions – The trail will be six (6) feet wide with one (1) foot shoulders on each side. The total length of the trail is approximately 1,650 feet long.[1] The length was modified as described in the Recreation Management Plan.
- Trail Surface – The trail will have a compacted aggregate surface.
- Trail Structure - Development of the trail along the existing steep embankment will necessitate terracing by means of rockery walls, pre-cast concrete retaining wall systems, soil bags and gabion baskets.
- Mitigation – Mitigation for project shoreline impacts will entail development of a riparian planting corridor and placement of large woody debris including logs and rootwads. Riparian plants will include native grasses, shrubs and trees.
- Viewpoint – A viewpoint with an interpretive sign and bench will be located along the trail as illustrated in Figure 1.The interpretative sign will highlight the local Native American History.

[1] See Rocky Reach Recreation Resources Management and Implementation Plan Dated February 12, 2010, Appendix B

- Fencing – A 6 foot high chain link fence will be located on the uphill side of the trail. A three rail wood fence will be located on the downhill side of the trail.


CITY OF ENTIAT
ENTIAT PARK
Trail Connection to proposed Entiat Park Waterfront Trail
Entiat River Road
This drawing is for infomational purposes only
Trail Connection to proposed Entiatqua Outdoor Learning Center
COLUMBIA RIVER
VIEWPOINT WITH INTERPRETIVE SIGN AND BENCH
SR 97A
C&C RR
ENTIAT RIVER
N
Legend
PROPOSED ENTIAQUA TRAIL
1 inch = 100 feet
FIGURE 1: ENTIATQUA TRAIL CONCEPTUAL PLAN
12/22/2011

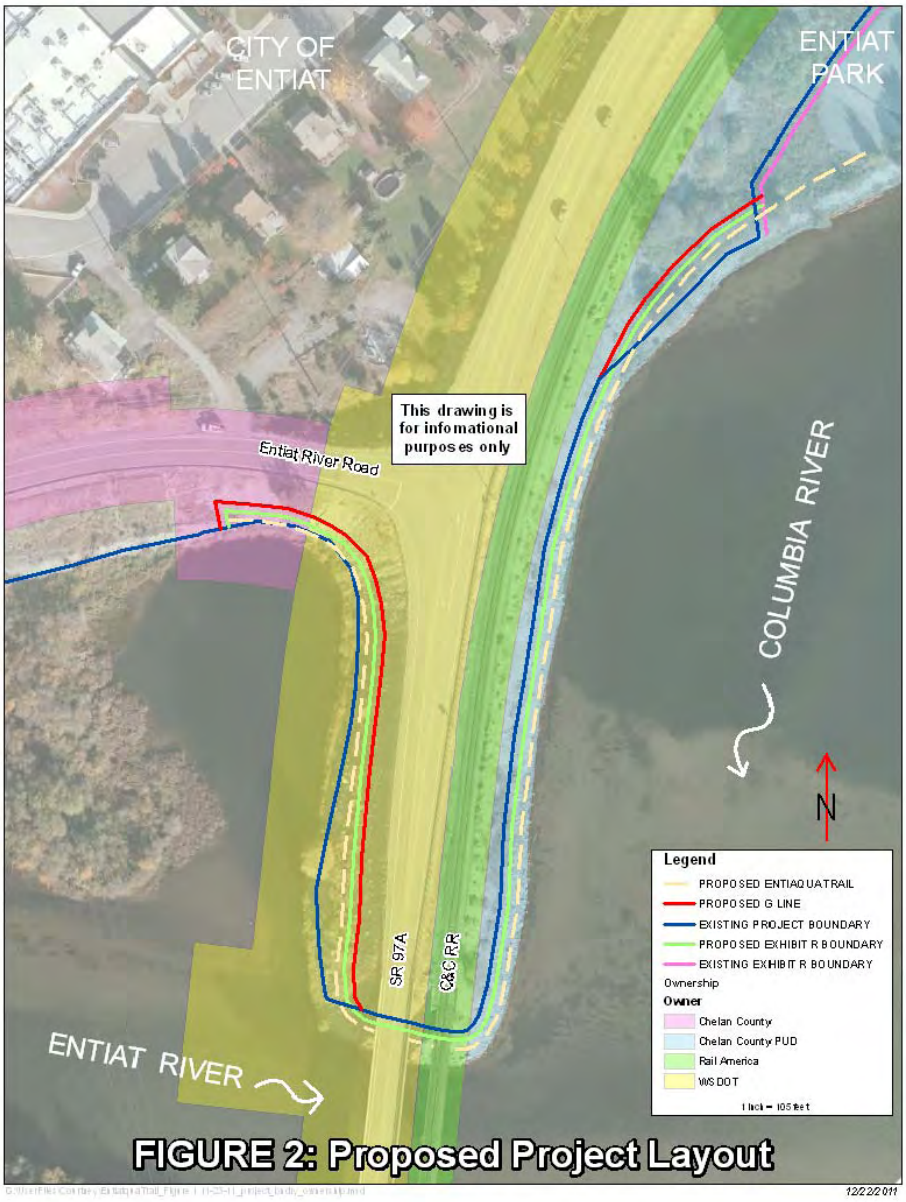


FIGURE 2: Proposed Project Layout

Study Findings – Construction Accessibility Constraints

Construction access to the trail site is limited by the highway/railroad embankment and the river bodies as illustrated in Figure 1. During the study period, it was determined that construction equipment would most likely access the trail site from Entiat Park or the proposed Entiatqua Outdoor Learning Center. The Learning Center access entails using a 2,000 foot long single lane (narrow), unimproved road. During construction of the trail, equipment would also be constrained to the single lane trail (i.e. no turning movements or passing). These constraining conditions are workable, but result in a more costly and time intensive construction operation.

Study Findings – Site Conditions

Chelan County PUD studied the feasibility of constructing the trail along the steep earth embankment by conducting geotechnical analyses. The analyses consisted of: (1) general site assessment, (2) conceptual design review and recommendations, and (3) preliminary design review and recommendations. These analyses, prepared by Shannon & Wilson, Inc., are provided in Appendix C of this study.

The geotechnical analyses evaluated site conditions and recommended differing techniques for trail construction. The preliminary design drawings, shown in Appendix B, are based on these recommendations and incorporate comments received from NOAA Fisheries. In summary, results of the geotechnical analyses indicate site conditions, while challenging, are not an impediment to trail construction.

Study Findings - Trail's Proximity to a Major Transportation Corridor

As shown in Figure 1, the trail runs parallel with and crosses below both the Cascade and Columbia Railroad and State Highway 97A. The trail as proposed would be built on the embankment which supports the highway and railroad. The geotechnical analysis evaluated potential impacts to the transportation corridor and concluded trail construction would not adversely impact the corridor.

During the study period, it was determined that extensive permitting of the trail will not be required by Washington State Department of Transportation (WDOT), rather their only requirement will be for Chelan County PUD to obtain a General Permit for construction of the trail below the bridge. Chelan County PUD has already initiated efforts to attain this permitting and believes it will not impede construction of the trail.

The portion of the trail running parallel with the highway north of the bridge is within the Entiat City Limits and therefore resides within the jurisdictional limits of the City. The City and Chelan County PUD will therefore be required to enter into a right-of-way agreement for the portion of the trail running adjacent to Highway 97A. As the primary project stakeholder the City of Entiat has expressed their willingness to enter into right-of-way agreement for the trail.

Chelan County PUD has acquired the necessary land rights and easements to permit construction of the trail along and below the Cascade and Columbia Railroad.

Study Findings – Environmental Permitting

Construction of the trail as proposed in Appendix B will require the following environmental permits:

- United State Army Corps of Engineers (USACE) 404 permit
- Washington State Department of Fish & Wildlife (WDFW) Hydraulic Project Approval
- Shoreline Permit as administered by the City of Entiat

Chelan County PUD has conducted a permit pre-application review with National Oceanic and Atmospheric Administration (NOAA) Fisheries Service and with WDFW. The pre-application review included site visits and conference calls to discuss the project as documented in Table 1. Comments and feedback provided by the two agencies has been incorporated into the preliminary design drawings shown in Appendix B.

The end result of the pre-application review was a determination that environmental permits to allow construction of the trail can be obtained.

Cost

The Rocky Reach Comprehensive Settlement Agreement (Chapter 9, Section 4.5.3) identified a cost of $1.2 million for construction of the Entiatqua Trail. Chelan County PUD has developed a cost estimate based on the preliminary design drawings in Appendix B and determined the trail can be built for this amount.

Table 1: Consultation

AGENCY	CONSULTATION FORMAT	CONSULTATION DATE
NOAA Fisheries	Pre-Application Office and Site Meeting	Sept. 26, 2011
NOAA Fisheries	Conference Call	October 25, 2011
NOAA Fisheries	Conference Call	November 23, 2011
WDFW	Pre-Application Site Mtg.	November 22, 2011
C&C Railroad	E-mail	August 25, 2011
WSDOT	Office Meeting	May 17, 2011
WSDOT	E-mail	Sept. 22, 2011

Proposed Implementation Schedule

Design: January 1, 2012 to February 28, 2012
Permitting: March 1, 2012 to April 30, 2013
FERC Construction Document Submittal including acquired permits: May 1, 2013 to June 30, 2013
Bid & Award: July 1, 2013 to Sept. 31, 2013
Construction: October 1, 2013 – June 1, 2014

Other Considerations

Soil Erosion and Sedimentation Control Measures will be employed during construction of the trail and submitted with construction drawings. Measures will include, but not be limited to the following devices: straw wattles, silt fencing and silt curtains.

The needs of the disabled were considered during the conceptual design of the trail. The trail design includes grades that are conducive to wheel chairs.

Chelan County PUD will be responsible for construction of the trail. The City of Entiat in agreement with Chelan County PUD will oversee the operation and maintenance of the trail and be responsible for trash clean-up and removal.

Conclusion

Chelan County PUD has determined it is feasible to construct the Entiatqua Trail as illustrated in the Appendix B - Preliminary Design Drawings. Therefore, Chelan County PUD intends to further develop the design based on project stakeholder involvement. At the appropriate time permit applications will then be submitted.

APPENDIX A – FERC ORDER
APPENDIX B – PRELIMINARY DESIGN DRAWINGS
APPENDIX C – GEOTECHNICAL ANALYSES
APPENDIX D – CONSULTATION

APPENDIX A – FERC ORDER

133 FERC ¶ 62,040
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Public Utility District No. 1 of Chelan County, Washington Project No. 2145-102

ORDER MODIFYING AND APPROVING REVISED RECREATION MANAGEMENT PLAN
(Issued October 12, 2010)

1. On February 12, 2010, Public Utility District No. 1 of Chelan County (Chelan County PUD or licensee), licensee for the Rocky Reach Hydroelectric Project (FERC No. 2145), filed a revised Recreation Resource Management Plan (plan) pursuant to Article 406 of the license.[1] The project is located on the Columbia River in the City of Entiat, in Chelan County, Washington.

LICENSE REQUIREMENTS

2. Article 406 requires the licensee to file the revised plan for Commission approval. The plan is to include, but not be limited to, a description of the project's seven recreation sites: Rocky Reach Visitor Center and Park, Lincoln Rock State Park, Orondo Park, Entiat Park, Daroga State Park, Chelan Falls/Powerhouse Park, and Beebe Bridge Park; and provisions to develop specific recreation improvements at some of the sites. These sites and improvements include: (1) Lincoln Rock State Park: (a) development of a group campground, (b) improvements to the day-use area, and (c) a new interpretive trail with signage; (2) construction of a 1-mile-long non-motorized trail (a.k.a. Rocky Reach Trail), with signage and a bench, from Lincoln Rock State Park to the fish bypass viewing station located approximately 300 feet downstream from the Rocky Reach Dam; (3) Daroga State Park: (a) enhancement of the shoreline (e.g., revegetation with native species and improvement to the boat launch), (b) improvement of the vault toilets, and (c) a new interpretive trail with signage; (4) Entiat Park: (a) improvement of the day-use area, (b) improvement of the campground area, and (c) construction of an approximate 4,340-foot-long non-motorized trail (Entiatqua Trail) with a viewpoint, signage, and bench to provide additional public access to project lands and waters; and (5) Orondo Park: design and upgrade the irrigation system.

[1] 126 FERC ¶ 61,138, Order on Offer of Settlement and Issuing New License, issued on February 19, 2009.

3. The plan is also to include: design drawings of the new recreation measures, a description of soil erosion and sediment control measures to be used where ground-disturbing activities are proposed, a discussion of how the needs of the disabled were considered in the planning and design of the recreation facilities, a provision for trash clean-up and removal, a cost for each facility, and an implementation schedule.

4. The plan is to be developed after consultation with the Washington Department of Fish and Wildlife (WDFW), Washington State Parks and Recreation Commission (WSPRC), National Park Service, U.S. Bureau of Land Management, and the City of Entiat, Washington. The plan is also to be developed in coordination with the Wildlife Habitat Management Plan required under Article 403, so that recreation enhancements do not conflict with wildlife and associated habitat at the project. The Commission reserves the right to require changes to the revised plan.

DESCRIPTION OF THE PROPOSED PLAN

5. The purpose of the plan is to revise the Recreation Resources Management Plan filed with the Commission on March 20, 2006, as part of the Rocky Reach Comprehensive Settlement Agreement for the project license. The plan describes the existing facilities at the project's seven recreation sites and proposed improvements at Lincoln Rock State Park, Daroga State Park, Entiat Park, and Orondo Park.[2] The information provided in the plan includes a description of ownership, operation, and maintenance responsibilities for each site; information about existing facilities and recreational use levels; as-built drawings of the existing facilities at each site; and a description of the proposed improvements, including cost estimates and an implementation schedule. The licensee prepared the plan in consultation with the required agencies and other stakeholders.

6. In addition, the licensee proposes to prepare and file with the Commission, final construction drawings for the proposed improvements at each site, including erosion and sedimentation control measures, trash clean-up and removal provisions, and American with Disabilities Act accessibility measures. The licensee proposes to file the final drawings 60 days prior to construction and as-built drawings of the completed improvements within 60 days after completion. The licensee proposes to complete all the improvements within the next 10 years, with construction start dates for each proposed improvement, varying from 2012 to 2015.

[2] The licensee states that it completed the required boat launch and vault toilet improvements at Daroga State Park and the required upgraded irrigation system at Orondo Park.

7. Regarding the Entiatqua Trail, the license proposes to conduct a feasibility study, within one year of the Commission's approval of the proposed plan, to determine if the planned trail can be built. During the initial planning of the trail, concerns were raised regarding the need for extensive environmental permitting, site conditions, accessibility constraints, and the trail's proximity to a major transportation corridor, including highways and bridges. The licensee, with the concurrence of stakeholders, proposes to further study the matter in consultation with the City of Entiat, Washington State Department of Transportation, C&C Railway, and appropriate agencies. If the study and consultation show that the trail can be built, the licensee would file conceptual drawings, cost estimates, and an implementation schedule with the Commission. If it is determined that the trail cannot be built, the licensee proposes to submit a reasonable alternative for Commission approval.

AGENCY CONSULTATION

8. Chelan County PUD developed the plan in consultation with the National Park Service, WDFW, WSPRC, U.S. Bureau of Land Management, City of Entiat, and the Rocky Reach Recreation and Wildlife Forums. The licensee received comments from WSPRC, WDFW, and the Rocky Reach Wildlife Forum. The commenting parties expressed support for the proposed plan and had minor comments and/or recommendations on the draft plan. No other comments were received. The licensee adequately addresses and/or incorporates the agency comments and recommendations in the proposed plan.

DISCUSSION

9. The licensee's proposed plan adequately addresses the required information under article 406 and provides for the development of the required recreational improvements. The proposed submission of final construction drawings for the improvements at Entiat Park, Lincoln Rock State Park, Daroga State Park and Rocky Reach Trail would allow the Commission to review such plans prior to implementation. In order to ensure that such plans are appropriate and consistent with the conceptual drawings/descriptions in the proposed plan, the Commission should reserve the right to require changes to the final plans.

10. The licensee should file the proposed feasibility study results to determine whether or not the Entiaqua Trail can be built. The proposed study would ensure that the noted concerns are fully considered prior to taking any further action on the facility. The study should include the results of the proposed analysis and recommendations for further action on the trail (i.e. either built the trail as proposed or implement an appropriate alternative). The filing should also include documentation of consultation with

appropriate entities and agencies on the proposed study, study results, and any proposed actions based on such results.

11. If the study results find that the required trail can be built, the licensee's filing should include the proposed development information, as well as a description of soil erosion and sediment control measures to be used where ground-disturbing activities are proposed, a discussion of how the needs of the disabled were considered in the planning and design of the trail, a provision for trash clean-up and removal, and identification of the entity(ies) responsible for construction, operation, and maintenance of the trail. The Commission should reserve the right to require changes to the plan based on the results of the study and consultation.

12. If the required trail cannot be built, the licensee's filing should include, for Commission approval, a plan and schedule for a reasonable alternative, including the development items noted above, and as appropriate, design drawings, cost estimates, and an implementation schedule.

13. In order to accurately include all existing and proposed recreation facilities in the Commission's geographic database for the project, the licensee should also file site-specific information on the location of the existing and proposed facilities, except the Entiaqua Trail, based on the information contained within the proposed plan. Further, the licensee should file as-built drawings for these sites, as proposed, upon completion of the proposed improvements.[3]

14. Implementation of the plan would provide for additional public recreational opportunities at the project. The licensee's plan adequately fulfills the requirements of Article 406 of the license and should be approved, with the above modifications.

The Director orders:

(A) The recreation resource management plan for the Rocky Reach hydroelectric Project, filed on February 12, 2010, as modified by paragraphs B, C, D, and E, is approved.

(B) Within 1 year of the date of issuance of this order, the licensee shall complete the proposed Entiatqua Trail Feasibility Study and file the study results with the Commission along with documentation of agency consultation. The licensee shall conduct the study in consultation with the City of Entiat, Washington State Department

[3] We note that proposed plan contains an as-built drawing of Onondo Park and that the proposed improvements to this site have already been completed.

of Transportation, C&C Railway, Washington Department of Fish and Wildlife, Washington State Parks and Recreation Commission, National Park Service, and U.S. Bureau of Land Management. The licensee shall allow a minimum of 30 days for the agencies to comment and to make recommendations on the study results and any proposed actions, prior to filing the study results with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on project-specific reasons.

(1) If the study finds that the required trail can be built, the licensee's filing shall include the proposed development information for the trail, as well as a description of soil erosion and sediment control measures to be used where ground-disturbing activities are proposed, a discussion of how the needs of the disabled were considered in the planning and design of the trail, a provision for trash clean-up and removal, and identification of the entity(ies) responsible for construction, operation, and maintenance of the trail. The Commission should reserve the right to require changes to the approved plan based on the results of the study and consultation.

(2) If the study finds that the required trail cannot be built, the licensee's filing shall include, for Commission approval, a plan and schedule for a reasonable alternative, including, as appropriate, a description of soil erosion and sediment control measures to be used where ground-disturbing activities are proposed, a discussion of how the needs of the disabled were considered in the planning and design of the alternative facility, a provision for trash clean-up and removal, and identification of the entity(ies) responsible for construction, operation, and maintenance of the alternative facility, design drawings, cost estimates, and an implementation schedule.

(C) At least 60 days prior to the start of construction of proposed improvements at Entiat Park, Lincoln Rock State Park, Daroga State Park and the Rocky Reach Trail, the licensee shall file final construction drawings for the improvements at the subject site, including erosion and sedimentation control measures, trash clean-up and removal provisions, a discussion of how the needs of the disabled were considered in the planning and design of the improvements. The Commission reserves the right to require changes to the final construction plans.

(D) Within 60 days from the date of completion of the proposed improvements at Entiat Park, Lincoln Rock State Park, Daroga State Park and the Rocky Reach Trail sites, the licensee shall file, for Commission approval, an as-built drawing for each site, as the proposed improvements at the specific site are completed, showing the location, type and layout of the existing and newly completed recreation facilities in relation to the project boundary.

(E) The following as-built drawing, filed on February 12, 2010 is approved and made part of the license.

Exhibit	FERC No.	Title
R-1	2145-133	Orondo Park

(F) Within 45 days of the date of issuance of this order, the licensee shall file the drawing approved in ordering paragraph (E), above, in aperture card and electronic format.

(1) Three sets of the approved drawings shall be reproduced on silver or gelatin 35 mm microfilm. All microfilm shall be mounted on type D (3-1/4" X 7-3/8") aperture cards. Prior to microfilming, the FERC Project Drawing Number (e.g., 2145-133) shall be shown in the margin below the title block of the approved drawings. After mounting, the FERC Drawing Number shall be typed on the upper right corner of each aperture card. Additionally, the Project Number, FERC Exhibit (e.g., R-1), Drawing Title, and date of this order shall be typed on the upper left corner of each aperture card. See Fig.1.

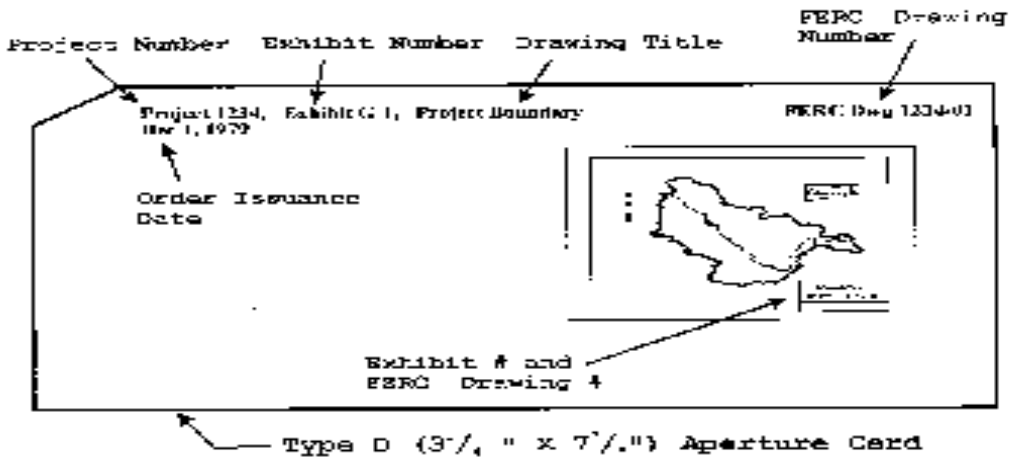


Figure 1 Sample Aperture Card Format

Two of the sets of aperture cards shall be filed with the Secretary of the Commission, ATTN: OEP/DHAC. The third set shall be filed with the Commission's Division of Dam Safety and Inspections, Portland Regional Office.

(2) The licensee shall file two separate sets of exhibit drawings in electronic raster format with the Secretary of the Commission, ATTN: OEP/DHAC. A third set shall be

filed with the Commission's Division of Dam Safety and Inspections, Chicago Regional Office. Each drawing must be a separate electronic file, and the file name shall include: FERC Project Drawing Number, FERC Exhibit, Drawing Title, date of this order, and file extension in the following format [2145-133, R-1, Orondo Park, MM-DD-YYYY.TIF]. Electronic drawings shall meet the following format specification:

IMAGERY – black & white raster file
FILE TYPE – Tagged Image File Format, (TIFF) CCITT Group 4
RESOLUTION – 300 dpi desired, (300 dpi min)
DRAWING SIZE FORMAT - 24" X 36" (min), 28" X 40" (max)
FILE SIZE – less than 1 MB desired

(E) Within 90 days of the issuance date of this order, the licensee shall file location point data representative of each existing and proposed recreation facility provided by the proejct's approved recreation plan. The location points must be positionally accurate to comply, at a minimum, with National Map Accuracy Standards for maps at a 1:24,000 scale. The location points must include latitude/longitude in decimal degrees based on the horizontal reference datum of the North American Datum of 1983 (NAD 83).

(F) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the FPA, 16 U.S.C. § 8251 (2006), and the Commission's regulations at 18 C.F.R. § 385.713 (2010). The filing of a request for rehearing does not operate as a stay of the effective date of this order, or of any other date specified in this order. The licensee's failure to file a request for rehearing shall constitute acceptance of this order.

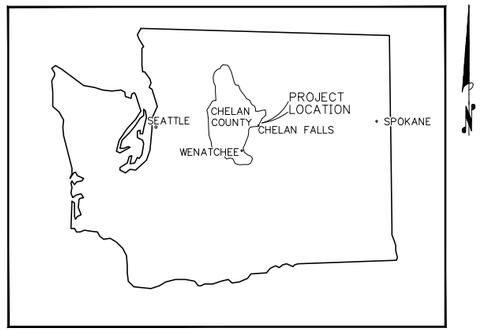
Robert J. Fletcher
Chief, Land Resources Branch
Division of Hydropower
Administration and Compliance

APPENDIX B – PRELIMINARY DESIGN DRAWINGS

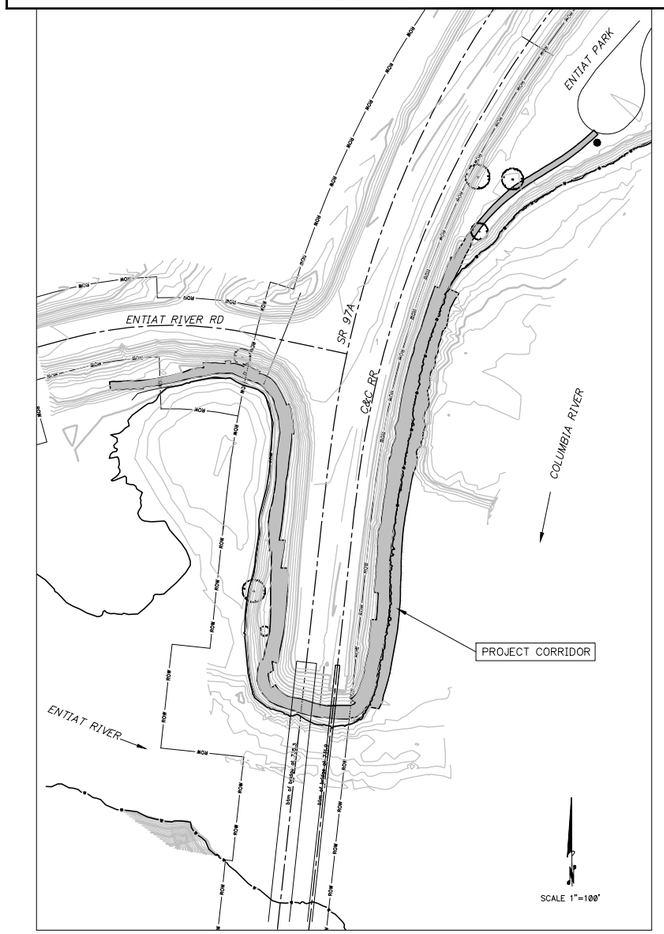
ENTIATQUA TRAIL PROJECT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

LOCATION MAP



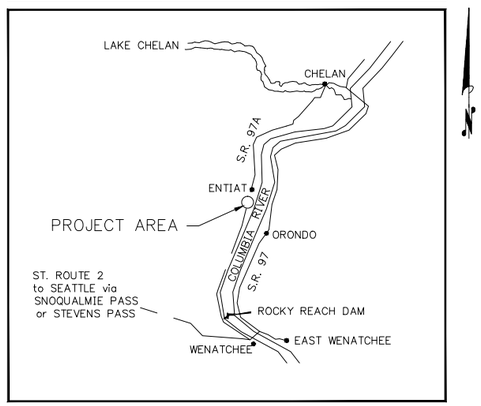
PROJECT MAP



BID DRAWING INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
1	0911-50GA-0001	MAPS AND SHEET INDEX
2	0911-50SK-0030	PROJECT OVERVIEW
3	0911-50SK-0031	COLUMBIA RIVER PLAN 1
4	0911-50SK-0032	COLUMBIA RIVER PLAN 2
5	0911-50SK-0021	COLUMBIA RIVER SECTION - STA. 4+50
6	0911-50SK-0020	COLUMBIA RIVER SECTION - STA. 8+00
7	0911-50SK-0023	SECTION AT SR97A BRIDGE C/L STA. 10+26
8	0911-50SK-0024	ENTIAT RIVER SECTION - STA. 10+26 AT SR97A BRIDGE C/L
9	0911-50SK-0028	ENTIAT RIVER SECTION - STA. 11+72
10	0911-50SK-0022	ENTIAT RIVER SECTION - STA. 15+46
11	0911-50SK-00XX	LOG STRUCTURES DETAILS
12	0911-50SK-00XX	ROCK STRUCTURES SECTIONS AND DETAILS

VICINITY MAP OF CHELAN



CONTACT PERSONNEL

CASEY HALL	CHELAN COUNTY PUD NO. 1 - CONSTRUCTION MANAGER	509-661-4965
COURT HILL	CHELAN COUNTY PUD NO. 1 - ENGINEER	509-661-4143

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

CHELAN PUD NO.1	SCALE SEE DWG		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			
PRIM. ENG. COURT HILL						
2ND ENG.	1	12/1/11	PRELIMINARY DESIGN	CRH	SCF	
PROJ. MGR. BOB SEABECK	REV	DATE	REVISION	REQ. BY	DRFT	

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

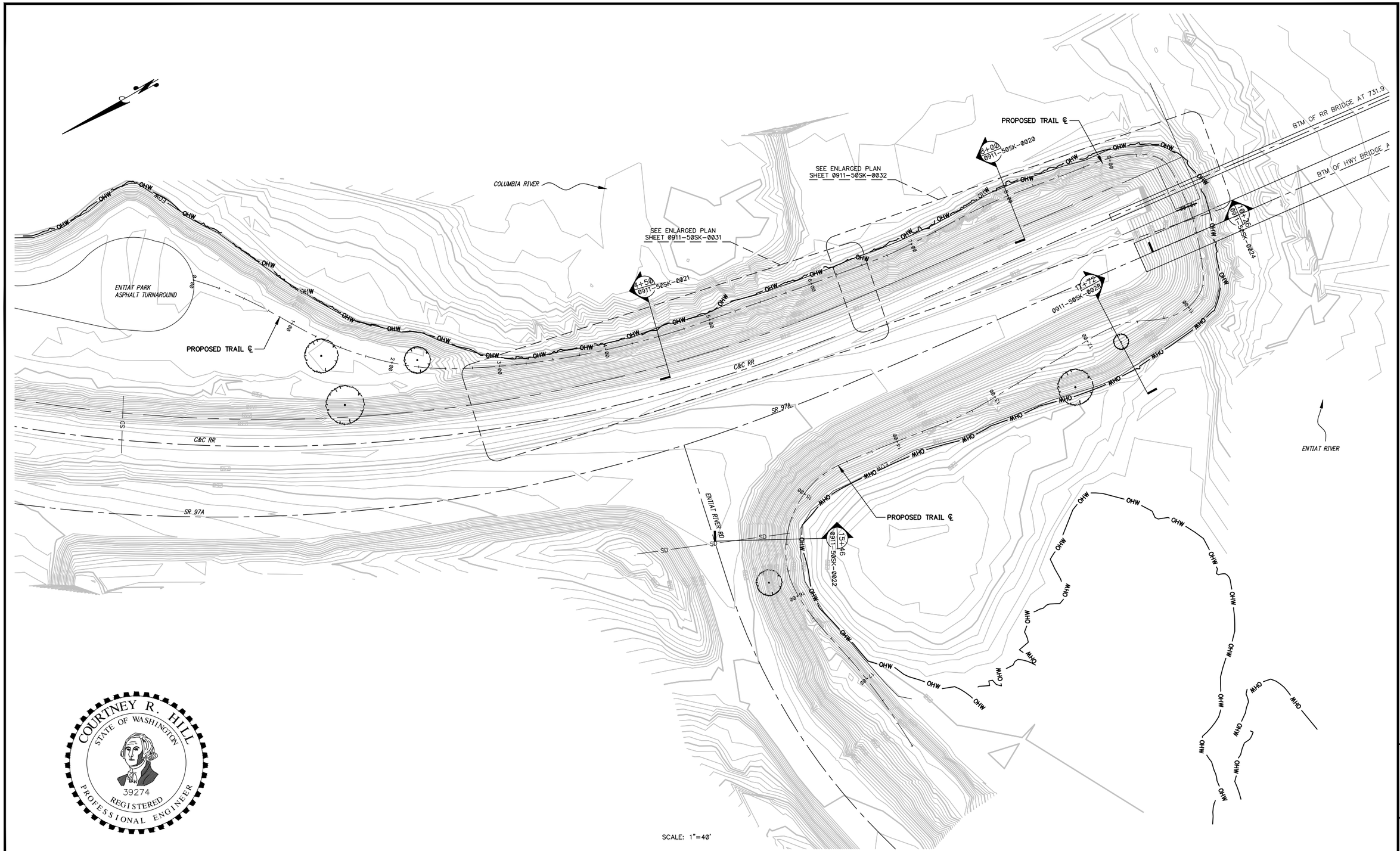
P.U.D. CHELAN COUNTY

ENTIAT PARK
ENTIATQUA TRAIL
MAPS & SHEET INDEX

SHEET	1 OF 14
REVISION	1
DATE	12/1/11
DWG.	0911-50GA-0001

ORIG. DRAWN JEC
ORIG. DATE 2/10/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:



SCALE: 1"=40'

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

CHELAN PUD NO.1		SCALE SEE SHEET		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.		
PRIM. ENG. COURT HILL						
2ND ENG.	0	12/1/11	PRELIMINARY DESIGN		CRH	SCF
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

