City of Brookings
Curry County, Oregon

FERRY CREEK FEASIBILITY STUDY 2018

JUNE 2018

DRAFT

The Dyer Partnership
Engineers & Planners, Inc.

Project No. 145.80

1330 Teakwood Avenue
Coos Bay, Oregon 97420
(541) 269-0732
www.dyerpart.com

759 West Central Avenue
Sutherlin, Oregon 97479
(541) 459-4619

1165 South Park Street
Lebanon, Oregon 97355
(541) 405-4520

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INTRODUCTION

SECTION 1: **INTRODUCTION**

1.1 Background and Need

The City of Brookings, which is situated just north of the Oregon-Californian border, acquired their water system from the Brookings Water Co. in the 1970's. At that time, the primary source of raw water was the Ferry Creek Reservoir. The first addition the City made to the existing infrastructure was a new intake (Tide Rock Intake) located on the Chetco River. Once the intake was constructed the City no longer drew water from the Ferry Creek Reservoir. The new intake was located near the mouth of the Chetco River, and as time progressed salt intrusion began to pose a threat to the quality of the raw water. As concerns related to saltwater intrusion mounted, the City decided to relocate the intake further upstream. The new intake has a Rainney Collector configuration.

In recent years saltwater has begun moving further up the Chetco River. In 2014 Harbor Water District (HWD) raw water intake, which is just two miles downstream of the Rainney Collector, could not withdraw raw water from the river as it contained salt. As a result, bottled water was necessary to meet the potable water needs of the residents. In an attempt to avoid finding their residents in the same situation, the City of Brookings started looking for a source of water to serve the residents in the event that water cannot be withdrawn from the Rainney Collector intake. The Ferry Creek Reservoir was seen as a viable option as it had served the residents of the City of Brookings in past years.

Before the City could begin to develop plans for the reservoir they had to assess the condition of the Ferry Creek Dam. In 2015 and 2016, the Dam Safety Division of the Oregon Water Resource Department (OWRD) completed an inspection summary of Ferry Creek Dam. These reports can be found in Appendix A. In those reports the OWRD designated the dam as 'unsatisfactory condition'. If the condition of the dam is not addressed, the dam could be designated as 'unsafe', and would no longer be a viable option as an additional water source. This designation states that the dam could fail under extreme load or operating conditions potentially resulting in loss of life or personal injury.

Aware of both the need for a redundant water supply and the rehabilitation/or removal of the Ferry Creek Dam, the City has been evaluating alternatives that would address the known issues. In 2015 a study which examined redundant water supply alternatives determined that rehabilitation of the Ferry Creek Dam was the most cost effective way of providing the City with a redundant water supply. In 2016 the City developed a preliminary geotechnical report which examined the soils within the dam structure. These referenced documents are cited in the next section of the study.

In 2017 the City decided to further examine the feasibility of the recommended redundant water supply improvement knowing this could address both the need for a redundant supply, and the risk associated with the current condition of Ferry Creek Dam. The City was also interested in the feasibility of dam removal in the event that a cost of using the reservoir as a redundant supply was prohibitive.

In July of 2017 the City received a grant from the Water Conservation, Reuse and Storage Grant (Grant GA-0125-17) administered by the Oregon Water Resources Department, for the development of this feasibility study.

1.2 Description

In general, the feasibility study was prepared to identify deficiencies or challenges that would prevent implementation of various improvement alternatives and to more clearly define the benefits and costs associated with implementation and long-term operation of these alternatives. This document will build upon the information already gathered in previous studies, and incorporate additional geotechnical evaluations. The following includes a brief description of the scope of work.

1.3 Scope of Work

The scope of work approved by Oregon Water Resources Department for development of this feasibility study included the following tasks:

Task I – Literature Review

A literature review of all pertinent work by others to date will be reviewed. We anticipate this will primarily include geotechnical reports, dam inspection reports, geologic maps including geologic hazard maps and Lidar imagery.

Task 2 – Site Reconnaissance and Geologic Study

Jim Maitland, P.E., G.E. and Brooke Running, C.E.G. will visit the site with Keith Mills, P.E., G.E., the State Engineer for the Oregon Dam Safety Program, to evaluate the feasibility of repairing the existing dam, and to review potential locations for a new dam.

At that time, a site reconnaissance will be completed to evaluate the site and slope surface features. Based on the literature review, questionable areas or features will be investigated. Any slope features such as concentrated erosion, drainages, headwalls, or other evidence of slope instability will be mapped. Geologic contacts or other features will also be mapped.

Task 3 – Project Meetings

Project meetings will be required with the design team and the City as required to discuss the existing data and the results of the site reconnaissance and geologic study. The meetings will serve as a chance to develop recommendations on the feasibility of keeping the existing dam or to move forward with selecting a location for the new structure. Dyer expects this task will involve two project meetings in Coos Bay and one conference call.

Task 4 – Develop Alternative Locations

Based on Tasks 1 and 2, alternative locations will be proposed in consultation with the design team. Consideration will be given to the site geology, topography and orientation of the proposed alignment.

Task 5 – Develop Conceptual Cross-Sections

Up to three conceptual cross-sections will be developed based on Task 4. The cross-sections will include an interpretation of the existing geology/subsurface conditions beneath the proposed dam alignment based on existing information and proposed materials for the new dam.

Task 6 – Environmental Considerations

Review and outline the necessary environmental considerations that are needed to address removing the existing dam and also for the removal and replacement of the existing dam.

Task 7 – Feasibility Study

Information from the previous tasks will be summarized in the feasibility study. We anticipate the report will include existing subsurface data by others, a discussion of the site geology and topography including geologic and seismic hazards, environmental considerations for the necessary improvements and proposed alternative locations and cross sections. Develop preliminary cost estimates for each of the options.

Task 8 – OAR 690-600-0050 (2) Planning Study Criteria

This task identified planning study criteria additional obligations as required by OAR 690-600-0050(2).

a. Analyses of bypass, optimum peak, flushing and other ecological flows of the affected stream and the impact of the storage project on those flows;

b. Comparative analyses of alternative means of supplying water, including but not limited to the costs and benefits of conservation and efficiency alternatives and the extent to which long-term water supply needs may be met using those alternatives;

c. Analyses of environmental harm or impacts from the proposed storage project;

d. Evaluation of the need for and feasibility of using stored water to augment in-stream flows to conserve, maintain and enhance aquatic life, fish life and any other ecological values; and

e. In addition, if the storage project is for municipal use, the grant agreement will require an analysis of local and regional water demand and the proposed storage project's relationship to existing and planned water supply projects.

SECTION 2:

BACKGROUND INFORMATION

SECTION 2: **BACKGROUND INFORMATION**

2.1 Project Planning Area

The primary focus of this study will be Ferry Creek Reservoir and the associated dam structure. However, the impact to the water systems within the City of Brookings and along the Chetco River will also be examined. The Ferry Creek Dam is located on Ferry Creek in the Chetco River watershed, in Township 40S Range 13W Section 32 of Curry County near Brookings, Oregon.

The City of Brookings, Oregon is situated at the mouth of the Chetco River where it enters the Pacific Ocean in Southwestern Oregon, Curry County, just six miles north from the border with California and 26 miles south of Gold Beach, Oregon. Highway 101 bisects the town. The City of Brookings is surrounded on the north by forested hills with a number of drainages. Included in the Urban Growth Boundary (UGB) of Brookings is the unincorporated community of Harbor, which was not included in this study. A location map is shown in Figure 2.3.1.

2.2 Previous Studies

In the development of this study all prior planning documents related to the scope of this project were reviewed. This documentation was used to attain a better understanding of the current problems at the Ferry Creek Reservoir, and to present improvement alternatives that are either new, or further vetted. The previous planning documents are listed below:

1. *City of Brookings Water System Master Plan Update,* ***April 2014, PACE***
2. *Final Report on Feasibility Study for Restoration of Ferry Creek Reservoir Brookings, Oregon,* ***May 30, 1997, Dames & Moore***
3. *City of Brookings, 18" C905 PVC Raw Water Line on North Bank Chetco Co. Road,* Record Drawings, ***January 2007, HGE Project No. 06.101***
4. *City of Brookings Redundant Water Supply Plan,* ***August 2015, Civil West***
5. *Preliminary Geotechnical Investigation and Data Report,* ***March 2016, Geotechnical Resources Inc.***

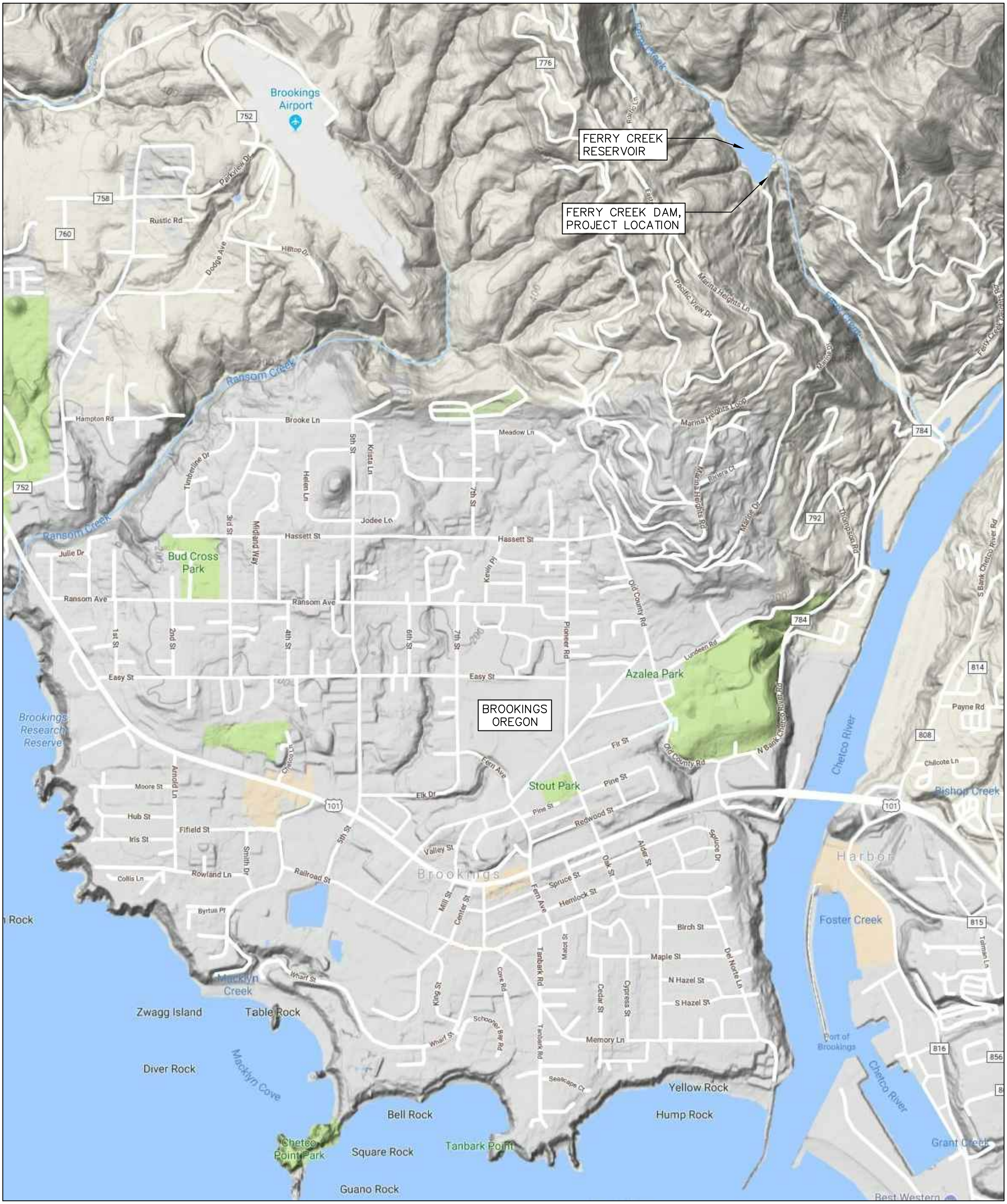
Information from these documents will be referenced throughout this study.

2.3 Existing Water System

In the year 2013, the City of Brookings public water system included 3,354 connections through which the City provided quality water to 7,244 persons. Each component of this water system is briefly discussed below.

Raw Water Intake: The Ferry Creek Reservoir was originally constructed around 1913 by the C & O Lumber Company. In 1945 the Brookings Water Co. began the complete rebuild of the dam from bedrock up. At that time the reservoir was the raw water source for the residents of Brookings. Construction was completed in the late 1960's. In 1973, the water system, including the reservoir, was purchased by the City. Shortly thereafter, the City constructed the Tide Rock Intake on the Chetco River, and abandoned the Ferry Creek Reservoir. The reservoir has remained unused for the last 40 years.

As time progressed the Ocean's salt water began moving up the Chetco River. To avoid experiencing salt intrusion at the Tide Rock Intake, the City built a new intake up river named the Rainney Collector.



THE DYER PARTNERSHIP ENGINEERS & PLANNERS, INC.	*CITY OF BROOKINGS* *FERRY CREEK DAM FEASIBILITY STUDY*	FIGURE NO.
DATE: JUNE, 2018 PROJECT NO.: 145.80	*LOCATION MAP*	*2.3.1*

According to the current Water Master Plan (WMP), the intake structure is in fair condition, withdraws water approximately 10-feet below water surface, and has a capacity of 9.3 cubic feet per second (cfs). Although the intake structure capacity is 9.3 cfs, the intake pump capacity is significantly less, and thereby limits the capacity of the intake system to 5.57 cfs when all three intake pumps are online, and 3.12 cfs under normal operating parameters (2 pumps online). Due to the type of intake structure, this intake is referred to as the Rainney Collector intake.

Since its construction, salt water has continued to push up stream. In 2014 the salt water reached the Harbor Water District (HWD) intake, which required their Water Treatment Plant (WTP) to shut down. This intake is just two miles downstream of the Rainney Collector.

Although the City of Brookings's intake is meeting supply demands, and is in fair condition, the City is concerned that the salt water intrusion may reach the current intake, and render the intake useless. There is currently no backup system in place if this event does occur. This is a situation that the City would like remedied.

Water Treatment Plant: The City's WTP is located near North Bank Road, alongside Joe Hall Creek, and was constructed in 1976. No major improvement projects have been under taken at the WTP since its construction. The WTP has a treatment capacity of 2 mgd, and utilizes a conventional rapid sand filtration process. The filters are only used when the turbidity in the raw water is high. This is typically during winter months. When turbidity is low, the intake water is disinfected, and conveyed directly to the clear well.

Storage System: The City's water storage system includes 11 ground-level water reservoirs ranging in size from 3,000 to 1,600,000 gallons, and totaling 3.6 million gallons.

Distribution System: The distribution system is divided into four primary service areas. The pipes within the system range in size from 2 to 16 inches, and are made of materials typical for their age of construction. Sections of the distribution system date back to the 1900's.

The water system description provided above is intended to give a brief system overview. For a more detailed description of the City's water infrastructure, please refer the 2014 Water Master Plan.

2.4 Ferry Creek Dam Condition

OWRD most recently inspected the Ferry Creek Dam in 2009, 2015, and 2016. In both the 2015 and 2016 inspection reports, the dam was categorized as 'unsatisfactory'. The dam will therefore be inspected annually until the condition issues are addressed. If they are not addressed, the dam can be declared unsafe, and could no longer be considered an option for an additional raw water source. Field Inspection reports can be found in Appendix A. The condition concerns of the dam are noted in the dam inspection reports listed below:

- ❖ Reservoir level was 3-feet below the dam crest when inspected. At the low point along the dam crest, the minimum freeboard was 2-feet, which is unsafe.
- ❖ There was moderate growth of vegetation at the spillway approach. This restricts flood flow into the spillway.
- ❖ On the dam crest, soil has settled and created a low spot which lowers the total reservoir storage by approximately 2.4 feet.

- The spillway control section appears very narrow for passage of a probable maximum flood, which is the design standard for a high-hazard rated dam. There are significant defects in the concrete control part of the spillway.

- Slope movement near the spillway could compromise the ability of the spillway to pass flood flow.

- Multiple outlet pipes present multiple opportunities for leakage which can cause dam failure.

- The valving on two of the outlets is on the downstream side of the pipe which pressurizes the pipes. Pressure in the aged pipes could cause leaking which could result in internal erosion, ultimately dam failure.

- Low level outlet is leaking at approximately 15 to 20 gpm. Valve was not operable.

- There is no functional valve to drain the dam during an emergency.

As noted by OWRD the dam is currently in poor condition. If a seismic event did occur there is a high probability that the dam could overtop, or be structurally compromised. In its current condition, the Ferry Creek Dam poses a significant threat to downstream residents.

SECTION 3:

WATER RIGHTS EVALUATIONS

SECTION 3: **WATER RIGHTS EVALUATIONS**

This section examines the City's current water rights, and their relationship to the projected demands, and available raw water supply sources. The purpose is to demonstrate that the City will not need the Ferry Creek Reservoir to operate as a primary source of water during any point over the next 20 years. The reservoir/dam improvements would be completed solely to provide a redundant water supply in the event of salt intrusion reaching the Rainney Collector.

3.1 City Water Rights vs. Demand

The City has 5.57 cfs of surface water rights from Chetco River, but only diverts a maximum of 3.12 cfs. The City will need to increase their maximum diversion to approximately 5.23 cfs by the year 2038. See Table 3.1.1. The numbers found in the table were taken from the 2014 WMP. 2037 flows were calculated using the Average Annual Growth Rate (AAGR) taken from the WMP (2.0%).

TABLE 3.1.1
PROJECTED POPULATION GROWTH AND WATER NEED

Projected Water Production Demands						
Year	2013	2018	2023	2028	2033	2038
Population	7,467	8,244	9,102	10,050	11,096	12,251
EDUs	5,090	5,620	6,205	6,851	7,564	8,188
ADD (mgd)	0.9	1	1.1	1.2	1.3	1.4
MDD (mgd)	2.1	2.3	2.6	2.8	3.1	3.4
PHD (mgd)	3.5	3.8	4.2	4.6	5.1	5.6
ADD (cfs)	1.39	1.55	1.7	1.86	2.01	2.2
MDD (cfs)	3.25	3.56	4.02	4.33	4.8	**5.23**

EDU-Equivalent Dwelling Unit *MDD-Maximum Daily Demand*
ADD-Average Daily Demand *PHD-Peak Hourly Demand*

The City's water rights are listed in Table 3.1.2:

TABLE 3.1.2
EXISTING WATER RIGHTS

Source	Permit No.	Certificate No.	Priority Date	Quantity
Chetco River (S) (Intake)	27610	83682	9/14/1961	**4 cfs**
Chetco River (S) (Intake)	31293	87358	1/21/1966	**1.57 cfs**
Chetco River (G)	G5601	64614	8/14/1972	6 cfs
Chetco River (S)	51383		12/12/1990	1 cfs
Chetco River (R)	R11535		5/13/1993	62.3 Ac-ft
Chetco River (R)	51595		5/13/1993	62.3 Ac-ft
Ferry Creek (S)	1740	2078	8/22/1913	3 cfs
Ferry Creek (R)	372	1407	8/9/1916	1.5 MG
Ferry Creek (R)	408	2071	8/25/1917	28 Ac-ft
Ferry Creek (R)	31224	46861	2/10/1966	167.4 Ac-ft
Ferry Creek (R)	R4720	46860	2/10/1966	167.4 Ac-ft
Joe Hall Creek (S)	4674	4953	6/23/1920	2.5 cfs
Ransom Creek (S)	18123	20734	2/24/1948	0.53 cfs

S-Surface Raw Water Source *R-Reservoir Raw Water Source*
G-Ground Raw Water Source

As shown in Table 3.1.2, the City has water rights at the current intake totaling 5.57 cfs. Therefore, the current water rights at the City's Rainney Collector intake are sufficient to meet the projected demand for 2038 (5.23 cfs). As a result, for the next 20 years, no further raw water supply sources will be required for normal operation of the water system.

3.2 Non-City Water Rights and Associated Impacts

Currently there are no water rights along Ferry Creek outside of those owned by the City. Therefore, any alterations to the dam will not impact any other water right holders.

SECTION 4:

CULTURAL AND ENVIRONMENTAL IMPACTS

SECTION 4: **CULTURAL AND ENVIRONMENTAL IMPACTS**

This section will consider archaeological impacts, environmental impacts and analyses of environmental harm to the reservoir area and streams from the proposed project.

Temporary impacts resulting from construction could impact wildlife within the creek if Best Management Practices (BMPs) are not strictly adhered to. Ferry Creek watershed plays host to a delicate ecosystem and the Oregon Coast coho salmon (*Oncorhynchus kisutch*) which is considered threatened. Approximately a quarter mile downstream of the Ferry Creek Dam, the creek is considered essential salmon habitat which restricts certain construction activities and riparian zone development. The dam removal and/or replacement will be constructed upstream of any riparian zones and will have minimal direct impact on the essential habitat.

If BMPs are not followed there is potential for construction activities to have a negative impact on the habitat downstream of the dam. Dam removal and/or replacement will require considerable earth movement. There is potential throughout the excavation and fill process for soils to enter Ferry Creek downstream of the dam and increase the turbidity within the water. This could result in: a temperature difference in the water, reduced vision for fish seeking food, and reduced opportunity for photosynthesis to promote plankton growth, thereby reducing the food available to certain fish. The BMPs would also need to be in place to protect the fish as they are transferred from the reservoir to an upstream/downstream location during construction. Appendix B shows the extent to which Ferry Creek is considered essential salmon habitat.

If the dam removal alternative discussed in Section 9 was undertaken, the banks would be returned to their natural state, and the water would flow with its original quantity and quality. The quantity of water in the stream would be improved as the water stored in the reservoir could augment stream flows when drought conditions exist. Increasing the dam height could impact existing wetlands around the perimeter of the reservoir. However, as water levels increase, a larger area of wetlands would be created along the perimeter of the reservoir. This alternative would also open up a mile of stream for non-anadromous fish migration. This project would have a positive environmental impact.

4.1 Environmental Impacts

Fish Passage

The state requires fish passage to be provided on all dam rehabilitation projects 'where native migratory fish are presently or were historically present'. Although these policies weren't in place during the original construction of the dam, any dam replacement project would require the City to meet all Oregon Administrative Rules (OAR), including meeting all fish passage requirements. The rehabilitation of the dam would obstruct approximately a mile of habitat for the migratory fish between the Ferry Creek waterfall, and the Ferry Creek Dam. If fish passage is not provided at the dam, one mile of fish passage would need to be provided for habitat elsewhere.

Constructing fish passage at the Ferry Creek Dam is cost prohibitive, and therefore other sites were examined to mitigate the fish passage lost at the dam. The project site recommended by Oregon Department of Fish and Wildlife (ODFW) was located along Nell Creek. The existing culvert extending under the roadway is currently perched, and needs to be replaced with a culvert that will facilitate fish passage. This project would provide roughly one mile of new habitat for native migratory fish.

Stream Augmentation

The dam replacement project would incorporate a mechanism for stream flow augmentation. Under most circumstances, both National Marine Fisheries Service and Oregon Department of Fish and Wildlife require a minimum water depth of one foot and streamflow temperature deviation of less than one degree Fahrenheit for fish passage. Low flow conditions in Ferry Creek downstream of the dam occur for most of the summer dry period (June – October).

Augmenting streamflow by diverting twenty-five percent of all water diverted to the Ferry Creek Reservoir would help maintain the minimum depth in lower Ferry Creek during low flow conditions thereby increasing water depth within the creek for the migratory fish.

ODFW

Correspondence with Steve Mazur, Supervisory District Fish Biologist, and Greg Apke, Fish Passage Program Leader, was conducted during the formulation of this study. In those discussions the primary point of concern relating to dam replacement was native migratory fish.

As mentioned previously, the construction of the Ferry Creek Dam removed almost a mile of migratory creek habitat from those fish downstream of the dam. Replacement of the dam is a trigger that would require either fish passage to be provided at the new dam, or fish passage mitigation to be provided at another project site. In the discussions with ODFW, a preliminary site was determined to be a more viable option for fish passage mitigation, then constructing a fish friendly spillway. This site and associated project is discussed more in depth in Section 9.

Wetlands

The National Wetland Inventory collects wetland data and inserts it into a GIS mapping system. This map covers the United States, and is available online. Figure 4.1.1 shows the designated wetland areas around the project site. Although no designated wetland areas are shown around the Ferry Creek Reservoir, there is some plant life along the perimeter of the reservoir that would suggest the presence of wetlands. Before beginning any construction, or filing a Joint Permit Application (JPA), the City would need to have a wetland delineation completed to verify the existence of wetlands around the perimeter.

Chetco River Hatchery

Currently there is an Acclimation Project for juvenile salmon within the Ferry Creek Reservoir. The salmon are placed in the reservoir for two weeks before they are released into the Chetco River. Construction would prohibit this process from occurring. In order to determine the impact of this project the following questions were sent to Steve Mazur, Supervisory District Fish Biologist with ODWF:

1. If the dam removal/replacement project was going to be completed is there any window in which construction could be completed that wouldn't impact the acclimation project?

2. Is this a program that could be moved elsewhere for a year, during construction, or are there no other viable options?
3. Do you see any other ways this project may impact local hatcheries?

Mr. Mazur responded as follows:

> *"The Ferry Creek Acclimation Site would be impacted from no pool/low pool or construction constraints from mid October to mid November. That being said, the acclimation site is not critical to the hatchery fall Chinook program and ODFW could suspend it for the period of any construction phase. The fall Chinook smolts would be released directly into the Chetco River rather than spending two weeks acclimating to Ferry Creek.*
>
> *There would be no impact on local hatcheries from the project."*

From this correspondence it can be gathered that there will be no impact on local hatcheries.

4.2 Cultural Impacts

SHPO

John Pouley with the Oregon State Historic Preservation Office (SHPO) was contacted regarding any archaeological issues that may exist at the site. An excerpt from his response is given below:

> *"According to the SHPO statewide database, archaeological sites are not known to exist within the proposed project location. Based on the information provided, Oregon SHPO does not have any concerns with the project proceeding as planned.*
>
> *During project implementation, if an archaeological object or feature is encountered, please stop all ground disturbing activity at that location, and contact our office (503 986-0980) to report the find. According to Oregon Revised Statute (ORS) 358.905(a)(A-C), "archaeological objects are at least 75 years old, are part of the physical record of an indigenous or other culture found in the state or waters of the state and are the material remains of past human life or activity."*

Impacted Tribes

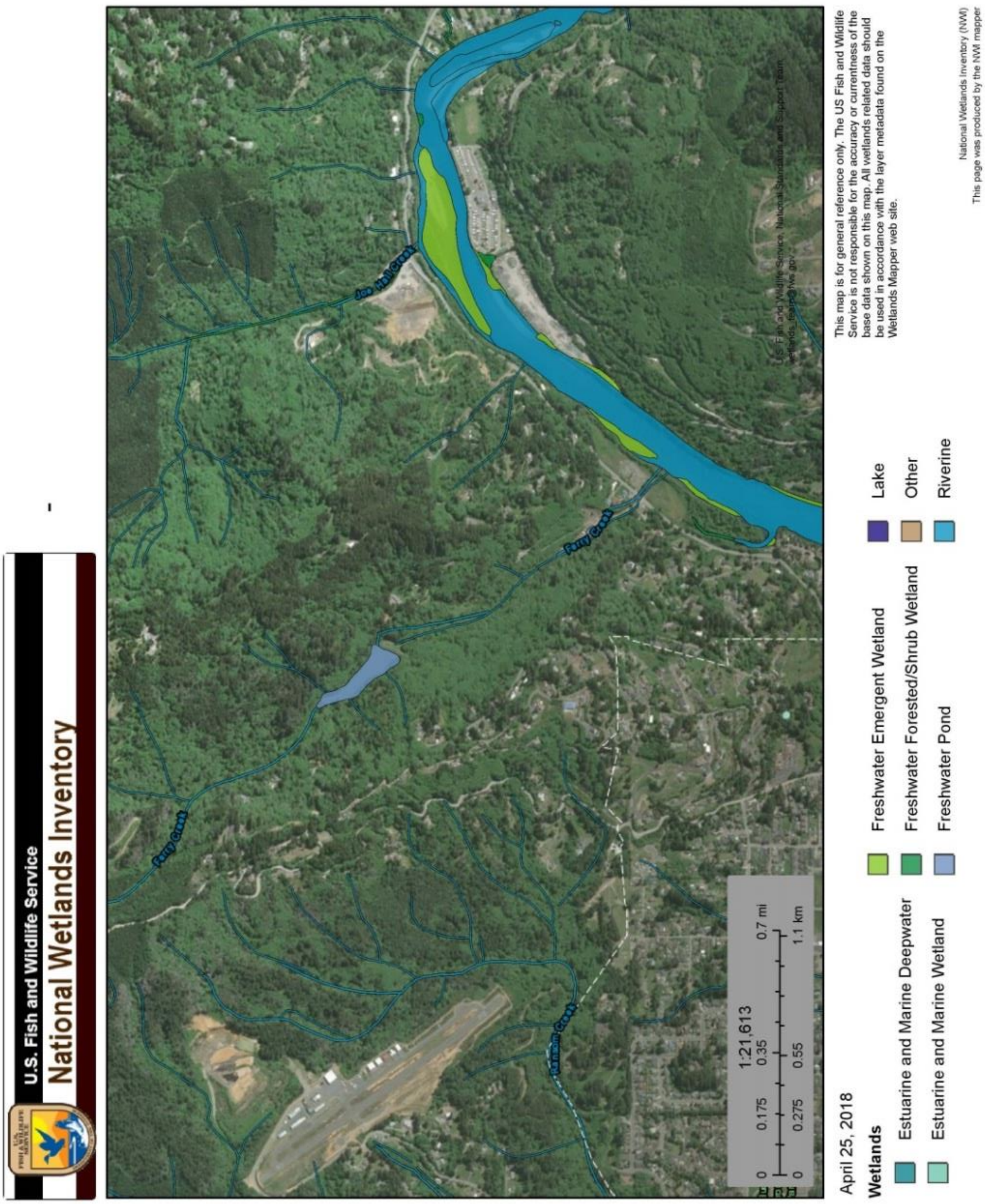
Karen Quigley, Executive Director of the Legislative Commission on Indian Services was contacted to determine the Indian Tribes that might have cultural interest in the project site. We were directed to Robert Kentta, Cultural Resources Director of the Confederated Tribes of Siletz Indians.

Mr. Kentta was contacted, and an excerpt from his email is provided below:

> *"I'm copying my asst. Peter, Stan Van (biologist) and Adrienne Crookes who has many family members in the Brookings area.*
>
> *She can reach out to her family as she deems appropriate -'they can contact you directly as community members, or contact one of us to ask the Tribe to represent their issue, if they believe there is an issue that they believe rises to a Tribal concern."*

No further response was given, so it is assumed that there would be no significant cultural impact to the Confederated Tribes of Siletz Tribes.

FIGURE 4.1.1
NATIONAL WETLANDS INVENTORY



SECTION 5:

NON-ENVIRONMENTAL IMPACTS

SECTION 5: **NON-ENVIRONMENTAL IMPACTS**

This section will discuss the potential impacts of implementing either the dam removal or dam replacement project discussed in Section 9. These projects could potentially have an effect on neighboring communities, other water users, the City's current Capital Improvement Plan (CIP), and the Chetco River hatchery. This section will examine these potential impacts. Environmental and archeological impacts were discussed separately in Section 4. Water right impacts were discussed in Section 3.

5.1 Non Environmental Project Impacts

Impact to Neighboring Communities

In recent years salt intrusion in the Chetco River has contaminated the drinking waters of the Harbor Water District (HWD). In 2015 the HWD developed the 'Brookings-Harbor Water Infrastructure and Resiliency Study, Mr. Griggs' document described several alternatives for addressing the salt intrusion issue.

Two of the alternatives presented involved completing an inter-tie between the City of Brookings, and Harbor Water District water systems. The City of Brookings intake is better shielded from salt intrusion as it is further upstream. With the two systems intertied, HWD would have access to treated water in the event that salt intrusion reached their intake.

If the inter-tie was constructed the addition of Ferry Creek Reservoir as an emergency water supply would benefit HWD. In the event that salt intrusion reached the Rainney Collector intake, the reservoir would provide treated water to both communities until other options were available.

Dam removal or replacement will have minimal direct impact on neighboring communities. This project will not affect water quality or quantity within Ferry Creek or the Chetco River, and therefore will not have an effect on neighboring community's current water supply. Increased traffic caused by the conveyance of soils on and off site will primarily be contained to City Limits. Sound levels created by construction processes would also be primarily contained within City Limits.

Impact to Existing Capital Improvement Plan Projects

The current CIP primarily consists of projects that address treatment, fire flow, conditions and storage issues. None of the projects on the CIP develop a redundant water supply that will address the potential loss of raw water due to salt intrusion. Nor do any of the projects remove the threat posed by Ferry Creek Dam. For this reason, this project and the current CIP are independent, and will have minimal impact on each other.

Depending on the priority the City chooses to give the Ferry Creek Reservoir project, monies that would have been otherwise used for CIP projects would be used to fund the reservoir project. This could indirectly impact the CIP projects as there would be fewer funds available for project completion. There is the potential of receiving funding from the state for this project. See Section 10 for funding alternatives.

Impact to Other Water Users

As discussed in Section 3, there are no water rights along Ferry Creek, downstream of the reservoir. Therefore there would be no impact to water rights users along Ferry Creek.

All water right holders along the Chetco River downstream of Ferry Creek would benefit from the removal or replacement of the dam. Removal of the dam would return Ferry Creek to its natural flow regime, and would minimize water loss due to evaporation thereby conveying more water to the Chetco River throughout the year. Replacing the dam would include flow augmentation, which would provide more flows to the Chetco River during the dryer months of the year thereby increasing the water available to water right holders when they need it the most.

SECTION 6:

HYDROLOGICAL ANALYSIS

SECTION 6: **HYDROLOGICAL ANALYSIS**

The Ferry Creek Reservoir currently stores raw a portion of the water flowing through Ferry Creek. The diverted raw water could be used for municipal raw water supply in the case that salt intrusion reached the Rainney Collector intake. This stored water could also be used for streamflow augmentation. This section will provide insight to the physical and hydrological characteristics of the watershed and the associated impacts of the reservoir. The information produced in this section will be used to assess the hydraulic and hydrologic feasibility of implementing the proposed in channel reservoir. To better understand the hydraulic and hydrologic relationships within the watershed, the following major tasks were undertaken:

- Identify the physical characteristics of the watershed.
- Identify environmental constraints and regulations.
- Identify a relationship between streamflow and meteorological events.
- Verify the feasibility of storing water at the reservoir.
- Verify the feasibility of releasing raw water for municipal use and streamflow augmentation.
- Address future changes.

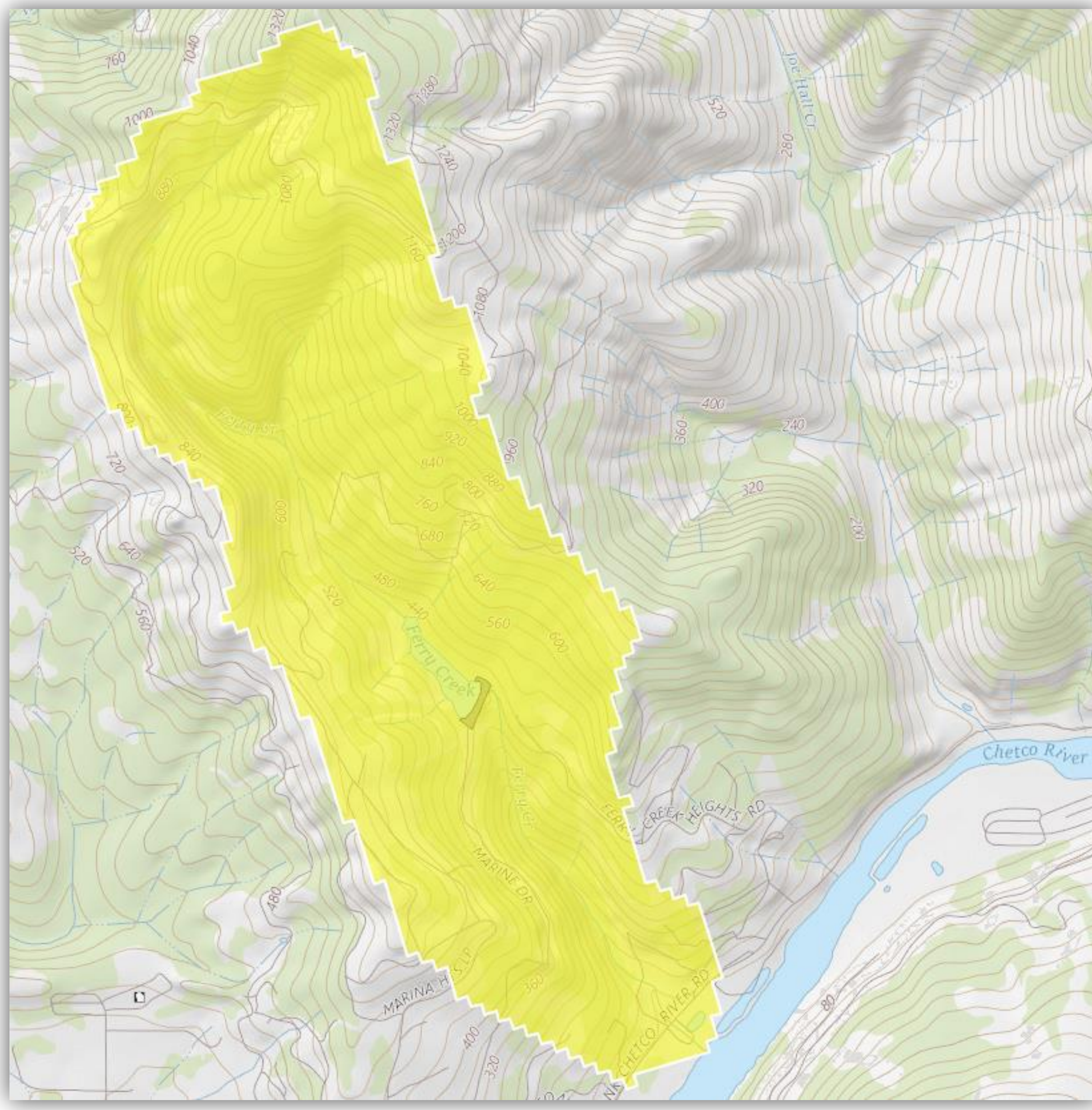
6.1 Watershed

The contributing watershed is comprised of the Ferry Creek basin which has an area of 550 acres (0.72 square miles). The lower reaches of Ferry Creek are near sea level and the upper reaches are about 1000-feet above sea level. The watershed has an average slope of 45% with a shallower slope of 5% at the lower reaches of the watershed near the Chetco River. Ferry Creek is a first order perennial stream. The reservoir is located at the north end of Marine Drive along Ferry Creek. Figure 6.1.1 shows the watershed delineation. The upper portions of the watershed consist mainly of forested lands. The forested portion of the watershed consist of shore pine, Sitka spruce, western hemlock, and Douglas-fir. The lower portions of the watershed consist of mainly low density urban developments with sporadic forestland. The existing reservoir has a relatively small footprint of 3.86 acres when compared to the contributing watershed 462 acres. Once construction is completed, removal or heightening of the Ferry Creek Dam will only have a minor impact on the overall hydrological function of the watershed. Table 6.1.1 is a summary of the watershed characteristics and these values will be used as basepoint data for the hydrologic analysis.

TABLE 6.1.1
PHYSICAL CHARACTERISTIC OF THE WATERSHED

DESCRIPTION	VALUE
Ferry Creek Reservoir Basin Area	3.86 Acres
Watershed Area	550 Acres
Watershed Average Slope	30%
Lowest Point in Watershed	5 feet above MSL
Highest Point in Watershed	1000 feet above MSL

FIGURE 6.1.1
FERRY CREEK WATERSHED



Climate

The watershed has a Marine West Coast-Mediterranean climate (Köppen classification Csb), which is common to most of the Oregon Coast. Climate data for this section is based on published daily meteorological observations from the Western Regional Climate Center Station ID: Brookings 2 SE, Oregon (351055). In the winter months rain and overcast conditions are common. The summers are mostly dry. Below freezing temperatures and snow can occur during the winter; however, this is not very common and usually occurs on average less than once a year. Extreme temperatures of 20°F or lower are extremely rare, usually happening about once every five years. Summers are dry and cool with an average

July high temperature of approximately 68°F while lows are generally from 50°F to 60°F. The City of Brooking's highest reading of 103°F occurred on September 9, 1973 and the lowest reading of 18°F was observed only three months later on December 8, 1973. Table 6.1.2 below is a summary of the temperature and precipitation for the watershed. The intent of the precipitation averages below are to illustrate the overall weather norms.

TABLE 6.1.2
30-YEAR AVERAGE CLIMATE DATA

Month	Mean Max. Temperature (F)	Mean Temperature (F)	Mean Min. Temperature (F)	Mean Precipitation
Jan	54.1	47.35	40.6	12.18
Feb	55.7	47.6	41.4	9.85
Mar	56.9	48.7	41.6	9.19
Apr	59.2	50.2	43	5.74
May	62.6	53.6	45.9	3.74
Jun	66	57	48.9	2.02
Jul	67.2	59.6	50.8	0.57
Aug	67.1	59.7	51.4	0.85
Sep	68	57.9	50.6	2.2
Oct	64.2	54.2	47.7	6.22
Nov	58.5	49.9	44.3	11.21
Dec	54.8	46.6	41.4	12.58
Annual	61.2	52.7	45.6	76.34

Flow Data

In general, Ferry Creek flows can be described as "flashy", running high during storms but becoming "nearly dry" during the summer. The exact flows cannot be determined as a stream gauge has never been installed in Ferry Creek.

Without a stream gauge, no flow data exists. Therefore, all flow characteristics were approximated using hydraulic analysis. For this study the Soil Conservation Service (SCS) Curve Number method, in combination with local rain gauge data was used to estimate the existing creek flows.

6.2 Hydrology and Hydraulics

During a storm event, water from snow melt or soil saturation runs down the mountainous slopes within the basin and into Ferry Creek. Water is stored behind the dam until the water elevation matches the elevation of the spillway. At that point, all additional flows are conveyed downstream via the spillway. The impounded water behind the dam is referred to as Ferry Creek Reservoir.

A capacity survey in 2018 indicated that the reservoir currently stores approximately 26 million gallons of raw water. If the elevation of the crest is increased by 9-feet the storage would be 39 million gallons. The current average daily demand of the City is 900,000 gallons of water a day. Without considering downstream flow requirements, the existing and expanded water volumes within the reservoir will supply the City with water for 29, and 43 days respectively.

The intent of the hydrological analysis is to verify the feasibility of diverting enough raw water to adequately supply municipal emergency needs and streamflow augmentation. To verify feasibility it is first necessary to identify the quantity and timing of raw water diversion to the reservoir. The feasibility analysis of diverting raw water to the reservoir includes the following major tasks:

- Calculate streamflow based upon precipitation data.
- Produce a rating curve for an idealized section of Ferry Creek to identify a streamflow threshold that would cause water depths below the 1-foot minimum.
- Determine optimum peak flow.
- Determine flushing flows.
- Analysis of rating curve with the streamflow calculations to identify the maximum interval the reservoir could be used as an emergency water source.
- Produce a typical diversion and streamflow augmentation schedule. Compare diversion and streamflow augmentation schedule with municipal demand to verify raw water availability.

Estimated Monthly Streamflow

No river gauges are present along Ferry Creek; therefore monthly streamflow was calculated using the SCS Curve Number Method.

The SCS Curve Number Method is a simple, widely used and efficient method for determining the approximate volume of runoff from a rainfall event in a particular area. Although the method is designed for a single storm event, it can be scaled to find average monthly and annual runoff values. Only two variables need to be defined for this method and they are rainfall amount and Curve Number (CN). The CN is based on the area's hydrologic soil group, land use, treatment and hydrologic condition. The general equations for the SCS Curve Number Method are as follows:

$$S = \left(\frac{1000}{CN}\right) - 10) \qquad Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where,

Q = actual runoff
S = potential maximum retention after runoff begins
P = potential maximum runoff (total rainfall if no initial abstraction-Taken from local rain gauge)
CN= is an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess

Using these equations runoff volumes were calculated for each month. The tabulated flows are shown in Table 6.2.1 shown below. The flows in Table 6.2.1 represent average monthly flows. Peak flows are much larger during storm events, and are increased even further by saturated soils. Section 6.8 discusses peak flows connected to storm events.

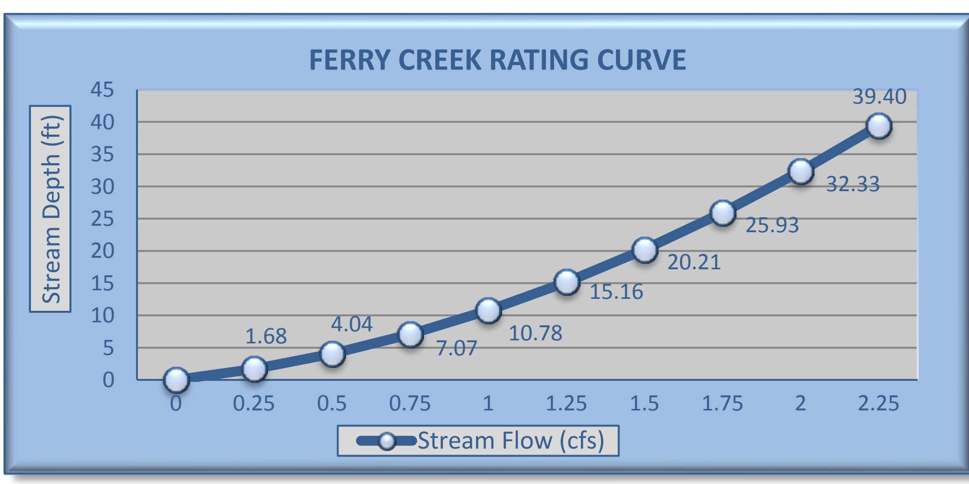
TABLE 6.2.1
AVERAGE MONTHLY STREAMFLOW

Month	Percipitation (in.)	Runoff (in.)	Area (Ac)	Runoff Volume (Ac-in.)	Runoff Volume (ft^3)	Flow (cfs)
Jan	11.84	8	550	4400	15,972,000	5.96
Feb	9.96	6	550	3300	11,979,000	4.95
Mar	9.43	5.6	550	3080	11,180,400	4.17
Apr	6.47	2.6	550	1430	5,190,900	2.00
May	3.85	1.1	550	605	2,196,150	0.82
Jun	2.02	0.8	550	440	1,597,200	0.62
Jul	0.43	0	550	0	0	0.00
Aug	0.72	0	550	0	0	0.00
Sep	1.39	0.9	550	495	1,796,850	0.69
Oct	5.36	3	550	1650	5,989,500	2.24
Nov	11.24	7.2	550	3960	14,374,800	5.55
Dec	14.51	8.4	550	4620	16,770,600	6.26

Ferry Creek Rating Curve

A rating curve of a typical section of Ferry Creek near the point of diversion will identify the relationship between streamflow and channel depth. The rating curve is developed by using the Manning's Equation for open channel flow. The normal channel depth was calculated for various flowrates in Ferry Creek near the point of diversion. The channel geometry of Ferry Creek changes depending on the location in the watershed. The reach near the point of diversion is narrow with steep channel side slopes. For this analysis the channel geometry was approximated. The channel slope was set at 0.1, bottom width was set at 1-foot, channel embankment slope was set at 1, and manning's number was 0.04. Figure 6.2.1 shows the approximate rating curve for Ferry Creek near the point of diversion.

FIGURE 6.2.1
FERRY CREEK RATING CURVE



Optimum Peak Flow

Elevated or optimal peak flows serve several functions. The functions can be divided up between ecological triggering flows that trigger key behaviors such as migration or spawning and geomorphic maintenance flows which help build and maintain overall ecological habitat. The ecological timing related discharges that are associated with biological behavior shifts are most often species and location specific. These ecological flows are normally needed on a seasonally reoccurring basis. Some examples include:

- ❖ Elevated flows to flush juvenile migrating fish downstream,
- ❖ Elevated flows to initiate upstream migration of adults, or
- ❖ Elevated flows to complete life cycle dynamics of aquatic insects and other aquatic organisms.

According to OAR 635-400-0015, the Oregon Method was used to determine optimal peak flows within Ferry Creek. The Oregon Method dictates the required depth of the creek for various biological functions. The required depth and the geometry of the channel were used to determine the optimal peak flow required. Minimum stream depths for spawning, and passage are 0.8, and 0.6 respectively. Minimum required flow for spawning is 7.10 cfs, and adult passage is 4.52 cfs.

According to National Marine Fisheries Service (NMFS), the required stream depth for fish passage is 1-foot. At this depth, the optimal streamflow would be 10.78 cfs. This study will default to the higher optimal streamflow set by NMFS.

The calculated average monthly flows within Ferry Creek at the location of the reservoir are insufficient to generate minimum spawning, and adult passage depths within Ferry Creek. However, increased stream flows resulting from winter storm events and saturated soils will provide sufficient water depth to facilitate fish passage and spawning. This has been verified by an ODFW field survey. Find correspondence in Appendix E.

Flushing Flows

The purpose of channel maintenance or flushing flows are to provide conditions conducive to creating or maintaining stream morphology and habitat. The concern is more focused on the physical structure of the stream and its long term in nature. Specific channel maintenance objectives include:

- ❖ Move existing streambeds and gravels allowing for “cleaning” of gravels intruded with fines which improves spawning habitat and foods sources in the medium and long-term by providing higher quality macro invertebrate habitat;
- ❖ Scour and fill against encroaching riparian vegetation which allows the stream to retain its bed form rather than loosing conveyance capacity and stream habitat;
- ❖ Retain bed configurations including the formation of riffles, pools, and other channel unit habitats;

- Create conditions for the replenishment of streamside vegetation such as cottonwoods to maintain long-term riparian functions,

- Maintain large wood movement and function by providing elevated flows to allow wood to be reconfigured and recruited through bank scour mechanisms, and/or

- Streamflow needs associated with habitat maintenance can be determined with more general methods.

Oregon streams are considered generally “supply limited” and tend to be armored. Most have high flow variability, a reasonable approach would be to have a rarer event for a “trigger flow” than one that occurs every 1.4 years or more (i.e. Castro and Jackson’s bank full flow recurrence values). For Oregon gravel bed streams, a 2-year recurrence flood event represents a likely place where significant sediment transport and bed movement is occurring and would be a reasonable streamflow level for a flushing flow.

A 2-year storm event across the basin was modeled using the computer program AutoCAD Storm and Sanitary Analysis. The program employs the SCS TR-20 method for analyzing runoff quantities. The calculated runoff for a 2-year recurrent storm event was 75 cfs. As the Ferry Creek flushing flow is set by the 2-year storm even, it also equals 75 cfs.

Basin Runoff vs. Creek Flow Requirements

The intent of creating a raw water diversion and streamflow augmentation schedule is to model the typical operation of the reservoir. Modeling the typical operation of the reservoir will give insight to the diversion and augmentation timing and verify the feasibility of the proposed alternatives.

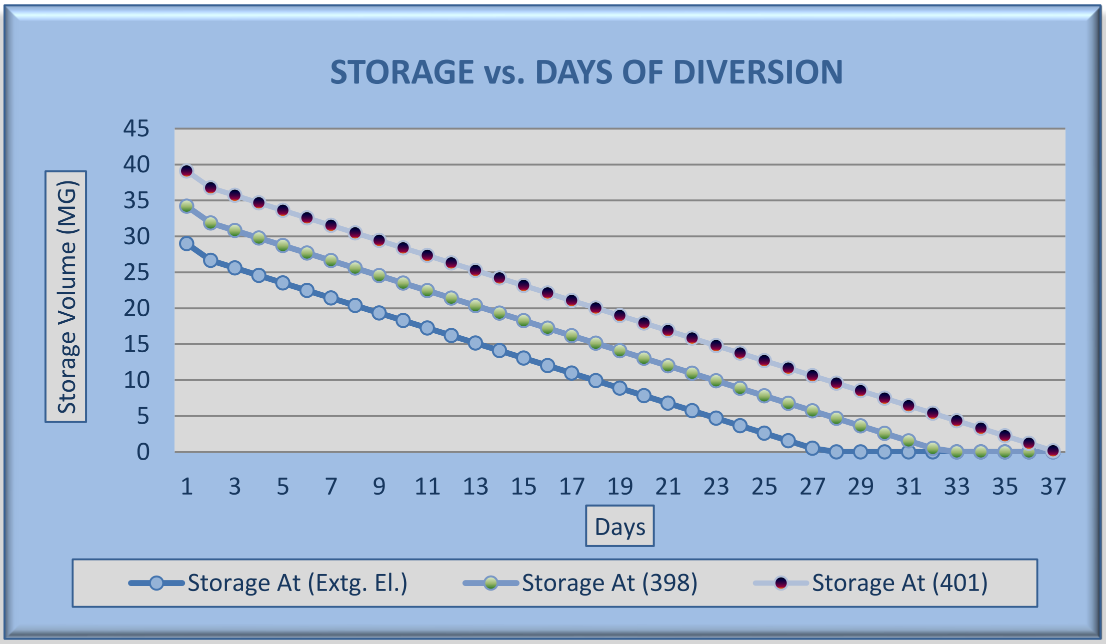
Under normal operating conditions, all natural flows within Ferry Creek will bypass the dam, and continue downstream. An exception to this flow regime occurs when there is a need to fill the reservoir. This need would arise following: construction of dam improvements, reservoir draining required for maintenance, or when the reservoir has been drawn down by the City while operating under emergency conditions. Filling of the reservoir is to occur during wet weather months, and not to exceed 1 cfs flow rate. As these occurrences will be rare, there is minimal need for flow augmentation as the natural flow of the creek will be maintained.

On the occasion that water from Ferry Creek is retained behind the dam to fill the reservoir, a portion of the water will be stored for future augmentation of Ferry Creek flows. The quantity of raw water released for streamflow augmentation will be twenty-five percent of the raw water diverted for storage. The water will be released at 1 cfs. If drought conditions exist, the augmented flow rate can be increased as needed.

Since the reservoir is only used under emergency conditions, the feasibility of diverting water to the City throughout the year was not evaluated. Instead, the feasibility of the reservoir operating as an emergency water source was evaluated by determining the length of time the reservoir could supply emergency raw water to the City while augmenting stream flows.

The length of time the reservoir could divert raw water to the City, while augmenting stream flows, was determined by dividing the volume of water stored within the reservoir by the raw water demand of the City in addition to the augmentation flow rate. Figure 6.2.2 depicts the relationship between the volume of water remaining in the reservoir, and the number of days the water is diverted to meet City raw water demands, and augmentation requirements. The figure shows three graphs which represent the various finished heights discussed for the dam. The period of time that the reservoir could operate as an emergency water supply while augmenting stream flow ranges from 19 to 29 days depending on the finished height of the dam. This would provide the City with enough time to better respond to salt intrusion at the Rainney Collector intake, and therefore is a feasible solution that addresses the City's concerns.

FIGURE 6.2.2
RESERVOIR SUPPLY TIME



SECTION 7:
GEOTECHNICAL INVESTIGATION

SECTION 7: **GEOTECHNICAL INVESTIGATION**

7.1 Geotechnical Findings

A preliminary Geotechnical Investigation was prepared by Foundation Engineering, Inc. in March/April 2018. This document is included in the study as Section 7.

Geotechnical Investigation

Ferry Creek Dam

Curry County, Oregon

Prepared for:

Dyer Partnership Engineers & Planners, Inc.
Coos Bay, Oregon

April 3, 2018

Professional Geotechnical Services

Foundation Engineering, Inc.

Steve Major, P.E.
Dyer Partnership Engineers & Planners, Inc.
1330 Teakwood Avenue
Coos Bay, OR 97420

April 3, 2018

Ferry Creek Dam
Geotechnical Investigation
Curry County, Oregon

Project 2170192

Dear Mr. Major:

We have completed the requested geotechnical investigation for the above-referenced project. Our report includes a description of our work, a summary of previous subsurface investigation and laboratory testing, a discussion of site the conditions, a description of engineering analyses, and a discussion of existing hazards.

Our preliminary analysis indicated the existing dam is not expected to survive a large Cascadia Subduction Zone (CSZ) earthquake. Therefore, our work focused on identifying options for rehabilitating or replacing the dam. Additional work needed for final design is also discussed, in the event the City elects to proceed with dam replacement.

It has been a pleasure assisting you with this phase of your project. Please do not hesitate to contact us if you have any questions or if you require further assistance.

Sincerely,

FOUNDATION ENGINEERING, INC.

David L. Running, P.E., G.E.
Senior Geotechnical Engineer

James K. Maitland, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
62647PE
OREGON
NOV. 9, 1999
DAVID L. RUNNING
Expires: 12/31/18

Brooke K. Running, C.E.G
Project Geologist

DLR/JKM/BKR/wg
enclosure

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FERRY CREEK DAM
CURRY COUNTY, OREGON

BACKGROUND

The Ferry Creek Dam is located east of Brookings, just outside of the City's urban growth boundary, in Curry County, Oregon. The site location is shown on Figure 1A (Appendix A). The dam is owned by the City of Brookings. It has been designated as a high-risk dam by the Oregon Water Resources Department (OWRD) due to its condition and potential hazard to residences downstream.

The City of Brookings would like to retain the reservoir, and potentially increase its capacity to serve as a backup water source. The City retained Dyer Partnership Engineers & Planners, Inc. (Dyer) to evaluate the dam and develop possible rehabilitation or replacement options, as appropriate. Dyer retained Foundation Engineering, Inc. as the geotechnical consultant. Our work was authorized by a contract dated August 29, 2017.

APPROACH AND SCOPE OF WORK

We developed a phased-approach for this project. The approach and scope were outlined in a proposal dated February 16, 2017. The current phase of work, Phase 1, includes:

- a literature review
- a site reconnaissance and geologic hazard study
- evaluation of the static and seismic slope stability of the existing dam
- evaluation of rehabilitation options, if appropriate
- preliminary evaluation of dam replacement options, if needed
- preparation of this geotechnical report
- meetings to discuss the collected information

This report focuses on the Phase 1 work. If the City elects to proceed with the design of a replacement dam, additional (Phase 2) engineering work will be required.

LITERATURE REVIEW

We reviewed reports, photographs, maps, and sources to evaluate the local geology, identify seismic hazards, and evaluate the condition of the existing dam. The review included the following:

- Reservoir photographs from the 1960s
- Report on Bankus Dam, Ferry Creek Reservoir (Rohde, 1966)
- Land Use Geology of Western Curry County, Oregon (Beaulieu and Hughes, 1976)
- Geology, Mineral Resources, and Rock Material of Curry County, Oregon, (Ramp et al., 1977)
- Final Report of Feasibility Study for Reconstruction of Ferry Creek Reservoir, (Dames & Moore, 1997)
- US Geologic Survey (USGS) Interactive Fault Map, (USGS, 2006a)
- US Geologic Survey (USGS) Quarternary Fault and Fold Database, (USGS, 2006b)
- Ferry Creek Reservoir Inspection, Permit R4720, (Smith, 2009)
- Landslide Inventory Map of the Harbor Hills Area, Curry County, Oregon, (Burns et al., 2013)
- Landslide Inventory of Coastal Curry County, Oregon, (Burns et al., 2014)
- Oregon Active Faults, (Niewendorp, 2014)
- Redundant Water Supply Plan, City of Brookings, (Civil West, 2015a)
- Schematic Project Update, City of Brookings, (Civil West, 2015b)
- Redundant Water Supply Schematic Plans, City of Brookings, (Civil West, 2015c)
- Preliminary Geotechnical Investigation and Data Report, Ferry Creek Reservoir, (GRI, 2016)
- Ferry Creek Dam (F-25) – Inspection Summary, (Mills, 2016)
- HazVu Viewer Online Map, (DOGAMI, 2018)
- LiDAR Data Viewer Online Map, (DOGAMI, 2017a)
- SLIDO Viewer Online Map, (DOGAMI, 2017b)

More detailed descriptions of the sources listed above are provided in the Reference section at the end of this report. Where appropriate, we have included drawings, boring logs, and maps from previous studies and reports in the appendices.

GEOLOGY

Local Geology

The geology in southwestern Oregon represents fault-bounded, geologically-diverse blocks accreted to the continental margin (Orr and Orr, 1999). This tectonically and structurally complex region contains a mélange of sedimentary, volcanic, and plutonic igneous and metamorphic rocks that have been extensively folded, faulted, and sheared (Orr and Orr, 1999).

The project is located along the western foothills of the Klamath Mountain physiographic province of southwestern Oregon immediately east of the Pacific Ocean. Local geologic mapping indicates the project area is underlain by the Dothan Formation (Beaulieu and Hughes, 1976; Ramp et al., 1977) (Figure 2A).

The Dothan Formation near Brookings consists of a mixture of primarily sandstone (graywacke) and siltstone with minor amounts of greenstone and chert. The Dothan Formation also includes bimrocks, which are variable sized masses of hard bedrock surrounded by softer bedrock of a different lithology. Weathering of the Dothan Formation typically produces colluvium consisting of silt and clayey silt with variable proportions of sand, gravel, and cobbles. Landslides and landslide debris are common in areas underlain by the Dothan Formation.

Site Geology

GRI drilled two exploratory borings (B-1 and B-2) through the dam in 2015. The approximate boring locations are shown on Figure 3A (Appendix A). Those borings encountered relatively uniform subsurface conditions with dam fill, underlain by ±5 to 15 feet of colluvium/landslide debris, followed by bedrock. The bedrock consists of alternating layers of sandstone and siltstone consistent with the geologic map. More detailed descriptions of the subsurface conditions in the borings are provided in a subsequent section of this report and copies of the logs are found in Appendix C.

Geologic observations during our site visit focused on the spillway and the bedrock exposed within the south-central slope of the dam embankment. The exposed bedrock is a bimrock composed of intrusive igneous rock, likely quartz diorite. It is unknown if this bimrock is attached to the underlying sandstone or siltstone or if it is an independent block.

Much of the spillway fill consists of angular to subangular cobbles and boulders composed mainly of sandstone with occasional quartz diorite (bimrock sourced or from higher up in the slope).

The eastern slopes above the spillway are composed of angular sandstone cobbles and boulders and colluvial material derived from the weathered sandstone. Farther downstream, we observed a possible dark grey-black sandstone outcrop as well as another larger bimrock.

