CITY OF PHOENIX

Water and Wastewater Unit Cost Study

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FINAL / August 2024

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Contents

Appendices

Tables

Figures

Abbreviations

$M	million dollars
AACE	Association for the Advancement of Cost Engineering
ACDC	Arizona Canal Diversion Channel
APS	Arizona Public Service
AWWA	American Water Works Association
BAF	biological aerated filter
BPS	booster pump station
CA&I	Construction Administration and Inspection
CIP	capital improvement projects
City	City of Phoenix
CMAR	Construction Manager at Risk
CMU	concrete masonry units
DIP	ductile iron pipe
DPR	direct potable reuse
ENR CCI	Engineering News Record Construction Cost Index
ft/sec	feet per second
GAC	granular activated carbon
gpd	gallons per day
HDPE	high-density polyethylene
HVAC	heating, ventilating, and air conditioning
in.	inch
MG	million gallons
mgd	million gallons per day
MH	manhole
N/A	not available
PFAS	polyfluoroalkyl substances
PRV	pressure reducing valve
psi	pounds per square inch
PVNGS	Palo Verde Nuclear Generating Station
RCP	reinforced concrete pipe
RO	reverse osmosis
TBD	to be determined
TDH	total dynamic head
UCS	Unit Cost Study
UF	ultrafiltration
UV AOP	ultraviolet advanced oxidation process
VCP	vitrified clay pipe
WRA	Whitman, Requardt & Associates, LLP
WRF	water reclamation facility
WRP	water reclamation plant

WSD	Water Services Department
WSP	welded steel pipe
WWTP	wastewater treatment plant

SECTION 1 INTRODUCTION

1.1 Background

The City of Phoenix (City) uses water and wastewater infrastructure unit costs for infrastructure planning, developing financing plans, and budgeting for impact fee funded capital improvements and projects that are driven by growth. The City updates unit costs every five years. The purpose of this Water and Wastewater Unit Cost Study (UCS) is to update these unit costs for the next several years.

The City's Water Services Department (WSD) is required to project future land use development, water and wastewater demands, and identify necessary water and wastewater infrastructure improvements to meet water and wastewater needs of a growing customer base. The WSD allocates the costs for new water and wastewater infrastructure to different types of customers and determines how costs should be fairly allocated between existing customers and future development. Infrastructure unit costs play a key role in this process.

Where possible, the unit costs were developed using infrastructure described by the City's Design Guidance Manuals. Unit costs were developed from information provided by manufacturers and vendors, recent City projects, bid tab information, job order contracts, and unit cost databases.

The UCS was last updated in 2018. In 2022, the City contracted with Carollo to update water and wastewater unit costs. The updated unit costs are summarized in this report. An Excel file that accompanies the report contains the detailed unit cost information, with built in flexibility to adjust some cost multipliers to adapt unit costs to specific projects, and to update the cost of individual infrastructure components as these costs change in time.

1.2 Purpose

The purpose of this report is to present the unit costs for water and wastewater infrastructure, and to provide background information and assumptions upon which the unit costs are based. This unit cost information will help the City's WSD plan the cost of future impact fee funded capital improvement projects (CIP) and budget expansion of water and wastewater systems to serve the City's water and sewer customers. Unit cost information will also help the City to fairly allocate costs between current and future customers.

1.3 Unit Cost Study Scope

Table 1 presents the water pipelines and infrastructure facilities and sizes for which unit costs are established. Table 2 presents the wastewater pipelines and infrastructure facilities for which unit costs are established.

At the City's request, the cost per gallon of wastewater treatment with a focus on advanced treatment costs are also included for planned construction or expansion of the North Gateway Water Reclamation Plant (WRP), Cave Creek Water Reclamation Facility (WRF), and 91st Avenue WRF, including the costs of advanced treatment. These costs are provided as a means of allocating water resource development costs for future water reclamation activities. These costs were developed as a part of other projects and brought together in one location for this project.

At the City's request, the cost to expand the Deer Valley and 24th Street water treatment plants is also included in the study.