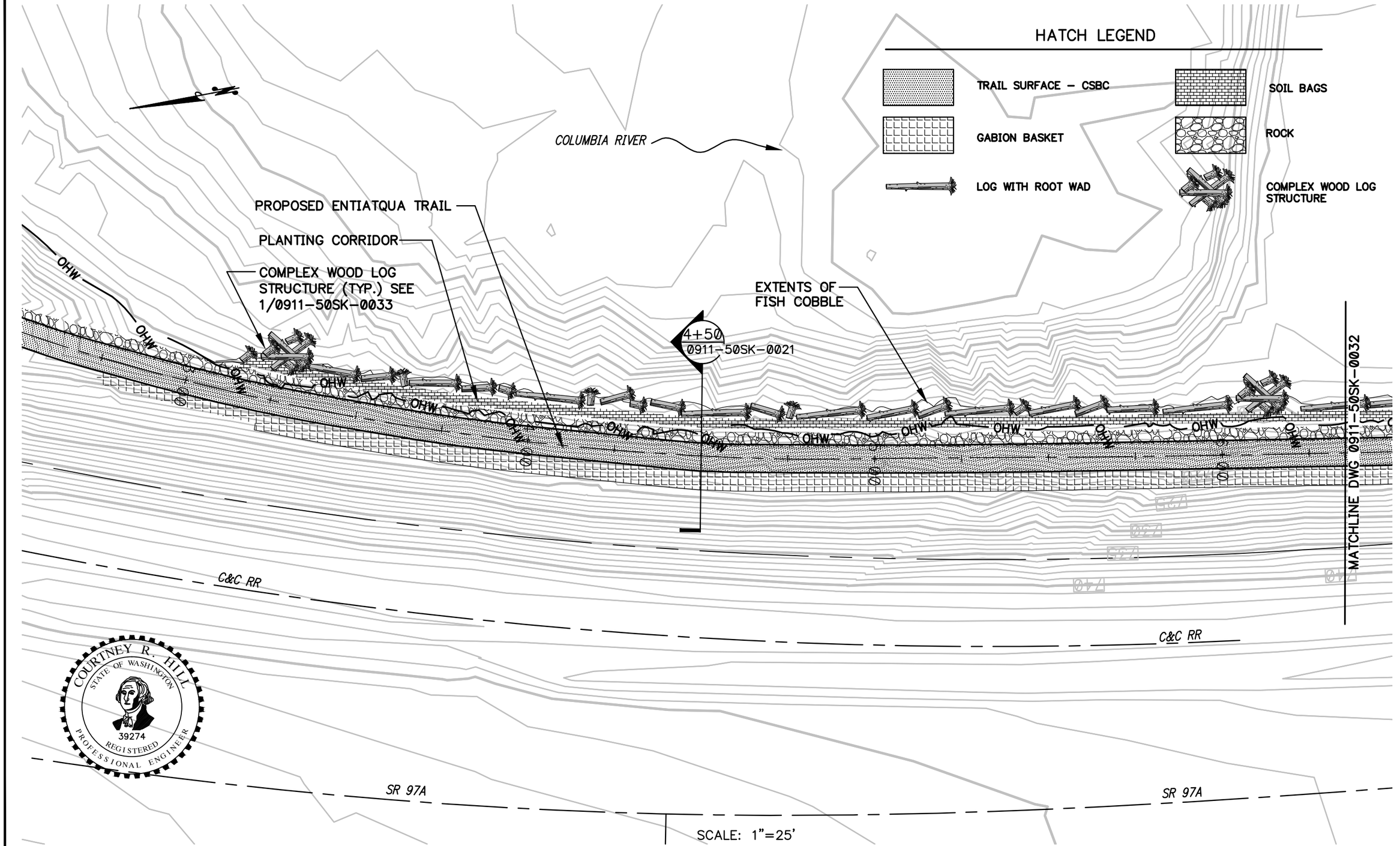
P.U.D. CHELAN COUNTY

ENTIAT PARK
ENTIATQUA TRAIL
PROJECT OVERVIEW

SHEET 2 OF 12
REVISION 0
DATE 12/1/11
DWG. 0911-50SK-0030

ORIG. DRAWN JEC
ORIG. DATE 2/10/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:



COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

CHELAN PUD NO.1	SCALE SEE SHEET		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.		
PRIM. ENG. COURT HILL					
2ND ENG.	0	12/1/11	PRELIMINARY DESIGN	CRH	SCF
PROJ. MGR.	REV	DATE	REVISION	REQ. BY	DRFT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

ENTIAT PARK
ENTIATQUA TRAIL
COLUMBIA RIVER PLAN 1

SHEET 3 OF 12
REVISION 0
DATE 12/1/11
DWG. 0911-50SK-0031

ORIG. DRAWN JEC
ORIG. DATE 2/10/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:

HATCH LEGEND

- TRAIL SURFACE – CSBC
- GABION BASKET
- LOG WITH ROOT WAD
- SOIL BAGS
- ROCK
- COMPLEX WOOD LOG STRUCTURE

COLUMBIA RIVER

PROPOSED ENTIATQUA TRAIL

PLANTING CORRIDOR

8+00
0911–50SK–0020

EXTENTS OF FISH COBBLE

COMPLEX WOOD LOG STRUCTURE (TYP.) SEE 1/0911–50SK–0033

MATCHLINE DWG 0911–50SK–0031

OHW

MHO

C&C RR

SR 97A

ENTIAT RIVER

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

SCALE: 1"=25'

CHELAN PUD NO.1		SCALE SEE SHEET		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			
PRIM. ENG. COURT HILL							
2ND ENG.		Ø	12/1/11	PRELIMINARY DESIGN		CRH	SCF
PROJ. MGR.		REV	DATE	REVISION		REQ. BY	DRFT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

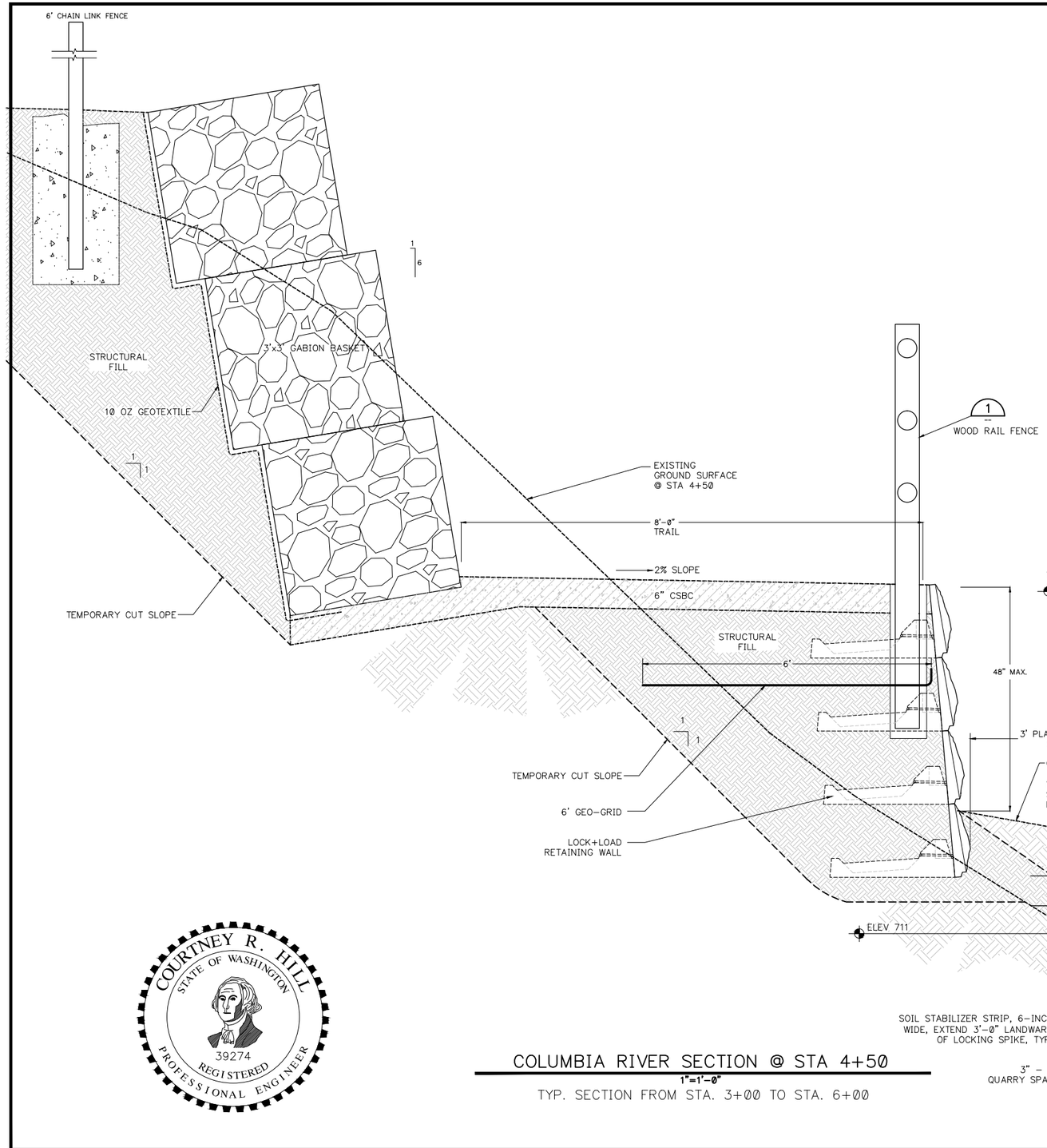
P.U.D. CHELAN COUNTY

ENTIAT PARK
ENTIATQUA TRAIL
COLUMBIA RIVER PLAN 2

SHEET	4 OF 12
REVISION	Ø
DATE	12/1/11
DWG.	0911–50SK–0032

ORIG. DRAWN JEC
ORIG. DATE 2/10/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:



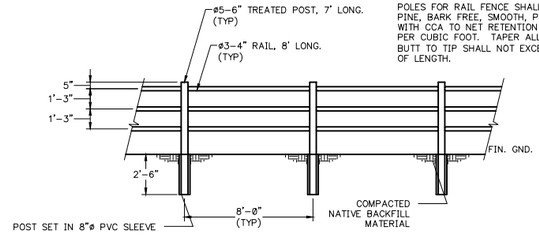
COLUMBIA RIVER SECTION @ STA 4+50

1"=1'-0"

TYP. SECTION FROM STA. 3+00 TO STA. 6+00

NOTES:

POLES FOR RAIL FENCE SHALL BE LODGE POLE PINE, BARK FREE, SMOOTH, PRESSURE TREATED WITH CCA TO NET RETENTION OF 0.4 POUNDS PER CUBIC FOOT. TAPER ALLOWANCE FROM BUTT TO TIP SHALL NOT EXCEED 1" FOR 10' OF LENGTH.



1 RAIL FENCE ELEVATION

NTS

NOTES:

1. PLACE SEED MIX AND OTHER PLANTS AS SHOWN ON DWG. XXXX-XXXX-XXXX ALONG ENTIRE LENGTH OF COIR FABRIC CORRIDOR.
2. PLANT 80% OF LIVE STAKE LENGTH IN/UNDER/THROUGH SOIL BAGS.
3. THE PORTION OF LIVE STAKE EXPOSED SHALL CONTAIN 2 TO 5 BUD SCARS AND SHALL BE CUT SQUARE TO THE END.
4. THE BURIED END OF THE LIVE STAKE (BUTT-END) SHALL BE ANGLED CUT.
5. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON (OCT 30 – NOV 30).
6. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS AND THROUGH SOIL BAGS.
7. SOAK CUTTINGS CONTINUOUSLY PRIOR TO INSTALLATION.
8. ONLY NURSERY GROWN STOCK SHALL BE USED. HARVESTING OF WILD PLANTS IS NOT ACCEPTABLE.
9. COIR FABRIC AND GEOTEXTILE TO OVERLAP 12"-18" BELOW SOIL BAGS.

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

CHELAN PUD NO.1	SCALE SEE DWG		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			
PRIM. ENG. COURT HILL						
2ND ENG.	0	12/1/2011	PRELIMINARY DESIGN		CRH	TPD
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT

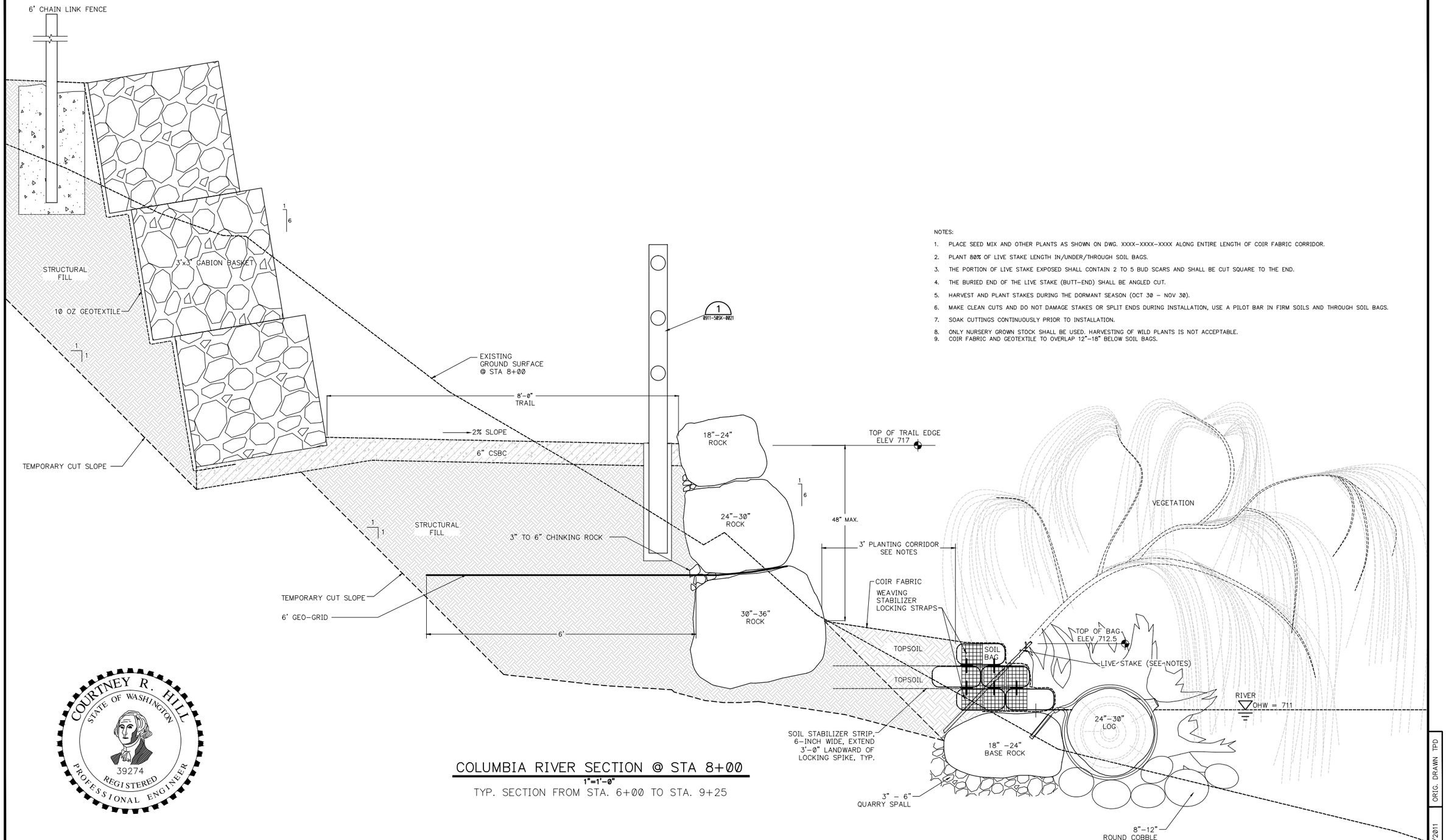
PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

Entiat Park
ENTIATQUA TRAIL
COLUMBIA RIVER SECTION – STA 4+50

SHEET 5 OF 12
REVISION 0
DATE 12/1/2011
DWG. 0911-50SK-0021

ORIG. DRAWN TPD
ORIG. DATE 9/1/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:



NOTES:

1. PLACE SEED MIX AND OTHER PLANTS AS SHOWN ON DWG. XXXX-XXXX-XXXX ALONG ENTIRE LENGTH OF COIR FABRIC CORRIDOR.
2. PLANT 80% OF LIVE STAKE LENGTH IN/UNDER/THROUGH SOIL BAGS.
3. THE PORTION OF LIVE STAKE EXPOSED SHALL CONTAIN 2 TO 5 BUD SCARS AND SHALL BE CUT SQUARE TO THE END.
4. THE BURIED END OF THE LIVE STAKE (BUTT-END) SHALL BE ANGLED CUT.
5. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON (OCT 30 – NOV 30).
6. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS AND THROUGH SOIL BAGS.
7. SOAK CUTTINGS CONTINUOUSLY PRIOR TO INSTALLATION.
8. ONLY NURSERY GROWN STOCK SHALL BE USED. HARVESTING OF WILD PLANTS IS NOT ACCEPTABLE.
9. COIR FABRIC AND GEOTEXTILE TO OVERLAP 12"-18" BELOW SOIL BAGS.

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

COLUMBIA RIVER SECTION @ STA 8+00

1"=1'-0"

TYP. SECTION FROM STA. 6+00 TO STA. 9+25

CHELAN PUD NO.1	SCALE SEE DWG		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.				
PRIM. ENG. COURT HILL							
2ND ENG.	0	12/1/2011	PRELIMINARY DESIGN			CRH	TPD
PROJ. MGR.	REV	DATE	REVISION			REQ. BY	DRFT

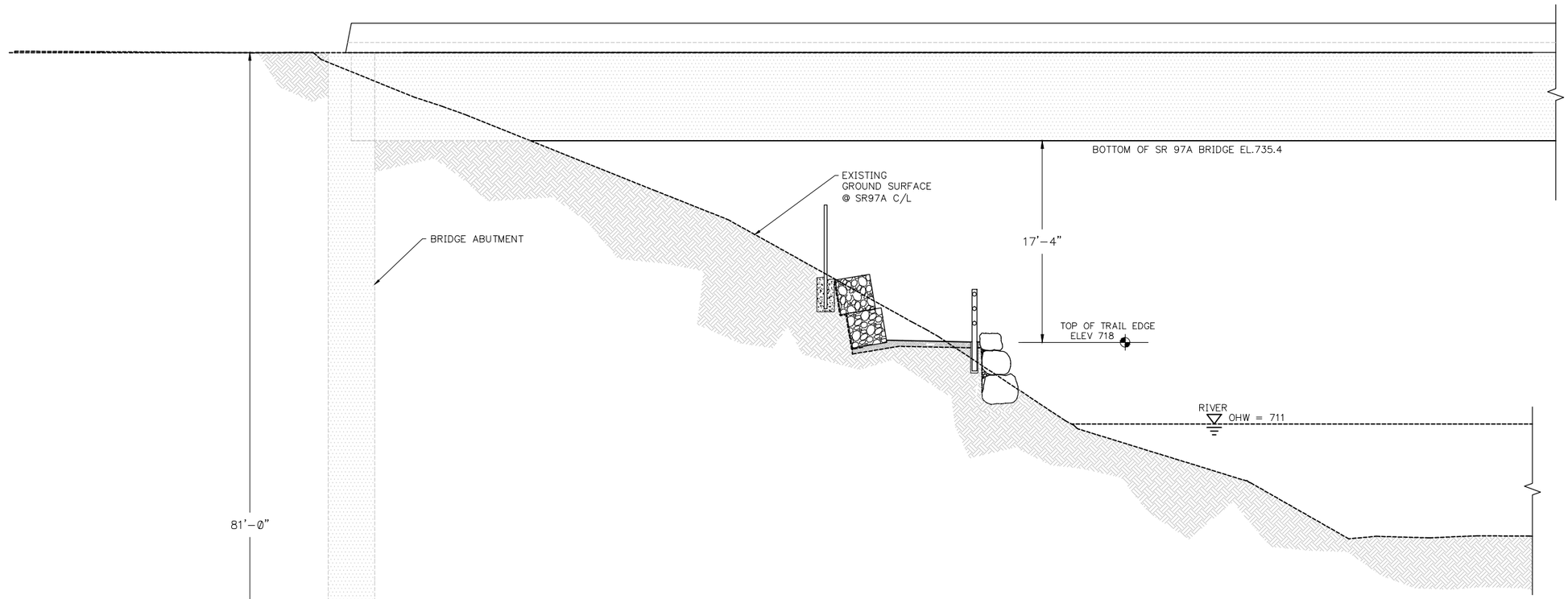
PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

P.U.D. CHELAN COUNTY

Entiat Park
ENTIATQUA TRAIL
COLUMBIA RIVER SECTION – STA 8+00

SHEET	6 OF 12
REVISION	0
DATE	12/1/2011
DWG.	0911-50SK-0020
ORIG. DRAWN	TPD
ORIG. DATE	9/1/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #:



COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

SECTION @ SR97A BRIDGE C/L

1"=5'-0"

CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE Ø 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			
PRIM. ENG. COURT HILL					
2ND ENG.	Ø	12/1/2011	PRELIMINARY DESIGN	CRH	SCF
PROJ. MGR.	REV	DATE	REVISION	REQ. BY	DRFT

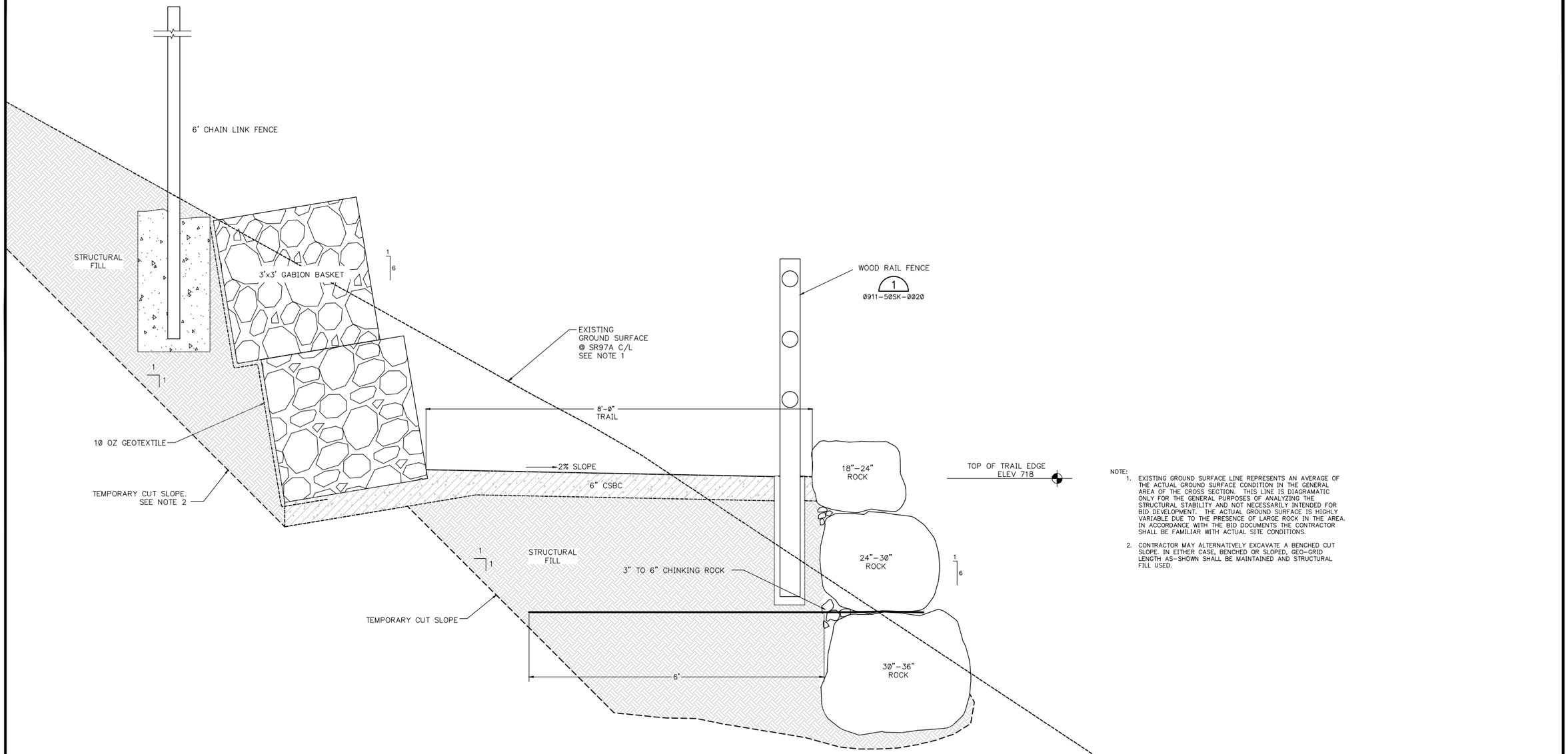
PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

Entiat Park
ENTIATQUA TRAIL
SECTION AT SR97A BRIDGE C/L STA. 10+26

SHEET 7 OF 12
REVISION Ø
DATE 12/1/2011
DWG. 0911-50SK-0023

ORIG. DRAWN TPD
ORIG. DATE 10/27/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #: –



NOTE:

1. EXISTING GROUND SURFACE LINE REPRESENTS AN AVERAGE OF THE ACTUAL GROUND SURFACE CONDITION IN THE GENERAL AREA OF THE CROSS SECTION. THIS LINE IS DIAGRAMATIC ONLY FOR THE GENERAL PURPOSES OF ANALYZING THE STRUCTURAL STABILITY AND NOT NECESSARILY INTENDED FOR BID DEVELOPMENT. THE ACTUAL GROUND SURFACE IS HIGHLY VARIABLE DUE TO THE PRESENCE OF LARGE ROCK IN THE AREA. IN ACCORDANCE WITH THE BID DOCUMENTS THE CONTRACTOR SHALL BE FAMILIAR WITH ACTUAL SITE CONDITIONS.
2. CONTRACTOR MAY ALTERNATIVELY EXCAVATE A BENCHED CUT SLOPE. IN EITHER CASE, BENCHED OR SLOPED, GEO-GRID LENGTH AS-SHOWN SHALL BE MAINTAINED AND STRUCTURAL FILL USED.

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

ENTIAT RIVER SECTION @ SR97A BRIDGE C/L – STA 10+26

1"=1'-0"

TYP. SECTION FROM STA. 9+25 TO STA. 11+25

CHELAN PUD NO.1		SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING.	VERIFY SCALE 0 — 1"	IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.		
PRIM. ENG. COURT HILL							
2ND ENG.	0	12/1/2011	PRELIMINARY DESIGN			CRH	SCF
PROJ. MGR.	REV	DATE	REVISION			REQ. BY	DRFT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

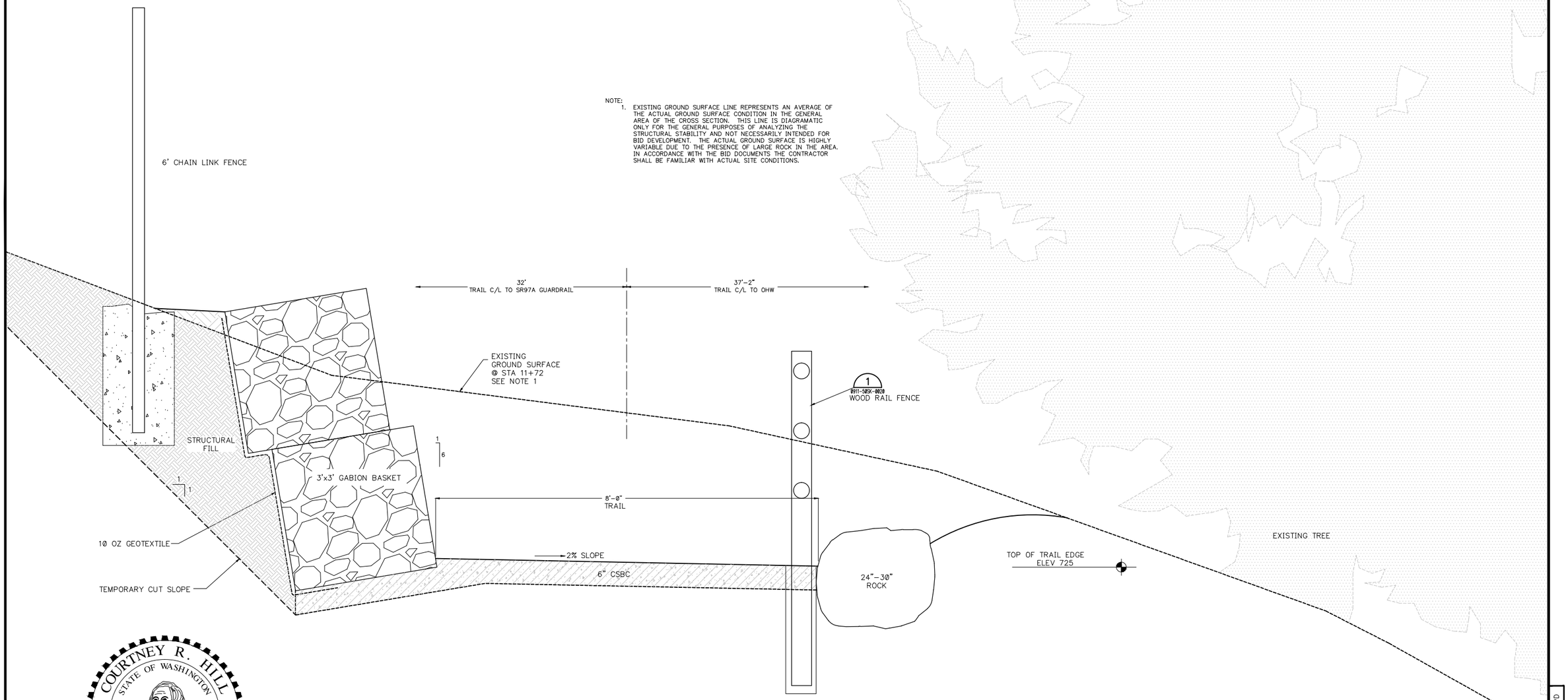
Entiat Park
ENTIATQUA TRAIL
ENTIAT RIVER SECTION – STA 10+26
AT SR97A BRIDGE C/L

SHEET 8 OF 12
REVISION Ø
DATE 12/1/2011
DWG. 0911-50SK-0024

ORIG. DRAWN TPD
ORIG. DATE 10/27/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #: –

NOTE:
1. EXISTING GROUND SURFACE LINE REPRESENTS AN AVERAGE OF THE ACTUAL GROUND SURFACE CONDITION IN THE GENERAL AREA OF THE CROSS SECTION. THIS LINE IS DIAGRAMATIC ONLY FOR THE GENERAL PURPOSES OF ANALYZING THE STRUCTURAL STABILITY AND NOT NECESSARILY INTENDED FOR BID DEVELOPMENT. THE ACTUAL GROUND SURFACE IS HIGHLY VARIABLE DUE TO THE PRESENCE OF LARGE ROCK IN THE AREA. IN ACCORDANCE WITH THE BID DOCUMENTS THE CONTRACTOR SHALL BE FAMILIAR WITH ACTUAL SITE CONDITIONS.



COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

ENTIAT RIVER SECTION @ STA 11+72

1"=1'-0"

TYP. SECTION FROM STA. 11+25 TO STA. 13+00

CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE Ø 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.				
PRIM. ENG. COURT HILL						
2ND ENG.	Ø	12/1/2011	PRELIMINARY DESIGN		CRH	SCF
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT

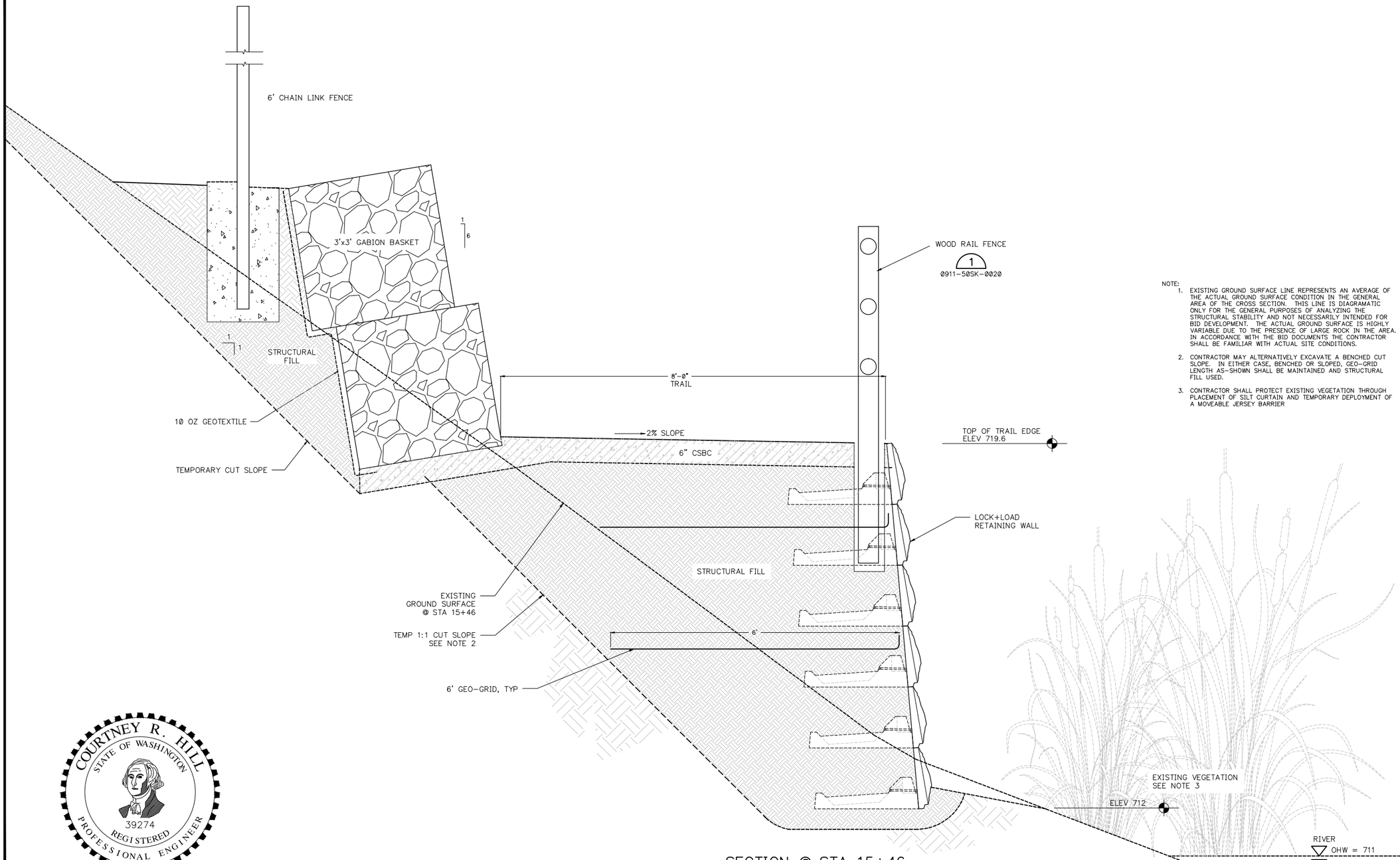
PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

Entiat Park
ENTIATQUA TRAIL
ENTIAT RIVER SECTION – AT STA 11+72

SHEET	9 OF 12
REVISION	Ø
DATE	12/1/2011
DWG.	0911-50SK-0028

ORIG. DRAWN TPD
ORIG. DATE 10/27/2011

DOCUMENT CLASS: ID: ORIGINAL DWG. #: –



NOTE:

1. EXISTING GROUND SURFACE LINE REPRESENTS AN AVERAGE OF THE ACTUAL GROUND SURFACE CONDITION IN THE GENERAL AREA OF THE CROSS SECTION. THIS LINE IS DIAGRAMATIC ONLY FOR THE GENERAL PURPOSES OF ANALYZING THE STRUCTURAL STABILITY AND NOT NECESSARILY INTENDED FOR BID DEVELOPMENT. THE ACTUAL GROUND SURFACE IS HIGHLY VARIABLE DUE TO THE PRESENCE OF LARGE ROCK IN THE AREA. IN ACCORDANCE WITH THE BID DOCUMENTS THE CONTRACTOR SHALL BE FAMILIAR WITH ACTUAL SITE CONDITIONS.
2. CONTRACTOR MAY ALTERNATIVELY EXCAVATE A BENCHED CUT SLOPE. IN EITHER CASE, BENCHED OR SLOPED, GEO-GRID LENGTH AS-SHOWN SHALL BE MAINTAINED AND STRUCTURAL FILL USED.
3. CONTRACTOR SHALL PROTECT EXISTING VEGETATION THROUGH PLACEMENT OF SILT CURTAIN AND TEMPORARY DEPLOYMENT OF A MOVEABLE JERSEY BARRIER

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

SECTION @ STA 15+46

1"=1'-0"

TYP. SECTION FROM STA. 13+00 TO STA. 17+50

ORIG. DRAWN TPD

ORIG. DATE 9/1/2011

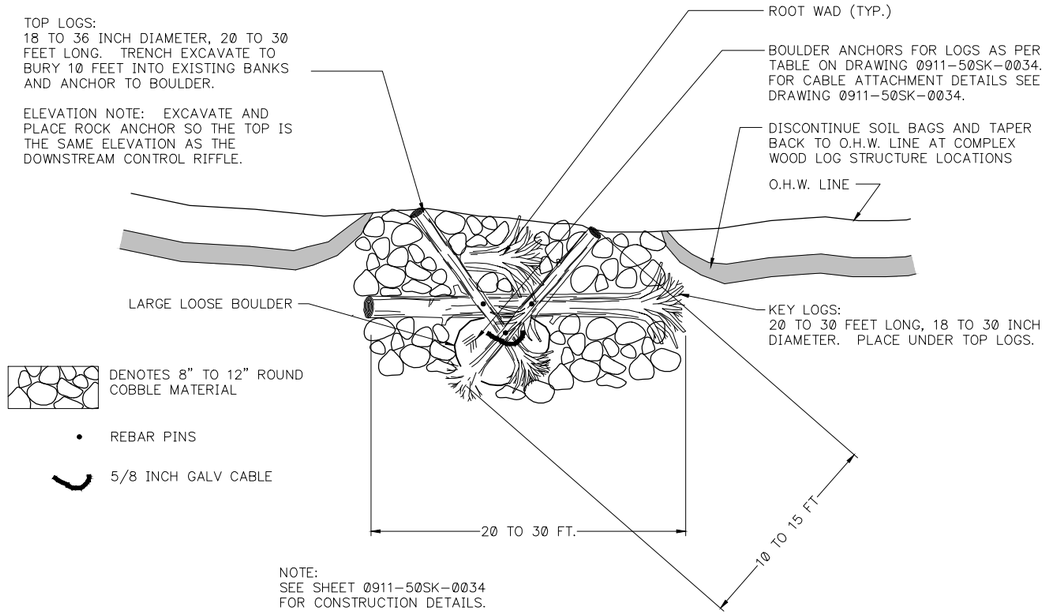
CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.				
PRIM. ENG. COURT HILL						
2ND ENG.	0	12/1/2011	PRELIMINARY DESIGN		CRH	SCF
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

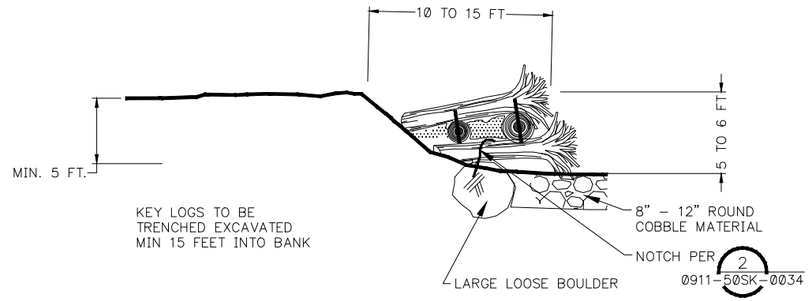
Entiat Park
ENTIATQUA TRAIL
ENTIAT RIVER SECTION – STA 15+46

SHEET 10 OF 12
REVISION 0
DATE 12/1/2011
DWG. 0911-50SK-0022

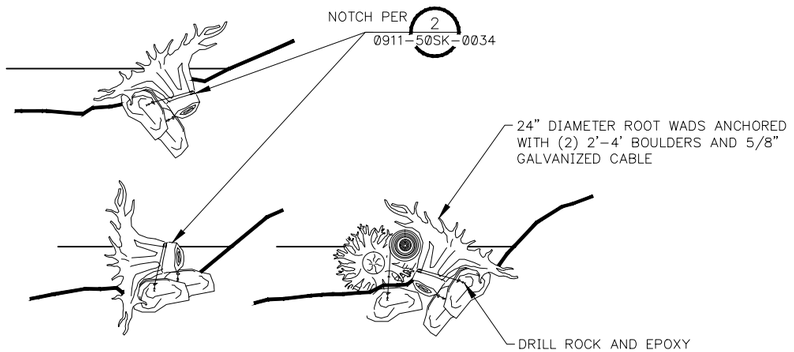
DOCUMENT CLASS: ID: ORIGINAL DWG. #: –



TYPICAL V-LOG JAM PLAN DETAIL 1
NTS



TYPICAL LOG JAM SECTION DETAIL 2
NTS



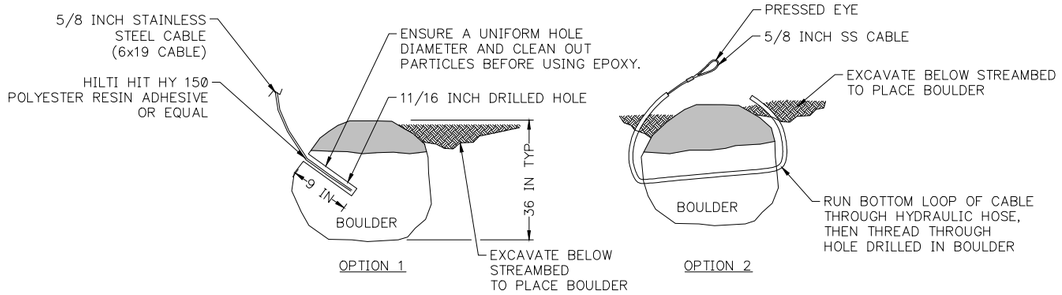
TYPICAL ROOT WAD DETAIL 3
NTS

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

	CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY WENATCHEE, WASHINGTON	ENTIAT PARK LOG STRUCTURES DETAILS
	PRIM. ENG. COURT HILL						SHEET 11 OF 12
	2ND ENG.	0	12/1/11	PRELIMINARY DESIGN	CRH SCF		REVISION 0
	PROJ. MGR.	REV	DATE	REVISION	REQ. BY DRFT		DATE 12/1/11
							DWG. 0911-50SK-0033

ORIG. DRAWN ANC
ORIG. DATE 11/28/11

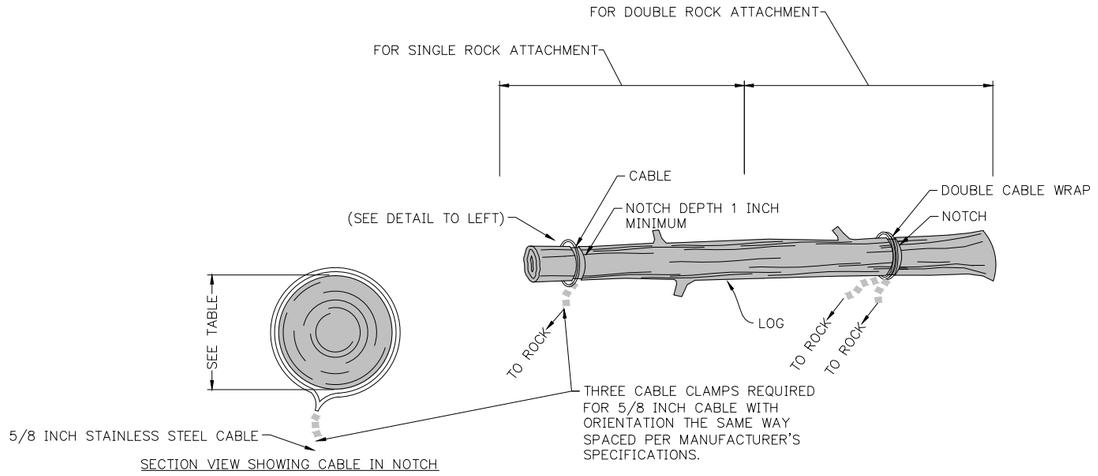
DOCUMENT CLASS: ID: ORIGINAL DWG. #:



DRILL 11/16–IN HOLE 9–IN DEEP. FILL HOLE WITH HILTI HIT HY150 OR SIMILAR. INSERT CABLE PER MANUFACTURER'S SPECIFICATIONS.

SECURING CABLE TO BOULDER — 1

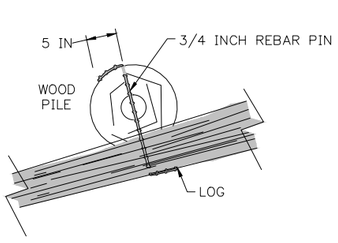
NTS



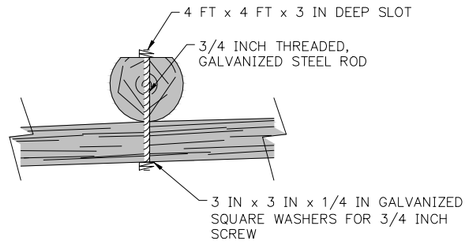
SECTION VIEW SHOWING CABLE IN NOTCH

CABLING DETAIL TO SINGLE OR DOUBLE ROCKS — 2

NTS



DRILL 3/4"–DIAMETER HOLES THROUGH WOOD PILE AND LOG. DRIVE 3/4" REBAR (MINIMUM 2 FEET OR LOG DIAMETER) INTO EACH. BEND REBAR OVER SO NOT EXPOSED.



OPTIONAL BOLTED CONNECTION.
DRILL 3/4 INCH HOLES THROUGH BOTH LOGS. CUT 4 FT x 4 FT X 3 IN DEEP INTO TOP LOG. INSERT 3/4 INCH GALVANIZED THREADED ROD AND ATTACH AT BOTH ENDS WITH WASHERS AND NUTS. MAINTAIN A MINIMUM 15 INCHES FROM END OF WOOD PILE TO PIN LOCATION.

REBAR PIN DETAILS — 3

NTS

LWD ANCHOR TABLE ASSUMING TWO ROCKS PER LWD PIECE (WEIGHT OF EACH ROCK, ROCK DIAMETER)

LOG DIAMETER (INCHES)	LOG LENGTH (FEET, TIP TO BASE) 10	20	30	40
18	1150 LBS, 28 INCH	1870 LBS, 33 INCH	2600 LBS, 37 INCH	3300 LBS, 40 INCH
24	1630 LBS, 31 INCH	2600 LBS, 36 INCH	3500 LBS, 41 INCH	4500 LBS, 44 INCH
36	2400 LBS, 36 INCH	3800 LBS, 42 INCH	5300 LBS, 46 INCH	6700 LBS, 50 INCH

ASSUMPTIONS

1. VALUES ARE FOR EACH ROCK.
2. LOGS HAVE ROOTWADS ATTACHED
3. LOG DIAMETER IS AVERAGE OF BASE AND END

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.					
PRIM. ENG. COURT HILL							
2ND ENG.	0	12/1/11	AS-BUILT		CRH	SCF	
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT	

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

ENTIAT PARK
ROCK STRUCTURES SECTIONS AND DETAILS

SHEET 12 OF 12
REVISION 0
DATE 12/1/11
DWG. 0911–50SK–0034

ORIG. DRAWN ANC
ORIG. DATE 8/31/2007

DOCUMENT CLASS: ID: ORIGINAL DWG. #:

APPENDIX C – GEOTECHNICAL ANALYSES

1 – General Site Assessment

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MINNESOTA
MISSOURI
OREGON
WASHINGTON

May 6, 2011

Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County
327 N. Wenatchee Avenue
Wenatchee, WA 98801

RE: CONCEPTUAL GEOTECHNICAL ENGINEERING RECOMMENDATIONS, PROPOSED ENTIATQUA TRAIL ENTIAT, WASHINGTON

Dear Mr. Hill:

This letter presents our preliminary recommendations for the proposed Entiatqua Trail in Entiat, Washington. Our scope of services for this project included:

- Field reconnaissance;
- Literature review;
- Performing engineering analyses; and
- Preparing this letter report.

We performed these services in general accordance with our proposal dated March 11, 2011.

SITE AND PROJECT DESCRIPTION

The proposed trail will connect Entiat Park with the proposed Entiatqua Outdoor Learning Center. Entiat Park is between US Highway 97 and the C&C Railroad, and the west shore of the Columbia River. The proposed Entiatqua Outdoor Learning Center will be on the shores of the Entiat River, south of Entiat River Road and west of US Highway 97.

Most of the proposed trail will be along the US Highway 97 and C&C Railroad embankment. The embankments are sparsely vegetated with grass, brush, and small trees.

The proposed trail will be 6 feet wide and will be surfaced with compacted aggregate. Other project elements could include viewpoints, a pedestrian barrier to separate the trail from US Highway 97 and the C&C railroad, benches and signs, and restorative planting. Figure 1 shows the Site Plan.

400 NORTH 34TH STREET · SUITE 100
P.O. BOX 300303
SEATTLE, WASHINGTON 98103
206·632·8020 FAX 206·695·6777
TDD: 1·800·833·6388
www.shannonwilson.com

Because of the relatively steep embankment slopes, much of the proposed trail could require placing fills into the river and/or retaining walls. Trail construction could require excavation into the existing embankment to create a bench for the trail.

LITERATURE REVIEW AND SITE RECONNAISSANCE

We met with you on April 13, 2011, to review information about the construction of the US Highway 97 and C&C Railroad embankments and perform a site reconnaissance. We reviewed the following information:

- Photographs of US Highway 97 and C&C Railroad embankment/bridge construction;
- As-built cross-sections of the embankments; and
- Preliminary plans, cross-sections, and profiles of the proposed trail.

Based on this information, we understand that the US Highway 97 and C&C Railroad embankment was built from rock quarried from the cliffs on the south side of the Entiat River. The construction of the embankment and associated bridges was completed before Rocky Reach Dam began operation and raised the level of the Columbia River to its current elevation. The ordinary high water mark (OHWM) for the Columbia River near the project site is elevation 711 feet (NAVD88). Public Utility District No. 1 of Chelan County (PUD) is studying the feasibility of raising the OHWM to 714 feet (NAVD88).

During our site reconnaissance, we walked along the proposed trail alignment. We made the following observations:

- The embankment side slopes are generally between 30 and 40 degrees, with locally steeper areas, particularly on the east side and northwest corner of the embankment;
- The embankment fill material generally comprises 1- to 3-foot-diameter angular boulders (tonalite of the Chelan Complex) with a sandy matrix; and
- A 1-foot-thick layer of rounded, 3- to 12-inch cobbles covers portions of the embankment, particularly on the east side of the embankment.

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on our literature review and site reconnaissance, we performed engineering analyses to develop conceptual recommendations for design of the proposed trail. Based on our analyses, we recommend the following for conceptual planning purposes:

- Permanent cut slopes could be 1.5 horizontal to 1 vertical (1.5H:1V); and
- Permanent, unreinforced fill slopes could be 1.5H:1V, provided they are constructed from suitable fill material (e.g., on-site embankment fill or well-graded angular sand and gravel).

Figures 2 through 5 show conceptual cross-sections at four locations along the proposed trail alignment. We recommend constructing the trail on fill sections:

- Along the east side of the embankment (Figure 2); and
- At the northwest corner of the embankment (Figure 5).

The trail could be constructed on cut or fill sections:

- Under the C&C Railroad and US Highway 97 bridges (Figure 3); and
- Along the west side of the embankment (Figure 4).

New fill should be constructed on benches cut into the existing slope. Cuts that would require permanent slopes steeper than 1.5H:1V should be retained. Additional studies are needed to evaluate temporary cut slopes.

The PUD should evaluate environmental and permitting impacts of placing fill slopes into the Columbia and Entiat Rivers. An alternative to placing fill in the rivers would be using reinforced soil slopes or mechanically stabilized earth walls to support the trail and reduce the filled area in the rivers. Reinforced soil slopes could be built at 1H:1V or steeper. Depending on the reinforcing material and fascia, the slope face could be vegetated. For example, geocells could be used to reinforce the slope and provide a topsoil zone sufficient to retain moisture and promote plant growth.

On the west side of the railroad/highway embankment, the PUD could consider placing the proposed trail on a boardwalk or bridge. The bridge could extend across a portion of the Entiat River through nearby wetlands. Figure 1 shows possible bridge locations.

A boardwalk or bridge could likely be supported on deep foundations, such as micropiles or pin piles. Micropiles are drilled deep foundation elements, typically about 6 inches in diameter, that are filled with grout and reinforced with rebar. Pin piles are small-diameter (typically 6 inches or less) driven pipe piles. Micropiles and pin piles can be installed with relatively small equipment.

We recommend performing subsurface explorations to evaluate standup in excavations made in the existing embankment near the proposed trail alignment. We also recommend performing subsurface explorations in the Columbia and Entiat Rivers to evaluate the depth and relative density of the river sediment. Our letter, dated May 2, 2011, contains a proposed scope of services for additional subsurface explorations.

CLOSING REMARKS

This letter was prepared for the exclusive use of PUD. The purpose of this letter was to provide conceptual-level engineering recommendations for planning the Entiatqua Trail project. The recommendations in this letter should not be used for construction. The analyses, conclusions, and recommendations contained in this letter are based on the information in our literature review and our site visit. We did not perform subsurface explorations for this study.

Within the limitations of the scope, schedule, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either expressed or implied.

The scope of our geotechnical services did not include any environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air on or below the site, or any evaluation for disposal of contaminated soils or groundwater.

We did not evaluate the project site for potential impacts to natural resources, including wetlands, endangered species, or environmentally critical areas. Shannon & Wilson has staff experienced in these issues should they arise.

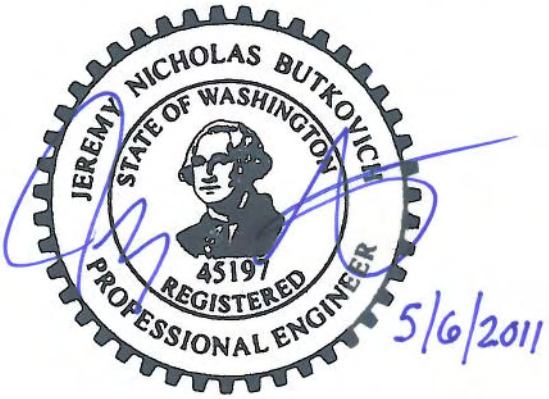
SHANNON & WILSON, INC.

Shannon & Wilson, Inc. has prepared a document, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our reports. This document is enclosed with this letter report.

We trust that this information meets your current needs. Please call if you have questions.

Sincerely,

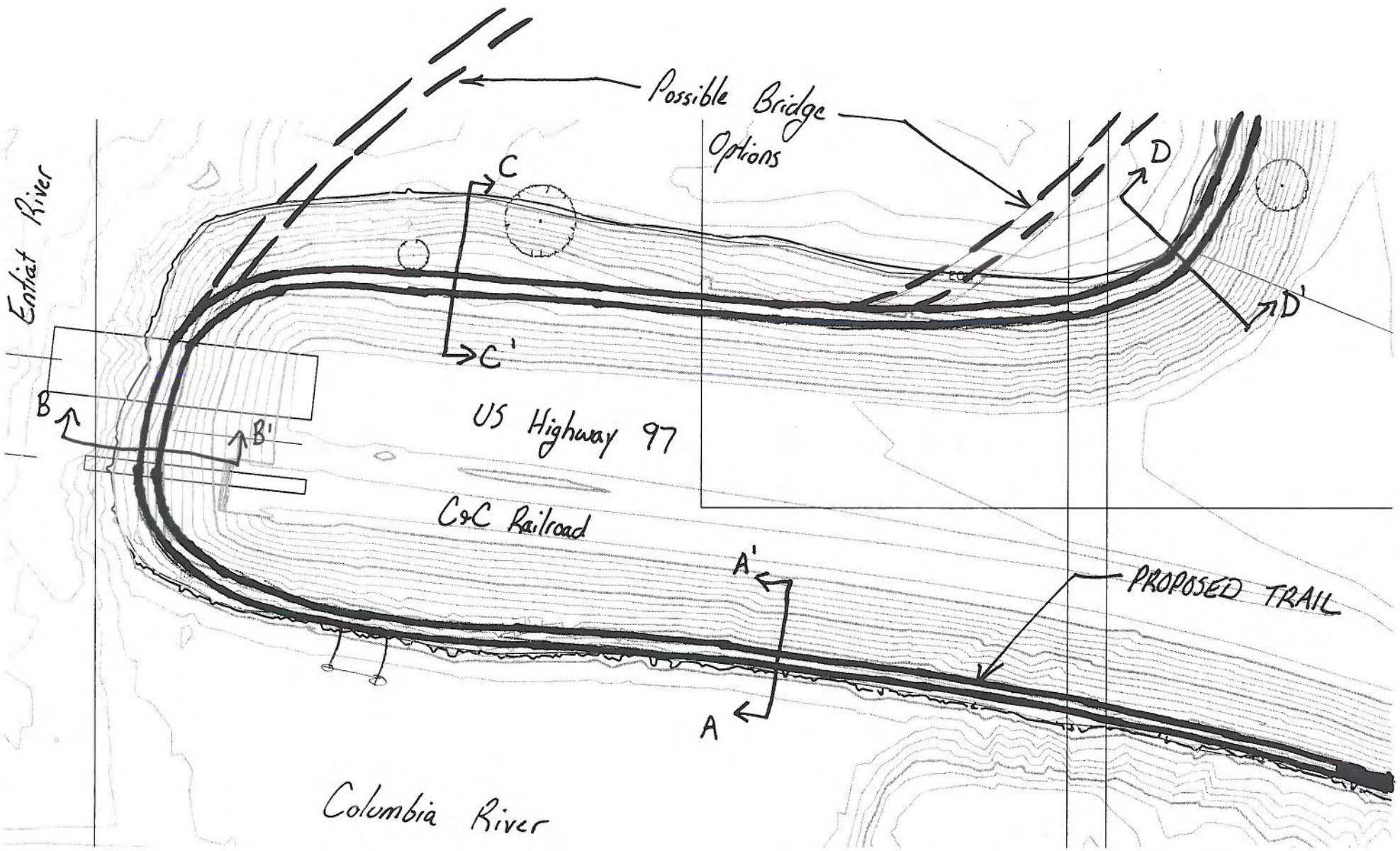
SHANNON & WILSON, INC.



Jeremy N. Butkovich, P.E.
Principal Engineer

JNB:CAR/jnb

Enc: Figure 1 – Site Plan
Figure 2 – Section A-A'
Figure 3 – Section B-B'
Figure 4 – Section C-C'
Figure 5 – Section D-D'
Important Information About Your Geotechnical/Environmental Report



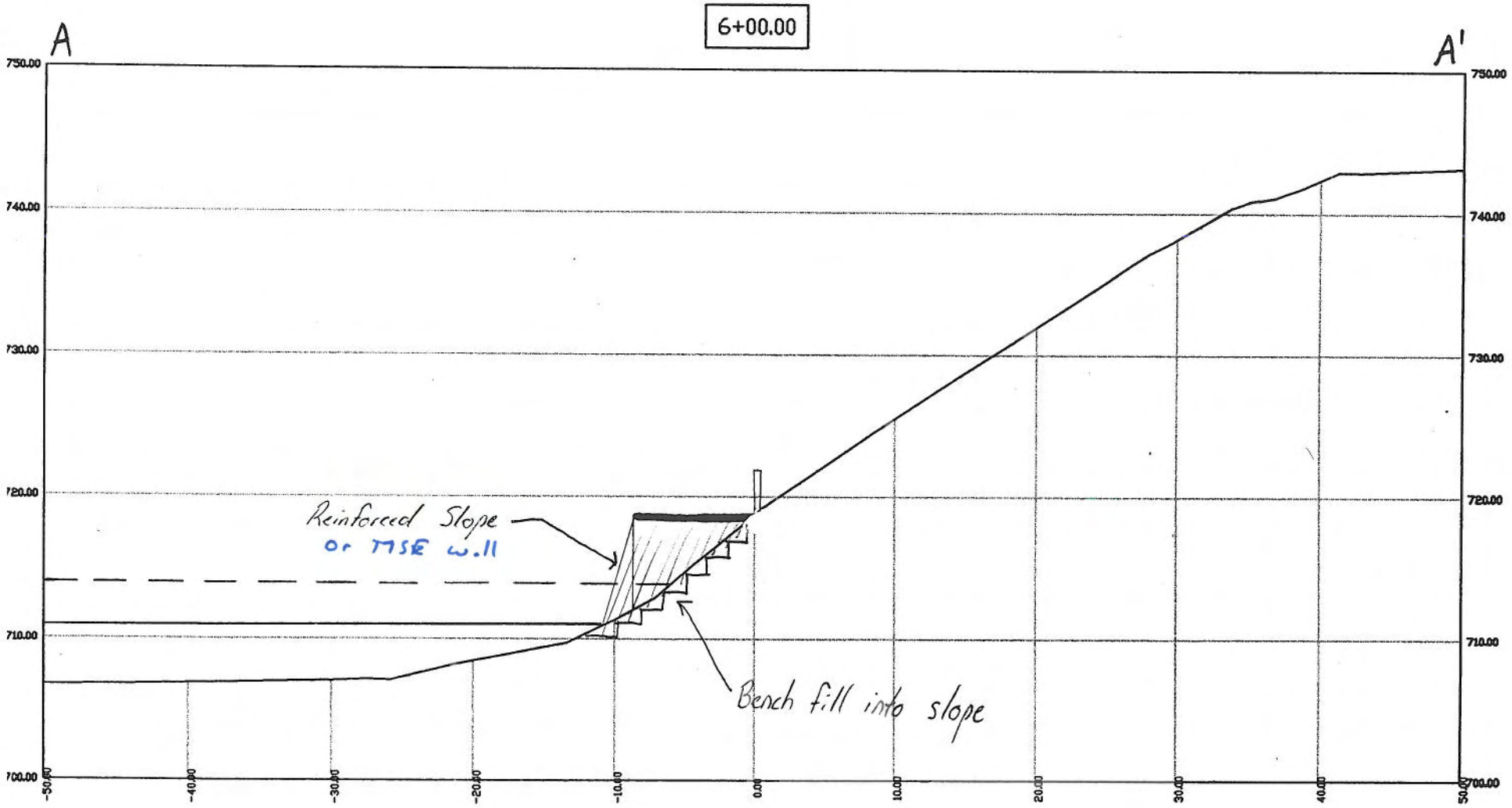
Profile View of ENTIATQUA TRAIL PROFILE - EG (1)

Station

SITE PLAN

FIG. 1

East Side



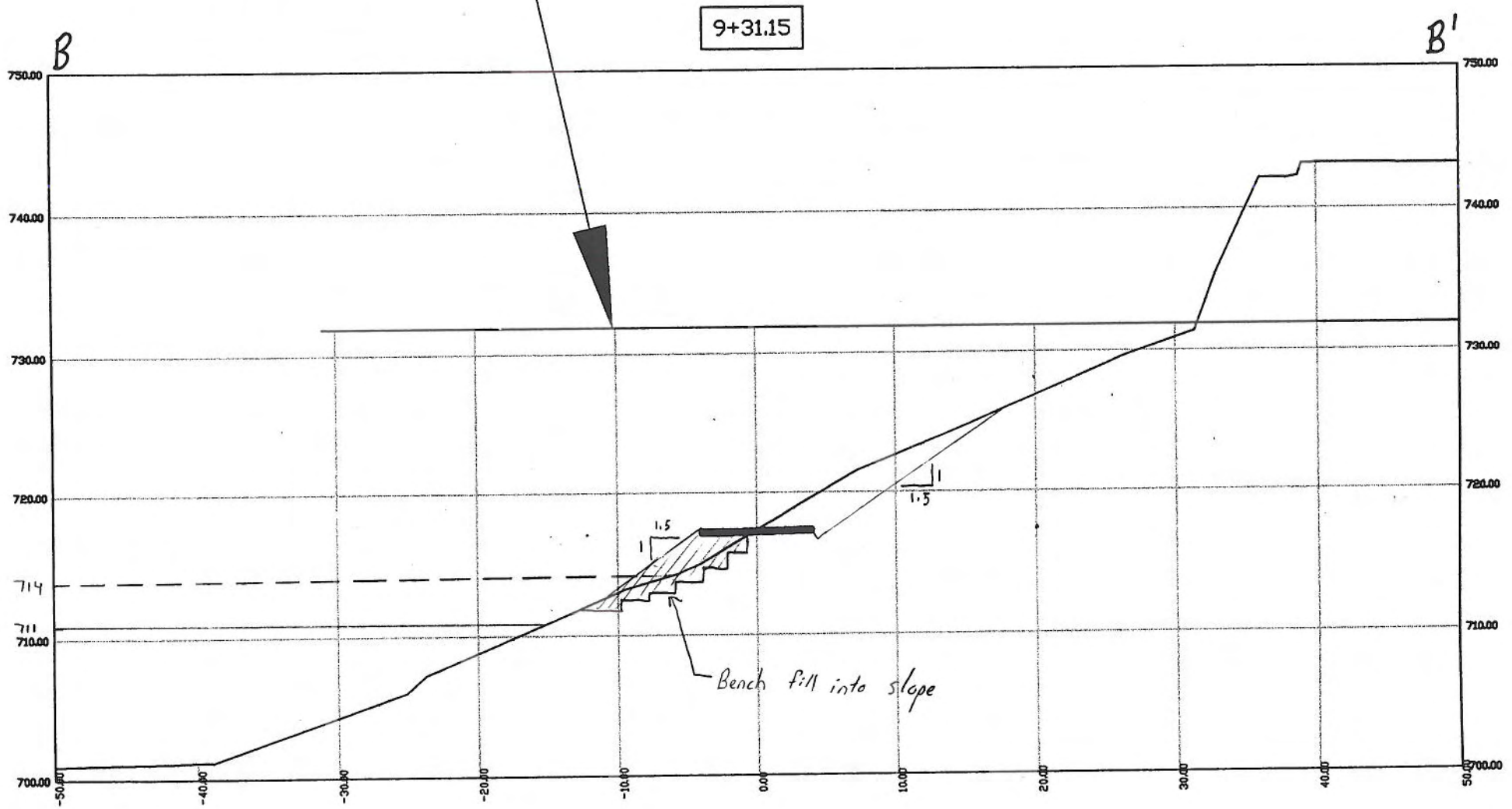
SECTION A-A'