The soil and rock observed along the creek/ravine are consistent with the anticipated weathering products of bedrock shown on the local geologic mapping.

GEOLOGIC HAZARDS

We have developed conclusions regarding the geologic hazards based on the GRI subsurface profiles and our limited observations on site. The conclusions are also based on our knowledge of the site geology, a review of previous geotechnical and seismic studies performed in the area, and available geologic hazard maps including information available from Oregon Department of Geology and Mineral Industries (DOGAMI).

Geologic and seismic hazard studies by DOGAMI include the Brookings area. DOGAMI also provides online hazard information through HazVu, LiDAR and SLIDO viewers. This information is considered only a guide and does not have precedence over site-specific evaluations. The following sections provide a discussion of the potential geologic hazards.

Faulting and Fault Rupture

We completed a review of nearby faults to evaluate the seismic setting and the seismic sources. Nearby faults include the Cascadia Subduction Zone (CSZ) and local crustal faults. These seismic sources are described below.

The site along the southern Oregon Coast lies ±55 miles inland from the surface expression of the CSZ (Goldfinger et al., 1992). The CSZ is a converging, oblique plate boundary where the Juan de Fuca plate is being subducted beneath the western edge of the North American continent (Geomatrix Consultants, 1995). The CSZ extends from central Vancouver Island in British Columbia, Canada, through Washington and Oregon to Northern California (Atwater, 1970). The CSZ is capable of generating earthquakes within the descending Juan de Fuca plate (intraplate), along the inclined interface between the two plates (interface or Benioff Zone), or within the overriding North American Plate (crustal) (Weaver and Shedlock, 1996). The site is in an area of potentially high seismic activity due to its proximity to the CSZ.

Crustal faulting characterizes the complexly folded and faulted Klamath Mountains. There are scattered concealed and inferred crustal faults and folds located within ±40 miles of the site. The USGS identifies eight potentially active Quaternary (<1.6 million years) crustal fault zones within this area. Table 1 provides a summary of information for these faults, including unnamed offshore and Cascadia fold and thrust belt faults. Additional fault information is available in the literature (Personius et al., 2003; USGS, 2006b). A list and discussion of folds and faults associated with the CSZ can be found on the USGS website (http://earthquake.usgs.gov/hazards/qfaults/or/index.php).

Table 1. Potentially Active Quaternary Crustal Faults within ± 40 miles of the Ferry Creek Dam

Fault Name	Length (miles)	Distance from Site (miles)	Most Recent Estimated Deformation	Slip Rate (mm/year)
Chetco River (#898)	±5	0.02 E	<130,000 years	0.2 - 1.0
Whaleshead (#897)	±27	±6 to 30 N	<130,000 years	0.2 - 1.0
Bald Mountain-Big Lagoon (#787)	±59	±15 to W	<130,000 years	0.2 - 1.0
Unnamed South of Crescent City (#431)	±10[4]	±19 S-SW	<1.6 million years	unspecified
Lost Man (#147)	±39[4]	±19 S-SW	<1.6 million years	0.2 - 1.0
Battle Rock (#896)	±30	±28 N	<750,000 years	<0.2
Cascadia Thrust and Fold Belt (#784)	±300	±29 to 53 W	<15,000 years	1.0 - 5.0
Grogan (#11)	±96	±34 S	<1.6 million years	0.2 - 1.0
Surpur Creek (#148)	±27	±38 SE	<1.6 million years	unspecified

Notes: 1. Fault data based on Personius et al. (2003) and USGS (2006a and 2006b).
2. Distance from site to nearest surface projection of the fault.
3. Slip rate data from Table H-1 (Petersen et al., 2008).
4. Fault length (miles) estimated from USGS (2006a).

All of the faults listed in Table 1 are USGS Class A faults. Class A faults have geologic evidence supporting tectonic movement in the Quaternary, known or presumed to be associated with large-magnitude earthquakes (Personius et al., 2003).

The north-trending Chetco River fault (#898) is the closest mapped potentially-active crustal fault. The Chetco River fault was originally mapped by Kelsey and Bockheim (1994). The fault is shown on the USGS interactive map (Figure 4A), which places the fault near the northeast end of the dam (USGS, 2006b; USGS, 2006a). The USGS record for this fault indicates potential activity within the last ±130,000 years with a 0.2 to 1 mm/year slip rate. The last review date of the USGS fault record for the Chetco River fault was in 2002.

The Chetco River fault is not shown on other regional geologic maps and it is not included on the State of Oregon active fault list (2014). We discussed this fault with Clark Niewendorp of DOGAMI (Niewendorp, 2017) who assembled the Oregon active fault list. He indicated it is possible the fault was inadvertently omitted from their list. He also indicated the accuracy of the mapped fault location is debatable and the fault location can be off by several hundred to thousands of feet or more, if the fault exists. The DOGAMI LiDAR image for the site shown on Figure 5A does not show any apparent signs of a fault lineament (DOGAMI, 2017a). If the project proceeds to final design, additional site reconnaissance is recommended to look for evidence of fault movement or displacement in this area.

While there are nearby crustal seismic sources, the risks associated with the rupture of the CSZ is much greater than for local faults. Therefore, the stability analyses in this investigation focused on CSZ earthquakes.

Ground Motion Amplification

Ground motion amplification is the influence of a soil deposit on the earthquake motion. As seismic energy propagates up through the soil strata, the ground motion is typically increased (i.e., amplified) or decreased (i.e., attenuated) to some extent. The amount of amplification depends on the soil conditions.

The available borings indicate the dam is up to ±40 feet tall and is composed of silt with varying amounts of clay, sand, and gravel. The fine-grained fill ranges from soft to very stiff. At the boring locations, the dam is underlain by ±5 to 15 feet of medium stiff to stiff clayey silt (colluvium and landslide debris), followed by bedrock at depths of ±40 to 45 feet below the dam crest.

We anticipate the risk of ground amplification is low (±10% or less) for a CSZ earthquake because the dam is underlain by shallow bedrock and the peak ground accelerations (PGA's) will be high. This is consistent with the available ground Motion Hazard Map, which indicates a negligible amplification hazard in this area. The highest mapped amplification hazard is along the floodplain of the Chetco River (Madin and Wang, 1999).

The amplification hazard is relatively low. However, the site is expected to experience severe ground shaking during a large crustal or subduction zone earthquake due to its close proximity to potentially active Quaternary crustal faults and the CSZ (DOGAMI, 2016).

Landslides and Earthquake-Induced Landslides

Weathering of the Dothan Formation bedrock in the coastal climate has resulted in thick zones of decomposed rock and clay-rich soil. Landslides formed in the clay-rich weathered bedrock are common features on the steep slopes of the Southern Oregon Coast and Curry County. These slides typically involve the weathered zone, but may also include large blocks of rock or follow shear zones within the bedrock (Burns et al., 2013; Burns et al., 2014; DOGAMI, 2017b).

The existing topography at the site consists of a drainage that has been dammed. The DOGAMI LiDAR imaging shows landforms typical of landslide topography north and east of the reservoir and dam (DOGAMI, 2017a) (Figure 5A). This is also supported by local landslide mapping which indicates mapped landslides extend along the entire north shore of the reservoir, along a portion of the west shore, and adjacent to the northeast abutment of the dam (Burns et al., 2014; DOGAMI, 2017b) (Figure 6A). Damage to the existing spillway (described in a subsequent section of this report) appears to be due to on-going slope creep of some of this material.

In our experience, large landslide complexes typically include multiple zones showing various rates of movement and resulting damage. Based on the available information, we believe the landslide hazard is high at this site, particularly in the steeper slopes and in terrain that has previously experienced landslides. Current inactive landslides may be reactivated by earthquakes, precipitation, or fluctuations in the reservoir level from operation of the dam.

Landslide movement along the reservoir banks may result in debris extending into the reservoir and displacing water. For a large slide, it is possible the debris could displace enough water to overtop the dam. The overtopping may not lead to dam failure but would likely require some mitigation. Overtopping could also impact residences downstream. Landslides occurring close to the dam could potentially compromise the operation of the dam. The landslide debris extending into the water would reduce the capacity of the reservoir. Depending on the volume of the debris, the reservoir may have to be drained following a landslide to allow the removal of this material.

Liquefaction, Settlement and Lateral Spread

Liquefiable soils typically consist of saturated, loose, fine-grained sand and non-plastic or low plasticity silt (i.e., PI less than 8). The soil encountered in the borings completed by GRI indicate the embankment fill is composed of predominantly silty material with varying amounts of clay, sand, gravel, and cobbles. The fill ranges from soft to very stiff. There is no description of the plasticity of the soils in the boring logs. However, based on the soil descriptions, we anticipate the silty embankment fill has low to medium plasticity and the underlying colluvial clayey silt has medium plasticity.

We believe the risk of liquefaction is low due to the stiffness and the estimated plasticity of the soil. This is consistent with the HazVu mapping which indicates low liquefaction susceptibility in the project area (DOGAMI, 2016). Most of the area is mapped with minimal liquefaction hazard. The highest mapped liquefaction hazard is along the Chetco River (Madin and Wang, 1999).

The existing dam embankment consists of predominantly fine-grained soil. Due to the plasticity of the fill, liquefaction is not expected to be a significant issue. However, sustained, strong ground motion may lead to softening and loss of strength in the softer fill. The stability of the dam under seismic loading is address in subsequent sections of this report.

DAM HISTORY AND DESCRIPTION

Carl Rohde, P.E. prepared a report dated February 1, 1966, on the condition of the dam, which was then referred to as the Bankus Dam and Ferry Creek Reservoir (Rohde, 1966). The report provided some history of the dam. At the time the report was prepared, the dam was apparently operating to provide a water supply to the City of Brookings. It was reported to be filled during the spring and drawn down in the summer by use. During the winter, it was kept empty with the outlet pipe left open to pass normal stream flow.

A narrative in the Rohde report describes the original dam as having been built by the C&O Lumber Company in about 1913. It was reportedly completely rebuilt by the Brookings Water Company. The re-construction began in 1945. Most of the work was completed in 1952 and 1953, but with on-going work up to 1966. The report states the core area of the dam was stripped to bedrock and extended into "firm undisturbed material in the abutments". This assertion was based on:

- conversations with Mr. Elmer Bankus and personnel who performed the work
- examination of photographs taken during construction
- exploratory holes drilled along the dam axis that indicated an abrupt change in character from compacted fill to partially decomposed rock

The Rohde report describes the following dimensions and slopes:

- Crest width 15 feet
- Height above streambed: 44 feet
- Slope of downstream face: 1.25(H):1(V)
- Slope of upstream face: 1.5(H):1(V)

The Rohde report states the examination of the embankment, both empty and full revealed no problems with seepage, settlement, erosion, cracks, or fissures. The report also cites the presence of a 16-inch diameter steel outlet pipe with valve control extending through the embankment and a 36-inch diameter concrete pipe conduit at the bottom of the fill "to pass stream flows during the time the reservoir is empty".

SITE RECONNAISSANCE AND SITE CONDITIONS

We visited the site on September 26, 2017, to observe site conditions. We were accompanied by Steve Major, P.E. (Dyer) and Keith Mills, P.E. (OWRD). During our site visit, we observed the condition of the dam and surrounding area, noted key features, and took photographs. Some of the key site features are described below.

- The dam is located ±1½ miles from the City center within a well-defined ravine accessed via Marine Drive.
- The dam axis trends northeast-southwest. The impounded reservoir lies on the northwest side of the dam.
- The dam is ±325 feet long. Photo 1B (Appendix B) shows a view of the dam crest looking from the southern end. Photo 2B shows a view of the dam crest looking from the northern end. Photos 3B and 4B show the retained reservoir.
- The depth of the water impounded by the dam is not currently known. Civil West (2015a) estimates the reservoir covers ±5 acres and has a capacity of ±29 million gallons. The City has water rights that would allow storage of 55 million gallons at this location.
- The City does not have records of any maintenance of the dam. Therefore, the rate at which sediment accumulates in the bottom of the reservoir has not been established. Future soundings and probing will be required to confirm water and sediment depths.
- The top of the embankment has a level crest with rounded edges. Therefore, crest width is poorly defined. The crest widens significantly within the northern section of the dam. (Photo 5B).
- A 1966 dam condition report indicates the upstream face of the embankment slopes at 1.5(H):1(V). The downstream face slopes at ± 1.25(H):1(V).
- At least two metal discharge pipes emerge from the downstream face of the dam (Photos 6B through 8B). These pipes were reportedly installed to obtain water from the reservoir at different times of the season (as it was being drawn down). The inlet valves for these pipes reportedly do not function. We observed water flowing from a 3-foot diameter discharge pipe during our visit (Photo 8B). The source of this leakage is not currently known.

- The spillway lies at the northeast end of the dam. The water flows over a small concrete weir (Photo 9B) and down a shotcrete-lined chute (Photo 10B). Near the weir, we noted voids in the shotcrete chute (Photo 11B). Water was flowing into the voids and emerging from beneath the liner downslope at a point where the channels steepens and connects to a concrete-walled channel.
- The walls of the spillway have been braced. However, creep of the slope uphill from the spillway has pushed and tilted the walls (Photo 12B).
- Water from the spillway empties into a rock-strewn ravine (Photo 13B). Further downhill, the ravine becomes steeper.
- A bimrock is exposed in the approximate middle of downslope face the dam (Photo 14B). Photos taken during the original construction show this feature being incorporated into the embankment. It is not currently known if this rock represents an isolated, detached rock fragment or if the base of the bimrock is attached to the underlying sandstone or siltstone. Future exploration will be needed to investigate its nature.
- We did not observe any concentrated seepage emerging from the downstream face of the dam.

OWRD OBSERVATIONS AND PREVIOUS STUDY

The dam was recently inspected by the OWRD. In a letter dated February 1, 2016, OWRD indicated they had changed the hazard rating to high based on dam breach inundation analysis and the presence of homes located downstream of North Bank Chetco Road. As a result of this change, OWRD will now inspect the dam annually.

The 2016 letter included the following observations or comments:

- An unsafe freeboard (±2 feet) was observed at the time of the inspection.
- No signs of recent slope movement of the crest of the dam or the slopes were noted.
- Moderate growth of vegetation was noted in the spillway approach, which could restrict flood flow into the spillway.
- The spillway control section was very narrow and its ability to pass a probable maximum flood was questioned.
- Significant defects were noted in the concrete elements of the spillway.
- Hillside movement and deformation of spillway walls was noted. The possibility of future slope movement compromising the ability of the spillway to pass a flood flow was raised.

- Multiple conduit penetrations through the dam were noted. The possibility was raised that these conduits may be pressurized (since the control valves are located on the downstream end). The letter expressed concern with possible internal erosion and dam failure as a result of leakage from a pressurized system.

In the letter's summary, OWRD described the dam as being in "unsatisfactory condition" and concluded it needed major rehabilitation.

SUBSURFACE CONDITIONS

No field exploration was conducted as part of this scope of work. The condition of the embankment fill and the underlying materials is based on two borings (B-1 and B-2) completed by GRI in 2015. B-1 was drilled in the northern portion of the dam, where the crest widens. B-2 was drilled in the narrower southern portion of the dam. Figure 3A shows the approximate boring locations based on the site map in the GRI report. Copies of the boring logs are included in Appendix C.

Embankment Fill

The borings indicate the embankment fill extends to depths of ±40 feet (at B-1) and ±25 feet (at B-2). The deeper soil extending to 45 feet in B-1 and to ±40 feet in B-2 may also be fill. We anticipate the deepest part of the dam is just south of B-1, within the original alignment of Ferry Creek.

The fill is described as consisting of predominantly silt with varying amounts of clay, sand, gravel, and cobbles. A layer of sandy gravel was encountered in the fill in B-2 from ±14 to 17.5 feet. Standard Penetration Test (SPT) N-values ranging from 7 to 14 blows/foot (bpf) were typically recorded within the fill, with one anomalously high value (28 bpf) recorded in B-2 at ±5 feet. The higher N-values were associated with sampling using a 3-inch diameter sampler.

Very soft fill was reported in B-1 at ±25 feet and in B-2 at ±10 feet. At these depths N-values of 0 were recorded, which indicated the split-spoon sampler sank under the static weight of the drilling rod and hammer.

Natural water contents plotted on the two boring logs typically indicate relatively similar values within the fill, despite variations in the N-values. We surmise the scatter in SPT data is indicative of variable materials and compactive effort, and possibly poor-quality control during placement.

Pieces of wood debris up to ±4 inches long were encountered in B-2 at ±20 feet. Approximately 5 gallons of drilling fluid was lost at that depth, possibly suggesting a layer of concentrated debris.

Colluvium/Landslide Debris

In both boring logs, the embankment fill is underlain by soil described as "colluvium/landslide debris". In B-1, this material consists of stiff clayey silt to silt with some clay extending from ±40 to 45 feet. An N-value of 24 bpf was recorded at the surface of this material.

In B-2, the log indicated colluvium/landslide debris consisting of sandy silt with trace clay and silt with some gravel and sand from ±25 to 40 feet. N-values of 12 to 22 bpf were recorded in this material. Woody debris was reported in B-2 from ±17 to 20 feet.

The logs identify these soils as colluvium/landslide debris. However, we believe at least a portion of the soil described as colluvium/landslide debris in B-2 is fill based on linear interpolation between the ground elevations upstream and downstream of the dam. The soil described as colluvium/landslide debris in B-1 may also be fill, since the 1966 condition report indicated the core area was stripped to bedrock prior to constructing the dam.

Bedrock

In B-1, interbedded sandstone and siltstone was reported from ±45 to 65 feet. The bedrock is characterized as predominantly decomposed to moderately weathered and extremely soft to very soft (R0 to R1). The bedrock contains gravel-sized fragments of medium hard (R3) sandstone. N-values in bedrock ranged from 29 bpf to practical sampling refusal (i.e., N>100 bpf).

From ±65 to 76.5 feet (the maximum drilling depth), the rock is described as extremely soft (R0), decomposed siltstone and extremely soft to very soft (R0 to R1), moderately weathered sandstone and siltstone (Mélange/Dothan Formation). The rock contains gravel-sized fragments of medium hard (R3) sandstone. Cobble to boulder-sized fragments of hard to very hard (R4 to R5) green stone/chert were also noted at ±70 feet. N-values in this rock unit ranged from 13 bpf to practical sampling refusal. The sampling refusal at ±70 feet is apparently due to the presence of the cobble to boulder-sized greenstone/chert rock fragments noted this depth.

Bedrock was encountered in B-2 at a depth of ±40 feet. From ±40 to 49 feet, the bedrock is described as moderately weathered, extremely soft to soft (R0 to R2) siltstone. The siltstone contains gravel-sized fragments of medium hard to hard (R3 to R4) sandstone, which would explain the note of "heavy drill chatter" at ±43 feet.

Extremely soft (R0) decomposed siltstone (Mélange/Dothan Formation) was reported from ±49 to 61.5 feet (the maximum drilling depth). Practical sampling refusal (i.e., N-values > 100) were reported in the upper siltstone formation. N-values below ±49 feet ranged from 29 to 33 bpf. Therefore, there is a distinct difference is bedrock hardness between the two bedrock units. All bedrock units are consistent with the local geologic mapping.

Ground Water Levels

The use of mud-rotary drilling techniques precluded a direct measurement of the water level in the embankment fill. GRI reported free water in the soil samples at depths of ±12.5 feet (in B-1) and at ±14 feet (in B-2). Vibrating wire piezometers (VWP's) were installed in B-1 in the fill at a depth of ±25 feet and in the underlying colluvium/landslide debris at a depth of ±40 feet. A VWP was also installed in B-2 in the colluvium/landslide debris at a depth of ±30 feet.

Measurements in late October 2015 and mid-February 2016 indicated water levels in B-1 ranging from ±10.2 to 12.6 feet (in the upper VWP) and ±21.5 to 21.7 feet (in the deeper VWP). Water levels of ±12.6 to 13.5 feet were recorded in B-2. The reservoir level was reported to be ±3 to 4 feet below the dam crest between September 2015 and February 2016. During the wet season, the reported typical reservoir level was ±3 feet below the dam crest.

AVAILABLE LABORATORY DATA

No laboratory testing was conducted for this portion of the work. Previous laboratory testing was performed by the Oregon State Highway Department, Materials Division in 1961. That work was run on a bulk "sack" sample and a "tube" sample, but there is no description of the sources. The testing was cited in the1966 Rohde report and included an Atterberg limits test, a moisture-density curve, a hydrometer analysis, a sieve analysis, and permeability tests. The same report cites what appears to be a sand cone test and a reported in-place density of 135 pcf (which was discounted by the engineer as being too high).

GRI conducted moisture content tests on samples obtained from the two borings drilled in 2015. They also estimated in-place densities from samples trimmed from Shelby tubes. Those results are summarized in Table 3A of their report. The test results are included in Appendix C of this report for reference.

Two direct shear tests were run on remolded samples of the silt fill obtained in B-1 from depths of ±20 and 28 feet. Copies of those tests are included in Appendix C of this report. The test results indicate an internal friction angle (ϕ) of 28° and a cohesion intercept (c) ranging from ±375 to 500 psf. These are peak values and may not represent the long-term strength of the embankment.

DISCUSSION OF GEOTECHNICAL ISSUES CONCERNING THE EXISTING DAM

Based on our investigation we have identified a number of key geotechnical issues that impact the existing dam as discussed in the following sections.

Penetrations Through Embankment

There are at least two conduits penetrating the existing embankment. One of those appears to be a pressurized system, with control valves on the upstream end. These valves reportedly have not been operated or maintained for many years. Therefore, their condition may be questionable. Some seepage was noted at the outlet end of the larger pipe. We were unable to find any information concerning how the pipes were backfilled or whether any water stops were installed along the conduits.

The presence of multiple penetrations through the existing fill represents a higher risk to the stability of the dam. This is particularly the case where the penetrations are associated with pressurized conduits. Leakage from a pressurized conduit could cause severe internal erosion of the embankment fill, potentially compromising the overall stability of the dam. Leakage can occur under static or seismic loading conditions. Leakage is more likely during a large magnitude, long-duration earthquake, when deformations of the embankment could damage the conduits.

The Condition of the Existing Fill

The condition of the existing embankment fill is described in a previous section of this report and in more detail in the appended boring logs. Concerns with the quality or condition of the existing fill include:

- Very soft layers were noted in the fill in B-1 at ±25 feet and in B-2 at ±10 feet (as indicated by N-values of 0 at those depths). Furthermore, in B-2, an N-value of 5 was recorded at ±20 feet, and a zone of "very soft" soil was also reported at ±30 feet.
- A ±3.5-foot thick layer of loose sandy gravel was noted in the fill in B-2 from ±14 to 17.5 feet.
- The SPT N-values and natural water contents in the fill materials vary with depth.
- Woody debris (up to 4 inches long) and loss of drilling fluid was noted in B-2 at ±20 feet. The loss of circulation during drilling may indicate the presence of voids within the fill.

All of the above conditions imply a variable quality and condition of the embankment fill, possible poor-quality control and/or variable compactive effort during construction, and zones of fill that are potentially susceptible to seepage. Furthermore, zones of soft soil described above represent layers of potential weakness within the embankment fill. These soft materials are particularly susceptible to strain-softening during strong, sustained ground motion.

Presence of an Embedded Rock Feature

Photographs provided to us (apparently taken during the most recent construction of the dam) show the dam was constructed around a large bimrock. As previously discussed, we do not currently know if this feature represents and isolated boulder or if it is connected to the underlying bedrock.

If the bimrock feature is an isolated boulder, apparently it was so large the dam builders did not want to remove it and simply built around it. Additional exploration (described below) will be needed to confirm whether or not this feature is connected to the bedrock. In either case, the presence of this rock feature is unusual for an earthen dam. Furthermore, its behavior relative to the embankment fill during a sustained seismic event is unknown. Our main concern would be with the possible separation of fill around the contact with the rock during strong ground motion. If the dam is to be replaced, we have concluded this feature should be removed before the new dam is constructed.

Presence of Colluvium/Landslide Debris at Base of Dam

Previous studies and analyses of the dam (such as the 1997 Dames & Moore evaluation) assumed the dam was constructed on bedrock. Those studies lacked field explorations. It appears that assumption was based on photographs taken during construction of the dam and on interviews with people familiar with its construction. It is possible the materials were misidentified in the construction photographs or the anecdotal information is incorrect.

The borings by GRI identified a ±5 to 15-foot thick layer of colluvium/landslide debris below the embankment. Organics (described as rootlets, plant matter, and wood debris) reported in B-1 between ±40 and 45 feet is consistent with colluvium/landslide debris. It is possible this material is embankment fill that was misidentified as colluvium/landslide debris. However, that would indicate fill containing organic matter was incorporated into the lower portion of the dam.

The N-values in the layer identified as colluvium/landslide debris indicate the material is medium stiff to stiff. Our main concern with the presence of colluvial or landslide debris is the nature of the contact with the underlying bedrock. If the layer found is truly colluvium, the contact with the bedrock surface is expected to be variable and potentially questionable. This condition may represent a fatal flaw with the existing dam. Any new embankment construction should extend to bedrock so that an intimate contact can be created between the rock and fill.

Spillway Condition

The spillway is located at the northeast end of the dam. Water flowing through the voids in the floor of the spillway is bypassing some of the existing shotcrete and is undermining the floor. On-going creep of the adjacent hillside has also deformed and damaged the concrete spillway walls. Further movement is likely to eventually cause collapse of the walls. In its current condition, the spillway is not adequate to pass a significant flow, let alone a design storm. Therefore, any rehabilitation of the dam would require complete reconstruction of the spillway. Further site reconnaissance and study will be needed to better understand and define the extent of the slope movement adjacent to the existing spillway and determine if it can be stabilized. In the absence of such information, it should be assumed the new spillway should be built on the opposite end of the dam, away from the current slope movement.

PRELIMINARY ANALYSIS OF THE EXISTING DAM

Seismic Design Parameters

Earthquake design parameters for the evaluation of the existing dam and rehabilitation and replacement options were selected using a deterministic approach generally consistent with the FEMA Federal Guidelines for Dam Safety (FEMA, 2005) and the Oregon Dam Safety Rules (OWRD, 2015). OWRD Section 690-020-0038 requires significant hazard dams be evaluated for a 0.2% annual probability of exceedance earthquake. This corresponds to a probability of exceedance of ±5% in 50 years or a return period of ±975 years. The interactive deaggregation tool on the USGS website (USGS, 2014) was used to evaluate the distribution of seismic sources assuming a ±975-year return interval.

The interactive deaggregation indicates the local seismic hazard is dominated by CSZ interface earthquakes with a moment magnitude (M_w) between 8.2 and 9.1. CSZ interface earthquakes represent ±81% of the overall hazard. Crustal earthquakes with M_w values between 6 and 7.5 represent the remainder of the hazard. We selected the M_w 9 CSZ interface earthquake for our analysis due to the high risk associated with this event.

PGA values on bedrock were calculated using most of the same ground motion prediction equations (GMPE's) and weighting used in the development of the USGS 2014 hazard maps. The exception was the updated 2016 version of the BC Hydro GMPE (Abrahamson et al., 2016) was substituted for the 2012 BC Hydro GMPE used in USGS 2014. The 2016 version of the BC Hydro GMPE contains updated data from subduction zone earthquakes in Chile (2010) and Japan (2011) that may better predict a subduction zone earthquake in the Cascadia region. Table 2 summarizes the selected GMPE's and weighting factors.

Table 2. Selected GMPE's and Weighting Factors

GMPE	Weighting Factor
Atkinson and Boore (2003) Global	0.1
Zhao et al. (2006)	0.3
Atkinson and Macias (2009)	0.3
Abrahamson et al. (BC Hydro 2016)	0.3

Mean (50th percentile) and mean plus one standard deviation (84th percentile) peak ground accelerations were calculated. The selected magnitude-distance (M-R) pairs and calculated PGA values on rock and peak horizontal ground surface accelerations ($PHA_{Surface}$) are summarized in Table 3. Due to the shallow bedrock and high PGA values, we assumed the ground amplification would be negligible. Therefore, $PHA_{Surface} = PGA_{Bedrock}$. Future design investigation should consider the seismic response of the dam to the bedrock ground motion.

Table 3. Magnitude, Distance, and PGA and PHA Values for Seismic Analysis

Earthquake Source	M-R Pair	Assumed Depth (km)	Calculated $PGA_{Bedrock}$ (g)	Calculated $PHA_{Surface}$ (g)
CSZ Interface (50th Percentile)	M9, 15 km	20	0.54	0.54
CSZ Interface (84th Percentile)	M9, 15 km	20	1.04	1.04

Existing Dam Cross-Section and Slope Stability Model

A cross-section of the existing dam was created for slope stability analysis based on Detail 2 on Sheet C4 of the preliminary drawings of the dam developed by Civil West (Civil West, 2015b). This drawing is included as Figure 7A. The approximate location of this cross-section is shown on Figure 3A. The Civil West detail provides the approximate shape and slope of the existing dam surface. For the model used in our analysis, the slope was smoothed to approximate the existing dam shown in Figure 8A. The slope of the downstream side of the dam beyond the toe was approximated as 5(H):1(V), based on an average slope of the natural topography of the site along the creek. The crest of the existing dam is at ±El. 392 and was assumed to be ±22 feet wide. The upstream ground elevation (i.e., the bottom of reservoir elevation) was estimated to be at ±El. 354.

Figure 9A shows the dam profile for Cross-Section B-B' which follows the length of the dam (Figure 2A). This figure was developed based on the dam profile shown in Figure 7A and the GRI boring logs. An original ground surface is shown on Figure 9A. This ground surface is based on the plans from 1966. However, based on the conditions in B-2 and the topography upstream and downstream of the dam, it is apparent deep embankment fill extends to the south of this ground line. Therefore, we believe the ground line shown on the 1966 plans represents the ground surface during the reconstruction of a portion of the dam. We plotted an estimated original ground line on Figure 9A based on the logs and linear interpolation between the topographic contours upstream and downstream of the dam.

For slope stability analysis, we developed a subsurface cross-section based on B-1. The B-1 profile was selected because it represents the deeper profile (compared to B-2). The maximum fill depth is expected to be near B-1. The embankment fill was divided into generalized layers based on similar soil descriptions and similar N-values described in boring B-1. The model cross-section includes ±40 feet of fill and ±5 feet of colluvium/landslide debris, underlain by siltstone. The siltstone appears to slope gently towards the upstream side of the dam, which is consistent with the observed site topography. The colluvium layer was modeled with a uniform thickness of 5 feet, following the inclination of the underlying siltstone.

The water level in the reservoir was assumed to be at El. 387 (i.e., ±5 feet below the dam crest). A seepage analysis was not conducted for this preliminary analysis. The ground water table was assumed to run from the upstream face of the dam at El. 387 to the downstream toe of the dam at El. 354, and then follow along the ground surface on the downstream side of the dam.

Soil densities and strength parameters were selected based on the measured N-values, the direct shear tests performed by GRI, and engineering judgement based on our previous experience with similar materials. The assumed parameters are summarized in Table 4 and are also shown on the analysis figures and summary table in Appendix D.

Table 4. Assumed Existing Dam Soil Properties

Material	Soil Property		
	γ (pcf)	ϕ (°)	c (psf)
Existing Fill (EF)	120	28	200
Colluvium (C)	120	30	200
Siltstone (S)	150	40	2000

For each of the analyses in this report, failure surfaces were selected extending at least one-third the way across the crest of the dam to evaluate instability that could lead to dam failure. All FS values presented in this report were calculated using Spencer's Method and a circular failure surface. Block failure surfaces were also checked. The block failure surfaces generally had a higher FS than for the circular failure surfaces.

It should be noted the FS values presented in this report are based on assumed soil strengths correlated to SPT N-values from a limited number of borings. We believe reasonable soil strength parameters were used. However, the actual stability may vary due to the variability of the soil conditions. This information is most useful to provide a general evaluation of the existing dam stability and to provide a basis for evaluating relative improvement for various rehabilitation options.

Static and pseudo static slope stability analyses were completed. For pseudo-static analysis, a design horizontal acceleration (k_h) of one-third to one-half of the estimated $PHA_{Surface}$ is typically used. The reduction accounts for the non-rigid nature of the soil and the fact the peak ground acceleration only exists for a short period of time and does not necessarily align perpendicular to the slope (Kramer, 1996). For the analysis, we used k_h values of 0.27g (one-half of the estimated 50^{th} percentile $PHA_{Surface}$) and 0.52g (one-half of the estimated 84^{th} percentile $PHA_{Surface}$).

Static Slope Stability

Static slope stability analysis for the existing dam was completed using Slide 5.0 software with the cross-section shown on Figure 8A and the subsurface information shown in Figure 9A. The Slide model is shown in Figure 1D (Appendix D). The results indicate a static factor of safety (FS) of 1.13 for the existing dam.

A minimum FS of 1.5 is typically required for static loading conditions at normal reservoir levels. A lower minimum FS of 1.2 is typically required for static loading with reservoir levels corresponding to the probable maximum flood (BLM, 2011). The analysis for the existing dam indicates factors below these minimum values for both of these scenarios.

Seismic Slope Stability

Pseudo-static slope stability analysis was completed using Slide 5.0 to evaluate the seismic stability of the existing dam. The analysis used the same geometry, soil densities, and ϕ values used in the static slope stability analyses described above.

A minimum FS of 1.1 is typically recommended for pseudo-static analysis. For the existing dam configuration with the reservoir at El. 392, the results indicate a minimum FS of 0.72 for 50^{th} percentile ground motions (Figure 2D) and 0.52 for 84^{th} percentile ground motions (Figure 3D). FS values less than 1.0 for seismic loading do not necessarily indicate imminent slope failure but may indicate potential lateral movement. FS values of 0.52 to 0.72 suggest a high risk for large-scale deformation and embankment failure.

Seismic Slope Displacement

Potential slope displacement associated with the design earthquakes was evaluated using the method developed by Bray et al. (2018). This method is based on analyses utilizing a non-linear coupled sliding block model and a database of 810 ground motion records for subduction zone earthquakes having M_w of at least 7.0. Bray et al. (2018) validated the model by comparing the calculated displacements with measured displacements for 12 case histories including 9 earth dams and a coastline slope subjected to subduction zone earthquakes. The calculated displacements compared relatively well to the observed displacements for those case studies.

Input parameters for the analysis include the dam height (H), the yield acceleration of the slope (k_y), the dam's natural period (T_s), the earthquake M_w, and spectral accelerations (S_a) corresponding to a period of $1.5T_s$. The k_y value is based on the pseudo-static slope stability analysis and k_y is the horizontal acceleration corresponding to a FS of 1.0. T_s was calculated as $2.6H/V_s$, where V_s is the average shear wave velocity of the embankment fill. We calculated a range of T_s values assuming V_s values ranging from 600 to 800 ft/s based on our experience with similar materials. The M_w was assumed to be 9 and the S_a values at a period of $1.5T_s$ were calculated based on the CSZ GMPE's and weighting factors summarized in Table 2.

The results of our analyses for the existing dam indicate potential slope displacements ranging from ±2.2 to 10.6 feet for 50th percentile ground motions and potential slope displacements ranging from ±5.8 to 24.8 feet for 84th percentile ground motions. We believe the calculated displacements are reasonable based on the low FS and k_y values calculated from the slope stability analysis.

Seismic Settlement

We completed Swaisgood analysis (Swaisgood, 2003) to estimate the potential seismic settlement of the existing dam. This empirical approach is based on a survey of 70 existing dams subjected to earthquake loading. The primary factors used in the analysis are the dam height, the alluvium thickness beneath the dam, the earthquake magnitude and the peak ground acceleration (PGA) on bedrock. Analyses were completed for a M_w 9 CSZ earthquake. The results for the M_w 9 CSZ earthquake with 50th percentile ground motions indicate ±8 inches of settlement. Swaisgood analysis is not applicable for the 84th percentile ground motions because the PGA is too high.

PRELIMINARY CONCLUSIONS AND DISCUSSION OF MITIGATION OPTIONS

Preliminary Conclusions

OWRD has concluded the existing dam requires significant rehabilitation. This conclusion is consistent with our observations and with the results of our slope stability and displacement analyses, which indicate lower than desirable factors of safety and estimated relatively large displacements. The seismic loading is expected to be the critical condition since the dam has remained in service for decades under static loading conditions. The stability analysis completed to date indicates the existing dam will likely fail under sustained, strong ground motion, which would be typical of a large CSZ earthquake.

Discussion of Potential Mitigation Options

Potential mitigation options considered to date include:

- Do nothing.
- Drain the reservoir and breach or remove the dam.
- Rehabilitate the dam.
- Replace the dam.

These options are discussed below.

Do Nothing

The existing dam has several current problems that have been described above. The dam poses a risk if left in its current condition (i.e., retaining a full reservoir). Therefore, the "do nothing" option does not appear to be viable.

Drain the Reservoir and Breach or Remove the Dam

If the dam is not to be replaced, the existing embankment would have to be drained, breached, or removed. Simply draining the reservoir would probably be the least costly option. However, a provision would be required to pass design flood flows through the outlet structure. Passing the design flood would likely require at least a breach or notch in the existing dam. Alternatively, the dam may be completely removed, which would require a significant amount of earthwork and hauling of the soil to a disposal site. This option would also require the removal of any accumulated sediment in the floor of the reservoir and restoration of the original stream bed.

Rehabilitate the Dam

The option of leaving the existing dam in place and rehabilitating it has been considered in previous studies. This approach would add a rock fill to the exterior upstream and downstream faces of the existing dam in combination with reconstructing the spillway, and extending the existing inlet and outlet works. The rehabilitation would also have to mitigate the risks associated with the conduits that extend through the dam, which may require replacing or decommissioning these structures.

We completed static and seismic analyses using Slide 5.0 software to evaluate the effectiveness of improving the stability of the dam by adding a rock fill to the upstream and downstream slopes. Consistent with the previous studies, we assumed the rock fill would have 2(H):1(V) finished slopes as shown on the Slide model in Figure 4D. The rock fill was assumed to have a moist unit weight of 130 pcf, a ϕ of 42 degrees, and no cohesion. All other parameters remained the same as the cases described in the previous sections.

The results for the rehabilitated dam indicate a FS of 1.45 for static loading. For seismic loading, the results indicate a FS of 0.84 for 50th percentile ground motions (Figure 5D) and 0.59 for 84th percentile ground motions (Figure 6D). We completed displacement analysis for this configuration using the method of Bray et al. (2018). The results indicate potential slope displacements ranging from ±5 to 23 inches for

50^{th} percentile ground motions and potential slope displacements ranging from ±1.7 to 7.5 feet for 84^{th} percentile ground motions.

While the results indicate the addition of rock fill would improve the slope stability, the low seismic FS values are still significantly lower than desirable, and the relatively high estimated displacements are indicative of a high risk for large-scale deformation and embankment failure. Therefore, we have concluded this approach is not feasible for mitigating the slope stability issues.

The presence of the large bimrock that is integrated into the downstream face of the dam is also potentially problematic for dam rehabilitation since its response to ground motion is expected to be different from the surrounding embankment fill, possibly leading to distress at the contact between the bimrock and the adjacent fill.

Based on the analysis completed to date and the other considerations described above, we have concluded rehabilitating the existing dam is not feasible.

CONCEPTUAL CROSS-SECTIONS AND PRELIMINARY ANALYSIS FOR THE REPLACEMENT DAM

Discussion of Replacement Dam Alignment

If the reservoir is to remain in use and/or if it is to be raised to increase storage capacity, it is our opinion replacement of the existing dam is the only feasible option. Relocating the dam downstream is not practical because the slope of the terrain steepens suddenly, and the downstream face of a replacement embankment would have difficulty "catching". Relocating the dam a significant distance upstream also does not appear to be practical without significant reduction in storage capacity.

During our initial site reconnaissance, we discussed potential alignments for a replacement embankment with Keith Mills, P.E. Based on our field observations, there was a consensus that the only viable location for replacing the embankment is close to its present location. However, we discussed a minor readjustment in the alignment to facilitate abutment construction and spillway relocation to the southern end of the dam. That alignment is shown on Figure 10A. It represents a modest rotation of the current alignment, by moving the southwest corner slightly to the north, to take advantage of the existing terrain. With this alignment, the northern end of the dam would remain approximately the same (but the spillway would be eliminated on that side).

The analyses described in subsequent sections of this report are based on the anticipated cross-section at the deepest point in the embankment. As such, slight variations in the dam alignment should not materially change the critical cross-section nor the results of the stability analyses.

Conceptual Cross-Sections for the Replacement Dam

We completed preliminary analysis to evaluate the suitability of reconstructing the dam using on-site and imported materials. Two scenarios were considered including constructing a new dam to match the current crest elevation and constructing a new dam that is 10 feet taller than the existing dam to increase the storage volume of the reservoir. The reservoir water level was assumed to be 5 feet below the dam crest for both options.

For our preliminary analysis, we assumed 2(H):1(V) slopes on the upstream and downstream flanks. These slopes were selected to fit the site geometry as close as practical to the original dam footprint. These slopes are steeper than the 2.5(H):1(V) to 3(H):1(V) slopes typically used for earth dams. We also completed an analysis for a more conventional cross-section with a 3(H):1(V) downstream slope and a 2.5(H):1(V) upstream slope.

For analyses, we assumed most of the existing embankment fill would be re-used for the construction of a low-permeability core. The core would be protected by a shell of imported granular rock fill. A chimney drain or filter zone would be constructed on the downstream side of the core to intercept seepage through the core and reduce the risk of slope instability on the downstream face. Table 5 summarizes the soil parameters assumed for the analysis.

Table 5. Conceptual Replacement Dam Soil Properties

Material	Soil Property		
	γ (pcf)	ϕ (°)	c (psf)
Recompacted Fill	120	32	50
Rock Fill	130	42	0
Siltstone	150	40	2,000

Preliminary Slope Stability and Displacement Analyses for Replacement Dam Options

Slope stability analysis was competed for the conceptual replacement options using Slide 5.0. We evaluated the following configurations:

- Reconstructed dam with current crest elevation (El. 392) and 2(H):1(V) slopes
- Reconstructed dam with the crest raised 10 feet (El. 402) and 2(H):1(V) slopes
- Reconstructed dam with current crest elevation (El. 392) and a 3(H):1(V) downstream slope and a 2.5(H) 1(V) upstream slope
- Reconstructed dam with the crest raised 10 feet (El. 402) and a 3(H):1(V) downstream slope and a 2.5(H) 1(V) upstream slope

Figure 7D shows the Slide model for a replacement option with 2(H):1(V) side slopes and the dam crest matching the current crest elevation. Static analysis for this configuration indicated a FS of ±1.8. Pseudo-static seismic analyses indicated a FS value of ±1.0 for 50^{th} percentile ground motions and a FS value of ±0.7 for 84^{th} percentile ground motions (Figures 8D and 9D).

Figure 10D shows the Slide model for a replacement option with 2(H):1(V) side slopes and the dam crest raised by 10 feet above the current crest elevation. Static analysis for this configuration indicated a FS of ±1.9. Pseudo-static seismic analyses indicated a FS value of ±1.1 for 50^{th} percentile ground motions and a FS value of ±0.7 for 84^{th} percentile ground motions (Figures 11D and 12D).

The results of the analysis indicate dam configurations with 2(H):1(H) slopes would be stable for static conditions. However, the pseudo-static seismic analyses indicate FS values between ±1.0 and 1.1 for 50^{th} percentile ground motions and a FS value of ±0.7 for 84^{th} percentile ground motions. These FS values are at or below the typical 1.0 to 1.1 required for seismic design. The FS values below 1 indicate the dam may not fail during the design seismic event, but there is significant potential for deformation.

We used the method of Bray et al. (2018) to estimate seismic displacements for dam configurations with 2(H):1(H) slopes. We calculated a range of T_s values for the dam assuming V_s values ranging from 800 to 1,500 ft/s for the compacted fill. The results indicate potential slope displacements ranging from ±2 to 8 inches for 50^{th} percentile ground motions and potential slope displacements ranging from ±8 to 37 inches for 84^{th} percentile ground motions.

Figure 13D shows the Slide model for a replacement option with a 3(H):1(V) slope downstream, a 2.5(H):1(V) slope upstream, and the dam crest matching the current crest elevation. Static analysis for this configuration indicated a FS of ±2.7. Pseudo-static seismic analyses indicated a FS value of ±1.3 for 50^{th} percentile ground motions and a FS value of ±0.85 for 84^{th} percentile ground motions (Figures 14D and 15D).

Figure 16D shows the Slide model for a replacement option with a 3(H):1(V) slope downstream, a 2.5(H):1(V) slope upstream, and the dam crest raised by 10 feet above the current crest elevation. Static analysis for this configuration indicated a FS of ±2.75. Pseudo-static seismic analyses indicated a FS value of ±1.35 for 50th percentile ground motions and a FS value of ±0.87 for 84th percentile ground motions (Figures 17D and 18D).

The FS values for both configurations with 2.5(H):1(V) to 3(H):1(V) side slopes satisfy the requirements for static and seismic loading with 50th percentile ground motions. The FS values for 84% ground motions are less than 1, indicating potential for deformation. However, some deformation may be acceptable for this extreme event. Displacement analysis for this configuration using the method of Bray et al. (2018) indicates potential slope displacements ranging from ±1 to 3 inches for 50th percentile ground motions and potential slope displacements ranging from ±3 to 16 inches for 84th percentile ground motions. We believe these displacements should be acceptable.

Table 6 summarizes the results of the analyses for static and seismic loading conditions.

Table 6. Factors of Safety and Estimated Seismic Displacements for Conceptual Earth Dam Replacement Options

Case Description	Loading Condition		
	Static	Seismic - 50th%	Seismic - 84th%
Reconstructed Dam with Current Crest Elevation (El. 392) and 2(H):1(V) Slopes	FS = 1.75 D = n/a	FS = 1.01 D = ±2 to 8 in	FS = 0.71 D = ±8 to 40 in
Reconstructed Dam with Raised Crest (El. 402) and 2(H):1(V) Slopes	FS = 1.89 D = n/a	FS = 1.05 D = ±2 to 7 in	FS = 0.73 D = ±6 to 37 in
Reconstructed Dam with Current Crest Elevation (El. 392) and 3(H):1(V) Downstream Slope and 2.5(H):1(V) Upstream Slope	FS = 2.72 D = n/a	FS = 1.32 D = ±1 to 3 in	FS = 0.85 D = ±3 to 16 in
Reconstructed Dam with Raised Crest (El. 402) and 3(H):1(V) Downstream Slope and 2.5(H):1(V) Upstream Slope	FS = 2.75 D = n/a	FS = 1.35 D = ±1 to 3 in	FS = 0.87 D = ±3 to 15 in

Based on the results of the analyses, we have concluded a new earth dam with a 3(H):1(V) downstream slope and a 2.5(H):1(V) upstream slope would provide adequate performance for static and seismic loading conditions. This configuration is typical for earth dams in seismic environments. Due to the sloping terrain, constructing a dam with these slopes will require shifting the alignment of the dam upstream from its current location, which will reduce the storage capacity of the reservoir.

Material Requirements for the Earth Dam Option

Dyer is preparing a cost estimate for the earth dam replacement option. To assist in this effort, we have developed a conceptual cross-section (Figure 12A) for a new earth dam with a raised crest, a 3(H):1(V) downstream slope and a 2.5(H):1(V) upstream slope. We have also provided preliminary specifications for the various materials needed to construct a new earth dam. Dyer has indicated most of these materials are locally available or can be produced locally. It should be noted the actual type of materials, gradations, and their specifications should be developed as part of the design effort, if replacement with a new earth dam is selected.

Riprap

Riprap would be used to line the outer faces of the slopes. Riprap should consist of 2 to 3-foot minus, angular, sound rock. These maximum sizes of rock correspond to ODOT Class 700 and ODOT Class 2000 rock, respectively. The rock should have all fractured faces and contain no soil or fines (i.e., material passing the standard #200 sieve).

Jaw-Run Rock

Jaw-run rock may be used as a transition material between the rip-rap and the dam core. It should consist of 6 to 8-inch minus, well-graded, sound, crushed quarry rock containing less than 5% fines (i.e., passing the #200 sieve).

Filter/Chimney Material

Filter material used chimney drain material should consist of 2-inch minus, open graded, crushed quarry rock with less than 0.5% fines. We do not recommend the use of rounded gravel as filter material.

Backfill and Bedding Material

Material used for pipe bedding or as structural backfill should consist of 1-inch minus, well-graded, crushed quarry rock or crushed gravel containing less than 5% fines.

CLSM (CDF)

Controlled Low Strength Material (CLSM) or Controlled Density Fill (CDF) should consist of a flowable, sand-cement mixture free of large aggregate. It should have a 7-day unconfined compressive strength of between 200 and 300 psi.

Roller Compacted Concrete Option

An alternative to constructing a new earth dam would be to construct a new roller compacted concrete (RCC) dam. RCC construction involves placing concrete with low moisture content and little or no slump in relatively thin (e.g., 1-foot) layers and compacting each layer using a vibratory roller. The material placement is similar to embankment construction. The RCC is placed in successive horizontal layers (i.e., lifts), which sometimes results in stepped dam slopes resembling a staircase.

RCC concrete mixes use similar materials to conventional Portland Cement concrete (PCC) including cement, pozzolan (e.g., fly ash), coarse aggregate, sand, water, and typical additives. The main difference between conventional concrete mixes and RCC is in the proportion of the materials, with RCC mixes being drier and having little or no slump. Pozzolans are also used in a higher percentage of the cementitious material to reduce heat generation so that concrete lifts can be placed quickly. RCC structures typically provide strengths similar to that of PCC gravity dams, but at a fraction of the cost and with faster placement.

A conceptual cross-section of a typical RCC dam is shown in Figure 12A. This cross-section is for illustrative purposes only and is not intended for design. For this site, the primary advantage to building an RCC dam is an RCC structure would provide comparable seismic stability to an earth dam but with a smaller footprint. The reduced footprint would reduce reservoir volume loss compared to an earth dam. Another benefit is the risk associated with overtopping and internal erosion of RCC dams is less than for earth dams because RCC is inherently more resistant to erosion. With a RCC dam, the spillway can be constructed integrally within the RCC structure.

Construction timing for a RCC dam should be comparable or potentially faster than construction of an earth dam. This is because RCC lifts can be placed almost continuously and with uniform material properties during wet or dry weather. Earth dam construction would be limited to dry weather and may require more sorting and processing to remove unsuitable materials and adjust the soil at its optimum moisture content for compaction.

RCC dams have been constructed around the world since the 1960s and the first RCC dam built in the United States was the Willow Creek Dam in Oregon in 1982. Over the past 40 years, the construction of RCC dams has developed significantly and is now a common approach. ASI Constructors (2011) have compiled a list of over 50 RCC dams constructed in the United States between 1982 and 2011. Based on the ASI data, the average RCC dam is ±120 ft tall, ±1,150 ft long, and contains ±250,000 yd^3 (cubic yards) of concrete. The average cost for the average RCC dam is $23 million with a unit cost of $92/$yd^3$.

In 2015, HDR Engineering Inc. (HDR) completed a seismic evaluation of Big Creek Dam in Newport, Oregon (HDR, 2015). HDR provided replacement options including a new 108-ft tall by 650-foot long earth dam with an estimated cost of $17.8 million or a 100-ft tall by 450-foot long RCC dam with an estimated cost of $19 million. The RCC cost estimate for the Big Creek Dam is comparable to the average cost from the ASI data. However, we understand the entire cost of the Big Creek Dam project is anticipated to increase to $50 to $60 million with the addition of other items including a fish ladder, access roads, and other items.

Based on the size of the Ferry Creek Dam and the typical unit costs, we anticipate construction costs for an RCC dam at Ferry Creek could range from $10 million to $15 million.

CONCLUSIONS

Dam Replacement Options

The results of our preliminary analysis indicate leaving the dam as is or rehabilitating the dam are not viable options due to the high seismic hazard. Therefore, dam replacement is required if the reservoir is to remain in service.

Dam replacement options include constructing a new earth dam with a 3(H):1(V) downstream slope and a 2.5(H):1(V) upstream slope or constructing a new RCC structure. Each of these options has advantages and disadvantages. For an earth dam, the primary advantage is it would allow reuse of most of the existing dam material. The primary disadvantage is the increased size relative to the current dam would require shifting the dam alignment upstream thereby reducing the volume of the reservoir. Also, reuse of existing materials will require extensive processing and moisture-conditioning of these materials. Most of the earthwork will only be possible during the dry summer months.

For the RCC option, the primary advantage is it would allow construction of a dam with a small footprint similar to the existing dam. That would allow construction without loss of reservoir volume. The RCC dam would also be less susceptible to damage from earthquakes and more resistant to erosion. Also, the spillway could be incorporated into the RCC structure and the placement of RCC embankment material could continue year-round. The primary disadvantage is RCC construction would require use of a large volume of imported material and would require the existing embankment materials to be hauled off.

Hillside Slope Stability

While it should be possible to reconstruct a new earth dam or RCC dam that would adequately withstand the design earthquake, it should be understood the stability of the hillsides surrounding the reservoir are also a major consideration. As previously discussed, mapped landslides extend along the entire north shore of the reservoir, as well as along a portion of the west shore, and adjacent to the northeast abutment of the dam (Figure 6A). The current damage to the existing spillway is due to on-going creep of landslide material, providing evidence of current instability under static loading conditions.

We anticipate the landslide risk will be significantly higher during a large CSZ earthquake, given the high ground accelerations and long duration of such an event. Slopes that are currently marginally stable for static conditions (i.e., slopes with a static FS near 1) are unlikely to be stable during a CSZ earthquake. Inactive slides along the reservoir may also be reactivated by precipitation or fluctuations in the reservoir level, although these slope failures would likely be less extensive than earthquake-induced landslides. Landslides occurring close to the dam could cover portions of the dam. Therefore, the spillway and any structures or equipment would need to be installed on the southern portion of the dam to reduce the risk of damaging these structures.

In the event of a long-duration CSZ earthquake, landslides may extend along more than half of the perimeter of the reservoir. Given the proximity of the existing slopes to the reservoir, we anticipate landslide movement would result in debris extending into the reservoir and displacing water. At a minimum, landslide debris extending into the water would reduce the capacity of the reservoir. Depending on the volume of the debris, the reservoir may have to be drained to allow the removal of this material and restore the storage volume.

We believe it is possible the debris from a large landslide (e.g., landslides induced by a CSZ earthquake) could displace enough water to overtop the dam. The overtopping may not lead to dam failure but would likely require some mitigation. Depending on the displaced water volume, flooding due to overtopping may also impact residences downstream.

Mitigation of the landslide hazard is likely to be impractical due to the size of the landslides and the limited access to these slopes. If it were possible to mitigate the landslide hazard, we believe the costs of mitigating the landslide hazard in addition to reconstructing the dam would be prohibitive. Therefore, the risks associated with the landslide hazard will have to be weighed when evaluating the suitability of constructing a new dam at this location. At a minimum, the freeboard of the dam would need to accommodate displacement of the water and the City would have to establish a contingency budget to accommodate draining the reservoir and removing the debris following an earthquake-induced landslide.

RECOMMENDATIONS FOR ADDITIONAL WORK

Additional site investigation and geotechnical work laboratory is needed to evaluate the feasibility of constructing an earth fill dam with the available on-site materials and to evaluate the stability of the adjacent slopes. Key elements of those work items are detailed below.

Surveying and Hydraulic Sounding

An accurate topographic site plan will be required early in the design process. The site survey should include the existing reservoir basin, the area downstream from the dam, and the side slopes above both planned abutments and the spillway. We also recommend the topographic survey extend sufficient far upslope to develop a base map for evaluating the stability for the slopes adjacent to the reservoir. The information can also be used to develop a storage curve for the proposed replacement dam.

A sounding of the reservoir bottom will also be needed prior to final design to evaluate the limits and thickness of any accumulated sediment. That data would provide information for estimating costs for stripping the reservoir bottom.

Geologic Reconnaissance and Preliminary Slope Evaluation

Geologic reconnaissance is needed to evaluate the condition of the slopes at the ends of the dam and along the edges if the reservoir. It is particularly important to evaluate the slope directly uphill of the existing spillway that is currently creeping and the other slopes that are mapped as landslides. The reconnaissance will include mapping of the slopes to identify evidence of current and potential instability. The surface observations along with the survey information will be used to develop a preliminary estimate of the size and depth of the slides.

Following the reconnaissance, preliminary slope stability analysis and slope displacement analysis should be completed for selected locations along the perimeter of the reservoir. The results would be used to evaluate the potential hazard posed by these slopes. If the project is considered feasible following this work, field exploration should follow as described in the following section to better define the slope hazard and to evaluate the existing dam materials.

Field Exploration

Exploration of Hillsides above the Reservoir and Revised Slope Stability Analysis

Exploratory drilling should be completed within the mapped landslide areas along the edges of the reservoir and adjacent to the northeast end of the dam. Inclinometer casings should be installed in these borings to allow for monitoring of ground movement and help evaluate the depth of the on-going creep. Access will need to be developed to these areas or remote access drilling equipment will be required.

The data collected from exploratory drilling will be used to revise the preliminary slope stability analysis. This analysis should be completed before continuing with additional work. Once that analysis is completed, the risk of slope instability should be reviewed with the City to confirm the risk is acceptable for a replacement dam.

Exploration of Existing Dam and Abutments

Additional borings should also be drilled on the existing dam and at the planned abutments. The drilling should extend through the embankment fill and into the underlying bedrock. The borings should be completed using hollow-stem auger drilling through the soil. Drilling should also include rock coring to evaluate the condition of the rock and obtained from the bedrock for subsequent strength tests.

Relatively large samples of the existing embankment fill and underlying colluvium/landslide debris will be needed for laboratory testing to evaluate whether or not the dam can be reconstructed using these materials. Therefore, the hollow-stem auger drilling will have to be supplemented by one or more borings advanced through the embankment using Rotosonic drilling techniques to allow retrieval of continuous, large-diameter samples.

The replacement dam will have to key into the hillside on both sides of the ravine. A series of exploratory test pits should be completed at these locations to evaluate the subsurface conditions at the proposed abutments, locate competent formations into which the new dam can be key into, and supplement the boring information in areas not accessible with conventional drilling equipment.

The connection of the bimrock exposed on the dam to the underlying bedrock should be investigated. We recommend digging a series of test pits at the base of the bimrock to determine if this feature represents a continuous rock formation or a very large, but isolated boulder.

Laboratory Testing

Index tests (natural water content, Atterberg limits, and percent fines) are typically run on soil specimens obtained from the exploratory borings and test pits. These tests help characterize the embankment fill, the colluvium/landslide debris, and the native soils at the abutments. The index tests are also useful in comparing materials from differing portions of the site.

Establishing the compaction characteristics of the existing fill and of the native soils is critical in developing specifications for core construction and for preparation of strength specimens for strength tests. Moisture-density curves should be developed using bulk samples obtained from the abutments (where excavation is expected) and from Rotosonic samples obtained from the existing embankment fill. Strength parameters for stability analyses of the new embankment will have to be obtained from direct shear, triaxial shear, or ring shear tests run on remolded specimens. Flexible wall permeability tests run on remolded specimens will be required to provide parameters for seepage analysis.

During field exploration, core specimens should be obtained from the bedrock underlying the dam site. Analyses completed to date suggest the bedrock is sufficiently strong to support the new embankment dam and critical failure modes do not extend into the bedrock. However, unconfined compression tests should be run on bedrock specimens obtained from various depths to confirm the rock strength and for use in the overall stability analyses.

We have assumed suppliers of planned imported fill will provide the typical test results for their materials (e.g., gradation, soundness, etc.). It is anticipated presumptive strength parameters (i.e., angle internal friction) will be assumed for these materials in the slope stability analysis since they are typically too coarse for conventional laboratory testing.

Geotechnical Analysis

A variety of analyses will be required for the final design of the new replacement dam. Those analyses will likely include:

- Evaluation of inclinometer data and stability analysis for slopes above the reservoir, in particular, for the slope along the northeast side of the existing dam and along the north shore of the reservoir. If the dam crest is raised, impacts on the existing side slopes of the ravine will also have to be evaluated. Provisions for slope stabilization may be required, depending on the results of the slope evaluation.
- Bearing capacity of the foundation materials beneath the dam
- Embankment settlement
- Sliding analysis
- Seepage analysis
- Slope stability for static and seismic conditions
- Deformation analysis for seismic loading

Hydraulic Analysis and Spillway Design

Design of the primary spillway will require hydrologic and hydraulic analyses (by others) to establish its dimensions and geometry. Hydrologic analysis of the watershed will also be required to establish the storage-volume curve and storm event flows for spillway design and to size the emergency outlet discharge pipe.

Materials Reconnaissance

If earth dam construction is selected, several types of imported materials will be required for construction in addition to the on-site materials. The imported materials would include:

- Riprap to provide erosion protection at the spillway outfall

- Large quarry rock for construction of the outer shells
- Crushed rock for the filter material for a chimney drain or transition zone
- Crushed rock backfill for planned structures
- Specially-graded granular fill for construct filter collars around conduits
- CLSM for use as bedding material for conduits or at locations where a hydraulic barrier is required

Potential sources, production capacities, and haul distances for the above materials should be researched as the basis for selecting imported fill and for specifying materials for construction.

VARIATION OF SUBSURFACE CONDITIONS, USE OF THIS REPORT AND WARRANTY

The analyses, conclusions and preliminary recommendations contained herein assume the site conditions observed during our reconnaissance and subsurface conditions encountered in previous borings (by others) are representative of the overall condition of the dam. It should be clearly understood that the reliability of the analyses and associated conclusions are based on assumptions that require future confirmation. None of the cross-sections or material recommendations are intended for final design or construction. If the existing dam is to be replaced, additional geotechnical analysis and design, and design of other key elements will be required as part of final design. The anticipated scope of that additional geotechnical work is described within this report.

This report was prepared for the exclusive use of Dyer Partnership Engineers & Planners, Inc., the City of Brooking and design consultants for the evaluation of the Ferry Creek Dam in Brookings, Oregon. Information contained herein should not be used for other sites or for unanticipated construction without our written consent. This report is intended for preliminary planning. Contractors using this information to estimate construction quantities or costs do so at their own risk.

Our services do not include any survey or assessment of potential surface contamination or contamination of the soil or ground water by hazardous or toxic materials. We assume those services, if needed, have been completed by others. We will assume no responsibility or liability for any engineering judgment, analysis or design performed by others.

Our work was done in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

We trust this information satisfies your current needs. Please contact us with any questions or if we can be of further assistance.

Attachments

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Appendix A

Figures

Professional
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Foundation Engineering, Inc.

