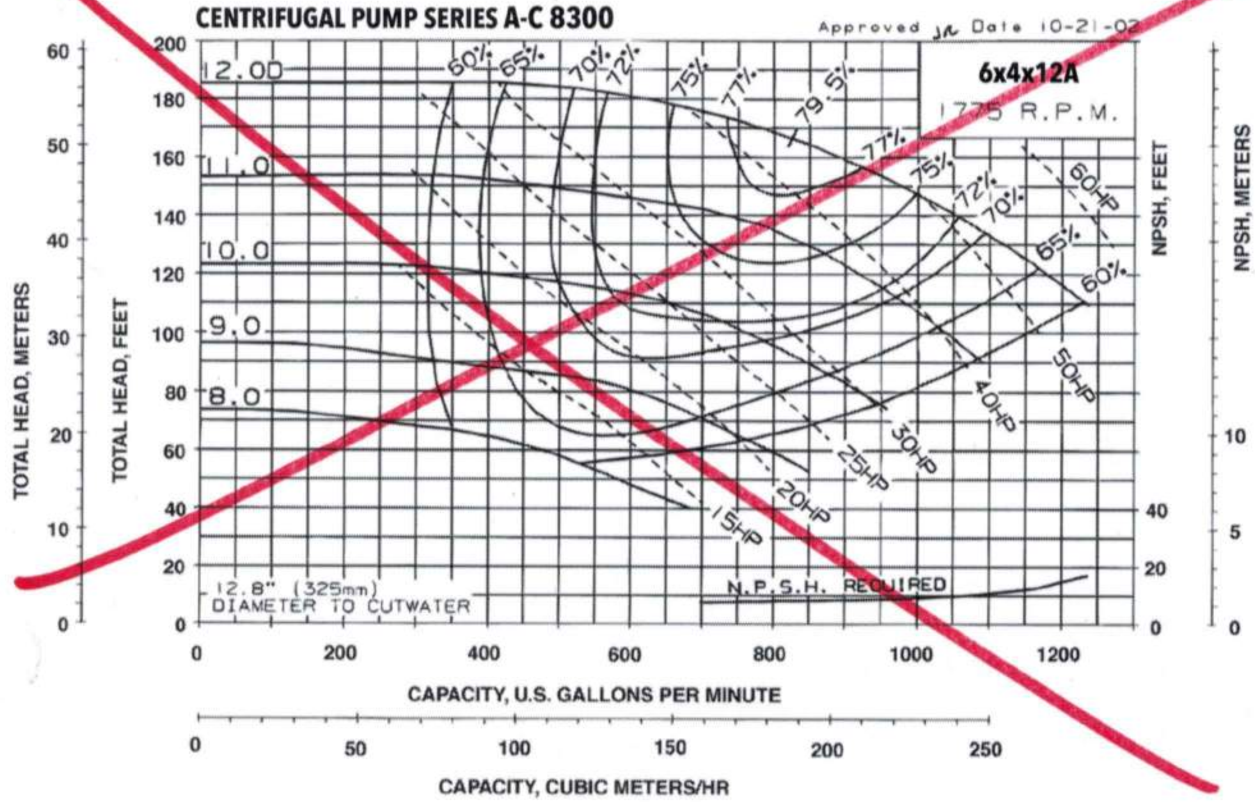
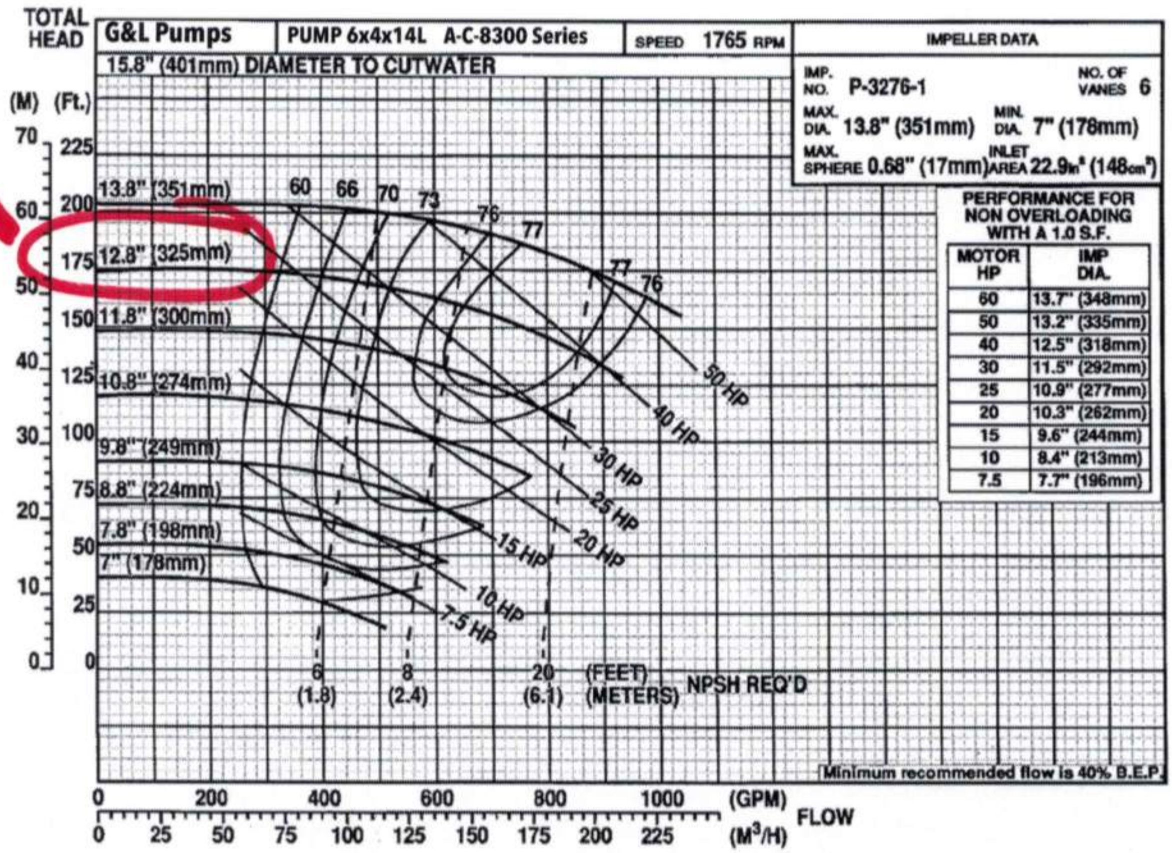
Appendix A

Pump Station Pump Curves

1750 RPM PUMP CURVES

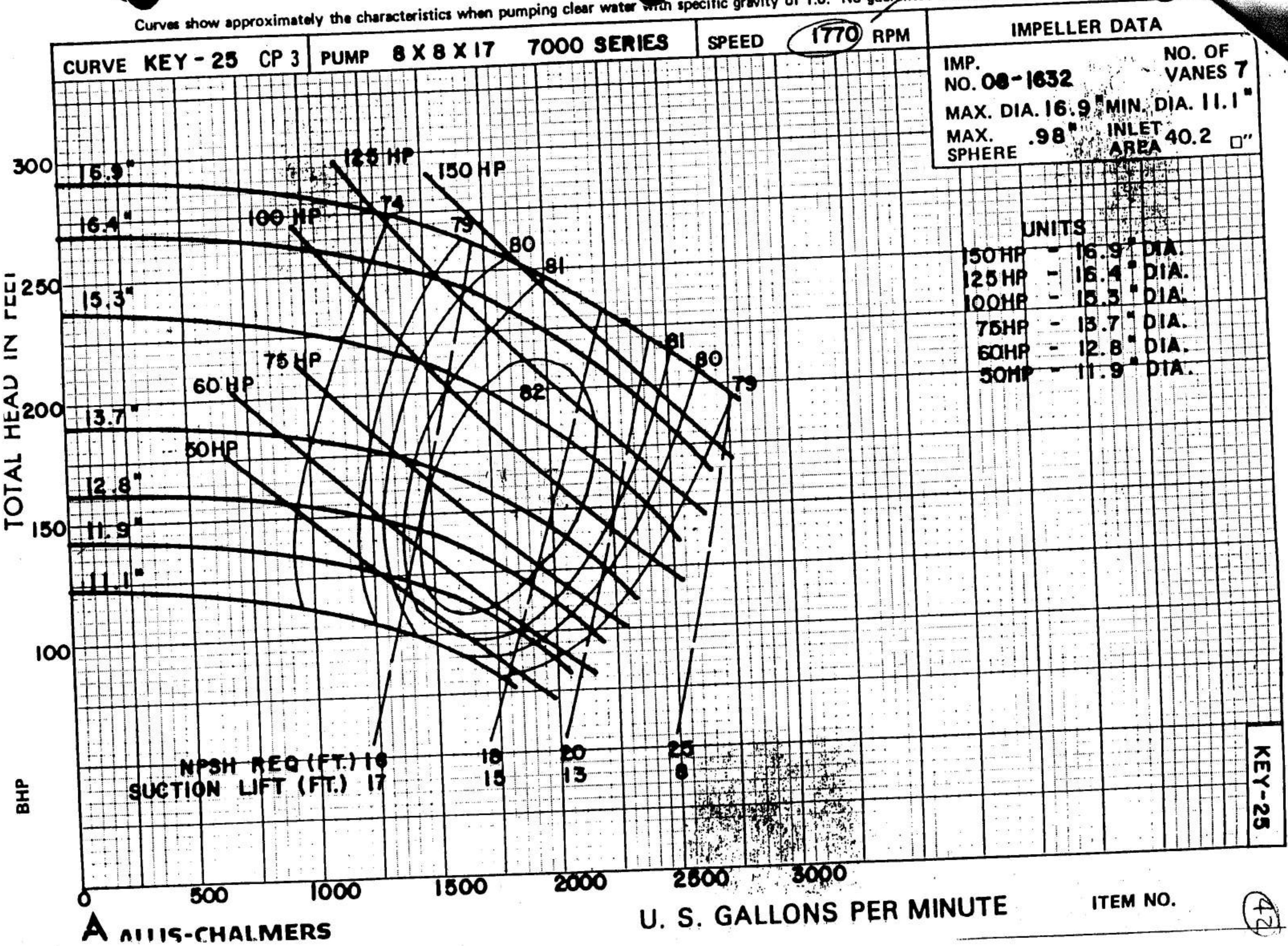
AKA 3408A





34th #2

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated p[illegible]



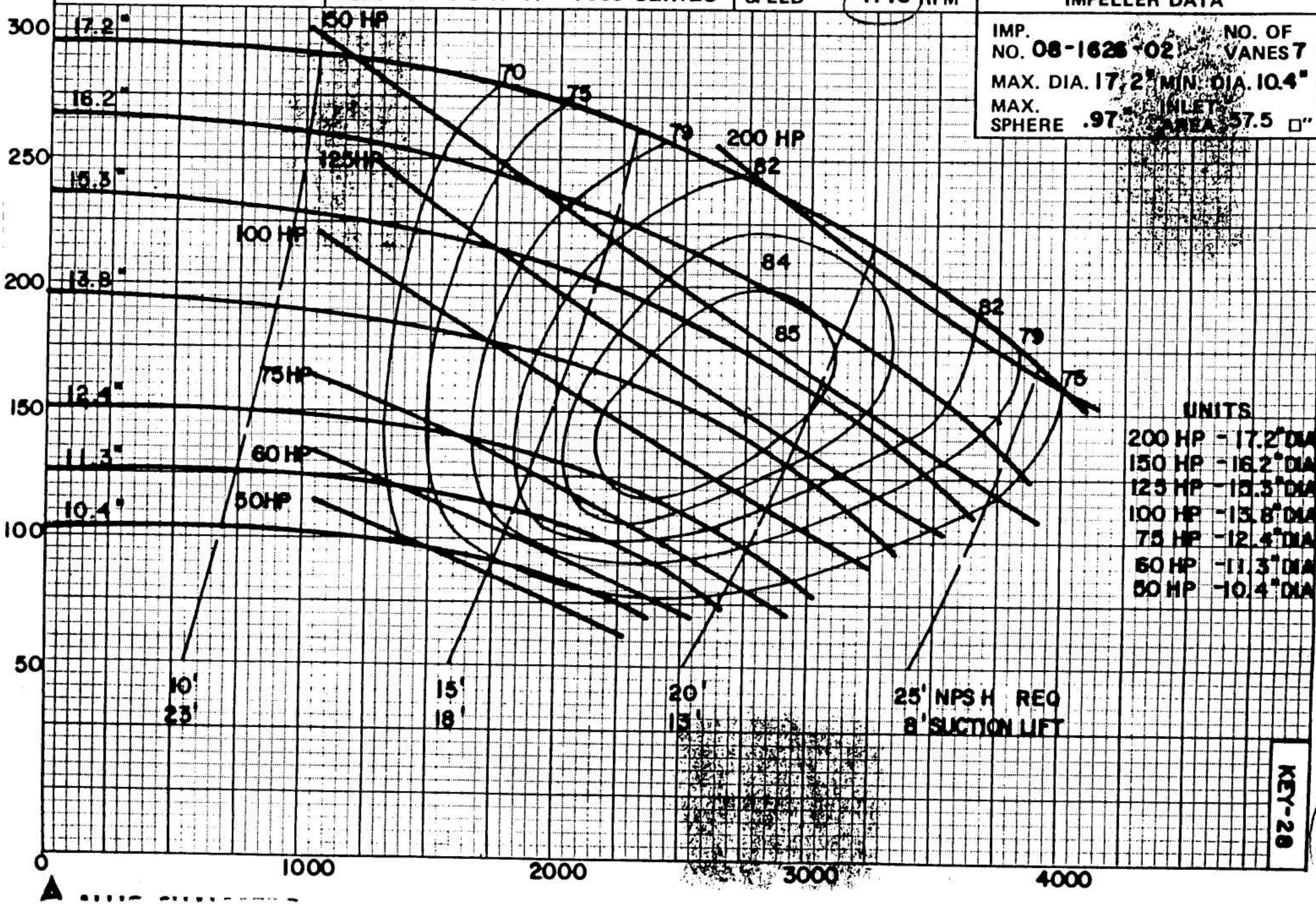
34th #3

#43

NPS 1750

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.

CURVE KEY-28 CP 3	PUMP 10 X 8 X 17 7000 SERIES	SPEED 1770 RPM	IMPELLER DATA
			IMP. NO. 08-1628-02 NO. OF VANES 7
			MAX. DIA. 17.2" MIN. DIA. 10.4"
			MAX. SPHERE .97" INLET AREA 57.5 □"



#43

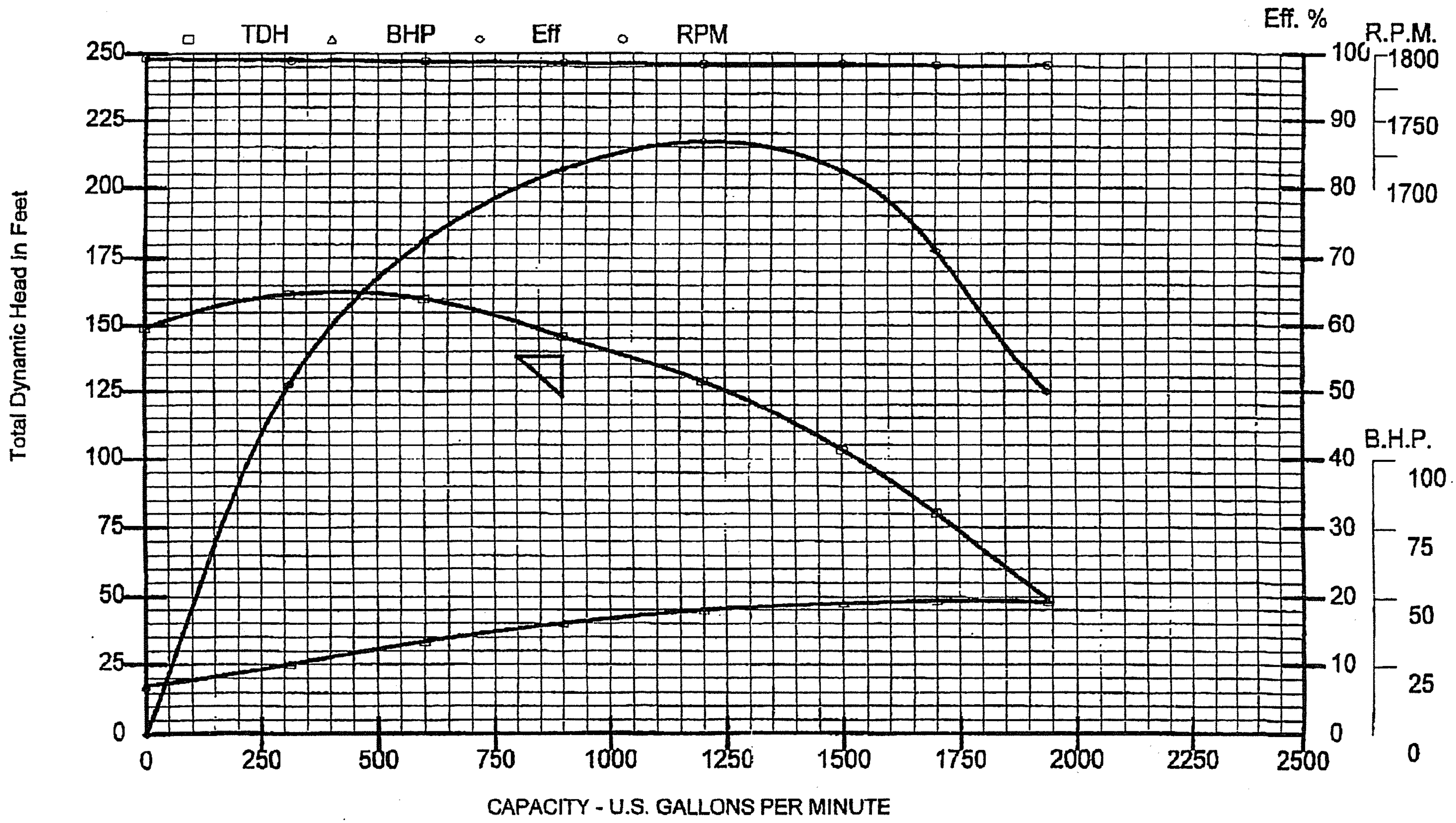
Gibson #1

Certified By 3/20/99 Date

AURORA®
PENTAIR PUMP GROUP

Pump No:	99-05492-1
Size:	5x6x15
Type:	411
R.P.M.:	Test
Stage:	1
Spec. Gravity:	1.0
Imp. Dia.:	12.37
Impeller Patt. No:	
Curve No:	168857
Test No:	0399163
Plotted By:	5260, DM
Date:	03/20/99

QUEEN PUMP
Customer



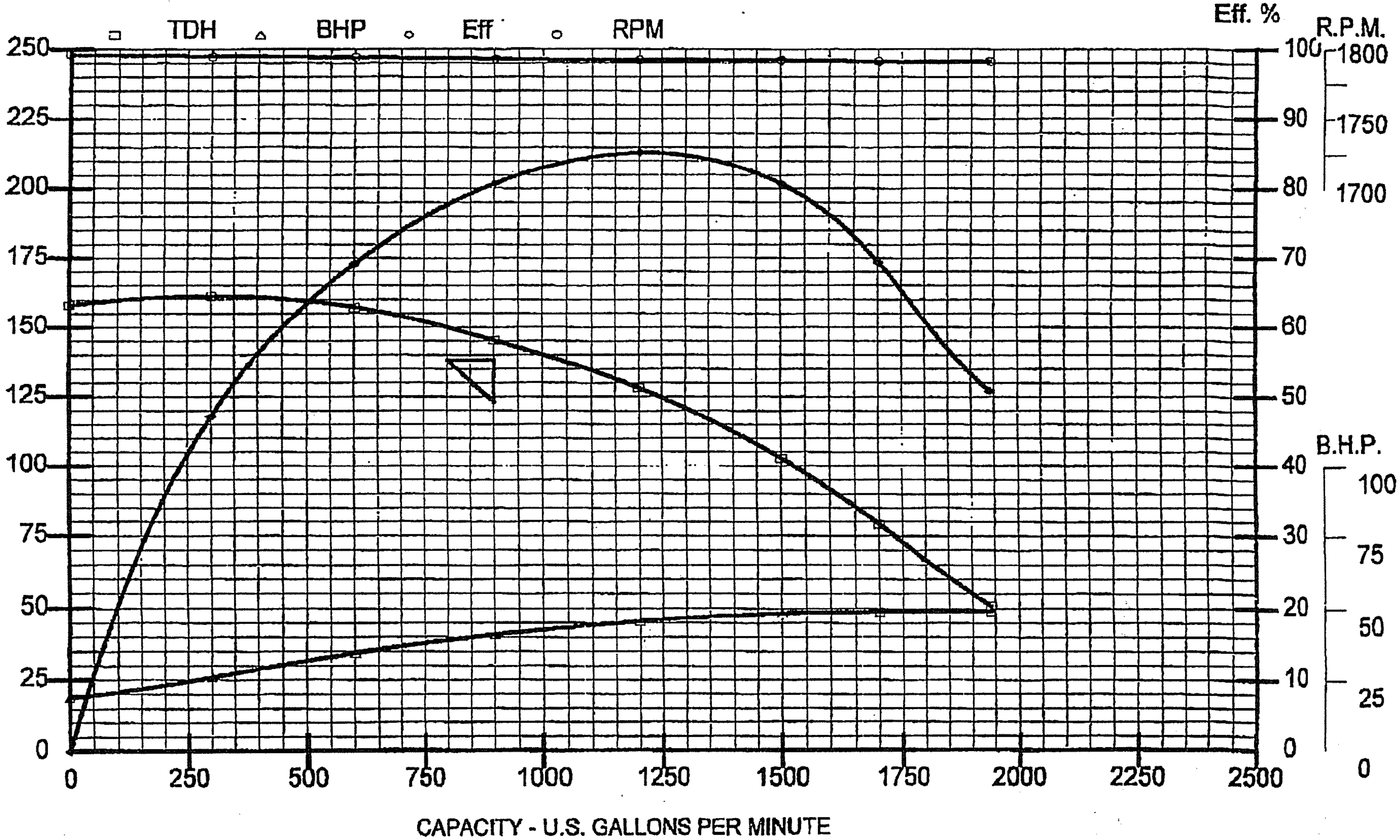
Gibson #2

Certified By 3/20/99 Date

AURORA®
PENTAIR PUMP GROUP

Pump No: 99-05[illegible]2-2
Size: 5x6x15
Type: 411
R.P.M.: Test
Stage: 1
Spec. Gravity: 1.0
Imp. Dia.: 12.37
Impeller Patt. No:
Curve No: 168854
Test No: 0399162
Plotted By: 5260, DM
Date: 03/20/99

QUEEN PUMP
Customer



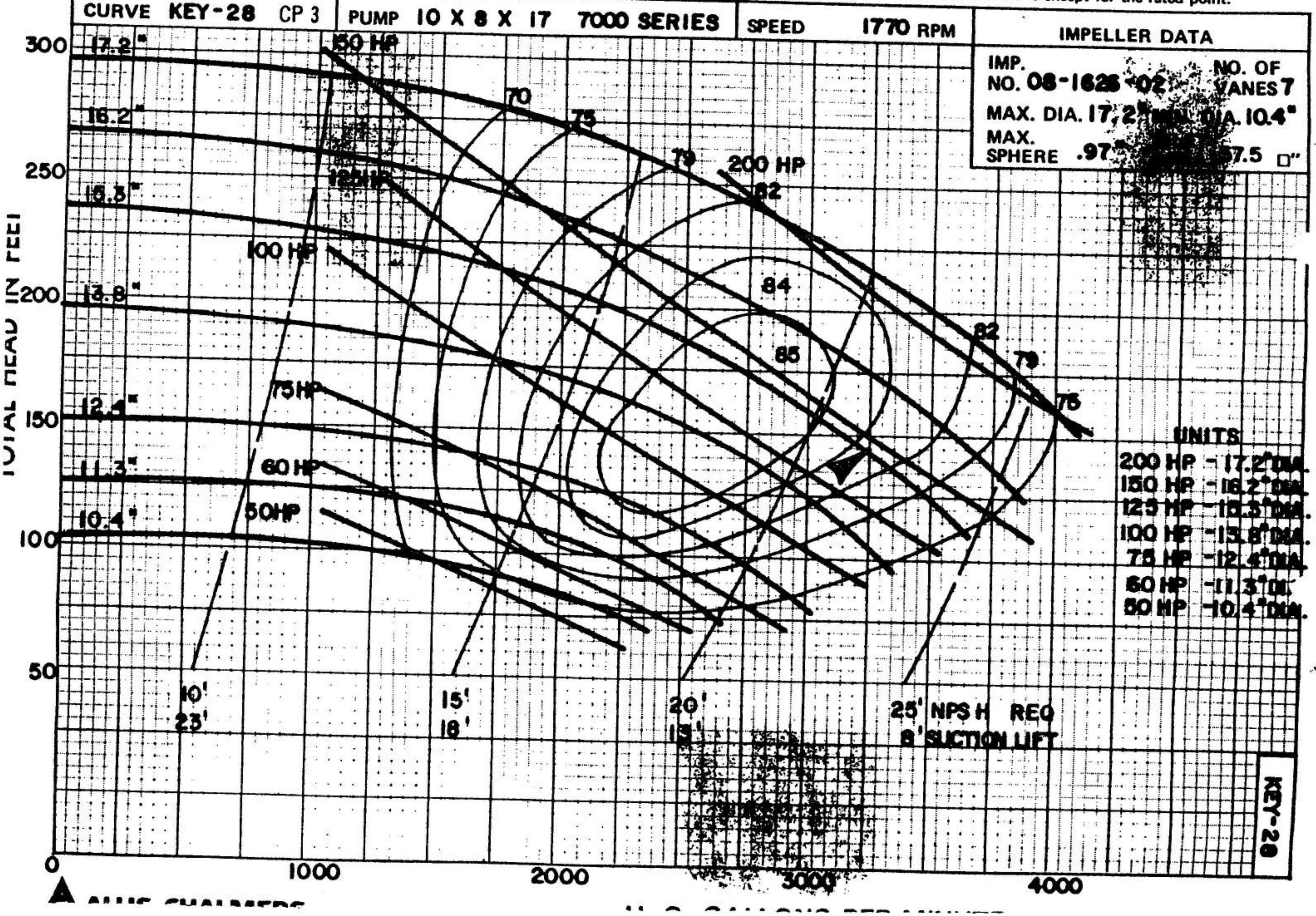
Vine #1

#11

#11

S.O. 06357
3250GPM @ 145'
150 HP MOTOR

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.



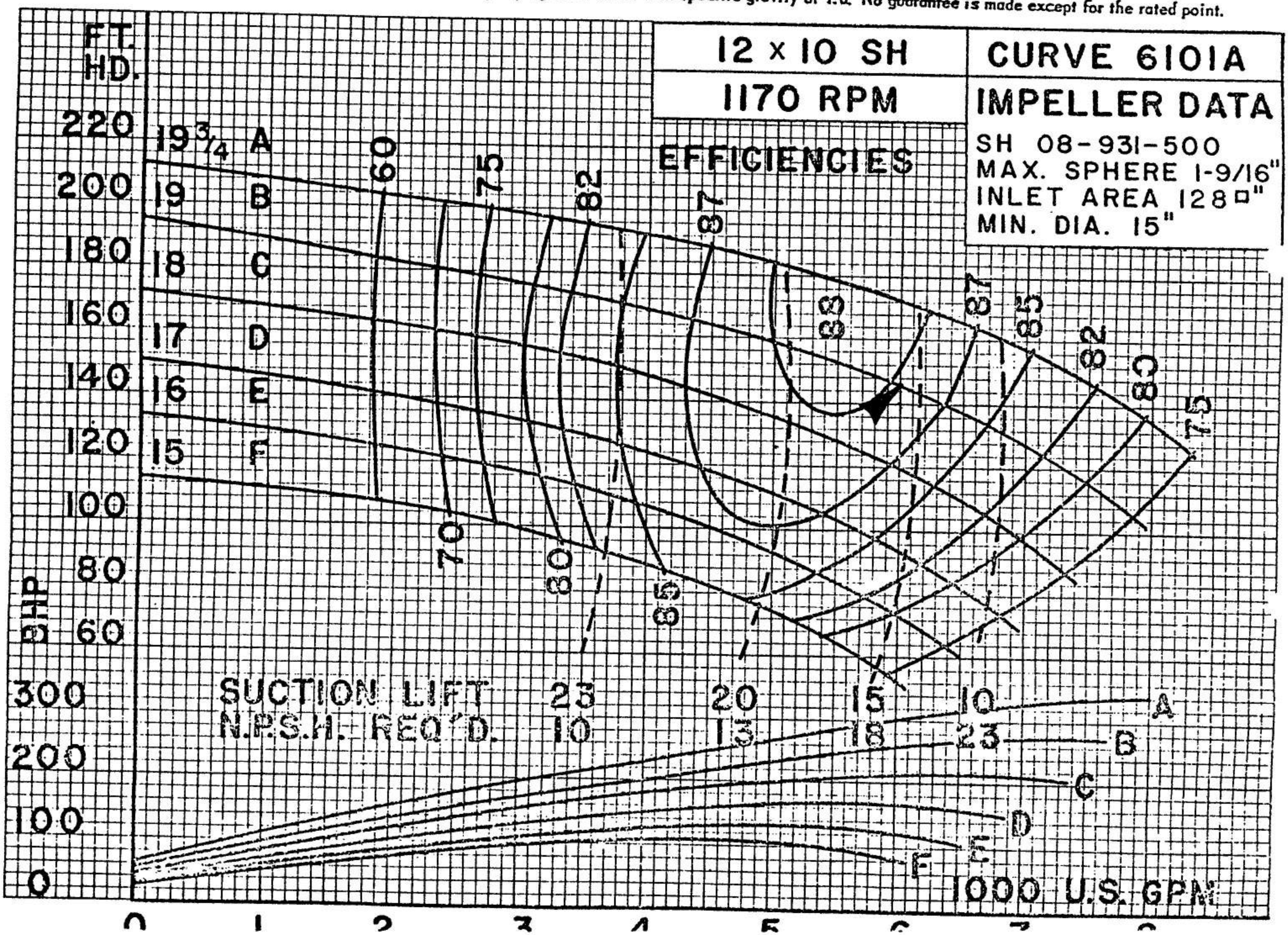
Vine #2 & #5

#15 & 12
#12 & 15

S.O. 5190
6000 GPM @ 145'
300 HP MOTOR

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.

ALLIS-CHALMERS MFG. CO.

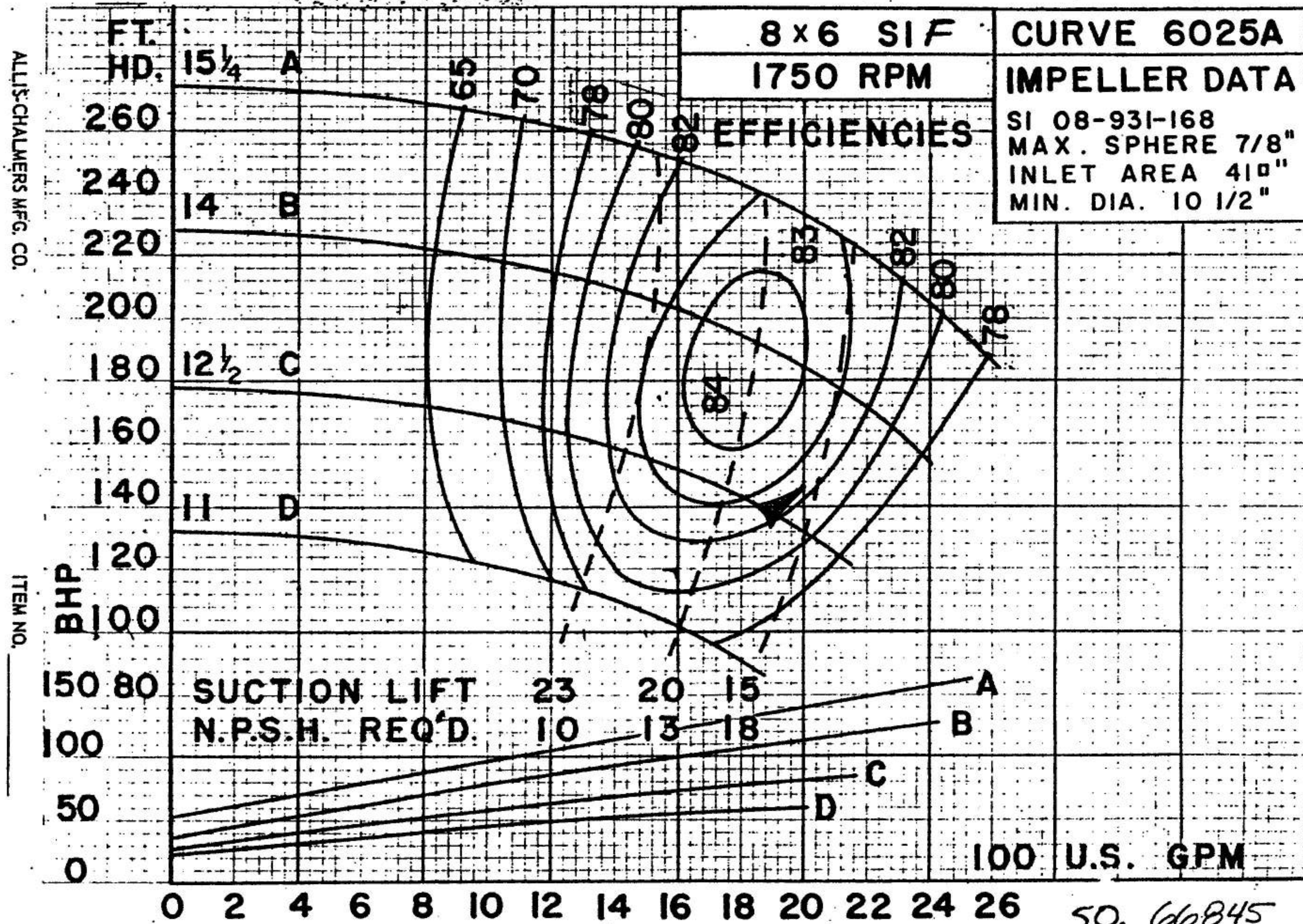


ITEM NO.

Vine #3

#13

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.



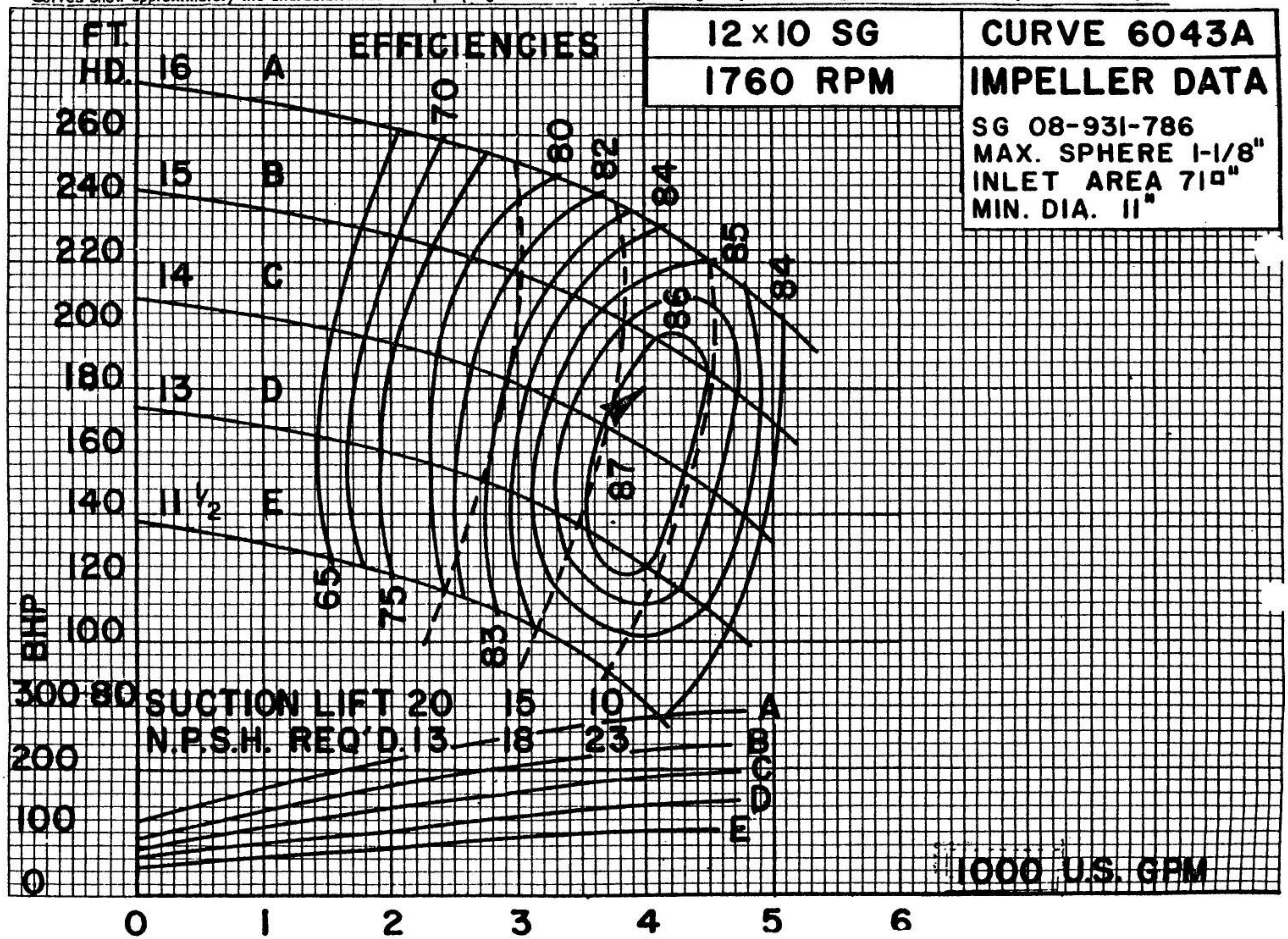
S.O. 66845
2000GPM @ 145'
100HP MOTOR.

Vine #4

#14

S.O. 63423
4000 GPM @ 180'
200 HP MOTOR

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.



ALLIS-CHALMERS MFG. CO.

ITEM NO.

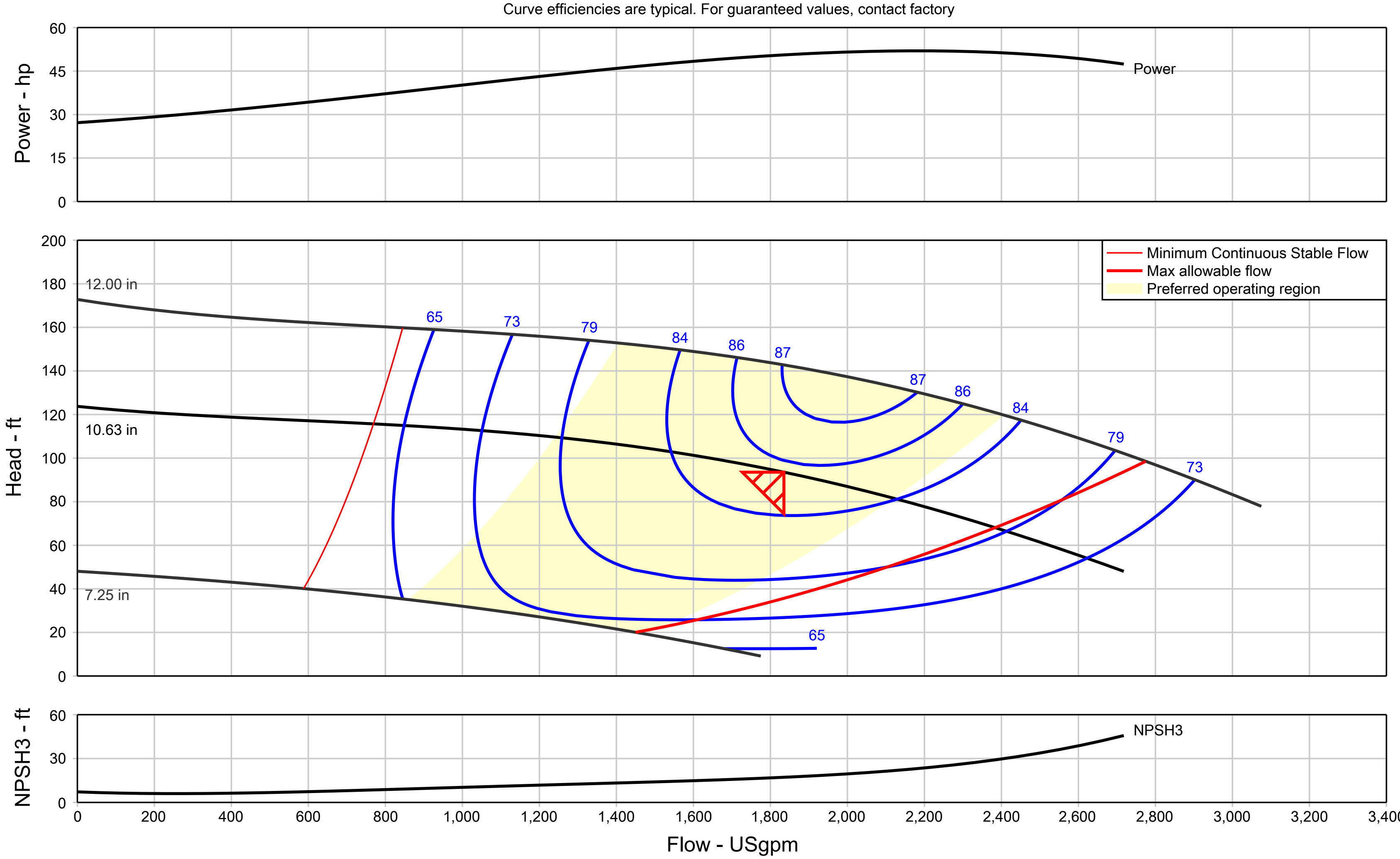
PENTAIR

North Albany pumps

Customer :
Project name : Default

Pump Performance Curve

Encompass 2.0 - 19.5.6 20.0.5



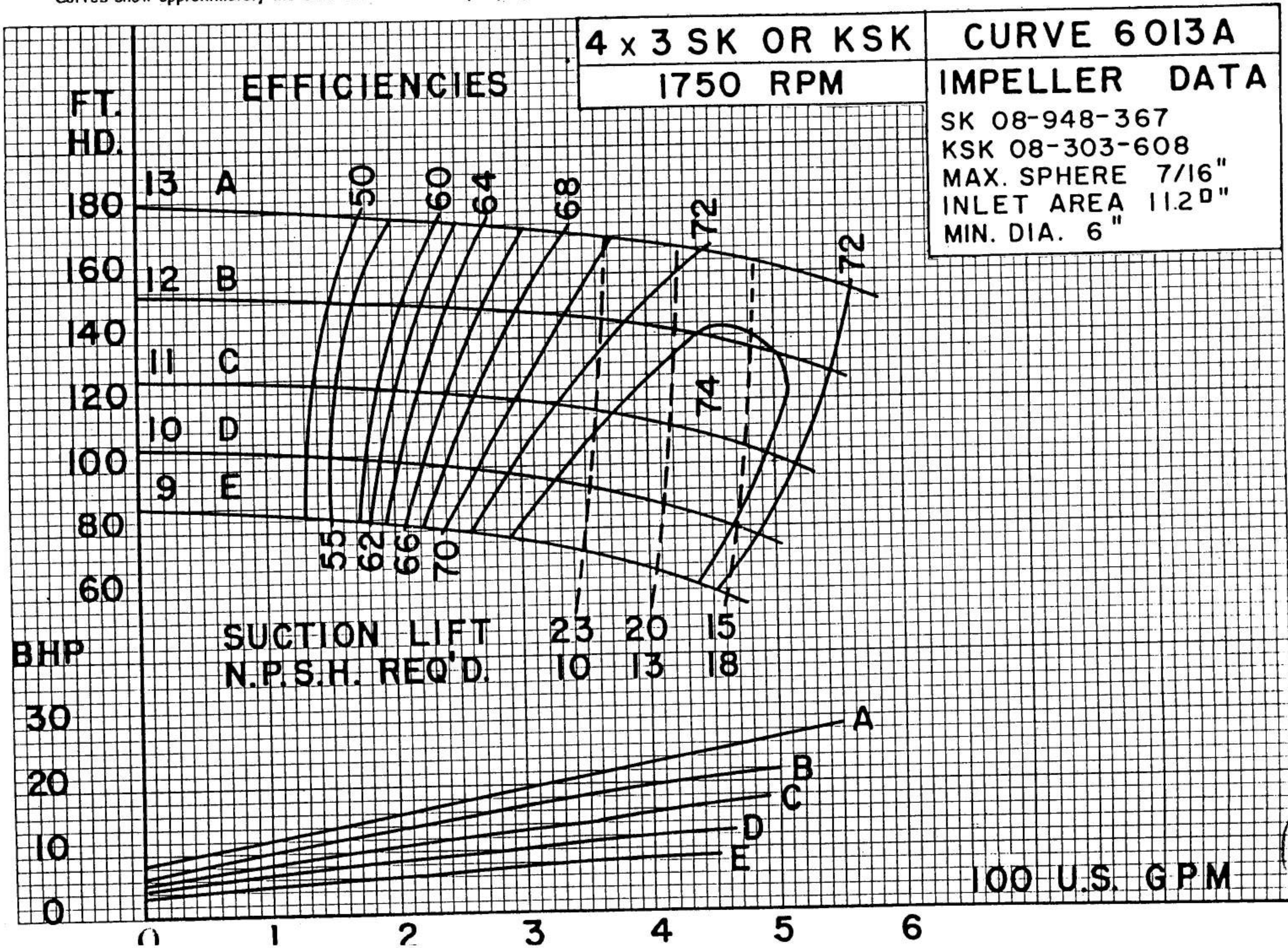
Item number	: 012	Size	: 410 - 8x8x11B	Flow, rated	: 1,835.2 USgpm
Service	:	Stages	: 1	Differential head / pressure, rated	: 93.53 ft
Quantity	: 1	Speed, rated	: 1775 rpm	NPSH required	: 17.19 ft
Quote number	: 1048197	Based on curve number	: 14-8x8x11B-1775 Rev 11/15/12	Fluid density, rated / max	: 1.000 / 1.000 SG
Date last saved	: 23 Mar 2020 11:50 AM			Viscosity	: 1.00 cP
		Efficiency	: 85.69 %	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
		Power, rated	: 50.58 hp		

Queen #1

#21

Queen & Hill #21

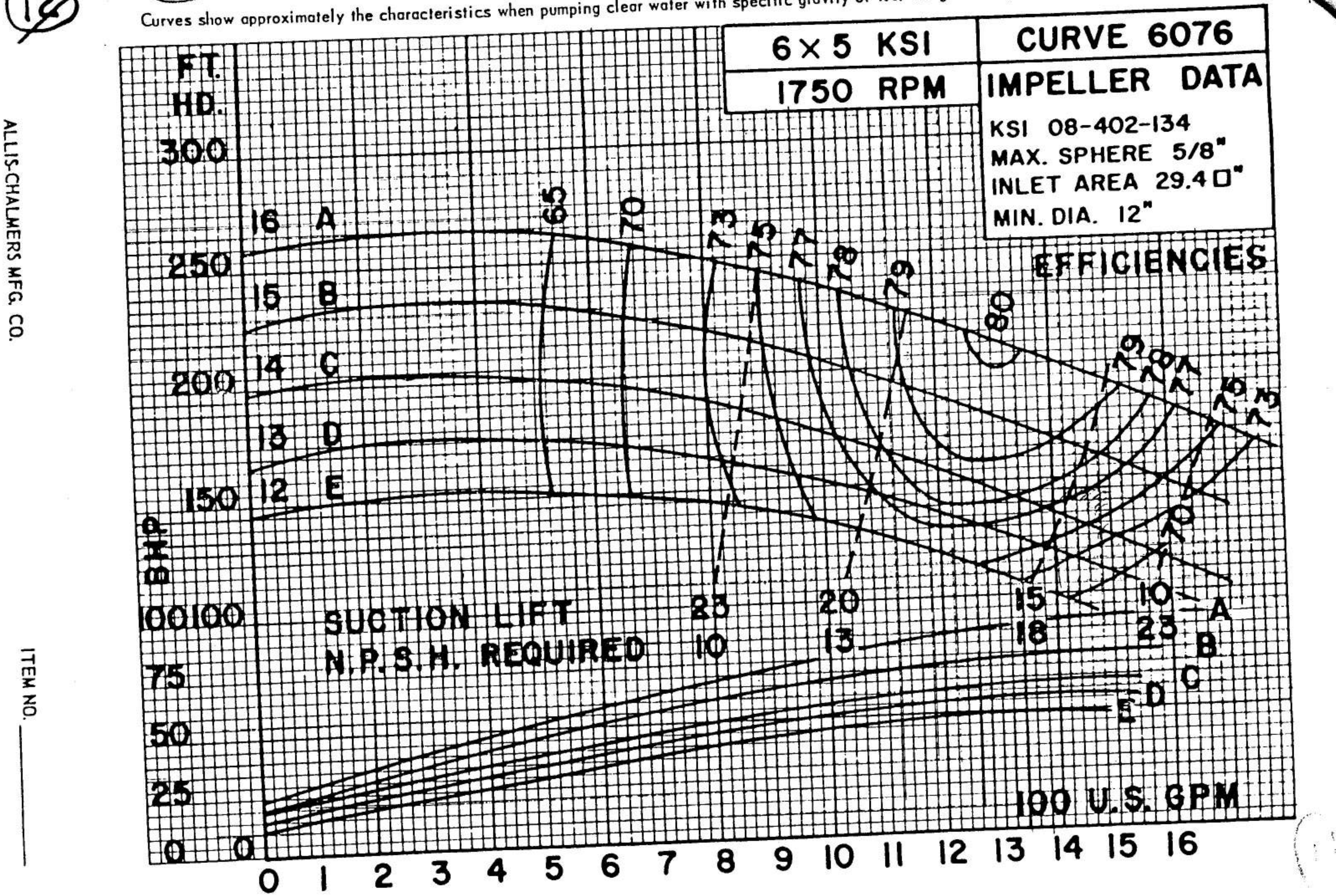
Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.



21

Queen #2

Curves show approximately the characteristics when pumping clear water with specific gravity of 1.0. No guarantee is made except for the rated point.



CONSTANT SPEED (1) JOCKEY PUMP

GRUNDFOS

Company name: Cascade Water Works, Inc
Created by: Jonathan Smith
Phone: 503-364-4888
Fax: 503-364-7444
Date: 10/18/06

Project: Albany Zone 4 Booster
Reference number: -

Client: -
Client number: -
Contact: -

Position	*Count*	*Description*	*Unit price*
	1	**CR 10-4 A-GJ-A-E HQQE**	On request

Product No.: 96522490
Vertical, non-self-priming, multistage, in-line, centrifugal pump for installation in pipe systems and mounting on a foundation.

CONSTANT SPEED JOCKEY PUMP

The pump has the following characteristics:

- Impellers and intermediate chambers are made of Stainless steel DIN W.-Nr. 1.4301 DIN W.-Nr..
- Pump head and base are made of Cast iron.
- The shaft seal has assembly length according to DIN 24960.
- Power transmission is via cast iron split coupling.
- Pipework connection is via ANSI flanges.

The motor is a 1-phase AC motor.

Liquid:

Liquid temperature range:	-4 .. 248 °F

Technical:

Speed for pump data:	3457 rpm
Rated flow:	53.28 US GPM
Rated head:	146 ft
Shaft seal:	HQQE
Approvals on nameplate:	NEMA
Curve tolerance:	ISO 9906 Annex A

Materials:

Pump housing:	Cast iron EN-JL1030 DIN W.-Nr. A48-30 B ASTM
Impeller:	Stainless steel 1.4301 DIN W.-Nr. 304 AISI

Installation:

Maximum ambient temperature:	104 °F
Max pressure at stated temp:	232 / 250 psi/°F 232 / -4 psi/°F
Flange standard:	ANSI
Pipe connection:	2"
Pressure stage:	Class 250
Flange size for motor:	182TC

Electrical data:

Motor type:	3628L
Number of poles:	2
Rated power - P2:	3 HP

Company name: Cascade Water Works, Inc
Created by: Jonathan Smith
Phone: 503-364-4888
Fax: 503-364-7444
Date: 10/18/06

Project: Albany Zone 4 Booster
Reference number: -

Client: -
Client number: -
Contact: -

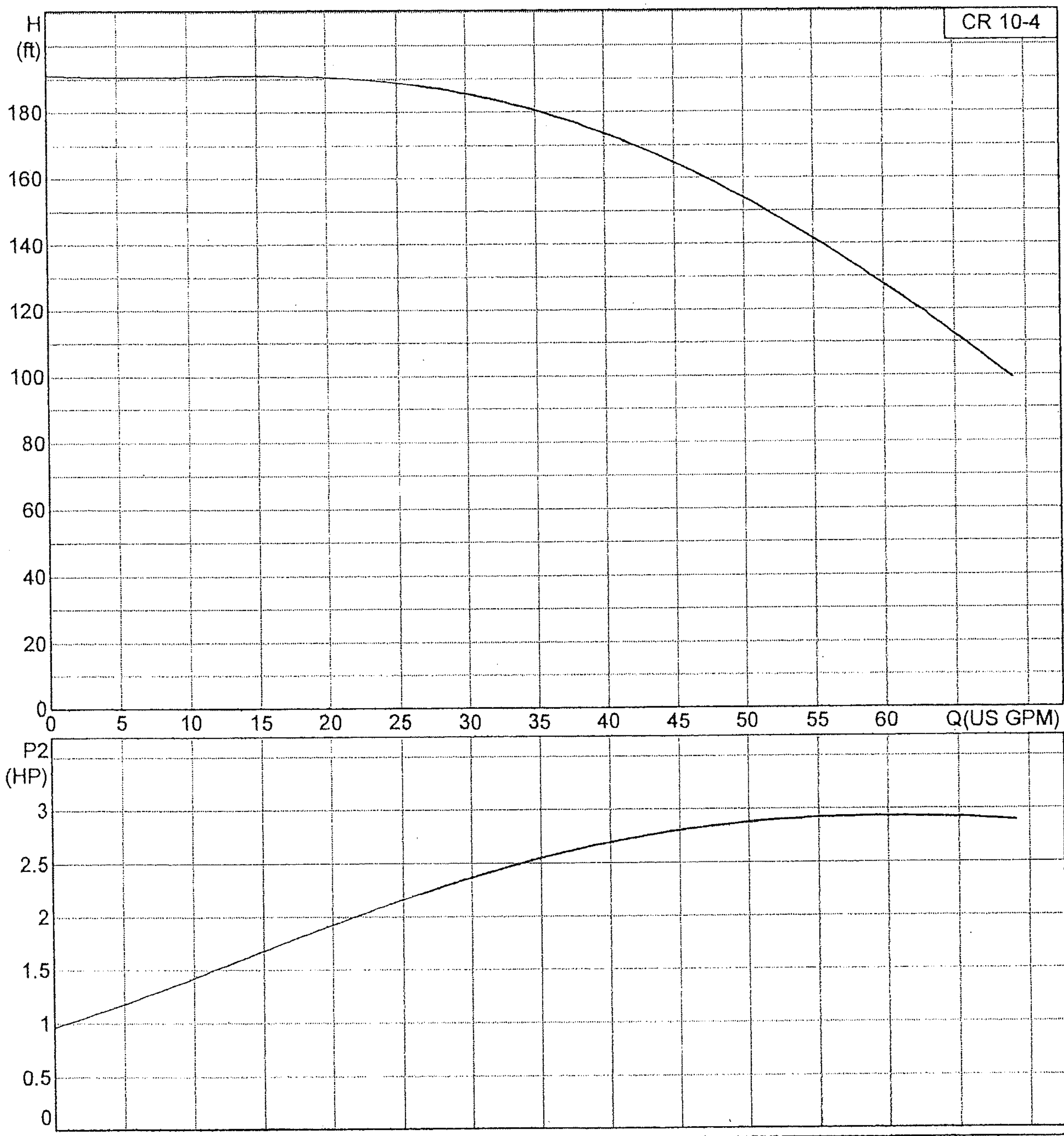
Position	*Count*	*Description*		*Unit price*
		Power (P2) required by pump:	3 HP	
		Main frequency:	60 Hz	
		Rated voltage:	1 x 115 / 208-230 V	
		Rated current:	28 / 16-14 A	
		Rated speed:	3450 rpm	
		Enclosure class (IEC 34-5):	IP23	
		Insulation class (IEC 85):	B	
		Others:		
		Net weight:	163 lb	
		Shipping volume:	4.94 ft^3	

Company name:	Cascade Water Works, Inc
Created by:	Jonathan Smith
Phone:	503-364-4888
Fax:	503-364-7444
Date:	10/18/06

Project:	Albany Zone 4 Booster	**Client:**	-
Reference number:	-	**Client number:**	-
Position:		**Contact:**	-

Valley View #3

96522490 CR 10-4



Valley View 1&2

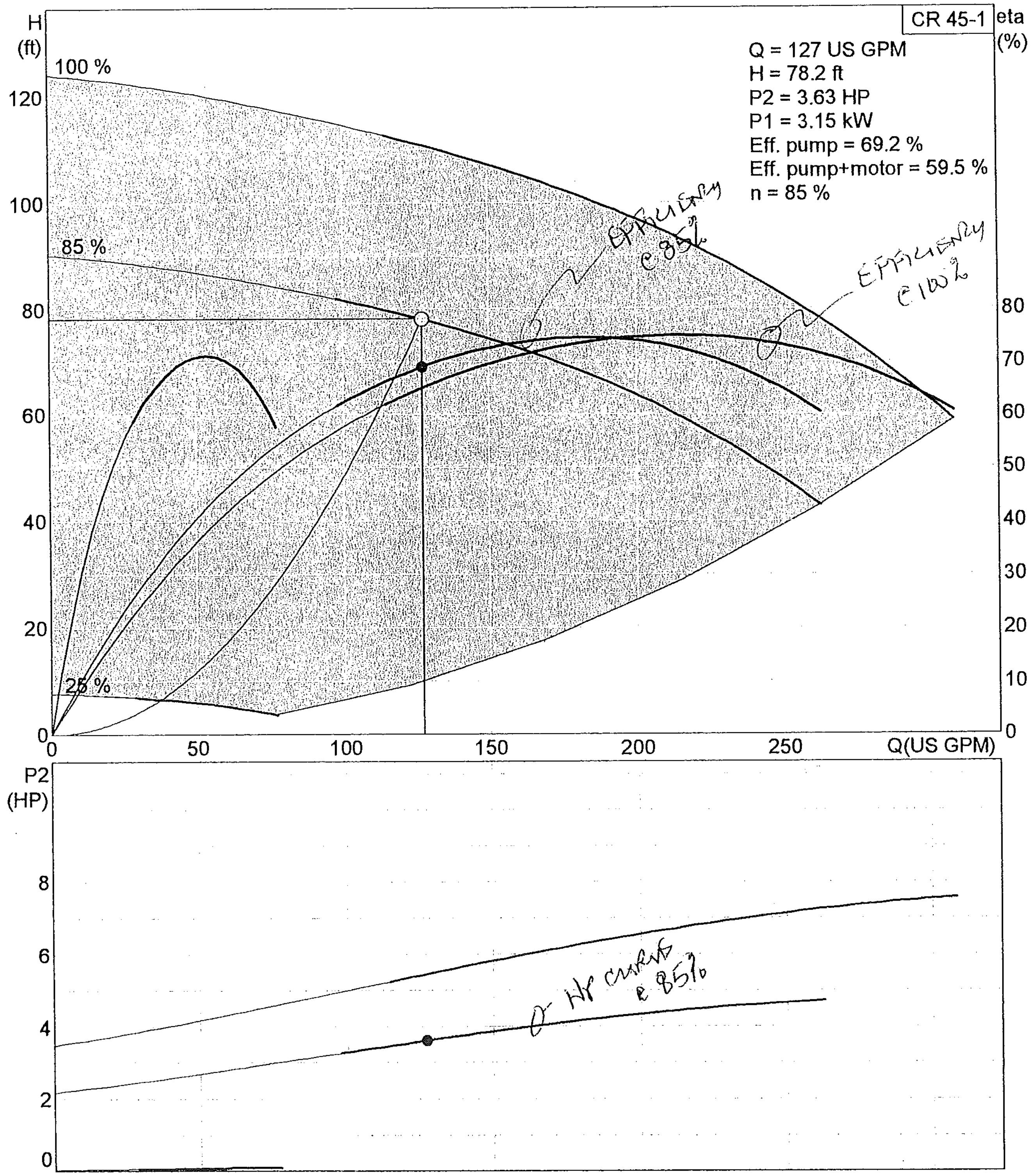
VFD (2)

GRUNDFOS

Company name:	Cascade Water Works, Inc.
Created by:	Jonathan Smith
Phone:	503-364-4888
Fax:	503-364-7444
Date:	8/29/2007

Project:	Albany Zone 4 Booster Station	**Client:**	City of Albany, Oregon
Reference Number:		**Client Number:**	541-917-7645
Position:		**Contact:**	Staci Belcastro

96419118 CR 45-1



Appendix B

System Validation Results

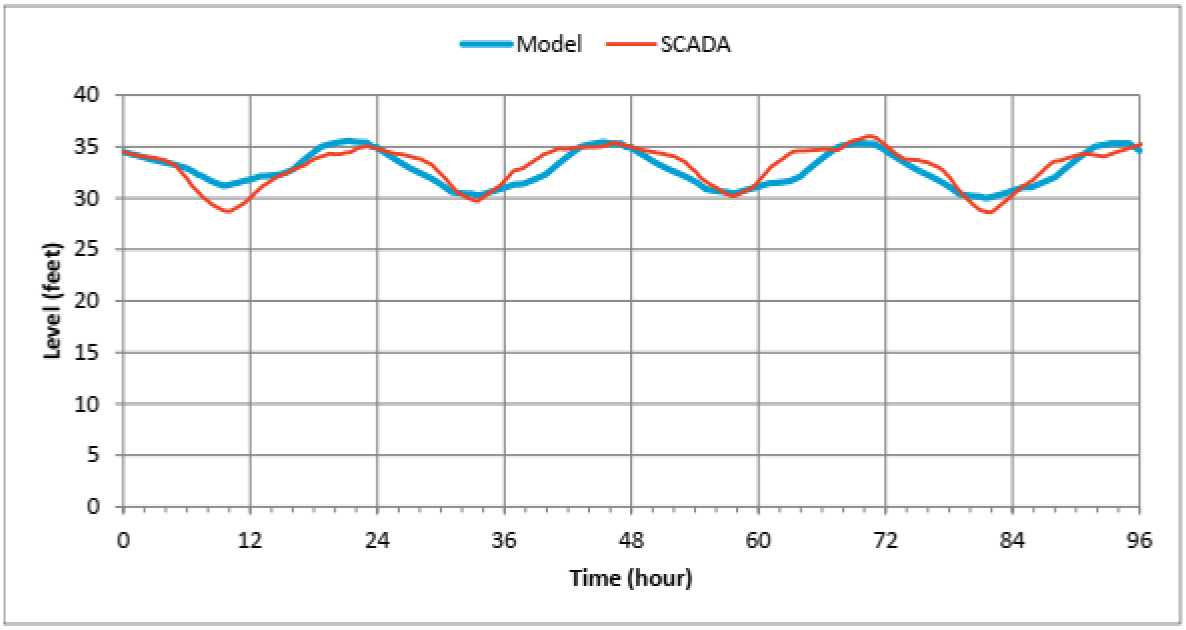


Figure B-1. Broadway Level

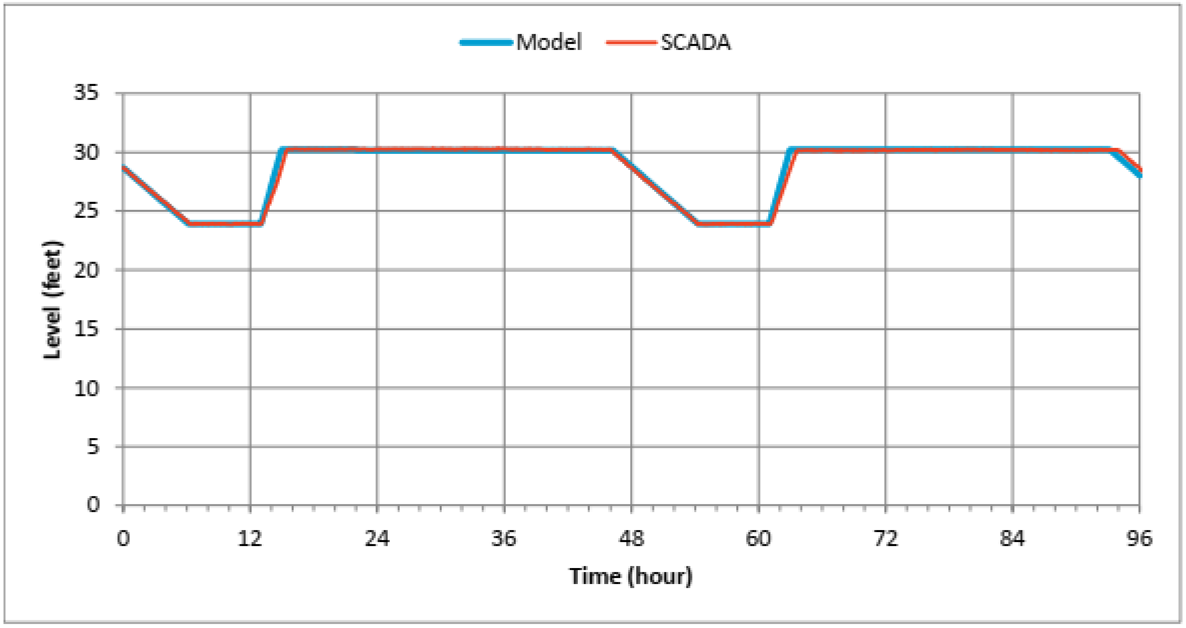


Figure B-2. 34th Level

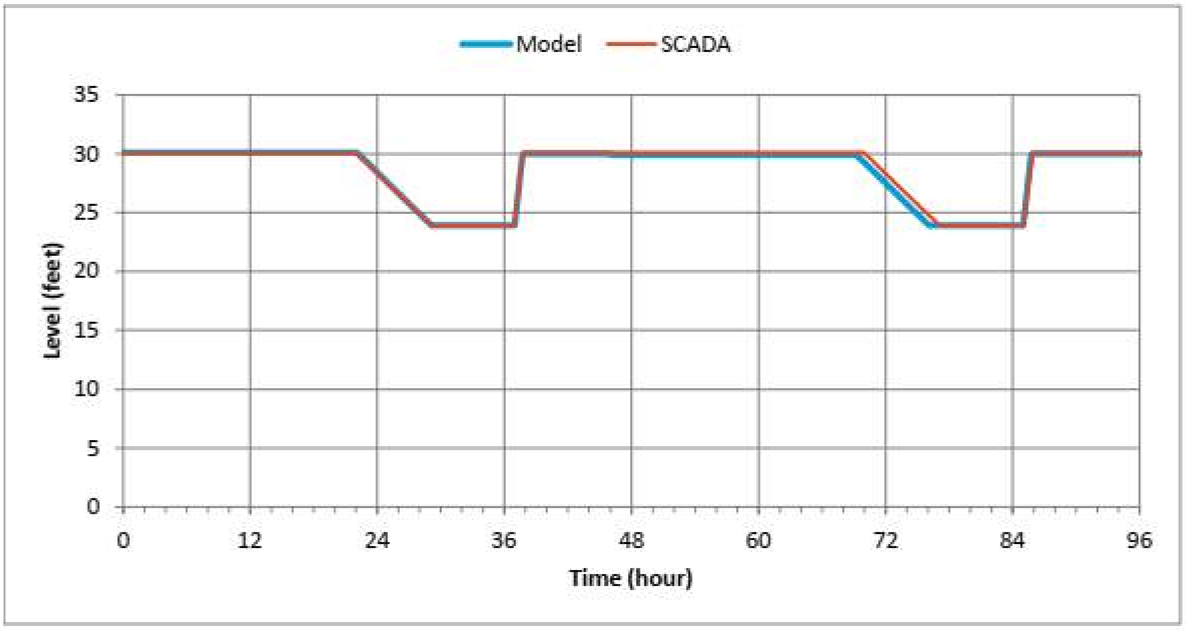


Figure B-3. Queen Level

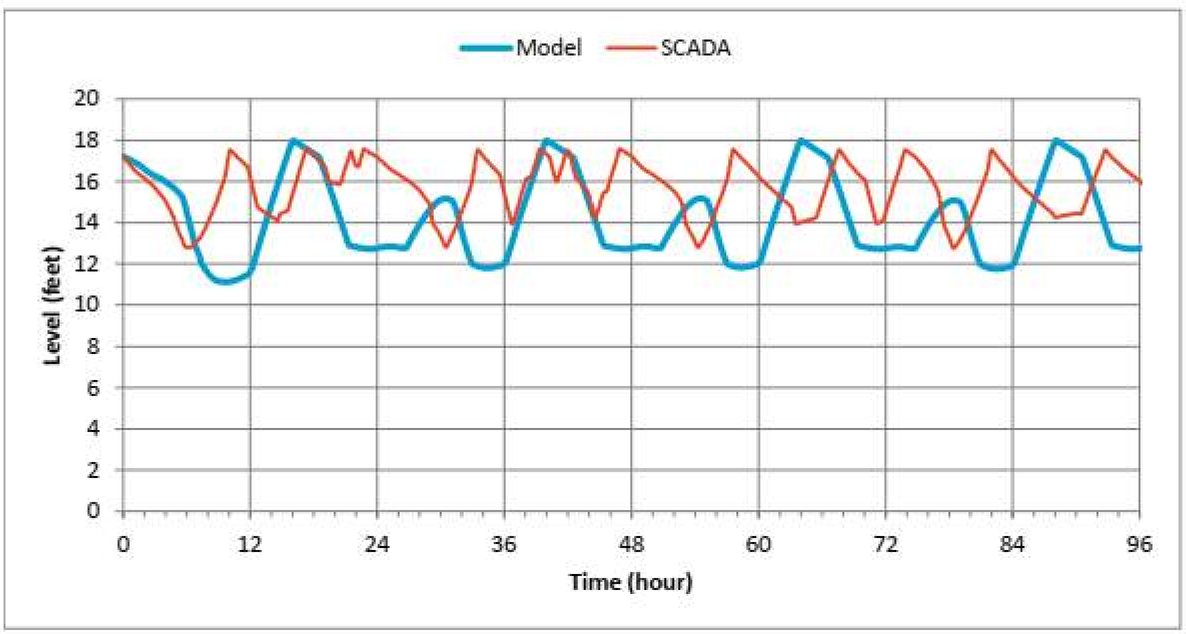


Figure B-4. Wildwood Level

Note: Irregular levels during calibration period. Model controls represent typical min/max levels.