FIG. 2

CHELAN PUD NO 1

Under Bridge

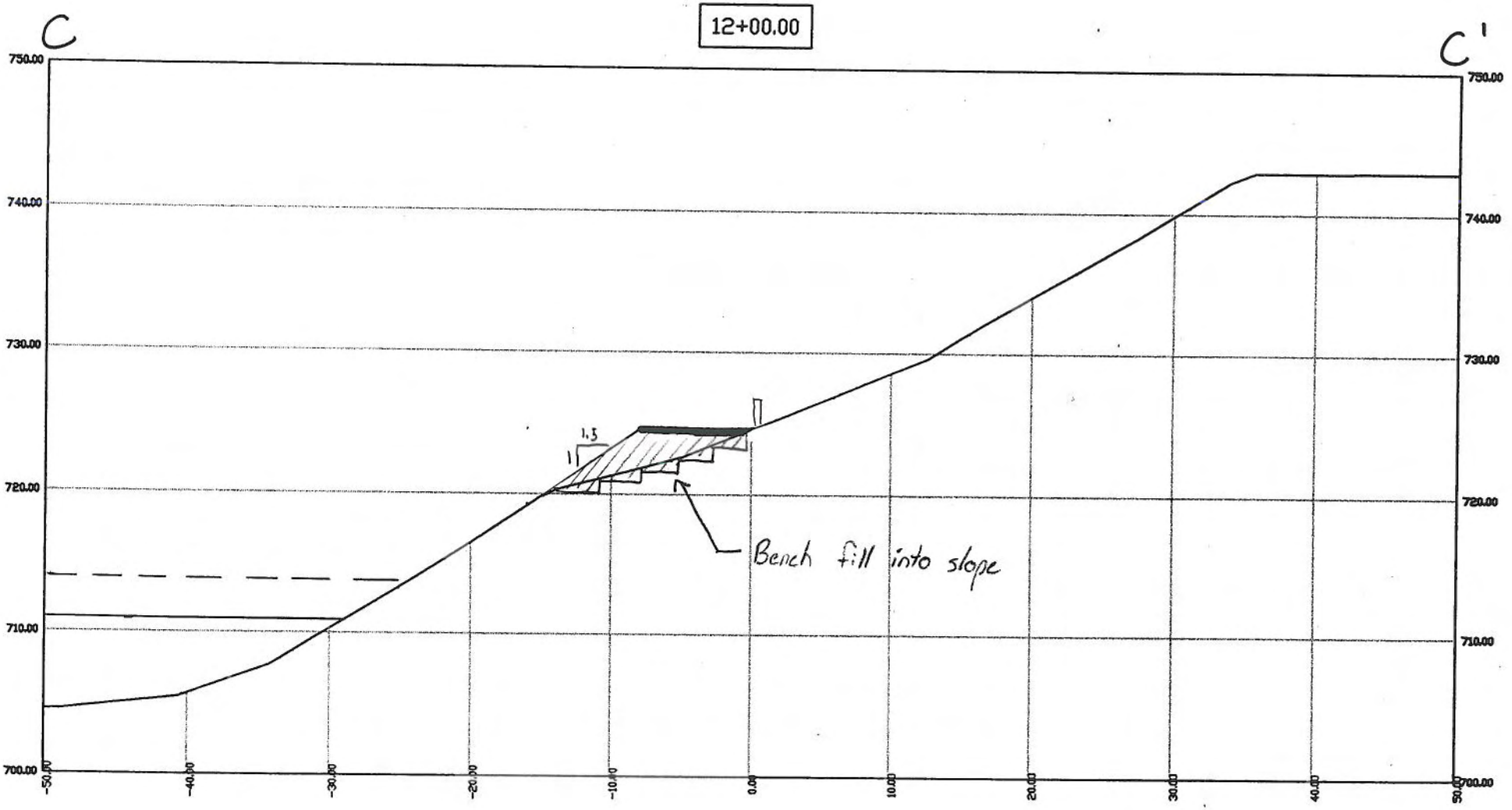
R BRIDGE,
EV. 731.9'



SECTION B-B'

FIG. 3

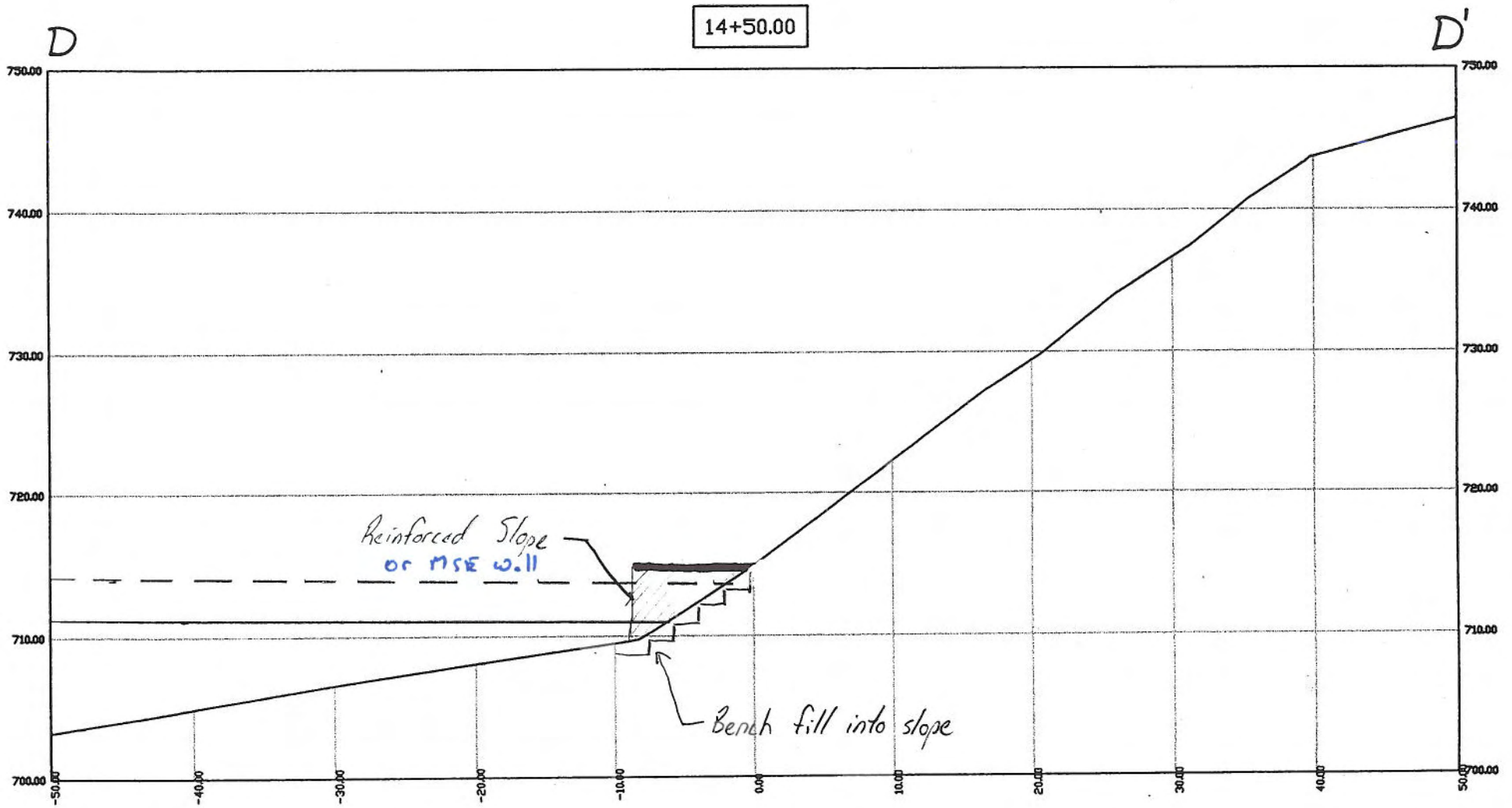
West Side



SECTION C-C'

FIG. 4

NW Corner



SECTION D-D'

FIG. 5

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-21501-001

Date: May 6, 2011
To: Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

2 – Conceptual Design Review and Recommendations

Geotechnical Report
Entiatqua Trail
Entiat, Washington

June 13, 2011

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Excellence. Innovation. Service. Value.

Since 1954.

Submitted To:
Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County
327 N. Wenatchee Avenue
Wenatchee, Washington 98801

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103

21-1-21501-002

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont.)

FIGURES

APPENDICES

GEOTECHNICAL REPORT
ENTIATQUA TRAIL
ENTIAT, WASHINGTON

1.0 INTRODUCTION

This report presents the results of subsurface explorations, laboratory tests, and geotechnical engineering studies performed for the proposed Entiatqua Trail in Entiat, Washington. Our geotechnical studies include evaluating the subsurface conditions and formulating geotechnical engineering recommendations for use in the design and construction of the proposed project.

Our scope of geotechnical services included the following:

- Excavating two test pits along the proposed trail alignment;
- Performing two penetration tests at the toe of the existing highway embankment;
- Performing geotechnical laboratory testing on selected soil samples;
- Conducting engineering analyses; and
- Preparing this report.

We provided our services in general accordance with our proposal dated May 2, 2011.

We previously prepared a letter, dated May 6, 2011, which presented conceptual geotechnical engineering recommendations for the proposed trail. As part of our scope of services for that letter, we performed a field reconnaissance of the proposed trail site and reviewed information about the construction of the existing embankment.

2.0 SITE AND PROJECT DESCRIPTION

The proposed trail will connect Entiat Park with the proposed Entiatqua Outdoor Learning Center (Figure 1). Entiat Park is between U.S. Highway 97 and the C&C Railroad, and the west shore of the Columbia River. The proposed Entiatqua Outdoor Learning Center will be on the shores of the Entiat River, south of Entiat River Road and west of U.S. Highway 97.

Most of the proposed trail will be along the U.S. Highway 97 and C&C Railroad embankment. As described in our May 6, 2011, letter, we understand that the embankment was built from rock quarried from the cliffs on the south side of the Entiat River. The construction of the embankment and associated bridges was completed before Rocky Reach Dam began operation and raised the level of the Columbia River to its current elevation.

The ordinary high water mark (OHWM) for the Columbia River near the project site is elevation 711 feet (North American Vertical Datum of 1988 [NAVD88]). Public Utility District (PUD) No. 1 of Chelan County is studying the feasibility of raising the OHWM to 714 feet (NAVD88).

The embankment is sparsely vegetated with grass, brush, and small trees. The embankment side slopes are generally between 30 and 40 degrees, with locally steeper areas, particularly on the east side and northwest corner of the embankment.

The proposed trail will be 6 feet wide and will be surfaced with compacted aggregate. Where practical, the trail will be 8 feet wide to include two 1-foot-wide shoulders. Other project elements could include viewpoints, a pedestrian barrier to separate the trail from U.S. Highway 97 and the C&C railroad, benches and signs, and restorative planting.

3.0 SUBSURFACE EXPLORATIONS

To evaluate the subsurface conditions at the project site, we excavated and sampled two test pits and performed two penetration tests. We also performed a site reconnaissance, as described in our May 6, 2011, letter.

Because of difficult access to the embankment side slopes, our test pits were excavated at the edges of the embankment. Test pits TP-1 and TP-2 were each excavated to a depth of about 10 feet.

Penetration tests P-1 and P-2 were advanced to depths of 11 and 10 feet, respectively. The tests were performed in the Columbia and Entiat Rivers, about 3 to 5 feet from shore.

Appendix A, Subsurface Explorations, describes the methodology and procedures used for performing and sampling the explorations. Figures A-2 through A-4 in Appendix A show the test pit and penetration test logs.

Figure 2 shows the approximate exploration locations. We estimated the exploration locations by measuring from existing site features. The exploration locations should be considered approximate.

4.0 GEOTECHNICAL LABORATORY TESTING

We performed geotechnical laboratory tests on selected samples retrieved from the explorations and used the test results to characterize soil index properties. We used the index properties to

estimate the soil engineering properties. The soil tests included visual classification, natural water content, and mechanical sieve analyses.

The Shannon & Wilson soil laboratory performed the tests. Appendix B, Geotechnical Laboratory Testing Procedures and Results, describes the test methods and summarizes the test results. The test pit logs in Appendix A show the natural water content.

5.0 SUBSURFACE CONDITIONS

We based our subsurface interpretation on

- The subsurface conditions exposed in the test pits,
- The results of the hand penetration tests,
- Our literature review, and
- Our site reconnaissance.

The test pits encountered about 10 feet of gravelly sand. The test pits did not encounter groundwater.

Based on our site reconnaissance and literature review (described in our May 6, 2011, letter), we believe the embankment generally comprises 1- to 3-foot-diameter angular boulders (tonalite of the Chelan Complex) with a sandy, gravelly matrix. A 1-foot-thick layer of rounded, 3- to 12-inch rounded cobbles covers portions of the embankment, particularly on the east side of the embankment.

The Columbia/Entiat River sediments at the toe of the embankment were likely deposited since the Rocky Reach Dam raised the rivers to their current levels. Based on the results of the penetration tests, the sediments likely comprise very loose to loose, silty sand and sandy silt. The sediments likely extend to and over portions of the embankment fill material.

6.0 ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

The following sections present the results of our engineering analysis, including trail construction options, viewpoint foundations, seismic design considerations, settlement analyses, global stability analyses. We also present opinions of probable construction cost for each trail construction option.

6.1 Trail Construction Options

After reviewing the results of the subsurface explorations and our previous site reconnaissance, we recommend considering three options for constructing the trail:

- Permanent cut slopes;
- Unreinforced fill slopes; and
- Reinforced soil slopes/walls.

Based on the existing site topography, we recommend using the following construction methods along the trail alignment:

- Reinforced soil slopes/walls from about Station 2+00 to 9+00;
- Combination of permanent cut slopes and unreinforced fill slopes from about Station 9+00 to 10+50;
- Unreinforced fill slopes from about Station 10+50 to 12+50; and
- Reinforced soil slopes/walls from about Station 12+50 to 15+50.

The following sections describe the three alternatives for constructing the proposed trail.

6.1.1 Permanent Cut Slopes

Permanent cut slopes could be used to bench the proposed trail into the existing slope in areas where the cuts would not impact adjacent structures or rights-of-way. Based on the subsurface conditions encountered in the test pits and our site reconnaissance observations, permanent cut slopes should not exceed 1.5 horizontal to 1 vertical (1.5H:1V).

Permanent cut slopes could include a 4-foot-high near-vertical cut at the base of the slope. The near-vertical cut should be supported with stacked ecology blocks (or similar), and be inclined at an angle of at least 1H:8V.

6.1.2 Unreinforced Fill Slopes

Unreinforced fill slopes could be used to support the proposed trail in areas where the fill would not impact the adjacent river, or where the fill impact is properly mitigated. Unreinforced fill slopes should be constructed from structural fill, placed, and compacted in accordance with our recommendations in Section 7.2. The fill slopes should not be steeper than 1.5H:1V.

Section 7.1 presents recommendations for placing fill in the rivers if unreinforced fill slopes extend into the rivers. Fill slopes near the water line should be armored to prevent erosion from wave action.

6.1.3 Reinforced Soil Slopes and Mechanically Stabilized Earth Walls (MSEW)

Reinforced soil slopes (RSS) or MSEW could support the proposed trail in areas to avoid or reduce impacts to the shoreline that would occur with unreinforced slope fills. RSS and MSEW incorporate reinforcing elements (such as geosynthetics or steel strips) to reinforce soil and increase slope stability. RSS typically have face slope angles less than 70 degrees. Depending on the reinforcing material and fascia, the MSEW/RSS face could be vegetated.

Some MSEW and RSS systems are proprietary; individual manufacturers design and provide the RSS/MSEW system. Some common types of proprietary RSS/MSEW are provided by:

- Hilfiker Retaining Walls (e.g., Eureka Reinforced Soil and Steepen Slope Wall systems);
- VSL Corporation (e.g., VSoL);
- Reinforced Earth Company (e.g., Reinforced Earth and Retained Earth systems); and
- Tensar (e.g., Mesa, ARES, and Sierra systems).

We recommend contacting individual manufacturers for additional information about their products.

To construct an RSS or MSEW on the existing slope, a bench would be excavated at the base of the slope/wall. The bench would be about 50 to 70 percent of the height of the slope/wall, and a temporary cut slope would be located behind the bench.

Section 6.5 presents design recommendations for MSEW. RSS systems should be designed based on global stability analyses that incorporate the proposed reinforcement length, reinforcement strength, and slope geometry. If the PUD selects an RSS system, Shannon & Wilson could provide the design services.

6.2 Planning Level Opinion of Probable Construction Cost

The following sections present our planning-level opinions of probable construction cost (OPCCs) for each of the three trail construction options described above. The purpose of the

OPCCs is that the PUD use them in selecting trail construction alternatives and for planning purposes. We used the following information to develop our OPCCs:

- Discussions with local contractors;
- Construction cost data (RSMeans, 2011); and
- Our experience with similar projects.

For comparison purposes, we present each OPCC as a cost per foot of trail. The OPCCs assume that each trail construction option is independent; e.g., a permanent cut slope and unreinforced fill slope would not be used at the same trail cross section.

Our OPCCs do not account for:

- Delays due to weather or soil conditions;
- Costs for installing temporary erosion and sedimentation control;
- Trail surfacing; or
- Mitigation required for encroaching on the adjacent rivers.

The OPCCs are preliminary and are based on the project as we understand it.

6.2.1 Permanent Cut Slopes

In our opinion, permanent cut slopes could be constructed for about $25 to $75 per foot of trail. We assumed the following for our OPCC:

- One excavator, excavator operator, and laborer;
- One cubic yard (cy) of excavated soil per foot of trail;
- Excavated soil would be re-used on site;
- The cut slope would be vegetated over an area of 20 square feet per foot (sf/ft) of trail; and
- A wall of two stacked ecology blocks (or similar) would be placed at the toe of the cut slope, adjacent to the trail.

6.2.2 Unreinforced Fill Slopes

In our opinion, unreinforced fill slopes could be constructed for about $75 to $125 per foot of trail. We assumed the following for our OPCC:

- One excavator, excavator operator, and laborer for excavating benches in the slope and placing fill;

- One vibrating roller compactor and operator for compacting fill;
- Excavated soil would be processed and re-used on site;
- Imported fill soil would be required;
- Four cy of fill would be placed per foot of trail;
- Erosion protection would be used to protect fill near river level; and
- The fill slope would be vegetated over an area of 20 sf/ft of trail.

6.2.3 Reinforced Soil Slopes

In our opinion, RSS could be constructed for about $200 to $300 per foot of trail. We assumed the following for our OPCC:

- The slope would be 10 feet high at 0.5H to 1V;
- One excavator, excavator operator, and laborer for excavating and placing fill;
- One vibrating roller compactor and operator for compacting fill away from the RSS face;
- One walk-behind plate compactor and operator for compacting fill near the RSS face;
- Excavated soil would be re-used on site;
- Imported fill soil would be required;
- Three cy of fill would be placed per foot of trail; and
- The RSS would be vegetated over an area of 20 sf/ft of trail.

6.2.4 Mechanically Stabilized Earth Walls (MSEW)

In our opinion, MSEW could be constructed for about $300 to $500 per foot of trail. We assumed the following for our OPCC:

- The wall would be 10 feet high;
- One excavator, excavator operator, and laborer for excavating and placing fill;
- One vibrating roller compactor and operator for compacting fill away from the MSEW face;
- One walk-behind plate compactor and operator for compacting fill near the MSEW face;
- Excavated soil would be re-used on site;
- Imported fill soil would be required;

- Three cy of fill would be placed per foot of trail; and
- The MSEW face would be vegetated.

6.3 Viewpoint Foundations

We understand that several viewpoints may be constructed adjacent to the trail. The viewpoints could extend into the Columbia/Entiat Rivers, and could be supported on MSEW/RSS systems, or on deep foundations. Deep foundations could be used to reduce the impact of viewpoints extending into or over the adjacent rivers.

If deep foundations are selected to support the viewpoints, we recommend using pin piles. Pin piles are small-diameter (typically 6 inches or less) driven pipe piles that are typically installed using a pneumatic jackhammer or other impact hammer. The impact hammer can be mounted on a small excavator (e.g., Bobcat). Pipe sections can be added until the desired pile depth and capacity are achieved.

We recommend an allowable vertical capacity of 20 kips for 4-inch-diameter pin piles and 30 kips for 6-inch-diameter pin piles driven to refusal.

6.4 Seismic Design Considerations

The project is located in a moderately active seismic region. We evaluated the seismic hazard at the project site in general accordance with the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (AASHTO, 2010). For design, AASHTO (2010) considers an earthquake with a 7 percent probability of exceedance in 75 years, or about a 1,000-year return period (with a deterministic maximum cap in some regions).

For our analyses, we considered the peak ground acceleration (PGA) of the design earthquake. The U.S. Geological Survey and Frankel and others (2002) have conducted regional probabilistic ground motion studies and estimate that the bedrock PGA in the project area is 0.14 gravity (g).

AASHTO (2010) also considers the effect of local soil conditions on the design PGA value. To account for site amplification/damping effects, we scale the bedrock PGA value by site soil response factors. The site classification determines the site soil response factors. Based on the subsurface conditions encountered in our explorations, we recommend using a Site Class D to characterize the site subsurface conditions. Based on a Site Class D and the bedrock PGA, the design soil PGA for this project is 0.22g.

6.5 Mechanically Stabilized Earth Walls (MSEW) Design Recommendations

6.5.1 Lateral Earth Pressures

The lateral pressures acting on MSEW depend on many factors, including:

- Method of backfill placement;
- Degree of compaction;
- Backfill slope;
- Surcharge loads;
- Type of backfill soil and/or adjacent native soil;
- Drainage; and
- Whether the wall can yield laterally during or after backfill placement.

MSEW are flexible and generally move/rotate a small amount during construction. Therefore, the walls should be designed for active earth pressures. We provide the following recommendations for lateral earth pressures:

- Use an active lateral earth pressure equivalent to a fluid unit weight of 50 pounds per cubic foot;
- Analyze seismic loading conditions using a uniformly distributed pressure increase of 15 pounds per square foot per foot of wall height (added to static loading); and
- Include lateral earth pressures caused by surcharges behind the wall, as shown in Figure 4.

The lateral earth pressures act at the back of the MSEW reinforcement zone and account for the embankment slope behind the wall.

We used the Mononobe-Okabe equation (AASHTO, 2010) to estimate the seismic lateral load increment. We used a horizontal seismic coefficient of 0.1g, which is about one-half of the soil PGA value. The magnitude of this coefficient accounts for the fact that the PGA occurs only a few times within the record of earthquake shaking and that the actual earthquake ground motion is cyclic in nature, as opposed to a static force.

Our lateral earth pressure recommendations assume:

- The MSEW has a vertical face and a backslope of 1.5H:1V.
- MSEW backfill is placed and compacted in accordance with our recommendations in Section 7.2.

- Backfill materials are free draining and do not allow hydrostatic pressure buildup behind the wall.

6.5.2 Lateral Resistance

Lateral resistance for MSEW would be provided by passive pressure against the embedded portion of the walls by friction along the base of the walls. We recommend a minimum wall embedment of 2 feet. Because the wall embedment will be relatively small, the passive resistance would be negligible.

To estimate friction resistance at the base of the walls, we recommend using:

- A coefficient of friction of 0.6 if discontinuous reinforcement (e.g., strips) are used; or
- A coefficient of friction of 0.4 if continuous reinforcement (e.g., grids, fabrics, or sheets) are used.

6.6 Settlement

We estimated settlement beneath the RSS/MSEW systems and unreinforced fill slopes using elastic theory. We assumed a slope/wall height of 10 feet. We estimated soil settlement parameters based on the relative density of the subsurface soil and our experience in similar geology.

Based on our settlement calculations, we estimate that the slopes/walls could settle about ½ inch. The settlement would occur as the slopes/walls are constructed. Our estimate assumes that the slope/wall subgrades are prepared in accordance with our recommendations in Section 7.1.

6.7 Global Stability

We evaluated the global stability of the different trail construction options under static and seismic loads using the computer program SLOPE/W (Geo-Slope, 2007). We used SLOPE/W to analyze many potential failure surfaces at four representative trail cross sections. For each potential failure surface, we used the general limit equilibrium method (Fredlund and Krahn, 1977), which satisfies both force and moment equilibrium, to calculate a factor of safety (FS) against slope failure.

The FS is the ratio of the forces available to resist movement to the forces of the driving soil mass. An FS of 1.0 means that the driving and resisting forces are equal. An FS of less than 1.0 means that the driving forces are greater than the resisting forces, indicating an unstable

slope. The potential failure surface with the lowest FS is called the critical failure surface. We considered target minimum critical failure surface FSs of 1.5 for static stability and 1.1 for seismic stability.

We selected soil strength parameters for the stability analyses using the results of field explorations, laboratory testing results, and our experience. We assumed that potential failure surfaces would pass beneath the reinforced soil zone. Similar to the Mononobe-Okabe analysis (Section 6.4), we applied a horizontal seismic coefficient of 0.1g for the seismic case.

Our analysis results show that the critical failure surface FS values meet target minimum values for static and seismic loading.

We did not evaluate the internal stability of the MSEW/RSS systems, nor did we consider global failure surfaces that may pass through the reinforced soil zone. The MSEW/RSS designer must consider these failure modes during the design process.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Site Preparation and Grading

We recommend the following steps for preparing the trail subgrade:

- Clear trees and brush;
- Remove roots, stumps, concrete, asphalt, and other debris;
- Strip organic and loose material;
- Excavate to the desired grades; and
- Proof-roll and compact the exposed subgrade surface as needed to a dense and unyielding condition.

Areas that are wet, soft, loose, or yielding when proof rolled or during compaction should be further compacted, removed and reconditioned, or replaced with compacted structural fill so that a dense and unyielding condition is achieved.

We recommend that a qualified geotechnical engineer's representative be on site to evaluate the exposed subgrade during site preparation and grading.

If fill is placed in the rivers, we recommend excavating at least 2 feet of the existing river sediment to form a bench for the fill. Foundation stabilization material, such as free-draining

quarry spalls or a mixture of boulders, cobbles, and gravel (e.g., the existing embankment fill material), should be placed below the water line to create a firm working platform for construction of the fill slope.

7.2 Fill Placement and Compaction

All fill soil should be structural fill, which should:

- Consist of a well-graded mixture of sand and gravel;
- Be free of organics and debris;
- Have a moisture content within ±2 percent of its optimum;
- Have a gravel content between 25 and 50 percent retained on a No. 4 sieve; and
- Have a maximum particle size of 3 inches.

Structural fill placed behind/within MSEW and RSS should have less than 5 percent fines (material passing the No. 200 mesh sieve, based on the minus ¾ inch fraction). Other imported structural fill should contain less than 15 percent fines. All fines should be nonplastic. Examples of suitable fill soil gradations from the Washington State Department of Transportation (WSDOT) and American Public Works Association (APWA) Standard Specifications (WSDOT/APWA, 2010) include Gravel Backfill for Walls, Section 9.03-12(2), for walls; and Gravel Borrow, Section 9-03.14(1), for other areas.

Before placing structural fill in areas above river level, we recommend draining ponded water from the area. We recommend placing structural fill in uniform lifts and compacting the fill to a dense and unyielding condition, at least 95 percent of the Modified Proctor maximum dry density (ASTM International D 1557).

Hand-operated mechanical compactors should be used within 3 feet of wall faces; heavy equipment compactors should not be used near walls. Lift thickness should not exceed 8 inches for heavy equipment compactors or 4 inches for hand-operated mechanical compactors.

If placed adjacent to an existing slope, structural fill should be benched into the slope. Benches should have a maximum height of 3 feet.

7.3 Use of On-Site Soil

In our opinion, the existing native sand could be reused as general structural fill (i.e., behind MSEW/RSS reinforcement zones or in unreinforced fill slopes). The existing embankment material could be reused as general structural fill in unreinforced fill slopes, provided that

material greater than 3 inches in diameter is removed. Material lager tan 3 inches could be used to fill in the river or as erosion protection.

7.4 Excavations

Temporary cut slopes could be used to bench the proposed trail into the existing slope and facilitate construction of fill slopes, RSS, and MSEW. The practical steepness of temporary slopes will depend on factors such as:

- The presence and abundance of groundwater;
- The type and density of the soil;
- The depth of excavation;
- Surcharge loading adjacent to the excavation, such as that from excavated material or construction equipment; and
- The duration of construction.

For planning purposes, we recommend assuming that temporary slopes could be excavated at 1H:1V in the native sandy soil and 0.5H:1V in the existing embankment material. The slopes may be subject to erosion. We recommend protecting the slope against erosion during construction.

Consistent with conventional construction practice, the Contractor should be responsible for temporary excavation slopes. The Contractor is continually at the site, is able to observe the nature and conditions of the subsurface materials encountered, including groundwater, and is responsible for the methods, sequence, and schedule of construction. Flatter cut slopes or temporary shoring could be required where loose soil or seepage is encountered or if instability is observed. Regardless of the construction method used, all excavation work should be accomplished in compliance with applicable local, state, and federal safety codes.

7.5 Wet Weather Earthwork

We recommend performing earthwork during dry weather. During wet weather, placing and compacting fill material can be difficult. In-place soil or fill soil that is too wet to suitably compact should be removed and replaced with structural fill. Most of the existing site soil is subject to erosion during periods of heavy rainfall. Excavations should be protected against erosion.

8.0 ADDITIONAL SERVICES

We recommend that Shannon & Wilson be retained to review those portions of the plans and specifications pertaining to geotechnical aspects of construction to evaluate if they are consistent with our recommendations. We also recommend that we observe the geotechnical aspects of construction, which will allow us to verify the subsurface conditions as they are exposed during construction and to evaluate if the work is accomplished in accordance with our recommendations.

If the PUD selects RSS to support portions of the proposed trail, we recommend that Shannon & Wilson provide design services for the slopes.

9.0 LIMITATIONS

This report was prepared for the exclusive use of the PUD for the Entiatqua Trail project. It should be made available to prospective contractors for information on factual data only, and not as a warranty of subsurface conditions such as those interpreted from the exploration logs and presented in the discussions of subsurface conditions included in this report.

Within the limitations of the scope, schedule, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either expressed or implied.

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist and further assume that the explorations are representative of the subsurface conditions throughout the project site; that is, the subsurface conditions everywhere are not significantly different from those disclosed by the explorations. Our conclusions and recommendations are based on our understanding of the project as described in this report and the site conditions as interpreted from the explorations.

If, during final design and construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present, we should be advised at once so that we could review these conditions and reconsider our recommendations where necessary. If there is substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed because of natural forces or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations concerning the changed conditions or the time lapse.

Unanticipated soil conditions are commonly encountered and cannot fully be determined merely by taking soil samples from a limited number of test pits or performing a limited number of penetration tests. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The opinion of probable costs to construct the work described in this report is based solely upon our experience with construction on similar projects, contractor and supplier information, and other information presented in this report. Our opinion of probable construction costs include a number of assumptions as to actual subsurface conditions that will be encountered. These assumptions include decisions of other design professionals and government agency personnel, the means and methods of construction the Contractor will employ, the Contractor's techniques in determining price and market conditions at the time, and other factors over which we have no control. Given the assumptions that must be made, Shannon & Wilson, Inc. cannot guarantee the accuracy of the opinion of probable construction costs.

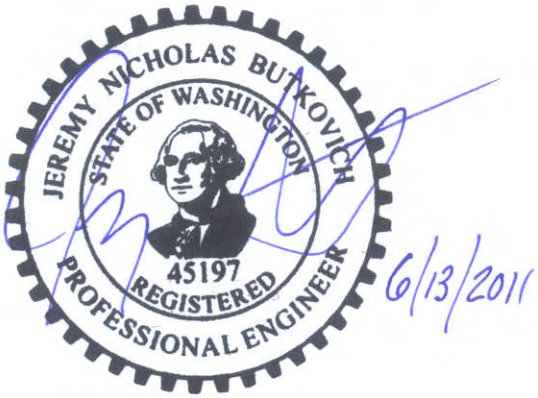
Shannon & Wilson, Inc. is not a construction cost estimator or construction contractor, nor should our rendering of an opinion of probable construction costs be considered equivalent to the nature and extent of services a construction cost estimator or contractor would provide.

The scope of our geotechnical services did not include environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air on or below the site, or any evaluation for disposal of contaminated soils or groundwater.

We did not evaluate the project site for potential impacts to natural resources, including wetlands, endangered species, or environmentally critical areas. Shannon & Wilson has staff experienced in these issues should they arise.

Shannon & Wilson has prepared Appendix C, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our reports.

SHANNON & WILSON, INC.



Jeremy N. Butkovich, P.E.
Principal Engineer

JNB:CAR/jnb

10.0 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 2010, AASHTO LRFD bridge design specifications: customary U.S. units (5th ed.): Washington, D.C., AASHTO, 2 v.

ASTM International, 2010, 2010 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 - D 5876: West Conshohocken, Pa.

Frankel, A.D.; Petersen, M.D.; Mueller, C.S.; Haller, K.M.; and others, 2002, Documentation for the 2002 update of the national seismic hazard maps: USGS Open-File Report 02-420.

Fredlund, D.G., and Krahn, J., 1977, Comparison of slope stability methods of analysis: Canadian Geotechnical Journal, v. 14, no. 3, p. 429 439.

Geo-Slope, 2007, Documentation for the SLOPE\W Version 7 Software, Geo-Slope International Ltd., Calgary, Alberta.

RSMeans, 2011, Heavy Construction Cost Data, Reed Construction Data: Norwell, MA.

Washington State Department of Transportation and American Public Works Association (WSDOT/APWA), 2010, Standard specifications for road, bridge, and municipal construction: English Units, M 41-10: Olympia, Wash.