Note: Base map obtained from Pickatrail.com.

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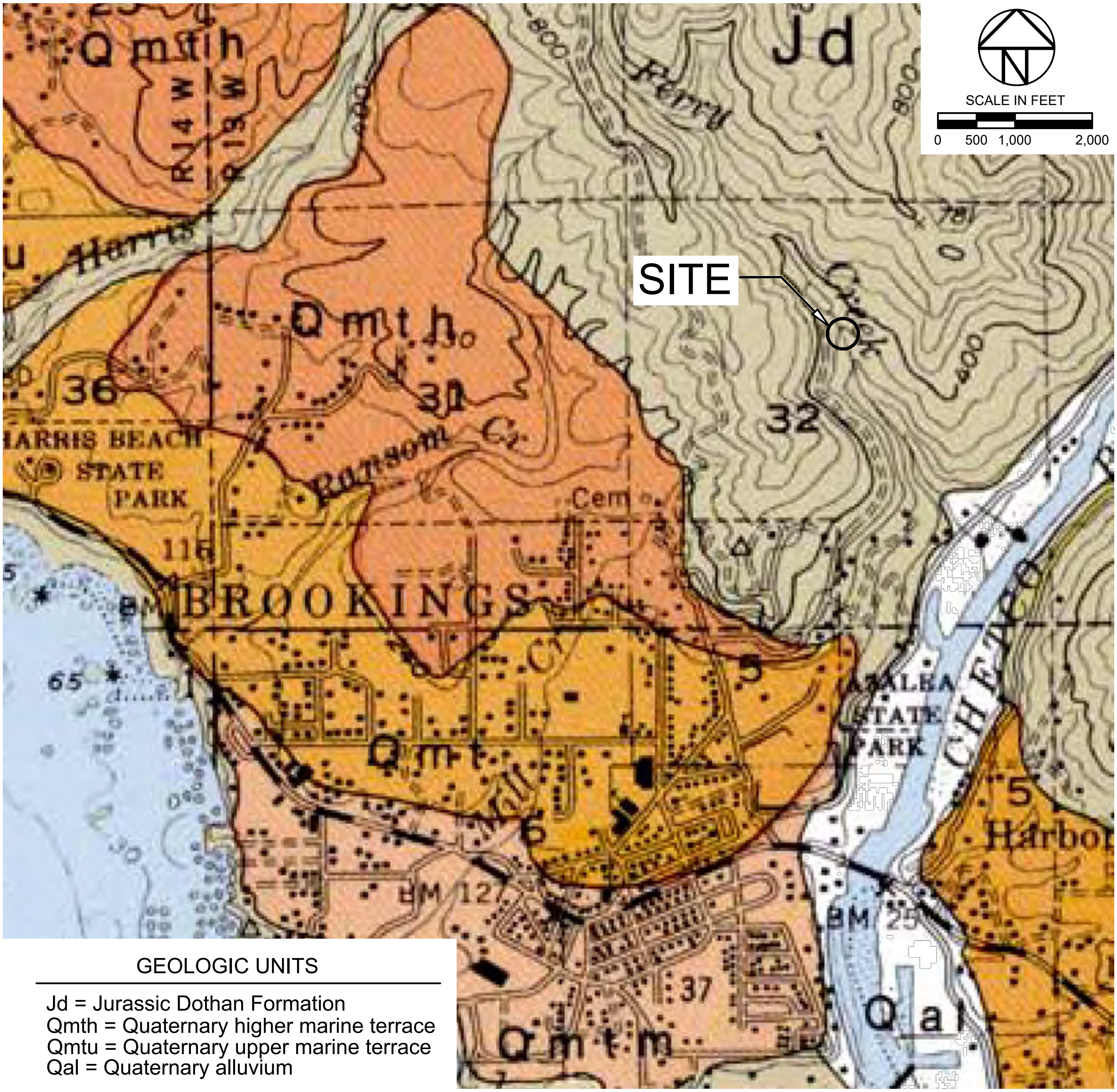
VICINITY MAP

FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
1A

FILE NAME: FIG 1A



Note: Portion of geologic map obtained from Cape Ferrelo Quadrangle, Beaulieu and Hughes, 1976.

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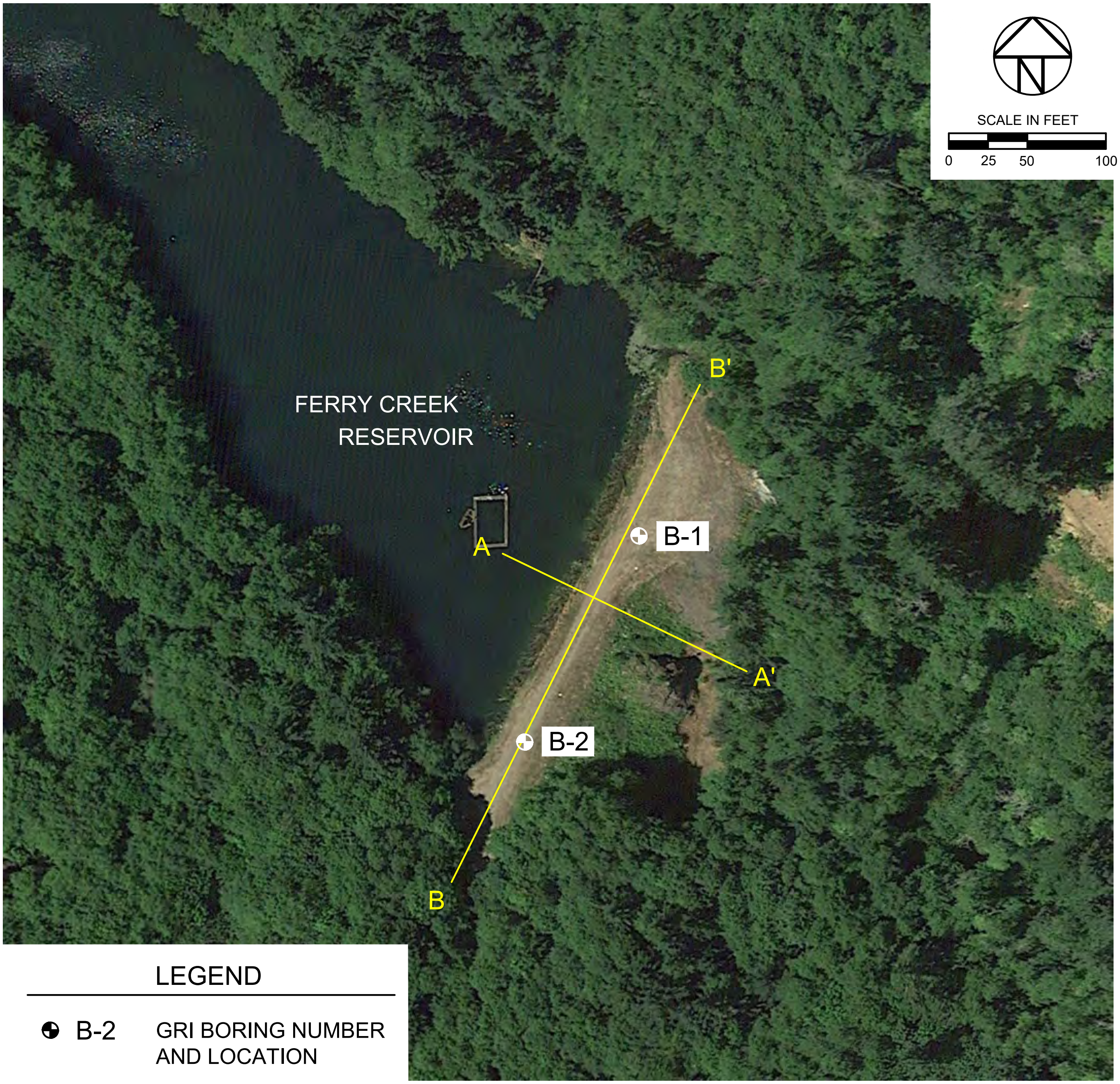
LOCAL GEOLOGIC MAP

FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
2A

FILE NAME: FIG 2A



LEGEND

B-2 GRI BORING NUMBER AND LOCATION

NOTES:
1. BORING LOCATIONS WERE ESTIMATED BASED ON LOCATIONS SHOWN IN GRI'S PRELIMINARY GEOTECHNICAL INVESTIGATION AND DATA REPORT DATED MARCH 21, 2016, AND ARE APPROXIMATE.
2. AERIAL IMAGE OBTAINED FROM GOOGLE EARTH.
3. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.

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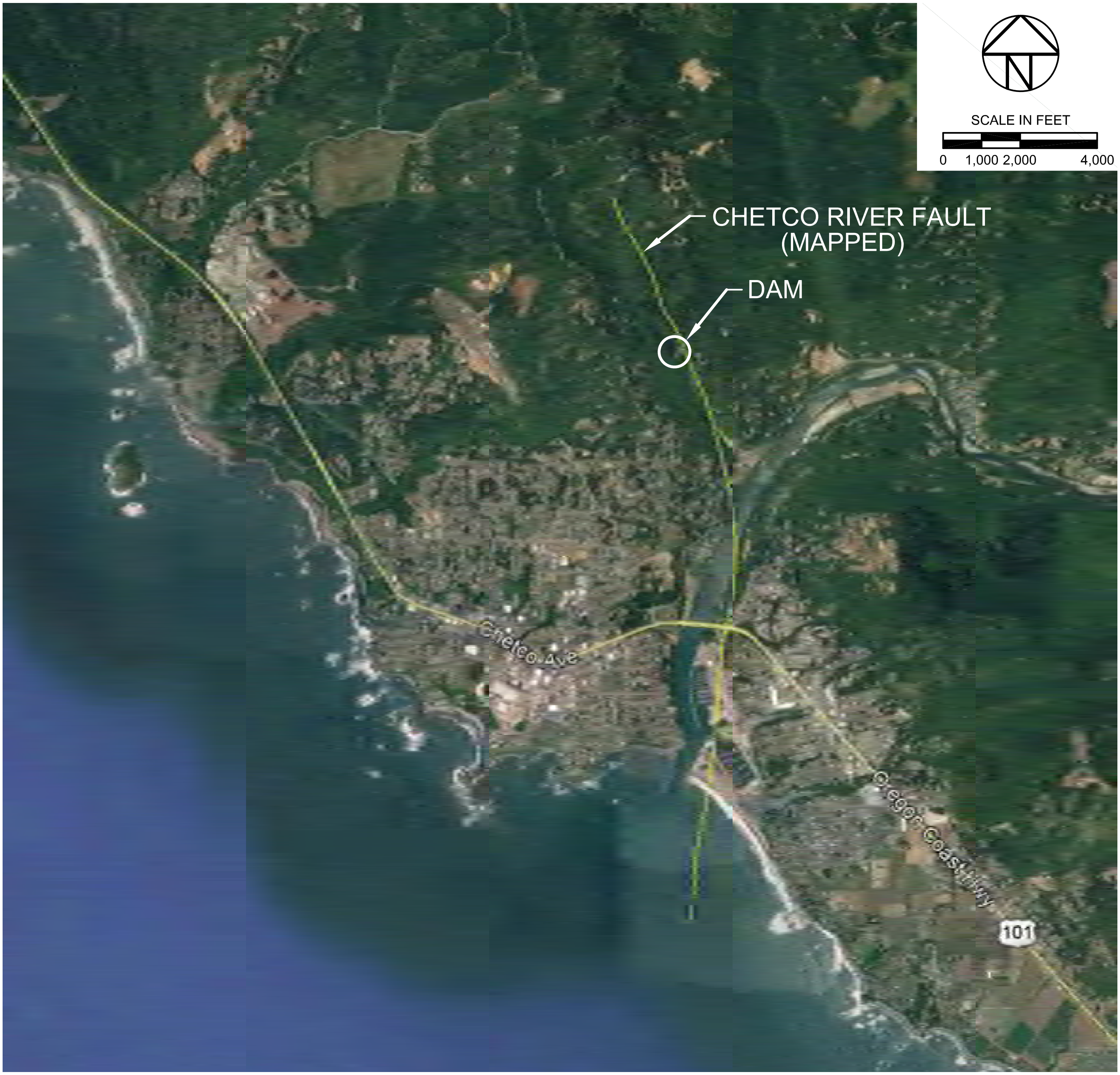
SITE LAYOUT, BORING AND CROSS-SECTION LOCATIONS
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
3A

FILE NAME: FIG 3A



Notes:
1. Aerial image obtained from Google Earth.
2. Fault location based on USGS, 2006a and Kelsey and Bockheim, 1994.

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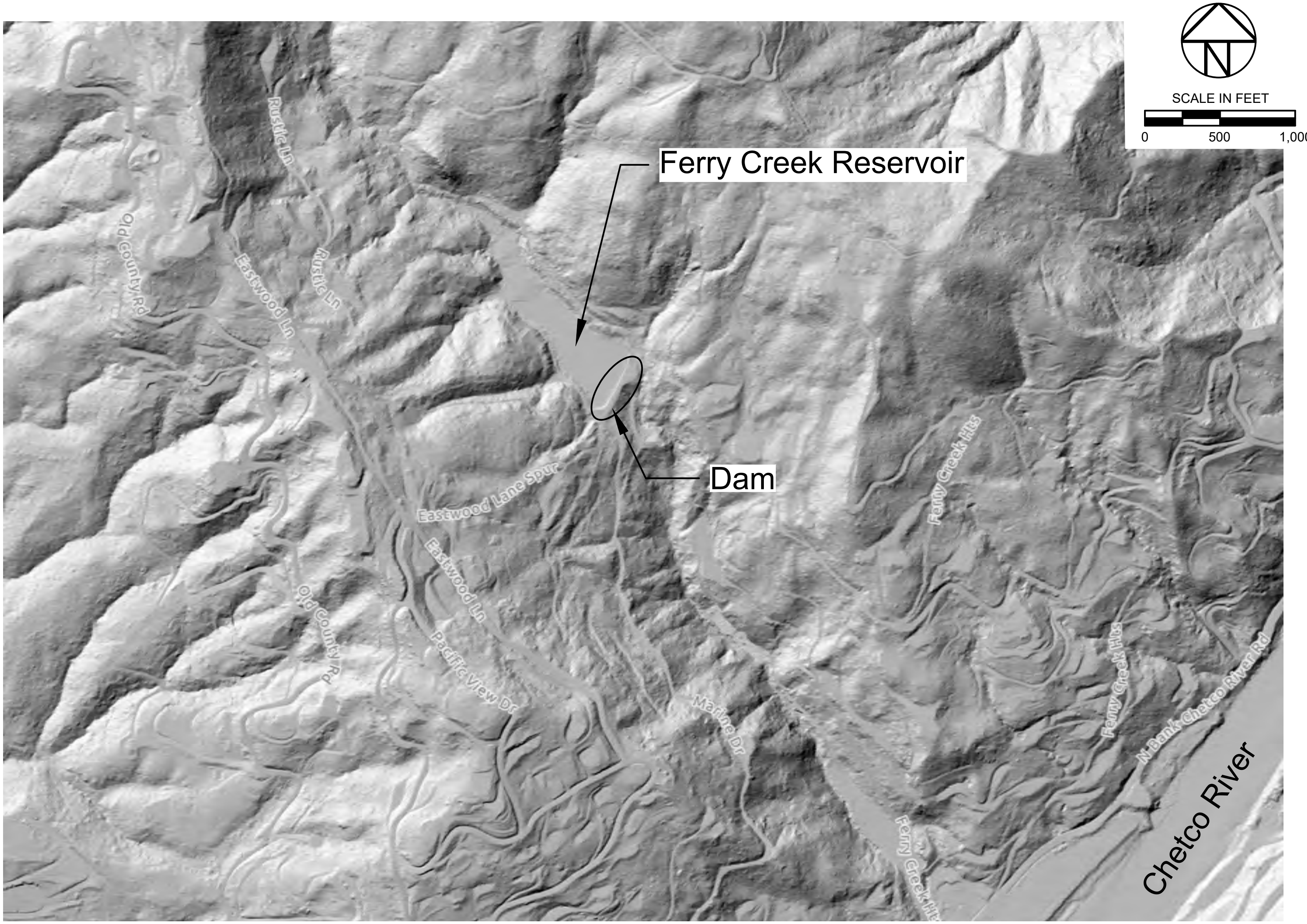
APPROXIMATE MAPPED LOCATION OF CHETCO RIVER FAULT
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
4A

FILE NAME: FIG 4A



Note: LiDAR Image obtained from the DOGAMI Hazvu website http://gis.dogami.oregon.gov/hazvu/ (DOGAMI, 2018)

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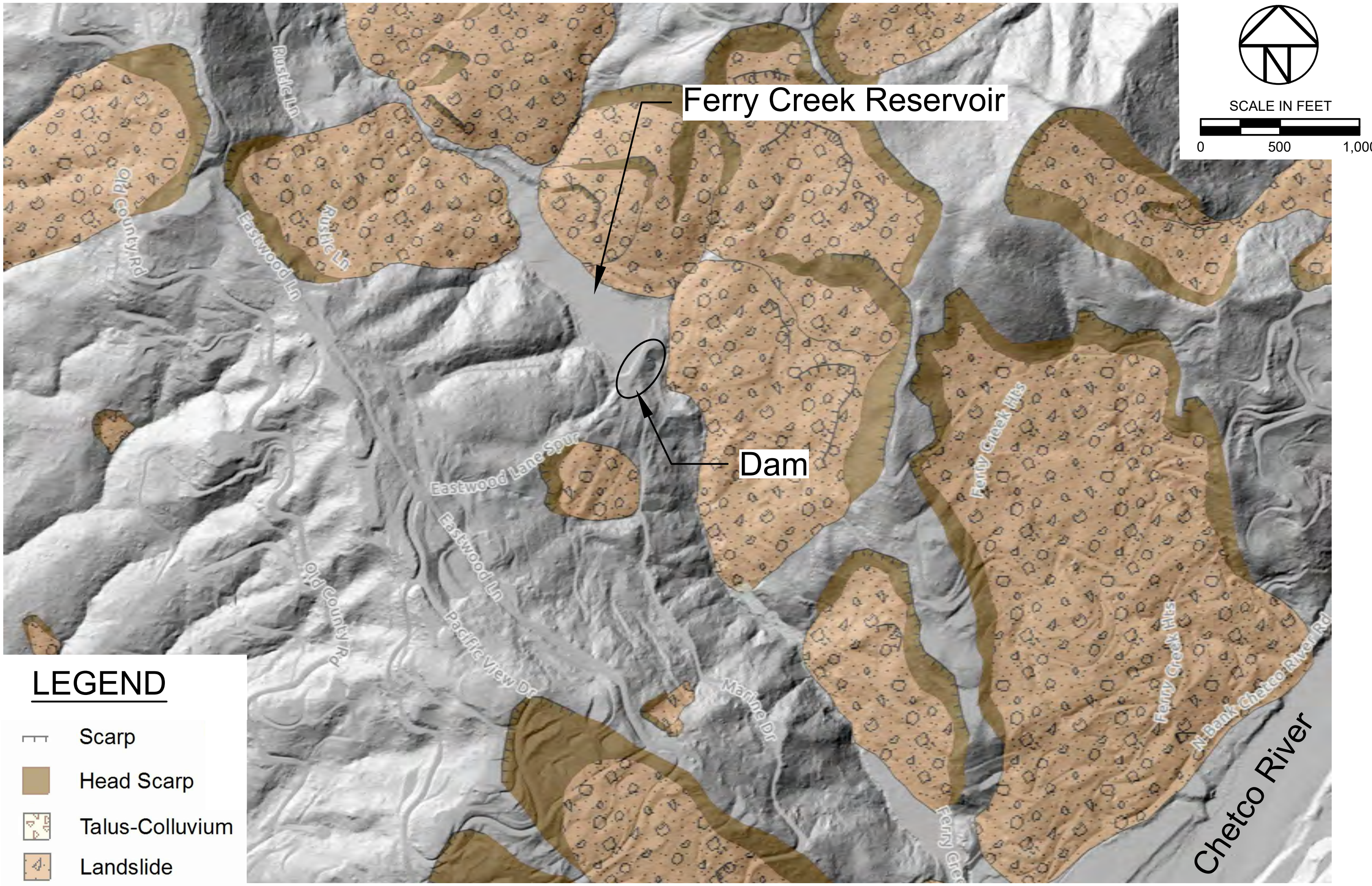
DOGAMI LIDAR IMAGE

FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
5A

FILE NAME:FIG 5A



Note: LiDAR Image and landslide inventory obtained from the DOGAMI Hazvu website http://gis.dogami.oregon.gov/hazvu/ (DOGAMI, 2018)

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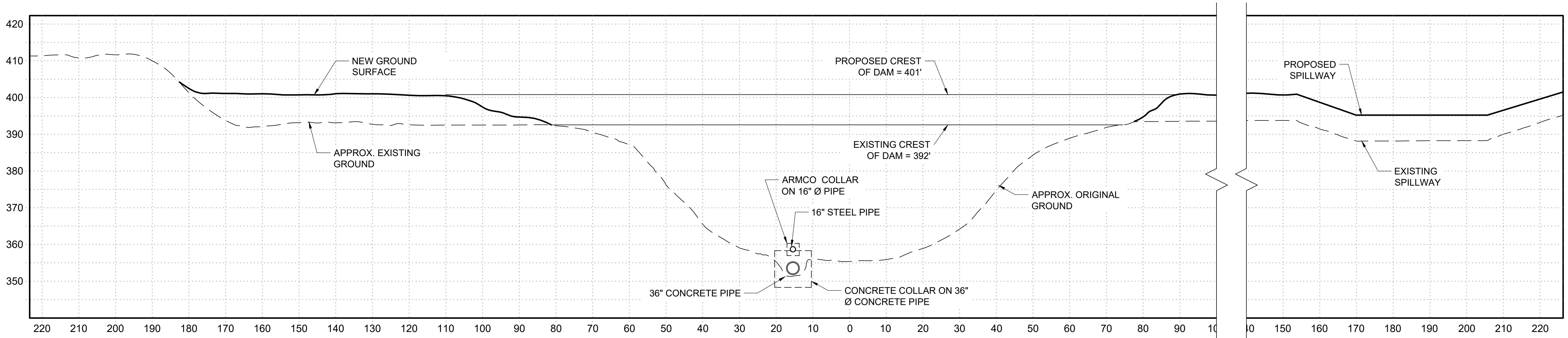
LANDSLIDE INVENTORY MAP

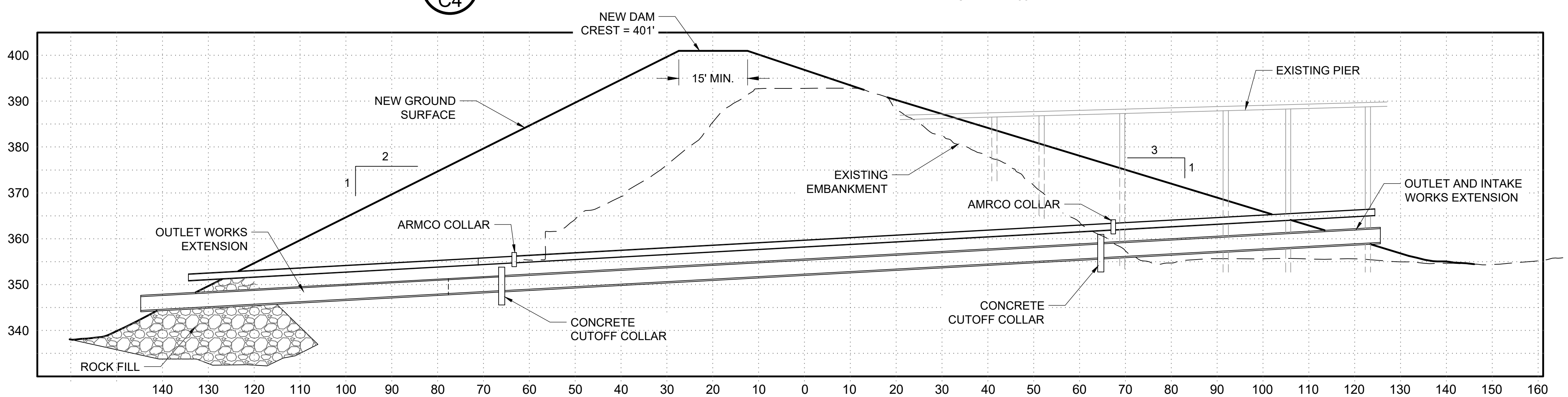
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
6A

FILE NAME:FIG 6A



1 C4 EXISTING DAM PROFILE
SCALE: 1" = 30'



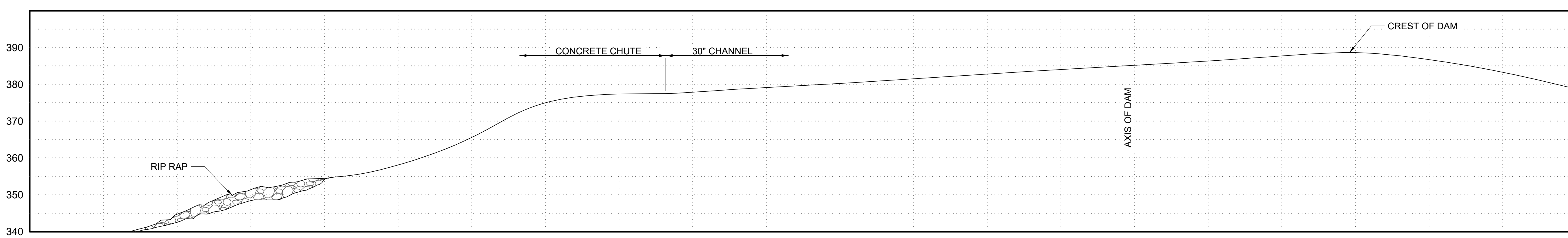
2 C4 EXISTING DAM CROSS SECTION
SCALE: 1" = 30'

SHEET NOTES

1. THE PRO□ILE, SECTION, AND DETAIL DRA□INGS ON THIS SHEET □ERE CREATED AS A REPRODUCTION O□ DRA□INGS ORIGINALLY PREPARED □Y CARL ROHDE, CONSULTING ENGINEER, IN 1□□□ □OR THE CITY O□ □ROO□INGS. ACTUAL CONDITIONS AT THE □AN□US DAM AND SPILL□AY MAY □ARY □ROM CONDITIONS SHO□N IN THESE DRA□INGS.

GENERAL NOTES

1. THESE DRAWINGS CONVEY SCHEMATIC LEVEL DESIGNS ONLY, AND ARE THUS PRELIMINARY IN NATURE. THESE DRAWINGS ARE NOT TO BE USED FOR CONSTRUCTION. FINAL LAYOUT, EARTHWORK, PIPE SIZING, PUMP STATION DESIGN, ETC. ARE TO BE DETERMINED AS A PART OF THE FINAL DESIGN PHASE.
2. PROPERTY BOUNDARIES, RIGHT OF WAY LINES, TOPOGRAPHY, RIVERS & STREAMS, AND EXISTING SYSTEM FEATURES SUCH AS PIPES, RESERVOIRS, AND PUMP STATIONS, ARE BASED OFF OF DATA FROM MULTIPLE SOURCES PROVIDED BY THE CITY TO CIVIL WEST ENGINEERING. THESE DATA REPRESENT WORK COMPLETED IN PREVIOUS PROJECTS FROM YEARS AGO, AS WELL AS GIS MAPPING DATA FROM THE CITY.



3 C4 SPILLWAY PROFILE @ CENTERLINE
SCALE: 1" = 30'

Figure 7A

PRELIMINARY

Civil West Engineering Services, Inc.
486 E Street
Coos Bay, Oregon 97420
541-266-8601
www.civilwest.com

REV.	DATE	DESCRIPTION	BY

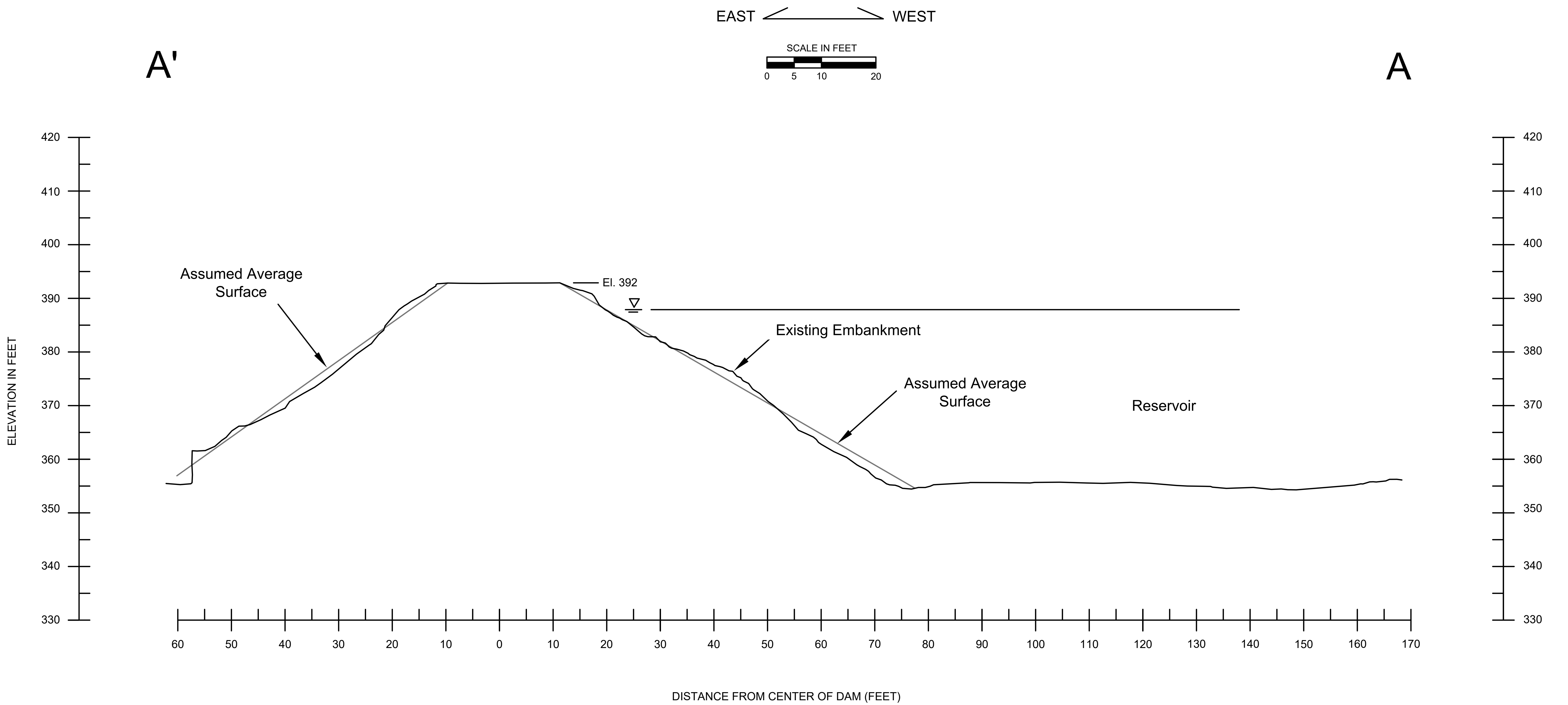
Designed By: ALF
Drawn By: ALF
Checked By: MLG
Project No: 1103-003

CITY OF BROOKINGS
CURRY COUNTY, OREGON

REDUNDANT WATER SUPPLY PLAN

BANKUS DAM PROFILE

Sheet No. C4
Date SEPT 2015



NOTES:
1. EXISTING GROUND SURFACE BASED ON CIVIL WEST ENGINEERING SERVICES, INC. FIGURE C4 (SEE FIGURE 7A).
2. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.

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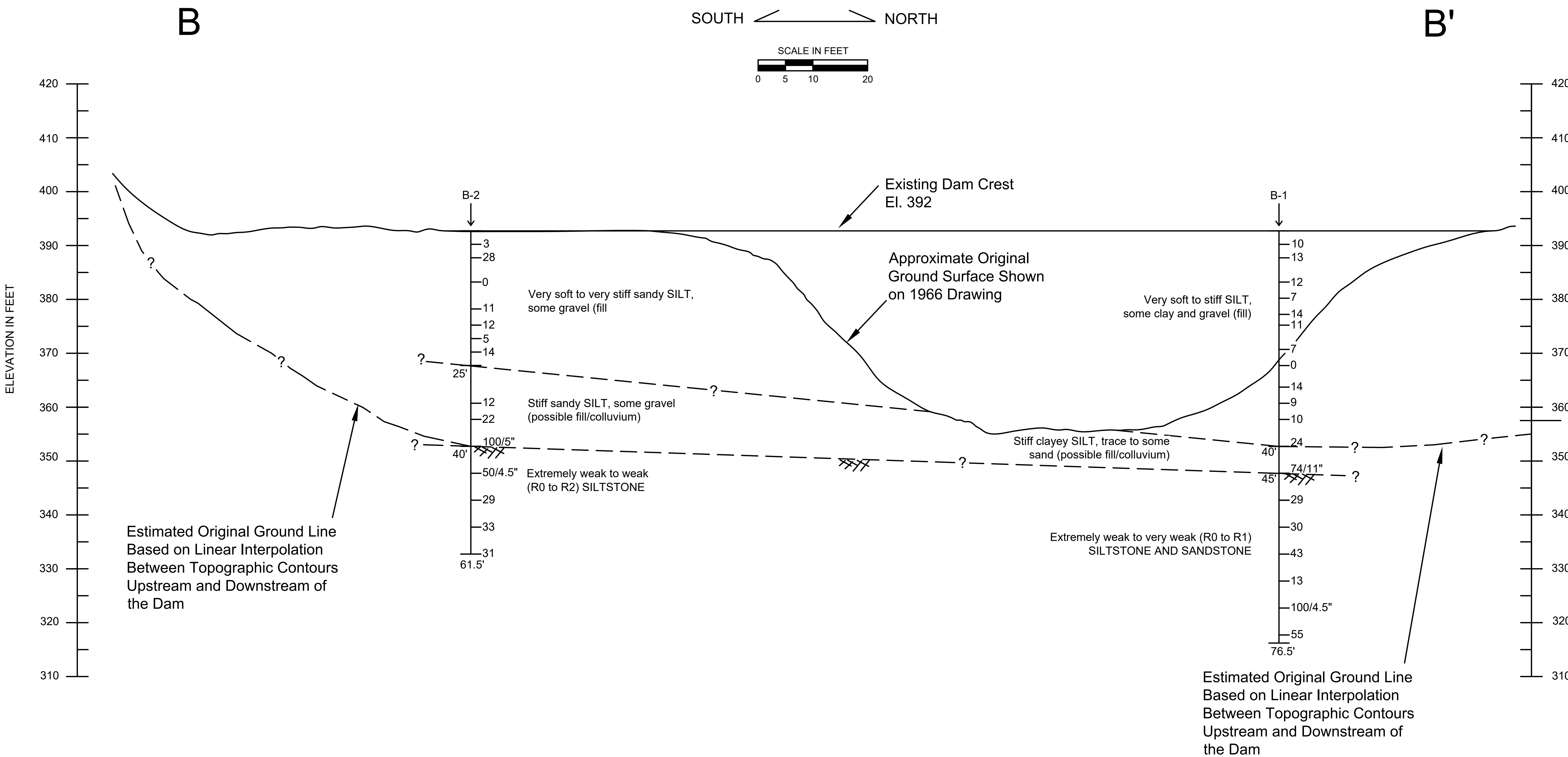
EXISTING DAM SURFACE PROFILE
CROSS-SECTION A-A'
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
8A

FILE NAME:FIG 8A



NOTES:
1. EXISTING AND ORIGINAL GROUND SURFACES BASED ON CIVIL WEST ENGINEERING SERVICES, INC. FIGURE C4 (SEE FIGURE 7A).
2. SUBSURFACE PROFILES BASED ON BORINGS BY GRI (SEE APPENDIX C).
3. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.

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SURFACE AND SUBSURFACE CONDITIONS
CROSS-SECTION B-B'
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
9A

FILE NAME:FIG 9A

Note: Aerial image obtained from Google Earth.

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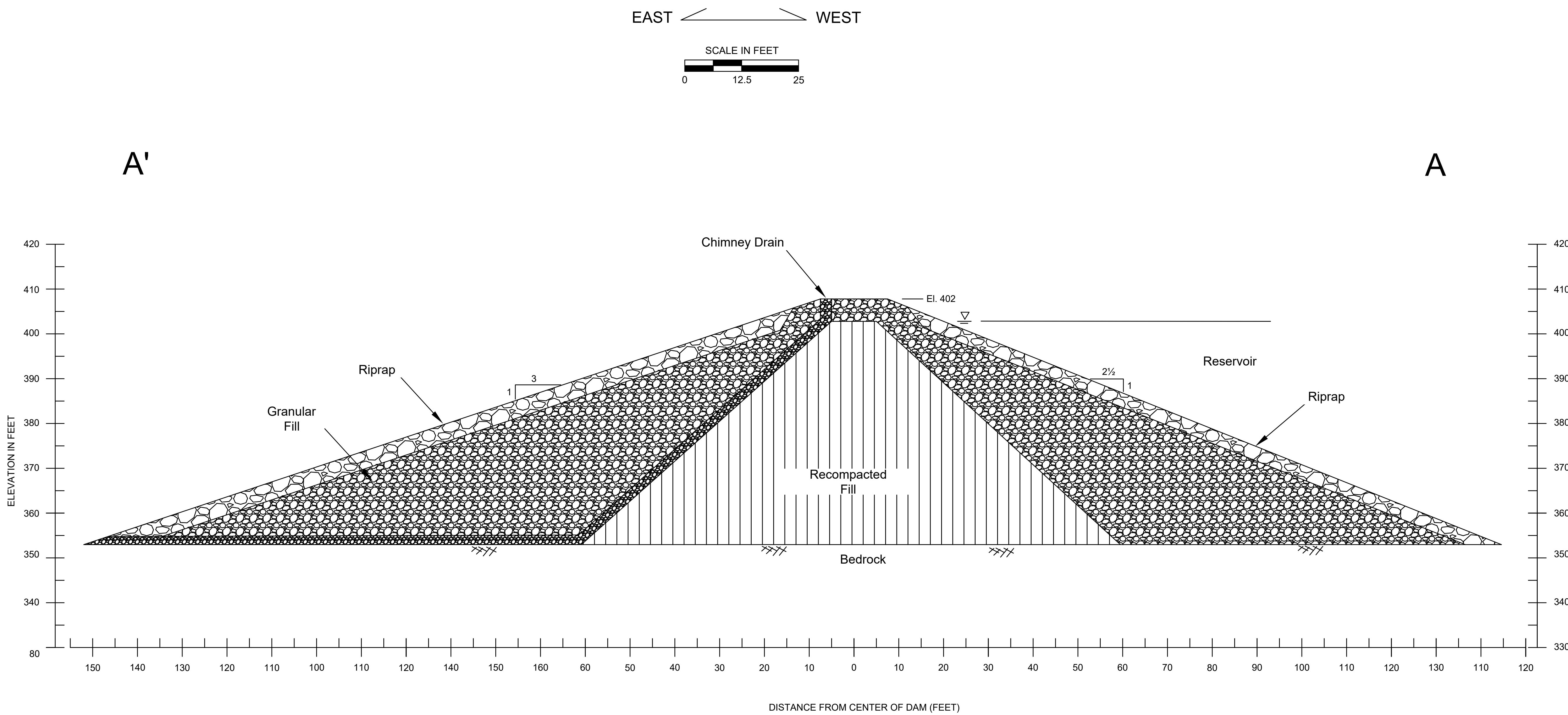
PROPOSED DAM REALIGNMENT

FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
10A

FILE NAME: FIG 10A



NOTES:
1. DAM CONFIGURATION IS CONCEPTUAL AND FOR PRELIMINARY EVALUATION ONLY.
2. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.

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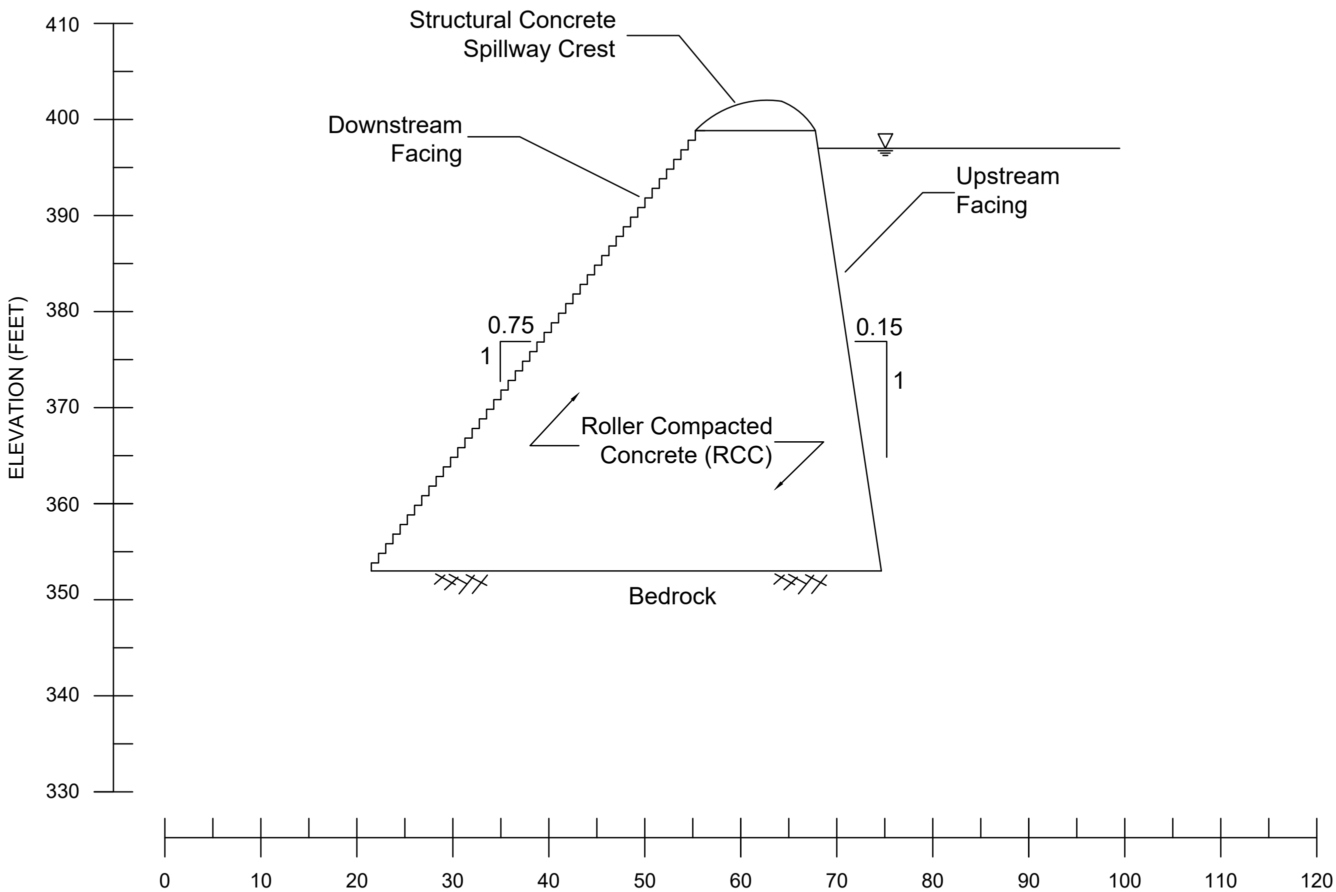
CONCEPTUAL REPLACEMENT EARTH DAM
WITH CREST ELEV. RAISED 10 FEET
FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
11A

FILE NAME:FIG 11A



NOTE:
DAM CROSS SECTION IS CONCEPTUAL AND ONLY FOR THE PURPOSE OF ILLUSTRATING A TYPICAL ROLLER COMPACTED CONCRETE DAM CROSS SECTION. IT IS NOT TO BE USED FOR DESIGN PURPOSES.

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CONCEPTUAL RCC DAM CROSS-SECTION

FERRY CREEK DAM
CURRY COUNTY, OREGON

FIGURE NO.
12A

FILE NAME: FIG 12A

Appendix B

Photographs

Professional
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Services

Foundation Engineering, Inc.

Photo 1B. View of the dam crest looking northeast from the southern end.

Photo 2B. View of the dam crest looking southwest from the northern end.

Photo 3B. View of the reservoir looking northwest from the south half of the dam.

Photo 4B. View of the reservoir looking northwest from the north half of the dam.

Photo 5B. View of the widened crest section looking southwest.

Photo 6B. Pipe exposed on the downstream face of the dam.

Photo 7B. Pipe exposed on the downstream face of dam.

Photo 8B. Water flowing from the discharge pipe at the toe of the dam.

Photo 9B. Concrete weir at the spillway.

Photo 10B. Shotcrete chute below the weir looking southeast.

Photo 11B. Voids in shotcrete chute

Photo 12B. Tilting and braced spillway walls looking southeast.

Photo 13B. Ravine below the spillway looking southeast.

Photo 14B. Bimrock feature exposed on the downstream face of dam looking west.

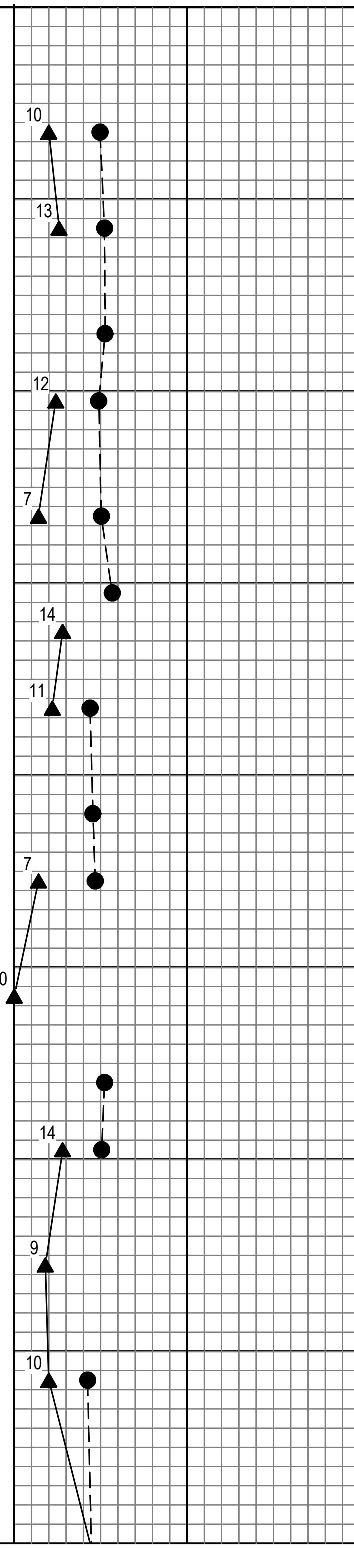
Appendix C

Boring Logs and Laboratory Test Results (From GRI Report)

Professional Geotechnical Services

Foundation Engineering, Inc.

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	▲ BLOWS PER FOOT ● MOISTURE CONTENT, % □ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS
		Surface Elevation: Not Available							
		SILT, some clay and gravel, trace sand, brown to dark brown, and dark gray, stiff, moist (Fill)							Drill chatter below 2 ft
					S-1		4 4 6	10	
5		---some sand, moist to wet at 5 ft ---dark gray at 5.5 ft			S-2		4 5 8	13	
		---trace gravel and sand below 7.5 ft			S-3				Dry Density = 101 pcf
10		---some sand to sandy, trace clay, orange-brown to brown, contains gravel-sized fragments of black mudstone below 10 ft			S-4		2 5 7	12	10.2 ft (10/22/16) (B-1, P-1)
		---trace to some clay, medium stiff, wet below 12.5 ft			S-5		2 3 4	7	12.6 ft (02/19/16) (B-1, P-1)
15		---some gravel and cobbles, stiff below 15.5 ft			S-6				
					S-7		12 8 6	14	Drill chatter on cobbles between 15.5 to 17.5 ft
					S-8		2 6 5	11	
20		---medium stiff, cobbles absent at 20 ft			S-9				Dry Density = 107 pcf 21.5 ft (2/19/16) 21.7 ft (10/22/16) (B-1, P-2)
					S-10		5 3 4	7	
25		---very soft at 25 ft		P	S-11		0 0 0	0	Set Piezometer B-1_P-1 at 25 ft: SN1502451
		---contains cobbles at 27 ft			S-12				
		---stiff at 29 ft							
30					S-13		8 10 4	14	
		Gravelly SILT, trace sand and clay, orange-brown to gray, stiff, wet (Fill)	32.0		S-14		5 6 3	9	
35		Clayey SILT, some gravel, orange-brown, medium stiff, moist to wet (Fill)	35.0		S-15		5 5 5	10	
40									



(CONTINUED NEXT PAGE)

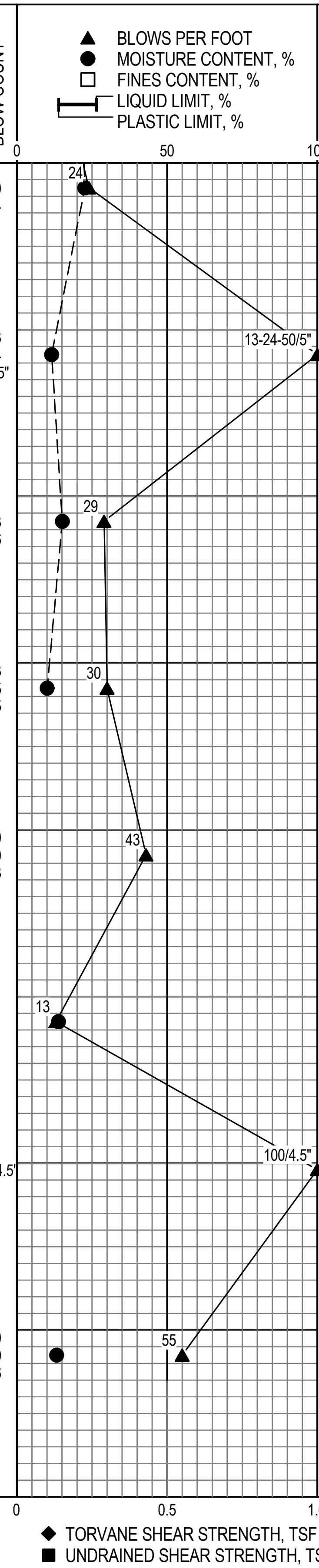
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: C. Ell	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 9/9/15	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** CME 75 HT Truck-Mounted Drill Rig **Hole Diameter:** 4.5 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** 80%
Note: See Legend for Explanation of Symbols	

GRI

BORING B-1

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	INSTALLATION	SAMPLE NO.	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Surface Elevation: Not Available					
	Clayey SILT to SILT, some clay, trace to some sand, some gravel, gray to green-gray, stiff, wet, contains organics including rootlets, plant matter, and woody debris (Colluvium/Landslide Debris),	40.0	P	S-16	6 10 14	Set Piezometer B-1_P-2 at 40 ft: SN1502578
45	SANDSTONE and SILTSTONE, gray, predominantly decomposed, extremely soft to very soft (R0 to R1), very close fracture spacing, moist to wet contains gravel-sized fragments of medium hard (R3) sandstone.	45.0		S-17	13 24 50/5"	
50	SILTSTONE, gray to brown to red-brown, decomposed, extremely soft to very soft (R0 to R1), very close fracture spacing, moist contains gravel-sized fragments of medium hard (R3) sandstone	50.0		S-18	7 13 16	Driller notes rock is not coreable and has interlayers of soft to hard material. Intermittent drill chatter observed between 50 and 55 ft.
55	SANDSTONE, light brown, predominantly decomposed to moderately weathered, extremely soft to very soft (R0 to R1), very close fracture spacing, wet, contains gravel-sized fragments of medium hard (R3) sandstone	55.0		S-19	13 15 15	Material is consistency of silty to sandy gravel between 55 ft and 65 ft
60	---green-gray, moderately weathered to slightly weathered, very soft (R1), contains gravel-sized fragments of medium hard to hard (R3 to R4) sandstone below 60 ft			S-20	20 20 23	Heavy drill chatter between 62 and 63 ft Driller notes soft zone between 63 and 65 ft
65	SILTSTONE, dark gray, decomposed, extremely soft (R0), very close fracture spacing, moist, contains gravel-sized fragments of medium hard (R3) sandstone (Mélange/Dothan Formation)	65.0		S-21	2 5 8	
70	---contains cobble- to boulder-sized fragments of hard to very hard (R4 to R5) greenstone/chert below 70 ft			S-22	100/4.5"	
75	SANDSTONE AND SILTSTONE, gray to green-gray, moderately weathered to slightly weathered, extremely soft to very soft (R0 to R1), very close fracture spacing, moist to wet, contains gravel-sized fragments of medium hard (R3) sandstone (Mélange/Dothan Formation)	75.0 / 76.5		S-23	30 29 26	
80	(9/10/2015)					



5526 T14 BORING LOG GRI DATA TEMPLATE.GDT 3/21/16

GRI

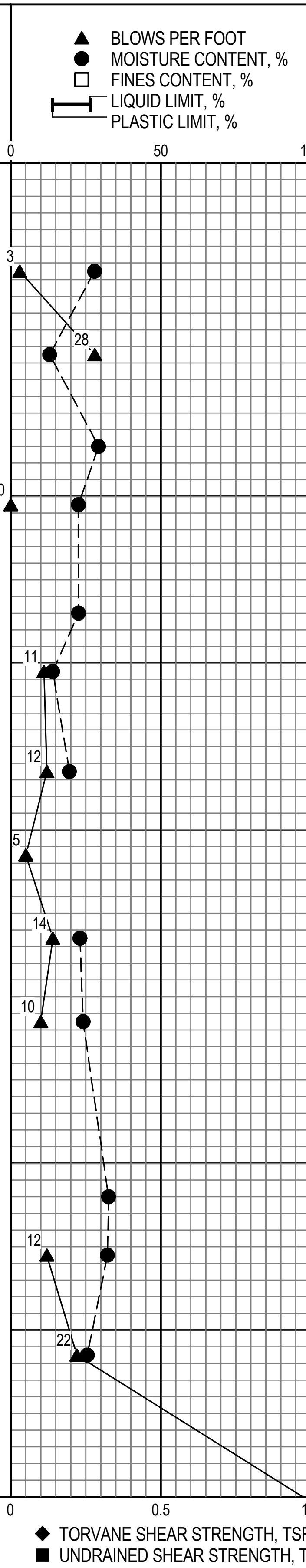
BORING B-1

MAR. 2016 JOB NO. 5526 TASK 14 FIG. 1A

BORING B-2

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
0	Sandy SILT, some gravel, trace sand, red-brown, brown, and gray, soft, moist (Fill)		S-1	1, 2, 1	
5	---very stiff at 5 ft		S-2	17, 18, 10	
			S-3		Dry Density = 92 pcf
10	---trace gravel, very soft at 10 ft		S-4	0, 0, 0	
					(B-2. P-1) 12.6 ft (10/22/16)
			S-5		13.5 ft (2/19/16))7 pcf (B-2, P-1)
15	Sandy GRAVEL, trace to some silt, brown to gray, loose, wet, rounded (Fill)	14.0	S-6	1, 4, 7	
	SILT, some sand, trace to some gravel, trace clay, green-brown, brown, orange-brown, gray, and dark gray, medium stiff, wet, contains up to 4-in.-long pieces of wood debris (Fill)	17.5	S-7	6, 4, 8	
20	---gravelly at 20 ft		S-8	0, 0, 5	Lost 5 gal. of drilling fluid at 20 ft
	---some gravel, trace sand at 22.5 ft		S-9	4, 7, 7	
25	Sandy SILT, trace to some gravel, trace clay, brown, green-brown, gray, stiff, wet, angular gravel (Colluvium/Landslide Debris)	25.0	S-10	3, 3, 7	Drill chatter between 25 and 30 ft
					Driller notes more sand in cuttings from 28 to 30 ft
30	---very soft at 30 ft				
	SILT, some gravel to gravelly, some sand, brown, gray, black, red-brown, medium stiff, wet, angular gravel (Colluvium/Landslide Debris)	31.0	S-11		Set Piezometer B-2-P-1 at 30 ft: SN1502450
			S-12	3, 5, 7	
35	---stiff at 35 ft		S-13	5, 12, 10	
40					



(CONTINUED NEXT PAGE)

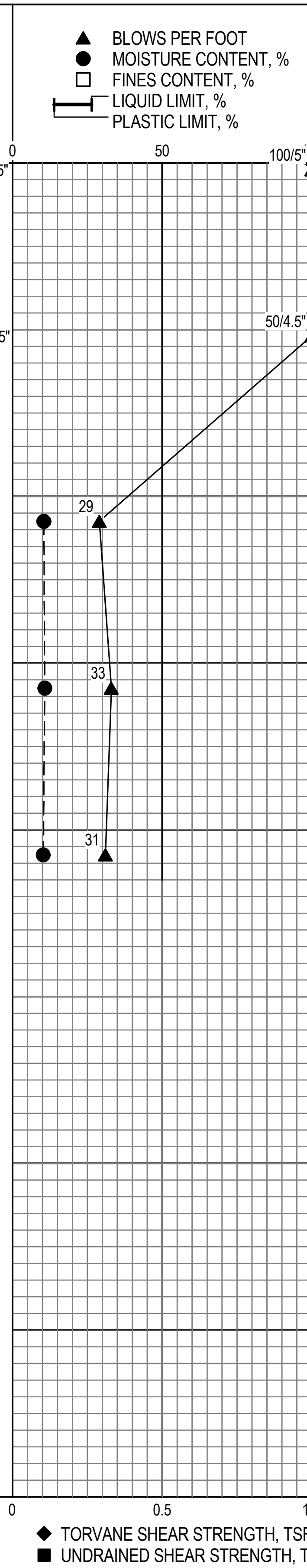
Logged By: C. Ell	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 9/10/15	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** CME 75 HT Truck-Mounted Drill Rig **Hole Diameter:** 4.5 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** 80%
Note: See Legend for Explanation of Symbols	

GRI

BORING B-2

MAR. 2016 JOB NO. 5526 TASK 14 FIG. 2A

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Surface Elevation: Not Available				
	SILTSTONE, light brown, moderately weathered, very soft to soft (R1 to R2), very close fracture spacing with dark brown staining on surfaces, wet, contains gravel-sized fragments of medium hard to hard (R3 to R4) sandstone	40.0	S-14	100/5"	Heavy drill chatter at 43 ft
45			S-15	50/4.5"	
	---extremely soft to soft (R0 to R1) at 46.5 ft				Driller notes soft zone at 46.5 ft
	SILTSTONE, dark gray, decomposed, extremely soft (R0), very close fracture spacing, wet (Mélange/Dothan Formation)	49.0			
50			S-16	4 10 19	
55	---predominantly decomposed at 55 ft		S-17	9 14 19	
60			S-18	11 14 17	
	(9/10/2015)	61.5			
65					
70					
75					
80					



5526 T14 BORING LOG GRI DATA TEMPLATE.GDT 3/21/16

GRI

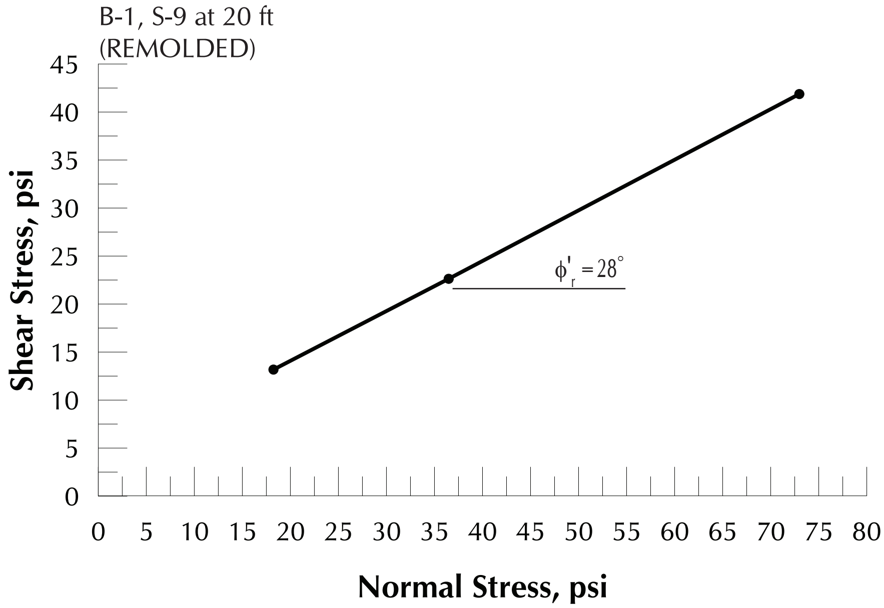
BORING B-2

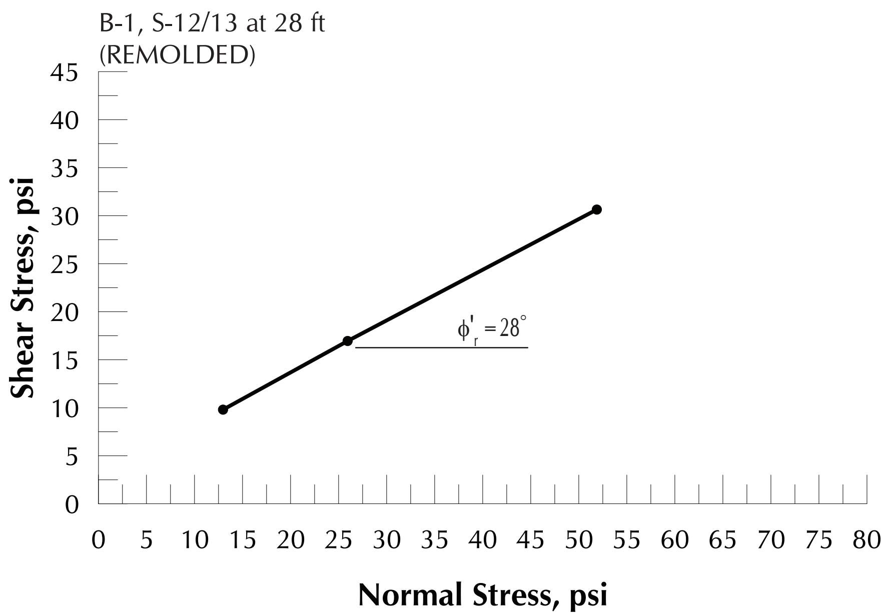
MAR. 2016 JOB NO. 5526 TASK 14 FIG. 2A

Table 3A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
B-1	S-1	2.5	–	25	–	–	–	–	FILL
	S-2	5.0	–	26	–	–	–	–	FILL
	S-3	7.5	–	26	101	–	–	–	FILL
	S-4	9.5	–	24	–	–	–	–	FILL
	S-5	12.5	–	25	–	–	–	–	FILL
	S-6	15.0	–	28	–	–	–	–	FILL
	S-8	17.5	–	22	–	–	–	–	FILL
	S-9	20.0	–	23	107	–	–	–	FILL
	S-10	22.0	–	23	–	–	–	–	FILL
	S-12	27.0	–	26	–	–	–	–	FILL
	S-13	29.0	–	25	–	–	–	–	FILL
	S-15	35.0	–	21	–	–	–	–	FILL
	S-16	40.0	–	23	–	–	–	–	Clayey SILT
	S-17	45.0	–	12	–	–	–	–	SANDSTONE
	S-18	50.0	–	15	–	–	–	–	SILTSTONE
	S-19	55.0	–	10	–	–	–	–	SANDSTONE
	S-21	65.0	–	14	–	–	–	–	SILTSTONE
	S-23	75.0	–	13	–	–	–	–	SANDSTONE
B-2	S-1	2.5	–	28	–	–	–	–	FILL
	S-2	5.0	–	13	–	–	–	–	FILL
	S-3	7.5	–	29	92	–	–	–	FILL
	S-4	9.5	–	23	–	–	–	–	FILL
	S-5	12.5	–	23	107	–	–	–	FILL
	S-6	14.5	–	14	–	–	–	–	FILL
	S-7	17.5	–	20	–	–	–	–	FILL
	S-9	22.5	–	23	–	–	–	–	FILL
	S-10	25.0	–	24	–	–	–	–	Sandy SILT
	S-11	30.0	–	33	–	–	–	–	Sandy SILT
	S-12	32.0	–	32	–	–	–	–	SILT
	S-13	35.0	–	25	–	–	–	–	SILT
	S-16	50.0	–	10	–	–	–	–	SILTSTONE
	S-17	55.0	–	11	–	–	–	–	SILTSTONE
	S-18	60.0	–	10	–	–	–	–	SILTSTONE





ϕ'_r = PEAK ANGLE OF INTERNAL FRICTION OF A REMOLDED SAMPLE

GRI

DIRECT SHEAR TEST RESULTS

Appendix D

Engineering Analyses

Professional
Geotechnical
Services

Foundation Engineering, Inc.