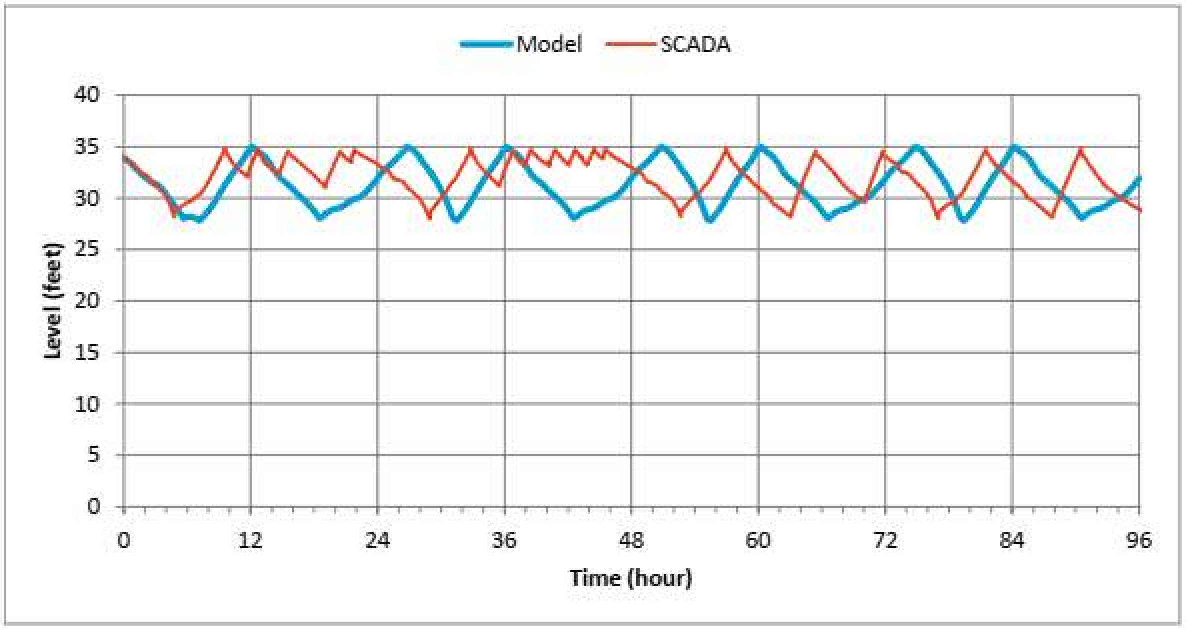


Figure B-5. Valley View Middle Level

Note: Irregular levels during calibration period. Model controls represent typical min/max levels.

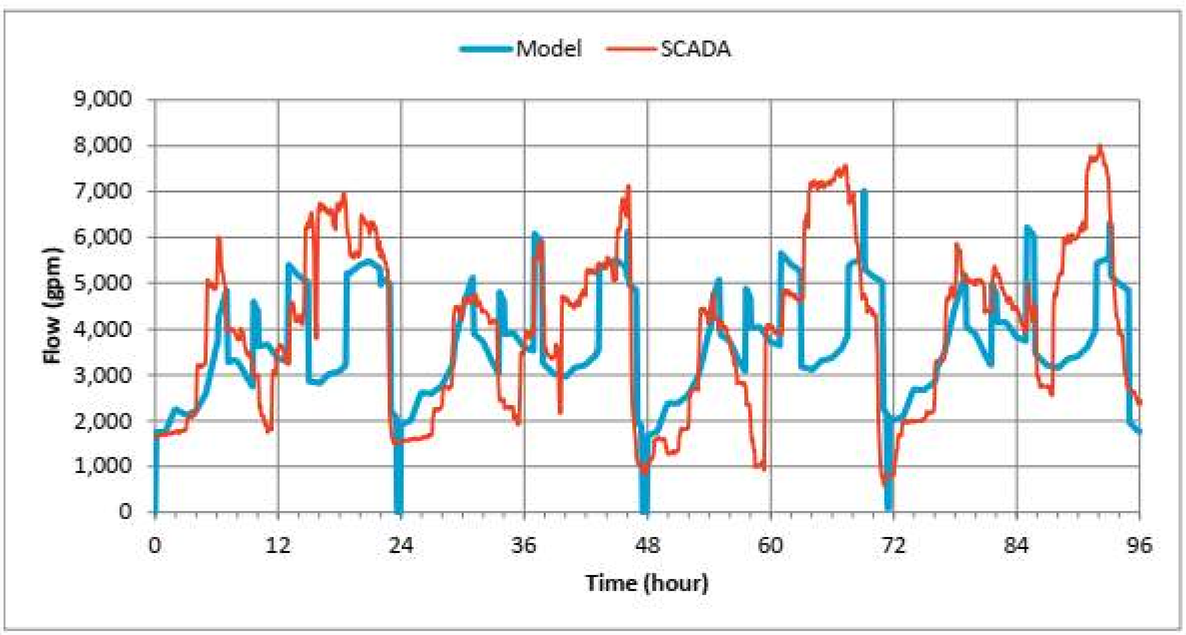


Figure B-6. Albany Flow Meter

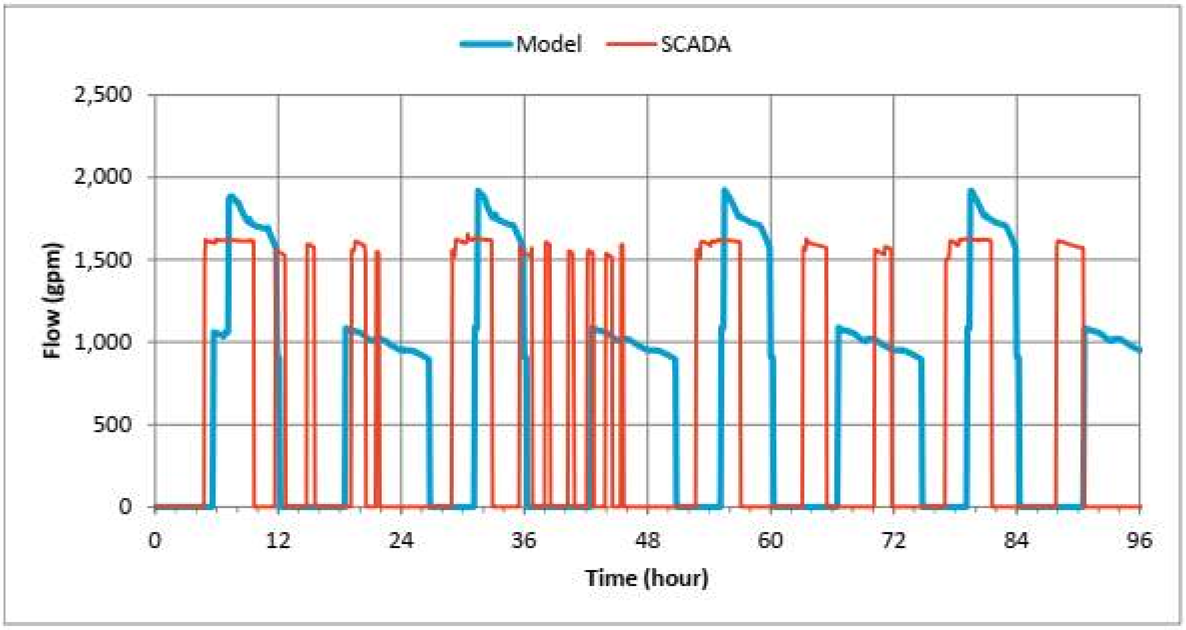


Figure B-7. Gibson Hill PS flow

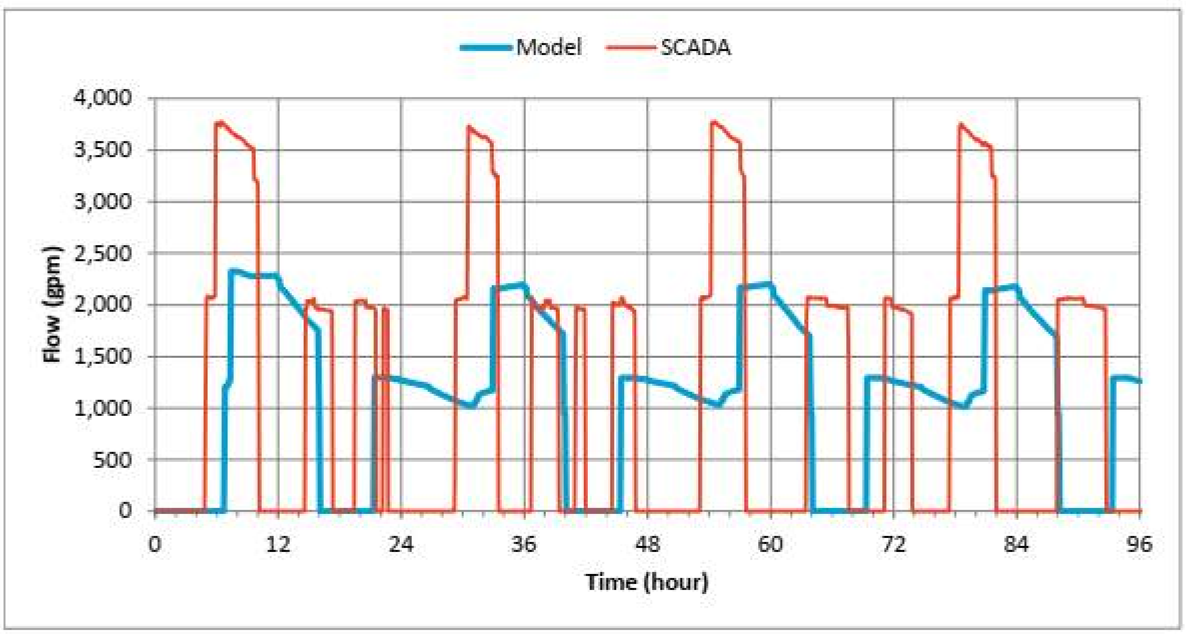


Figure B-8. North Albany Pump Station Flow

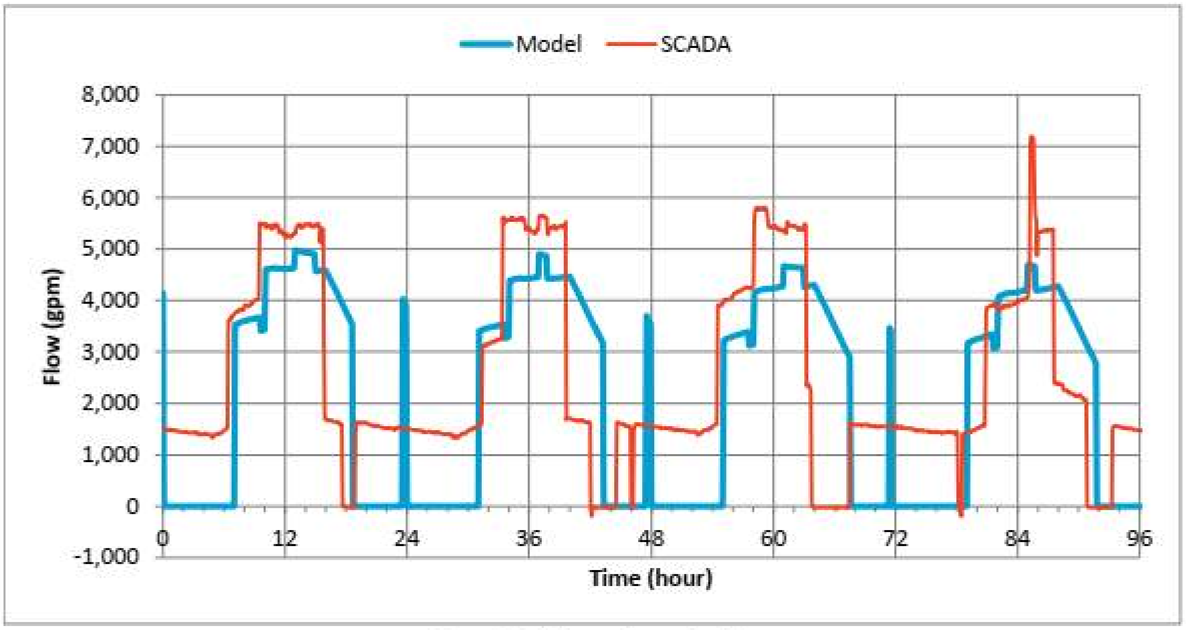


Figure B-9. Vine net production

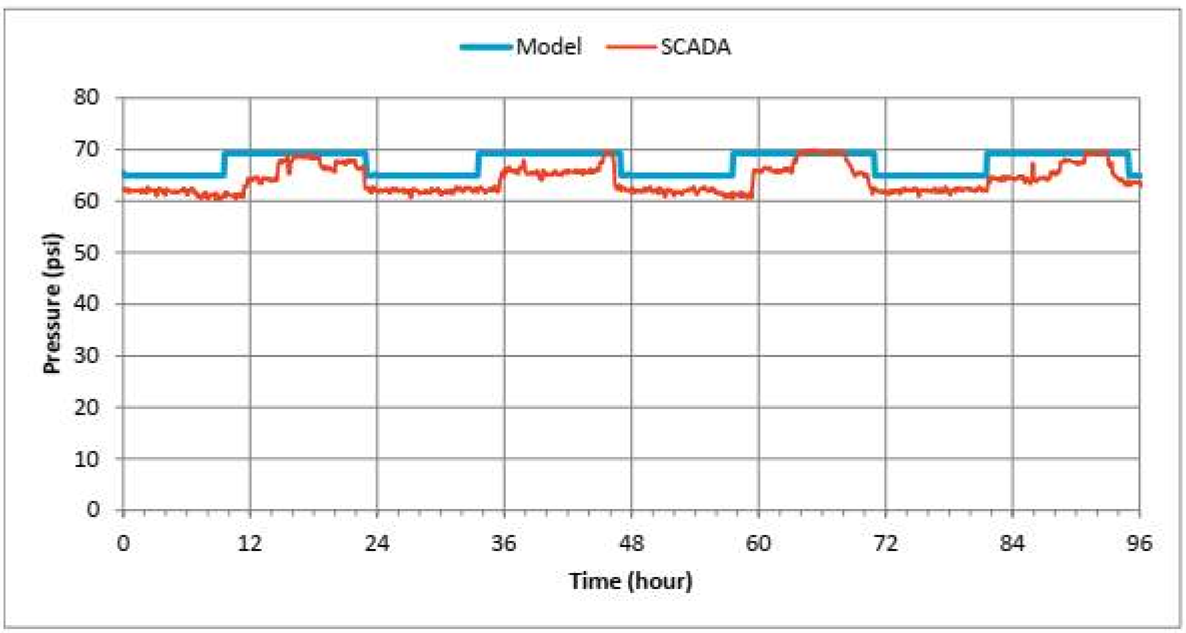


Figure B-10. Albany Metering Pipe Downstream Pressure

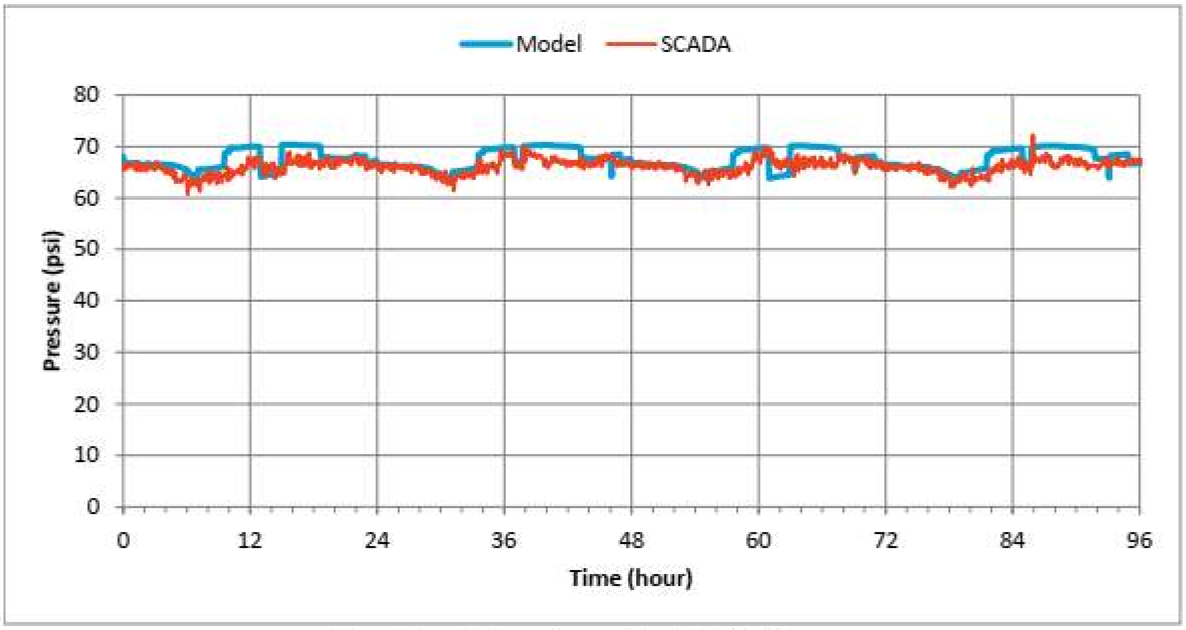


Figure B-11. College Green LS Distribution Pressure

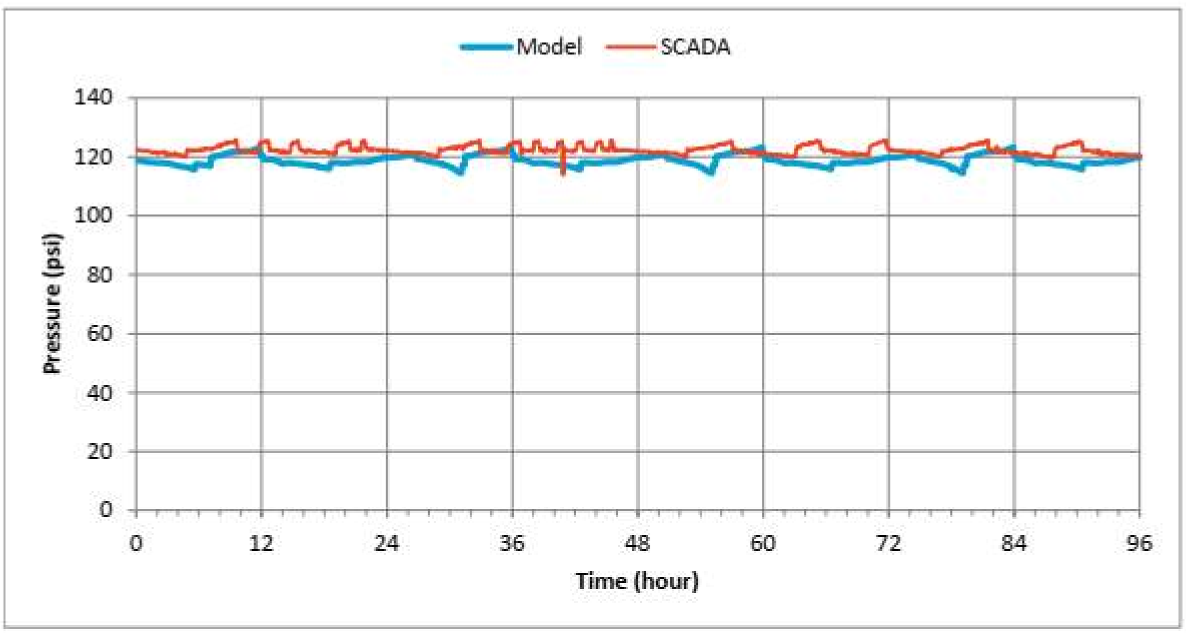


Figure B-12. Gibson Hill PS Discharge Pressure

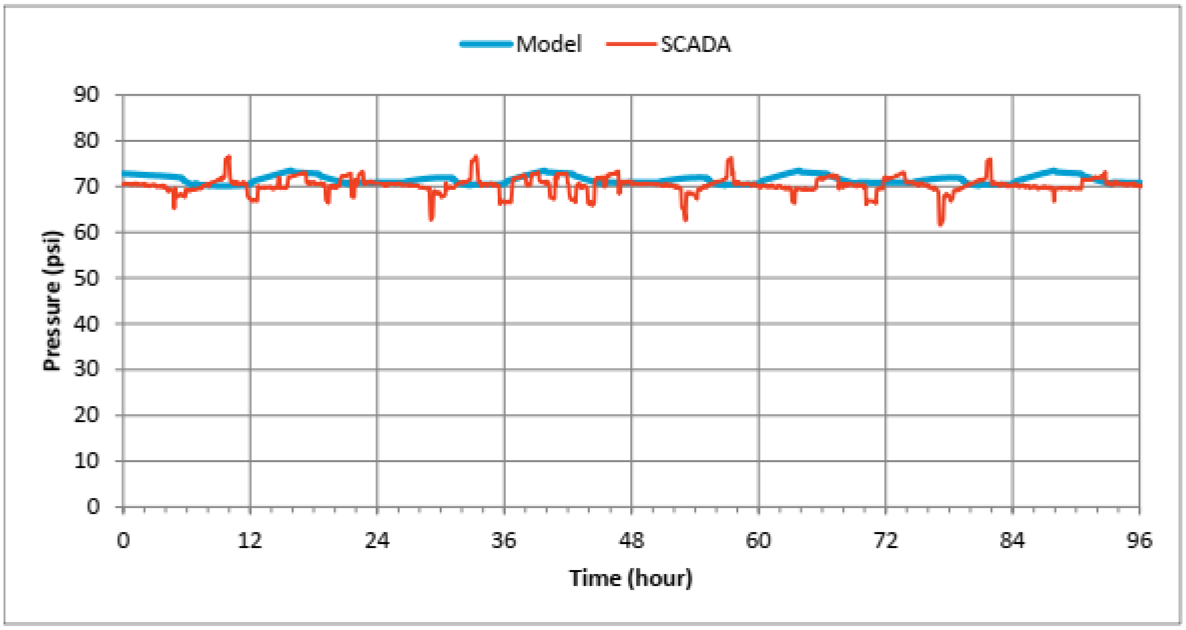


Figure B-13. Gibson Hill PS Suction Pressure

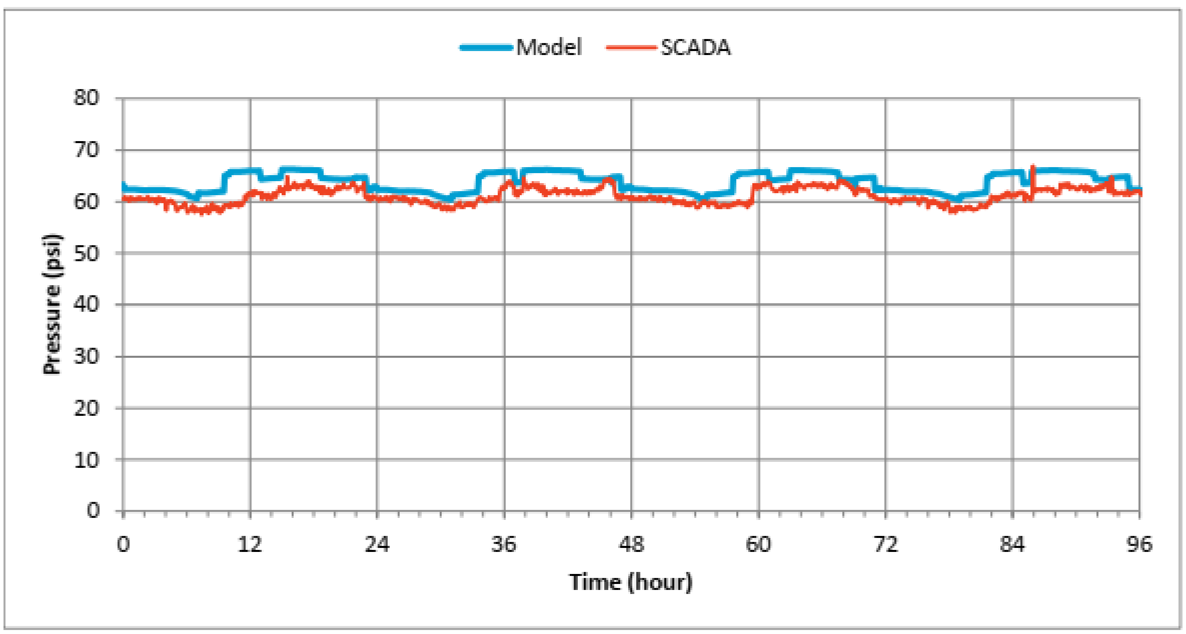


Figure B-14. Lawndale Distribution Pressure

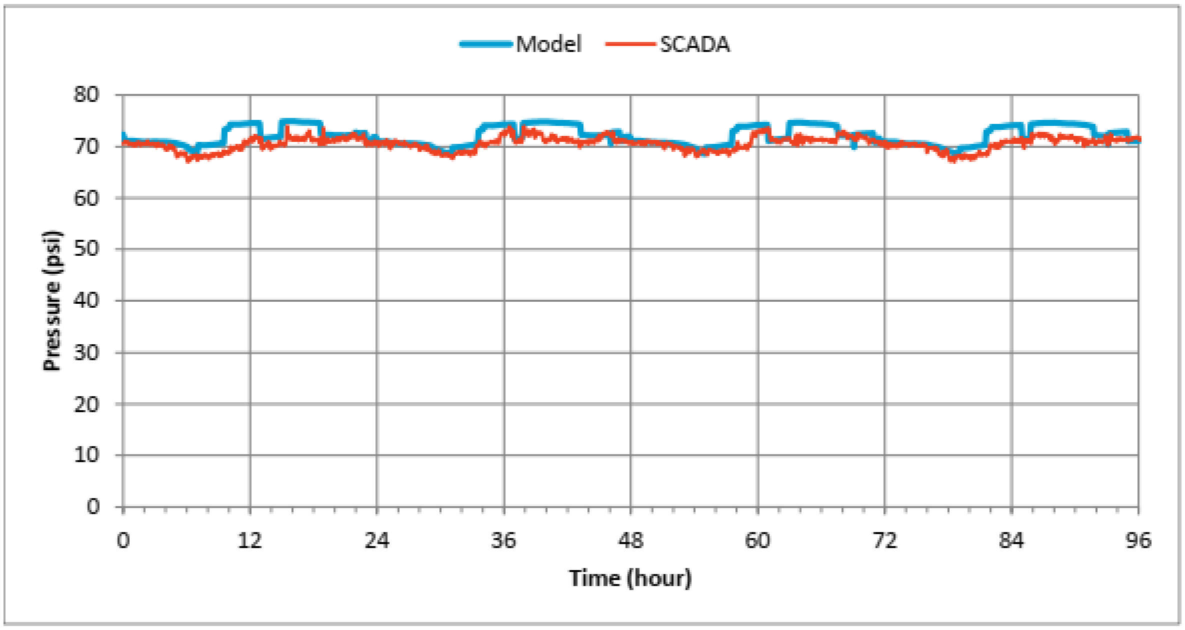


Figure B-15. Umatilla LS Distribution Pressure

Appendix C

Basis for Cost Estimating TM

WEST YOST
Water. Engineered.

5 Centerpointe Drive
Suite 130
Lake Oswego OR 97035

503.451.4500 phone
530.756.5991 fax
westyost.com

TECHNICAL MEMORANDUM

DATE: March 28, 2024

Project No.: 519-50-22-21
SENT VIA: EMAIL

DTO: Ryan Beathe, Project Manager

PREPARED BY: Noelle Drath, PE 94519

FROM: Walt Meyer, PE 10945

REVIEWED BY: Tim Banyai, PE 60715
Catherine Dummer, PE 58548

SUBJECT: Basis for Cost Estimating

This technical memorandum details the basis for cost estimating which is used for cost estimating and economic evaluations of proposed projects in the City of Albany Water Master Plan (WMP). The factors that influence the cost estimating process presented in this memorandum include:

- Present Worth Analysis
- Cost Estimate Basis
- Basis of Costs Over Time
- Construction Cost Estimating Assumptions
- Project Related Capital Cost Assumptions
- Unit Costs for Construction of Water Facilities

PRESENT WORTH ANALYSIS

The economic evaluation of projects depends on a comparison of the present worth cost for each proposed project. The present value of future annual costs including operation, maintenance, and refurbishment costs, is calculated based on the period of operation and the value of money termed the discount rate. The U.S. Treasury sets statutory discount rates and the 2023 rate for water resource projects is 2.5 percent, which is used for life cycle cost analysis in the plan.

COST ESTIMATE BASIS

Construction and operating costs for the water system improvements will be based on an evaluation of each specific improvement. Estimates will be prepared using the construction costs of similar unit processes. The cost estimates presented in the Albany WMP are AACE International Class 5 planning estimates, for Study or Feasibility purposes. Class 5 estimates have 0 to 2 percent of project definition with a targeted -50 percent to +100 percent accuracy.

The primary purpose of these estimate is to provide the City with a basis for comparing alternatives. The aggregate cost of a particular course of action may also be used for long-range budget planning, with appropriate consideration for the potential variability in project scope, economic factors, and the ongoing evolving construction materials and techniques. Preliminary design and detailed design efforts will be necessary to refine and confirm the estimated costs.

With the exception of the construction contingency, the construction costs presented in this Water Master Plan represent an engineer's opinion of probable construction cost (OPCC). The total of the component costs, distributed costs, estimating contingency, and other contractor costs and profit was calculated as the engineer's preliminary OPCC. The OPCC plus the construction contingency represent an estimated construction budget. The total capital cost is then calculated as the sum of the engineer's preliminary OPCC, the construction contingency, and other project- related capital costs.

BASIS FOR COSTS OVER TIME

Future changes in the costs of material, labor, and equipment as inflation causes increased capital costs, will increase with each project option. Therefore, decisions that are based on today's cost would be similar as costs inflate. For planning of future projects, financing must include the impact of inflation.

Costs can be expected to undergo long-term changes in keeping with corresponding changes in the national economy. One of the best available barometers of these changes is the Engineering News-Record (ENR) construction cost index (CCI). It is computed from the prices for structural steel, Portland cement, lumber, and common labor, and is based on a value of 100 in the year 1913.

The construction costs developed in this report are based on the projected Seattle ENR CCI index for March 2023 of 15,107. The Seattle ENR CCI was selected instead of the 20-Cities ENR because the City uses it for their pipeline cost estimating. The costs presented here may be related to those at any time in the past or future by applying the ratio of the then-prevailing cost index to the Seattle ENR CCI for March 2023. For capital planning, costs are required to be escalated based on the time of construction.

If major improvements or additional chemicals are needed as part of a specific improvement, an additional operating cost for labor and materials will be included.

CONSTRUCTION COSTS ESTIMATE ASSUMPTIONS

The assumptions and methods used to prepare the construction cost estimates developed for WMP are discussed in this section. The topics addressed include:

- Base Construction Cost
- Contractor Costs and Profit

Base Construction Cost

Costs for individual facility components were estimated using a variety of sources. In some cases, estimates of quantities of materials were developed, while in others lump sums based on similar project were used.

Distributed costs account for costs that are not included in the component costs at this level of planning. Distributed costs include: paving, grading, and yard piping; miscellaneous mechanical and piping; electrical; and instrumentation and control. For some facility components the cost of major components was estimated, and then facility-specific multipliers were used to account for the related electrical, yard piping, and other distributed costs. For some of the larger facility components, estimates of quantities of materials were developed to define some of the distributed costs.

Contractor Costs and Profit

Other contractor costs include mobilization, demobilization, general overhead, and general conditions including bonds and insurance. These cost factors, as well as contractor profit are calculated as a multiple of the total base and distributed costs. The multipliers used are listed in Table 1. The amounts for some items, such as mobilization or demobilization will ultimately vary depending on the nature of the work and the particular contractor selected; nevertheless, the factors provide a reasonable estimate and are useful when used in conjunction with appropriate contingencies. The mobilization and demobilization markup of 8.5% and contractor overhead and profit markup of 23% matches what was used on the City of Albany Riverfront Interceptor Planning Cost.

Table 1. Multipliers for Other Contractor Costs and Profit

Item	Markup Percentage, %
Mobilization and Demobilization	8.5
Contractor's Overhead and Profit	23
Contractor's General Conditions (Bonds and Insurance, other requirements)	10
Total	**41.5**

PROJECT RELATED CAPITAL COST ASSUMPTIONS

The non-construction costs (those costs not included in the construction contract), are predicted as a percentage of the estimated construction costs. The non-construction costs addressed include:

- Contingencies
- Engineering, Legal, and Administrative Costs

Contingencies

Because of the limitations of cost estimates based on planning information, cost estimates must allow for items that are not identified in the conceptual development of a given alternative, unanticipated improvements, variation in final quantities, adverse construction conditions, and other unforeseeable difficulties that will increase the final construction cost. A total contingency allowance of 30 percent is applied to estimated construction cost for these items.

Engineering, Legal, and Administrative Costs

The cost of engineering and construction management services for major projects typically includes special investigations, a predesign report, surveying, foundation exploration, preparation of contract drawings and specifications, construction management, start-up services, and the preparation of operation and maintenance manuals. Legal and administrative fees also contribute to the part of a project's capital cost. Administrative costs are associated with the internal planning and budgeting, the administration of engineering and construction contracts, and liaison with regulatory and funding agencies. For the water master plan, an average of 30 percent of the contract cost is assumed for total engineering, legal, and administrative costs.

A summary of these Project Related Capital Cost Markups is shown in Table 2. The markups for reservoirs, pump stations, and WTPs presented in Table 2 match the markup percentages used in the City of Albany Riverfront Interceptor Planning Cost.

Table 2. Project Related Capital Cost Markups

Markups	Percentage, %
Contingency	30
Engineering, Legal, Administration Costs	30
Total	**60**

An example application of these allowances to a project with an assumed base construction cost of $1.0 million is shown in Table 3.

Table 3. Example Application of Contingency Costs

Cost Component	Percent	Cost, dollars
Estimated Base Construction Cost before Mark-ups[(a)]	--	1,000,000
Construction Cost Markups		
Mobilization and Demobilization	8.5	85,000
Contractor's Overhead and Profit	23	230,000
Contractor's General Conditions (Bonds, Insurance, other requirements)	10	100,000
Subtotal Construction Costs		**$1,415,000**
Capital Cost Markups		
Contingency	30	425,000
Engineering, Legal, Administration Costs	30	425,000
Total Project Cost Allowances		**$950,000**
Estimated Total Project Cost		**$2,365,000**

(a) Assumed cost of an example project.

UNIT COSTS FOR CONSTRUCTION OF WATER FACILITIES

Unit costs for the construction of water facilities including pipelines, pump stations, and reservoirs are established as a basis of cost estimating for improvements identified in the Water Master Plan. The unit costs for construction already include construction cost markups.

Pipeline Unit Costs

Unit construction costs for potable water pipelines 4 through 36 inches in diameter are provided in Table 4. These unit costs are categorized by typical pipeline construction either in developed areas (e.g., in urban or suburban roads) or undeveloped areas (e.g., across open fields or in rural roads) and are representative of pipeline construction under common or normal conditions. Special or difficult conditions would increase costs significantly.

The unit construction costs presented below generally include pipeline materials, trenching, placing and jointing pipe, valves, fittings, hydrants, service connections, placing imported pipe bedding, native backfill material, and partial asphalt pavement replacement, if required. Table 4 costs are based on cost data provided by the City. However, the costs presented in Table 4 do not include jacking and boring pipe or constructing boring and receiving pits. Jack and bore costs are shown in Table 5 and should be added where required.

Table 4. Unit Construction Costs for Pipelines[a]

Pipeline Size	Unit Construction Cost, dollars/linear foot[b]	
	Developed Areas	Undeveloped Areas
4-inch diameter	348	248
6-inch diameter	363	263
8-inch diameter	381	281
10-inch diameter	391	291
12-inch diameter	400	300
14-inch diameter	467	363
16-inch diameter	533	425
18-inch diameter	600	488
20-inch diameter	667	550
24-inch diameter	800	675
30-inch diameter	950	825
36-inch diameter	1,100	975

(a) Albany provided pipeline capital costs for 2023. These costs were reduced down to construction costs using markups in Table 2.
(b) Estimated construction costs do not reflect an adjustment to account for the current economic bidding climate.

Table 5. Unit Construction Costs for Jack and Bore

Pipeline Size	Unit Construction Cost, dollars/linear foot[a]
12-inch diameter (24-inch diameter casing)	1150
16-inch diameter (30-inch diameter casing)	1360
18-inch diameter (32-inch diameter casing)	1480
24-inch diameter (36-inch diameter casing)	1800

(a) Estimated construction costs do not reflect an adjustment to account for the current economic bidding climate. Includes pit allowance.

Pump Station Unit Costs

Pump stations will be required at ground level and below grade reservoirs to lift water to the hydraulic grade of the City's water distribution system. Estimated construction costs for reservoir pump stations, as shown in Table 6, are based on enclosed stations with architectural and landscaping treatment suitable for residential areas. Pump station costs can vary considerably, depending on architectural design, pumping head, and pumping capacity. Therefore, these costs presented below are representative of construction under common or normal conditions and would be significantly higher for special or difficult conditions.

Pump station cost estimates include the installation of the pumps, site piping, earthwork, paving, on site backup/standby power generator, SCADA, and related sitework.

Table 6. Construction Costs for Booster Pump Stations

Firm Capacity, mgd[a]	Estimated Construction Cost, million dollars[b]
1	1.6
2	2.0
3	2.2
5	2.7

(a) Equal to the total pumping capacity with the largest pump out of service or on standby.
(b) Estimated construction costs do not reflect an adjustment to account for the current economic bidding climate.

Reservoir Unit Costs

Table 7 summarizes the estimated construction costs for treated water storage reservoirs between the size range of 1.0 to 5.0 MG. These costs generally include the installation of the storage reservoirs, site piping, earthwork, paving, instrumentation, and related sitework. These costs are representative of construction under normal excavation and foundation conditions and would be significantly higher for special or difficult foundation requirements.

Table 7. Construction Costs for Treated Water Storage Reservoirs

Capacity, MG	Estimated Construction Cost, million dollars[a]	
	Above-ground Concrete	Above-ground Steel
1.0	3.5	2.8
2.0	4.7	4.4
3.0	5.8	6.3
4.0	7.0	8.0
5.0	8.1	9.8

(a) Estimated construction costs do not reflect an adjustment to account for the current economic bidding climate.

REFERENCES

AACE International. Feb 2005. Cost Estimate Classification System – *As Applied in Engineering, Procurement, and Construction For the Process Industries.*

Engineering News Record. February 2023. *Construction Cost Index History.* Accessed at https://www.enr.com/economics/historical_indices/construction_cost_index_history on 2023.02.03.

Federal Register. November 2022. *Volume 87, No. 213.* Accessed at https://www.govinfo.gov/content/pkg/FR-2022-11-04/pdf/2022-24084.pdf on 2023.02.03.

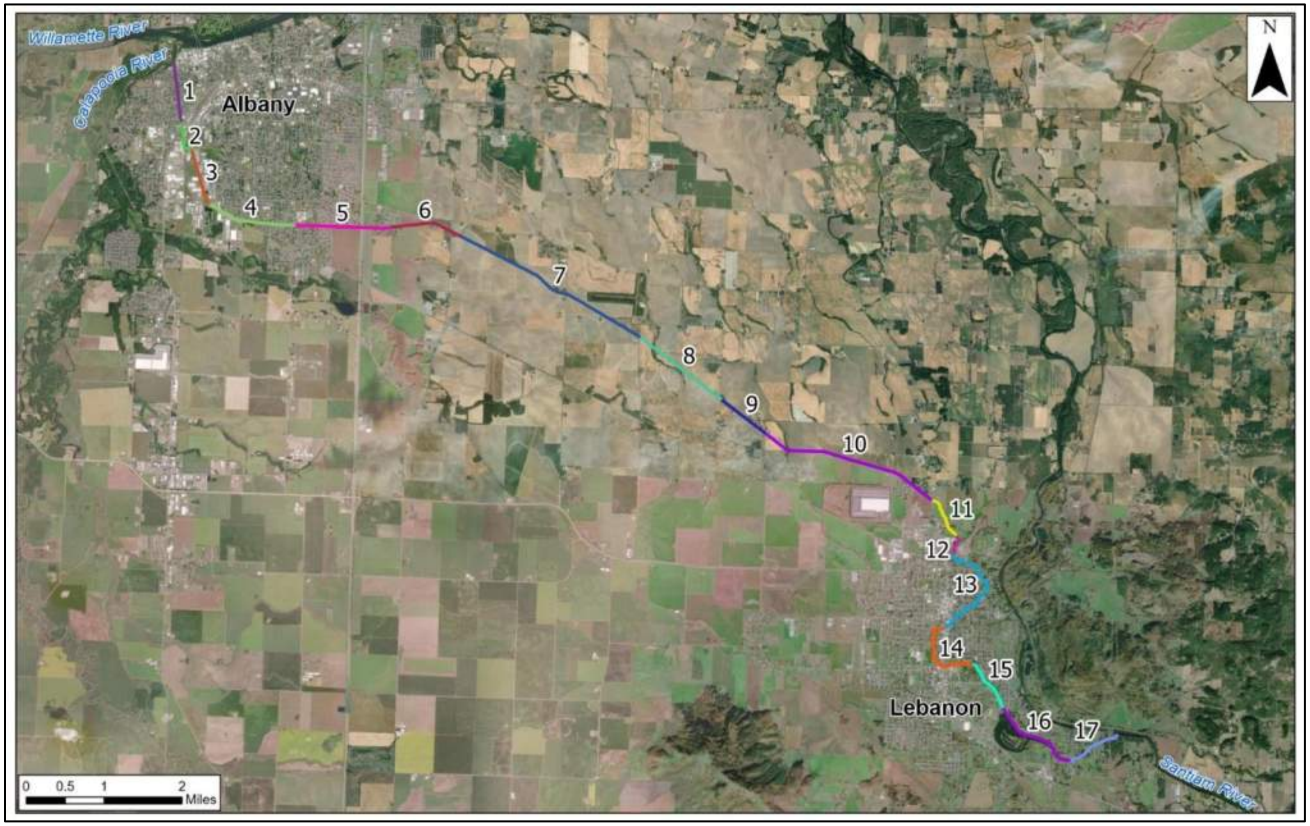
Appendix D

CIP Project Sheets

Canal CIP Sheets

Medium & Low Priority Canal Projects

PROJECT NUMBER(S): B-C-1
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2044 to 2070



PROJECT PURPOSE AND DESCRIPTION:

A total of 27 canal sites were identified as medium priority and 109 canal sites were identified as a low priority and assigned a repair strategy for cost estimating. It is recommended that this project be re-evaluated during the next WMP update.

ESTIMATED COST:

CONSTRUCTION COST: $12,500,000

CAPITAL COST: $20,000,000

RANGE: $10,000,000 - $40,000,000

Canal Retaining Wall Improvements from 14^{th} to Queen Avenue

PROJECT NUMBER(S): L-C-1
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2034 - 2036

PROJECT PURPOSE AND DESCRIPTION:

The retaining wall in the canal between 14th and Queen Avenue needs repairing. The City provided the repair cost of $2,000 per foot. The distance between the blocks was measured as 910 feet on each side which totals 1820 feet of repair.

ESTIMATED COST:

CONSTRUCTION COST: $3,640,000

CAPITAL COST: $5,820,000

RANGE: $2,910,000 - $11,700,000

Long-Term Canal Dredging

PROJECT NUMBER(S): L-C-2

PROJECT DRIVER: Condition

TRIGGER: Future Need

ESTIMATED START & END DATE 2035 - 2036

PROJECT PURPOSE AND DESCRIPTION:

The City dredges the downtown area (starting at Vine Street WTP south approximately 4,300 feet) of the canal. This project will include removal of sedimentation, plants and other debris required to maintain the capacity and mitigate flooding of adjacent properties. The 2024-2028 Capital Improvement Program included a cost of $900,000.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $900,000

RANGE: $450,000 - $1,800,000

Canal Retaining Wall Improvements from 6th to 7th Avenue

PROJECT NUMBER(S): M-C-1
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2029 – 2030

PROJECT PURPOSE AND DESCRIPTION:

The retaining wall in the canal between 6th and 7th Avenue needs repairing. The City provided the repair cost of $2,500 per foot. The distance between the blocks was measured as 225 feet on each side which totals 450 feet of repair.

ESTIMATED COST:

CONSTRUCTION COST: $1,130,000

CAPITAL COST: $1,810,000

RANGE: $910,000 - $3,620,000

Canal Retaining Wall Improvements from 7th to 8th Avenue

PROJECT NUMBER(S): M-C-2
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2031 - 2032

PROJECT PURPOSE AND DESCRIPTION:

The retaining wall in the canal between 7th and 8th Avenue needs repairing. The City provided the repair cost of $2,000 per foot. The distance between the blocks was measured as 250 feet on each side which totals 500 feet of repair.

ESTIMATED COST:

CONSTRUCTION COST: $1,000,000

CAPITAL COST: $1,600,000

RANGE: $800,000 - $3,200,000

Medium-Term Canal Dredging

PROJECT NUMBER(S): M-C-3
PROJECT DRIVER: Condition
TRIGGER: Future Need
ESTIMATED START & END DATE 2030 – 2031

PROJECT PURPOSE AND DESCRIPTION:

The City dredges the downtown area (starting at Vine St WTP south approximately 4,300 feet) of the canal. This project will include removal of sedimentation, plants and other debris required to maintain the capacity and mitigate flooding of adjacent properties. The 2024-2028 Capital Improvement Program included a cost of $900,000.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $900,000

RANGE: $450,000 - $1,800,000

High Priority Canal Projects

PROJECT NUMBER(S): N-C-1
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2024 - 2043

PROJECT PURPOSE AND DESCRIPTION:

A total of 41 canal sites were identified as a high priority. The proposed budget for the canal repairs the high priority sites over the next 20-years. Each canal site was assigned a repair strategy for cost estimating.

ESTIMATED COST:

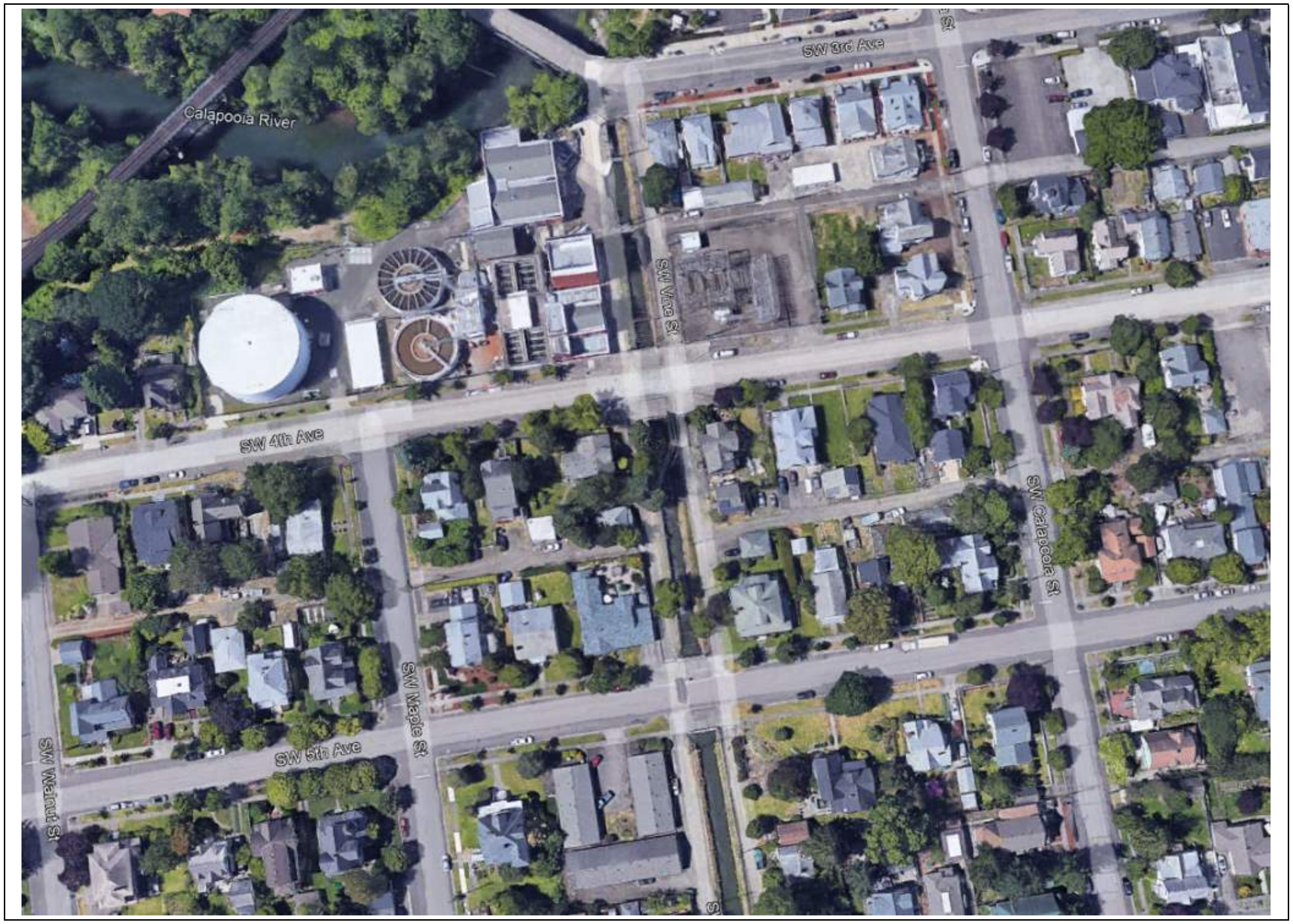
CONSTRUCTION COST: $6,140,000

CAPITAL COST: $9,820,000

RANGE: $4,910,000 - $19,700,000

Canal Bank Repair (Retaining Wall Improvements) from 4th to 6th Avenue

PROJECT NUMBER(S): N-C-2
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2024 - 2025



PROJECT PURPOSE AND DESCRIPTION:

This is an existing project the City is currently planning for 2024, and is listed here for reference. The retaining wall in the canal between 4th and 6th avenue needs repairing and is estimated by the City in to have a capital cost of $1,300,000. This project cost is not included in the WMP CIP budget because it is already included in the City budget for 2024-2028 CIP projects.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Added Security Fencing & Fall Protection

PROJECT NUMBER(S): N-C-3
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025 – 2027

PROJECT PURPOSE AND DESCRIPTION:

A few sites were identified for installation of security fencing and/or fall protection including:

1 Crown Zellerbach gates,
2 Albany Gates,
3 Periwinkle Creek Diversion,
4 34th Ave Debris Screen,
5 Vine St Intake Bar Screen.

ESTIMATED COST:

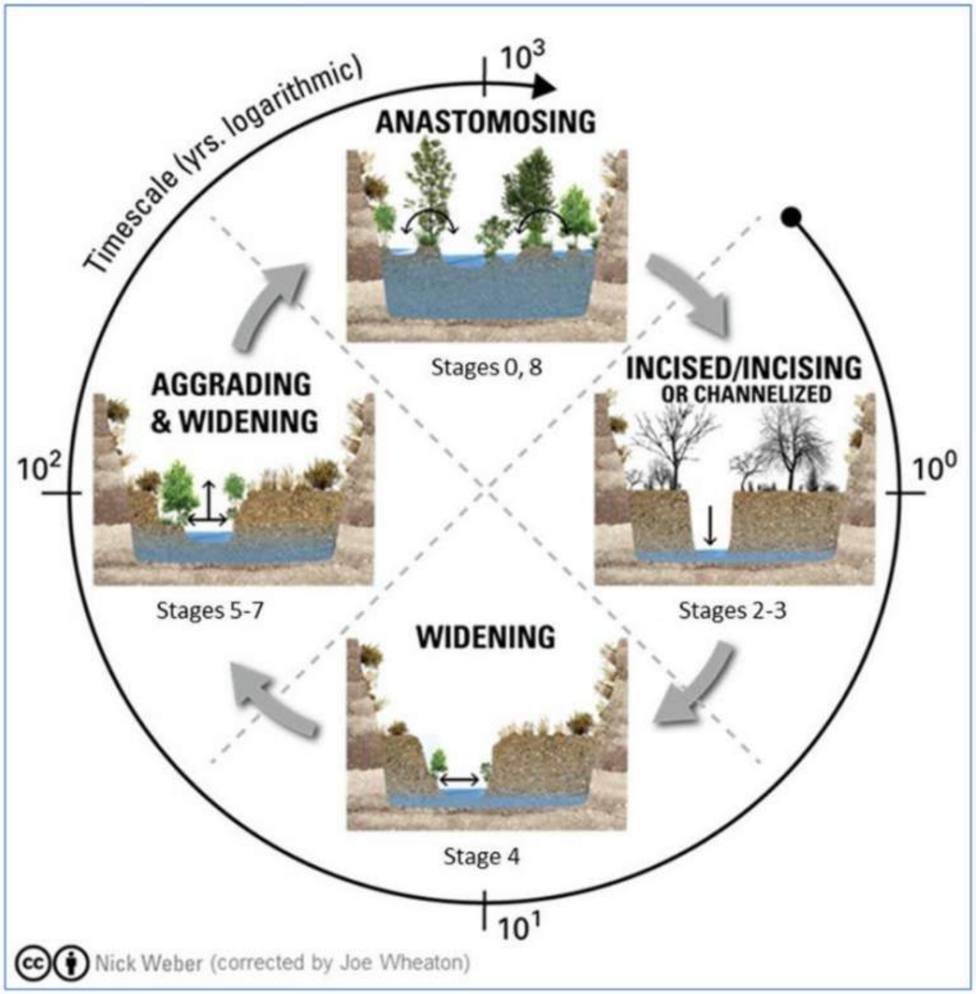
CONSTRUCTION COST: $40,000

CAPITAL COST: $64,000

RANGE: $32,000 - $130,000

Canal Adaptive Management Plan

PROJECT NUMBER(S): N-C-4
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2024 - 2043



PROJECT PURPOSE AND DESCRIPTION:

A key component of the AMP would be development and implementation of a long-term plan to monitor key locations in the canal and collect regular, high-quality survey data to identify and quantify degradational or aggradational trends, which will better inform the need for grade control structures to be included in future CIPs. The costs presented assume that the AMP will require monitoring every 5 years for the next 20 years.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $100,000

RANGE: $50,000 - $200,000

Cheadle Lake Berm Geotechnical Analysis

PROJECT NUMBER(S): N-C-5
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2024 – 2025

PROJECT PURPOSE AND DESCRIPTION:

It is recommended to conduct additional geotechnical work including exploratory drilling and analysis to evaluate the stability of the berm for both static and seismic loading conditions.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $45,000

RANGE: $23,000 - $90,000

Near-Term Canal Dredging

PROJECT NUMBER(S): N-C-6
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025 – 2026

PROJECT PURPOSE AND DESCRIPTION:

This is an existing project the City is currently planning for 2025, and is listed here for reference. The City dredges the downtown area (starting at Vine Street WTP south approximately 4,300 feet) of the canal. This project will include removal of sedimentation, plants and other debris required to maintain the capacity and mitigate flooding of adjacent properties. The 2024-2028 Capital Improvement Program included a cost of $900,000.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $900,000

RANGE: $450,000 - $1,800,000

Lebanon Intake Structure Modification Evaluation

PROJECT NUMBER(S): N-C-7

PROJECT DRIVER: Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026

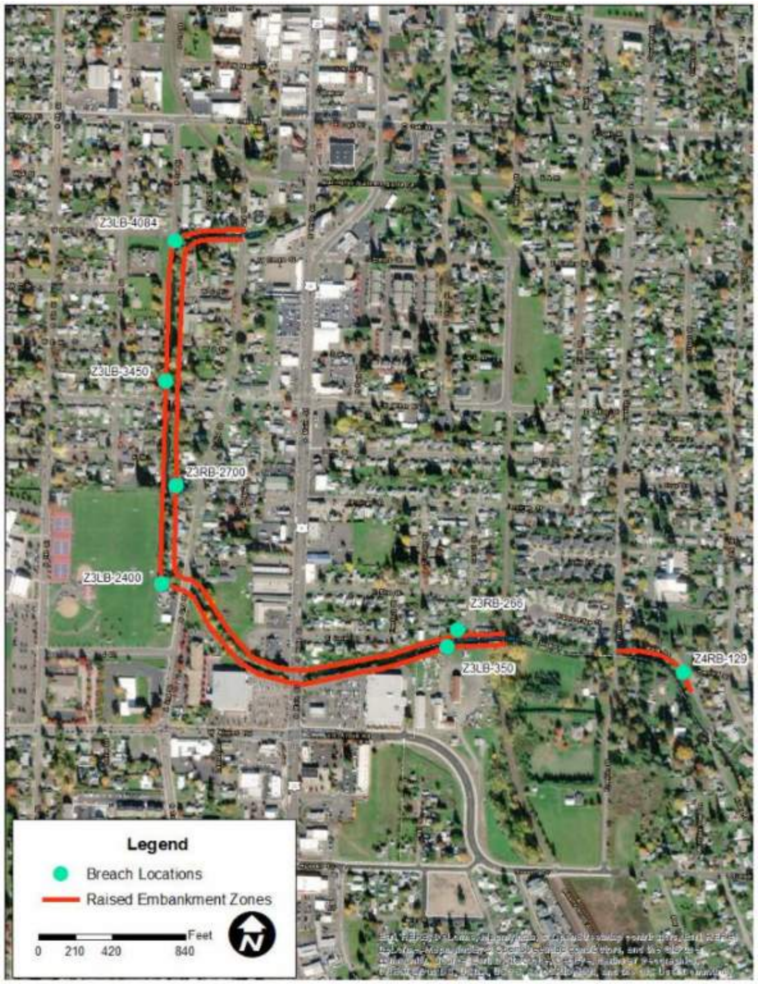


Figure 4. Raised Embankment Upstream of Lebanon Intake Structure

PROJECT PURPOSE AND DESCRIPTION:

With the recent relocation of the City of Lebanon's water treatment plant off the canal, the intake diversion structure is no longer needed to create backwater to divert to Lebanon's treatment plant and it could potentially be modified in such a way to lower upstream water surface elevations and reduce flood risk from potential embankment failures. Two potential alternatives were identified for modification. Further evaluation of the preliminary alternatives is recommended.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $50,000

RANGE: $25,000 - $100,000

Hydropower CIP Sheets

Vine St Hydropower Generator Inspection and Contingency

PROJECT NUMBER(S): N-H-1
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2024 – 2025

PROJECT PURPOSE AND DESCRIPTION:

The generator requires inspection which should come before the utilization analysis to assess any further upgrades required for operation. This project includes the inspection, approximately $40,000, and contingency , approximately $400,000, for possible recommended upgrades.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $440,000

RANGE: $220,000 - $880,000

Vine St Hydropower Operator Data & Turbine Utilization Analysis

PROJECT NUMBER(S): N-H-2

PROJECT DRIVER: Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2024-2025

PROJECT PURPOSE AND DESCRIPTION:

Preliminary evaluation indicates that the combined turbine system efficiency can be improved anywhere from 4.3 percent to 26.5 percent with a newly designed runner and wicket gates. Additional analysis is recommended to determine the root causes of turbine down time when canal flow would otherwise allow for generation.

ESTIMATED COST:

CONSTRUCTION COST:NA

CAPITAL COST: $8,500

RANGE: $4,000 - $17,000

Vine St Hydropower Combined Upgrades

PROJECT NUMBER(S): N-H-3
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2026 - 2027

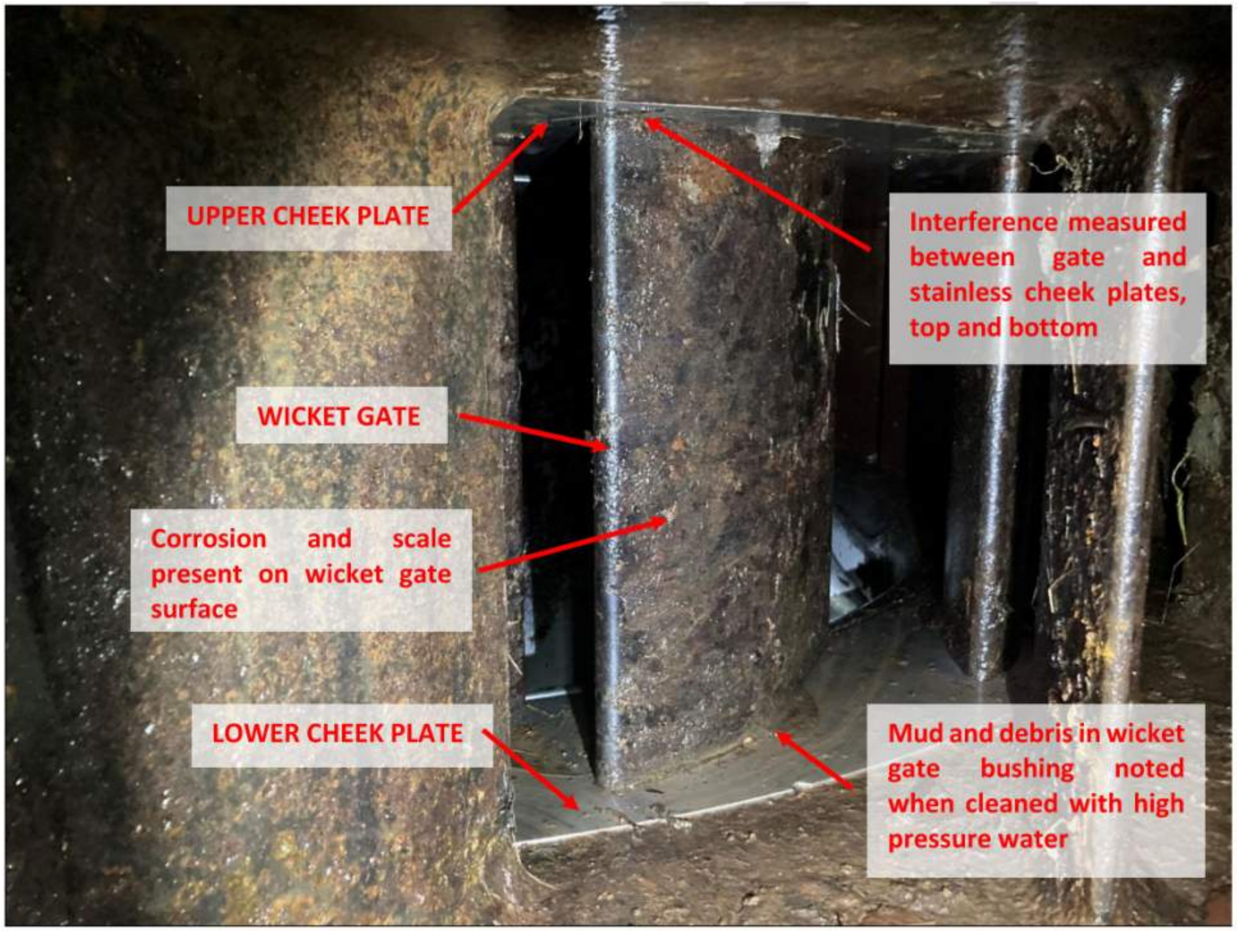


Figure 1 – Typical View of the Wicket Gate Showing Corrosion on the Blade Surface and General Locations of Interference and Probable Binding

PROJECT PURPOSE AND DESCRIPTION:

The upgrades are grouped together because they all require the disassembly and reassembly of the turbine. Upgrades include wicket gate replacement, bearing replacement, and spiral case flange for cleaning. It also includes the inspection, blasting, and coating of the interior of the turbine and contingencies for welding repairs, approximately $100,000, and shop repairs, approximately $75,000.

ESTIMATED COST:

CONSTRUCTION COST: $1,120,000

CAPITAL COST: $1,1790,000

RANGE: $900,000 - $3,580,000

Vine St Hydropower Turbine Power Unit

PROJECT NUMBER(S): N-H-4
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2026 - 2027

PROJECT PURPOSE AND DESCRIPTION:

The HPU has some design/build characteristics which make it unintuitive to use and maintain. It is apparent that the hydraulic pump(s) run continuously during operation of the turbine while other HPU designs run only when needed, thus saving a considerable amount of energy over the lifespan of the unit. It is recommended that the current HPU be replaced with one of newer design.

ESTIMATED COST:

CONSTRUCTION COST: $163,000

CAPITAL COST: $261,000

RANGE: $131,000 - $522,000

Vine St Hydropower Turbine Personnel Training

PROJECT NUMBER(S): N-H-5
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2027 - 2027

PROJECT PURPOSE AND DESCRIPTION:

The controls system has several project specific peculiarities that make the human machine interface (HMI) un-intuitive to operate and appear to be sources of confusion. It is recommended that the controls system be reviewed by a professional and that a training session be held to familiarize the users with the architecture and operation of the system.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $8,500

RANGE: $4,000 - $17,000

Vine St Hydropower Intake and Trash Rack Evaluation

PROJECT NUMBER(S): N-H-6
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2027 – 2027

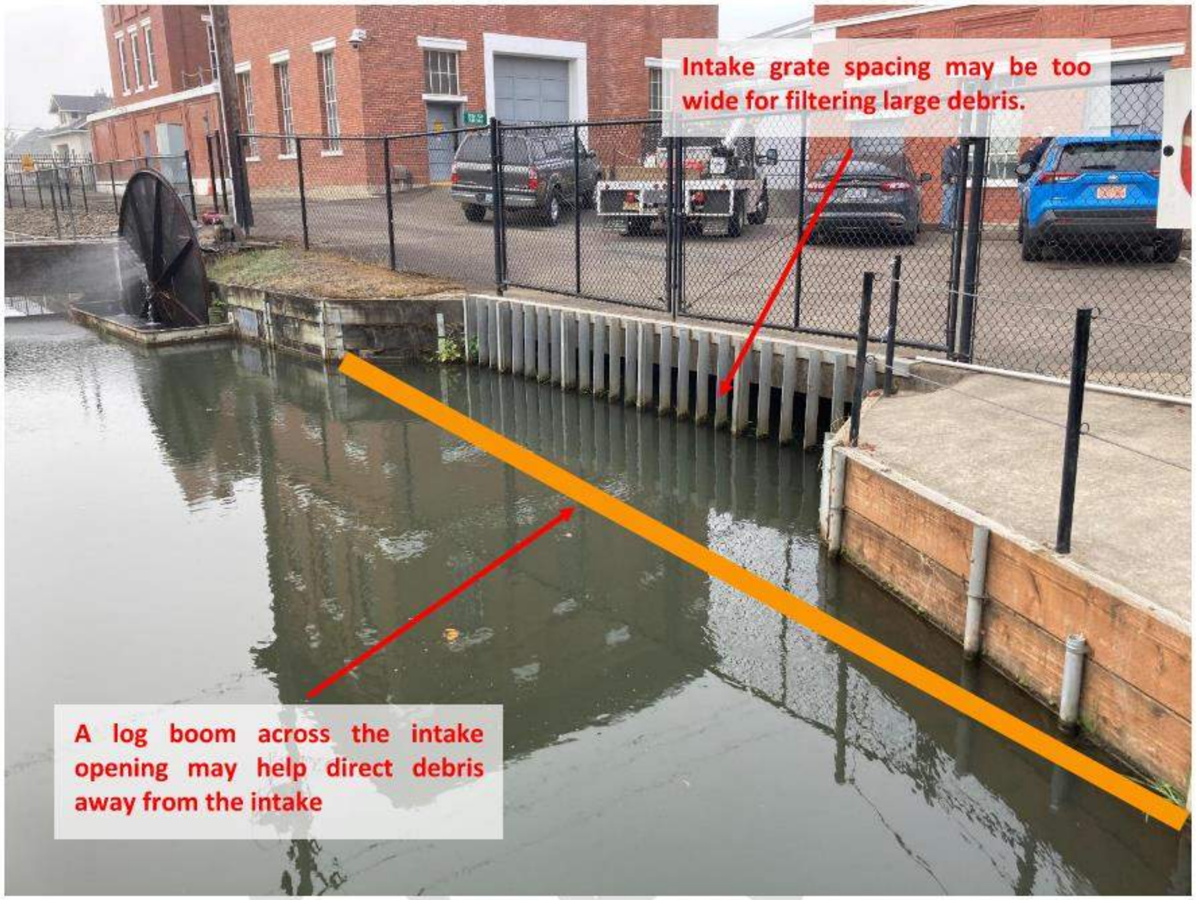


Figure 3 – A Closer Intake Grate Spacing and/or Boom to Direct Large Debris Away from the Turbine Intake may Result in Fewer Outages Due to Required Trash Rack Maintenance

PROJECT PURPOSE AND DESCRIPTION:

It is recommended to perform further investigation of the hydropower intake and trash rack for the potential to improve generation time and decrease maintenance costs.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $15,000

RANGE: $8,000 - $30,000

Vine ST WTP Sheets

Vine St WTP Filter 7 & 8 Silica Sand Layer

PROJECT NUMBER(S): L-WTP-1
PROJECT DRIVER: Future Need
TRIGGER: Performance (Optional)
ESTIMATED START & END DATE 2041-2043

PROJECT PURPOSE AND DESCRIPTION:

In 2019, it was determined that Vine St WTP Filters #7 and #8 do not include silica media. The next time the anthracite media is replaced, it is recommended to consider adding silica sand to Filters #7 and #8.

