Klamath River Renewal Project

City of Yreka Waterline Modification Project Design Documentation Report

IFC% Redesign Submittal

Revision No. 4

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5/25/2022
CIVIL
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May 2022

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Revision Log

Revision No.	Date	Revision Description
0	December 18, 2020	50% Design Submittal
1	February 5, 2021	100% Design Submittal
2	September 3, 2021	90% Redesign Submittal
3	January 17, 2022	100% Redesign Submittal
4	May 25,2022	IFC Submittal

1.0 Introduction and Background

1.1 Purpose

The purpose of this report is to present the design documentation associated with development of the City of Yreka Waterline Modification Project (Project).

1.2 Background

1.2.1 Location

The Project is located in Siskiyou County northeast of Iron Gate Dam near Hornbrook, California. The Project is located near the intersection of Copco Road and Daggett Road southwest of the Daggett Road Bridge crossing the Klamath River.

1.2.2 Project Description

1.2.2.1 City of Yreka Waterline

The Klamath River Restoration Project includes removal of four dams along the Klamath River, including the Iron Gate Reservoir. Within the reservoir, near Daggett Road Bridge, the City of Yreka (City) has a 24-inch diameter waterline minimally buried in the reservoir bed. According to the as-built record drawings prepared by Piemme, Neill, and Bryan and Clair A. Hill Associates in 1968, the existing pipeline was constructed by laying the pipe directly on the Iron Gate Reservoir bed and protecting with a riprap berm (CDM Smith, 2020a). A replacement pipe crossing is required before dam removal and reservoir drawdown to ensure an uninterrupted water supply for the City of Yreka.

1.3 Report Organization

This Design Documentation Report (DDR) is a record of the design effort for the Project and specifically describes the details of the design process and work effort. The DDR consists of a summary of the design elements, design criteria, methods and approach, engineering calculations, and pertinent references. The major report sections and intended purpose are presented in Table 1-1.

Table 1-1. Major Report Sections and Purpose

Section	Description	Purpose
1	Introduction and Background	Presents the background, a description of the overall Project, and the report organization.
2	Design Criteria	Summarizes the basic design criteria that are used as the basis for the design of the City of Yreka Waterline Modification Project.
3	Project Description	Describes the City of Yreka Waterline Modification Project.
4	Civil Design	Includes information related to the civil design associated with the City of Yreka Waterline Modification.
5	Hydraulic Design	Presents the hydraulic analysis of the pipe modification for the City of Yreka Waterline Modification Project.
6	Thrust Block Design	Includes information related to the design of the thrust blocks associated with the City of Yreka Waterline Modification.
7	Structural Design	Includes a discussion about thermal expansion of the pipe along the new Daggett Bridge. For detailed information regarding the Daggett Bridge pipe support see the Daggett Bridge DDR prepared by McMillen Jacobs.
8	References	Documents the references used in developing the design.
Appendices		
A	Civil Design Calculations	Presents the detailed calculations related to civil design.
B	Hydraulic Design Calculations	Presents the detailed calculations related to hydraulic design.
C	Geotechnical Logs	Presents the geotechnical borings in the vicinity of the proposed pipeline alignment

2.0 Design Criteria

2.1 Pertinent Data

Pertinent data for the Project include the assumed survey datum, topographic mapping, and references as described below.

2.1.1 Survey Datum

The Project data provided by the Klamath River Renewal Corporation (KRRC) were supplied in reference to the North American Vertical Datum of 1988 (NAVD88, Geoid 12B). This is the vertical datum that will be used on all drawings and in all calculations submitted as deliverable for the Project. The horizontal coordinate system is the California Coordinate System of 1983, Zone 1 North American Datum of 1983 (NAD83) in feet.

2.1.2 Topographic Mapping

Topographic data was supplied by KRRC and included the Light Detection and Ranging (LiDAR) and sonar survey performed in 2018 by GMA Hydrology, Inc. for the entire site.

2.2 References and Data Sources

A wide range of data sources and references were used in developing this DDR. Specific data related to the conceptual design of the Project were obtained from the various technical analyses and memoranda prepared by CDM Smith, which include the following:

- CDM Smith. 2020a. Yreka 50% Design Technical Memorandum.
- CDM Smith. 2020b. Yreka Water Conveyance Pipeline 50% Drawings.
- CDM Smith. 2020c. Yreka Water Conveyance Pipeline 50% Opinion of Probable Construction Costs (OPCC).
- CDM Smith and AECOM. 2019. Klamath River Renewal Project Geotechnical Data Report.
- Clair H. Hill and Associates. 1968. Main Transmission Line Klamath River Crossing.
- Knight Piésold Consulting and Kiewit. 2020. Fall Creek Culvert (Daggett Road) Drawings.
- The California Oregon Power Company. 1981. Daggett Road Bridge Drawings.
- Yreka, email 5.27.2021 Rob Taylor to Jodi Burns on pump station operating pressures

Additional data sources, including publicly available aerial imagery, U.S. Geological Survey (USGS) maps, USGS streamflow gaging station data, soils maps, as-constructed drawings, and standard engineering reference documents, were used.

2.3 General Design Criteria and Standards

2.3.1 Standard List of Terms and Abbreviations

ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
AWS	American Welding Society
CCOR	California Code of Regulations
CLSM	Controlled low strength material
cfs	cubic feet per second
CGP	Construction General Permit
ECP	Erosion Control Plan
ft	feet
ft^3	cubic feet
GBR	Geotechnical Baseline Report
gpm	gallons per minute
HEC-RAS	Hydrologic Engineering Center River Analysis System
KRRC	Klamath River Renewal Corporation
LiDAR	Light Detection and Ranging Survey
mm	millimeter
NAD	North American Datum
NAVD	North American Vertical Datum
Project	City of Yreka Waterline Modification Project
pcf	pounds per cubic foot
psf	pounds per square foot
psi	founds per square inch
USGS	United States Geological Survey

2.4 Civil Design Criteria

2.4.1 Erosion Control Plan

The contractor will be required to obtain a Construction Storm Water General Permit from the California State Water Resources Control Board prior to construction. Construction General Permits (CGPs) are required for construction projects that result in greater than 1 acre of soil disturbance. The CGP requires temporary and post-construction Best Management Practices to prevent erosion and reduce sediment discharges from construction sites. Prior to permit issuance by Siskiyou County, submittal of an Erosion Control Plan (ECP) to the appropriate Director at Siskiyou County is required. The ECP shall include methods for controlling runoff, erosion, and sediment movement.

2.4.2 Materials

The material properties assumed for preparation of permanent waterline design are listed in Table 2-1.

Table 2-1. Mechanical Materials

Component	Materials
Buried Permanent Piping	25-inch AWWA Steel Pipe OR 24-inch ASTM Steel Pipe
Valves	Stainless Steel and Ductile Iron
Hardware	Stainless Steel

2.5 Hydraulic Design Criteria

2.5.1 Applicable Codes and Standards

The following codes, standards, and specifications will serve as the general design criteria for the hydraulic design of the City of Yreka Waterline Modification.

Table 2-2. Hydraulic Standards, References, and Standards of Practice

Standard	Reference
HDC 228-4	Hydraulic Design Criteria (HDC). 1987. *In-Line Conical Transitions and Abrupt Transitions, Loss Coefficients*. HDC 228-4 to 228-4/1. U.S. Army Corps of Engineers. Revised 11-87.
Rennels & Hudson, 2012	Rennels, Donald C. and Hudson, Hobart M. 2012. *Pipe Flow, A Practical and Comprehensive Guide*. Hoboken, New Jersey: John Wiley & Sons.
Tullis, 1989	Tullis, J.P. 1989. *Hydraulics of Pipelines: Pumps, Valves, Cavitation, Transients*. John Wiley & Sons, Inc.

2.5.2 Hydraulic Design Criteria

The proposed hydraulic engineering criteria are presented in the tables below. The criteria presented within these tables represent the anticipated operation and design elements used in the Project development. The criteria were developed to represent the existing operation of the City of Yreka water conveyance system. According to the City, up to three (3) pumps will be called upon to run based on tank level set points at the 135,000-gallon Klamath Pass tank. Three (3) of the available four (4) pumps are fixed speed and can discharge approximately 2,500 gallons per minute (gpm), therefore, flows rates are approximately 6 cubic feet per second (cfs) / 2,688 gpm for one (1) pump running, 11 cfs / 4,928 gpm for two (2) pumps running, and 15 cfs / 6,720 gpm for all three (3) pumps in operation. The fourth (spare) pump is VFD controlled and can maintain a constant tank level intermittently in the winter when only one pump is sufficient and does not operate while the other three pumps are running.

Figure 2-1 and Figure 2-2 graphs were supplied by the City and show the typical flow rates in million gallons per day (MGD) for the winter and summer scenarios. During the winter months, as shown in Figure 2-1, the City water system typically conveys approximately 4 million gallons per day (MGD) or 6 cfs / 2,688 gpm. During the summer months, as shown in Figure 2-2, the City water system typically conveys up to approximately 7 MGD or 11 cfs / 4,928 gpm. Figure 2-3 was supplied by the city to show the hydraulic grade lines for the project and were used to calculate the surge pressure.

The City of Yreka provided the pump operating parameters in Table 2-3 with up to two pumps running. The operating pressure with all three pumps running was calculated. A Hazen Williams "C" value was adjusted to match the discharge pressure of pumps 1 and 2 field tests and then used to calculate the pressure of all three pumps running.

Table 2-3. Pump Station Discharge Pressure Criteria

Operating Condition	Pressure (psi)	Comments
No pumps running	260	Klamath Pass level: 7.7 ft, Flow: 0 MGD
Pump #1 running	263	Klamath Pass level: 8.4 ft, Flow: 3.66 MGD
Pump #1 running	267	Klamath Pass level 17.2 ft, Flow: 3.49 MGD
Pump #1 and #2 running	268	Klamath Pass level: 10.5 ft, Flow: 7.12 MGD
Pump #1 and #2 running	270	Klamath Pass level: 17.0 ft, Flow: 7.04 MGD
Pump #1, #2, and #3 running	276	16 psi line losses calculated for 6,720 gpm through 10,000 LF of 23" ID pipeline between pump station and Klamath Pass Tank using Hazen Williams "C" Value of 130.

Table 2-4 provides a summary of the pipeline operating pressures.