0 1000 2000

Approximate Scale in Feet

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, image by U.S. Geological Survey reproduced by permission granted by Google Earth ™ Mapping Service.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

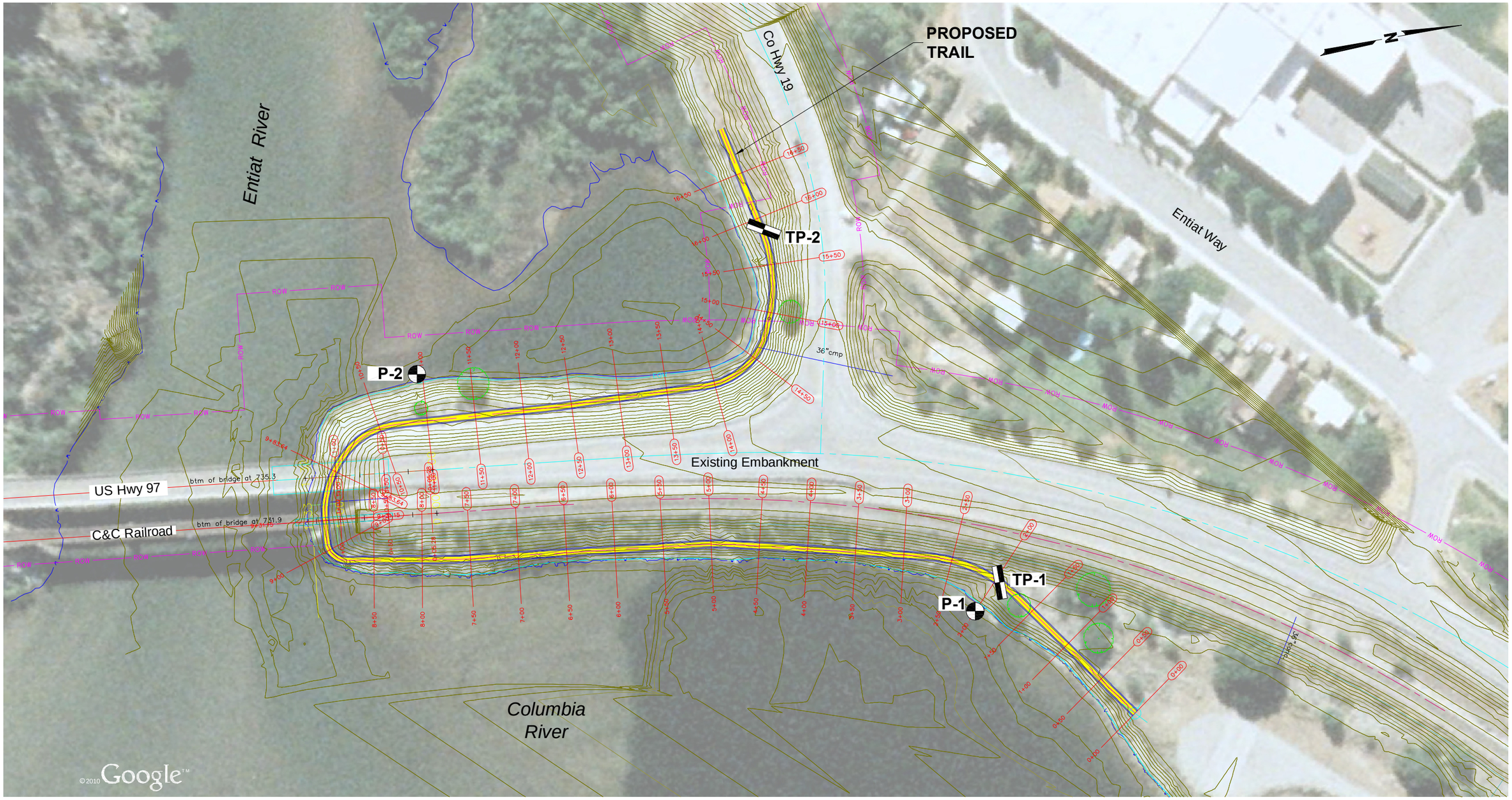
VICINITY MAP

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1

Filename: J:\211\21501-002\21-1-21501-002 Fig 1.dwg Date: 06-09-2011 Login: sac



0 100 200

Scale in Feet

NOTE

Figure adapted from *"Entiatqua Trail Full Set 3-10-2011.DWG"*, dated 4-28-11.
Aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

LEGEND

P-1 Penetration Test Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

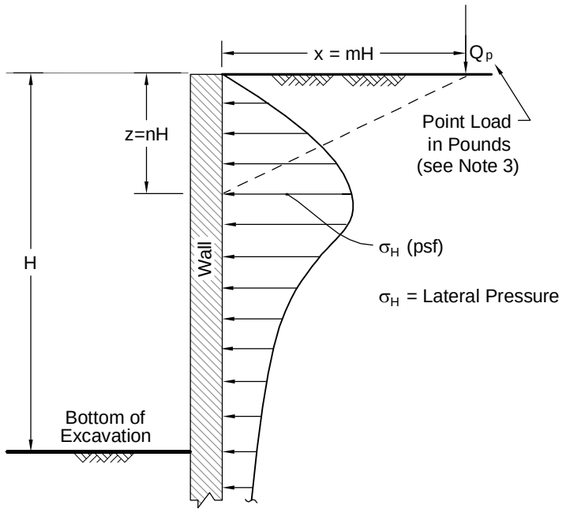
SITE AND EXPLORATION PLAN

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

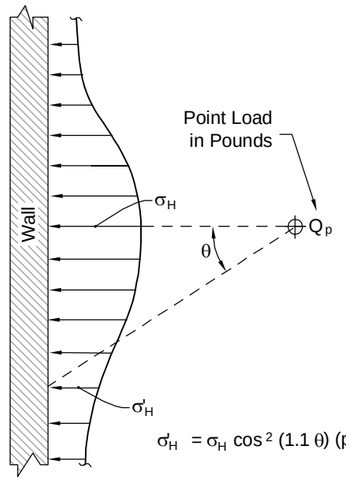
Filename: J:\21\21501-002\21-1-21501-002 Fig 2.dwg Date: 06-09-2011 Login: sac



ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3}$ (psf) (see Note 3)

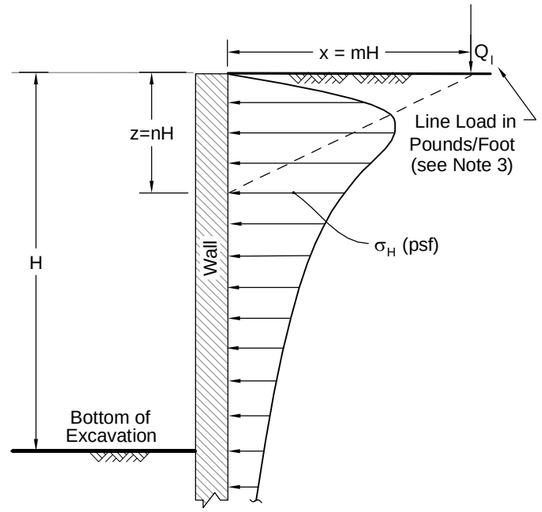
For m > 0.4: $\sigma_H = 1.77 \frac{Q_p}{H^2} \frac{m^2 n^2}{(m^2 + n^2)^3}$ (psf)



PLAN VIEW

A) LATERAL PRESSURE DUE TO POINT LOAD
i.e. SMALL ISOLATED FOOTING OR WHEEL LOAD

(NAVFAC DM 7.2, 1986)



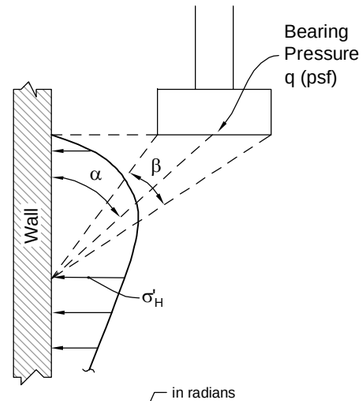
ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.20 \frac{Q_l}{H} \frac{n}{(0.16 + n^2)^2}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.28 \frac{Q_l}{H} \frac{m^2 n}{(m^2 + n^2)^2}$ (psf)

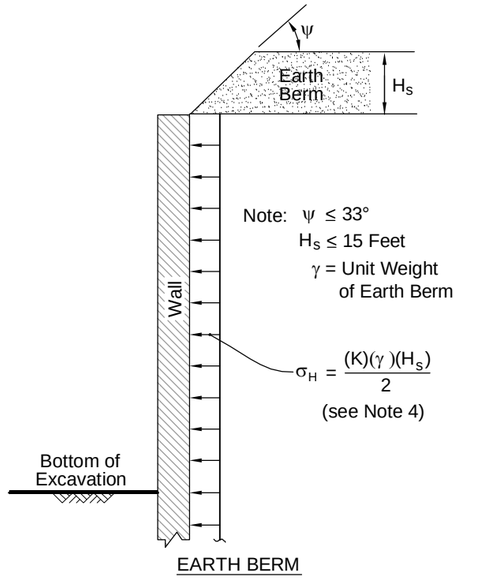
B) LATERAL PRESSURE DUE TO LINE LOAD
i.e. NARROW CONTINUOUS FOOTING
PARALLEL TO WALL

(NAVFAC DM 7.2, 1986)

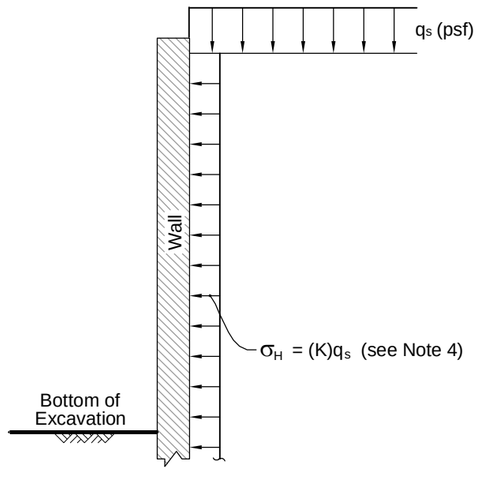


C) LATERAL PRESSURE DUE TO STRIP LOAD

(derived from Fang, *Foundation Engineering Handbook* , 1991)



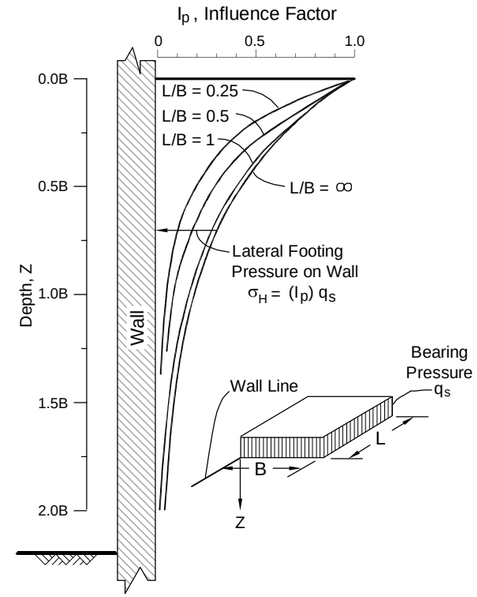
EARTH BERM



UNIFORM SURCHARGE

D) LATERAL PRESSURE DUE TO EARTH BERM
OR UNIFORM SURCHARGE

(derived from Poulos and Davis, *Elastic Solutions for Soil and Rock Mechanics* , 1974; and Terzaghi and Peck, *Soil Mechanics in Engineering Practice* , 1967)



E) LATERAL PRESSURE DUE
TO ADJACENT FOOTING

(derived from NAVFAC DM 7.2, 1986; and Sandhu, *Earth Pressure on Walls Due to Surcharge* , 1974)

NOTES

1. Figures are not drawn to scale.
2. Applicable surcharge pressures should be added to appropriate permanent wall lateral earth and water pressure.
3. If point or line loads are close to the back of the wall such that m ≤ 0.4, it may be more appropriate to model the actual load distribution (i.e., Detail E) or use more rigorous analysis methods.
4. Use a K value of K=0.4.
5. For areas where fill will be placed immediately behind and above the top elevation of the wall, Diagram D can be used to determine loads on the wall. For narrow fills adjacent to the wall, Diagram C can be used.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

RECOMMENDED SURCHARGE LOADING FOR TEMPORARY AND PERMANENT WALLS

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3

File: J:\21\21501-002\21-1-21501-002 Fig 3.dwg Date: 06-09-2011 Author: sac

APPENDIX A

SUBSURFACE EXPLORATIONS

APPENDIX A

SUBSURFACE EXPLORATIONS

TABLE OF CONTENTS

FIGURES

APPENDIX A

SUBSURFACE EXPLORATIONS

A.1 GENERAL

The field exploration program for this project consisted of excavating two test pits and performing two penetration tests. Figures A-2 and A-3 present the test pit logs and Figure A-3 presents the penetration test logs. Figure 2 in the main text shows the approximate exploration locations. Figure A-1 presents a soil classification and log key as a reference for symbols and information presented on the test pit logs.

A.2 TEST PITS

We excavated two test pits, designated TP-1 and TP-2, on May 19, 2011. Each excavation was about 10 feet deep. The City of Entiat excavated the test pits using a John Deere 310G Excavator/Loader.

A Shannon & Wilson representative observed, logged, and collected soil samples from the test pits. Samples were classified in the field, placed in airtight jars or bags, and returned to our laboratory for testing.

A.3 PENETRATION TESTS

Two Shannon & Wilson representatives performed the penetration tests in the Columbia and Entiat Rivers, about 5 to 10 feet from shore. Because of difficult site access and loose soil, we used nonstandard equipment. The purpose of the penetration tests was to evaluate the relative density of the existing river sediment.

The penetration tests comprised driving 5-foot-long segments of 2-inch diameter polyvinyl chloride (PVC) pipe (P-1) or 5-foot-long segments of 1-inch outside diameter steel pipe (P-2). We drove the pipes into the soil using a 10-pound sledgehammer with a 31-inch arm. We recorded the number of blows to drive the pipe every 12 inches. Each hammer blow was dropped from a height of approximately 20 inches. Figure A-3 plots the number of hammer blows per foot versus depth.

P-1 reached refusal between 11 and 12 feet below the mudline when the PVC pipe broke after 100 blows. The mudline was about 16 inches below the water level at P-1.

P-2 reached refusal between 10 and 11 feet below the mudline when the threading connecting segments of the steel pipe broke after 15 blows. The mudline was about 15 inches below the water level at P-2.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this page. Soil descriptions are based on visual-manual procedures (ASTM D 2488) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 40 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

GRAIN SIZE DEFINITION

DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.8 mm)
SAND*	
- Fine	#200 to #40 (0.8 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

** Unless otherwise noted, grain size varies from fine to coarse.*

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) (From USACE Tech Memo 3-357)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GC		Silty gravels, gravel-sand-silt mixtures
			GW		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clayss of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
			CH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/ gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

SOIL CLASSIFICATION AND LOG KEY

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1

Filename: J:\211\21501-002\21-1-21501-002 TPs.dwg Date: 06-09-2011 Login: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

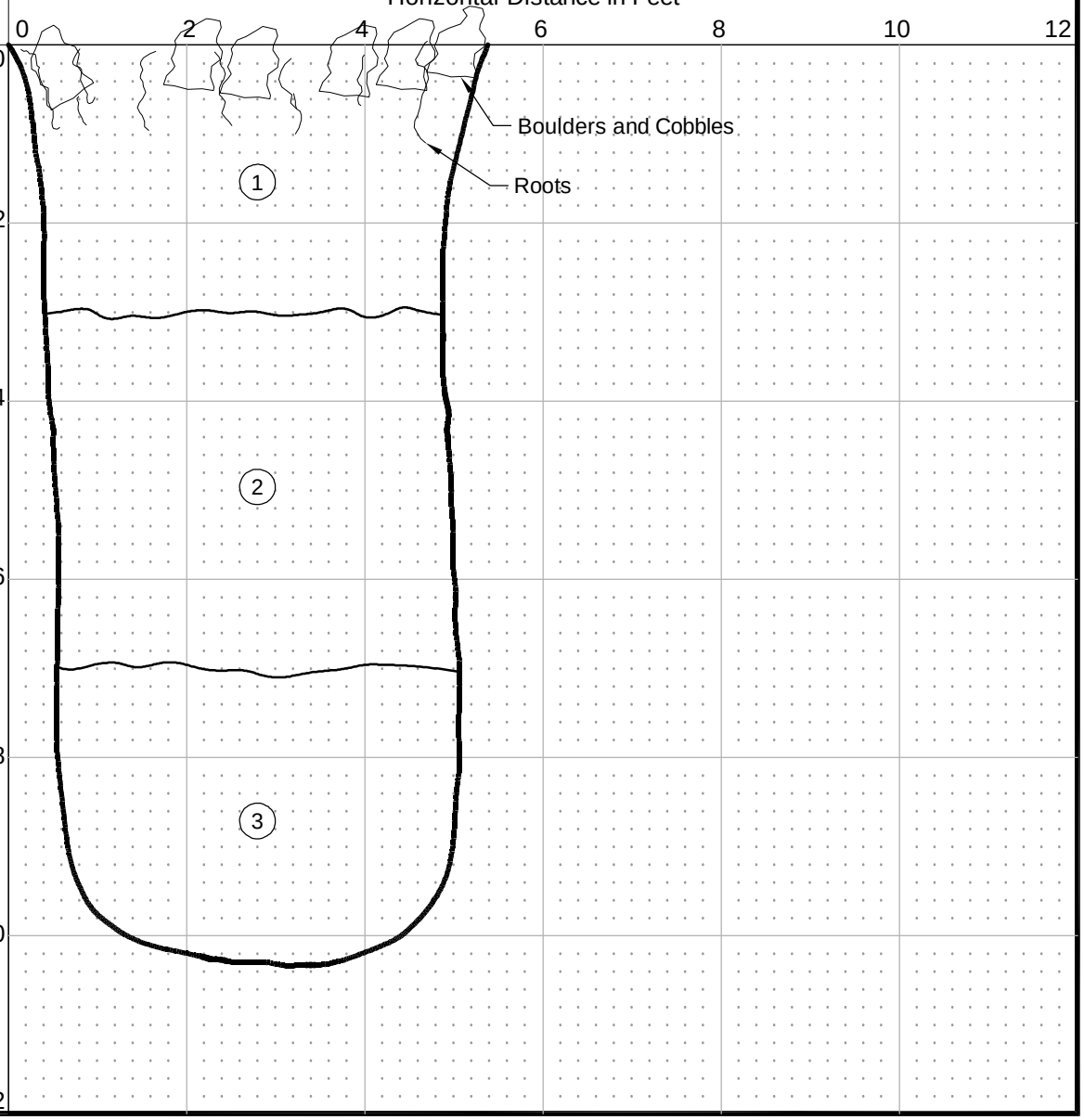
LOG OF TEST PIT TP-1

JOB NO: 21-1-21501-002 DATE: 5-19-2011 LOCATION: See Site and Exploration Plan

PROJECT: Entiatqua Trail

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium dense, brown, sandy GRAVEL with numerous 3- to 12-inch diameter cobbles, scattered angular boulders up to 18 inches in diameter; moist; fine roots to 1 foot depth; GP.	None Observed	3.3	S-1 Bag 1	0 2
(2) Medium dense, gray-brown, sandy GRAVEL with numerous 3- to 12-inch diameter cobbles and scattered boulders up to (24 inches); GP.		3.4	S-2	4
(3) Medium dense to dense, brown, slightly silty, gravelly fine to medium SAND, occasional angular 1-foot diameter boulders; moist; sewer pipe debris at approximately 10 feet; SP-SM.		8.6	Bag 2 & S-3	6 8 10 12

Sketch of West Pit Side — Surface Elevation: About 720 feet



NOTES

1. The test pit was excavated perpendicular to the slope of the embankment.
2. The pit was left open for about 1.5 hours. Little to no caving was observed during this time, but cracks were visible in the walls.

FIG. A-2

Filename: J:\211\21501-002\21-1-21501-002 TPs.dwg Date: 06-09-2011 Login: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-2

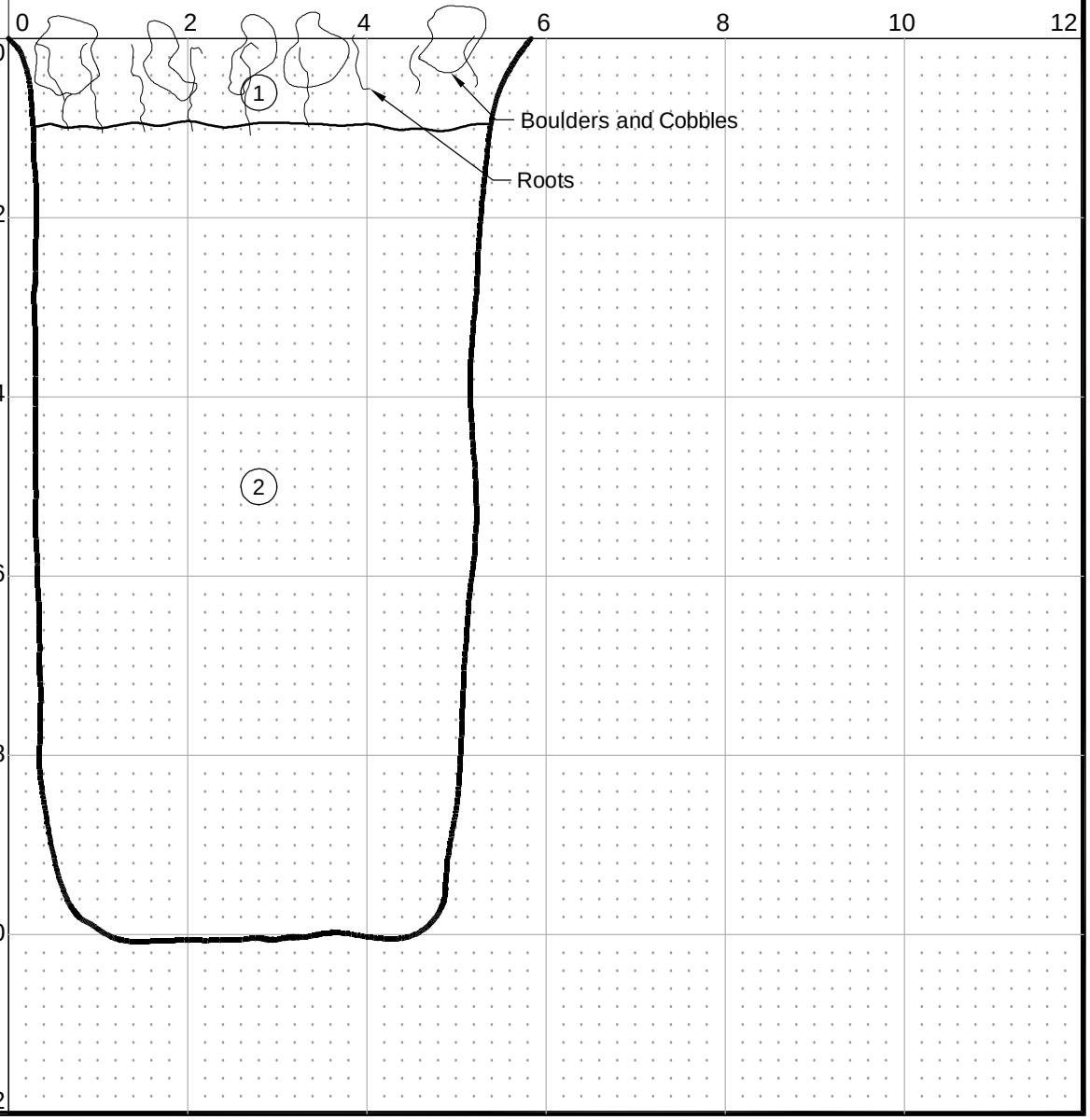
JOB NO: 21-1-21501-002 DATE: 5-19-2011 LOCATION: See Site and Exploration Plan

PROJECT: Entiatqua Trail

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Angular gravel, cobbles, and boulders (up to 2 feet in diameter), fine roots to approximately 1 foot deep.	None Observed			0
(2) Medium dense, brown, slightly silty, gravelly fine to medium SAND, occasional 3- to 4-inch diameter cobbles; moist; denser with depth; SP-SM.		5.2	S-1	2
				4
				6
		5.3	Bag 1 & S-2	8
				10
				12

Sketch of Northeast Pit Side

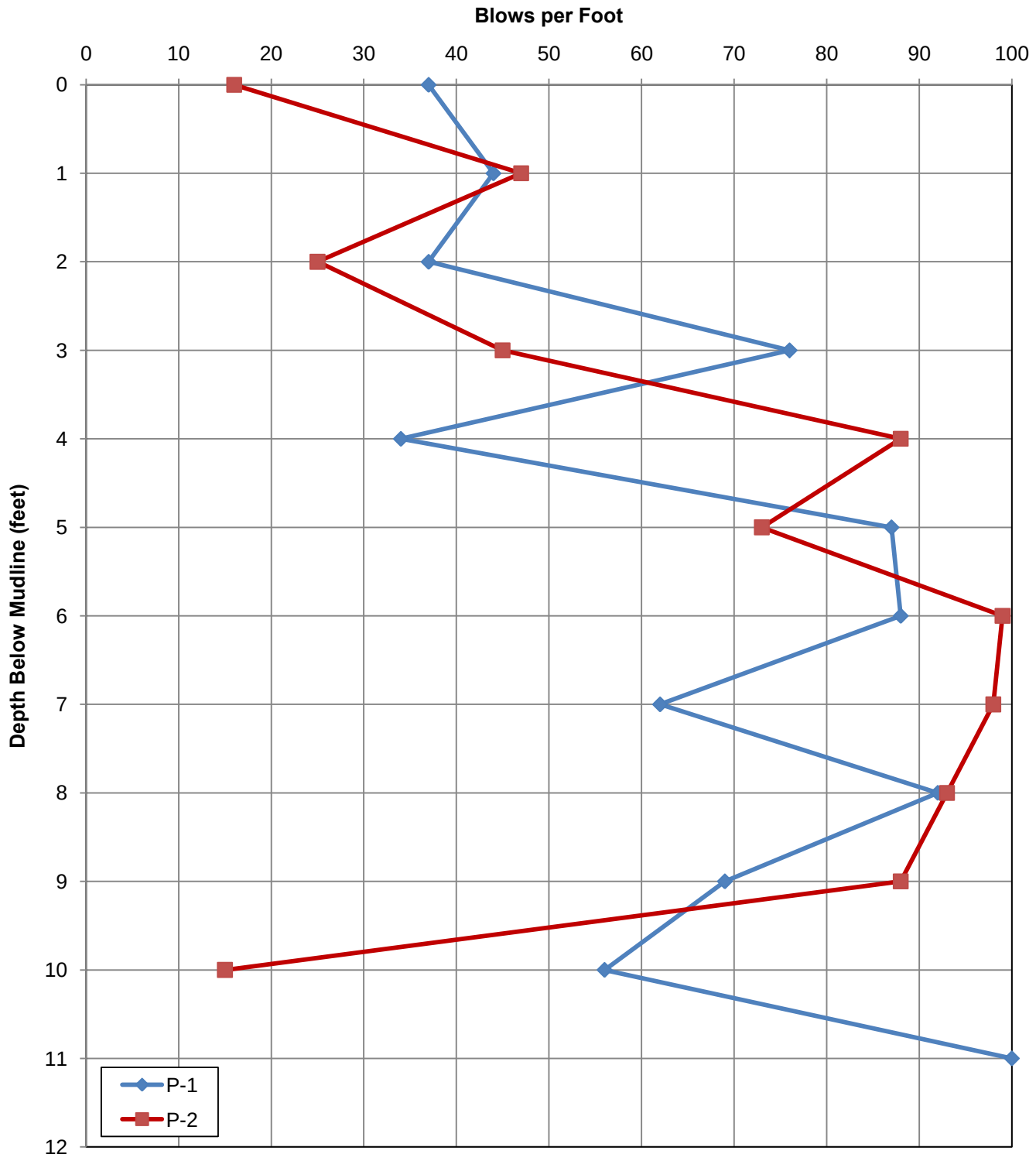
Surface Elevation: About 720 feet



NOTES

1. The test pit was excavated perpendicular to the slope of the embankment.
2. The pit was left open for about 1.5 hours. Little to no caving was observed during this time, but cracks were visible in the walls.

FIG. A-3



NOTES

1. For P-1, a 1.5-inch-diameter PVC pipe was driven by hand using a 10-pound sledge hammer with a 31 inch handle.
2. For P-2, a 1-inch-diameter steel pipe was driven by hand using a 10-pound sledge hammer with a 31 inch handle.
3. Blow counts at 3 feet deep for P-1 may be artificially high due to low energy transfer during the first 25 blows.
4. The PVC piping broke after 100 blows for 11 inches at 11 feet deep for P-1. The steel piping broke after 15 blows at 10 feet deep for P-2.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

PENETRATION TEST DRIVING RESISTANCE
P-1 AND P-2

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

TABLE OF CONTENTS

FIGURE

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

B.1 INTRODUCTION

This appendix contains the results of the laboratory testing program conducted for the Entiatqua Trail project. Shannon & Wilson's Seattle laboratory tested selected soil samples from the project site in order to evaluate index properties and engineering characteristics of the soils. The following paragraphs present descriptions of the tests. Laboratory tests were conducted in accordance with appropriate ASTM International (ASTM) standards.

B.2 VISUAL CLASSIFICATION

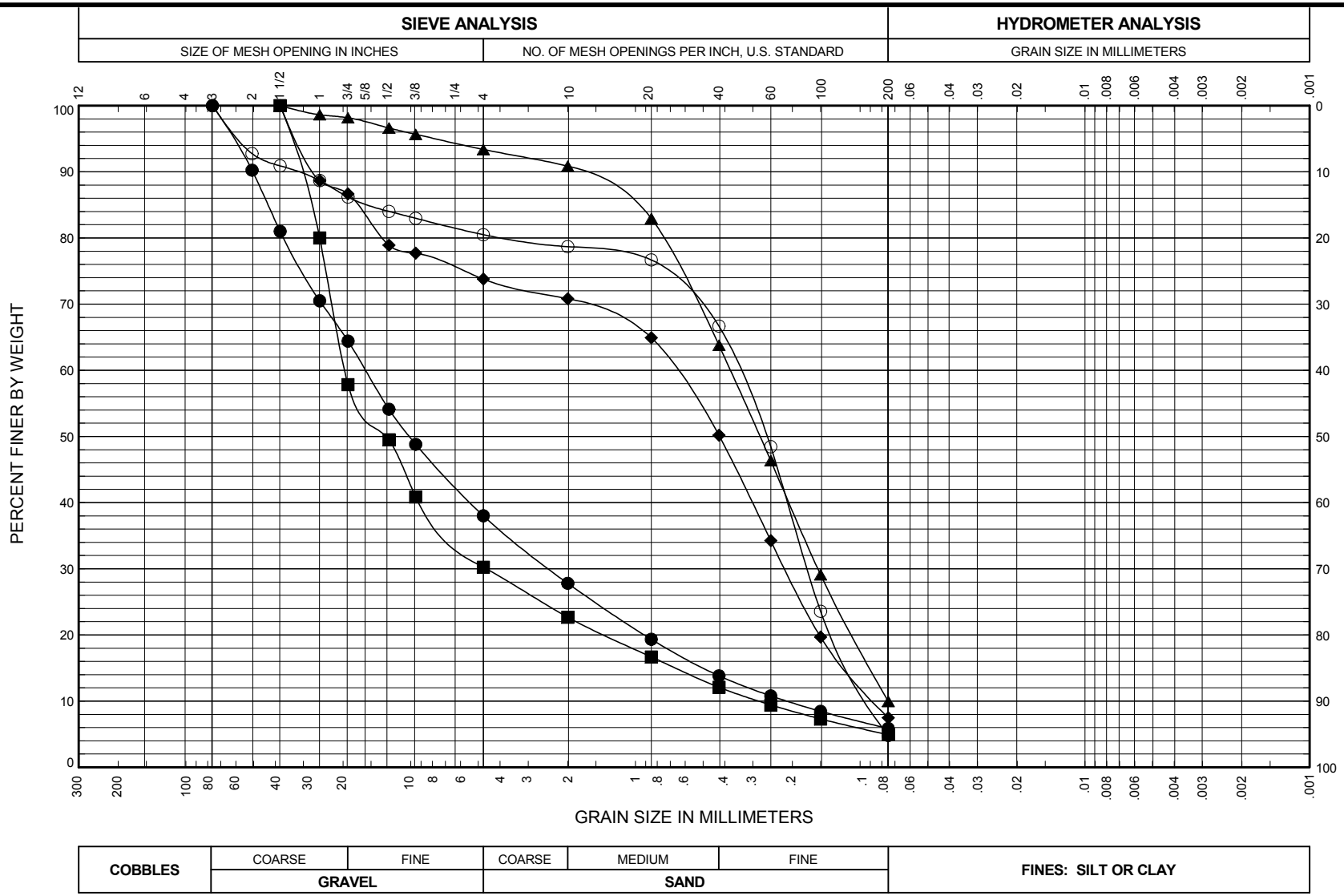
Soil samples were classified using the Unified Soil Classification System (USCS) with the modifications shown in Figure A-1 (Appendix A). Classification of the samples tested in the laboratory was based on ASTM D 2487, Standard Test Method for Classification of Soil for Engineering Purposes. Samples not tested in the laboratory were classified based on ASTM D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure).

B.3 WATER CONTENT DETERMINATION

Water content was determined on most samples collected in general accordance with ASTM D 2216, Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock. The water content is shown on the test pit logs in Appendix A.

B.4 GRAIN SIZE ANALYSIS

The grain size distribution of selected samples was tested in general accordance with ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils. Results of these analyses are presented in Figure B-1. Each gradation sheet provides the USCS group symbol, the sample description, and water content.



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● TP-1, Bag 1	2.0	GW-GM	Gray, slightly silty, sandy GRAVEL	5.9	3.3			
■ TP-1, S-2	3.0	GP	Gray-brown, sandy GRAVEL, trace of silt	4.9	3.4			
▲ TP-1, Bag 2	8.0	SP-SM	Brown, slightly gravelly, slightly silty SAND	10.0	8.6			
◆ TP-2, S-1	2.0	SP-SM	Brown, slightly silty, gravelly SAND	7.5	5.2			
○ TP-2, Bag 1	8.0	SP	Brown, gravelly SAND, trace of silt	4.8	5.3			

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

GRAIN SIZE DISTRIBUTION

June 2011 21-1-21501-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-1

FIG. B-1

GSA MAIN 21-21501.GPJ SHAN_WIL.GDT 6/9/11

APPENDIX C

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-21501-002

Date: June 13, 2011
To: Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

3 – Preliminary Design Review and Recommendations

Geotechnical Report
Entiatqua Trail
Entiat, Washington

December 6, 2011

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Excellence. Innovation. Service. Value.

Since 1954.

Submitted To:
Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County
327 N. Wenatchee Avenue
Wenatchee, Washington 98801

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103

21-1-21501-003

TABLE OF CONTENTS

Page

FIGURES

APPENDICES

GEOTECHNICAL REPORT
ENTIATQUA TRAIL
ENTIAT, WASHINGTON

1.0 INTRODUCTION

This report presents the results of geotechnical engineering studies performed for the proposed Entiatqua Trail in Entiat, Washington. Our geotechnical studies included formulating geotechnical engineering recommendations for use in the design and construction of the proposed project.

Our scope of geotechnical services included the following:

- Reviewing project plans provided by PUD No. 1 of Chelan County (dated December 1, 2011);
- Evaluating construction considerations;
- Conducting engineering analyses; and
- Preparing this report.

We provided our services in general accordance with our proposal dated October 26, 2011.

We previously prepared a report, dated June 2011, which presented geotechnical engineering recommendations for the proposed trail. As part of our scope of services for that report, we conducted a subsurface exploration program at the proposed trail site, and provided engineering design recommendations for the proposed trail.