ESTIMATED COST:

CONSTRUCTION COST: $300,000

CAPITAL COST: $480,000

RANGE: $240,000 - $960,000

Vine St WTP Filter Media Coring

PROJECT NUMBER(S): M-WTP-1
PROJECT DRIVER: Performance
TRIGGER: Future Need
ESTIMATED START & END DATE 2029-2029

PROJECT PURPOSE AND DESCRIPTION:

It is recommended to perform periodic coring at each filter to examine the full column of media closely.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $50,000

RANGE: $25,000 - $100,000

Vine St WTP Raw Water Pump Station Pipes

PROJECT NUMBER(S): M-WTP-3

PROJECT DRIVER: Existing Need

TRIGGER: Condition

ESTIMATED START & END DATE 2033 – 2033

PROJECT PURPOSE AND DESCRIPTION:

The existing Raw Water Pump Station pipes are chipping and need recoating.

ESTIMATED COST:

CONSTRUCTION COST: $20,000

CAPITAL COST: $32,000

RANGE: $16,000 - $64,000

Vine St WTP Raw Water Splitter Coating

PROJECT NUMBER(S): M-WTP-4
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2033--2033

PROJECT PURPOSE AND DESCRIPTION:

The raw water splitter is rusted. It is recommended to coat it.

ESTIMATED COST:

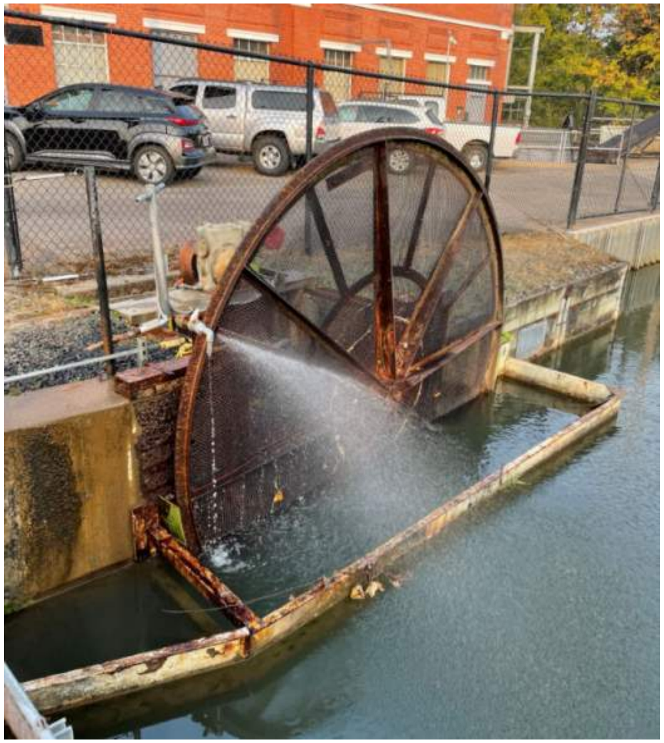
CONSTRUCTION COST: $30,000

CAPITAL COST: $50,000

RANGE: $25,000 - $96,000

Vine St WTP Raw Water Intake Screen Replacement

PROJECT NUMBER(S): M-WTP-5
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2033-2033



PROJECT PURPOSE AND DESCRIPTION:

The raw water screen and its various components are rusted and need replacement.

ESTIMATED COST:

CONSTRUCTION COST: $125,000

CAPITAL COST: $197,000

RANGE: $100,000 - $400,000

Vine St WTP Chemical Injection Vault Pipes

PROJECT NUMBER(S): M-WTP-6
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2033-2033

PROJECT PURPOSE AND DESCRIPTION:

Vine St WTP Chemical Injection Vault piping, bolts, and pipe supports have rust. Measure pipe thickness. Replace or recoat. Replace bolts. Replace pipe supports, as necessary.

ESTIMATED COST:

- Assumes recoating and not replacement

CONSTRUCTION COST: $30,000

CAPITAL COST: $50,000

RANGE: $25,000 - $96,000

Vine St Facilities Viability Study

PROJECT NUMBER(S): N-SS-1

PROJECT DRIVER: Future Need

TRIGGER: Planning

ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

In light of the condition and seismic concerns at the Vine Street WTP, and the extent of improvements at the Hydroelectric Facility and Canal, it is recommended for the City to perform a viability study to evaluate different alternatives for the future of the Vine St site. First, the viability study should include the alternative of Vine St WTP replacement with a new WTP. Project numbers N-SS-1A, N-SS-1B, etc. convey the many capital projects recommended at the existing Vine St WTP, if it is not decommissioned. The viability study should include an analysis of the cost of reactive maintenance at the existing Vine St WTP and the amount of extended lifetime from performing those projects compared to the cost and lifetime of a new WTP investment. The viability study should also consider the challenges and feasibility of replacing structures at Vine St WTP, due to their historical nature, and the phasing challenges if the Vine St WTP is able to remain in service while performing the major recommended upgrades. The viability study should look at multiple different locations for a new WTP and perform a cost-benefits analysis for each location. The initial evaluation done as part of this WMP suggests that a new is approximately $87,500,000 capital cost as detailed further on the next page. The viability study should refine assumptions with a new WTP and update the cost estimate.

Next, the hydroelectric facility should be evaluated. A generator inspection should be performed and identify estimated generator upgrade costs. The study should update the expected cost of improvement at the Hydroelectric facility and refine the return-on-investment analysis. The viability study should also include the alternative to decommission the hydroelectric facility and what to do with non-consumptive water rights.

Then, impacts to the canal should be considered in the viability study. Different locations of a WTP may impact the flow and required repairs of the Canal, which should be evaluated. Also, the decision to potentially decommission the Hydroelectric Facility may also have an impact on canal flows and repairs which should be encompassed. The study should determine if recommendations for repairs and remediation to the Canal will change with different alternatives and the cost impacts associated.

Last, as the City considers replacement alternatives for of the Vine St WTP, there may be an opportunity to consolidate some of the Zone 1 storage and pumping into a single location by decommissioning the Maple, Queen, and 34th reservoirs and pump stations and constructing an equivalent storage volume and pumping capabilities at a new WTP site. The option of Zone 1 consolidation is recommended for further hydraulic and cost evaluation as part of the Vine St. viability study.

VIABILITY STUDY ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $750,000

RANGE: $375,000 - $1,500,000

PRELIMINARY COST ESTIMATE OF NEW WATER TREATMENT PLANT		
ASSUMPTIONS		
• 10 MGD initial WTP capacity. • Room for future expansion up to 20 MGD • Raw Water Pump Station assumes a building, an intake from the canal, and four pumps. • Membrane Building assumes pressurized membrane system (Membranes, feed pumps, backwashing strainers, valve racks, reverse filtration pumps, CIP tank and system, neutralization tank and system, air compressors, & air receiver), electrical room, meeting room, bathrooms, and lab. • Chemical Building includes sodium hypochlorite generation, fluoride, citric acid, aluminum chlorohydrate, fluoride, sodium bisulfate, and clean-in-place system. For chemicals, tanks and metering pumps are assumed. • Backwash Basin is assumed to be outdoor and exposed. • Reservoir Storage includes two concrete above ground concrete tanks totaling 4.3 MG to replace existing Zone 1 storage and pumping (Maple, Queen, and 34th). • Finished Water Pump Station includes a building and 4 pumps. • Does not include land acquisition.		
DESCRIPTION		ESTIMATED COST
Raw Water Pump Station		$4,100,000
Membrane Building		$30,300,000
Chemical Building		$5,500,000
Backwash Basin		$1,300,000
Reservoirs		$9,400,000
Finished Water Pump Station		$4,100,000
ENGINEER'S PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST		**$54,700,000**
Construction Contingency	30%	$16,400,000
Engineering Design, Legal, and Administrative Costs	30%	$16,400,000
ENGINEER'S PRELIMINARY OPINION OF PROBABLE TOTAL CAPITAL COST		**$87,500,000**

Vine St WTP Raw Water Pump Station Replacement

Project N-SS-1A supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1A
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Raw Water Pump Station is noncompliant for nearly all of the items on the ASCE/SEI 41-17 Checklist for this building type. Prepare for replacement of this structure. A seismic retrofit for a structure of this age and type is not appropriate for this essential facility.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Hydroelectric Building Replacement

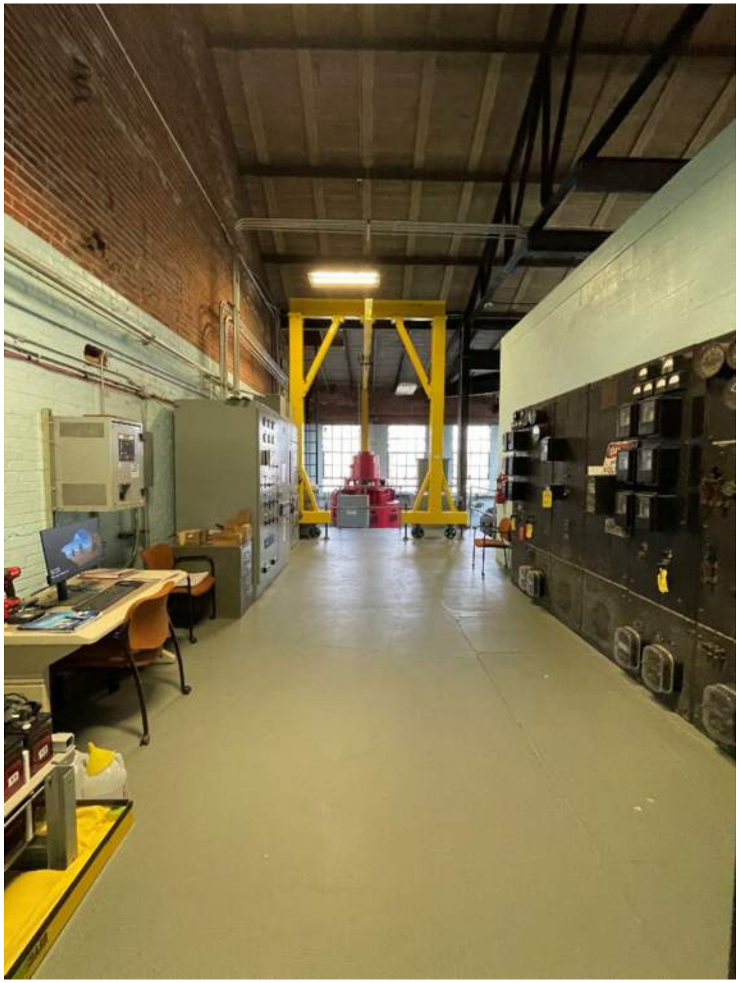
Project N-SS-1B supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1B

PROJECT DRIVER: Seismic/Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026



PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Hydroelectric Building is noncompliant for nearly all of the items on the ASCE/SEI 41-17 Checklist for this building type. Prepare for replacement of this structure. A seismic retrofit for a structure of this age and type is not appropriate for this essential facility.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Control/Chemical Storage Building Replacement

Project N-SS-1C supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1C
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Control Building/ Chemical Storage Building reinforcing bar details do not comply with recommended standards. A seismic retrofit to address the shortcomings identified by the ASCE/SEI 41-17 checklist would be very difficult to perform.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Soda Ash Building Replacement

Project N-SS-1D supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S):	N-SS-1D
PROJECT DRIVER:	Seismic/Condition
TRIGGER:	Existing Need
ESTIMATED START & END DATE	2025-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Soda Ash Building is noncompliant for nearly all of the items on the ASCE/SEI 41-17 Checklist for this building type. Prepare for replacement of this structure. A seismic retrofit for a structure of this age and type is not appropriate for this essential facility.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Filters 1-6 Building Replacement

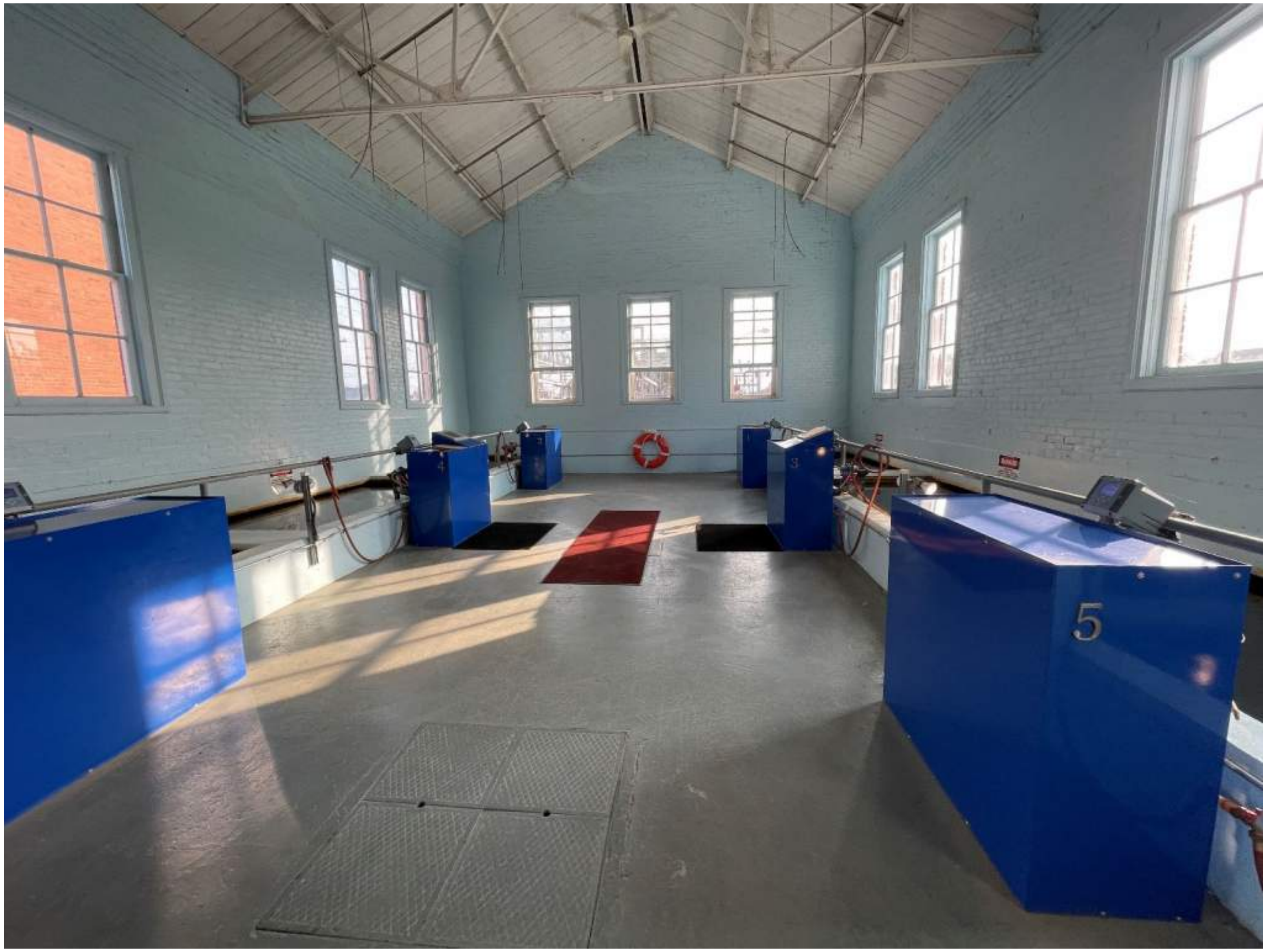
Project N-SS-1E supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1E

PROJECT DRIVER: Seismic/Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026



PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Filters 1-6 Building is noncompliant for nearly all of the items on the ASCE/SEI 41-17 Checklist for this building type. Prepare for replacement of this structure. A seismic retrofit for a structure of this age and type is not appropriate for this essential facility.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Filters 7-10 Building Replacement

Project N-SS-1F supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1F

PROJECT DRIVER: Seismic/Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP, reinforcing bar details for the Filters 7-10 Building are unknown for the ASCE/SEI 41-17 Checklist for this building type. It is unlikely that any reinforcing bars are appropriately sized, spaced and placed. Prepare for replacement of this structure. A seismic retrofit for a structure of this age and type is extremely difficult for this essential facility.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Accelator 1 Foundation

Project N-SS-1G supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1G

PROJECT DRIVER: Seismic/ Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

At Vine St WTP, the perimeter columns below the exterior walls of Accelator 1 create a vertical irregularity and weak lateral force resisting system at the base. Infill between the existing columns with a concrete wall footing to eliminate the vertical irregularity. Tie the foundations together. If executed, the construction cost of this project is estimated at $286,000. If this structure is planned for future decommissioning due to the new WTP, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Accelator 2 Foundation

Project N-SS-1H supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S):	N-SS-1H
PROJECT DRIVER:	Seismic/ Condition
TRIGGER:	Existing Need
ESTIMATED START & END DATE	2025-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Accelator 2 is not bolted to the foundation and relies on friction between the steel and concrete. Maintenance of steel wall is recommended. Consider adding anchor bolts capable of resisting uplift and sliding seismic forces. Clean and remove moss, mold and rust then maintain tank coating. If executed, the construction cost of this project is estimated at $603,000. If this structure is planned for future decommissioning due to the new WTP, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Elevated Pipes and Cables

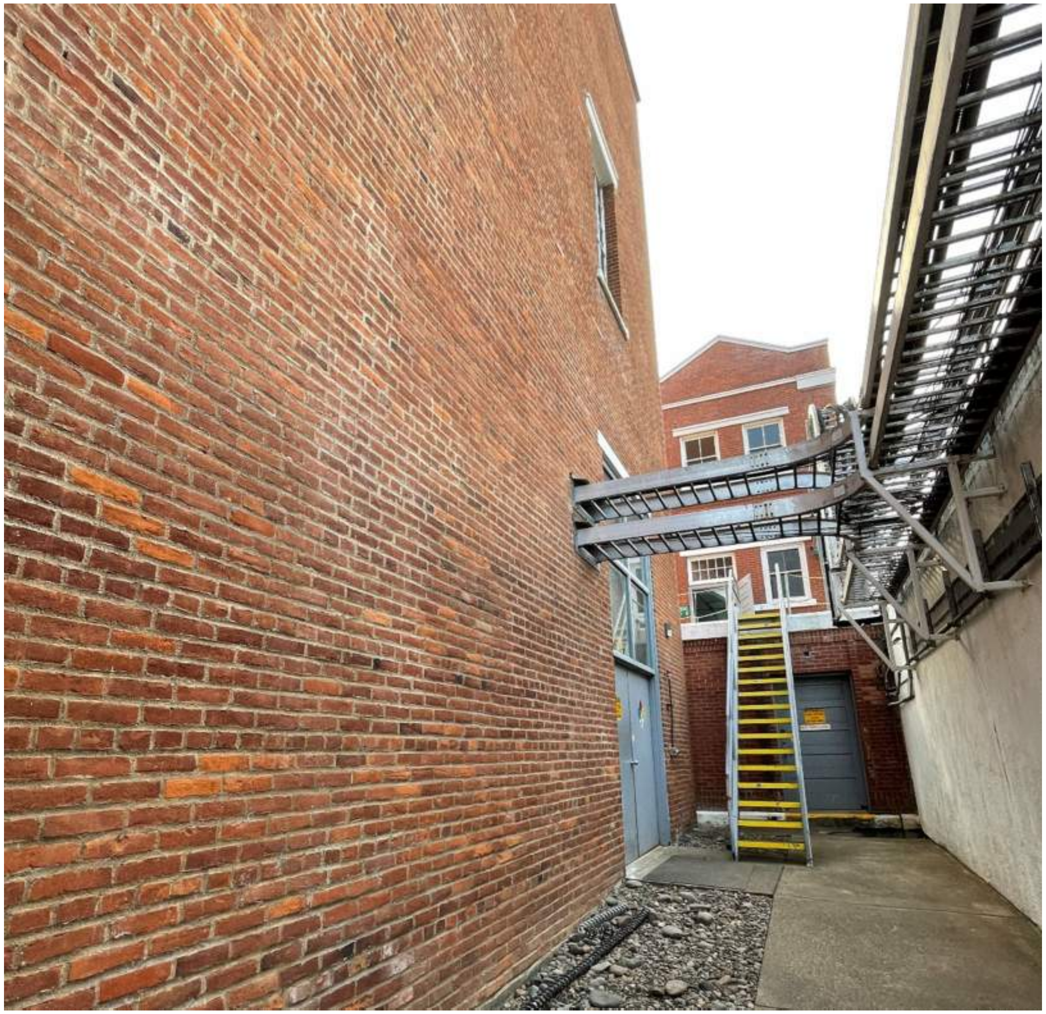
Project N-SS-1I supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1I

PROJECT DRIVER: Seismic

TRIGGER: Existing Need

ESTIMATED START & END DATE 2025-2026



PROJECT PURPOSE AND DESCRIPTION:

There are several elevated pipes and cable trays spanning between different structures. These elements present a falling hazard during a seismic event, particularly when located near egress areas. They also tie structures together, preventing them from moving independently. Elevated pipes and cable trays should be relocated to ground level or retrofitted to allow differential movement of the structure they are spanning between.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Unreinforced Brick Parapet

Project N-SS-1J supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S): N-SS-1J
PROJECT DRIVER: Seismic
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025-2026

PROJECT PURPOSE AND DESCRIPTION:

There are multiple structures at Vine St WTP that have an unreinforced brick parapet wall elements, which project above the roof, present a falling hazard during a seismic event particularly when located over areas of egress. The structures include the Raw Water Pump Station, Hydroelectric Building, Soda Ash Building, and Filters 1-6. It is recommended that the unreinforced brick parapets be removed so that the walls do not project above the roof, or they should be laterally braced to the roof framing for seismic & wind forces.

ESTIMATED COST:

CONSTRUCTION COST: NA

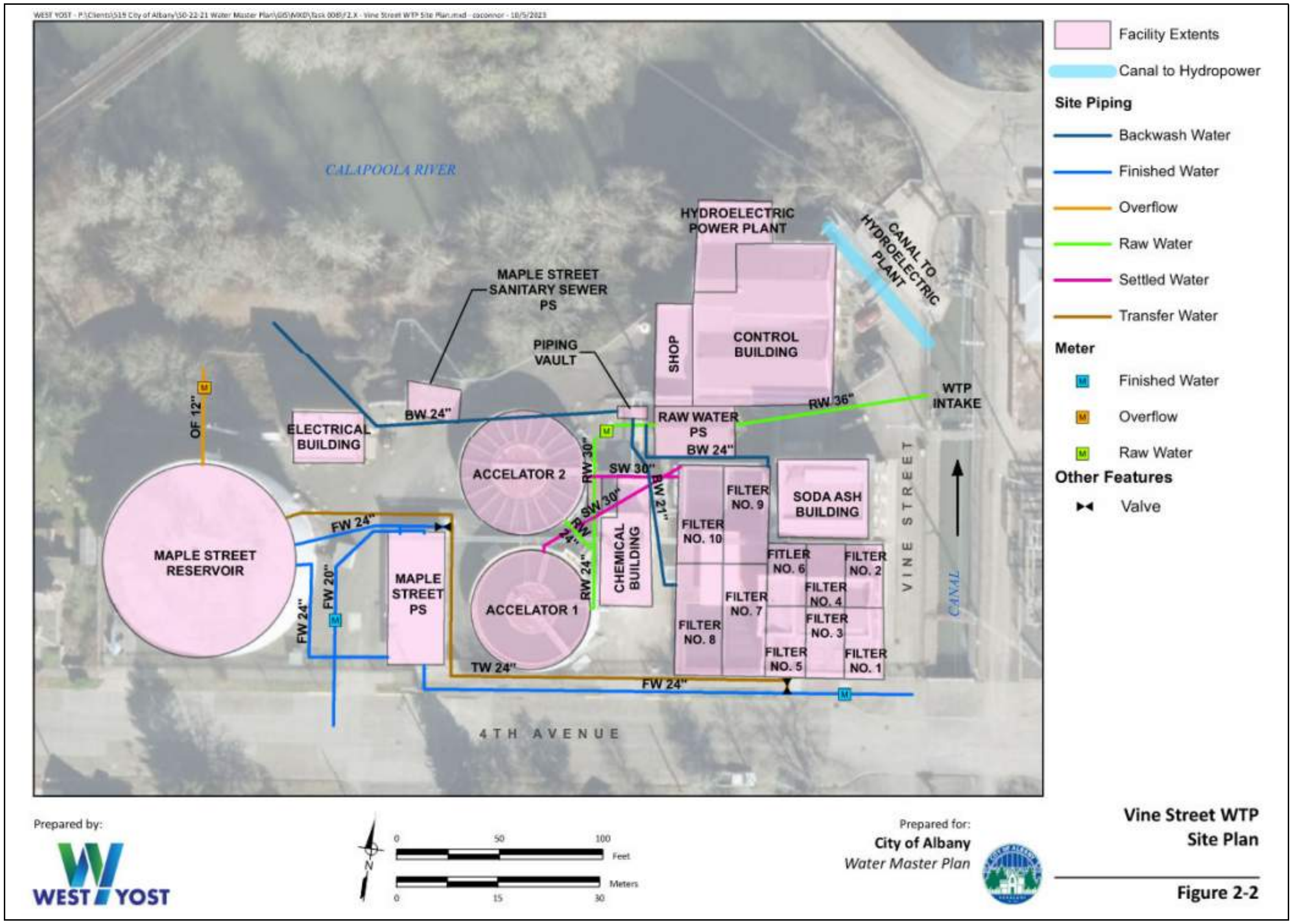
CAPITAL COST: NA

RANGE: NA

Vine St WTP Geotechnical Study

Project N-SS-1K supports the need for project N-SS-1, Vine St Facilities Viability Study.

PROJECT NUMBER(S):	N-SS-1K
PROJECT DRIVER:	Seismic
TRIGGER:	Existing Need
ESTIMATED START & END DATE	2025-2026



PROJECT PURPOSE AND DESCRIPTION:

Preliminary evaluation has shown that the liquefaction and lateral spread hazards are low at the Vine Street WTP site, but exploratory drilling on site and analysis would be needed to confirm. The mapped landslide hazard corresponds to the ±45-foot-tall steep slope (slope ≥ 1.5H:1V) between the facility and the Calapooia River. If Vine St WTP were not replaced, or if Maple St Reservoir and Pump station remain in service long-term, exploratory drilling and analysis is recommended to confirm the subsurface conditions and evaluate the seismic-induced landslide hazard. If executed, the capital cost of this project is estimated at $75,000.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Vine St WTP Backwash System Check Valves

PROJECT NUMBER(S): N-WTP-3
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2027-2028

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP backwash system appears to have no check valves. Add check valves if possible.

ESTIMATED COST:

CONSTRUCTION COST: $185,000

CAPITAL COST: $300,000

RANGE: $150,000 - $600,000

Vine St WTP Backwash Pump Base

PROJECT NUMBER(S): N-WTP-4
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2027-2028

PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP large backwash pump has a cracked base. Confirm pump anchorage is secure or replace concrete pad under pump base.

ESTIMATED COST:

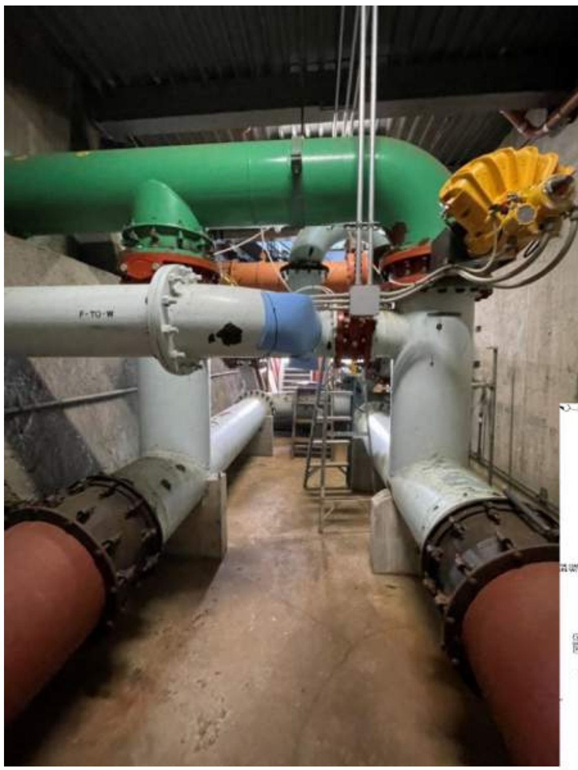
CONSTRUCTION COST: $5,000

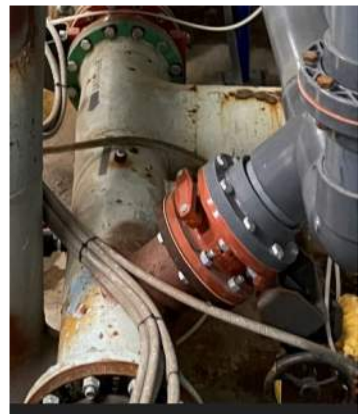
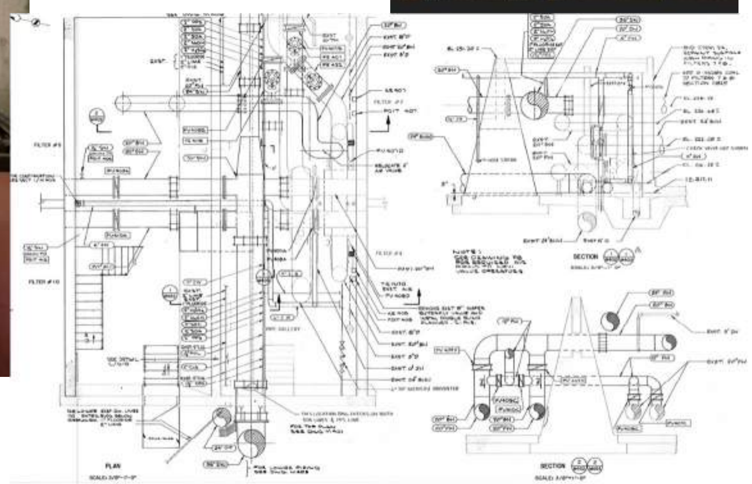
CAPITAL COST: $8,000

RANGE: $4000 - $16,000

Vine St WTP Filter Gallery Pipes

PROJECT NUMBER(S): N-WTP-5
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2026-2026



PROJECT PURPOSE AND DESCRIPTION:

The filter pipe gallery pipes have rust and are corroded. Additional pipe supports may be required. Perform pipe thickness test and recoat or replace pipes, as necessary.

ESTIMATED COST:

- Assumed replacement of 10” steel pipe in Filter Gallery 1-6
- Assumed 30% of pipes to be replaced for filter gallery 7-10
- Assumed recoating of all existing and new pipe

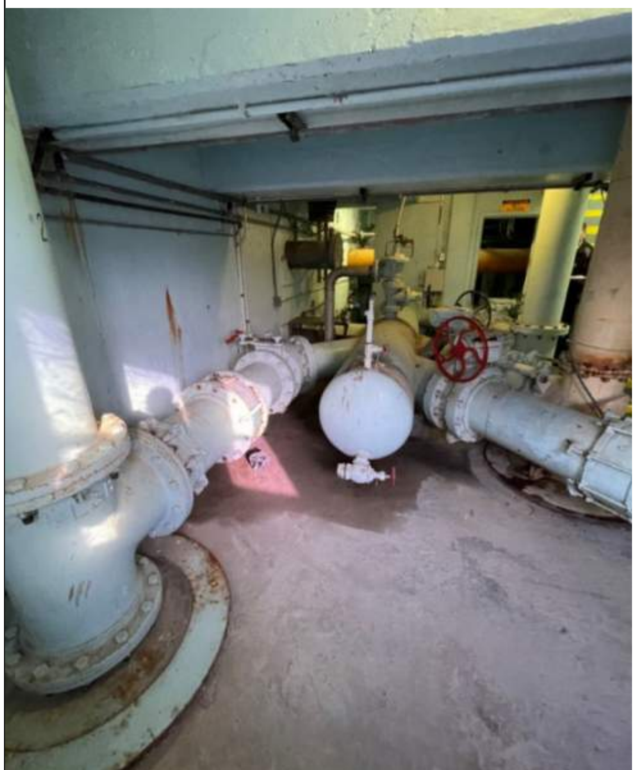
CONSTRUCTION COST: $860,000

CAPITAL COST: $1,380,000

RANGE: $690,000 - $2,752,000

Vine St WTP Transfer Water Pump Station Pipes

PROJECT NUMBER(S): N-WTP-6
PROJECT DRIVER: Existing Need
TRIGGER: Seismic and Condition
ESTIMATED START & END DATE 2026 - 2026



PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP Transfer Water PS piping has rust. Appears to have no check valves. May need more pipe supports including lateral supports, may need more dismantling joints. Measure pipe thickness and recoat or replace pipes, as necessary. Add pipe supports within 2 feet of changes of direction, where practical. Add check valves and dismantling joints where practical.

ESTIMATED COST:

- Assumed 25% of pipes to be replaced for transfer pump station pipes
- Assumed recoating of all existing and new pipe
- Assumes 2 wafer style check valves

CONSTRUCTION COST: $50,000

CAPITAL COST: $80,000

RANGE: $40,000 - $160,000

Vine St WTP RWPS Flow Meter Vault Pipes

PROJECT NUMBER(S): N-WTP-7
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2026-2026

PROJECT PURPOSE AND DESCRIPTION:

The Vine St RWPS Flow Meter Vault piping has rust. Measure pipe thickness. Replace or recoat.

ESTIMATED COST:

- Assumes recoating of pipe not replacement

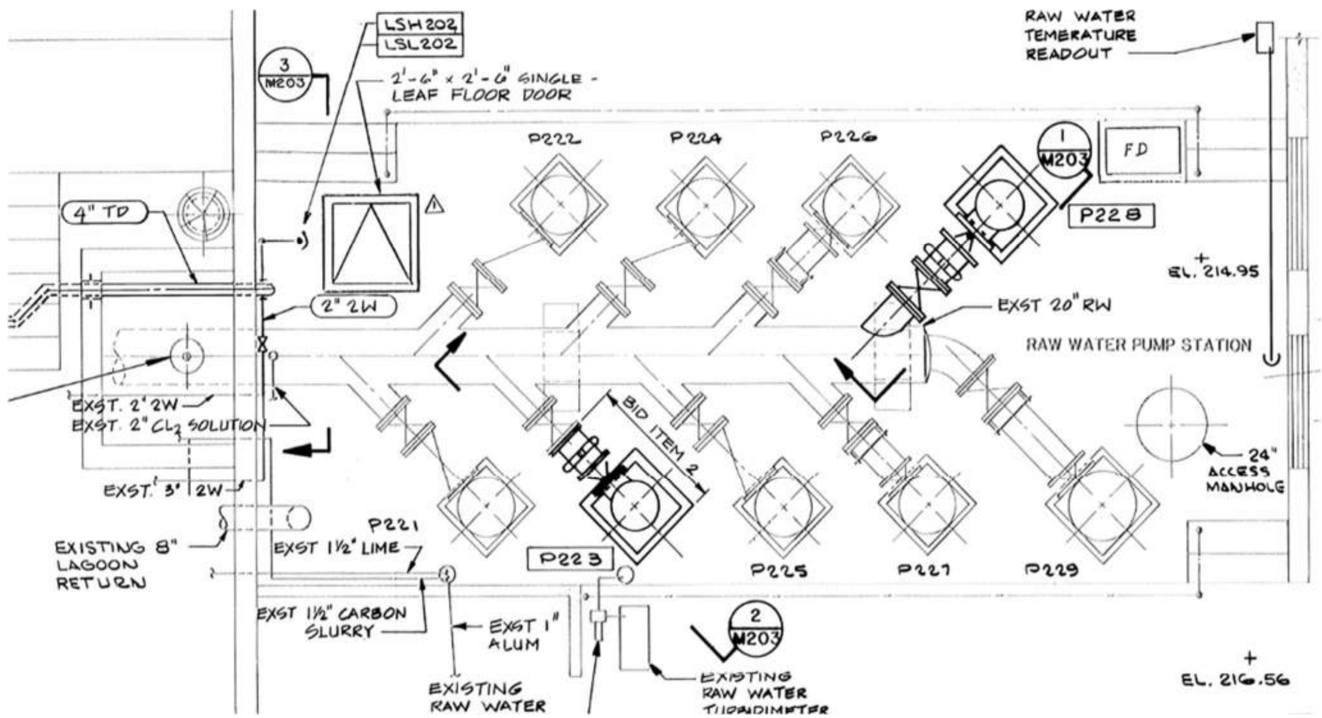
CONSTRUCTION COST: $5,000

CAPITAL COST: $8,000

RANGE: $4,000 - $16,000

Vine St WTP RWPS Check Valves

PROJECT NUMBER(S): N-WTP-8
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2028-2028



PROJECT PURPOSE AND DESCRIPTION:

The raw water pumps are missing five check valves. Add check valves where practical.

ESTIMATED COST:

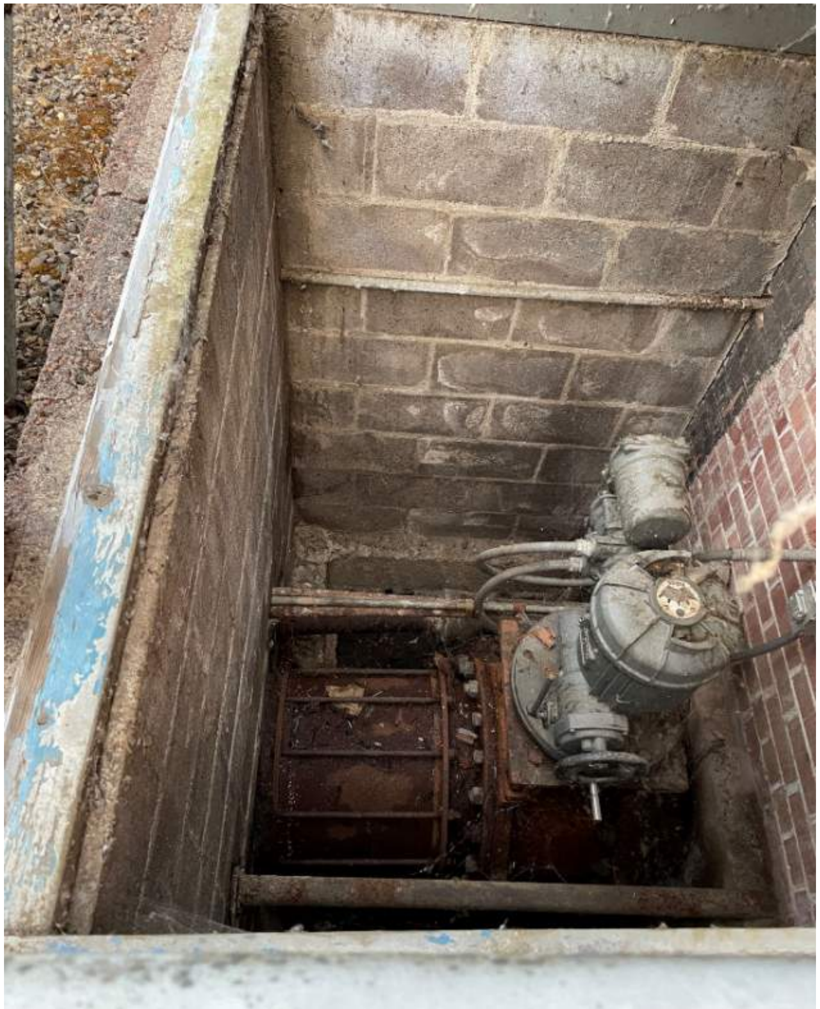
CONSTRUCTION COST: $105,000

CAPITAL COST: $170,000

RANGE: $85,000 - $336,000

Vine St WTP RWPS Valve Vault

PROJECT NUMBER(S): N-WTP-9
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2025-2026



PROJECT PURPOSE AND DESCRIPTION:

The Vine St WTP RWPS Valve Vault piping and valve are rusted. Measure pipe thickness. Replace or recoat. Replace valve.

ESTIMATED COST:

- Assumes replacement of vault, pipe, and valve

CONSTRUCTION COST: $125,000

CAPITAL COST: $200,000

RANGE: $100,000 - $400,000

Vine St WTP Chemical Tank Anchorage

PROJECT NUMBER(S): N-WTP-11
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2024-2024

PROJECT PURPOSE AND DESCRIPTION:

Liquid chemical room tanks may need more anchorage. Provide added tank anchorage as needed. Add MSDS on tanks as needed.

ESTIMATED COST:

CONSTRUCTION COST: $5,000

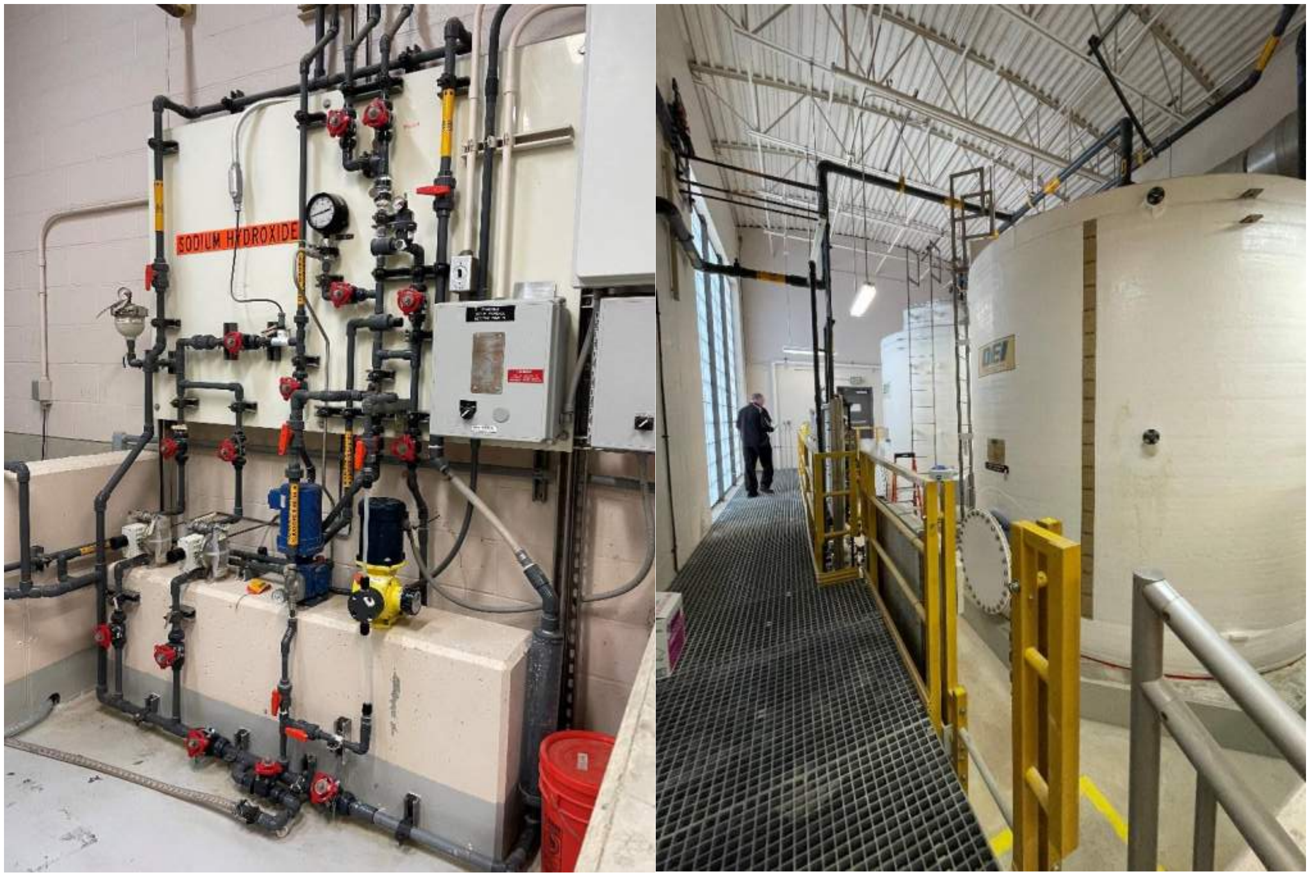
CAPITAL COST: $8,000

RANGE: $4,000 - $16,000

AM WTP CIP Sheets

AM WTP Chemical Improvements

PROJECT NUMBER(S): L-WTP-2
PROJECT DRIVER: Performance (Optional)
TRIGGER: Future Condition Concerns
ESTIMATED START & END DATE 2041-2043



PROJECT PURPOSE AND DESCRIPTION:

Optional Project: When the condition of the sodium hypochlorite and caustic tanks and piping requires improvement, the City can consider installing a sodium hypochlorite on site generation for improved availability of sodium hypochlorite.

ESTIMATED COST:

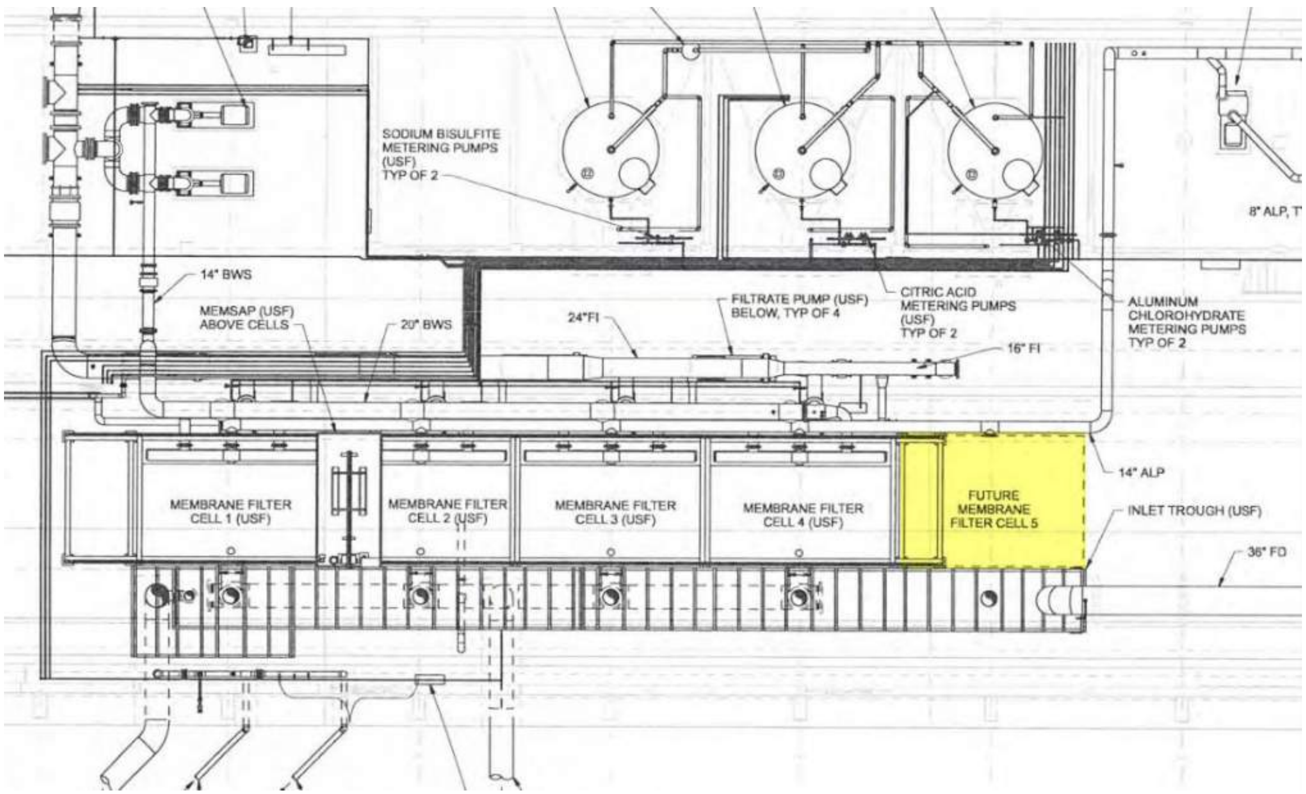
CONSTRUCTION COST: $1,000,000

CAPITAL COST: $1,600,000

RANGE: $800,000 - $3,200,000

AM WTP 5th Filter Cell

PROJECT NUMBER(S): M-WTP-2
PROJECT DRIVER: Capacity/Performance
TRIGGER: Existing Need
ESTIMATED START & END DATE 2031-2033



PROJECT PURPOSE AND DESCRIPTION:

It is recommended that a 5th membrane cell be installed. It can be used to improve cleaning and maintenance of the membranes for existing needs and in the future, membranes can be added to reach the Ultimate plant capacity.

ESTIMATED COST:

CONSTRUCTION COST: $1,820,000

CAPITAL COST: $2,910,000

RANGE: $1,460,000 - $5,820,000

AM WTP Replace Filter Cell Header Pipes

PROJECT NUMBER(S): M-WTP-7
PROJECT DRIVER: Performance
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

The existing header pipes for the filter cells have cracked and failed multiple times. It is thought that the pipe thickness may need to be thicker. It is recommended to replace the cell header pipes and consider a thicker pipe and stronger connection.

ESTIMATED COST:

CONSTRUCTION COST: $150,000

CAPITAL COST: $240,000

RANGE: $120,000 - $480,000

AM WTP Clean in Place Pump

PROJECT NUMBER(S): M-WTP-8
PROJECT DRIVER: Redundancy
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

There is only one existing clean-in-place pump used to clean AM WTP filter membranes. It is recommended to install a second pump for redundancy.

ESTIMATED COST:

CONSTRUCTION COST: $125,000

CAPITAL COST: $200,000

RANGE: $100,000 - $400,000

AM WTP Membrane Replacement

PROJECT NUMBER(S): N-WTP-1
PROJECT DRIVER: Capacity
TRIGGER: Replacement Schedule
ESTIMATED START & END DATE 2026-2028

PROJECT PURPOSE AND DESCRIPTION:

Membrane lifespan is 10 years and the next replacement cycle is 2026-2028. The City plans to increase the number of membranes to the maximum 648 membranes per cell at that point which is recommended to achieve full capacity.

ESTIMATED COST:

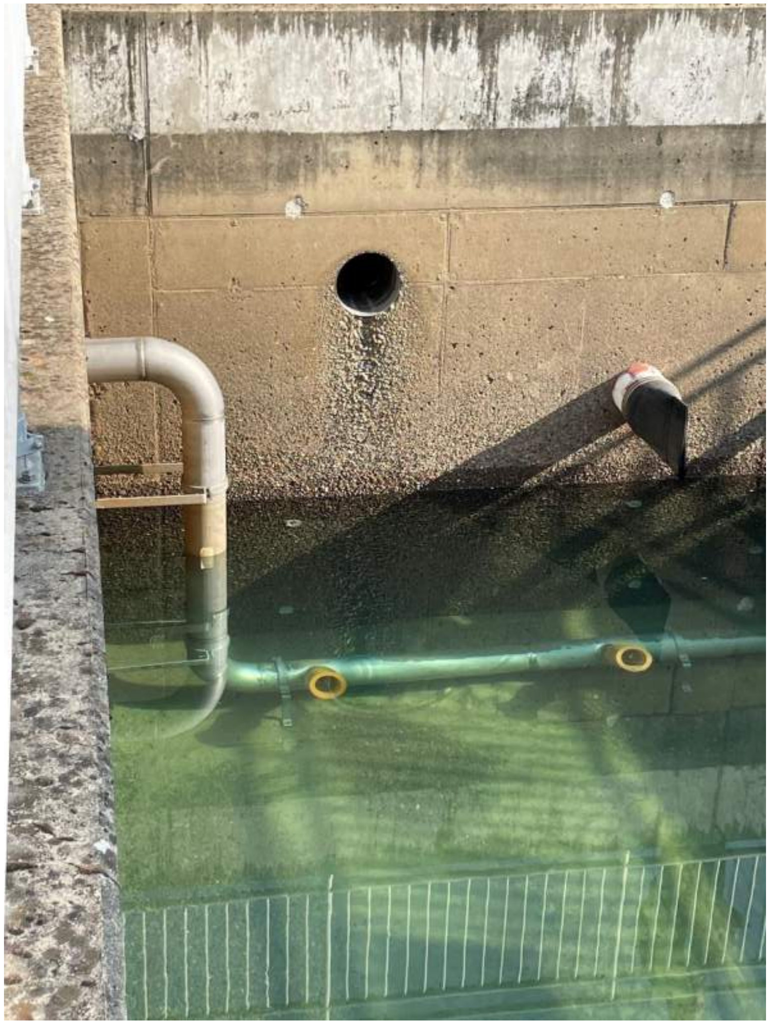
CONSTRUCTION COST: $3,500,000

CAPITAL COST: $5,600,000

RANGE: $2,800,000 - $11,200,000

AM WTP Neutralization Basin Concrete Repair

PROJECT NUMBER(S): N-WTP-2
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2028-2028



PROJECT PURPOSE AND DESCRIPTION:

The AM WTP Neutralization Basin concrete wall has exposed aggregate near the inlet and below the waterline. Clean and provide a coating repair for the concrete with significant surface loss and exposed aggregate to prevent further loss of wall thickness.

ESTIMATED COST:

CONSTRUCTION COST: $170,000

CAPITAL COST: $272,000

RANGE: $136,000 - $544,000

AM WTP Chemical Tanks Seismic Straps

PROJECT NUMBER(S): N-WTP-10
PROJECT DRIVER: Seismic
TRIGGER: Existing Need
ESTIMATED START & END DATE 2024-2024

PROJECT PURPOSE AND DESCRIPTION:

A&M WTP Chemical Tanks appear to have no seismic straps. Consider adding seismic straps.

ESTIMATED COST:

CONSTRUCTION COST: $25,000

CAPITAL COST: $40,000

RANGE: $20,000 - $80,000

AM WTP RWPS Valve Replacement

PROJECT NUMBER(S): N-WTP-12
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2027-2028

PROJECT PURPOSE AND DESCRIPTION:

AM WTP RWPS has one of the valves that is not sealing fully so the City can't isolate the wet well. Low level valves are also especially hard to isolate. Consider replacing all lowest level valves.

ESTIMATED COST:

CONSTRUCTION COST: $500,000

CAPITAL COST: $800,000

RANGE: $400,000 - $1,600,000

Storage Reservoirs and Pump Stations

Maple St Pump Station Roof Connection

PROJECT NUMBER(S): B-PS-1
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2044-2045

PROJECT PURPOSE AND DESCRIPTION:

The Maple St PS roof to wall connection may not be adequate to resist all seismic forces. During a maintenance re-roofing project for this building, upgrade the roof to wall connection. If executed, the construction cost of this project is estimated at $288,000. If this structure is planned for future decommissioning, the City may choose not to implement this project. It is recommended that this project be re-evaluated during the next WMP update.

ESTIMATED COST:

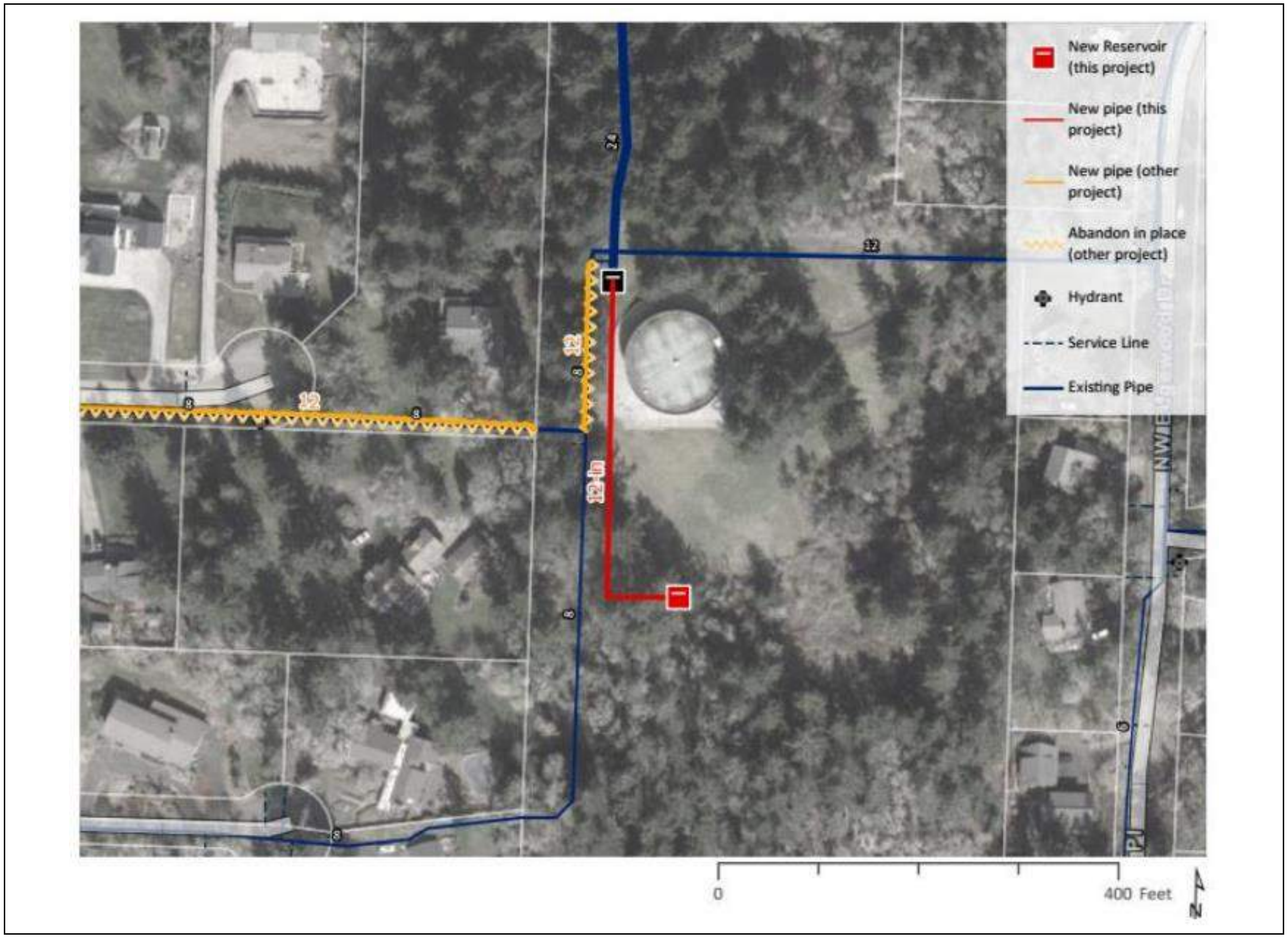
CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

North Albany Storage

PROJECT NUMBER(S): B-S-1
PROJECT DRIVER: Capacity
TRIGGER: When average demand for summer months is 13.9 mgd
ESTIMATED START & END DATE 2063 – 2065



PROJECT PURPOSE AND DESCRIPTION:

By approximately 2063 (medium demand scenario), total system storage needs in the summer will exceed available capacity, assuming all existing reservoirs remain in service. The Wildwood and Valley View reservoirs specifically will not have enough storage to meet the requirements. There is no room at the Valley View site for additional storage, but there is room at the Wildwood site and the Broadway site for an at-grade steel or concrete reservoir. The Wildwood site is a more efficient location for operations because it serves Zone 2. (If the Broadway site was selected, it would need to be paired with additional pumping capacity at the North Albany Pump Station.) This project assumes a 2.0 MG reservoir is needed to meet summer buildout storage requirements in North Albany. It is recommended that this project be re-evaluated during the next WMP update.

ESTIMATED COST:

- 280 LF 12-inch pipe (undeveloped area)
- (1) 2 MG steel reservoir

CONSTRUCTION COST: $4,480,000

CAPITAL COST: $7,200,000

RANGE: $3,600,000 - $14,400,000

34th St Reservoir Anchor Bolts

PROJECT NUMBER(S): L-S-1
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2035-2037

PROJECT PURPOSE AND DESCRIPTION:

The 34th St Reservoir is not bolted to the foundation and relies on friction between the steel & concrete. Maintenance of steel wall is recommended. Consider adding anchor bolts capable of resisting uplift and sliding seismic forces. Clean and remove moss, mold and rust then maintain tank coating.

If executed, the construction cost of this project is estimated at $1,936,000. If this structure is planned for future decommissioning, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Queen Ave Reservoir Anchor Bolts

PROJECT NUMBER(S): L-S-2
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2035-2037

PROJECT PURPOSE AND DESCRIPTION:

The Queen Ave Reservoir is not bolted to the foundation and relies on friction between the steel and concrete. Maintenance of steel wall is recommended. Consider adding anchor bolts capable of resisting uplift and sliding seismic forces. Clean and remove moss, mold and rust then maintain tank coating.

If executed, the construction cost of this project is estimated at $1,197,000. If this structure is planned for future decommissioning, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Gibson Hill PS Replacement

PROJECT NUMBER(S): M-PS-1
PROJECT DRIVER: Capacity
TRIGGER: When Total MDD for Zones 2 and 3 exceeds 1.3 mgd
ESTIMATED START & END DATE 2030 - 2032

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to meet the future pumping capacity requirements for supplying Zones 3 and 4. Demands in these zones are approaching the total capacity of the Gibson Hill Pump Station (GHPS). This does not leave any backup capacity in case of maintenance needs or for redundancy. Further evaluation is needed to determine the feasibility of upgrading the existing pump station capacity. This project assumes a new pump station will be constructed near the existing GHPS site by 2030 (medium demand scenario) and the existing pump station will be retired. The pump station should be constructed in two phases. The first phase should have enough firm capacity to meet medium-term and long-term requirements, with room for expansion to meet buildout requirements in a second phase which will likely needed by about 2051.

ESTIMATED COST:

- 100 LF 24-inch pipe (developed area)
- 1 - 3 MG pump station

CONSTRUCTION COST: $2,280,000

CAPITAL COST: $3,650,000

RANGE: $1,830,000 - $7,300,000

Gibson Hill Pump Station Anchor Bolts

Project M-PS-1A supports the need for project M-PS-1, Gibson Hill PS Replacement

PROJECT NUMBER(S): M-PS-1A
PROJECT DRIVER: Seismic
TRIGGER: Existing Need
ESTIMATED START & END DATE 2030-2032

PROJECT PURPOSE AND DESCRIPTION:

No hold down hardware and anchor bolts are visible or shown on the existing drawings. Remove finishes and provide appropriate hold down anchors. If these connections are not present, provide the appropriate hold downs and sill bolts.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

34th St Pump Station Roof Connection

PROJECT NUMBER(S): M-PS-2
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

The 34th St Pump Station roof to wall connection of the Pump Station is non-compliant. During a maintenance re-roofing project for this building, upgrade the roof to wall connection.

If executed, the construction cost of this project is estimated at $142,000. If this structure is planned for future decommissioning, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Queen Ave Pump Station Roof Connection

PROJECT NUMBER(S): M-PS-3
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

The Queen Ave Pump Station roof to wall connection of the Pump Station is non-compliant. During a maintenance re-roofing project for this building, upgrade the roof to wall connection.

If executed, the construction cost of this project is estimated at $95,000. If this structure is planned for future decommissioning, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Maple St Reservoir Anchor Bolts

PROJECT NUMBER(S): M-S-1
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

The Maple St Reservoir is not bolted to the foundation and relies on friction between the steel & concrete. Maintenance of steel wall is recommended. Consider adding anchor bolts capable of resisting uplift and sliding seismic forces. Clean and remove moss, mold and rust then maintain tank coating.

If executed, the construction cost of this project is estimated at $1,884,000. If this structure is planned for future decommissioning, the City may choose not to implement this project.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Valley View Reservoirs Anchor Bolts

PROJECT NUMBER(S): M-S-2
PROJECT DRIVER: Seismic/Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2032-2033

PROJECT PURPOSE AND DESCRIPTION:

The Valley View Reservoirs are not bolted to the foundation and relies on friction between the steel & concrete. Maintenance of steel wall is recommended. Consider adding anchor bolts capable of resisting uplift & sliding seismic forces. Clean and remove moss, mold and rust then maintain tank coating.

ESTIMATED COST:

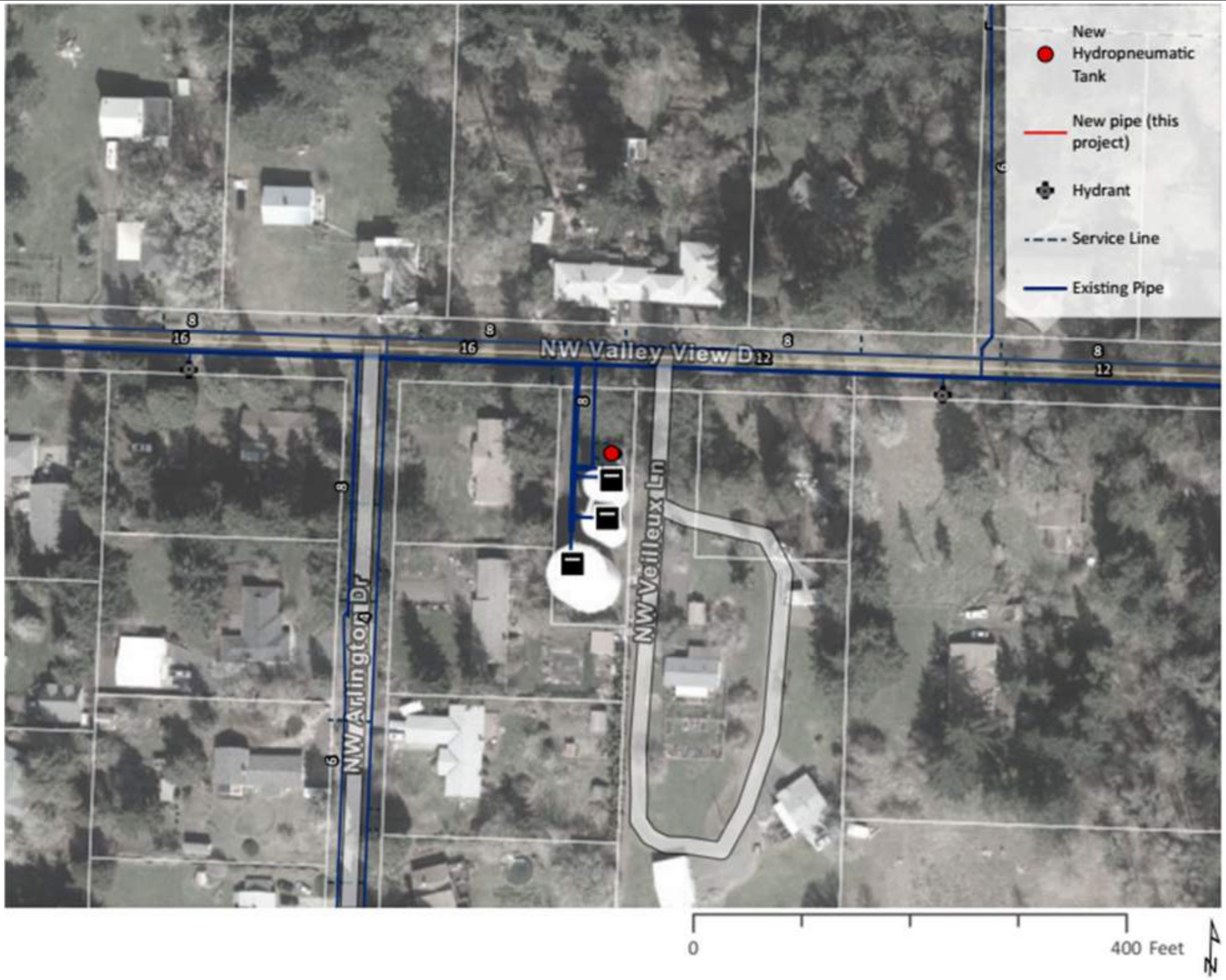
CONSTRUCTION COST: $2,220,000

CAPITAL COST: $3,550,000

RANGE: $1,780,000 - $7,100,000

Valley View Hydropneumatic Tank

PROJECT NUMBER(S): N-PS-1
PROJECT DRIVER: Capacity (optional)
TRIGGER: Existing Need
ESTIMATED START & END DATE 2025 - 2026



PROJECT PURPOSE AND DESCRIPTION:

Optional Project. The Valley View pump station currently includes a 450-gallon hydropneumatic surge tank. The existing tank is undersized and empties too quickly, causing the pumps to turn on and off frequently. This causes excess wear on the pump components, particularly the motors, leading to a reduced life. Adding a second 450-gallon tank would allow the pumps to meet the maximum starts/hour criteria with alternating pumps. This project is optional because replacing the pump motors more frequently may be an acceptable solution, given the small size of the motors. In addition, the City has recently changed operations of the pumps and tanks to reduce the number of pump starts and extend the life of the pump motors.