Table 2-4. Operating Pressure Summary

Operating Condition	Value	Comments
Pump Station Elevation	2,402 ft	MAIN_TRANSMISSION_LINE_SCHEDULE_A_SHT030_20140325_0001.
New Waterline Low Elevation	2,326 ft	STA: 15+11.98 ft Sheet C103 City of Yreka Water Line Drawings
Pumping Highwater HGL at max operating pressure	3,039 ft	Using 276 psi discharge pressure with three pumps on
Static + Surge HGL	3,165 ft	See Figure 2.3 taken from MAIN_TRANSMISSION_LINE_SCHEDULE_A_SHT006_20140325_0001
Pipeline Maximum Operating Pressure	309 psi	(3,039 ft – 2,326 ft) x 0.433 psi/ft = 309 psi
Pipeline Surge Pressure	363 psi	(3,165 ft – 2,326 ft) x 0.433 psi/ft = 363 psi

Table 2-5. Flow Criteria

Criteria	Units	Value	Comments
Maximum Design Flow	cfs	15	Maximum Design Flow with three pumps running.
Average Summer Peak Flow Rate	cfs	11	Peak Flow rate during summer months with two pumps running.
Average Winter Peak Flow Rate	cfs	6	Peak Flow rate during winter months with one pump running.
Pipe Diameter	inches	24 or 25	Existing Pipe Diameter is 24-inch
Existing Pipe Length	feet	1,325	Pipe length between STA 1236+00 to 1222+75
New Pipe Length	feet	3,267	Permanent Pipe Length
Pipeline Chlorination	mg/L	0.5 – 2	Chlorine is added to pipeline at upstream pump station

Table 2-6. Hydraulic Criteria

Criteria	Units	Value	Comments
Mortar Lining Roughness	ft	0.000036	WRL Research Report 158
Epoxy Lined Steel Pipe	ft	0.000049	Rennels & Hudson, 2012 Very smooth, similar to plastic pipe
Miter Bend Loss Coef.	-	varies	Equation 15.5 - Rennels & Hudson, 2012
Full Open Isolation Valve Coef.	-	0.20	Tullis, 1989

Criteria	Units	Value	Comments
Converging Flow thru Branch Tee Coef.	-	1.10	Diagram 16.10 - Rennels & Hudson, 2012
Diverging Flow thru Branch Tee Coef.	-	1.30	Diagram 16.2 - Rennels & Hudson, 2012
Expansion Reducer Coef.	-	varies	HDC 228-4
Contraction Reducer Coef.	-	varies	HDC 228-4

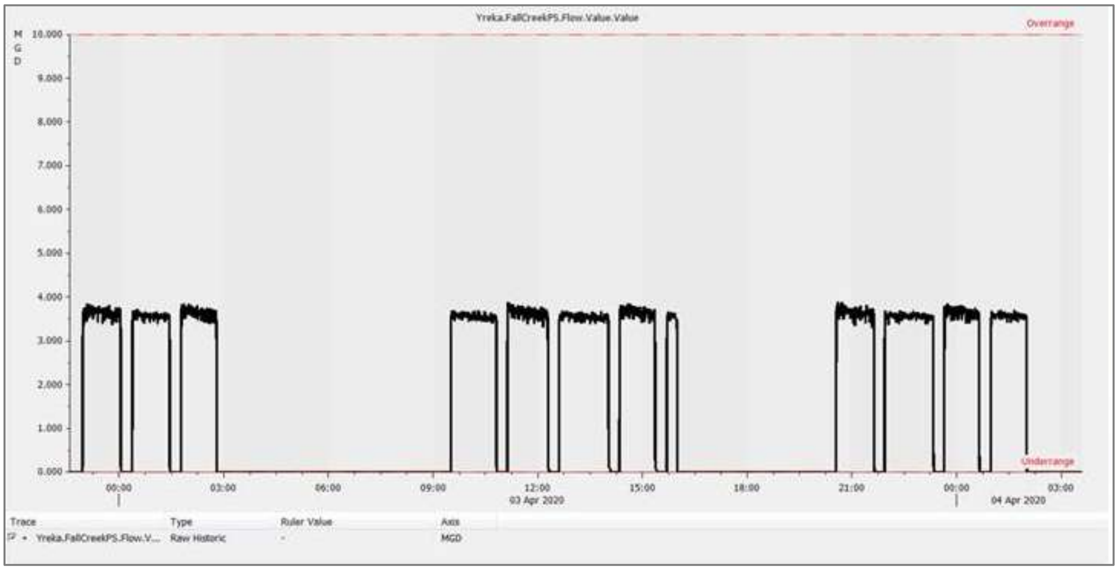


Figure 2-1. City of Yreka Winter Flow Rates in MGD.

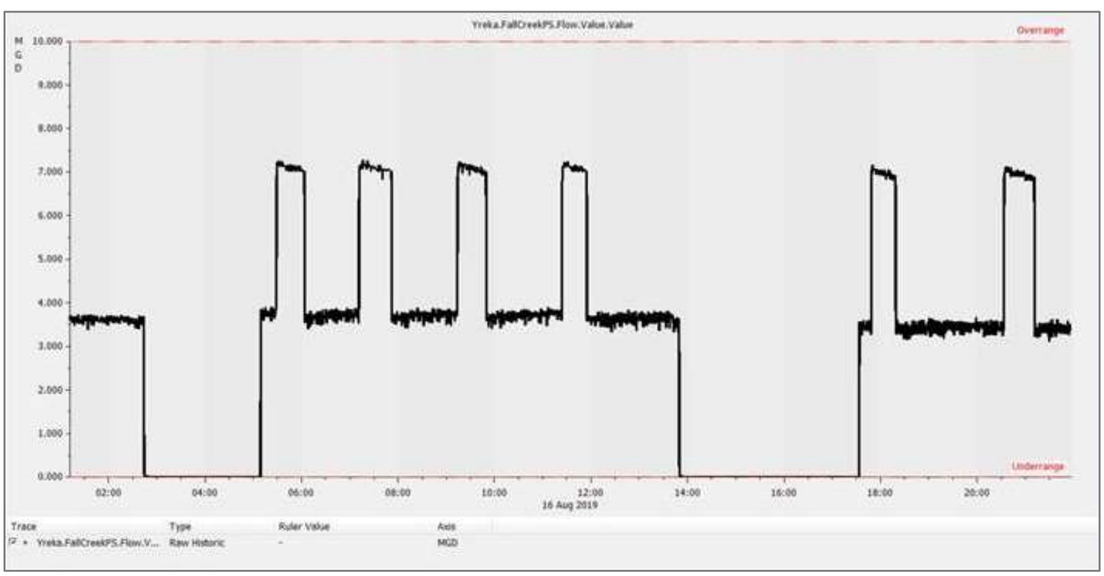


Figure 2-2. City of Yreka Summer Flow Rates in MGD.

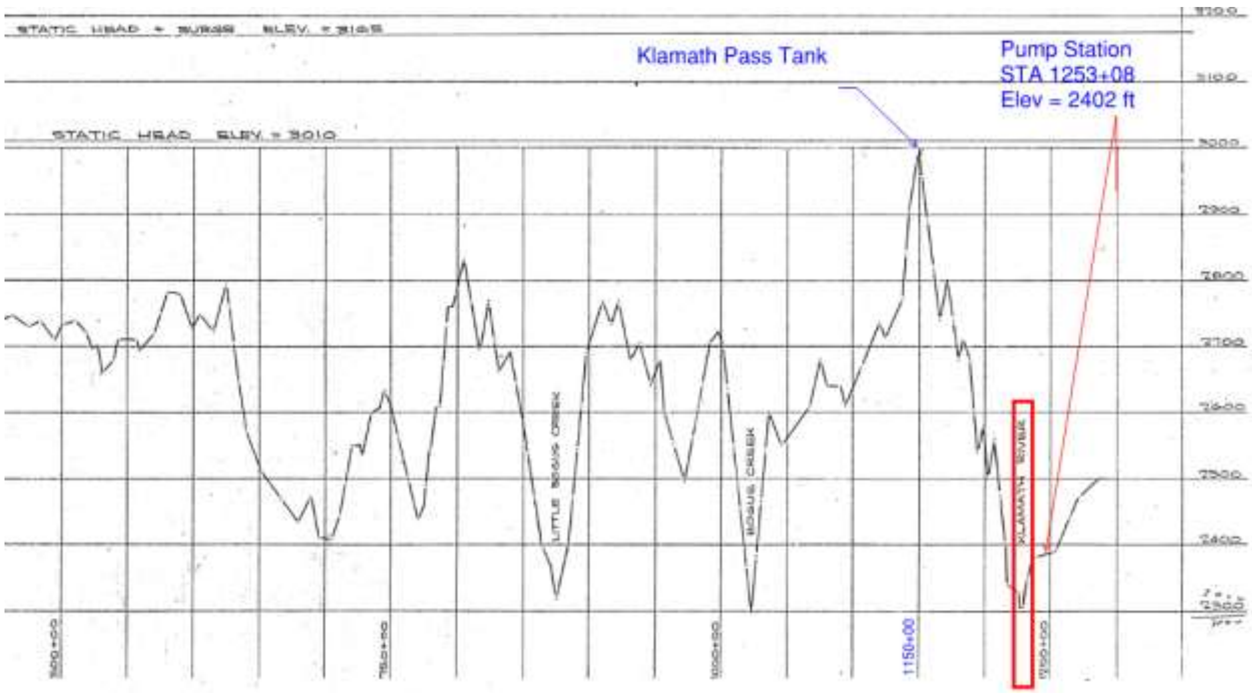


Figure 2-3. City of Yreka Hydraulic Grade Lines from As-Built Drawings

2.6 Geotechnical

CDM Smith and AECOM Technical Services, Inc. prepared a Geotechnical Data Report for KRRC in June 2019. Nine (9) borings, BI-02, BI-03, B-201, B-202, B-203, B-205, B-206, B-207, and B-208 were drilled in the vicinity of the City of Yreka waterline location. BI-02, BI-03, and B-203 were drilled by Taber Drilling. Boring BI-02 was drilled with a truck mounted CME-55 drill rig and borings BI-03 and B-203 were drilled over water with a barge mounted CME055 drill rig. Borings B-201, B-202 and B-206 were drilled by Pitcher Drilling Company with a track-mounted Fraste XL drill rig; boringsB-202 and B-206 were drilled at a 60 degree inclination from horizontal and a true north bearing of 205 and 295 degrees, respectively. Borings B-205, B-207 and B-208 were drilled by Gregg Drilling with a truck mounted Mobile B-53 drill rig. All borings were advanced with rotary wash, HQ-3 rock core methods. The borings reached depths of 67.0 feet (BI-02), 35.1 feet (BI-03), 50.5 (B-201), 100.5 feet (B-202), 120.0 feet (B-203), 62.0 feet (B-205), 100.0 feet (B-206), 81.1 feet (B-207) and 80.0 feet (B-208) below ground surface. Borings are shown relative to the proposed water line in Figure 3-1.

The Project site has various rock and soil types that were categorized into six (6) units based on their similar geotechnical characteristics and origins:

- Unit 2: Floodplain and Overbank Deposits
- Unit 3: River Alluvium
- Unit 4: Weathering Zone
- Unit 5: Volcanic Creccia/Tuff
- Unit 6: Basalt/Andesite

- Unit 7: Volcanic Mudstone

Unit 2 consists of predominantly fine-grained alluvial soils (floodplain and overbank deposits), fine-grained residual soils, and clayey-gravelly colluvium. This unit was encountered at all on-land boring locations to depths between 12 and 19 feet beneath ground surface.

