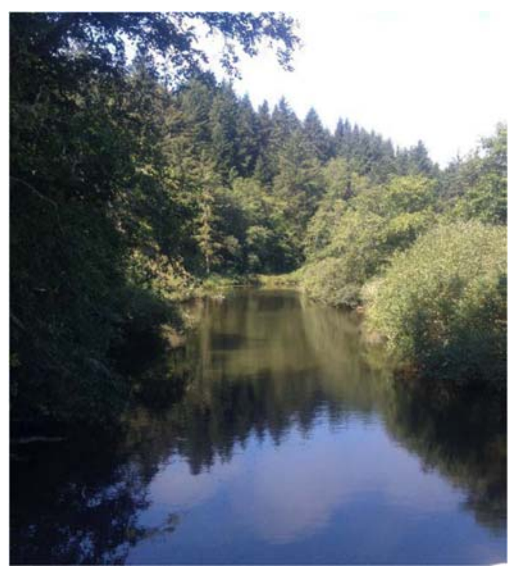
FINAL

Preliminary Engineering Report for Seal Rock Water District, Oregon: Beaver Creek Water Supply Project

Prepared for

USDA Rural Development Loan Program

May 2017



CH2M HILL Engineers, Inc.
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REGISTERED PROFESSIONAL ENGINEER
13248
OREGON
JULY 17, 1986
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RENEWAL DATE: 12/31/17

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Acronyms and Abbreviations

AC	asbestos cement
cfs	cubic feet per second
CH2M	CH2M HILL Engineers, Inc.
CM-GC	construction manager-general contractor
District	Seal Rock Water District
EDU	equivalent dwelling unit
gpcd	gallons per capita per day
gpd	gallons per day
kW	kilowatt
LEED	Leadership in Energy and Environmental Design
mgd	million gallons per day
OWRD	Oregon Water Resources Department
PER	Preliminary Engineering Report
project	proposed new water supply system
SWOT	strengths-weaknesses-opportunities-threats
USDA	United States Department of Agriculture

Project Planning

1.1 Project Purpose

The Seal Rock Water District (District) may apply for a grant and loan from the United States Department of Agriculture (USDA) Rural Development Loan Program to partially fund a new water supply project targeted to serve customers in the District service area. The District is a municipal drinking water provider, with the state and federal identification public water system No. 00798. The proposed project would develop the components necessary to construct the new water supply system for the District.

Currently, the District obtains all of its water as treated, potable water from the City of Toledo, as a bulk purchasing customer. The supply from Toledo has inherent vulnerabilities; additionally, the District would be faced with a significant capital investment to maintain the Toledo supply. As an alternative to this vulnerable supply, the District intends to develop the proposed new water supply system from Beaver Creek, which is located centrally within the District's service boundaries.

1.2 Location and Service Area

The District serves an area on the central Oregon coast from south of Newport to the portion of Waldport lying north of the Alsea Bay. Figure 1 provides a map showing the District's service area. The distance from the north end to the south end of the system is about 11 miles. Beaver Creek lies about 4 miles from the north end and 7 miles from the south end. The District's office lies approximately 1.6 miles south of Beaver Creek.

The authorized service area, according to the District's water right permit (Oregon Water Resources Department [OWRD] Permit No. 55012), is within the District's service boundaries, which is shown as the cross-hatched area in Figure 1, copied from the permit.

The proposed water source is Beaver Creek at approximately river mile 2.1. The specific location contained in the water rights permit is NE ¼ SW ¼ Section 20 T12S R11W; 610 feet south and 1,360 feet east from the W ¼ corner, Section 20.

1.3 Current and Projected Water Use and Service Population

As of December 2016, the District had approximately 2,600 active customer accounts and served a population of approximately 5,000. In terms of equivalent dwelling units (EDUs), the District served 2,892. Nearly 95 percent of the customers are classified as residential, either single family or multifamily, with the remaining 5 percent consisting of commercial, industrial, and government (including parks and the airport) accounts. In terms of metered sales, approximately 70 percent of water is consumed at residential accounts and 30 percent by commercial, industrial, and government customers.

One of the common water utility measurements is annual average day demand or more generally referred to as simply average day demand. The average day demand equals the total water required over a year's period divided by 365 days per year. By using the term *demand*, the reference is to all water entering the system. In the case of the District's current system, demand is equal to the flow entering the distribution system through the master meter connection to Toledo. Once the District develops the Beaver Creek supply, the production delivered from the treatment plant into the system will need to match system demand.

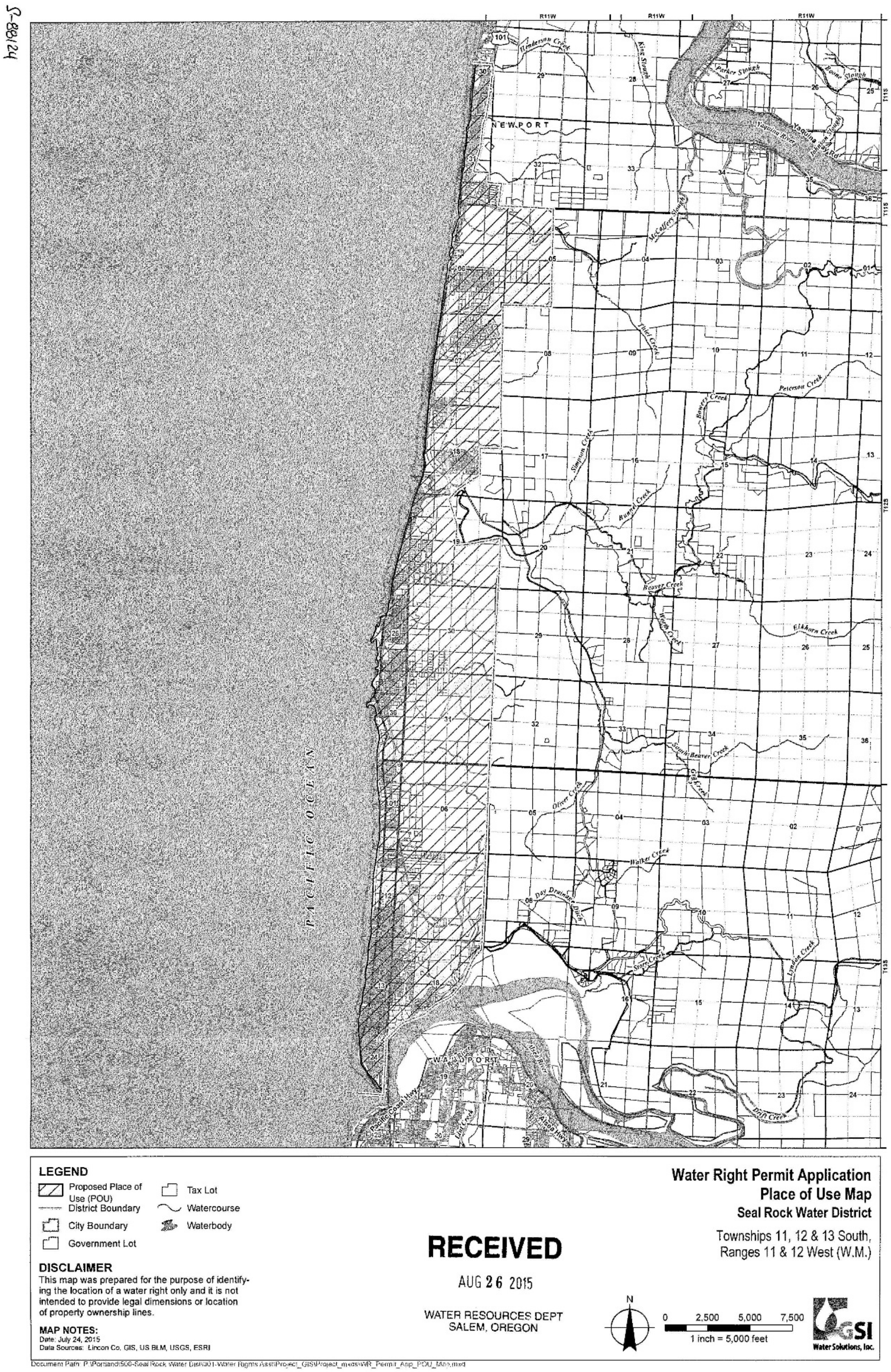

Figure 1. Seal Rock Water District Service Area

Water demand used in this manner includes revenue and nonrevenue water. Revenue water is all water recorded as metered use by customers. Nonrevenue water is the difference between demand and metered customer use. Sources of nonrevenue water include unmetered but authorized uses (such as for flushing hydrants), evaporation and overflow from reservoir tanks, and water lost to leakage, among other contributions.

A specific water utility measurement is maximum day demand. This is highest total water requirement for any single 24-hour day during the year. This is a critical term for water supply planning because the capacity of the water supply must be equal to or greater than the maximum day demand or a shortfall will occur. Water utilities include finished water storage reservoirs but these are not designed to make up for a supply shortfall. Instead, they provide storage for peak periods during a maximum day demand, as well as for the unusually high flows needed for fire-fighting and for emergency interruptions of the supply system.

Furthermore, a water utility's supply should be designed not only to meet the current maximum day demand, but should also take into account the projected future maximum day demand.

1.3.1 Water Demand History

Water flows entering the District's system are recorded by a master meter at the Toledo connection. The total annual flows entering the system have ranged from 108 to 128 million gallons per year for the period of April 2007 through December 2016. When converted to average day demand, the range has been 300,000 to 350,000 gallons per day (gpd), with an average for the period of 320,000 gpd.

The value for 2016 was 350,000 gpd, or the highest from 2007-2016. However, the second-highest value, 340,000 gpd, occurred in 2008. As shown in Figure 2, the average day demand dropped to its lowest value in recent years in 2013 and has since steadily climbed.

During this same period, the maximum day demands have ranged from approximately 650,000 to 770,000 gpd. The master meter is read and recorded every few days, so the record of the maximum day demand value is incomplete. The values determined in this report use a peaking factor of 2.2 for maximum to average day demand, which is approximately the peaking factor developed in the District's April 2014 *Preliminary Engineering Report for Water System Improvements – Phase 3*.

The recent maximum day demand history shows the same pattern as the average day demand, since the maximum values are based on a multiplier of the average values. These values are also displayed in Figure 2.

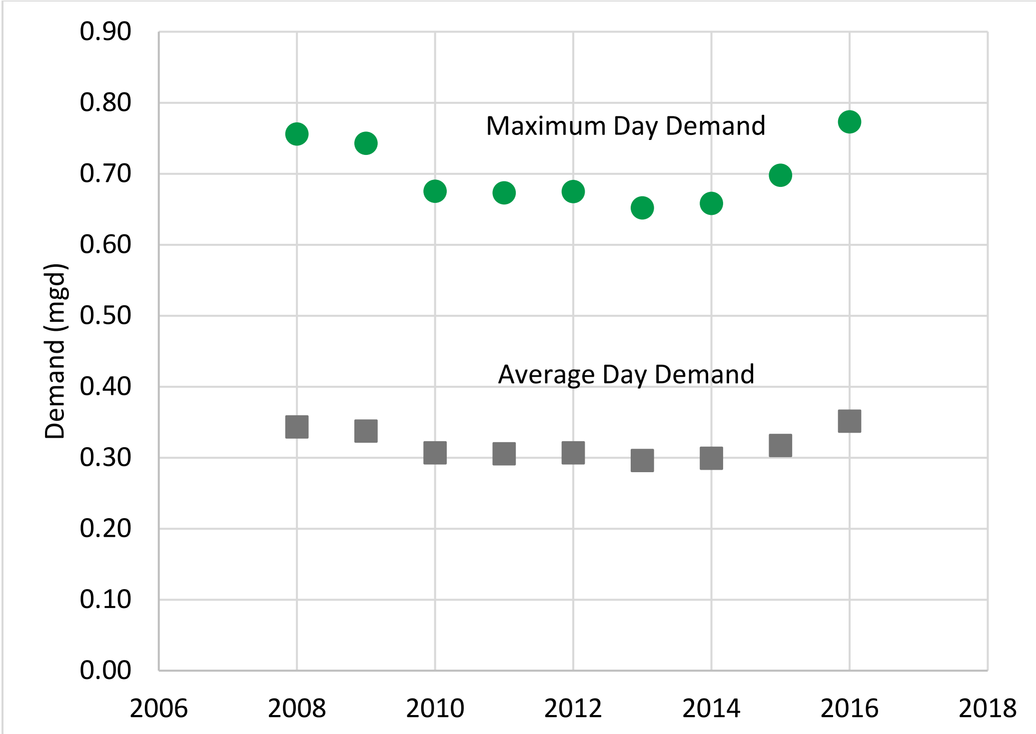

Figure 2. Average and Maximum Day Demand History

According to the District's *Water Management and Conservation Plan* (March 2014), the service population for 2013 consisted of approximately 4,100 full-time residents, with a summer peak population of approximately 5,200. The number of full-time residents had increased to about 4,600 by 2016. The District serves an unincorporated community with a large number of second homes and rentals. Therefore, it is difficult to determine a specific service population. The estimates provided herein are based on Lincoln County's average of 1.65 persons per housing unit and a total of 2,489 housing units at the time the plan was prepared.

It is common to put average and maximum day demands into per capita terms, both for understanding current water use patterns and to use in projecting future demands. However, the per capita values for the District are very approximate because of the uncertainties surrounding the service population. Using the estimates for full-time residents, the following per capita values were estimated for recent water use in the District. These same values will be applied to population forecasts to project future demands.

- Average day demand = 75 gallons per capita per day (gpcd)
- Maximum day demand = 165 gpcd

1.3.2 High Water Use Customers

Based on records for November 2015 through October 2016, only six customers averaged more than 1,000 gpd of water, as summarized in Table 1-1. Five of the six were commercial accounts and the remaining high-use customer was for a multifamily complex. The total use by these customers during this period was approximately 7 percent of the total metered use in the District.

Table 1-1. High Water Use Customers

Account No.	Type	Annual use (gal)	Daily average use (gpd)
110	Commercial	3,298,360	9,012
225	Multi-family residential	2,105,210	5,752

Table 1-1. High Water Use Customers

Account No.	Type	Annual use (gal)	Daily average use (gpd)
224	Commercial	1,251,350	3,419
228	Commercial	1,000,170	2,733
108	Commercial	826,650	2,259
220	Commercial	489,460	1,337

1.3.3 Nonrevenue Water

The District actively strives to minimize nonrevenue water. However, nonrevenue water is a component of every municipal water system demand and must be considered in water supply planning. Figure 3 illustrates sources of revenue and nonrevenue water. Nonrevenue water includes metering inaccuracies, authorized but unmetered uses, and leakage.

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td rowspan="4">System Input Volume = System Demand
(For Cornelius, the flow entering the system as measured at the master meters)</td><td rowspan="2">Authorized Consumption</td><td>Billed Authorized Consumption</td><td>Billed metered consumption
Billed unmetered consumption</td><td>Revenue Water</td></tr>
<tr><td>Unbilled Authorized Consumption</td><td>Unbilled metered consumption
Unbilled, unmetered consumption</td><td rowspan="3">Nonrevenue Water</td></tr>
<tr><td rowspan="2">Water Losses</td><td>Apparent Losses</td><td>Unauthorized consumption
Metering inaccuracies
Systematic data handling errors</td></tr>
<tr><td>Real Losses</td><td>Leaks in distribution pipes
Leaks and overflow from storage tank
Leaks in service connections up to point of customer meters</td></tr>
</table>

Figure 3. Components of Revenue and Nonrevenue Water[1]

Figure 4 provides nonrevenue water trends for the District. There was a general upward trend in the percentage of nonrevenue water until 2016, which saw a marked decline. The District's 2014 *Water Management and Conservation Plan* discusses both the causes of nonrevenue water and the District's actions to reduce the nonrevenue water rate. The average per capita values of 75 and 165 gpcd for average and maximum day demands include nonrevenue and revenue water use.

[1] Adopted from AWWA Manual of Water Supply Practices M36. *Water Audits and Loss Control Programs, Third Edition,* 2003.

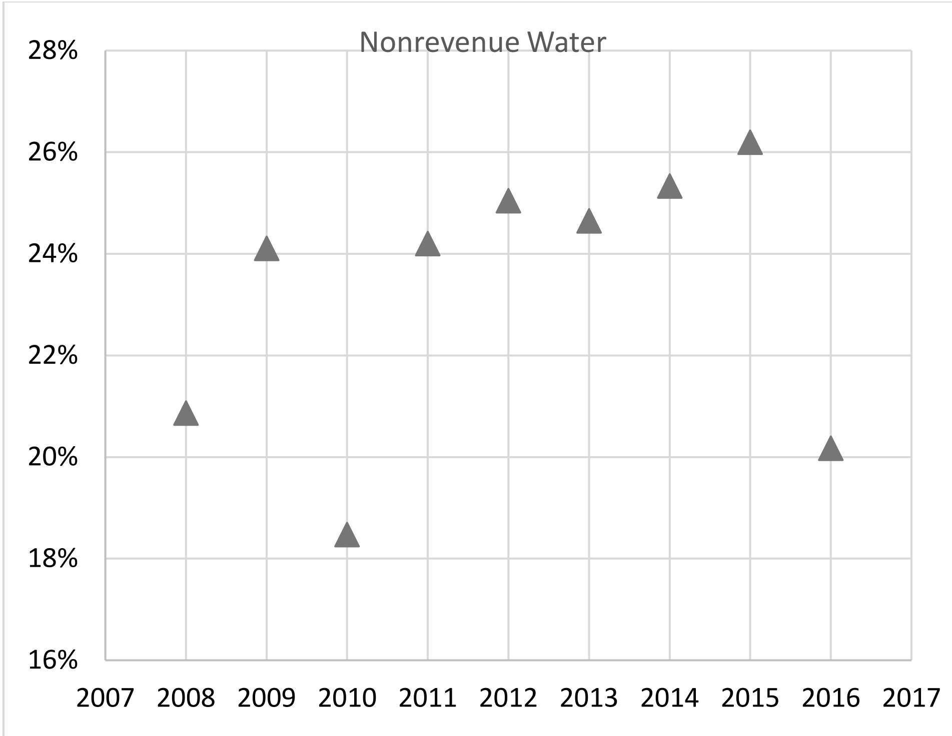

Figure 4. Nonrevenue Water Rates as a Percent of Average Day Demands for 2008-2016

1.3.4 Water Demand Projections

The March 2014 plan concluded that the population growth rate averaged 1.5 percent per year for the period of 1997-2007 but declined to 0.22 percent per year for 2007-2013. The District tracks new meter requests and according to these records, reported that the average annual growth rate for 2014-2016 was 0.25 percent. The District recommended using 0.25 percent per year for projecting demands.