ESTIMATED COST:

- (1) 450 gal hydropneumatic tank

CONSTRUCTION COST: $8.500

CAPITAL COST: $14,000

RANGE: $7,000 - $28,000

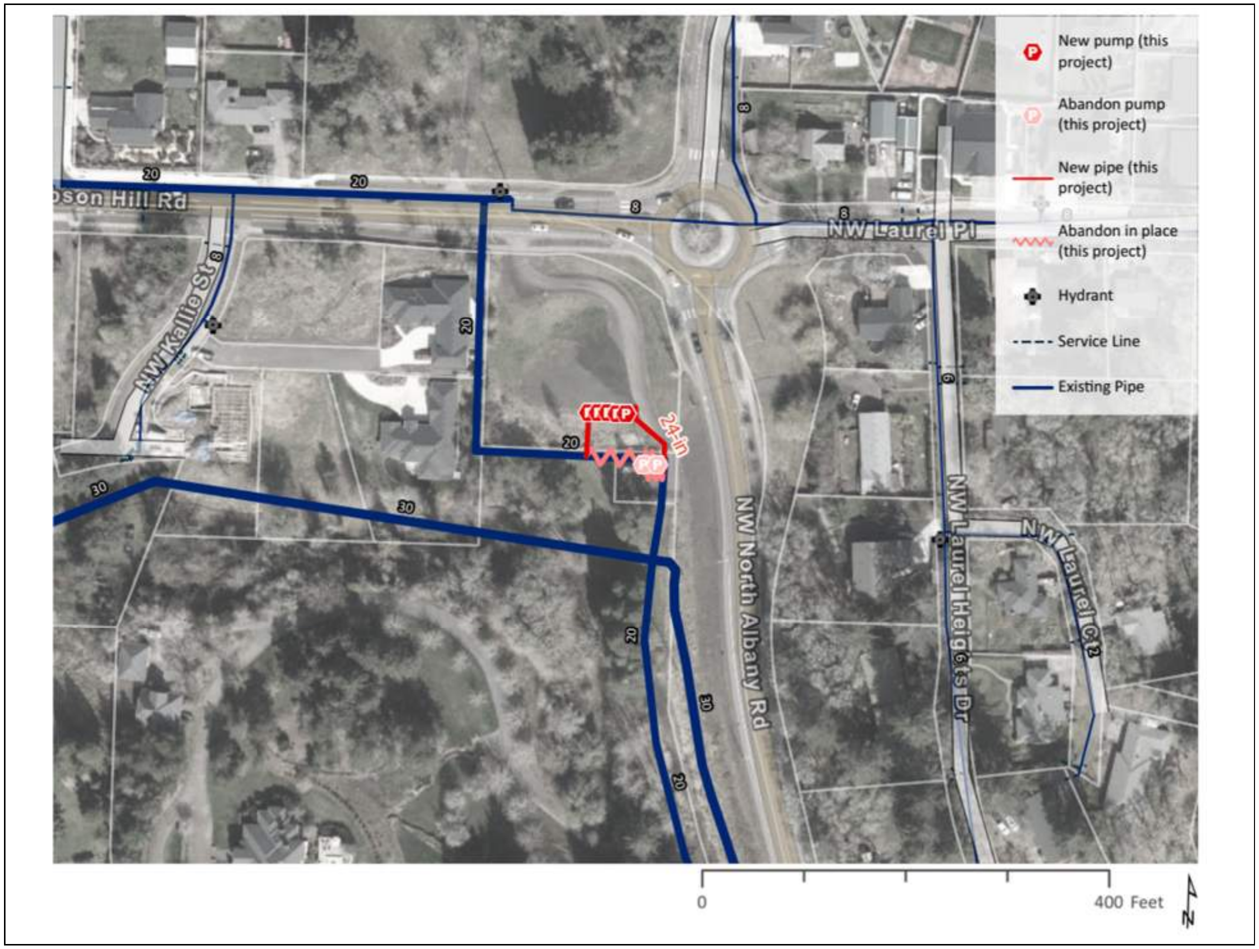
North Albany PS Replacement

PROJECT NUMBER(S): N-PS-2

PROJECT DRIVER: Capacity/Seismic/Condition

TRIGGER: When Total MDD for Zones 2,3, and 4 exceeds 2.6 mgd

ESTIMATED START & END DATE 2028 - 2029



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to meet the future pumping capacity requirements for supplying Zones 2, 3, and 4. Demands in these zones are approaching the firm capacity of the North Albany Pump Station (NAPS). This project assumes a new pump station will be constructed near the existing NAPS site around 2028 (based on recent demand trends) and the existing pump station will be retired. The pump station should be constructed in two phases. The first phase should have enough firm capacity to meet medium-term and long-term requirements, with room for expansion to meet buildout requirements in a second phase which will likely needed by about 2053 (Medium Demand Scenario). If demands follow the medium scenario, the first phase of this project could be constructed around 2034.

ESTIMATED COST:

- 100 LF 24-inch pipe (undeveloped area)
- 1 – 5 mgd pump station

CONSTRUCTION COST: $2,770,000

CAPITAL COST: $4,430,000

RANGE: $2,220,000 to $8,900,000

North Albany Pump Station Building Replacement

Project N-PS-2A supports the need for Project N-PS-2, North Albany PS Replacement

PROJECT NUMBER(S): N-PS-2A

PROJECT DRIVER: Seismic/Condition

TRIGGER: Existing Need

ESTIMATED START & END DATE 2028-2029

PROJECT PURPOSE AND DESCRIPTION:

The North Albany Pump Station is noncompliant for nearly all of the items on the ASCE/SEI 41-17 Checklist for this building type. There is cracking at several locations at exterior of building walls. The Corner of North Albany Pump Station building structure appears to be rebuilt but not finished at interior of pump station. Prepare for replacement of this structure.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Maple St Reservoir Coating

PROJECT NUMBER(S): N-S-1
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2024-2025

PROJECT PURPOSE AND DESCRIPTION:

This is an existing project the City is currently planning for 2024, and is listed here for reference. The City can't pressure wash the existing Maple St Reservoir coating because it can chip the coating and expose the orange coating underneath which may contain lead. Recoat Reservoir. The City estimates a capital cost of $500,000 when combined with Vine St Hydropower Penstock Coating. The price for the reservoir coating is assumed to be half, , $250,000. This project cost is not included in the WMP CIP budget because it is already included in the City budget for 2024-2028 CIP projects.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Queen Avenue Reservoir Coating

PROJECT NUMBER(S): N-S-2
PROJECT DRIVER: Existing Need
TRIGGER: Condition
ESTIMATED START & END DATE 2024-2025

PROJECT PURPOSE AND DESCRIPTION:

This is an existing project the City is currently planning for 2024, and is listed here for reference. The Queen Ave Reservoir paint is chipping. Recoat reservoir. The City estimates a capital cost of $200,000. This project cost is not included in the WMP CIP budget because it is already included in the City budget for 2024-2028 CIP projects.

ESTIMATED COST:

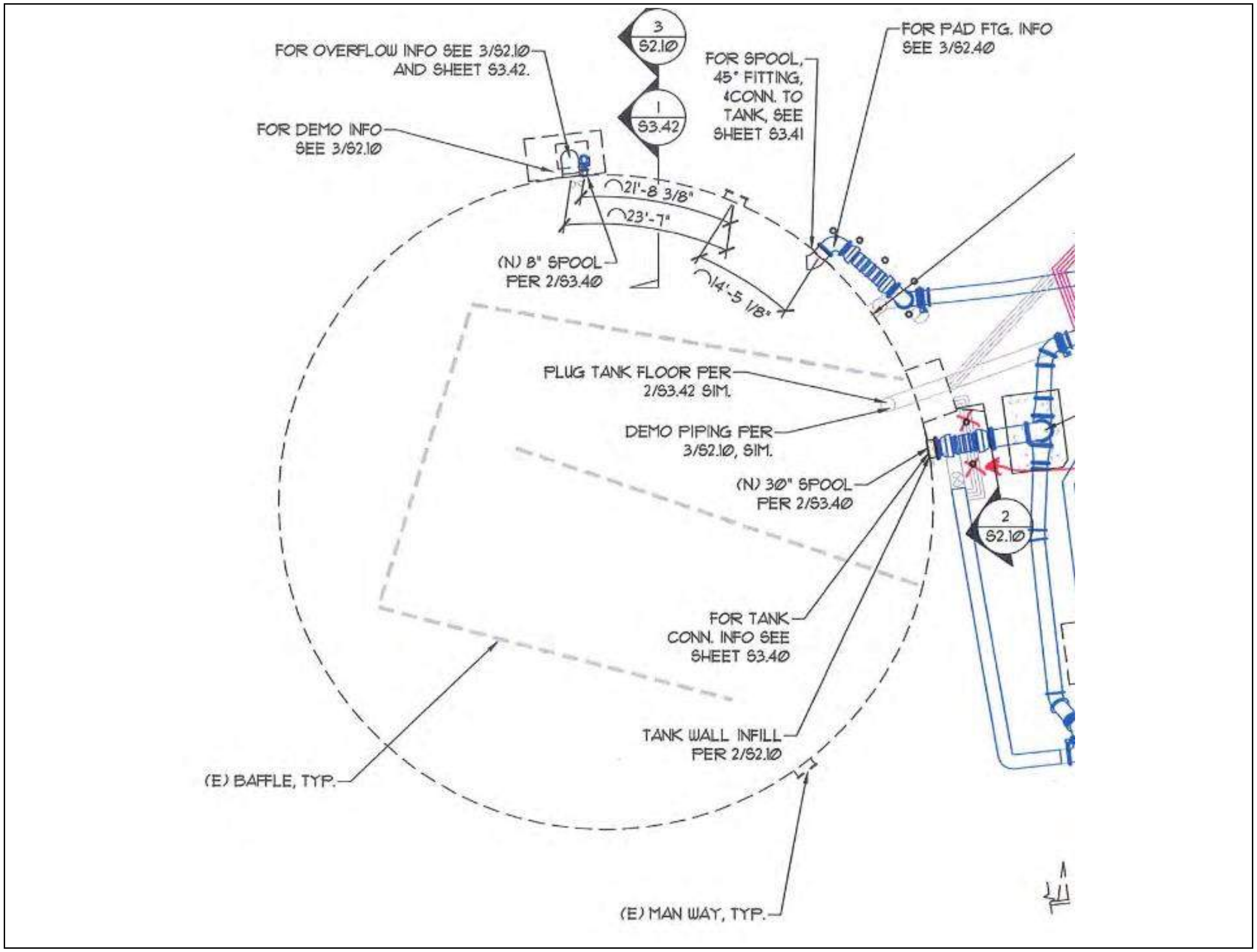
CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Maple St Reservoir Baffle Investigations

PROJECT NUMBER(S): N-S-3
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2026-2027



PROJECT PURPOSE AND DESCRIPTION:

Maple St Reservoir has concerns about a baffle tear inside reservoir. Perform further investigation of condition of baffle tear inside reservoir.

ESTIMATED COST:

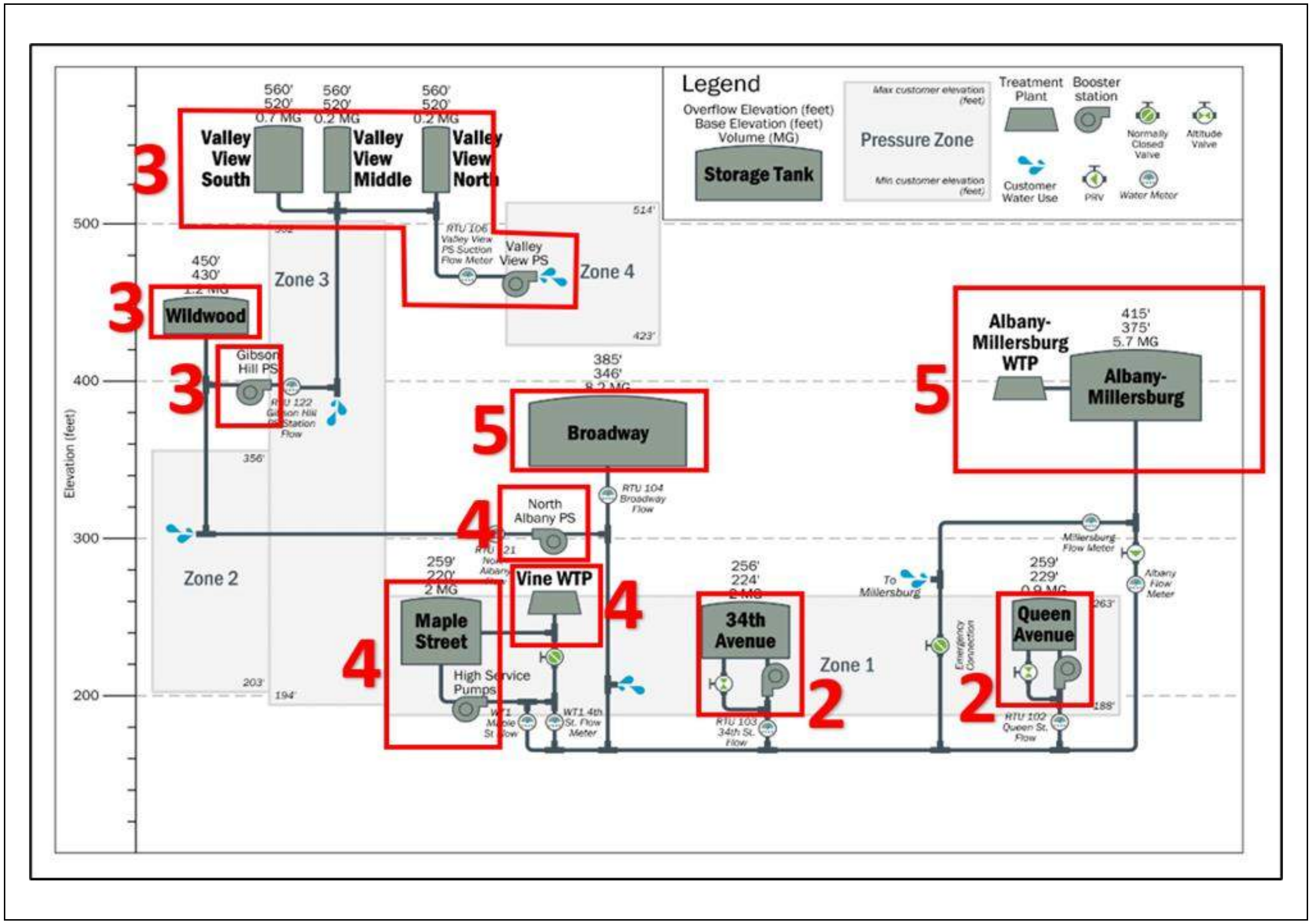
CONSTRUCTION COST: $50,000

CAPITAL COST: $80,000

RANGE: $40,000 - $160,000

Maple, Wildwood, and Valley View Reservoirs Seismic Valves

PROJECT NUMBER(S): N-S-4
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2026-2028



PROJECT PURPOSE AND DESCRIPTION:

It is recommended to install seismic valves at the remaining high priority reservoirs including Maple, Wildwood, and Valley View.

ESTIMATED COST:

CONSTRUCTION COST: $300,000

CAPITAL COST: $480,000

RANGE: $240,000 - $960,000

Distribution Projects

South Albany Development 1

PROJECT NUMBER(S): L-D-1

PROJECT DRIVER: Development-driven

TRIGGER: As needed for development

ESTIMATED START & END DATE 2041 - 2043

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in South Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $1,477,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 3,480 LF 16-inch pipe (undeveloped area)

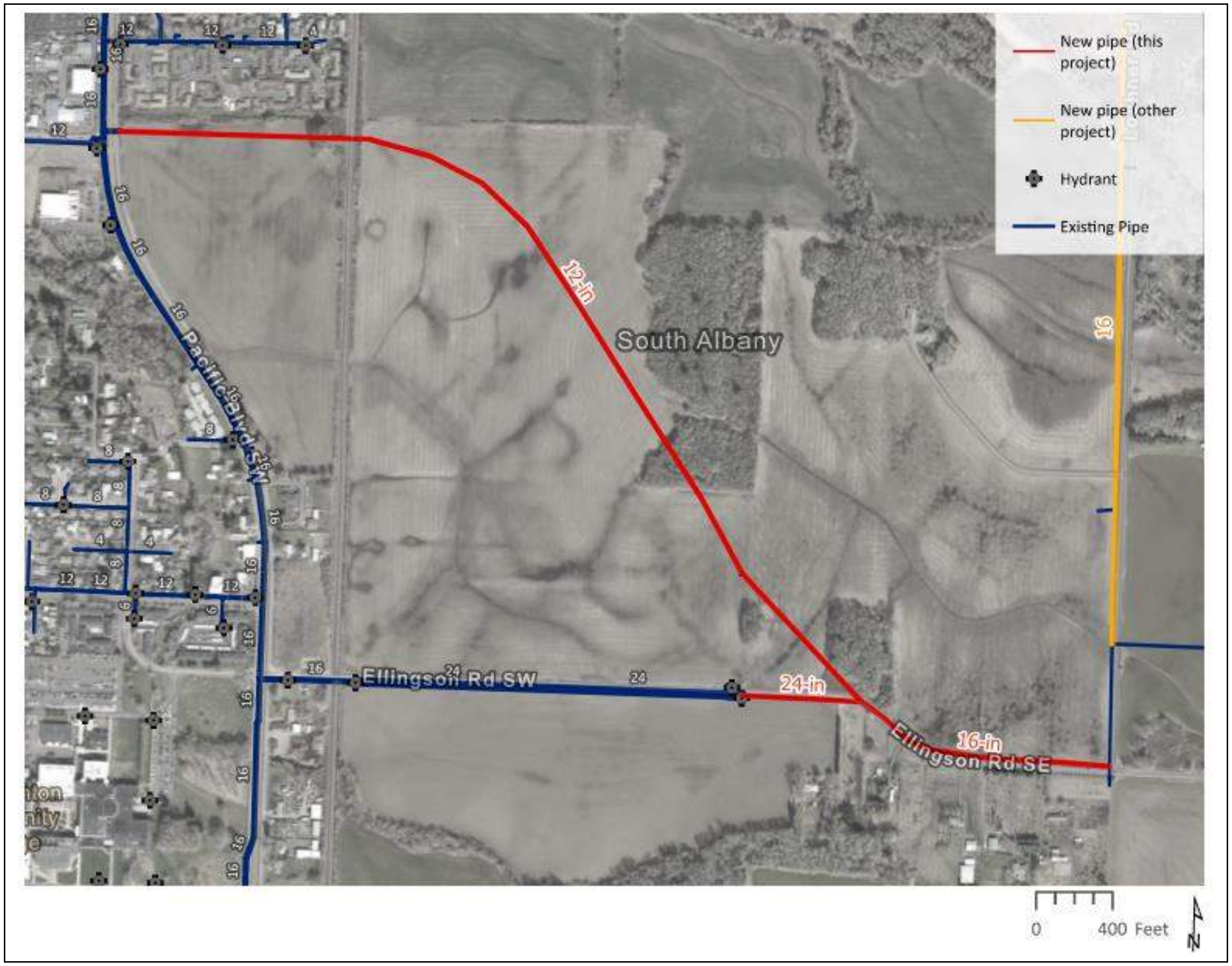
CONSTRUCTION COST: $370,000

CAPITAL COST: $590,000

RANGE: $300,000 - $1,180,000

South Albany Development 2

PROJECT NUMBER(S): L-D-2
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2041 - 2043



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in South Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $2,318,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 4,350 LF 12-inch pipe (undeveloped area)
- 1,390 LF 16-inch pipe (undeveloped area)
- 630 LF 24-inch pipe (undeveloped area)

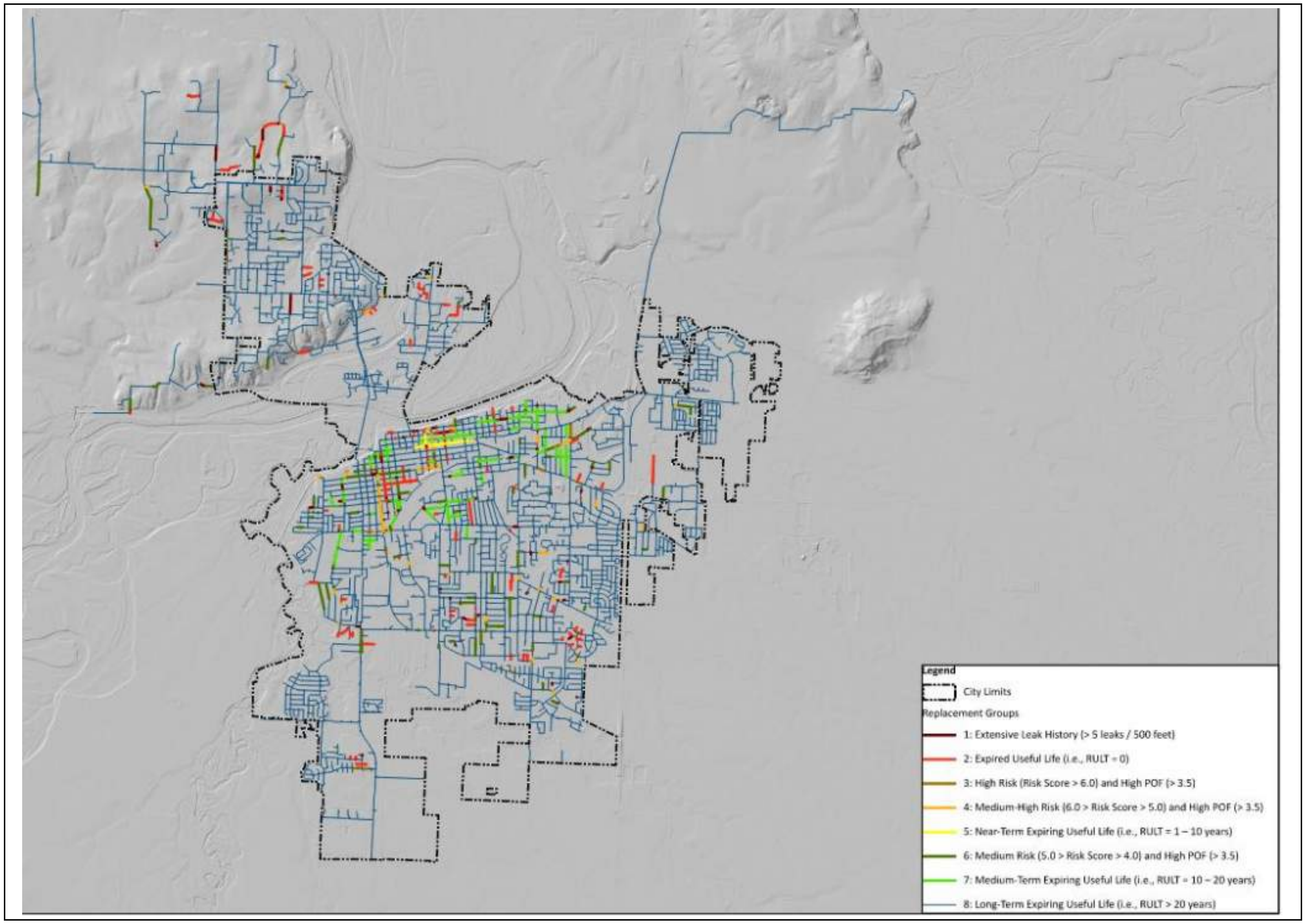
CONSTRUCTION COST: $580,000

CAPITAL COST: $930,000

RANGE: $470,000 - $1,860,000

Long-Term Distribution System Pipeline Replacement Program

PROJECT NUMBER(S): L-D-3
PROJECT DRIVER: Condition
TRIGGER: Future Need
ESTIMATED START & END DATE 2034-2043



PROJECT PURPOSE AND DESCRIPTION:

The City of Albany has an annual budget dedicated for water main replacement. This budget is used for pipeline replacement to improve the overall health of the water system by reducing the potential for water main breaks and leaks. This budget assumes $3,250,000 annual budget for pipeline replacement.

ESTIMATED COST:

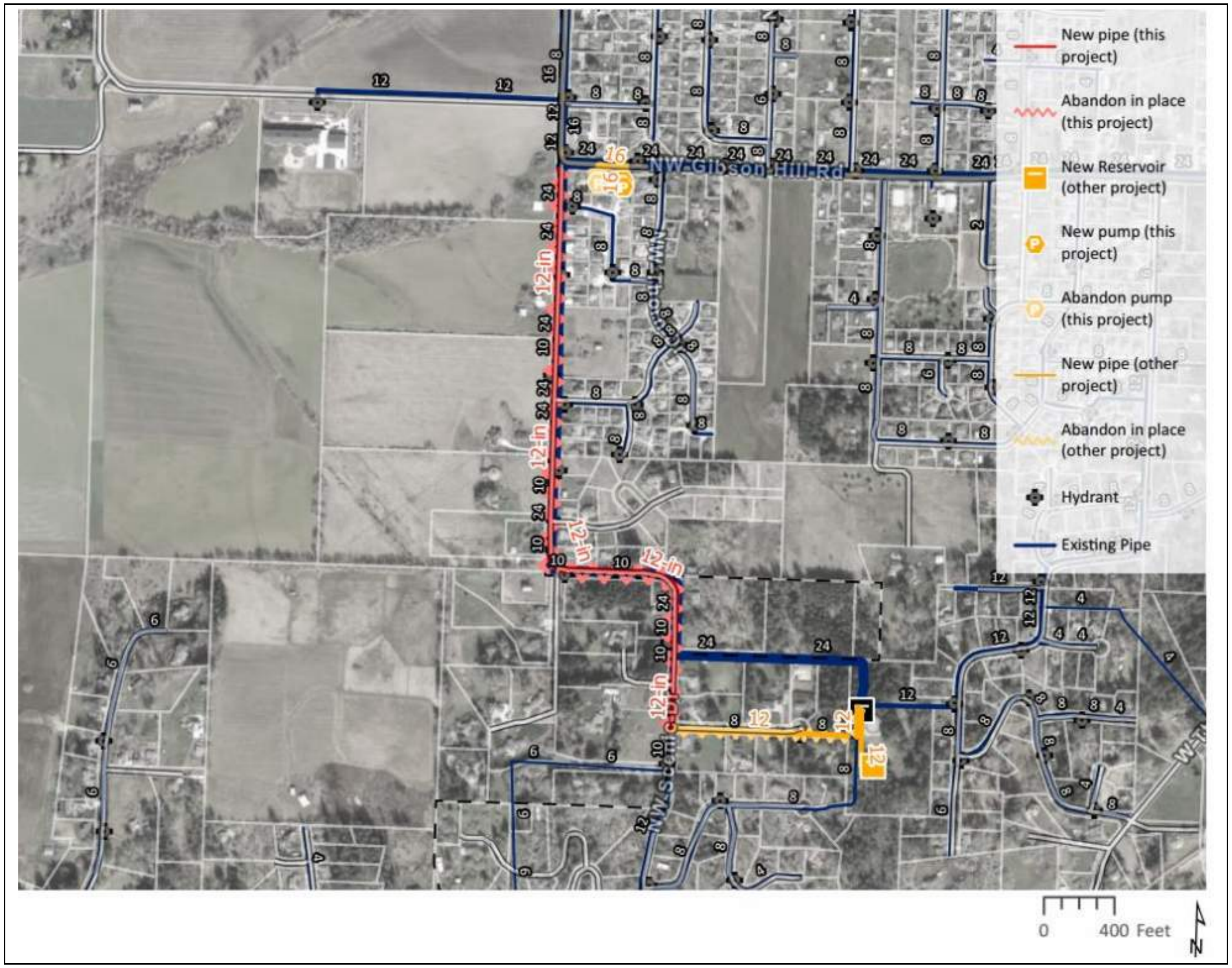
CONSTRUCTION COST: $29,250,000

CAPITAL COST: $46,800,000

RANGE: $23,400,000 - $93,600,000

Zone 2 South Flow Improvement 2

PROJECT NUMBER(S): M-D-1
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2029 - 2030



PROJECT PURPOSE AND DESCRIPTION:

This project eliminates an existing fire flow deficiency in Zone 2 near the Wildwood Reservoir. Pressures in this area are currently 50-90 psi, but due to poor looping and the long distance from the Valley View Reservoirs, hydrants in this area cannot meet the required fire flow of 1,500 gpm. Project N-D-2 eliminates some of the fire flow deficiencies in the short term. This project provides a long-term solution that allows all the hydrants in this area to provide 1,500 gpm. This project involves replacing a large quantity of 10-inch pipe with 12-inch between Gibson Hill Rd and Wildwood Dr and is therefore recommended to be completed as part of the pipe renewal and replacement program.

ESTIMATED COST:

- 3,850 LF 12-inch pipe (developed area)

CONSTRUCTION COST: $1,540,000

CAPITAL COST: $2,460,000

RANGE: $1,230,000 - $4,920,000

Heritage Mall Fire Flow Improvement

PROJECT NUMBER(S): M-D-2
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2029 - 2030

PROJECT PURPOSE AND DESCRIPTION:

New pipe needed to alleviate fire flow capacity deficiencies near the Heritage Mall. This type of land use requires a fire flow of 3,500 gpm (see Chapter 4). Only a few of the hydrants in this area can supply 3,500 gpm. This project allows most of the hydrants surrounding the mall to supply 3,500 gpm during a fire.

ESTIMATED COST:

- 700 LF 8-inch pipe (developed area)
- 90 LF 12-inch pipe (developed area)

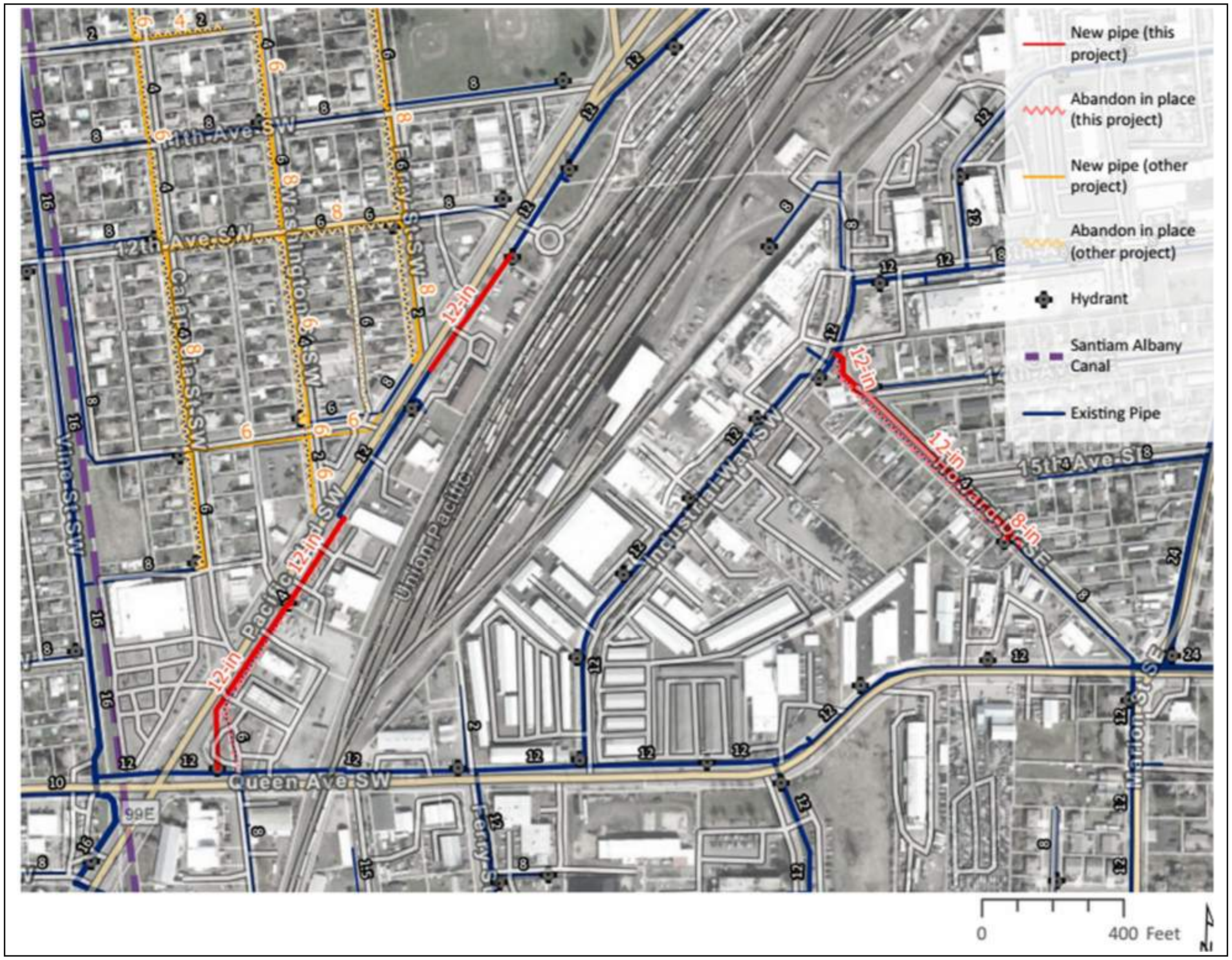
CONSTRUCTION COST: $300,000

CAPITAL COST: $480,000

RANGE: $240,000 - $960,000

Rail Yard Fire Flow Improvement

PROJECT NUMBER(S): M-D-3
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2029 - 2030



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required fire flow to nearby customers. Medium-density residential, commercial, and industrial customers in this area require a fire flow of 2,500 to 3,500 gpm. These flows cannot be provided by the existing system due to insufficient looping and small pipes.

ESTIMATED COST:

- 1,590 LF 8-inch pipe (developed area)
- 1,960 LF 12-inch pipe (developed area)

CONSTRUCTION COST: $1,390,000

CAPITAL COST: $2,220,000

RANGE: $1,110,000 - $4,440,000

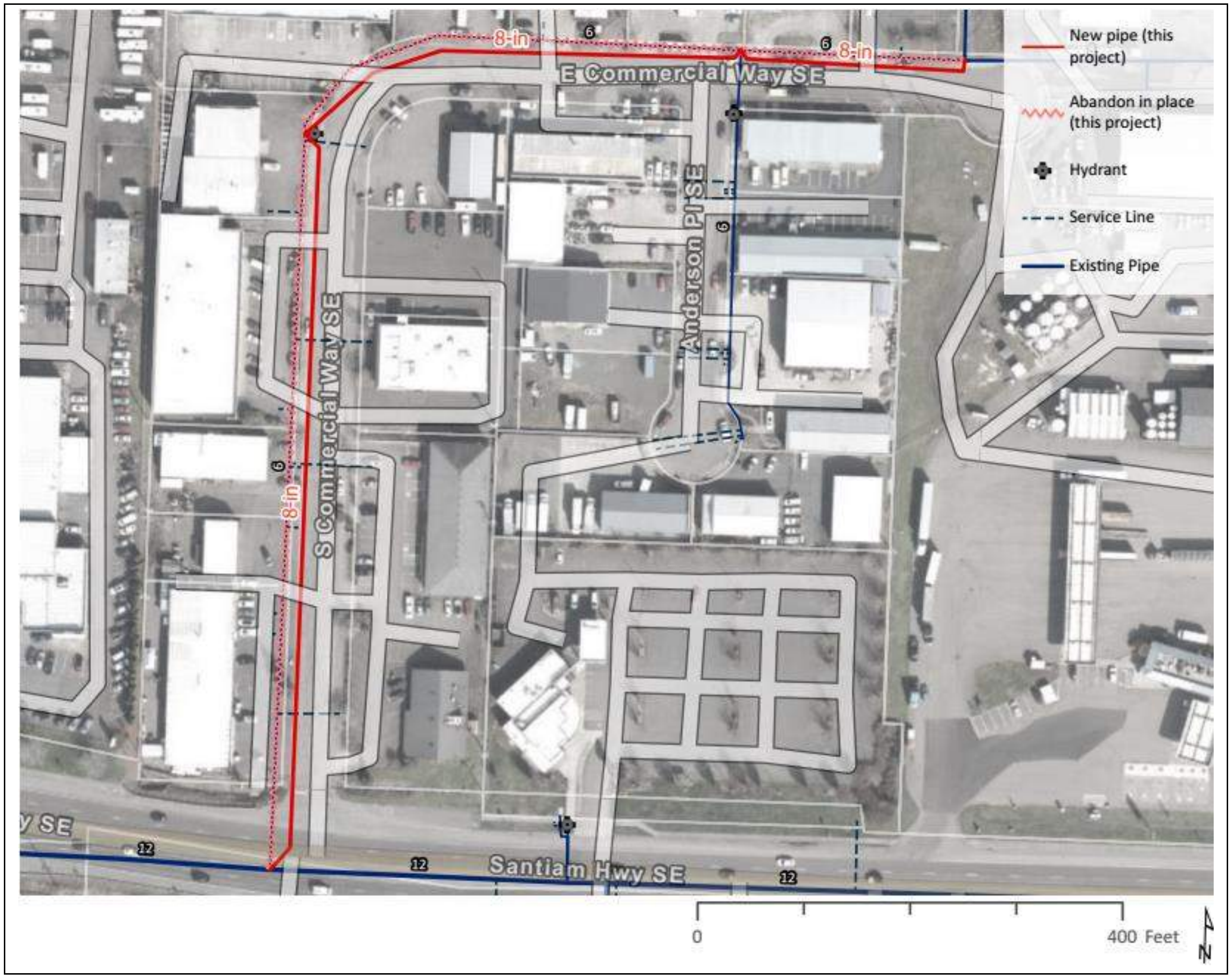
Commercial Way Fire Flow Improvement

PROJECT NUMBER(S): M-D-4

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2029 - 2030



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to commercial customers in the area shown. This flow cannot be provided by the existing 6-inch pipes, which should be replaced with 8-inch pipes.

ESTIMATED COST:

- 1,370 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $520,000

CAPITAL COST: $830,000

RANGE: $420,000 - $1,660,000

South Shore Elementary Fire Flow Improvement

PROJECT NUMBER(S): M-D-5
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2030 - 2031

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to South Shore Elementary School. This flow cannot be provided by the existing 6-inch pipes, which should be replaced with 8-inch pipes.

ESTIMATED COST:

- 460 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $180,000

CAPITAL COST: $290,000

RANGE: $150,000 - $580,000

Umatilla St Fire Flow Improvement

PROJECT NUMBER(S): M-D-6
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2030 - 2031

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 2,500 gpm fire flow to medium-density residential customers on SW Umatilla St. This flow cannot be provided by the existing 6-inch pipe. Adding looping from the north end of this pipe will allow the required flow to be provided.

ESTIMATED COST:

- 210 LF 6-inch pipe (developed area)

CONSTRUCTION COST: $76,000

CAPITAL COST: $120,000

RANGE: $60,000 - $240,000

1st Ave Fire Flow Improvement

PROJECT NUMBER(S): M-D-7

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2030 - 2031

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 2,500 gpm fire flow to medium-density residential customers on 1st Avenue. This flow cannot be provided by the existing 4-inch pipe. Replacing the 4-inch pipe with 6-inch will allow the required flow to be provided.

ESTIMATED COST:

- 340 LF 6-inch pipe (developed area)

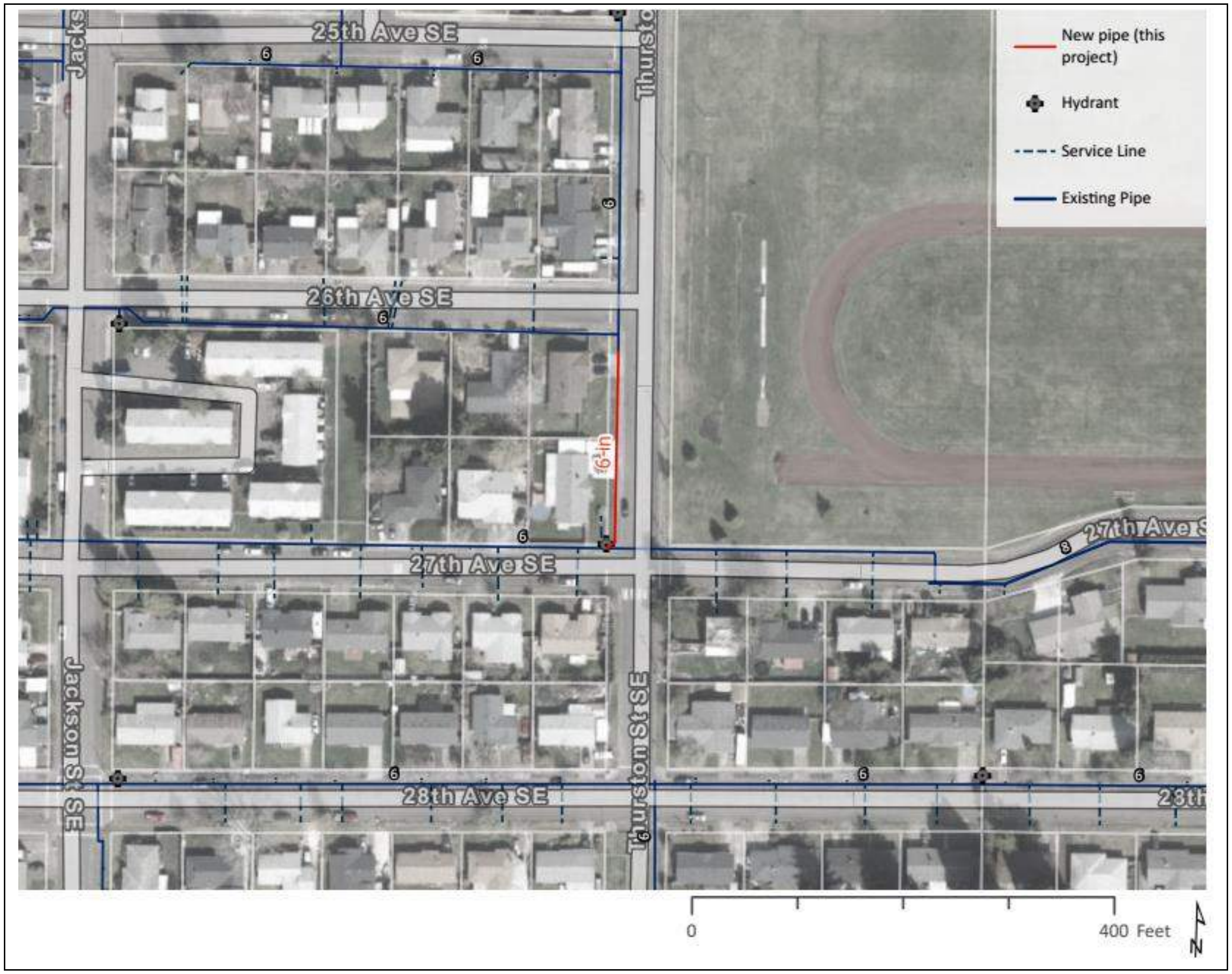
CONSTRUCTION COST: $120,000

CAPITAL COST: $190,000

RANGE: $100,000 - $380,000

Thurston St Fire Flow Improvement

PROJECT NUMBER(S): M-D-8
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2030 - 2031



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 1,500 gpm fire flow to low-density residential customers near 27th Ave and Thurston St. This flow cannot be provided by the existing 6-inch pipe due to insufficient looping. Constructing this 6-inch will improve looping and allow the required flow to be provided.

ESTIMATED COST:

- 190 LF 6-inch pipe (developed area)

CONSTRUCTION COST: $70,000

CAPITAL COST: $110,000

RANGE: $55,000 - $220,000

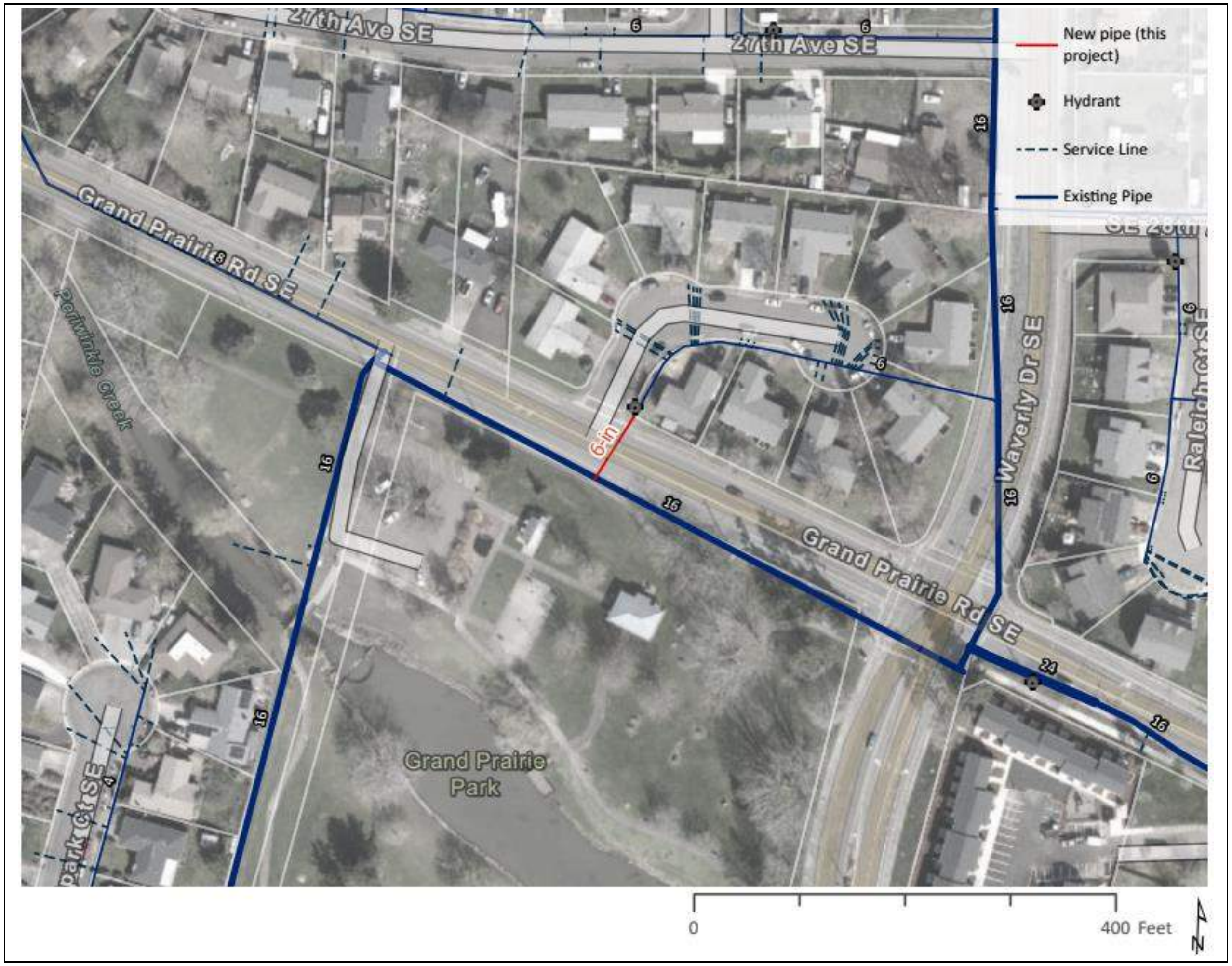
Prairie Pl Fire Flow Improvement

PROJECT NUMBER(S): M-D-9

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2030 - 2031



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 2,500 gpm fire flow to medium-density residential customers on Prairie Pl SE. This flow cannot be provided by the existing 6-inch pipe. Adding looping from the south end of this pipe across Grand Prairie Rd will allow the required flow to be provided. Alternatively, the existing 6-inch pipe on Prairie Pl could be replaced with 8-inch.

ESTIMATED COST:

- 70 LF 6-inch pipe (developed area)

CONSTRUCTION COST: $25,000

CAPITAL COST: $40,000

RANGE: $20,000 to $80,000

Lyon St Fire Flow Improvement

PROJECT NUMBER(S): M-D-10

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2031 - 2032

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to nearby commercial customers. This flow cannot be provided by the existing pipes due to insufficient looping. Adding 8-inch looping along Lyon St will allow the required flow to be provided.

ESTIMATED COST:

- 170 LF 8-inch pipe (developed area)

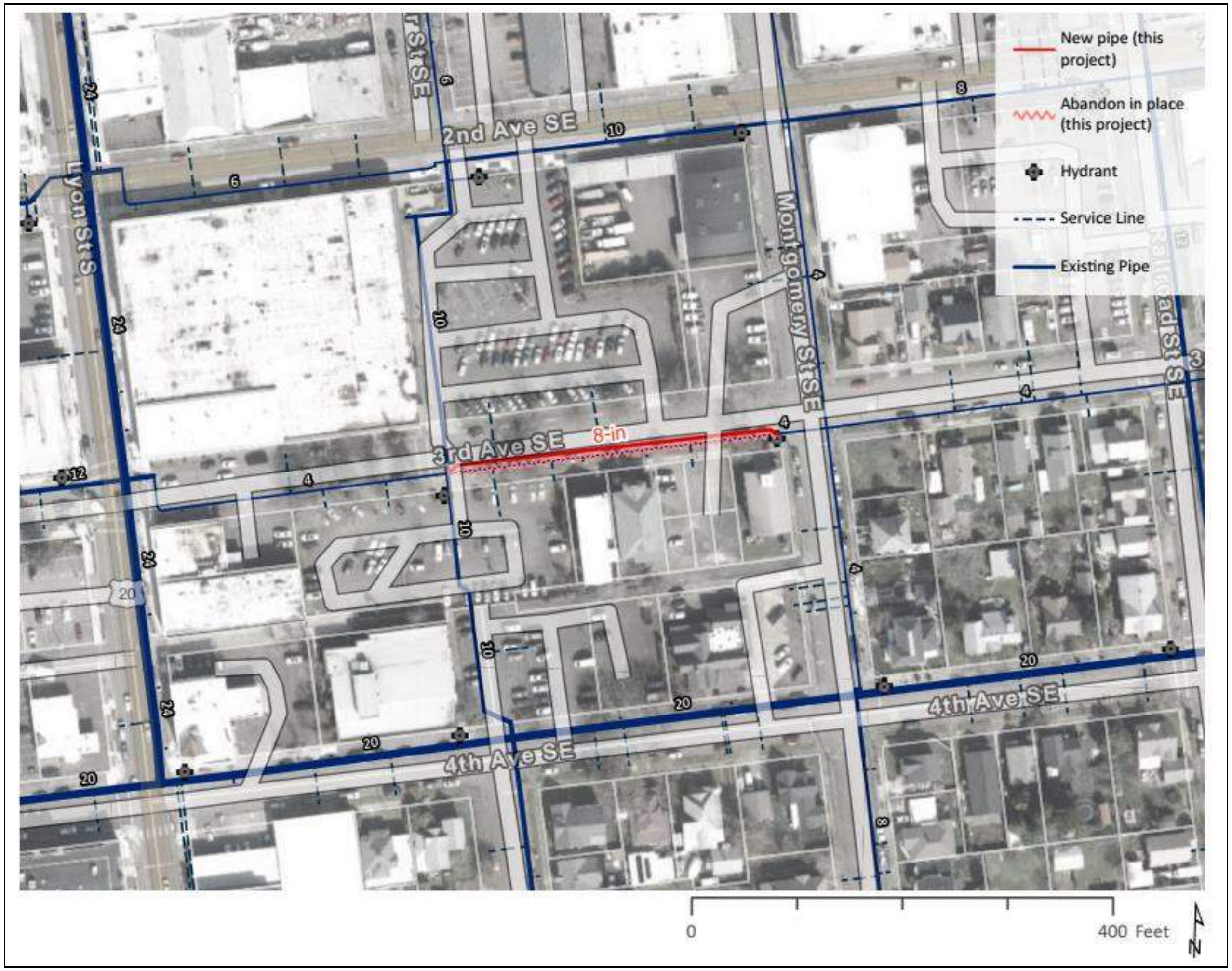
CONSTRUCTION COST: $65,000

CAPITAL COST: $100,000

RANGE: $50,000 - $200,000

3rd Ave Fire Flow Improvement 1

PROJECT NUMBER(S): M-D-11
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2031 - 2032



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to commercial customers in the area shown. This flow cannot be provided by the existing 4-inch pipes which are too small. Replacing the 4-inch pipe on 3rd Ave with 8-inch will allow the required flow to be provided.

ESTIMATED COST:

- 320 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $120,000

CAPITAL COST: $190,000

RANGE: $100,000 - $380,000

3rd Ave Fire Flow Improvement 2

PROJECT NUMBER(S): M-D-12

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2031 - 2032

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to commercial customers in the area shown. This flow cannot be provided by the existing 6-inch pipes. Replacing the 6-inch pipe on 3rd Ave with 8-inch will allow the required flow to be provided.

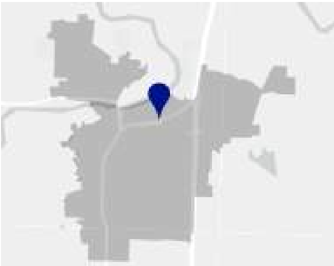
ESTIMATED COST:

- 290 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $110,000

CAPITAL COST: $180,000

RANGE: $90,000 - $360,000



Geary St Fire Flow Improvement

PROJECT NUMBER(S): M-D-13
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2031 - 2032

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 2,500 gpm fire flow to medium-density residential customers on Geary St. This flow cannot be provided by the existing 6-inch pipe due to insufficient looping.

Adding looping from Willamette Ave will allow the required flow to be provided.

ESTIMATED COST:

- 250 LF 6-inch pipe (developed area)

CONSTRUCTION COST: $90,000

CAPITAL COST: $140,000

RANGE: $70,000 - $280,000

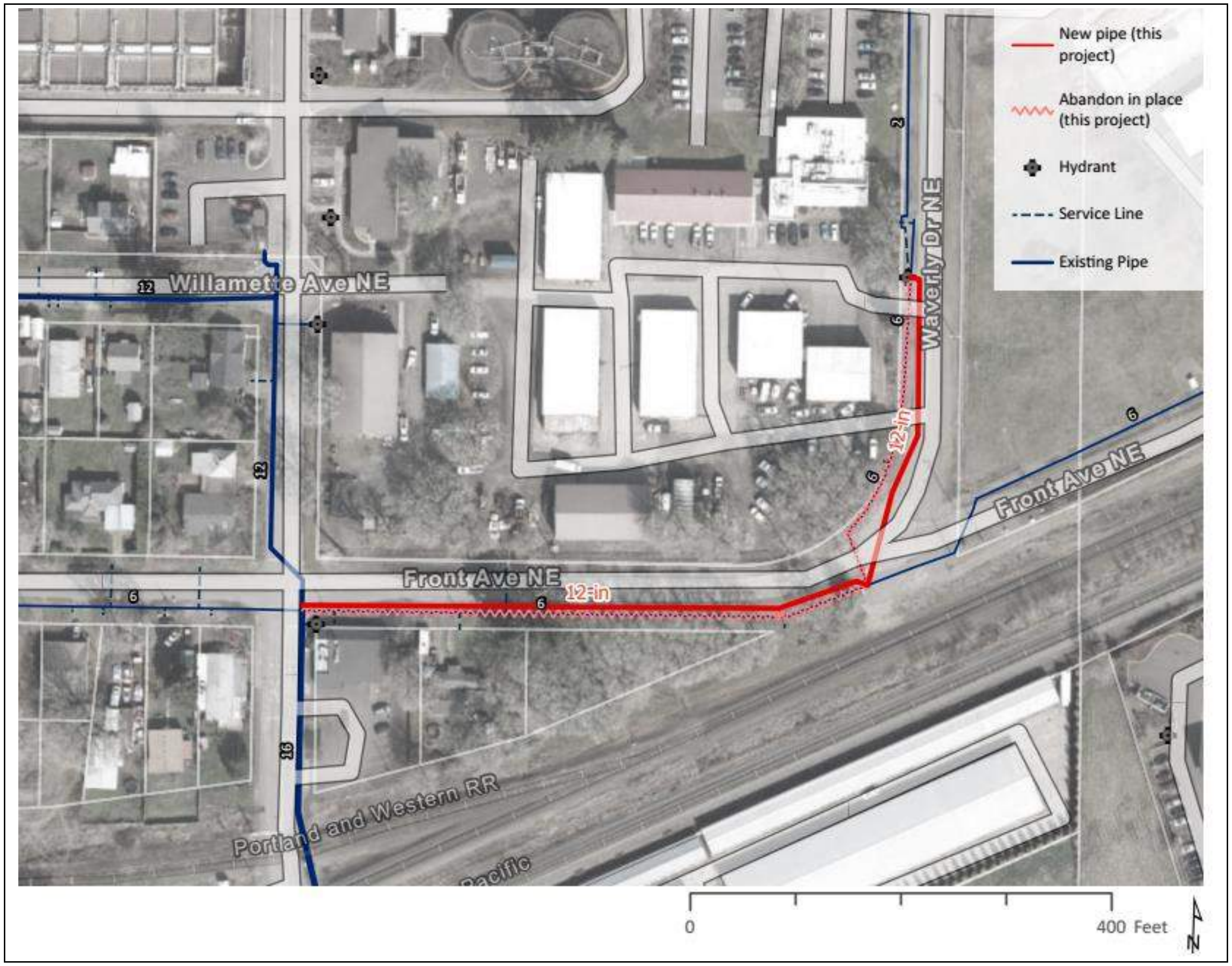
Waverly Dr Fire Flow Improvement

PROJECT NUMBER(S): M-D-14

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2031 - 2032



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to customers on Waverly Dr. This flow cannot be provided by the existing 6-inch pipes. Replacing the 6-inch pipe on 3rd Ave with 12-inch will allow the required flow to be provided.

ESTIMATED COST:

- 850 LF 12-inch pipe (developed area)

CONSTRUCTION COST: $340,000

CAPITAL COST: $540,000

RANGE: $270,000 - $1,080,000

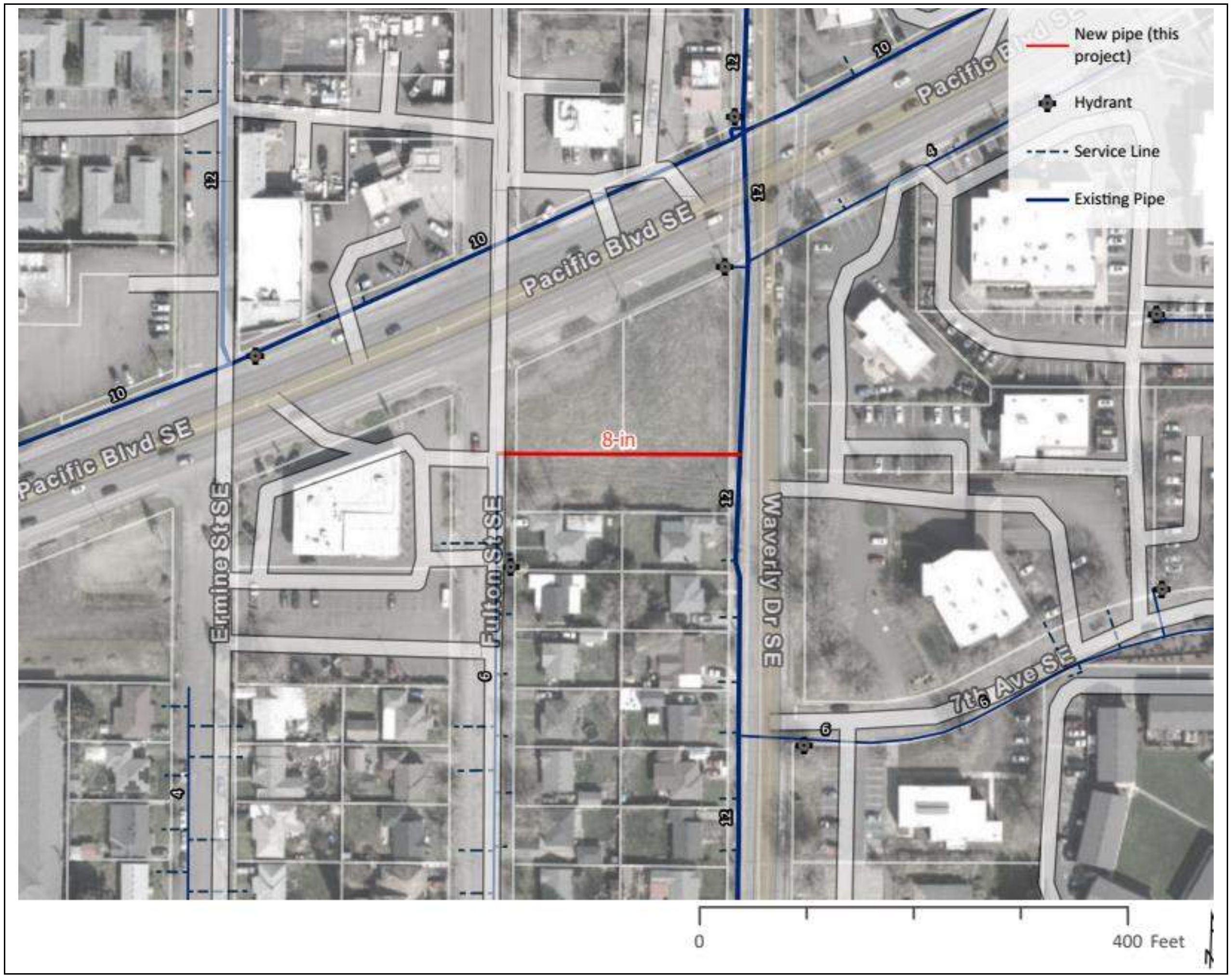
Front St Fire Flow Improvement

PROJECT NUMBER(S): M-D-15

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2032 - 2033



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to the commercial customer on Front St. This flow cannot be provided by the existing 6-inch pipe due to insufficient looping. Adding an 8-inch pipe from Waverly Dr will improve looping and allow the required flow to be provided.

ESTIMATED COST:

- 230 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $90,000

CAPITAL COST: $140,000

RANGE: $70,000 - $280,000

Broadway Street Fire Flow Improvement

PROJECT NUMBER(S): M-D-16
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2032 - 2033

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 3,500 gpm fire flow to the commercial customers on Broadway St. This flow cannot be provided by the existing pipes due to insufficient looping. Adding an 8-inch pipe from Liberty St will improve looping and allow the required flow to be provided.

ESTIMATED COST:

- 850 LF 8-inch pipe (developed area)

CONSTRUCTION COST: $320,000

CAPITAL COST: $510,000

RANGE: $260,000 - $1,020,000

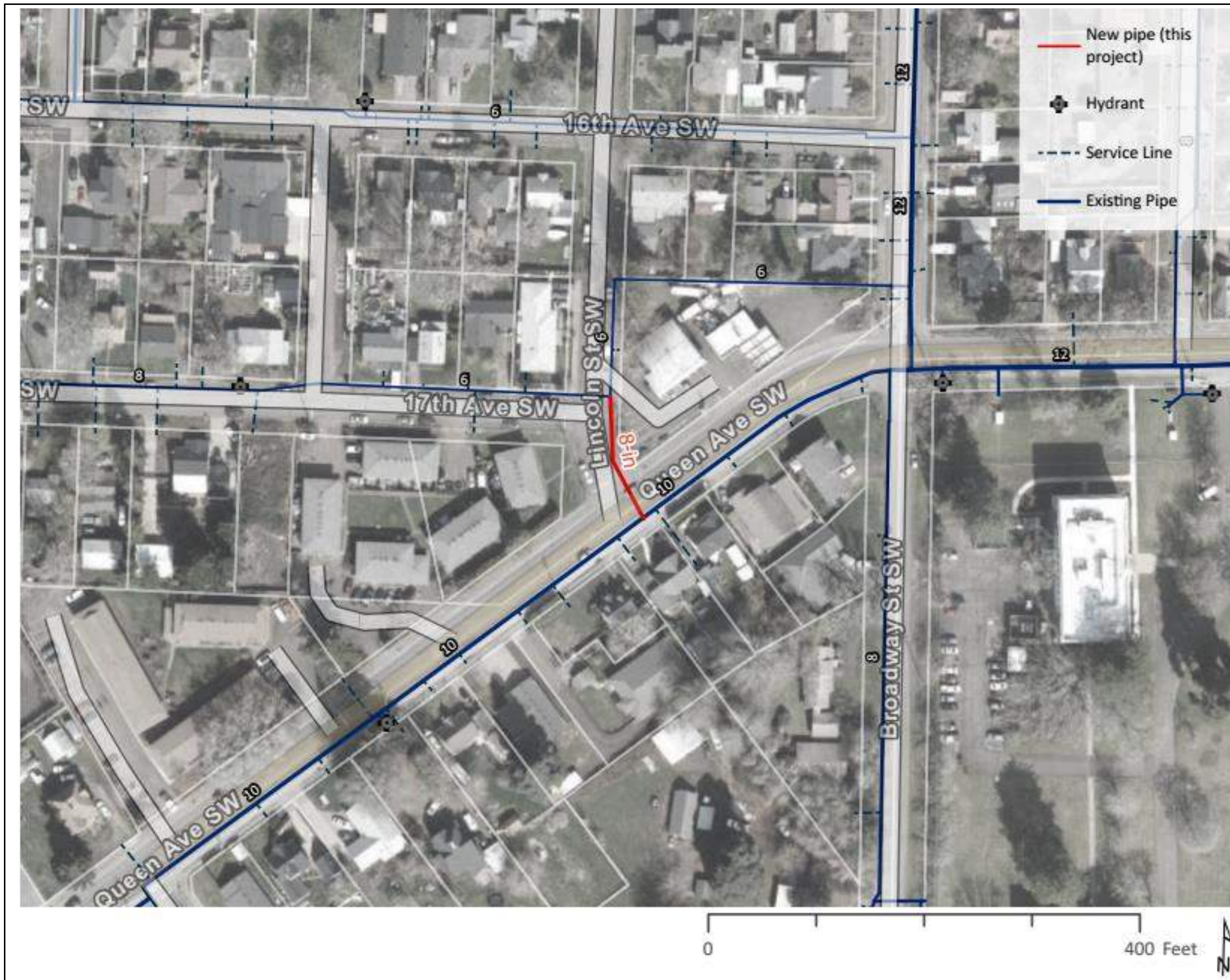
17th Avenue Fire Flow Improvement

PROJECT NUMBER(S): M-D-17

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2032 - 2033



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 2,500 gpm fire flow to medium-density residential customers on 17th Ave. This flow cannot be provided by the existing 6-inch pipe. Adding looping from Queen Ave will allow the required flow to be provided.