Table 1 Water Pipelines and Infrastructure Facilities Included in Unit Cost Study

Facility	Units	Size
Water Pipeline(1)	in.	6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90
Booster Pump Station (BPS)(2)	mgd	5, 10, 15, 20, 30, 40, 60
Pressure Reducing Valve Station(2)	mgd	1, 3, 5, 10, 20, 30, 40, 50, 60, 70
Wells	mgd	1, 1.5, 3
Wellhead Treatment	mgd	1, 1.5, 3
Steel Storage Tank	MG	2, 3
Concrete Reservoir	MG	2, 3, 5, 10, 15, 20, 30, 40

Notes:
in. - inch(es); mgd - million gallons per day; MG - million gallons
(1) Pipe material varies by diameter according to the City's design guidelines.
(2) Includes unit costs for phased facilities.

Table 2 Wastewater Pipelines and Infrastructure Facilities Included in the Unit Cost Study

Facility	Units	Size
Gravity Sewer Main(1)	in.	8, 12, 15, 16, 18, 20, 21, 24, 27, 30, 33, 36, 39, 42, 48, 54, 60, 66, 72, 81, 84, 87, 90
Sewer Force Main(1)	in.	4, 6, 8, 10, 12, 14, 16, 20, 24, 30
Sewer Lift Station(2)	mgd	1, 3, 3.5, 5, 8, 12, 16, 25, 40

Notes:
(1) Pipe material varies by diameter according to the City's design guidelines.
(2) Includes unit costs for phased facilities.

1.4 Report Organization

This report is organized in the following sections:

- Methodology - This section contains a description of the methods used to develop the unit cost model.
- General Construction Costs - This section addresses the cost items needed to obtain a construction cost, which is the cost a contractor would bid to do the job, and Construction Manager at Risk (CMAR) unit cost from the direct costs.
- Remote Water Facilities - This section contains the parameters and assumptions for water facilities.
- Wastewater Facilities - This section contains the parameters and assumptions for wastewater facilities.
- Wastewater Treatment - This section contains the costs per unit of capacity for the 91st Ave WWTP, North Gateway WRF, and Cave Creek WRF.
- Water Treatment - This section contains the costs per unit of capacity for water treatment for the 24th Street and Deer Valley water treatment facilities.

SECTION 2 METHODOLOGY

2.1 Design Guidelines

City standard drawings were used to determine layouts and components of facilities where standard drawings exist. Where facilities that did not have standard drawings in the City's design manuals, facility components were determined using project bid packages.

The following resources were used to identify the components of facilities that were costed:

- City of Phoenix WSD Water Remote Facilities Design Guidance Manual, 2013 (Design Guidance Manual).
- City of Phoenix WSD Design Standards Manual for Water and Wastewater Systems, 2021.
- City of Phoenix WSD Lift Station Design Guidance Manual, 2012 (Lift Station Design Guidance Manual).

To identify components that were not included in the standards and guidance manuals, meetings were conducted with the WSD Remote Facilities, Water Pipeline, Sewer Lift Station, and Sewer Pipeline groups to identify the following information needed to develop unit costs:

- Size range for each facility type.
- Pipe materials and size ranges for each pipe material.
- Infrastructure components for each facility type.
- Categories of cost items that need to be applied to different facility types.

2.2 Unit Cost Model

2.2.1 Cost Development Approach

Unit costs for each facility and pipeline were created by applying the following steps:

1. Identify the infrastructure components that are assembled to create a facility.
2. Calculate the material, labor, and equipment cost of each component.
3. Sum the costs of individual components to obtain a direct cost.
4. Project level costs including contractor overhead and profit, sales tax, and general conditions are calculated as a percentage of the direct cost and then summed to obtain a construction cost, which is the price a contractor would expect to be paid to construct the facility.
5. Apply a multiplier of 15 percent to the construction cost to also obtain the cost for the CMAR alternate delivery procurement method.

Engineering design, construction administration, permitting and City fees have not been included in this cost model.

A unit cost spreadsheet tool has been created to calculate unit costs. The spreadsheet contains a database of individual cost components, and individual unit cost sheets for water and wastewater remote facilities, water pipelines, and sewer pipelines. The spreadsheet contains details of the components that are included in each unit cost. The spreadsheet is designed to be updated as individual cost components change. Key parameters in each unit cost spreadsheet can be changed to adapt the costs to the requirements of specific projects. Appendix A contains information useful to use the spreadsheet.