SLOPE STABILITY AND DISPLACEMENT EVALUATION SUMMARY

Existing dam with the crest at El. 392 and reservoir at El. 387 (Assumed average reservoir Level)

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	1.13	1D	n/a	n/a	n/a	
Seismic (mean)	0.72	2D	26	57	128	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.06g
Seismic (mean +1σ)	0.52	3D	69	298	143	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.06g

Rehabilitated dam with the crest at El. 392, reservoir at El. 387, and a 2:1(H:V) rock fill upstream and downstream

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	1.45	4D	n/a	n/a	n/a	
Seismic (mean)	0.84	5D	5	10	23	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.17g
Seismic (mean +1σ)	0.59	6D	20	42	90	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.17g

Reconstructed dam with the crest at El. 392, reservoir at El. 387, and a 2:1(H:V) rock fill upstream and downstream

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	1.75	7D	n/a	n/a	n/a	
Seismic (mean)	1.01	8D	2	4	8	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.27g
Seismic (mean +1σ)	0.71	9D	8	18	40	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.27g

Reconstructed dam with the crest raised to El. 402, reservoir at El. 397, and a 2:1(H:V) rock fill upstream and downstream

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	1.89	10D	n/a	n/a	n/a	
Seismic (mean)	1.05	11D	2	3	7	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.29g
Seismic (mean +1σ)	0.73	12D	6	15	37	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.29g

Reconstructed dam with the crest at El. 392, reservoir at El. 387, and a 3:1(H:V) downstream and 2.5:1(H:V) upstream rock fill

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	2.72	13D	n/a	n/a	n/a	
Seismic (mean)	1.32	14D	1	1	3	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.41g
Seismic (mean +1σ)	0.85	15D	3	7	16	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.41g

Reconstructed dam with the crest at El. 402, reservoir at El. 397, and a 3:1(H:V) downstream and 2.5:1(H:V) upstream rock fill

Loading Condition	Slope Stability		Estimated Displacement (inches)			
	FS	Figure	Min.	Median	Max.	
Static	2.75	16D	n/a	n/a	n/a	
Seismic (mean)	1.35	17D	1	1	3	PGA_{Rock} = 0.54g, $PGA_{surface}$ = 0.54g, k_h = 0.27g, k_y= 0.42g
Seismic (mean +1σ)	0.87	18D	3	7	15	PGA_{Rock} = 1.04g, $PGA_{surface}$ = 1.04g, k_h = 0.52g, k_y = 0.42g

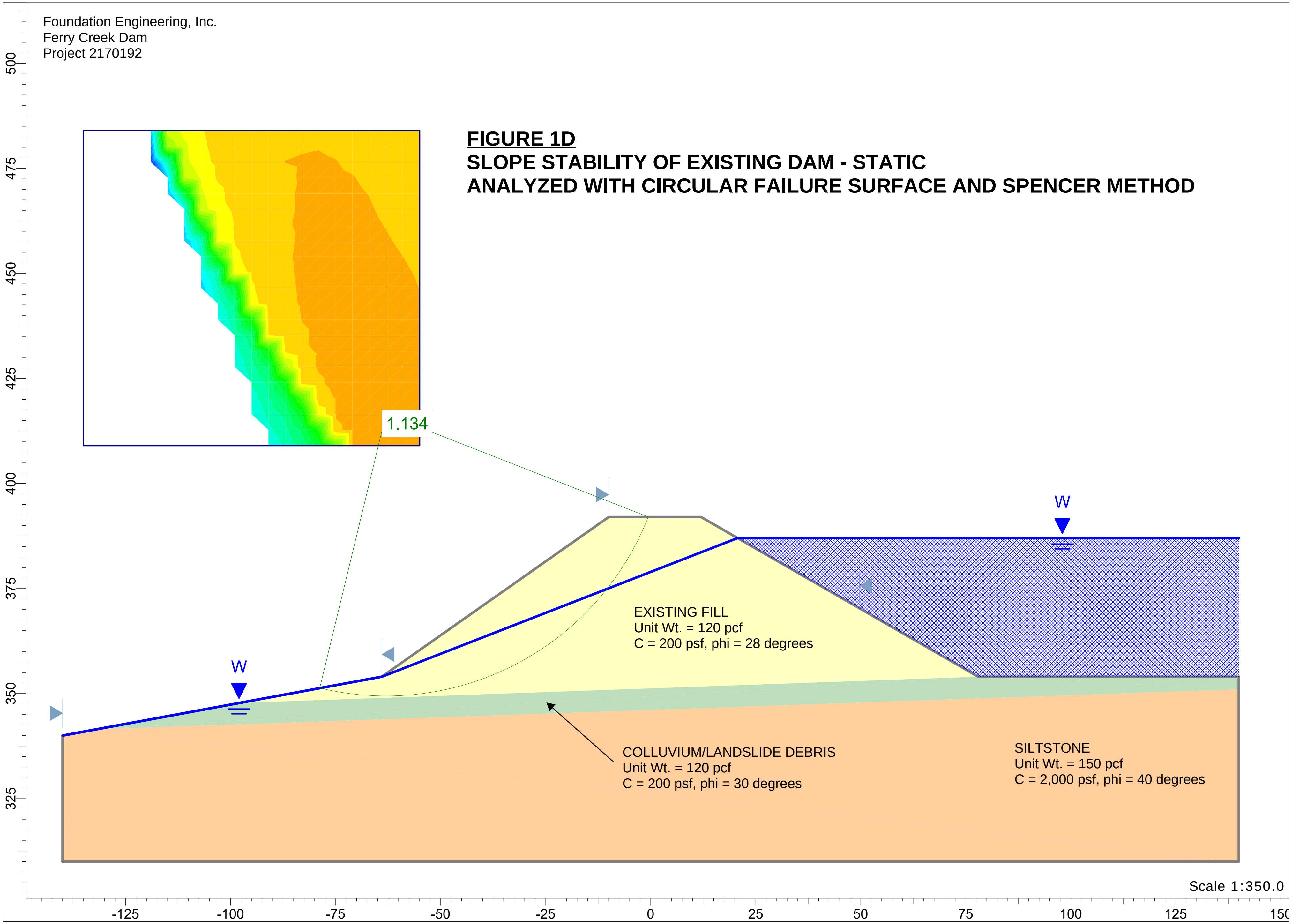


FIGURE 1D
SLOPE STABILITY OF EXISTING DAM - STATIC
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD

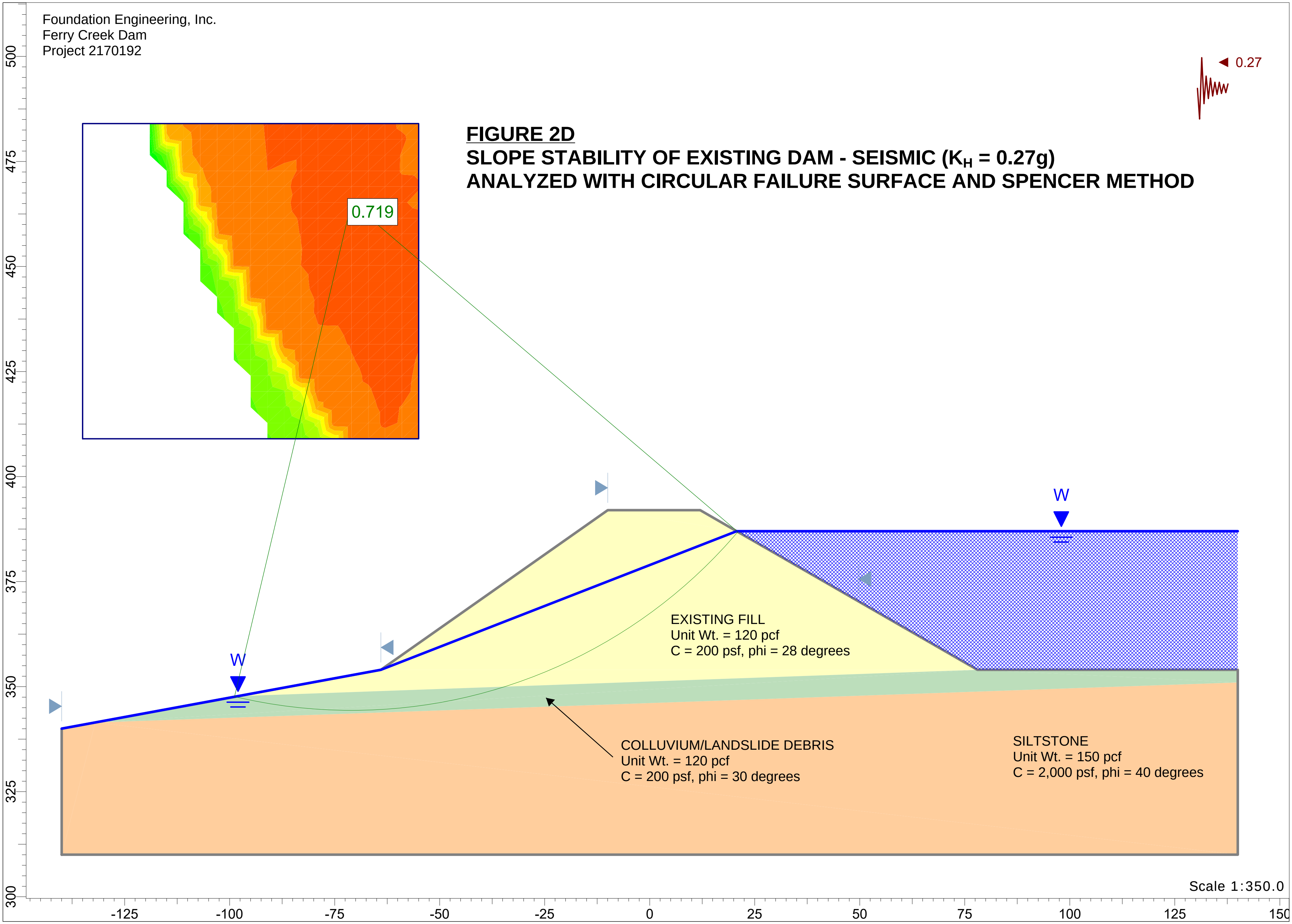


FIGURE 2D

SLOPE STABILITY OF EXISTING DAM - SEISMIC (K_H = 0.27g)

ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD

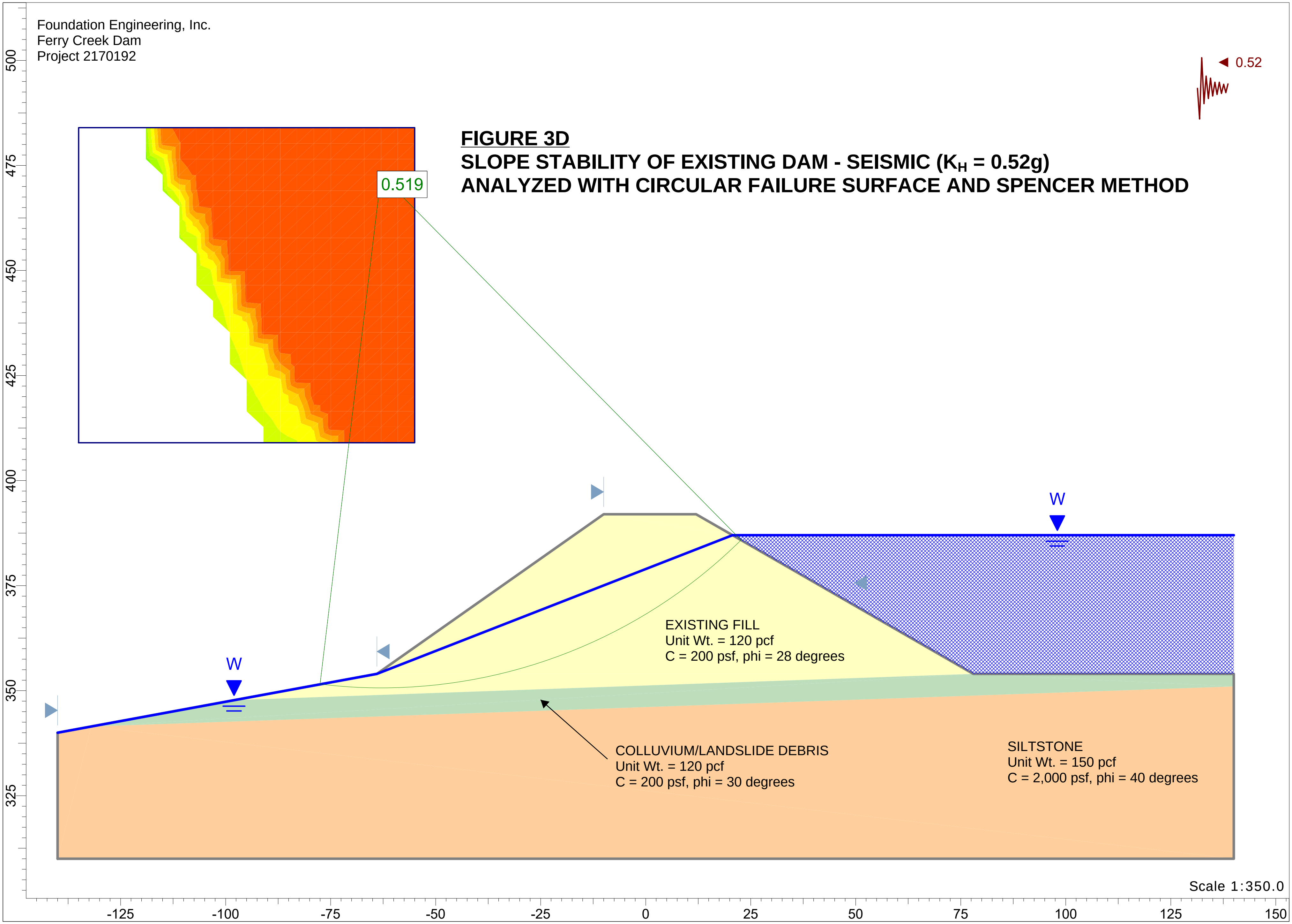


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FIGURE 3D
SLOPE STABILITY OF EXISTING DAM - SEISMIC (K_H = 0.52g)
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD
0.52
0.519
W
W
EXISTING FILL
Unit Wt. = 120 pcf
C = 200 psf, phi = 28 degrees
COLLUVIUM/LANDSLIDE DEBRIS
Unit Wt. = 120 pcf
C = 200 psf, phi = 30 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
Scale 1:350.0
500
475
450
425
400
375
350
325
-125
-100
-75
-50
-25
0
25
50
75
100
125
150

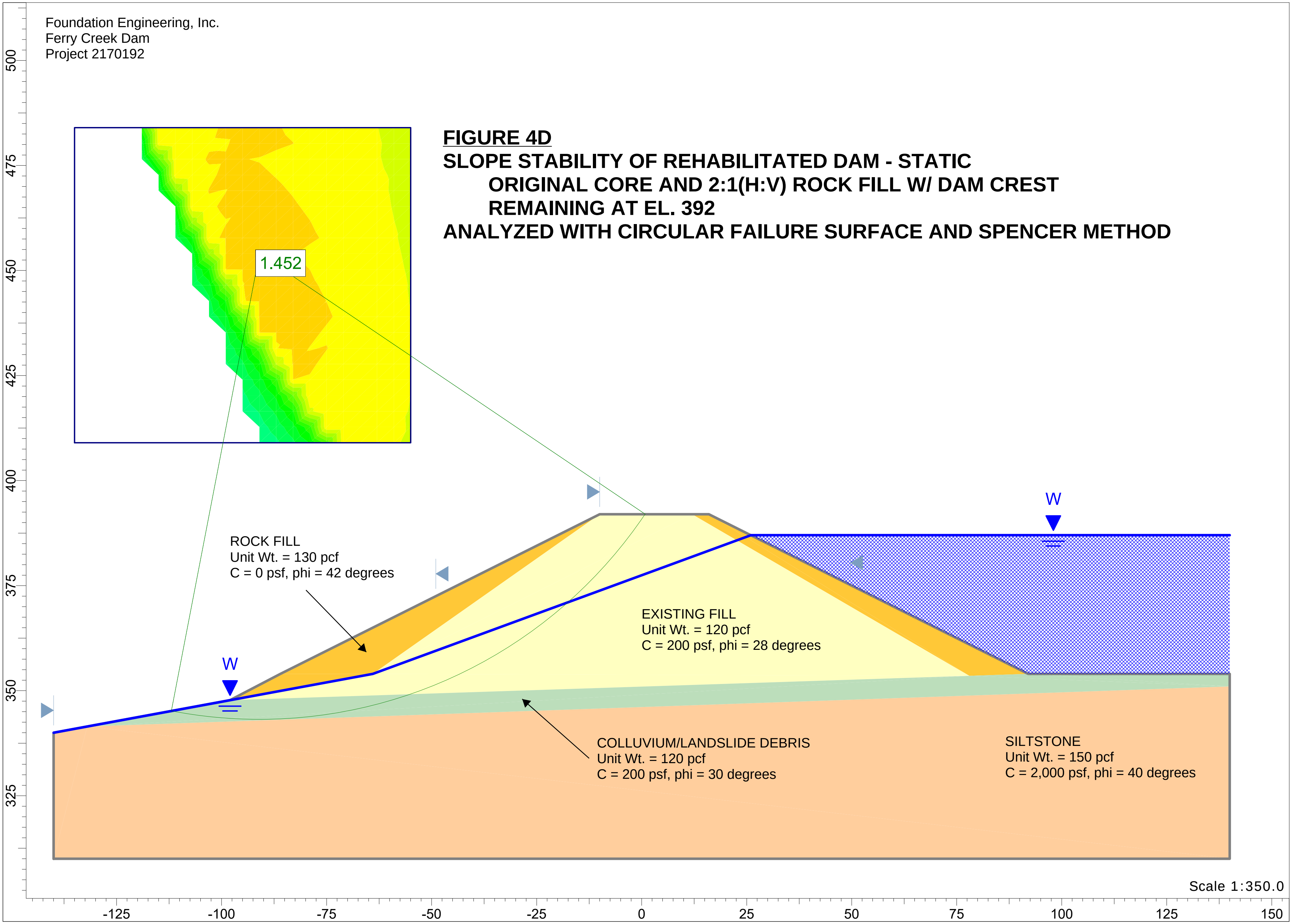


FIGURE 4D

SLOPE STABILITY OF REHABILITATED DAM - STATIC

ORIGINAL CORE AND 2:1(H:V) ROCK FILL W/ DAM CREST REMAINING AT EL. 392

ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD

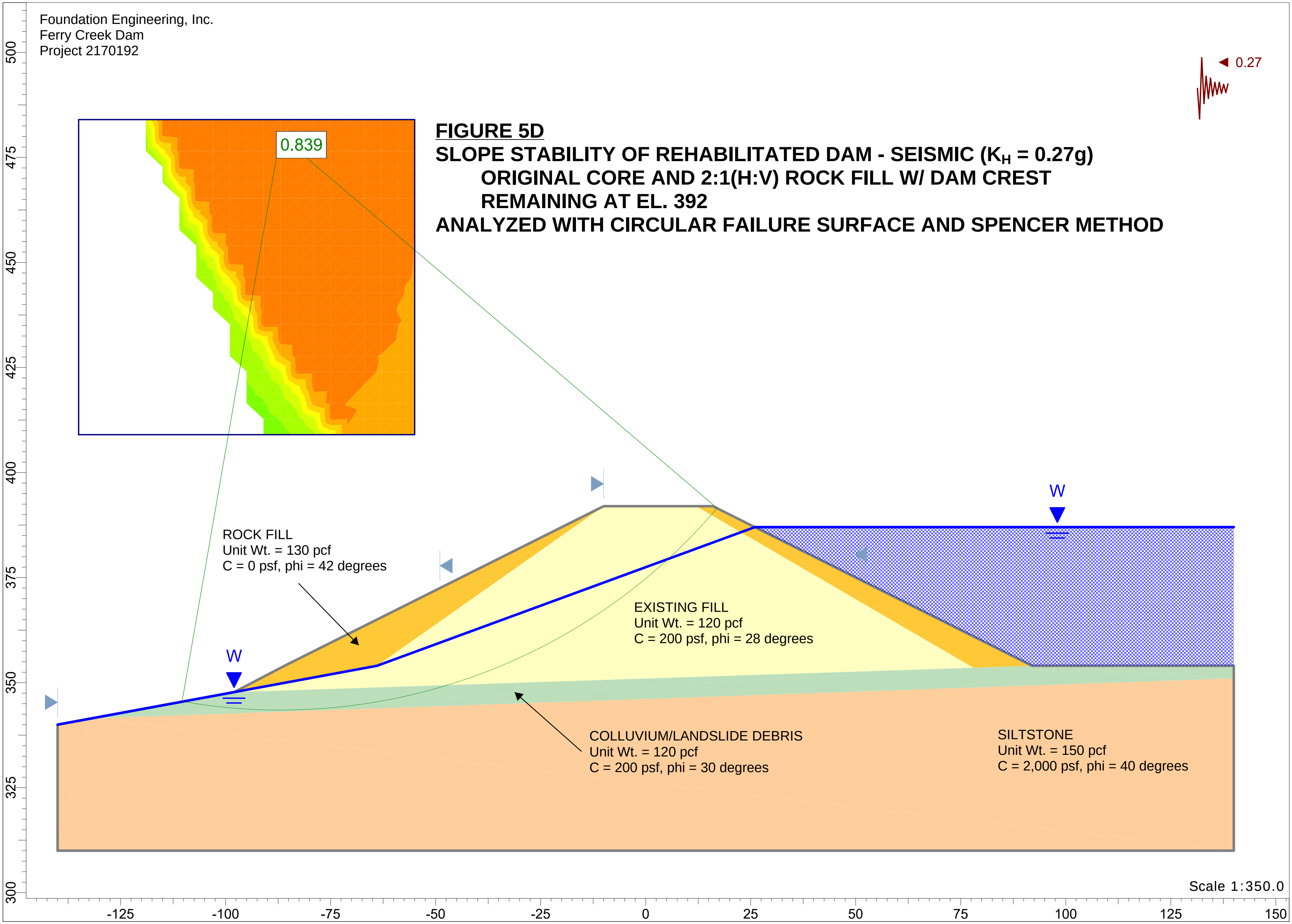
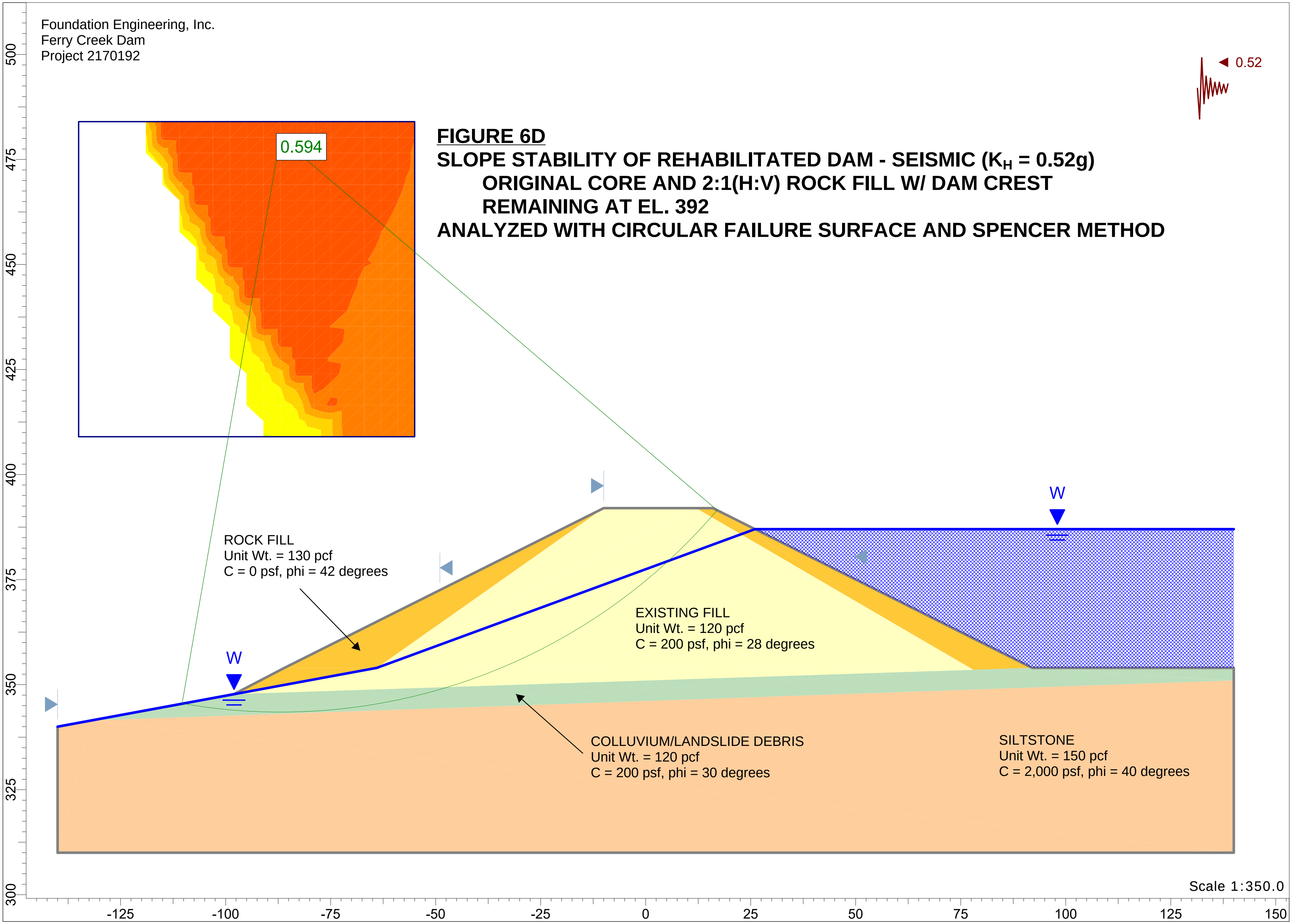


FIGURE 5D

SLOPE STABILITY OF REHABILITATED DAM - SEISMIC (K_H = 0.27g)
ORIGINAL CORE AND 2:1(H:V) ROCK FILL W/ DAM CREST REMAINING AT EL. 392
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD



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0.52
FIGURE 6D
SLOPE STABILITY OF REHABILITATED DAM - SEISMIC (K$_H$ = 0.52g)
ORIGINAL CORE AND 2:1(H:V) ROCK FILL W/ DAM CREST
REMAINING AT EL. 392
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD
0.594
W
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
EXISTING FILL
Unit Wt. = 120 pcf
C = 200 psf, phi = 28 degrees
COLLUVIUM/LANDSLIDE DEBRIS
Unit Wt. = 120 pcf
C = 200 psf, phi = 30 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
Scale 1:350.0
500
475
450
425
400
375
350
325
300
-125
-100
-75
-50
-25
0
25
50
75
100
125
150

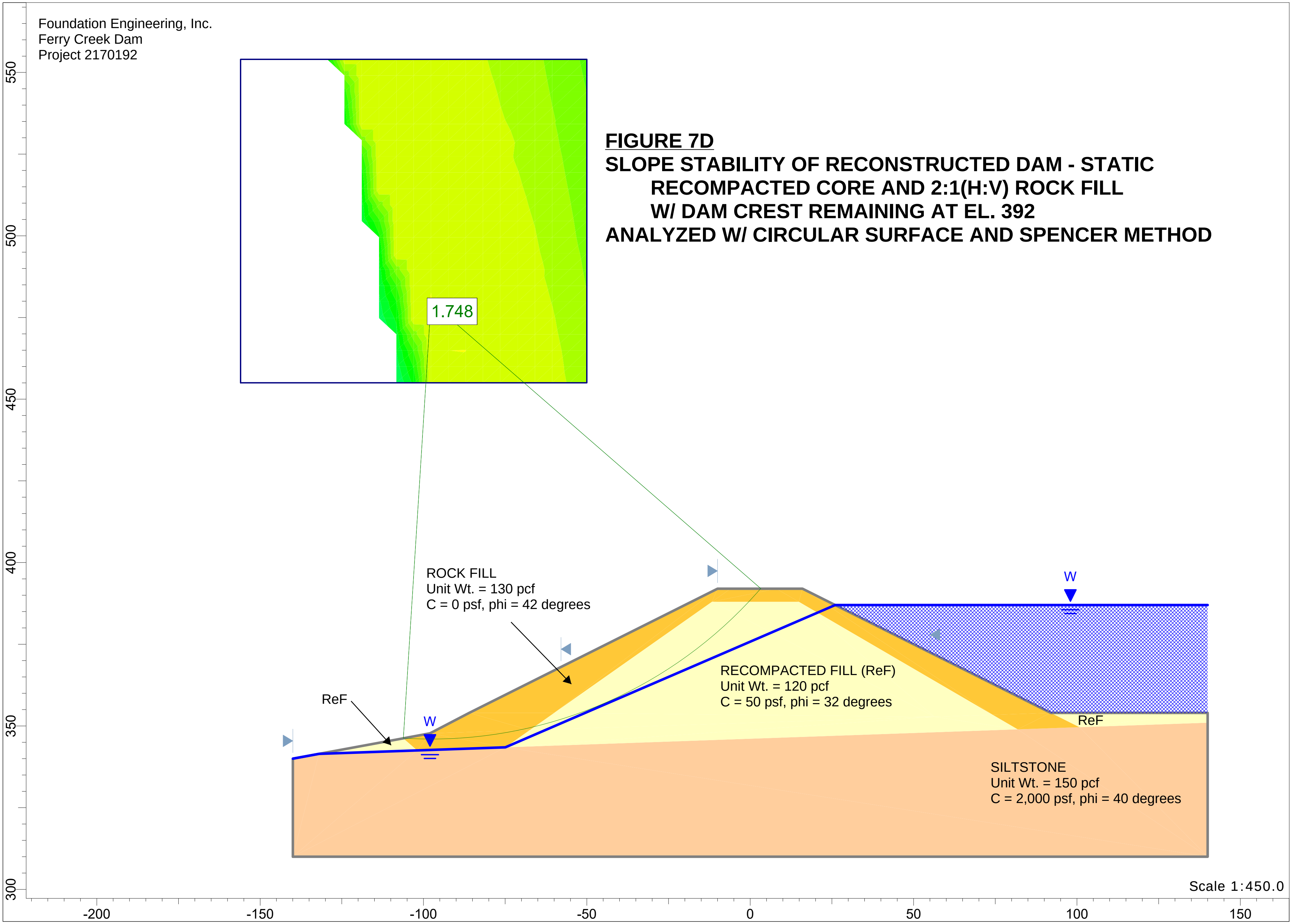

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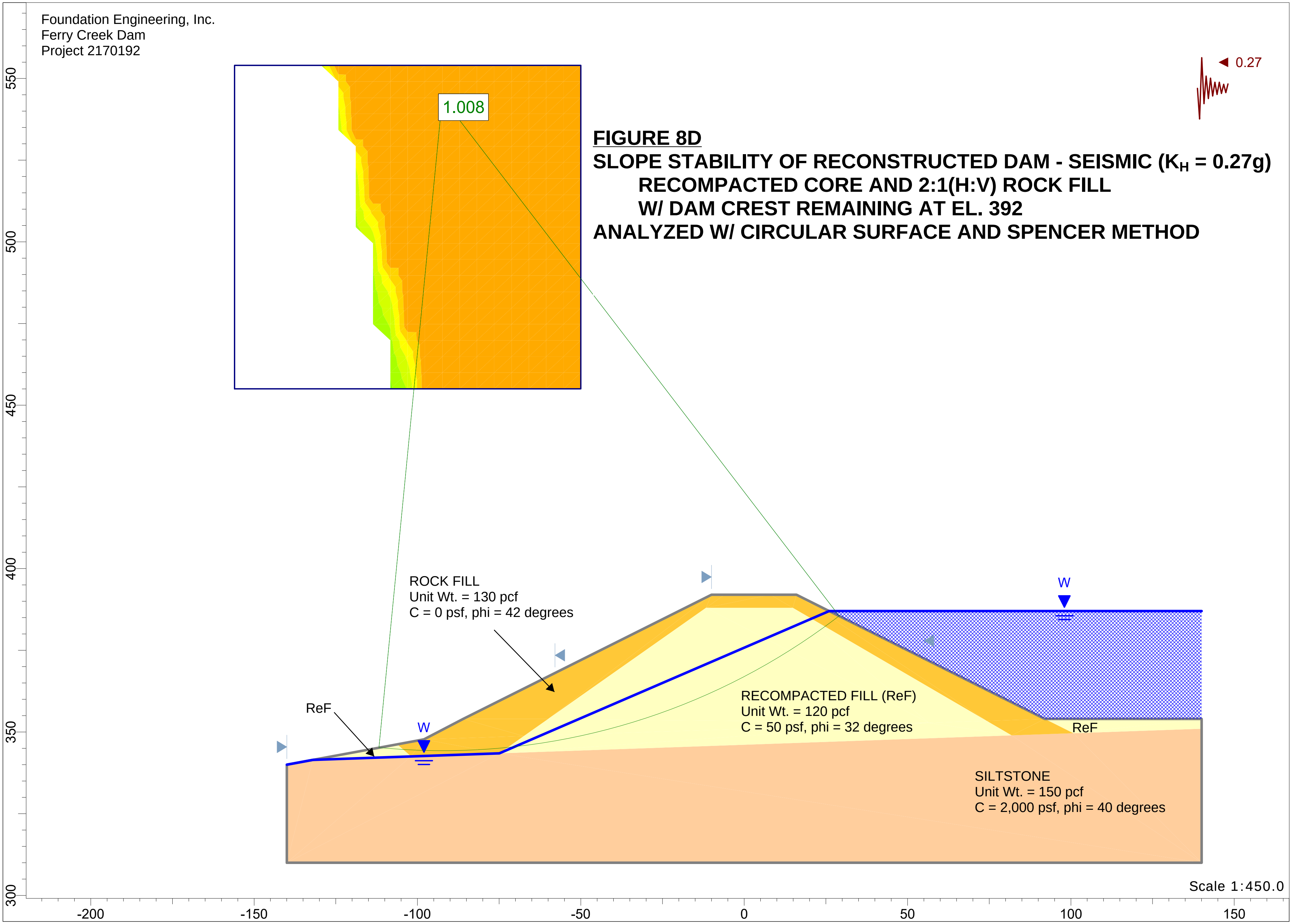
FIGURE 7D
SLOPE STABILITY OF RECONSTRUCTED DAM - STATIC
RECOMPACTED CORE AND 2:1(H:V) ROCK FILL
W/ DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
1.748
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
ReF
W
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
Scale 1:450.0
550
500
450
400
350
300
-200
-150
-100
-50
0
50
100
150



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Ferry Creek Dam
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0.27
1.008
FIGURE 8D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.27g)
RECOMPACTED CORE AND 2:1(H:V) ROCK FILL
W/ DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
ReF
W
W
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
ReF
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
Scale 1:450.0
550
500
450
400
350
300
-200
-150
-100
-50
0
50
100
150

FIGURE 9D

SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.52g)
RECOMPACTED CORE AND 2:1(H:V) ROCK FILL
W/ DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD

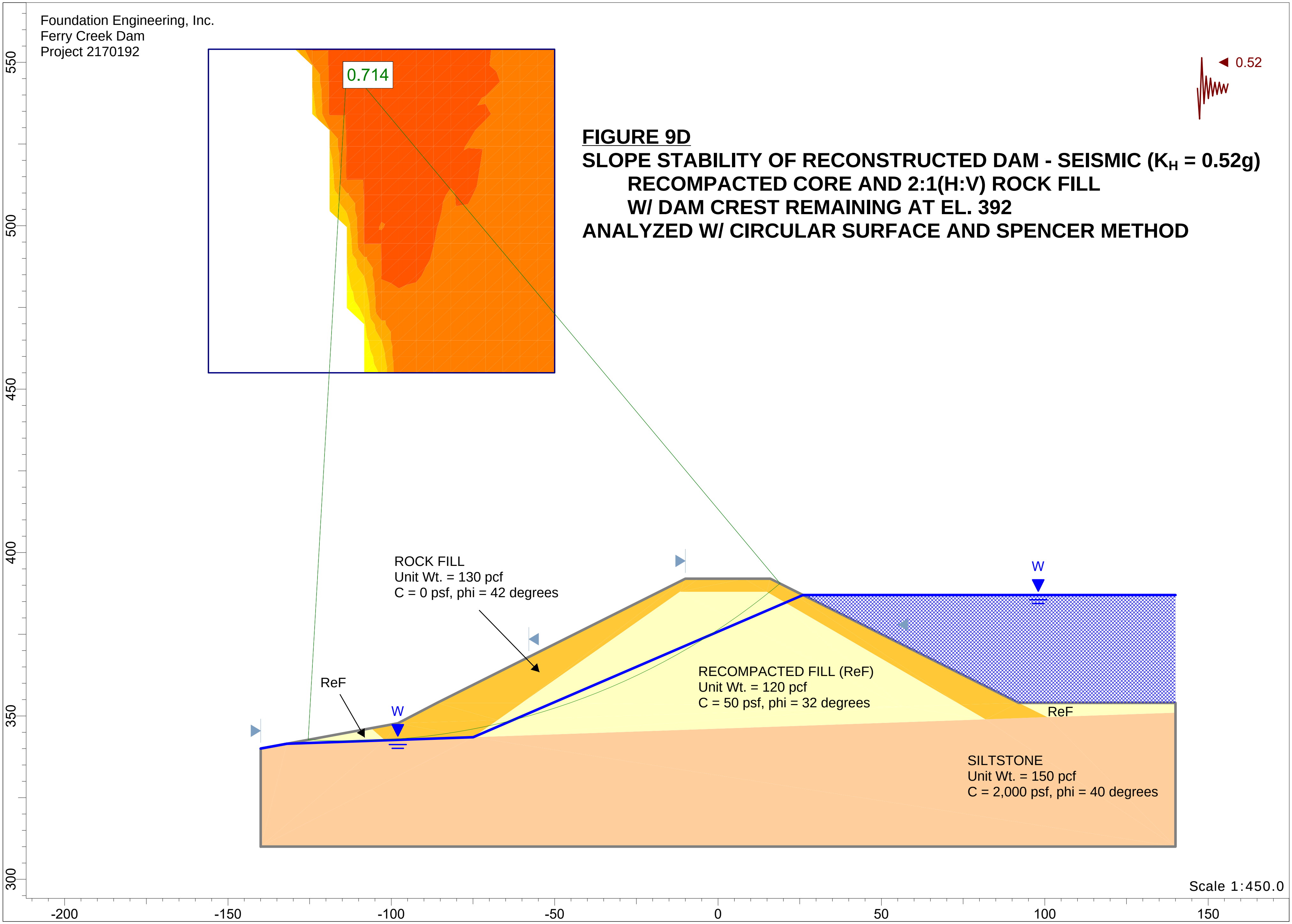

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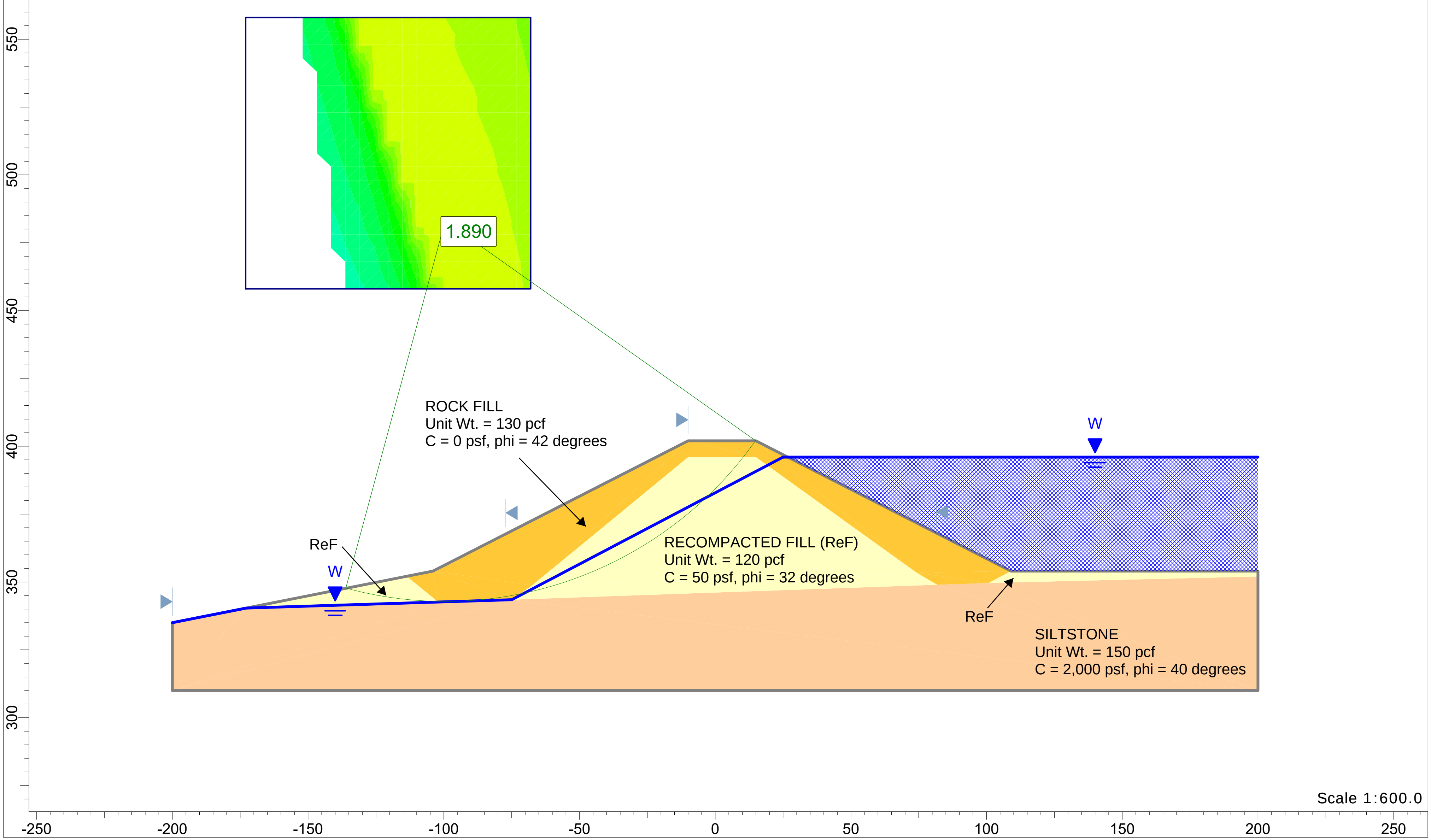
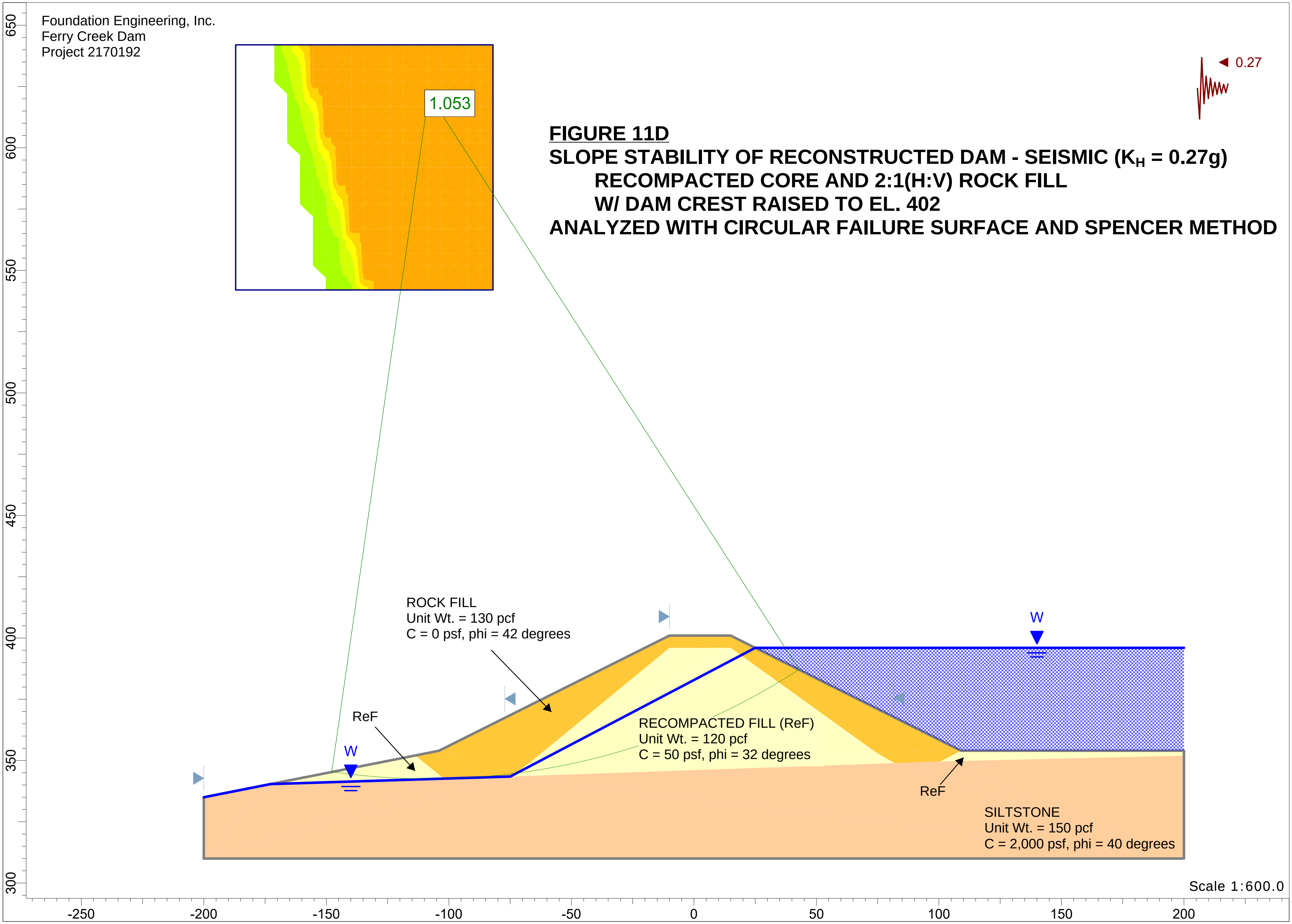
FIGURE 10D
SLOPE STABILITY OF RECONSTRUCTED DAM - STATIC
RECOMPACTED CORE AND 2:1(H:V) ROCK FILL
W/ DAM CREST RAISED TO EL. 402
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD





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1.053
0.27
FIGURE 11D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.27g)
RECOMPACTED CORE AND 2:1(H:V) ROCK FILL
W/ DAM CREST RAISED TO EL. 402
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
ReF
W
W
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
ReF
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
Scale 1:600.0
650
600
550
500
450
400
350
300
-250
-200
-150
-100
-50
0
50
100
150
200

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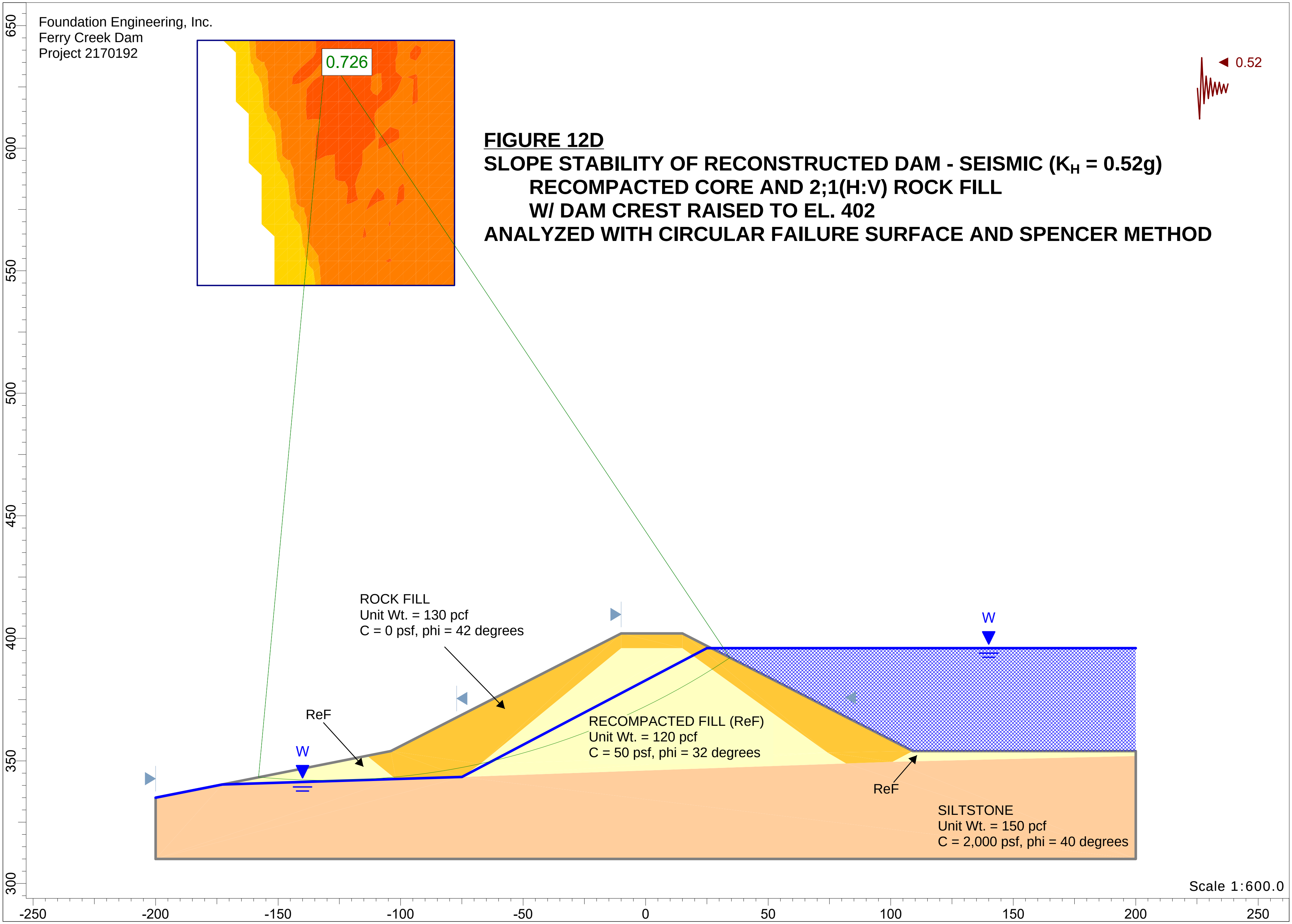
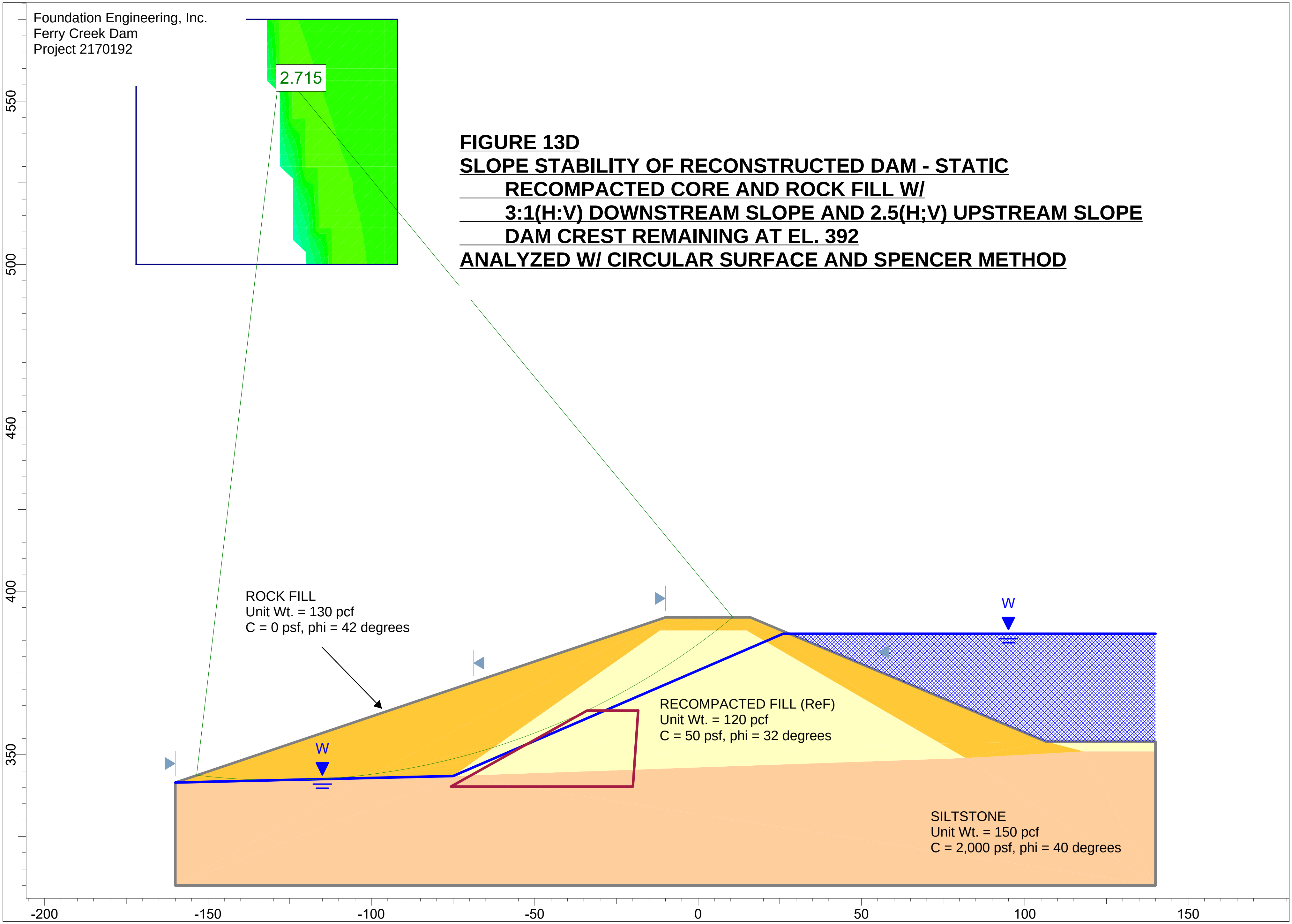
FIGURE 12D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.52g)
RECOMPACTED CORE AND 2;1(H:V) ROCK FILL
W/ DAM CREST RAISED TO EL. 402
ANALYZED WITH CIRCULAR FAILURE SURFACE AND SPENCER METHOD

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Ferry Creek Dam
Project 2170192
2.715
FIGURE 13D
SLOPE STABILITY OF RECONSTRUCTED DAM - STATIC
RECOMPACTED CORE AND ROCK FILL W/
3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE
DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
W
W
550
500
450
400
350
-200
-150
-100
-50
0
50
100
150

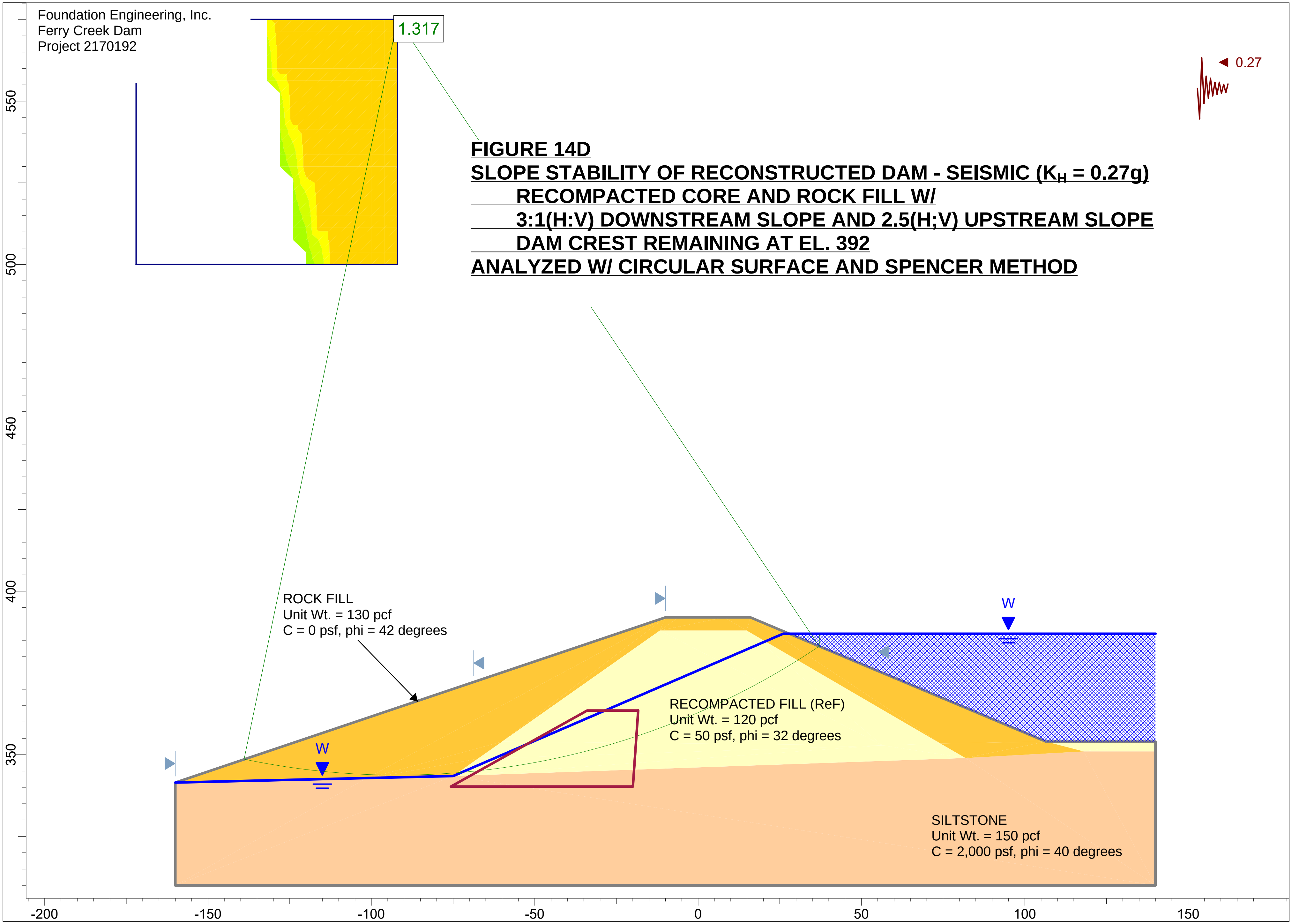
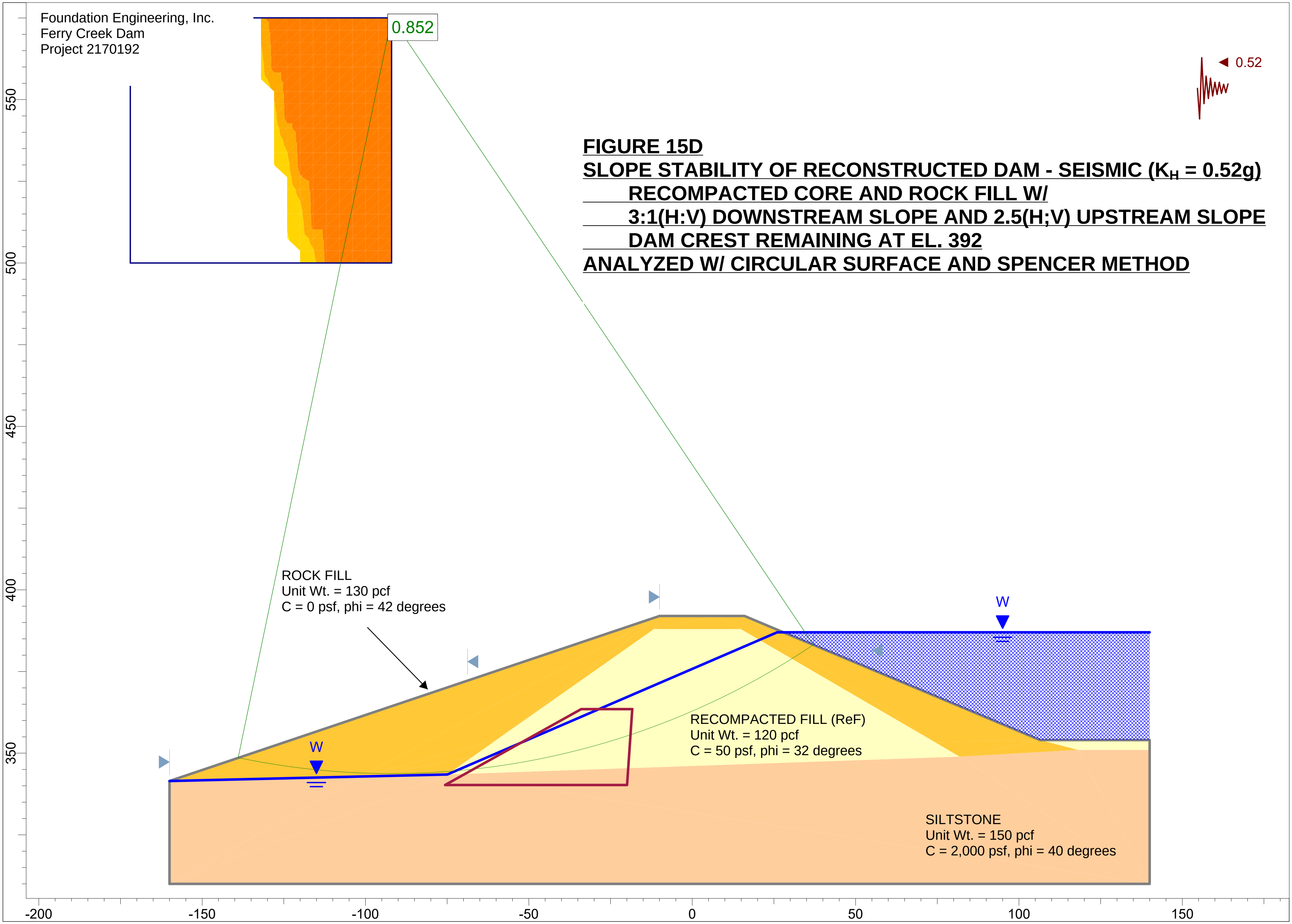