Unit 3 includes coarse-grained alluvial deposits deposited by fluvial processes. Other geologic processes may have contributed such as mass wasting in conjunction with reworking of materials by fluvial processes or reworking of a weathering zone. These soils were encountered in BI-03 and B-203 within the river with a thickness of about 4 feet, and in B-201, B-202, and B-208 beneath the floodplain and overbank soils (Unit 2) at the southern river plain, with varying thickness between 10 and 36 feet. The greatest depth of this deposit was recorded in B-208 about 53 feet beneath ground surface.

Unit 4 includes rock that has been completely weathered and decomposed to soil or detached from the underlying bedrock, forming a transition zone from the overburden soils to the less weathered rock below. This unit was encountered beneath Unit 2 in borings B-205, B-206, and B-207 with thicknesses between 2 and 5 feet.

Unit 5 includes low-strength rock geologically categorized as volcanic breccia, volcanic conglomerate, and tuff. This unit was encountered in all borings with the exception of B-201. This unit was encountered in BI-02, B-205, and B-207 underlying the floodplain & overbank soils (Unit 2), in BI-03, B-202, B-203, and B-208 underlying the river alluvium (Unit 3), and in B-206 below an intrusion of high-strength rock (Unit 6).

Unit 6 includes high-strength Basalt and Andesite. It was encountered in B-201, B-203, and B-206 beneath the river alluvium (Unit 3) and within the volcanic breccia/tuff (Unit 5). B-201 was completed within this unit. B-203 encountered several intrusions/layers of this unit of varying apparent thickness and at various depths within the rocks of Unit 5. B-206 was advanced through this unit to a depth of 64 feet before transitioning into the volcanic breccia/tuff of Unit 5. At boring locations B-203 and B-206 the basaltic rock is interpreted as lava layers or intrusions (dikes) within the volcanic breccia/tuff of Unit 5.

Unit 7 was encountered only in boring B-202 beneath the volcanic breccia/tuff (Unit 5) at a depth of 78 feet beneath the ground surface (CDM Smith 2020a).

3.0 Project Description

3.1 General Site Layout

The general site layout is depicted in Figure 3-1, and shows the major components of the proposed City waterline improvements. The new improvements include construction of a new 24 or 25-inch diameter steel pipe along Daggett Road and supported across the new Daggett Bridge across the Klamath River. The new pipe will extend from a connection point near the intersection of Copco Road and Daggett Road, along the existing Daggett Road on the north side of the Klamath River, across the new Daggett Road Bridge, and then to a connection point on the south abutment of the reservoir.

Figure 3-1. General Site Layout

4.0 Civil Design

4.1 General Description

This section presents the civil design elements for the Project.

4.1.1 Erosion and Sediment Control

The Contractor is required to install, monitor, and maintain erosion and sediment control measures as identified within the Project Drawings, and prepare the required documents discussed in Section 2.4 as determined by the various regulatory agencies. The erosion control measures shall be maintained for the duration of the construction project. The Contractor will be required to install specified permanent post-construction measures as required for the Project. The permanent measures are designed to protect the exposed slopes until the vegetation is fully established. Following construction, the disturbed areas of the Project site will be revegetated with native plant mixes. The Contractor will be required to submit a Notice of Termination (NOT) to the State Water Resources Control Board (SWRCB) after completing the Project. This is required to be relieved from the Construction General Permit requirements. Final soil stabilization throughout the proposed Project area must be achieved prior to the SWRCB approval of the NOT.

4.2 Pipe Material Selection

The contractor will be given the option of using either a 25-inch diameter standard AWWA C200 steel pipe system, or a 24-inch diameter standard ASTM A53 steel pipe system. Either of these pipe materials allow for efficient shop design and fabrication of all needed pipe spools with butt-welded joints. These common piping systems have the advantages of being very durable to weather and other environmental exposure, typically provides for a simple fully restrained pipe system, and provides the ability to make some field modifications if needed. All flanges will be ASME B16.5 Class 300.

Air release valves will be placed at high points to expel air during operation and allow air to enter the pipe when the pipe is drained. The Air Valves will be Crisping Universal Air Valves with ductile iron bodies a a minimum operating pressure o 400 psi.

Isolation valves will be placed on the up and downstream connections to the existing 24-inch pipeline and on the pipe drains. The valves will be Dezurik high performance butterfly valves with stainless steel bodies and minimum operating pressures of 720 psi. Dismantling joints will be provided in the 24-inch valve vaults to aid in future maintenance of the valves. Dismantling joints will be Romac DJ400 series specified with and operating pressure of 375 psi and ASME B 16.5 Class 300 flanges.

4.3 AWWA C200 Steel Pipe

The steel pipe and specials shall conform to requirements of AWWA C200, and to the Project Specification Section 33 11 11 – Steel Pipe, Specials and Fittings. The steel pipe material shall have a minimum yield stress of 42,000 pounds per square-inch (psi) or 42 ksi. This pipe material allows for efficient shop design and fabrication of pipe spools with typical joints being butt welded joints for the buried portions of the pipe. The interior lining and exterior coating of the buried steel pipe systems will be cement mortar or epoxy systems meeting the AWWA standards.

4.4 ASTM A53 Steel Pipe

The steel pipe and specials shall conform to requirements of ASTM A53, and to the Project Specification Section 40 23 15 – Steel Pipe (ASTM A53). The steel pipe material shall have a minimum yield stress of 36,000 psi or 36 ksi. This pipe material allows for efficient shop design and fabrication of pipe spools with typical joints being factory butt welded joints for the buried portions of the pipe. The interior lining and exterior coating of the buried steel pipe systems will be liquid epoxy and fusion bonded systems meeting the AWWA standards.

4.5 Daggett Bridge Steel Pipe Section

The system is design to have flanged joints at the new Daggett Bridge crossing. Flanged joints (ASME B16.5 Class 300) along the bridge crossing will aid in constructability of the pipe. The interior lining and exterior coating of the exposed steel pipe systems at the new Daggett Bridge crossing will be provided in a liquid epoxy system meeting the AWWA C210 standard. The wall thickness will be increased to 0.750 inches and the pipe will be covered to provide ballistic protection.

4.6 Buried Pipe Trench Configuration

Below-grade piping will be installed in a cut-and-cover trench configuration having a minimum bottom width of 3 feet more than the outside diameter of the installed pipe. A minimum soil cover of 2.5-feet is provided above the top of the buried pipe outside of roads and 3 ft min under roads.

Pipe bedding will be a minimum of 4-inches of sand (Type SNF). Backfill for the pipe zone material up to a minimum height of 6 inches above the top of pipe will likely be either sand (Type SNF) or imported structural fill 3/4-inch minus well-graded material (Type SF) compacted to a minimum of 90% modified proctor. As an alternative, the Contractor has the option of placing controlled low strength material (CLSM) within the pipe zone if warranted in the field. CLSM is a self-compacting, cementitious material that essentially achieves 100% of compaction during placement.

The below-grade piping crossing a new culvert at Fall Creek will be installed in a cut-and-cover trench configuration. The new pipe above the culvert will be CLSM encased where a 3 ft cover cannot be achieved due to the depth of the new Fall Creek culvert.

4.7 Pipe Drains

The pipe is designed to be equipped with drain lines located at low points along the new pipe alignment to allow the City to dechlorinate the pipeline after construction and then used later to drain the pipeline in rare instances for maintenance. There will be a 4-inch diameter connection point with a 4-inch diameter isolation valve. If the pipeline needs to be taken out of service, the City will first turn off the pumps and then close the new downstream 24-inch diameter isolation valve (V-01 Sheet C100) on the pipeline to prevent the higher pressure column of water downstream and up to the Klamath Pass Tank from free flowing into this section of pipeline. This 24-inch isolation valve is located in a buried vault at the connection point to the existing pipeline. The City can then open the 4-inch diameter valve leading to the to a 4-inch diameter blind flange. This flange will allow the City to connect a mobile dechlorination unit to the pipeline and discharge the water with a chlorine residual allowable to discharge to the Klamath River.

5.0 Hydraulic Design

5.1 Existing Waterline Hydraulic Analysis

The headloss in the existing waterline from Station 1236+00 to 1222+75 was calculated to compare against the anticipated headloss for the new waterline alignment. The Colebrook-White equation was used to calculate the friction headloss for the existing mortar-lined steel pipe. The minor losses consisted of eight (8) horizontal and vertical miter bends. The pipe roughness and minor loss coefficients used to calculate the headloss are shown in Table 5-1. The calculated headloss from Station 1236+00 to 1222+75 is shown in Table 5-2. Additional calculations can be found in Appendix B.

Table 5-1. Existing Waterline Pipe Roughness and Minor Loss Coef. (Station 1236+00 – 1222+75)

Description	Units	Value
Mortar Lining Roughness	mm	0.11
33.22° Miter Bend Loss Coef.	-	0.18
34.37° Miter Bend Loss Coef.	-	0.19
33.50° Miter Bend Loss Coef.	-	0.18
5.50° Miter Bend Loss Coef.	-	0.02
6.00° Miter Bend Loss Coef.	-	0.02
12.00° Miter Bend Loss Coef.	-	0.05
18.50° Miter Bend Loss Coef.	-	0.08
20.00° Miter Bend Loss Coef.	-	0.09

Table 5-2. Existing Waterline Headloss from Station 1236+00 to 1222+75

Flow (cfs)	Velocity (ft/s)	Friction Losses (ft)	Minor Losses (ft)	Total Headloss (ft)
15	5.4	4.6	0.4	5.0
11	3.9	2.6	0.2	2.8
6	2.1	0.8	0.1	0.9

5.2 Waterline Hydraulic Analysis

The Colebrook-White equation was used to calculate the friction headloss for the proposed steel pipe. The minor losses consisted of tees, isolation valve, reducers, and several miter bends. Additional information and calculations can be found in Appendix B.

5.2.1 Headloss Comparison

The headloss was calculated for the following two different pipe sizes:

- 25-inch OD Cement Mortar Lined Steel Pipe
- 24-inch OD Epoxy Lined Steel Pipe

The pipe roughness for mortar and epoxy lined pipe used are 0.01 mm and 0.0015 mm respectively. The minor loss coefficients representing the bends, branches, and valves can be found in Appendix B. It was assumed that the diverging and converging tees, and isolation valves would be the same diameter as the existing mortar lined steel pipe. The calculated headloss in the different pipe sizes with comparison to the existing pipe headloss is shown in Table 5-3.

Table 5-3. New Alignment Headloss Comparison

Flow (cfs)	Existing Total Headloss (ft)	25-inch Mortar Lined Total Headloss (ft)	24-inch Epoxy Lined Total Headloss (ft)
15	5.0	10.3	11.0
11	2.8	5.8	6.2
6	0.9	1.9	2.0

The pump system up to Klamath Pass tank has a discharge pressure of approximately 637 ft (276 psi discharge pressure with all three pumps running); the increased headloss as a result of the new pipeline will stay within one percent of the overall system losses while operating all three pumps.