2.0 SITE AND PROJECT DESCRIPTION

The proposed trail will connect Entiat Park with the proposed Entiatqua Outdoor Learning Center (Figure 1). Entiat Park is between U.S. Highway 97 and the C&C Railroad, and the west shore of the Columbia River. The proposed Entiatqua Outdoor Learning Center will be on the shores of the Entiat River, south of Entiat River Road and west of U.S. Highway 97.

Most of the proposed trail will be along the U.S. Highway 97 and C&C Railroad embankment. The embankment was built from rock quarried from the cliffs on the south side of the Entiat River. The construction of the embankment and associated bridges was completed before Rocky Reach Dam began operation and raised the level of the Columbia River to its current elevation.

The ordinary high water mark (OHWM) for the Columbia River near the project site is elevation 711 feet (North American Vertical Datum of 1988 [NAVD88]). Public Utility District (PUD) No. 1 of Chelan County is studying the feasibility of raising the OHWM to 714 feet (NAVD88).

The embankment is sparsely vegetated with grass, brush, and small trees. The embankment side slopes are generally between 30 and 40 degrees, with locally steeper areas, particularly on the east side and northwest corner of the embankment.

The proposed trail will be 8 feet wide and will be surfaced with compacted aggregate. The trail will be benched into the existing highway/railroad embankment. Figure 2 shows the proposed trail alignment. Retaining walls will support the trail and the cut slope. The project plans show three types of retaining systems: gabion walls, rockeries, and Lock+Load^{TM} walls.

As described in our June 2011 report, we believe the embankment generally comprises 1- to 3-foot-diameter angular boulders (tonalite of the Chelan Complex) with a sandy, gravelly matrix. A 1-foot-thick layer of rounded, 3- to 12-inch rounded cobbles covers portions of the embankment, particularly on the east side of the embankment.

3.0 ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Retaining wall stability has four components: external, internal, global, and compound. External stability involves translation or rotation of the retaining wall mass. Internal stability involves failure of reinforcing elements in the wall (e.g., geosynthetic reinforcement in mechanically-stabilized earth walls). Global stability involves failure surfaces that do not directly involve the retaining wall (e.g., slope failures that pass under the wall mass). Compound stability involves global failure surfaces that pass through a portion of the retaining wall.

We analyzed the stability of three proposed wall cross-sections: Station 4+50, the US 97A crossing, and Station 15+46. The PUD provided the wall designs at each cross-section.

3.1 External and Internal Stability

We used the computer program MSEW, Version 3.0 (ADAMA Engineering, 2007), to evaluate external and internal stability of each wall cross-section. We included an assumed surcharge live load of 150 pounds per square foot on the trail, and applied earth pressures consistent with the recommendations in our June 2011 report. For seismic cases, we used a horizontal seismic coefficient of 0.1g, which is about one-half of the soil peak ground acceleration (PGA) value (see our June 2011 report). The magnitude of this coefficient accounts for the fact that the PGA

occurs only a few times within the record of earthquake shaking and that the actual earthquake ground motion is cyclic in nature, as opposed to a static force.

Appendix A presents the engineering calculations for our analyses. Based on the results of our analyses, we recommend the following:

- Lock+Load™ walls taller than 4 feet should be reinforced with two layers of geogrid reinforcement;
- Lock+Load™ reinforcement should be at least 6 feet long and should be located at depths of 2 and 4 feet below the top of the wall;
- If the rockery exposed height is greater than 2 feet, geogrid reinforcement should be placed between each rockery rock layer;
- Rockery reinforcement should be at least 6 feet long; and
- Rockeries should be embedded at least 2 feet into compacted structural fill or dense native soil.

Geogrid reinforcement should:

- Meet the requirements of the Washington State Department of Transportation and American Public Works Association (WSDOT/APWA) (2010) Section 6-14.2, Materials for Geosynthetic Retaining Walls; and
- Have a minimum ultimate tensile strength of 4,000 pounds per foot.

The PUD incorporated our design recommendations into their trail design presented in the December 1, 2011, plan set. We analyzed three cross sections from the plan set for global and compound stability.

3.2 Global and Compound Stability

We evaluated the global and compound stability of the cross sections under static and seismic loads using the computer program SLOPE/W (Geo-Slope, 2007). We used SLOPE/W to analyze many potential failure surfaces at each cross section. For each potential failure surface, we used the general limit equilibrium method (Fredlund and Krahn, 1977), which satisfies both force and moment equilibrium, to calculate a factor of safety (FS) against slope failure.

The FS is the ratio of the forces available to resist movement to the forces of the driving soil mass. An FS of 1.0 means that the driving and resisting forces are equal. An FS of less than 1.0 means that the driving forces are greater than the resisting forces, indicating an unstable slope. The potential failure surface with the lowest FS is called the critical failure surface. We considered target minimum critical failure surface FSs of 1.5 for static stability and 1.1 for seismic stability in accordance with American Association of State Highway and Transportation Officials (2010) guidelines.

We selected soil strength parameters for the stability analyses using the results of field explorations, laboratory testing results, and our experience. We assumed that potential failure surfaces would pass beneath the reinforced soil zone. As in our internal and external stability analyses, we applied a horizontal seismic coefficient of 0.1g for the seismic case.

Figures 3 through 5 present the results of our analyses. The results show that the critical failure surface FS values meet target minimum values for static and seismic loading.

4.0 CONSTRUCTION CONSIDERATIONS

4.1 Site Preparation and Grading

We recommend the following steps for preparing the trail subgrade:

- Clear trees and brush;
- Remove roots, stumps, concrete, asphalt, and other debris;
- Strip organic and loose material;
- Excavate to the desired grades; and
- Proof-roll and compact the exposed subgrade surface as needed to a dense and unyielding condition.

Areas that are wet, soft, loose, or yielding when proof-rolled or during compaction should be further compacted, removed and reconditioned, or replaced with compacted structural fill so that a dense and unyielding condition is achieved.

We recommend that a qualified geotechnical engineer's representative be on site to evaluate the exposed subgrade during site preparation and grading.

If fill is placed in the rivers, we recommend excavating at least 2 feet of the existing river sediment to form a bench for the fill. Foundation stabilization material, such as free-draining quarry spalls or a mixture of boulders, cobbles, and gravel (e.g., the existing embankment fill material), should be placed below the water line to create a firm working platform for construction of the fill.

4.2 Fill Material

Fill soil placed beneath, behind, or within structures (e.g., behind/within retaining walls) should be structural fill. Structural fill is a fill soil that meets a specified gradation and has been placed and compacted in a specified manner. The following sections present our recommendations for structural fill.

4.2.1 Gradation

Imported structural fill soil should:

- Consist of a well-graded mixture of sand and gravel;
- Be free of organics and debris;
- Have a moisture content within ±2 percent of its optimum; and
- Have a maximum particle size of smaller than 4 inches.

Structural fill should have less than 7 percent fines (material passing the No. 200 mesh sieve, based on the minus ¾ inch fraction), and should be free draining. All fines should be nonplastic.

Examples of suitable fill soil gradations from WSDOT/APWA (2010) include:

- Gravel Borrow for Geosynthetic Retaining Wall, Section 9.03-14(4) for structural fill in geogrid-reinforced zones; and
- Gravel Borrow, Section 9-03.14(1) for structural fill in other areas.

4.2.2 Placement and Compaction

Before placing structural fill, we recommend draining ponded water from the area. We recommend placing structural fill in uniform lifts, and compacting the fill to a dense and unyielding condition and to at least 95 percent of its Modified Proctor maximum dry density (ASTM International [ASTM, 2010] D 1557).

Hand-operated mechanical compactors should be used within 3 feet of wall faces; heavy equipment compactors should not be used near walls. Lift thickness should not exceed 8 inches for heavy equipment compactors or 4 inches for hand-operated mechanical compactors.

If placed adjacent to an existing slope, structural fill should be benched into the slope. Benches should have a maximum height of 3 feet and penetrate the slope at least 3 feet.

Backfill for geogrid-reinforced walls should be placed and compacted according to WSDOT/APWA (2010) 6-14.3(4).

4.2.3 Use of On-site Soil

In our opinion, the existing native soil could be reused as structural fill, provided that material greater than 4 inches in diameter is removed and the fines content is less than 7 percent. The Contractor should be prepared to screen the on-site soil to remove material greater than 4 inches in diameter. Material larger than 4 inches could be used to fill in the river or as erosion protection. Based on laboratory testing performed for our June 2011 report, the fines content of the native soil ranges from about 5 to 10 percent. The Contractor should be prepared to perform grain size analyses to confirm that the fines content of the soil is less than 7 percent.

4.3 Excavations

Temporary cut slopes could be used to bench the proposed trail into the existing slope and facilitate wall construction. The practical steepness of temporary slopes will depend on factors such as:

- The presence and abundance of groundwater;
- The type and density of the soil;
- The depth of excavation;
- Surcharge loading adjacent to the excavation, such as that from excavated material or construction equipment; and
- The duration of construction.

For planning purposes, we recommend assuming that temporary slopes less than 8 feet high could be excavated at 0.75 Horizontal to 1 Vertical (0.75H:1V) in the existing embankment material. The slopes may be subject to erosion. We recommend protecting the slope against erosion during construction.

Consistent with conventional construction practice, the Contractor should be responsible for temporary excavation slopes. The Contractor is continually at the site, is able to observe the nature and conditions of the subsurface materials encountered, including groundwater, and is responsible for the methods, sequence, and schedule of construction. Flatter cut slopes or temporary shoring could be required where loose soil or seepage is encountered or if instability is observed. Regardless of the construction method used, all excavation work should be accomplished in compliance with applicable local, state, and federal safety codes.

4.4 Wet Weather Earthwork

We recommend performing earthwork during dry weather. During wet weather, placing and compacting fill material can be difficult. In-place soil or fill soil that is too wet to suitably compact should be removed and replaced with structural fill. Most of the existing site soil is subject to erosion during periods of heavy rainfall. Excavations should be protected against erosion.

5.0 ADDITIONAL SERVICES

We recommend that Shannon & Wilson be retained to review those portions of the plans and specifications pertaining to geotechnical aspects of construction to evaluate if they are consistent with our recommendations. We also recommend that we observe the geotechnical aspects of construction, which will allow us to verify the subsurface conditions as they are exposed during construction and to evaluate if the work is accomplished in accordance with our recommendations.

6.0 LIMITATIONS

This report was prepared for the exclusive use of the PUD for the Entiatqua Trail project. It should be made available to prospective contractors for information on factual data only, and not as a warranty of subsurface conditions such as those interpreted from the exploration logs and presented in the discussions of subsurface conditions included in this report.

Within the limitations of the scope, schedule, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either expressed or implied.

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist and further assume that the explorations are representative of the subsurface conditions throughout the project site; that is, the subsurface conditions everywhere are not significantly different from those disclosed by the explorations. Our conclusions and recommendations are based on our understanding of the project as described in this report and the site conditions as interpreted from the explorations.

If, during final design and construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present, we should be advised at once so that we could review these conditions and reconsider our recommendations where necessary. If there is substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed because of natural forces or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations concerning the changed conditions or the time lapse.

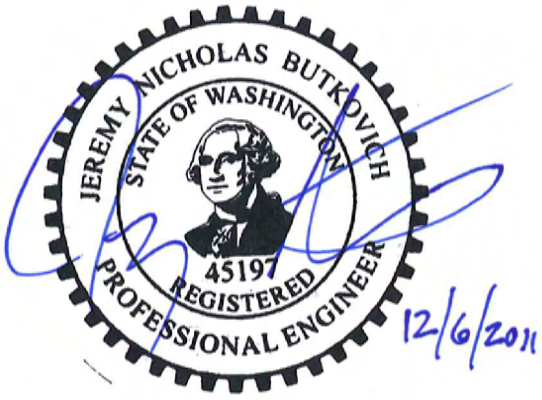
Unanticipated soil conditions are commonly encountered and cannot fully be determined merely by taking soil samples from a limited number of test pits or performing a limited number of penetration tests. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The scope of our geotechnical services did not include environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air on or below the site, or any evaluation for disposal of contaminated soils or groundwater.

We did not evaluate the project site for potential impacts to natural resources, including wetlands, endangered species, or environmentally critical areas. Shannon & Wilson has staff experienced in these issues should they arise.

Shannon & Wilson has prepared Appendix B, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our reports.

SHANNON & WILSON, INC.



Jeremy N. Butkovich, P.E.
Principal Engineer

JNB:CAR/jnb

7.0 REFERENCES

ADAMA Engineering, 2007, MSEW 3.0, Newark, Delaware.

American Association of State Highway and Transportation Officials (AASHTO), 2010, AASHTO LRFD bridge design specifications: customary U.S. units (5th ed.): Washington, D.C., AASHTO, 2 v.

ASTM International (ASTM), 2010, 2010 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 - D 5876: West Conshohocken, Pa.

Fredlund, D.G., and Krahn, J., 1977, Comparison of slope stability methods of analysis: Canadian Geotechnical Journal, v. 14, no. 3, p. 429 439.

Geo-Slope, 2007, Documentation for the SLOPE\W Version 7 Software, Geo-Slope International Ltd., Calgary, Alberta.

Washington State Department of Transportation and American Public Works Association (WSDOT/APWA), 2010, Standard specifications for road, bridge, and municipal construction: English Units, M 41-10: Olympia, Wash.

0 1000 2000

Approximate Scale in Feet

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, image by U.S. Geological Survey reproduced by permission granted by Google Earth ™ Mapping Service.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

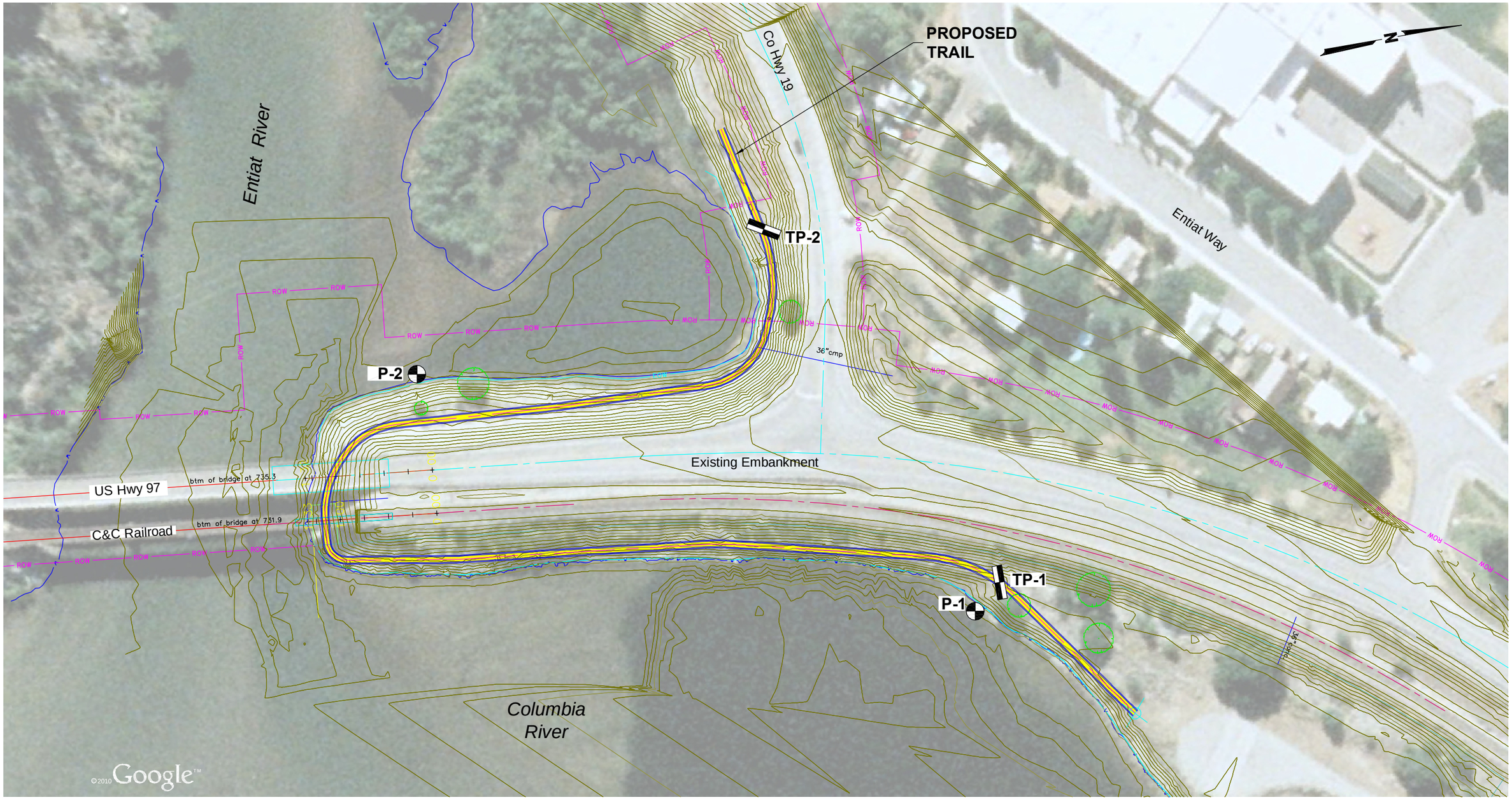
VICINITY MAP

November 2011 21-1-21501-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1

Filename: J:\211\21501-003\21-1-21501-003 Fig 1.dwg Date: 11-16-2011 Login: sac



0 100 200

Scale in Feet

LEGEND

P-1 Penetration Test Designation and Approximate Location (See June 13,2011 report)

TP-1 Test Pit Designation and Approximate Location (See June 13,2011 report)

NOTE

Figure adapted from *"Entiatqua Trail Full Set 3-10-2011.DWG"*, dated 4-28-11.
Aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

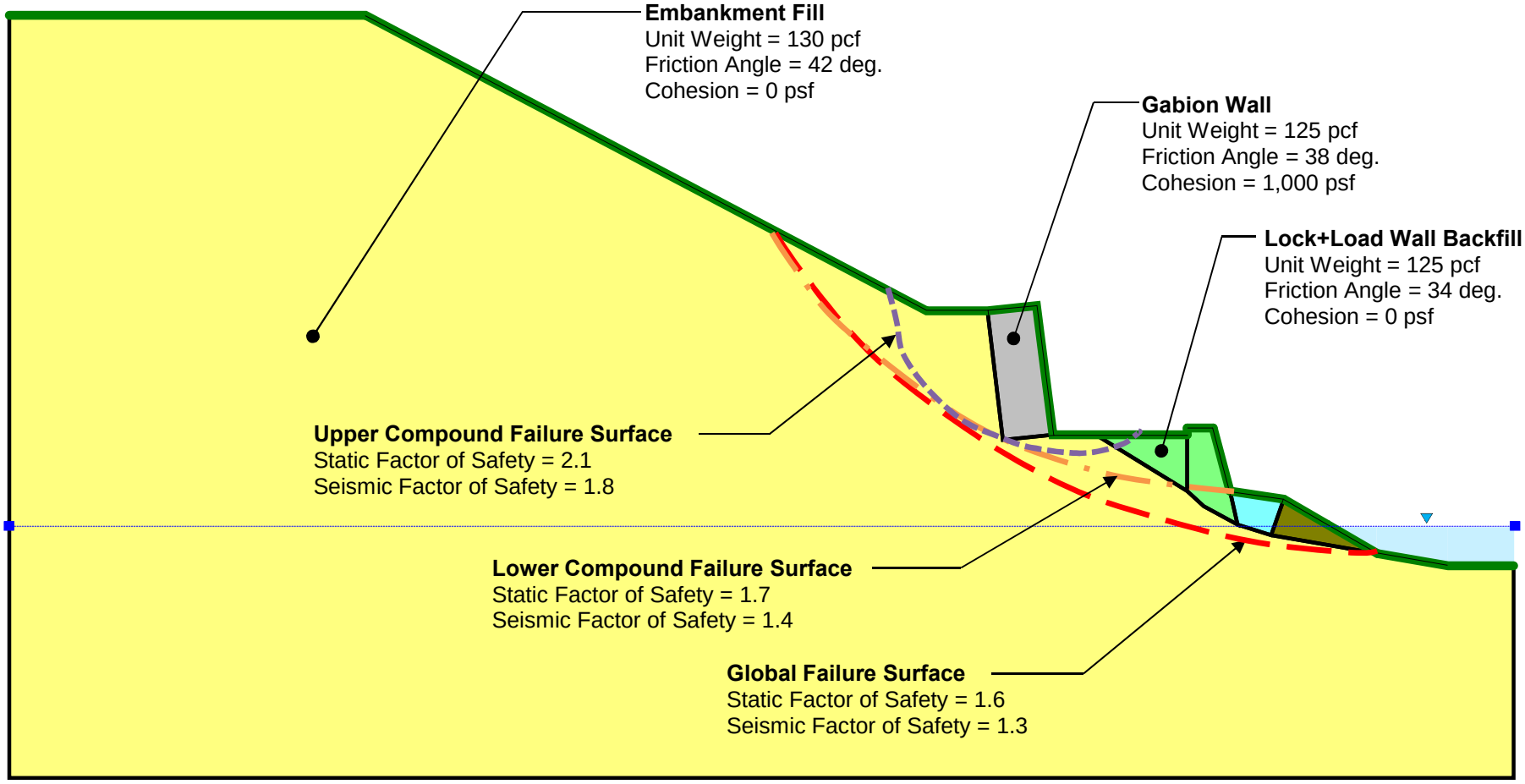
SITE AND EXPLORATION PLAN

November 2011 21-1-21501-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

Filename: J:\21\21501-003\21-1-21501-003 Fig 2.dwg Date: 11-17-2011 Login: sac



NOTES

1. We analyzed the slope stability using the computer program SLOPE/W (GeoStudio, 2008).
2. For the seismic cases, we applied a horizontal acceleration coefficient of 0.11 gravity.
3. We modeled the wall geometry provided by Chelan County PUD No. 1.
4. pcf = pounds per cubic foot
   deg. = degrees
   psf = pounds per square foot
   lb/ft = pounds per foot

FIG. 3

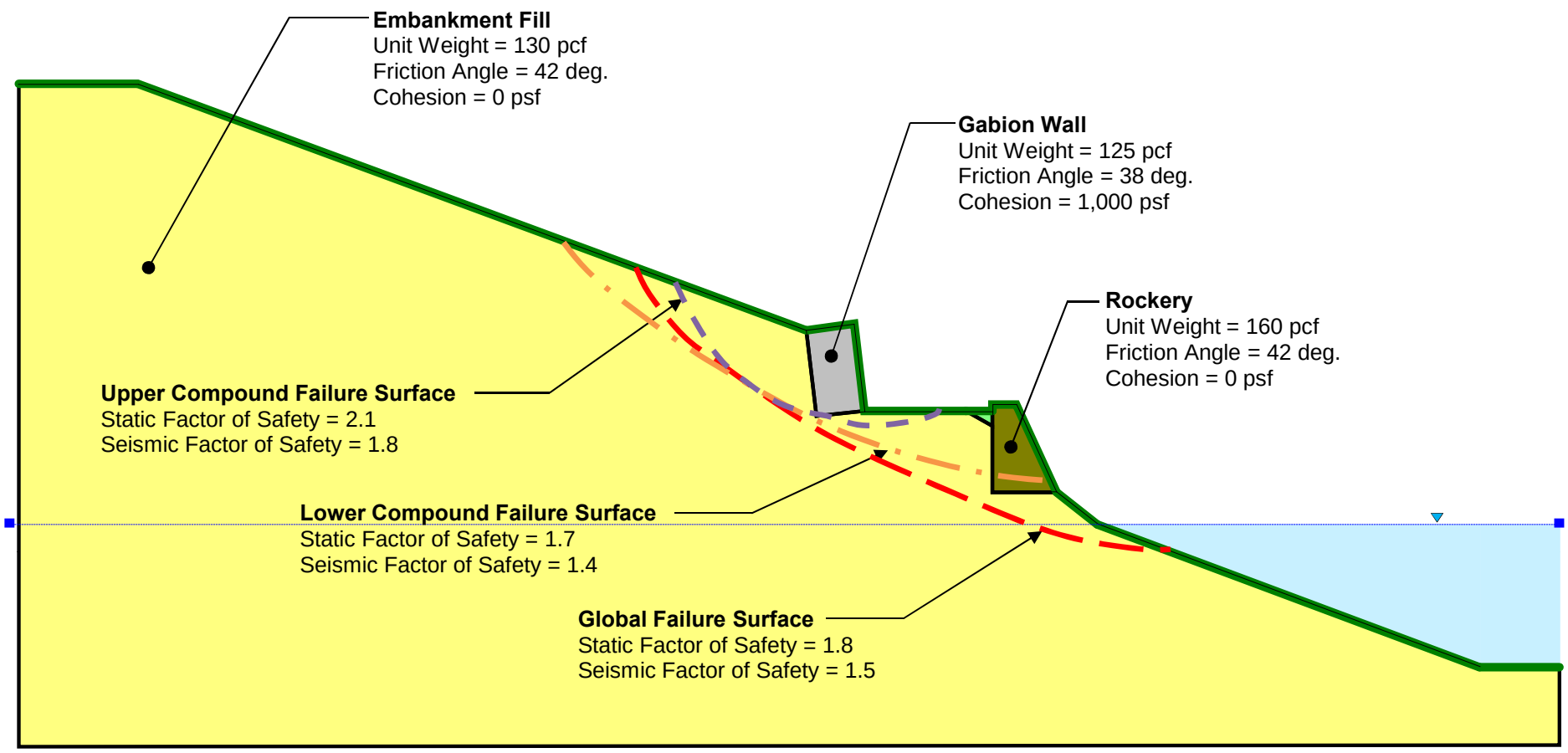
Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

STABILITY ANALYSIS RESULTS
STATION 4+50

November 2011 21-1-21501-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3



NOTES

1. We analyzed the slope stability using the computer program SLOPE/W (GeoStudio, 2008).
2. For the seismic cases, we applied a horizontal acceleration coefficient of 0.11 gravity.
3. We modeled the wall geometry provided by Chelan County PUD No. 1.
4. pcf = pounds per cubic foot
   deg. = degrees
   psf = pounds per square foot
   lb/ft = pounds per foot

FIG. 4

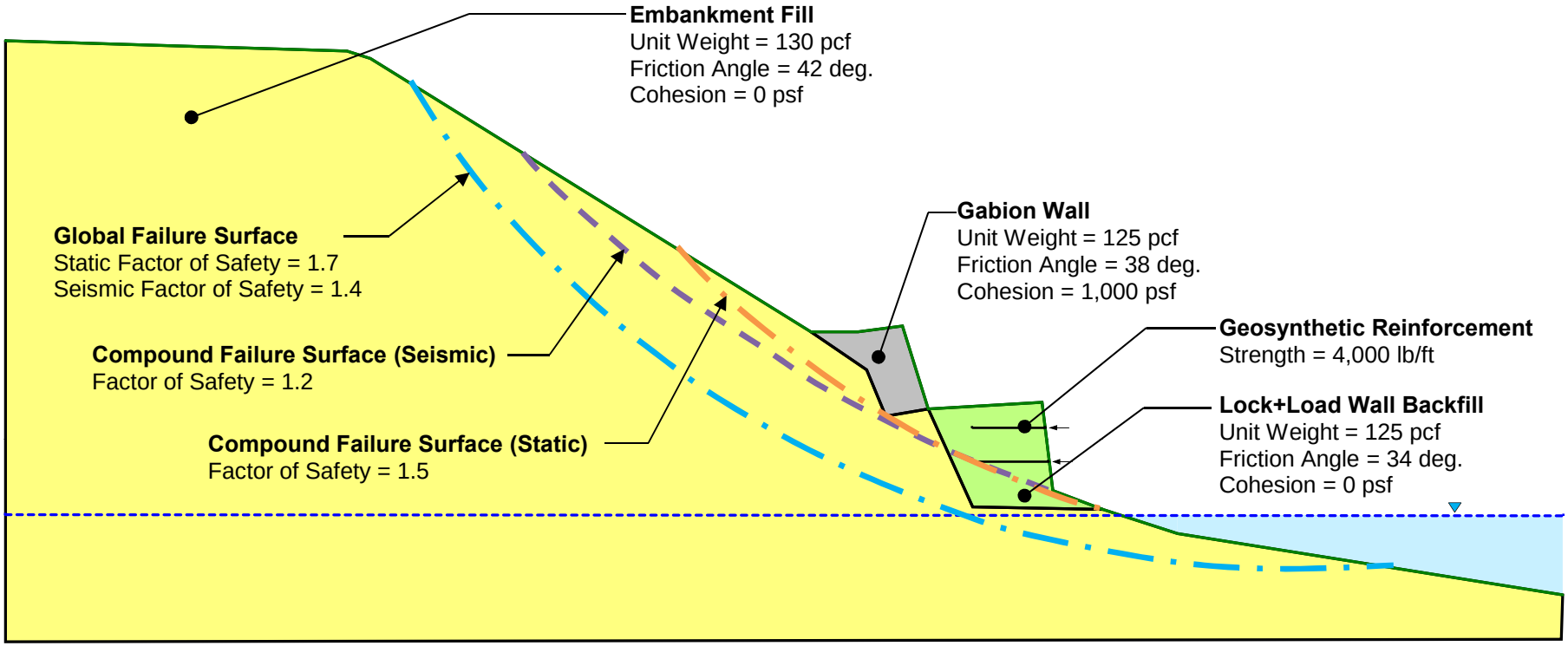
Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

STABILITY ANALYSIS RESULTS
SECTION AT SR 97A BRIDGE

November 2011 21-1-21501-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4



NOTES

1. We analyzed the slope stability using the computer program SLOPE/W (GeoStudio, 2008).
2. For the seismic cases, we applied a horizontal acceleration coefficient of 0.11 gravity.
3. We modeled the wall geometry provided by Chelan County PUD No. 1.
4. pcf = pounds per cubic foot
   deg. = degrees
   psf = pounds per square foot
   lb/ft = pounds per foot

FIG. 5

Entiatqua Trail
Chelan County PUD No. 1
Entiat, Washington

STABILITY ANALYSIS RESULTS
STATION 15+46

November 2011 21-1-21501-003

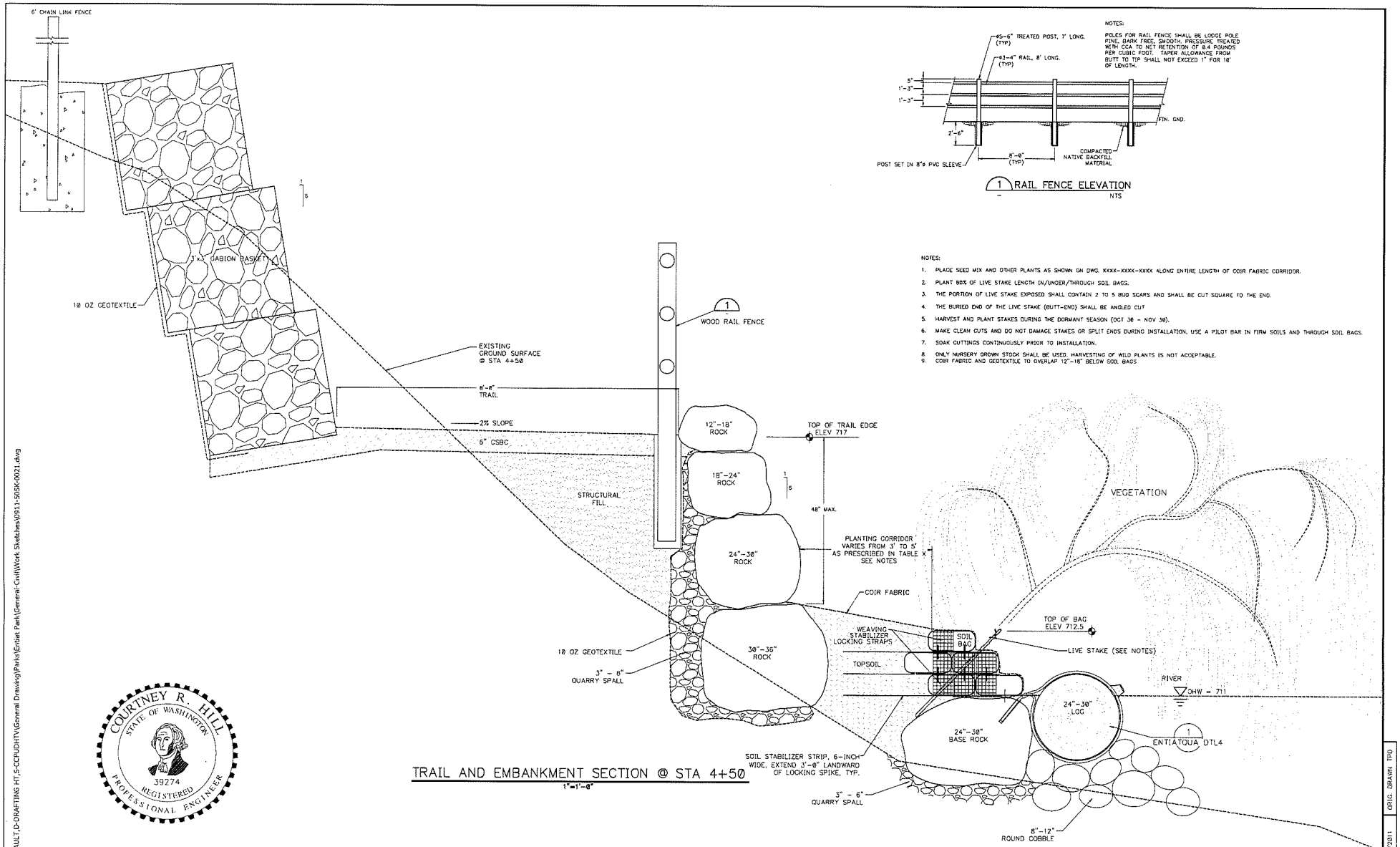
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 5

APPENDIX A

ENGINEERING CALCULATIONS

STATION 4+50



TRAIL AND EMBANKMENT SECTION @ STA 4+50
1"=1'-0"