FIGURE 14D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.27g)
RECOMPACTED CORE AND ROCK FILL W/
3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE
DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD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Ferry Creek Dam
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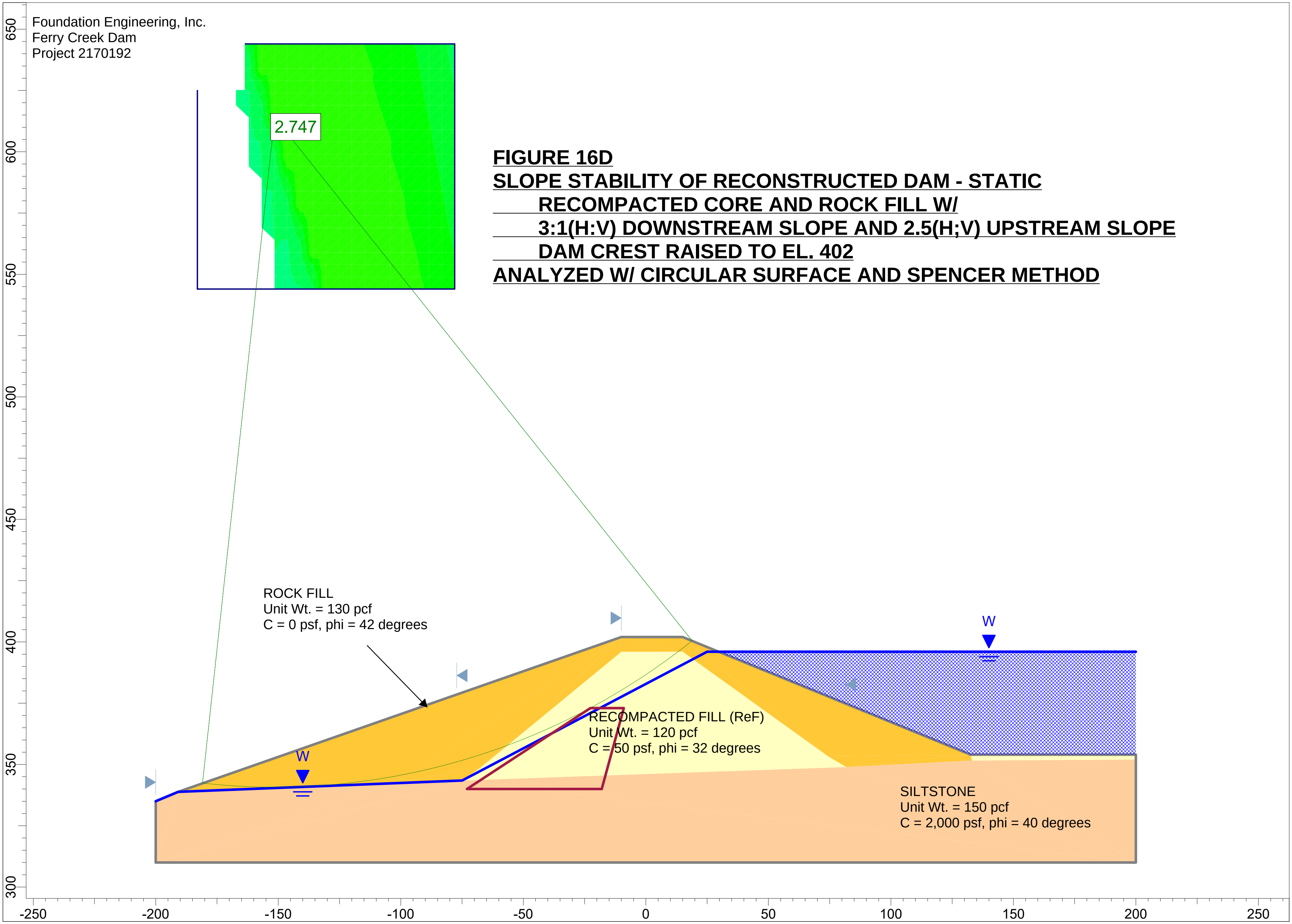
0.852
0.52
FIGURE 15D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (KH = 0.52g)
RECOMPACTED CORE AND ROCK FILL W/
3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE
DAM CREST REMAINING AT EL. 392
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
W
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
550
500
450
400
350
-200
-150
-100
-50
0
50
100
150



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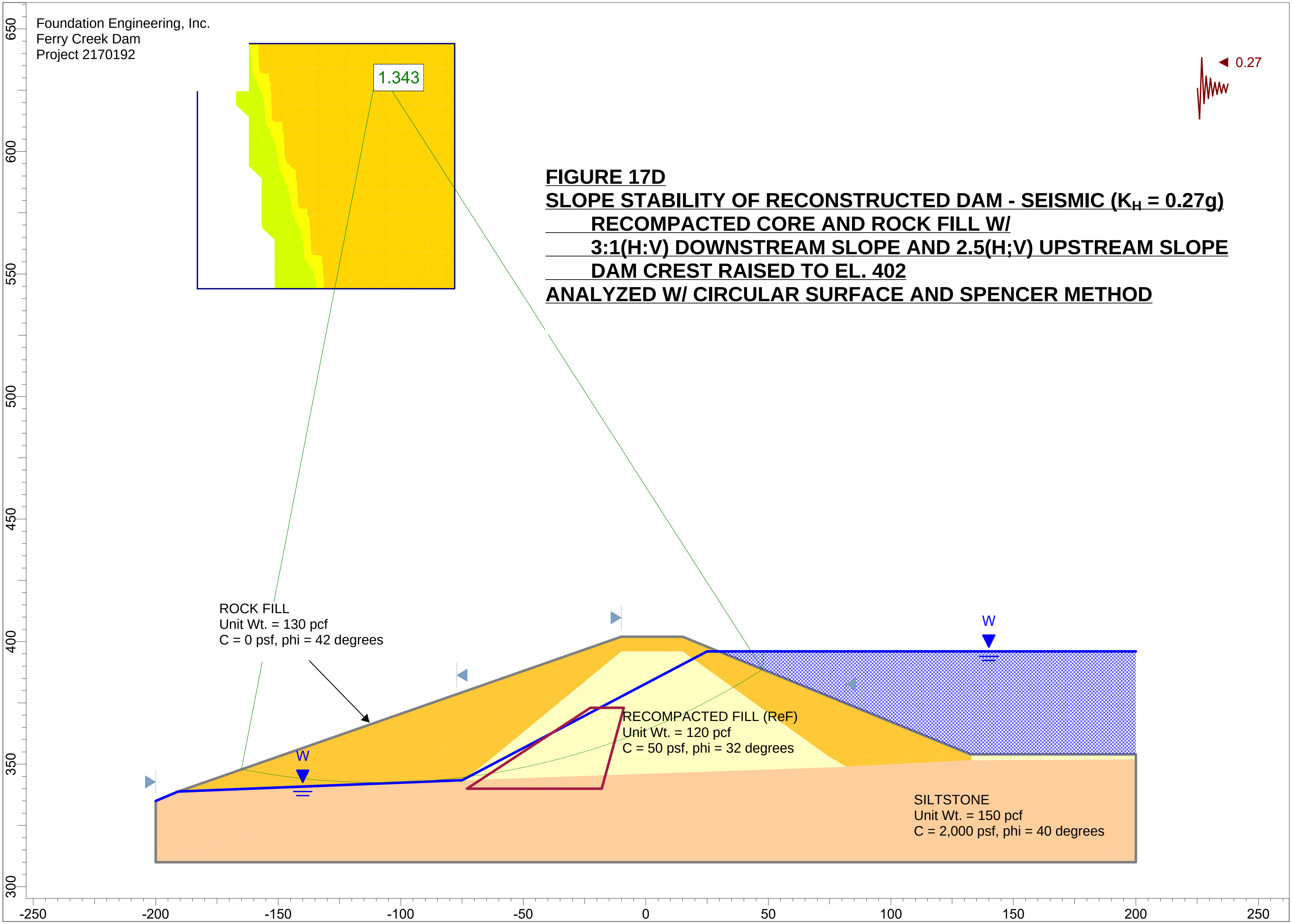
2.747
FIGURE 16D
SLOPE STABILITY OF RECONSTRUCTED DAM - STATIC
RECOMPACTED CORE AND ROCK FILL W/
3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE
DAM CREST RAISED TO EL. 402
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
W
W
650
600
550
500
450
400
350
300
-250
-200
-150
-100
-50
0
50
100
150
200
250


Foundation Engineering, Inc.
Ferry Creek Dam
Project 2170192
1.343
0.27
FIGURE 17D
SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (KH = 0.27g)
RECOMPACTED CORE AND ROCK FILL W/
3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE
DAM CREST RAISED TO EL. 402
ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD
ROCK FILL
Unit Wt. = 130 pcf
C = 0 psf, phi = 42 degrees
RECOMPACTED FILL (ReF)
Unit Wt. = 120 pcf
C = 50 psf, phi = 32 degrees
SILTSTONE
Unit Wt. = 150 pcf
C = 2,000 psf, phi = 40 degrees
W
W
650
600
550
500
450
400
350
300
-250
-200
-150
-100
-50
0
50
100
150
200
250

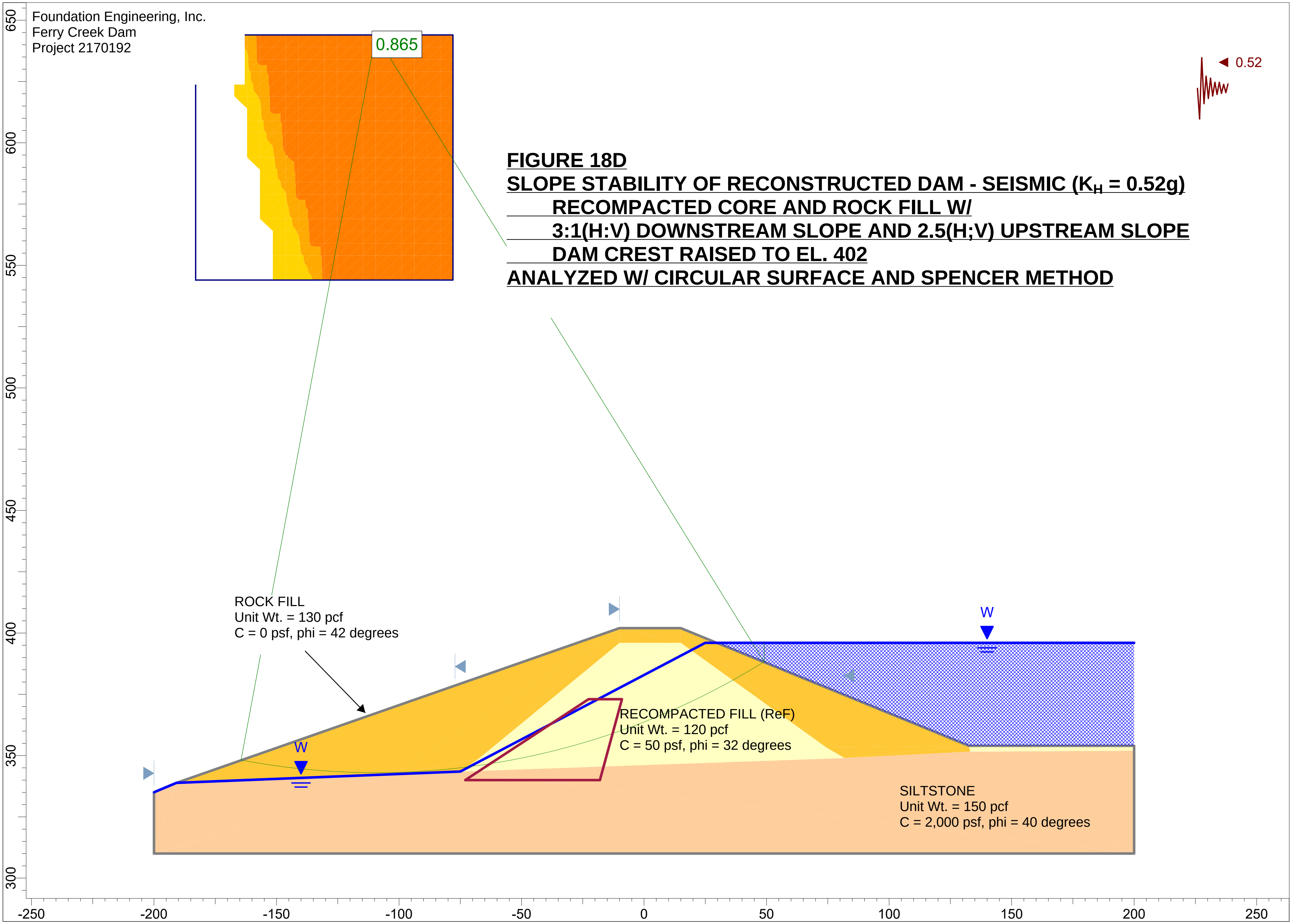


FIGURE 18D

SLOPE STABILITY OF RECONSTRUCTED DAM - SEISMIC (K_H = 0.52g)

RECOMPACTED CORE AND ROCK FILL W/

3:1(H:V) DOWNSTREAM SLOPE AND 2.5(H;V) UPSTREAM SLOPE

DAM CREST RAISED TO EL. 402

ANALYZED W/ CIRCULAR SURFACE AND SPENCER METHOD

SECTION 8:
PERMITTING

SECTION 8: **PERMITTING**

This task identifies the required permits and applications that must be prepared and submitted for approval. The following agencies were contacted and respective permitting needs are listed as follows:

8.1 Required Permits

United States Army Corps of Engineers (USACE)

Permit Likely Required - Nation Wide Permit – File with Joint Permit Application (JPA). Contacted Tyler Krug with Corp of Engineers (COE). He stated:

> "*Relocating the dam would likely trigger the need for a federal permit from the Corps pursuant to Section 404 of the Clean Water Act because the act of relocating the dam would likely result in either the discharge of dredged and/or fill material into Ferry Creek proper or abutting/adjacent wetlands.*
>
> *We may have a few Nationwide Permits (NWP) that might cover this work but, use of those NWP's is dependent on an applicant meeting both the terms and conditions of the NWP's. If the project can't fit a NWP we would need to likely process this request as an individual permit."*
>
> It was also stated: *"A Biological Assessment, or some form of Environmental Assessment may be required during the consultation process with NFMS." This will only apply if the USACE does not determine the project to be of 'no impact'.*

The COE also mentioned that with an increase in water elevation within the reservoir, there may be loss of wetlands. This would need to be calculated and included in the permitting documentation. Wetland mitigation may be a requirement of the permit.

Department of State Lands (DSL)

A removal/fill permit will be required. There is significant fill and excavation involved in the removal/replacement of the dam. Additionally, the project may touch wetlands. Therefore a removal/fill permit from DSL will be required. This will be part of the Joint Permit Application filed collectively with COE and DSL.

National Marine and Fisheries Service

Michelle McMullin with NMFS was contacted. No permit is required from NFMS, however, the COE may consult them during the JPA process. That consultation may result in additional requirements being added to the JPA. With the project at its current progression, NMFS was unable to provide specific stipulations that could accompany the permitting of the recommended project.

1. When Michelle was asked if a Biological Assessment would be required by their agency if consulted by the COE. The response was as follows:

   "If the Corps requests consultation, then NMFS will need sufficient information to conduct an independent analysis."

2. Based on this response it seems likely if the COE consults NMFS, or if federal funding is sought, a full Biological Assessment will need to be developed by the City.

Water Quality Certification

Certification will need to be obtained. This is typically done through the permitting processes with the COE, and DSL. With appropriate best management practices in place, this project should pose no threat to water quality. Acquiring this permit should not present any issues.

Department of Environmental Quality (DEQ)

National Pollutant Discharge Elimination System (NPDES) 1200C Permit – would be required before construction. This is typically the responsibility of the Contractor.

1. A permit for reservoir construction will be obtained during the design process.

2. Section 10 of the Rivers and Harbors Appropriation Act of 1899 – no obstructions, or excavations and fills shall be constructed in any navigable waterways as part of this project.

3. Section 404 Clean Water Act – No disposal dredging or fill material discharged into navigable water, shellfish beds, and fishery areas is anticipated.

4. Conditional Use Permit – Not required. No change in property use.

Water Rights

For all proposed alternatives within this study no new water right permits will be required. See Section 3 for more information.

8.2 Related Requirements

SHPO & Tribes

No permit necessary. Confederated Tribes of the Siletz Indians – An email was sent to Mr. Robert Kentta describing the project and asking if he had any concerns related to the project site. His response which stated he had no specific concerns regarding the project site was given in Section 4. No further correspondence was received from the Tribe.

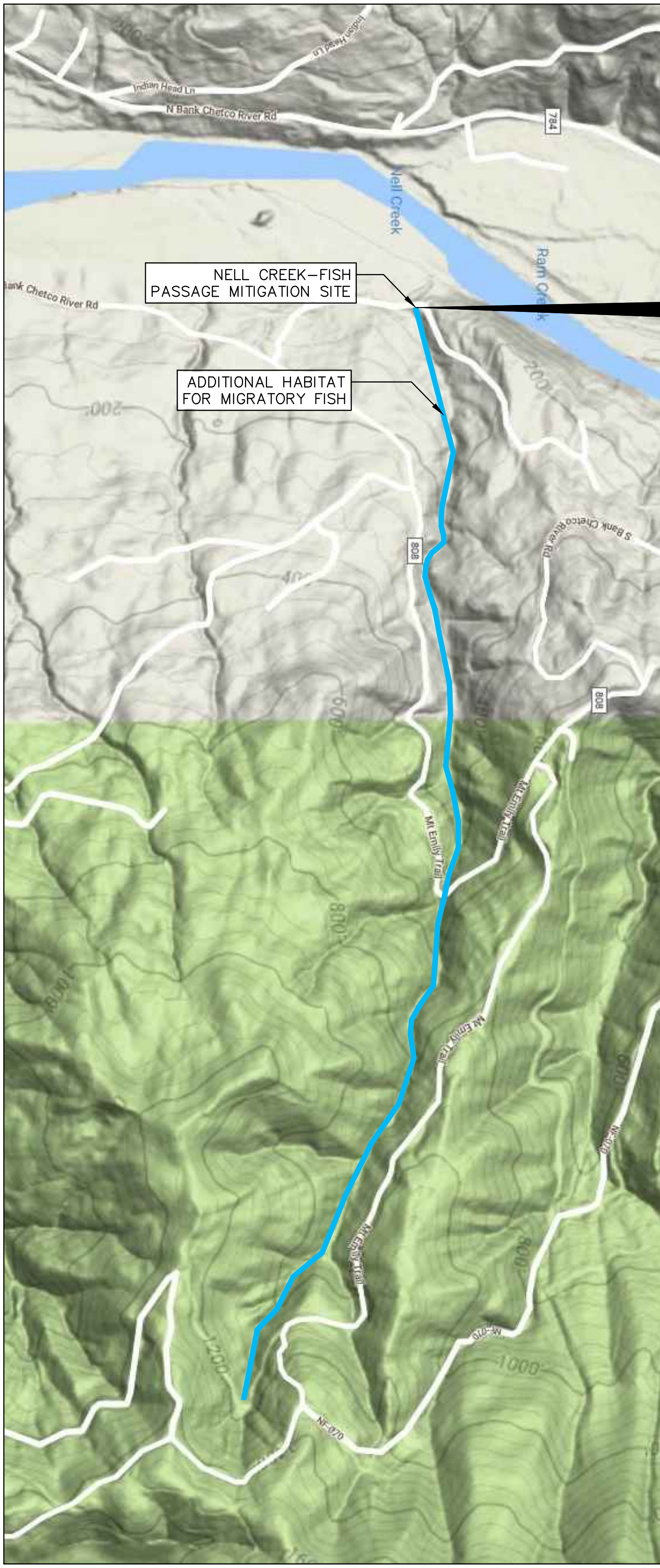
Oregon Department of Fish & Wildlife

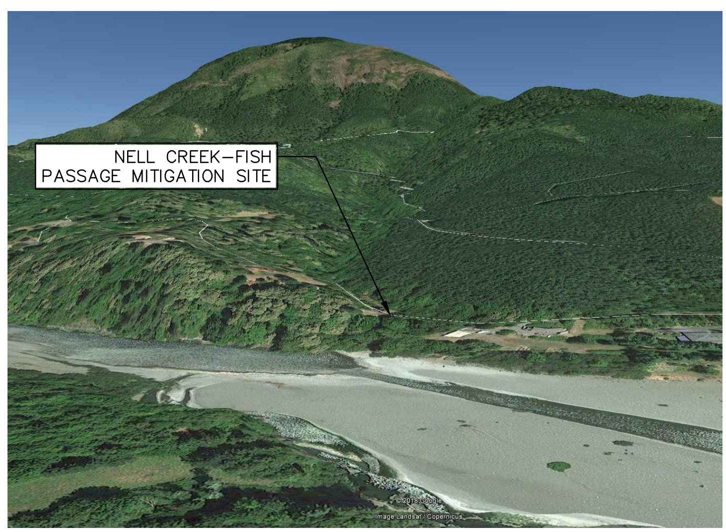
Contacted Mr. Steve Mazur and Mr. Greg Apke with ODFW – No permit required. However there are requirements that will impact the project, and more than likely be attached to the Joint Permit Application with COE and DSL. These are as follows:

1. Fish Passage Mitigation will be required. A Fish Passage Waiver will need to be completed, submitted and approved before the project can enter into construction. This will require a project description of the mitigation project, and a timeline for its completion.

    a. The Mitigation Site will be along Nell Creek. A culvert under an unnamed road west of S. Bank Chetco River Rd. is currently blocking fish passage along Nell Creek. This culvert will be replaced with a fish friendly alternative. See Figure 8.2.1 for Mitigation Site.

2. Construction would require consideration of the ODFW juvenile fish acclamation program. Construction timing would need to be approved by ODFW.





THE DYER PARTNERSHIP ENGINEERS & PLANNERS, INC.	*CITY OF BROOKINGS FERRY CREEK DAM FEASIBILITY STUDY*	FIGURE NO.
DATE: JUNE, 2018	*PROPOSED FISH PASSAGE MITIGATION SITE*	*8.2.1*
PROJECT NO.: 145.80		

SECTION 9:

PROJECT ALTERNATIVE ANALYSIS

SECTION 9: **PROJECT ALTERNATIVE ANALYSIS**

The selection of project alternatives found in this section was based upon the following considerations:

- The recommendations/requirements of the Dam Safety Division of the OWRD.
- The City's need for an emergency water supply.

In the OWRD dam inspection report dated November 23, 2016 (found in appendix A), OWRD indicated that the Ferry Creek Dam rating was changed to "high" based upon a dam breach inundation analysis. Also, the condition of the dam was found to be "unsatisfactory" and in need of "major rehabilitation". The report states that it is "essential that a plan to make this dam safe be developed." Compliance with this request would require complete removal or rehabilitation of the dam and associated spillway.

As discussed in prior sections, the City currently has no emergency raw water supply in the event that saltwater intrusion reaches the Rainney Collector Intake. If an intrusion event did occur, the City has no other water supply. This occurrence would pose a health risk to the community. Using the Ferry Creek Reservoir as an emergency water supply would minimize any risk associated with salt water intrusion or mechanical failure of the intake.

Water quality samples were taken from the Ferry Creek reservoir at depths of 5 feet, and 30 feet. The lab results are shown in Appendix C. At 30 foot depths the levels of manganese were 0.288 mg/l, and the EPA requirement for treated water is 0.05 mg/ l. All alternatives incorporating use of the reservoir as a raw water supply will require installation of a potassium permanganate chemical injection system at the WTP to reduce the levels of manganese in the raw water. All other sampled compounds were within required limits. With the exception of manganese, the raw water within Ferry Creek is treatable with the equipment currently in place at the WTP.

This section presents and evaluates several project alternatives developed to address the problems outlined above. The primary alternatives discussed are listed below:

1. No Action.
2. Complete removal of dam.
3. Replacement of current earthen dam with higher crest elevation, altered alignment, and shallower slopes.
4. Replacement of current earthen dam with existing elevations and alignment, and shallower slopes.
5. Replacement of current earthen dam with a Roller Compacted Concrete (RCC) dam structure.

"Storage Specific Study Requirements" are discussed in Appendix D. These are presented as required by the funding agency's scope of work and listed as "Exhibit C" in the grant agreement #GA-0125-17.

9.1 Project Alternatives

Alternative 1 – No Action

The 'No Action' alternative would include any improvements required to maintain current use of this facility. The primary tasks required for this alternative are the replacement of the existing spillway, replacement of reservoir drainage piping, and rehab of the crest of the dam removing all low spots.

In their last Dam Inspection Report OWRD cited the insufficiencies of the existing Ferry Creek Dam which warranted changing the status of the dam to unsatisfactory condition, and high hazard. Below is an excerpt from the inspection report that summarizes the insufficiencies.

> *"The combination of the low spot on the crest, the issues with the spillway, multiple non-functional conduits, and the fact that the dam is located in a high-seismic shaking zone all cause this dam to remain in UNSATISFACTORY condition."*

'Unsatisfactory' condition designation by the OWRD means the dam is:

1. Marginally functional under normal conditions, but could be a potential problem under extreme loading or operating conditions not routinely experienced.

2. In need of Intensive maintenance program necessary to prevent further deterioration.

The Geotechnical Investigation Report found in Section 7 of this study concluded the following regarding the existing dam:

> *"OWRD has concluded the existing dam requires significant rehabilitation. This conclusion is consistent with our observations and with the results of our slope stability and displacement analyses, which indicate lower than desirable factors of safety and estimated relatively large displacements. The seismic loading is expected to be the critical condition since the dam has remained in service for decades under static loading conditions. The stability analysis completed to date indicates the existing dam will likely fail under sustained, strong ground motion, which would be typical of a large CSZ earthquake"*

Given the current condition of the dam and the threat it poses to residences downstream, maintaining the dam in its current condition is not a viable alternative, and is not discussed further.

Alternative 2 – Complete Dam Removal

This alternative would include complete removal of the dam and all associated structures, and restoration of the original creek channel and native flora. This process would require approximately 46,000 cubic yards of excavation. The soils would be hauled off site for disposal. This quantity of excavation would require improvements to the access road which would allow them to facilitate heavy equipment traffic.

Removal of the dam will provide fish passage and allow the creek to begin recreating a channel through the former impoundment. As the stream channel narrows, velocity increases and sediment transport begins again, fluvial features including localized pools, riffles, runs as well as depositional areas will develop. These physical features create the foundation for habitat with an assortment of water depths, velocities and substrate types. Since these features will take form naturally with the restoration of flow and sediment transport, manipulation of the streambed or creation of these features is not imperative. In addition, due to the low slope of the bed in the impoundment, engineered grade control structures designed to insure aquatic organism passage are not necessary.

Quicker project time, reduced earth movement, and recreation of natural habitat all reduce the environmental impacts of this alternative relative to the other project alternatives. For more information on environmental impacts refer to Section 4.

Advantages:

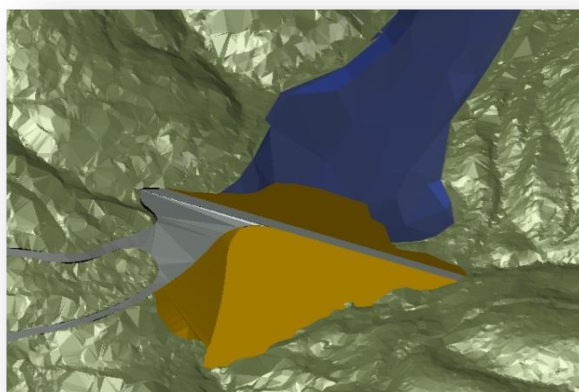
- Most economical of all alternatives.
- Restores natural habitat for fish.
- Removes any risks to downstream residents resulting from seismic activity.

Disadvantages:

- Does not provide the City with an emergency water supply in the event of salt intrusion or mechanical malfunction of intake.
- Would remove the juvenile salmon acclimation project which has facilitated the process of adding nearly 40,000 fish to the Chetco River each year for the last three years.

Alternative 3 – Re-Alignment and Expansion of Ferry Creek Dam

In the City of Brookings Redundant Water Supply Plan document, the City studied several alternatives that would expand the City's water storage. The study concluded that development of the Ferry Creek Reservoir was the best redundant supply alternative.



The recommended supply alternative from this study was chosen as Alternative 3. The project scope has broadened, and associated cost increased, but the overall approach to and intent of the improvement has not changed.

Alternative 3 includes: the removal of the Ferry Creek Dam to bedrock, construction of an earthen dam with a higher crest elevation and altered alignment, relocation of the dam spillway, construction of an outlet structure, construction of transmission lines which will convey raw water from the reservoir to the WTP, WTP improvements, construction of a new drain line and associated outfall, and completion of a fish passage mitigation project. See Figure 8.2.1 for site location. With the considerable earth movement required for the project, road improvements will also be necessary to facilitate heavy equipment access.

The reservoir is positioned along Ferry Creek on two parcels of land totaling 42 acres (tax map 40S13W32B, tax lot 100 & 1900). This parcel provides an adequately sized site to construct all described improvements. The existing crest of the dam would increase from 392-feet to 401-feet. The storage volume of the dam would increase from 26 to 39 Million Gallons. The increased volume extends the amount of time the emergency supply can sustain the City under emergency conditions. The additional volume will also further facilitate the release of water for stream flow augmentation. See Figure 9.1.1 for Alternative 3 project layout.

The earthen dam's materials and slopes would be as recommended in the Geotechnical Investigation Report. Excerpts from this document describing these features are provided below:

'Based on the results of the analyses, we have concluded a new earth dam with a 3(H):1(V) downstream slope and a 2.5(H):1(V) upstream slope would provide adequate performance for static and seismic loading conditions. This configuration is typical for earth dams in seismic environments. Due to the sloping terrain, constructing a dam with these slopes will require shifting the alignment of the dam upstream from its current location, which will reduce the storage capacity of the reservoir.'

> ***'Riprap***
> *Riprap would be used to line the outer faces of the slopes. Riprap should consist of 2 to 3-foot minus, angular, sound rock. These maximum sizes of rock correspond to ODOT Class 700 and ODOT Class 2000 rock, respectively. The rock should have all fractured faces and contain no soil or fines (i.e., material passing the standard #200 sieve).*
>
> ***Jaw-Run Rock***
> *Jaw-run rock may be used as a transition material between the rip-rap and the dam core. It should consist of 6 to 8-inch minus, well-graded, sound, crushed quarry rock containing less than 5% fines (i.e., passing the #200 sieve).*
>
> ***Filter/ Chimney Material***
> *Filter material used chimney drain material should consist of 2-inch minus, open graded, crushed quarry rock with less than 0.5% fines. We do not recommend the use of rounded gravel as filter material.*
>
> ***Backfill and Bedding Material***
> *Material used for pipe bedding or as structural backfill should consist of 1-inch minus, well-graded, crushed quarry rock or crushed gravel containing less than 5% fines.*
>
> ***CLSM (CDF)***
> *Controlled Low Strength Material (CLSM) or Controlled Density Fill (CDF) should consist of a flowable, sand-cement mixture free of large aggregate. It should have a 7-day unconfined compressive strength of between 200 and 300 psi.'*

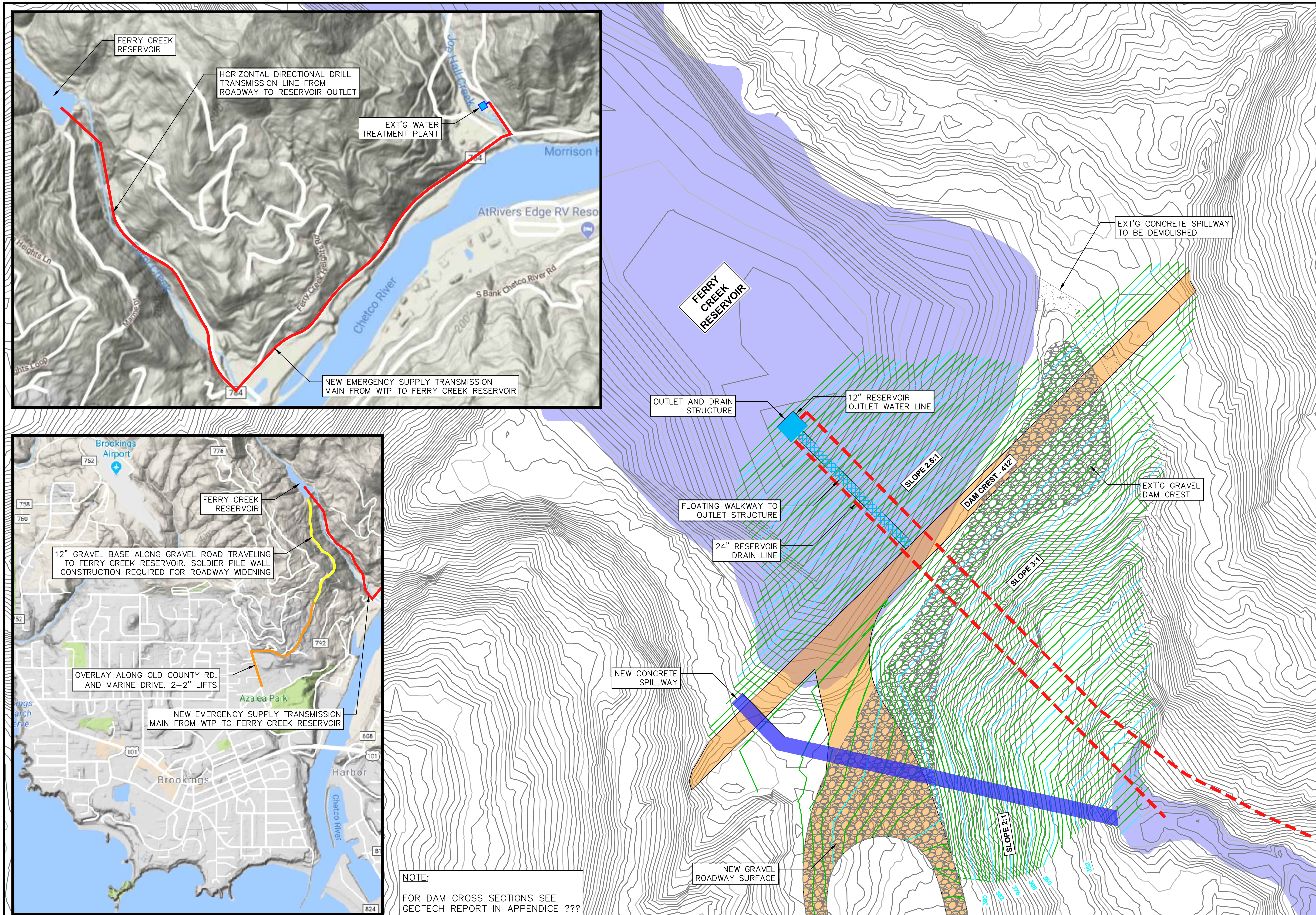


FIGURE NO. 9.1.1

CITY OF BROOKINGS: FERRY CREEK DAM FEASIBILITY STUDY

ALTERNATIVE 3: DAM REPLACEMENT PRELIMINARY SITE LAYOUT

THE DYER PARTNERSHIP
ENGINEERS & PLANNERS

DATE: APRIL 2018

PROJECT NO.: 145.80

Water entering the reservoir will either be stored or diverted to one of two locations. Water will be conveyed to either the WTP through a 12-inch raw water main, or used for streamflow augmentation through an 18-inch pipe which discharges into Ferry Creek. A fish screen will be provided on all inlets into the outlet structure.

Advantages:

- ❖ Provides the City with an emergency water supply.
- ❖ Most economical of all additional water supply alternatives.
- ❖ Restores natural habitat to fish along Nell Creek via the fish passage mitigation project.
- ❖ Retains area for juvenile salmon acclimation project.

Disadvantages:

- ❖ Large footprint will reduce available water storage.
- ❖ Re-alignment of Dam will reduce available water storage within the dam.
- ❖ Impact on local residents due to increased traffic resulting from hauling excavated and fill materials.
- ❖ Structural integrity can be more easily compromised than a RCC dam discussed in Alternative 5.
- ❖ Does not address the instability of the hillsides surrounding the dam. There are mapped landslide areas surrounding the reservoir (See Figure 6A in the Geotechnical Investigation document found in Section 7). It is possible that during a seismic event, the slopes could become unstable causing the soils and vegetation to slide into the reservoir. This could contaminate the emergency water supply, and/or block the water flow, and potentially overtop the dam.

For Alternative 3 site layout see Figure 9.1.1. For more soil information refer to the Geotechnical Investigation document found in Section 7. For alignment, and cross sections of the new dam see Figures 1D-18D in the Geotechnical Investigation Report.

Alternative 4 – Re-Alignment of Ferry Creek Dam

This alternative is identical to Alternative 3 with the exception of the replacement dam will maintain the crest elevation of the existing earthen dam. The upstream and downstream slopes will be shallowed at 2.5:1 and 3:1 respectively as recommended in the Geotechnical Investigation. This alternative has the same advantages and disadvantages as Alternative 3; however it will only provide 26 million gallons of emergency storage instead of the 39 million gallons made available with Alternative 3.

Advantages:

- Provides the City with an emergency water supply.
- Low cost per gallon of storage provided.
- Restores natural habitat to fish along Nell Creek via the fish passage mitigation project.
- Retains area for juvenile salmon acclimation project.

Disadvantages:

- Large footprint will reduce available water storage.
- Significant impact on local residents due to increased traffic.
- Structural integrity can be more easily compromised than a RCC dam.
- Does not address the instability of the hillsides surrounding the dam. There are mapped landslide areas surrounding the reservoir (See Figure 6A in the Geotechnical Investigation document found in Section 7). It is possible that during a seismic event, the slopes could become unstable causing the soils and vegetation to slide into the reservoir. This could contaminate the emergency water supply, and/or block the water flow, and potentially overtop the dam.

Alternative 5 – Remove Existing Dam and Build Roller Compacted Concrete (RCC) Dam

This alternative is also identical to Alternative 3 with the exception of the replacement dam being a RCC dam instead of an earthen dam. The slopes on this type of dam are considerably steeper then earthen dam, thereby allowing for additional water storage with a smaller foot print. Refer to Figure 12A in the Geotechnical Investigation document found in Section 7 of this study.

Advantages:

- Smallest footprint of all alternatives allowing for more water storage.
- Increased strength in structure. More durable during seismic events.
- Restores almost a mile of natural habitat to migratory fish along Nell Creek via the fish passage mitigation project.
- Retains area for juvenile salmon acclimation project.
- Simplified spillway construction.
- Smaller construction window.

Disadvantages:

- ❖ Significant impact on local residents due to increased traffic resulting from hauling excavated and fill materials.
- ❖ Construction is more costly than other alternatives.
- ❖ Does not address hillside slope stability issues discussed in the 'Geotechnical Investigation'.

For more information on the construction and design components of the RCC alternative see Geotechnical Investigation document.

9.2 Basis for Cost Estimates

The estimated construction costs in this Study are based on actual construction bidding results from similar work, published cost guides, other construction cost experience, and material prices. Reference was made to the as-built drawings, and system maps of the existing facilities to determine construction quantities, elevations of the reservoirs and major components, and locations of distribution lines. Where required, estimates were based on preliminary layouts of the proposed improvements.

Future changes in the cost of labor, equipment, and materials may justify comparable changes in the cost estimates presented herein. For this reason, common engineering practices usually tie the cost estimates to a particular index that varies in proportion to long-term changes in the national economy. The Engineering News Record (ENR) construction cost index is most commonly used. This index is based on the value of 100 for the year 1913. Average yearly values for the past ten years are summarized in Table 9.2.1.

TABLE 9.2.1
ENR CONSTRUCTION COST INDEX – 2006 TO 2016 (1)

Year	Index	Change
2018	10,924	1.75%
2017	10,737	3.85%
2016	10,338	2.83%
2015	10,054	2.53%
2014	9,806	2.71%
2013	9,547	2.57%
2012	9,308	2.62%
2011	9,070	3.08%
2010	8,799	2.67%
2009	8,570	3.13%
2008	8,310	4.32%
2007	7,966	2.77%
Average Annual %		**2.92%**

(1) Index based on July of each year at 20-city average labor rates and material prices.

Cost estimates presented in this Study for construction performed should be projected with a minimum increase of three percent per year. Future yearly ENR indices can be used to calculate the cost of projects for their construction year based on the annual growth in the ENR index.

Contingencies

A planning level contingency factor equal to approximately fifteen percent of the estimated construction cost has been added. In recognition that the cost estimates presented are based on conceptual planning, allowances must be made for variations in final quantities, bidding market conditions, adverse construction conditions, unanticipated specialized investigation and studies, and other difficulties which cannot be foreseen at this time but may tend to increase final costs.

Engineering

The cost of engineering services for major projects typically includes special investigations, a predesign report, surveying, foundation exploration, preparation of contract drawings and specifications, bidding services, construction management, inspection, construction staking, start-up services, and the preparation of operation and maintenance manuals. Depending on the size and type of project, engineering costs may range from fifteen to twenty five percent of the contract cost when all of the above services are provided. The lower percentage applies to large projects without complicated mechanical systems. The higher percentage applies to small, complicated projects. Additional engineering services may be required for specialized projects. This could include geotechnical evaluations, structural evaluations, and other specialized consulting activities.

Legal and Administrative

An allowance of five percent of construction costs have been added for legal and administrative services. This allowance is intended to include internal project planning and budgeting, grant administration, liaison, interest on interim loan financing, legal services, review fees, legal advertising, and other related expenses associated with the project.

Environmental Review

In order for a project to be eligible for federal and/or state grants and loans, a review of anticipated environmental impacts of the proposed improvements is required. The primary goal of the environmental review is to help public officials make decisions that are based on the understanding and consideration of the environmental consequences of their actions, and to take actions that protect, restore, and enhance the environment. To accomplish these tasks, the National Environmental Policy Act (NEPA) was promulgated. The NEPA requires federal agencies or monies originating from federal programs to either prepare or have prepared written assessments or statements that describe the: 1) affected environment and environmental consequences of a proposed project; 2) reasonable or practicable alternatives to the proposed project; and 3) any mitigation measures necessary to avoid or minimize adverse environmental effects.

The environmental review will include one of the following four levels:

- ❖ Determination of categorical exclusion without an environmental impact or assessment report.
- ❖ Determination of categorical exclusion with an environmental impact or assessment report.
- ❖ Preparation of an environmental impact or assessment report.
- ❖ Preparation of an environmental impact statement.

Within this Study, the cost for performing the anticipated environmental review was estimated based on the projects being financed with publicly financed grants and loans. The cost for the environmental review will be based on previous experience in preparing the required documents. If funding is obtained from a public funding agency, then the City will likely be required to submit some form of environmental report that examines the potential impact of the proposed improvements on local habitat and species. Review and approval by the affected agencies could take up to twelve (12) months or more.

Permitting

For the cost estimates prepared in this study, it was assumed that the General Contractor would bear the cost of permitting. Therefore, no permitting costs are included in these estimates. The JPA is an exception. A preliminary cost for the JPA process was included in the cost estimates.

9.3 Preliminary Cost Estimates

Alternative 2 – Complete Dam Removal

This alternative would include complete removal of the dam and all associated structures, and restoration of the original creek channel and native flora. This process would require approximately 36,000 cubic yards of excavation. The soils would be hauled off site for disposal. To facilitate the high quantity of truck traffic to and from the site, road improvements would be required.

Road improvements would include: approximately 2700 feet of asphaltic concrete (AC) overlay (2-2 inch lift) along Marine Drive, 1500 feet of AC overlay (2-2 inch lifts) along Old County Rd., and 3500 feet of 12-inch gravel overlay on the road extending from Marine Dr. to the reservoir. See Figure 9.3.2 for roadway improvement alignments. Associated costs for this alternative are listed in Table 9.3.1.

TABLE 9.3.1
TOTAL PROJECT COST ESTIMATE

Item	Description	Unit	Quantity	Unit Price	Total
1	Construct Facilities & Temporary Controls	LS	1	$ 201,900	$ 201,900
2	Demolition	LS	1	$ 100,950	$ 100,950
3	Full-Depth Reclamation and Grading	SY	1500	$ 5	$ 7,500
4	Paving Grid Fabric	SY	1500	$ 10	$ 15,000
5	Crack Sealing	LF	2500	$ 2	$ 5,000
6	AC Pavement	TON	1500	$ 140	$ 210,000
7	Frame Adjustments	EA	15	$ 1,000	$ 15,000
8	Pavement Striping	LF	8600	$ 1	$ 8,600
9	Foundation Stabalization-Gravel Road	CY	2050	$ 60	$ 123,000
10	Erosion Control	LS	1	$ 25,000	$ 25,000
11	Excavation	CY	36,000	$ 30	$ 1,080,000
12	Rock Removal	CY	300	$ 400	$ 120,000
13	Riprap	TON	1,900	$ 40	$ 76,000
14	Slope Stabilization (Hydro Seeding, Fabric)	LS	1	$ 25,000	$ 25,000
15	Natural Habitat Restoration	LS	1	$ 20,000	$ 20,000
				Subtotal	$ 2,032,950
		Contingency			$ 304,940
		Permitting			$ 100,000
		Engineering			$ 406,590
		Legal. Admin./Finan			$ 101,650
				Total	$ 2,946,130

Alternative 3 – Re-Alignment of Existing Dam, and Relocation of Existing Spillway

Alternative 3 includes: the removal of Ferry Creek earthen dam down to bedrock, construction of an earthen dam with an elevated crest and altered alignment, relocation of the dam spillway, construction of an outlet structure, construction of transmission lines which would convey raw water from the reservoir to the WTP, construction of a new drain line and associated outfall structure, and completion of a fish passage mitigation project. To facilitate the high quantity of truck traffic to and from the site, road improvements would be required.

Road improvements would be as described in Alternative 2. Water line improvements would include: 1300 feet of horizontal directional drilling, 6,550 feet of raw water transmission line, and one pressure reducing station. The outlet structure would be a concrete tower with two outlets, and multiple inlets at varied heights. Valves would be installed at each inlet/outlet to control the intake level, and to direct flows to Ferry Creek or the WTP. Associated costs for this alternative are listed in Table 9.3.2.

TABLE 9.3.2
TOTAL PROJECT COST ESTIMATE

Item	Description	Unit	Quantity	Unit Price	Total
1	Construction Facilities & Temporary Controls	LS	1	$ 644,000	$ 644,000
2	Mobilization/Demobilization	LS	1	$ 219,000	$ 219,000
3	Full-Depth Reclamation and Grading	SY	1,500	$ 5.00	$ 7,500
4	Paving Grid Fabric	SY	1,500	$ 10.00	$ 15,000
5	Crack Sealing	LF	2,500	$ 2.00	$ 5,000
6	AC Pavement	TON	1,500	$ 140.00	$ 210,000
7	Frame Adjustments	EA	15	$ 1,000.00	$ 15,000
8	Pavement Striping	LF	8,600	$ 1.00	$ 8,600
9	Foundation Stabalization-Gravel Road	CY	2,050	$ 60.00	$ 123,000
10	12" PVC Transmission Line-Class III Backfill	LF	6,550	$ 85	$ 556,750
11	12" Hprizontal Directional Drill (HDD)	LF	1,300	$ 250	$ 325,000
12	Misc. 12" Fittings	LS	1	$ 25,000	$ 25,000
13	Pressure Reducing Station	LS	1	$ 50,000	$ 50,000
14	Drain Line Replacement (18" DI)-Exted From Inlet Structure	LF	300	$ 150	$ 45,000
15	Outlet Waterline Structure	LS	1	$ 400,000	$ 400,000
16	Spillw ay Replacement	LS	1	$ 490,000	$ 490,000
17	RipRap	TON	30	$ 40	$ 1,200
18	Fill Material (Recompacted Core)	CY	22,000	$ 15	$ 330,000
19	Fill Material (Rock)	CY	38,000	$ 35	$ 1,330,000
20	Fill Material (Native Fill)	CY	1,500	$ 15	$ 22,500
21	Excavation (Reused On Site-Recompacted Core)	CY	22,000	$ 15	$ 330,000
22	Excavation (Hauled Off Site)	CY	14,000	$ 30	$ 420,000
23	Rock Removal	CY	200	$ 400	$ 80,000
23	Fish Passage Mitigation Project	LS	1	$ 500,000	$ 500,000
25	Chemical Injection System, Water Quality Treatment	LS	1	$ 15,000	$ 15,000
				Subtotal	$ 6,167,550
		Contingency			$ 925,133
		Engineering			$ 1,233,510
		Legal, Admin, Financing			$ 308,378
		Sampling-Water Quality Study			$ 30,000
		Environmental-Permitting			$ 150,000
				Total	$ 8,815,000

Alternative 4 – Re-Alignment of Ferry Creek Dam

Alternative 4 includes all project components described in Alternative 3 with the exception of the heightened dam crest elevation. This cost breakdown is identical with the exception of fill yardage, and outlet structure height. The overall project cost is $7,710,000. This alternative is not cost effective as Alternative 3 provides 13 million gallons of additional storage for an additional $1,105,000.

Alternative 5 – Remove Existing Dam and a RCC Dam

Alternative 5 includes: the removal of the Ferry Creek Dam, construction of a RCC dam with higher crest, relocation of the dam spillway, construction of transmission lines which will convey raw water from the reservoir to the WTP, and completion of a fish passage mitigation project. With the considerable earth movement required for the project, road improvements will also be necessary to facilitate heavy equipment access.

Based on the Geotechnical Investigation Report, the RCC will cost 10-15 million dollars. This does not include water transmission line, outlet structure, road improvements, environmental work, or the fish passage project which adds approximately another one million dollars to the project cost. With all project components included the alternative is estimated to cost approximately 11-16 million dollars.

9.4 Recommended Alternative

The recommended alternative is Alternative 3. Alternative 3 will: provide continuance of the fish acclimation project at the Ferry Creek Reservoir, make available approximately one mile of fish habitat along Nell Creek, will deliver streamflow augmentation during summer months, develop the most cost effective redundant water supply currently available to the City, and will remove the threat of the dam in its current condition.

As mentioned within the Geotechnical Investigation Report, more site investigation is recommended to verify the stability of the slopes surrounding the reservoir during a seismic event. Although it is highly unlikely that soil movement along the side slopes would threaten the stability of the dam, it could easily contaminate the water. In that instance the reservoir would only be a redundant supply available during salt intrusion, and not a major seismic occurrence.

9.5 Annual Operating and Maintenance Costs

Annual maintenance activities were identified with input from City staff. Preventative maintenance consists of tasks considered necessary to keep the reservoir in good working order. Monitoring and inspection are items that should be regularly performed as maintenance duties and may be conditions of a new reservoir permit. Replacement and maintenance items include the costs to replace and maintain items that require substantial costs that may not occur annually but will require budgeting. Table 9.5.1 lists the specific maintenance items for each generalized maintenance category described above.

TABLE 9.5.1
ANNUAL O&M COSTS

No.	Item	Quantity	Unit	Unit Price	Total Price
Preventive Maintenance					
1	Vegetation Mowing	1	EA	$227.16	$ 227
2	Brush Removal	2	EA	$494.20	$ 988
3	Maintain/grade embankment & access roads	1	EA	$483.51	$ 484
4	Maintain/repair embankment	1	EA	$98.18	$ 98
5	Remove and repair rodent damage	1	EA	$84.00	$ 84
6	Maintain/Repair security fence	1	EA	$100.00	$ 100
7	Cleaning (algea & dirt)	1	EA	$500.00	$ 500
8	Cleaning basin & spillway (sediment removal)	1	EA	$3,000.00	$ 3,000
9	Repair & verify calibration of measurement equip.	1	EA	$650.00	$ 650
10	Dredge settling pond(s)	0.2	EA	$10,000.00	$ 2,000
Monitoring/Inspection					
11	Monitoring - visual	12	EA	$50.00	$ 600
12	Inspection - after storm/disaster events	3	EA	$150.00	$ 450
13	Inspection - all with Engineer	1	EA	$500.00	$ 1,000
Replacement/Maintenance					
14	Valves (maintain all valves once every 7 years	0.14	EA	$7,750.00	$ 1,107
15	Valves (replace 2 valves once every 20 years)	0.10	EA	$8,000.00	$ 800
Total Yearly Operating & Maintenance Costs					$ 12,088

SECTION 10:
FUNDING AND RATE ANALYSIS

SECTION 10: **Funding and Rate Analysis**

10.1 Grants and Loans

Outside funding assistance, in the form of grants or low interest loans, will be necessary to make some of the proposed improvements affordable to the residents of the City of Brookings. The amount and types of outside funding will dictate the amount of local funding the City will have to secure. In evaluating grant and local programs, the major objective is to select a program, or a combination of programs, which are most applicable and available for the intended project.

A brief description of the major federal and state funding programs, which are typically utilized to assist qualifying communities in the financing of major water system improvement programs, is given below. Each of the government assistance programs has particular prerequisites and requirements. With each program's requirements, not all communities or projects may qualify for each of these programs.

Rural Water Loans and Grants

The Rural Development Administration (Rural Development) manages the loans and grants for water programs that were formerly overseen by the Farmers Home Administration. While these programs are administered by a new agency, the program requirements are essentially the same. The Rural Utilities Service (RUS) is one of three entities that comprise the USDAs Rural Development mission area. The RUS supports various programs that provide financial and technical assistance for development and operation of safe and affordable water supply systems.

Rural Development has the authority to make loans to public bodies and non-profit corporations to construct or improve essential community facilities, including water systems. Grants are also available to applicants who meet the Median Household Income (MHI) requirements. While eligible applicants must have a population less than 10,000, priority is given to public entities in areas with populations of less than 5,500 people, for improvements to restore a deteriorating water conveyance system, or to improve, enlarge, or modify a water facility. Preference is also given to requests that involve the merging of small facilities and those serving low-income communities.

In addition, borrowers must meet the following stipulations:

- Be unable to obtain needed funds from other sources at reasonable rates and terms.
- Legal capacity to borrow and repay loans, to pledge security for loans, and to operate and maintain the facilities or services.
- Financially sound and able to manage the facility effectively.
- Financially sound facility based on taxes, assessments, revenues, fees, or other satisfactory sources of income to pay all facility costs including Operation and Maintenance (O&M), and to retire the indebtedness and maintain a reserve.
- Water and waste disposal systems must be consistent with any development plans of state, multi-jurisdictional area, county, or municipality in which the proposed project is located. All facilities must comply with federal, state, and local laws including those concerned with zoning regulations, health and sanitation standards, and the control of water pollution.

Loan and grant funds may be used for water and waste disposal systems. Improvements must be consistent with any development plans of state, multi-jurisdictional area, county, or municipality in which the proposed project is located. All facilities must comply with federal, state, and local laws including those concerned with zoning regulations, health and sanitation standards, and the control of water pollution.

Interim commercial financing will normally be used during construction and Rural Development funds will be available when the project is completed. If interim financing is not available or if the project cost is less than $50,000, multiple advances of Rural Development funds may be made as construction progresses.

The maximum term on all loans is 40 years. However, no repayment period will exceed any statutory limitation on the organization's borrowing authority, nor the useful life of the improvement of the facility to be financed. Interest rates are set quarterly and are based on current market yields for municipal obligations. Current interest rates may be obtained from any Rural Development office.

The following rates currently apply for the Rural Development program:

Market Rate. Those applicants pay the market rate whose Median Household Income (MHI) of the service area is more than the $52,855 (Oregon non-metropolitan MHI). The market rate is currently 3.375%.

Intermediate Rate. The intermediate rate is paid by those applicants whose MHI of the service area is less than 80% of the Oregon non-metropolitan MHI. The intermediate rate is 2.75%.

Poverty Line Rate. Those applicants whose MHI of the service area is below $32,984 (80% of the State MHI) pay the lowest rate. Improvements must also be required by a governing agency to correct a regulatory violation or health risk. The current poverty line rate is 2.00%.

The grants are calculated on the basis of eligible costs that do not include the costs attributable to reserve capacity or interim financing. In addition, grant funds cannot be used to reduce total user costs below that of comparable communities funded by RUS.

Eligibility for the Rural Water and Waste Disposal grants and loans is currently based on 2010 Census data. The 2010 MHI for the City is $40,316. At this MHI, the City may be eligible for a maximum grant of up to 45%. If any of the projects were required by a governing agency for the health and safety of the service population, those projects would be at a two percent interest rate, and could receive a grant of up to 75%. Table 10.1.1 summarizes the RD funding options.

TABLE 10.1.1
RURAL DEVELOPMENT GRANT FUNDS/INTEREST RATES
BASED ON MEDIAN HOUSEHOLD INCOME

Median Household Income (MHI)	Maximum Grant (a)	Interest Rate (b)
<$42,284	75%	2.00%
$42,285 - $52,285	45%	2.75%
>$52,285	0%	3.38%

[a] MHI<42,284 may be considered for a grant up to 75% of eligible project cost if the project is needed to alleviate a health or sanitary problem.
[b] Rates are current as of February of 2017.

Other restrictions and requirements may be associated with these loans and grants. If the City becomes eligible for grant assistance, the grant will apply only to eligible project costs and is only available after a City has incurred long-term debt resulting in an annual debt service obligation equal to one-half of one percent of the MHI. To receive a Rural Utilities Service Loan, the City must secure bonding authority, usually in the form of general obligation or revenue bonds.

Oregon Community Development Block Grant Program (CDBG)

The Community Development Block Grant Program (CDBG) section of the Infrastructure Finance Authority (IFA) administers the CDBG Program. Grants and technical assistance are available to develop livable urban communities for persons of low and moderate incomes by expanding economic opportunities and providing housing and suitable living environments.

Non-metropolitan cities and counties in rural Oregon can apply for and receive grants. Oregon Tribes, urban cities (Ashland, Bend, Corvallis, Eugene, Gresham, Hillsboro, Medford, Portland, Salem and Springfield) and counties (Clackamas, Multnomah, and Washington) receive funds directly from Housing and Urban Development (HUD).

All projects must meet one of three national objectives:

- The proposed activities must benefit low and moderate income individuals.
- The activities must aid in the prevention or elimination of slums or blight.
- There must be an urgent need that poses a serious and immediate threat to the health or welfare of the community.

Funding amounts are based on:

- The applicant’s need;
- the availability of funds; and
- other restrictions defined in the program’s guidelines.

The following are the maximum grants possible for any individual project, by category:

- Water and Wastewater Improvements: $2,500,000 except preliminary/engineering planning grants: $150,000

Safe Drinking Water Revolving Loan Fund (SDWRLF)

Each year the state of Oregon Health Authority receives an allotment from the federal government for the Safe Drinking Water Revolving Loan Fund. The funds along with a 20% state match are used to make low interest loans to finance needed drinking water system improvements. Funds may be used for the following types of activities all aspects of a public water system, includes construction costs, from source of supply, filtration, treatment, storage, transmission, and metering.

While many activities are eligible for SDWRLF financing, the following activities are considered ineligible activities. These activities include <u>dams or rehabilitation of dams</u>, purchase of water rights unless owned on a system that is being purchased through a consolidation project, finished water reservoirs, administrative costs, operation and maintenance expenses, and projects primarily intended to supply or attract future growth. Therefore only the new raw water transmission main and associated components would be eligible for funding through the SDWRLF.

The program's financing is available to all sizes of water systems. Municipal, nonprofit and privately owned community water systems are eligible, as well as nonprofit non-community systems. Terms of the loan are 20 years at 80% of the state/local bond rate. This rate is currently 2.66% (June 2018). Financially disadvantaged applicants can get up to a 30-year loan at an interest rate of one percent, as well as the possibility of some principal forgiveness.

The Oregon Health Authority and the Oregon Economic and Community Development Department (OECDD) rates proposed projects. Highest ratings are given to projects that present the following:

- Addresses the most serious risk to human health.
- Necessary to ensure Safe Drinking Water Act compliance.
- Applicant has the greatest financial need, on a per household basis, according to affordability criteria.

Special consideration is given to projects at small water systems that serve 10,000 or fewer people, consolidating or merging with another system as a solution to a compliance problem, and which have an innovative solution to the stated problem.

Additional consideration will be given to disadvantaged communities. The definition of a disadvantaged community has changed to one in which the average annual water rate will exceed one and quarter percent of local Median Household income.