Figure 5 (using mgd) and Figure 6 (using cubic feet per second [cfs]) display average and maximum day demand projections using the growth rate of 0.25 percent and the previously determined per capita use rates. The projections account for both revenue and nonrevenue water, since the production from the source must supply all water needed in the system whether or not it becomes metered customer use. The units of million gallons per day (mgd) are the most commonly used units for describing water production and demands.

Figure 6, showing the same values converted to cfs is provided for comparison to the District's water rights. The District obtained a water right for 2.0 cfs on Beaver Creek. According to the demand projections presented herein, the 2040 maximum day demand is estimated to equal 1.25 cfs. This would suggest that the water right of 2.0 cfs is sufficient to meet the long-term needs of the District, particularly if the District continues to make progress on reducing nonrevenue water rates.

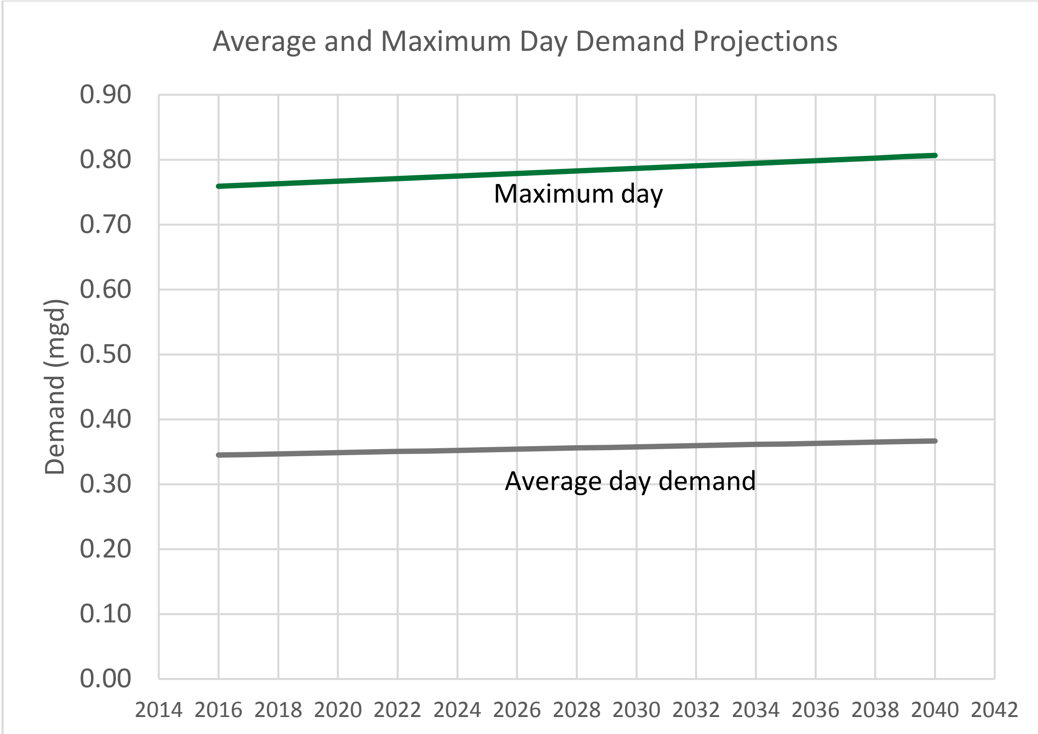

Figure 5. Average and Maximum Day Demand Projections (mgd)

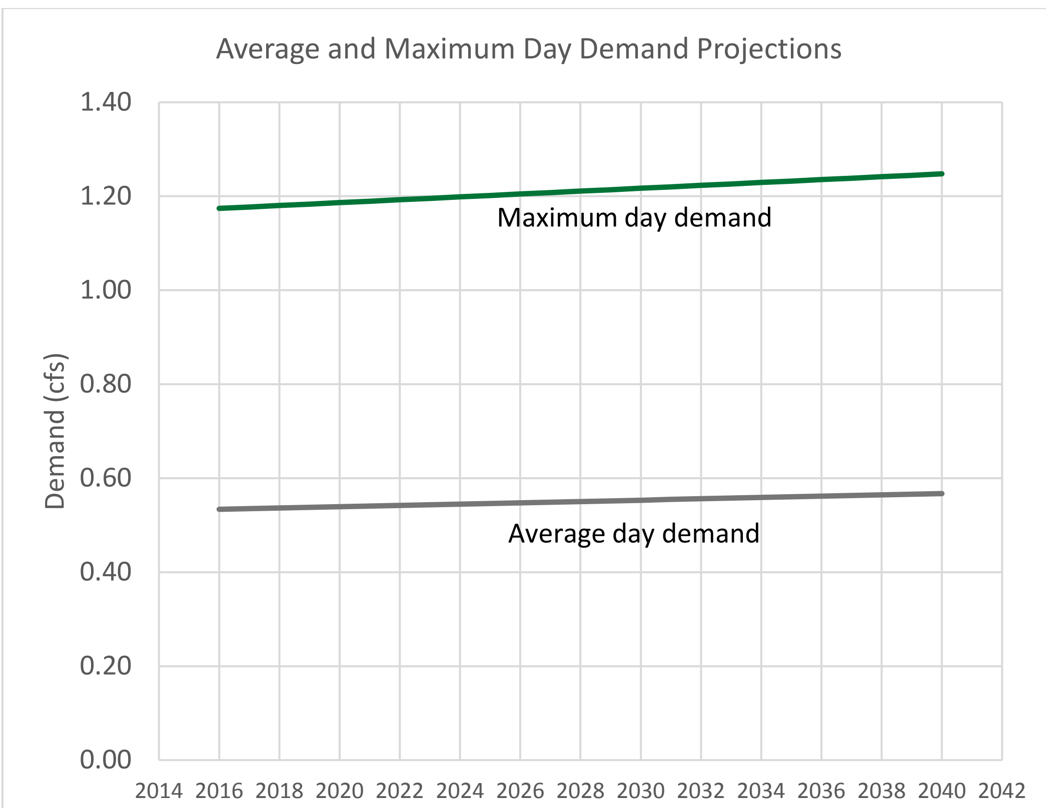

Figure 6. Average and Maximum Day Demand Projections (cfs)

1.4 Community Engagement

As described in the *Reconnaissance-Level Source Water Study* (Civil West Engineering Services, Inc., 2015a), the District has actively engaged the public throughout the planning process, including through the following avenues:

- A bill insert was sent to all District customers in December 2014. The insert explained the District's current water supply, the concerns with this supply, water source options that were being considered, and provided avenues for customers to maintain engagement.
- The District has repeatedly invited customers to attend its monthly board meetings, held the second Thursday of each month.
- The District has provided periodic updates on the project via its website at www.SRWD.org.
- The District held a public briefing on December 8, 2014, to present information gathered to date and to solicit input from the community and stakeholders. Attendees included representatives of the Mid Coast Watershed Council, Oregon Department of Fish and Wildlife, and the Wetlands Conservancy. Input from stakeholders attending this meeting were captured and considered in the *Reconnaissance-Level Source Water Study* (Civil West Engineering Services, Inc., 2015).
- The District has held individual meetings with local Oregon Department of Fish and Wildlife and Oregon Department of Environmental Quality staff to more fully understand and consider these agencies' concerns about fish and fish habitat.
- The District has worked with neighboring property owners affected by proposed improvements to include private property input into the planning process. In addition, the District is working with property owners for the purpose of developing access agreements or right-of-way easements for use of property.
- The District has been in contact with Lincoln County Planning and Development Department as well as Lincoln County Public Works regarding access and permitting for the installation of the raw water supply line.
- The District has provided a public presentation to the Lincoln County Multi-Jurisdictional Hazard Mitigation Committee regarding the Beaver Creek water supply plan.
- The District has also worked extensively involving biologist from the Mid Coast Watershed Council and the Lincoln County Soil and Water Conservation District, along with coastal stewards representing the Oregon Wetland Conservancy in an ongoing effort to maintain input from local stakeholders.

Existing Facilities

2.1 System Hydraulic Schematic and Maps

A schematic of the District's water system is provided in Appendix A. It illustrates major facilities and their respective elevations. Currently, the District obtains all of its water supply as treated, potable water from the City of Toledo. Therefore, the system does not include any withdrawal and treatment facilities. Appendix B provides maps of the District's system, divided into two 11-inch by 17-inch sections.

2.2 System Description, History, and Conditions

Seal Rock Water District is the largest water district on the Oregon coast in terms of service population. It serves the area in Lincoln County between Newport and Waldport, including a substantial portion of Waldport which lies north of the Alsea Bay. The District's boundaries were formed in 1956 after the merger of two separate, contiguous water districts. It was at that time that the District received its municipal articles of incorporation.

2.2.1 Distribution Pipe

The District system consists of approximately 63 miles of pipelines, serving six pressure zones, and supplying approximately 150 fire hydrants. The 63 miles includes 8 miles of 12- and 14-inch transmission line from Toledo.

The pipe network within the District's service boundary ranges from 2-inch to 12-inch in diameter, with a small amount of 14-inch HDPE pipe (with an inside diameter of 12 inches). Over 30 percent of the system is 4 inches in diameter or less with approximately 10 miles of 2-inch diameter pipe. A pipe inventory is provided in Figure 7.

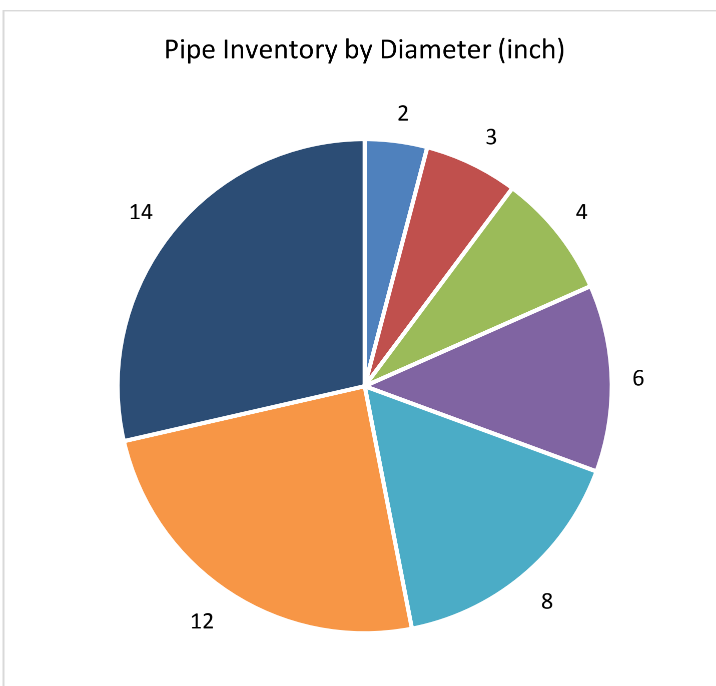

Figure 7. District pipe inventory

A serious deficiency in the District's system is that much of the 2- and 3-inch diameter piping is nonpressure-rated ABS plastic, which was not designed for potable use. This pipe frequently breaks. The District's crews are systematically replacing 2-inch lines throughout the system and will move on to any 3-inch ABS plastic aver time.

In 2012, the District implemented Phase 1 and 2 improvements for the distribution system, which included installing 14 new fire hydrants, a new pressure-reducing valve from 123rd Street to Highway 101, and the following lengths of pipe (which were included in Figure 7):

- 6-inch diameter: 2,790 feet
- 8-inch diameter: 7,200 feet
- 12-inch diameter: 2,230 feet
- 14-inch diameter: 7,050 feet

2.2.2 Pump Stations

The District's distribution system currently includes six pump stations, as listed below. However, once the Beaver Creek supply is developed, the Toledo Pump Station will not normally be used. The stations listed as *booster* pump stations are equipped with hydropneumatic tanks. They feed small, "closed-end" sections of the distribution system, areas without gravity storage.

- Toledo Pump Station
- Lost Creek Booster Pump Station (built 1997, fiberglass enclosure, good condition)
- Cross Street Booster Pump Station (built 1998, masonry construction, 196 square foot building, good condition)
- York Pump Station (rebuilt in 2014, wood-frame construction, approximately 200 square foot building, good condition)
- Driftwood Booster Pump Station (built 1982, wood frame construction, 242-square foot building, good condition)
- Bayshore Booster Pump Station (built 1998, masonry construction, 196-square foot building, good condition)

2.2.3 Reservoir Tanks

The system currently has two finished water storage reservoirs. The Lost Creek Reservoir is a 1.5-million-gallon tank serving the north end of the system. It was constructed in 2005. It is a bolted steel tank, with a glass-fused-to-steel factory finish on the floor and walls. This type of metal coating system does not require repainting as is necessary for a welded steel tank. It has an aluminum roof. The tank fills from the Toledo transmission line upstream of a pressure reducing valve, with an overflow elevation of 301 feet. This elevation is higher than the hydraulic grade line of the rest of the system.

The Driftwood Reservoir is a 1.0-million-gallon storage tank serving the south end of the system. It was constructed in 1982. It is constructed of welded COR-TEN (aka corten) steel.

The total storage volume of 2.5 million gallons is about two times the current maximum day demand. This is the volume available for meeting equalization needs (hour-by-hour fluctuations in water demands), for meeting fire flows, and for emergencies.

2.2.4 Supervisory Control and Data Acquisition System

The District's supervisory control and data acquisition (SCADA) system was installed in 2008. It uses Rockwell Automation's Factory Talk technology. It is considered to be in excellent condition.

2.3 Financial Status of Existing Facilities

The District currently employees nine full-time staff.

The District updated its rate structure in July 2016. The typical cost for a single-family residence is approximately $57 per month. This value is based on a typical single family residence use of 3,713 gallons per month, which is derived from the average day demand value of 75 gpcd and average household size of 1.65 people per household. The District's current rate structure for a ¾-inch residential meter consists of a base charge of $28.50 per month. The use rate is an inclining block structure, with higher unit costs as use increases. The cost is $6.08 per 1,000 gallons for the first 1,000 gallons of monthly use and $8.41 per 1,000 gallons for use between 1,000 and 5,000 gallons per month. Applying these charges, the typical use of 3,713 gallons per month results in costs of $28.50 for base, $6.08 for the first 1,000 gallons, and 2,713 gallons multiplied by $8.41/1,000 gallons, totaling $57.39 per month.

2.4 Audits

The District's 2014 *Water Management and Conservation Plan* included a general audit of water use and revenue versus nonrevenue water in the District. The water use and nonrevenue water values have been updated through 2016 within this report.

No recent energy audits have been conducted for the District.

Need for Project

3.1 Health, Sanitation, and Security

The goal of the project is to provide a safe, sustainable, and resilient drinking water supply for the District's customers. The District's current supply, which is a purchase of treated water from the City of Toledo, is vulnerable to landslides, flooding, and particularly, from a major earthquake. Water is delivered to the District through a 10-mile long transmission pipeline, 7 miles of which are owned by the District. Many sections of the transmission pipeline are at risk of failure in an earthquake.

A Cascadia Subduction Zone earthquake is a major concern for coastal communities in Oregon. According to Oregon State University researchers, a Cascadia Subduction Zone earthquake with a magnitude 8 to 9 intensity has a one in three likelihood of occurrence in the next 50 years.[2] This would be an unprecedented event for the region in the time since it has become widely populated and developed. The new water supply system will be designed to minimize damage during such an event and to facilitate rapid recovery. Because it would be an unprecedented occurrence, it is unknown whether current design standards are sufficient to protect against damage; it is unlikely that any design approach can fully protect against damage and resiliency must incorporate elements to facilitate recovery. That will be the approach considered in the planning and design of the Beaver Creek water supply to maximize health and sanitation benefits for the community.

Even apart from a major earthquake, the existing transmission pipeline from Toledo has proven to be vulnerable to leaks and breaks from slides and ground movement that occurs periodically along the alignment. The District has found it necessary to repair or replace many sections of the line over the past three decades, as listed in Table 3-1. Although the total cost for these projects is high, only a relatively small portion of the transmission line has been replaced to date.

Table 3-1. District Repair and Replacement Projects for Toledo Transmission Pipeline

Date	Description	Cost
1990-91	Poole Slough line replacement	$21,700
1991-92	Relocation along South Bay Road	$29,400
1991-92	Poole Slough line replacement	$73,700
2003-04	Improvements and replacement along South Bay Road	$119,900
2005	Poole Slough directional drill replacement	$825,600
2011	South Bay high-density polyethylene pipe installation; creek crossings and horizontal direction drill	$1,541,300
2011-12	South Bay Road Bridge line relocation	$33,900
2016	South Bay Road emergency repair	$30,300
TOTAL		$2,675,800

Goldfinger, C., Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutiérrez-Pastor, J., Eriksson, A.T., Gràcia, E., Dunhill, G., Enkin, R.J., Dallimore, A., and Vallier, T. 2012. *Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone*. U.S. Geological Survey Professional Paper 1661–F. 170 p. https://pubs.usgs.gov/pp/pp1661f/.

3.2 Financial Viability

A benefit-cost analysis for the proposed Beaver Creek supply project was recently prepared by Antares Planning Group, LLC. The resulting memo, *Potable Water System Upgrade, Seal Rock Water District, Oregon, Technical Memorandum on Benefit-Cost Analysis*, is attached as Appendix C. The evaluation concluded that the proposed project provides a favorable benefit to cost ratio of 1.85.