ESTIMATED COST:

- 120 LF 8-inch pipe (developed area)

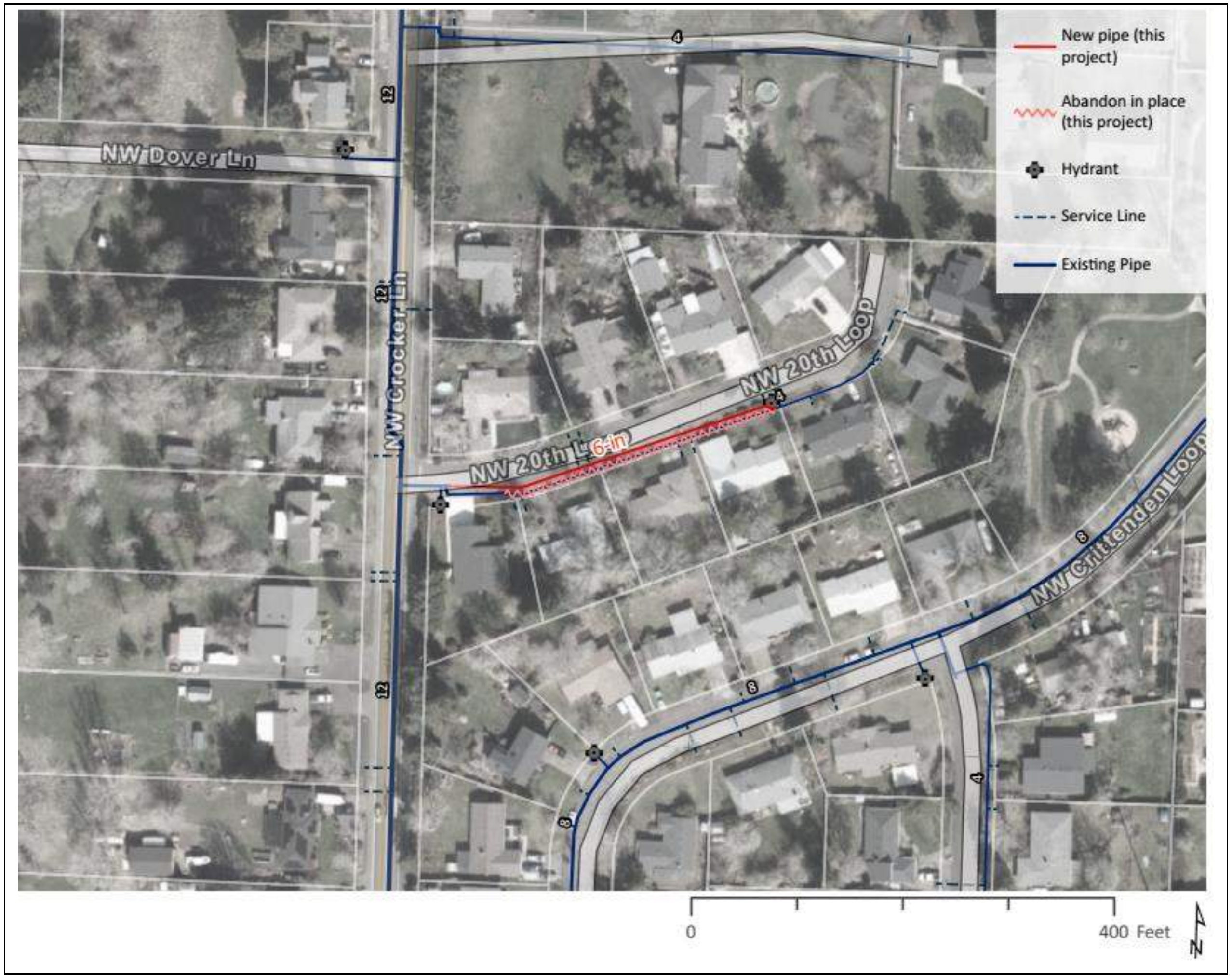
CONSTRUCTION COST: $46,000

CAPITAL COST: $74,000

RANGE: $37,000 - $150,000

20th Loop Fire Flow Improvement

PROJECT NUMBER(S): M-D-18
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2032 - 2033



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 1,500 gpm fire flow to low-density residential customers on NW 20th Loop. This flow cannot be provided by the existing 4-inch pipe. Replacing the 4-inch pipe with 6-inch will allow the required flow to be provided.

ESTIMATED COST:

- 320 LF 6-inch pipe (developed area)

CONSTRUCTION COST: $120,000

CAPITAL COST: $190,000

RANGE: $100,000 - $380,000

Bloom LN Fire Flow Improvement

PROJECT NUMBER(S): M-D-19
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2032 - 2033

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply the required 1,500 gpm fire flow to low-density residential customers on Bloom Ln. This flow cannot be provided by the existing 6-inch pipe. Adding looping from Arroyo Ridge Dr will allow the required flow to be provided.

ESTIMATED COST:

- 203 LF 6-inch pipe (developed area)

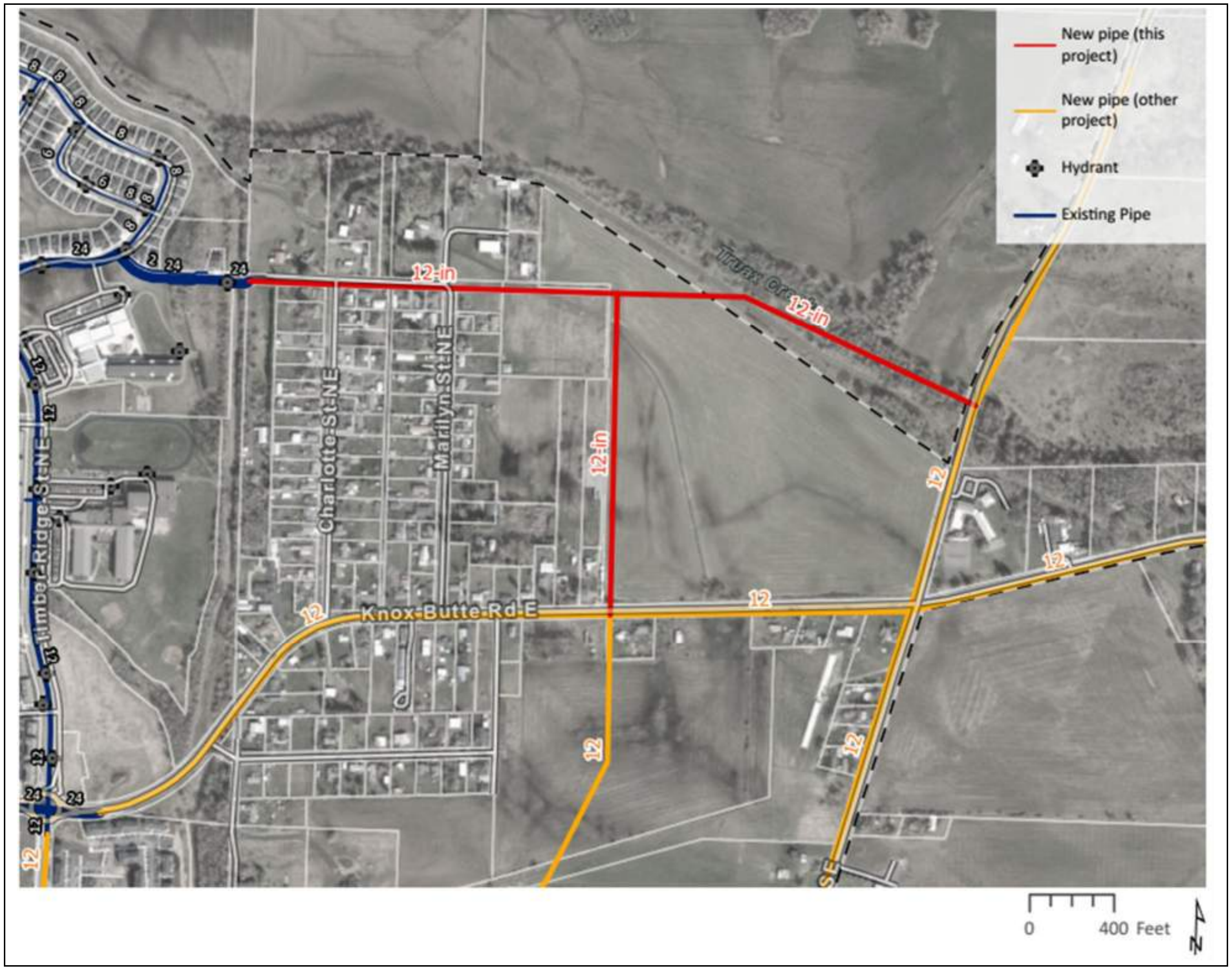
CONSTRUCTION COST: $74,000

CAPITAL COST: $120,000

RANGE: $60,000 - $240,000

East Albany Development 1

PROJECT NUMBER(S): M-D-20
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2029 - 2031



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $1,524,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 5,080 LF 12-inch pipe (undeveloped area)

CONSTRUCTION COST: $380,000

CAPITAL COST: $610,000

RANGE: $310,000 - $1,220,000

East Albany Development 2

PROJECT NUMBER(S): M-D-21
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2029 - 2031

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $2,370,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 7,900 LF 12-inch pipe (undeveloped area)

CONSTRUCTION COST: $590,000

CAPITAL COST: $940,000

RANGE: $470,000 to $1,880,000

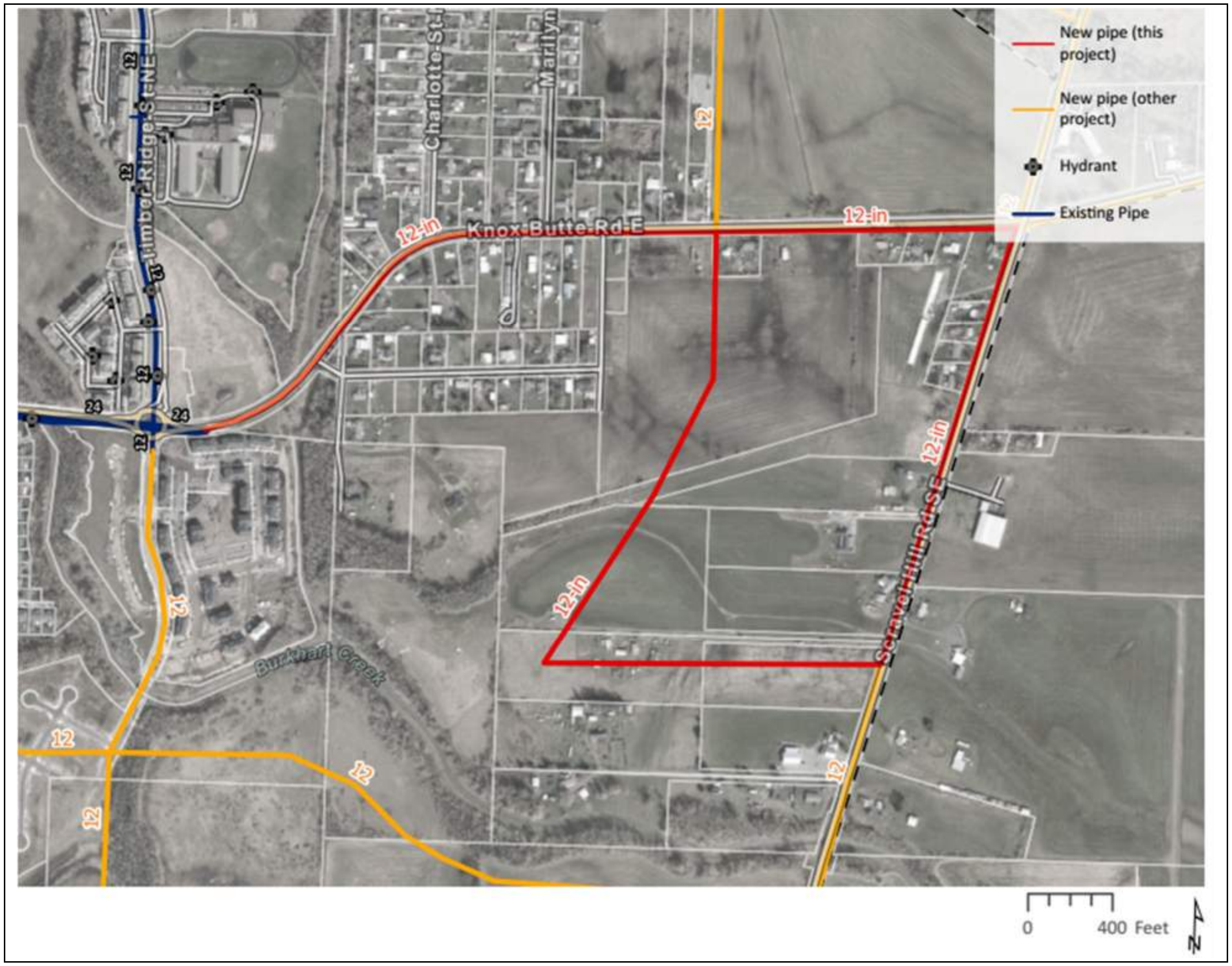
East Albany Development 3

PROJECT NUMBER(S): M-D-22

PROJECT DRIVER: Development-driven

TRIGGER: As needed for development

ESTIMATED START & END DATE 2029 - 2031



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $3,069,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 10,230 LF 12-inch pipe (undeveloped area)

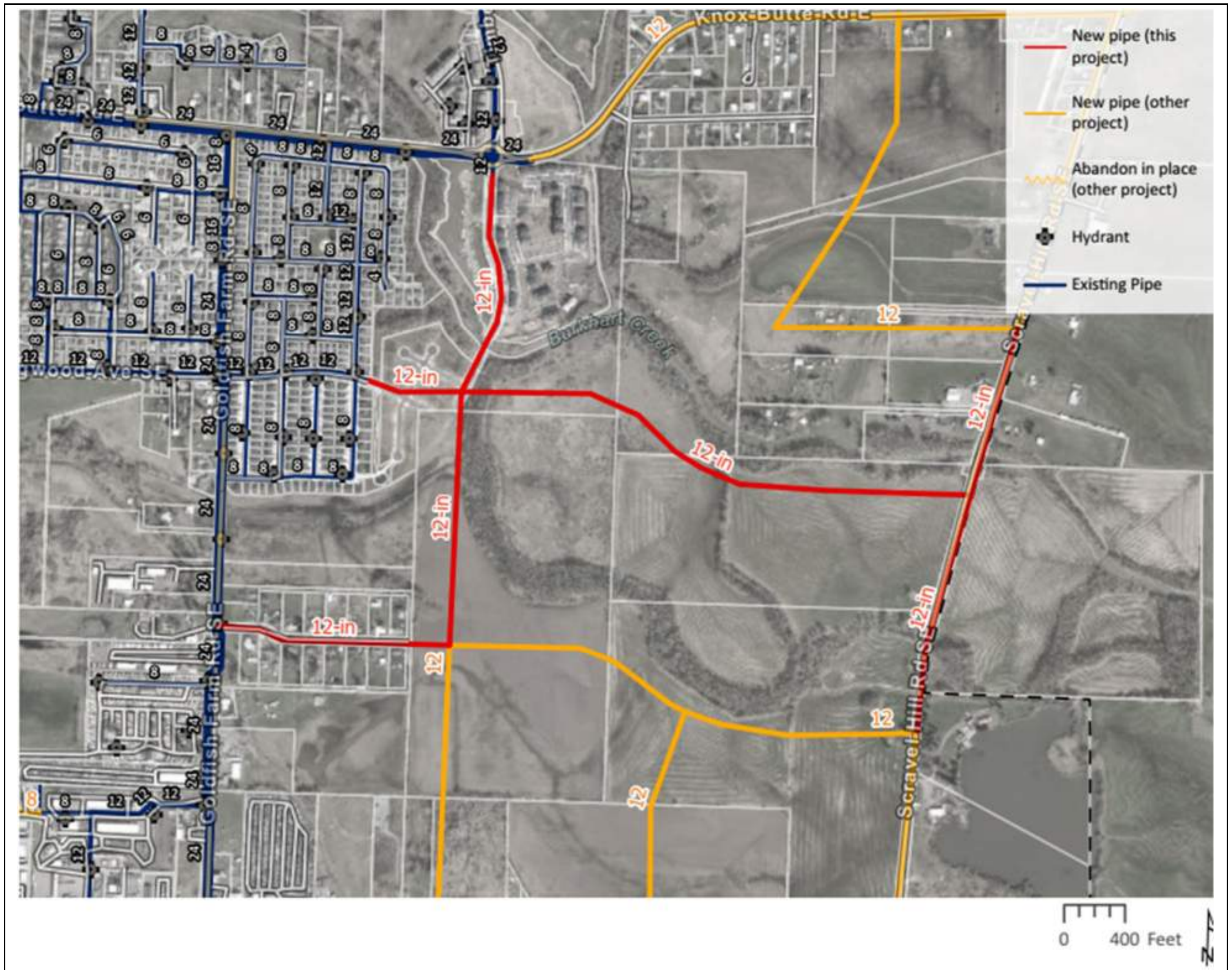
CONSTRUCTION COST: $770,000

CAPITAL COST: $1,230,000

RANGE: $620,000 to $2,460,000

East Albany Development 4

PROJECT NUMBER(S): M-D-23
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2031 - 2033



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $3,477,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 11,590 LF 12-inch pipe (undeveloped area)

CONSTRUCTION COST: $870,000

CAPITAL COST: $1,390,000

RANGE: $700,000 – $2,780,000

East Albany Development 5

PROJECT NUMBER(S): M-D-24
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2031 - 2033

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $3,630,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 12,110 LF 12-inch pipe (undeveloped area)

CONSTRUCTION COST: $910,000

CAPITAL COST: $1,460,000

RANGE: $730,000 to $2,920,000

East Albany Development 6

PROJECT NUMBER(S): M-D-25
PROJECT DRIVER: Development-driven
TRIGGER: As needed for development
ESTIMATED START & END DATE 2031 - 2033

PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $1,824,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 6,080 LF 12-inch pipe (undeveloped area)

CONSTRUCTION COST: $460,000

CAPITAL COST: $740,000

RANGE: $370,000 - $1,480,000

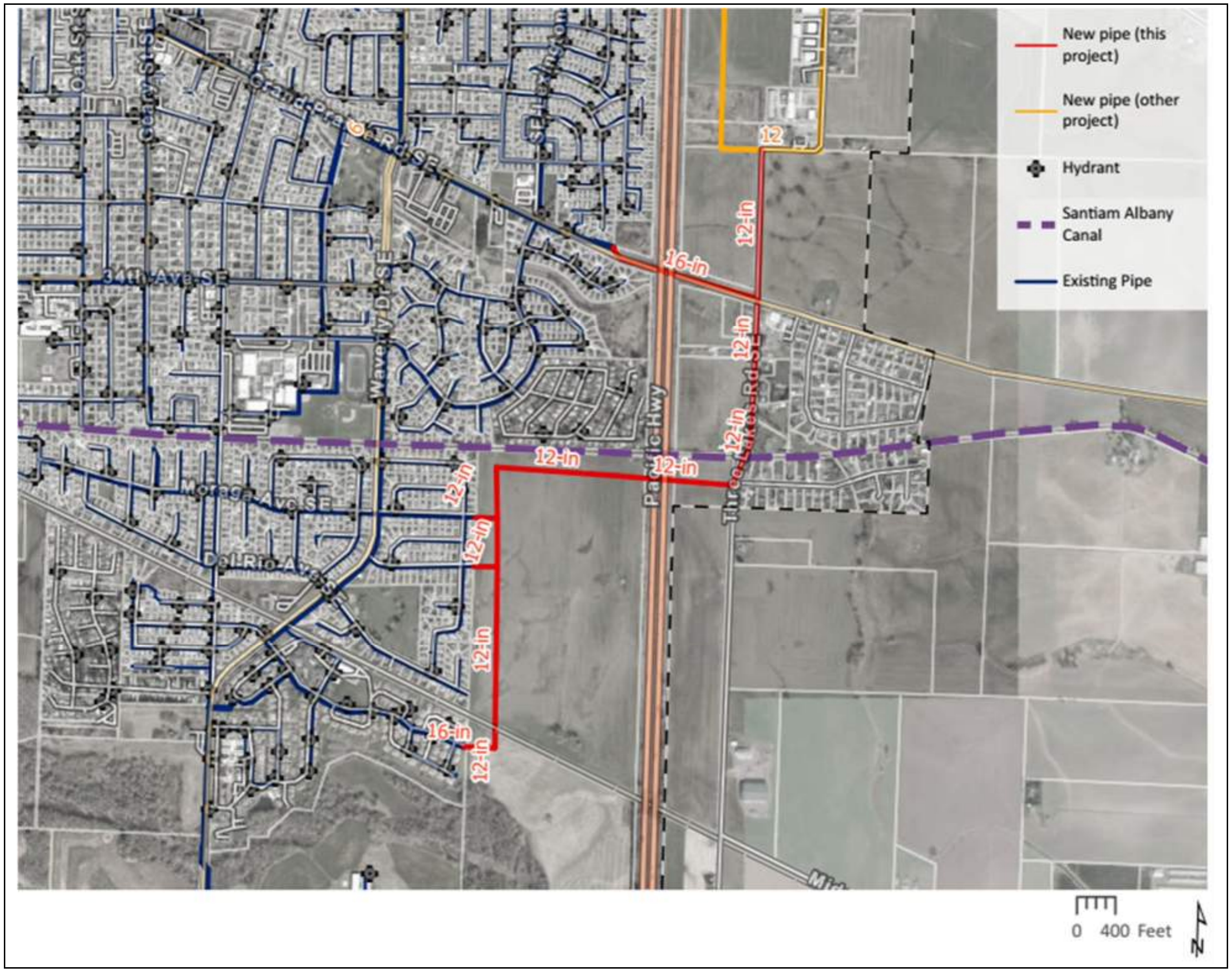
East Albany Development 7

PROJECT NUMBER(S): M-D-26

PROJECT DRIVER: Development-driven

TRIGGER: As needed for development

ESTIMATED START & END DATE 2031 - 2033



PROJECT PURPOSE AND DESCRIPTION:

This project is needed to supply expected future development in East Albany. It is assumed that the Developer will pay for the main costs but the City will pay for costs associated with additional capacity. The total construction cost is $3,408,000 and it is assumed that the City will pay 25%.

ESTIMATED COST:

- 11,360 LF 12-inch pipe (undeveloped area)

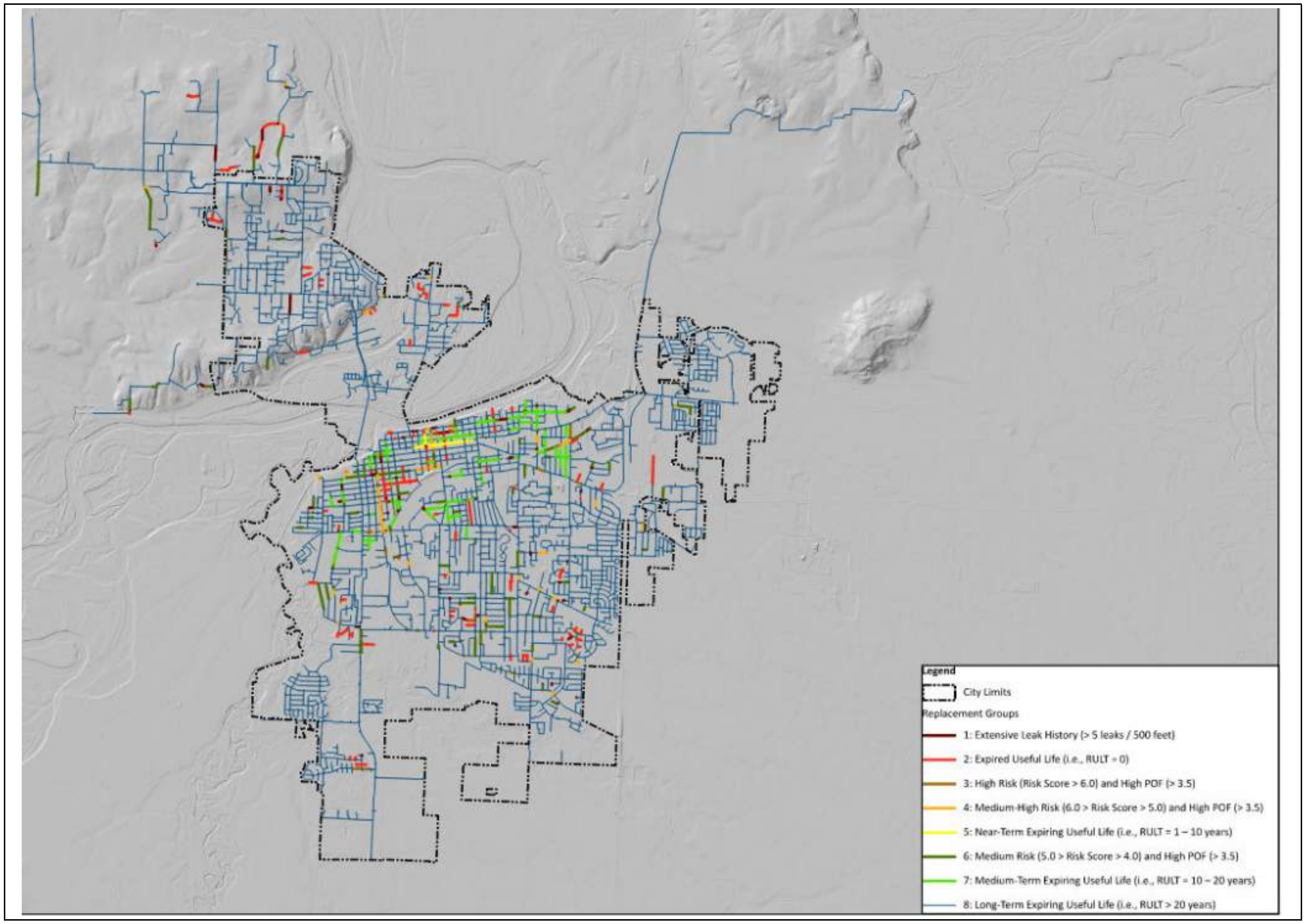
CONSTRUCTION COST: $850,000

CAPITAL COST: $1,360,000

RANGE: $680,000 - $2,720,000

Medium-Term Distribution System Pipeline Replacement Program

PROJECT NUMBER(S): M-D-27
PROJECT DRIVER: Condition
TRIGGER: Future Need
ESTIMATED START & END DATE 2029-2033



PROJECT PURPOSE AND DESCRIPTION:

The City of Albany has an annual budget dedicated for water main replacement. This budget is used for pipeline replacement to improve the overall health of the water system by reducing the potential for water main breaks and leaks. This budget assumes $3,250,000 annual budget for pipeline replacement.

ESTIMATED COST:

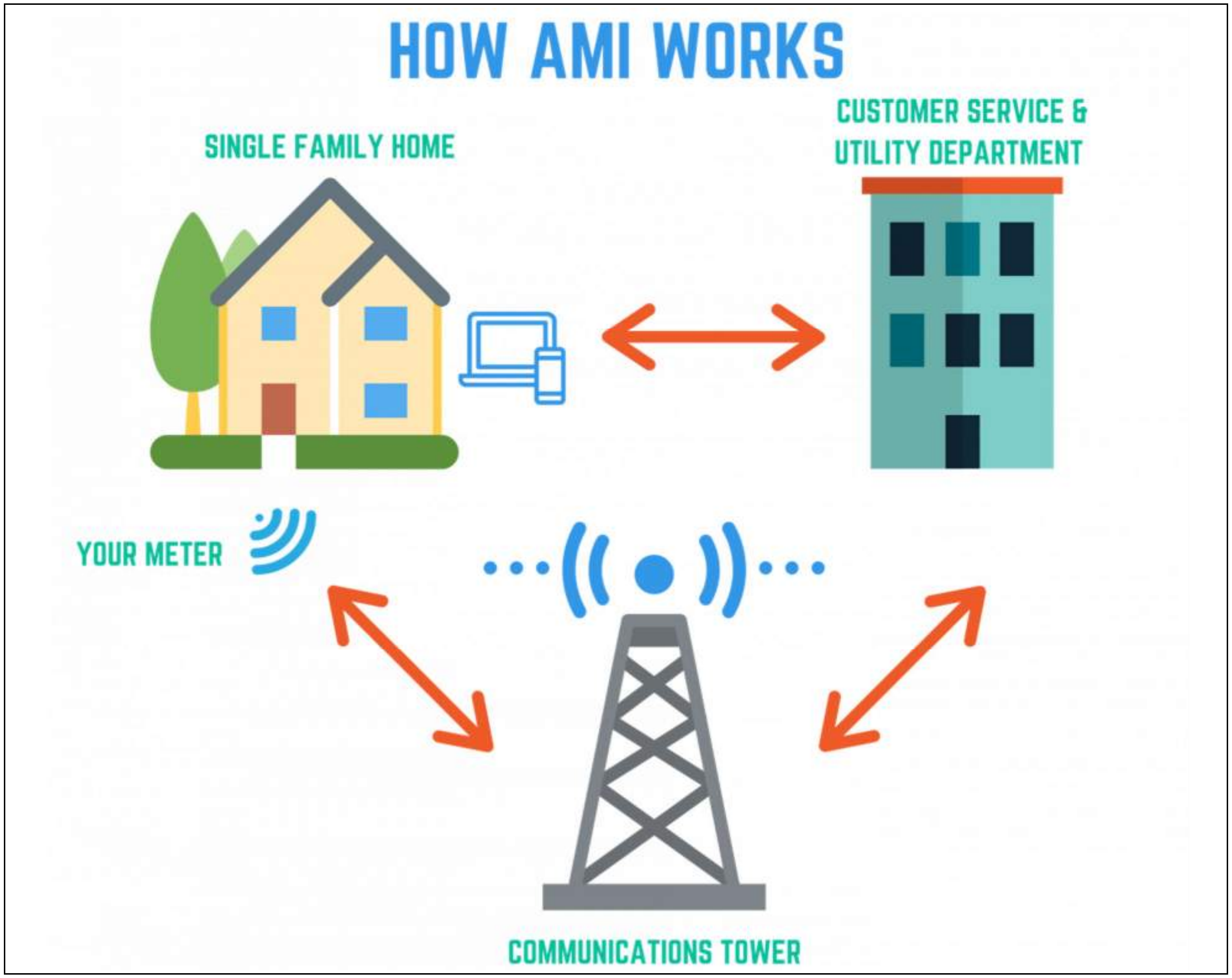
CONSTRUCTION COST: $13,000,000

CAPITAL COST: $20,800,000

RANGE: $10,400,000 - $41,600,000

Advanced Metering Infrastructure

PROJECT NUMBER(S): N-D-1
PROJECT DRIVER: Performance
TRIGGER: Existing need
ESTIMATED START & END DATE 2024 - 2028



PROJECT PURPOSE AND DESCRIPTION:

The City has over 18,900 water meters and is in the process of concerting to advanced metering infrastructure (AMI) which allows meter reading through transmitters instead of through contracting a meter reading service. Currently 41% of the water meters in service have the AMI capability. In the current biennium and going forward, the City is planning to save $500,000 a year for this AMI project and plans to apply for grant funding with the goal of completing the AMI installation in the entire system in the next 5 years.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $2,000,000

RANGE: $1,000,000 to $4,000,000

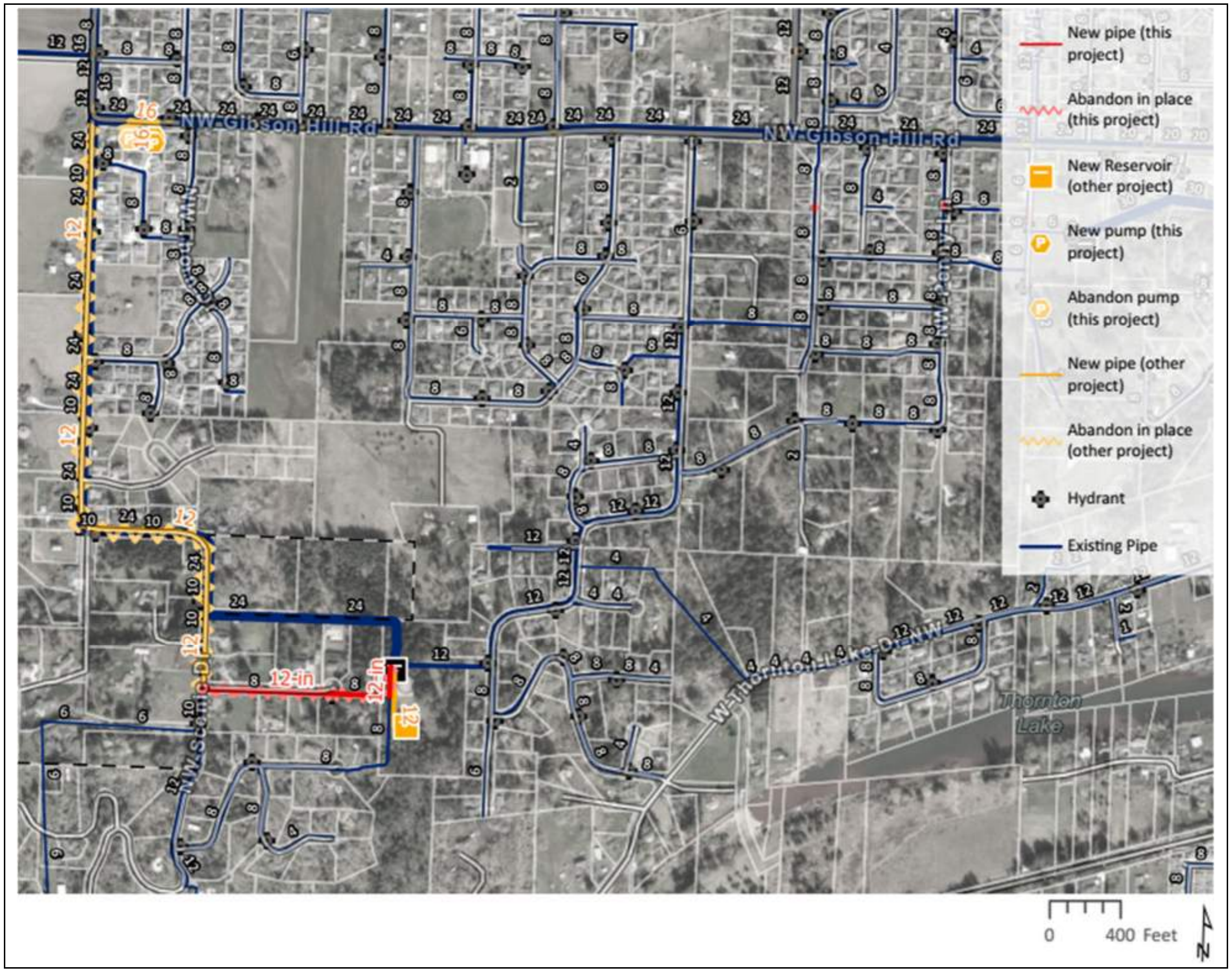
Zone 2 South Flow Improvement 1

PROJECT NUMBER(S): N-D-2

PROJECT DRIVER: Fire Flow

TRIGGER: Existing need

ESTIMATED START & END DATE 2027 - 2028



PROJECT PURPOSE AND DESCRIPTION:

This project reduces the severity of an existing fire flow deficiencies in Zone 2 near the Wildwood Reservoir. Pressures in this area are currently about 50-90 psi during normal conditions, but due to poor looping and the long distance from the Valley View Reservoirs, hydrants in this area cannot meet the required fire flow of 1,500 gpm. Project M-D-1 eliminates all the fire flow deficiencies but requires replacement of a large quantity of pipe. This project provides a short-term solution that reduces (but does not eliminate) the number of hydrants unable to supply 1,500 gpm. This project involves replacing a short segment of 8-inch pipe with 12-inch and constructing three new double check valves from Zone 1 to Zone 2. The 12-inch pipe alleviates a constriction near the Wildwood Reservoir, and the check valves will open to allow water from Zone 2 to supply fire demands near the boundary of Zone 1 and Zone 2.

ESTIMATED COST:

- 1,290 LF 12-inch pipe (developed area)
- (3) 8-inch check valve

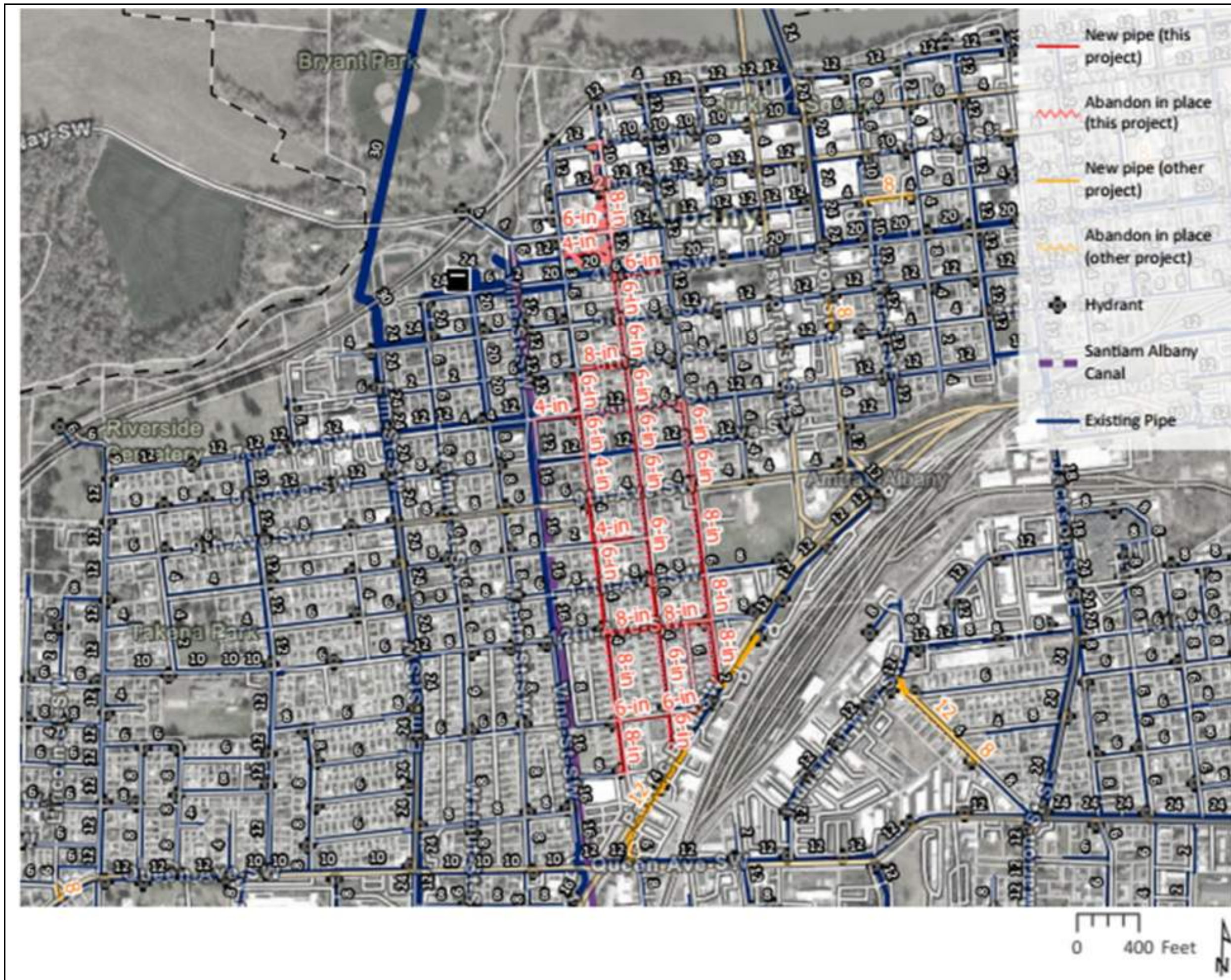
CONSTRUCTION COST: $540,000

CAPITAL COST: $860,000

RANGE: $430,000 to $1,7200,000

Washington Street Area Projects

PROJECT NUMBER(S): N-D-3
PROJECT DRIVER: Fire Flow
TRIGGER: Existing need
ESTIMATED START & END DATE 2024 - 2025



PROJECT PURPOSE AND DESCRIPTION:

This is an existing project the City is currently planning for 2024, and is listed here for reference. This project will replace aging 4-inch and 6-inch pipes near Washington Street. This project will also eliminate existing fire flow deficiencies along Highway 99. The estimated capital cost is $6,580,000. This project cost is not included in the WMP CIP budget because it is already included in the City budget.

ESTIMATED COST:

- 1,170 LF 4-inch pipe (developed area)
- 6,230 LF 6-inch pipe (developed area)
- 3,790 LF 8-inch pipe (developed area)

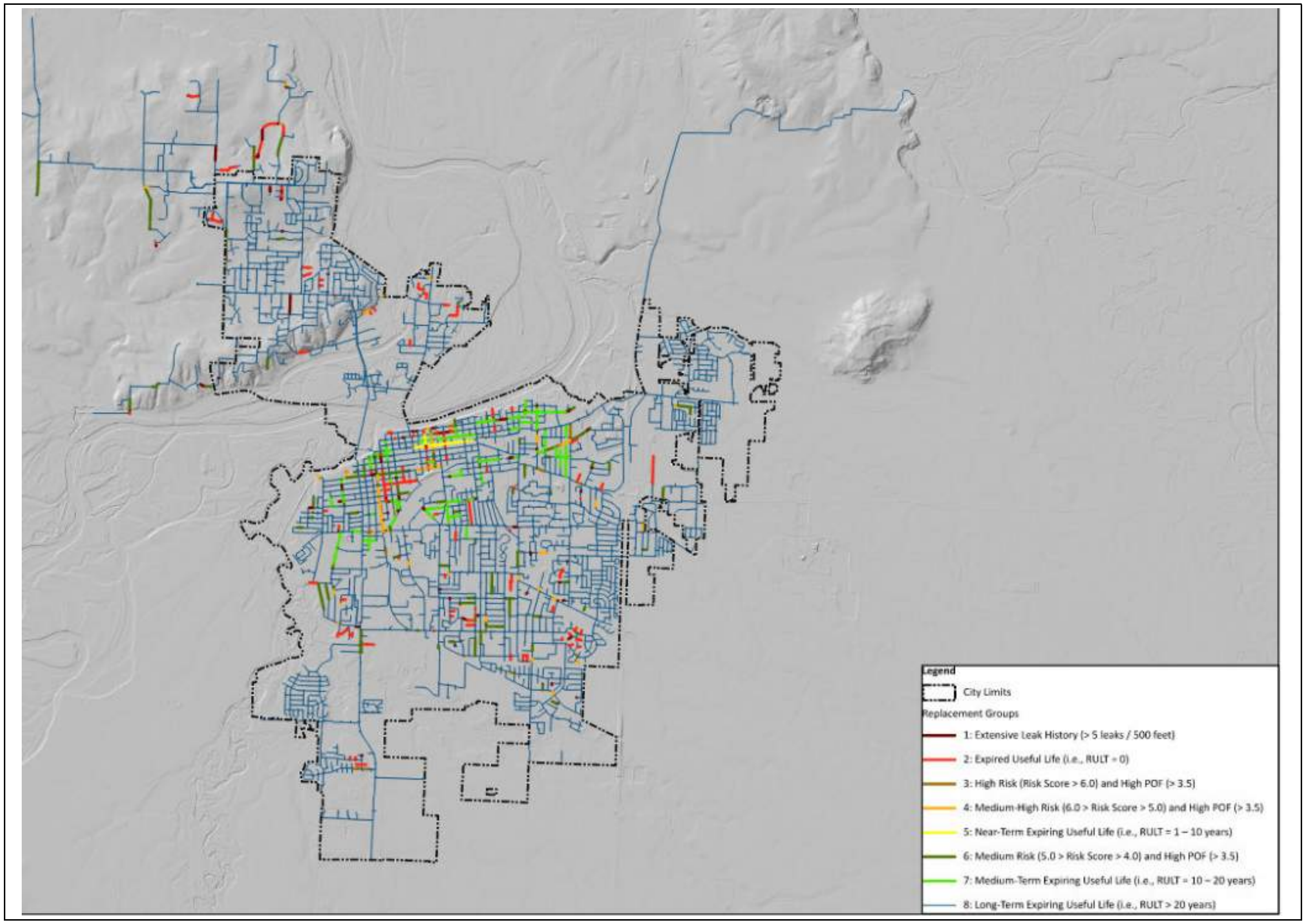
CONSTRUCTION COST: NA

CAPITAL COST: NA

RANGE: NA

Near-Term Distribution System Pipeline Replacement Program

PROJECT NUMBER(S): N-D-4
PROJECT DRIVER: Condition
TRIGGER: Existing Need
ESTIMATED START & END DATE 2024-2028



PROJECT PURPOSE AND DESCRIPTION:

The City of Albany has an annual budget dedicated for water main replacement. This budget is used for pipeline replacement to improve the overall health of the water system by reducing the potential for water main breaks and leaks. This budget assumes $3,250,000 annual budget for pipeline replacement.

ESTIMATED COST:

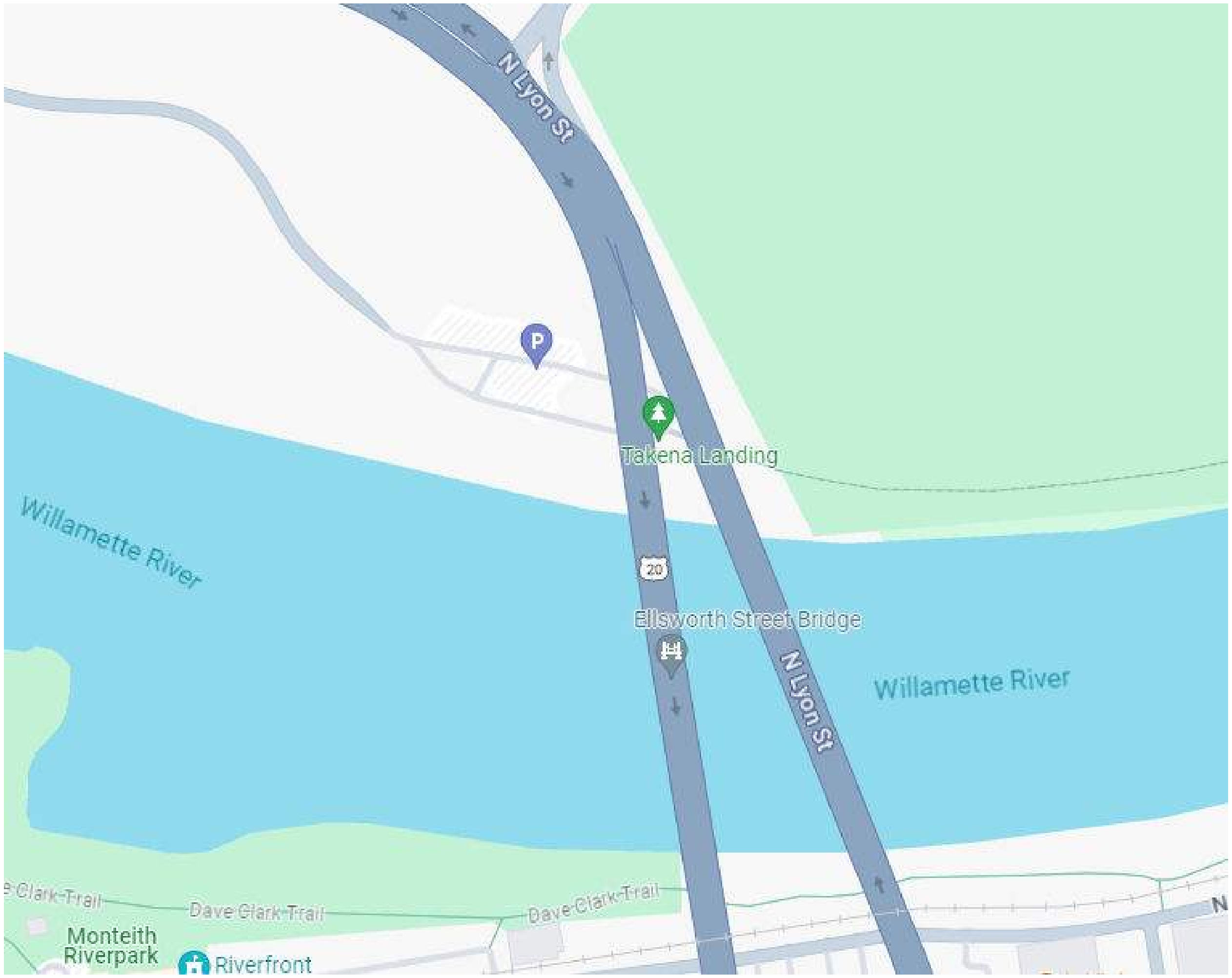
CONSTRUCTION COST: $13,000,000

CAPITAL COST: $20,800,000

RANGE: $10,400,000 - $41,600,000

Lyons St Bridge Crossing Seismic Isolation Valves

PROJECT NUMBER(S): N-D-5
PROJECT DRIVER: Seismic
TRIGGER: Existing Need
ESTIMATED START & END DATE 2026-2026



PROJECT PURPOSE AND DESCRIPTION:

In correspondence with the Oregon Department of Transportation (ODOT), the informal discussions indicated that the Highway 20 bridge (Lyons St. Bridge) will suffer catastrophic damage and likely severely or completely damage the 24-inch steel main that is hung on the bridge. Ensuring isolation valves at each end of the bridge are operable and located to isolate the damaged line as soon as possible is the recommended mitigation at this juncture. When ODOT replaces the bridge, or seismically upgrades the bridge, an effort to reinforce or replace the 24-inch main should occur at that time.

ESTIMATED COST:

CONSTRUCTION COST: $100,000

CAPITAL COST: $160,000

RANGE: $80,000 - $320,000

Supplemental Studies

Water System Master Plan

PROJECT NUMBER(S): L-SS-1

PROJECT DRIVER: Future Need

TRIGGER: Planning

ESTIMATED START & END DATE 2042-2043

PROJECT PURPOSE AND DESCRIPTION:

Per OAR 333-061-0060, a master plan is required to evaluate the needs of the water system for at least a 20-year period.

ESTIMATED COST:

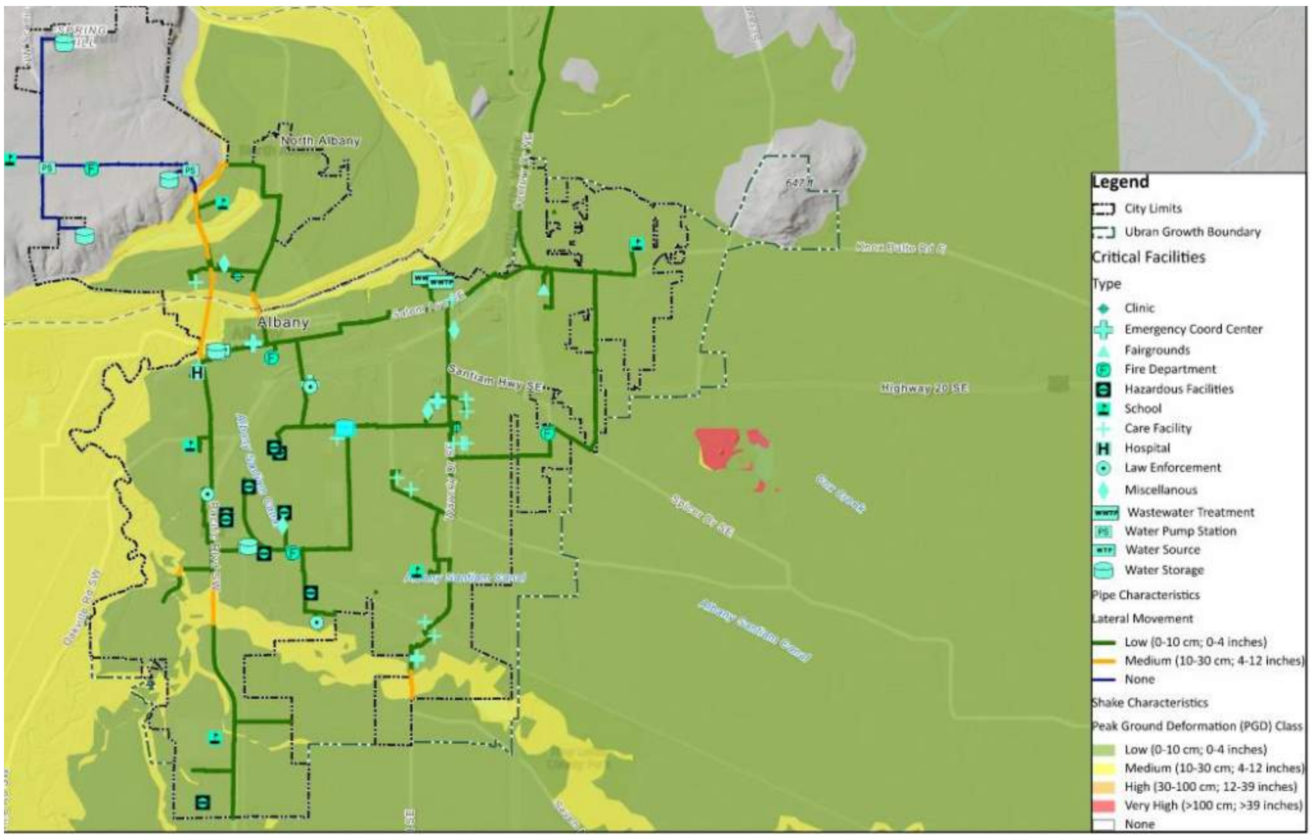
CONSTRUCTION COST: NA

CAPITAL COST: $1,000,000

RANGE: $500,000 - $2,000,000

Emergency Water Supply Plan

PROJECT NUMBER(S): M-SS-1
PROJECT DRIVER: Future Need
TRIGGER: Planning
ESTIMATED START & END DATE 2029-2030



PROJECT PURPOSE AND DESCRIPTION:

It is recommended that the City conduct an emergency water supply plan specifically for North Albany service area, which is dependent on two river crossings for water supply. This plan should investigate ground water opportunities as an emergency source in North Albany, as well as other potential tactics to help supply provisional water after a disaster.

ESTIMATED COST:

CONSTRUCTION COST: NA

CAPITAL COST: $75,000

RANGE: $38,000 - $150,000

Appendix E

Canal Condition Assessment TM

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WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

5 Centerpointe Drive
Suite 130
Lake Oswego OR 97035

503.451.4500 phone
530.756.5991 fax
westyost.com

TECHNICAL MEMORANDUM

DATE: March 21, 2024

Project No.: 519-50-22-21
SENT VIA: EMAIL

TO: Ryan Beathe, PE (City of Albany)

CC: Mel Damewood, PE 13672 (West Yost)

FROM: Ken Puhn, PE 85518 (WEST Consultants)

REVIEWED BY: Hans Hadley, PE 77018 (WEST Consultants)
Mel Damewood, PE 13672 (West Yost)

SUBJECT: Santiam-Albany Canal Bank Condition Assessment

REGISTERED PROFESSIONAL ENGINEER
85518PE
Kenneth D Puhn
OREGON
MAY 21, 2014
KENNETH D. PUHN
EXPIRES: 12/31/2024

EXECUTIVE SUMMARY

Background

The City of Albany (City) owns the 18.2-mile-long Santiam-Albany Canal (Canal), which has a history of channel bed degradation and exhibits a significant number of bank failures along its entire length. A bank stability study was completed for the City in 2008 (Otak, 2008) which included a field-based assessment of the canal and identified failure locations. Since the bank failure inventory was completed 15 years ago, only a small number of the previously identified sites have been rehabilitated, and new failures continue to be observed. WEST Consultants Inc. (WEST) updated the inventory via a 'rapid assessment' of the entire canal. The purpose of the rapid assessment was to:

- Determine if the previously identified sites have degraded further
- Evaluate the current condition of the rehabilitated sites
- Identify new failure sites that have occurred since the 2008 study
- Provide recommendations and a prioritized list of CIP projects for the previous/new failure sites

In addition to the rapid assessment, a survey of the canal thalweg was conducted to assess if the canal is continuing to experience bed degradation and to reevaluate the grade control recommendations in the 2008 study. The City is also considering removal or modification of the abandoned Lebanon water intake structure. This structure causes upstream sedimentation and increased flood risk associated with the potential failure of the upstream raised canal embankments located in the reach between the structure and Garvord Street. An analysis was conducted to determine if modification of the structure could reduce upstream water surface elevations in order to reduce the potential flood risk. Lastly, the City is concerned about sedimentation that is occurring in the canal reach located immediately upstream of the Vine Street Water Treatment Plant (WTP). Therefore, an evaluation was conducted to determine if the WTP intake gates can be operated in a manner that will help flush sediment from this location.

Bank Inventory and Site Prioritization

The 2023 rapid reconnaissance observations indicate that the condition of the canal has continued to decline since the 2008 study. Eight of the 87 original sites were repaired as capital improvement projects following the recommendations from the 2008 study. All of the repaired sites were observed to be in good condition. Of the remaining 79 original sites, 51 were found to be in worse condition, 16 were observed to be in the same condition, 6 were observed to be in better condition, and 6 sites could not be observed due to difficult field conditions. Most of the original sites have increased in length since the 2008 study. The average length of the non-repaired original sites has increased from 30 ft to 67 ft. During the rapid reconnaissance effort, 98 new sites were identified and documented.

All sites (original and new) were assigned a repair priority of High, Medium, or Low based on their location and associated risk factors, such as proximity to nearby infrastructure. Of the 177 total sites, 41 (23 percent) were assigned high priority, 27 (15 percent) were assigned medium priority, and 109 (62 percent) were assigned low priority.

Each site was assigned one of four conceptual repair design along with an anticipated repair cost based on planning level (Class 5) unit cost estimates developed by Brown and Caldwell (B&C). B&C recommends that canal CIP projects be grouped such that total project length is at least 100 ft and project costs meet or exceed $500,000 to avoid “small project” premiums. B&C also recommends consideration of a programmatic 404 permit for the entire canal to facilitate a more streamlined permitting process.

Grade Control Review

A comparison of the 2023 channel profile survey data with available historic data indicates that significant degradation of the canal has occurred since the late 1800’s, particularly in reaches 3 through 8. Direct numerical comparison of elevation data sets is subject to error due to the varied quality of the data sources. However, the data indicate that most significant degradation appears to have occurred in Reach 6, with the amount of degradation decreasing in the upstream direction. Degradation has continued to occur in reaches 3 through 6 between 2007 and 2023; however, the data appear to indicate that reaches 7 through 10 have not experienced reach-wide degradation over the past 15 years. Upstream of Reach 9, both aggradation and degradation are occurring. Since the canal has been in operation for nearly 130 years, it is possible that the majority of the expected incision and widening has already taken place, in particular in the lower and middle reaches of the canal. However, it is possible that the degradational trend may continue upstream, though likely at a reduced rate.

Based on review of the available data, there does not appear to be a need for grade control structures at this time. It is recommended that the 2008 study grade control recommendations for reaches 7 and 8 be placed on hold. Further, it is recommended that the City consider developing an adaptive management plan (AMP) for the canal. A key component of the AMP would be development and implementation of a long-term plan to monitor key locations in the canal and collect regular, high-quality survey data to identify and quantify degradational or aggradational trends, which will better inform the need for grade control structures to be included in future CIPs.

Lebanon Intake Structure

A conceptual level analysis consisting of five different alternatives of intake structure modifications and/or upstream dredging were considered and modeled using the available HEC-RAS hydraulic model provided by the City. None of the alternatives included removal of the entire intake structure since the structure also provides beneficial grade control to protect against channel incision. Only Alternatives 4 and 5 provide significant flood risk benefit when considered in the context of the FERC bank failure flood risk analysis. Alternatives 4 and 5, which assume a reduction in the controlling elevation of the structure down to 346.41 ft and dredging upstream from RS 77,611 to RS 83,384 by an average depth of 3.2 ft produced an average reduction in water surface elevations of 2.4 ft along the dredged portion of the canal. This reduces the water surface elevations below the adjacent landward ground elevations for all but one localized low spot along the right overbank near RS 81,000. Either of these alternatives would significantly reduce the number of potential breach locations. Further reductions in water surface elevations would require more significant dredging which may exacerbate bank instabilities. Accordingly, the flood risk for this location could potentially be addressed by placing a minor amount of fill on the landward side of the embankment. Of the five alternatives, only Alternatives 4 and 5 provide significant flood risk benefit when considered in the context of the FERC bank failure flood risk analysis. The conceptual level dredge geometry for Alternatives 4 and 5 requires that approximately 14,500 cubic yards of material be removed from the canal. Detailed analysis and design will be needed if the City desires to move forward with a dredging project. This will reduce the potential for the project to have adverse impacts on bank stability and existing infrastructures (e.g., bridges) located within the reach.

Flushing Analysis

The HEC-RAS hydraulic model provided by the City was converted from steady to unsteady flow and used to assess gate operations with respect to sediment flushing. The City would like to be able to flush upstream sediment through the gate and out of the canal to reduce or possibly eliminate the need for periodic dredging. The results of the simulated drawdown procedure indicate that it is not feasible to flush sediment through the radial gate by modifying operations. The upstream extent of the influence of the drawdown on velocities and water surface elevations is approximately RS 641. However, at all cross sections between the gate and RS 641, the values for maximum velocity and shear stress during the drawdown procedure deviated only slightly from the values experienced during normal steady flow operation of the canal with the radial gate in the fully open position. The maximum increase in velocity and shear stress were 0.2 ft/s and 0.04 lb/ft2, respectively. These relatively minor increases are unlikely to affect sediment transport conditions within the canal.

OVERVIEW AND PURPOSE

The City of Albany (City) owns, operates, and maintains the 18.2-mile-long Santiam-Albany Canal (Canal). The earthen canal flows from its point of diversion on the South Santiam River through the City of Lebanon, unincorporated areas of Linn County, and the City of Albany (City), before discharging to the Calapooia River downstream of the Vine Street Water Treatment Plant (WTP) and Albany Hydropower Project (AHP) (Figure 1).The canal serves as the water supply for the Vine Street WTP and the hydropower facility. The Canal also provides water for irrigation and agricultural activities. Primary structures located along the Canal are the fish screens and head gate structure located at the diversion from the South Santiam River, two inline control structures in Lebanon, and the intakes for the Vine Street WTP and the hydropower project in Albany.

Figure 1. Canal Reach Designations

The canal has a history of degradation and exhibits a significant number of bank failures along its entire length. A bank stability study document titled "Santiam-Albany Canal Rehabilitation-Bank Stability Analysis" was completed for the City in 2008 (Otak, 2008). The study included a field-based assessment of the canal which identified failure locations, characterized the likely associated failure mechanism(s), provided recommendations for stabilization of the identified sites, and recommended projects to mitigate the identified drivers of failure in hopes of preventing continued degradation of the canal. The study identified 87 failure sites which were categorized into high and low repair priority. The study also presented a selection of nine conceptual repair designs (and associated unit costs) that could be applied to the failure sites. 50 of the 87 sites were incorporated into the 2009 Canal Capital Improvement Program (CIP) report developed by the City (revised in 2012), which included estimated repair costs for the 50 sites. Eight CIP sites have since been rehabilitated and 6 had been removed from the CIP priority list. No action has been taken on the remaining 36 sites.

The last condition assessment of the canal was in 2008. However, new bank failures continue to be identified, most recently near South Albany High School. Since the bank failure inventory is 15 years old, only a handful of the identified high priority sites have been rehabilitated, and new failures continue to be observed, the City requested that WEST Consultants update the inventory via a 'rapid assessment' of the entire canal. The purpose of the rapid assessment is to:

- Determine if the previously identified sites have degraded further
- Evaluate the current condition of the rehabilitated sites
- Identify new failure sites that have occurred since the 2008 study
- Provide recommendations and a prioritized list of CIP projects for the original/new failure sites

ANALYSIS METHODOLOGY

The elevation of the canal is approximately 358 ft (NAVD88) just downstream of the intake fish screens at the headgates, and approximately 212 ft just upstream of the AHP. The canal slope varies with location but averages about 0.0015 ft/ft. The Canal is believed to have been constructed largely by hand in the late 1800's and has been in operation for over 130 years. The 2008 study divided the canal into 17 reaches, with individual reach lengths ranging from 0.3 to 2.7 miles (Figure 1). The planform of the canal varies by location. It is generally straight (with some minor bends) downstream of the City of Lebanon (Reaches 1 through 10) and has low to moderate sinuosity through and upstream of the City of Lebanon (Reaches 11-17). Approximately 7.5 miles of the canal's total length is located within the residential and urban developments of the cities of Lebanon and Albany, while the remaining 10.7 miles are located within rural agricultural land.

To understand the current condition of the canal and develop an understanding of the underlying causes, the following tasks were conducted: (1) Rapid reconnaissance of the canal by boat, (2) survey of the canal thalweg, and (3) review of the grade control recommendations in the 2008 study. The results of the condition of the canal will guide recommendations to address areas of existing erosion/failure. The City is also concerned about sedimentation that is occurring in the reach located immediately upstream of the Vine Street WTP and wants to evaluate if the canal intake gates can be operated in a manner that will help flush sediment from this location (Section 2.4 of this memo).

Bank Failure Inventory Rapid Assessment

To understand the current conditions along the canal, a rapid reconnaissance of the canal was conducted over a five-day period in January 2023 (Table 1). During this time, the City reduced the flow in the canal to approximately 50 cfs so that the lower portions of the canal banks could be observed and to help facilitate safe conditions for travel within the canal. The reconnaissance was conducted using a 12 ft johnboat with a small outboard motor, though flow depths in the canal were not sufficient to use the motor during the majority of the reconnaissance effort.

Table 1. Schedule of Reconnaissance

Date	Reaches	Original Sites, #	New Site, #	Total Sites, #
January 4, 2023	14-17	1	6	7
January 5, 2023	8-13	11	20	31
January 6, 2023	7	30	13	43
January 10, 2023	1,6	20	21	41
January 12, 2023	2-5	25	38	63
	Total	**87**	**98**	**185**

As part of the reconnaissance work, brief stops were made at each of the original 87 sites to observe their condition. At each site, the location was recorded using a resource grade Garmin handheld GPS device, photographs were taken, and observations were documented. While at each site, a comparison was made to the 2008 study site photos and the site was categorized as being in Worse, Same, or Better condition. Also, if the length of the site appeared to have significantly changed compared to 2008, a visual estimate of the new length was made. Exact measurements were not collected due to the time constraints associated with the rapid assessment.

In addition to visiting all of the original sites, 98 new sites observed to contain failures or significant erosion (e.g., vertical or near vertical banks) were identified and documented. At each site, the location was recorded using a resource grade Garmin handheld GPS device, the condition of the site was documented, photographs were taken, and visual estimates of length and height of the damaged bank were recorded. It should be noted that the majority of the canal exhibits evidence of erosion along the upper or lower channel banks. However, selection of the newly documented sites was limited to areas of erosion/failures with similar severity to the sites documented in the 2008 study.

Although not included in the scope of work, information for 35 other sites of interest that were deemed to be potentially useful to the City was documented. These included locations of significant obstructions of the canal or structures due to brush and trees and bank repairs (e.g., riprap) that were not included on the City's list of CIP projects.

Following completion of the rapid field reconnaissance, the field notes for each site were entered into a GIS shapefile attribute table. For the original sites, the GIS shapefile attribute table from the 2008 study was updated with new information. All of the original data was retained and the newly estimated length, general observations, and comparative condition were appended for each site.

For new sites, a GIS shapefile was developed from the collected GPS points. Observations of estimated length, height, and general condition were added to the shapefile attribute table. In addition, river stations and site IDs were assigned. The site IDs from the 2008 study were based on the GPS waypoint number (e.g. WP450). However, the assigned ID numbers are not ordered sequentially along the canal. For simplicity and to avoid confusion when comparing to the 2008 study, the site IDs from 2008 were retained. The new sites collected in 2023 were assigned site IDs in numerical order from downstream to upstream starting at number 1,000. Additionally, all original and new sites were assigned a River Station (RS) (in feet [ft]) based on its distance from the downstream end of the canal. Photographic logs were developed for both the new and the original sites.

The 2008 study developed a prioritized list of canal bank repair sites. The 87 sites were assigned a repair priority of either High or Low. The shapefile attribute table contains columns for notes relating to four risk factors that may influence a particular site. These included utilities, buildings, roads, and downstream. Unfortunately, specific details of the site prioritization method were not provided in the 2008 study report and the prioritization did not appear to directly correlate to site dimensions or the presence of one or more of the four risk factors.

For this study, the original sites and the new sites were assigned a priority of High, Medium, or Low. For each site, assessments were made for the four risk factors based on review of field data; aerial imagery; and a GIS shapefile from the 2008 study that noted the locations of utilities entering, leaving, or crossing the canal, and other relevant structures. Additionally, the sites were assigned a Setting (rural, suburban, urban) and Land Use (agricultural, residential) classification. To prioritize the sites, a two-step process was used.

For the first step, an initial prioritization was assigned using the following rules:

- If the site has at least one risk factor it was assigned a priority of Medium.
- If the setting for the site is suburban or urban, it was assigned a priority of Medium.
- If the land use for the site is residential, it was assigned a priority of Medium.
- If the site has at least one risk factor and is also classified as either suburban/urban or residential, it was assigned a priority of High.
- All other sites were assigned a priority of Low.

For the second step, each site was individually reviewed and adjusted as needed using professional judgement. For example:

- If a site was assigned a priority of High but has small dimensions (based on observed length or height), it was reduced to a priority of Medium or Low.
- If a site is located within a suburban area but one bank is residential and the other borders a field, the site priority was reduced to Medium or Low if the damaged bank borders the field.
- If an original site was previously assigned a priority of High but was observed to be in "Better" condition, it was reduced to Medium or Low.