The National Dam Rehabilitation Program (NDRP)

Sec. 5006 of the Water Infrastructure Improvements for the Nation Act (WIIN) establishes a grant program to assist local communities to rehabilitate, repair, or remove a high-hazard potential dam before it fails. The program would allow communities to make the preemptive investment into aging infrastructure and in the process make the communities below a dam safer.

The dam rehabilitation program is administered by the Federal Emergency Management Agency (FEMA) which is currently responsible for administering the National Dam Safety Program (NDSP). The NDSP has an extremely successful track record of locating and identifying the conditions of dams across the country, but until now there has been no comprehensive program to rehabilitate dams. FEMA and the State Dam Safety Programs will determine which dams receive funding.

Dams determined to be high-hazard potential by the State Dam Safety Program, have an Emergency Action Plan (EAP) approved by the State Dam Safety Program and fail to meet minimum dam safety standards or pose an unacceptable risk to the public are eligible. Excluded dams include: federally-owned dams, licensed hydroelectric dams, and dams built under the authority of the Secretary of Agriculture. Each state with an established Dam Safety Regulatory Program (currently all states except Alabama) are eligible to receive the funds and distribute them to dam owners/sponsors. The first one third of the total available funding will be equally distributed among participating states. The remaining two thirds of the funds will be distributed based on need. Nonfederal sponsors (local communities and nonprofit organizations) must contribute at least 35% of the cost of the project and grants are capped at $7.5 million. For grants over $1 million Qualification Based Selection (QBS) is required.

The program is authorized at $10 million for FY 2017-2018, $25 million for FY 2019, $40 million for FY 2020 and $60 million for FY 2021-2026 for a total authorization of $445 million over ten years.

10.2 Local Funding Sources

The amount and type of local funding obligations for water system improvements will depend, in part, on the amount of grant funding anticipated and the requirements of potential loan funding. Local revenue sources for capital expenditures include *ad valorem* taxes, various types of bonds, water service charges, connection fees, and system development charges. The local funding sources and financing mechanisms that are most common and appropriate for the improvements identified in this study are described below.

General Obligation Bonds

A General Obligation Bond (G.O.) is backed by the full faith and credit of the issuer. For payment of the principal and interest on the bond, the issuer may levy *ad valorem* general property taxes. Such taxes are not needed if revenue from assessments, user charges or some other sources are sufficient to cover debt service.

Oregon Revised Statutes limit the maximum term to 40 years for cities. Except in the event that Rural Utilities Service will purchase the bonds, the realistic term for which general obligation bonds should be issued is 15 to 20 years. Under the present economic climate, the lower interest rates will be associated with the shorter terms.

Financing of water system improvements by General Obligation Bonds is usually accomplished by the following procedure:

- Determination of the capital costs required for the improvement.
- An election authorizing the sale of General Obligation Bonds.
- Following voter approval, the bonds are offered for sale.
- The revenue from the bond sale is used to pay the capital costs associated with the projects.

From a fund raising viewpoint, general obligation bonds are preferable to revenue bonds in matters of simplicity and cost of issuance. Since the bonds are secured by the power to tax, these bonds usually command a lower interest rate than other types of bonds. General Obligation Bonds lend themselves readily to competitive public sale at a reasonable interest rate because of their high degree of security, tax-exempt status, and general acceptance.

These bonds can be revenue-supported wherein a portion of the user fee is pledged toward payment of the debt service. Using this method, the need to collect additional property taxes to retire the obligated bonds is eliminated. Such revenue-supported general obligation bonds have the most of the advantages of revenue bonds, but also maintain the lower interest rate and ready marketability of General Obligation Bonds.

Other advantages of general obligation bonds over other types of bonds are as follows.

- The laws authorizing General Obligation Bonds are less restrictive than those governing other types of bonds.
- By the levying of taxes, the debt is repaid by all property benefited and not just the system users.
- Taxes paid in the retirement of these bonds are IRS deductible.
- General Obligation Bonds offer flexibility to retire the bonds by tax levy and/or user charge revenue.

The disadvantage of General Obligation Bond debt is that it is often added to the debt ratios of the underlying municipality, thereby restricting the flexibility of the municipality to issue debt for other purposes. Furthermore, General Obligation Bonds are normally associated with the financing of facilities that benefit an entire community, must be approved by a majority vote and often necessitate extensive public information programs. A majority vote often requires waiting for a general election in order to obtain an adequate voter turnout. Waiting for a general election may take years, and too often a project needs to be undertaken in a much shorter amount of time.

Revenue Bonds

Revenue bonds are becoming a frequently used option for long-term debt. These bonds are an acceptable alternative and offer some advantages to general obligation bonds. Revenue bonds are payable solely from charges made for the services provided. These bonds cannot be paid from tax levies or special assessments; their only security is the borrower's promise to operate the system in a way that will provide sufficient net revenue to meet the debt service and other obligations of the bond issue.

Many communities prefer revenue bonding, as opposed to General Obligation Bonding, because its insures that no tax will be levied. In addition, debt obligation will be limited to system users since repayment is derived from user fees. Another advantage of revenue bonds is that they do not count against a municipality's direct debt, but instead are considered “overlapping debt.” This feature can be a crucial advantage for a municipality near its debt limit or for the rating agencies, which consider very closely the amount of direct debt when assigning credit ratings. Revenue bonds also may be used in financing projects extending beyond normal municipal boundaries. These bonds may be supported by a pledge of revenues received in any legitimate and ongoing area of operation, within or without the geographical boundaries of the issuer.

Municipalities may elect to issue revenue bonds for revenue producing facilities without a vote of the electorate (ORS 288.805-288.945). In this case, certain notice and posting requirements must be met and a 60-day waiting period is mandatory. A petition signed by five percent of the municipality's registered voters may cause the issue to be referred to an election.

Ad Valorem Taxes

Ad valorem property taxes are often used as revenue source for utility improvements. Property taxes may be levied on real estate, personal property or both. Historically, *ad valorem* taxes were the traditional means of obtaining revenue to support all local governmental functions.

A marked advantage of these taxes is the simplicity of the system; it requires no monitoring program for developing charges, additional accounting and billing work is minimal, and default on payments is rare. In addition, *ad valorem* taxation provides a means of financing that reaches all property owners that benefit from a water system, whether a property is developed or not. The construction costs for the project are shared proportionally among all property owners based on the assessed value of each property.

Ad valorem taxation, however, is less likely to result in individual users paying their proportionate share of the costs as compared to their benefits. Public hearings and an election with voter approval would be required to implement *ad valorem* taxation.

User Fees

User fees can be used to retire General Obligation Bonds, and are commonly the sole source of revenue to retire revenue bonds and to finance operation and maintenance. User fees represent monthly charges of all residences, businesses, and other users that are connected to the water system. These fees are established by resolution and can be modified, as needed, to account for increased or decreased operating and maintenance costs. The monthly charges are usually based on the class of user (e.g. single family dwelling, multiple family dwelling, schools, etc.) and the quantity of water through a user's connection.

10.3 Financing Strategy

A financing strategy or plan must provide a mechanism to generate capital funds in sufficient amounts to pay for the proposed improvements over the relatively short duration in design and construction, generally two years. The financing strategy must also identify the manner in which annual revenue will be generated to cover the expense for long-term debt repayment and the on-going operation and maintenance of the system. The objectives of a financial strategy include the following:

- Identify the capital improvement cost for the project and the estimated expense for operation and maintenance.
- Evaluate the potential funding sources and select the most viable program.
- Determine the availability of outside funding sources and identify the local cost share.
- Determine the cost to system users to finance the local share and the annual cost for operation and maintenance.

With any of the proposed funding sources within the financial strategy, the City is advised to confirm specific funding amounts with the appropriate funding agencies prior to making local financing arrangements.

A financial strategy to address financing of the Ferry Creek Dam Removal and Replacement project is discussed below.

Grants and Low Interest Loans

Three types or programs of project funding were identified as viable for funding the recommended improvement: 1) Rural Development Grants and Loans, 2) NDRP, 3) SDWRLF and CDBG, and 4) private financing. Based on these funding programs, four alternative funding packages were compiled and evaluated. These alternatives are designated as A, B, C and D alternatives. A summary of the funding alternatives for these improvements is given in Table 10.3.1. The calculations shown in Table 10.3.1 are assumed a total project cost equivalent to that of the recommended Dam Removal and Replacement project ($8,735,000). Also, it assumes the number of Equivalent Dwelling Units within the water system is 5,620 as shown in the most recent Water Master Plan.

TABLE 10.3.1
FUNDING ALTERNATIVES IMPROVEMENTS

Funding Source	Grant Amount, $ (1)	Loan Amount, $ (1)	Loan Term, yrs	Interest Rate, %	Rate Increase, $/EDU/mth (2)
Alternative A – Rural Development (RD)/Water/Wastewater Financing Program Grants & Loans					
Rural Development	$2,183,750	$6,551,250	40	2.38%	$3.79
Alternative B – National Dam Rehabilitation Program					
NDRP	$5,677,750	$3,057,250	40	4.35%	$2.41
Alternative C – SDWRLF and Community Development Block Grant					
SDWRLF	$1,247,000	$4,988,000	20	2.83%	$4.89
CDBG	$2,500,000				
Alternative D – Private Loan					
Private Funding	--	$8,735,000	25	4.35%	$8.60

(1) Amount based on current dollars.
(2) Based on 5,620 EDUs. EDUs associated with non-profit or City use was not included in the total EDU tabulation.

The projected rate increases anticipated from the funding options range from $2.41 to $8.60 per EDU per month. These rate increases are very significantly in magnitude and should be investigated further at a "One-Stop" meeting with the funding agencies and with discussions with private funding sources. For the purposes of this financing plan, further evaluation will be made with the most conservative value, which is $8.60 per EDU per month.

10.4 Local Financing Requirements

The financing plan for the improvements is based on the City securing authorization to issue bonds ranging from $3,057,250 to $8,735,000. A breakdown of approximate monthly water user costs for the improvements, based on present worth costs and including current water O&M budget and debt reserve is given in Table 10.4.1. For this table, it was assumed that the City's debt service for the improvements would be $8,735,000 with private loan funding (Alternative D). The estimated total monthly average cost to each EDU is anticipated to be approximately $44.62. A grant for Alternative A, B, and C funding options is conditional upon the funding agencies determination of the City's eligibility for funding. The grants funds will not be offered by Rural Development if the City does not acquire authorization to issue bonds in the minimum amount required by the agency.

TABLE 10.4.1
APPROXIMATE MONTHLY USER COSTS

Item	Annual Cost	Monthly User Cost/EDU (1)
Debt Service on $8,375,000	$580,019	$8.60
Debt Service @ 10%	$58,002	$0.86
O&M Cost – Yr 2017-18 Budget	$2,041,889	$35.15
Total	$2,281,565	$44.62

(1) Based on 5,620 EDUs. EDUs associated with non-profit or City use was not included in the total EDU tabulation

10.5 Affordability

One major consideration in deciding on any proposed capital improvements is the user's ability to support the full cost, including debt repayment of utility service. Several measures of household affordability or ability-to-pay have been proposed or are currently being utilized.

The majority of affordability indicators are largely a function of income and rates. One of the most common affordability indicators is the ratio of annual user charges to the Median Household Income. The threshold of affordability for this ratio varies from one and a half to two and half percent of Median Household Income.

Affordability of rates and projected rate increases are also factors when bond rating agencies are determining credit quality. Fitch Ratings generally considers combined water and sewer service rates higher than two percent of Median Household Income (or one percent for individual water and wastewater utilities) to be financially taxing (Water and Sewer Revenue Bond Rating Guidelines, Fitch Ratings September 3, 2015).

A summary of affordability measures and thresholds from selected studies is provided in Table 10.5.1

TABLE 10.5.1
SUMMARY OF AFFORDABILITY MEASURES AND THRESHOLDS

Source	Indicator(s)	Threshold
Future Investment in Drinking Water & Wastewater Infrastructure (2002)	Ratio of annual user charge & median household income	2.5% of MHI
Rural Utilities Service Water & Waste Disposal Loans & Grants	Debt service portion of annual user charge & median household income (MHI)	>0.5% & MHI below poverty line or >1.0% & MHI between 80 & 100% of statewide non-metropolitan MHI
Department of Housing & Urban Development	Ratio of water & sewer bills, & household income	1.3 to 1.4%
National Consumer Law Center "The Poor and the Elderly – Drowning in the High Cost of Water", circa 1991	Ratio of sum of water & sewer bills & household income	>2.00 %
EPA Economic Guidance for Water Quality Standards Workbook (1995)	Ratio of annual user charge & median household income	<1.0% - no hardship expected 1.0 – 2.0% - mid-range >2.0% may be unreasonable burden
Affordability Criteria For Small Drinking Water Systems: An EPA Science Advisory Board Report (2002)	Discussion of affordability threshold, expenditure baselines, and differences in cost, income, and benefits	1. >1.0% must provide additional security. 2. >2.5% - system probably cannot issue debt
National Drinking Water Advisory Council Affordability Recommendations (2003)	EPA national affordability threshold given size category	grounds for consideration of measures other than median income
State of Idaho Assessment Tools for SRF Loans	Ratio of annual user charge & median household income	1.5% MHI

Abbreviations: AUC – Annual User Charge
MHI – Median Household Income

One limitation of using the ratio of annual user charges to the MHI is the determination of a representative MHI for a community. Currently, most funding agencies still utilize the 2010 Census data for making this determination. We have chosen to use the estimated 2015 MHI value from the Census Bureau in combination with the Consumer Price Index (CPI) for all urban consumers (CPI-U) to approximate the current MHI. The underlying assumption is that wages in the area have increased in a similar manner to that of the CPI-U. Data for the CPI-U was taken for the years 2015 through 2016 for the month of December. The percentage increase in the CPI-U between 2015 and 2016 was applied to the estimated 2015 MHI. This resulted in an estimated 2016 MHI of $40,316. The affordability of existing and future water rates within the City of Brookings is summarized in Table 10.5.2

TABLE 10.5.2
AFFORDABILITY OF PROJECTED WATER USER COSTS FOR THE CITY OF BROOKINGS

AFFORDABILITY TABULATIONS	
Median Household Income (MHI)	$40,316
Current Rates	
Estimated Monthly User Charge/EDU ($)	$31.19
Annual User Charge/ MHI (%)	0.93%
Projected Rates	
Estimated Monthly User Charge/EDU ($)	$44.62
Annual User Charge/ MHI (%)	1.33%

To fund the recommended project the rate increase would push the rate vs. MHI percentage to 1.33%. This is well within current standards as discussed previously. This percentage is low enough that it may reduce the amount of available grants.

APPENDICES

APPENDIX A: Supply Alternatives-Storage Specific Study Requirements

Task 10. OAR 690-600-0050 (2) Planning Study Criteria

a. Analyses of by-pass, optimum peak, flushing and other ecological flows of the affected stream and the impact of the storage project on those flows;

The intent of the rehabilitated dam and reservoir is to provide the City with a sustainable source of raw water in the event that saltwater intrusion reaches the Rainey Collector. The Ferry Creek reservoir does not require bypass pumping and so analysis of bypass pumping is not applicable. The amount and timing of raw water diversion will prevent any substantial impact on ecological flows. Under most circumstances, both National Marine Fisheries Service (NMFS) and Oregon Department of Fish and Wildlife (ODFW) require a minimum water depth of 1 foot and streamflow temperature deviation of less than one degree Fahrenheit for fish passage. For this study, ecological flows will be considered the 1 foot minimum flow depth as defined by NMFS and ODFW.

Low flow conditions in Ferry Creek downstream of the confluence with Geiger Creek occur for most of the summer dry period (June – October). During the drier months the flow rate in Ferry Creek is very low as there is minimal snowmelt, and groundwater to supply water to the stream. In the winter months the flow rate is highly variable and depends on precipitation. This watershed is very responsive to precipitation and drought that cause large fluctuations in flowrate.

Current flow regime will be minimally impacted by the rehabilitation of the dam and reservoir. Following construction of the rebuilt dam, a portion of the winter streamflow will be kept in the reservoir for future use. Once the reservoir is filled, all flows will bypass the dam. A portion of the storage is available to augment streamflow during drought conditions. The remaining storage will only be withdrawn on the rare occurrence of saltwater intrusion at the Rainey Collector Intake.

It is recommended a new stream gauge be installed along Ferry Creek. The new stream gauge station will allow the City to monitor and control raw water diversion and streamflow augmentation based on real time data. The hydrologic and hydraulic analysis found in Section 7 of this report concludes that stream flows in exceedance of 10.78 cfs provide adequate ecological flows for fish passage. The calculated flows within Ferry Creek near the dam will not reach the flow rate required for fish passage. This is evidenced by the absence of fish life near the area of the dam.

The optimum peak and flushing flows occur during above average high flow periods. During above average high flows fine sediments become mobilized and suspended within the water column. If these suspended sediments are diverted into the reservoir then there is potential for maintenance and water quality problems. It is therefore unlikely that raw water would be diverted at the same time flushing flows occur.

The purpose of channel maintenance or flushing flows are to provide conditions conducive to creating or maintaining stream morphology and habitat and the concern is more focused on the physical structure of the stream and is long term in nature. For Oregon gravel bed streams, a 2 year recurrence flood event represents a likely place where significant sediment transport and bed movement is occurring and would be a reasonable streamflow level for a flushing flow.

A 2-year storm event across the basin was modeled using a computer program called AutoCAD Storm and Sanitary Analysis. The program employs the Soils Conservation Service (SCS) TR-20 method for analyzing runoff quantities. The calculated runoff for a 2-year recurrent storm event was 65.73 cfs. As the Ferry Creek flushing flow is set by the 2-year storm even, it also equals 65.73 cfs.

b. Comparative analyses of alternative means of supplying water, including but not limited to the costs and benefits of conservation and efficiency alternatives and the extent to which long-term water supply needs may be met using those alternatives;

The City has adequate water rights, however it is possible that the source could be compromised and storage is necessary to mitigate that issue. Table G.1 summarizes the cost comparison of six alternatives that would address the City's problem with adequate water storage was prepared. Those are as listed below:

The six alternatives were considered and the new 39.1 MG Ferry Creek Reservoir is recommended. This alternative has the lowest cost per gallon and therefore is the most economical. The following is a description of the alternatives and the issues associated with them.

Dike Construction Further Up-Stream: A dike constructed along Ferry Creek, upstream of the dam, would allow for additional system storage. However, due to the steepness of the creek bed, and banks, the additional storage volumes would be insignificant relative to the cost of construction. Much of the cost is related to developing site access.

250,000 Gallon Treated Water Storage Tank: The construction of a new 0.25 MG Treated Water Storage Tank is part of the City's current CIP. This alternative would provide additional storage that could provide water if the current intake is taken offline. The City's Average Daily Demand (ADD), is approximately 1.0 MGD. With this demand, the reservoir would only provide a quarter-day of supply to the City under emergency conditions. This is not sufficient enough to be a viable alternative.

Tide Rock Intake Improvement: In the 1980's the City transitioned their intake point from the Tide Rock intake to the Rainey Collector Intake. The Tide Rock intake has been offline and untouched since the late 60's and therefore is in irreparable condition.

This alternative would require the complete reconstruction of the intake facilities. An updated cost estimate for this project was developed by adding inflation indices to the cost estimate found in the 'City of Brooking Water Redundant Water Supply Plan'. The cost is considerable while the benefit is minimal.

Although new Tide Rock Intake could function as a backup raw water supply if the Rainey Collector Intake or associated transmission line became inoperable, it would not function as an emergency source if salt intrusion reached the Rainey Collector. As the Tide Rock Intake is downstream of the Rainey Collector Intake, salt intrusion would reach it before the Rainey Collector Intake. This project would not provide a backup raw water source under the same conditions as the Ferry Creek Reservoir would, and therefore would not address the City's current concerns.

Water Conservation: The City has successfully implemented water conservation measures for several years. According to the Water Master Plan Brooking's per capita consumption rate at that time was 77 gpcd. This is far less than the 113 gpcd listed for public supply by U.S. Department of the Interior in 2010.

According to the Water Master Plan the distribution system is fully metered and loss is estimated to be approximately 10 percent. A certain amount of loss is inevitable and depends on many factors such as total pipe length, water usage, and water pressure. 10 percent loss throughout the water systems is considered low. OAR 690-086-0150 (4)(e) requires a systematic leak detection program if an annual water indicates that leakage exceeds 10 percent. Reducing the water loss further would require considerable time and money to narrow the exact source of the remaining water loss. For the small amount of additional water the City would conserve, they would be spending a significant amount.

Additionally, water conservation will not address the need for an emergency raw water source. This alternative would simply allow existing storage to last slightly longer if the raw water supply is cut off.

Expansion of the Ferry Creek Reservoir: The reservoir was the primary raw water source for the City of Brookings until the 60's. Since, the reservoir has been offline. Reservoir piping has degraded; embankments around the spillway have begun to slide, and the condition of the road across the dam is poor. For these reasons, the dam is considered hazardous and needs to be removed, or rehabilitated.

This alternative includes: re-aligning the dam, constructing new piping and valving at the reservoir site, constructing a new transmission line running from the Ferry Creek Reservoir to the WTP, and raising the crest of the dam to 398 feet. At this crest elevation, the reservoir could supply the City with raw water for 20 days while augmenting Ferry Creek's streamflow with 1 cfs.

This alternative would provide the City with an emergency water supply, would increase the current storage of that supply, allows for augmentation of Ferry Creek streamflow, and is cost effective.

Table G.1 Cost Comparison of Alternatives

Option	Total Cost	Cost per gallon
Dike Construction Further Up Ferry Creek	$273,480	$0.88
New .25 MG Treated Water Storage Tank	$859,750	$1.45
Original Intake Restoration	$1,710,000	$1.18
Water Conservation	N/A	N/A
Expansion of the Ferry Creek Storage Reservoir (34.2 MG)	$2,511,674	$0.27
Expansion of the Ferry Creek Storage Reservoir (39.1 MG)	$3,042,039	$0.22

c. Analyses of environmental harm or impacts from the proposed storage project; and

Sections 5, 6, 7, and 8 address impacts to the environment, and other water users.

d. Evaluation of the need for and feasibility of using stored water to augment in-stream flows to conserve, maintain and enhance aquatic life, fish life and any other ecological values;

Augmenting low flows during dry months would benefit the water quality for aquatic organisms by increasing flow depth and reducing river temperature. The need for augmenting stream flows has become more apparent with the change in climate. Climate change has shown a tendency to increase the frequency of drought years which exacerbates the depletion of stream flows. Augmenting low flows may be required by some funding agencies.

Following construction of the re-aligned dam, the reservoir will be filled. Filling of the reservoir should occur during winter months. Once the reservoir is filled, water will only be withdrawn from the reservoir during summer months to augment Ferry Creek streamflow, and for the City in the event that saltwater intrusion reaches the Rainey Collector intake.

Ferry Creek watershed plays host to a delicate ecosystem and the Oregon Coast coho salmon (*Oncorhynchus kisutch*) which is considered threatened. Ferry Creek downstream of the Ferry Creek dam is considered essential salmon habitat which restricts certain construction activities and riparian zone development. Appendix B shows the extent to which Ferry Creek is considered essential salmon habitat. Under most circumstances, both National Marine Fisheries Service and Oregon Department of Fish and Wildlife require a minimum water depth of 1 foot and streamflow temperature deviation of less than one degree Fahrenheit for fish passage. Low flow conditions in Ferry Creek occur for most of the summer dry period (June – October). Augmenting streamflow by diverting twenty-five percent of all water diverted to the reservoir would help maintain the minimum depth in lower Ferry Creek during low flow conditions.

Wet and warm weather flows immediately downstream of the dam will not provide the one foot depth required for fish passage and migration. The augmented water is intended to benefit wildlife that can be found significantly downstream of the dam along Ferry Creek. The ideal period for raw water diversion to the reservoir is between November and March, when streamflow exceeds 2 cfs.

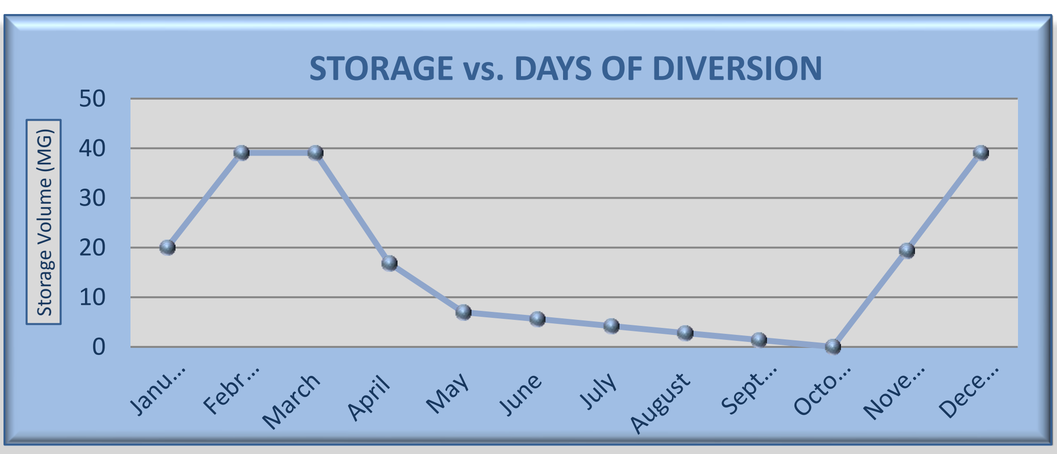
Table G.2 Ferry Creek Streamflow Pattern

Description	Value
Streamflow in Exceedance of 2 cfs per Year (days)	151
Streamflow Below 2 cfs per Year (days)	214

The intent of creating a raw water diversion and streamflow augmentation schedule is to model the typical operation of the reservoir. Modeling the typical operation of the reservoir will give insight to the diversion and augmentation timing and verify the feasibility of a sustainable operation. This model will also help to determine the period for which the City could operate the reservoir as an emergency water source while augmenting streamflow.

To determine the flow rate of augmentation the total volume available for augmentation was divided by the number of days Ferry Creek streamflow would be augmented. It was assumed that: the volume available for augmentation was equal to 25% (9.8mg) of the stored water, and that the number of days on which flow augmentation would occur was equivalent to the days Ferry Creek streamflow was less than 2 cfs. This calculation results in an augmentation rate of 45 gpm. If ODFW determined to minimize the augmentation window, then the flows could be increased.

Figure G.1
Ferry Creek Storage Volumes Over Time



The remaining 75% (29.3 mg) of the water stored would need to be kept as the back-up raw water source for the City. Using the Maximum Daily Demand (MDD) of 2.3 mgd, and an Average Daily Demand (ADD) of 1.0 mgd, which were taken from the most recent WMP, the remaining volume would supply the City with water for 28 days. This calculation assumes the first day of raw water consumption is MDD while the remaining are ADD. Figure G.1 depicts the storage volume as a function of time over the dry weather period.

e. In addition, if the storage project is for municipal use, the grant agreement will require an analysis of local and regional water demand and the proposed storage project's relationship to existing and planned water supply projects.

The dam rehabilitation project would provide raw water storage for emergency use by the City of Brookings.

Section 4 addresses projected population growth, water needs and the limits of the surface water source. This section describes the current capacity and status of Ferry Creek reservoir. The City's MDD is projected to increase from 3.56 cfs in 2018 to 5.15 cfs in 2037.

This increase in raw water demand will have little impact on Ferry Creek reservoir. As Ferry Creek will not function as a constant source of raw water, an increase in demand from the City will only effect the period of time the reservoir could function as an emergency raw water supply. With the increase in demand between 2018 and 2037, the length of time the reservoir could provide an emergency supply to the City would decrease from 37 to 27 days.

The Dam-Realignment project would not require any alterations to the current CIP projects relating to supply or storage. The City's current CIP includes one project which will increase capacity of the supply system, and one that will increase the water storage within the system. These projects are: WTP replacement, or upgrade, and the new Old County 250,000 gal. storage tank project. The reservoir will only be used as an emergency supply, therefore the increase in storage and supply capacity will be required regardless of the alterations to the Ferry Creek dam, and associated reservoir. The development of the dam re-alignment project will have no impact on the existing CIP supply/storage projects.

The Dam Re-alignment project would also have limited impact on the neighboring communities for two reasons. The first is the overall function of the reservoir. The project would store water along Ferry Creek during wet weather months, and withdraw them only in the event of an emergency. During dry weather months Ferry Creek flows will be augmented by the water stored in the reservoir. This project would effectively decrease available water along Ferry Creek while flows were already high, and increase available water when flows were low, and most needed. The second reason for minimal impact is the absence of other users along Ferry Creek. Currently, all water rights along Ferry Creek are owned by the City. Withdrawing from the Creek will impact no other water right holders along Ferry Creek.

The closest neighboring community water system is operated by the Harbor Water PUD. They withdraw water from the Chetco River downstream from the Brooking's Rainey Collector Intake. Ferry Creek is a tributary of the Chetco River, and thereby any water withdrawn from Ferry Creek would reduce the water conveyed to the river. However, Brookings would be normally withdrawing directly from the Chetco River. As a result, anytime an emergency occurs, and Brookings transitions its intake point from the Chetco River to the Ferry Creek Reservoir, it would have zero impact on the water available to the neighboring communities.

APPENDIX B: Water Quality Lab Results

NEILSON RESEARCH CORPORATION

Environmental Testing Laboratory

5/8/2018

Gary Milliman
City of Brookings
898 Elk Drive
Brookings, OR 97415

TEL: (541) 469-2163
FAX (541) 412-7153

RE: Ferry Creek Reservoir

Order No.: 1804A00

Dear Gary Milliman:

Neilson Research Corporation received 2 sample(s) on 4/26/2018 for the analyses presented in the following report.

The results relate only to the parameters tested or to the sample as received by the laboratory. This report shall not be reproduced except in full, without the written approval of Neilson Research Corporation. If you have any questions regarding these test results, please feel free to call.

Sincerely,
Neilson Research Corporation

Tamra R. Schmedemann
Project Manager

245 S Grape St ● Medford, OR 97501 ● (541) 770-5678
400 SE G St, Suite B ● Grants Pass, OR 97526 ● (541) 479-4053
www.nrclabs.com

Neilson Research Corporation

245 South Grape Street, Medford, Oregon 97501 541-770-5678 Fax 541-770-2901

Analysis Report ORELAP 100016 EPA OR00028

CLIENT:	City of Brookings	**Date:** 08-May-18	
Project:	Ferry Creek Reservoir	**CASE NARRATIVE**	
Lab Order:	1804A00		

The analyses were performed according to the guidelines in the Neilson Research Corporation Quality Assurance Program. This report contains analytical results for the sample(s) as received by the laboratory.

Neilson Research Corporation certifies that this report is in compliance with the requirements of NELAP. No unusual difficulties were experienced during analysis of this batch except as noted below or qualified with data flags on the reports.

Neilson Research Corporation

245 South Grape Street, Medford, Oregon 97501 541-770-5678 Fax 541-770-2901

Analysis Report

ORELAP 100016
EPA OR00028

City of Brookings
898 Elk Drive
Brookings, OR 97415

Lab Order: **1804A00**
NRC Sample ID: **1804A00-01A**
Collection Date: **4/25/2018 9:15:00 AM**
Received Date: **4/26/2018 9:45:00 AM**
Reported Date: **5/8/2018 4:05:09 PM**

Ferry Creek Reservoir

,

PWS ID#:
Source ID:
Matrix: Aqueous

Client Sample ID: X (30-ft depth)
Sample Location: Grab
Collectors Name: Ray Page

ANALYTICAL RESULTS

Analyses	Code	Method	NELAP Accredited	Result	Qual	MRL	Units	EPA Limit	Date Analyzed	Analyst
Color		SM 2120B	A	**15**		5	Color Units	15	4/26/2018 5:52:00 PM	EAT
Specific Conductance		SM 2510B	A	**63.8**		1	µmhos/cm		4/26/2018	CSB
Cyanide	1024	EPA 335.4	A	**ND**		0.003	mg/L	0.2	4/27/2018	SJK
Fluoride	1025	EPA 300.0	A	**ND**		0.2	mg/L	4	4/26/2018 5:28:29 PM	SCM
Nitrate Nitrogen	1040	EPA 300.0	A	**0.466**		0.2	mg/L	10	4/26/2018 5:28:29 PM	SCM
Nitrite Nitrogen	1041	EPA 300.0	A	**ND**		0.05	mg/L	1	4/26/2018 5:28:29 PM	SCM
Nitrogen, Nitrate-Nitrite	1038	EPA 300.0	A	**0.466**		0.2	mg/L	10	4/26/2018 5:28:29 PM	SCM
Sulfate	1055	EPA 300.0	A	**2.34**		0.5	mg/L	250	4/26/2018 5:28:29 PM	SCM
Mercury	1035	EPA 245.1	A	**ND**		0.0002	mg/L	0.002	5/1/2018	JWC
Hardness, Total (As CaCO3)		SM 2340B	A	**17.4**		6.62	mg/L	250	4/30/2018	JWC
Aluminum		EPA 200.7	A	**0.143**		0.01	mg/L	0.05 - 0.	4/30/2018	JWC
Iron		EPA 200.7	A	**0.260**		0.015	mg/L	0.3	4/30/2018	JWC
Sodium	1052	EPA 200.7	A	**5.94**		1	mg/L	N.L.	4/30/2018	JWC
Antimony	1074	EPA 200.8	A	**ND**		0.0005	mg/L	0.006	4/30/2018	JWC
Arsenic	1005	EPA 200.8	A	**ND**		0.001	mg/L	0.01	4/30/2018	JWC
Barium	1010	EPA 200.8	A	**0.0327**		0.0005	mg/L	2	4/30/2018	JWC
Beryllium	1075	EPA 200.8	A	**ND**		0.0001	mg/L	0.004	4/30/2018	JWC
Cadmium	1015	EPA 200.8	A	**ND**		0.0001	mg/L	0.005	4/30/2018	JWC
Chromium	1020	EPA 200.8	A	**ND**		0.001	mg/L	0.1	4/30/2018	JWC
Copper	1022	EPA 200.8	A	**0.000889**		0.0005	mg/L	1.3	4/30/2018	JWC
Lead	1030	EPA 200.8	A	**ND**		0.0001	mg/L	0.015	4/30/2018	JWC

Notes: ND - Not Detected at the MRL
MDL = Method Detection Limit
N.L. = No Limit

1

Neilson Research Corporation

245 South Grape Street, Medford, Oregon 97501 541-770-5678 Fax 541-770-2901

Analysis Report

ORELAP 100016
EPA OR00028

City of Brookings
898 Elk Drive
Brookings, OR 97415

Lab Order: **1804A00**
NRC Sample ID: **1804A00-01A**
Collection Date: **4/25/2018 9:15:00 AM**
Received Date: **4/26/2018 9:45:00 AM**
Reported Date: **5/8/2018 4:05:09 PM**

Ferry Creek Reservoir

,

PWS ID#:
Source ID:
Matrix: Aqueous

Client Sample ID: X (30-ft depth)
Sample Location: Grab
Collectors Name: Ray Page

ANALYTICAL RESULTS

Analyses	Code	Method	NELAP Accredited	Result	Qual	MRL	Units	EPA Limit	Date Analyzed	Analyst
Manganese		EPA 200.8	A	**0.288**	*	0.005	mg/L	0.05	4/30/2018	JWC
Nickel	1036	EPA 200.8	A	**0.000637**		0.0005	mg/L	N.L.	4/30/2018	JWC
Selenium	1045	EPA 200.8	A	**ND**		0.0005	mg/L	0.05	4/30/2018	JWC
Silver		EPA 200.8	A	**ND**		0.0001	mg/L	0.1	4/30/2018	JWC
Thallium	1085	EPA 200.8	A	**ND**		0.0005	mg/L	0.002	4/30/2018	JWC
Zinc		EPA 200.8	A	**ND**		0.005	mg/L	5	4/30/2018	JWC
Langelier Index		SM 203		**-3.41**		0	Index	>Neg V	5/7/2018	CSB
MBAS		SM 5540C	A	**ND**		0.04	mg/L	0.5	4/26/2018 2:00:00 PM	CSB
Odor		SM 2150 B	A	**ND**	HR	1	T.O.N.	3	4/26/2018 11:25:00 AM	EAT
pH		SM 4500H-B	A	**6.17**	HR *	0.1	pH Units	6.5 - 8.5	4/26/2018 5:15:00 PM	CSB
Total Dissolved Solids (Residue, Filterable)	1930	SM 2540-C	A	**31.2**		5	mg/L	N.L.	4/26/2018	SCM
Total Solids		SM 2540B	A	**41.0**		5	mg/L	500	4/30/2018	SCM
Turbidity		SM 2130B	A	**2.48**	*	0.1	NTU	1-5	4/26/2018 5:15:00 PM	CSB

Notes: ND - Not Detected at the MRL
MDL = Method Detection Limit
N.L. = No Limit

2

Neilson Research Corporation

245 South Grape Street, Medford, Oregon 97501 541-770-5678 Fax 541-770-2901

Analysis Report

ORELAP 100016
EPA OR00028

City of Brookings
898 Elk Drive
Brookings, OR 97415

Lab Order: **1804A00**
NRC Sample ID: **1804A00-02A**
Collection Date: **4/25/2018 9:15:00 AM**
Received Date: **4/26/2018 9:45:00 AM**
Reported Date: **5/8/2018 4:05:09 PM**

Ferry Creek Reservoir

,

PWS ID#:
Source ID:
Matrix: Aqueous

Client Sample ID: No Marking (5-ft depth)
Sample Location: Grab
Collectors Name: Ray Page

ANALYTICAL RESULTS

Analyses	Code	Method	NELAP Accredited	Result	Qual	MRL	Units	EPA Limit	Date Analyzed	Analyst
Color		SM 2120B	A	**20**	*	5	Color Units	15	4/26/2018 5:52:00 PM	EAT
Specific Conductance		SM 2510B	A	**57.1**		1	µmhos/cm		4/26/2018	CSB
Cyanide	1024	EPA 335.4	A	**ND**		0.003	mg/L	0.2	4/27/2018	SJK
Fluoride	1025	EPA 300.0	A	**ND**		0.2	mg/L	4	4/26/2018 5:56:09 PM	SCM
Nitrate Nitrogen	1040	EPA 300.0	A	**0.914**		0.2	mg/L	10	4/26/2018 5:56:09 PM	SCM
Nitrite Nitrogen	1041	EPA 300.0	A	**ND**		0.05	mg/L	1	4/26/2018 5:56:09 PM	SCM
Nitrogen, Nitrate-Nitrite	1038	EPA 300.0	A	**0.914**		0.2	mg/L	10	4/26/2018 5:56:09 PM	SCM
Sulfate	1055	EPA 300.0	A	**2.28**		0.5	mg/L	250	4/26/2018 5:56:09 PM	SCM
Mercury	1035	EPA 245.1	A	**ND**		0.0002	mg/L	0.002	5/1/2018	JWC
Hardness, Total (As CaCO3)		SM 2340B	A	**17.5**		6.62	mg/L	250	4/30/2018	JWC
Aluminum		EPA 200.7	A	**0.128**		0.01	mg/L	0.05 - 0.	4/30/2018	JWC
Iron		EPA 200.7	A	**0.173**		0.015	mg/L	0.3	4/30/2018	JWC
Sodium	1052	EPA 200.7	A	**6.14**		1	mg/L	N.L.	4/30/2018	JWC
Antimony	1074	EPA 200.8	A	**ND**		0.0005	mg/L	0.006	4/30/2018	JWC
Arsenic	1005	EPA 200.8	A	**ND**		0.001	mg/L	0.01	4/30/2018	JWC
Barium	1010	EPA 200.8	A	**0.0251**		0.0005	mg/L	2	4/30/2018	JWC
Beryllium	1075	EPA 200.8	A	**ND**		0.0001	mg/L	0.004	4/30/2018	JWC
Cadmium	1015	EPA 200.8	A	**ND**		0.0001	mg/L	0.005	4/30/2018	JWC
Chromium	1020	EPA 200.8	A	**ND**		0.001	mg/L	0.1	4/30/2018	JWC
Copper	1022	EPA 200.8	A	**ND**		0.0005	mg/L	1.3	4/30/2018	JWC
Lead	1030	EPA 200.8	A	**ND**		0.0001	mg/L	0.015	4/30/2018	JWC

Notes: ND - Not Detected at the MRL N.L. = No Limit
MDL = Method Detection Limit

3

Neilson Research Corporation

245 South Grape Street, Medford, Oregon 97501 541-770-5678 Fax 541-770-2901

Analysis Report

ORELAP 100016
EPA OR00028

City of Brookings
898 Elk Drive
Brookings, OR 97415

Lab Order: **1804A00**
NRC Sample ID: **1804A00-02A**
Collection Date: **4/25/2018 9:15:00 AM**
Received Date: **4/26/2018 9:45:00 AM**
Reported Date: **5/8/2018 4:05:09 PM**

Ferry Creek Reservoir

,

PWS ID#:
Source ID:
Matrix: Aqueous

Client Sample ID: No Marking (5-ft depth)
Sample Location: Grab
Collectors Name: Ray Page

ANALYTICAL RESULTS

Analyses	Code	Method	NELAP Accredited	Result	Qual	MRL	Units	EPA Limit	Date Analyzed	Analyst
Manganese		EPA 200.8	A	**0.0212**		0.005	mg/L	0.05	4/30/2018	JWC
Nickel	1036	EPA 200.8	A	**ND**		0.0005	mg/L	N.L.	4/30/2018	JWC
Selenium	1045	EPA 200.8	A	**ND**		0.0005	mg/L	0.05	4/30/2018	JWC
Silver		EPA 200.8	A	**ND**		0.0001	mg/L	0.1	4/30/2018	JWC
Thallium	1085	EPA 200.8	A	**ND**		0.0005	mg/L	0.002	4/30/2018	JWC
Zinc		EPA 200.8	A	**ND**		0.005	mg/L	5	4/30/2018	JWC
Langelier Index		SM 203		**-2.36**		0	Index	>Neg V	5/7/2018	CSB
MBAS		SM 5540C	A	**ND**		0.04	mg/L	0.5	4/26/2018 2:00:00 PM	CSB
Odor		SM 2150 B	A	**3.2**	*HR	1	T.O.N.	3	4/26/2018 12:21:00 PM	EAT
pH		SM 4500H-B	A	**7.25**	HR	0.1	pH Units	6.5 - 8.5	4/26/2018 5:15:00 PM	CSB
Total Dissolved Solids (Residue, Filterable)	1930	SM 2540-C	A	**30.0**		5	mg/L	N.L.	4/26/2018	SCM
Total Solids		SM 2540B	A	**53.0**		5	mg/L	500	4/30/2018	SCM
Turbidity		SM 2130B	A	**2.79**	*	0.1	NTU	1-5	4/26/2018 5:15:00 PM	CSB

Notes: ND - Not Detected at the MRL
MDL = Method Detection Limit
N.L. = No Limit

4

Neilson Research Corporation

DATA FLAGS

B	Analyte detected in the associated method blank.
BA	BOD Alternative Calculation: The initial results performed by Standard Methods did not fall within parameters of the Standard Methods calculation. An alternate approved calculation was performed using the HACH method and the value reported is an estimated concentration.
C	Sample(s) does not meet NELAP/ORELAP sample acceptance criteria. See Case Narrative.
C1	Sample(s) does not meet NELAP/ORELAP sample acceptance criteria for temperature.
CF	Results confirmed by re-analysis.
CU	Cleanup performed as specified by method.
D1	The diesel elution pattern for the sample is not typical.
D2	The sample appears to be a heavier hydrocarbon range than diesel.
D3	The sample appears to be a lighter hydrocarbon range than diesel.
D4	Detected hydrocarbons do not have pattern and range consistent with typical petroleum products and may be due to biogenic interference.
D5	Detected hydrocarbons in the diesel range appear to be weathered diesel.
E	Estimated value.
ER	Elevated reporting limit due to matrix. Report limits (MDLs, MRLs & PQLs) are adjusted based on variations in sample preparation amounts, analytical dilutions, and percent solids, where applicable.
FC	Fecal Coliforms: Sample(s) received past 40 CFR Part 136 specified holding time. Results reported as estimated values.
G1	The gasoline elution pattern for the sample is not typical.
G2	The sample appears to be a heavier hydrocarbon range than gasoline.
G3	The sample appears to be a lighter hydrocarbon range than gasoline.
G4	Detected hydrocarbons in the gasoline range appear to be weathered gasoline.
HP	Sample re-analysis performed outside of method specified holding time.
HR	Sample received outside of method specified holding time.
HS	Sample analyzed for volatile organics contained headspace.
HT	At the client's request, the sample was analyzed outside of method specified holding time.
H	Analysis performed outside of method specified holding time.
J	Analyte detected below the Minimum Reporting Limit (MRL) and above the Method Detection Limit (MDL). The J flag result is an estimated value and the user should be aware that this data is of limited reliability.
L	Dissolved metals were not filtered within 15 minutes of collection per 40 CFR Part 136.
MI	Surrogate or Matrix Spike recovery is out of control limits due to matrix interference. Sample results may be biased.
N	See Case Narrative on page 2 of report.
Q	Closing continuing calibration verification (CCV) or laboratory control sample (LCS) exceeded high recovery limits, but associated samples are non-detect and the sample results are not affected. Data meets EPA/NELAP requirements.
R	Relative percent difference (RPD) is outside of the accepted recovery limits.
R1	Relative percent difference (RPD) is outside of the accepted recovery limits. However, analyses are not controlled on RPD values for sample concentrations that are less than the reporting limit.
R3	The relative percent difference (RPD) and/or percent recovery for the duplicate (DUP) or matrix spike (MS)/matrix spike duplicate (MSD) cannot be accurately calculated due to the concentration of analyte already present in the sample.
R4	Duplicate analysis failed due to result being at or near method reporting limit.
S	Surrogate and/or matrix spike recovery is outside of the accepted recovery limits. Sample results may be biased.
S1	Surrogate or matrix spike recovery is outside of control limits due to dilution necessary for analysis.
SC	Sub-contracted to another laboratory for analysis.
SP	Sample(s) were not collected per EPA Method 5035A protocols. The results are considered minimum values.
T	Toxicity Characteristic Leaching Procedure – Sample submitted contained < 0.5% solids. If the waste contains <0.5% dry solids, the liquid portion of the waste, after filtration, is defined as the TCLP extract.
#	Value exceeds regulatory level for TCLP contaminant.
X1	The motor oil elution pattern for the sample is not typical.
X2	The sample appears to be a heavier hydrocarbon range than motor oil.
X3	The sample appears to be a lighter hydrocarbon range than motor oil.
*	Value exceeds Maximum Contaminant Level or is outside the acceptable range.

NRC SOP QA-1104/AD-3100
Revision 4
Effective Date: 1/10/18

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ALKALINITY_W

Sample ID **MB-R103084**	SampType: **MBLK**	TestCode: **ALKALINITY_** Units: **mg/L**	Prep Date:	RunNo: **103084**
Client ID: **ZZZZZ**	Batch ID: **R103084**	TestNo: **SM 2320B**	Analysis Date: **4/26/2018**	SeqNo: **1557464**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	10.0									

Sample ID **LCS-R103084**	SampType: **LCS**	TestCode: **ALKALINITY_** Units: **mg/L**	Prep Date:	RunNo: **103084**
Client ID: **ZZZZZ**	Batch ID: **R103084**	TestNo: **SM 2320B**	Analysis Date: **4/26/2018**	SeqNo: **1557465**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	48.00	10.0	50	0	96.0	80	120				

Sample ID **1804947-01ADUP**	SampType: **DUP**	TestCode: **ALKALINITY_** Units: **mg/L**	Prep Date:	RunNo: **103084**
Client ID: **ZZZZZ**	Batch ID: **R103084**	TestNo: **SM 2320B**	Analysis Date: **4/26/2018**	SeqNo: **1557472**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	54.00	10.0						56	3.64	10	

Qualifiers:
E Value above quantitation range
ND Not Detected at the Minimum Reporting Limit
H Holding times for preparation or analysis exceeded
R RPD outside accepted recovery limits
J Analyte detected below quantitation limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ALKALINITY_W

Sample ID **MB-R103084** SampType: **MBLK** TestCode: **ALKALINITY_** Units: **mg/L** Prep Date: RunNo: **103084**
Client ID: **ZZZZZ** Batch ID: **R103084** TestNo: **SM 2320B** Analysis Date: **4/26/2018** SeqNo: **1557464**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	10.0									

Sample ID **LCS-R103084** SampType: **LCS** TestCode: **ALKALINITY_** Units: **mg/L** Prep Date: RunNo: **103084**
Client ID: **ZZZZZ** Batch ID: **R103084** TestNo: **SM 2320B** Analysis Date: **4/26/2018** SeqNo: **1557465**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	48.00	10.0	50	0	96.0	80	120				

Sample ID **1804947-01ADUP** SampType: **DUP** TestCode: **ALKALINITY_** Units: **mg/L** Prep Date: RunNo: **103084**
Client ID: **ZZZZZ** Batch ID: **R103084** TestNo: **SM 2320B** Analysis Date: **4/26/2018** SeqNo: **1557472**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	54.00	10.0						56	3.64	10	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: COLOR

Sample ID **MB-R103111** SampType: **MBLK** TestCode: **COLOR** Units: **Color Units** Prep Date: RunNo: **103111**
Client ID: **ZZZZZ** Batch ID: **R103111** TestNo: **SM 2120B** Analysis Date: **4/26/2018** SeqNo: **1557908**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Color	ND	5.0									

Sample ID **1804A00-02ADUP** SampType: **DUP** TestCode: **COLOR** Units: **Color Units** Prep Date: RunNo: **103111**
Client ID: **No Marking (5-ft de** Batch ID: **R103111** TestNo: **SM 2120B** Analysis Date: **4/26/2018** SeqNo: **1557916**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Color	20.00	5.0						20	0	10	*

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

Neilson Research Corporation

Date: 08-May-18

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: COND_DW

Sample ID **LCS-R103106**	SampType: **LCS**	TestCode: **COND_DW**	Units: **µmhos/cm**	Prep Date:					RunNo: **103106**			
Client ID: **ZZZZZ**	Batch ID: **R103106**	TestNo: **SM 2510B**		Analysis Date: **4/26/2018**					SeqNo: **1557861**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual	
Specific Conductance	1361	1.00	1413	0	96.3	90	110					

Sample ID **1804A19-01BDUP**	SampType: **DUP**	TestCode: **COND_DW**	Units: **µmhos/cm**	Prep Date:					RunNo: **103106**			
Client ID: **ZZZZZ**	Batch ID: **R103106**	TestNo: **SM 2510B**		Analysis Date: **4/26/2018**					SeqNo: **1557866**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual	
Specific Conductance	5.460	1.00						5.3	2.97	10		

Qualifiers:
E Value above quantitation range
H Holding times for preparation or analysis exceeded
J Analyte detected below quantitation limits
ND Not Detected at the Minimum Reporting Limit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: CYANIDE_DW_AUTO

Sample ID **MB-40986** SampType: **MBLK** TestCode: **CYANIDE_D** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103136**
Client ID: **ZZZZZ** Batch ID: **40986** TestNo: **EPA 335.4** **(EPA 335.3)** Analysis Date: **4/27/2018** SeqNo: **1558361**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cyanide	ND	0.00300									

Sample ID **LCS-40986** SampType: **LCS** TestCode: **CYANIDE_D** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103136**
Client ID: **ZZZZZ** Batch ID: **40986** TestNo: **EPA 335.4** **(EPA 335.3)** Analysis Date: **4/27/2018** SeqNo: **1558360**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cyanide	0.5590	0.0300	0.59	0	94.7	90	110				

Sample ID **1804941-01AMS** SampType: **MS** TestCode: **CYANIDE_D** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103136**
Client ID: **ZZZZZ** Batch ID: **40986** TestNo: **EPA 335.4** **(EPA 335.3)** Analysis Date: **4/27/2018** SeqNo: **1558353**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cyanide	0.4620	0.0300	0.59	0	78.3	80	120				MI

Sample ID **1804941-01AMSD** SampType: **MSD** TestCode: **CYANIDE_D** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103136**
Client ID: **ZZZZZ** Batch ID: **40986** TestNo: **EPA 335.4** **(EPA 335.3)** Analysis Date: **4/27/2018** SeqNo: **1558354**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cyanide	0.4880	0.0300	0.59	0	82.7	80	120	0.462	5.47	20	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: EPA300_PWS

Sample ID **MBLK** SampType: **MBLK** TestCode: **EPA300_PW** Units: **mg/L** Prep Date: RunNo: **103098**
Client ID: **ZZZZZ** Batch ID: **R103098** TestNo: **EPA 300.0** Analysis Date: **4/26/2018** SeqNo: **1557685**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.200									
Nitrate Nitrogen	ND	0.200									
Nitrite Nitrogen	ND	0.0500									
Sulfate	ND	0.500									
Nitrogen, Nitrate-Nitrite	ND	0.200									

Sample ID **LCS** SampType: **LCS** TestCode: **EPA300_PW** Units: **mg/L** Prep Date: RunNo: **103098**
Client ID: **ZZZZZ** Batch ID: **R103098** TestNo: **EPA 300.0** Analysis Date: **4/26/2018** SeqNo: **1557686**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.9605	0.200	1	0	96.1	90	110				
Nitrate Nitrogen	0.9595	0.200	1	0	96.0	90	110				
Nitrite Nitrogen	0.4878	0.0500	0.5	0	97.6	90	110				
Sulfate	5.831	0.500	6	0	97.2	90	110				
Nitrogen, Nitrate-Nitrite	1.447	0.200	1.5	0	96.5	90	110				

Sample ID **1804A01-01BMS** SampType: **MS** TestCode: **EPA300_PW** Units: **mg/L** Prep Date: RunNo: **103098**
Client ID: **ZZZZZ** Batch ID: **R103098** TestNo: **EPA 300.0** Analysis Date: **4/26/2018** SeqNo: **1557688**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.9797	0.200	1	0.03181	94.8	80	120				
Nitrate Nitrogen	1.024	0.200	1	0.06892	95.5	80	120				
Nitrite Nitrogen	0.4971	0.0500	0.5	0	99.4	80	120				
Sulfate	8.194	0.500	6	2.446	95.8	80	120				
Nitrogen, Nitrate-Nitrite	1.521	0.200	1.5	0.06892	96.8	80	120				

Qualifiers:
- E Value above quantitation range
- ND Not Detected at the Minimum Reporting Limit
- H Holding times for preparation or analysis exceeded
- R RPD outside accepted recovery limits
- J Analyte detected below quantitation limits
- S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: EPA300_PWS

Sample ID **1804A01-01BMSD** SampType: **MSD** TestCode: **EPA300_PW** Units: **mg/L** Prep Date: RunNo: **103098**
Client ID: **ZZZZZ** Batch ID: **R103098** TestNo: **EPA 300.0** Analysis Date: **4/26/2018** SeqNo: **1557689**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	1.016	0.200	1	0.03181	98.4	80	120	0.9797	3.62	15	
Nitrate Nitrogen	1.027	0.200	1	0.06892	95.8	80	120	1.024	0.296	15	
Nitrite Nitrogen	0.5184	0.0500	0.5	0	104	80	120	0.4971	4.19	15	
Sulfate	8.104	0.500	6	2.446	94.3	80	120	8.194	1.10	15	
Nitrogen, Nitrate-Nitrite	1.546	0.200	1.5	0.06892	98.5	80	120	0	0	15	

Qualifiers:
E Value above quantitation range
ND Not Detected at the Minimum Reporting Limit
H Holding times for preparation or analysis exceeded
R RPD outside accepted recovery limits
J Analyte detected below quantitation limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: HG_DW

Sample ID **MB-41015** SampType: **MBLK** TestCode: **HG_DW** Units: **mg/L** Prep Date: **5/1/2018** RunNo: **103208**
Client ID: **ZZZZZ** Batch ID: **41015** TestNo: **EPA 245.1** **(EPA 245.1/7** Analysis Date: **5/1/2018** SeqNo: **1559617**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	ND	0.000200									

Sample ID **LCS-41015** SampType: **LCS** TestCode: **HG_DW** Units: **mg/L** Prep Date: **5/1/2018** RunNo: **103208**
Client ID: **ZZZZZ** Batch ID: **41015** TestNo: **EPA 245.1** **(EPA 245.1/7** Analysis Date: **5/1/2018** SeqNo: **1559618**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.004623	0.000200	0.005	0	92.5	80	120				

Sample ID **1804A00-01AMS** SampType: **MS** TestCode: **HG_DW** Units: **mg/L** Prep Date: **5/1/2018** RunNo: **103208**
Client ID: **X (30-ft depth)** Batch ID: **41015** TestNo: **EPA 245.1** **(EPA 245.1/7** Analysis Date: **5/1/2018** SeqNo: **1559622**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.004633	0.000200	0.005	0	92.7	75	125				

Sample ID **1804A00-01AMSD** SampType: **MSD** TestCode: **HG_DW** Units: **mg/L** Prep Date: **5/1/2018** RunNo: **103208**
Client ID: **X (30-ft depth)** Batch ID: **41015** TestNo: **EPA 245.1** **(EPA 245.1/7** Analysis Date: **5/1/2018** SeqNo: **1559623**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.004869	0.000200	0.005	0	97.4	75	125	0.004633	4.97	20	

Qualifiers:
E Value above quantitation range
ND Not Detected at the Minimum Reporting Limit
H Holding times for preparation or analysis exceeded
R RPD outside accepted recovery limits
J Analyte detected below quantitation limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICP-HARD_DW

Sample ID **MB-41004**	SampType: **MBLK**	TestCode: **ICP-HARD_D**	Units: **mg/L**		Prep Date: **4/30/2018**		RunNo: **103170**			
Client ID: **ZZZZZ**	Batch ID: **41004**	TestNo: **SM 2340B**	**(EPA 200.7)**		Analysis Date: **4/30/2018**		SeqNo: **1559066**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hardness, Total (As CaCO3)	ND	6.62									

Sample ID **LCS-41004**	SampType: **LCS**	TestCode: **ICP-HARD_D**	Units: **mg/L**		Prep Date: **4/30/2018**		RunNo: **103170**			
Client ID: **ZZZZZ**	Batch ID: **41004**	TestNo: **SM 2340B**	**(EPA 200.7)**		Analysis Date: **4/30/2018**		SeqNo: **1559067**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hardness, Total (As CaCO3)	ND	6.62	6.615	0	91.9	85	115				

Sample ID **1804A00-02AMS**	SampType: **MS**	TestCode: **ICP-HARD_D**	Units: **mg/L**		Prep Date: **4/30/2018**		RunNo: **103170**			
Client ID: **No Marking (5-ft de**	Batch ID: **41004**	TestNo: **SM 2340B**	**(EPA 200.7)**		Analysis Date: **4/30/2018**		SeqNo: **1559080**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hardness, Total (As CaCO3)	150.5	6.62	138	17.51	96.4	70	130				

Sample ID **1804A00-02AMSD**	SampType: **MSD**	TestCode: **ICP-HARD_D**	Units: **mg/L**		Prep Date: **4/30/2018**		RunNo: **103170**			
Client ID: **No Marking (5-ft de**	Batch ID: **41004**	TestNo: **SM 2340B**	**(EPA 200.7)**		Analysis Date: **4/30/2018**		SeqNo: **1559081**			
Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hardness, Total (As CaCO3)	156.2	6.62	138	17.51	101	70	130	150.5	3.71	20	

Qualifiers:
E Value above quantitation range
ND Not Detected at the Minimum Reporting Limit
H Holding times for preparation or analysis exceeded
R RPD outside accepted recovery limits
J Analyte detected below quantitation limits
S Spike Recovery outside accepted recovery limits

Neilson Research Corporation

Date: 08-May-18

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICP_200.7_DW

Sample ID **MB-41004** SampType: **MBLK** TestCode: **ICP_200.7_D** Units: **mg/L** Prep Date: **4/30/2018** RunNo: **103169**
Client ID: **ZZZZZ** Batch ID: **41004** TestNo: **EPA 200.7** **(EPA 200.7)** Analysis Date: **4/30/2018** SeqNo: **1559028**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	0.0100									
Hardness, Total (As CaCO3)	ND	6.62									
Iron	ND	0.0150									
Sodium	ND	1.00									

Sample ID **LCS-41004** SampType: **LCS** TestCode: **ICP_200.7_D** Units: **mg/L** Prep Date: **4/30/2018** RunNo: **103169**
Client ID: **ZZZZZ** Batch ID: **41004** TestNo: **EPA 200.7** **(EPA 200.7)** Analysis Date: **4/30/2018** SeqNo: **1559029**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	0.8900	0.0100	1	0	89.0	85	115				
Hardness, Total (As CaCO3)	ND	6.62	6.615	0	91.9	85	115				
Iron	0.9656	0.0150	1	0	96.6	85	115				
Sodium	1.864	1.00	2	0	93.2	85	115				

Sample ID **1804A00-02AMS** SampType: **MS** TestCode: **ICP_200.7_D** Units: **mg/L** Prep Date: **4/30/2018** RunNo: **103169**
Client ID: **No Marking (5-ft de** Batch ID: **41004** TestNo: **EPA 200.7** **(EPA 200.7)** Analysis Date: **4/30/2018** SeqNo: **1559042**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	19.87	0.0100	21	0.1275	94.0	70	130				
Hardness, Total (As CaCO3)	150.5	6.62	138.8	17.51	95.8	70	130				
Iron	20.25	0.0150	21	0.1726	95.6	70	130				
Sodium	27.36	1.00	22	6.139	96.5	70	130				

Sample ID **1804A00-02AMSD** SampType: **MSD** TestCode: **ICP_200.7_D** Units: **mg/L** Prep Date: **4/30/2018** RunNo: **103169**
Client ID: **No Marking (5-ft de** Batch ID: **41004** TestNo: **EPA 200.7** **(EPA 200.7)** Analysis Date: **4/30/2018** SeqNo: **1559043**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	20.58	0.0100	21	0.1275	97.4	70	130	19.87	3.51	20	
Hardness, Total (As CaCO3)	156.2	6.62	138.8	17.51	99.9	70	130	150.5	3.71	20	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

Neilson Research Corporation

Date: 08-May-18

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICP_200.7_DW

Sample ID **1804A00-02AMSD**	SampType: **MSD**	TestCode: **ICP_200.7_D**	Units: **mg/L**	Prep Date: **4/30/2018**	RunNo: **103169**
Client ID: **No Marking (5-ft de**	Batch ID: **41004**	TestNo: **EPA 200.7**	**(EPA 200.7)**	Analysis Date: **4/30/2018**	SeqNo: **1559043**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Iron	21.02	0.0150	21	0.1726	99.3	70	130	20.25	3.73	20	
Sodium	28.41	1.00	22	6.139	101	70	130	27.36	3.77	20	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