2.2.2 Data Sources

The following sources of information were used to obtain cost data that was used to develop the unit costs:

1. Bid tabs and Job Order Agreements from 2020 to 2022 provided by the City. Most of this information came from rehabilitation projects, so the number of new construction projects was limited.
2. Recent construction project information available to Carollo.
3. Vendors and manufacturers.
4. Cost databases include R.S. Means and Carollo Engineers, Inc., unit cost database.

2.2.3 Cost Escalation

Construction cost estimates used for planning purposes have often been escalated using the Engineering News Record Construction Cost Index (ENR CCI), which is a general construction index based on a 20-city average of common labor rates, structural steel, Portland cement, and two-by-four lumber with a base year of 1913. While this index, which is published monthly, has been a convenient and a frequently utilized tool for budgetary construction cost escalation across many industries for decades, costs for construction of water and wastewater infrastructure projects have escalated at a higher pace than increases in the ENR CCI since early 2020, when the contractor community and manufacturing network that support the water/wastewater industry experienced significant disruptions and resource shortages due to COVID-19, and in 2022 and early 2023 significantly higher inflation rates. These labor and supply chain impacts for materials and equipment have resulted in cost increases that exceed historical general construction trends.

Whitman, Requardt & Associates, LLP (WRA), based in Baltimore, Maryland, has published the Handy Whitman Index® of Public Utility Construction Costs™ continuously since 1924. This publication is updated semi-annually in January and July and documents historical cost trends in electric utility, building construction, gas utility, and water utility construction over six geographical regions. The Handy-Whitman index is based on basic materials, equipment, wage rates, and other prices specific to common types of construction in each market. The water utility construction index is based on the following types of construction and equipment:

- Water source facilities.
- Pumping plants.
- Treatment plants.
- Transmission facilities (reservoirs, tanks, mains).
- Distribution facilities (pipelines, meters, hydrants).
- Miscellaneous items (specifically flocculation, clarification, and filter gallery equipment).

WRA develops a separate index for six geographical regions with similar characteristics throughout the United States to account for differing regional cost trends. Arizona is part of the Plateau region, which includes Arizona, New Mexico, Nevada, Utah, Colorado, Idaho, Wyoming, and Montana. Figure 1 shows a comparison of the ENR CCI, Handy-Whitman USA Average, and Handy-Whitman Plateau Region Index of Water Utility Construction Costs from 2010 until the present. As shown in Figure 1, the growth rate of the Handy-Whitman Water Utility Construction indices outpaced that of the ENR CCI over the past three years and the most recent data point indicates the Handy-Whitman escalation has slowed down and is now similar to the ENR CCI escalation. Since the Handy Whitman Index provides a better representation of cost escalation for costs that have been obtained prior to 2023 compared to ENR CCR. Costs in the cost model have been updated to September 2023. In the UCS, when bid tab costs of previous costs needed to be updated to current costs, the Handy Whitman Plateau Region cost index was used to update the costs.

The consequence of the unusual cost escalation that has occurred in the past five years is that the unit costs in this 2024 Water and Wastewater UCS are significantly higher than the costs in the City's 2019 UCS. As examples, the cost of a 12-inch ductile iron water main with pavement replacement is currently $490 per foot verses $353 per foot in the 2019 study. The cost of a well with an 18-inch casing is $5.6 million versus $3.8 million in the 2019 study. The cost of a 20-mgd pump station is $12.1 million versus $9.8 million in the 2019 study.