1 RAIL FENCE ELEVATION
NTS

COURTNEY R. HILL
STATE OF WASHINGTON
39274
REGISTERED
PROFESSIONAL ENGINEER

\\COBALT\ham\AULT_D-DRAFTING HT\5-CCPUDHTV\General Drawing\Parks\Entiat Park\General-Civil\Work Sketches\0911-50SK-0021.dwg

CHELAN PUD NO.1		SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING.	VERIFY SCALE @ 1"	IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.		
PRIM. ENG. C.HILL							
2ND ENG.	0	10/10/2011	FEASIBILITY			CRH	TPD
PROJ. MGR.	REV	DATE	REVISION			REQ. BY	DRFT

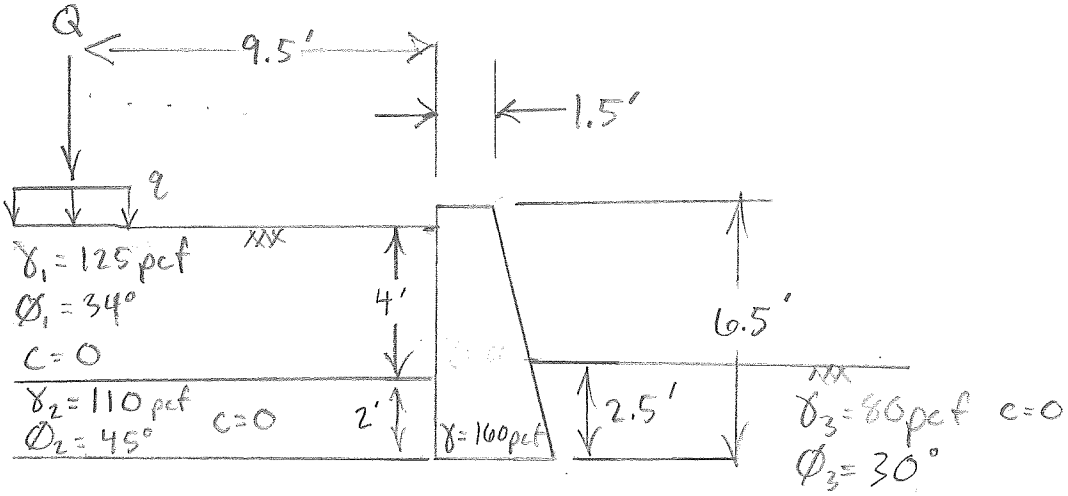
PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

Entiat Park
ENTIATQUA TRAIL
TYPICAL SECTION - DEEP WATER
FIGURE 3

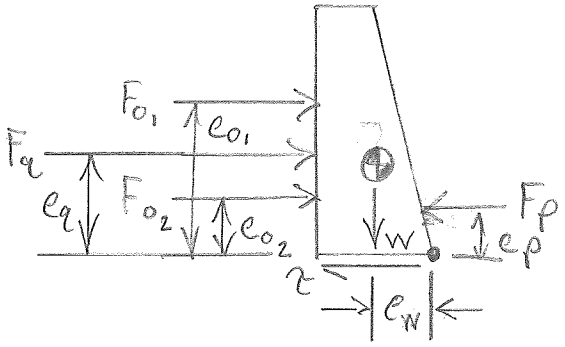
SHEET	2 OF 2
REVISION	0
DATE	10/10/2011
DWG.	0911-50SK-0021

ORIG. DRAWN TPD
ORIG. DATE 9/1/2011

EXTERNAL STABILITY CALCS. Sta 4+50



FBD



STATIC LOAD CALCS:

$K_{a_1} = \tan^2(45 - \phi_1/2) = \tan^2(45 - 34/2) = 0.28$

$K_{a_2} = \tan^2(45 - \phi_2/2) = \tan^2(45 - 45/2) = 0.17$

$F_{o_1} = \frac{1}{2}\gamma_1 (4')^2 K_{a_1} = \frac{1}{2}(125\text{ pcf})\,16\text{ ft}^2\,(0.28) = 280\text{ lb/ft}$

$F_{o_2} = \frac{1}{2}\left[\gamma_1(4')K_{a_1} + \left[\gamma_1(4')K_{a_1} + \gamma_2(2')K_{a_2}\right]\right]2'$

$= \frac{1}{2}\left[125(4)\,0.28 + \left[125(4)\,0.28 + 110(2)\,0.17\right]\right]2 = 317\text{ lb/ft}$

$e_{o_1} = 3.33'$

$e_{o_2} = \dfrac{34(0.67) + 280(1)}{34 + 280} = 0.96'$

$F_q = 937\text{ lb/ft}$

$e_q = 1.79'$

$K_p \approx \tan^2\left(45 + \frac{\phi_3}{2}\right) = \tan^2(45 + 30/2) = 3$

$F_p = \frac{1}{2}\gamma_3 (2.5')^2 K_p = \frac{1}{2}(80\,pcf)(2.5')^2 = 750$ lb/ft

$e_p = 0.83'$

$W = A\gamma = 13.5\,ft^2(160\,pcf) = 2160$ lb/ft

$e_w = 1.83'$

SEISMIC LOAD CALCS:

$A = 0.1 \Rightarrow k_h = (1.45 - A)A = 0.135$

MONONOBE-OKABE EQN $\Rightarrow \theta = \tan^{-1}(k_h) = \tan^{-1}(0.135) = 7.69$

$$K_{ae_1} = \frac{\cos^2(\phi - \theta)}{\cos\theta\cos(\phi_w + \theta)\left[1 + \sqrt{\frac{\sin(\phi + \phi_w)\sin(\phi - \theta)}{\cos(\phi_w + \theta)}}\right]^2}$$

$$K_{ae_1} = \frac{\cos^2(34 - 7.69)}{\cos(7.69)\cos(42 + 7.69)\left[1 + \sqrt{\frac{\sin(34+42)\sin(34-7.69)}{\cos(42+7.69)}}\right]^2}$$

$= 0.38$

$$K_{ae_2} = \frac{\cos^2(45 - 7.69)}{\cos(7.69)\cos(48 + 7.69)\left[1 + \sqrt{\frac{\sin(45+48)\sin(45-7.69)}{\cos(48+7.69)}}\right]^2}$$

$= 0.27$

$F_{oe_1} = \frac{1}{2}(125)4^2(0.38) = 380$ lb/ft

$F_{oe_2} = \frac{1}{2}\left[125(4)0.38 + \left[125(4)0.38 + 110(2)0.27\right]\right]2 = 439$ lb/ft

OVERTURNING:

$d_w = 2.5'$

$B = 3'$

$W = 2160\ lb/ft$

$$\Sigma M_{RES.} = W e_w + F_p e_p = 2160(1.83) + 750(0.83) = 4575\ \frac{lb\text{-}ft}{ft}$$

$$\Sigma M_{PRIV.} = F_{oc_1} e_{o_1} + F_{oe_2} e_{o_2} + F_q e_q = 380(3.33) + 439(0.96) + 937(1.79)$$

$$= 3364\ \frac{lb\text{-}ft}{ft}$$

$$FS_{O.T.} = \frac{\Sigma M_{RES}}{\Sigma M_{PRIV}} = \frac{4575}{3364} = 1.36 \geq 0.75(2) = 1.5$$

(JUST FAILS)

Reduce wall height or include geogrid reinforcement

New design includes Lock+Load wall; see Section 15+46 calculations.

SLIDING:

$$\Sigma F_{RES.} = 2160 \tan(45) + 750 \ {}^{lb}/_{ft} = 2910 \ {}^{lb}/_{ft}$$

$$\Sigma F_{DRIV} = 280 + 317 + 937 = 1534 \ {}^{lb}/_{ft}$$

$$FS_{SLIDING} = \frac{2910}{1534} = 1.90 > 0.75(1.5) = 1.13 \quad \boxed{\text{SAFE}}$$

BEARING CAPACITY:

$$e = \frac{\Sigma M_{DRIV}}{W} = \frac{3364}{2160} = 1.56 > \frac{B}{6} = 0.5 \quad \therefore \text{TENSION AT BASE}$$

CALC. B_{MIN} REQUIRED FOR COMP. ACROSS ENTIRE BASE:

$$0.5 > \frac{3364}{480 B_{MIN} + 720}$$

$$240 B_{MIN} + 360 > 3364$$

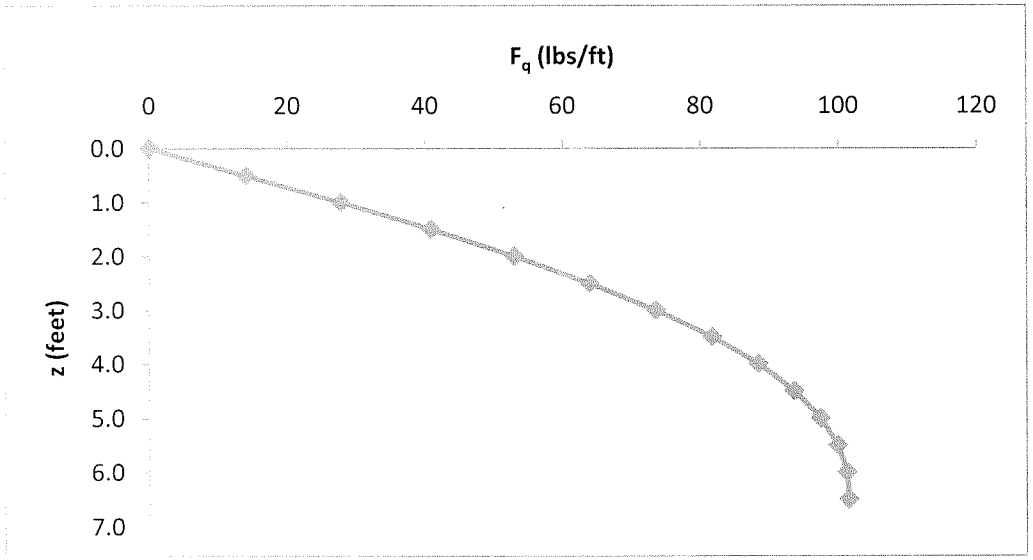
$$B_{MIN} > 12.5'$$

SINCE $e > B/6 \Rightarrow \sigma_{V_{max}} = \frac{4W}{3(B-2e)} = \frac{4(2160)}{3(4-2(1.56))} = 3273 \text{ psf}$

$$q_{ULT} = \frac{1}{2}(110)3(60) = 9405 \text{ psf}$$

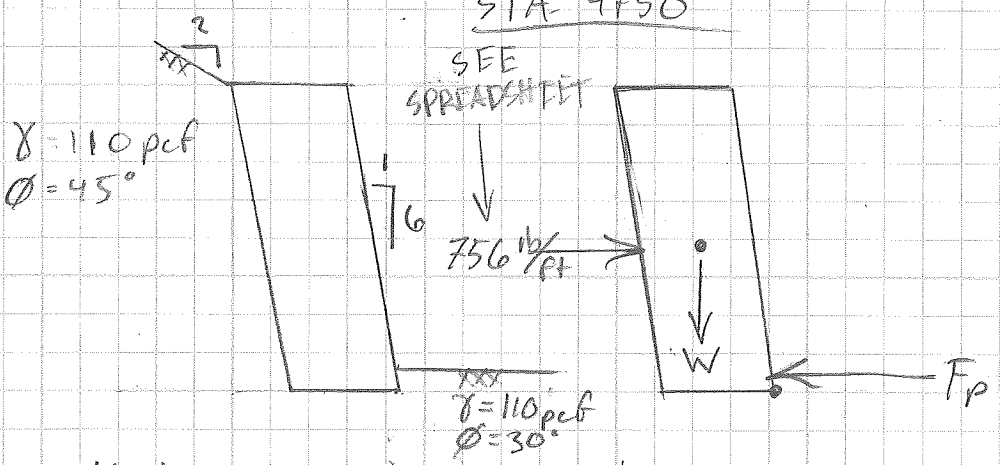
$$FS_{B.C.} = \frac{9405}{3273} = 2.87 > 0.75(1.5) \quad \boxed{\text{SAFE}}$$

z	n	$\sigma_h = F_q$ (lbs/ft)	A_i	c_iA_i	e_q (feet)
0.0	0.00	0.00	0.00	0.00	1.79
0.5	0.07	14.07	7.03	3.52	
1.0	0.14	27.80	13.90	13.90	
1.5	0.21	40.86	20.43	30.65	
2.0	0.29	52.98	26.49	52.98	
2.5	0.36	63.93	31.97	79.92	
3.0	0.43	73.54	36.77	110.31	
3.5	0.50	81.70	40.85	142.98	
4.0	0.57	88.38	44.19	176.76	
4.5	0.64	93.59	46.79	210.57	
5.0	0.71	97.39	48.69	243.47	
5.5	0.79	99.88	49.94	274.68	
6.0	0.86	101.19	50.60	303.57	
6.5	0.93	101.46	50.73	329.73	
	Σ =	936.77	468.39	1973.03	



EXTERNAL STABILITY CALCS. GABION WALLS

STA 4+50



$W = 3'(3')3(100\ pcf) = 2800\ lb/ft$

$K_p = \tan^2(45 + 30/2) = 3$

$F_p = \frac{1}{2}(110\ pcf)(0.5')^2 3 = 41.3\ lb/ft$

OVERTURNING:

$\Sigma M_{RES} = W(2.4') + F_p(0.25')$

$= 2800(2.9') + 41.3(0.25') = 8130\ \frac{lb\text{-}ft}{ft}$

$\Sigma M_{DRIV} = 756(4) = 3024\ \frac{lb\text{-}ft}{ft}$

$\rightarrow FS_{O.T} = \frac{8130}{3024} = 2.69 > 0.75(2) = 1.5$ **SAFE**

SLIDING:

$\Sigma F_{RES} = 2800 \tan(30) + 41.3 = 1658\ lb/ft$

$\Sigma F_{DRIVE} = 756$

$FS_{SLIDING} = \frac{1658}{756} = 2.19 > 0.75(1.5) = 1.125$ **SAFE**

BEARING CAPACITY:

$$e = \frac{\Sigma M_{DRIV}}{W} = \frac{3024}{2800} = 1.08 > \frac{B}{6} = 0.5$$ TENSION @ BASE

$$\therefore q_{V_{max}} = \frac{4W}{3(B-2e)} = \frac{4(2600)}{3(3-2(1.08))} = 4444 \text{ psf}$$

$$q_{ULT} = \frac{1}{2}(110)\,3\,(60) = 9405 \text{ psf}$$

(N_γ)

$$FS = \frac{9405}{4444} = 2.12 > 0.75(2) = 1.5$$ SAFE

Calculation of Dynamic Earth Pressures
(Ø soil with no liquefaction)

Job No.: 21-1-21501-003
Date: 11/11/2011
by: BRC
Wall/Footing: Sta 4+50
Conditions:

	INPUT	
Height of Retained Soil, H (ft)	8	
Soil Unit Weight, gamma (pcf)	110	
Soil Angle of Friction, ϕ (deg.)	45	0.7854 Angles (rad.)
Horizontal Acceleration Coefficient, kh (g's)	0.1	Assume kh=1/2*PGA
Vertical Acceleration Coefficient, kv (g's)	0	
Angle of Friction between soil & wall, δ (deg.)	40	0.6981 Angles (rad.)
Slope of Soil Face, θ (deg.)	-10	-0.1745 Angles (rad.)
Slope Behind Wall, β (deg.)	26	0.4538 Angles (rad.)
Theta	5.7106	0.0997

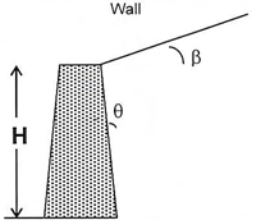
RESULTS

		Dynamic	Static	
			Rankine	Coulomb
ACTIVE	Active Earth Pressure Coefficient with Earthquake Effect, Kae	0.215	0.146	0.139
	Active Pressure at Base of Wall (psf)	189	128	122
	Active Pressure Equivalent Fluid Weight (pcf)	24	16	15
	Active Earth Force on Wall, Ea (lb)	756	513	488
	Δkae		0.069	0.076
	Dynamic Active Earth Force Increment		242.6	267.2
	Uniformly Distributed Active Pressure Increase		30.3	33.4
	Percent Increase in Active pressure		47%	55%
	Uniformly Distributed Active Pressure Increase divided by the wall height (psf/ft)		3.8	4.2
PASSIVE	Passive Earth Pressure Coefficient with Earthquake Effect, Kpe	8.360	99.705	8.999
	Passive Pressure at Base of Wall (psf)	7.357E+03	8.774E+04	7.919E+03
	Passive Pressure Equivalent Fluid Weight (pcf)	9.196E+02	1.097E+04	9.899E+02
	Passive Earth Force on Wall, Ep (lb)	2.943E+04	3.510E+05	3.168E+04

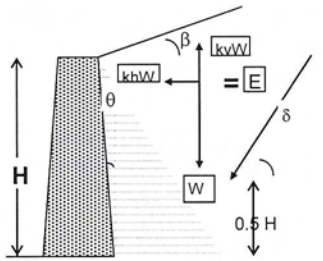
		Dynamic	Static
			Rankine
AT REST	At Rest Earth Pressure Coefficient with Earthquake Effect, Koe	0.353	0.293
	At Rest Pressure at Base of Wall (psf)	311	258
	At Rest Pressure Equivalent Fluid Weight (pcf)	39	32
	At Rest Earth Force on Wall, Eo (lb)	1244	1031
	Δkae		0.061
	Dynamic At Rest Earth Force Increment		213
	Uniformly Distributed At Rest Pressure Increase		27
	Percent Increase in Active pressure		21%
	Uniformly Distributed At Rest Pressure Increase divided by the wall height (psf/ft)		3.3

DIAGRAMS

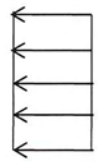
Wall



Pressure Distribution



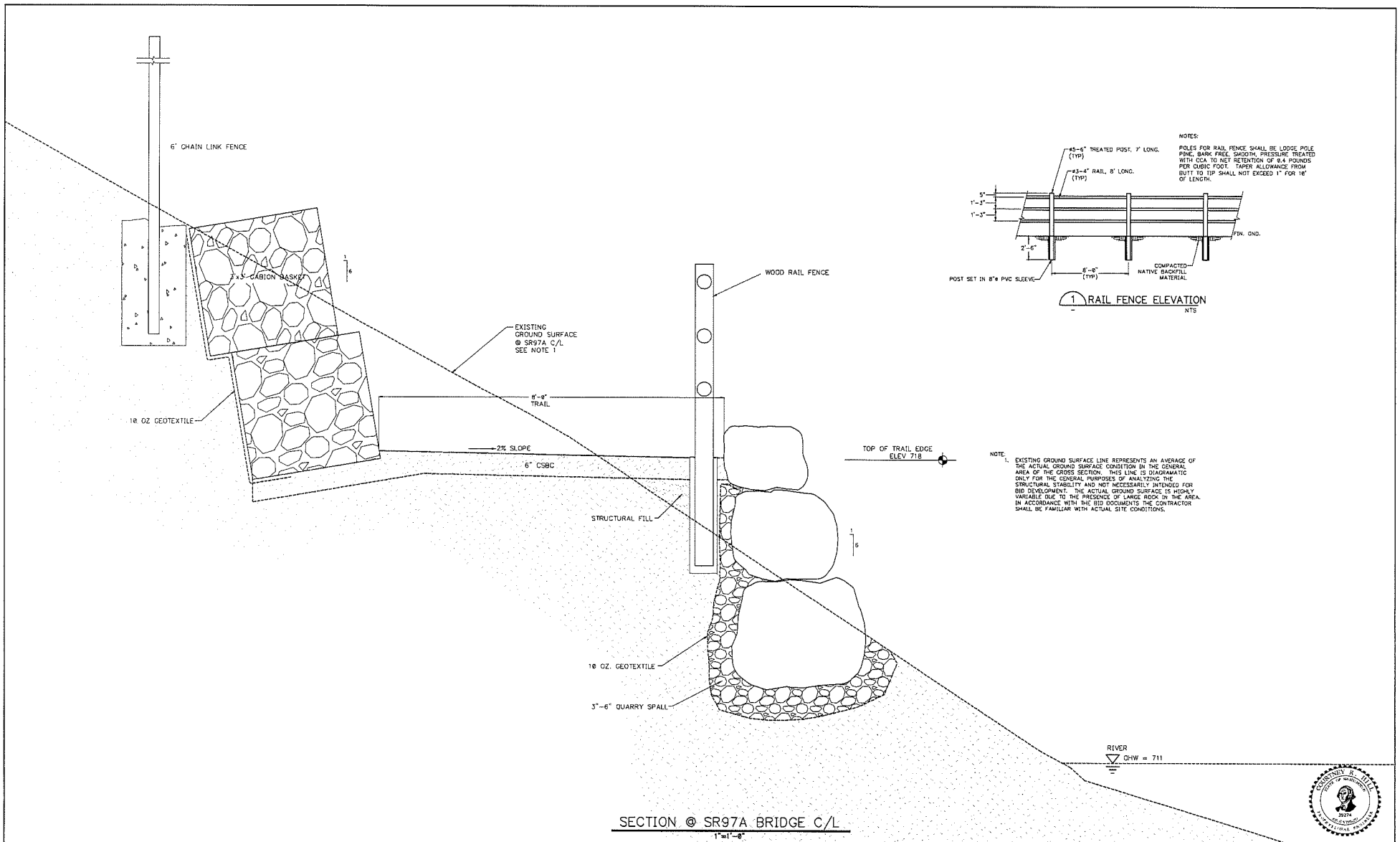
Seismic Increment



$0.5\gamma H[Kae(1-k_v)-Ka]$

Notes:
1. When calculating equivalent fluid weight, this spreadsheet assumes that the pressures and associated force E (active or passive) acts horizontally.
2. Active and Passive dynamic earth pressure coefficients are calculated using Mononobe-Okabe Method. At Rest dynamic earth pressure coefficient is calculated using Zhang et al. (1998) with R = 0.

STATION AT SR97A BRIDGE



SECTION @ SR97A BRIDGE C/L

1"=1'-0"

1 RAIL FENCE ELEVATION

NTS

NOTES:

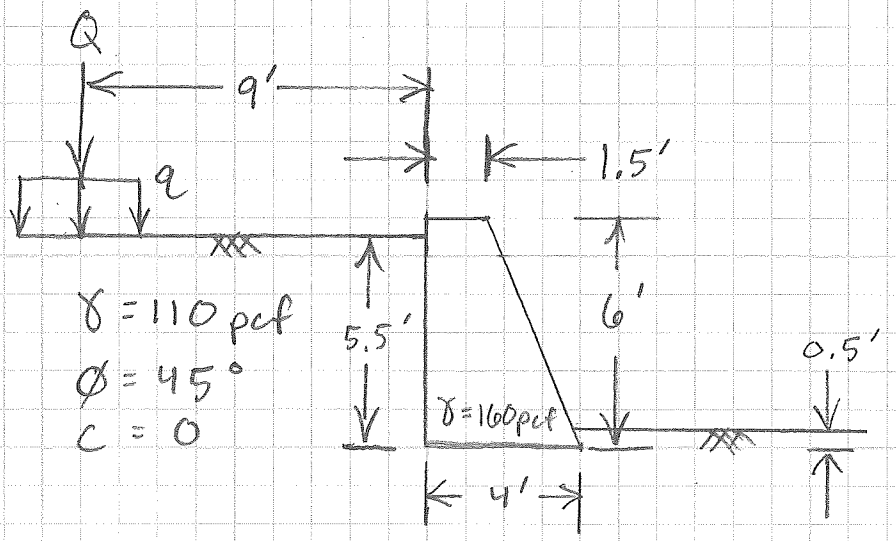
POLES FOR RAIL FENCE SHALL BE LODGE POLE PINE, BARK FREE, SMOOTH, PRESSURE TREATED WITH CCA TO NET RETENTION OF 0.4 POUNDS PER CUBIC FOOT. TAPER ALLOWANCE FROM BUTT TO TIP SHALL NOT EXCEED 1" FOR 18' OF LENGTH.

NOTE:

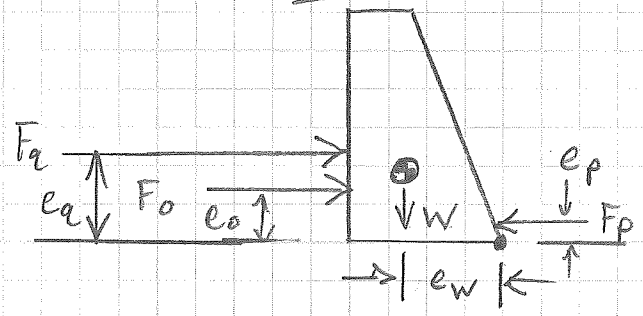
1. EXISTING GROUND SURFACE LINE REPRESENTS AN AVERAGE OF THE ACTUAL GROUND SURFACE CONDITION IN THE GENERAL AREA OF THE CROSS SECTION. THIS LINE IS DIAGRAMATIC ONLY FOR THE GENERAL PURPOSES OF ANALYZING THE STRUCTURAL STABILITY AND NOT NECESSARILY INTENDED FOR BID DEVELOPMENT. THE ACTUAL GROUND SURFACE IS HIGHLY VARIABLE DUE TO THE PRESENCE OF LARGE ROCK IN THE AREA. IN ACCORDANCE WITH THE BID DOCUMENTS THE CONTRACTOR SHALL BE FAMILIAR WITH ACTUAL SITE CONDITIONS.

CHELAN PUD NO.1	SCALE SEE DWG	BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			**PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY** WENATCHEE, WASHINGTON	*Entiat Park* ENTIATQUA TRAIL TYPICAL SECTION – AT SR97A BRIDGE C/L FIGURE 6
PRIM. ENG. C.HILL						SHEET 1 OF 1
2ND ENG.	Ø	10/27/2011	FEASIBILITY	CRH	TPD	REVISION Ø
PROJ. MGR.	REV	DATE	REVISION	REQ. BY	DRFT	DATE 10/27/2011
						DWG. 0911-50SK-0024

EXTERNAL STABILITY



FBD



SEISMIC LOAD CALCS:

$A = 0.1 \Rightarrow k_h = (1.45 - A)A = 0.135$

USING MONONOBE & OKABE $\Rightarrow \theta = \tan^{-1}(k_h) = 7.69$

$$K_{ae} = \frac{\cos^2(\phi - \theta)}{\cos\theta \cos(\phi_w + \theta)\left[1 + \sqrt{\frac{\sin(\phi+\phi_w)\sin(\phi-\theta)}{\cos(\phi_w+\theta)}}\right]^2}$$

ASSUME $\phi_w \approx 42°$

$$K_{ae} = \frac{\cos^2(45 - 7.69)}{\cos(7.69)\cos(42+7.69)\left[1 + \sqrt{\frac{\sin(45+42)\sin(45-7.69)}{\cos(42+7.69)}}\right]^2}$$

$= 0.25$

$K_p = \tan^2(45 + \phi/2) = \tan^2(45 + 45/2) = 5.83$

$F_o = \frac{1}{2} \gamma H^2 K_{a_e} = \frac{1}{2}(110)\,5.5^2\,(0.25) = 416$ lb/ft

$e_o = 1.83'$

$F_q = 597$ lb/ft
$e_q = 1.27'$
} SEE SPREADSHEET
LATERAL LOADS MODELED BY STRIPLOAD

$W = A\,\gamma_{wall} = 15.4\ ft^2\,(160\ pcf) = 2464$ lb/ft

$e_w = \dfrac{8.25(3.25) + 6.88(1.67)}{15.4} = 2.49'$

$F_p = \frac{1}{2} \gamma d_w^2 K_p = \frac{1}{2}(110)(0.5)^2\,5.83 = 80$ lb/ft

$e_p = 0.17'$

OVERTURNING:

$$\Sigma M_{RES.} = W e_w + F_p e_p = 2464\,(2.49) + 80\,(0.17)$$
$$= 6148 \text{ lb-ft/ft}$$

$$\Sigma M_{DRIV.} = F_o e_o + F_q e_q = 416\,(1.83) + 597\,(1.27)$$
$$= 1519 \text{ lb-ft/ft}$$

$$FS_{O.T} = \frac{6149}{1519} = 4.05 > 0.75\,(2) = 1.5 \quad \boxed{\text{SAFE}}$$

SLIDING:

USE MIN ϕ

$$\Sigma F_{RES} = W \tan(\phi) + F_p$$
$$= 2464 \tan(45) + 80 = 2544 \text{ lb/ft}$$

$$\Sigma F_{DRIV} = F_o + F_q = 416 + 597 = 1013 \text{ lb/ft}$$

$$FS_{SLIDING} = \frac{2544}{1013} = 2.51 > 0.7\,(1.5) = 1.05 \quad \boxed{\text{SAFE}}$$

BEARING CAPACITY:

$$e = \frac{\Sigma M_{DRIV}}{W} = \frac{1519}{2464} = 0.62 < \frac{B}{6} = 0.67 \;\checkmark$$

$$\therefore \sigma_{V_{max}} = \frac{W}{4}\left[1 + \frac{6(0.62)}{4}\right] = 1189 \text{ psf}$$

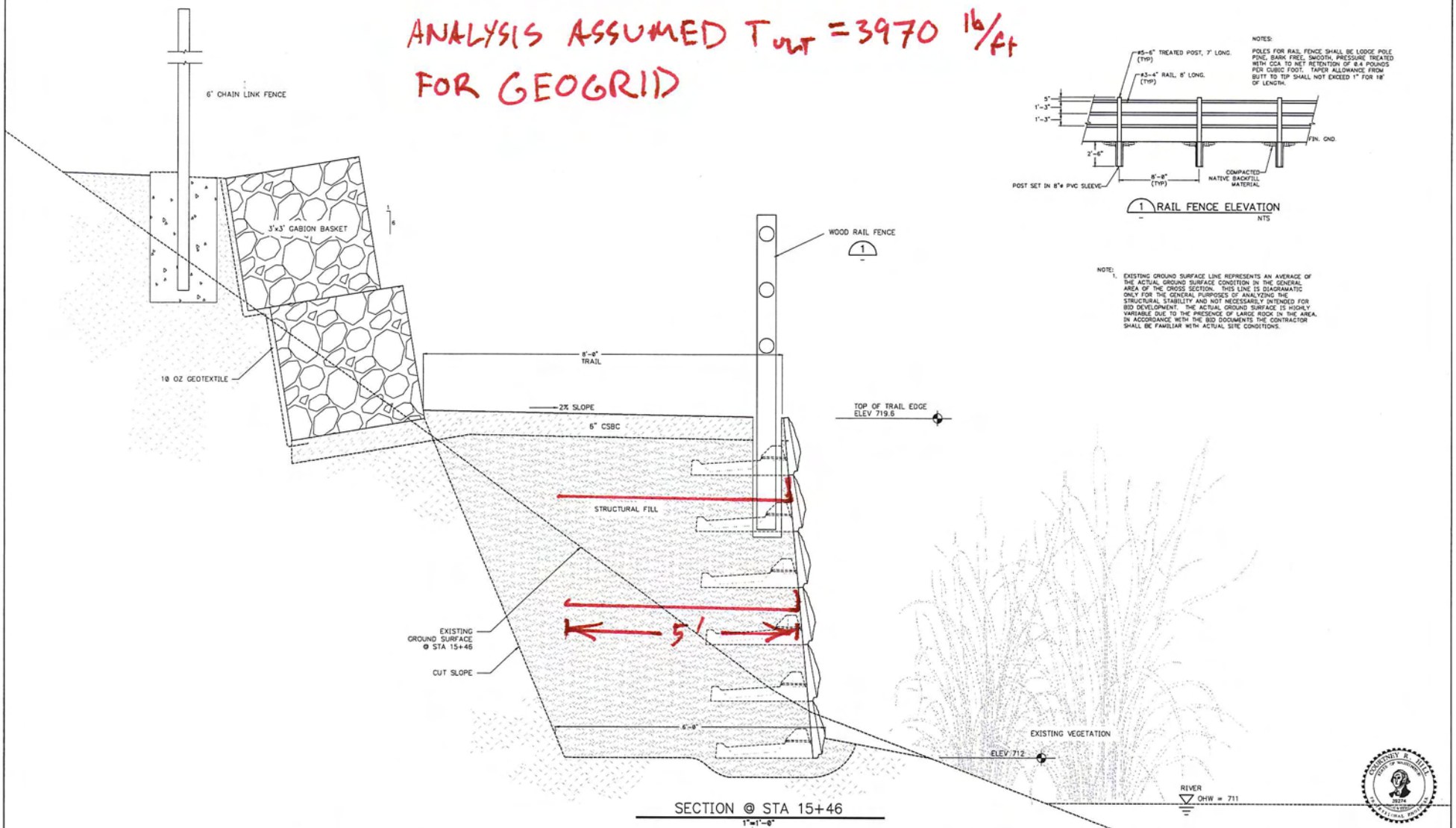
$$q_{ULT} = \frac{1}{2}(110)\,4\,(60) = 13200 \text{ psf}$$

(N_γ)

$$FS_{BEARING} = \frac{13200}{1189} = 11.1 >> 0.75\,(2) = 1.5 \quad \boxed{\text{SAFE}}$$

STATION 15+46

ANALYSIS ASSUMED T_{ult} = 3970 lb/ft FOR GEOGRID



SECTION @ STA 15+46
1"=1'-0"

NOTES:
POLES FOR RAIL FENCE SHALL BE LODGE POLE PINE, BARK FREE, SMOOTH, PRESSURE TREATED WITH CCA TO NET RETENTION OF 0.4 POUNDS PER CUBIC FOOT. TAPER ALLOWANCE FROM BUTT TO TIP SHALL NOT EXCEED 1" FOR 18' OF LENGTH.

1 RAIL FENCE ELEVATION
NTS

NOTE:
1. EXISTING GROUND SURFACE LINE REPRESENTS AN AVERAGE OF THE ACTUAL GROUND SURFACE CONDITION IN THE GENERAL AREA OF THE CROSS SECTION. THIS LINE IS DIAGRAMATIC ONLY FOR THE GENERAL PURPOSES OF ANALYZING THE STRUCTURAL STABILITY AND NOT NECESSARILY INTENDED FOR BID DEVELOPMENT. THE ACTUAL GROUND SURFACE IS HIGHLY VARIABLE DUE TO THE PRESENCE OF LARGE ROCK IN THE AREA. IN ACCORDANCE WITH THE BID DOCUMENTS THE CONTRACTOR SHALL BE FAMILIAR WITH ACTUAL SITE CONDITIONS.