3.3 Aging Infrastructure

The existing 10 miles of 12-inch pipe that delivers water into the system from Toledo is mostly constructed of asbestos cement (AC) material and was constructed in the 1970s. It was common to use AC pipe during this era. Since it is not metallic and therefore, not prone to corrosion, it was thought that AC pipe would provide a very long useful life. Contrary to this expectation, water utilities have found that AC pipe softens with age, resulting in a high rate of failure as it approaches 50 years in age.

Nearly 20 percent of the District's distribution system piping consists of small diameter (2- to 4-inch) steel and AC pipe that was installed in the 1960s and 1970s. These pipes are prone to leaks and breaks. Therefore, the District has been systematically replacing these lines. They are also inadequately sized to provide sufficient fire flows.

The District has made substantial investments in recent years in replacing and adding pipelines, to create a more reliable distribution network. The existing pump stations and reservoirs are considered in good condition, with many years of serviceable life remaining.

3.4 Growth

Demand projection estimates have been presented earlier in this report. They are based on the best available information provided by the District. The anticipated rate of growth for the District, at 0.25 percent per year, is a modest estimate that reflects recent trends.

SECTION 4

Alternatives Considered

The information presented in this section on alternatives drew upon the *Reconnaissance-Level Source Water Study* (Civil West Engineering Services, Inc., 2015a), the *Raw Water Alternatives Analysis – Addendum No. 1* to the reconnaissance report (Civil West Engineering Services, Inc., 2015b), the *Riverbank Infiltration Gallery Assessment Beaver Creek; Formation Sampling* (GSI Water Solutions, Inc., 2015), and the *Phase IV Conceptual Design Report for the Seal Rock Water District Beaver Creek Water Supply* (CH2M, 2016).

4.1 Source Water Alternatives

The *Reconnaissance-Level Source Water Study* describes the source water evaluation conducted in the early stages of this project. The following alternative sources were considered:

1. Henderson Creek
2. Thiel Creek
3. Hill Creek
4. Collins Creek
5. Beaver Creek
6. Small lakes in the area of Lost Lake
7. Drift Creek (tributary to Alsea River)

An early screening eliminated three of these alternatives from further analysis. Hill Creek and Collins Creek were eliminated because of insufficient stream flow, poor water quality, and limited access options. The group of small lakes near Lost Lake were eliminated because of insufficient water quantity and poor water quality.

The remaining four alternatives were evaluated using the following criteria:

- Water quality
- Supply sufficiency
- Resiliency/risk
- Environmental impacts
- Regulatory complexity
- Capital cost
- Operations and maintenance cost

After closer examination, it was determined that Henderson Creek, Thiel Creek, and Drift Creek would not reliably provide the necessary quantity of water during the summer months. Beaver Creek has sufficient flows to meet the current and future year-round demands of the District. Furthermore, Beaver Creek scored equally as well as any of the other three options in the categories of having no specific source water quality concerns, of minimizing manmade risks and providing a resilient supply, of minimizing environmental impacts, and having options for addressing any regulatory issues. These conclusions were based on detailed analyses of each of the supply alternatives, as described in Appendix C of the reconnaissance study.

4.2 Intake Location and Type Alternatives

Once Beaver Creek was selected as the water source, the District proceeded with developing and filing for a water rights permit. The District filed a water rights permit application with OWRD in August 2015. The Department issued a proposed final order in June 2016 and no protests were received during the protest period which ended in August 2016. The permit was subsequently issued with a priority date of August 26, 2015.

The point of diversion listed in the permit is by the South Beaver Creek Road Bridge, which is just downstream of the confluence of South Beaver Creek with the main stem of Beaver Creek. South Beaver Creek provides approximately one-third of the overall Beaver Creek flow and therefore, it was necessary to locate the diversion downstream of the confluence to obtain sufficient year-round water quantity.

The *Riverbank Infiltration Gallery Assessment Beaver Creek; Formation Sampling* examined options for a subsurface withdrawal system, using a shallow riverbank well or an infiltration gallery. This study examined three potential locations, one at the bridge and another two 1,000-2,000 feet downstream of the bridge. The study concluded that the soil types were not conducive to a subsurface withdrawal system.

Based on the findings to date, the *Phase IV Conceptual Design Report for the Seal Rock Water District Beaver Creek Water Supply* study examined potential locations for a direct river withdrawal system and concluded that the only feasible option was at the bridge location, on the downstream left bank. The river depth and curvature are favorable for an intake at this location. Furthermore, it is the only location with land above the 100-year floodplain in close proximity. Land above the 100-year floodplain within 500 feet and ideally, within 100 feet of the intake pumps is needed for locating the electrical building with motor starters for the pumps. This site also offers convenient and reliable access from the existing county road. Other sites that were considered would have involved extensive road access construction through wetland areas and the supporting electrical buildings would need to have been located more than 500 feet away from the pumps.

As described in the Phase IV report, the intake withdrawal structure design is constrained by the need to comply with fish protection requirements and a need to minimize impacts to a popular recreational creek. The preliminary design alternatives were examined against the following criteria and regulatory requirements:

- Minimize visual and noise impacts for recreational users of Beaver Creek
- Provide a facility with maximum seismic/tsunami resiliency
- Minimize maintenance, particularly in-water maintenance activities
- Maximize operator and public safety
- Comply with the water rights permit conditions of the OWRD, including the monitoring requirements of the Oregon Department of Environmental Quality included in the permit
- Comply with the fish protection and other design criteria of the Oregon Drinking Water Services section of the Oregon Health Authority
- Comply with the fish protection and other design criteria of the Oregon Department of Fish and Wildlife and the National Marine Fisheries Service

It uses a slant wedge-wire fish screen set parallel to the creek flow. The portion of the structure extending into the creek will be subsurface, with the screen face only visible during low flows. This minimizes visual impacts for kayakers and canoeists using the creek. The intake pumps are to be submersible type, minimizing visual and noise impacts. It is expected that the final design will be developed in accordance with these concepts.

4.3 Treatment Plant Site Alternatives

The *Phase IV Conceptual Design Report for the Seal Rock Water District Beaver Creek Water Supply* study evaluated three treatment plant site alternatives. The three alternatives had previously been identified by the District based on their proximity to Beaver Creek, of having relatively flat ground of sufficient size, of having an elevation above the tsunami inundation zone, and of being available for purchase or already owned by the District.

The three properties were designated as the south, north, and Makai sites. The south site is located south of the proposed intake site along South Beaver Creek Road. The north site is located northwest of the intersection of Beaver Creek and South Beaver Creek Roads. The Makai site is already owned by the District and is the site of the abandoned Makai storage tank.

A strengths-weaknesses-opportunities-threats (SWOT) process was used to compare the three alternative sites. The SWOT analysis was applied to the plant site itself, to the needed access road to the site, and for the necessary raw and finished water pipelines for each alternative. Based on this process and conceptual level costs, the Makai site was the selected alternative. The SWOT analysis summary table is included in Appendix D.

4.4 Raw Water Pipeline Alternatives

For much of the raw water pipeline alignment, the only feasible alternative is to locate the pipeline in or alongside of South and North Beaver Creek Roads. Other alignments would involve wetland impacts, are located on privately held property, and/or would result in a longer pipeline.

South Beaver Creek and North Beaver Creek Roads are Lincoln County roads. The placement of the pipeline along the roads, whether in the shoulder or under the fog line or under a traffic lane, will depend on limitations set by the county, and these limitations are not yet known. The placement is important because of two reasons. One is that for portions of the alignment, there are wetlands on both sides of the road. It will be advantageous in these sections to keep the pipe trench to a minimum depth and to include trench cutoff walls periodically to avoid creating a French drain. The second factor is that the placement of the pipe in the roadway may dictate the extent of pavement replacement that is necessary. If the pipe can be placed in the shoulder, it may be possible to avoid pavement damage and replacement. If the pipe is under the fog line or a traffic lane, it will probably be necessary to replace the pavement to the center line, as required by Oregon Department of Transportation for their roads.

Although the overall alignment is to follow the existing county roads, alternative alignments and alternative construction approaches were examined for two sections of the raw water line. The proposed intake location on the southwest corner of the bridge requires that the raw water pipeline cross Beaver Creek from the south to the north. Two alternatives were considered for this crossing. One was to hang the pipeline on the underside of the county bridge. The second alternative was to use a bored approach to install the pipeline under the creek. The installation on the bridge would be less expensive than a bored approach but the pipeline would more vulnerable to flood impacts and vandalism. Additionally, Lincoln County was contacted about the possibility of mounting the pipeline on the county-owned bridge and they had objections to this approach. Therefore, as described in the Phase IV study, the proposed approach is to install the pipeline across the creek using horizontal directional drilling.

The second section of the raw water pipeline that presented alternatives was for the westerly end. As shown in the Phase IV study, the proposed approach is to turn north from Beaver Creek Road and cross private properties to the Makai treatment plant site. This is contingent on obtaining easements through private property. The alternative would be for the pipeline to continue on Beaver Creek Road to Highway 101, turn north on Highway 101, and then return to the east to the Makai site through the residential neighborhood accessed on NW Estate Drive. This alternative would keep the pipeline in public right of way but would add significantly to the length. Since the proposed pipeline material is high density polyethylene with fused joints, there will be almost no maintenance and the maintenance benefits gained by keeping it within public right of way are very minimal. Therefore, as a cost-saving measure and as an approach to reduce construction within the 100-year floodplain, the proposed approach is to turn north and uphill from Beaver Creek Road and cross private property. The final route selection through the private property is dependent on obtaining an easement agreement with the property owner.

In addition to the route selection, alternatives for where to place the pipeline relative to the roads were considered. In some locations, it may be possible to position the pipeline underneath the shoulder gravel so that pavement is not damaged. However, the final decision on placement depends on limitations placed by Lincoln County and the need to avoid buried power lines.

4.5 Treatment Process Alternatives

The treatment process selection is described in the Phase IV report. In addition to the information presented in that report, CH2M HILL Engineers, Inc. (CH2M) has been performing bench-scale treatability testing for the Beaver Creek source to refine and confirm the preliminary treatment process selection.

The core of the proposed process is the use of low-pressure fiber membranes. These are commonly used for drinking water treatment, and offer the advantage of minimizing the need for operator intervention to produce a reliably safe drinking water, as compared to the more involved control needed for a media filtration/coagulation treatment process. The reliability of membrane filtration treatment address one of the District's overall goals for achieving a reliable water supply. Additionally, the technical background needed to operate a membrane filtration plant is more in line with the District's current staff expertise than would be a chemical-coagulation filtration system.

The proposed treatment system will use a low dose of sodium permanganate, 0.1-0.2 mg/L, to oxidize naturally occurring iron so that it can be filtered in the membranes. It will use a small dose of aluminum chlorohydrate, 4.0-8.0 mg/L, to remove dissolved organic carbon that contributes to the formation of disinfection by-products. These are common water treatment approaches. It is unknown at this stage whether a corrosion control chemical will need to be added to the finished water. Space will be provided in the treatment building to accommodate the future addition of a system.

The plan is for the District to prepurchase the membrane system equipment prior to final design because different membrane vendors provide equipment packages that vary in layout and chemical cleaning systems. This is the most common approach for design of treatment plants using this type of equipment.

4.6 Treatment Plant Backwash Waste Disposal Alternatives

Approximately 6 percent of the pumped raw water flow to the treatment plant will be used for backwashing the membrane filters. Two options were considered for handling this waste flow. One was to install pumping and treatment systems to allow much of this flow to be recycled through the plant to be recovered as finished water. The other was to discharge this waste flow to Beaver Creek. Recycle is not recommended because it requires substantial cost for a relatively small gain in finished water plant capacity and because it adds significantly to the complexity of the system.

Based on discussions with Oregon Department of Environmental Quality, the waste flow from the backwash ponds must be piped to a discharge into Beaver Creek. It cannot be disposed of into the natural drainage near the plant property even though this drainage leads to Beaver Creek.

4.7 Treatment Plant Clearwell Tank Alternatives

A treatment plant clearwell is a necessary project component as described in the Phase IV report. Several alternatives were considered for the clearwell tank, including the tank material selection, the tank(s) dimension, the storage volume, and the number of tanks. These factors are interrelated.

If possible, it is desirable to position the tank on the property and to select the tank height such that water flow from the tank into the system could be by gravity, thus eliminating the need for a finished water pump station. Based on the system hydraulic schematic, it appears this is possible provided the tank operates with a normal low water level of approximately 240 feet elevation. The southern half of the treatment plant property will have an approximate finished grade of 222 feet, and this would allow the use of tank of typical height to provide a normal low water level of 240 feet.

Two primary options exist for tank material for potable water storage. One is the use of concrete and the second is the use of steel. Steel tanks can either be welded steel or bolted steel. If the tank is constructed of either concrete or glass-lined, bolted steel, a single tank can be used because there is virtually no requirement for removing the tank from service for maintenance. However, for a painted, welded steel tank, it is necessary to remove it from service for 6-8 weeks every 20-30 years for repainting. The District could not reliably obtain water from Newport or Toledo for this length of time, especially 20 years into the future when Newport's own needs for water will have grown and the Toledo transmission pipeline will have further deteriorated. Therefore, the use of painted welded steel drives the need for two tanks, if not initially, at some point in the future.

Even though the District current has a glass-lined, bolted steel tank, and it has performed acceptably to date, CH2M does not recommend this alternative because of reported problems.[3] It is not a proven, long-term solution. Concrete is a viable alternative but it has a significantly higher first cost than painted, welded steel for tanks of the size being considered. The proposed alternative is to install a 500,000-gallon painted, welded steel tank as part of the initial project, and to leave room for the addition of a second, smaller tank in the future before repainting of the first tank is required.

4.8 Electrical Service and Backup Power Alternatives

In keeping with the desire for a reliable and resilient water supply, alternatives were considered for providing backup electrical power for both the intake and treatment plant equipment. There was a strong desire to minimize the footprint of facilities at the intake because of the limited land availability above the 100-year floodplain and in accordance with the property owner's desire to limit the amount of property allocated to the District. In addition, the use of a backup generator at the site would add to the visual and noise impacts on recreational users and would add significantly the project cost for housing this equipment inside of a building to protect it against vandalism. Therefore, the decision was to have the District obtain a trailer-mounted backup generator that could be moved to the intake when needed.

The treatment plant site is appropriate for a permanent backup generator. It is an isolated site where the regular operation of a generator for maintenance and testing will have no noise impacts on neighbors or recreational users. There is sufficient property and it will be enclosed in a fenced area.

The use of solar panels mounted on the treatment plant building roof was evaluated during preparation of this Preliminary Engineering Report (PER) as a means to reducing imported energy needs. The center roof line of the membrane building is currently aligned on a north-south axis, meaning the two halves of the roof face east and west. The option of installing a 1-kilowatt (kW) system on either the east or west

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[3] The following Oregon communities have experienced construction or long-term problems with glass-lined, bolted steel tanks: Harrisburg, Eugene Water & Electric Board, and Bend.

side of the roof was evaluated, and to consider the possible benefit of rotating the building, the power generation potential for a south facing solar panel system was also evaluated.

To conduct the analyses, it was assumed that the trees that currently shade the property would be removed during construction and the cost of installation would be approximately $3.00 per Watt of capacity. A 1-kW system would therefore cost about $3,000. Based on weather conditions for this location and using an electricity value of $0.08 per kilowatt-hour, the annual cost offset provided by a solar panel array would be approximately $100. At these values, the installation would not provide a positive return on investment for approximately 30 years, which is equal to or even beyond the expected useful life of the equipment. It may be possible for this program to qualify for an incentive of $500 from the Central Lincoln People's Utility District for a 1-kW installed facility, but this would only marginally shorten the time to a positive return on investment. Therefore, a solar collection system is not included with the project.

4.9 Project Delivery Alternatives

As described in the Phase IV report, two alternative project delivery options were considered for the project, conventional design-bid-build and construction manager-general contractor (CM-GC). The CM-GC process is thought to offer some advantages for this project. However, the District is considering obtaining part of the financing for the project from the U.S. Department of Agriculture Rural Development program, and according to information provided by representatives of the program, they will not fund water infrastructure projects using the CM-GC process. Therefore, the planned project delivery approach is to use the conventional design-bid-build process.

Selection of Alternative

5.1 Summary of Selected Alternatives

As in the previous section, the information presented in this section on the selection of alternatives drew upon the *Reconnaissance-Level Source Water Study* (Civil West Engineering Services, Inc., 2015a), the *Raw Water Alternatives Analysis – Addendum No. 1* to the reconnaissance report (Civil West Engineering Services, Inc., 2015b), the *Riverbank Infiltration Gallery Assessment Beaver Creek; Formation Sampling* (GSI Water Solutions, Inc., 2015), and the *Phase IV Conceptual Design Report for the Seal Rock Water District Beaver Creek Water Supply* (CH2M, 2016).

The following alternatives were selected for the project:

- Source water: Beaver Creek
- Withdrawal location: southwest quadrant of the Beaver Creek Bridge
- Intake type: active, slanted screen, using submersible pumps and mostly buried structure
- Treatment plant site: Makai site
- Raw water pipeline alignment: along South Beaver Creek and North Beaver Creek Roads, using horizontal direction drilling to cross Beaver Creek, and turning north from the road through private property to the plant site
- Treatment process: membrane filtration using oxidation by sodium permanganate and coagulation using aluminum chlorohydrate
- Treatment plant backwash disposal: discharge to Beaver Creek
- Treatment plant clearwell: 500,000 gallon welded steel tank, with room allowed for future addition of second tank
- Backup power for intake: trailer-mounted backup generator
- Backup power for treatment plant: permanent generator

5.2 Life Cycle Cost Analysis

A benefit-cost analysis for the proposed Beaver Creek supply project was recently prepared by Antares Planning Group, LLC. The resulting memo, *Potable Water System Upgrade, Seal Rock Water District, Oregon, Technical Memorandum on Benefit-Cost Analysis*, is attached as Appendix C. The evaluation concluded that the proposed project provides a favorable benefit to cost ratio of 1.85.