Vertical Thalweg Stability and Grade Control Analysis

The 2008 study included an assessment of trends in the vertical stability of the canal to determine if grade control structures were needed to help address bank stability issues. Channel morphology (channel shape and planform) is driven by four primary factors: channel slope, discharge, sediment composition, and sediment supply. Watercourses adapt to changes in these factors by adjusting their morphology to establish a new state of dynamic equilibrium. Human made channels, particularly those with non-natural characteristic (such as ditches and canals), can be particularly susceptible to instabilities and changes to their morphology, unless they are carefully engineered based on consideration of the previously mentioned factors. Canals typically have very straight or low sinuosity planforms in order to maintain specific slopes, shorten their total length, and maintain target water surface elevations at specific locations needed for irrigation or water supply diversions. The straight planforms of canals often result in non-ideal slopes, which can result in either degradation (lowering of the channel elevation through erosion of the channel bed) in cases where the slope is too steep, or sedimentation in cases where the slope is too flat. Further, the headgate structures of canals often significantly reduce upstream sediment supply which can cause degradation. Degradation of the channel is a common reaction to reduced sediment inputs and steep gradients. As the channel bottom degrades, the bank slope steepens, and undermining of the bank toe often occurs, leading to bank failure.

In the 2008 study, three sets of available profile data were compared to identify areas where the canal bed may be aggrading or degrading. The datasets compared included “Original Conditions” (assumed to be from the year 1873), and the years 1890 and 2007. Comparative data for 1873 and 1890 were only available from reaches 3-13 (RS 6,100 to RS 64,300); therefore, no conclusions could be drawn for reaches 1-2 and 14-17. The analysis concluded that degradation has occurred within all reaches of the canal where historic data were available. Reported degradation ranged from 1.5 ft to 7.5 ft, though no information was provided regarding the method used to develop these estimates.

Incision of a channel is a process where the steam cuts into the surrounding valley through degradation (erosion) of the channel bed. The 2008 study report states that incision is more notable in the lower reaches of the canal and that this process may continue to propagate upstream over time. It was also noted that upstream progress of the incision is being partially halted by the large rock grade control structure located approximately 700 ft upstream of Fry Road, at the boundary between reaches 6 and 7. The study report recommended that seven grade control structures be built in reaches 7 and 8 to halt continued degradation of the channel. Observations made during the rapid field reconnaissance efforts revealed that none of these recommended structures were built.

The significant historic degradation of the canal is believed to have occurred for two primary reasons. (1) The headgate structure cuts off the upstream sediment supply to the canal and (2) the canal has a relative straight planform for most of its length, which results in a steeper slope compared to a natural watercourse resulting in sediment transport capacity that exceeds the sediment supply. As documented in the 2008 study report, the canal has been transitioning through phases of the Channel Evolution Model (SEM) (Figure 2). Stages 2 and 3 of the SEM involve incision of the channel into the floodplain. This is followed by Stage 4, in which the channel widens due to destabilization of the banks. As noted in Figure 2, Stages 2 and 3 typically occur over a relatively brief time span in disturbed or straightened channels. By contrast, Stage 4 (widening) occurs over tens of years. Stages 5-7 follow, during which the bed aggrades, and the channel may continue to widen, and a new floodplain develops within the incised channel.

For this updated assessment, WEST personnel surveyed the canal thalweg (lowest point in the channel bed) between January 23 and 27, 2023 to develop a current longitudinal profile. The survey was conducted by walking the entire length of the canal and collecting survey points along the channel thalweg. This new profile was compared to previous data to determine if the trends identified in 2008 have continued and if the grade control recommendations are still valid or require modifications.

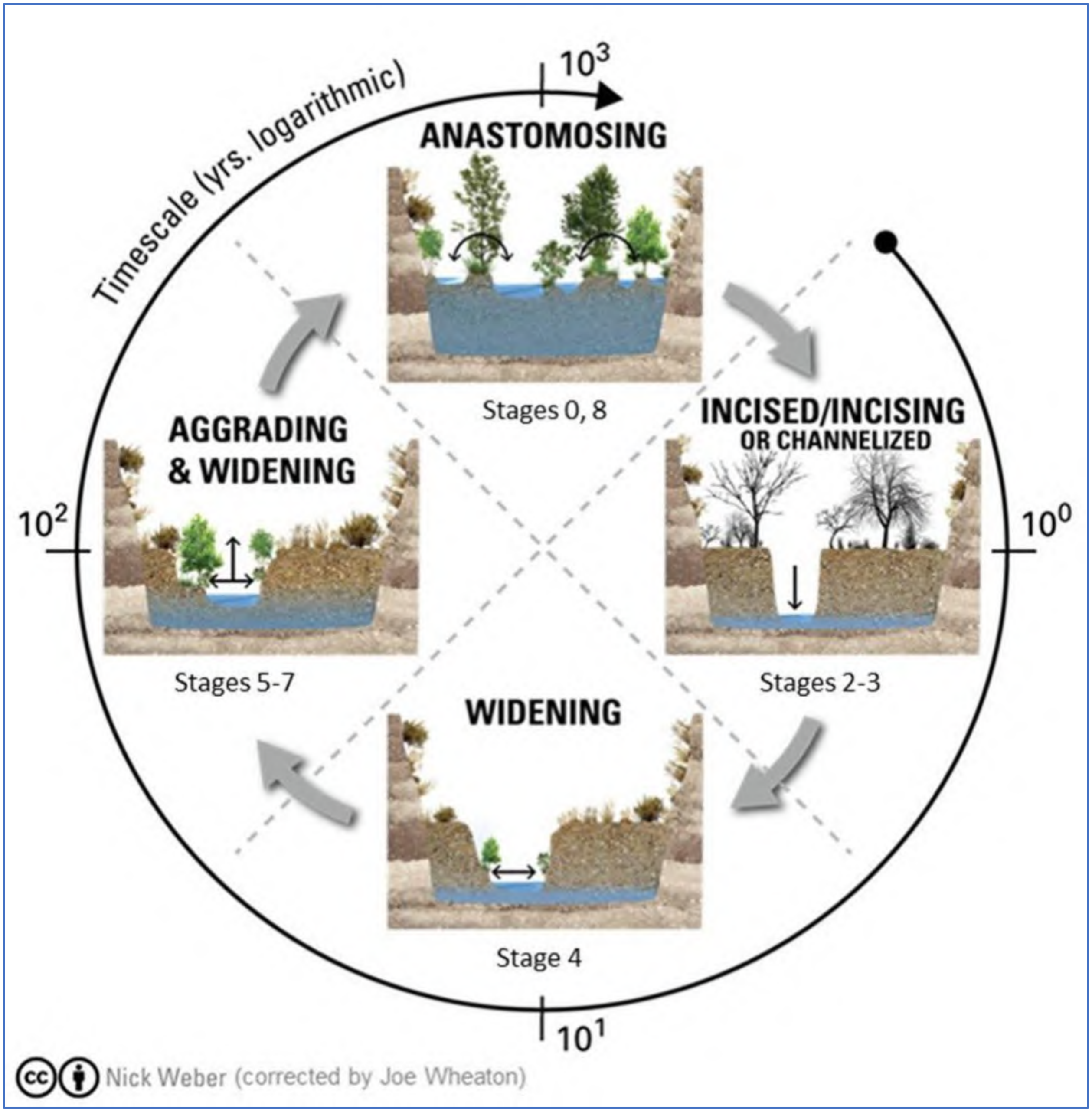


Figure 2. Channel Evolution Model (From FHWA HEC-16)

The survey began at a point located approximately 275 ft downstream of the fish screen structure at the head of the canal in the City of Lebanon and ended at SW 4th Avenue in the City of Albany. The City reduced flow in the canal to approximately 10 cfs to reduce water surface elevations and facilitate safe conditions. A total of 1,750 points were collected via survey grade GPS equipment, at an average longitudinal spacing of 50 ft. Supplemental points were collected as needed if significant inflection points were observed. The data were collected by walking rather than by boat for three reasons. (1) Water depths were too shallow to allow use of a boat mounted single beam sonar; (2) a significant amount of vegetation, downed trees and other obstructions, both above and below the water line, made use of a boat impractical; and (3) increasing flow in the canal to achieve the required depths for using sonar would result in hazardous conditions due to high velocities combined with debris and other obstacles such as weirs, flow control structures, and low clearance crossings (culverts, bridges, utilities lines). Survey points were collected with a Topcon HiPer VR GNSS receiver and FC-6000 field tablet running MAGNET Field survey software. The survey data are referenced to NAD 1983 Oregon State Plane North (2011) horizontal datum and the North American Vertical Datum of 1988 (NAVD88). The Oregon Real-time GPS Network provided real-time kinematic corrections. Survey data were collected for nearly the entire length of the canal; however, gaps in the data occur in six locations. The data gaps range from 250 ft to 1,000 ft in length and occur where the water was too deep to be safely waded.

The original canal thalweg profile, along with reported thalweg elevations from 1890 and 2007 were available from the canal profile figure in the 2008 study. The original station/elevation data used to develop the figure were not available. To allow for graphical comparison of historical canal profile data with the 2023 survey data, a data digitizer software, Dagra Version 2.0.12 (Blue Leaf, 2012), was used to convert the hard copy historic profile plot into a tabular data set. The extracted tabular data for the "original conditions", 1890, and 2007 profiles were plotted on a graph of the HEC-RAS model profile (largely based on 2007 data) and the 2023 thalweg survey data to evaluate the chronological changes in the canal profile. To facilitate the comparison, all elevations extracted from the 2008 Otak study were converted from the National Geodetic Vertical Datum of 1929 (NGVD29) to the North American Vertical Datum of 1988 (NAVD88) by adding 3.34 ft. This conversion value was determined using the National Oceanic and Atmospheric Administration's (NOAA) National Geodetic Survey (NGS) Coordinate Conversion and Transformation Tool (NCAT).

A comparison of the canal stationing for each dataset was conducted to verify proper horizontal alignment of the existing profile plots with the 2023 survey data. The stationing of the 2016 HEC-RAS model was checked by comparing the model's cross section stationing with distances measured along the canal using ArcGIS. The stationing of the HEC-RAS cross sections and values measured along the city-provided canal shapefile were found to be in close agreement. Fixed landmarks, such as grade control structures and streets, were used to align the historic data extracted from the 2008 study with the 2023 survey data. The landmark stationing extracted from the 2008 study matched closely with those provided as attributes in the City's GIS files for the canal. After verification of horizontal and vertical alignment of the datasets, the profiles and landmarks were plotted on a single graph shown in Figure 3.

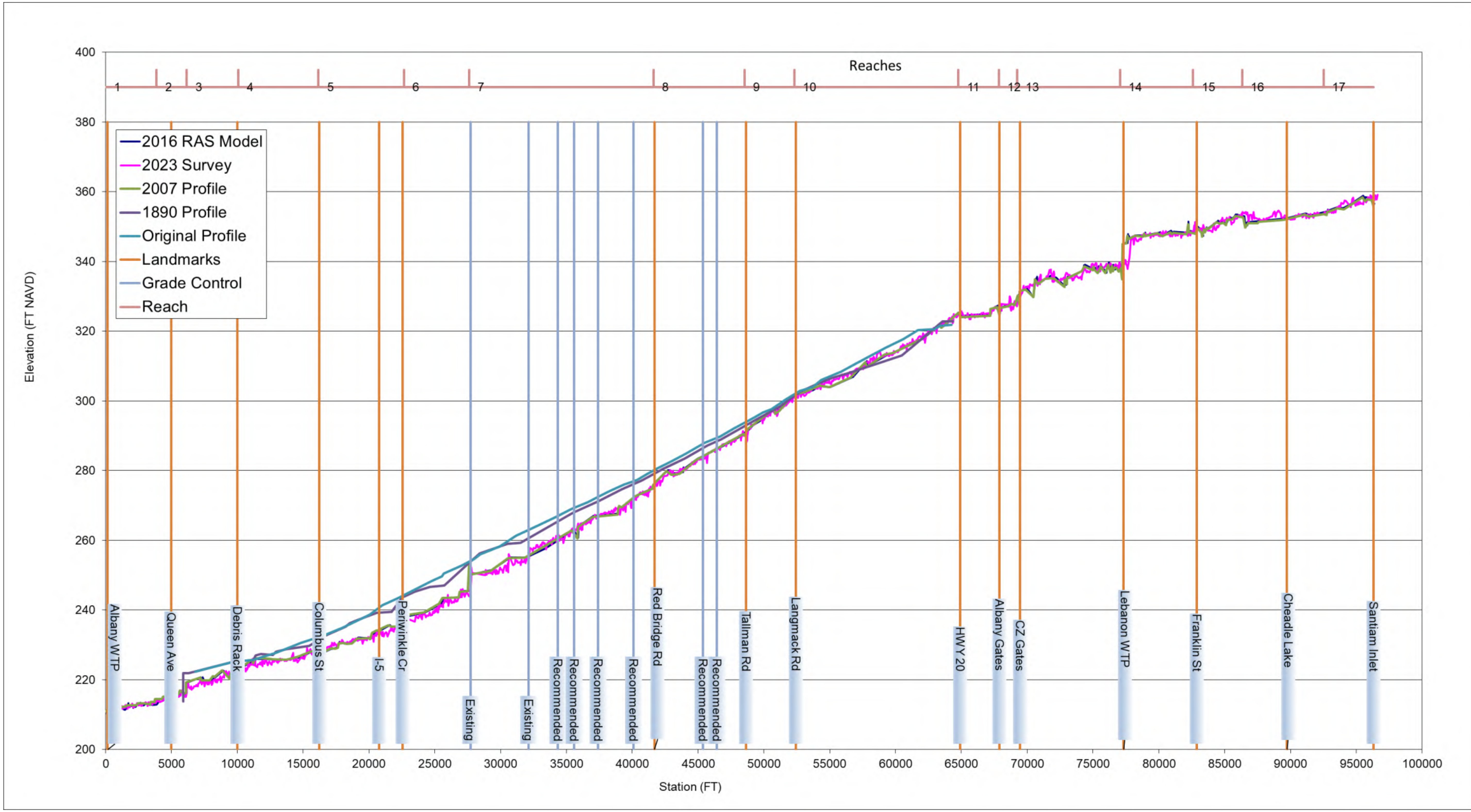


Figure 3. Canal Thalweg Profile

Lebanon Intake Structure Dredging Analysis

The City of Lebanon previously operated a water intake structure located near W. A Street and Highway 20. They recently built a new municipal water withdrawal facility on the South Santiam River and have since stopped diverting water from the canal. The canal banks in the reach immediately upstream of the facility from RS 77,721 to RS 83,396 consist of raised embankments that are elevated above adjacent grade on the landward side of the embankments (Figure 4). When the canal is flowing at design capacity, water surface elevations in the canal exceed adjacent landward grade (Figure 5). Accordingly, failure of the embankments poses a flood risk to nearby properties. This risk level was recently evaluated (WEST, 2020) to develop a hazard rating for the canal due to requirements of the FERC relicensing process. The resulting hazard rating was determined to be 'Considerable'. Since the intake diversion structure is no longer needed for water withdrawals, it could potentially be removed or modified in such a way to lower upstream water surface elevations, which would reduce the flood risk from a potential embankment failure and potentially lower the hazard rating for the canal.

The abandoned water intake consists of a vertical standpipe and a radial gate. Historically, the radial gate was used to adjust the upstream water surface elevation in order to control the amount of water that flows over the top of the standpipe into the City of Lebanon's water supply system. To investigate potential benefits of removal or modification of the structure, WEST used the City's HEC-RAS model of the canal to analyze several conceptual-level modifications for the design capacity discharge. The goal of the alternatives analysis was to identify one or more modifications that would lower water surface elevations below the adjacent landward ground elevations. This would essentially eliminate the risk of bank failure and associated flooding. None of the alternatives included removal of the entire intake structure, since the structure also provides beneficial grade control to protect against channel incision. The five alternatives considered are as follows:

1. Lowering of the intake weir to the elevation of the bottom of the radial gate (346.41 ft).
2. Alternative 1 plus minor dredging of local high spots immediately upstream of the intake.
3. Alternative 1 plus dredging upstream of the intake from RS 77,611 to RS 82,827 by an average depth of 1.5 ft.
4. Alternative 1 plus dredging upstream of the intake from RS 77,611 to RS 83,384 by an average depth of 3.2 ft.
5. Modification or replacement of the intake facility structure with a 25-ft-wide rectangular weir with a crest elevation of 346.41 ft plus dredging upstream of the intake from RS 77,611 to RS 83,384 by an average depth of 3.2 ft.

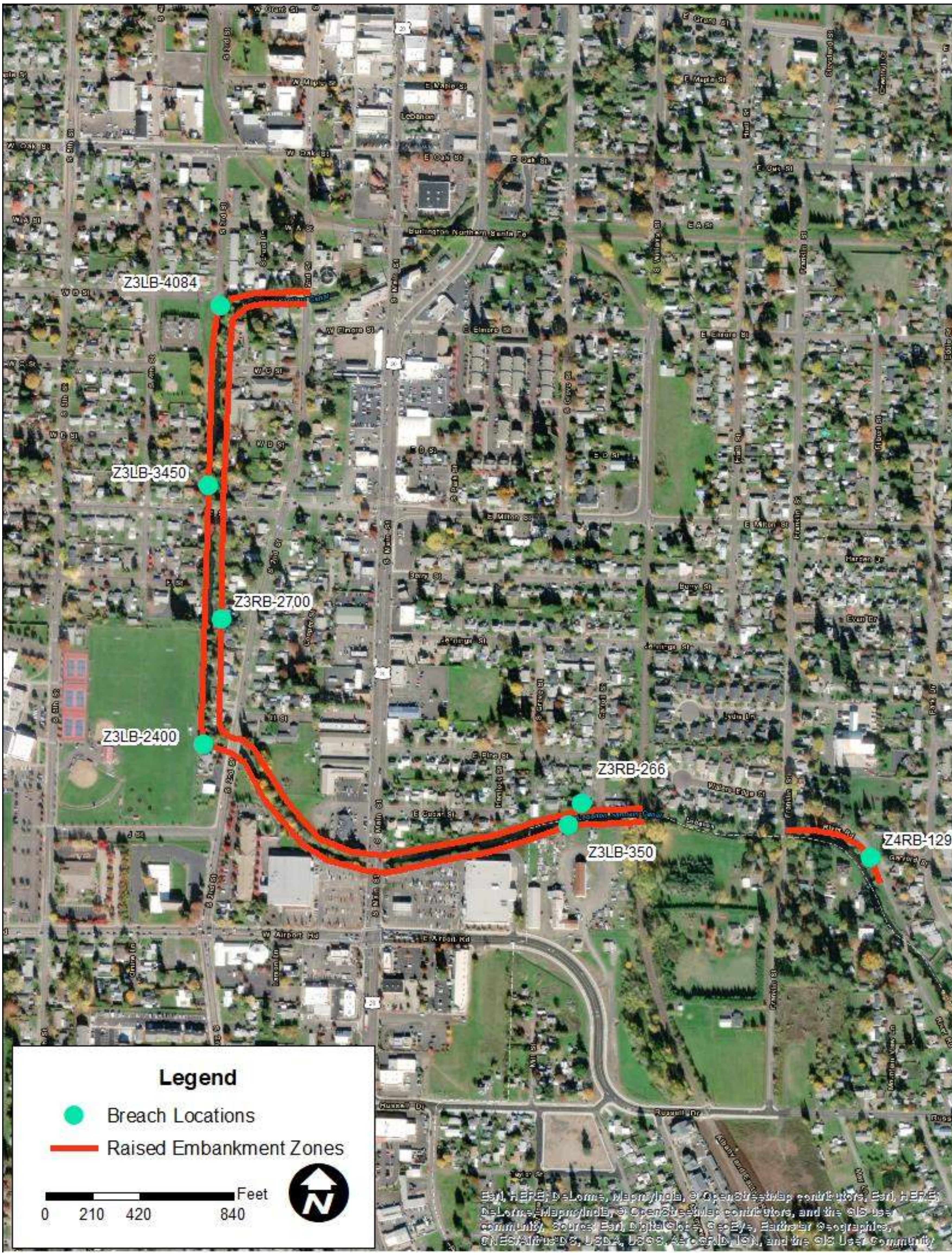


Figure 4. Raised Embankment Upstream of Lebanon Intake Structure

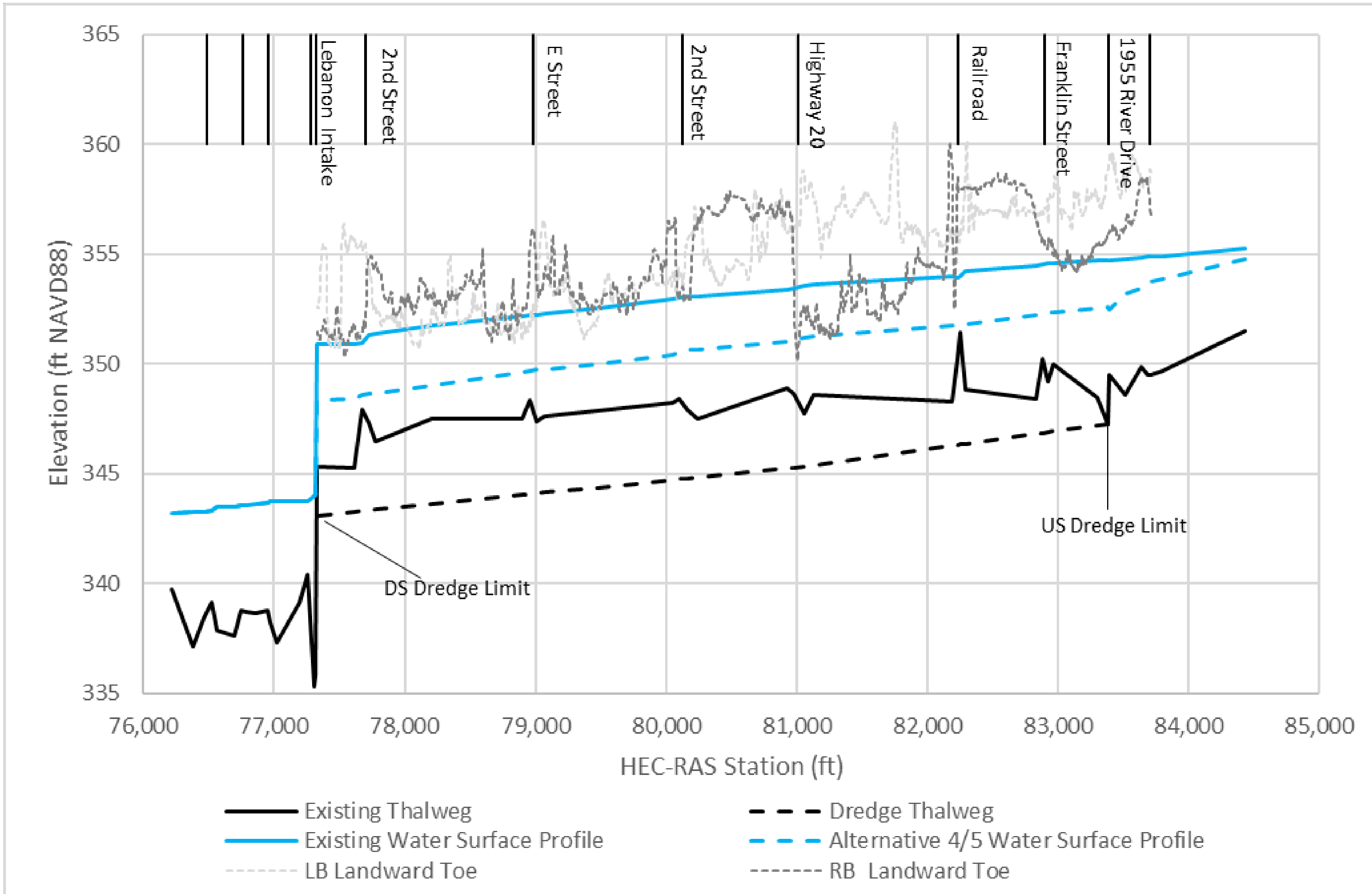


Figure 5. Existing and Alternative 4/5 Water Surface Elevations Near Lebanon Intake Structure

Sediment Flushing at Vine Street Facility

The City indicated that sedimentation is a concern in the lower part of Reach 1. Reach 1 begins at the downstream terminus of the canal and extends upstream to RS 3,860, approximately 300 ft downstream of Highway 99E. As seen in Figure 6, sediment deposition appears to be occurring between RS 284 and RS 1,281, with possible additional sedimentation occurring further upstream. A radial gate is located at RS 95, the outflow of which outfalls to the Calapooia River. The radial gate is 7 ft tall by 8.7 ft wide, and has a bottom sill elevation of 207.35 ft. The surface of the upstream sediment deposits extends approximately 2 to 3 ft above the bottom elevation of the gate depending on location. The City would like to understand if the radial gate can be operated in a manner to help flush upstream sediment through the gate and out of the canal, to eliminate or reduce the need for periodic dredging.

The city provided HEC-RAS hydraulic model was used to analyze the hydraulic conditions in the canal. The analysis was conducted in two parts. First, a steady flow plan was developed which simulated the peak canal design flow of 220 cfs under a range of gate opening heights ranging from 1 ft to 6 ft. The purpose of this exercise was to determine a reasonable minimum gate opening height which could be used to raise the headwater elevation without causing upstream flooding. A review of the model indicated that 2 ft was a reasonable minimum gate opening to use as starting condition for the flushing analysis.

For the second part of the analysis, a new hydraulic model was developed by duplicating the canal geometry within HEC-RAS and truncating the canal at RS 9,739, since the analysis only concerns the lower reach of the canal. The model was converted from steady flow to unsteady flow and a 6-hour simulation was developed in which the canal flowed at a steady rate of 220 cfs for 3 hours (to stabilize the model) prior to opening the gate at its maximum rate. This was done to drop the headwater depth as quickly as possible in an attempt to increase velocities and shear stresses by an amount sufficient to mobilize the sediment and flush it through the gate. A gate opening rate of approximately 0.64 ft/minute was used based on information provided by the city (email communication with Ryan Beathe 9/19/2023). Maximum average channel velocity and average shear stress values for the drawdown procedure were then compared to those that occur during steady flow conditions with the gate fully open, which is the condition that produces the highest velocities and shear stresses under normal operations.

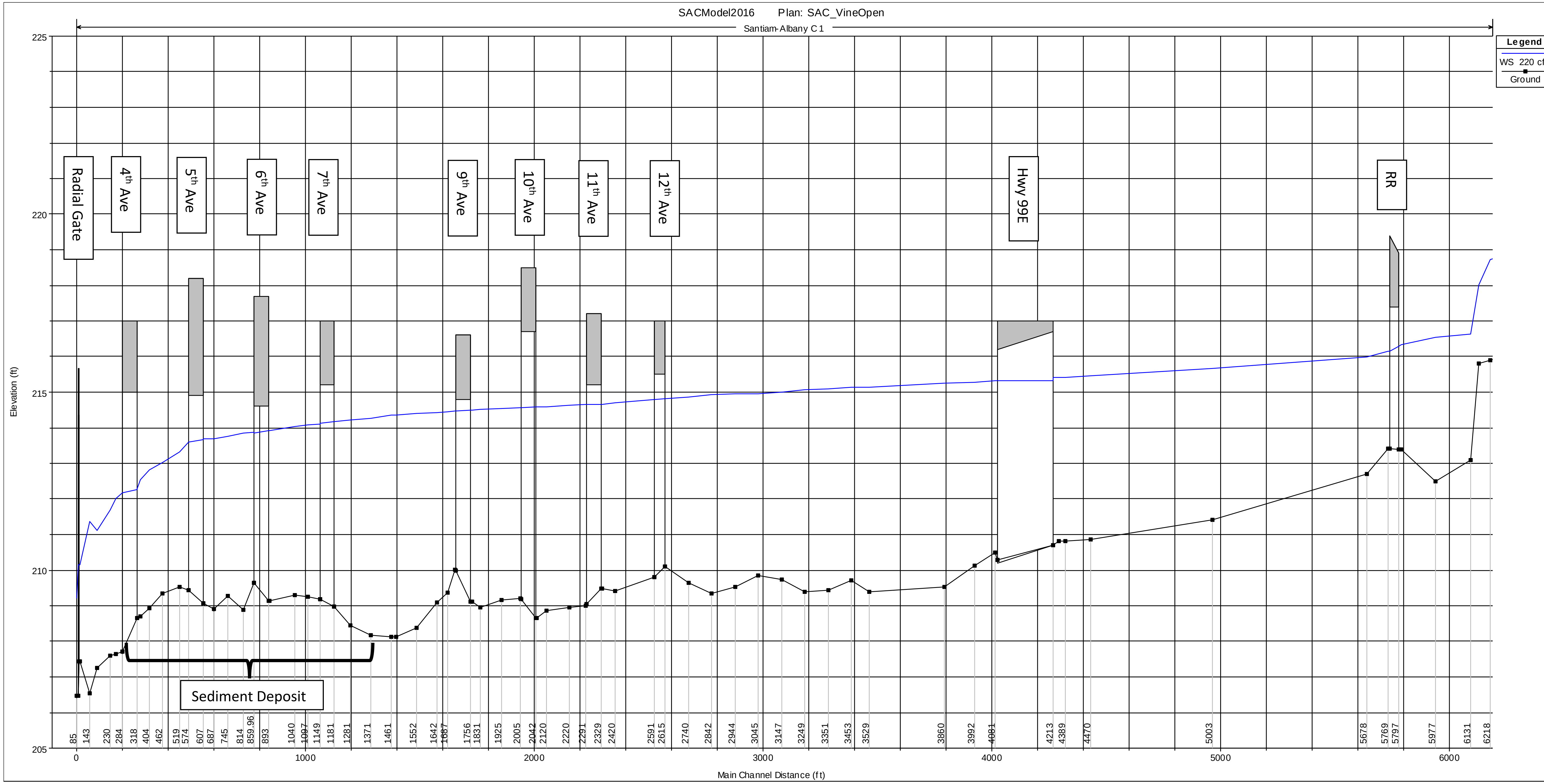


Figure 6. Canal Thalweg Profile

ANALYSIS RESULTS AND CONCLUSIONS

Bank Stability Analysis

Overall, the canal has experienced significant degradation, resulting in over-steepened banks and a substantial number of bank failures throughout most of its length. A comparison of the original sites from the 2008 study and 2023 conditions is provided in Table 2. As seen in Table 2, 8 of the 87 original sites have been repaired as capital improvement projects since the 2008 study, and the repairs were all observed to be in good condition. Of the remaining 79 original sites, 51 were found to be in worse condition, 16 were observed to the same condition, 6 were observed to be in better condition, and another 6 sites were not observable due to field conditions. Sites were generally considered to be in better condition if they had experienced an increase in protective vegetation on the bank. A summary comparison of the bank lengths for 2008 and 2023 is provided in Table 3. As seen in Table 3, most of the original sites have increased in length since the 2008 study. The average length of the non-repaired original sites in 2008 and 2023 was 30 ft and 67 ft, respectively. This represents an average increase of 126 percent over the 15-year period. A summary of the number of sites per reach is provided in Table 4. As seen in Table 4, reaches 4 through 7 have the highest density of sites, and reaches 5 through 7 have the largest number of new sites. A data table listing summary information for the original sites is provided in Appendix A. All available information for the original sites is provided in the attribute tables in the accompanying GIS shapefiles. A photographic log for the original sites is provided in Appendix B.

Table 2. Comparison of 2008 vs 2023 Conditions at Original Bank Failure Sites

Change in Condition	Site, #	Change 2008 to 2023, percent
Better	6	7
Same	16	18
Worse	51	59
Repaired	8	9
Unknown/Other*	6	7

*Includes sites where comparison could not be made due to conditions like brush, or sites with mixed results (e.g. partially repaired, but with new failure/erosion)

Table 3. Comparison of 2008 vs 2023 Bank Lengths

Change in Length*	Sites, #	Change 2008 to 2023, percent
Increase	37	47
Same	40	51
Unknown**	2	3

*Excludes repaired sites
**Includes sites with indeterminate length

Table 4. Sites By Reach					
Reach	Original Sites, # (2008)	New Sites (2023)(#)	Total Sites(#)	Total Reach Length(mi)	Site Density (sites/mi)
1	0	1	1	0.7	1.4
2	0	0	0	0.4	0.0
3	0	3	3	0.7	4.0
4	1	10	11	1.2	9.5
5	24	25	49	1.2	39.9
6	20	20	40	0.9	42.7
7	29	13	42	2.7	15.8
8	5	3	8	1.3	6.1
9	3	0	3	0.7	4.2
10	2	12	14	2.4	5.9
11	0	3	3	0.6	5.1
12	0	0	0	0.3	0.0
13	2	2	4	1.5	2.7
14	0	5	5	1.1	4.8
15	1	1	2	0.7	2.8
16	0	0	0	1.2	0.0
17	0	0	0	0.7	0.0
Total	**87**	**98**	**185**	**18.3**	**--**

During the rapid reconnaissance effort, 98 new sites were observed and documented. Nine of these new sites were at locations previously identified as "Minor" during the 2008 study. Thirty-five other sites of interest that were deemed to be potentially useful to the City were also documented. These included locations of significant obstructions of the canal or structures due to brush and trees and bank repairs (e.g., riprap) that were not included on the City's list of CIP projects. Those sites are provided in accompanying GIS shapefiles but are not otherwise discussed in this report. A summary of prioritizations for all sites is provided in Table 5. A photographic log for all new sites is provided in Appendix C. A data table listing summary information for the new sites is provided in Appendix A. A set of map panels showing all failure locations and their repair prioritization is provided in Appendix D. All available information for the new sites are provided in the attribute tables of accompanying GIS shapefiles.

Table 5. Final Site Repair Prioritization				
Priority	No. of Original Sites (2008)	No. of New Sites (2023)	Total Sites	Percent of Total
High	17	24	41	23
Medium	7	20	27	15
Low	55	54	109	62
Total	**79***	**98**	**177**	**100**
*Less than 87 sites since some have been repaired since 2008				

Grade Control Recommendations

The 2023 thalweg profile was compared to existing profile data to identify trends in the vertical stability of the canal. Direct comparison of the various datasets is difficult due to the varied quality and quantity of the data. For example, the year 1890 profile contains only 45 ordinates, versus 409 ordinates from the HEC-RAS model and 1,591 from the 2023 survey. Further, the ordinates are not located in the same locations along the canal, preventing comparisons at identical locations. Calculations of average channel elevations by reach were done using two methods, each of which are subject to error due to the varied datasets. For the first method, the average elevation values for each reach, based on all available elevation data, were calculated, and are provided in Table 6. For the second method, the difference between the thalweg elevation at each HEC-RAS model cross section and the nearest 2023 survey point was calculated. Cross sections that were located in areas with significant gaps in the 2023 survey data were omitted from the calculation. The results of this comparison are provided in Table 7. The 2008 study recommended grade control structures at several locations within reaches 7 and 8. A profile of reaches 7 through 10 is provided as Figure 7.

As seen in Figure 3 significant degradation of the canal has occurred since the late 1800's, in particular in reaches 3 through 8. The most significant degradation appears to have occurred in Reach 6, with the amount of degradation decreasing in the upstream direction. As seen in Table 6, degradation continued to occur in reaches 3-6 between 2007 (HEC-RAS) and 2023; however, the channel appears to have stabilized or even become slightly aggradational in reaches 7-9. Upstream of Reach 9, both aggradation and degradation are occurring. The 2023 survey to 2007 (HEC-RAS) cross section comparison shown in Table 7 shows a more distinct trend of minor degradation in the lower reaches with minor aggradation in the upper reaches. The 2008 study recommended that grade control structures be constructed in reaches 7 and 8 (see locations in Figure 7); however, a comparison of available data shown in Table 6 and Table 7, and Figure 7 indicates that the degradation trend may be slowing or reversing. If this is the case, the previously recommended grade control may no longer be necessary. The SEM shows that channel incision and widening typically happens over timescales of tens of years. Since the canal has been in operation for nearly 130 years, it is possible that the majority of the incision and widening has already taken place, in particular in the lower and middle reaches of the canal. However, it is possible that the degradational trend may continue upstream, though likely at a reduced rate. As previously stated, direct numerical comparison of elevations between years is subject to error due to the varied quality of the data sources. However, the profiles shown in Figure 7 appear to indicate that reaches 7-10 have not experienced reach-wide degradation over the past 15 years.

Based on review of the available data, there does not appear to be a need for grade control structures at this time. It is recommended that the 2008 study grade control recommendations for reaches 7 and 8 be placed on hold. Further, it is recommended that the City consider developing an adaptive management plan (AMP) for the canal. A key component of the AMP would be development and implementation of a long-term plan to monitor key locations in the canal and collect regular, high-quality data to identify and quantify degradational or aggradational trends, which will better inform the need for grade control structures to be included in future CIPs.

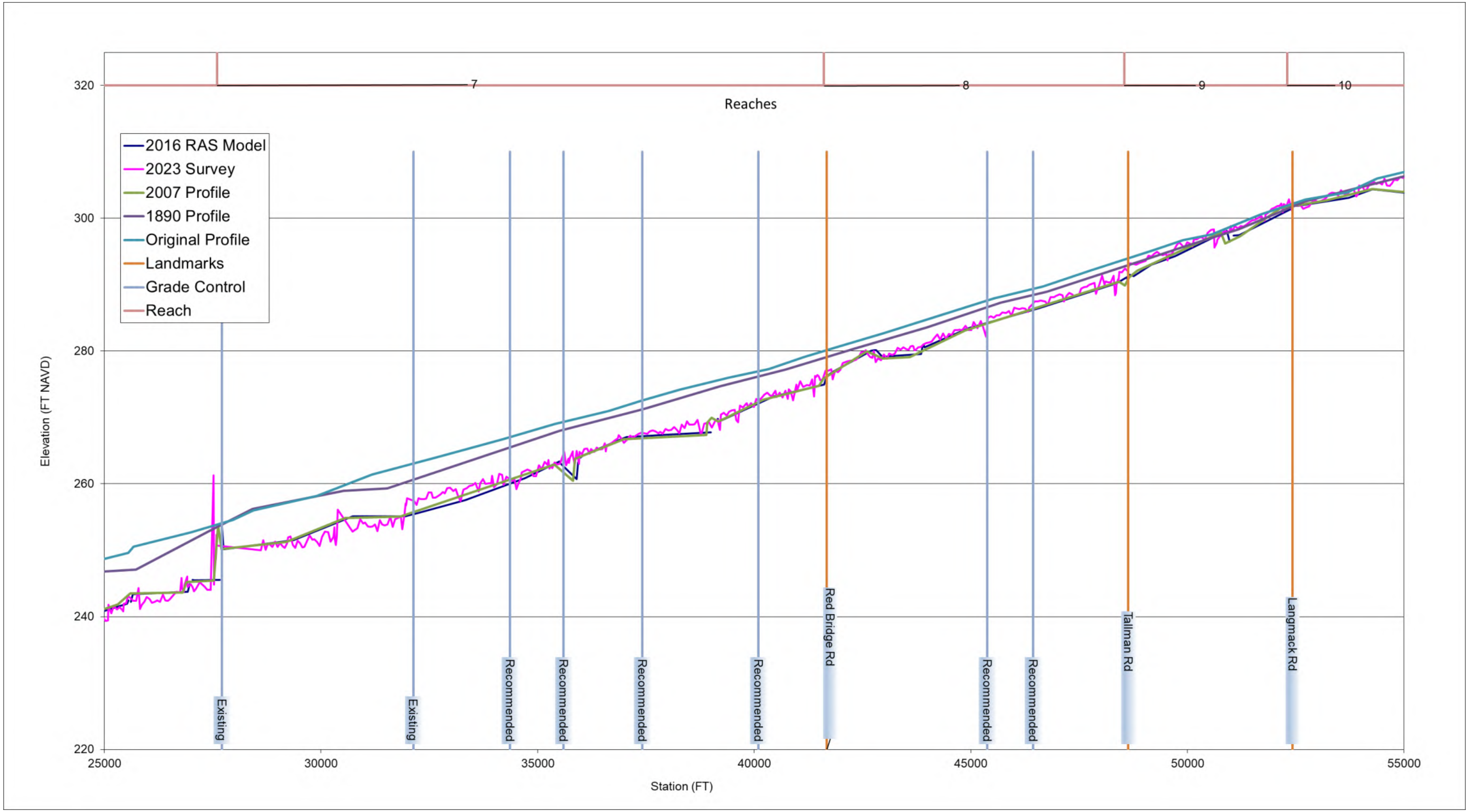


Figure 7. Profile of Reaches 7 through 10

Table 6. Comparison of Average Canal Bed Profile Elevations

	Average Elevation (ft)					Difference (ft)			
Reach	Original Conditions (approx. 1873)	1890 Profile	2007 Profile	HEC-RAS Model (2007)	2023 Survey	1890 minus Original	HEC-RAS minus Original	2023 minus HEC-RAS	2023-2007
Reach 1	–	–	212.79	212.24	212.68	–	–	0.4	-0.1
Reach 2	–	217.85	216.14	214.90	214.89	–	-1.7	0.0	-1.2
Reach 3	223.55	223.59	221.50	221.09	219.86	0.0	-2.1	-1.2	-1.6
Reach 4	228.07	227.68	225.95	226.02	225.21	-0.4	-1.7	-0.8	-0.7
Reach 5	238.22	237.66	232.59	233.28	232.15	-0.6	-5.1	-1.1	-0.4
Reach 6	250.28	247.98	243.16	243.21	241.30	-2.3	-4.8	-1.9	-1.9
Reach 7	267.69	266.53	263.64	261.70	261.81	-1.2	-2.9	0.1	-1.8
Reach 8	286.32	285.03	282.29	280.79	282.66	-1.3	-2.7	1.9	0.4
Reach 9	297.52	295.97	295.14	294.08	295.61	-1.6	-0.8	1.5	0.5
Reach 10	313.50	311.85	312.60	311.24	311.84	-1.6	0.7	0.6	-0.8
Reach 11	–	–	325.43	325.50	324.92	–	–	-0.6	-0.5
Reach 12	–	–	326.73	326.95	327.84	–	–	0.9	1.1
Reach 13	–	–	335.58	334.64	335.69	–	–	1.1	0.1
Reach 14	–	–	346.28	346.44	346.12	–	–	-0.3	-0.2
Reach 15	–	–	349.99	351.18	350.81	–	–	-0.4	0.8
Reach 16	–	–	351.75	351.83	353.06	–	–	1.2	1.3
Reach 17	–	–	355.80	356.33	356.45	–	–	0.1	0.6

Table 7. Comparison of HEC-RAS and Nearest 2023 Survey Data

Canal Reach	2023 survey minus 2007 HEC-RAS elevation, ft	Cross Sections in Computation, #	Rate of Change, ft/yr
1	0.2	55	0.015
2	0.1	14	0.007
3	-0.5	14	-0.031
4	-0.6	10	-0.036
5	0.0	25	0.001
6	-0.3	9	-0.016
7	-0.1	24	-0.004
8	-0.3	20	-0.021
9	-0.1	9	-0.008
10	0.3	19	0.019
11	0.4	11	0.027
12	0.3	6	0.016
13	0.5	59	0.032
14	0.6	25	0.035
15	0.3	40	0.021
16	0.6	7	0.037
17	1.1	14	0.069

Dredging Analysis Recommendations

Based on the HEC-RAS model results, Alternatives 1 and 2 produced localized reductions in the water surface elevations close to the intake structure and provide no flood risk benefit in the event of a bank failure. Alternative 3 produced an average reduction in water surface elevations of 1.4 ft along the dredged portion of the canal. This reduces the water surface elevations below adjacent landward grade in several areas, which does provide some flood risk benefit. However, in this scenario the water surface remains above the adjacent ground elevations between RS 81,000 and RS 82,190.

Alternatives 4 and 5 produced similar results, with an average reduction in water surface elevations of 2.4 ft along the dredged portion of the canal. This reduces the water surface elevations below the adjacent landward ground elevations for all but one localized low spot along the right overbank near RS 81,000 (Figure 5). Either of these alternatives would significantly reduce the number of potential breach locations. Further reductions in water surface elevations would require more significant dredging which may exacerbate bank instabilities. Accordingly, the flood risk for this location could potentially be addressed by placing a minor amount of fill on the landward side of the embankment. Of the five alternatives, only Alternative 4 and 5 provides significant flood risk benefit when considered in the context of the FERC bank failure flood risk analysis. Based on the conceptual level Alternative 4 and 5 dredge geometry, approximately 14,500 cubic yards of material would need to be removed from the canal. A map of the dredge extents is provided in Figure 8. A comparison of existing conditions vs. Alternatives 4 and 5 dredge condition geometry is shown in Appendix E.

It should be recognized that the results described above for Alternatives 4 and 5 are based on a conceptual level analysis, and that dredging and lowering of weir crest elevation could cause localized destabilization of the banks in the upstream reach. A stable channel design, which considers the likely impact of these changes on sediment transport conditions, has not been conducted as part of this alternative analysis. Additionally, multiple road bridges cross the canal within this reach. The potential impacts to the stability of these structures must be considered. Detailed analysis and design will be required if the City desires to move forward with a dredging project.

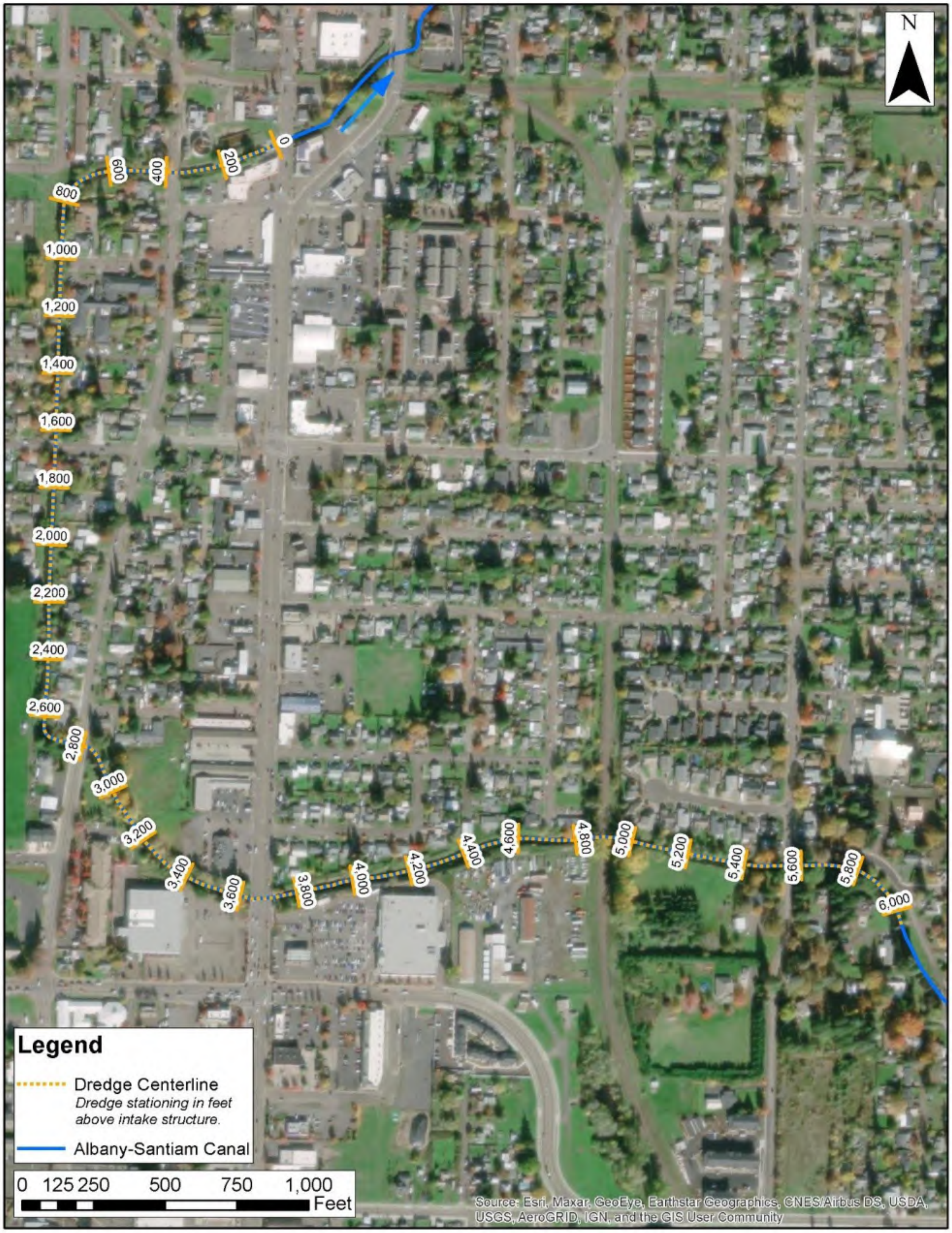


Figure 8. Alternative 4 Dredging Extents

Vine Street Sediment Flushing Recommendations

The results of the simulated drawdown procedure show that using gate operation to mobilize sediment and flush it through the radial gate is not feasible. The upstream extent of the influence of the drawdown procedure on velocities and water surface elevations is approximately RS 641. However, as seen in Table 8, for all cross sections between the gate and RS 641, maximum velocity and shear stress values for the drawdown procedure only deviated slightly from the maximum values experienced during normal steady flow operation of the canal with the radial gate fully open. The maximum increase in velocity and shear stress were 0.2 ft/s and 0.04 lb/ft2, respectively. These relatively minor increases are unlikely to affect sediment transport conditions within the canal.

It should be noted that this is a conceptual level analysis and that there are limitations to the resolution of the data within the model. The minimum gate opening of 2 ft used for the start of the analysis should not be duplicated in practice as there is uncertainty regarding the potential for upstream flooding under this scenario.

Table 8. Summary of Flushing Analysis Results

Canal Reach	2023 survey minus 2007 HEC-RAS elevation, ft		Cross Sections in Computation, #		Rate of Change, ft/yr	
	Vel Chnl	Shear Chan	Vel Chnl	Shear Chan	Vel Chnl	Shear Chan
RS	(ft/s)	(lb/sq ft)	(ft/s)	(lb/sq ft)	(ft/s)	(lb/sq ft)
687	3.2	0.17	3.2	0.18	0.0	0.01
641	2.7	0.13	2.8	0.13	0.1	0.00
5th Ave Bridge						
574	3.0	0.16	3.1	0.17	0.1	0.01
519	4.8	0.43	4.8	0.45	0.0	0.02
462	5.1	0.50	5.2	0.52	0.1	0.02
404	5.0	0.49	5.1	0.51	0.1	0.02
365	5.7	0.65	5.8	0.69	0.1	0.04
351	6.5	0.87	6.7	0.91	0.2	0.04
4th Ave Bridge						
284	5.0	0.47	5.0	0.49	0.0	0.02
256	5.3	0.54	5.4	0.56	0.1	0.02
230	6.3	0.77	6.3	0.78	0.0	0.01
174	7.1	1.03	7.1	1.03	0.0	0.00
143	4.1	0.32	4.1	0.30	0.0	-0.02
Radial Gate						

CAPITAL IMPROVEMENTS AND COSTS

During the 2008 study, a prioritized list of canal bank repairs was developed. A selection of nine repair concept sketches was assembled. A unit cost was developed for each of the nine designs, assuming a typical repair length of 65 ft. Individual repair concepts were not assigned to each site. The 87 sites were assigned a repair priority of either High or Low, though specific details of the prioritization method were not provided in the 2008 study report. In the 2008 study, 22 original sites were assigned high priority and 65 assigned low priority. Of those sites, 8 have since been repaired. Based on the 2023 rapid assessment, which included documentation of 177 total sites, 41 (23 percent) were assigned high priority, 27 (15 percent) were assigned medium priority, and 109 (62 percent) were assigned low priority. In order to help prioritize CIP funds, conceptual repair designs and estimated costs have been developed.

Several factors were considered for the selection of the conceptual repair designs. These include cost, ease of construction, bank height, typical water depths and velocities, potential site constraints, and input from City staff. Based on discussion with the City, recent canal repairs conducted by the City use a biotechnical design consisting of a riprap blanket on the lower bank, with plantings and erosion control measures on the upper bank. For the 2023 CIP analysis, 4 repair concepts are provided which originate from ODOT and other sources. Each site has been assigned a preferred repair design. In some cases, a secondary or tertiary repair option has been assigned, based on additional considerations. Typical sections of the proposed repair options are provided in Appendix F. The proposed designs include:

- Stacked Boulder Toe
- Riprap Blanket
- Wrapped Soil Lifts (Soil Blanket)
- Cast in Place Concrete Retaining Wall

A HEC-RAS model of the canal was provided to WEST by the City. Using the interpolation feature within HEC-RAS, cross sections were interpolated at 50 ft intervals along the length of the canal so that a representative cross section could be assigned to each repair site. Model output such as the channel depth (assuming the maximum canal design flow of 220 cfs) and flow velocity was extracted and assigned to each site. Maximum channel depths ranged from 4 ft to 8 ft. Flow velocities are generally low, ranging from 1.2 ft/s to 4.8 ft/s, with an average of 3.0 ft/s. This information was used to help select the repair option and inform the CIP cost estimates.

Designs 1 through 3, include both 'hard' (rock) and 'soft' (plantings) components. To determine a unit cost for the designs, a typical value was assigned for each component. The linear vertical distance for the 'hard' component was based on review of maximum channel depth at each site, plus a buffer of one foot. Based on review of this data for each site, an average value of 7 ft was chosen. The linear vertical distance of the 'soft' component was based on the larger of either 5 ft or the difference of the eroded bank height (eroded portion of the bank only) minus the max channel depth. In other words, if the damaged portion of the bank extended more than 5 ft above the estimated water surface, the 'soft' repair component was based on the approximate height of the damaged portion of the bank. Based on review of this data for each site, an average value of 7 ft was chosen.

Design 4 was developed by Brown & Caldwell for repair of the right bank of sites WP708/709/710 where canal widening has resulted in over 300 linear ft of vertical bank immediately adjacent to a large outbuilding and driveway. Due to the load of the building on the bank, a more robust geotechnical solution is required. This design could potentially be used on the opposite bank (Site 1047), where significant erosion (though not as severe as WP708-710), is located close to a large outbuilding.

Riprap bank protection size needed for the repair designs was estimated using ODOT and HEC-11 criteria and output from the HEC-RAS model for the cross section located closest to each repair location. Based on the design flow of 220 cfs, a riprap angle of 33.69 degrees (1.5H:1V side slope), and a stability factor of 2, the D_{50} for all sites corresponds to ODOT Class 50 riprap. The estimates of required riprap size were done using approximate methods in order to help facilitate development of design unit costs. Accordingly, each site should be investigated in more detail as individual projects are carried forward.

Using the assumptions presented above, Brown & Caldwell (B&C) developed Class 5 unit costs (0 percent - 2 percent design, conceptual level) for the 4 repair options (Table 9). The unit costs are based on 100 linear ft. A unit size of 100 linear feet was used due to the large premium that would be required for contractor mobilization for small projects. B&C recommends that canal CIP projects be grouped such that total project length is at least 100 ft and project costs meet or exceed $500,000 to avoid “small project” premiums. The provided Gross Contractor Costs include:

- Mobilization/demobilization
- Construction
- Bonds and insurance
- Construction contingency
- Contractor markups

Projects with total linear distances significantly less than 100 ft would likely incur a 50 percent ‘small project’ premium on the contractor unit cost. Projects with difficult access (noted in the GIS shapefiles) would likely incur a 60 percent premium on the contractor unit cost. The total unit cost provided in Table 9 includes the City CIP Contingency (30 percent), Permitting ($7k per project), and Engineering Admin and Legal (30 percent). B&C recommends consideration of a programmatic 404 permit for the entire canal to facilitate a more streamlined permitting process. Further details on the assumptions and cost development process can be found in the B&C memo: *Water Master Plan – Canal Restoration*, and other materials provided in Appendix G. Tables listing the original and new sites along with their estimated repair costs are provided in Appendix H. The estimated costs are based on the B&C unit costs and the estimated lengths from the rapid assessment. Permitting costs are also scaled for sites smaller than 100 ft assuming multiple sites would be lumped into a single project to avoid the 50 percent ‘small project’ premium; however, the permit cost is capped at $7,000 for individual sites that exceed 100 ft. Sites noted to have potentially difficult access based on review of aerial imagery have been marked in the table; however, the 60 percent contractor cost premium has not been applied since ground inspection of access conditions is required for each project. Similarly, costs have not been adjusted for sites with lengths of less than 100 ft, as it is assumed projects will be grouped to avoid the estimated 50 percent premium. A summary of total CIP costs by site prioritization is shown in Table 10.

Table 9. CIP Cost Estimates ($/100 linear ft)					
Description	Construction Cost (includes contractor markups)	Permitting Cost = Lump Sum per Project	City CIP Contingency Cost = 30 Percent of Construction	Engineering Admin and Legal = 30 Percent of Construction	Total Capital Cost
Stacked Boulder Toe	160,000	7,000	48,000	48,000	263,000
Riprap Blanket	166,000	7,000	50,000	50,000	273,000
Wrapped Soil Lifts	142,000	7,000	43,000	43,000	235,000
Concrete Retaining Wall	738,000	7,000	221,000	221,000	1,187,000

Table 10. Summary of CIP Costs For All Sites, $	
Prioritization	Total Capital Cost
High	9,816,000
Medium	3,048,000
Low	16,921,000
Total	**29,785,000**

REFERENCES

Blue Leaf Software, Dagra Version 2.0.12, 2012

Federal Highway Administration (FHWA). 2023. Highways in the River Environment: Roads, Rivers, and Floodplains, FHWA-HIF-23-004, Hydraulic Engineering Circular No. 16, Second Edition, Washington, D.C., January 2023.

Federal Highway Administration (FHWA). 2023. Evaluating Scour at Bridges, FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18, Fifth Edition, Washington, D.C., April 2012.

Oregon Department of Transportation (ODOT). 2014. Highway Division, Hydraulics Manual, ODOT, Salem, Oregon, April 2014.

OTAK. 2008. Santiam-Albany Canal Rehabilitation Bank Stability Analysis, June 12, 2008.

WEST Consultants, Inc. 2020. Santiam-Albany Canal Hazard Rating Evaluation, July 9, 2020

Appendix A

Major Failure Locations

Summary Information – Original Sites

Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Condition 2023	Notes 2023
wp295	15305	Suburban	Residential	LB	13	7	Better	Bank more rounded, less steep, more vegetation
wp288	16220	Suburban	Residential	LB	0	9	Repaired	Site now repaired. In good condition
wp287	16267	Suburban	Residential	LB	0	10	Repaired	Site now repaired. In good condition
wp286	16306	Suburban	Residential	LB	0	8	Repaired	No comments
wp284	16390	Suburban	Residential	LB	48	8	Worse	LB obscured by brush. RB now eroded for 100'
wp275	17442	Suburban	Residential	LB	50	8	Worse	Original failure not seen. Currently vertical bank for 50-60'
wp266	18689	Suburban	Residential	RB	100	9	Worse	Longer and steeper. Now 100'
wp263	18702	Suburban	Residential	LB	100	9	Worse	Now 100' long and US end is indistinct. Steep and undercut. Reach between site 260 and 263 has misc. vertical failures, too much to log individually
wp260	19037	Suburban	Residential	RB	40	8	Worse	Area near original wood fence now gone. Now 40'. Reach between site 260 and 263 has misc. vertical failures, too much to log individually
wp258	19080	Suburban	Agricultural	LB	18	9	Better	LB repaired and in better condition
wp257	19119	Suburban	Residential	RB	45	8	Worse	Entire reach from pipe to US bridge has lots of intermittent failures. Site is same length but steeper and missing some trees from original photos
wp255	19291	Suburban	Agricultural	LB	18	9	Worse	LB about the same, maybe a little more eroded. RB steep and eroded with less material than in original photos
wp250	19803	Suburban	Agricultural	LB	60	9	Worse	Now 60' long of steep bank
wp246	20003	Suburban	Agricultural	LB	25	9	Worse	Now 25'. See also small failure on RB.
wp242	20201	Suburban	Agricultural	LB	164	9	Worse	Much longer (164ft). Still additional issues DS beyond the GPS end pt.
wp236	20568	Suburban	Agricultural	LB	14	8	Worse	Similar size but slightly more eroded.
wp235	20633	Suburban	Agricultural	RB	35	8	Same	No comments
wp230	20889	Rural	Agricultural	LB	15	10	Same	Tree in original photo 253 is gone. Site is about the same but this reach from bridge to bridge has lots of issues
wp227	21058	Rural	Agricultural	RB	20	10	Worse	Steeper & obstructed by blackberries
wp223	21337	Rural	Agricultural	LB	147	10	Worse	Original tree appears to be gone. Now steep eroded bank for approx 150'. Some toe riprap on both banks
wp220	21521	Suburban	Residential	RB	50	10	Worse	Tree gone, bank now steeper. Now 50-60' of vertical bank on RB
wp219	21528	Suburban	Residential	LB	80	10	Worse	Intermittent failures 80'+. New site on opposite bank, 60'
wp710	22012	Suburban	Residential	RB	313	9	Worse	Site now merged with 708/709 (included in length). Failed and vertical banks extend much further DS to next DS GPS/Photo Pt
wp709	22042	Suburban	Residential	RB	313	9	Worse	Site now merged with 708/710 (included in length). Entire RB is vertical and puts building and (soon) driveway at risk
wp708	22118	Suburban	Residential	RB	313	9	Worse	Site now merged with 709/710. Building at risk, nearly vertical bank for 200'+.