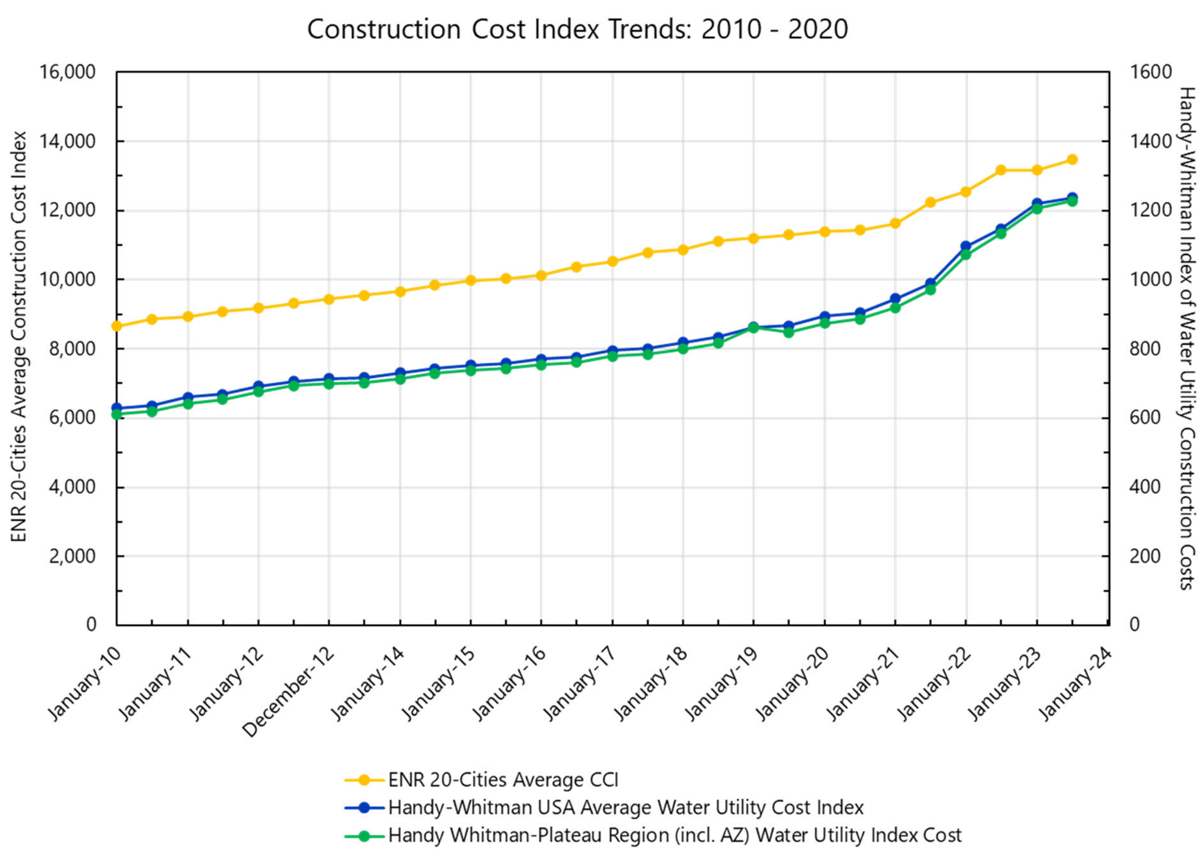


Figure 1 Comparison of ENR CCI and Handy-Whitman Water Utility Construction Cost Indices

2.2.4 Cost Accuracy

Cost model estimates are Association for the Advancement of Cost Engineering (AACE) Class 5 planning level costs. Unit cost estimates were prepared in accordance with the guidelines of the AACE International for a Class 5 estimate unless otherwise noted. Table 3 summarizes the AACE International cost estimating classifications, the level of project definition (percent of design), use, appropriate cost estimating methodologies, and the expected accuracy of each class. Design work would need to be undertaken to obtain more precise cost estimates.

Table 3 AACE International Cost Estimating Classification Summary

Estimate Class	Maturity Level of Project Definition Deliverables - (Level of Engineering Design)	End Use	Typical Cost Estimating Methodology Used	Expected Accuracy Range (Low/High)
Class 5	0% to 2%	Conceptual screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -10% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

SECTION 3 CONSTRUCTION COST ASSUMPTIONS

The following sections describe components of the unit costs that are included in more than one set of unit costs.

3.1 Pipelines

Pipeline unit costs include the following:

1. Trenching and subgrade excavation.
2. Backfill with Class B material.
3. Pavement cut and replacement, with micro seal across half of the street width.
4. Fittings, isolation valves, and manholes (MH) where needed.
5. Bypass pumping.
6. Traffic control.