5.3 Nonmonetary Factors

As presented in the preceding chapter of this report, both monetary and nonmonetary factors were considered in selecting project alternatives. The evaluation of alternative water sources was based on several nonmonetary criteria. The SWOT analysis for alternative properties for the treatment plant lists nonmonetary factors considered in the selection process. The intake location and type considered both monetary and nonmonetary factors. The treatment process selection considered both monetary and nonmonetary factors.

Proposed Project

6.1 Preliminary Project Design

The preliminary project design is described in the following design drawings provided in Appendix E:

1. Overall project map
2. Process flow schematic
3. Intake civil site plan
4. Intake withdrawal facility
5. Intake electrical building floor plan
6. Water treatment plant site plan
7. Water treatment building floor plan

These drawings present preliminary design concepts, only, and will be modified as the design is prepared. The design will be subject to review and approval by the Oregon Health Authority Drinking Water Services program.

In addition to the drawings, renderings of the possible appearance of the intake withdrawal facility, showing cut-away views, and showing the completed facility as times passes, are included in the appendix.

6.1.1 Water Supply

The water supply will be obtained from a direct surface, screened intake on Beaver Creek, located at approximately river mile 2.1, just downstream of the South Beaver Creek Road Bridge. The withdrawal facility is positioned on the southwest quadrant of the bridge crossing to take advantage of more stable ground and a nearby location for the electrical building that will be above the 100-year floodplain.

Beaver Creek is a high-value recreational stream, attracting many kayakers and canoeists. In recognition of this recreational use, the preliminary design of the withdrawal facility has a minimal visual impact. The potential for noise pollution is minimized by using submersible pumps.

Three pumps are planned for the intake, each sized at 50 percent of the maximum withdrawal rate of 2.0 cfs (1.29 mgd). This provides redundancy.

6.1.2 Raw Water Pipeline

The raw water pipeline will follow the alignment of South Beaver Creek Road to the intersection with North Beaver Creek Road. It will then follow North Beaver Creek Road to the west until it turns north through private property to the plant site. The planned size and material is 14-inch nominal DR 9 high-density polyethylene (HDPE).

The section of the raw water line along South Beaver Creek Road, from south of the bridge to approximately 500 feet north of the bridge, will be installed using horizontal directional drilling.

6.1.3 Treatment

A possible mechanical floorplan for the treatment building is provided with the drawings in Appendix E. This sample layout is based on one membrane supplier’s equipment package; the layout will change depending on the selected membrane treatment equipment. The selection of the membrane filtration equipment will be limited to those vendors that are listed by the Oregon Health Authority Drinking Water Services program as meeting the target microbial removal rates. These vendors are the following:

- Tonka Water (Dow) Memcor membranes
- GE Zenon
- BASF Multibore membranes
- Pall Corporation
- Scinor Water America
- Seccua Corporation
- Evoqua Water Technologies, Toray membranes
- WesTech Engineering, Inc.

6.1.4 Storage

The painted, welded steel tank will be designed and specified in accordance with American Water Works Association Standard D-103. Only paint approved by NSF for use in contact with potable water (NSF Standard 61) will be allowed for the interior of the tank. The tank will be positioned on the south half of the plant property, with a floor elevation of approximately 222 feet. The proposed dimensions for the 500,000-gallon tank will be a diameter of 50 feet and an overflow elevation of 256 feet, with a normal low water level of approximately 240 feet.

The location and dimensions will enable it to provide gravity service to the District's service area, as the 240-foot hydraulic grade line matches the hydraulic grade line in the system. The one exception is for filling the Lost Creek Storage Tank. This reservoir has an overflow elevation of 301 feet. It is filled directly by the Toledo Pump Station through the Toledo transmission line. Water from this tank currently passes through a pressure reducing valve before being introduced into the system. The proposed Beaver Creek system clearwell will be at a slightly lower elevation, with an overflow elevation of approximately 256 feet compared the Lost Creek Storage Tank overflow elevation of 301 feet. This difference in head of 45 feet will be provided by the proposed new Lost Creek Booster Pump Station, installed in parallel to the existing pressure reducing valve.

6.1.5 Finished Water Pipeline

The proposed finished water pipeline is a 12-inch ductile iron line that will be trenched in the existing gravel access road to the plant site. It will connect to the District's existing 12-inch ductile iron pipeline on NW Kona Street.

6.2 Project Schedule

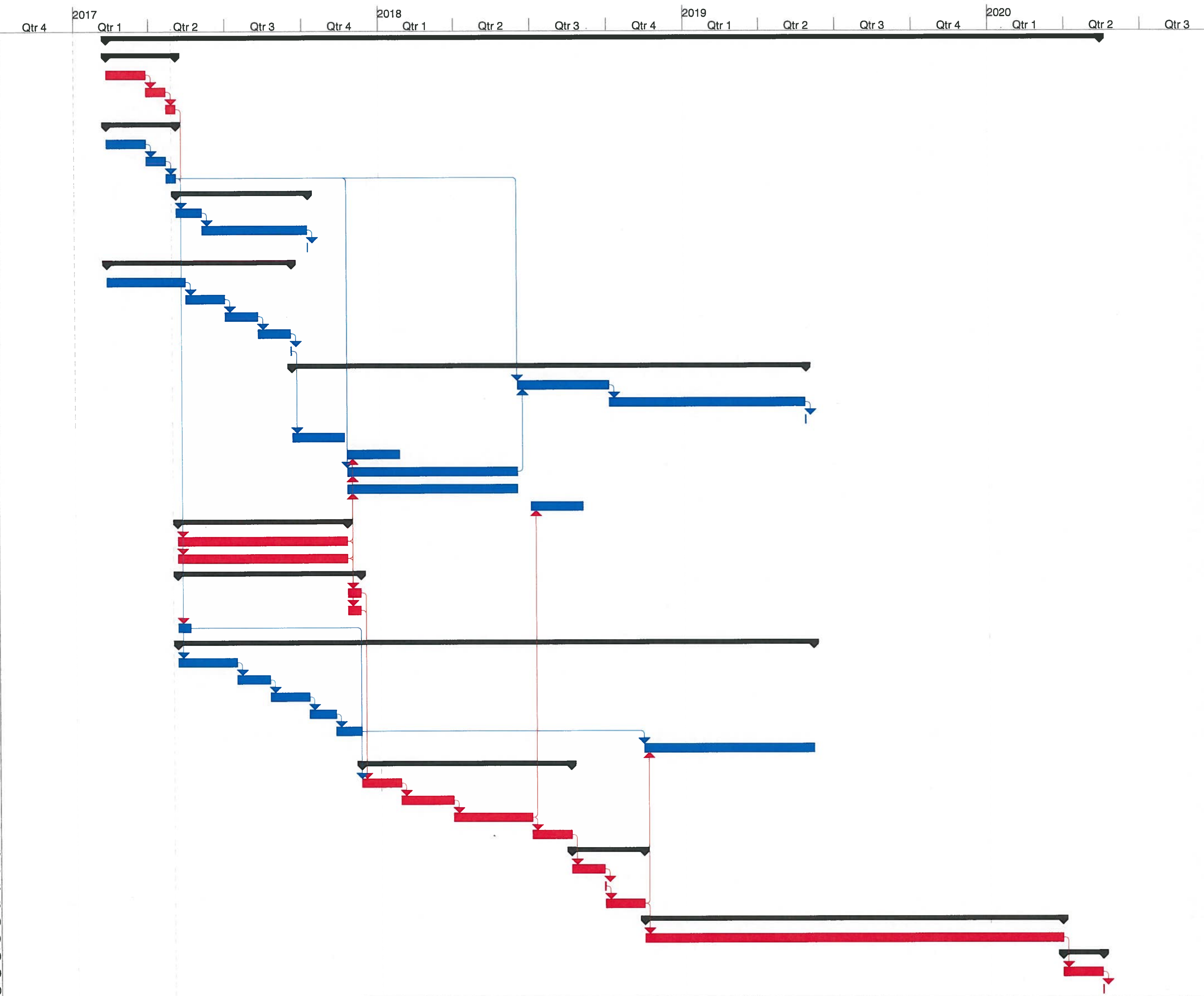
The preliminary project schedule is provided in Figure 8. Adherence to this schedule primarily depends on easement acquisitions.

6.3 Permit Requirements

The permitting requirements for the project are discussed in the companion Environmental Report. The permitting requirements are expected to include the following:

- Facilities to comply with OWRD requirements for water quantity and quality monitoring (with Oregon Department of Environmental Quality nexus)
- Oregon Division of State Lands and U.S. Army Corps of Engineers Joint 404 permit
- Oregon Department of Environmental Quality general permit for backwash discharge
- Plan review and approval by the Oregon Health Authority Drinking Water Services program
- Building permit from Lincoln County

ID	Task Name	Duration	Start	Finish
1	**Beaver Creek Water Supply Development**	**1063 days**	**Thu 2/9/17**	**Thu 5/14/20**
2	**Preliminary Engineering Report**	**74 days**	**Thu 2/9/17**	**Tue 5/2/17**
3	Submit draft of PER	42 days	Thu 2/9/17	Tue 3/28/17
4	Receive review comments from District	22 days	Tue 3/28/17	Fri 4/21/17
5	Final PER to submit to USDA	10 days	Fri 4/21/17	Tue 5/2/17
6	**Environmental Report**	**74 days**	**Thu 2/9/17**	**Tue 5/2/17**
7	Submit draft of ER	42 days	Thu 2/9/17	Tue 3/28/17
8	Receive review comments from District	22 days	Tue 3/28/17	Fri 4/21/17
9	Final ER to submit to USDA	10 days	Fri 4/21/17	Tue 5/2/17
10	**Obtain project funding**	**141 days**	**Wed 5/3/17**	**Sat 10/7/17**
11	Funding application	28 days	Wed 5/3/17	Fri 6/2/17
12	Notice of funding award	112 days	Sat 6/3/17	Fri 10/6/17
13	Funds available	1 day	Fri 10/6/17	Sat 10/7/17
14	**Raw Water Line Easement**	**197 days**	**Thu 2/9/17**	**Sun 9/17/17**
15	Visit with owner, prelim route	84 days	Thu 2/9/17	Sun 5/14/17
16	Survey proposed route, submit files	42 days	Sun 5/14/17	Thu 6/29/17
17	Preliminary design sufficient for preparing eas	35 days	Fri 6/30/17	Tue 8/8/17
18	Surveyor and attorney prepare document	35 days	Tue 8/8/17	Sat 9/16/17
19	Obtain final easement	1 day	Sat 9/16/17	Sun 9/17/17
20	**Permitting**	**550 days**	**Mon 9/18/17**	**Sun 5/26/19**
21	Prepare 404 permit application	98 days	Thu 6/14/18	Tue 10/2/18
22	Agency review of 404 permit	210 days	Tue 10/2/18	Sat 5/25/19
23	Receive 404 permit	1 day	Sat 5/25/19	Sun 5/26/19
24	Submit Lincoln Cty permit for pipeline	56 days	Mon 9/18/17	Sun 11/19/17
25	County building permit submission	56 days	Wed 11/22/17	Wed 1/24/18
26	County zoning for intake	182 days	Wed 11/22/17	Thu 6/14/18
27	County zoning - plant property addition	182 days	Wed 11/22/17	Thu 6/14/18
28	Obtain state drinking water plan approval	56 days	Sat 6/30/18	Fri 8/31/18
29	**Land purchases**	**182 days**	**Wed 5/3/17**	**Wed 11/22/17**
30	Obtain intake land easement	182 days	Wed 5/3/17	Wed 11/22/17
31	Purchase water plant land addition	182 days	Wed 5/3/17	Wed 11/22/17
32	**Surveying**	**196 days**	**Wed 5/3/17**	**Fri 12/8/17**
33	Boundary survey for intake property	14 days	Wed 11/22/17	Fri 12/8/17
34	Boundary survey for plant property	14 days	Wed 11/22/17	Fri 12/8/17
35	Raw water line	14 days	Wed 5/3/17	Thu 5/18/17
36	**Membrane procurement**	**680 days**	**Wed 5/3/17**	**Mon 6/3/19**
37	Prepare document	63 days	Wed 5/3/17	Wed 7/12/17
38	Advertisement period	35 days	Wed 7/12/17	Sun 8/20/17
39	Award and contracting	42 days	Mon 8/21/17	Fri 10/6/17
40	First submittal	28 days	Fri 10/6/17	Tue 11/7/17
41	Final submittal	28 days	Tue 11/7/17	Fri 12/8/17
42	Equipment delivery	182 days	Mon 11/12/18	Mon 6/3/19
43	**Final design**	**224 days**	**Fri 12/8/17**	**Thu 8/16/18**
44	Geotechnical investigation	42 days	Fri 12/8/17	Wed 1/24/18
45	Preliminary design	56 days	Wed 1/24/18	Wed 3/28/18
46	Final design to 90%	84 days	Wed 3/28/18	Fri 6/29/18
47	Final design to 100%	42 days	Sat 6/30/18	Thu 8/16/18
48	**Construction bidding**	**78 days**	**Thu 8/16/18**	**Sun 11/11/18**
49	Advertisement period	35 days	Thu 8/16/18	Mon 9/24/18
50	Receive bids	1 day	Mon 9/24/18	Tue 9/25/18
51	Award and contracting	42 days	Tue 9/25/18	Sun 11/11/18
52	**Construction**	**448 days**	**Mon 11/12/18**	**Fri 3/27/20**
53	Construction	448 days	Mon 11/12/18	Fri 3/27/20
54	**Commissioning**	**43 days**	**Fri 3/27/20**	**Thu 5/14/20**
55	Commissioning	42 days	Fri 3/27/20	Wed 5/13/20
56	Full-time operation by District	1 day	Wed 5/13/20	Thu 5/14/20



Project: Seal RockPrelim Eng Rpt
Date: Fri 4/28/17

Task
Critical Task
Milestone
Summary
Rolled Up Task
Rolled Up Critical Task
Rolled Up Milestone
Rolled Up Progress
Split
External Tasks
Project Summary
Group By Summary
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Progress
Deadline

6.4 Sustainability Considerations

6.4.1 Water and Energy Efficiency

As unpeopled spaces, the intake electrical building and the membrane treatment building will generally be held at ambient temperatures. Each will be equipped with electric space heaters to provide acceptable work spaces during times of operation and maintenance activities. They will include ventilation louvers and fans to reduce the heat load from operating equipment during summer months.

6.4.2 Green Infrastructure

Very little irrigation is practiced in this area of the Oregon coast and there are no plans to include an irrigation system with the proposed project. There are no nearby opportunities to use the backwash waste for irrigation. Similarly, there are no opportunities to capture and use stormwater for beneficial use.

In CH2M's experience, water treatment plant buildings are not good candidate buildings for obtaining Leadership in Energy and Environmental Design (LEED) certification. Several of the LEED categories do not apply and 'extra' features, adding expense and environmental impacts, need to be added to score LEED points. However, despite not pursuing LEED certification, the building design and requirements for construction will include a number of sustainability features, as follow:

6.4.2.1 Site Development

- Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. Do so by creating and implementing an Erosion and Sedimentation Control Plan for all construction activities associated with project.
- Minimize parking capacity – reduce pollution and land development impacts from single occupancy vehicle use.
- Stormwater design –
  - Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, and managing stormwater runoff.
  - Reduce or eliminate water pollution by reducing impervious cover, increasing onsite infiltration, eliminating sources of contaminants, and removing pollutants from stormwater runoff
- Heat island effect – roof: use roofing materials with solar reflectance characteristics that allow reflectance of a maximum amount of solar energy
- Light pollution reduction – minimize light trespass from the building and site to reduce potential sky-glow and negative impacts on nighttime visibility and nocturnal environments.

6.4.3 Water Efficiency

- Water use reduction: Reduce potable water demand for plumbing fixtures by 20 percent over baseline of current code maximum flow rates through the use of high-efficiency fixtures.

6.4.3.1 Energy

- Design lighting and heating, ventilating, and air conditioning (HVAC) systems to use 10 percent less energy than code minimum baseline.
- Do not use CFC-based refrigerants in the building HVAC system.

6.4.3.2 Materials and Resources

- Provide an easily accessible area that serves the entire building and is dedicated to the collection and storage of nonhazardous materials for recycling, including paper, cardboard, glass, plastics, and metals.
- Implement a construction waste management plan to divert at least 75 percent of nonhazardous construction waste from going to landfill.
- Use building materials that use recycled content (10 percent over baseline of products that have no recycled content).
- Use building materials that use materials that are locally sourced to reduce transportation energy waste (10 percent over baseline of products that have are not locally sourced).
- Use minimum of 50 percent Forest Stewardship Council certified wood products.

6.4.3.3 Indoor Environmental Quality

- Design ventilation system to meet or exceed minimum outdoor air ventilation rates require by ASHRAE 62.1-2004 to contribute to occupant well-being.
- Reduce the quantity of indoor air contaminants that are odorous, irritating and or harmful to the well-being of the building occupants by using low emitting products. This would include low volatile organic chemicals content for adhesives, sealants, paints, and coatings, as well as using composite wood products with no added urea-formaldehyde resins.
- Provide daylight and views for occupied areas of building (office).

6.4.4 Solar Power

The use of solar panels mounted on the treatment plant building roof was evaluated during preparation of this PER as a means to reducing imported energy needs. The center roof line of the membrane building is currently aligned on a north-south axis, meaning the two halves of the roof face east and west. The option of installing a 1-kW system on either the east or west side of the roof was evaluated and it was found that the solar production benefit-cost ratio was insufficient to justify the expense. Solar collectors are not planned for the project.

6.5 Total Project Cost Estimate (Engineer’s Opinion of Probable Cost)

The engineer’s opinion of probable capital cost is provided in Table 6-1. The total estimate is approximately $12,700,000. This includes construction, land easements, engineering, construction program management, and construction contingency.