6.0 Thrust Block Design

Engineering soil properties were selected based on the subsurface conditions and soil properties provided in borings B15 and B17 from the Klamath River Renewal Project Geotechnical Data Report prepared by AECOM / CDM Smith (June 2019) and are included in Appendix C. Boring B17 indicates a gravelly clay with sand while Boring B15 indicates a sandy lean clay. A horizontal bearing strength of 3,500 psi is used in the thrust block design calculations in Appendix A. It is noted that the proposed pipeline is welded steel thus fully restrained which will provide additional thrust restraint through soil friction along the pipeline lengths.

Figure 6-1. Boring Locations

7.0 Structural Design

7.1 Structural Support Locations

Structural support locations for the 24 or 25-inch pipeline along new Daggett Bridge are discussed in detail in the Daggett Bridge DDR. Please refer to the Daggett Bridge Design for details of the structural supports along the new Daggett Bridge.

7.2 Expansion Joints and Differential Settlement Joints

The new Daggett Road Bridge will included new exposed 24-inch or 25-inch diameter pipeline which will be subject to strain resulting from thermal expansion and contraction. It is anticipated that the pipeline could be subject to temperature differentials of up to 100-degrees during the service life. The change in temperature will result in a change in length of approximately 2-inches. To accommodate this change in length, an expansion/contraction joint is located on the horizontal run for thermal expansion of the pipeline and one at each abutment to accommodate differential settlement. The expansion/contraction joints will be Romac Flex-Tend flexible expansion joints and have a minimum operating pressure of 350 psi and include ANSI Class 300 flanges to connect to the new steel pipe.

8.0 References

CDM Smith and AECOM. 2019. Klamath River Renewal Project Geotechnical Data Report.

CDM Smith (2020a), "50% Design Technical Memorandum (DRAFT), Yreka Water Conveyance Pipeline (YWCP) Crossing of the Klamath River Using a Utility Bridge, Klamath River Renewal Project, Klamath River Renewal Corporation", To: Seth Gentzler, AECOM, From: Ben Swann and Sri Rajah, CDM Smith.. January 17, 2020.

CDM Smith (2020b), Yreka Water Conveyance Pipeline 50% Drawings.

CDM Smith (2020c), "Klamath Restoration Project – Yreka Water Conveyance Pipeline (YWCO) Class 3-4 Opinion of Probable Construction Cost (OPCC) Estimate, Klamath River Renewal Corporation", To: Seth Gentzler, AECOM, From: Ben Swann, Sri Rajah, and Bill Camp, CDM Smith. January 17, 2020.

Clair H. Hill & Associates. 1968. Main Transmission Line Klamath River Crossing.

Hydraulic Design Criteria (HDC). 1987. *In-Line Conical Transitions and Abrupt Transitions, Loss Coefficients*. HDC 228-4 to 228-4/1. U.S. Army Corps of Engineers. Revised 11-87.

Rennels, Donald C. and Hudson, Hobart M. 2012. *Pipe Flow, A Practical and Comprehensive Guide*. Hoboken, New Jersey: John Wiley & Sons.

Tullis, J.P. 1989. Hydraulics of Pipelines: Pumps, Valves, Cavitation, Transients. John Wiley & Sons, Inc.

Appendix A
Civil Design Calculations

Calculation Cover Sheet

LICENSED PROFESSIONAL ENGINEER
JEFFREY ALAN LOWY
C 79836
5/25/2022
CIVIL
STATE OF CALIFORNIA

Project: City of Yreka Waterline Modification

Client: Klamath River Renewal Corporation **Proj. No** 20-120

Title: Yreka Waterline Design Calculations

Prepared By, Name: Ryan Hudson

Prepared By, Signature: Ryan Hudson **Date:** 5/25/2022

Peer Reviewed By, Name: Jeff Lowy

Peer Reviewed, Signature: Jeff Lowy **Date:** 5/25/2022

SUBJECT:	Klamath River Renewal Corperation	**BY:**	R. Hudson	**CHK'D BY:**	J. Lowy
	City of Yreka Waterline Modification	**DATE:**	5/25/2022		
	Table of Contents	**PROJECT NO.:**	20-120		

Table of Content

SUBJECT: Klamath River Renewal Corporation | **BY:** R. Hudson | **CHK'D BY:** J. Lowy
City of Yreka Waterline Modification | **DATE:** 5/25/2022
Steel Pipe Stress | **PROJECT NO.:** 20-120

Purpose

The purpose of this calculation sheet is to calculate the stress on the A53 Steel permanent pipeline, Option A.

References

Information - Input

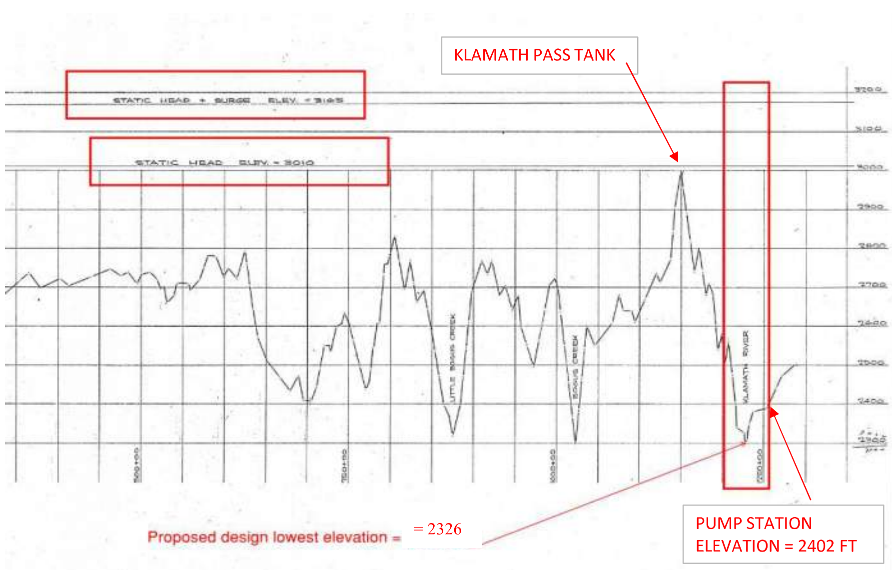
Calculation

Hydraulic and Stress Calculations for City of Yreka Waterline Sizing - Option A A53 Steel Pipe

Owner: **KRRP**
Project: **KRRP - City of Yreka Waterline Modification Project**
Segment #: **Option A Pipe** — Date: 5/17/2022
Segment Max Pres: **363 psig** **(Surge pressure per Hydrauilc Profile shown on this Sheet)**
End Joint Type: **Butt Weld**
Pipe Type: **Restrained**

Speadsheet Input Parameters (Bold):			(Manual Inputs are in Bold)
f	Darcy-Weisb. Friction Factor	**0.01**	
C_{hw}	Hazen-Williams Coef for lined Stl Pipe:	**135**	assumes new polyurethane or epoxy lined pipe
Q	Design Max. Flow Rate	**15**	cfs, all three pumps running
	Segment Lengths		
	Total Length of Waterline	**3,267**	ft
	Length of Waterline	**3,267**	ft
	Equival. Length of Fittings in Segment	**-**	ft (assume 5% for initial estimates)
	Steel Pipe Characteristics		
W	Specific Weight of Steel	**490**	lb/in^3
t	Shell Thickness	**D/240**	inch (minimum for handling for lining and coating per AWWA EQ 4-4)
	Stl Yield Stress	**36,000**	psi, minimum yield strength A53 Grade A Steel Pipe
S	Stl Allowable Stress	18,000	psi (50% yield stress per AWWA M11 p 51 recommendations)
Homax	Max Operating Head	**713.0**	**ft**
Hsurge	Surge	**839.0**	**ft**

*H is the average head over the length of the pipeline that would result in about an average thickness of the penstock -
- based upon hoop-stress design approach. Use a value that is about 60 to 70% of the max head to be conservative
Economic Diameter 1: Minimum thickness for shipping & handling
Economic Diameter 2: Internal Pressure Governs



McMILLEN JACOBS ASSOCIATES

Maximum Operating Pressure HGL =	3039	ft	Using 276 psi discharge pressure (from field pump test) at pump station with three pumps on
Surge (Max Pressure) HGL =	3165	ft	From figure above
Lowest Pipe Invert =	2326	ft	From drawings
Max Operating Head =	713	ft	309 psi
Surge =	839	ft	363 psi

$$t = \frac{pD_o}{2s}$$

Where:

t = pipe wall thickness for the internal pressure, in.
p = internal pressure, psi
D_o = outside diameter of steel pipe cylinder (not including coatings), in.
s = allowable design stress, psi

System Input Data

Max Operating Head =	**713**	ft	

Minimum Pipe Wall thickness (Handling)

Approximate Diam =	**24.0**	in	(for handling calc only)
Min wall thickness =	0.100	in	D/240 for steel pipe with cement motrar lining and flexible coating(AWWA M11 EQ. 4-4 p.52)
Min wall thickness =	0.188	in	(Nothing less than 3/16" for manufacturing process of steel)

Wall thickness Internal Hoop Stress Calculations -(under Static & Surge Conditions)

Max Operating Conditions

Static Surge multiplier:	**1.00**	unitless	(1.0 for static pressure condition)
Allowable stress in stl:	18,000	psi	allows for upto 50% of yield stress under static conditions
Hydro-static pres only: p =	309	psi	Hydro-static pressure only at Bottom of Segment
t (hydro-static) =	0.206	inch	wall thickness for hydrostatic with static surge multiplier condition

Dynamic Condition w/Transient

Allowable stress in stl:	27,000	psi	allows for upto 75% of yield stress (during short term surge per AWWA M11 p. 51 recommendations)
Static + Surge pres: p =	363	psi	Static +Surge Pressure - Worst Case (ignores actual losses in the HGL)
t =	0.161	inch	wall thickness for surge condition in pipeline area
Design Wall thickness =	**0.375**	**in**	**0.750 in WT is used for the bridge to enhance ballistic protection**
Design Wall Thickness Meets Hydrostatic	Yes		
Design Wall Thickness Meets Static + Surge	Yes		

Conclusion

The above calculation shows that a A53 steel pipe with t = 3/8" will be adequate for the Yreka Waterline pipe.

SUBJECT:	Klamath River Renewal Corporation	**BY:** R. Hudson	**CHK'D BY:** J. Lowy
	City of Yreka Waterline Modification	**DATE:** 5/25/2022	
	Steel Pipe Stress	**PROJECT NO.:** 20-120	

Purpose

The purpose of this calculation sheet is to calculate the stress on the AWWA Steel 25" OD permanent pipeline, Option C.