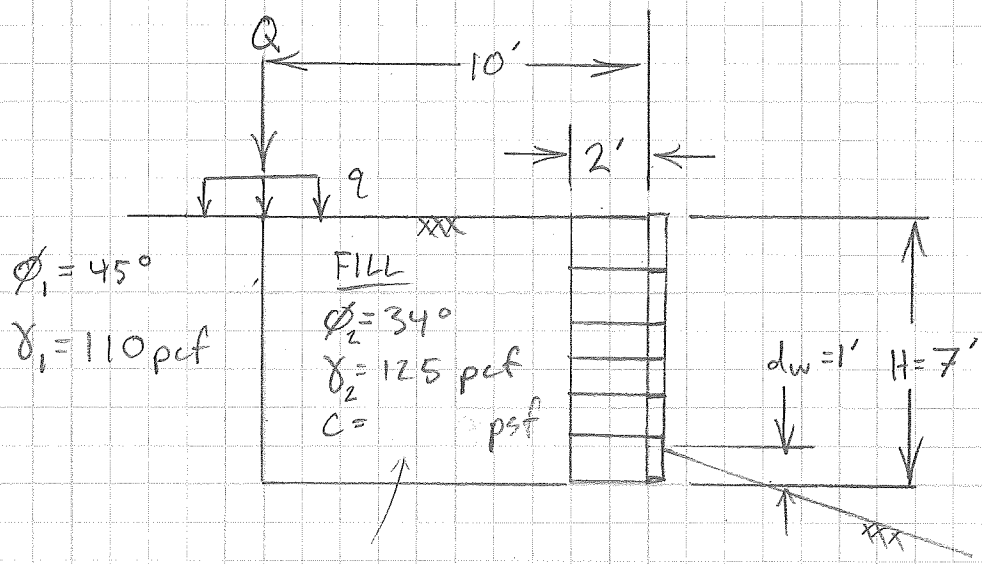
CHELAN PUD NO.1		SCALE SEE DWG		BAR IS ONE INCH ON ORIGINAL DRAWING. VERIFY SCALE 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.			
PRIM. ENG. C.HILL							
2ND ENG.	0	10/27/2011	FEASIBILITY		CRH	TPD	
PROJ. MGR.	REV	DATE	REVISION		REQ. BY	DRFT	

PUBLIC UTILITY DISTRICT NO. 1 OF CHELAN COUNTY
WENATCHEE, WASHINGTON

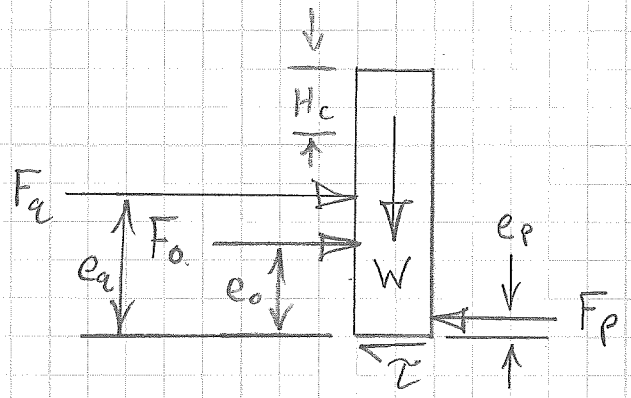
Entiat Park
ENTIATQUA TRAIL
TYPICAL SECTION – STEEP BEND
FIGURE 9

SHEET	1 OF 1
REVISION	0
DATE	10/27/2011
DWG.	0911-50SK-0022

STA 15+46 EXTERNAL STABILITY CALCS.



FBD



LOAD CALCS:

$K_a = \tan^2(45 - \phi_2/2) = \tan^2(45 - 34/2) = 0.28$ "FILL"

$K_p = \tan^2(45 + \phi_1/2) = \tan^2(45 + 45/2) = 5.83$ "NATIVE"

$H_c = \dfrac{2c}{\gamma_2 \sqrt{K_a}} = \dfrac{2(\quad \text{psf})}{125\sqrt{0.28}} =$

ASSUME $C = 0 \Rightarrow H_c = 0.0'$

$F_o = \dfrac{\gamma_2 H^2 K_a}{2} - 2cH\sqrt{K_a} + \dfrac{2c^2}{\gamma_2} = \frac{1}{2}(125\text{ pcf})7^2(0.28)$

$= 858$ lb/ft

$e_o = 2.3'$

$F_q = 792$ lb/ft
$e_q = 2.58'$
} SEE SPREADSHEET
ASSUMED $\gamma_{GABIONS} = 100$ pcf $\Rightarrow Q = 1800$ lbs

OVERTURNING:

$d_w = 1'$

$B = 2'$

$W = 60 \frac{lbs}{ft}(6) + 125\ pcf\,(7')2' = 2110$ lb/ft

$\Sigma M_{RES.} = W(B/2) + \frac{1}{2}\gamma_1 d_w^2 K_p e_p' =$

2110 lb/ft $\left(\frac{2'}{2}\right) + \frac{1}{2}(110\ pcf)(1')^2 5.83(0.33') = 2216$ lb-ft/ft

$\Sigma M_{O.T.} = F_o e_o + F_q e_q = 858(2.3) + 792(2.58) = 4017$ lb-ft/ft

$\Rightarrow FS_{O.T.} = \frac{\Sigma M_{RES.}}{\Sigma M_{O.T.}} = \frac{2216}{4017} = 0.55 < 2$ FAILS

CALC. B_{MIN}:

$\Sigma M_{RES.} = [\overbrace{360}^{W} + 875 B_{MIN}]\left(\frac{B_{MIN}}{2}\right) + 105.81$

$= 180 B_{MIN} + 437.5 B_{MIN}^2 + 105.81$

$FS_{O.T.} = \frac{437.5 B_{MIN}^2 + 180 B_{MIN} + 105.81}{4017} \geq 2$

$= 437.5 B_{MIN}^2 + 180 B_{MIN} - 7928.19 \geq 0$

$\Rightarrow B_{MIN} \geq 4'$

SLIDING:

USE MIN ϕ

$$\Sigma F_{RES.} = W \tan \phi_2 + F_p = 2110 \text{ lb/ft} \tan(34) + 105.81 = 1529 \text{ lb/ft}$$

$$\Sigma F_{DRIV.} = F_a + F_q = 858 + 792 = 1650 \text{ lb/ft}$$

$$FS_{SLIDING} = \frac{1529}{1650} = 0.93 < 1.5 \quad \text{FAILS}$$

CALC. B_{MIN}:

$$\Sigma F_{RES.} = [360 + 875 B_{MIN}] \tan(34) + 105.81 =$$
$$= 242.82 + 590.19 B_{MIN} + 105.81$$
$$= 348.63 + 590.19 B_{MIN}$$

$$FS_{SLIDING} = \frac{348.63 + 590.19 B_{MIN}}{1650} \geq 1.5$$

$$B_{MIN} \geq 3.6'$$

BEARING CAPACITY:

$$\sigma_v = \frac{W}{B - 2e} \qquad e = \frac{\Sigma M_{O.T.}}{W}$$

$$\Sigma M_{O.T.} = 4017 \text{ lb-ft/ft}$$

$$W = 2110 \text{ lb/ft}$$

$$e = \frac{4017}{2110} = 1.90 > \frac{B}{6} = 0.33 \therefore \text{TENSION @ BASE}$$

CALC. B SUCH THAT $e < B/6$:

$$e = \frac{4017}{360 + 875B} < \frac{1}{6} B$$

$$0 < 60B + 145.83B^2 - 4017$$

$$B = 5.1'$$

$e = 0.85$

$\sigma_v = \frac{W}{B-2e} = \frac{360 + 875(5.1)}{5.1 - 2(0.85)} = 1419 \text{ psf}$

$\phi_{SUBGRADE} = \phi_1 = 45^\circ \Rightarrow N_\gamma \approx 57$

$q_{ULT} = \frac{1}{2}(110 pcf)\,5.1(57) = 15989 \text{ psf}$

$FS_{BEARING} = \frac{q_{ULT}}{\sigma_v} = \frac{15989}{1419} = 11$ SAFE

FINAL NOTES:

LOAD DISTRIBUTION ALONG BASE CONTROLS B_{MIN} REQUIRED FOR SOUND DESIGN.

$B_{MIN} \geq 5'$

THIS IS CONSISTENT W/ FHWA RECOMMENDED REINF. LENGTHS OF $L = 0.7H$

$5' > 0.7(7) > 4.9'$

$FS_{O.T.}$, $FS_{SLIDING}$, $FS_{BEARING}$ USED IN ANALYSIS WERE MANUFACTURER RECS. (LOCK+LOAD).

TITLE PAGE
==========

PROJECT IDENTIFICATION: LOCK+LOAD with 2.5ft CF - No Geogrid -
Project Number:

Client:
Designer: Chelan County PUD No 1
Station Number: 15+46
Description: 3 Stones High (4 Ft.) 1:10 Std. Batter. No Backslope

Company's information:
Shannon & Wilson, Inc.
400 North 34th St.

Seattle, WA 98103
Telephone #:
Fax #:
E-Mail:

File path and name: C:\Documents and Settings\brc\Desktop\MSEW\Sta 15+46.BEN

Original date and time of creating this file: Tue Oct 28 09:42:49 2008
PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA
REINFORCED SOIL
Unit weight, gamma = 125.0 lb/ft ^{3}
Design value of internal angle of friction, phi = 34.0 °
RETAINED SOIL
Unit weight, gamma = 110.0 lb/ft ^{3}
Design value of internal angle of friction, phi = 45.0 °
FOUNDATION SOIL (Considered as an equivalent uniform soil)
Equivalent unit weight, gamma_equiv. = 110.0 lb/ft ^{3}
Equivalent internal angle of friction, phi_equiv. = 45.0 °
Equivalent cohesion, c_equiv. = 0.0 lb/ft ^{2}
Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS
Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ksii = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.1716 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)
BEARING CAPACITY
Bearing capacity coefficients (calculated by MSEW): Nc = 0.00
N_gamma = 56.50

SEISMICITY
Maximum ground acceleration coefficient, Alpha_o = 0.10
Kae (Alpha_o > 0) = 0.1988
Kae (Alpha_o = 0) = 0.1386
d Kae = 0.0602 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3970.0	4800.0	7810.0	9870.0	N/A
Durability reduction factor, RFd	1.0	1.0	1.0	1.0	N/A
Install.-damage reduc. fact., RFid	1.05	1.05	1.05	1.05	N/A
Creep reduction factor, RFc	2.60	2.60	2.60	2.60	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	N/A
Friction angle along geogrid-soil interface, ro	24.22	24.22	24.22	24.22	N/A
Pullout resistance factor, F*	0.7·tan(ph)	0.7·tan(ph)	0.7·tan(ph)	0.7·tan(ph)	N/A
Scale-effect correc. factor, alpha	0.8	0.8	0.8	0.8	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 2.50 ft. Horizontal distance to Center of Gravity of panel is 1.25 ft.
Average unit weight of panel is gamma_f = 135.00 lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	N/A
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	N/A
Overall safety factor: connec. break, Fs	N/A	N/A	N/A	N/A	N/A
Overall safety factor: connec.pullout,Fs	N/A	N/A	N/A	N/A	N/A
CRu = Tult-connection/Tult-geogrid	0.00	0.00	0.00	0.00	N/A

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 7.00 [ft] {Embedded depth is E = 1.00 ft, and height above top of finished bottom grade is H = 6.00 ft }
Batter, omega 5.8 [deg]
Backslope, beta 2.0 [deg]
Backslope rise 0.3 [ft] Broken back equiv. angle, I = 1.15° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Pv-d = 1800.0 and Pv-l = 0.0 [lb/ft].
Footing width, b=3.0 [ft]. Distance of center of footing from wall face, d = 10.0 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 7.56, Foundation Interface: Direct sliding, Fs = 5.754, Eccentricity, e/L = 0.0186.

GEOGRID			CONNECTION					
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [pullout resistance]	Fs-overall [connect. break]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccent. e/L
1	2.45	5.00	1	N/A	0.00	2.11	2.106	2.385	5.939	-0.0024

2	5.05	5.00	1	N/A	0.00	7.40	7.402	2.675	13.243	-0.0122

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.26, Foundation Interface: Direct sliding, Fs = 2.936, Eccentricity, e/L = 0.0984.

GEOGRID				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [pullout resistance]	Fs-overall [connect. break]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccent. e/L
1	2.45	5.00	1	N/A	0.00	1.99	1.989	1.655	3.069	0.0303
2	5.05	5.00	1	N/A	0.00	6.45	6.449	1.546	7.161	-0.0064

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
Ultimate bearing capacity, q-ult	6466	5393	[lb/ft ²]
Meyerhof stress, sigma_v	855.0	1025.7	[lb/ft ²]
Eccentricity, e	0.09	0.49	[ft]
Eccentricity, e/L	0.019	0.099	
Fs calculated	7.56	5.26	
Base length	5.00	5.00	[ft]

DIRECT SLIDING for GIVEN LAYOUT

Along reinforced and foundation soils interface: Fs-static = 5.754 and Fs-seismic = 2.936

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid type #
1	2.45	5.00	5.939	3.069	1
2	5.05	5.00	13.243	7.161	1

ECCENTRICITY for GIVEN LAYOUT

Along reinforced and foundation soils interface: e/L static = 0.0186 and e/L

seismic = 0.0984

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e/L Static	e/L Seismic	Geogrid type #
1	2.45	5.00	-0.0024	0.0303	1
2	5.05	5.00	-0.0122	-0.0064	1

RESULTS for STRENGTH

#	Geogrid Elevation [ft]	Tavilable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic
1	2.45	1454	690.52	105.39	N/A	2.106	N/A	1.989
2	5.05	1454	196.46	75.46	N/A	7.402	N/A	6.449

RESULTS for CONNECTION (static conditions)

#	Geogrid Elevat. [ft]	Connect. force, To connec break, [lb/ft]	Reduc. factor for connec pull. CRu	Reduc. factor connec strength, Tc-break criterion CRs	Available connect. strength, Tc-pull. criterion [lb/ft]	Available connect. strength, Tavail. [lb/ft]	Available Geogrid strength, Spec.Actu. [lb/ft]	Fs-overall connection break Spec.Actu.	Fs-overall connection pullout Spec.Actu.	Fs-overall Geogrid strength
1	2.45	691	0.00	N/A	0	N/A	1454	N/A	0.00	N/A	N/A	N/A	2.11
2	5.05	196	0.00	N/A	0	N/A	1454	N/A	0.00	N/A	N/A	N/A	7.40

RESULTS for CONNECTION (seismic conditions)

# Geogrid	Connect. Elevat. To [ft]	Reduc. force, for connec break, [lb/ft]	Reduc. factor for connec pull. CRu	Reduc. factor connec CRs	Available connect. strength, Tc-break criterion [lb/ft]	Available connect. strength, Tc-pull. criterion [lb/ft]	Available Geogrid strength, Tavail. [lb/ft]	Fs-overall connection break Spec.Actu.	Fs-overall connection pullout Spec.Actu.	Fs-overall Geogrid strength Spec.Actu.
1	2.45	796	0.00	N/A	0	N/A	1454	N/A	0.00	N/A	N/A	N/A	1.99
2	5.05	272	0.00	N/A	0	N/A	1454	N/A	0.00	N/A	N/A	N/A	6.45

RESULTS for PULLOUT

# Geogrid	Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail. Static Pullout Pr [lb/ft]	Specif. Static Fs	Actual Static Fs	Avail. Seismic Pullout Pr [lb/ft]	Specif. Seismic Fs	Actual Seismic Fs
1	2.45	1.000	691	105	3.94	1.06	1646.6	N/A	2.385	1317.2	N/A	1.655
2	5.05	1.000	196	75	2.82	2.18	525.6	N/A	2.675	420.5	N/A	1.546

APPENDIX B

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-21501-003

Date: December 6, 2011
To: Mr. Courtney Hill, P.E.
Public Utility District No. 1 of Chelan County

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

APPENDIX D – CONSULTATION

Pre-Permitting Consultation

APPENDIX D - CONSULTATION

- **The following documents the pre-permitting discussions to determine whether or not the trail could be permitted:**

NOAA Fisheries Service

Date: September 26, 2011
Location: Chelan County PUD Offices and Entiatqua Trail Site
Present: Waikele Frantz (CCPUD), Steve Hays (CCPUD), Casey Hall (CCPUD), Courtney Hill (CCPUD), Justin Yeager (NOAA Fisheries)

NOAA Fisheries Comments:

- Construction of new riparian habitat is not sufficient mitigation for the loss of aquatic habitat resulting from in-water fill along the shoreline.
- Shallow water habitat exists from Station 6+00 to Sta. 9+25 (Columbia River) and as such shoreline stabilization techniques (ie. in-water fill) may be more difficult to permit. Fish friendly stabilization techniques will need to be used.
- Filling below ordinary high water of the Entiat River is not likely to be permitted unless the loss of aquatic habitat can be mitigated to the satisfaction of NOAA Fisheries.

CCPUD Response:

- Stabilization techniques will include fish friendly habitat.
- Trail design will evaluate methods to avoid fill in the Entiat River.

……..

Date: October 25, 2011
Location: Telephone Conference Call between Wenatchee, WA and Ellensburg, WA
Present: Courtney Hill (CCPUD), Waikele Frantz (CCPUD), Casey Hall (CCPUD) and Justin Yeager (CCPUD)

NOAA Fisheries Comments:

- Use of large rounded cobble and wood logs is a move in the right direction; however the logs need more complexity to be fish friendly.
- Additional detail is required before support can be given regarding the ability to permit the trail.

CCPUD Response:

- We will add more complexity and provide additional drawings to show more detail.

……..

Date: November 21, 2011
E-mail Communication from Justin Yeager to Courtney Hill

NOAA Fisheries Comments:

- From Justin Yeager: “Even though, your design for the Entiat River side of the trail does not need in-water work permits, the agencies would still consider it an interrelated activity and would be looking at that piece as part of this action. So I would encourage you to include that section in any pre-review we do.”

CCPUD Response:

- Courtney Hill transmitted the applicable design drawings to Justin Yeager in a reply e-mail. Courtney then followed-up with a phone conversation with Justin to clarify further the revised drawings and Justin appreciated the pre-review. He said that including this section of the trail will be helpful as the permitting agencies go through the final permitting process.

Washington State Department of Fish & Wildlife (WDF&W)
Date: November 22, 2011
Location: Entiatqua Trail Site
Present: Courtney Hill (CCPUD), Waikele Frantz (CCPUD), Ray Heit (CCPUD), Graham Simon (WDFW) and Patrick Verhey (WDFW)

The meeting was informational in nature and WDFW appreciated the opportunity to view the project and did not see any issues at this time.

- **Two organizations important to the success of this project are the Cascade and Columbia Railroad and the Washington State Department of Transportation. The following documents discussions with both of these organizations.**

Cascade and Columbia Railroad (C&C RR)
Chelan County PUD has acquired the necessary land rights and easements to permit construction of the trail along and below the Cascade and Columbia Railroad.

On August 24 contact was made by Chelan PUD’s real estate department to the railroad regarding the easement that Chelan PUD purchased in anticipation of construction of this trail. In addition, the General Site Assessment and the Conceptual Design (Appendix C) were sent to the railroad for comment. The following summarizes their response to these documents.

Date: August 25, 20ll
E-mail Correspondence from Larry Romaine (C&C RR) via Buck Workman (C&C RR) to Steve Vaughn (CCPUD)

C&C RR Comments:
“This request has my approval.”

(a summary of the e-mail string leading up to this response is below)

CCPUD Response: None

From: Workman, Buck (GPRK) [mailto:Buck.Workman@RailAmerica.com]
Sent: Thursday, August 25, 2011 8:45 AM
To: Vaughn, Steve
Cc: Hill, Courtney
Subject: FW: Entiat Trail

Steve---see below response from Larry Romaine.
Buck

From: Romaine, Larry (GPRK)
Sent: Thursday, August 25, 2011 8:37 AM
To: Bader, Marc (RA West); Riehl, Bill (RA.GPRK)
Cc: Workman, Buck (GPRK)
Subject: RE: Entiat Trail

This request has my approval.

Larry Romaine
AVP - Engineering Services
Office: 904-538-6054
Fax: 904-394-1730
Cell: 904-307-4388
e-mail: Larry.Romaine@railamerica.com

RailAmerica, Inc.

From: Workman, Buck (GPRK)
Sent: Wednesday, August 24, 2011 12:20 PM
To: Bader, Marc (RA West)
Subject: FW: Entiat Trail

Marc—See below and attached……let me know if you have concerns.
Thanks,
Buck

From: Vaughn, Steve [mailto:Steve.Vaughn@chelanpud.org]
Sent: Wednesday, August 24, 2011 12:32 PM
To: Workman, Buck (GPRK)
Cc: Hill, Courtney
Subject: Entiat Trail

Buck,
Greetings,

I've attached some additional information regarding the Entiat trail location crossing under the railroad. Court Hill our engineer thought you may want to review.

As you know this portion of the trail crosses under the railroad at an easement point purchased by the PUD. The Federal Energy Regulatory Commission (FERC) asked that we get any comments you might have concerning this project.

We would like to have any comments you may have on this by the end of August for our report back to FERC.

Thanks for your time. Steve

Washington State Department of Transportation (WSDOT)

Date: February 18, 2010
Present: Courtney Hill (CCPUD), Waikele Hampton (CCPUD), Ray Heit (CCPUD), Bob Whitehall (Entiat City), Tim Larson (CCPUD), Kris Pomianek (CCPUD), Claton Belmont (WSDOT), Mosstafa Sadia (WSDOT), Dan Lewis (WSDOT)

The meeting was informational in nature. No specific comments were provided

……

Date: May 17, 2011
Present: Courtney Hill (CCPUD), Tim Larson (CCPUD), Chad Rissman (WSDOT), Dan Lewis (CCPUD), Frank Sblendorio (WSDOT), Mitch Reister (WSDOT), Dave Bierschbach (WSDOT) and Kirk Berg (WSDOT)

WSDOT Comments:

- Frank Sblendorio (WSDOT) – My review indicates the project will not require extensive permitting from WSDOT but rather only a simple general permit.

CCPUD Comments:

- Chelan County PUD will make application for the general permit.

……

Date: September 22, 2011
E-mail Correspondence from Dan Lewis (WSDOT) to Courtney Hill (CCPUD)

WSDOT Comments:

- This project is in the city limits so anything outside the pavement edge/curb is city responsibility unless it could impact our facilities. A permit would not be required from WSDOT for the trail unless it actually impacts WSDOT's facility in some way.
- Looking at the Geotechnical Report that Shannon & Wilson completed for the Chelan County PUD, the area under the bridge will be a combination of permanent cut slopes and unreinforced fill slopes (Sta. 9+00 to 10+50). The report states that a permanent cut slope is either a 1.5:1 slope and/or a 4 feet vertical cut with ecology blocks at 1:8. This permanent cut slope has the potential to impact the bridge foundation however the report does not show any calculations or cross sections showing the cut slope under the bridge relative to the spread footing.
- Another area recommends reinforced soil slopes/walls (Sta. 2+00 to 9+00 and Sta. 12+50 to 15+50). The report states that this is a type of MSE wall/slope where the excavation would be 50 to 70 percent of the wall height for the geogrid. We have no cross sections showing the highway relative to this cut.

Shoring might have to be reviewed by us during construction if it is close to our highway.

- Specific design calculations and cross section/site plan are needed showing our highway facilities (elevations, horizontal and vertical distances, etc). This will need to be sent to HQ Geotech once we have a charge number for HQ to review and more information.

CCPUD Response:

- We agree that a permit will be required with the City of Entiat for portions of the trail outside WSDOT responsibility.
- Additional drawing details and calculations will be provided as part of the design and WSDOT permit approval process.

Date: December 14, 2011
Phone conversation with Bill Gould, WSDOT local Wenatchee office with Courtney Hill (CCPUD)

The following represents documentation of consultation with WSDOT via phone conversation.

Bill Gould with the WSDOT local Wenatchee office called me as a follow up to our recent e-mail exchange with Dan Lewis. As you know Bill has replaced Dan as the primary contact from WSDOT on the Entiatqua Trail project. I explained to Bill that we are moving from the feasibility phase to design phase and would like to start the General Permit process. He understood and indicated he would e-mail me the necessary paperwork to get started (reimbursable cost form).

Bill also brought up the need for ADA compliance. I told him that we had discussed this need at earlier meetings and it was not clear as to what ADA standard or guideline was applicable to this project. I did mention we had determined that the FHWA guideline was not applicable or feasible based on the site conditions (steep shoulder adjacent to the river). He indicated he was not the right person and would need someone else from WSDOT to provide insight. He did ask if there were federal dollars being spent and I indicated there were not. I also told Bill the environmental permits constrain us on the amount of in-water fill we can place and therefore the width of the trail. He seemed to understand.

Bill was also aware that we would need a right-of-way easement for the portion of the trail within the City (where SR97A is inside city jurisdiction). Bill indicated city's often ask DOT to review work of this nature. He wanted to know if the city was taken care of or if they needed to be involved in that review process. I told him I would inquire.

After today Bill will be out of the office for the remainder of the year. I told him I would be sending him a packet (Shannon and Wilson Geo-tech Report and preliminary design drawings) with additional information for DOT review.

Forum Consultation

The following e-mail was sent Thu 12/1/2011 2:22 PM to the Rocky Reach Recreation Forum including Rail American and Washington State Department of Transportation:

Alcoa	***Bob Huber***
Bureau of Land Management	***Diane Priebe*** ***Karen Kelleher***
City of Entiat	***Keith Vradenburg*** ***Bob Whitehall***
Department of Ecology	***Pat Irle***
Entiat School District	***Mike Wyant***
National Parks Service	***Susan Rosebrough***
Puget Sound Energy	***Ken Finicle***
Rail America	***Buck Workman***
Recreation and Conservation Office	***Steve McLellan***
US Fish and Wildlife Service	***Steve Lewis***
Washington Department of Fish and Wildlife	***Patrick Verhey***
Washington State Department of Transportation	***Dan Lewis***
Washington State Parks	***Jim Harris*** ***Bill Fraser***

Good afternoon everyone!

I am attaching for your review the draft feasibility study that we will be sending to FERC for approval on the Entiatqua Trail that is proposed to be built from the south end of Entiat Park under both the railroad and highway bridges to an area called the Entiatqua Learning Center near the mouth of the Entiat River.

In the past few months, I have sent you information on this trail and have appreciated your input. With your input and further discussion with permitting agencies, DOT and the railroad, we have made some adjustments to the original plan and would ask you once again to take a look and provide your comments.

You will notice at the end of the report that there are appendices listed. As each one is a large document and a summary of each is in the study, I have not included them with this e-mail but am happy to provide them to you upon request. Those appendices are, the FERC order, preliminary design drawings, geo-technical analysis and consultation details.

I am hopeful to send this feasibility study to FERC before the end of the year, so an early response would be greatly appreciated. As always, if you have any questions, do not hesitate to call or e-mail me.

Thank you for your help and my best to you for save and happy holidays!

Kris

Kris Pomianek
Recreation Resource Advisor
Chelan County PUD
P.O. Box 1231
Wenatchee, WA 98807-1231
509-661-4186 work
509-679-0813 cellular
kris.pomianek@chelanpud.org

Follow-up e-mail sent Mon 12/12/2011 9:16 AM

Good morning everyone -

I am e-mailing today with a friendly reminder for any input that you might have to the attached draft Feasibility Study that was conducted on the Entiatqua Trail in Entiat.

I am hoping to send this study to FERC for approval by the end of the year, so I would appreciate hearing back from you at your earliest convenience. I know that you have had a chance to evaluate this project twice before as we were moving through the study development and your comments from those responses will be included in the final report sent to FERC.

This study includes modifications to the trail to reflect the changes suggested by permitting agencies and we are pleased that we were able to come up with a reasonable solution to the challenges that this trail originally posed. If you could take one last look at this final draft and provide comment, it would be great appreciated and if you would like copies of the attachments, please let me know and I will get those to you as well. If I do not hear back from you, I will accept your concurrence.

Thank you very much for your help and once again, may you enjoy safe and happy holidays!

Kris

Kris Pomianek
Recreation Resource Advisor
Chelan County PUD
P.O. Box 1231
Wenatchee, WA 98807-1231
509-661-4186 work
509-679-0813 cellular
kris.pomianek@chelanpud.org

Date	Agency	Comment	Response
December 19	Pat Irle Department of Ecology	Below is the response I got from one of our construction storm water people. If you need more information, you could call him. "I would recommend that they get the Construction Stormwater General Permit due to the proximity of the project to the water, and then potential length of time it would take to grow vegetation on the areas disturbed and not covered by hardened surface. Thanks Bryan Neet (ECY)." Also, I was just wondering if you have talked to the wildlife people about the bighorn that might try to cross the highway due to the presence of accessible water.	Thank you Pat for your comments - First, we do have plans to apply for a Construction Stormwater General Permit. We'll be doing that about the same time we submit construction documents to FERC. Second, we do not see any issues with the bighorn sheep and their ability to access water. Aside from a trail being there, there will be no difference in water accessibility. Again, thank you for your comments. Kris
December 13	Bob Huber Alcoa	Looks like a good alternative. Suggest you install non-reflective chain link (black) for aesthetics	Bob – good call – I will pass that along to our final design folks – I appreciate you getting back to me - Kris
December 2	Jim Harris Washington State Parks	State Parks has no comments at this time. We continue to support the project. Thanks, Jim	Thank you, Jim - Kris

On August 17, 2011 the following e-mail was sent out to the Karen Kelleher of the Bureau of Land Management, Jim Harris of Washington State Parks and Susan Rosebrough of the National Parks Service.

After the e-mail was sent out, it was determined that additional time was needed to complete the environmental evaluation and consultation with the agencies.

As a result, a time extension until December 31, 2011 was requested on September 14, 2011.

From: Pomianek, Kris
Sent: Wednesday, August 17, 2011 9:56 AM
To: Karen Kelleher; Harris, Jim; Susan Rosebrough
Cc: Heit, Ray; Smith, Michelle; Sokolowski, Rosana; Bitterman, Deborah; Hill, Courtney
Subject: Entiatqua Trail
Attachments: Typical Section expanded 7-23-11.pdf; Typical Section in detail 7-23-11.pdf; EntiatquaTrail_Permit.pdf

Good morning -

In October, 2010, FERC approved the Recreation Resources Management Plan for the Rocky Reach Reservoir. You may remember that in the plan a trail is proposed in Entiat called the Entiatqua Trail. The trail would extend from the south end of the park, under the railroad and under the highway to an outdoor learning center along the Entiat River that the City of Entiat will be building in the near future.

At the time of submitting the recreation plan, it was not clear whether we would be able to build the trail as proposed. Additional discussions needed to occur with DOT, the railroad, WDFW and the City of Entiat. In addition, an engineering study needed to be done to determine the feasibility of actually building the trail. In the order from FERC, they asked us to complete that consultation and feasibility

within one year and submit it to them along with conceptual drawings, cost estimates and an implementation schedule.

All of that work is now finished and it has been determined that the trail can be built, and will be complete by Spring, 2014 (pending permits), at the cost proposed in the settlement agreement, $1.2 million (2005$).

The last piece necessary before submitting to FERC, is consultation with you. Please take a moment to view the attachments and provide me with your feedback by September 17 and if you have any questions or concerns, do not hesitate to e-mail me or give me a call.

Thank you for your help on this important component of the recreation plan.

Kris

Kris Pomianek
Recreation Resource Advisor
Chelan County PUD
P.O. Box 1231
Wenatchee, WA 98807-1231
509-661-4186 work
509-679-0813 cellular
kris.pomianek@chelanpud.org

Date	Agency	Comment	Response
August 23	Jim Harris Washington State Parks	Washington State Parks is supportive of the progress being made on this initiative. The Agency continues to support the concept and are happy that the feasibility work has been able to locate a route that meets adjacent landowner needs and preliminary environmental design considerations.	Thank you very much for your input, Jim - I am going to be sure and consult with Court on your suggestions. Your comment that the public's recreation facilities are not disposable or temporary is an important thing to remember - I will keep you posted as we move along – Kris

		I have the same concern for this project, as with most current "fish friendly" designs, as shown in the typical section detail. This shoreline bio-engineering works well for low and moderate river flow levels. They are based on the geo- physics of a meandering stream. During high velocity flows, the meandering stream removes portions of riparian areas and hence the name "meandering". In the design presented, when flow rates wash out the soil bags or overtop them and scour out the topsoil behind the bio-engineered shoreline, the anchor rocks become your only facility protection, if undermined, serious facility damage occurs. The publics recreation facilities are not disposable or temporary in value. I would suggest that all recreation developers and managers strongly urge environmental regulators to allow a coarse fractured rock layer 1'- 2' below the topsoil surface, between the anchor rock and the large shoreline rock. This provides riparian growth, with the shade needed to prevent water temperature increases and other	Comments from lead engineer, Courtney Hill: Jim's comments were directed at the environmental permitting agencies. He knows and understands the constraints we have to work with. As an owner's representative of shoreline habitat Jim has observed what type of stabilization techniques work best in the long run (more rock less soil). I don't think his comments are necessarily site specific as much as they are a broad generalization . . . permitting robust shoreline stabilization is a statewide challenge. It's a good comment and will be important to our meetings with NOAA fisheries.

		positive functions of a riparian area, but during high flows, if the riparian is stripped away, there remains a second, stronger protective barrier, prior to damage to built facilities. Congratulations on the progress and good luck on permitting, Jim Harris, Eastern Region Director Washington State Parks and Recreation Commission.	
August 17	Susan Rosebrough National Parks Service	Thanks Kris, Nice to see that this is getting so close to being implemented! Thanks for all your work on this.	Thank you for your comments, Susan! Kris
August 17	Karen Kelleher Bureau of Land Management	No comment	Karen was contacted by phone.