Neilson Research Corporation

Date: 08-May-18

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICPMS_200.8_PWS

Sample ID **MB-40995** SampType: **MBLK** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **ZZZZZ** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558668**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Antimony	ND	0.000500									
Arsenic	ND	0.00100									
Barium	ND	0.000500									
Beryllium	ND	0.000100									
Cadmium	ND	0.000100									
Chromium	ND	0.00100									
Copper	ND	0.000500									
Lead	ND	0.000100									
Manganese	ND	0.00500									
Nickel	ND	0.000500									
Selenium	ND	0.000500									
Silver	ND	0.000100									
Thallium	ND	0.000500									
Zinc	ND	0.00500									

Sample ID **LCS-40995** SampType: **LCS** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **ZZZZZ** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558669**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Antimony	0.09910	0.000500	0.1	0	99.1	85	115				
Arsenic	0.09576	0.00100	0.1	0	95.8	85	115				
Barium	0.09936	0.000500	0.1	0	99.4	85	115				
Beryllium	0.09524	0.000100	0.1	0	95.2	85	115				
Cadmium	0.09676	0.000100	0.1	0	96.8	85	115				
Chromium	0.09679	0.00100	0.1	0	96.8	85	115				
Copper	0.09808	0.000500	0.1	0	98.1	85	115				
Lead	0.09694	0.000100	0.1	0	96.9	85	115				
Manganese	0.09997	0.00500	0.1	0	100	85	115				
Nickel	0.09693	0.000500	0.1	0	96.9	85	115				

Qualifiers:
E Value above quantitation range
H Holding times for preparation or analysis exceeded
J Analyte detected below quantitation limits
ND Not Detected at the Minimum Reporting Limit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICPMS_200.8_PWS

Sample ID **LCS-40995** SampType: **LCS** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **ZZZZZ** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558669**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Selenium	0.09635	0.000500	0.1	0	96.4	85	115				
Silver	0.09468	0.000100	0.1	0	94.7	85	115				
Thallium	0.09718	0.000500	0.1	0	97.2	85	115				
Zinc	0.09482	0.00500	0.1	0	94.8	85	115				

Sample ID **1804A00-02AMS** SampType: **MS** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **No Marking (5-ft de** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558674**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Antimony	0.09876	0.000500	0.1	0.000062	98.7	70	130				
Arsenic	0.09462	0.00100	0.1	0	94.6	70	130				
Barium	0.1230	0.000500	0.1	0.02505	98.0	70	130				
Beryllium	0.09364	0.000100	0.1	0.000003	93.6	70	130				
Cadmium	0.09425	0.000100	0.1	0	94.2	70	130				
Chromium	0.09414	0.00100	0.1	0.000272	93.9	70	130				
Copper	0.09537	0.000500	0.1	0.000414	95.0	70	130				
Lead	0.09464	0.000100	0.1	0	94.6	70	130				
Manganese	0.1177	0.00500	0.1	0.02121	96.5	70	130				
Nickel	0.09373	0.000500	0.1	0.000305	93.4	70	130				
Selenium	0.09413	0.000500	0.1	0.000115	94.0	70	130				
Silver	0.09212	0.000100	0.1	0.000003	92.1	70	130				
Thallium	0.09476	0.000500	0.1	0	94.8	70	130				
Zinc	0.09309	0.00500	0.1	0	93.1	70	130				

Sample ID **1804A00-02AMSD** SampType: **MSD** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **No Marking (5-ft de** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558675**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Antimony	0.09923	0.000500	0.1	0.000062	99.2	70	130	0.09876	0.481	20	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: ICPMS_200.8_PWS

Sample ID **1804A00-02AMSD** SampType: **MSD** TestCode: **ICPMS_200.8** Units: **mg/L** Prep Date: **4/27/2018** RunNo: **103156**
Client ID: **No Marking (5-ft de** Batch ID: **40995** TestNo: **EPA 200.8** **(EPA 200.8)** Analysis Date: **4/30/2018** SeqNo: **1558675**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.09681	0.00100	0.1	0	96.8	70	130	0.09462	2.28	20	
Barium	0.1251	0.000500	0.1	0.02505	100	70	130	0.123	1.66	20	
Beryllium	0.09525	0.000100	0.1	0.000003	95.2	70	130	0.09364	1.71	20	
Cadmium	0.09604	0.000100	0.1	0	96.0	70	130	0.09425	1.88	20	
Chromium	0.09533	0.00100	0.1	0.000272	95.1	70	130	0.09414	1.25	20	
Copper	0.09729	0.000500	0.1	0.000414	96.9	70	130	0.09537	2.00	20	
Lead	0.09583	0.000100	0.1	0	95.8	70	130	0.09464	1.24	20	
Manganese	0.1194	0.00500	0.1	0.02121	98.2	70	130	0.1177	1.47	20	
Nickel	0.09568	0.000500	0.1	0.000305	95.4	70	130	0.09373	2.07	20	
Selenium	0.09546	0.000500	0.1	0.000115	95.3	70	130	0.09413	1.40	20	
Silver	0.09403	0.000100	0.1	0.000003	94.0	70	130	0.09212	2.05	20	
Thallium	0.09694	0.000500	0.1	0	96.9	70	130	0.09476	2.27	20	
Zinc	0.09393	0.00500	0.1	0	93.9	70	130	0.09309	0.899	20	

Qualifiers:
E Value above quantitation range
H Holding times for preparation or analysis exceeded
J Analyte detected below quantitation limits
ND Not Detected at the Minimum Reporting Limit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: MBAS

Sample ID **MB-R103153**	SampType: **MBLK**	TestCode: **MBAS**	Units: **mg/L**	Prep Date:		RunNo: **103153**
Client ID: **ZZZZZ**	Batch ID: **R103153**	TestNo: **SM 5540C**		Analysis Date: **4/26/2018**		SeqNo: **1558535**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
MBAS	ND	0.100									

Sample ID **LCS-R103153**	SampType: **LCS**	TestCode: **MBAS**	Units: **mg/L**	Prep Date:		RunNo: **103153**
Client ID: **ZZZZZ**	Batch ID: **R103153**	TestNo: **SM 5540C**		Analysis Date: **4/26/2018**		SeqNo: **1558536**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
MBAS	0.8280	0.100	0.83	0	99.8	80	120				

Sample ID **1804A00-01AMS**	SampType: **MS**	TestCode: **MBAS**	Units: **mg/L**	Prep Date:		RunNo: **103153**
Client ID: **X (30-ft depth)**	Batch ID: **R103153**	TestNo: **SM 5540C**		Analysis Date: **4/26/2018**		SeqNo: **1558540**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
MBAS	0.1121	0.0400	0.12	0	93.4	80	120				

Sample ID **1804A00-01AMSD**	SampType: **MSD**	TestCode: **MBAS**	Units: **mg/L**	Prep Date:		RunNo: **103153**
Client ID: **X (30-ft depth)**	Batch ID: **R103153**	TestNo: **SM 5540C**		Analysis Date: **4/26/2018**		SeqNo: **1558541**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
MBAS	0.1169	0.0400	0.12	0	97.4	80	120	0.1121	4.25	15	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: PH_DW

Sample ID **LCS-R103104** SampType: **LCS** TestCode: **PH_DW** Units: **pH Units** Prep Date: RunNo: **103104**
Client ID: **ZZZZZ** Batch ID: **R103104** TestNo: **SM 4500H-B** Analysis Date: **4/26/2018** SeqNo: **1557847**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	6.850	0.10	6.86	0	99.9	97.1	102.9				

Sample ID **1804A19-01BDUP** SampType: **DUP** TestCode: **PH_DW** Units: **pH Units** Prep Date: RunNo: **103104**
Client ID: **ZZZZZ** Batch ID: **R103104** TestNo: **SM 4500H-B** Analysis Date: **4/26/2018** SeqNo: **1557852**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	5.930	0.10						6.04	1.84	10	*

Qualifiers:
E Value above quantitation range
H Holding times for preparation or analysis exceeded
J Analyte detected below quantitation limits
ND Not Detected at the Minimum Reporting Limit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: SOLIDS_TDS_W

Sample ID **MB-R103116** SampType: **MBLK** TestCode: **SOLIDS_TDS** Units: **mg/L** Prep Date: RunNo: **103116**
Client ID: **ZZZZZ** Batch ID: **R103116** TestNo: **SM 2540-C** Analysis Date: **4/26/2018** SeqNo: **1557966**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	ND	5.00									

Sample ID **LCS-R103116** SampType: **LCS** TestCode: **SOLIDS_TDS** Units: **mg/L** Prep Date: RunNo: **103116**
Client ID: **ZZZZZ** Batch ID: **R103116** TestNo: **SM 2540-C** Analysis Date: **4/26/2018** SeqNo: **1557967**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	88.75	5.00	100	0	88.8	80	120				

Sample ID **1804830-01ADUP** SampType: **DUP** TestCode: **SOLIDS_TDS** Units: **mg/L** Prep Date: RunNo: **103116**
Client ID: **ZZZZZ** Batch ID: **R103116** TestNo: **SM 2540-C** Analysis Date: **4/26/2018** SeqNo: **1557969**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	274.0	8.00						286	4.29	5	

Qualifiers:
E Value above quantitation range
ND Not Detected at the Minimum Reporting Limit
H Holding times for preparation or analysis exceeded
R RPD outside accepted recovery limits
J Analyte detected below quantitation limits
S Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: SOLIDS_TOT_W

Sample ID **MB-R103306**	SampType: **MBLK**	TestCode: **SOLIDS_TOT** Units: **mg/L**	Prep Date:	RunNo: **103306**
Client ID: **ZZZZZ**	Batch ID: **R103306**	TestNo: **SM 2540B**	Analysis Date: **4/30/2018**	SeqNo: **1561673**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Solids	5.000	5.00									

Sample ID **LCS-R103306**	SampType: **LCS**	TestCode: **SOLIDS_TOT** Units: **mg/L**	Prep Date:	RunNo: **103306**
Client ID: **ZZZZZ**	Batch ID: **R103306**	TestNo: **SM 2540B**	Analysis Date: **4/30/2018**	SeqNo: **1561674**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Solids	101.0	5.00	100	5	96.0	80	120				

Sample ID **1804A00-02ADUP**	SampType: **DUP**	TestCode: **SOLIDS_TOT** Units: **mg/L**	Prep Date:	RunNo: **103306**
Client ID: **No Marking (5-ft de**	Batch ID: **R103306**	TestNo: **SM 2540B**	Analysis Date: **4/30/2018**	SeqNo: **1561678**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Solids	54.00	5.00						53	1.87	5	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

CLIENT: City of Brookings
Work Order: 1804A00
Project: Ferry Creek Reservoir

ANALYTICAL QC SUMMARY REPORT

TestCode: TURBIDITY_DW

Sample ID **MB-R103103** SampType: **MBLK** TestCode: **TURBIDITY_** Units: **NTU** Prep Date: RunNo: **103103**
Client ID: **ZZZZZ** Batch ID: **R103103** TestNo: **SM 2130B** Analysis Date: **4/26/2018** SeqNo: **1557839**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	ND	0.100									

Sample ID **LCS-R103103** SampType: **LCS** TestCode: **TURBIDITY_** Units: **NTU** Prep Date: RunNo: **103103**
Client ID: **ZZZZZ** Batch ID: **R103103** TestNo: **SM 2130B** Analysis Date: **4/26/2018** SeqNo: **1557840**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	4.280	0.100	4.54	0	94.3	90	110				

Sample ID **1804A00-01ADUP** SampType: **DUP** TestCode: **TURBIDITY_** Units: **NTU** Prep Date: RunNo: **103103**
Client ID: **X (30-ft depth)** Batch ID: **R103103** TestNo: **SM 2130B** Analysis Date: **4/26/2018** SeqNo: **1557842**

Analyte	Result	MRL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	2.560	0.100						2.48	3.17	10	*

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Minimum Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

NEILSON RESEARCH CORPORATION
Environmental Testing Laboratory
245 South Grape Street * Medford, OR 97501
(541) 770-5678 fax (541) 770-2901

Chain of Custody Record

This Chain of Custody is a LEGAL DOCUMENT and must be filled out accurately.

Section A
Required Client Information

Company:	City of Brookings
Address:	898 Elk Drive
Brookings, OR 97415	
Email:	gmilliman@brookings.or.us
Phone: 541-469-1101	Fax: 541-469-3650
Collected By (Print):	Ray Page
Collected By (Sign):	[signature]
Email Report _X_ Yes ___ No	Mail Report _X_ Yes ___ No
Fax Report ___ Yes _X_ No	

Section B
Required Project Information

Project Name: Ferry Creek Reservoir
Project Number:
Report To: gmilliman@brookings.or.us
Copy To: brian.helliwell@ch2m.com

Section C
Invoice Information

Attention: Gary Milliman
Company Name: City of Brookings
Address: 898 Elk Drive
Brookings, OR 97415
P.O. # FC-25042018

Section D
Rush Status (Subject to Scheduling)

___ Standard 10-14 Days
___ 5 Business Days (50% surcharge)
___ 3 Business Days (75% surcharge)
___ 24 - 48 hours (100% surcharge)
___ Other ____________
Authorized ___ Yes ___ No

Section E
Sample Information

NRC Workorder # (Lab Use Only) 1804A00

Sample ID	Comp/Grab	Matrix*	Date Collected	Time Collected	No. of Containers	IOC	pH	120.1	ICP-MS	300	TEM	SEC	160.3	180.1		Remarks/Field Data	NRC Sample # (Lab Use Only)
X (30-ft depth)	Grab	W	4/25/2018	9:15	4	2	2	4	2	2	2	2	2	2			01A
No Marking (5-ft depth)	Grab	W	4/25/2018	9:15	4	2	2	4	2	2	2	2	2	2			02A

*Matrix: DW - Drinking Water WW - Wastewater W - Water S - Soil/Solid SL - Sludge O - Oil WP - Wipe OT - Other

Section F
Relinquish/Receive

	Sign	Print	Date	Time
Relinquished By:	[signature]	Raymond C Page	4/25/2018	11:30
Received By:				
Relinquished By:				
Received By:				
Relinquished By:				
Received By Laboratory:	[signature]	Jordan Merrill	4-26-18	945

Quote #829

Section G
Lab Use Only

Temp: 4.4°C
4°C +/- 2°C: _X_ Yes ___ No
Received on Ice: _X_ Yes ___ No
Number of Bottles Received: 8
pH Checked:
COC Seals Intact: ___ Yes ___ No ___ NA
Field Blank Included: ___ Yes ___ No
Received Via ___ UPS _X_ FedEX ___ Other ___ Hand
Payment: _X_ Invoice ___ Cash ___ VISA, M/C ___ Check # ______ Amount ______

APPENDIX C: OWRD Dam Inspection Reports

Oregon
Kate Brown, Governor

Water Resources Department
725 Summer St NE, Suite A
Salem, OR 97301
(503) 986-0900
Fax (503) 986-0904

February 1, 2016

Gary Milliman, City Manager
City of Brookings
898 Elk Drive
Brookings, OR 97415

Re: Ferry Creek Dam (F-25) – Inspection Summary

This dam was inspected on October 6, 2015. I performed the inspection with Greg Wacker, Watermaster District 19. Ray Page from the City was also there for the inspection, and we met briefly with you and Laura Lee Snook, after our inspection. The Water Resources Department conducts routine inspections of the dam's exterior surfaces to identify conditions that might affect the safety of the dam. Dams are assigned a hazard rating based on downstream hazard to people and property. OWRD conducts review of hazard ratings as resources are available. The hazard rating of this dam has changed to high based on the dam breach inundation analysis and homes off of the North Bank Chetco Road. The dam will now be inspected on an annual basis.

Summary: The dam has not been recently operated for water supply purposes, and is in unsatisfactory condition. It had been rated as low-hazard by this agency, so had not been a frequently inspected dam, and this was the first time I have performed the inspection. Multiple issues of concern were identified at the dam, as described in this inspection letter.

Results of Inspection:

Ferry Creek Reservoir

The reservoir level was 3-feet below the dam crest when inspected. Minimum freeboard was 2-feet, which is unsafe. The reservoir was fairly clean, with no large floating logs. The photo above shows, what is believed to be, the inlet structure for the conduits. It is unknown if this is operational.

Crest of dam

The crest of the dam also serves as road access across the dam. The surface is moderately rutted. I observed no sign of recent slope movement on the crest or either face of the dam. Inspection for animal damage was limited by heavy cattail cover on the upstream face.

Spillway approach channel

There was moderate growth of vegetation at the spillway approach. This restricts flood flow into the spillway.

Spillway control section

The spillway control section appears very narrow for passage of a probable maximum flood, which is the design standard for a high-hazard rated dam. There are significant defects in the concrete control part of the spillway, as shown in the next photo.

Slope movement into spillway control section

The hillslope adjacent to the spillway has, at some point, moved towards the spillway control section. Struts have been placed and may be reducing or temporarily controlling slope movement. Additional movement is a very real possibility, and such movement would greatly compromise ability of the spillway to pass flood flow.

First and Second valves

There are multiple conduits that penetrate through this dam. This is very atypical. Each conduit provides a potential location for leakage into the dam. It also appears that these pipes, with valves on the downstream side, may very well be pressurized. There was no opportunity to inspect the conduit, since the upstream end was submerged and the downstream end was buried and connected to the pressurized irrigation system. A conduit is pressurized when the control valve is at or below the outlet of the dam, instead of in the reservoir on the upstream face. Most dams are designed for gravity flow, not for pressurized conduits. Conduits are pipe, and depending on the type of pipe and the age of the pipe, risk of high-pressure leakage exists in a pressurized system. In an earthen dam, this high pressure water can cause severe internal erosion, and this can result in rapid dam failure.

Intermediate and bottom valves

To date, I had not inspected an embankment dam with many penetrating conduits. It may not be possible to make the dam safe with penetrating conduits.

Downstream face of dam

It appears the dam may have been built into and/or around an outcrop or boulder on the left side of the photo above. Accurate characterization of the geologic conditions at this dam will be essential in deciding how to move forward.

The combination of the spillway, multiple non-functional conduits and high-seismic shaking zone, put this dam into UNSAFTISFACTORY condition. It is essential that a plan to make this dam safe be developed, and progress begin on improving the safety of this dam.

Making This Dam Safe: This dam is in need of major rehabilitation. This should be under the direction of an experienced dam engineer, with geotechnical, hydrologic and seismic expertise. In addition, an Emergency Action Plan should be developed for this high-hazard dam. We would be happy to prepare a draft EAP for your review, upon notification from you.

We use a standard inspection form, and a copy of the field inspection sheet for this dam is attached. I plan on another routine inspection next year. Please let me know if you have any questions about this inspection. I understand this is the first correspondence from this agency on these serious issues. It is essential to develop and a timeframe for making this dam safe.

Sincerely,

Keith Mills

Keith Mills, P.E., State Engineer
(503) 986-0840
Cell (541) 706-0849

C: Greg Wacker, Watermaster District 19
Dam Safety File F-25

State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1271
(503) 986-0900

Dam Safety Inspection Form

Name of Dam: Ferry Ck File #: F-25

Height: 65 ft. Storage: 167 ac. ft. Permit: R-4720 NID #: OR- 00437

Hazard: ☐ Low ☐ Significant ☐ High * ☑ **Request Inundation Analysis for change**

Inspector(s): Mills, Wacker Watermaster District: 19

Others on site: Ray Page

Date: 10-2-2015 Weather: Sunny

Prior Inspection Date: 1-15-2009 Issues from prior inspection: ______

Expedited Re-inspection Needed: ☐ Next Inspection Date: 2016

***Rating Criteria**: 5-Very good; 4-Adequate 3-Maintenance or minor repair needed*
2-Serious repair needed; 1- *Urgent dam safety issue – action now - Contact dam owner and dam safety engineer directly*

I. Dam	☑ **Earth** ☐ **Rock** ☐ **Concrete** ☐ **Other**	**Rating**
Up. Slope	Vegetation, Animals, Erosion, Wave Action, Depression, Whirlpool adjacent	4-
Crest	Width, Surfacing, Vegetation, Trampling, Depression, Cracks, Breaching	4
Down. Slope	Vegetation, Animals, Erosion, Seepage, Leak (muddy), Bulge, Depression, Slide	3
R. Abutment	Vegetation, Animals, Erosion, Seepage, Leak (muddy)	3
L. Abutment	Vegetation, Animals, Erosion, Seepage, Leak (muddy)	3
Toe	Vegetation, Erosion, Seepage, Leak (muddy), Boil	3
Seepage/leak flow	Right ___ gpm Center ___ gpm Left ___ gpm Other ___ gpm (use comment)	4
Auxiliary dike (s)	☐ No ☐ Yes ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ over 5	
Comments:		

II. Reservoir	**Pool elevation:** -38 **Point of Reference:** Crest	**Rating**
Minimum freeboard	Vertical distance debris from debris line to crest 28 ft.	2
Floating Debris/Trash	☑ Clean ☐ Around reservoir ☐ Near spillway	4
Log Boom	☐ Not needed ☐ Present ☑ Needed ☐ Deterioration ☐ Ineffective	3
Unusual Conditions	☐ None ☑ Active Landslide ☐ Wildfire in Watershed ☐ Other (comments)	—
Comments:	Signs slope movement, activity unknown	

III. Toe Drains #									
Flow (gpm)									
Damage									
Sediment									
Rating									

IV. Conduit	Control: ☐ Manual ☐ Power ☐ Other ☐ Conduit Control missing	**Rating**
Inlet	☑ **Submerged** ☐ **Debris on Trash Rack** ☐ **Deterioration**	—
Trickle tube	☑ **None** ☐ **Screened** ☐ **Blockage** ☐ **Deterioration**	—
Control/Stem	☐ **Operable** ☑ **Damaged** ☑ **Missing**	2
Valve(s) cycling	☐ **Frozen** ☑ **unknown** ☐ **past year** ☐ **frequent**	2
Size: 18"	**Material** concrete **Condition** ancient / old	3
Outlet Structure	☑ Overgrown ☐ Clean ☑ Pressurized ☐ Leaking ______ gpm	✓
Secondary outlet	☑ Yes ☐ No Type ____________ Diameter _____ in.	3
Comments:	multiple pipes, 3 or 4 levels	

V. Spillway	☐ **Earth** ☐ **Rock** ☐ **Concrete** ☐ **Other**	**Rating**
Modifications	☐ None ☐ Reduction in capacity ☐ Feature not on design	—
Approach Channel	☐ Clear ☐ Trees/brush ☐ debris ☐ erosion brush	2
Control Section	Width ____ Depth ____ ☑ Concrete ☑ Rock ☐ Soil ☐ Culvert ☐ Unstable	2
Flashboards/Gate	☑ None ☐ In place ☐ operational ☐ deteriorated	—
Discharge Channel	☐ Clear ☐ Trees/brush ☐ leakage leaking ☐ headcutting (____ feet approaching control section, depth ____ feet.)	3
Stilling basin	☑ N/A ☐ Functional ☐ Minor Erosion ☐ Severe Erosion/Undercutting	—
Aux. Spillway	☐ Yes ☑ No (use comments below)	
Comments:	Spillway retaining wall showing [illegible]	

VI. Access and Security		**Rating**
Vehicle access	☐ Public road ☐ all weather road ☑ dirt road ☐ cross country	3
Fencing, signage	☑ Remote ☐ Gate ☐ Secure Fence ☐ Camera ☐ Uncontrolled	—
New Structure below dam	Dwelling ___ feet Paved public road ____ feet Other sig building ____ feet	—
Emergency Action Plan	☐ Not required ☐ Completed ________ at dam (dated ________) ☑ None	3
Comments:		

Instrumentation data reviewed: ☐ N/A ☐ Yes ☐ No

Other:

____

____

____

____

Oregon
Kate Brown, Governor

Water Resources Department
725 Summer St NE, Suite A
Salem, OR 97301
(503) 986-0900
Fax (503) 986-0904

November 23rd, 2016

Paul Stevens, Public Works Director
City of Brookings
898 Elk Drive
Brookings, OR 97415

Re: Ferry Creek Dam (F-25) – Inspection Summary

I inspected this dam on October 4, 2016, with Dam Safety Specialist, Tony Janicek, District 19 Watermaster Greg Wacker, and Water Resource Engineer Lyndsey Croghan. You, along with Chrissy Bevens and Ray Page from the City of Brookings Public Works, were also there for the inspection. The Water Resources Department conducts routine inspections of the dam's exterior surfaces to identify conditions that might affect the safety of the dam. Dams are assigned a hazard rating based on downstream hazard to people and property, not on the condition of the dam. The department has classified Ferry Creek Dam as a high hazard dam and therefore we inspected it annually.

Summary: The dam has not been operated recently for water supply purposes and is in UNSATISFACTORY condition. Several issues of concern were identified at the dam and are illustrated and described in the following photos and text.

Results of Inspection:

Vegetation on the downstream slope, right abutment and toe of the dam

The reservoir level was 3.1 feet below the dam crest when inspected. Minimum freeboard was 2.1 feet, which is potentially unsafe due to the condition issues with this dam. On the dam crest, soil has settled and created a low spot which lowers the total reservoir storage by approximately 2.4 feet.

Low spots on the dam crest are typical of older earth fill dams and occur as a result of crest movement due to settlement or compaction of the soil material. Settlement occurs naturally overtime through settlement of the soil particles while compaction occurs through animal or human activity. Low spots on the crest reduce the minimum freeboard which can increase the potential for overtopping of the dam during a significant storm event. Overtopping of the dam can lead to a catastrophic dam failure.

Steel struts preventing spillway channel retaining wall failure

Based on measurements taken during our inspection, the spillway appears to be undersized for a moderately sized storm event. It should be noted that the only definitive means to determine if the spillway is truly undersized, is through a detailed engineering analysis. However, our rough calculations indicate that there is enough reason for concern regarding the spillway capacity without the need for a full engineering analysis at this time. Consequently, it is extremely likely that in a moderately sized storm event the dam will be overtopped, possibly leading to a catastrophic failure of the dam.

In addition, the retaining walls of the discharge channel for the spillway are beginning to fail. The walls are currently held in place by steel struts. These struts are located within the spillway channel and therefore present an obstruction to flow. As a result, the capacity of the spillway is reduced from the "as-designed" condition.

Vegetation in the emergency spillway control section

Partially buried spillway control section

There is a significant amount of vegetation in the emergency spillway control section and channel. It also appears that there was land slide into the spillway at some point in the past. This is evidenced by the fact that the control section (shown in the image above) is partially buried and the section, in its current condition, is not uniform. It also appears that there is a significant amount of material in the discharge channel just downstream of the control section. Both the vegetation and the material from the slide obstruct flow through the spillway and therefore reduce the capacity of the spillway to pass flood flows.

There is also a significant amount of vegetation on the downstream face, left and right abutments, and toe of the dam. Extensive vegetation prevents complete inspection of the dam surface and outlet control works. Visual inspection makes it possible to identify any deficiencies that may lead to unsafe operation of the dam; it is a critical component of a dam safety inspection. Common issues identified through visual inspection are embankment stability and movement, seepage, animal activity, poor condition of penetrating conduits, and lack of functionality of the outlet works.

Intermediate conduits with valves

Crack in housing of upper most intermediate valve

There are multiple conduits that penetrate through this dam. This is very atypical. Each conduit provides a potential location for leakage into the dam. Two of the conduits have valves on the downstream side which suggests that they might be pressurized. However, the upper intermediate conduit (upper left in the photo above) has a cracked housing so it is likely not pressurized. A conduit is pressurized when the control valve is at or below the outlet of the dam, instead of in the reservoir on the upstream face. Most dams are designed for gravity flow, not for pressurized conduits. Conduits are pipe, and depending on the type of pipe and the age of the pipe, risk of high-pressure leakage exists in a pressurized system. In an earthen dam, this high pressure water can cause severe internal erosion, and this can result in rapid dam failure. It does not appear that either of the two intermediate conduits has been used in some time.

Low level conduit

There is also a low level conduit that is not pressurized. This pipe is clearly leaking at approximately 15 to 20 cubic feet per second. Either the gate valve on the upstream side is partially open or there is a leak in the upstream valve or somewhere along the conduit. We were unable to inspect the upstream gate valve because it was submerged. There are no visible controls for the low level conduit. As a result, it is not operable. A properly working outlet conduit is a key safety feature of a dam. The controls and conduit must be functional to drain the dam during an emergency.

The combination of the low spot on the crest, the issues with the spillway, multiple non-functional conduits, and the fact that the dam is located in a high-seismic shaking zone all cause this dam to remain in UNSAFTISFACTORY condition.

Thank you for your recent efforts in developing a plan to make this dam safe. Please continue to work on this plan. I will support your efforts in any way that I can. Please don't hesitate to contact me, or other members of the dam safety staff, with any questions.

Recommendation(s):

1. Restore the dam crest height to the as designed condition by filling in the low spot(s) on the dam.
2. Monitor the reservoir level and freeboard if over 4 inches of rain in 24 hours has or is occurring.
3. Increase the minimum freeboard. A safe operating condition would be a minimum freeboard of no less than five feet. However, due to issues with the outlet conduits there is currently no way to release water from this dam. As a result, the safest way to release water would be through a siphon.
4. Remove debris and vegetation from the spillway channel so that the channel remains unobstructed and functions as designed.
5. Remove vegetation from the downstream face of the dam, right and left abutments, and toe of the dam.
6. Continue to analyze the safety of this dam and develop a plan for rehabilitation or removal based on analysis of the safety of the dam and the City's need for additional water supplies
7. An Emergency Action Plan should be developed for this high hazard dam. We will work with you on preparing a draft EAP.

We use a standard inspection form, and a copy of the field inspection sheet for this dam is attached. Thanks again for meeting with us. I plan on another routine inspection next year. Please let me know if you have any questions about this inspection. I look forward to future inspections of this dam.

Sincerely,

Keith Mills

Keith Mills, P.E., State Engineer
(503) 986-0840
Cell (541) 706-0849

C: Greg Wacker, Watermaster District 19
Dam Safety File F-25

Dam Safety Inspection Form

State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1271
(503) 986-0900

Name of Dam: FERRY CREEK File #: F-25

Height: 65 ft. Storage: 167 ac. ft. Permit: R-4720 NID #: OR- 00437

Hazard: ☐ Low ☐ Significant ☑ High ☐ **Request Inundation Analysis for change**

Inspector(s): MILLS, WACKER, CROGHAN, SANTCEK Watermaster District: 19

Others on site: CHRISSY BEVENS, PAUL STEVENS, RAY PAGE

Date: 10/04/2016 Weather: OVERCAST

Prior Inspection Date: 10/6/15 Issues from prior inspection:

Expedited Re-inspection Needed: ☐ Next Inspection Date: 2017

***Rating Criteria**: 5-Very good; 4-Adequate 3-Maintenance or minor repair needed*
2-Serious repair needed; 1- ***Urgent dam safety issue – action now - Contact dam owner and dam safety engineer directly***

I. Dam	☑ **Earth** ☐ **Rock** ☐ **Concrete** ☐ **Other**	**Rating**
Up. Slope	Vegetation, Animals, Erosion, Wave Action, Depression, Whirlpool adjacent	4
Crest	Width, Surfacing, Vegetation, Trampling, Depression, Cracks, Breaching OF VEG ... 2.4	3
Down. Slope	Vegetation, Animals, Erosion, Seepage, Leak (muddy), Bulge, Depression, Slide	3+
R. Abutment	Vegetation, Animals, Erosion, Seepage, Leak (muddy)	4-
L. Abutment	Vegetation, Animals, Erosion, Seepage, Leak (muddy)	4-
Toe	Vegetation, Erosion, Seepage, Leak (muddy), Boil	4-
Seepage/leak flow	Right ___ gpm Center ___ gpm Left ___ gpm Other ___ gpm (use comment)	—
Auxiliary dike (s)	☑ No ☐ Yes ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ over 5	—
Comments:		

II. Reservoir	**Pool elevation**: 3.1 **Point of Reference**: DAM CREST	**Rating**
Minimum freeboard	Vertical distance debris from debris line to crest 2.1 ft.	3
Floating Debris/Trash	☑ Clean ☐ Around reservoir ☐ Near spillway	4
Log Boom	☑ Not needed ☐ Present ☐ Needed ☐ Deterioration ☐ Ineffective	—
Unusual Conditions	☐ None ☐ Active Landslide ☐ Wildfire in Watershed ☐ Other (comments)	—
Comments:		

III. Toe Drains #									
Flow (gpm)									
Damage									
Sediment									
Rating									

IV. Conduit	Control: ☐ Manual ☐ Power ☐ Other ☐ Conduit Control missing	Rating
Inlet gate	☑ Submerged	—
Trash Rack	☑ Submerged	—
Control/Stem	☐ Clean ☐ Greased ☐ Irregular NOT OPERABLE	3
Valve(s) cycling	☐ Frozen ☐ unknown ☐ past year ☐ frequent NOT OPERABLE	3
Diameter:	Material CS / Condition RUSTED, [illegible]	3
Outlet Structure	☐ Overgrown ☐ Clean ☐ Pressurized ☐ Leaking ______ gpm UNKNOWN	3
Secondary outlet	☐ Yes ☑ No Type ______ Diameter ______ in.	—
Comments:	• UPPER PIPE 16" CONCRETE PIPE W/ 16" CRANE GATE VALVE. HOUSING IS CRACKED SO IT IS NOT LIKELY IT IS PRESSURIZED • MIDDLE VALVE ? • LOWER VALVE 30" CS 15-20 CFS LEAK	

V. Spillway	☑ Earth ☑ Rock ☑ Concrete ☐ Other	Rating
Modifications	☑ None ☐ Reduction in capacity ☐ Feature not on design	—
Approach Channel	☐ Clear ☑ Trees/brush ☑ debris ☐ erosion	3
Control Section	Width VARIES Depth VARIES ☑ Concrete ☐ Rock ☑ Soil ☐ Culvert ☐ Unstable	3
Flashboards/Gate	☑ None ☐ In place ☐ operational ☐ deteriorated	—
Discharge Channel	☐ Clear ☑ Trees/brush ☐ leakage ☐ headcutting (____ feet approaching control section, depth ____ feet.)	3
Stilling basin	☑ N/A ☐ Functional ☐ Minor Erosion ☐ Severe Erosion/Undercutting	—
Aux. Spillway	☐ Yes ☑ No (use comments below)	—
Comments:	SECTION OF CONCRETE CHANNEL WHERE [illegible] SMOOTH THERE IS A LEAK. LEAK COULD BE DUE TO [illegible] FLOW/BURROW[illegible]	

VI. Access and Security		Rating
Vehicle access	☐ Public road ☐ all weather road ☑ dirt road ☐ cross country	—
Fencing, signage	☐ Remote ☑ Gate ☐ Secure Fence ☐ Camera ☐ Uncontrolled	4
New Structure below dam	Dwelling ___ feet Paved public road ___ feet Other sig building ___ feet	—
Emergency Action Plan	☐ Not required ☐ Completed ______ at dam (dated ______) ☑ None	3
Comments:		

Instrumentation data reviewed: ☐ N/A ☐ Yes ☐ No

Other:

- LOW SPOT ON CREST NEAR SPILLWAY
- FREEBOARD
- SPILLWAY - CLEAR
- OUTLET CONDUIT

Oregon
Kate Brown, Governor

Water Resources Department
725 Summer St NE, Suite A
Salem, OR 97301
(503) 986-0900
Fax (503) 986-0904

February 25, 2018

Paul Stevens, Public Works Director
City of Brookings
898 Elk Drive
Brookings, OR 97415

Re: Ferry Creek Dam (F-25) – Inspection Summary

I inspected this dam on September 26, 2017. I met Jim Maitland from Foundation Engineering and Steve Major from The Dyer Partnership to discuss the feasibility study being conducted for this dam. We then met you after to discuss our different inspections and evaluations. The Water Resources Department conducts routine inspections of the dam's exterior surfaces to identify conditions that might affect the safety of the dam. Dams are assigned a hazard rating based on downstream hazard to people and property, not on the condition of the dam. The department has classified Ferry Creek Dam as a high hazard dam and therefore we inspect it annually.

Summary: The dam has not been operated recently for water supply purposes and is in UNSATISFACTORY condition. Several issues of concern have been identified at the dam and are illustrated and described in the following photos and text.

Results of Inspection:

The reservoir level was 3.6 feet below the dam crest when inspected. Minimum freeboard was 2.1 feet, which is poor and makes the dam vulnerable to overtopping in an extreme rainstorm or if the spillway is partly blocked. The reservoir was mostly clean.

Low spot in crest of dam

The dam crest is much lower than the rest of the crest at the location pictured above, about 50-100 feet from the spillway. This is the reason the freeboard is so low. We do appreciate the City's inspections during heavy rain events during the winter of 2017-17. It would not take much to improve safety through movement of fill from the high sections of the dam to this location, and making a level crest.

Spillway control section

There is brush, soil and cobbles on and around the concrete sill (spillway control section. It is important to keep significant obstructions out of the spillway if these obstructions reduce flow capacity through the spillway. With additional growth of vegetation this will start to be the case.

Spillway seriously overgrown

The spillway channel has been damaged by slow movement of a landslide into and under the spillway. In addition, blackberries have invaded the spillway, and there are trees encroaching at the sides of the spillway. These may further restrict flow through the spillway.

Lowest outlet pipe leaking

The flow through the lowest of the three conduits was measured at approximately 20 gallons per minute. No flow was observed in the other two conduits, however the middle conduit has a valve at the downstream end so it may be pressurized. A conduit is pressurized when the control valve is at or below the outlet of the dam, instead of in the reservoir on the upstream face. Most dams are designed for gravity flow, and not for pressurized conduits. Conduits are pipe, and depending on the type of pipe and the age of the pipe, risk of high pressure leakage exists in a pressurized system. In an earthen dam, this high pressure water can cause severe internal erosion, and this can result in rapid dam failure. In a low pressure situation, there is little pressure available to force water into and through the embankment. Whether it is actually pressurized is unknown.

Outlet pipes overgrown

The photo above shows the other two valves almost completely overgrown by blackberries and other brush. The dense brush prevents determination of possible seepage around either pipe the brush, and makes full inspection impossible.

Large rock monolith part of dam

There are ongoing feasibility studies looking at options for this dam and reservoir. The site condition, including the monolith above, are atypical as compared to most Oregon dams.

HB 3247 was passed by the Oregon legislature and sets criteria for high hazard dams. An EAP was just completed for this dam. One of the most important actions is to inspect this dam after heavy rains to see if the reservoir level approaches the crest. It will also be important to have an exercise within the City to see if the EAP works as intended.

Finally, most issues from last year's inspection are unchanged. The inspection form from last year may not have conveyed the safety status of this dam sufficiently. Most of the recommendations below are repeated from last year. It is very important for the safety of persons below dam to prioritize and act on at least most of these recommendations this year.

Recommendations:

1. Restore the dam crest height by moving material from the high spots to the low spots.
2. Continue to monitor the reservoir level and freeboard if over 4 inches of rain in 24 hours has occurred or is occurring.
3. Remove debris and vegetation from the spillway channel so that the channel remains unobstructed and functions as designed.
4. Remove vegetation from the downstream face of the dam, right and left abutments, and toe of the dam.
5. Continue to analyze the safety of this dam and develop a plan for rehabilitation or removal based on analysis of the safety of the dam and the City's need for additional water supplies
6. Exercise the new Emergency Action Plan completed for this high hazard dam.

We use a standard inspection form, and a copy of the field inspection sheet for this dam is attached. Thanks again for meeting with us. I plan on another routine inspection this year. Please let me know if you have any questions about this inspection.

Sincerely,

Keith Mills

Keith Mills, P.E., State Engineer
(503) 986-0840
Cell (541) 706-0849

C: Greg Wacker, Watermaster District 19
Dam Safety File F-25

Dam Safety Inspection Form

State of Oregon
Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1271
(503) 986-0900

Name of Dam: Ferry Creek Dam File #: F-25
Height: 65 ft. Storage: 167 ac. ft. Permit: R 4720 NID #: OR- 00435
High Hazard Dam Inspector(s): Mills District: 19
Others on site: Maitland, Major
Date: 9-26-17 Temperature: 80°F [x] Dry [ ] Rain [ ] Snow [ ] Now [ ] Recently
Prior Inspection Date: 10-4-16 Issues from prior inspection: Crest, conduits, control, seismic

***Rating Criteria**: 5-Exemplary; 4-Adequate 3-Maintenance or minor repair needed*
2-Serious repair needed; 1- ***Urgent dam safety issue – action now - Contact owner and dam safety directly***

General		**Rating**
Vehicle access	[ ] All weather road [x] Dirt road [ ] Cross country	3-
Access Control	[x] Gate [x] Locked and secured [ ] Fencing [ ] Signage [ ] Other ______	4
Detail:		

Reservoir	**Pool level:** -3'	**Point of Reference:** [x] Crest [ ] Gage ______	**Rating**
Minimum freeboard	**Vertical distance from debris line to lowest place on crest** 2' **ft.**		2+
Condition	[ ] Floating Debris/Trash [ ] Log Boom [ ] Unusual Conditions (see "Detail") clean		4
Detail:			

Spillway	[ ] **Earth** [x] **Rock** [x] **Concrete** [ ] **Other**	**Rating**
Capacity	[x] **Reduced by feature not on design** [ ] **Sized for PMF**	2
Approach Channel	[ ] Clear [x] **Trees/brush** [ ] **Debris** [ ] Erosion	3
Control Section	[x] Concrete [ ] Rock [ ] Soil [ ] Culvert [ ] **Unstable**	4-
Spillway dimensions	Width ____ Depth ____ Gradient [ ] Survey Attached last year	-
Flashboards/Gate	[x] None [ ] In place [ ] Operational [ ] Deteriorated	
Discharge Channel	[ ] Clear [x] Trees/brush [ ] Leakage [ ] **Headcutting** (____ feet from spillway control section, depth ____ feet.)	4-
Stilling basin	[ ] N/A [x] Functional [ ] Minor Erosion [ ] **Severe Erosion/Undercutting**	4
Aux. Spillway	[ ] Yes [ ] No (use "Detail" below)	
Detail:	large boulders base of spillway	

Seepage/Leakage		**Rating**
Serious conditions	[ ] **Leakage** [ ] **Piping** [ ] **Discolored water** [ ] **Boils** [ ] **Other** [ ] None PLL	4
Locations*	[ ] No evidence [ ] Center [ ] Left [ ] Right [ ] **Around pipe** [ ] On dam ______	-
Flow	[x] Wet vegetation [ ] Spongy [ ] Standing water [ ] Flow ______ gpm	4
Toe drains	[ ] None [ ] Working [ ] Damaged [ ] Buried	-
Detail:		

Conduit	Control: ☐ Manual ☐ Power ☐ Other ☐ Conduit Control missing	Rating
Inlet	☑ Submerged ☐ Debris on Trash Rack ☐ Deterioration	—
Control/Stem	☐ Operable ☐ Damaged ☑ Missing ☐ Inoperable ☐ Unknown	2
Valve(s) cycling	☐ Frozen ☐ Unknown ☐ Past year ☐ Frequent	—
Principal conduit	Diameter/Size: ________ Material Steel Condition ?	—
Primary outlet	☑ Overgrown ☐ Clean ☐ (circled) Pressurized ☐ Leaking 20 gpm	2+
Other outlet(s)	☑ Yes ☐ No Type(s)________________ Diameter(s) ______ in.	2+
Detail:		

Structure of dam	☑ Earth ☐ Rock ☐ Concrete ☐ Other	Rating
Distress	☐ Cracks - offset ______ in ☐ Landslide(s) ☐ Sinkhole(s) ☑ Crest Settlement ☐ Narrow crest ☐ Wave erosion ☐ Trampling ☐ Surface erosion ☐ None	3−
Locations*		
Other	Describe ________________	
Aux. dike (s)	☑ No ☐ Yes ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ over 5	—
Seismic	☐ Designed for EQ ☑ Priority for analysis ☐ Liquifaction/deformation potential ?	2
Animals	☐ Nutria ☐ Badger Other ____________ ☐ Unknown	Rating
Burrows	☐ Observed | max diameter ____ in max depth ____ ft ☐ Trails ☑ None	4
Locations*		
Vegetation		Rating
Cover	☐ Low grass ☐ high grass ☑ brush ☐ blackberries ☐ small trees ☐ large trees	
Locations*	blackberries toe	3
Impairs inspection	☐ toe seepage ☐ conduit outlet ☐ spillway ☐ upstream face ☐ downstream face	
Detail:		

****Locations* – *Upstream face, Crest, Downstream face, Left and Right abutments, Toe***

Emergency Action Plan	Created: (Yes) No Revision Date ________ Located On-site: Yes No	Rating
Inundation mapping type	☐ Sunny Day ☑ Intermediate ☐ PMF ☐ None	4
Emergency Classification	Outlined in EAP: (Yes) No Possible Failure Mode(s):	4
Emergency Communication	Outlined in EAP: (Yes) No Are contacts up to date: (Yes) No	4
EAP Exercise & Review	Frequency__________ Date last exercised/reviewed None	3

Expedited Re-inspection Needed: ☐ Next Inspection Date: 2010

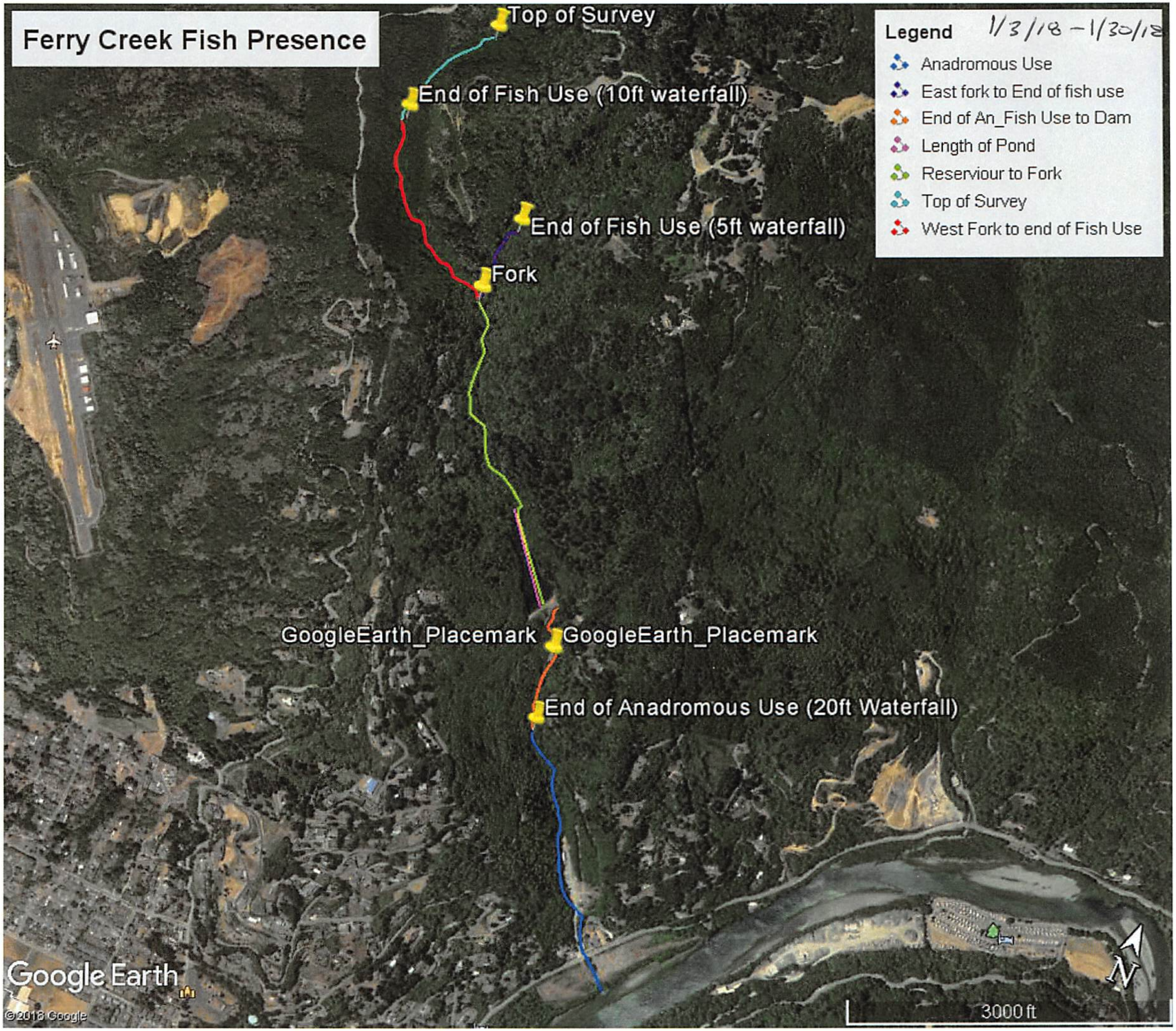
Other Issues or Additional Detail Needed:

____

____

____

APPENDIX D: ODFW Map-Anadromous Fish Map


Ferry Creek Fish Presence
Legend
1/3/18 – 1/30/18
Anadromous Use
East fork to End of fish use
End of An_Fish Use to Dam
Length of Pond
Reserviour to Fork
Top of Survey
West Fork to end of Fish Use
Top of Survey
End of Fish Use (10ft waterfall)
End of Fish Use (5ft waterfall)
Fork
GoogleEarth_Placemark
GoogleEarth_Placemark
End of Anadromous Use (20ft Waterfall)
Google Earth
©2018 Google
3000 ft
N

APPENDIX E: Environmental and Permitting

ODFW Correspondence

SHPO and Tribe Correspondence

COE Correspondence

NMFS Correspondence

APPENDIX E.1: ODFW Correspondence

J Parmenter

From: Greg D Apke <Greg.D.Apke@state.or.us>
Sent: Monday, April 02, 2018 9:27 AM
To: J Parmenter
Cc: Greg D Apke; Steve Mazur
Subject: RE: Ferry Creek Dram Feasibility Study

Importance: High

James,

I want to chime in on the state's fish passage policy, as defined in Oregon Revised Statute 509.580 to 509.901 and corresponding rules that govern fish passage (635-412-0005 through 0040), specifically as it relates to the City of Brooking's Ferry Creek Dam.

These statues (which we previously sent you on November 7th, 2017) apply to any and all artificial obstructions, as defined in 509.580(1) where native migratory fish are presently or were historically present. A comprehensive list of native migratory fish is defined in Oregon Administrative Rule (635-412-0032. As such, the state' fish passage policy defines specific trigger events that invoke the state's passage authority and compel the owner (City of Brookings). To be clear, yes this policy applies to sites situated above anadromous native migratory fish.

Here are the actions defined in state law that "trigger" Oregon's fish passage requirements. These include:

- Construction:
  - Original construction
  - Major replacement
  - Structural modifications that increase storage or diversion capacity
- Fundamental change in permit status which is defined as "a change in regulatory approval for the operation of an artificial obstruction where the regulatory agency has discretion to impose additional conditions on the applicant, including but not limited to licensing, relicensing, reauthorization or the granting of new water rights, but not including water right transfers or routine maintenance permits", or
- Abandonment

ORS 509.585 requires a person owning or operating an artificial obstruction shall, prior to construction, fundamental change in permit status or abandonment of the artificial obstruction in any waters of this state, obtain a determination from the department as to whether native migratory fish are or historically have been present in the waters. If the department determines that native migratory fish are or historically have been present in the waters, the person owning or operating the artificial obstruction shall either submit a proposal for fish passage to the department or apply for a waiver pursuant to 509.585(7). Approval of the proposed fish passage facility or of the alternatives to fish passage must be obtained from the department prior to construction, permit modification or abandonment of the artificial obstruction.

In your email below, you mentioned dam removal as an alternative that was previously evaluated. ODFW would most certainly encourage the City to give strong consideration to permanent dam removal as a viable alternative. We would be happy to have this discussion with the City and I am more than happy to contact the appropriate staff at the City.

If you have further questions about this law as it relates to the Ferry Creek Dam, please contact me.

Greg Apke
ODFW, Statewide Fish Passage Program Leader
503-947-6228 (wk)
503-931-4361 (cell)

From: Steve Mazur
Sent: Monday, April 02, 2018 7:28 AM
To: J Parmenter <jparmenter@dyerpart.com>
Cc: Greg D Apke <Greg.D.Apke@coho2.dfw.state.or.us>
Subject: RE: Ferry Creek Dram Feasibility Study

James,

There are coastal cutthroat above and below the dam. The dam is not natural. Fish cannot move upstream or safely move downstream of the dam. It is a passage impediment to coastal cutthroat along with other non-game species. The fish passage statutes are on our website if you need to review what constitutes a trigger.

Steve

Steven Mazur
Supervisory District Fish Biologist
Rogue Watershed District
P.O. Box 642
29907 Airport Way
Gold Beach, OR 97444
541-247-7605 x 222 office
541-247-2321 fax

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Wednesday, March 28, 2018 10:37 AM
To: Steve.J.Mazur@state.or.us
Subject: Ferry Creek Dram Feasibility Study

Good Morning Steve,

I would just like to clarify for all involved the exact occurrence that is triggering the need for fish passage mitigation at the Ferry Creek Dam site. Given that the City was told in the past that removing the dam would have zero impact on the fish, and therefore denied funding for dam removal, we are looking for a very specific description of why they are currently being told dam rehab will impact the fish. This clarification should get us all on the same page.

I do believe some of the confusion stems from the Fish Presence Map. It states 'end of Anadromous fish' at the 20 ft waterfall, if the migrating fish naturally end at the waterfall, what is the dam blocking? My assumption is it is the non-anadromous fish between the waterfall and dam that would normally migrate upstream, but please verify this with a description of the exact trigger. Thank you for your time and consideration.

Regards, James

J Parmenter

From: Greg D Apke <Greg.D.Apke@state.or.us>
Sent: Tuesday, November 07, 2017 11:50 AM
To: J Parmenter
Cc: Greg D Apke (greg.d.apke@state.or.us); Steve Mazur
Subject: Ferry Creek Dam - City of Brookings ODFW Fish Passage Rules and Regulations
Attachments: ORS 509 Fish Passage Statutes.pdf; OAR 635 Div 412 - Fish Psg.pdf

Importance: High

James –

Attached is the state's fish passage law (ORS) and corresponding administrative rules (OAR's).

The sections specific to fish passage waiver include ORS 509.585(7) and most important OAR 635-412-0025 (Waivers and Exemptions) and 0040 (Mitigation Criteria).

Please pay particular attention to the mitigation criteria as these are specific to fish passage waivers are define mitigation expectations.

Hope this helps and as always, give me call if you have any questions.

Thanks, Greg

****
Greg Apke
Oregon Department of Fish and Wildlife - Fish Division
Statewide Fish Passage Program Leader
4034 Fairview Industrial Drive SE
Salem, Oregon 97302
503-947-6228 (office)
503-931-4361 (cell)
greg.d.apke@state.or.us
ODFW Fish Passage Internet Access

****

J Parmenter

From: Greg D Apke <Greg.D.Apke@state.or.us>
Sent: Friday, November 17, 2017 1:34 PM
To: J Parmenter; Steve Mazur
Cc: Greg D Apke
Subject: RE: Ferry Creek

Thanks for taking and sending along the photos Steve. I concur, seems like typical stream discharges in many coastal tributaries, and I would not expect these Q's to deter or delay fish migration.

Greg

Greg Apke
ODFW, Statewide Fish Passage Program Leader
503-947-6228 (wk)
503-931-4361 (cell)

From: Steve Mazur
Sent: Friday, November 17, 2017 1:04 PM
To: J Parmenter <jparmenter@dyerpart.com>
Cc: Greg D Apke <Greg.D.Apke@coho2.dfw.state.or.us>
Subject: Ferry Creek

I was out at Ferry Creek Dam on Nov. 16. Took some pictures of spill way and creek below dam. Plenty of water for fish to move and this was only a small rain event. Steve

Steven Mazur
ODFW Acting District Fish Biologist
Rogue Watershed District
South Coast District
541-247-7605

J Parmenter

From: Steve Mazur <Steve.J.Mazur@state.or.us>
Sent: Wednesday, January 24, 2018 8:21 AM
To: J Parmenter
Cc: Greg D Apke
Subject: RE: Ferry Creek

James,

We were able to get most of the distribution completed upstream of the reservoir. Still need to finish the upper west fork/mainstem. Cutthroat are distributed throughout the upper watershed. Next dry period we should be able to finish. Have not looked downstream of dam yet to determine exactly where anadromous fish use would end.

Steve

Steven Mazur
Supervisory District Fish Biologist
Rogue Watershed District
P.O. Box 642
29907 Airport Way
Gold Beach, OR 97444
541-247-7605 x 222 office
541-247-2321 fax

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Wednesday, January 24, 2018 6:53 AM
To: Steve Mazur <Steve.J.Mazur@state.or.us>
Subject: RE: Ferry Creek

Good Morning Steve,

I am getting my quarterly reports ready for the City, and would like to give them an updated schedule. Much of this depends on the feedback from you. Please let me know when you think you will have completed the field survey so that we can discuss your findings. Have a great day.

Regards, James

From: Steve Mazur [mailto:Steve.J.Mazur@state.or.us]
Sent: Tuesday, January 02, 2018 8:04 AM
To: J Parmenter
Subject: RE: Ferry Creek

We have not been able to get out there. Hopefully in the next week or two. Steve

Steven Mazur
Supervisory District Fish Biologist
Rogue Watershed District
P.O. Box 642
29907 Airport Way
Gold Beach, OR 97444

541-247-7605 x 222 office
541-247-2321 fax

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Friday, December 29, 2017 9:27 AM
To: Steve Mazur <Steve.J.Mazur@state.or.us>
Subject: RE: Ferry Creek

Good Morning Steve,

I hope your holiday season is going well. We had talked about having another conference call once you had completed a field survey. Can you give me an update on the progress of the survey. Have a happy New Year!

Regards, James

From: Steve Mazur [mailto:Steve.J.Mazur@state.or.us]
Sent: Friday, November 17, 2017 1:04 PM
To: J Parmenter
Cc: Greg D Apke
Subject: Ferry Creek

I was out at Ferry Creek Dam on Nov. 16. Took some pictures of spill way and creek below dam. Plenty of water for fish to move and this was only a small rain event. Steve

Steven Mazur
ODFW Acting District Fish Biologist
Rogue Watershed District
South Coast District
541-247-7605

J Parmenter

From: Steve Mazur <Steve.J.Mazur@state.or.us>
Sent: Monday, June 04, 2018 7:57 AM
To: J Parmenter
Cc: Gary Milliman; John Weber
Subject: RE: Brookings-Ferry Creek Dam Feasibilty Study

The Ferry Creek Acclimation Site would be impacted from no pool/low pool or construction constraints from mid October to Mid November. That being said, the acclimation site is not critical to the hatchery fall Chinook program and ODFW could suspend it for the period of any construction phase. The fall Chinook smolts would be released directly into the Chetco River rather than spending two weeks acclimating to Ferry Creek.

There would be no impact on local hatcheries from the project.

Steven Mazur
Supervisory District Fish Biologist
Rogue Watershed District
P.O. Box 642
29907 Airport Way
Gold Beach, OR 97444
541-247-7605 x 222 office
541-247-2321 fax

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Friday, June 01, 2018 4:09 PM
To: Steve.J.Mazur@state.or.us
Subject: Brookings-Ferry Creek Dam Feasibilty Study

Good Afternoon Steve,

I wanted to touch base with you again regarding the Ferry Creek Dam Feasibility Study in Brookings, Oregon. More specifically regarding the juvenile salmon acclimation project. If the dam removal/replacement project was going to be completed is there any window in which construction could be completed that wouldn't impact the acclimation project? Is this a program that could be moved elsewhere for a year, during construction, or are there no other viable options?

Also, as far as I can tell this project would have no impact on local hatcheries, but I wanted to get your input on this. Thank you for your time and consideration. Have a good weekend.

Regards,

JAMES PARMENTER, P.E.
The Dyer Partnership Engineers and Planners, Inc.
1330 Teakwood Ave.
Coos Bay, OR 97420
Phone: 541-269-0732
Fax: 541-269-2044
Toll-Free: 877-773-8610

J Parmenter

From: Steve Mazur <Steve.J.Mazur@state.or.us>
Sent: Friday, October 27, 2017 9:12 AM
To: J Parmenter
Cc: Anna Pakenham Stevenson; Greg D Apke; Jenni M Dykstra; Mark Vargas
Subject: RE: Brookings Ferry Creek Dam Rehabilitation

James,

I am copying our ODFW fish passage and water resource folks in Salem. They can probably give you a better idea on what ODFW typically requires. We have a pretty good idea of fish use below the dam and know we do not have anadromous (Chinook, steelhead, or coho) use to the base of the current site. Resident cutthroat are present to the base of the dam, in and upstream of the reservoir. SONC Coho are or could be present in the lower creek. I did want to mention there is ample opportunity to work on restoration/fish passage on the lower reach of this creek. If down the road some type of mitigation is required.

Things we do not know:

1. How far cutthroat use extends upstream of the current reservoir.

2. How much habitat was lost when the dam was built and how much habitat is upstream of the dam

3. Did the current dam block cutthroat passage or was it built on a natural barrier to upstream passage.

4. Besides culverts blocking anadromous fish use in the lower creek, we do not have the exact location of the natural barrier blocking anadromous fish. Historic habitat surveys indicated that somewhere between river mile .5 to .75 falls/gradient would block anadromous fish. This is downstream of the dam.

If you need anything else, feel free to contact me. Steve

Steven Mazur
ODFW Acting District Fish Biologist
Rogue Watershed District
South Coast District
541-247-7605

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Thursday, October 26, 2017 3:23 PM
To: steve.j.mazur@state.or.us
Subject: FW: Brookings Ferry Creek Dam Rehabilitation

Good Afternoon Steve,

I just wanted to make sure you received my prior e-mail shown below. Please let me know if you have any questions.

Regards,

James

From: J Parmenter
Sent: Wednesday, October 18, 2017 3:10 PM
To: 'steve.j.mazur@state.or.us'
Subject: Brookings Ferry Creek Dam Rehabilitation

Steve,

As we discussed in our last phone conversation. I am beginning to develop a feasibility study for the Ferry Creek Dam in Brooking's Oregon. The feasibility study will explore multiple improvement alternatives, but will most likely recommend re-alignment of the earthen dam. I would like to include a section within the study that explains the required permitting, and any potential environmental impacts. To do this, I will need your input. We were hoping you could provide us with a list of endangered species in or near the project area.