References

Information - Input

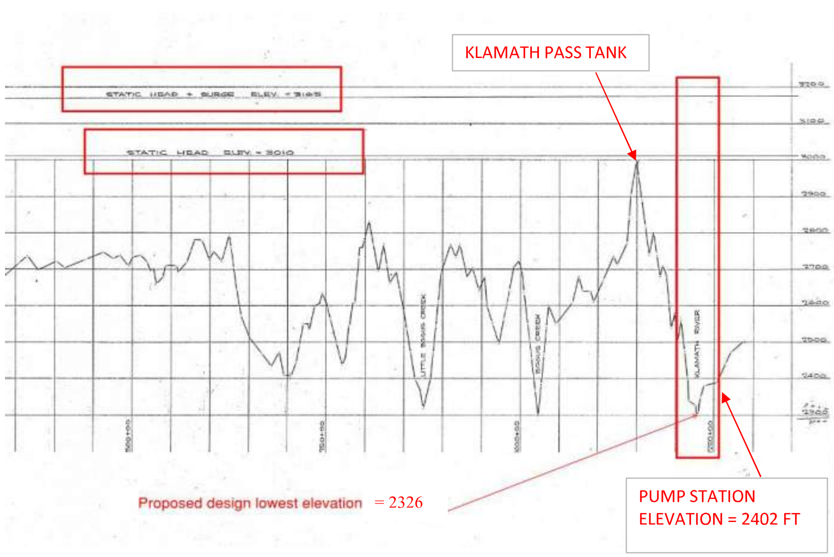
Calculation

Hydraulic and Stress Calculations for City of Yreka Waterline Sizing - Option B AWWA 25" OD Steel Pipe

Owner: **KRRP**
Project: **KRRP - City of Yreka Waterline Modification Project**
Segment #: **Option B Pipe** Date: 5/17/2022
Segment Max Pres: **363 psig** **(Surge pressure per Hydrauilc Profile shown on this Sheet)**
End Joint Type: **Butt Weld**
Pipe Type: **Restrained**

Speadsheet Input Parameters (Bold):			**(Manual Inputs are in Bold)**
f	Darcy-Weisb. Friction Factor	**0.01**	
C_{hw}	Hazen-Williams Coef for lined Stl Pipe:	**135**	assumes new polyurethane or epoxy lined pipe
Q	Design Max. Flow Rate	**15**	cfs, all three pumps running
	Segment Lengths		
	Total Length of Waterline	**3,267**	ft
	Length of Waterline	**3,267**	ft
	Equival. Length of Fittings in Segment	**-**	ft (assume 5% for initial estimates)
	Steel Pipe Characteristics		
W	Specific Weight of Steel	**490**	lb/in^3
t	Shell Thickness	**D/240**	inch (minimum for handling for lining and coating per AWWA EQ 4-4)
	Stl Yield Stress	**42,000**	psi
S	Stl Allowable Stress	21,000	psi (50% yield stress per AWWA M11 p 51 recommendations)
Homax	Max Operating Head	**713**	**ft**
Hsurge	Surge	**839**	**ft**

*H is the average head over the length of the pipeline that would result in about an average thickness of the penstock -
- based upon hoop-stress design approach. Use a value that is about 60 to 70% of the max head to be conservative
Economic Diameter 1: Minimum thickness for shipping & handling
Economic Diameter 2: Internal Pressure Governs



McMILLEN JACOBS ASSOCIATES

Maximum Operating Pressure HGL =	3039	ft	Using 276 psi discharge pressure (from field pump test) at pump station with three pumps on	
Surge (Max Pressure) HGL =	3165	ft	From figure above	
Lowest Pipe Invert =	2326	ft	From drawings	
Max Operating Head =	713	ft	309	psi
Surge =	839	ft	363	psi

$$t = \frac{pD_o}{2s}$$

Where:

t = pipe wall thickness for the internal pressure, in.
p = internal pressure, psi
D_o = outside diameter of steel pipe cylinder (not including coatings), in.
s = allowable design stress, psi

System Input Data

Max Operating Head = **713** ft

Minimum Pipe Wall thickness (Handling)

Approximate Diam =	**25.0**	in	(for handling calc only)
Min wall thickness =	0.104	in	D/240 for steel pipe with cement motrar lining and flexible coating(AWWA M11 EQ. 4-4 p.52)
Min wall thickness =	0.188	in	(Nothing less than 3/16" for manufacturing process of steel)

Wall thickness Internal Hoop Stress Calculations -(under Static & Surge Conditions)

Max Operating Conditions

Static Surge multiplier:	**1.00**	unitless	(1.0 for static pressure condition)
Allowable stress in stl:	21,000	psi	allows for upto 50% of yield stress under static conditions
Hydro-static pres only: p =	309	psi	Hydro-static pressure only at Bottom of Segment
t (hydro-static) =	0.184	inch	wall thickness for hydrostatic with static surge multiplier condition

Dynamic Condition w/Transient

Allowable stress in stl:	31,500	psi	allows for upto 75% of yield stress (during short term surge per AWWA M11 p. 51 recommendations)
Static + Surge pres: p =	363	psi	Static +Surge Pressure - Worst Case (ignores actual losses in the HGL)
t =	0.144	inch	wall thickness for surge condition in pipeline area
Design Wall thickness =	**0.3125**	**in**	**0.750 in WT is used for the bridge to enhance ballistic protection**

Design Wall Thickness Meets Hydrostatic	Yes
Design Wall Thickness Meets Static + Surge	Yes

Conclusion

The above calculation shows that a AWWA steel pipe with t = 5/16" will be adequate for the Yreka Waterline pipe.

SUBJECT: Klamath River Renewal Corporation — **BY:** R. Hudson — **CHK'D BY:** J. Lowy
City of Yreka Waterline Modification — **DATE:** 5/25/2022
Steel Pipe Defelction — **PROJECT NO.:** 20-120

Purpose

The purpose of this calculation is the calculate the deflection of the permanent pipe based on wall thickness.

References

Information - Input

Calculation

TABLE 1 - 24" DIA. STEEL WATER LINE PIPE

KRRP - City of Yreka Waterline Modification

Deflection Calculations for City of Yreka Waterline at Minimum Burial (2.5-ft Cover)

SPREADSHEET INPUTS		
Pipeline Steel Inside Diameter:	**23.3**	**inches**
Pipeline Lining Thickness:	**0.030**	**inches**
Modulus of Elasticity (E):	**30.0**	**x 10^6 psi**
Bedding Constant (K)	**0.1**	**-**
Depth of Cover over Pipe:	**2.5**	**feet**
Dead Load (Wdead):	50	lbs/lin. inch of pipe
Live Load (Wlive):	**168**	**lbs/lin. inch of pipe**
Total Pipe Load (W):	218	lbs/lin. inch of pipe
$K W r^3$ =	34,320	psi
Minimum Thickness (t) >	0.097	inches (Min. Thickness for Pipe Handling) - this formula uses the ID of the pipe

MW PIPELINE DEFLECTION DESIGN CRITERIA:

d / t < 240 for Handling Purposes of Steel Pipe (mortar lined)
Defl. < 2.25 % of Diameter for flex. coated (tape), flexible pipe
Defl. < 1.5 % of Diameter for mortar coated, flexible pipe

Assumes Cover at 125 lbs/ft3 Backfill) = (depth cover x 125 pcf /144) x dia. (inch)
HS-20 for 2.5' cover from AWWA M55 table at bottom of sheet for unpaved roads
7 psi x 24 inches = 168 lbs/in

IOWA PIPELINE DEFLECTION FORMULA = D_l x K x W x r^3 / (EI + 0.061 x E' x r^3)

Deflection Lag Factor (D_l):		**1.15**	**1.15**	**1.15**	**1.20**	**1.20**	**1.20**	**1.25**	**1.25**	**1.25**
Mod. of Soil Reaction (E') (psi):		**2,500**	**3,000**	**3,500**	**2,500**	**3,000**	**3,500**	**2,500**	**3,000**	**3,500**
		(Min. MW Lag Factor)						**(Std. MW Lag Factor=1.25)**		
Pipe Wall Thickness (t)	**Moment of Inertia (I) $I = t^3 / 12$**	**PIPELINE DEFLECTION**			**PIPELINE DEFLECTION**			**PIPELINE DEFLECTION**		
(inches)	**(inch^3)**	**(% of Diameter)**			**(% of Diameter)**			**(% of Diameter)**		
0.2500	**0.001302**	0.61	0.52	0.45	0.64	0.54	0.47	0.66	0.57	0.49
0.3125	**0.002543**	0.54	0.47	0.41	0.56	0.49	0.43	0.58	0.51	0.45
0.3750	**0.004395**	0.46	0.40	0.36	0.48	0.42	0.38	0.50	0.44	0.39
0.4375	**0.006978**	0.38	0.34	0.31	0.39	0.36	0.33	0.41	0.37	0.34
0.5000	**0.010417**	0.31	0.28	0.26	0.32	0.30	0.27	0.33	0.31	0.28
0.5625	**0.014832**	0.25	0.23	0.22	0.26	0.24	0.23	0.27	0.25	0.24
0.6250	**0.020345**	0.20	0.19	0.18	0.21	0.20	0.19	0.22	0.21	0.20
0.6875	**0.027079**	0.16	0.15	0.15	0.17	0.16	0.15	0.18	0.17	0.16
0.7500	**0.035156**	0.13	0.13	0.12	0.14	0.13	0.13	0.14	0.14	0.13

Table from AWWA M55

Table 5-3 AASHTO H20 loading under flexible pavement and unpaved roads

Height of Cover *(ft)*	Load *(psi)*
1.5	13.9
2.0	9.5
2.5	7.0
3.0	5.4
3.5	4.3
4	3.6
6	2.0
8	1.3
10	0.8

Conclusion

Steel pipe with t = 3/8" is adequately passes the deflection test

SUBJECT:	Klamath River Renewal Corporation	**BY:** R. Hudson	**CHK'D BY:** J. Lowy
	City of Yreka Waterline Modification	**DATE:** 5/25/2022	
	Steel Pipe Defelction	**PROJECT NO.:** 20-120	

Purpose

The purpose of this calculation is th ecalculate the deflection of the permanent pipe based on wall thickness.