Summary Information – Original Sites

Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Condition 2023	Notes 2023
wp694	23002	Suburban	Residential	LB	0	7	Repaired	Repaired CIP, good condition
wp689	23162	Suburban	Residential	LB	0	8	Repaired	Repaired CIP, good condition
wp684	23383	Suburban	Residential	RB	70	8	Worse	Steeper and fresh
wp676	24018	Rural	Agricultural	LB	100	8	Worse	Now 100' of intermittent failure and erosion
wp665	24961	Rural	Residential	LB	75	12	Worse	Both banks now eroded. Trees in photos gone, which improves conveyance, chan wider. RB 30' failure plus another 20' more. DS toe protected with riprap
wp657	25502	Rural	Agricultural	RB	100	15	Worse	Much worse, steeper and longer, material gone. See new DS GPT pt. 100' total on RB, Btw here and site 665 is in bad shape
wp656	25524	Rural	Residential	LB	100	15	Worse	Appears wider and steeper now that slumps have eroded away. Orig photo 203 very diff than current conditions. Blends into another 75+' of LB erosion
wp654	25621	Rural	Residential	LB	25	13	Worse	Now missing slightly more material but covered in brush/blackberries. Adjacent to driveway culvert
wp653	25644	Rural	Agricultural	RB	15	15	Better	Site now has small trees and brush and therefore more protection
wp652	25674	Rural	Residential	LB	75	14	Better	View partially obscured by blackberries, but bank appears to be in slightly better condition and has additional protection from brush/blackberries
wp650	25690	Rural	Agricultural	RB	51	15	Better	Photos are difficult to compare. Failure is likely the riprap repair in new photos. Slump material gone. Large tree is undercut and could fail
wp642	26053	Rural	Agricultural	RB	82	14	Worse	Trees in original photos are all gone. Site now steeper
wp640	26194	Rural	Agricultural	RB	60	16	Worse	Sluffs and trees gone, now steeper
wp638	26254	Rural	Agricultural	LB	110	16	Unknown	Condition unknown due to brush. WP taken slightly DS near site 640
wp637	26325	Rural	Agricultural	LB	48	15	Unknown	Condition unknown due to brush. However, there is a new failure directly opposite (WP 8, see photo 735)
wp633	26519	Rural	Agricultural	RB	50	14	Same	Stumps gone, water deeper this visit
wp616	27064	Rural	Agricultural	RB	Unknown	13	Unknown	Observation from top of bank. Condition unknown due to brush. Possibly steeper though
wp614	27166	Rural	Agricultural	RB	50	14	Worse	Observation from top of right bank. Toe material appears gone, now steeper, but protected by brush and trees
wp613	27233	Rural	Agricultural	LB	17	14	Unknown	Observation from top of right bank. Condition unknown due to brush. Possibly steeper though. Old rootwad and stump appear gone
wp610	27394	Rural	Agricultural	RB	70	14	Worse	Observation from top of right bank. Now 60-70' and steeper
wp579	29308	Rural	Agricultural	LB	26	13	Worse	Less trees and brush
wp577	29377	Rural	Agricultural	LB	40	13	Worse	Rootwad gone, bank close to vertical now
wp572	29428	Rural	Agricultural	LB	50	14	Worse	Two sections of 50'+ now

Summary Information – Original Sites								
Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Condition 2023	Notes 2023
wp571	29435	Rural	Agricultural	RB	20	14	Same	Slightly longer, but now more protective blackberries
wp566	29608	Rural	Agricultural	LB	33	14	Same	Banks on both sides slightly more vertical, but extent is similar
wp564	29654	Rural	Agricultural	LB	40	14	Worse	Now 40' long. Similar conditions in much of this reach from here US to riffle and large pipe. Entire reach has significant vertical banks
wp554	30467	Rural	Agricultural	RB	15	11	Worse	Site now vertical. Typical of this reach. See also issue on LB
wp541	32103	Rural	Agricultural	RB	40	9	Worse	Low angle material at toe in original photo 127 is now gone (and tree) and bank is near vertical now. This starts just DS of riprap repair
wp526	33547	Rural	Agricultural	LB	15	10	Same	Seems like a minor rather than major failure. Suggest dropping from existing sites list altogether.
wp516	34284	Rural	Agricultural	LB	25	11	Worse	Slightly longer (25') and taller/steeper. Hard to match site with old pics. Possible downcutting of channel?
wp515	34373	Rural	Agricultural	RB	12	12	Same	Trees in original photo 113 gone. Original photo 115 appears same, but slump material is gone. Most of canal in this zone is in bad condition and US
wp513	34472	Rural	Agricultural	LB	100	11	Worse	Slump material gone and bank eroded for a long way DS. Now about 100' long
wp509	34815	Rural	Agricultural	RB	60	9	Worse	Slump is now gone. Tree DS fell and entire site is now 75' long
wp498	35599	Rural	Agricultural	LB	24	8	Same	Slump is gone. Now site has consistent dimensions with rest of channel banks
wp491	35825	Rural	Residential	LB	29	11	Mixed	LB same condition but with more vegetation. RB looks worse. Tree in original photo 100 is gone
wp473	37447	Rural	Agricultural	LB	25	12	Same	Same condition, but now has less vegetation and less protection. Site is very different looking compared to old photos
wp471	37508	Rural	Agricultural	LB	unknown	11	Worse	Slump gone and eroded. Current length indeterminant since it blends into rest of US and DS vertical banks
wp469	37846	Rural	Agricultural	LB	100	10	Worse	Old debris is gone and geometry is more consistent, but the erosion/damage is longer
wp467	37927	Rural	Agricultural	RB	13	9	Same	Slump is about same, but less brush is present
wp465	38176	Rural	Agricultural	LB	24	10	Worse	RB is now vertical. Still same length, but this reach US to prior site (462) largely comprised of vertical banks
wp462	38477	Rural	Agricultural	LB	7	12	Worse	Slump is the same but entire reach US and DS of site is near vertical and veg (trees and brush) from original photos is mostly gone
wp454	39016	Rural	Agricultural	RB	70	9	Worse	Slightly worse due to lack of vegetation. A partial toe repair of dubious quality is present
wp451	39263	Rural	Agricultural	RB	15	9	Same	RB maybe in slightly better condition due to more protective vegetation. LB same condition
wp443	40097	Rural	Agricultural	LB	50	8	Mixed	LB is better due to repair, but length now 50'. 75% has been repaired

Summary Information – Original Sites								
Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Condition 2023	Notes 2023
wp442	40101	Rural	Agricultural	RB	50	9	Better	Area repaired but tree at DS end ready to fall and there are intermittent failures on RB for 75' upstream
wp439	40260	Rural	Agricultural	RB	100	10	Worse	Site now much worse. Now 100' long. Repair of LB looks good
wp437	40420	Rural	Agricultural	LB	100	10	Worse	Now two sections totaling 100'+. This section from here US to Site 434 is ripe for tree fall failures; bent trees everywhere showing bank movement
wp434	40824	Rural	Agricultural	LB	80	10	Worse	Site has grown to 80'. This reach has lots of potential failure sites from here to site 437
wp430	41101	Rural	Agricultural	RB	10	8	Worse	Original site is similar condition, but this reach has intermittent failures throughout (US and DS)
wp419	42391	Rural	Agricultural	LB	300	7	Worse	Extensive erosion. RB is vertical for 100' US and 200' total. LB vertical for 300'
wp391	46367	Rural	Agricultural	LB	100	8	Worse	Worse condition. Banks are steeper and perhaps channel slightly widened. Original length appears wrong, site is about 100' based on photos
wp390	46452	Rural	Agricultural	LB	30	8	Same	Site in similar condition. Previously fallen tree is now gone
wp384	46870	Rural	Agricultural	LB	30	8	Same	Large failure DS. Intermittent failures US&DS
wp383	47295	Rural	Agricultural	RB	18	9	Same	Site in similar condition, though more protective grasses present
wp6	49567	Rural	Agricultural	LB	40	2	Same	Site in similar condition, though more brush present to protect bank
wp9	50049	Rural	Agricultural	LB	80	6	Same	Site in similar condition
wp10	50095	Rural	Agricultural	LB	40	5	Better	Site in better condition
wp40	55986	Rural	Agricultural	LB	50	6	Worse	LB worse. Now 40-50' long and vertical. RB in decent condition and grass covered
wp67	61368	Rural	Residential	LB	255	1	Worse	Original site is roughly same condition, but erosion/failures now extends further US and DS. Large tree in original photo 14 gone
wp213	71608	Suburban	Residential	LB	20	4	Better	More vegetation present but leaves make clear observation difficult. Sluggish flow/backwater may be helping with passive restoration
wp193	75387	Urban	Residential	LB	55	10	Worse	Original site is roughly the same condition, but undercutting extends another 50'70' DS. Similar erosion present on RB but not failed
wp152	84130	Suburban	Residential	RB	0	4	Repaired	Site repaired with riprap. Good condition

Summary Information – New Sites

Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Notes 2023
1000	1238	Suburban	Residential	LB	25	2	Erosion of low bank along security fence
1002	6315	Suburban	Residential	LB	15	6	LB Failure (photo estimated dimensions)
1003	6467	Suburban	Residential	RB	30	6	RB failure/erosion, note clay shelf
1005	7794	Suburban	Residential	RB	30	6	RB erosion (photo estimated dimensions)
1006	10799	Suburban	Residential	LB	35	4	LB erosion near (20' from) RR. (photo estimated dimensions)
1009	14140	Suburban	Residential	LB	30	7	LB failure/erosion, near fence line (photo estimated dimensions)
1011	14431	Suburban	Residential	LB	30	8	Vertical erosion/possible historic failures on LB. Note clay bench layer. (photo estimated dimensions)
1012	14882	Suburban	Residential	LB	8	8	Small failure on LB
1014	15105	Suburban	Residential	LB	20	8	LB failure, near fence line. Old erosion/failure on RB also, may affect platform support
1015	15169	Suburban	Residential	LB	20	8	LB failure, (photo estimated dimensions)
1016	15347	Suburban	Residential	RB	unknown	unknown	Undermined utility footing. Infrastructure risk. Full repair length unknown
1017	15640	Suburban	Residential	LB	35	6	LB failure, near fence line
1018	15833	Suburban	Residential	LB	30	7	LB failure, near fence line
1019	15833	Suburban	Residential	RB	35	7	RB failure, near fence line and structures
1020	16390	Suburban	Residential	RB	100	7	RB failure across from site 284 (photo estimated dimensions)
1022	16681	Suburban	Residential	RB	40	7	RB failure (photo estimated dimensions)
1023	16882	Suburban	Residential	RB	40	7	RB failure (photo estimated dimensions)
1024	16882	Suburban	Residential	LB	15	7	LB block failure (photo estimated dimensions)
1025	17109	Suburban	Residential	RB	50	7	RB Failure
1026	17242	Suburban	Residential	RB	50	6	Continuing RB failures, note repair of LB (photo estimated dimensions)
1027	17372	Suburban	Residential	RB	50	6	Continuing series of intermittent failures of this reach. (This location dimensions photo estimated)
1028	17441	Suburban	Residential	RB	15	6	Continuing series of intermittent failures of this reach. (This location dimensions photo estimated)
1029	17573	Suburban	Residential	LB	25	6	LB failure, tree failed
1030	17614	Suburban	Residential	LB	60	6	LB erosion (photo estimated dimensions)
1031	17691	Suburban	Residential	RB	147	6	RB failure/erosion, erosion behind bridge wingwall. Critical issue.
1032	18244	Suburban	Residential	LB	15	7	LB failure, failed tree
1033	18373	Suburban	Residential	RB	40	7	RB failure. OTAK noted bank protection not seen
1034	18759	Suburban	Agricultural	LB	40	7	Failure/erosion of LB. Continues US further intermittently not included in dimensions (photo estimated dimensions)
1035	18929	Suburban	Agricultural	LB	40	6	LB failure/erosion (photo estimated height)

Summary Information – New Sites							
Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Notes 2023
1036	19291	Suburban	Agricultural	RB	40	8	RB erosion/failures across from site 255 (photo estimated dimensions)
1037	19475	Suburban	Agricultural	LB	50	8	Two LB failures, 7x15 and 8x35. Reporting total length
1038	19619	Suburban	Agricultural	LB	40	7	Erosion of LB at steep old failure
1040	20348	Suburban	Agricultural	LB	40	8	LB failure, some riprap present (photo estimated length)
1041	21211	Rural	Agricultural	LB	20	8	Bank failure (photo estimated dimensions)
1044	21574	Suburban	Agricultural	RB	60	8	Vertical bank erosion opposite bank from WP219. 60' of vertical bank DS of bridge (abuts bridge)
1045	21764	Suburban	Residential	LB	35	8	Failures along fence line on LB (photo estimated length)
1046	21764	Suburban	Residential	RB	50	8	Intermittent RB erosion and vertical banks. Possible historic small failures. Potential for future tree fall. (photo estimated length)
1047	21901	Suburban	Residential	LB	175	8	LB failure along entire fence line and to end of building
1049	22351	Suburban	Residential	LB	75	8	Large failure on LB. Sandy clay
1050	23577	Suburban	Agricultural	LB	75	8	LB failure
1052	23701	Rural	Agricultural	LB	150	8	Long LB failure/erosion
1053	23879	Rural	Agricultural	LB	60	8	LB failure/erosion
1054	23879	Rural	Agricultural	RB	30	8	RB failure/erosion, plus treefall on RB 20' further DS of end of this site
1056	24080	Rural	Agricultural	LB	100	8	LB failure plus intermittent issues on RB
1057	24201	Rural	Agricultural	LB	15	8	LB failure
1058	24201	Rural	Agricultural	RB	30	6	RB failure
1059	24320	Rural	Agricultural	LB	15	8	LB failure with partial riprap repair
1060	24497	Rural	Agricultural	RB	15	12	RB failure
1061	24601	Rural	Agricultural	RB	50	10	RB failure starting at DS end of LB site. Entire reach starting DS of driveway culvert continues to be bad
1062	24631	Rural	Agricultural	LB	30	10	Major LB failure, tree down. Entire reach starting DS of driveway culvert continues to be bad
1063	24761	Rural	Agricultural	LB	12	10	LB failure, two individual sites
1064	24856	Rural	Agricultural	LB	30	10	LB failure, this reach continues to have intermittent failures
1065	24856	Rural	Agricultural	RB	75	10	Long RB failure, this reach continues to have intermittent failures
1066	24977	Rural	Agricultural	RB	50	10	RB failure with riprap on toe at DS end (photo estimated dimensions)
1067	25171	Rural	Agricultural	LB	80	10	Long LB failure
1069	26326	Rural	Agricultural	RB	20	13	RB failure across from existing site WP637
1070	26423	Rural	Agricultural	RB	25	15	RB failure
1071	26498	Rural	Agricultural	LB	20	15	LB failure, at location of CIP24, which was not found

Summary Information – New Sites							
Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Notes 2023
1073	26909	Rural	Agricultural	RB	25	15	RB failure, near road culvert crossing
1074	28143	Rural	Agricultural	RB	60	6	RB failure/erosion. Potential tree fall
1075	30106	Rural	Agricultural	RB	100	8	Bad RB Failure
1077	30953	Rural	Agricultural	RB	50	8	RB Failure
1078	31196	Rural	Agricultural	LB	100	8	LB Failure
1079	31414	Rural	Agricultural	RB	50	8	RB Failure
1080	31775	Rural	Agricultural	RB	50	9	RB Failure
1081	32622	Rural	Agricultural	RB	100	6	Long RB failure/erosion
1085	36301	Rural	Agricultural	RB	80	6	RB failure
1086	37893	Rural	Agricultural	LB	100	8	LB failure between WP467 and WP 469
1087	38781	Rural	Agricultural	LB	40	8	Two failure areas on LB (photo estimated measurements)
1088	38960	Rural	Agricultural	LB	50	8	LB failure and erosion. (photo estimated measurements)
1089	39606	Rural	Agricultural	RB	60	8	RB failure
1090	41299	Rural	Agricultural	RB	30	8	RB failure/erosion (photo estimated measurements)
1092	46787	Rural	Agricultural	LB	30	8	LB failure, with old treefall
1093	47478	Rural	Agricultural	LB	60	5	Misc damage and erosion on LB. Variable height. (photo estimated measurements)
1094	48255	Rural	Agricultural	LB	25	7	LB failure/erosion, note clay shelf at toe
1095	56119	Rural	Agricultural	LB	150	8	Long LB failure, possibly merging with existing WP40
1096	56158	Rural	Agricultural	RB	40	8	Failure 8x40
1097	56659	Rural	Agricultural	RB	75	8	RB Failure
1098	57328	Rural	Agricultural	LB	150	5	LB failure, variable height 3-7 ft
1099	57328	Rural	Agricultural	RB	75	5	RB failure, variable height 3-7 ft
1100	59793	Rural	Agricultural	LB	75	4	Long LB failure/erosion
1101	61971	Rural	Agricultural	LB	305	6	Long LB failure, US/DS measured by GPS pts
1102	61971	Rural	Agricultural	RB	15	8	Slump on RB (photo estimated measurements)
1103	62353	Rural	Agricultural	RB	40	6	RB failure/erosion, trees at risk
1104	63615	Rural	Residential	RB	30	8	RB failure, affecting deck
1105	63636	Rural	Agricultural	LB	25	8	RB failure, likely old, btw trees. (photo estimated measurements)
1106	64315	Rural	Agricultural	LB	130	8	Long LB failure/erosion. Marked with US/DS gps pts for length
1109	67126	Rural	Agricultural	RB	15	6	RB failure

Summary Information – New Sites							
Site ID	RS	Setting	Land Use	Bank	Estimated Length, ft	Estimated Height, ft	Notes 2023
1110	67673	Rural	Agricultural	LB	65	10	Erosion and undercut on LB
1111	67793	Rural	Agricultural	LB	30	12	Failure and erosion on LB. RB also undercut
1113	76268	Suburban	Residential	LB/RB	240	5	Slumps/failures of low bank along park on both banks
1114	76856	Suburban	Residential	LB	120	6	Shallow slide and cantilever failures, near ped bridge. Some large rock present.
1115	80495	Suburban	Residential	LB	0	0	Undercut trees, at risk.
1116	80962	Suburban	Residential	LB	0	5	Eroded, undercut bank, trees at risk (photo estimated measurements)
1118	81481	Suburban	Residential	LB	500	5	Undercut tree on LB and long slump and erosion on RB
1119	81697	Suburban	Residential	RB	275	4	Fresh failure on RB
1120	81990	Suburban	Residential	RB	100	8	Slump on RB
1123	83124	Suburban	Residential	LB	60	3	Damage to LB at end of CIP 69, 60 ft length

Appendix B

Original Site Location Photo Log


Photo 1005: Upstream


Photo 1006: Downstream


Photo 1007: Left bank

Photo 3067: Upstream

Photo 3068: Downstream

Photo 3069: Left bank

Photo 3070: Upstream

Photo 3071: Downstream

Photo 3072: Left bank


Photo 3073: Upstream


Photo 3074: Downstream


Photo 3075: Left bank

Santiam-Albany Canal - 2023 Bank Assessment
Site: WP284   Station: 16390
Date: 1/26/2023


Photo 3076: Upstream


Photo 3077: Downstream


Photo 3078: Left bank


Photo 3079: Upstream toward right bank


Photo 969: Upstream


Photo 970: Downstream


Photo 971: Upstream to downstream left bank panorama


Photo 972: Upstream to downstream left bank panorama

Photo 973: Upstream to downstream left bank panorama

Photo 944: Upstream

Photo 945: Downstream

Photo 946: Upstream to downstream panorama of right bank

Photo 947: Upstream to downstream panorama of right bank

Photo 948: Upstream to downstream panorama of right bank


Photo 940: Upstream


Photo 941: Downstream


Photo 942: Upstream towards left bank (site plus upstream a ways)


Photo 943: Downstream towards left bank (undercut downstream of site)

Photo 928: Upstream

Photo 929: Downstream

Photo 931: Right bank

Photo 932: Right bank


Photo 928: Upstream


Photo 929: Downstream


Photo 930: Left bank

Photo 923: Upstream, see also right bank erosion upstream of tree

Photo 924: Downstream

Photo 925: Downstream to Upstream panorama of right bank

Photo 926: Downstream to Upstream panorama of right bank

Photo 927: Downstream to Upstream panorama of right bank

Photo 919: Upstream

Photo 918: Downstream

Photo 920: Upstream towards left bank

Photo 921: Downstream towards right bank


Photo 922: Right bank upstream of photo 921


Photo 906: Upstream


Photo 907: Downstream


Photo 908: Upstream to downstream panorama of left bank


Photo 909: Upstream to downstream panorama of left bank

Photo 910: Upstream to downstream panorama of left bank

Photo 901: Upstream

Photo 902: Downstream

Photo 903: Upstream to downstream panorama

Photo 904: Upstream to downstream panorama

Photo 900: Right bank

Photo 895: Upstream

Photo 896: Downstream

Photo 897: Upstream to downstream panorama

Photo 898: Upstream to downstream panorama

Photo 899: Upstream to downstream panorama


Photo 889: Upstream


Photo 890: Downstream


Photo 891: Left bank


Photo 883: Upstream


Photo 884: Downstream


Photo 885: Upstream to downstream panorama


Photo 886: Upstream to downstream panorama

Photo 887: Upstream to downstream panorama

Photo 882: Upstream

Photo 880: Downstream

Photo 881: Left bank

Photo 878: Downstream

Photo 879: Downstream towards right bank


Photo 874: Upstream


Photo 875: Downstream

Photo 862: Downstream toward site

Photo 863: Right bank

Photo 870: Right bank

Photo 867: Upstream

Photo 868: Downstream toward left bank

Photo 869: Left bank

Photo 855: Right bank

Photo 850: Upstream

Photo 851: Downstream

Photo 852: Downstream

Photo 854: Downstream toward right bank

Photo 850: Upstream from upstream end of site

Photo 851: Downstream

Photo 852: Downstream


Photo 828: Upstream


Photo 827: Downstream


Photo 829: Left bank

Photo 825: Downstream

Photo 826: Left bank

Photo 821: Upstream

Photo 822: Downstream

Photo 823: Downstream towards right bank

Photo 811: Upstream

Photo 808: Downstream

Photo 812: Downstream towards left bank


Photo 783: Upstream


Photo 784: Downstream


Photo 785: Left bank


Photo 786: Upstream towards right bank

Photo 787: Downstream towards right bank

Photo 774: Upstream towards right bank

Photo 771: Downstream

Photo 767: Upstream to Downstream panorama of right bank

Photo 768: Upstream to Downstream panorama of right bank


Photo 769: Upstream to Downstream panorama of right bank


Photo 772: Downstream towards left bank


Photo 764: Downstream


Photo 763: Left bank


Photo 765: Right bank


Photo 766: Upstream towards Left bank

Photo 775: Upstream towards Left bank

Photo 761: Downstream towards Left bank

Photo 759: Downstream


Photo 760: Right bank

Photo 756: Left bank

Photo 757: Left bank

Photo 751: Upstream

Photo 752: Right bank

Photo 753: Right bank

Photo 754: Upstream towards right bank


Photo 743: Upstream


Photo 744: Downstream


Photo 745: Right bank


Photo 743: Upstream


Photo 741: Downstream


Photo 742: Right bank


Photo 740: Upstream


Photo 739: Downstream

Photo 736: Upstream

Photo 737: Downstream

Photo 738: Left bank


Photo 726: Upstream


Photo 727: Downstream


Photo 725: Right bank

Photo 838: Taken from top of right bank

Photo 837: Taken from top of right bank


Photo 836: Left bank


Photo 833: Taken from top of right bank


Photo 834: Taken from top of right bank


Photo 835: Taken from top of right bank


Photo 712: Upstream


Photo 713: Downstream


Photo 714: Left bank


Photo 715: Left bank

Photo 717: Left bank downstream of site

Photo 708: Upstream

Photo 710: Downstream

Photo 709: Left bank

Photo 711: Left bank

Photo 702: Upstream

Photo 703: Downstream

Photo 705: Left bank

Photo 706: Left bank

Photo 707: Left bank


Photo 702: Upstream


Photo 703: Downstream


Photo 704: Right bank


Photo 697: Upstream


Photo 698: Downstream


Photo 699: Left bank


Photo 700: Right bank

Photo 694: Upstream

Photo 695: Downstream

Photo 696: Left bank


Photo 686: Upstream


Photo 688: Downstream


Photo 687: Upstream toward right bank


Photo 689: Left bank


Photo 665: Upstream


Photo 666: Downstream


Photo 667: Upstream toward right bank


Photo 669: Right bank

Photo 654: Upstream

Photo 655: Downstream

Photo 656: Left bank


Photo 649: Upstream


Photo 650: Downstream


Photo 651: Left bank


Photo 652: Left bank


Photo 645: Upstream


Photo 646: Downstream


Photo 647: Left bank


Photo 648: Right bank


Photo 640: Upstream


Photo 641: Downstream


Photo 642: Upstream to downstream panorama of left bank


Photo 643: Upstream to downstream panorama of left bank

Photo 644: Upstream to downstream panorama of left bank


Photo 636: Upstream


Photo 634: Downstream


Photo 637: Downstream to Upstream panorama of right bank


Photo 638: Downstream to Upstream panorama of right bank

Photo 639: Downstream to Upstream panorama of right bank


Photo 629: Upstream


Photo 630: Downstream


Photo 631: Left bank


Photo 632: Left bank


Photo 620: Upstream


Photo 621: Downstream


Photo 622: Downstream to upstream panoramarama of right bank


Photo 623: Downstream to upstream panoramarama of right bank


Photo 624: Downstream to upstream panoramarama of right bank


Photo 625: Left bank


Photo 626: Left bank


Photo 612: Upstream


Photo 613: Downstream


Photo 614: Left bank

Photo 608: Upstream


Photo 609: Downstream


Photo 610: Left bank


Photo 611: Right bank


Photo 604: Upstream


Photo 605: Downstream


Photo 606: Left bank


Photo 607: Left bank

Photo 601: Upstream

Photo 602: Downstream

Photo 603: Right bank


Photo 597: Upstream


Photo 598: Downstream


Photo 599: Left bank


Photo 600: Right bank

Photo 594: Upstream

Photo 595: Downstream

Photo 596: Left bank


Photo 586: Downstream toward right bank


Photo 587: Right bank


Photo 588: Right bank


Photo 589: Right bank

Photo 580: Upstream

Photo 582: Downstream

Photo 579: Right bank

Photo 581: Left bank


Photo 572: Left bank


Photo 573: Left bank


Photo 574: Left bank

Photo 567: Upstream

Photo 568: Downstream

Photo 569: Right bank

Photo 570: Right bank

Photo 563: Downstream toward left bank

Photo 564: Downstream toward right bank failure

Photo 565: Right bank

Photo 566: Right bank

Photo 559: Upstream

Photo 562: Downstream

Photo 560: Downstream toward left bank

Photo 561: Upstream toward left bank


Photo 556: Upstream


Photo 557: Downstream


Photo 555: Downstream toward left bank


Photo 552: Upstream


Photo 554: Downstream


Photo 553: Right bank


Photo 546: Upstream


Photo 547: Downstream


Photo 548: Left bank


Photo 549: Downstream toward left bank

Santiam-Albany Canal - 2023 Bank Assessment
Site: WP391 Station: 46367
Date: 1/5/2023


Photo 539: Upstream


Photo 540: Downstream


Photo 541: Left bank


Photo 542: Left bank

Photo 537: Upstream toward left bank

Photo 538: Downstream toward left bank

Photo 536: Left bank

Photo 3055: Upstream

Photo 3056: Downstream

Photo 3057: Left bank failure


Photo 524: Downstream


Photo 523: Right bank


Photo 515: Upstream


Photo 514: Downstream


Photo 516: Left bank


Photo 517: Left bank


Photo 508: Upstream


Photo 507: Downstream

Photo 509: Left bank

Photo 510: Upstream

Photo 511: Downstream

Photo 512: Left bank

Photo 513: Left bank

Santiam-Albany Canal - 2023 Bank Assessment
Site: WP40 Station: 55986
Date: 1/5/2023


Photo 503: Upstream


Photo 504: Downstream


Photo 502: Left bank


Photo 501: Right bank

Photo 2964: Upstream

Photo 2965: Downstream

Photo 2966: Original failure (left bank)

Photo 2967: Left bank downstream of failure


Photo 2968: Left bank upstream of failure


Photo 2940: Upstream


Photo 2941: Downstream


Photo 2942: Left bank


Photo 483: Upstream


Photo 484: Left bank


Photo 485: Left bank


Photo 486: Upstream toward right bank

Photo 466: Upstream

Photo 465: Downstream

Photo 467: Right bank

Photo 468: Right bank

Appendix C

New Site Location Photo Log

Santiam-Albany Canal - 2023 Bank Assessment
Site: 1000 Station: 1238
Date: 1/10/2023

Photo 841: Left bank

Photo 1044: Left bank failure/erosion

Photo 1036: Upstream

Photo 1037: Downstream

Photo 1038: Right bank

Photo 1039: Right bank

Photo 1040: Right bank

Photo 1041: Downstream toward left bank

Photo 1042: Left bank

Photo 1043: Left bank

Photo 1031: Downstream toward right bank

Photo 1032: Right bank


Photo 1024: Left bank


Photo 1025: Left bank


Photo 1017: Left bank


Photo 1018: Left bank


Photo 1014: Left bank


Photo 1015: Left bank

Photo 1013: Left bank


Photo 1009: Left bank


Photo 1010: Upstream toward right bank

Photo 1008: Left bank

Photo 1003: Right bank

Photo 1004: Right bank


Photo 999: Left bank


Photo 1001: Left bank


Photo 1002: Left bank


Photo 995: Upstream


Photo 996: Downstream


Photo 997: Upstream toward left bank


Photo 998: Downstream toward right bank

Photo 995: Upstream

Photo 996: Downstream

Photo 997: Upstream toward left bank

Photo 998: Downstream toward right bank

Photo 3076: Upstream

Photo 3077: Downstream

Photo 3079: Upstream toward right bank


Photo 994: Upstream


Photo 992: Downstream


Photo 993: Downstream toward left bank

Photo 988: Upstream

Photo 989: Right bank

Photo 990: Right bank

Photo 991: Right bank


Photo 985: Right bank


Photo 986: Right bank


Photo 987: Right bank


Photo 983: Left bank


Photo 984: Left bank

Photo 981: Right bank

Photo 982: Right bank


Photo 980: Downstream toward left bank


Photo 979: Right bank


Photo 981: Right bank


Photo 978: Downstream toward right bank


Photo 977: Right bank

Photo 975: Upstream toward right bank

Photo 974: Right bank


Photo 968: Upstream


Photo 967: Downstream


Photo 964: Left bank


Photo 965: Left bank

Santiam-Albany Canal - 2023 Bank Assessment
Site: 1029 Station: 17573
Date: 1/12/2023


Photo 966: Left bank


Photo 961: Left bank


Photo 962: Left bank


Photo 963: Left bank

Photo 956: Upstream

Photo 958: Upstream

Photo 957: Right bank

Photo 959: Downstream toward right bank


Photo 960: Right bank wingwall erosion


Photo 953: Upstream


Photo 954: Left bank


Photo 955: Left bank


Photo 950: Upstream


Photo 951: Downstream


Photo 952: Right bank


Photo 949: Left bank


Photo 939: Upstream toward left bank


Photo 938: Downstream toward left bank


Photo 936: Downstream


Photo 933: Left bank


Photo 934: Left bank


Photo 935: Left bank

Photo 921: Downstream toward right bank

Photo 922: Right bank Upstream of photo 921


Photo 914: Upstream toward left bank


Photo 915: Downstream toward left bank


Photo 913: Upstream toward left bank


Photo 912: Downstream toward left bank


Photo 892: Left bank


Photo 893: Downstream toward left bank, note riprap protecting small outfall


Photo 876: Left bank


Photo 877: Left bank


Photo 864: Right bank


Photo 865: Right bank


Photo 866: Right bank

Photo 858: Left bank

Photo 861: Left bank


Photo 859: Right bank


Photo 860: Downstream

Photo 857: Upstream toward left bank

Photo 856: Left bank


Photo 848: Upstream


Photo 845: Downstream


Photo 844: Downstream


Photo 842: Left bank


Photo 843: Left bank


Photo 846: Downstream toward left bank


Photo 847: Upstream toward left bank

Photo 820: Left bank

Photo 817: Left bank

Photo 816: Downstream

Photo 814: Left bank

Photo 815: Right bank


Photo 816: Downstream


Photo 814: Left bank


Photo 815: Right bank

Photo 808: Downstream toward left bank

Photo 806: Left bank

Photo 807: Right bank


Photo 805: Left bank

Photo 804: Right bank


Photo 801: Downstream toward right bank


Photo 802: Downstream toward right bank


Photo 803: Upstream toward left bank


Photo 794: Downstream


Photo 795: Upstream toward left bank


Photo 796: Upstream toward left bank


Photo 797: Downstream toward left bank


Photo 798: Downstream toward left bank


Photo 799: Downstream toward left bank


Photo 800: Left bank panorama


Photo 792: Left bank


Photo 793: Left bank


Photo 790: Upstream


Photo 791: Downstream


Photo 789: Left bank


Photo 788: Right bank


Photo 790: Upstream


Photo 791: Downstream


Photo 788: Right bank


Photo 789: Left bank

Photo 786: Right bank

Photo 787: Right bank with Riprap


Photo 777: Upstream toward left bank


Photo 778: Left bank


Photo 779: Left bank


Photo 780: Left bank


Photo 781: Left bank


Photo 782: Left bank


Photo 750: Right bank

Photo 735: Right bank

Photo 731: Upstream

Photo 733: Downstream

Photo 734: Right bank


Photo 728: Upstream


Photo 729: Downstream toward left bank


Photo 730: Left bank

Photo 724: Right bank


Photo 719: Right bank


Photo 720: Upstream toward right bank

Photo 690: Upstream

Photo 691: Downstream

Photo 692: Right bank

Photo 693: Downstream toward right bank


Photo 682: Downstream toward right bank


Photo 683: Right bank


Photo 684: Upstream toward right bank


Photo 685: Downstream


Photo 677: Upstream


Photo 678: Downstream


Photo 679: Left bank


Photo 680: Left bank

Photo 681: Left bank

Photo 673: Upstream

Photo 674: Downstream

Photo 675: Right bank

Photo 676: Upstream toward right bank


Photo 670: Upstream


Photo 671: Right bank


Photo 672: Downstream

Photo 662: Right bank


Photo 615: Upstream


Photo 616: Downstream


Photo 617: Right bank


Photo 618: Right bank


Photo 619: Right bank


Photo 604: Upstream


Photo 605: Downstream toward left bank


Photo 606: Left bank


Photo 607: Left bank

Photo 592: Left bank

Photo 593: Left bank

Photo 591: Downstream

Photo 590: Left bank


Photo 575: Right bank


Photo 576: Right bank


Photo 577: Right bank


Photo 578: Upstream toward right bank


Photo 551: Right bank


Photo 530: Upstream


Photo 531: Left bank


Photo 532: Left bank


Photo 533: Left bank


Photo 534: Left bank


Photo 3058: Left bank


Photo 518: Upstream


Photo 519: Downstream


Photo 520: Left bank


Photo 521: Left bank

Photo 522: Left bank

Photo 2970: Upstream

Photo 2971: Downstream

Photo 2972: Left bank

Photo 498: Downstream

Photo 499: Left bank

Photo 500: Left bank

Photo 501: Downstream toward right bank

Photo 2969: Downstream toward left bank


Photo 494: Upstream


Photo 495: Right bank


Photo 496: Right bank


Photo 497: Right bank

Photo 490: Upstream

Photo 491: Downstream

Photo 492: Left bank

Photo 493: Right bank


Photo 490: Upstream


Photo 491: Downstream


Photo 492: Left bank


Photo 493: Right bank

Photo 489: Upstream toward left bank

Photo 2961: Upstream

Photo 2962: Downstream

Photo 2963: Left bank

Photo 2960: Right bank

Photo 2959: Right bank

Photo 2957: Right bank


Photo 2958: Downstream toward right bank

Photo 2954: Upstream

Photo 2955: Downstream

Photo 2956: Left bank

Photo 2950: Right bank

Photo 2951: Upstream

Photo 2947: Upstream

Photo 2948: Downstream

Photo 2949: Right bank

Photo 2943: Upstream

Photo 2944: Downstream

Photo 2945: Left bank

Photo 2946: Right bank


Photo 2932: Upstream


Photo 2933: Downstream


Photo 2934: Right bank


Photo 2935: Left bank


Photo 2928: Upstream


Photo 2929: Downstream


Photo 2930: Left bank


Photo 2931: Left bank

Photo 2925: Left bank

Photo 2924: Upstream

Photo 2922: Downstream

Photo 2923: Left bank

Santiam-Albany Canal - 2023 Bank Assessment
Site: 1118 Station: 81481
Date: 1/4/2023


Photo 2918: Upstream


Photo 2919: Downstream


Photo 2920: Right bank


Photo 2921: Left bank


Photo 2912: Upstream


Photo 29813: Downstream


Photo 2915: Upstream to downstream panorama of right bank


Photo 2914: Upstream to downstream panorama of right bank

Photo 2916: Upstream to downstream panorama of right bank


Photo 2906: Upstream

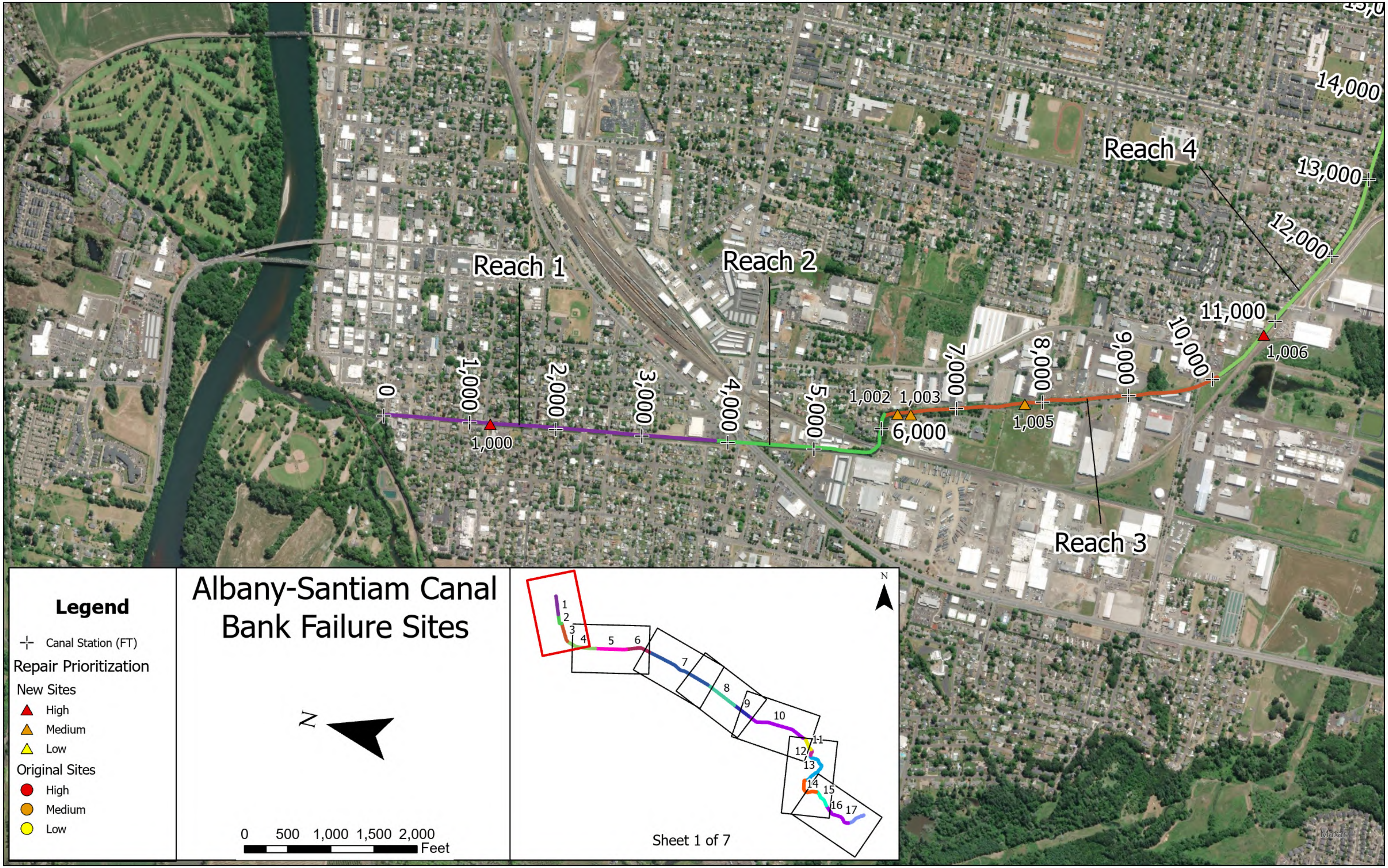

Photo 2907: Downstream


Photo 2908: Left bank

Photo 2902: Left bank

Appendix D

Bank Failure Sites Map



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Reach 3
Reach 4
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Canal Station (FT)
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Low
Original Sites
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Medium
Low
Albany-Santiam Canal
Bank Failure Sites
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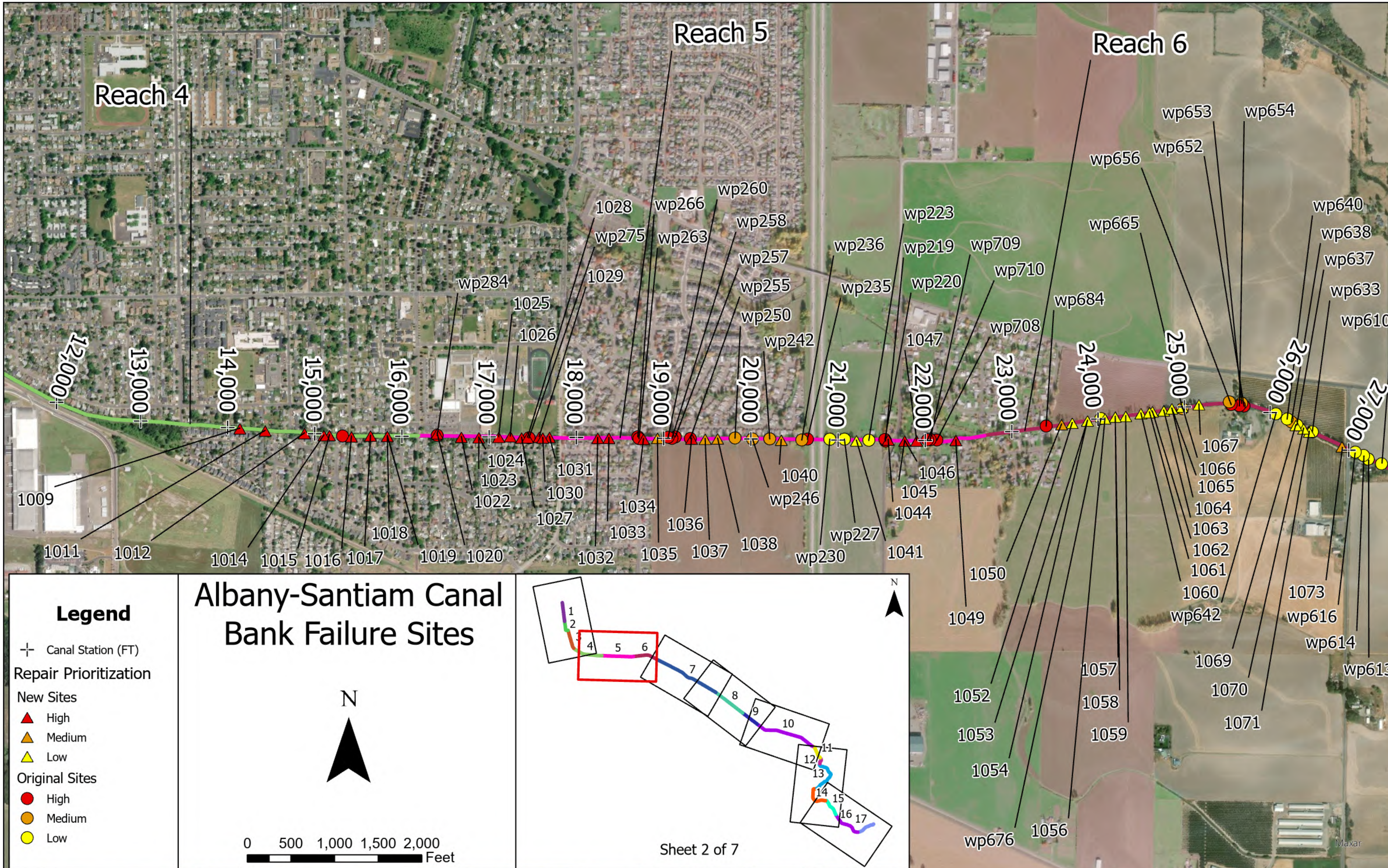
Sheet 1 of 7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Legend
Canal Station (FT)
Repair Prioritization
New Sites
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Sheet 2 of 7
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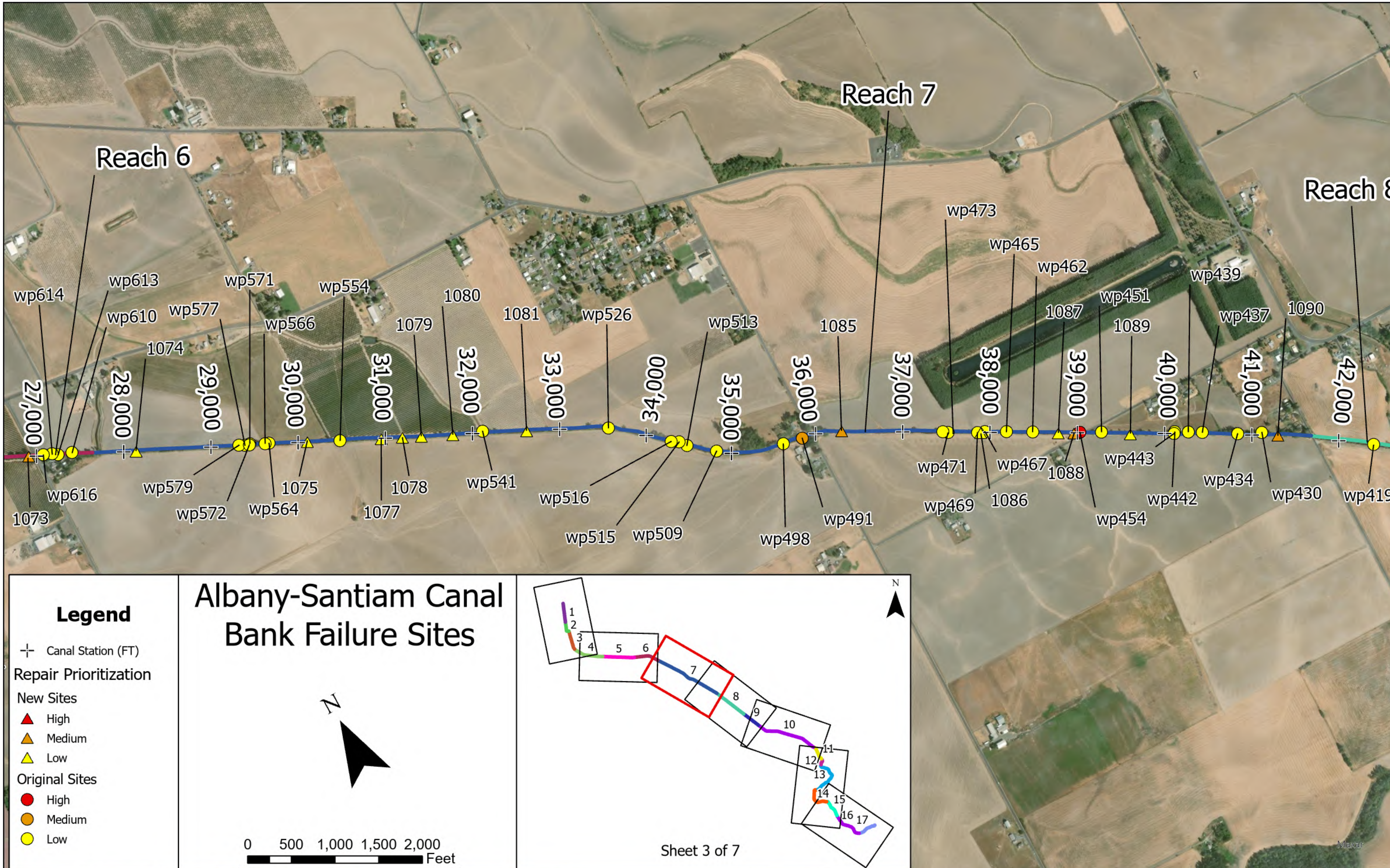
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Bank Failure Sites
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Legend
Canal Station (FT)
Repair Prioritization
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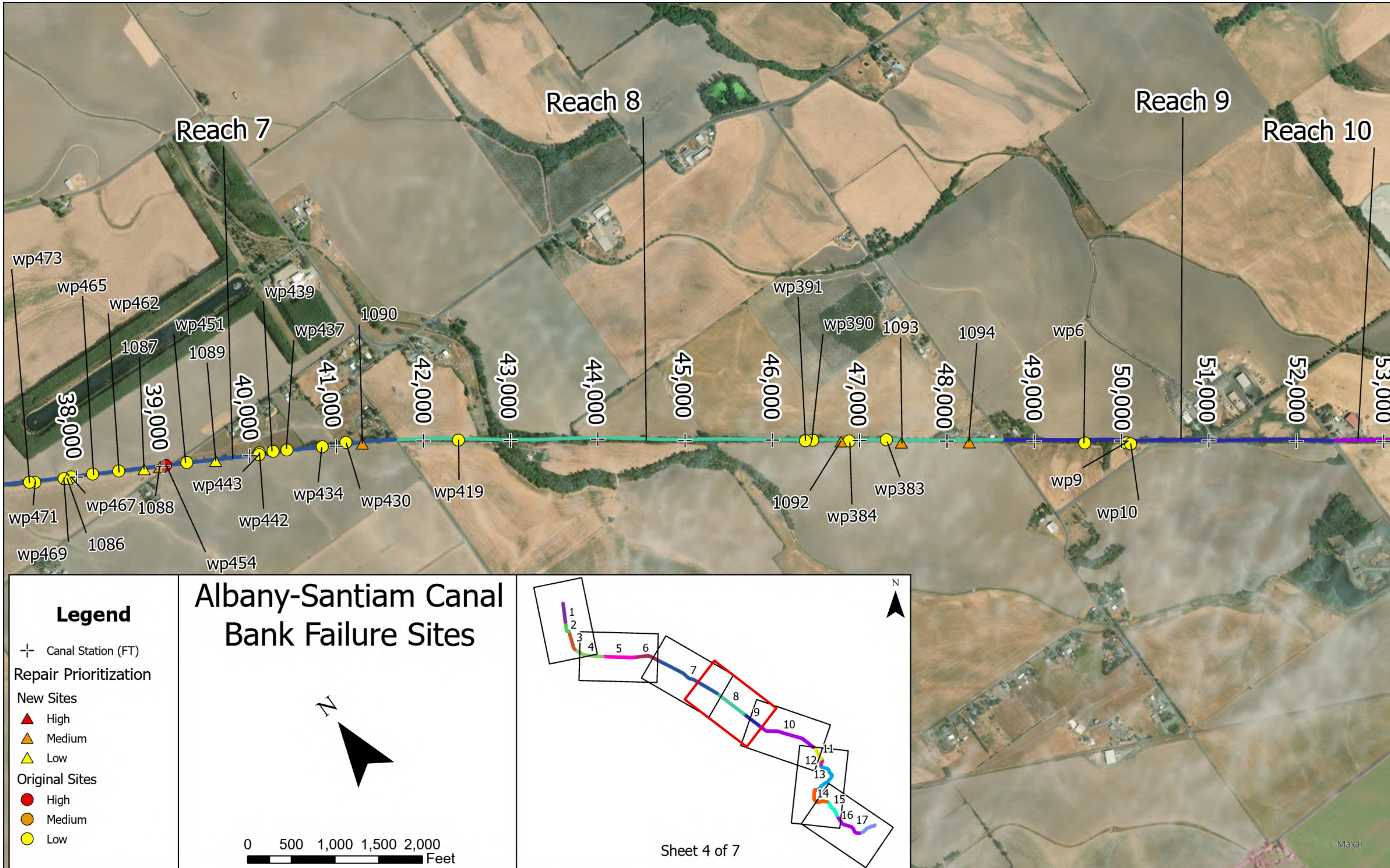
Sheet 3 of 7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Bank Failure Sites
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Legend
Canal Station (FT)
Repair Prioritization
New Sites
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Medium
Low
Original Sites
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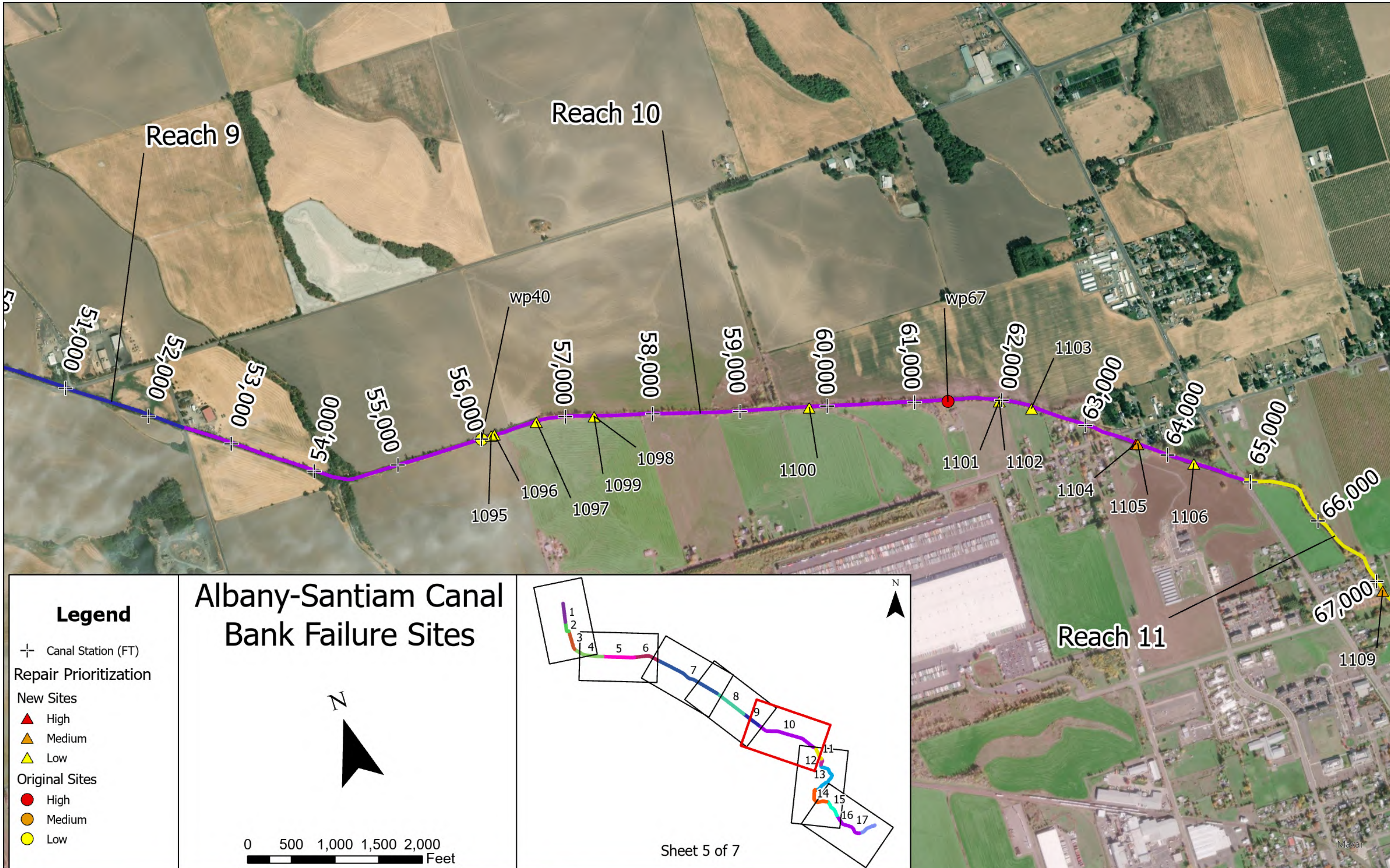
Sheet 4 of 7
Maxar


Albany-Santiam Canal
Bank Failure Sites
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Legend
Canal Station (FT)
Repair Prioritization
New Sites
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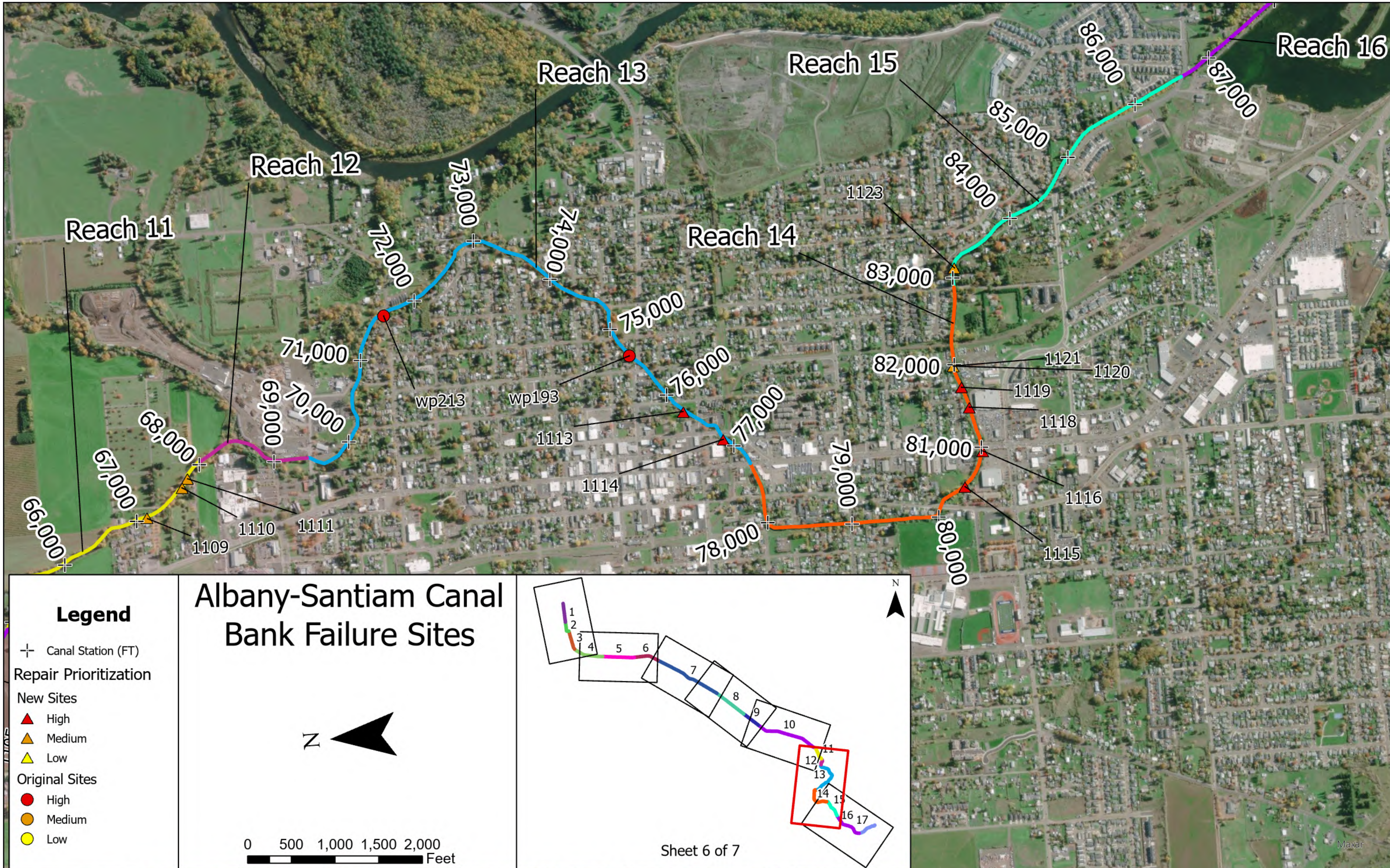
Sheet 5 of 7


Albany-Santiam Canal
Bank Failure Sites
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Legend
Canal Station (FT)
Repair Prioritization
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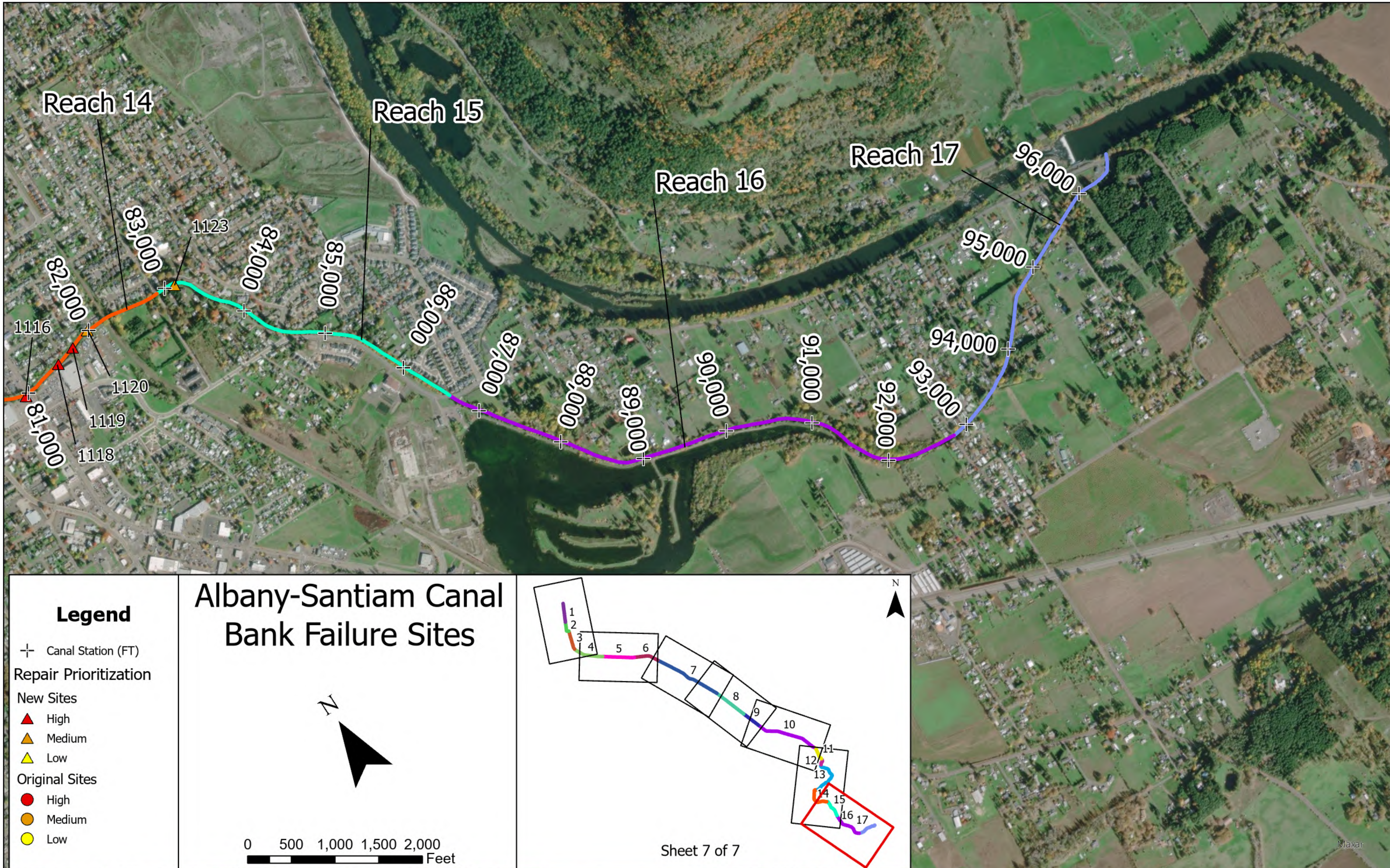
Sheet 6 of 7
Maxar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Canal Station (FT)
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Albany-Santiam Canal
Bank Failure Sites
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Sheet 7 of 7
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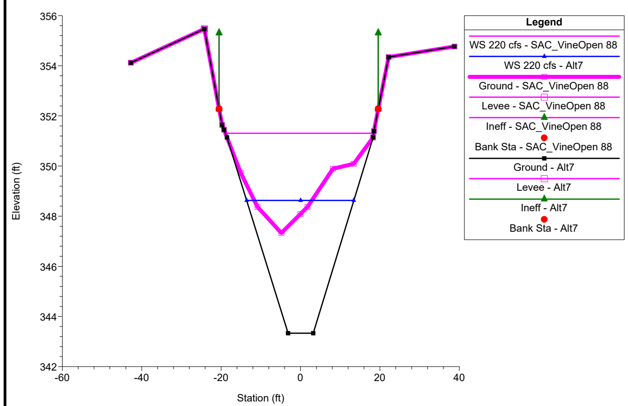
Maxar

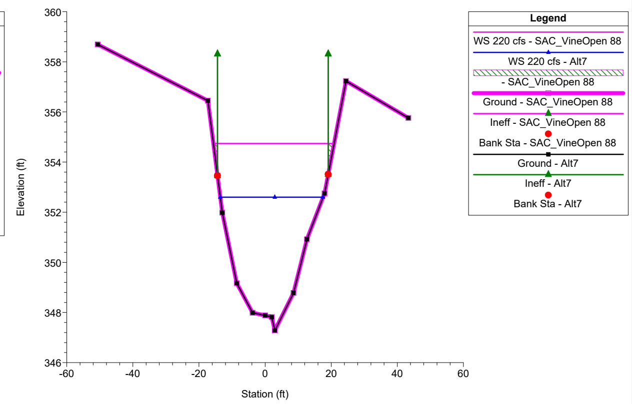
Appendix E

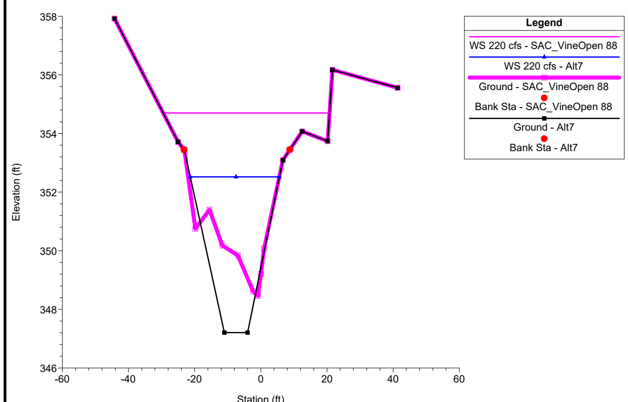
Dredge Geometry Comparison

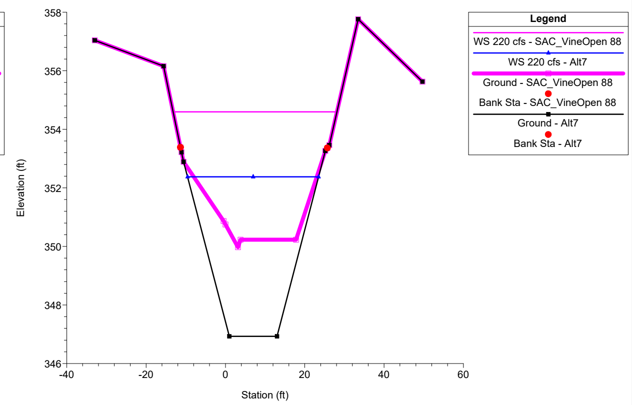
Upstm Xsec of 2nd St



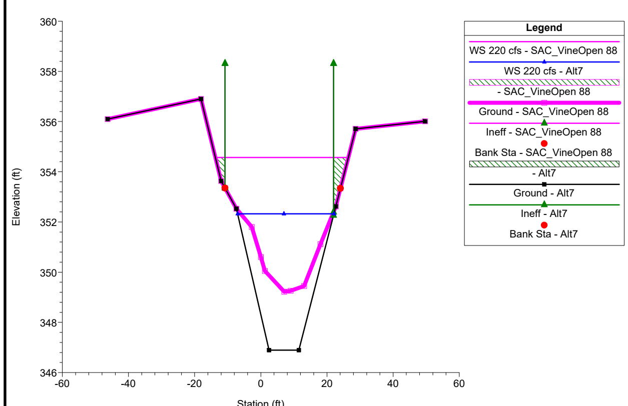
Dnstm Xsec of Private Drive (1955 River Dr)



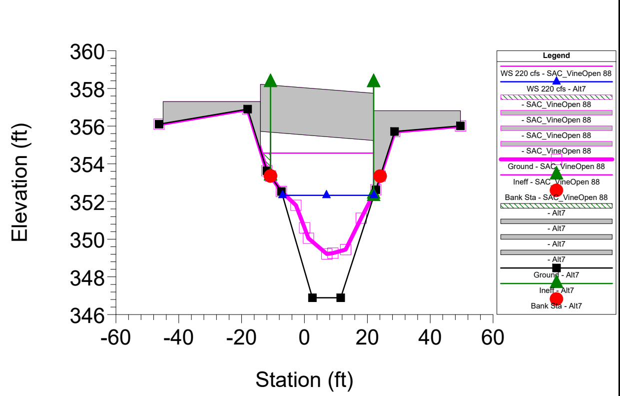




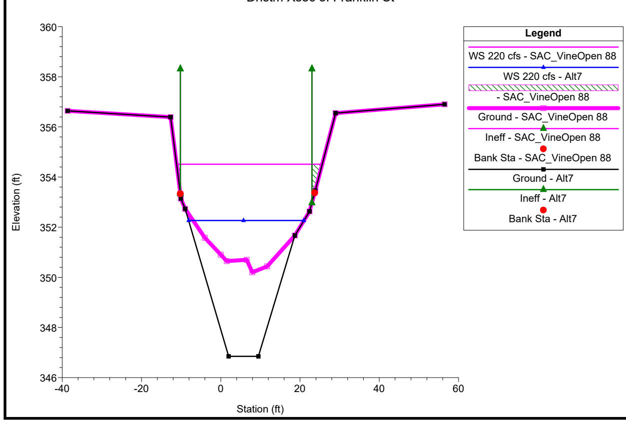
Upstm Xsec of Franklin St

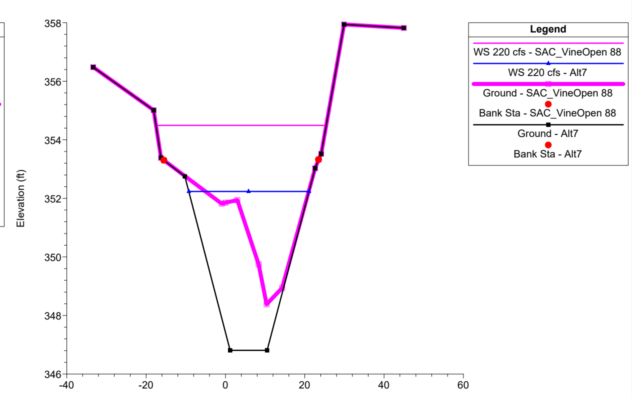


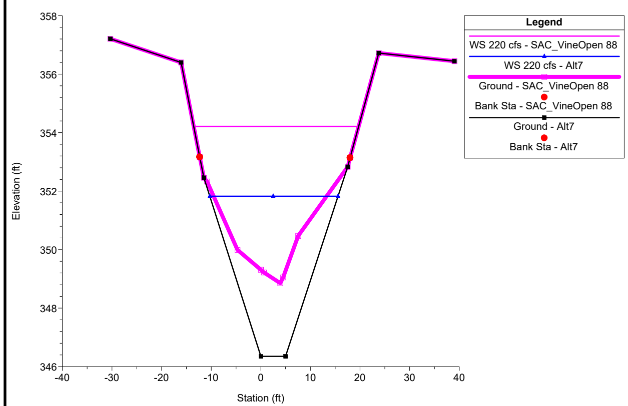
PWR #18 - Franklin Street



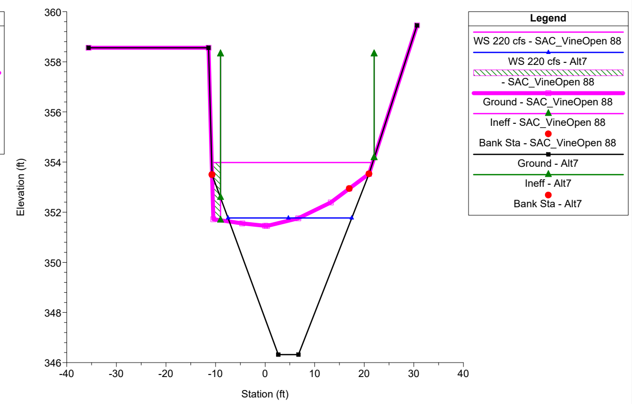
Dnstm Xsec of Franklin St



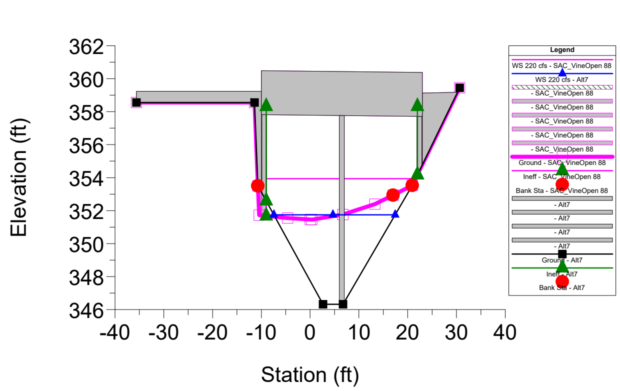




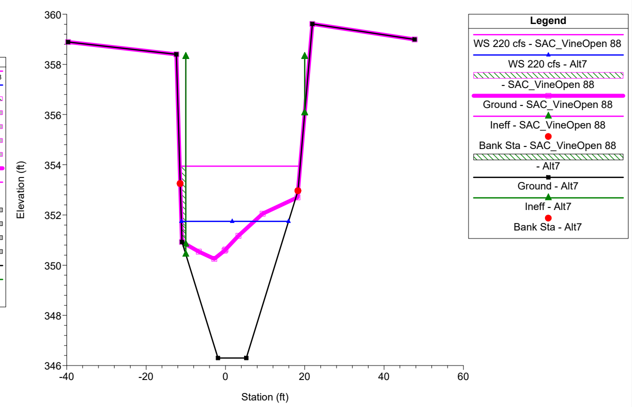
Upstm Xsec of Railroad Tracks

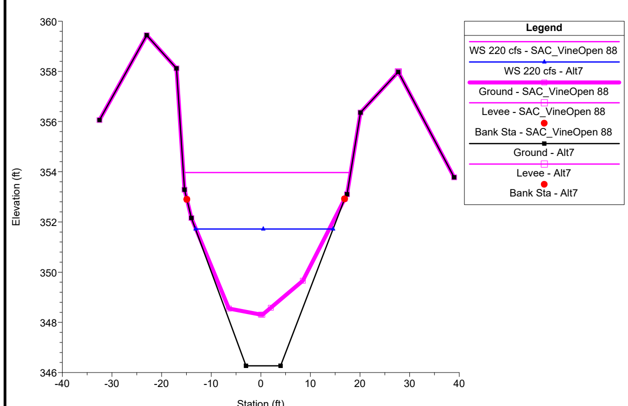


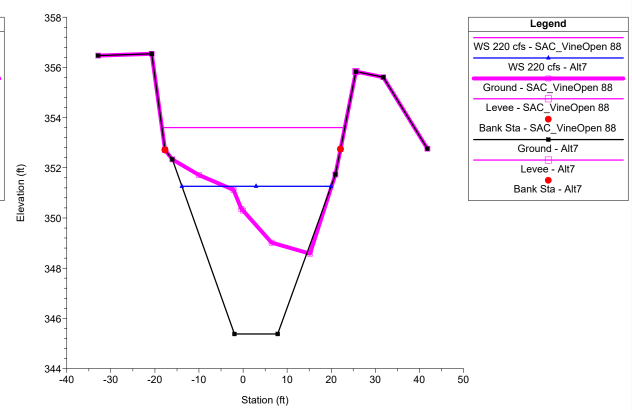
PWR #19 - Railroad Bridge



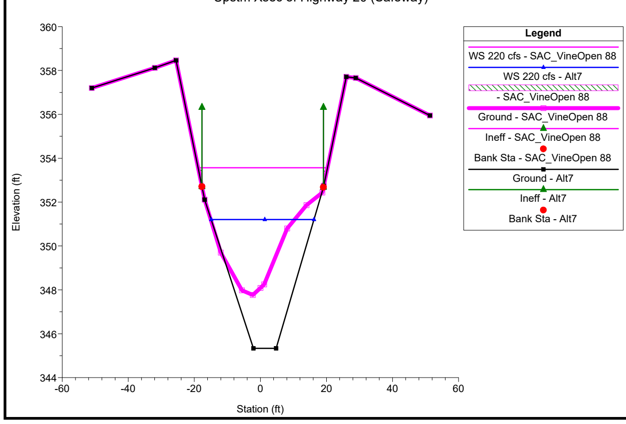
Dnstm Xsec of Railroad Tracks



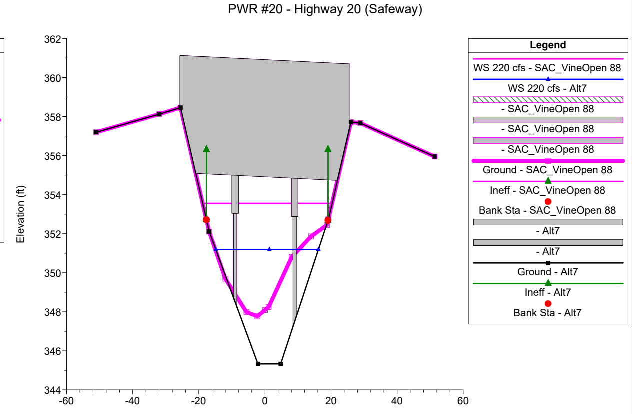




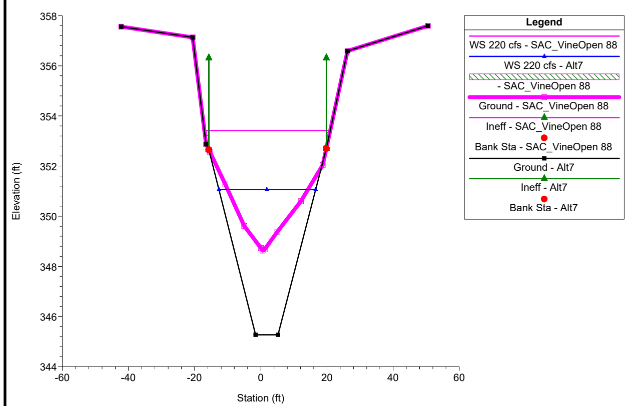
Upstm Xsec of Highway 20 (Safeway)