Table 6-1. Capital Cost Estimate

Item	Quantity	Units	Unit Cost	Line Total	Discussion
Intake (river structure and electrical building about 80 feet away)					
River intake structure	20	cy	$2,000	$40,000	
Coffer dam	1	ea	$50,000	$50,000	Allowance, based on Kernville infiltration gallery work
Wedge wire screen	8	sf	$750	$6,000	Stainless steel, specialized
Pumps and motors	3	ea	$60,000	$180,000	Installed cost. Based on discussion with manufacturer: Flygt NP3202SH-273 with FM rating and shielded cable, each at $45k + 2K for guide rail
Electrical - variable frequency drives for pumps	3	ea	$30,000	$90,000	Estimate by supplier
Raw water line to road	150	ft	$210	$31,500	14" nominal HDPE (from intake structure to start of HDD pipeline)
Air compressor, air lines	1	ea	$35,000	$35,000	Based on recent Kernville intake
Sodium permanganate metering pump and drum secondary containment	1	ea	$10,000	$10,000	Allowance
Water quality and river flow instrumentation	1	ea	$40,000	$40,000	Allowance for level indicator, conductivity probe, temperature upstream and downstream; streamflow gaging separate (installed beforehand at bridge by District)
Electrical installation	1	ea	$40,000	$40,000	Allowance
Electrical power supply	1	ea	$250,000	$250,000	Estimate provided by CPI for transmission extension
Building for electrical drives and blower	209	sf	$250	$52,250	Building 10'-8" x 18-8", 9' interior height, block material, with sound-absorbing interior
Retaining wall	35	ft	$200	$7,000	Maximum height 3'
Road and site improvements	1	ea	$10,000	$10,000	Allowance
Site restoration	1	ea	$10,000	$10,000	Allowance
Long-term easement	1	ac	$20,000	$20,000	Allowance as suggested by District
Raw water pipeline, 14" nominal HDPE					
Horizontal directional drilled installation under river	800	ft	$420	$336,000	Based on comparison with recent projects
Trenched line	7,300	ft	$210	$1,533,000	Shoulder, along existing S and then N Beaver Creek county road, then through private property
Easement purchase	1	ea	$20,000	$20,000	
Water treatment plant					
Pall membrane package	1	ea	$1,190,000	$1,190,000	Pall preliminary quote (provided June 3, 2016; other vendors expected to be similar)
General mechanical; installation of membrane equipment	1	ea	$120,000	$120,000	5 workers, 8 weeks = $120,000
Miscellaneous mechanical piping allowance	1	ea	$238,000	$238,000	20% of membrane equipment cost
Onsite hypochlorite system	1	ea	$100,000	$100,000	Based on $70k equipment quote from TMG, Inc., with allowance for installation
Coagulant system	1	ea	$50,000	$50,000	Feed pumps, valve arrangement; rough estimate based on recent Tualatin Valley WD facility
Building	4,108	sf	$228.72	$940,000	2016 RS Means office 1-story (reinforced concrete structure). Dimensions of approx. 52' x 79'.
Backup generator	1	ea	$130,000	$130,000	Installed cost for 250kW generator with a sound attenuated weatherproof enclosure and integral fuel tank with 48 hours of fuel

Table 6-1, continued. Capital Cost Estimate

Item	Quantity	Units	Unit Cost	Line Total	Discussion
Clearwell, welded steel, with typical ringwall foundation	500,000	gal	$1.40	$700,000	Quote provided by CBI tank contractors; approx. dimensions of 50' diameter by 36.5' sidewall height
Site improvements	1	acres	$20,000	$20,000	Allowance for gravel, misc. improvements
Retaining wall	130	feet	$150	$19,500	Along access road to south end of site
Site excavation (cut)	2,297	cy	$10	$23,000	
Site backfill (fill)	478	cy	$20	$9,560	
Export excess material	1,819	cy	$40	$73,000	Assumes disposal within 5 miles
Fence	600	ft	$41	$24,486	2016 RS Means 8' Aluminized Steel Fence
Yard piping					
Raw water, 14" HDPE	350	ft	$210	$73,500	
Finished water, 2" HDPE	250	ft	$40	$10,000	
Backwash waste, 3" HDPE	220	ft	$60	$13,200	
Filtrate, 8" ductile iron	190	ft	$120	$22,800	
Finished water, 12" ductile iron	260	ft	$180	$46,800	
Electrical power supply	1	ea	$56,000	$56,000	Preliminary estimate of cost to be paid by District to Central Lincoln PUD for extending 3-phase power to the Makai site
Electrical power buried conduit	1	ea	$50,000	$50,000	Allowance for buried conduit for new power feed from development to Makai site
Backwash basins					
Site Excavation (Cut)	625	cy	$10	$6,300	
Export Excess Material	625	cy	$40	$25,000	
Weir Gates	2	ea	$10,000	$20,000	
Concrete Liner	60	cy	$1,000	$60,000	
Concrete Walls & Footings	45	cy	$2,000	$90,000	
Backwash discharge outlet in river	1	ea	$10,000	$10,000	Allowance
Backwash discharge line	3,500	ft	$60	$210,000	3-inch line
Electrical	1	ea	$650,000	$650,000	15% of subtotal for plant
Instrumental and controls, SCADA	1	ea	$260,000	$260,000	6% of subtotal for plant
Finished water pipeline					
Trenched line, 12-inch	1,500	ft	$180	$270,000	Ductile iron, located along access road
Construction Summary					
Subtotal construction				$8,270,000	
Escalation, 2% per year				$170,000	To mid-point of construction, 12 months
Escalated subtotal construction				$8,440,000	
Contingency at 25%				$2,110,000	
Construction Estimate				**$10,600,000**	Class IV estimate; range of +50% to -30%
Engineering, Legal, and Administrative Services, Purchase of Land and Easements, Lost Creek Booster Pump Station					
Allowance for legal services, land purchase and access agreements, environmental mitigation, and addition of Lost Creek booster pump station				$640,000	As directed by District
Surveying				$10,000	Allowance for additional surveying to supplement work that has been done to date
Geotechnical site investigation				$50,000	Drilling of test holes. Observation for drilling and test pits. Lab tests. Interpretation of findings.
Permitting				$100,000	Joint DSL/USACE 404 permit application, county permits, other permits as described in Environmental Report
Membrane pre-purchase				$35,000	Pre-purchase process for membrane equipment
Design				$820,000	Engineering design to develop bid documents
Bid services				$25,000	
Services during construction				$400,000	Level and approach to construction observation not yet defined
Startup, support for first year of operations				$20,000	Allowance for technical support
Legal, engineering, land, Lost Creek pump station				**$2,100,000**	
			TOTAL PROJECT CAPITAL ESTIMATE	**$12,700,000**	

6.6 Annual Operating Budget

6.6.1 Income

The District's sources of revenue are water sales, proceeds from property tax revenue, fees, and miscellaneous revenues. The District has projected revenues at $2,371,900 for fiscal year 2017-2018. Table 6-2 provides the District's water rate schedule for 2017-2018.

Table 6-2. Domestic Inside District Rate Schedule for 2017-2018

Category	Cost
Base	$28.50
First 1000 gallons	$4.50 per 1,000 gallons
1,000 - 2,000 gallons	$5.40 per 1,000 gallons
2,000 - 3,000 gallons	$6.70 per 1,000 gallons
3,000 - 4,000 gallons	$7.75 per 1,000 gallons
4,000 - 5,000 gallons	$8.41 per 1,000 gallons
5,000 - 8,000 gallons	$9.36 per 1,000 gallons
8,000 - 14,000 gallons	$10.99 per 1,000 gallons
14,000 - 18,000 gallons	$13.73 per 1,000 gallons
18,000 - 21,000 gallons	$20.50 per 1,000 gallons
Greater than 21,000 gallons	$21.93 per 1,000 gallons

6.6.2 Annual Operation and Maintenance Costs

The estimated annual operating budget impact of the project is provided in Table 6-3. On an annualized basis, the operation and maintenance costs total $172,000.

Table 6-3. Annual Operation and Maintenance Cost Estimates

Category	Basis	Quantity	Units	Unit Cost	Line Item Total	Percent
Labor	Approximate additional labor	0.5	FTE	$80,000	$40,000	23%
Energy	Pumping from river to membranes and from membranes to clearwell	400,000	kWh	$0.08	$32,000	19%
Energy	Building systems, intake blower, controls, periodic membrane cleaning pumps	232,000	kWh	$0.08	$18,560	11%
Chemicals	Brine for hypochlorite generation, aluminum chlorohydrate (coagulant), membrane cleaning chemicals, bisulfite for dechlorination	1	Lump sum	$15,000	$15,000	9%
Maintenance	Allowance for annual equipment replacement, at 1% of capital cost	1%	Lump sum	$30,690	$30,700	18%
Membrane system maintenance	Contracted annual maintenance and optimization visit by membrane supplier	1	Lump sum	$4,000	$4,000	2%
Membrane replacement	Assume 10-year life, 108 membrane modules, $3,000 replacement cost each; annualized cost (sinking fund, n=10 years, i=0.50%)	1	Annualized	$32,000	$32,000	19%
				Total Annual O&M	**$172,000**	**100%**

6.6.3 Present Worth

Using the capital cost estimate and annual operation and maintenance cost estimates, the project present worth analysis was developed according to the methodology prescribed by USDA Rural Development. The net present value for the project was determined to be $7,220,000. The supporting values for deriving this number are shown in Table 6-4.

Table 6-4. Project Net Present Value

Item	Value	Description
n	20	year, Planning period
i	0.50%	Real discount rate (from OMB Circular A-94)
C	$12,700,000	Total capital cost estimate
O&M	$172,000	Annual O&M cost estimate
USPW (O&M)	$3,266,000	Present worth of annual O&M cost estimate
S	$9,525,000	Salvage value at end of planning period
SPPW (S)	$8,621,000	Present worth of salvage value
	$7,350,000	Net Present Value = C + USPW (O&M) - SPPW (S)

6.6.4 Debt Repayments

The tax levy in the General Fund represents the District’s permanent rate that can be used for operations. This rate equals $0.1259 per $1,000 of the assessed value of the District. The District’s General Obligation bond rate is projected to be $1.51 per $1,000 of assessed value. The Exempt Bond amount is $975,500 as the ad valorem property taxes to be certified for collection to pay bond indebtedness.

6.6.5 Debt Service Reserves

The District’s current debt service reserves include Revenue Bond reserves of $148,560, rainy day reserve funds of $46,680, depreciation fund reserves, which include Short-Lived Assets Replacement

Reserves (SLARRA), of $221,000, and system development charge reserves of $266,228. The total reserve fund amount projected for fiscal year 2017-2018 is $735,020.

6.6.6 Short-Lived Asset Reserve

Table 6-5 lists short-lived assets associated with the project. The conditions imposed by USDA Rural Development obligate the District to transfer $84,000 annually to short-lived assets replacement reserve account to fund replacement of assets with a 5- to 15-year lifespan.

Table 6-5. Short-Lived Assets

	Estimated Useful Life (years)			
Asset	**5**	**10**	**15**	**>15**
Intake Facility				
Intake pumps (3)				X
Intake pump variable frequency drives (3)				X
Intake wedge-wire screen (1)				X
Intake backflush blower (1)			X	
Sodium permanganate metering pump (1)		X		
Water quality and water level instruments (1 each)		X		
Water Treatment Plant				
Coagulant metering pumps (2)			X	
Coagulant storage tank (1)				X
Membrane feed tanks (3)				X
Membrane feed pumps (3)				X
Membrane feed pump variable frequency drives (3)				X
Membrane reverse filtration pumps (3)				X
Membrane reverse filtration variable frequency drives (3)				X
Membrane cartridges (108)		X		
Membrane chemical cleaning recirculation pumps (2)				X
Membrane air cleaning blower (2)			X	
Membrane actuated control valves (15)				X
Membrane valve actuators (15)				X
Bench-scale lab equipment	X			
Onsite hypochlorite generation equipment (2)				X
Hypochlorite metering pumps (2)			X	
Hypochlorite storage tank (1)				X
Backup generator				X
Clearwell tank (paint system, 1)				X
Flow meter for raw water (1)				X
Flow meter for finished water (1)				X

SECTION 7

Conclusions and Recommendations

The project is generally well-defined. The following items should be considered before and during final design:

- An Environmental Report has been prepared in coordination with this PER. The Environmental Report has identified environmental permitting needs for the project. Mitigation measures may be identified as the environmental permits are prepared and these should be factored into the design.
- To date, two rounds of treatability testing have been conducted on the Beaver Creek supply. Tests have been performed in CH2M's Corvallis Applied Science Lab, simulating the membrane filtration process, the use of sodium permanganate for pre-oxidation, and the use of aluminum chlorohydrate as the coagulant. The particular water quality concerns are elevated levels of iron and dissolved organics, the latter contributing to the formation of disinfection byproducts. At least one additional round of testing during a high organics loading period is recommended to confirm the proposed treatment process.
- The primary project uncertainties relate to property availability. The District is currently pursuing easements for the intake and raw water pipeline, and property purchase to add to the Makai water treatment plant site. These property issues are currently on the critical path for project implementation.
- Before commencing final design, the following activities need to be accomplished: additional surveying, a geotechnical field investigation, and prepurchase of the membrane equipment.

SECTION 8

References

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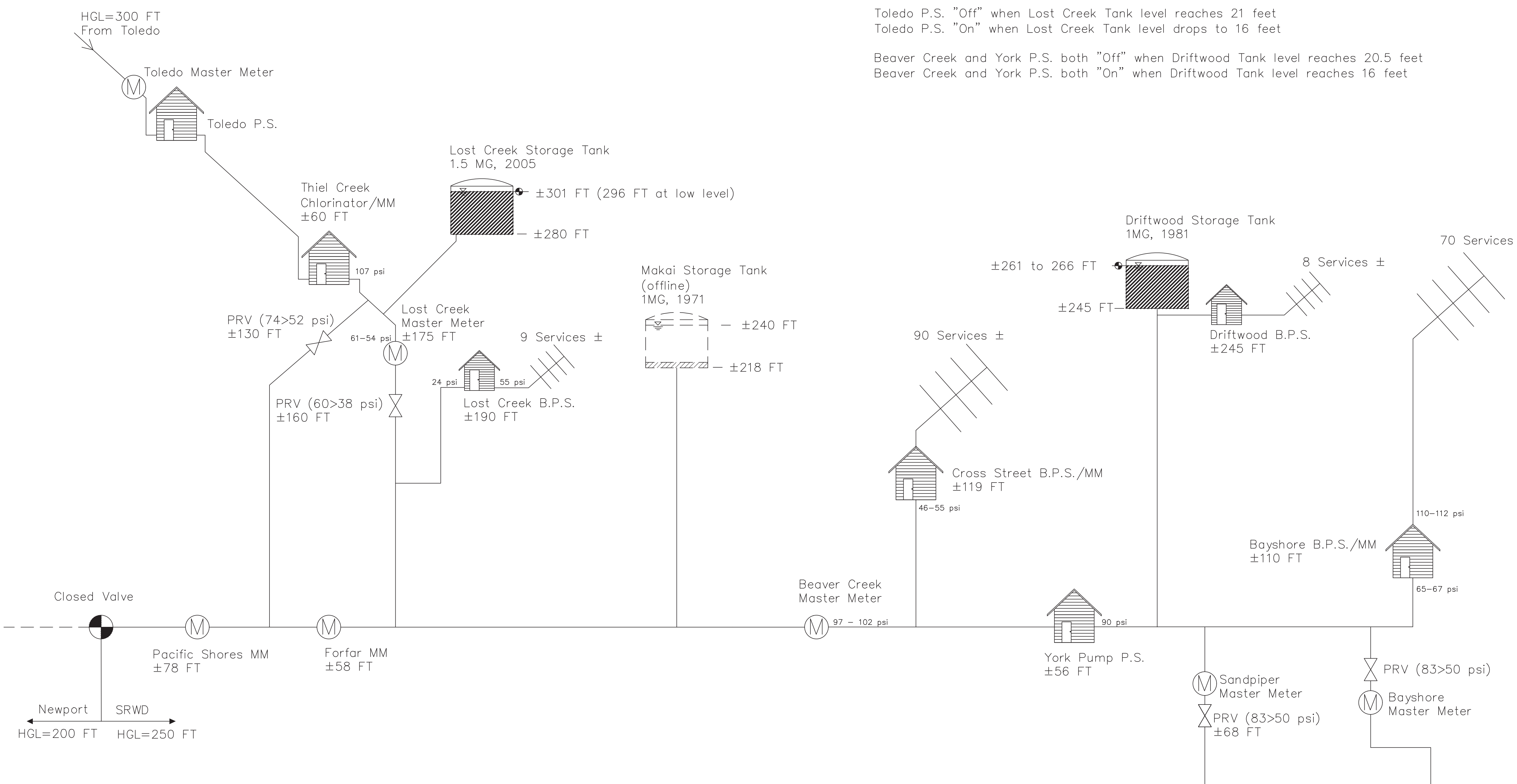
Goldfinger, C., Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutiérrez-Pastor, J., Eriksson, A.T., Gràcia, E., Dunhill, G., Enkin, R.J., Dallimore, A., and Vallier, T. 2012. T*urbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone*. U.S. Geological Survey Professional Paper 1661–F. 170 p. https://pubs.usgs.gov/pp/pp1661f/.

GSI Water Solutions, Inc. 2015. *Riverbank Infiltration Gallery Assessment Beaver Creek; Formation Sampling*. December 4.

Appendix A
Seal Rock Water District System Schematic



P.S. = Pump Station
B.P.S. = Booster Pump Station (with hydropneumatic tank)
MM = Master Meter
Vertical Datum = NAVD 88
HGL = Static Hydraulic Grade Line

Civil West Engineering Services, Inc.