References

Information - Input

Calculation

TABLE 1 - 25" DIA. STEEL WATER LINE PIPE

KRRP - City of Yreka Waterline Modification

Deflection Calculations for City of Yreka Waterline at Minimum Burial (2.5-ft Cover)

SPREADSHEET INPUTS			MW PIPELINE DEFLECTION DESIGN CRITERIA:
Pipeline Steel Inside Diameter:	**24.4**	**inches**	**d / t < 240 for Handling Purposes of Steel Pipe (mortar lined)**
Pipeline Lining Thickness:	**0.375**	**inches**	**Defl. < 2.25 % of Diameter for flex. coated (tape), flexible pipe**
Modulus of Elasticity (E):	**30.0**	**$x\ 10^6$ psi**	**Defl. < 1.5 % of Diameter for mortar coated, flexible pipe**
Bedding Constant (K)	**0.1**	**-**	
Depth of Cover over Pipe:	**2.5**	**feet**	
Dead Load (Wdead):	53	lbs/lin. inch of pipe	**(Assumes Cover at 125 lbs/ft3 Backfill) = (depth cover x 125 pcf /144) x dia. (inch)**
Live Load (Wlive):	**175**	**lbs/lin. inch of pipe**	**HS-20 for 2.5' cover from AWWA M55 table at bottom of sheet for unpaved roads 7 psi x 25 inches = 175 lbs/inch**
Total Pipe Load (W):	228	lbs/lin. inch of pipe	
$K\ W\ r^3$ =	41,256	psi	
Minimum Thickness (t) >	0.102	inches (Min. Thickness for Pipe Handling) - this formula uses the ID of the pipe	

IOWA PIPELINE DEFLECTION FORMULA = $D_l \times K \times W \times r^3 / (EI + 0.061 \times E' \times r^3)$

Deflection Lag Factor (D_l):		**1.15**	**1.15**	**1.15**	**1.20**	**1.20**	**1.20**	**1.25**	**1.25**	**1.25**
Mod. of Soil Reaction (E') (psi):		**2,500**	**3,000**	**3,500**	**2,500**	**3,000**	**3,500**	**2,500**	**3,000**	**3,500**
		(Min. MW Lag Factor)						**(Std. MW Lag Factor=1.25)**		
Pipe Wall Thickness (t)	**Moment of Inertia (I) $I = t^3 / 12$**	**PIPELINE DEFLECTION**			**PIPELINE DEFLECTION**			**PIPELINE DEFLECTION**		
(inches)	**($inch^3$)**	**(% of Diameter)**			**(% of Diameter)**			**(% of Diameter)**		
0.2500	**0.001302**	0.62	0.53	0.46	0.64	0.55	0.48	0.67	0.57	0.50
0.3125	**0.002543**	0.55	0.48	0.42	0.58	0.50	0.44	0.60	0.52	0.46
0.3750	**0.004395**	0.48	0.42	0.38	0.50	0.44	0.39	0.52	0.46	0.41
0.4375	**0.006978**	0.40	0.36	0.33	0.42	0.38	0.34	0.44	0.39	0.36
0.5000	**0.010417**	0.33	0.30	0.28	0.35	0.32	0.29	0.36	0.33	0.30
0.5625	**0.014832**	0.27	0.25	0.23	0.28	0.26	0.24	0.29	0.27	0.25
0.6250	**0.020345**	0.22	0.21	0.20	0.23	0.22	0.20	0.24	0.22	0.21
0.6875	**0.027079**	0.18	0.17	0.16	0.19	0.18	0.17	0.19	0.18	0.18
0.7500	**0.035156**	0.15	0.14	0.14	0.15	0.15	0.14	0.16	0.15	0.15

Table from AWWA M55

Table 5-3 AASHTO H20 loading under flexible pavement and unpaved roads

Height of Cover *(ft)*	Load *(psi)*
1.5	13.9
2.0	9.5
2.5	7.0
3.0	5.4
3.5	4.3
4	3.6
6	2.0
8	1.3
10	0.8

Conclusion

Steel pipe with t = 5/16" is adequately passes the deflection test

SUBJECT: Klamath River Renewal Corporation | **BY:** R. Hudson | **CHK'D BY:** J. Lowy
City of Yreka Water Line Modification | **DATE:** 5/25/2022
Pipe Vent Sizing | **PROJECT NO.:** 20-120

Purpose

The purpose of this calculation sheet is to size the vent pipes and combination air valves

References

- *Falvey, H.T. 1980. Air-Water Flow in Hydraulic Structures: Engineering Monograph No. 41. U.S. Department of the Interior, U.S. Bureau of Reclamation, Water and Power Resources Eservice Engineering and Research Center: Denver, CO. December 1980.*

- *Val-Matic Valve & Mfg. Corp. (Val-Matic). 2018. White Paper: Theory, Application, and Sizing of Air Valves. Accessed at www.valmatic.com.*

Method

For the pressure pipes, the combination air valves were sized according to the Val-Matic (2018) White Paper on theory, application, and sizing of air valves.

Air/Vacuum Release Valve Sizing
Equation 5

The following equation is used for sizing the air/vacuum release valve upstream of a steep slope. This performs two functions: (1) it allows the release of large amounts of air at filling so that there are no large trapped air pockets in the pipe, and (2) it releases any vacuum that may form at the top of the slope when draining the pipe. At filling there is potential for large pockets of air to get trapped at the top of the slope leading down to under the Klamath River, up over Fall Creek, and up over the Klamath River. At at the full 15 cfs flow through the supply pipe, on a the different design grades, it is expected that bubbles will move upstream and will not be carried downstream by the flow. This presents the potential for bubbles to permanently accumulate at the top of the slope, if unvented, and potentially impact the hydraulics of the pipe. Therefore, either an air-release valve or a air/vacuum release valve will be provided at the top of the slope. In either case, the required air flow will be calculated according to the Val-Matic equation 5:

$$Q_a = 678\gamma d_o^2 C_D \left(\frac{\Delta p\, p_1}{T_1 S_g}\right)^{1/2}$$

where:

- $Q_a =$ Air capacity of valve, SCFM
- $\gamma =$ Expansion Factor, .93 for exhaust at 2 psi
- $d_o =$ Diameter of valve, in
- $C_D =$ Orifice discharge coefficient, 0.6 for sharp corners
- $\Delta p =$ 2 psi for exhaust sizing w/out slow closure
- $p_1 =$ Inlet pressure, 16.7 psia for 2 psi differential
- $T_1 =$ Inlet temperature, 520 Rankine
- $S_g =$ Specific Gravity, 1 for air

The air capacity of the valve should be equal to the fill rate, as the valve will need to evacuate the volume of air (at 2 psi differential pressure) that is being replaced by the water fill rate. It is assumed that the fill rate will be 15 cfs, . This could potentially be exceeded, however, if an air release valve is used, then the valve will continue to vent trapped air after the line has achieved pressure and this is not a major concern.

Locations

The following locations were identified for necessary vent pipes and valves.

I.D.	Pipeline	Location	Type of Venting
AV-01	Permanent Pipe	Sta 0+10	Air/Vacuum (Transition from new to existing)
AV-02	Permanent Pipe	Sta 4+85	Air/Vacuum (High Point)
AV-03	Permanent Pipe	Sta 21+90	Air/Vacuum (High Point)
AV-04	Permanent Pipe	Sta 32+55	Air/Vacuum (High Point)

Calculations

Pressure Pipe Valve Sizing

	Location I.D.	Water Flow Rate, Q_w gpm	Air Demand, Q_d SCFM	Valve Size, d_o in	Expansion Factor, γ	Orifice Coeff, C_D	Diff. Pressure, Δp psi	Inlet Pressure*, p_1 psia	Valve Capacity†, Q_a SCFM	Sufficient?
	AV-01	6732	18	0.09375	0.71	0.6	150.73	320.7	25	OK
	AV-02	6732	18	0.09375	0.71	0.6	150.73	320.7	25	OK
	AV-03	6732	18	0.09375	0.71	0.6	150.73	320.7	25	OK
	AV-04	6732	18	0.09375	0.71	0.6	150.73	320.7	25	OK
Filling‡ ------	------------->	Release								
Turn 1 pump	AV-01	2244	300	3	0.93	0.6	2	16.7	863	OK
on	AV-02	2244	300	3	0.93	0.6	2	16.7	863	OK
	AV-03	2244	300	3	0.93	0.6	2	16.7	863	OK
	AV-04	2244	300	3	0.93	0.6	2	16.7	863	OK
Draining‡ ----	------------->	Vacuum								
Turn 1 pump	AV-01	2244	300	3	0.79	0.6	5	14.7	1087	OK
off	AV-02	2244	300	3	0.79	0.6	5	14.7	1087	OK
	AV-03	2244	300	3	0.79	0.6	5	14.7	1087	OK
	AV-04	2244	300	3	0.79	0.6	5	14.7	1087	OK

* Inlet pressure in psia, assumes 14.7 psi atmospheric

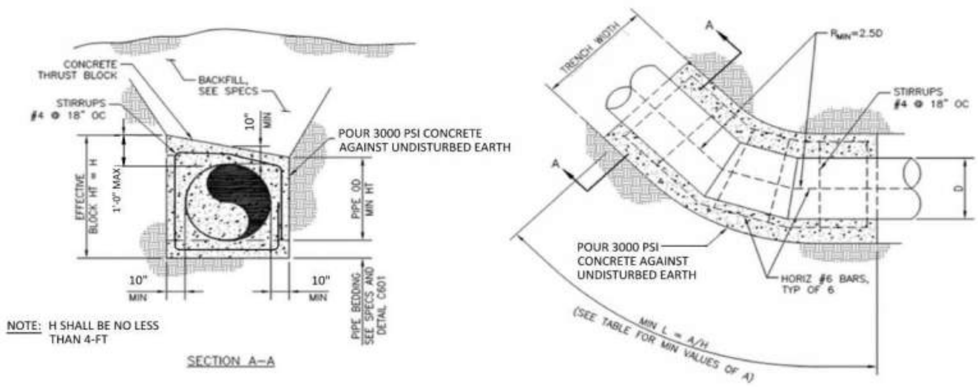
† Note, equations are different for two rows, as the applications are different. Do not drag down.

‡ Filling is a concern for all valves so both cases were looked at during the valve sizing.

Conclusions

Four locations were identified that would require air vents either because (1) trapped air would accumulate in pressure lines, or (2) air would be trapped at pipe filling and would not be flushed by maximum flows in the pipeline. For cases 1 and 2 the methods outlined by Val-Matic (2018) were used to size air-release or air/vacuum release valves. A summary for each of the identified locations is provided in the table below:

Location I.D.	Nom. Vent/Valve Size in	Air Demand, Q_a cfs
VT1	3	5.00
VT2	3	5.00
VT3	3	5.00
VT4	3	5.00



REQUIRED BEARING AREA TABLE (A = L*H) TABLE FOR BURIED THRUST BLOCKS, DETAIL C-906 (SQ. FT)
(TABLE ASSUMES PROJECT SPECIFIC UNDISTURBED TRENCH SOIL-BEARING CAPACITY OG 3,500 PSF)

PIPE BEND (DEG):	**22.5**	**45.0**	**65.0**
MAX OPERATING PRESSURE (PSI):	**< 310**	**< 310**	**< 310**
NOM PIPE DIAMETER (INCHES):	**3,500***		
24	16	31	43
25	17	33	47
	* NOTE THAT THIS BEARING CAPACITY DOES NOT APPLY TO ANY OTHER PORTIONS OF THE PROJECT & SHALL BE USED ONLY FOR THE WATERLINE THRUST BLOCKS CALCS. CONTRACTOR SHALL UTILIZE 310 PSIG PRESSURE COLUMN WHEN DETERMINING REQUIRED BEARKING AREA FROM TABLE ABOVE.		