3.2 Pump Stations, PRV Stations, Wells, and Lift Stations

Remote facilities is a term the City uses to refer to pump stations, pressure reducing valves (PRV), wells, and lift stations. The following cost components are included for these remote facilities:

1. Excavation and sitework.
2. A perimeter block wall with an access gate.
3. On-site structures.
4. Mechanical equipment.
5. Landscaping.
6. Site security.
7. Surge relief equipment.
8. A Salt River Project engineering design fee is required for facilities that require significant amounts of electricity.

3.3 Electrical & Instrumentation

Electrical and instrumentation costs include the following:

1. Power supplies, electrical equipment, wiring, conduit.
2. Security systems.
3. Supervisory control and data acquisition.
4. Electrical building.

Bid tabs and previous projects were evaluated to determine the percentage of the direct cost that would approximate electrical and instrumentation costs. Electrical costs were typically between 10 percent and 40 percent of direct costs. The percentage varies by facility type.

3.4 Painting & Coatings

Painting and coating costs include the following:

1. Exterior coatings and painting for exposed piping.
2. Interior coatings for storage tanks and reservoirs.
3. Building interior and exterior painting.

Bid tabs and previous projects were evaluated to determine the percentage of the direct cost to estimate painting and coating costs for each facility type.

Painting and coating costs are assumed to be 10 percent of total construction costs.

3.5 Disinfection

The City typically uses bulk sodium hypochlorite at 12.5 percent concentration for chlorine disinfection. These disinfection systems may be installed at future remote facilities.

Not all facilities will require disinfection so disinfection costs can be removed for facilities that do not require disinfection.

Disinfection equipment is stored in a building with electrical power and heating, ventilating, and air conditioning (HVAC), so the cost estimate includes the building.

The disinfection cost varies between 10 percent and 40 percent of the direct cost depending on the facility size.

3.6 Overhead, Profit, and Sales Tax

The following costs are included in the construction cost and can be adjusted:

1. Contractor overhead, estimated at 10 percent.
2. Contractor profit, estimated at 6 percent.
3. Sales tax, estimated at 8 percent for 65 percent of the construction cost.
4. General conditions, estimated at 10 percent.

3.7 Design, Construction Management, and Administration Costs

The following costs are not included in the construction cost but can be estimated based on construction cost:

1. Design. The City estimates the engineering design cost to be 15 percent of the construction cost.
2. Construction Administration and Inspection (CA&I). The City estimates CA&I costs to be 10 percent of the construction cost.
3. Contingencies. The City typically does not include additional contingencies in the impact fee funded CIP cost.
4. City administration. The City does not include administration costs in the budgeted impact fee funded CIP costs.
5. Property acquisition. The City calculates property acquisition costs based on the specific requirements of a project.

3.8 Future Cost Adjustments to Accommodate Inflation

Cost estimates in the UCS can be adjusted in the future to accommodate inflation. Current inflation rates are approximately five percent per year, but the City can adjust the escalation rate based on actual cost increases. To adjust the unit cost, the Phoenix_Unit_Cost_Template spreadsheet can be edited by adjusting the Unit Cost Database sheet. The Material Unit Cost, Labor Unit Cost, Const. Equip Cost, Sub Unit Cost, and Other Unit Cost (Columns E through I) will incorporate inflation by using the equation:

Updated cost = Original cost(1+annual escalation rate)^years after 2024*

All other equations in the Total Direct Unit Cost (Column J) and the values in this column will update automatically with the other updates. All costs in each unit cost infrastructure sheet are taken from the Total Direct Unit Cost column in the Unit Cost template spreadsheet so the unit costs are automatically updated when the Total Direct Unit Cost is updated.

SECTION 4 WATER FACILITIES

4.1 Water Distribution and Transmission Pipelines

4.1.1 Pipe Materials and Sizing

The City standards allow ductile iron pipe (DIP) up to 54 inches and welded steel pipe (WSP) from 24 inches to 90 inches. Pipe materials used for each diameter are presented in Table 4.