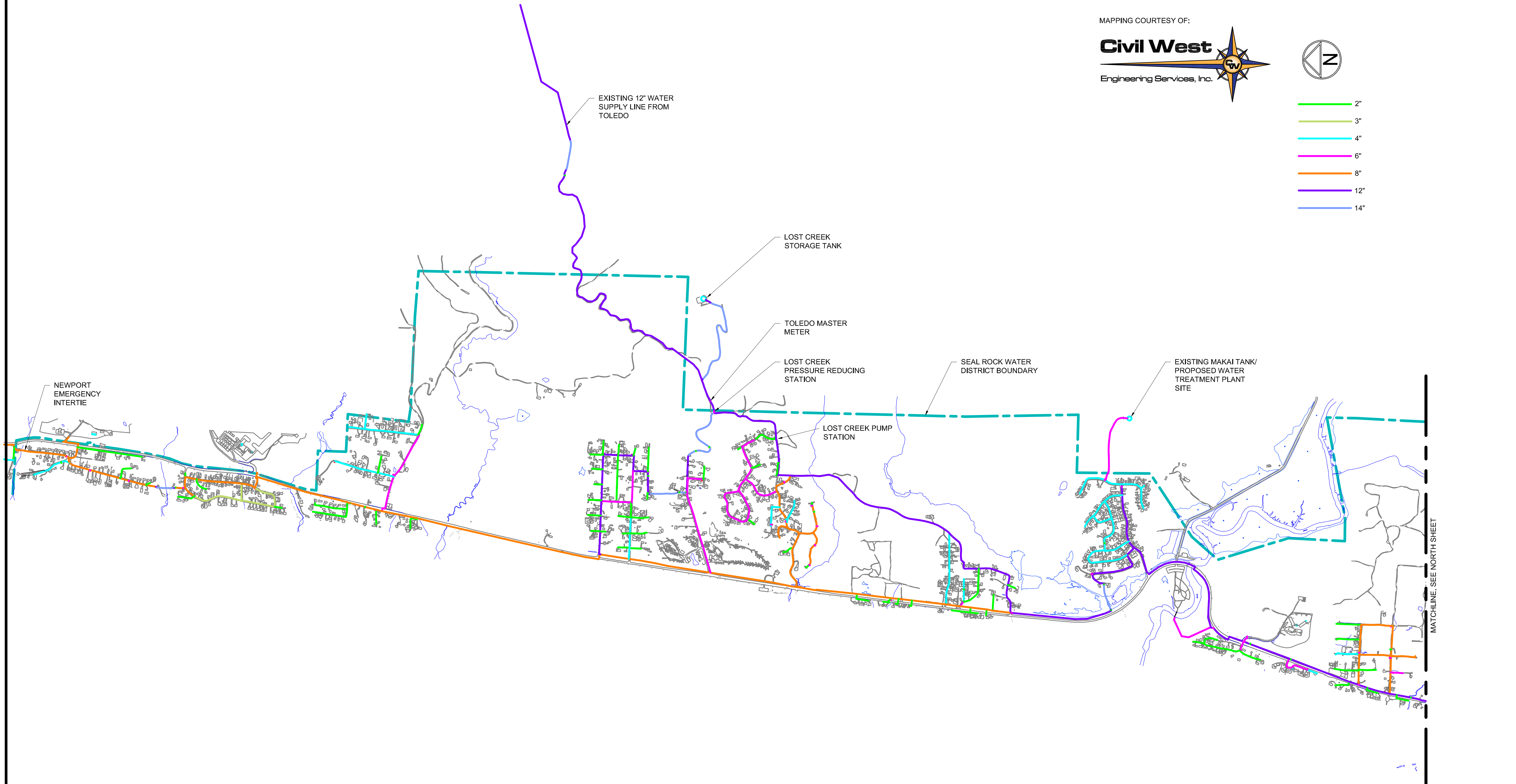
SEAL ROCK WATER DISTRICT
LINCOLN COUNTY, OREGON

WATER SYSTEM SCHEMATIC
WATER DISTRICT HYDRAULIC GRADIENT

0 1"
NTS
DRAWN BY: CMJ
DATE: FEBUARY 9, 2017

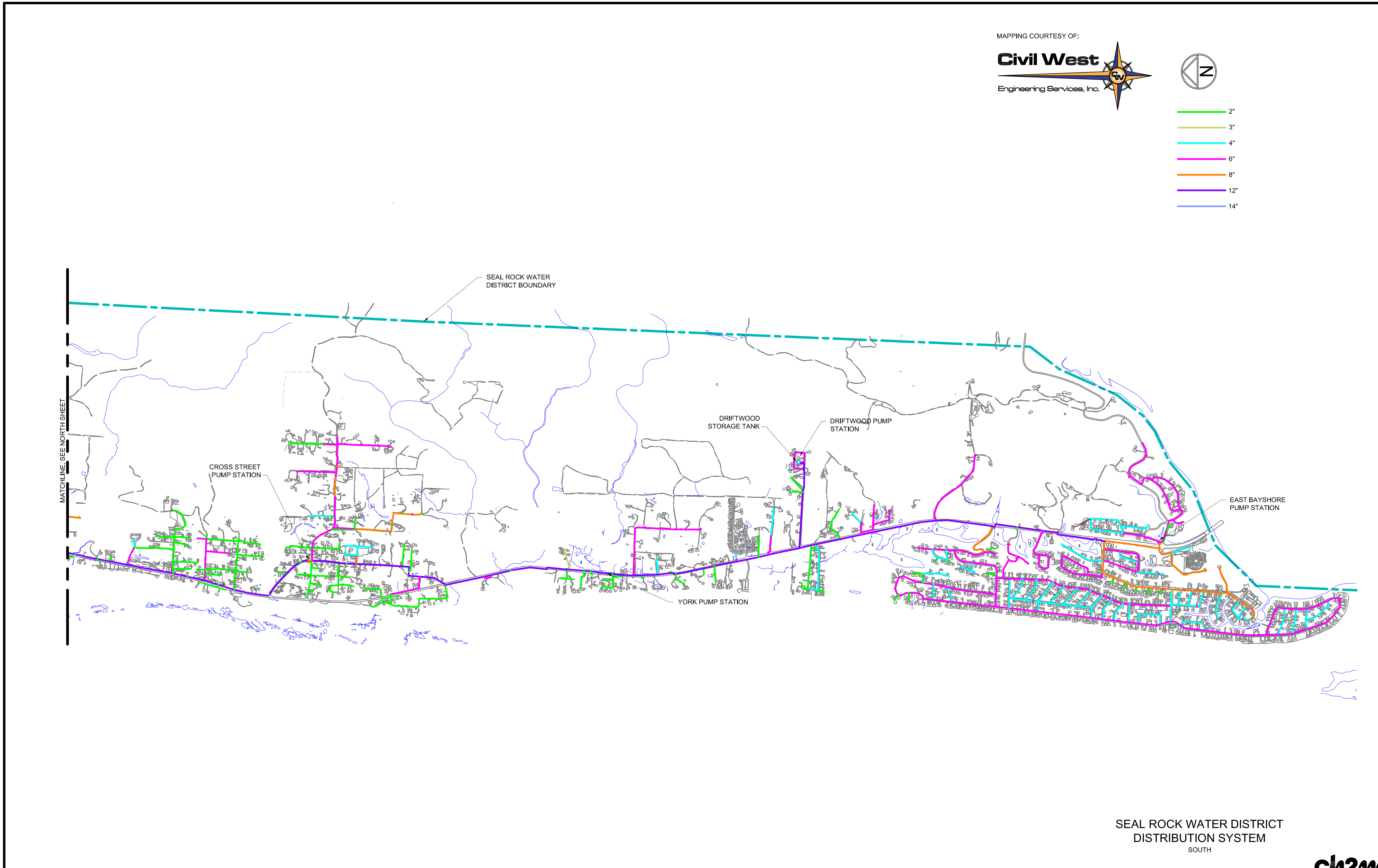
FIGURE
1

Appendix B
Seal Rock Water District Distribution System Maps



SEAL ROCK WATER DISTRICT
DISTRIBUTION SYSTEM
NORTH

ch2m



SEAL ROCK WATER DISTRICT
DISTRIBUTION SYSTEM
SOUTH

ch2m

Appendix C
Potable Water System Upgrade, Seal Rock Water District, Oregon, Technical Memorandum on Benefit-Cost Analysis

Potable Water System Upgrade
Seal Rock Water District, Oregon
Technical Memorandum on Benefit-Cost Analysis

Prepared by Antares Planning Group, LLC
Boulder, Colorado

1. Background

The Seal Rock Water District (SRWD) is located in Lincoln County, Oregon and serves a relatively long and narrow band of coastal land between the cities of Waldport and Newport. The District boundary extends from the north side of Alsea Bay at Waldport 11.5 miles northward to Henderson Creek near the Newport Municipal Airport. The current SRWD boundary encompasses 6,505 acres or 10.2 square miles.

The District has no water treatment facility of its own, so it purchases water from the City of Toledo, which is located slightly over ten miles to the northeast of the northern boundary of SRWD. The City of Toledo draws raw water from the Siletz River in the summer and from Mill Creek in the winter. After treatment at the Toledo WTP, water is transported to the SRWD through approximately 50,000 feet of 12-inch dedicated transmission piping.

The existing raw water intake, treatment plant, and transmission pipeline are old and highly vulnerable to the effects of natural hazards, especially soil movement and earthquakes. As discussed below and in the project application, a Cascadia M-8 or M-9 earthquake would result in severe damage to this system, with the result of very long-term loss of potable water service to SRWD's customers. The goal of this application is to fund a replacement for part of this system, combining the funding with other sources to complete the comprehensive replacement project. Note that although this HMGP project application requests grant funding for only a replacement transmission pipeline, this benefit-cost analysis uses the entire estimated project cost of $12.5M – this is because the transmission pipeline cannot function by itself as a mitigation solution. As such, the BCA includes both the benefits and the costs of the entire replacement system.

2. Mitigation Project Description

The HMGP project application includes extensive details about the proposed mitigation project, which is summarized here. The proposed project has three components:

1. New streamside raw water intake at Beaver Creek
2. New membrane water treatment plant
3. New 1.5-mile treated-water pipeline

As explained in the project application, while the existing treatment and transmission system functions effectively at present, it is highly vulnerable to earthquake risk, particularly from severe events such as the Cascadia M-9, which is now the basis of most seismic design for public infrastructure in the region. The proposed new system will be designed to withstand this event and those of lesser magnitudes. Although there has been no detailed seismic vulnerability study of the existing system, it was designed and constructed in the mid-1970s, when the potential for an M-9 event was not contemplated, and during which seismic design standards were minimal. Furthermore, it is worth noting that the existing pipeline crosses several areas where differential earth movement has caused a series of recent failures, clearly indicating the vulnerability of the system even under relatively minor stresses. Although these recent failures have not generally resulted in any long-term loss of function, it is clear that these problems will occur more frequently as the system continues to age.

3. Software and Methodology

This analysis was completed using the FEMA Benefit-Cost Analysis software, version 5.2.1. The analysis uses the damage-frequency methodology (expected damages). The sources and derivations of all figures used in the analysis are discussed in detail in the damage-specific subsections below.

4. Pre-Mitigation Risk

Although there is some risk of ongoing and repetitive physical damage to the existing system, the basis of this benefit-cost analysis is long-term loss of water service to the SRWD's customers due to earthquakes, with a focus on the Cascadia M-8 and M-9 events. The FEMA software calculates the value of lost water service based on three inputs and the default value of the service according to FEMA guidance. The inputs are:

a. Population served
b. Time of lost function (service restoration period)
c. Service value

a. Population Served

The population served by the SRWD varies significantly by season. The permanent resident population is estimated by the SRWD at approximately 5,000 (primarily South Beach; per SRWD) based on census data and local knowledge. Various sources (including the District's SCADA, which tracks water usage) indicate that summertime tourism increases the population very significantly, to an estimated 8,000. The BCA software requires a single population entry, so the average population is derived by assuming that the summer increase occurs in a period of three months, thus:

$$((5{,}000 * 9) + (8{,}000 * 3))/12 = (45{,}000 + 24{,}000)/12) = 69{,}000/12 = 5{,}750$$

Thus the average population served by the District is 5,750, and this figure is used in the analysis.

b. Time of Lost Function

The *2013 Oregon Resilience Plan* establishes estimated service restoration periods (time of lost function) for coastal water and sewer systems for a Cascadia M-9 earthquake. Under current conditions, the estimated restoration period is between one and three years (see Executive

Summary page XX, and text in Section 8 of the report). For the purpose of this analysis, the restoration time for an M-9 event is placed at the mid-point of this range, two years (730 days). Restoration time for an M-8 event is estimated as half this period, one year (365 days). Some damages to the system must be assumed in events of lesser magnitudes as well, so an earthquake with a return period of 100 years is assigned a restoration time of 30 days. As discussed in Subsection 6 below, an M-9 earthquake is estimated to have a return period of 308 years, and the M-8 event is estimated at 250 years.

c. Service Value

The FEMA BCA software assigns a fixed value of **$103.00 per capita per day** as the value potable water service. The basis of this figure is discussed at length in the *2011 Standard Economic Values* guidance, and is used verbatim in the present analysis.

5. Redundancy with the City of Newport Intertie

The Seal Rock Water District currently has an intertie with the City of Newport that provides a consistent source of potable water if SRWD experiences a water system loss of function. Although this arrangement does not provide nearly 100% normal capacity to SRWD customers, it is nevertheless effective at providing sufficient potable water and pressure for relatively short periods. However, like the existing SRWD system, the intertie has significant vulnerabilities to M-8+ earthquakes, and cannot be considered a reliable source of water following such an event (i.e. one that caused the SRWD system to fail). As such, the BCA does not include any reduction in system interruption.

6. Pre-Mitigation Frequency-Damage Inputs

Earthquake Return Periods

Return periods for M8.3+ and ~M9.0 earthquakes potentially affecting the SRWD are taken directly from the very recent state-of-the art paleoseisimic study by Goldfinger and others (2011 USGS Professional Paper 1661-F). The study documents at least 40 large magnitude earthquakes on the Cascadia Subduction Zone (CSZ) over the past ~10,000 years: 19-20 full or nearly full ruptures, four ruptures of the southern 50-70% of the margin, and 18-20 smaller southern margin ruptures. All of these events are very large magnitude earthquake ranging from M9.0 (up to M9.2) for the full or nearly full ruptures, to M8.5+ for the 50-70% ruptures, to about M8.3 for the southern margin only ruptures. The most active southern segments of the CSZ extend from Astoria, Oregon to northern California, and thus include the SRWD.

Using the mean age determination for the oldest paleoseismic event, 9,819 + 184 years, the mean return period for 40 or 42 M8.3+ earthquakes ranges from 245 years to 234 years. For this analysis the figure is rounded to 250 years. The probability of an M-9 event is determined via a statistical calculation, which is in turn based on estimated recurrence interval data provided by Dr. Chris Goldfinger, Director of the Active Tectonics and Seafloor Mapping Laboratory at Oregon State University. Table 1 provides the series of estimated probability-return period pairs for the CSZ M-9 event, which is shown in the yellow band. This BCA uses the mid-point of the he information provided by Dr. Goldfinger results in an estimated return period of 308 years for the event, as shown in the following table.

Table 1
Estimated Return Period for CSZ M-9 Event

Percent Chance in 50 Years	Return Period (Years)
2%	2475
5%	975
10%	475
12%	392
15%	308
18%	252
20%	225
30.50%	100

Note 1. There are several lines of evidence which strongly suggest that the above estimates are very conservative and may significantly underestimate the probability of a major CSZ earthquake and tsunami over the next 50 years:

- The 313 years that have passed since the last ~M9.0 event in 1700 already exceed the long-term average interval of less than 250 years for M8.3 or greater events.
- The average time interval for the last 5 ~M9.0 full rupture events before 1700 is only 350 years. Or, if the event in ~1504, which may be a less than full-rupture event, is excluded, the average time interval for the last four full rupture events is 435 years. The shortest interval between full rupture events over the past 2,000 years is only ~338 years, which is comparable to the 313 years since the 1700 event.
- More fundamentally, on active earthquake faults, like the Cascadia Subduction Zone, stress on the fault builds up continually, as the subducting ocean plates are pushed under the North American Plate. Stress builds up linearly with time and thus the longer the time interval since the last major earthquake, the greater the stress accumulation, and the higher the likelihood of the next major earthquake. In technical terms, the probability of a major earthquake on the CSZ is time-dependent, rather than being time-independent.

Given the above seismic history and considerations, the probabilities of M8.3+ and M9.0 earthquakes over the next 50 years is likely to be substantially higher than the long term averages (past 10,000 years) of about 20% and about 10%, respectively. Rather, the next 50-year probability for a M8.3+ earthquake is probably at least 30% and perhaps as high as 50%. The next 50-year probability for a M9.0 earthquake is probably at least 15% or perhaps higher.

Table 2 shows return interval and service restoration time inputs for the pre-mitigation frequency-damage table in the BCA software.

Table 2
***Pre*-Mitigation Frequency-Damage Table**

Event Return Interval	Service Restoration Time	Scenario Damages (Note 2)
100	30 days	$17,767,500
250	365 days	$216,171,250
308	730 days	$432,342,500

Note 2. The damages indicated in this column are scenario (deterministic) figures, i.e. they do not incorporate the probability of the event. The BCA software incorporates the probability as part of the benefits calculation shown in Table 4 below. The dollar figures are based on the $103 per capita per day default value in the software.

Post-Mitigation Frequency-Damage Inputs

The proposed mitigation project is engineered to resist the effects of the design seismic event, the Cascadia M-9. Although these elements of the overall system would likely continue to function, other more vulnerable elements such as end distribution components are not similarly designed and would likely experience damage and require repairs in order to resume full functionality. However, these are (relatively*)* simple repairs and would likely require only a month or two to fix even if the damage was significant. Times to repair these components and restore functionality are estimated based on experience and professional judgment. The estimated times are shown in Table 3 below.

Table 3
***Post*-Mitigation Frequency-Damage Table**

Event Return Interval	Service Restoration Time	Scenario Damages (Note 3)
100	7 days	$4,145,750
250	30 days	$17,767,500
308	60 days	$35,535,000

Note 3. The damages indicated in this column are scenario (deterministic) figures, i.e. they do not incorporate the probability of the event. The BCA software incorporates the probability as part of the benefits calculation shown in Table 4 below.