Appendix B
Hydraulic Design Calculations

Calculation Cover Sheet

LICENSED PROFESSIONAL ENGINEER
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5/25/2022
CIVIL
STATE OF CALIFORNIA

Project: City of Yreka Waterline Pipe Crossing

Client: Klamath River Renewal Project **Proj. No.:** 20-120

Title: Hydraulic Headloss Calculations

Prepared By, Name: Ryan Hudson

Prepared By, Signature: Ryan Hudson **Date:** 5/25/2022

Peer Reviewed By, Name: Jeff Lowy

Peer Reviewed, Signature: Jeff Lowy **Date:** 5/25/2022

SUBJECT:	Klamath River Renewal Project	**BY:** R. Hudson	**CHK'D BY:** J. Lowy
	City of Yreka Waterline Pipe Crossing	**DATE:** 5/25/2022	
	Hydraulic Calculations	**PROJECT NO.:** 20-120	

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SUBJECT:	Klamath River Renewal Project	**BY:** R. Hudson	**CHK'D BY:** J. Lowy
	City of Yreka Waterline Pipe Crossing	**DATE:** 5/25/2022	
	Existing Pipe Headloss	**PROJECT NO.:** 20-120	

Purpose

The purpose of this calculation sheet is to analyze the hydraulic headlosses in the Existing Pipe, that is to be bypassed.

References

- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*
- *Rennels, Donald C. and Hudson, Hobart M. (2012) Pipe Flow, A Practical and Comprehensive Guide. Hoboken, New Jersey: John Wiley & Sons.*
- *Dudgeon, C.R. (1983). Friction Loss Test on Cement Lined Stell Pipes. Research Report No. 158. The University of New South Wales, School of Civil Engineering, Water Research Laboratory. August 1983.*

Equations

$$h_L = \frac{fL}{D}\frac{V^2}{2g} + \sum K_l \frac{V^2}{2g}$$

$$\frac{1}{\sqrt{f}} = 1.14 - 2\log\left(\frac{e}{D} + \frac{9.35}{R_e\sqrt{f}}\right)$$ Colebrook-White Equation

$$V = \frac{Q}{A} \qquad A = \frac{\pi D^2}{4} \qquad R_e = \frac{VD}{\nu}$$

Where:

Q =	Flow Rate (ft³/s)	f =	friction factor
D =	Pipe Diameter (ft)	L =	Pipe Length
A =	Pipe Cross-Sectional Area (ft²)	g =	Gravitational Acceleration (ft/s²)
V =	Average Pipe Velocity (ft/s)	K_l =	Minor Loss Coefficient
e =	Pipe Roughness factors (ft)	h_L =	Headloss (ft)
R_e =	Reynolds Number		

Information

Unit Weight of Water, γ =	62.37	lbs/ft³	
Kinematic Viscosity, ν =	1.217E-05	ft²/s	Kinematic Viscosity at 60° F
Acceleration of Gravity, g =	32.2	ft/s²	
Density of Water, ρ =	1.938	slugs/ft³	
Mortar Lined Steel Pipe, e =	0.11	mm	Published Value for new mortar lined pipe, 0.011 mm (WRL Research Report 158)
Mortar Lined Steel Pipe, e =	0.00036	ft	using order of magnitude reduction to account for age
Pipe Outside Diameter, OD =	24	in	24 inch Mortar Lined Steel Pipe
Steel Thickness =	0.3125	in	
Mortar Lining Thickness =	0.375	in	
Pipe Inside Diameter, ID =	22.625	in	
Pipe Inside Diameter, ID =	1.89	ft	
Evaluated Pipe Length, L =	1325	ft	STA 1236+00 to 1222+75
33.22° Miter Bend, K_l =	0.18		Equation 15.5 (Rennels & Hudson, 2012)
34.37° Miter Bend, K_l =	0.19		Equation 15.5 (Rennels & Hudson, 2012)
33.50° Miter Bend, K_l =	0.18		Equation 15.5 (Rennels & Hudson, 2012)
5.50° Miter Bend, K_l =	0.02		Equation 15.5 (Rennels & Hudson, 2012)
6.00° Miter Bend, K_l =	0.02		Equation 15.5 (Rennels & Hudson, 2012)
12.00° Miter Bend, K_l =	0.05		Equation 15.5 (Rennels & Hudson, 2012)
18.50° Miter Bend, K_l =	0.08		Equation 15.5 (Rennels & Hudson, 2012)
20.00° Miter Bend, K_l =	0.09		Equation 15.5 (Rennels & Hudson, 2012)

Calculation - Existing Yreka Waterline - STA 1236+00 to 1224+0(

Flow, Q =	15.0	cfs	
Pipe Diameter ID, D =	1.89	ft	
Pipe Area, A =	2.79	ft²	
Pipe Length, L =	1325	ft	
Pipe Velocity, V =	5.37	ft/s	
Velocity Head =	0.448	ft	Velocity Head, $V^2/2g$
Pipe Rising Mains, e =	0.0004	ft	
Plastic Pipe friction factor, f =	0.0148		Colebrook-White Equation
friction Losses, h_f =	4.65	ft	Friction Losses, $fL/D\ (V^2/2g)$
Minor Loss, K_l =	0.81		Includes: Multiple Miter Bends
Minor Losses, h_l =	0.36	ft	Minor Losses, $K_l\ (V^2/2g)$
Total Losses, h_L =	5.01	ft	

Summary of Results - Existing Yreka Waterline

Flow (MGD)	Flow (cfs)	Velocity (ft/s)	friction Losses (ft)	Minor Losses (ft)	Total Headloss (ft)
9.7	15	5.4	4.6	0.4	5.0
7.1	11	3.9	2.6	0.2	2.8
3.9	6	2.1	0.8	0.1	0.9

SUBJECT: Klamath River Renewal Project
City of Yreka Waterline Pipe Crossing
New Alignment Pipe Headloss

BY: R. Hudson CHK'D BY: J Lowy
DATE: 5/25/2022
PROJECT NO.: 20-120

Purpose

The purpose of this calculation sheet is to analyze the hydraulic headlosses of the new alignment pipeline over Daggett Bridge.

References

- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*
- *Rennels, Donald C. and Hudson, Hobart M. (2012) Pipe Flow, A Practical and Comprehensive Guide. Hoboken, New Jersey: John Wiley & Sons.*
- *Hydraulic Design Criteria (HDC). (1987). In-Line Conical Transitions and Abrupt Transitions, Loss Coefficients. HDC 228-4 to 228-4/1. U.S. Army Corps of Engineers. Revised 11-87.*
- *Dudgeon, C.R. (1983). Friction Loss Test on Cement Lined Steel Pipes. Research Report No. 158. The University of New South Wales, School of Civil Engineering, Water Research Laboratory. August 1983.*

Equations

$$h_L = \frac{fL}{D}\frac{V^2}{2g} + \sum K_l \frac{V^2}{2g}$$

$$V = \frac{Q}{A} \qquad A = \frac{\pi D^2}{4} \qquad R_e = \frac{VD}{\nu}$$

$$\frac{1}{\sqrt{f}} = 1.14 - 2\log\left(\frac{e}{D} + \frac{9.35}{R_e\sqrt{f}}\right)$$ Colebrook-White Equation

Where:

Q = Flow Rate (ft³/s)
D = Pipe Diameter (ft)
A = Pipe Cross-Sectional Area (ft²)
V = Average Pipe Velocity (ft/s)
e = Pipe Roughness factors (ft)
R_e = Reynolds Number
f = friction factor
L = Pipe Length
g = Gravitational Acceleration (ft/s²)
K_l = Minor Loss Coefficient
h_L = Headloss (ft)

Information

Unit Weight of Water, γ =	62.37	lbs/ft³	
Kinematic Viscosity, ν =	1.217E-05	ft²/s	Kinematic Viscosity at 60° F
Acceleration of Gravity, g =	32.2	ft/s²	
Mortar Lined Steel Pipe, e =	0.01	mm	Published Value for new mortar lined pipe, 0.011 mm (WRL Research Report 158)
Mortar Lined Steel Pipe, e =	0.000036	ft	
Epoxy Lined Steel Pipe, e =	0.00150	mm	Very Smooth, similar to plastic pipe Table 8.1 Reynolds Hudson 2012
Epoxy Lined Steel Pipe, e =	0.0000049	ft	

Pipe Description	Outside Diameter (in)	Wall Thickness (in)	Lining Thickness (in)	Inside Diameter (in)	Inside Diameter (ft)
25" OD - Cement Mortar Lined	25.00	0.3125	0.375	23.625	1.97
24" OD - Epoxy Lined	24.00	0.375		23.25	1.94
25" OD - Epoxy Lined, Bridge	25.00	0.75		23.5	1.96
24" OD - Epoxy Lined. Bridge	24.00	0.75		22.5	1.88

Evaluated Pipe Length, L =	3267	ft	from Pipe STA 0+00 to 32+67			
32.0° Miter Bend, K_l =	0.17		Equation 15.5 (Rennels & Hudson, 2012)			
22.5° Miter Bend, K_l =	0.10		Equation 15.5 (Rennels & Hudson, 2012)			
45° Miter Bend, K_l =	0.30		Equation 15.5 (Rennels & Hudson, 2012)			
37° Miter Bend, K_l =	0.22		Equation 15.5 (Rennels & Hudson, 2012)			
63.36° Miter Bend, K_l =	0.59		Equation 15.5 (Rennels & Hudson, 2012)			
21.32° Miter Bend, K_l =	0.09		Equation 15.5 (Rennels & Hudson, 2012)			
22.5° Miter Bend, K_l =	0.10		Equation 15.5 (Rennels & Hudson, 2012)			
2.1° Miter Bend, K_l =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
16.4° Miter Bend, K_l =	0.07		Equation 15.5 (Rennels & Hudson, 2012)			
3.02° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
0.01° Miter Bend, Kl =	0.00		Equation 15.5 (Rennels & Hudson, 2012)			
3.34° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
2.26° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
2.92° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
0.71° Miter Bend, Kl =	0.00		Equation 15.5 (Rennels & Hudson, 2012)			
44.04° Miter Bend, Kl =	0.29		Equation 15.5 (Rennels & Hudson, 2012)			
45° Miter Bend, Kl =	0.30		Equation 15.5 (Rennels & Hudson, 2012)			
45° Miter Bend, Kl =	0.30		Equation 15.5 (Rennels & Hudson, 2012)			
45° Miter Bend, Kl =	0.30		Equation 15.5 (Rennels & Hudson, 2012)			
45° Miter Bend, Kl =	0.30		Equation 15.5 (Rennels & Hudson, 2012)			
43.68° Miter Bend, Kl =	0.29		Equation 15.5 (Rennels & Hudson, 2012)			
8.69° Miter Bend, Kl =	0.03		Equation 15.5 (Rennels & Hudson, 2012)			
6.46° Miter Bend, Kl =	0.02		Equation 15.5 (Rennels & Hudson, 2012)			
2.3° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
2.38° Miter Bend, Kl =	0.01		Equation 15.5 (Rennels & Hudson, 2012)			
Full Open Isolation Valve, K_l =	0.2		Full Open Butterfly Valve (Tullis, 1989)			x2
Converging Flow thru Branch Tee, K_l =	1.1		Diagram 16.10 (Rennels & Hudson, 2012)	q_3/q_1 =	1	
Diverging Flow thru Branch Tee, K_l =	1.3		Diagram 16.2 (Rennels & Hudson, 2012)	d_3/d_1 =	1	