Table 4 Water Pipeline Material, Diameter and Excavation Information

Diameter (in.)	Material		Excavation	
	Ductile Iron Pipe	Welded Steel Pipe	Trench Depth (feet)	Trench Width (feet)
6	✓		4.0	3.83
8	✓		4.0	4.00
10	✓		6.0	4.17
12	✓		6.0	4.33
16	✓		8.0	4.67
18	✓		8.0	5.08
24	✓	✓	8.0	5.25
30	✓	✓	8.0	5.58
36	✓	✓	8.0	6.50
42	✓	✓	10.0	7.00
48	✓	✓	10.0	8.00
54	✓	✓	12.0	8.50
60		✓	12.0	9.00
66		✓	12.0	9.50
72		✓	14.0	11.00
78		✓	14.0	11.50
84		✓	16.0	12.00
90		✓	16.0	13.17

4.1.2 Assumptions for Cost Estimation

Table 5 presents the assumptions used to develop costs, including the typical trench excavation depth.

Table 5 Assumptions for Water Pipeline Cost Estimates

Condition	Guideline/Assumption
Pipeline Bury Depth	
Distribution and Transmission Main	4 feet (6 in. to 8 in. diameter)
	6 feet (10 in. to 12 in. diameter)
	8 feet (16 in. to 30 in. diameter)
	10 feet (36 in. to 42 in. diameter)
	12 feet (48 in. to 54 in. diameter)
	14 feet (60 in. diameter)
	16 feet (66 in. to 78 in. diameter)
	17 feet (84 in. to 90 in. diameter)
Valves	
Line Valves (12 in. to 36 in.)	Direct bury gate or butterfly valves
Line Valves (>36 in.)	Butterfly valve with bypass assembly
Valve Spacing:	2 per mile (7 per mile for distribution mains and 2 per mile for transmission mains)
Excavation type	Hard digging

4.1.3 Unit Costs

Costs for easy, medium, hard, and hard rock excavation are in the unit cost spreadsheet. Hard excavation is assumed for the cost tables in this report. Costs include pavement replacement for the trench and microseal for the street width.

Table 6 presents unit costs for ductile iron and WSP. The construction cost is the design-bid-build cost and the CMAR cost is the cost for the CMAR project procurement method. Table 7 presents pipeline costs without pavement costs included.

Table 6 Ductile Iron and Welded Steel Pipeline Cost Summary

	Ductile Iron Pipe		Welded Steel Pipe	
Diameter (in.)	Construction Cost/ft. ($)	CMAR Cost/ft. ($)	Construction Cost/ft. ($)	CMAR Cost/ft. ($)
6	350	400	-	-
8	410	470	-	-
10	450	520	-	-
12	490	560	-	-
16	670	770	-	-
20	790	910	-	-
24	950	1,090	980	1,130
30	1,420	1,630	1,230	1,410
36	1,890	2,170	1,500	1,730
42	2,140	2,460	1,670	1,920
48	2,530	2,910	2,000	2,300
54	2,790	3,210	2,630	3,020
60	-	-	2,880	3,310
66	-	-	3,490	4,010
72	-	-	3,690	4,240
78	-	-	4,650	5,350
84	-	-	5,340	6,140
90	-	-	5,810	6,680

Table 7 Ductile Iron and Welded Steel Pipeline Cost Summary without Pavement Cost

Diameter (in.)	Ductile Iron Pipe		Welded Steel Pipe	
	Construction Cost/ft. ($)	CMAR Cost/ft. ($)	Construction Cost/ft. ($)	CMAR Cost/ft. ($)
6	210	240	-	-
8	260	300	-	-
10	310	360	-	-
12	350	400	-	-
16	510	590	-	-
20	650	750	-	-
24	780	900	830	950
30	1,240	1,430	1,040	1,200
36	1,710	1,970	1,320	1,520
42	1,950	2,240	1,670	1,920
48	2,320	2,670	1,790	2,060
54	2,570	2,960	2,410	2,770
60	-	-	2,630	3,020
66	-	-	3,210	3,690
72	-	-	3,420	3,930
78	-	-	4,380	5,040
84	-	-	5,040	5,800
90	-	-	5,490	6,310