I know fish passage is something that will need to be addressed if dam re-alignment or removal is to occur. When we began discussing a fish passage waiver on the phone you had mentioned that you needed information regarding fish types and movement patterns upstream of the dam. Is this information that we would collect, or something that is in your database?

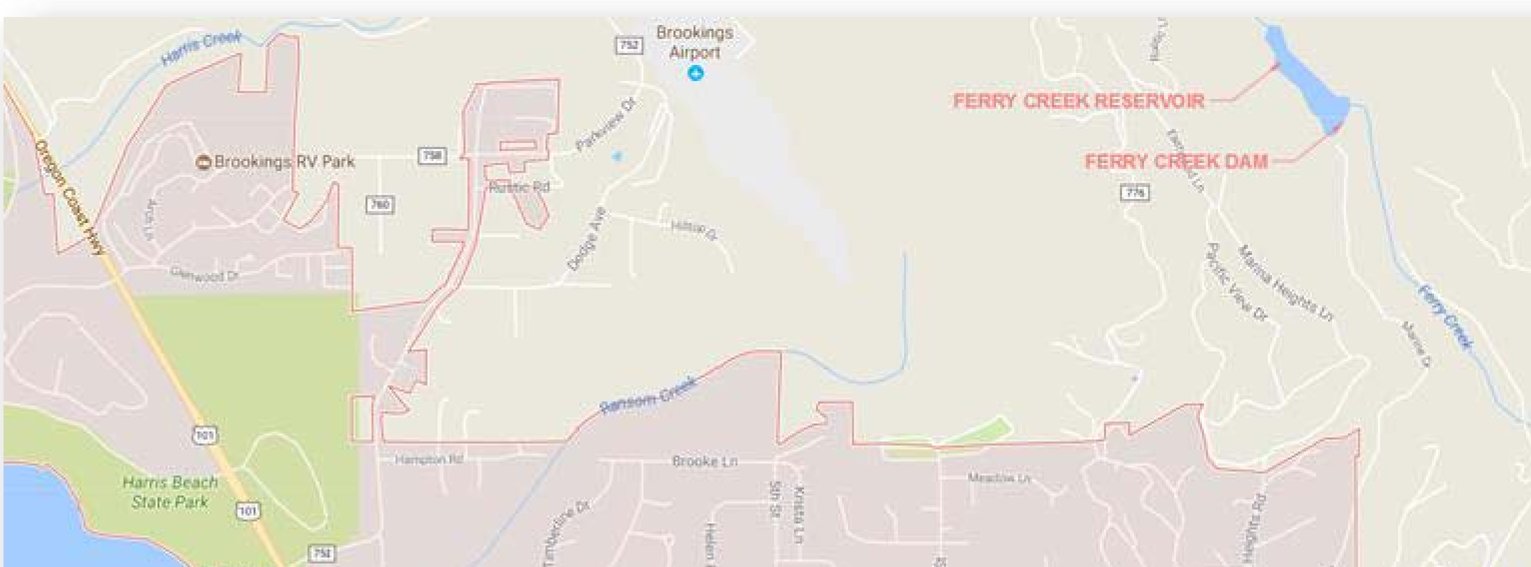
Also, the scope of the study includes discussion of the minimal or optimal stream flow (Required by the Oregon Water Resources Department feasibility study grant). These flows are dependent on the in-stream geometry and the wildlife present within the stream. From what I understand this is typically determined by ODFW. Do you have any information regarding the 'optimal peak' flow for Ferry Creek?

Just to be clear, we will not be filing for a permit or fish mitigation waiver yet, as we are only examining the feasibility of dam improvement alternatives. We are simply wanting to discuss the potential environmental requirements if dam re-alignment or removal was to occur. Your input and description of potential requirements associated with ODFW will be key. Please let me know what information you would need from us to facilitate responses to the questions herein. A brief description of the recommended project within the Feasibility Study and associated location maps are given below. Thank you for your time and consideration.

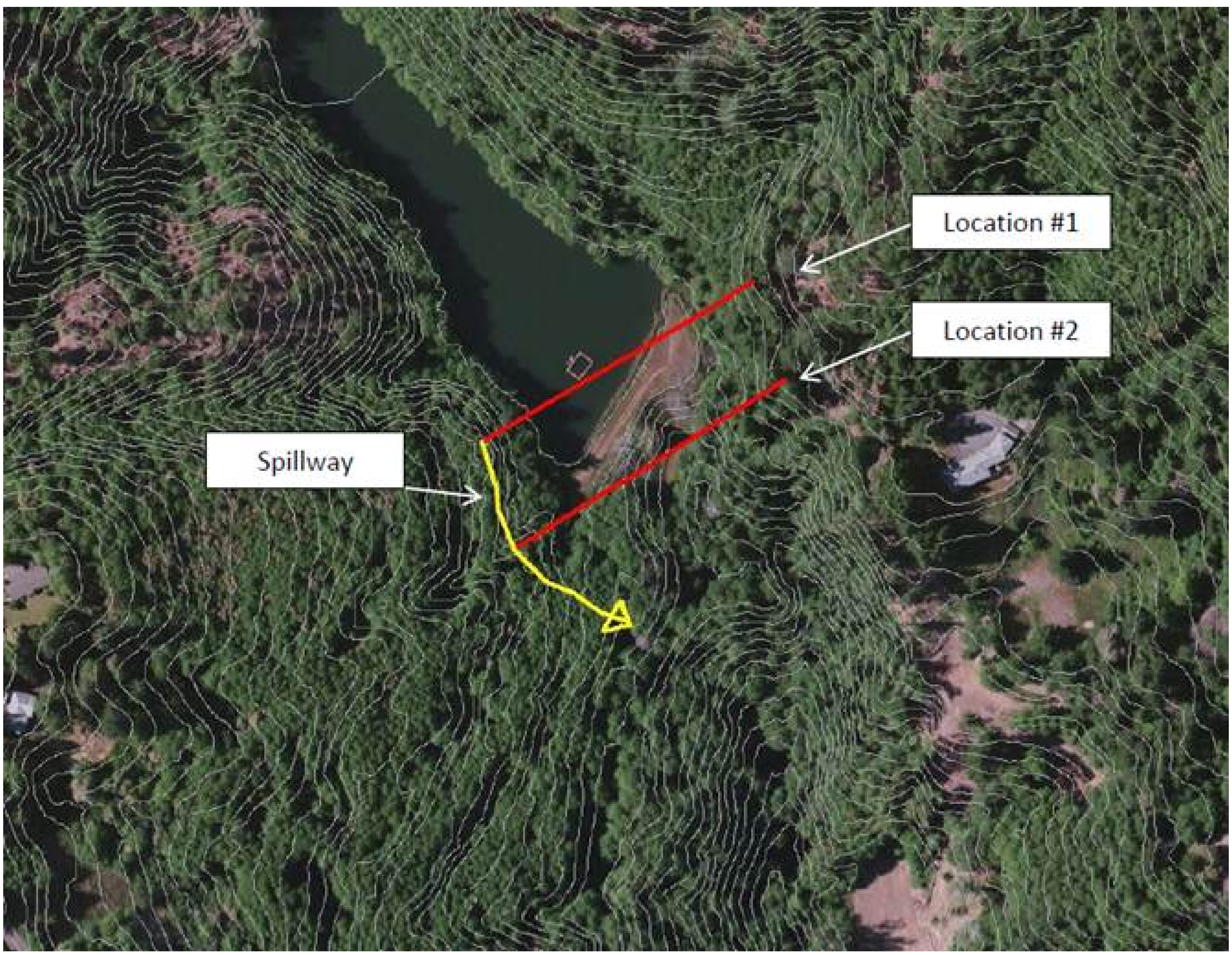
Recommended Project Description:

The dam at the Ferry Creek Reservoir in Brookings Oregon has been categorized by the Oregon Water Resources Department as in 'unsatisfactory' condition, and therefore poses a threat to the public. The Dam was originally constructed in the early 1900's and was rebuilt from the bedrock up in the 1960's. Due to the current condition of the dam, and the City's need for an emergency water supply, the City would like to rehabilitate the dam. The proposed project would re-align the dam, relocate the spillway, remove all existing piping, and install new downstream outlets to Ferry Creek, and to the WTP. Alignment options currently being discussed are shown below.

Project Location:



New Dam Alignment Alternatives:
New Dam Alignment Alternatives:



Regards,

James Parmenter, P.E.
The Dyer Partnership Engineers and Planners, Inc.
1330 Teakwood Ave.
Coos Bay, OR 97420
Phone: 541-269-0732
Fax: 541-269-2044
Toll-Free: 877-773-8610

J Parmenter

From: Steve Mazur <Steve.J.Mazur@state.or.us>
Sent: Friday, November 17, 2017 1:04 PM
To: J Parmenter
Cc: Greg D Apke
Subject: Ferry Creek
Attachments: IMG_0182.JPG; IMG_0186.JPG

I was out at Ferry Creek Dam on Nov. 16. Took some pictures of spill way and creek below dam. Plenty of water for fish to move and this was only a small rain event. Steve

Steven Mazur
ODFW Acting District Fish Biologist
Rogue Watershed District
South Coast District
541-247-7605

APPENDIX E.2: SHPO and Tribe Correspondence

Oregon
Kate Brown, Governor

Parks and Recreation Department
State Historic Preservation Office
725 Summer St NE Ste C
Salem, OR 97301-1266
Phone (503) 986-0690
Fax (503) 986-0793
www.oregonheritage.org

November 15, 2017

Mr. James Parmenter
Dyer Ptnrshp Eng and Plnr Inc
1330 Teakwood Avenue
Coos Bay, OR 97420

RE: SHPO Case No. 17-1730
City of Brookings, Ferry Creek Dam Project
Realignment of dam
Ferry Creek Reservoir, 40S13W32, Curry County

Dear Mr. Parmenter:

The Oregon State Historic Preservation Office (SHPO) received a request to review an application for the above referenced undertaking (project). According to the SHPO statewide database, archaeological sites are not known to exist within the proposed project location. Based on the information provided, Oregon SHPO does not have any concerns with the project proceeding as planned.

During project implementation, if an archaeological object or feature is encountered, please stop all ground disturbing activity at that location, and contact our office (503 986-0980) to report the find. According to Oregon Revised Statute (ORS) 358.905(a)(A-C), "archaeological objects are at least 75 years old, are part of the physical record of an indigenous or other culture found in the state or waters of the state and are the material remains of past human life or activity." Archaeological objects can include historic items (e.g., bottles, cans, bricks, window glass) and prehistoric items (e.g., stone tools, chipped stone flakes, butchered animal bones, ground stone implements, fire-cracked rock, charcoal, lithic quarries, house pit villages, camps). Archaeological features can be historic (e.g., foundations, privies, ships, homesteads, townsites) or prehistoric (e.g., housepit villages, hearths, cairns [clustered or piled rocks], rock images, shell midden). Under state law (ORS 358.905 and ORS 97.74) archaeological sites, objects and human remains are protected on both state public and private lands in Oregon. A person may not excavate, injure, destroy or alter an archaeological site or object located on public or private lands in Oregon unless that activity is authorized by a permit issued under ORS 390.235.

If you have any questions, please feel free to contact our office at your convenience. In order to help track your project accurately, please reference the SHPO case number above in all correspondence.

This letter refers to archaeological resources only. Comments pursuant to a review for above-ground historic resources will be sent separately.

Sincerely,

John D. Pouley

John Pouley, M.A., RPA
Assistant State Archaeologist
(503) 986-0675
john.pouley@oregon.gov

J Parmenter

From: GABRIEL Jessica * OPRD <Jessica.Gabriel@oregon.gov>
Sent: Monday, October 30, 2017 10:14 AM
To: J Parmenter
Subject: SHPO Case No.: 17-1730; City of Brookings, Ferry Creek Dam Project

Hello James,
In reviewing your email regarding the Ferry Creek Dam, because the dam is over 50 years of age, the structure will have to be documented and evaluated by the lead agency as part of the built environment. If the dam is found to be eligible for listing in the National Register of Historic Places, we would then discuss ways to avoid, minimize, or mitigate for adverse effects to the resource. Please feel free to contact me at your earliest convenience with any comments or questions you may have.

Thank you,
Jessica Gabriel
Historian
Oregon State Historic Preservation Office
725 Summer St NE, Suite C
Salem, OR 97301
503.986.0677

J Parmenter

From: Quigley Karen M <Karen.M.Quigley@oregonlegislature.gov>
Sent: Thursday, October 12, 2017 3:28 PM
To: J Parmenter
Subject: RE: City of Brookings-Ferry Creek Dam Feasibility Study

Hello James,

Thanks for your inquiry.

The federally recognized Tribe in Oregon with whom you should consult is Robert Kentta at the Confederated Tribes of Siletz. The Siletz have either treaty or aboriginal areas of interest in the Brookings area.

Robert's email is rkentta@ctsi.nsn.us

If you require Sec 106 consultation (the project has a federal nexus), in addition to Siletz, the Smith River Rancheria (Tolowa Dine) have indicated an interest in this area.

Karen

KAREN QUIGLEY, EXECUTIVE DIRECTOR
Legislative Commission on Indian Services
Karen.m.quigley@oregonlegislature.gov

From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Thursday, October 12, 2017 3:05 PM
To: Karen.Quigley@state.or.us
Subject: City of Brookings-Ferry Creek Dam Feasibility Study

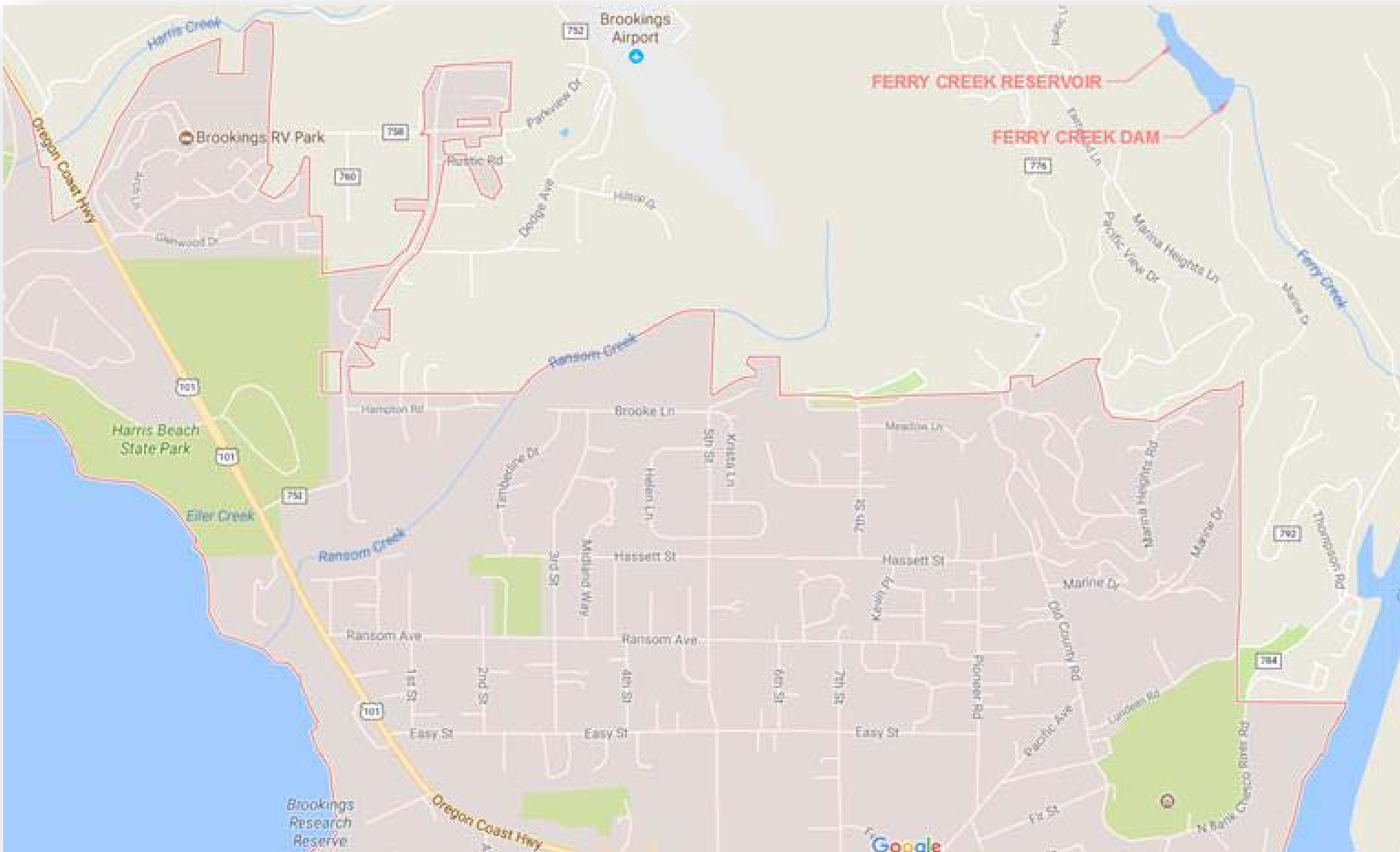
Hi Karen,

My name is James Parmenter. I am a engineer at The Dyer Partnership. I am currently developing a feasibility study for the removal or repair of the Ferry Creek Dam just east of Brookings, Oregon. As part of the feasibility study we would like to discuss all cultural, and environmental impacts the project will have, and what potential requirements might be established for the recommended project.

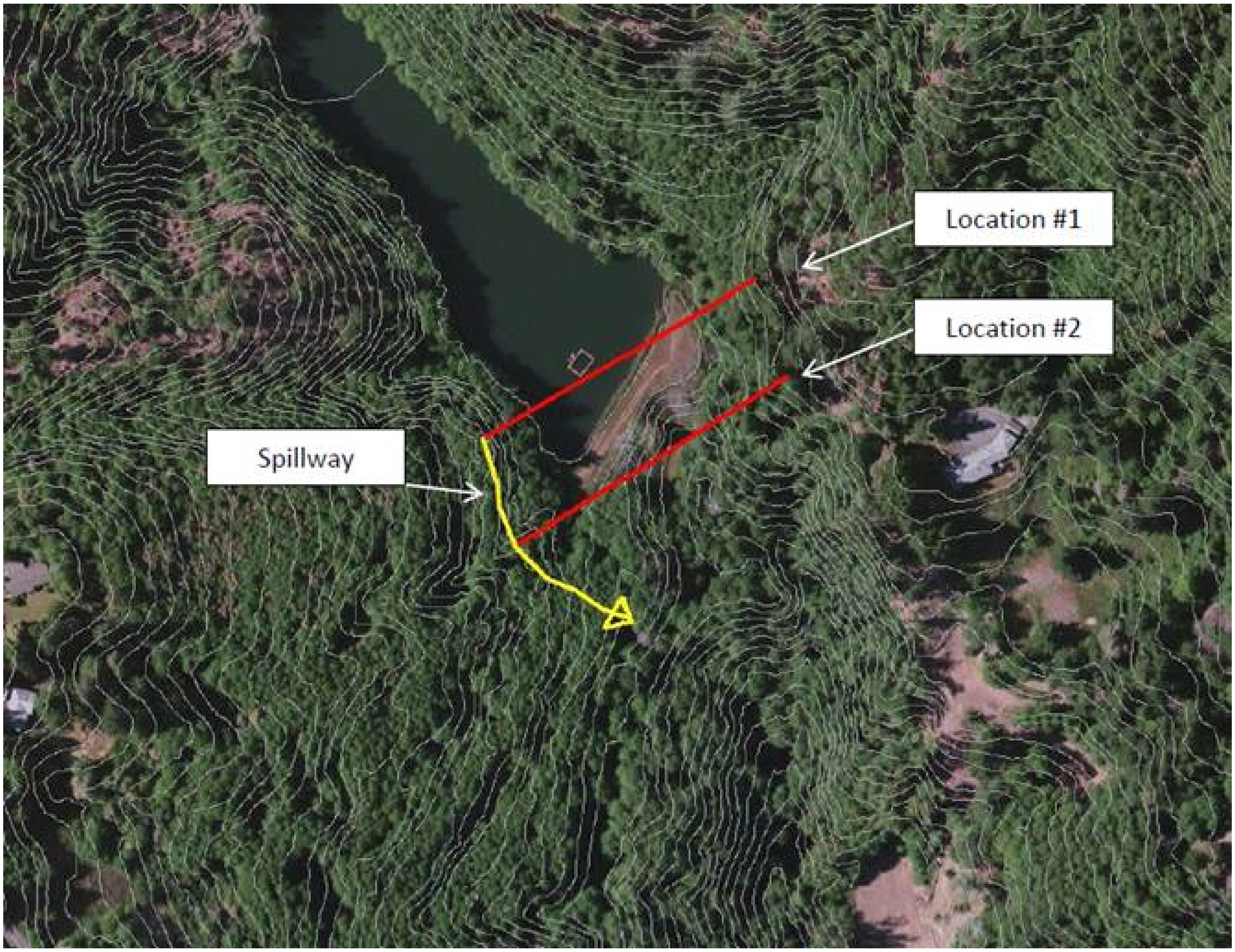
For this reason, I would like to notify the appropriate tribal governments of the proposed improvement and request their review of this project site from a cultural resources perspective. Below you will find a map showing the project location, and a brief project description. Could you please let me know which tribal governments to contact for a cultural resources review? If you need additional information about this project, its history or the City of Brookings's proposed work, please let me know. Thank you for your time and consideration.

Project Description: The dam at the Ferry Creek Reservoir in Brookings Oregon has been categorized by the Oregon Water Resources Department as in 'unsatisfactory' condition, and therefore poses a threat to the public. The Dam was originally constructed in the early 1900's and was rebuilt from the bedrock up in the 1960's. Due to the current condition of the dam, and the City's need for an emergency water supply, the City would like to rehabilitate the dam. The proposed project would re-align the dam, relocate the spillway, remove all existing piping, and install new downstream outlets to Ferry Creek, and to the WTP. Alignment options currently being discussed are shown below.

Project Location:



New Dam Alignment Alternatives:



Regards,

JAMES PARMENTER, P.E.
The Dyer Partnership Engineers and Planners, Inc.
1330 Teakwood Ave.
Coos Bay, OR 97420
Phone: 541-269-0732
Fax: 541-269-2044
Toll-Free: 877-773-8610

J Parmenter

From: Robert Kentta <rkentta@ctsi.nsn.us>
Sent: Wednesday, April 04, 2018 9:51 AM
To: J Parmenter; Stan van de Wetering; Adrienne Crookes; Peter Hatch
Subject: Re: Brookings-Oregon-Ferry Creek Feasibilty Study-Cultural Review Request

Hi James

Im copying my asst. Peter, Stan Van (biologist) and Adrienne Crookes who has many family members in the Brookings area.

She can reach out to her family as she deems appropriate -'they can contact you directly as community members, or contact one of us to ask the Tribe to represent their issue, if they believe there is an issue that they believe rises to a Tribal concern.

I see there may be cattails, tules or other wetland plants on the water edge, if tribal members are interested in harvesting some for cultural projects, is it possible to get permission?

Thanks again, if we have items to discuss, we'll be back in touch - if not, best of luck with your project.

Robert Kentta
Cultural Resources Director
Confederated Tribes of Siletz Indians

Sent from my iPhone

On Apr 4, 2018, at 8:40 AM, J Parmenter <jparmenter@dyerpart.com> wrote:

> Hi Robert,
>
> My name is James Parmenter. I am an engineer at The Dyer Partnership. I am currently developing a feasibility study for the removal or repair of the Ferry Creek Dam just east of Brookings, Oregon. As part of the feasibility study we would like to discuss all cultural, and environmental impacts the project will have, and what potential requirements might be established for the recommended project.
>
> For this reason, I wanted to contact you and request your review of this project from a cultural resources perspective. Below you will find a map showing the project location, and a brief project description. Could you please let me know if you have any cultural concerns related to the project type or location? If you need additional information about this project, its history, or the City of Brookings's proposed work, please let me know. Thank you for your time and consideration.
>
> **Project Description:** The dam at the Ferry Creek Reservoir in Brookings Oregon has been categorized by the Oregon Water Resources Department as in 'unsatisfactory' condition, and therefore poses a threat to the public. The Dam was originally constructed in the early 1900's and was rebuilt from the bedrock up in the 1960's. Due to the current condition of the dam, and the City's need for an emergency water supply, the City would like to rehabilitate the dam. The proposed project would re-align the dam,

relocate the spillway, remove all existing piping, and install new downstream outlets to Ferry Creek, and to the WTP. Alignment options currently being discussed are shown below.

Project Location:
<image005.png>

New Dam Alignment Alternatives:

<image004.jpg>

Regards,

JAMES PARMENTER, P.E.
The Dyer Partnership Engineers and Planners, Inc.
1330 Teakwood Ave.
Coos Bay, OR 97420
Phone: 541-269-0732
Fax: 541-269-2044
Toll-Free: 877-773-8610

APPENDIX E.3: COE Correspondence

J Parmenter

From: Krug, Tyler J CIV USARMY CENWP (US) <Tyler.J.Krug@usace.army.mil>
Sent: Tuesday, October 17, 2017 7:29 AM
To: J Parmenter
Subject: RE: Contact from Regulatory's public web page
Attachments: 2017 NWP T&C.PDF; Joint Permit Application MAR 121814.docx; BA outline.docx

Hi James,

Thank you for getting in touch with me. Relocating the dam would likely trigger the need for a federal permit from the Corps pursuant to Section 404 of the Clean Water Act because the act of relocating the dam would likely result in either the discharge of dredged and/or fill material into Ferry Creek proper or abutting/adjacent wetlands. The first step should probably be to conduct a wetland delineation so the boundaries of the aquatic resources can be mapped out correctly. From there you can pin down what impacts to said waters may exist through the chosen alternative.

We may have a few Nationwide Permits (NWP) that might cover this work but, use of those NWP's is dependent on an applicant meeting both the terms and conditions of the NWP's. If the project can't fit a NWP we would need to likely process this request as an individual permit. Please read through NWP 3 (Maintenance) and 39 (Commercial and Institutional Developments).

Biological Assessment (BA) and fish passage documentation: We wouldn't need this information for a complete pre-construction notification (PCN) for NWP or for completeness of an individual permit but we may need it to consult with the National Marine Fisheries Service (NMFS). I can reach out to NMFS to understand what their thoughts are on fish/habitat presence in Ferry Creek. Habitat in the creek itself is likely Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Act and there may be some steelhead, chinook, or Coho use of the creek as well. The creek may also be designated critical habitat for Southern Oregon Northern California Coasts Coho salmon up to the face of the dam. Your thoughts are on the right track though, we may need to consult with the NMFS.

Finished dam height: What would the pool elevation of the dam be? I ask because if the dam is raised in elevation there could be some fringe wetland loss around the dam pool. Please calculate that into the potential impact of the project upon aquatic resources.

I've attached our Joint Permit Application (JPA) which can be used as the Pre-Construction Notification (PCN) if the work might fit a NWP. The JPA is basically a form that marries the Oregon Department of State Lands (DSL) permitting process and Corps permitting process. It can also facilitate the local planning approval (block 10) and the coastal zone signature (block 11). Those are tied to interconnected processes with our federal permitting process (the Oregon DEQ 401 Water Quality Certification and the Oregon Department of Land Conservation & Development Coastal Zone Management Act concurrence).

Feel free to give me a call or email anytime. I think we're probably going to have some further pre-application meetings on this one. I'll reach out to NMFS in the meantime.

Thank you,

Tyler Krug
Regulatory Project Manager | USACE Portland District | North Bend Field Office
2201 N. Broadway Suite C | North Bend, Oregon 97459
Office: 541.756.2097 |Mobile: 541.520.6278 |Fax: 541.751.1624 |E-mail: Tyler.J.Krug@usace.army.mil Corps Portland District Regulatory Branch Website: http://www.nwp.usace.army.mil/Missions/Regulatory.aspx

Customer survey - Please let us know how we're doing:
http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey

-----Original Message-----
From: J Parmenter [mailto:jparmenter@dyerpart.com]
Sent: Monday, October 16, 2017 4:21 PM
To: Krug, Tyler J CIV USARMY CENWP (US) <Tyler.J.Krug@usace.army.mil>
Subject: [EXTERNAL] Contact from Regulatory's public web page

Tyler,

I am beginning to develop a feasibility study for the Ferry Creek Dam in Brooking's Oregon. The feasibility study will explore multiple improvement alternatives, but will most likely recommend re-alignment of the earthen dam. I would like to include a section within the study that explains the required permitting, and any potential construction requirements that may accompany the permits. This email was sent to request your input on these permitting requirements. I am assuming for either dam removal, or re-alignment the acquisition of a Nationwide Joint Permit Application (JPA) would be necessary. A Biological Assessment and Fish passage documentation would also be required for the completion of the JPA. Please let me know if my assumptions are correct. If there would be a way to fit this project into a programmatic permitting process, please let me know as this would be an easier process.

A brief description of the recommended project within the Feasibility Study and associated location maps are given below. Thank you for your time and consideration.

Recommended Project Description:

The dam at the Ferry Creek Reservoir in Brookings Oregon has been categorized by the Oregon Water Resources Department as in 'unsatisfactory' condition, and therefore poses a threat to the public. The Dam was originally constructed in the early 1900's and was rebuilt from the bedrock up in the 1960's. Due to the current condition of the dam, and the City's need for an emergency water supply, the City would like to rehabilitate the dam. The proposed project would re-align the dam, relocate the spillway, remove all existing piping, and install new downstream outlets to Ferry Creek, and to the WTP. Alignment options currently being discussed are shown below.

Project Location:

New Dam Alignment Alternatives:

New Dam Alignment Alternatives:

Regards,

James Parmenter, P.E.

The Dyer Partnership Engineers and Planners, Inc.

1330 Teakwood Ave.

Coos Bay, OR 97420

Phone: 541-269-0732

Fax: 541-269-2044

Toll-Free: 877-773-8610

APPENDIX E.4: NMFS Correspondence

From: Michelle McMullin - NOAA Federal <michelle.mcmullin@noaa.gov>
Sent: Thursday, April 05, 2018 1:31 PM
To: J Parmenter
Cc: Krug, Tyler NWP
Subject: Re: Brookings-Ferry Creek Feasiblity Study

James,

It doesn't appear the dam is all that far upstream of anadromy. Is Ferry Creek a perennial stream?

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Office: 541.957.3378
michelle.mcmullin@noaa.gov

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From: Michelle McMullin - NOAA Federal [mailto:michelle.mcmullin@noaa.gov]
Sent: Thursday, April 05, 2018 11:44 AM
To: J Parmenter
Cc: Krug, Tyler NWP
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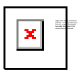

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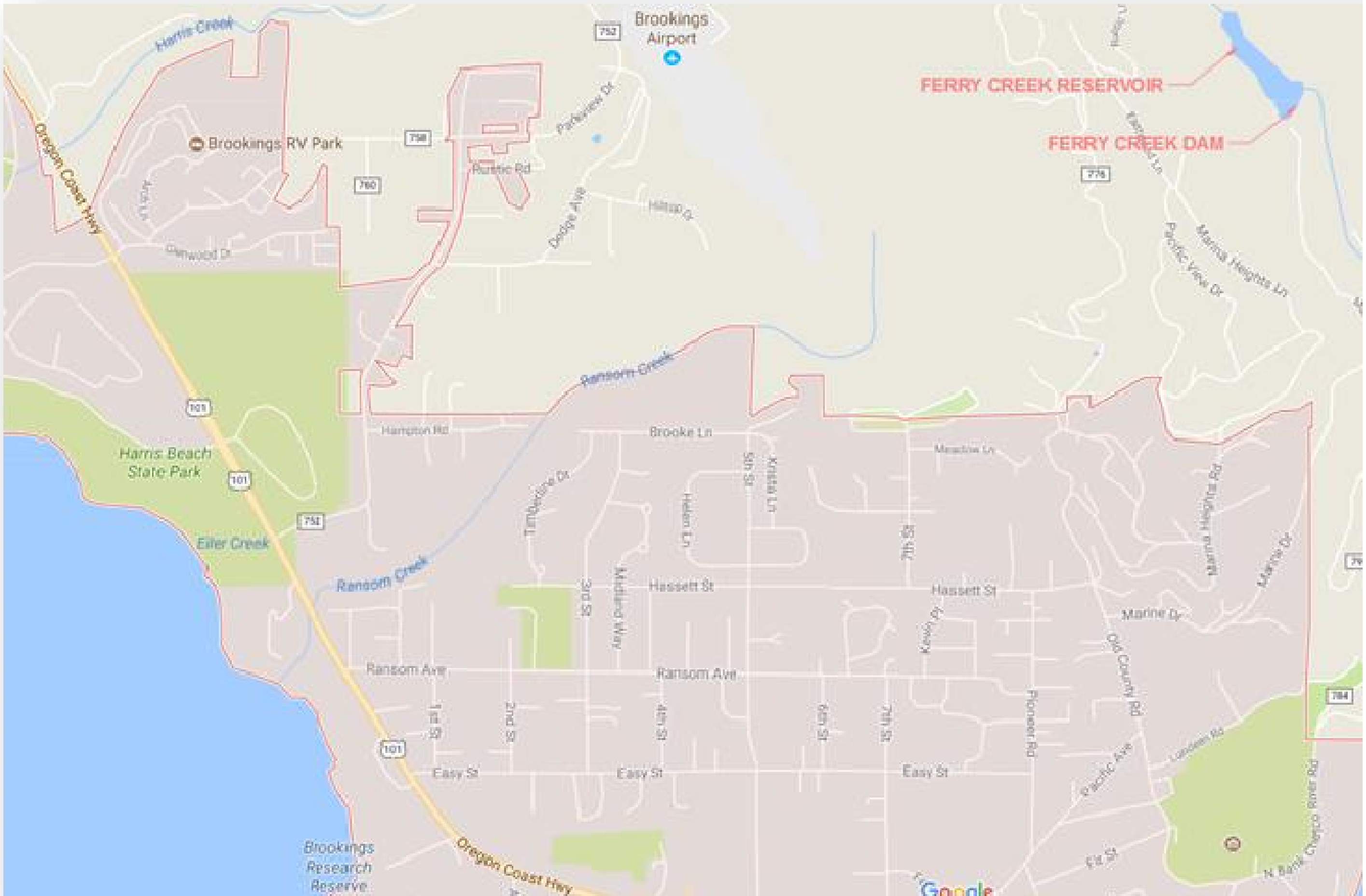
FERRY CREEK RESERVOIR
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Brookings
Airport
Brookings RV Park
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Oregon Coast Hwy
Rustic Rd
Dodge Ave
Ransom Creek
Brooke Ln
Harris Beach
State Park
Eiler Creek
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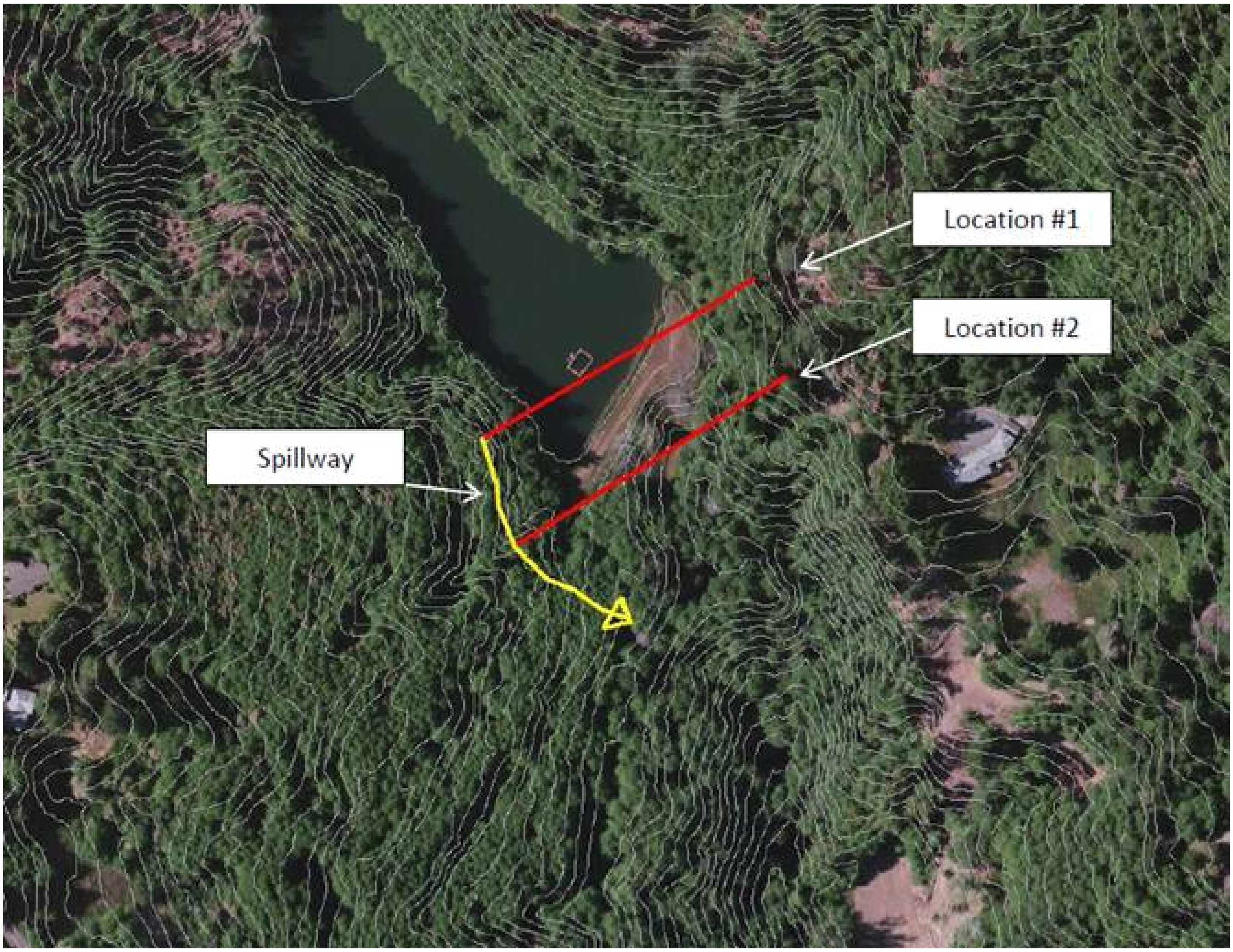

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JAMES PARMENTER, P.E.

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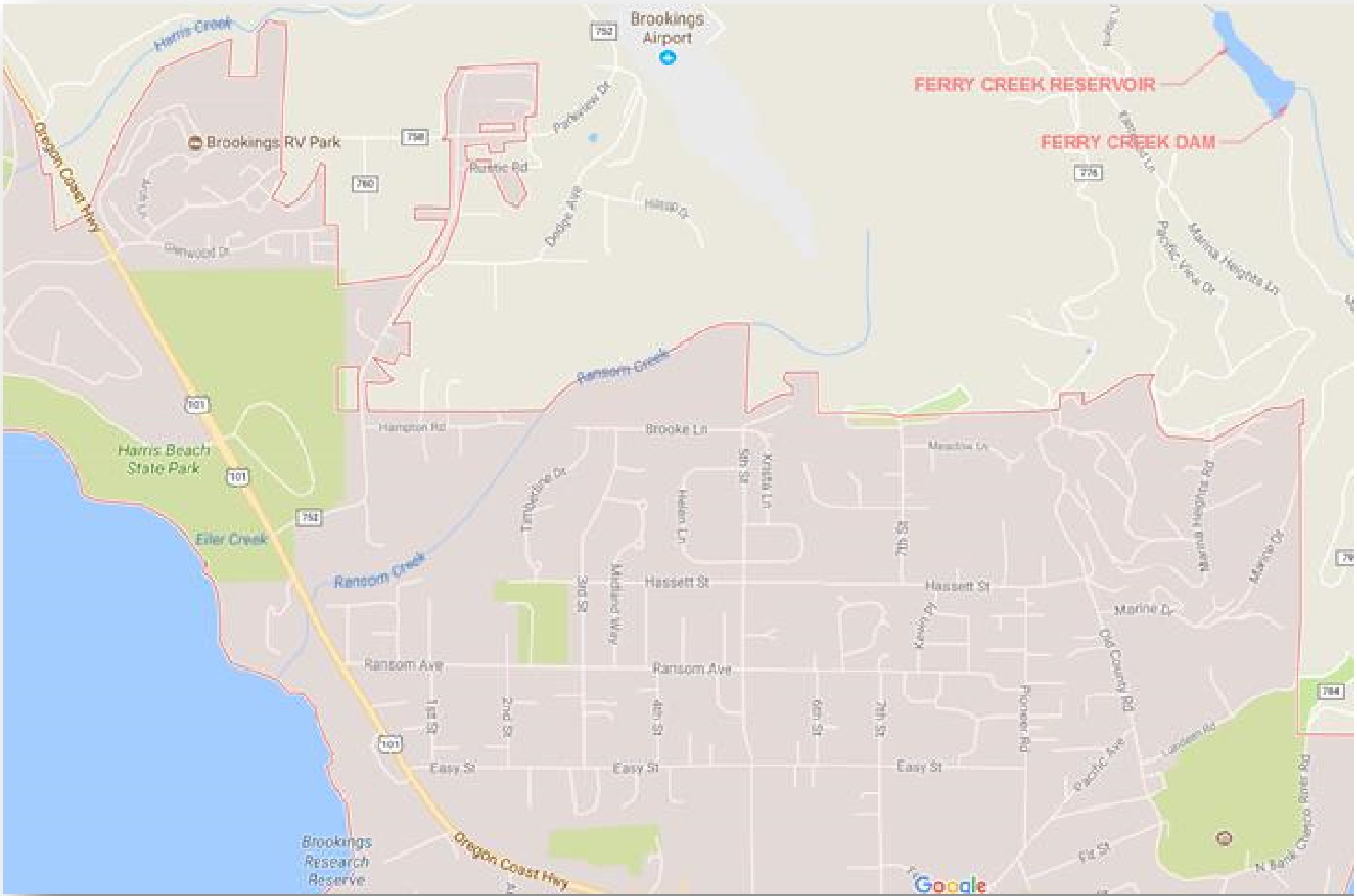

FERRY CREEK RESERVOIR
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Brookings Airport
Brookings RV Park
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Harris Beach State Park
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Hassett St
Ransom Ave
Easy St
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Brooke Ln
Old County Rd
Marina Heights Rd
Pacific View Dr
Marine Dr
Pioneer Rd
Fir St
Pacific Ave
Rustic Rd
Dodge Ave
Parkview Dr
Timberline Dr
Helen Ln
Midland Way
Kevin Dr
Hampton Rd
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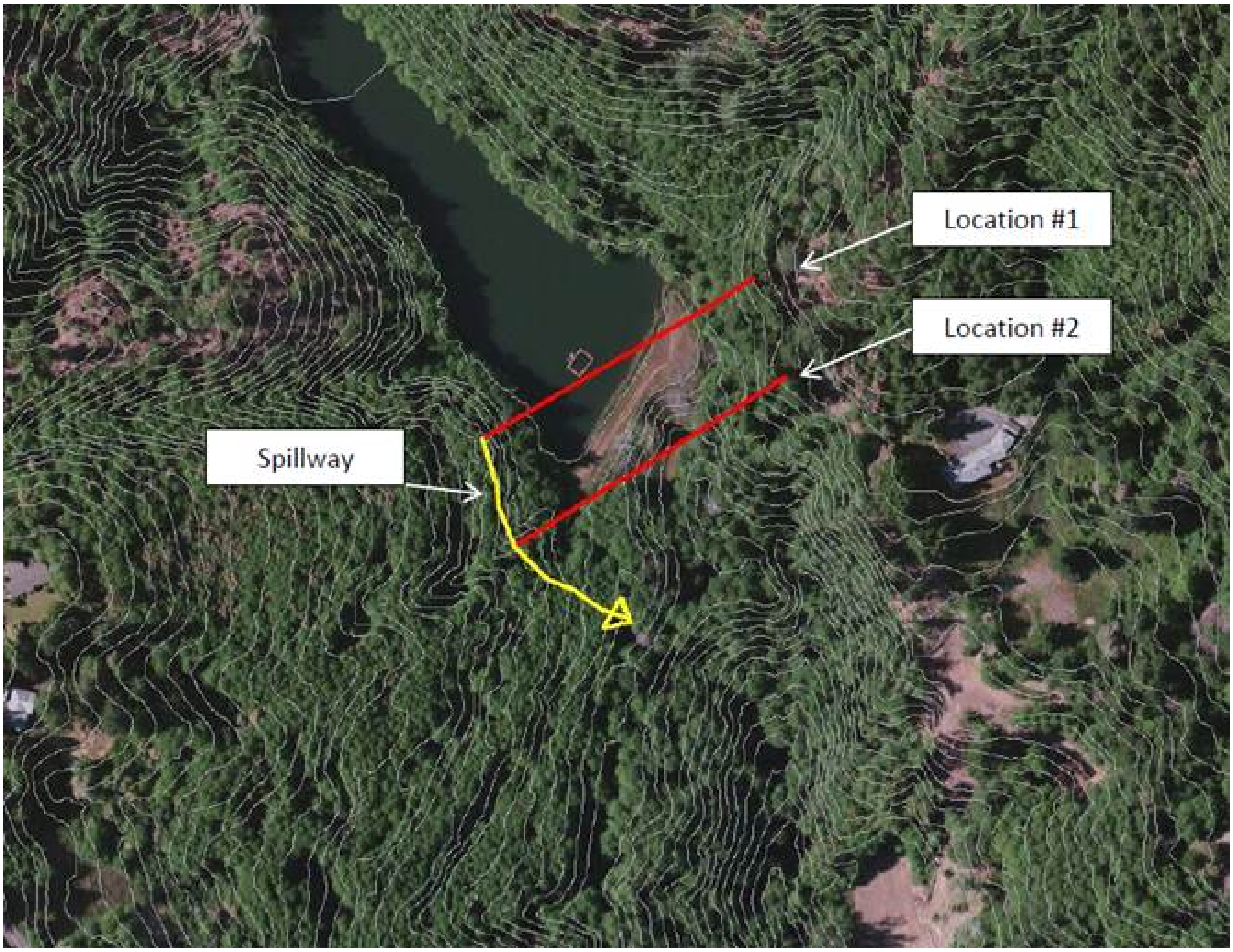

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From: Michelle McMullin - NOAA Federal <michelle.mcmullin@noaa.gov>
Sent: Tuesday, April 24, 2018 1:58 PM
To: J Parmenter
Subject: Re: Brookings-Ferry Creek Feasiblity Study

James,

I have no further information to provide given the very preliminary stages of the the project development at this time. Please feel free to reach out as the project develops.

Sincerely,

Michelle LaRue McMullin
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On Tue, Apr 17, 2018 at 9:05 AM, J Parmenter <jparmenter@dyerpart.com> wrote:

Greetings Michelle,

The dam is about a quarter mile upstream from the anadromous fish. Ferry creek is a perennial stream.

On the rare occasion that water is pulled from the reservoir there is no mechanism that would introduce contaminants into the reservoir. Quantity of water in the stream should not be an issue as we were planning on diverting water to maintain stream flows. Tyler did a good job of clarifying our communication with the Corps, if you have any questions regarding their involvement please let me know.

As I mentioned before, I am just trying to narrow down some of the requirements that may accompany the permitting project related to the recommended project. I was hoping you could tell me if consulted by COE, would a Biological Assessment typically be required, or no? If you don't have enough information to provide a very preliminary prediction of requirements, just let me know. Thank you for your time and consideration. Have a great day.

Regards, James

From: Michelle McMullin - NOAA Federal [mailto:michelle.mcmullin@noaa.gov]
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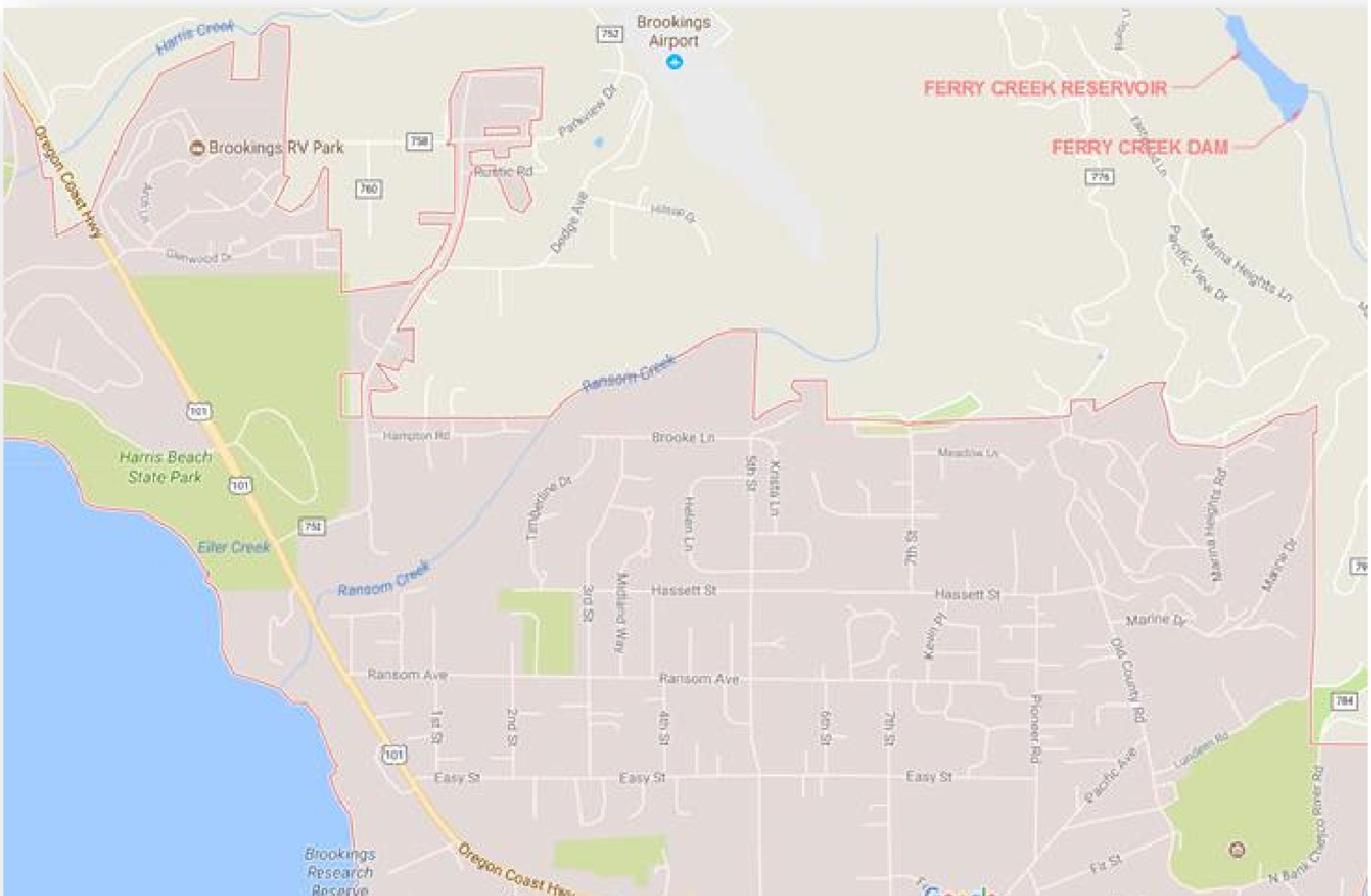

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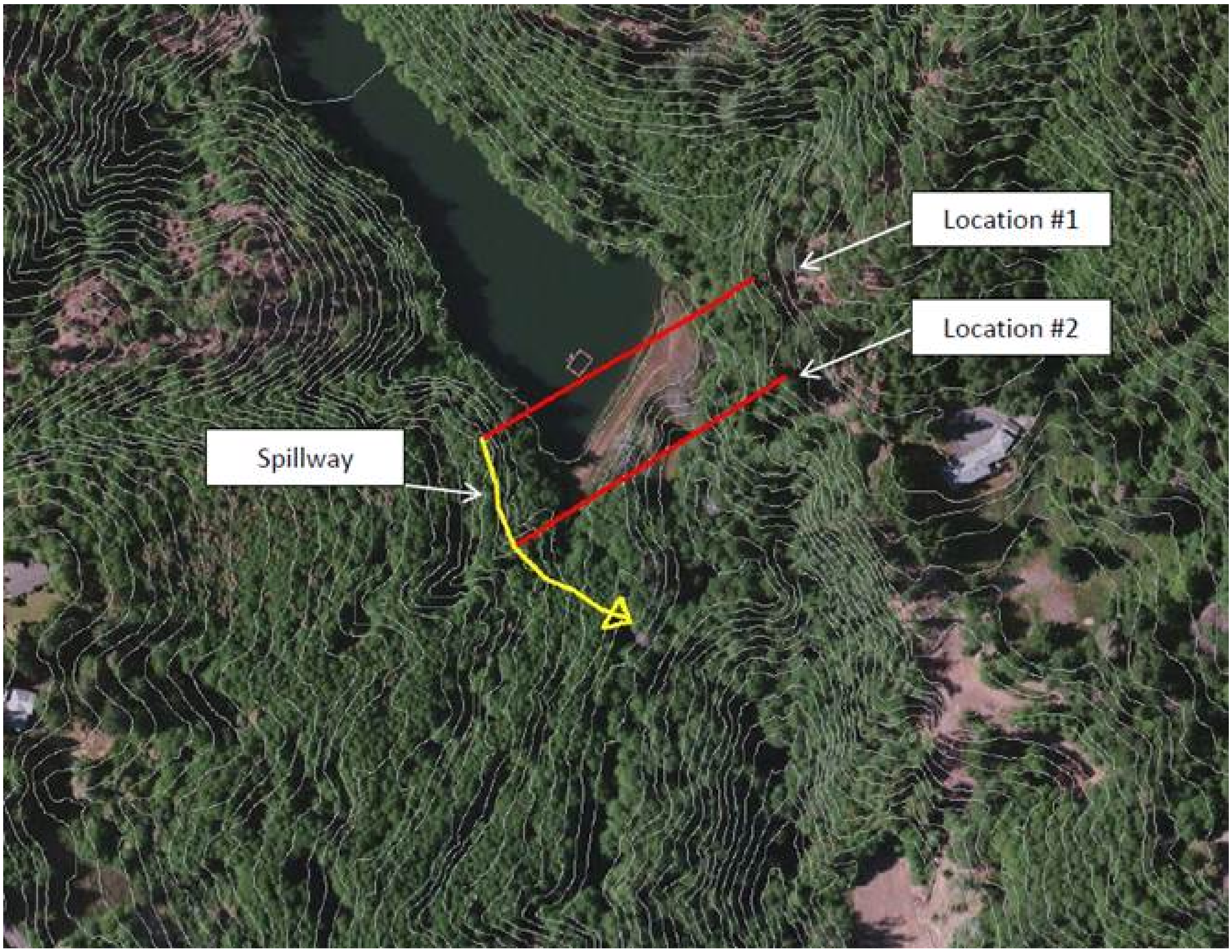

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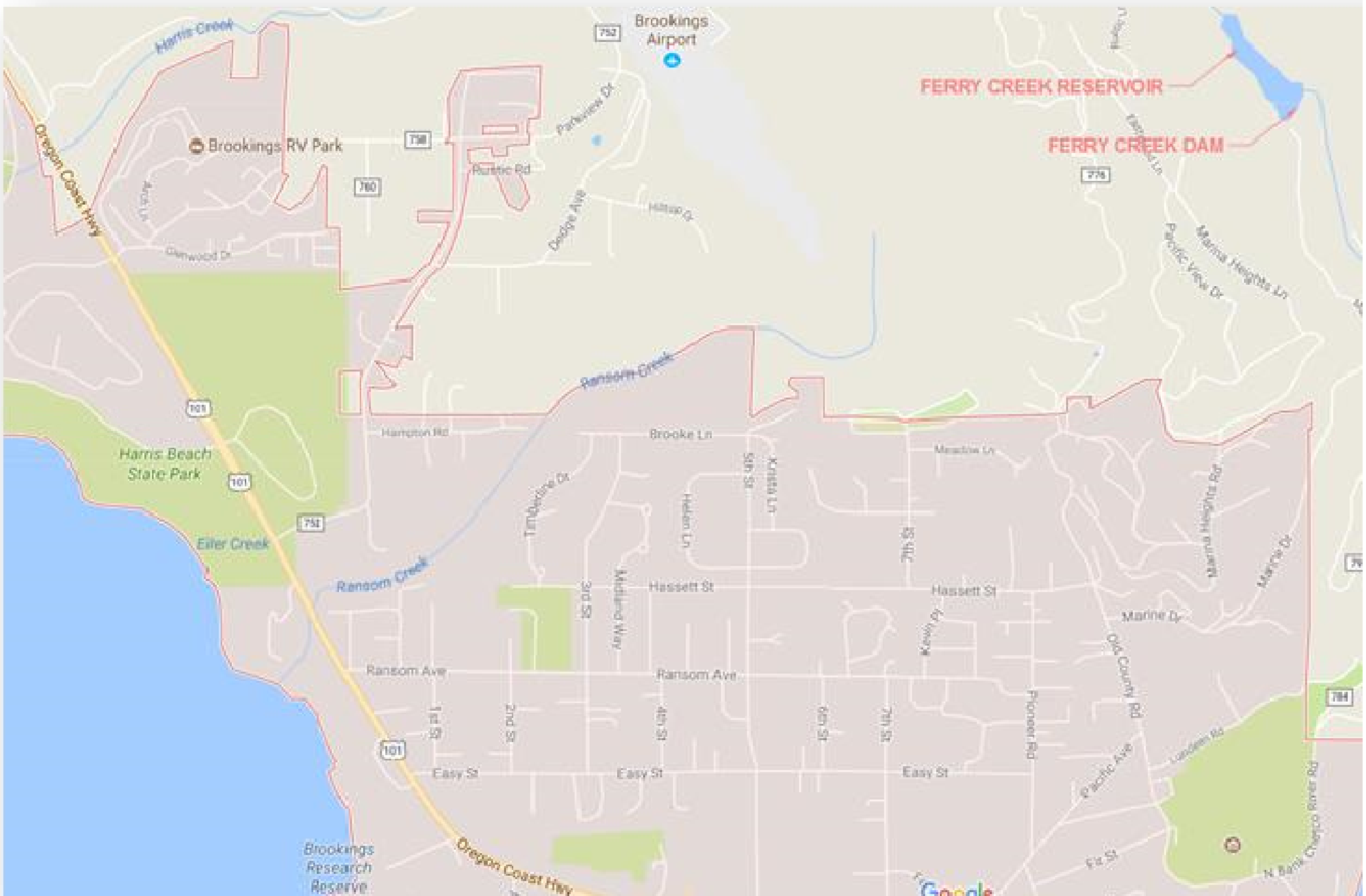

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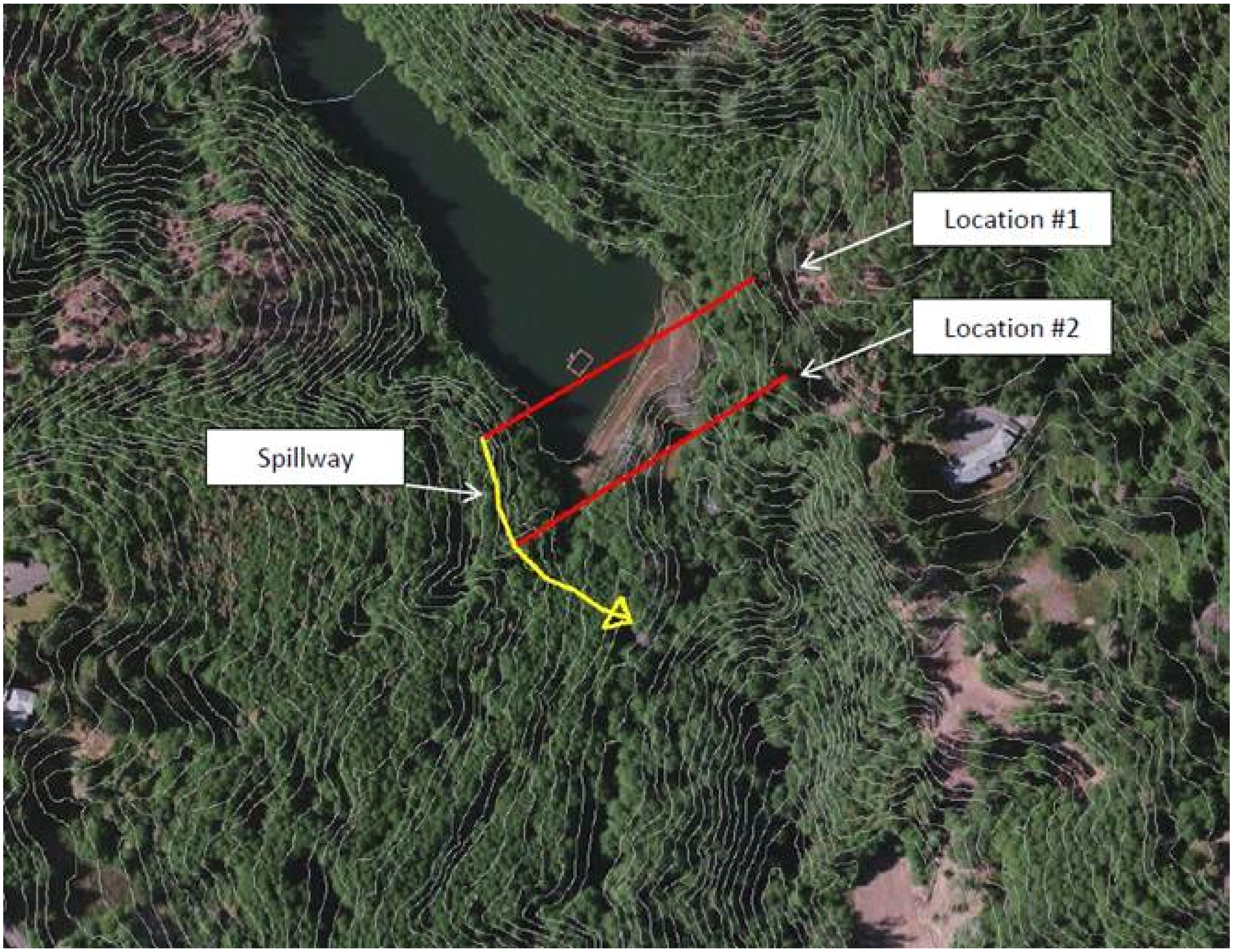

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