Project Construction and Maintenance Costs

As discussed in the project application, the estimated cost of all three elements (raw water intake, treatment plant, transmission line) is $12.5M. The Seal Rock Water District currently budgets $378,110 for maintenance and repair of the existing system. The District estimates that the new system will have a maintenance budget of $201,112 per year. As such, the District estimates a savings of $176,998 per year in such costs. However, the BCA software does not allow negative figures to be introduced into the calculation, so maintenance is entered as zero.

Project Useful Life

In accordance with FEMA guidance (final *BCA Reference Guide*, 2009, Appendix D) the proposed project is assigned a useful life of 50 years.

Results

Table 4 shows the results of the benefit-cost analysis. Based on the inputs described in the sections above, and the proposed cost, the mitigation project is cost-effective.

Table 4
Results of Benefit-Cost Analysis

Category	Value
Expected annual damages before mitigation	$1,847,913
Present value damages before mitigation	$25,502,578
Expected annual damages after mitigation	$172,815
Present value damages after mitigation	$2,384,976
Expected annual project benefits	$1,675,098
Present value project benefits (software)	$123,117,602
Project cost	$12,500,000
Benefit-cost ratio	**1.85**

Appendix D
Strengths-Weaknesses-Opportunities-Threat Analysis for Water Treatment Plant Site Alternatives

Seal Rock WD WTP Options

Option	Item	Strengths	Weaknesses	Opportunities	Threats
1 South Site	Plant site	Site is already partially prepared, mostly flat.	Small site--probably too small for plant facilities without major site work. Need to extend power lines, need to negotiate cost for replacement of barn	Use of site may help convince property owner to also sell land for intake	Requires negotiations with property owner for purchase. Site access may not be possible following tsunami (two vulnerable roads: Beaver Creek Road and South Beaver Creek Road). May required retaining walls to expand site for plant footprint.
	Plant access road	Access road in place.	Access road is relatively steep and too narrow		May require retaining wall to widen site and access road
	Raw water pipeline	Can follow South Beaver Creek Rd			Availability of alignment within road shoulder (versus needing to install under pavement at higher cost)
	Finished water pipeline	Can follow South Beaver Creek Rd	Requires crossing Beaver Cr at bridge. Long length of pipeline that is exposed to lateral spreading hazard along South Beaver Cr and North Beaver Cr Rds.		South Beaver Creek Rd is vulnerable to seismic damage. Beaver Cr Rd is vulnerable to seismic damage. Availability of alignment within road shoulder (versus needing to install under pavement at higher cost)
2 North Site	Plant site	Large land area appears to be available	Requires significant investment to survey land to understand amount of site work needed; may require substantial earthwork; need to bring in power	Property owner appears to be willing to sell	Permitting issues (clearing, zoning change)
	Plant access road	Do not need to cross Beaver Cr to access plant	Long access road installation with substantial earthwork and clearing; surveying required to understand feasible alignment; crosses wetland areas		Permitting for wetlands (including mitigation costs)
	Raw water pipeline		Requires 'extra' 3000 feet of line from road to site, has to cross Beaver Cr at bridge. Pipeline is exposed to lateral spreading hazard along South Beaver Cr Rd		Crosses a few apparent wetlands; Availability of alignment within road shoulder (versus needing to install under pavement at higher cost)
	Finished water pipeline	Does not have to follow South Beaver Cr Rd to cross Beaver Cr	Requires 'extra' 3000 feet of line from site down to road. Length of pipeline that is exposed to lateral spreading hazard along North Beaver Cr Rd.	Possibility to connect to Makai Tank overland. Possibility to go overland to North Beaver Cr Rd to shorten length of pipe.	Crosses a few apparent wetlands. May be necessary to extend small finished water pipeline back to intake owner's property to supply water in exchange for purchasing property.
3 Makai Site	Plant site	Site already prepared: flat, with fence; existing tank that can be reused; size appears adequate at 136 x 320 feet.	Constrained site; requires extension of higher voltage power lines	No pumping may be necessary from tank into system (more reliable supply in emergencies)	Intake will require larger sized pumps, which could be an issue for power supply. Appears that area of property beyond fence to the north is relatively flat but did not carefully view this portion of site. May not be able to confirm reuse of existing tank without further evaluation and design.
	Plant access road	Existing access road requiring only minimal work for plant needs			Construction access will be through neighborhood
	Raw water pipeline	Minimizes length of pipeline along Beaver Cr that is exposed to potentially lateral spreading	Long length of pipeline that is exposed to lateral spreading hazard along South Beaver Cr and North Beaver Cr Rds		Unknown if easements can be obtained to cross undeveloped land from Beaver Creek road to site
	Finished water pipeline	Eliminates pipeline along Beaver Cr that is exposed to potentially lateral spreading		District already installing 12-inch line with tee that may be sufficient	May be necessary to extend small finished water pipeline back to intake owner's property to supply water in exchange for purchasing property.

Appendix E
Preliminary Design Drawings

List of Preliminary Design Drawings

1. Overall site plan
2. Process flow diagram
3. Intake civil site plan
4. Intake plan, section, and detail
5. Intake electrical building floor plan
6. Water treatment plant civil overall site plan
7. Membrane building floor plan
8. Intake rendering drawings (6)

NO.	DATE	REVISION	BY	APVD
DSGN	DR	CHK	APVD	

Beaver Creek Water Supply

Seal Rock Water District

Seal Rock, OR

ch2m:

WATER TREATMENT PLANT

CIVIL

OVERALL SITE PLAN

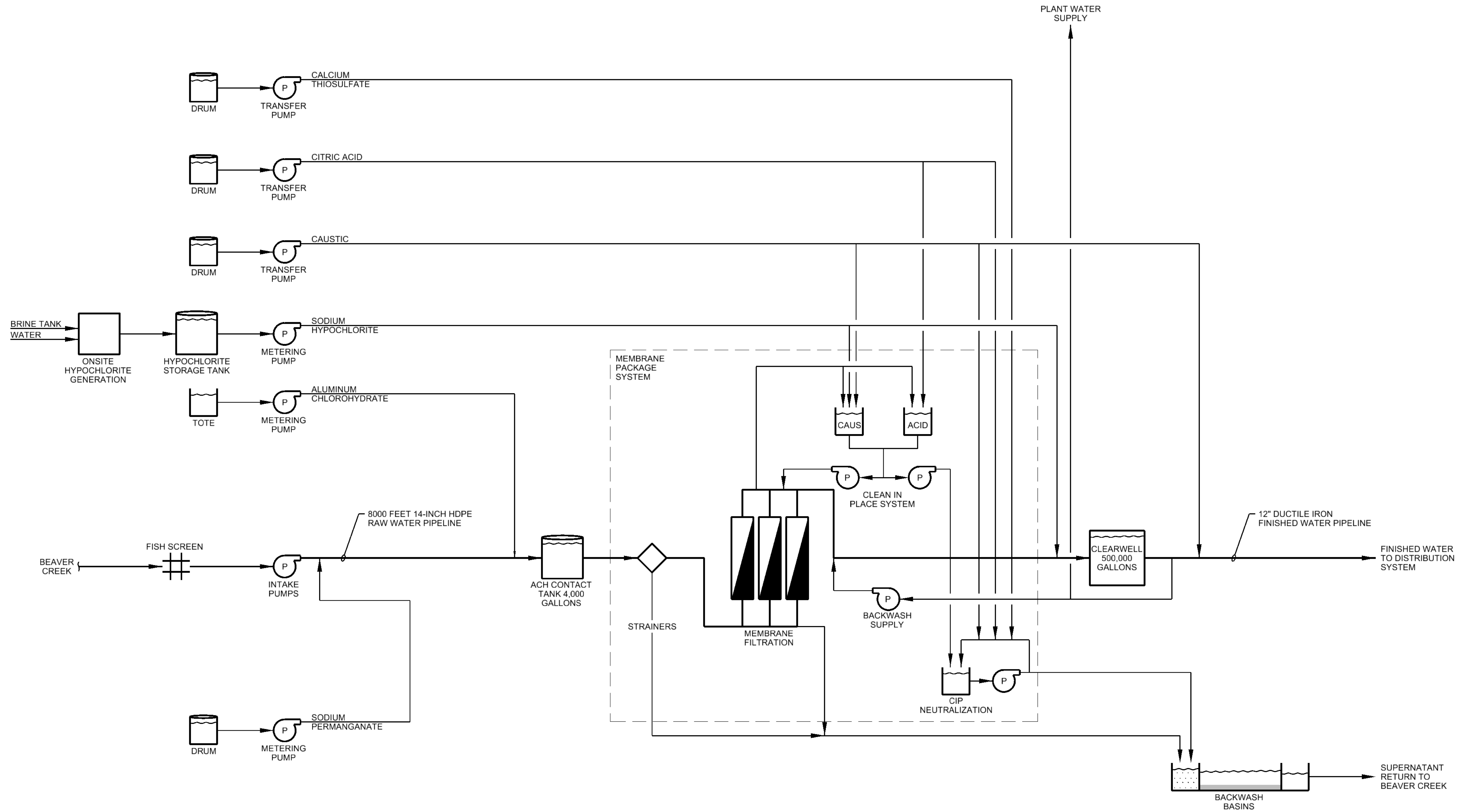
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	06-C-2000
SHEET	

PRELIMINARY DESIGN



SEAL ROCK WATER DISTRICT
PROCESS FLOW DIAGRAM

Beaver Creek Water Supply
Seal Rock Water District
Seal Rock, OR

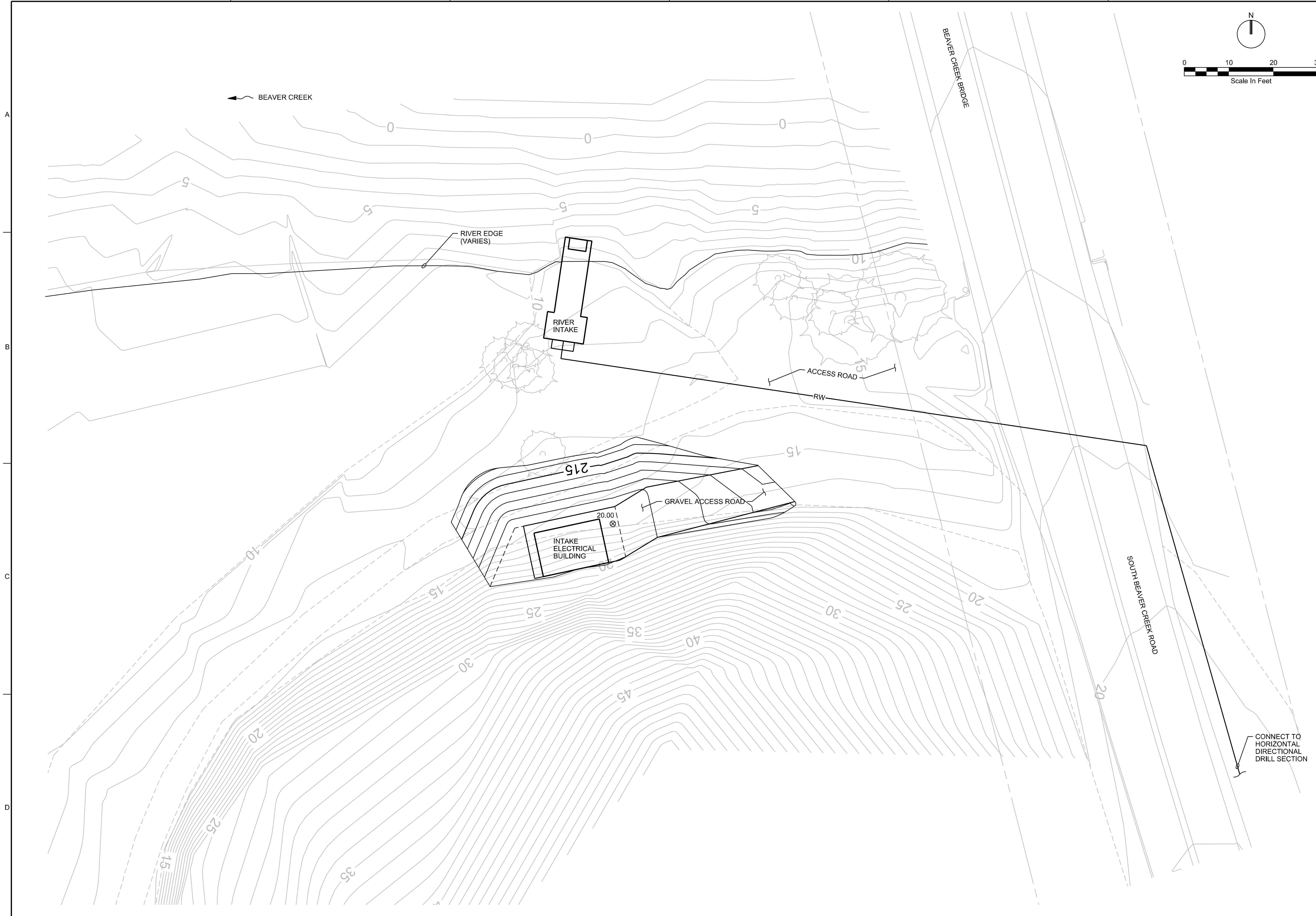
ch2m:
GENERAL
PROCESS FLOW DIAGRAM

VERIFY SCALE	
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"	
DATE	JANUARY 2017
PROJ	676178
DWG	01-G-101
SHEET	

NO.	DATE	REVISION	BY	APVD
DSGN	PM	DR	CHK GS	APVD PB

PB

PRELIMINARY DESIGN



NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

Beaver Creek Water Supply

Seal Rock Water District
Seal Rock, OR

ch2m

BEAVER CREEK INTAKE

CIVIL
SITE PLAN

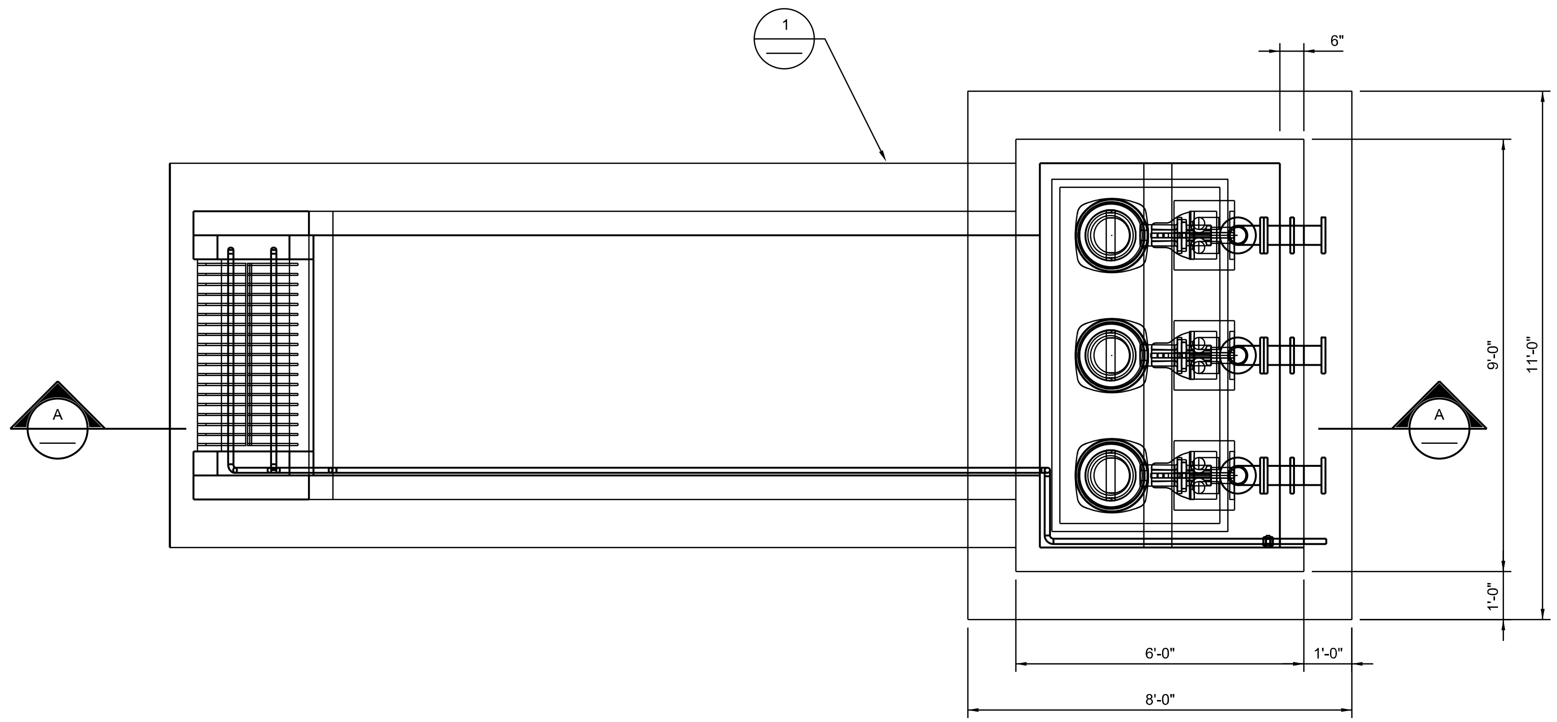
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