Calculation - New Alignment, Yreka Waterline, 25" OD - Cement Mortar Lined

Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.97	1.97	1.97	ft	25" OD - Cement Mortar Lined
Pipe Area, A =	3.04	3.04	3.04	ft^2	
Pipe Velocity, V =	4.93	3.61	1.97	ft/s	
Velocity Head =	0.377	0.203	0.060	ft	Velocity Head, $V^2/2g$
Minor Loss, K_l =	2.80	2.80	2.80		Includes: Converging and Diverging Tees, Isolation Valves (x2)
Minor Losses, h_l =	1.06	0.57	0.17	ft	Minor Losses, K_l ($V^2/2g$)
Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.97	1.97	1.97	ft	25" OD - Cement Mortar Lined
Pipe Area, A =	3.04	3.04	3.04	ft^2	
Pipe Length, L =	3003	3003	3003	ft	
Pipe Velocity, V =	4.93	3.61	1.97	ft/s	
Velocity Head =	0.377	0.203	0.060	ft	Velocity Head, $V^2/2g$
Pipe Rising Mains, e =	0.000036	0.000036	0.000036	ft	Mortar
Calculated Pipe friction factor, f =	0.0125	0.0131	0.0145		Colebrook-White Equation
friction Losses, h_f =	7.17	4.05	1.33	ft	Friction Losses, fL/D ($V^2/2g$)
Minor Loss, K_l =	3.87	3.87	3.87		Includes: Multiple Miter Bends
Minor Losses, h_l =	1.46	0.78	0.23	ft	Minor Losses, K_l ($V^2/2g$)
Total Losses, h_L =	8.63	4.83	1.57	ft	

Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.96	1.96	1.96	ft	25" OD - Epoxy Lined, Bridge
Pipe Area, A =	3.01	3.01	3.01	ft²	
Pipe Length, L =	264	264	264	ft	
Pipe Velocity, V =	4.98	3.65	1.99	ft/s	
Velocity Head =	0.385	0.207	0.062	ft	Velocity Head, $V^2/2g$
Pipe Rising Mains, e =	0.000005	0.000005	0.000005	ft	Mortar
Calculated Pipe friction factor, f =	0.0122	0.0128	0.0143		Colebrook-White Equation
friction Losses, h_f =	0.63	0.36	0.12	ft	Friction Losses, $fL/D\ (V^2/2g)$
Minor Loss, K_l =	0.00	0.00	0.00		Includes: Multiple Miter Bends
Minor Losses, h_l =	0.00	0.00	0.00	ft	Minor Losses, $K_l\ (V^2/2g)$
Total Losses, h_L =	0.63	0.36	0.12	ft	
Total Losses, H_L =	**10.31**	**5.76**	**1.86**	ft	

Calculation - New Alignment, Yreka Waterline, 24" OD - Epoxy Lined

Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.94	1.94	1.94	ft	24" OD - Epoxy Lined
Pipe Area, A =	2.95	2.95	2.95	ft²	
Pipe Velocity, V =	5.09	3.73	2.04	ft/s	
Velocity Head =	0.402	0.216	0.064	ft	Velocity Head, $V^2/2g$
Minor Loss, K_l =	2.80	2.80	2.80		Includes: Converging and Diverging Tees, Isolation Valves (x2)
Minor Losses, h_l =	1.13	0.61	0.18	ft	Minor Losses, $K_l\ (V^2/2g)$

Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.94	1.94	1.94	ft	24" OD - Epoxy Lined
Pipe Area, A =	2.95	2.95	2.95	ft²	
Pipe Length, L =	3003	3003	3003	ft	
Pipe Velocity, V =	5.09	3.73	2.04	ft/s	
Velocity Head =	0.402	0.216	0.064	ft	Velocity Head, $V^2/2g$
Pipe Rising Mains, e =	0.000005	0.000005	0.000005	ft	Epoxy
Calculated Pipe friction factor, f =	0.0121	0.0128	0.0143		Colebrook-White Equation
friction Losses, h_f =	7.56	4.29	1.42	ft	Friction Losses, $fL/D\ (V^2/2g)$
Minor Loss, K_l =	3.87	3.87	3.87		Includes: Multiple Miter Bends
Minor Losses, h_l =	1.56	0.84	0.25	ft	Minor Losses, $K_l\ (V^2/2g)$
Total Losses, h_L =	9.11	5.13	1.67	ft	

Flow, Q =	15.0	11.0	6.0	cfs	
Pipe Diameter ID, D =	1.88	1.88	1.88	ft	24" OD - Epoxy Lined, Bridge
Pipe Area, A =	2.76	2.76	2.76	ft²	
Pipe Length, L =	264	264	264	ft	
Pipe Velocity, V =	5.43	3.98	2.17	ft/s	
Velocity Head =	0.458	0.246	0.073	ft	Velocity Head, $V^2/2g$
Pipe Rising Mains, e =	0.000005	0.000005	0.000005	ft	Epoxy
Calculated Pipe friction factor, f =	0.0121	0.0127	0.0142		Colebrook-White Equation
friction Losses, h_f =	0.78	0.44	0.15	ft	Friction Losses, $fL/D\ (V^2/2g)$
Minor Loss, K_l =	0.00	0.00	0.00		Includes: Multiple Miter Bends
Minor Losses, h_l =	0.00	0.00	0.00	ft	Minor Losses, $K_l\ (V^2/2g)$
Total Losses, h_L =	0.78	0.44	0.15	ft	
Total Losses, H_L =	**11.02**	**6.17**	**2.00**	ft	

Results

25-inch Mortar Lined Steel Pipe

Flow (MGD)	Flow (cfs)	Pipe Velocity (ft/s)	friction Losses (ft)	Minor Losses (ft)	Total Headloss (ft)
9.7	15	4.9	7.8	2.5	10.3
7.1	11	3.6	4.4	1.4	5.8
3.9	6	2.0	1.5	0.4	1.9

24-inch Epoxy Lined Steel Pipe

Flow (MGD)	Flow (cfs)	Pipe Velocity (ft/s)	friction Losses (ft)	Minor Losses (ft)	Total Headloss (ft)
9.7	15	5.1	8.3	2.7	11.0
7.1	11	3.7	4.7	1.4	6.2
3.9	6	2.0	1.6	0.4	2.0

Comparison to Existing Pipeline Segement

Flow (MGD)	Flow (cfs)	Existing Total Headloss (ft)	25" Mortar Lined Total Headloss (ft)	Percent Change (%)	24" Epoxy Lined Total Headloss (ft)	Percent Change (%)
9.7	15	5.0	10.3	210%	11.0	220%
7.1	11	2.8	5.8	210%	6.2	220%
3.9	6	0.9	1.9	210%	2.0	230%

Appendix C
Geotechnical Boring Logs

FOR INFORMATION ONLY

Date(s) Drilled	**1/22/2019-1/23/209**	Logged By	**S. Janowski**	Checked By	**P. Respess**
Drilling Method	**Solid Stem Auger, HQ-3 Rock Core**	Drill Bit Size/Type	**4-inch solid stem auger, 4-inch diamond coring bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Truck Mounted CME 75**	Drilling Contractor	**Taber Drilling**	NAVD 88 Ground Surface Elevation	**2344 feet**
Groundwater Level	**11.7' 1/23/2019**	Sampling Methods	**2.5-inch ID ModCal, SPT, HQ Core Barrel**	Hammer Data	**Automatic hammer; 140 lbs, 30-inch drop**
Borehole Backfill	**Cement grout to ground surface**	Borehole Location	**North end of Daggett Road Bridge**	Coordinate Location	**N 2602349 E 6462482**

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows / 6 in.	Recovery, %	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
2344	0								SANDY LEAN CLAY with GRAVEL (CL); very stiff; moist; dark brown (10yr3/3); 20% subrounded to rounded GRAVEL to 3/4"; 20% fine- to medium-grained SAND; 60% medium plasticity FINES --FILL--						
	1														
2342	2														
	3														
2340	4														
	5										1-1 1-2	6 6 8	78		pp=3.0 tsf
2338	6														
	7								CLAYEY GRAVEL with SAND (SC); very dense; moist; yellowish brown to dark brown; interbedded layers of gravel with clay and sand --ALLUVIUM--						Fill estimate based on height of slope embankment
2336	8														
	9														
2334	10										2	100/1"	100		
	11								▼						
2332	12														
	13														

Project: Klamath River Renewal Project
Project Location: Copco and Iron Gate Reservoirs
Project Number: 60537920

Log of Soil and Core Boring B-17

Date(s) Drilled	**1/22/2019**	Logged By	**S. Janowski**	Checked By	**P. Respess**
Drilling Method	**Solid Stem Auger, HQ-3 Rock Core**	Drill Bit Size/Type	**4-inch solid stem auger, 4-inch diamond coring bit**	Total Depth of Borehole	**41.5 feet**
Drill Rig Type	**Truck Mounted CME 75**	Drilling Contractor	**Taber Drilling**	NAVD 88 Ground Surface Elevation	**2341 feet**
Groundwater Level	**Not encountered before HQ rock coring**	Sampling Methods	**2.5-inch ID ModCal, SPT, HQ Core Barrel**	Hammer Data	**Automatic hammer; 140 lbs, 30-inch drop**
Borehole Backfill	**Cement grout to ground surface**	Borehole Location	**South end of Daggett Road Bridge**	Coordinate Location	**N 2602195 E 6462721**

Elevation, feet	Depth, feet	Lithology	MATERIAL DESCRIPTION	Soil Sample Number	Blows / 6 in.	Recovery, %	FIELD NOTES AND TEST RESULTS
2341	0	Gravelly clay with sand	GRAVELLY CLAY with SAND (CL); stiff; moist; dark brown (7.5YR3/3); subangular to subrounded GRAVEL to 1/2"; medium-grained SAND; medium plasticity FINES --FILL--				
	5			1-1 1-2	5 50/5"	100	pp=1.0 tsf Driller adds water to facilitate advancement
	8.5	Sandy gravel	SANDY GRAVEL (GP); very dense; moist; brown; subangular to subrounded GRAVEL to 2.25"; medium- to coarse-grained SAND --ALLUVIUM--				
	10			2-1 2-2	42 50/4"	100	
	12.5	Breccia	VOLCANICLASTIC BRECCIA --TERTIARY VOLCANICS--				Driller felt change during advancement

Elevation scale: 2340, 2338, 2336, 2334, 2332, 2330, 2328. Depth scale: 0–13 feet.

Rock core columns (Run No., Box No., Recovery, %, Fractures per Foot, R Q D, %, Fracture Drawing Number) and Drill Time [Rate, ft/hr]: no entries on this sheet.