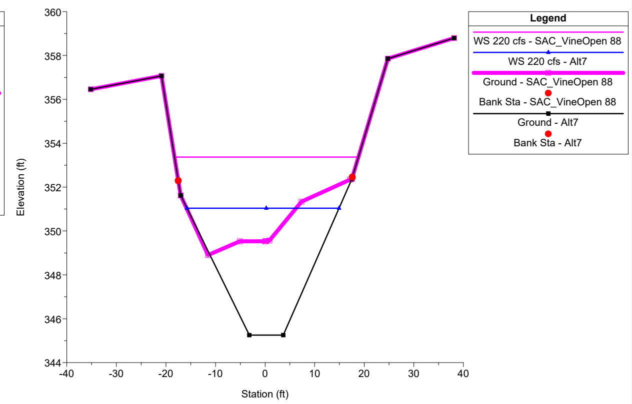


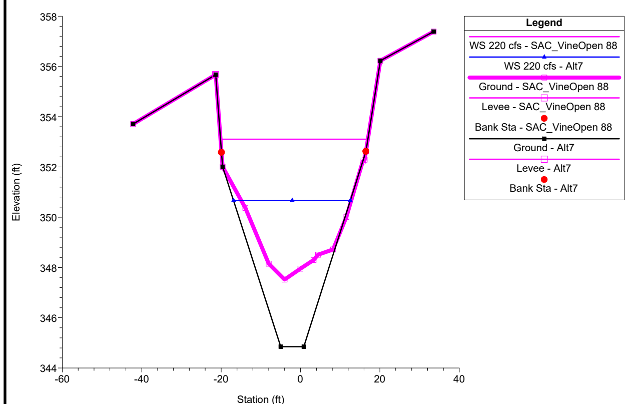
PWR #20 - Highway 20 (Safeway)



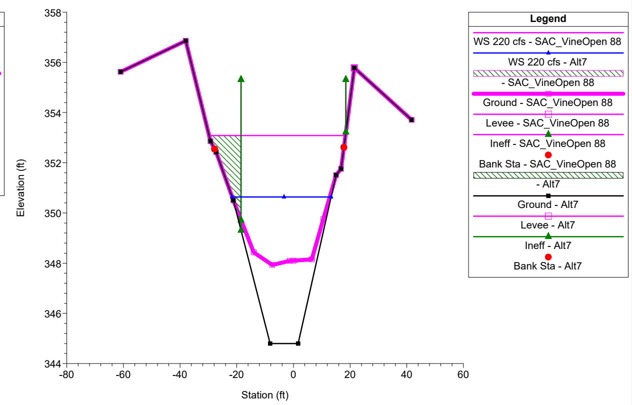
Dnstm Xsec of Highway 20 (Safeway)



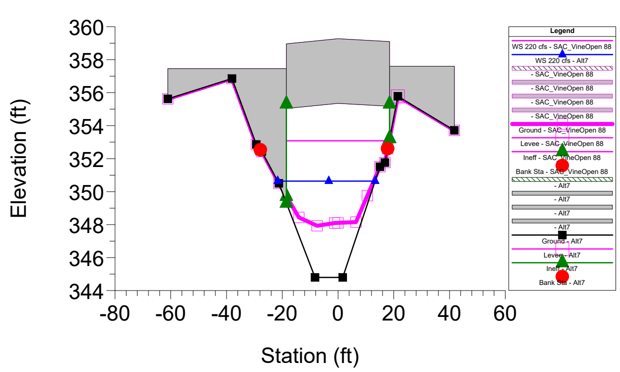




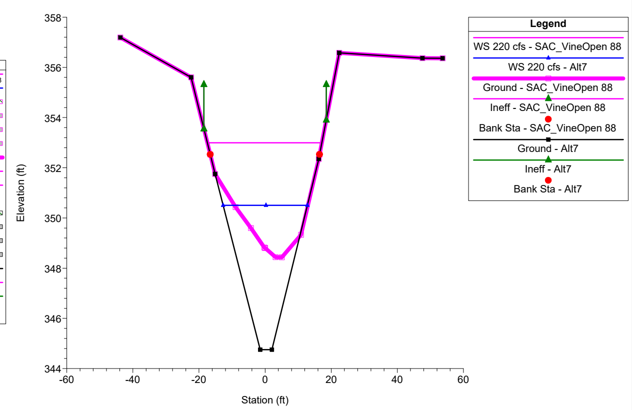
Upstm Xsec of 2nd St

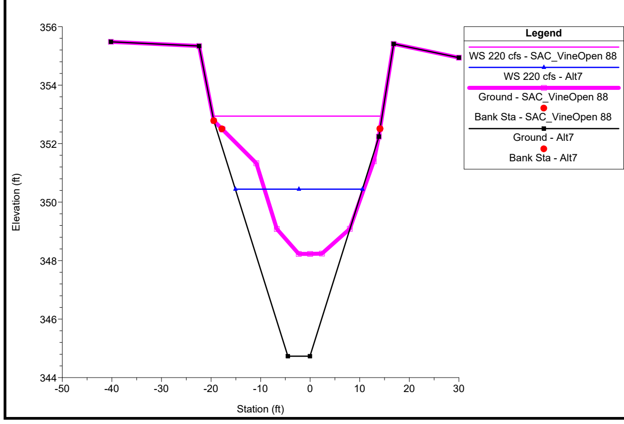


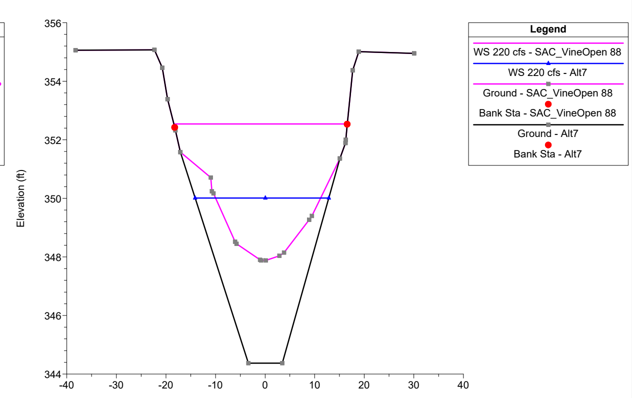
PWR #21 - 2nd Street

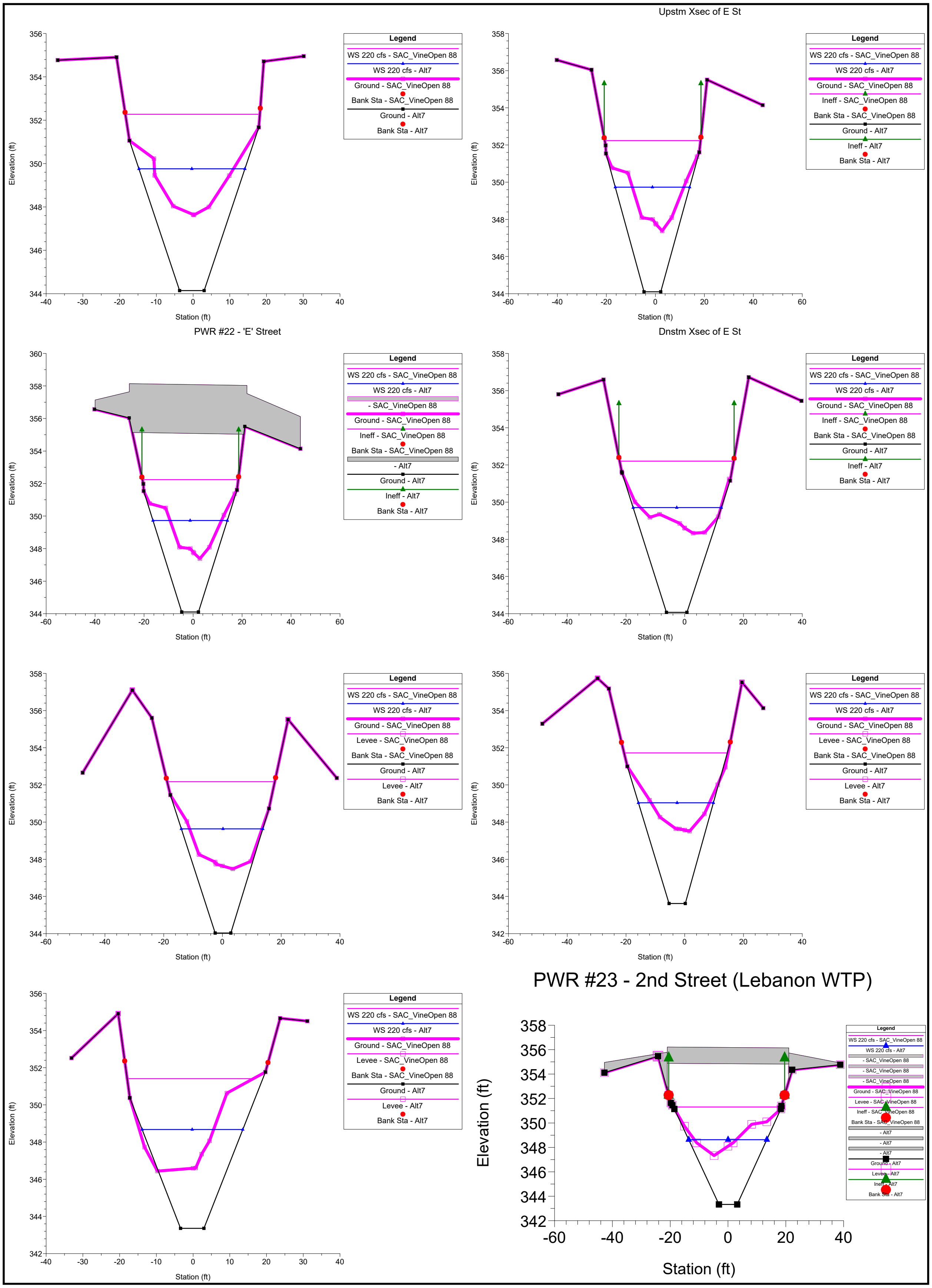


Dnstm Xsec of 2nd St

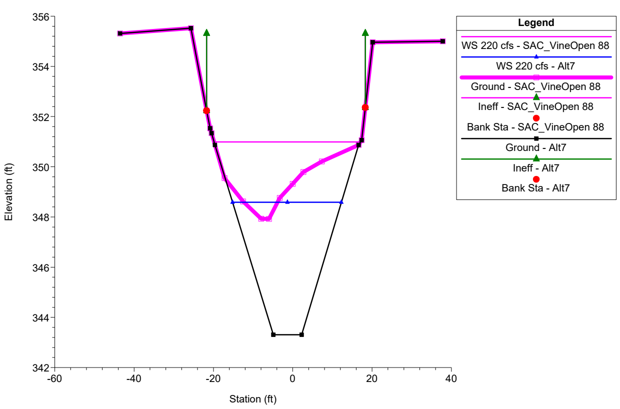


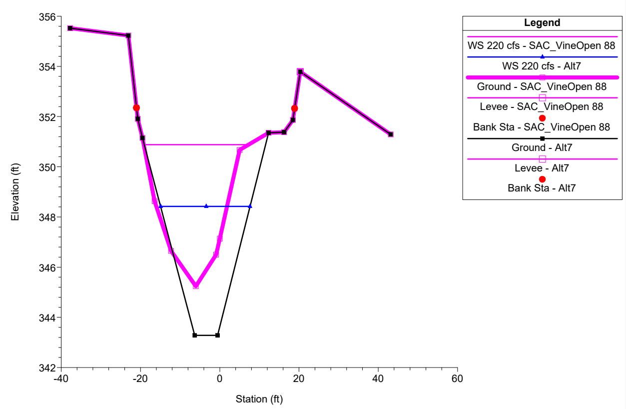





Upstm Xsec of E St
PWR #22 - 'E' Street
Dnstm Xsec of E St
PWR #23 - 2nd Street (Lebanon WTP)
Legend
WS 220 cfs - SAC_VineOpen 88
WS 220 cfs - Alt7
Ground - SAC_VineOpen 88
Ineff - SAC_VineOpen 88
Levee - SAC_VineOpen 88
Bank Sta - SAC_VineOpen 88
Ground - Alt7
Ineff - Alt7
Levee - Alt7
Bank Sta - Alt7
Elevation (ft)
Station (ft)

Dnstm Xsec of 2nd St

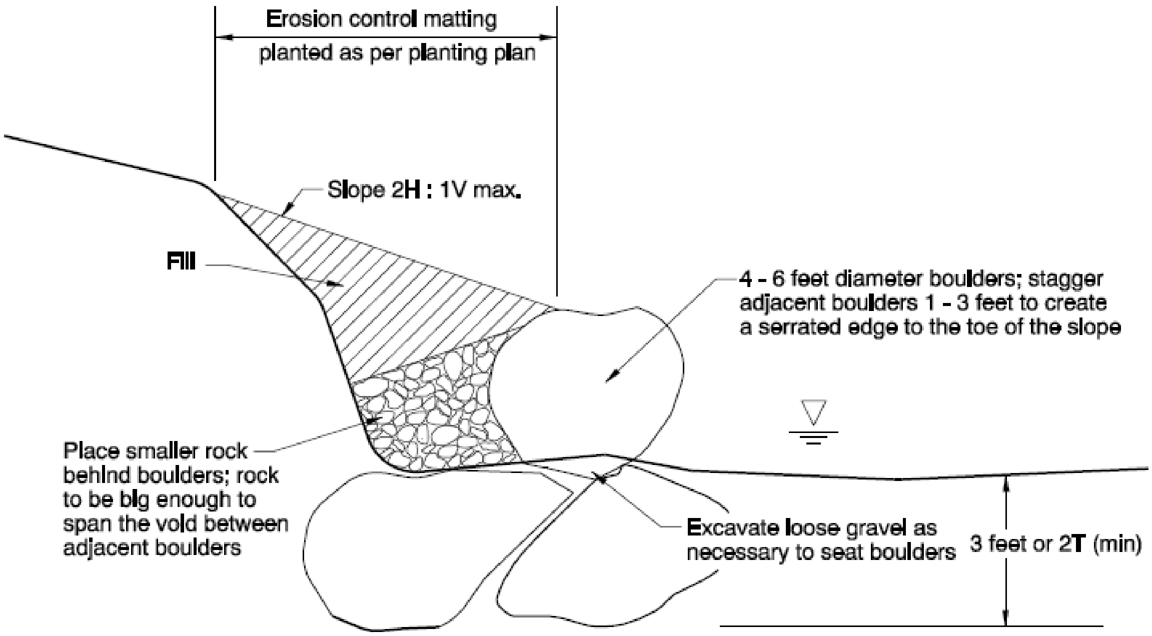




Appendix F

Repair Designs

Stacked Boulder Toe (ODOT, 2014)

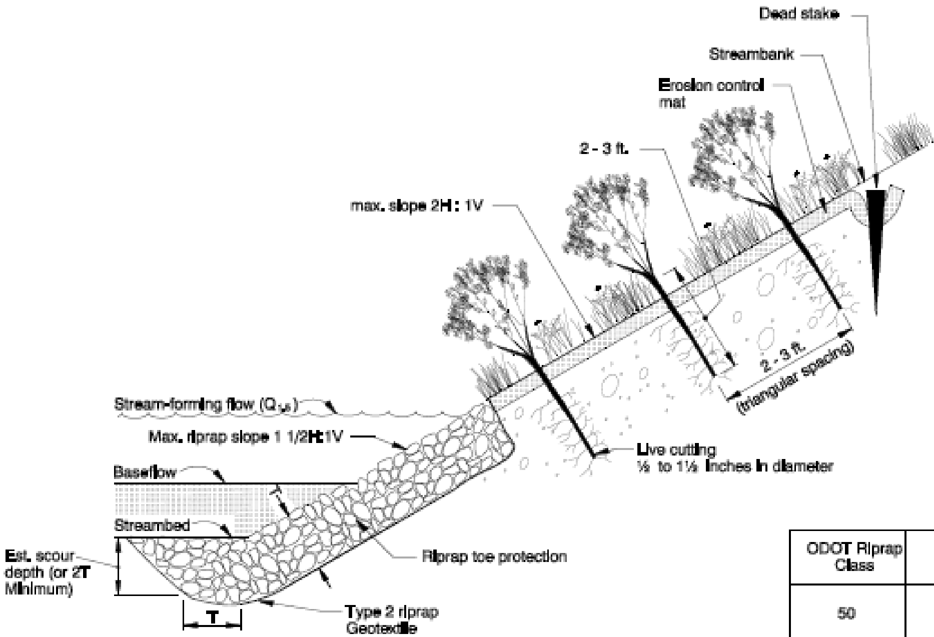


Notes:

1. Stream forming flow ($Q_{1.5}$) should be no higher than the top of the boulders.

2. Do not use where scour at the toe will undermine and destabilize the boulders.

Riprap Blanket (ODOT, 2014)



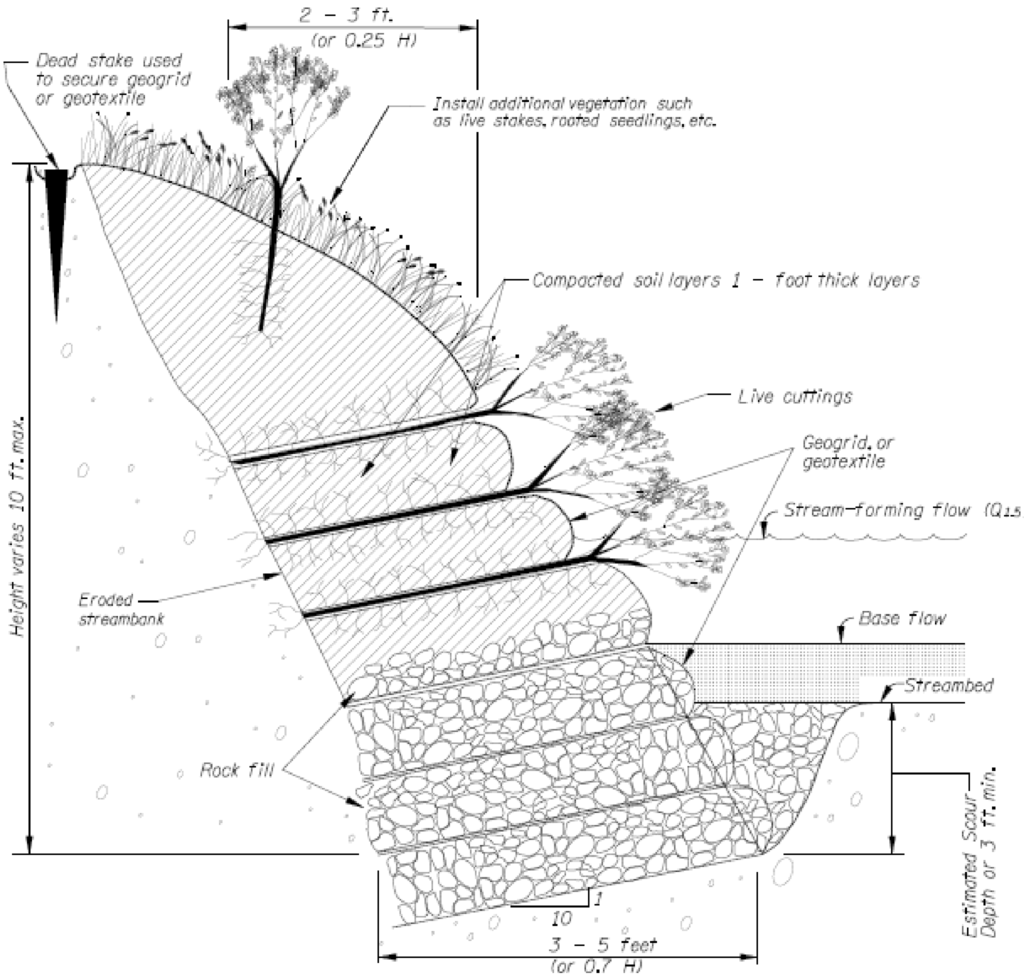
Notes:

1. Rooted/leafed condition of the living plant material is not representative of the time of installation.

2. Adapted from USDA, NRCS, Engineering Field Handbook, Chapter 16.

ODOT Riprap Class	T (ft)
50	1.0
100	1.5
200	2.0
700	3.0
2000	4.0

Wrapped Soil Lifts (ODOT, 2014)

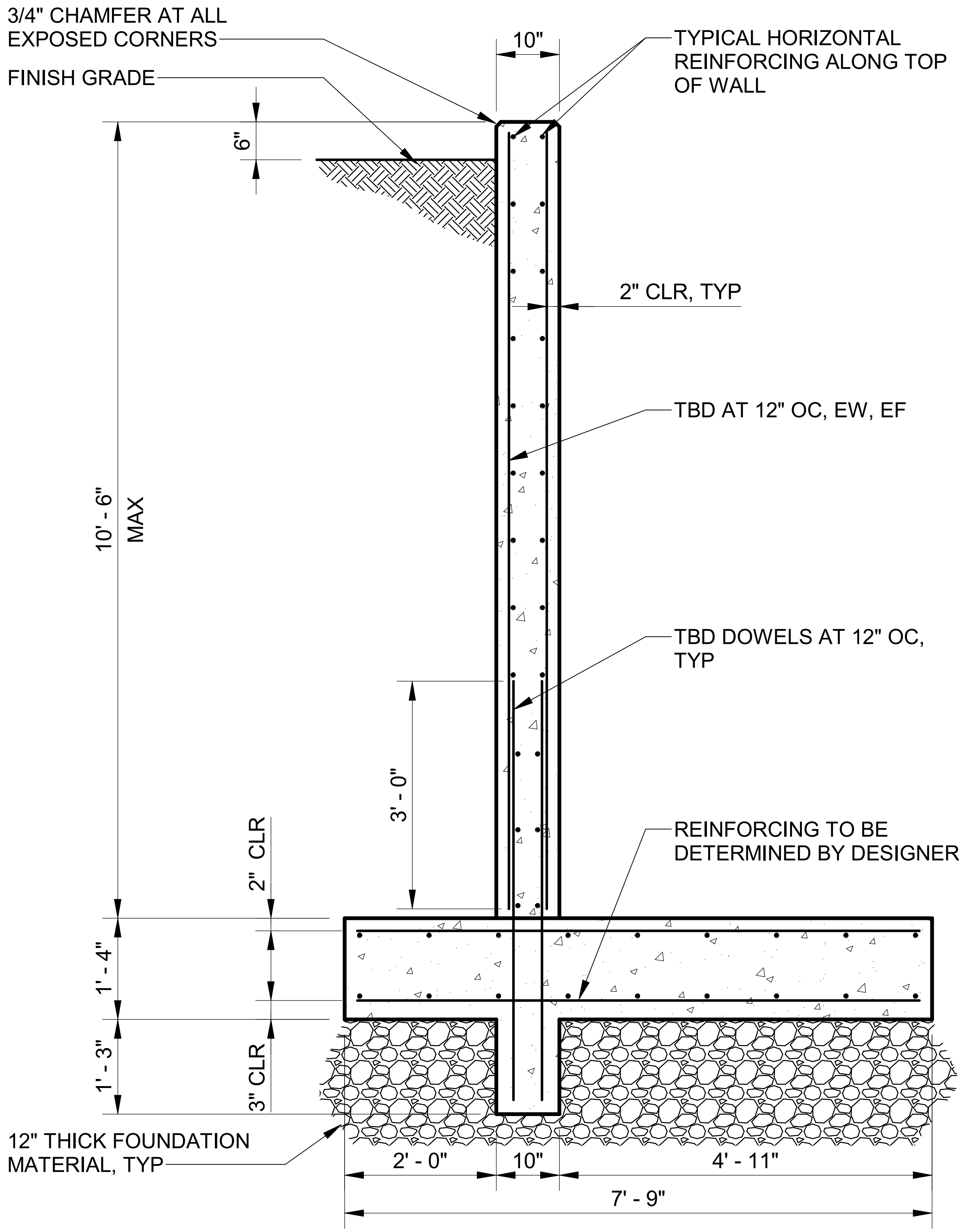


Notes:

1. This detail is for over–steepened, eroded banks 10 feet or less height (H). Vegetated geogrids that are higher than 10 feet will require a stability analysis.

2. Rooted/leafed condition of the living plant material is not representative of the time of installation.

3. Adapted from USDA, NRCS, Engineering Field Handbook, Chapter 16



NOTE: THIS IS NOT A DESIGN AND SHOULD NOT BE USED FOR CONSTRUCTION. GEOTECHNICAL CONDITIONS, LOAD PRESSURES, LATERAL EARTH PRESSURES, AND ALL OTHER DESIGN PARAMETERS MUST BE CONFIRMED BY THE DESIGNER

CONCEPT FOR VERTICAL RETAINING WALL BANK REPAIR

SCALE: 1/2" = 1'-0"

Brown AND Caldwell

ALBANY WATER MASTER PLAN
2022-23

VER:		TSG:	APPVD: Approver	DATE: 11/28/23

DRAWN BY:Author
PLOT DATE: 12/6/2023 7:23:06 AM
FILE LOCATION: C:\Users\TBouffard1\OneDrive - Brown and Caldwell\Documents\CDRIVE\Projects\STANDARD DETAIL PROJECT\BC_DPS 2020_Typical Details-TLB DRAFT_R21.rvt

Appendix G

CIP Cost Information

Memorandum

Date: November 16, 2023
To: Lynn Stevens, Seattle
From: Breeze Watler, Cincinnati
Reviewed by: William Agster, Denver
Copy to: Alan Peck, Portland
Project No.: 158852-270-272
Subject: Water Master Plan – Canal Restoration
Planning level
Basis of Estimate of Probable Construction Cost

The Basis of Estimate Report and supporting estimate reports for the subject project are attached. Please call me if you have questions or need additional information.

Enclosures (3):

1. Basis of Estimate Report
2. Summary Estimate
3. Detailed Estimate

Basis of Estimate Report

Introduction

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the Water Master Plan, City of Albany, OR.

Scope of Work

The scope of work for the project is unit prices on (4) different types of slope restoration techniques.

1. Stacked Boulder Toe
2. Soil Blanket
3. Riprap Blanket
4. Cast in Place Concrete Retaining Wall By-Pass

Background of this Estimate

The attached estimate of probable construction cost is based on documents dated August 2023, received by the Estimating and Scheduling Group (ESG). These documents are described as planning level based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 5 estimate. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete.

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
4. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
5. Major equipment costs are based on vendor supplied price quotes obtained by the project design team and/or estimators and on historical pricing of like equipment.
6. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material is included in the purchase price of major equipment items where so stated in that quotation.
7. Bulk material quantities are based on manual quantity take-offs.
8. There is enough electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.

9. Soils are of adequate nature to support the structures. No piles have been included in this estimate.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project except for the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

Allowances for Known but Undefined Work

The following allowances were made in the development of this estimate.

1. By Pass Pumping

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

Item	Rate (%)
Net Cost Markups	
Labor markup	15
Materials and process equipment	10
Equipment (construction-related)	10
Subcontractor	10
Other – Process Equipment	8
Material Shipping and Handling	2
Gross Cost Markups	
Contractor General Conditions	15
Start-up, Training and O&M	2
Construction Contingency	30
Builders Risk, Liability and Auto Insurance	2
Performance and Payment Bonds	1.5
Escalation to Midpoint of Construction	4

Labor Markup

The labor rates used in the estimate were derived from RS Means latest national average wage rate tables and city cost indexes. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising, and owner profit.

Materials and Process Equipment Markup

This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup

This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all the equipment needed for the job, but to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is like the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup

This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Contractor Startup, Training, and O&M Manuals

This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup, and O&M manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and troubleshoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance

This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country.

Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and the contractor's insurability at the time the project is bid.

Material Shipping and Handling

This can range from 2 to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paperwork, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the value of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets and bolts that may be missing from the equipment or materials shipped.

Escalation to Midpoint for Labor, Materials and Subcontractors

In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material, and equipment costs beyond values at the time the estimate is prepared. For this project, the anticipated rate of escalation is 4 percent per annum. This estimate is in 2023 dollars.

Undesigned/Undeveloped Contingency

The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that cannot be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage and area factors, construction contingency can range from 10 to 50 percent.

Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity, and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

Estimate Summary Report

Project Number:	158852-270-272
Estimate Issue Number:	1
Estimate Date:	8-30-2023
Lead Estimator:	Breeze Walter

Water Master Plan - Canal

City of Albany
Water Master Plan - Canal
Planning Level

Estimator	Breeze Walter
BC Project Manager	Lynn Stevens
BC Office	Seattle
Est Version Number	1
QA/QC Reviewer	William Agster
BC Project Number	158852-270-272

Brown AND Caldwell

Estimate Summary Report

11/16/2023 8:50 AM

Project Number: 158852-270-272
Estimate Issue Number: 1
Estimate Date: 8-30-2023
Lead Estimator: Breeze Walter

Water Master Plan - Canal

Description	Takeoff Quantity	Grand Total Price	Gross Total Cost with Markups
01 Total			
01 Stacked Boulder Toe			
01 Demolition			
01560 _Bypass Pumping	1.00 week	47,158.79 /week	47,159
31230 Site Clearing	1,600.00 sf	2.07 /sf	3,305
01 Demolition			50,464
02 Civil			
31999 Slope	100.00 cy	71.71 /cy	7,171
31999 Gravel Fill and Bolders	1.00 LS	101,430.95 /LS	101,431
32920 Plantings	1,800.00 sf	0.76 /sf	1,364
02 Civil			109,965
01 Stacked Boulder Toe	100.00 lf	1,604.29 /lf	160,429
02 Soil Blanket			
01 Demolition			
01560 _Bypass Pumping	1.00 week	47,158.77 /week	47,159
31230 Site Clearing	1,600.00 sf	2.07 /sf	3,305
01 Demolition			50,464
02 Civil			
31999 Slope	185.92 cy	66.18 /cy	12,304
31999 Gravel Fill	1.00 LS	77,027.07 /LS	77,027
32920 Plantings	2,200.00 sf	1.02 /sf	2,250
02 Civil			91,581
02 Soil Blanket	100.00 lf	1,420.45 /lf	142,045
03 Riprap Blanket			
01 Demolition			

Water Master Plan - Canal

Description	Takeoff Quantity	Grand Total Price	Gross Total Cost with Markups
01560 _Bypass Pumping	1.00 week	47,158.77 /week	47,159
31230 Site Clearing	1,600.00 sf	2.07 /sf	3,305
01 Demolition			**50,464**
02 Civil			
31999 Slope	100.00 cy	70.70 /cy	7,070
31999 Gravel Fill and Bolders	1.00 LS	107,074.97 /LS	107,075
32920 Plantings	2,100.00 sf	0.63 /sf	1,328
02 Civil			**115,473**
03 Riprap Blanket	**100.00 lf**	**1,659.37 /lf**	**165,937**
06 Canal Restoration - Cast In Place Concrete Retaining Wall Bypass Option			
02 Civil			
01560 Bypass Pumping	12.00 week	38,226.72 /week	458,721
31240 Dewatering Systems - Dry out Soil	5.00 unit	914.57 /unit	4,573
31250 Shoring Systems	4,725.00 sf	44.79 /sf	211,649
31290 Excavation and Backfill of Retaining Wall	3,123.81 cy	388.25 /cy	1,212,811
02 Civil			**1,887,753**
03 Concrete			
03305 Retaining Wall Base Slab - 315 LF	120.25 cy	1,288.55 /cy	154,953
03345 Reinforced Concrete Retaining Wall - 315 LF	114.24 cy	2,465.76 /cy	281,679
03 Concrete			**436,632**
06 Canal Restoration - Cast In Place Concrete Retaining Wall Bypass Option	**315.00 lf**	**7,379.00 /lf**	**2,324,385**
01 Total			**2,792,796**

City of Albany
Water Master Plan - Canal
Planning Level

Estimator	Breeze Walter
BC Project Manager	Lynn Stevens
BC Office	Seattle
Est Version Number	1
QA/QC Reviewer	William Agster

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
01 Total										
01 Stacked Boulder Toe										
01 Demolition										
01560 _Bypass Pumping										
01-58-08.00	BC-0115	Pumping system, bypass, 8-in pump, one primary pump, valves and 500 lf discharge piping, weekly rental	1.0 week	-	-	-	4,534	-	4,534.00 /week	4,534
01-58-08.00	BC-0215	Pumping system, bypass, 8-in pump, standby pump, weekly rental	1.0 week	-	-	-	813	-	813.00 /week	813
01-58-08.00	BC-0415	Pumping system, bypass, 8-in pump, ship, install, remove	1.0 ea	-	-	-	13,633	-	13,633.00 /ea	13,633
01-58-08.00	BC-0500	Pumping system, bypass, pump watch	42.0 hr	3,677	-	1,027	-	-	112.00 /hr	4,704
01-58-08.00	BC-0505	Pumping system, bypass, diesel fuel, Jan 2023	688.8 gal	-	2,686	-	-	-	3.90 /gal	2,686
		_Bypass Pumping	**1.0 week**	**3,677**	**2,686**	**1,027**	**18,980**		**26,370.32 /week**	**26,370**
31230 Site Clearing										
31-13-13.10	0400	Selective clearing, brush, medium clearing, with dozer, ball and chain, excludes removal offsite	1.0 acre	893	-	940	-	-	1,832.55 /acre	1,833
		Site Clearing	**1,600.0 sf**	**893**		**940**			**1.15 /sf**	**1,833**
		01 Demolition		**4,570**	**2,686**	**1,967**	**18,980**			**28,203**
02 Civil										
31999 Slope										
31-23-23.17	0170	Fill, from stockpile, 130 HP, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	100.0 lcy	173	-	214	-	-	3.86 /lcy	386
31-23-23.16	0020	Fill by borrow and utility bedding, borrow, for embankments, 1 mile haul, spread, by dozer	100.0 lcy	193	2,100	252	-	-	25.45 /lcy	2,545
31-23-23.24	0600	Compaction, structural, common fill, 8" lifts, vibratory plate	120.0 bcy	364	-	88	-	-	3.76 /bcy	452
31-23-16.42	0260	Excavating, bulk bank measure, 2 C.Y. capacity = 165 C.Y./hr, backhoe, hydraulic, crawler mounted, excluding truck loading	29.6 bcy	31	-	25	-	-	1.89 /bcy	56
01-54-36.50	0020	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	2.0 ea	344	-	192	-	-	267.95 /ea	536
		Slope	**100.0 cy**	**1,104**	**2,100**	**771**			**39.75 /cy**	**3,975**
31999 Gravel Fill and Bolders										
31-32-19.16	1510	Geosynthetic soil stabilization, geotextile fabric, woven, heavy duty, 600 lb. tensile strength	222.2 sy	112	733	-	-	-	3.80 /sy	846
31-37-13.10	0370	Rip-rap and rock lining, random, broken stone, 300 lb. average, dumped	600.0 ton	1,339	19,200	1,410	-	-	36.58 /ton	21,949
31-37-13.10	0200	Rip-rap and rock lining, random, broken stone, 18" minimum thickness, machine placed for slope protection, not grouted	222.2 sy	18,862	4,778	9,722	-	-	150.13 /sy	33,363

Phase	Item	Description	Quantity		Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit		Total Net Amount
		Gravel Fill and Bolders	**1.0**	**LS**	**20,314**	**24,711**	**11,132**			**56,156.93**	**/LS**	**56,157**
32920 Plantings												
32-93-13.10	0012	Ground cover, plants, pachysandra, excludes preparation of beds	2.0	c	247	248	-	-	-	247.60	/c	495
31-32-19.16	1500	Geosynthetic soil stabilization, geotextile fabric, woven, 200 lb. tensile strength	200.0	sy	97	160	-	-	-	1.28	/sy	257
		Plantings	**1,800.0**	**sf**	**344**	**408**				**0.42**	**/sf**	**752**
		02 Civil			**21,762**	**27,219**	**11,903**					**60,884**
		01 Stacked Boulder Toe	**100.0**	**lf**	**26,332**	**29,905**	**13,870**	**18,980**		**890.87**	**/lf**	**89,087**
02 Soil Blanket												
01 Demolition												
01560 _Bypass Pumping												
01-58-08.00	BC-0115	Pumping system, bypass, 8-in pump, one primary pump, valves and 500 lf discharge piping, weekly rental	1.0	week	-	-	-	4,534	-	4,534.00	/week	4,534
01-58-08.00	BC-0215	Pumping system, bypass, 8-in pump, standby pump, weekly rental	1.0	week	-	-	-	813	-	813.00	/week	813
01-58-08.00	BC-0415	Pumping system, bypass, 8-in pump, ship, install, remove	1.0	ea	-	-	-	13,633	-	13,633.00	/ea	13,633
01-58-08.00	BC-0500	Pumping system, bypass, pump watch	42.0	hr	3,677	-	1,027	-	-	112.00	/hr	4,704
01-58-08.00	BC-0505	Pumping system, bypass, diesel fuel, Jan 2023	688.8	gal	-	2,686	-	-	-	3.90	/gal	2,686
		_Bypass Pumping	**1.0**	**week**	**3,677**	**2,686**	**1,027**	**18,980**		**26,370.32**	**/week**	**26,370**
31230 Site Clearing												
31-13-13.10	0400	Selective clearing, brush, medium clearing, with dozer, ball and chain, excludes removal offsite	1.0	acre	893	-	940	-	-	1,832.55	/acre	1,833
		Site Clearing	**1,600.0**	**sf**	**893**		**940**			**1.15**	**/sf**	**1,833**
		01 Demolition			**4,570**	**2,686**	**1,967**	**18,980**				**28,203**
02 Civil												
31999 Slope												
31-23-23.17	0170	Fill, from stockpile, 130 HP, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	185.9	lcy	321	-	398	-	-	3.86	/lcy	718
31-23-23.16	0020	Fill by borrow and utility bedding, borrow, for embankments, 1 mile haul, spread, by dozer	185.9	lcy	360	3,904	469	-	-	25.45	/lcy	4,733
31-23-23.24	0600	Compaction, structural, common fill, 8" lifts, vibratory plate	222.2	bcy	673	-	163	-	-	3.76	/bcy	836
01-54-36.50	0020	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	2.0	ea	344	-	192	-	-	267.95	/ea	536
		Slope	**185.9**	**cy**	**1,698**	**3,904**	**1,221**			**36.70**	**/cy**	**6,823**

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
31999 Gravel Fill										
31-32-19.16	1510	Geosynthetic soil stabilization, geotextile fabric, woven, heavy duty, 600 lb. tensile strength	222.2 sy	112	733	-	-	-	3.80 /sy	846
31-37-13.10	0200	Rip-rap and rock lining, random, broken stone, 18" minimum thickness, machine placed for slope protection, not grouted	277.8 sy	23,578	5,972	12,153	-	-	150.13 /sy	41,704
		Gravel Fill	**1.0 LS**	**23,691**	**6,706**	**12,153**			**42,549.13 /LS**	**42,549**
32920 Plantings										
32-93-13.10	0012	Ground cover, plants, pachysandra, excludes preparation of beds	0.5 c	62	62	-	-	-	247.60 /c	124
31-32-19.16	1500	Geosynthetic soil stabilization, geotextile fabric, woven, 200 lb. tensile strength	744.4 sy	361	596	-	-	-	1.28 /sy	956
32-92-19.13	0101	Seeding, mechanical seeding, 44 lb./M.S.Y.	2,200.0 sf	96	66	-	-	-	0.07 /sf	162
		Plantings	**2,200.0 sf**	**518**	**724**				**0.56 /sf**	**1,242**
		02 Civil		**25,907**	**11,333**	**13,374**				**50,614**
		02 Soil Blanket	**100.0 lf**	**30,476**	**14,020**	**15,341**	**18,980**		**788.17 /lf**	**78,817**
03 Riprap Blanket										
01 Demolition										
01560 _Bypass Pumping										
01-58-08.00	BC-0115	Pumping system, bypass, 8-in pump, one primary pump, valves and 500 lf discharge piping, weekly rental	1.0 week	-	-	-	4,534	-	4,534.00 /week	4,534
01-58-08.00	BC-0215	Pumping system, bypass, 8-in pump, standby pump, weekly rental	1.0 week	-	-	-	813	-	813.00 /week	813
01-58-08.00	BC-0415	Pumping system, bypass, 8-in pump, ship, install, remove	1.0 ea	-	-	-	13,633	-	13,633.00 /ea	13,633
01-58-08.00	BC-0500	Pumping system, bypass, pump watch	42.0 hr	3,677	-	1,027	-	-	112.00 /hr	4,704
01-58-08.00	BC-0505	Pumping system, bypass, diesel fuel, Jan 2023	688.8 gal	-	2,686	-	-	-	3.90 /gal	2,686
		_Bypass Pumping	**1.0 week**	**3,677**	**2,686**	**1,027**	**18,980**		**26,370.32 /week**	**26,370**
31230 Site Clearing										
31-13-13.10	0400	Selective clearing, brush, medium clearing, with dozer, ball and chain, excludes removal offsite	1.0 acre	893	-	940	-	-	1,832.55 /acre	1,833
		Site Clearing	**1,600.0 sf**	**893**		**940**			**1.15 /sf**	**1,833**
		01 Demolition		**4,570**	**2,686**	**1,967**	**18,980**			**28,203**
02 Civil										
31999 Slope										
31-23-23.17	0170	Fill, from stockpile, 130 HP, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	100.0 lcy	173	-	214	-	-	3.86 /lcy	386

Phase	Item	Description	Quantity		Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit		Total Net Amount
31999 Slope												
31-23-23.16	0020	Fill by borrow and utility bedding, borrow, for embankments, 1 mile haul, spread, by dozer	100.0	lcy	193	2,100	252	-	-	25.45	/lcy	2,545
31-23-23.24	0600	Compaction, structural, common fill, 8" lifts, vibratory plate	120.0	bcy	364	-	88	-	-	3.76	/bcy	452
01-54-36.50	0020	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	2.0	ea	344	-	192	-	-	267.95	/ea	536
		Slope	**100.0**	**cy**	**1,074**	**2,100**	**746**			**39.19**	**/cy**	**3,919**
31999 Gravel Fill and Bolders												
31-32-19.16	1510	Geosynthetic soil stabilization, geotextile fabric, woven, heavy duty, 600 lb. tensile strength	200.0	sy	101	660	-	-	-	3.81	/sy	761
31-37-13.10	0200	Rip-rap and rock lining, random, broken stone, 18" minimum thickness, machine placed for slope protection, not grouted	388.9	sy	33,009	8,361	17,014	-	-	150.13	/sy	58,385
		Gravel Fill and Bolders	**1.0**	**LS**	**33,110**	**9,021**	**17,014**			**59,145.72**	**/LS**	**59,146**
32920 Plantings												
32-93-13.10	0012	Ground cover, plants, pachysandra, excludes preparation of beds	2.0	c	247	248	-	-	-	247.60	/c	495
31-25-14.16	0300	Synthetic erosion control, jute mesh #2, stapled	233.3	sy	173	63	-	-	-	1.01	/sy	236
		Plantings	**2,100.0**	**sf**	**420**	**311**				**0.35**	**/sf**	**731**
		02 Civil			**34,604**	**11,432**	**17,760**					**63,796**
		03 Riprap Blanket	**100.0**	**lf**	**39,174**	**14,118**	**19,727**	**18,980**		**919.99**	**/lf**	**91,999**
06 Canal Restoration - Cast In Place Concrete Retaining Wall Bypass Option												
02 Civil												
01560 Bypass Pumping												
01-58-08.00	BC-0120	Pumping system, bypass, 12-in pump, one primary pump, valves and 500 lf discharge piping, weekly rental	12.0	week	-	-	-	101,172	-	8,431.00	/week	101,172
01-58-08.00	BC-0220	Pumping system, bypass, 12-in pump, standby pump, weekly rental	12.0	week	-	-	-	18,720	-	1,560.00	/week	18,720
01-58-08.00	BC-0420	Pumping system, bypass, 12-in pump, ship, install, remove	1.0	ea	-	-	-	31,079	-	31,079.00	/ea	31,079
01-58-08.00	BC-0500	Pumping system, bypass, pump watch	504.0	hr	44,481	-	12,419	-	-	112.90	/hr	56,900
01-58-08.00	BC-0505	Pumping system, bypass, diesel fuel, Jan 2023	10,967.0	gal	-	48,145	-	-	-	4.39	/gal	48,145
		Bypass Pumping	**12.0**	**week**	**44,481**	**48,145**	**12,419**	**150,971**		**21,334.66**	**/week**	**256,016**
31240 Dewatering Systems - Dry out Soil												
31-23-19.20	0100	Dewatering, excavate drainage trench, with backhoe, 2' wide x 3' deep	70.0	cy	707	-	149	-	-	12.23	/cy	856
31-23-19.20	1600	Dewatering, sump hole construction, includes excavation and gravel pit	27.0	cf	42	32	6	-	-	2.98	/cf	80

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
31240 Dewatering Systems - Dry out Soil										
31-23-19.20	0650	Dewatering, pumping 8 hours, attended 2 hours per day, 4" discharge pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose	5.0 day	1,318	-	257	-	-	315.03 /day	1,575
		Dewatering Systems - Dry out Soil	**5.0 unit**	**2,067**	**32**	**413**			**502.31 /unit**	**2,512**
31250 Shoring Systems										
31-41-16.10	1300	Sheet piling, steel, 22 psf, 15' excavation, per S.F., drive, extract and salvage, excludes wales	4,725.0 sf	52,540	29,697	34,902	-	-	24.79 /sf	117,139
		Shoring Systems	**4,725.0 sf**	**52,540**	**29,697**	**34,902**			**24.79 /sf**	**117,139**
31290 Excavation and Backfill of Retaining Wall										
31-23-16.42	4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	3,123.8 bcy	27,234	-	26,778	-	-	17.29 /bcy	54,012
31-23-23.23	7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	118.9 bcy	367	-	89	-	-	3.83 /bcy	455
31-23-23.16	0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	829.5 lcy	10,765	35,288	1,592	-	-	57.44 /lcy	47,645
31-23-23.23	7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	713.3 bcy	2,200	-	533	-	-	3.83 /bcy	2,733
31-23-23.16	0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	1,816.1 lcy	23,571	77,263	3,485	-	-	57.44 /lcy	104,319
31-23-23.23	7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	1,579.2 bcy	4,871	-	1,179	-	-	3.83 /bcy	6,050
31-23-23.19	BC-0011	Loading trucks, 2.5 C.Y. bucket, front end loader, wheel mounted	3,123.8 bcy	2,092	-	1,357	-	-	1.10 /bcy	3,449
31-23-23.18	0550	Hauling,excavated borrow material,loose cubic yards,10 mile round trip,.6 loads/hr ,base wide rate,12 cy truck,highway haulers,excludes loading	3,904.8 lcy	44,055	-	55,320	-	-	25.45 /lcy	99,375
02-22-03.30	BC-0006	Dump Charge, typical urban city, fees only, bldg constr mat'ls	4,705.2 ton	-	-	-	-	363,159	77.18 /ton	363,159
		Excavation and Backfill of Retaining Wall	**3,123.8 cy**	**115,155**	**112,550**	**90,332**		**363,159**	**218.07 /cy**	**681,197**
		02 Civil		**214,243**	**190,424**	**138,066**	**150,971**	**363,159**		**1,056,863**
03 Concrete										
03305 Retaining Wall Base Slab - 315 LF										
03-11-13.45	0150	C.I.P. concrete forms, footing, continuous wall, plywood, 4 use, includes erecting, bracing, stripping and cleaning	858.5 sfca	4,836	3,849	-	-	-	10.12 /sfca	8,685

Phase	Item	Description	Quantity		Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit		Total Net Amount
03305 Retaining Wall Base Slab - 315 LF												
03-15-05.95	3000	Form oil, up to 1200 S.F. per gallon, coverage, includes material only	2.3	gal	-	34	-	-	-	14.69	/gal	34
03-21-10.60	0500	Reinforcing steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	13.5	ton	25,434	19,009	-	-	-	3,284.99	/ton	44,443
03-21-10.60	2000	Reinforcing steel, unload and sort, add to base	13.5	ton	892	-	353	-	-	92.02	/ton	1,245
03-21-10.60	2210	Reinforcing steel, crane cost for handling, average, add	13.5	ton	969	-	384	-	-	100.02	/ton	1,353
03-31-05.35	0300	Structural concrete,ready mix,normal weight,4000 psi,includes local aggregate,sand,portland cement and water,excludes all additives and treatments	126.3	cy	-	24,915	-	-	-	197.32	/cy	24,915
03-31-05.70	2150	Structural concrete, placing, continuous footing, deep, pumped, includes vibrating, excludes material	126.3	cy	4,123	-	733	-	-	38.46	/cy	4,856
		Retaining Wall Base Slab - 315 LF	**120.3**	**cy**	**36,254**	**47,806**	**1,470**			**711.24**	**/cy**	**85,530**
03345 Reinforced Concrete Retaining Wall - 315 LF												
03-11-13.85	9260	Cip concret forms,walls,steel framed plywd,over 8'16'hg,based 50 us purchsd forms,4 us bracing lumber,includes erecting,bracing,stripping and cleaning	7,402.5	sfca	68,873	6,825	-	-	-	10.23	/sfca	75,698
03-11-13.85	0500	C.I.P. concrete forms, wall, wood bulkhead with 2 piece keyway, 1 use, includes erecting, bracing, stripping and cleaning	94.0	lf	1,485	483	-	-	-	20.94	/lf	1,968
03-15-13.50	3500	Waterstop, rubber, center bulb, split, 3/8" thick x 6" wide	84.0	lf	411	633	-	-	-	12.43	/lf	1,044
03-15-13.50	5205	Waterstop, rubber, field union, 3/8" x 6" wide, walls	7.0	ea	99	212	-	-	-	44.43	/ea	311
03-11-13.85	0625	Keyway, top of wall, 4 use, tapered wood, 2" x 4"	315.0	lf	421	66	-	-	-	1.55	/lf	488
03-15-05.95	3050	Form oil, up to 800 S.F. per gallon, coverage, includes material only	19.7	gal	-	521	-	-	-	26.40	/gal	521
03-21-10.60	0700	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	10.0	ton	13,153	14,043	-	-	-	2,721.01	/ton	27,197
03-21-10.60	2010	Reinforcing in place, unloading & sorting, add - walls, cols, beams	10.0	ton	659	-	261	-	-	92.02	/ton	920
03-21-10.60	2225	Reinforcing, crane cost for handling, add to above, walls, cols, beams	10.0	ton	716	-	284	-	-	100.02	/ton	1,000
03-31-05.35	0350	Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sand,portland cement and water,includes BC standard additives	119.9	cy	-	27,758	-	-	-	231.42	/cy	27,758
03-31-05.70	5350	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	119.9	cy	5,222	-	929	-	-	51.28	/cy	6,151
03-35-29.60	0050	Concrete finishing, walls, burlap rub with grout, includes breaking ties and patching voids	7,402.5	sf	11,525	274	-	-	-	1.59	/sf	11,799

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
		Reinforced Concrete Retaining Wall - 315 LF	114.2 cy	102,565	50,816	1,473			1,355.56 /cy	154,854
		03 Concrete		138,818	98,622	2,944				240,384
		06 Canal Restoration - Cast In Place Concrete Retaining Wall Bypass Option	315.0 lf	353,061	289,046	141,010	150,971	363,159	4,118.24 /lf	1,297,247
		01 Total		449,043	347,090	189,947	207,911	363,159		1,557,150

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		5,119 hrs	449,043	
Material			347,090	
Subcontract			207,911	
Equipment		2,166 hrs	189,947	
Other			363,159	
			1,557,150	**1,557,150**
Labor Mark-up	15.00 %		67,357	
Material Mark-up	10.00 %		34,709	
Subcontractor Mark-up	10.00 %		20,791	
Construction Equipment Mark-up	10.00 %		18,995	
Other - Process Equip Mark-up	8.00 %		29,053	
			170,904	**1,728,054**
Material Shipping & Handling	2.00 %		6,942	
Net Markups			**6,942**	**1,734,996**
Contractor General Conditions	15.00 %		260,249	
			260,249	**1,995,246**
Start-Up, Training, O&M				
				1,995,246
Undesign/Undevelop Contingency	30.00 %		598,574	
			598,574	**2,593,819**
Bldg Risk, Liability Auto Ins	2.00 %		51,876	
			51,876	**2,645,696**
Payment and Performance Bonds	1.50 %		39,685	
			39,685	**2,685,381**
Escalation to Midpoint (ALL)	4.00 %		107,415	
			107,415	**2,792,796**
Excise Tax				
Gross Markups				**2,792,796**
Total				**2,792,796**

Appendix H

Individual Site Repair Costs

CIP Cost Estimates – Original Sites								
Site ID	RS	Bank	Estimated Length, ft	Estimated Height, ft	Repair Priority	Primary Repair Option	Potentially Difficult Access	Total Planning Level Cost, $
wp295	15305	LB	13	7	Med	Wrapped Soil Lifts	Yes	30,000
wp284	16390	LB	48	8	High	Riprap Blanket	Yes	131,000
wp275	17442	LB	50	8	High	Wrapped Soil Lifts	Yes	117,000
wp266	18689	RB	100	9	High	Wrapped Soil Lifts	Yes	234,000
wp263	18702	LB	100	9	High	Wrapped Soil Lifts	Yes	234,000
wp260	19037	RB	40	8	High	Wrapped Soil Lifts	Yes	94,000
wp258	19080	LB	18	9	Low	Riprap Blanket		49,000
wp257	19119	RB	45	8	High	Wrapped Soil Lifts	Yes	105,000
wp255	19291	LB	18	9	Low	Riprap Blanket		49,000
wp250	19803	LB	60	9	Low	Riprap Blanket		163,000
wp246	20003	LB	25	9	Med	Riprap Blanket		68,000
wp242	20201	LB	164	9	Low	Riprap Blanket		442,000
wp236	20568	LB	14	8	Low	Riprap Blanket		38,000
wp235	20633	RB	35	8	High	Riprap Blanket		95,000
wp230	20889	LB	15	10	Low	Riprap Blanket		41,000
wp227	21058	RB	20	10	Low	Riprap Blanket		54,000
wp223	21337	LB	147	10	Low	Riprap Blanket		397,000
wp220	21521	RB	50	10	High	Wrapped Soil Lifts		117,000
wp219	21528	LB	80	10	High	Wrapped Soil Lifts		187,000
wp 708 wp 709 wp 710	22012	RB	313	9	High	Concrete Wall*	Yes	3,702,000
wp684	23383	RB	70	8	High	Wrapped Soil Lifts	Yes	164,000
wp676	24018	LB	100	8	Low	Riprap Blanket		272,000
wp665	24961	LB	75	12	Low	Riprap Blanket		204,000
wp657	25502	RB	100	15	Med	Riprap Blanket		272,000
wp656	25524	LB	100	15	High	Riprap Blanket		272,000
wp654	25621	LB	25	13	Med	Riprap Blanket		68,000
wp653	25644	RB	15	15	Low	Riprap Blanket		41,000
wp652	25674	LB	75	14	Low	Riprap Blanket		204,000
wp650	25690	RB	51	15	Low	Riprap Blanket		139,000
wp642	26053	RB	82	14	Low	Riprap Blanket		223,000
wp640	26194	RB	60	16	Low	Riprap Blanket		163,000
wp638	26254	LB	110	16	Med	Riprap Blanket		299,000
wp637	26325	LB	48	15	Low	Riprap Blanket		131,000
wp633	26519	RB	50	14	Low	Riprap Blanket		136,000
wp616	27064	RB	Unknown	13	Low	Riprap Blanket	Yes	**
wp614	27166	RB	50	14	Low	Riprap Blanket	Yes	136,000
wp613	27233	LB	17	14	Low	Riprap Blanket	Yes	46,000
wp610	27394	RB	70	14	Low	Riprap Blanket	Yes	191,000
wp579	29308	LB	26	13	Low	Riprap Blanket		71,000
wp577	29377	LB	40	13	Low	Riprap Blanket		109,000
wp572	29428	LB	50	14	Low	Riprap Blanket		136,000

CIP Cost Estimates – Original Sites

Site ID	RS	Bank	Estimated Length, ft	Estimated Height, ft	Repair Priority	Primary Repair Option	Potentially Difficult Access	Total Planning Level Cost, $
wp571	29435	RB	20	14	Low	Riprap Blanket		54,000
wp566	29608	LB	33	14	Low	Riprap Blanket		90,000
wp564	29654	LB	40	14	Low	Riprap Blanket		109,000
wp554	30467	RB	15	11	High	Riprap Blanket		41,000
wp541	32103	RB	40	9	Med	Riprap Blanket		109,000
wp516	34284	LB	25	11	Low	Riprap Blanket		68,000
wp515	34373	RB	12	12	Low	Riprap Blanket		33,000
wp513	34472	LB	100	11	Low	Riprap Blanket		272,000
wp509	34815	RB	60	9	Low	Riprap Blanket		163,000
wp498	35599	LB	24	8	Low	Riprap Blanket		65,000
wp491	35825	LB	29	11	Med	Riprap Blanket		79,000
wp473	37447	LB	25	12	Low	Riprap Blanket		68,000
wp471	37508	LB	unknown	11	Low	Riprap Blanket		**
wp469	37846	LB	100	10	Low	Riprap Blanket		272,000
wp467	37927	RB	13	9	Low	Riprap Blanket		35,000
wp465	38176	LB	24	10	Low	Riprap Blanket		65,000
wp462	38477	LB	7	12	Low	Riprap Blanket		19,000
wp454	39016	RB	70	9	High	Riprap Blanket		191,000
wp451	39263	RB	15	9	Low	Wrapped Soil Lifts		35,000
wp443	40097	LB	50	8	Low	Riprap Blanket		136,000
wp442	40101	RB	50	9	Low	Riprap Blanket		136,000
wp439	40260	RB	100	10	Low	Riprap Blanket		272,000
wp437	40420	LB	100	10	Low	Riprap Blanket		272,000
wp434	40824	LB	80	10	Low	Riprap Blanket		218,000
wp430	41101	RB	10	8	Low	Riprap Blanket		27,000
wp419	42391	LB	300	7	Low	Riprap Blanket		803,000
wp391	46367	LB	100	8	Low	Riprap Blanket		272,000
wp390	46452	LB	30	8	Low	Riprap Blanket		82,000
wp384	46870	LB	30	8	Low	Riprap Blanket		82,000
wp383	47295	RB	18	9	Low	Riprap Blanket		49,000
wp6	49567	LB	40	2	Low	Riprap Blanket		109,000
wp9	50049	LB	80	6	Low	Riprap Blanket		218,000
wp10	50095	LB	40	5	Low	Riprap Blanket		109,000
wp40	55986	LB	50	6	Low	Riprap Blanket		136,000
wp67	61368	LB	255	1	Low	Riprap Blanket		684,000
wp213	71608	LB	20	4	Low	Stacked Boulder Toe		53,000
wp193	75387	LB	55	10	High	Wrapped Soil Lifts	Yes	129,000

* Original sites WP 708/09/10 have merged into a single 315 ft long site. Cost shown is for structural wall solution spanning all three original sites.

** Cost not available since site length was not able to be determined due to field conditions.

CIP Cost Estimates – New Sites

Site ID	RS	Bank	Estimated Length, ft	Estimated Height, ft	Repair Priority	Primary Repair Option	Potentially Difficult Access	Total Planning Level Cost, $
1000	1238	LB	25	2	Low	Wrapped Soil Lifts		59,000
1002	6315	LB	15	6	Low	Riprap Blanket		41,000
1003	6467	RB	30	6	Low	Riprap Blanket		82,000
1005	7794	RB	30	6	Medium	Wrapped Soil Lifts		70,000
1006	10799	LB	35	4	Medium	Stacked Boulder Toe		92,000
1009	14140	LB	30	7	High	Wrapped Soil Lifts	Yes	70,000
1011	14431	LB	30	8	High	Wrapped Soil Lifts	Yes	70,000
1012	14882	LB	8	8	High	Wrapped Soil Lifts	Yes	19,000
1014	15105	LB	20	8	High	Wrapped Soil Lifts	Yes	47,000
1015	15169	LB	20	8	High	Wrapped Soil Lifts	Yes	47,000
1016	15347	RB	*	*	High	Riprap Blanket *	Yes	*
1017	15640	LB	35	6	High	Wrapped Soil Lifts	Yes	82,000
1018	15833	LB	30	7	High	Wrapped Soil Lifts	Yes	70,000
1019	15833	RB	35	7	High	Wrapped Soil Lifts	Yes	82,000
1020	16390	RB	100	7	Medium	Wrapped Soil Lifts		234,000
1022	16681	RB	40	7	High	Wrapped Soil Lifts		94,000
1023	16882	RB	40	7	High	Wrapped Soil Lifts		94,000
1024	16882	LB	15	7	High	Wrapped Soil Lifts	Yes	35,000
1025	17109	RB	50	7	Medium	Wrapped Soil Lifts		117,000
1026	17242	RB	50	6	Medium	Wrapped Soil Lifts		117,000
1027	17372	RB	50	6	Medium	Wrapped Soil Lifts		117,000
1028	17441	RB	15	6	Medium	Wrapped Soil Lifts		35,000
1029	17573	LB	25	6	High	Wrapped Soil Lifts	Yes	59,000
1030	17614	LB	60	6	High	Wrapped Soil Lifts	Yes	141,000
1031	17691	RB	147	6	High	Riprap Blanket		397,000
1032	18244	LB	15	7	High	Wrapped Soil Lifts	Yes	35,000
1033	18373	RB	40	7	High	Wrapped Soil Lifts	Yes	94,000
1034	18759	LB	40	7	High	Wrapped Soil Lifts	Yes	94,000
1035	18929	LB	40	6	Low	Wrapped Soil Lifts		94,000
1036	19291	RB	40	8	Medium	Wrapped Soil Lifts	Yes	94,000
1037	19475	LB	50	8	Low	Riprap Blanket		136,000
1038	19619	LB	40	7	Low	Riprap Blanket		109,000
1040	20348	LB	40	8	Low	Riprap Blanket		109,000
1041	21211	LB	20	8	Low	Riprap Blanket		54,000
1044	21574	RB	60	8	High	Wrapped Soil Lifts		141,000
1045	21764	LB	35	8	High	Wrapped Soil Lifts	Yes	82,000
1046	21764	RB	50	8	Medium	Wrapped Soil Lifts		117,000
1047	21901	LB	175	8	High	Wrapped Soil Lifts	Yes	405,000
1049	22351	LB	75	8	Medium	Wrapped Soil Lifts	Yes	176,000
1050	23577	LB	75	8	Medium	Wrapped Soil Lifts		176,000
1052	23701	LB	150	8	Low	Riprap Blanket		405,000
1053	23879	LB	60	8	Low	Riprap Blanket		163,000

CIP Cost Estimates – New Sites								
Site ID	RS	Bank	Estimated Length, ft	Estimated Height, ft	Repair Priority	Primary Repair Option	Potentially Difficult Access	Total Planning Level Cost, $
1054	23879	RB	30	8	Low	Riprap Blanket		82,000
1056	24080	LB	100	8	Low	Riprap Blanket		272,000
1057	24201	LB	15	8	Low	Riprap Blanket		41,000
1058	24201	RB	30	6	Low	Riprap Blanket		82,000
1059	24320	LB	15	8	Low	Riprap Blanket		41,000
1060	24497	RB	15	12	Low	Riprap Blanket		41,000
1061	24601	RB	50	10	Low	Riprap Blanket		136,000
1062	24631	LB	30	10	Low	Riprap Blanket		82,000
1063	24761	LB	12	10	Low	Riprap Blanket		33,000
1064	24856	LB	30	10	Low	Riprap Blanket		82,000
1065	24856	RB	75	10	Low	Riprap Blanket		204,000
1066	24977	RB	50	10	Low	Riprap Blanket		136,000
1067	25171	LB	80	10	Low	Riprap Blanket		218,000
1069	26326	RB	20	13	Low	Riprap Blanket		54,000
1070	26423	RB	25	15	Low	Riprap Blanket		68,000
1071	26498	LB	20	15	Low	Riprap Blanket		54,000
1073	26909	RB	25	15	Medium	Riprap Blanket		68,000
1074	28143	RB	60	6	Low	Riprap Blanket		163,000
1075	30106	RB	100	8	Low	Riprap Blanket		272,000
1077	30953	RB	50	8	Low	Riprap Blanket		136,000
1078	31196	LB	100	8	Low	Riprap Blanket		272,000
1079	31414	RB	50	8	Low	Riprap Blanket		136,000
1080	31775	RB	50	9	Low	Riprap Blanket		136,000
1081	32622	RB	100	6	Low	Riprap Blanket		272,000
1085	36301	RB	80	6	Medium	Riprap Blanket		218,000
1086	37893	LB	100	8	Low	Riprap Blanket		272,000
1087	38781	LB	40	8	Low	Riprap Blanket		109,000
1088	38960	LB	50	8	Low	Riprap Blanket		136,000
1089	39606	RB	60	8	Low	Riprap Blanket		163,000
1090	41299	RB	30	8	Low	Riprap Blanket		82,000
1092	46787	LB	30	8	Low	Riprap Blanket		82,000
1093	47478	LB	60	5	Low	Riprap Blanket		163,000
1094	48255	LB	25	7	Low	Riprap Blanket		68,000
1095	56119	LB	150	8	Low	Riprap Blanket		405,000
1096	56158	RB	40	8	Low	Riprap Blanket		109,000
1097	56659	RB	75	8	Low	Riprap Blanket		204,000
1098	57328	LB	150	5	Low	Riprap Blanket		405,000
1099	57328	RB	75	5	Low	Riprap Blanket		204,000
1100	59793	LB	75	4	Low	Riprap Blanket		204,000
1101	61971	LB	305	6	Low	Riprap Blanket		817,000
1102	61971	RB	15	8	Low	Riprap Blanket		41,000
1103	62353	RB	40	6	Low	Riprap Blanket		109,000

CIP Cost Estimates – New Sites								
Site ID	RS	Bank	Estimated Length, ft	Estimated Height, ft	Repair Priority	Primary Repair Option	Potentially Difficult Access	Total Planning Level Cost, $
1104	63615	RB	30	8	High	Wrapped Soil Lifts		70,000
1105	63636	LB	25	8	Low	Riprap Blanket		68,000
1106	64315	LB	130	8	Low	Riprap Blanket		352,000
1109	67126	RB	15	6	Medium	Riprap Blanket		41,000
1110	67673	LB	65	10	Low	Wrapped Soil Lifts		152,000
1111	67793	LB	30	12	Low	Wrapped Soil Lifts		70,000
1113	76268	LB/RB	240	5	Medium	Stacked Boulder Toe		623,000
1114	76856	LB	120	6	Medium	Riprap Blanket		326,000
1115	80495	LB	n/a	n/a	Medium	Tree Removal & Monitor		**
1116	80962	LB	n/a	n/a	Medium	Tree Removal & Monitor		**
1118	81481	LB	500	5	High	Wrapped Soil Lifts		1,143,000
1119	81697	RB	275	4	High	Wrapped Soil Lifts	Yes	632,000
1120	81990	RB	100	8	Medium	Stacked Boulder Toe		264,000
1123	83124	LB	60	3	Medium	Riprap Blanket	Yes	163,000

* Repair necessity, method, and extent may depend on footing depth and other requirements. Cost not developed.
** Costs not developed for tree removal projects