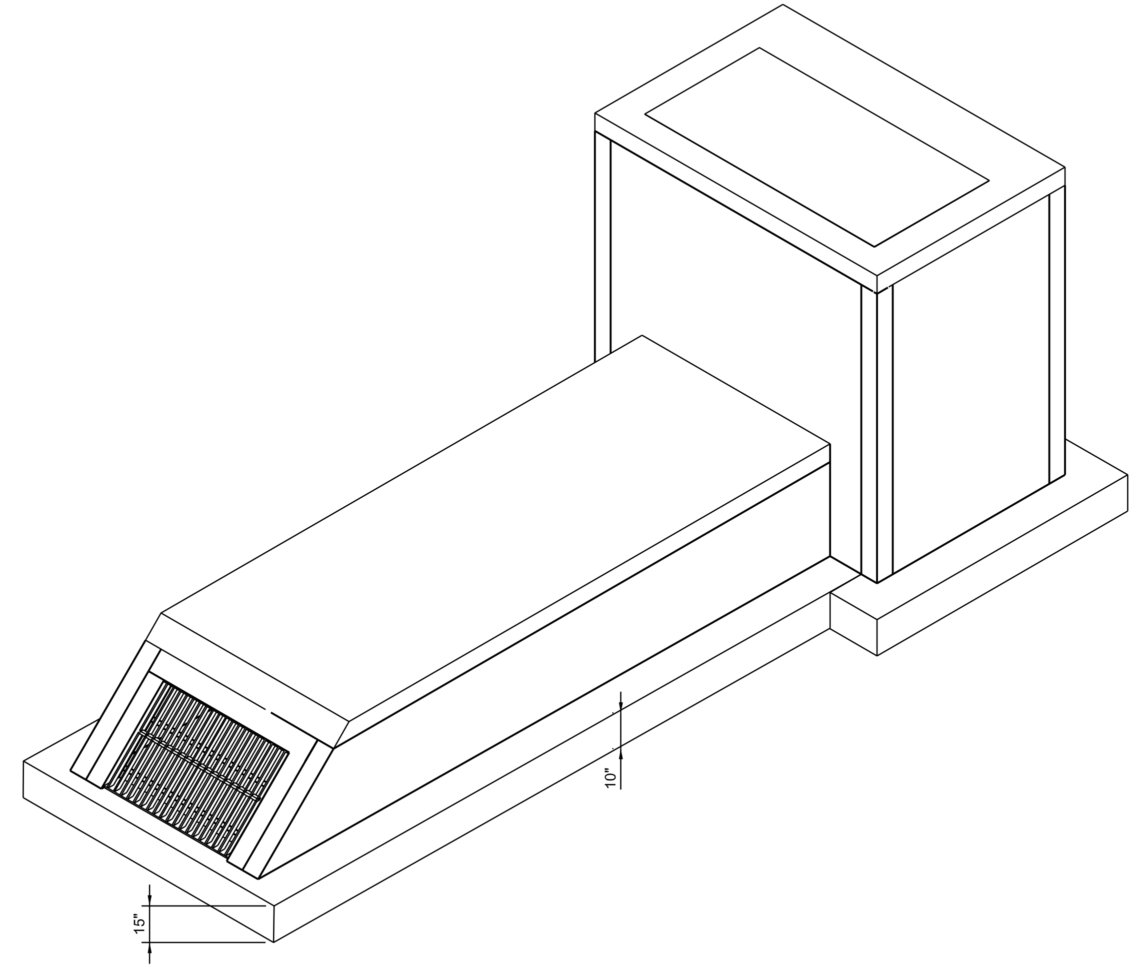
0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	06-C-2002
SHEET	

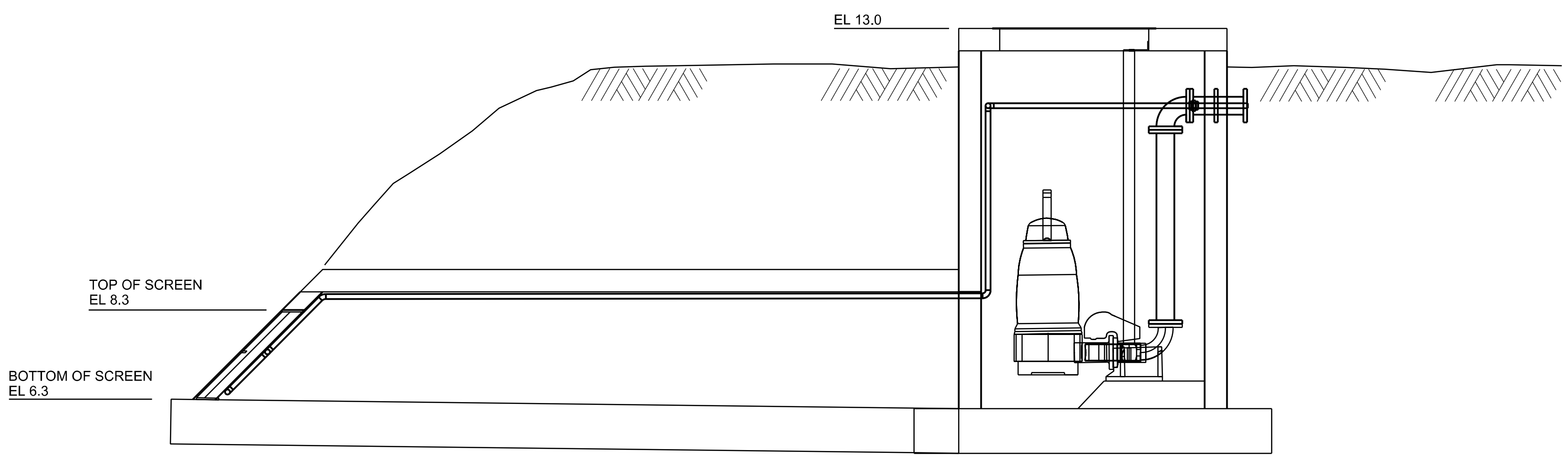
PRELIMINARY DESIGN



PLAN
1/2"=1'-0"



1 DETAIL
1"=1"



A SECTION
1/2"=1'-0"

NO.	DATE	REVISION	BY	APVD

DSGN | DR | CHK | APVD

Beaver Creek Water Supply
Seal Rock Water District
Seal Rock, OR

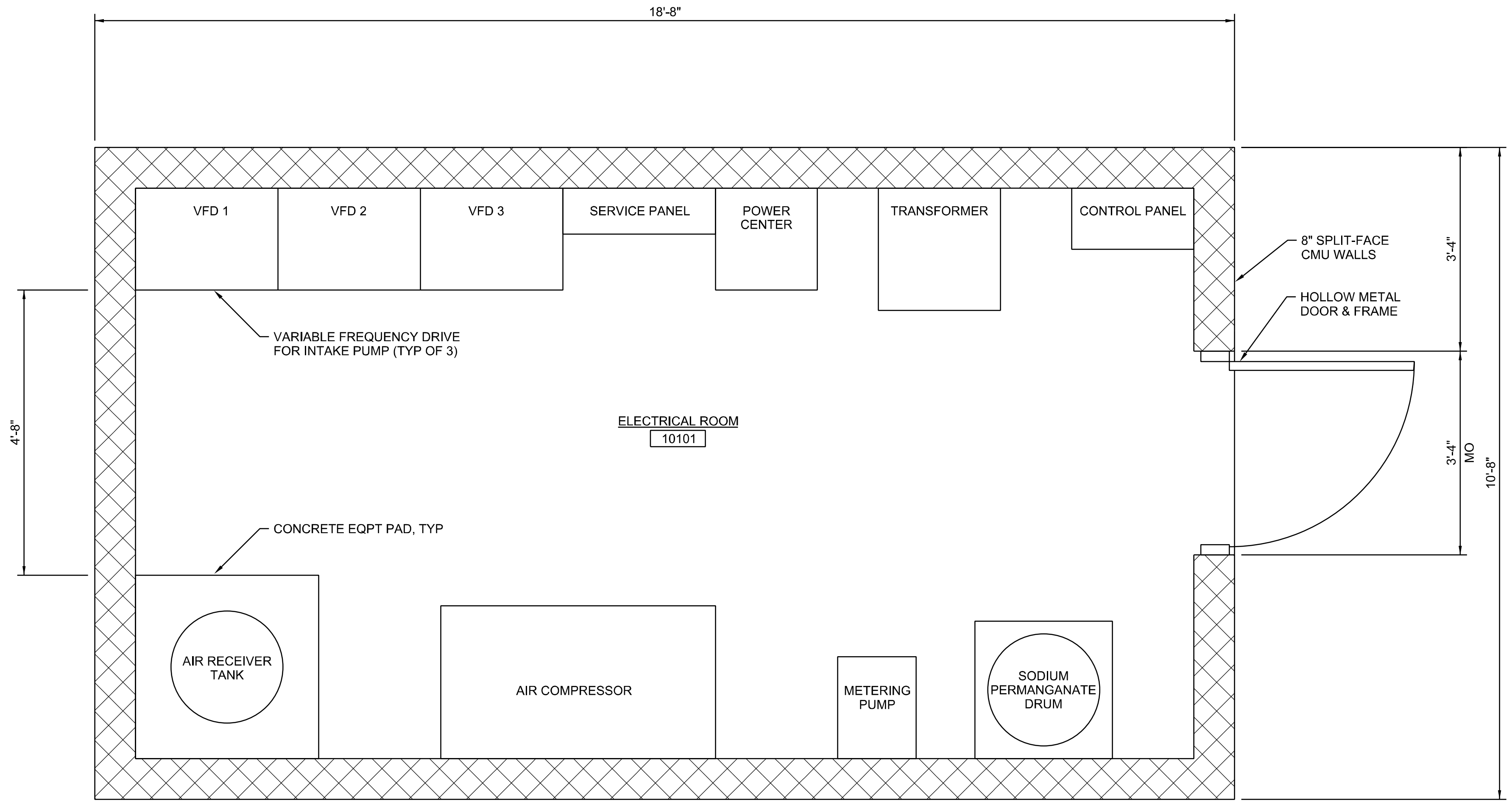
ch2m

INTAKE STRUCTURE
CIVIL
PLAN, SECTION, AND DETAIL

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	05-C-4001
SHEET	

PRELIMINARY DESIGN



FLOOR PLAN

3/4"=1'-0"

NO.	DATE	REVISION	BY	APVD

DSGN GB KIRSTEN | DR SD BARD | CHK BP TAVERNA | APVD

Beaver Creek Water Supply

Seal Rock Water District

Seal Rock, OR

ch2m

INTAKE ELECTRICAL BUILDING

ARCHITECTURAL FLOOR PLAN

AS NOTED

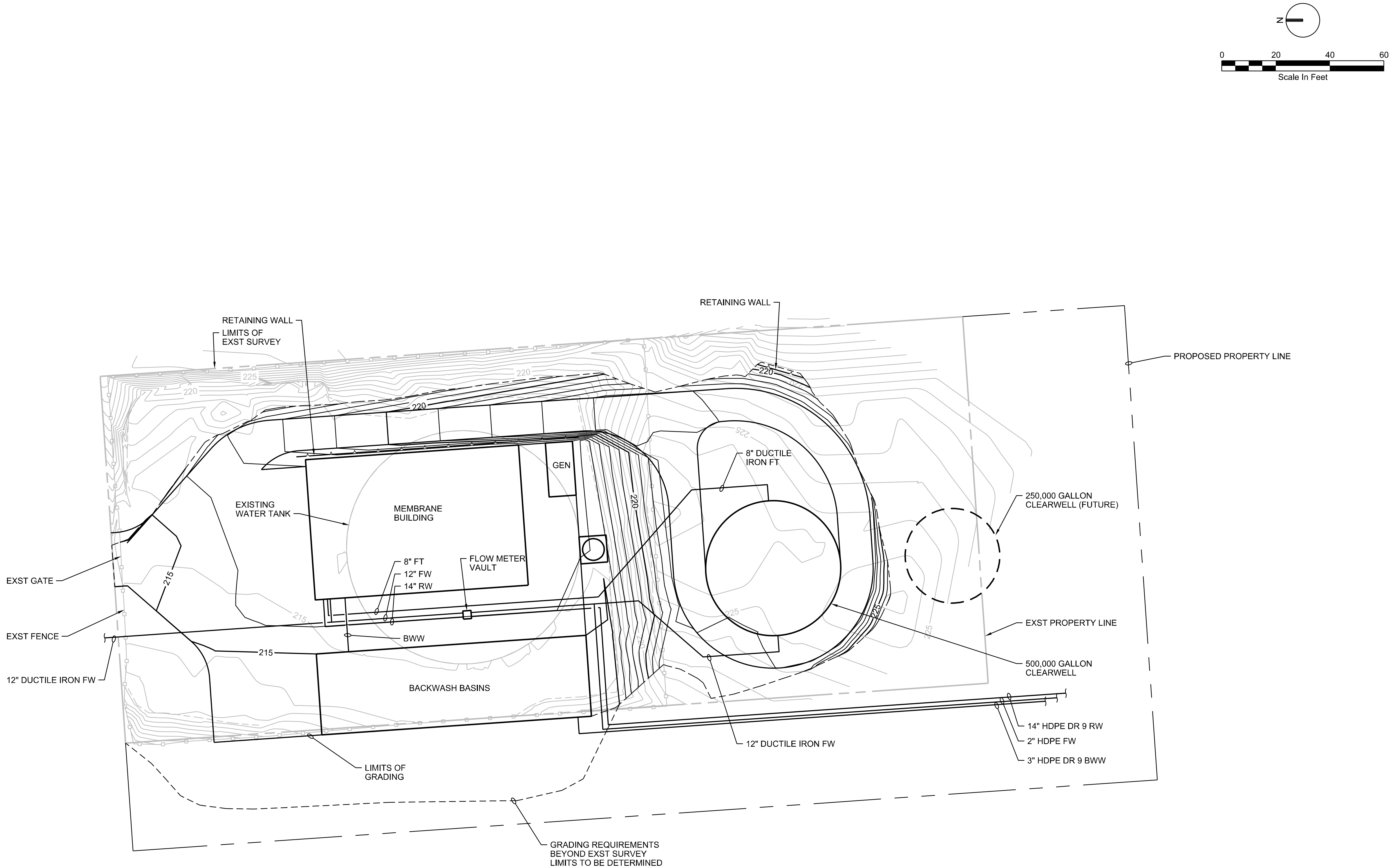
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	10-A-101
SHEET	

PRELIMINARY DESIGN



1 2 3 4 5 6

A B C D

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD

Beaver Creek Water Supply
Seal Rock Water District
Seal Rock, OR

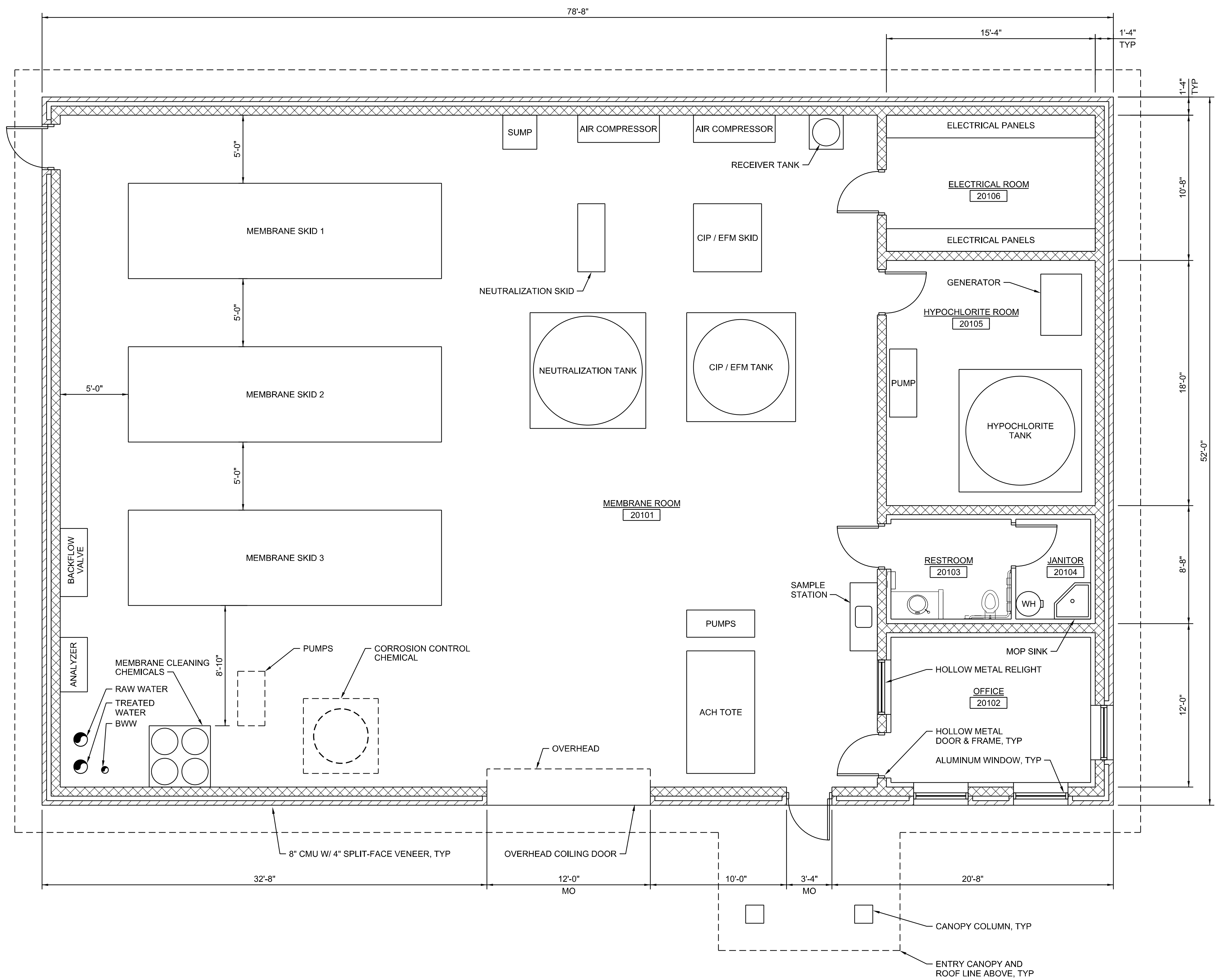
ch2m:

WATER TREATMENT PLANT
CIVIL
OVERALL SITE PLAN

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	06-C-2001
SHEET	

PRELIMINARY DESIGN



N

FLOOR PLAN
1/4"=1'-0"

NO.	DATE	REVISION	BY	APVD
DSGN GB KIRSTEN	DR SD BARD	CHK BP TAVERNA	APVD	

Beaver Creek Water Supply
Seal Rock Water District
Seal Rock, OR

ch2m

MEMBRANE BUILDING
ARCHITECTURAL FLOOR PLAN

AS NOTED
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	JANUARY 2017
PROJ	676178
DWG	20-A-101
SHEET	

PRELIMINARY DESIGN