4.1.4 Costs for Pipeline Crossing a Freeway

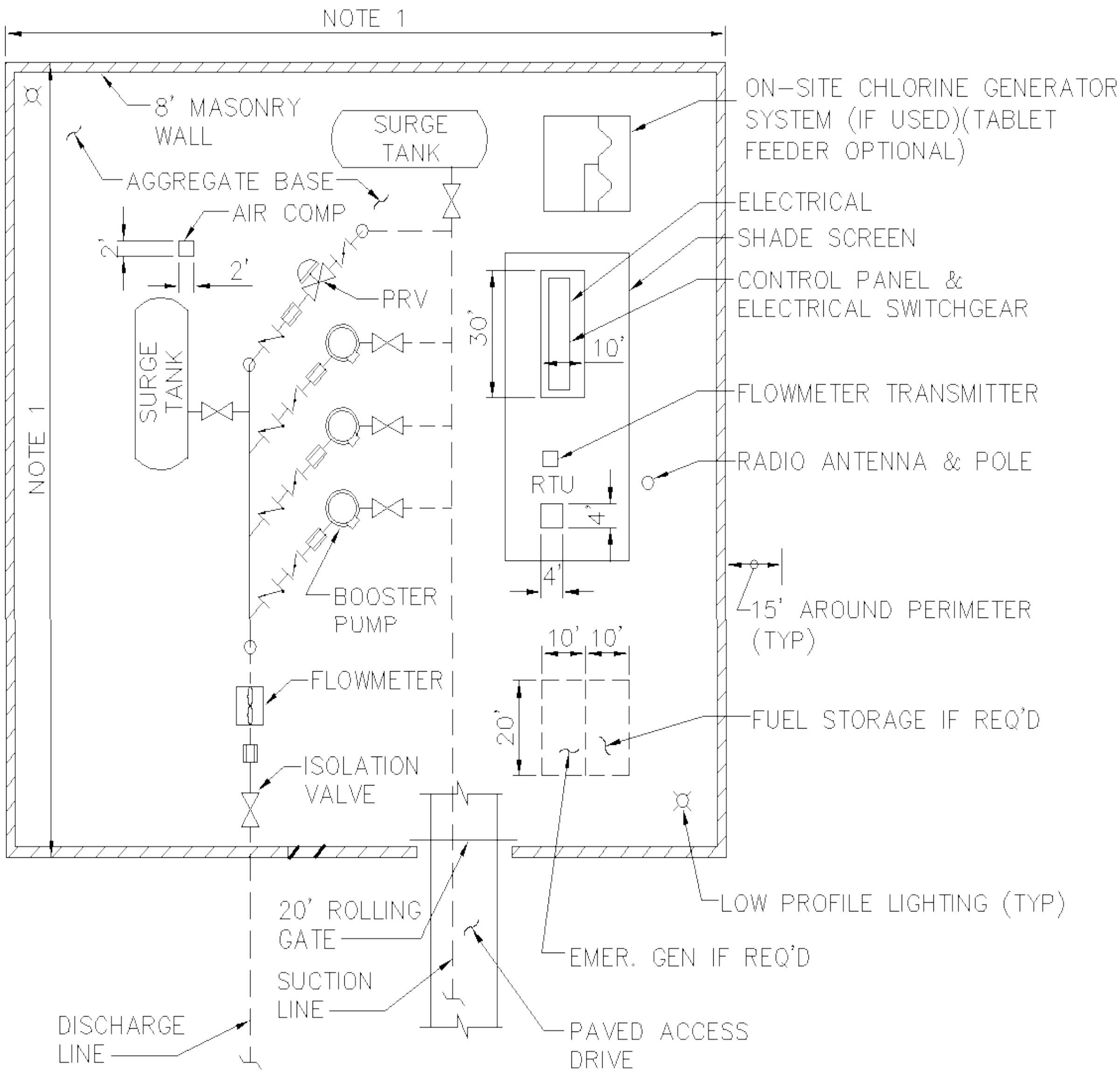
Table 8 shows the additional costs associated with a single-line pipeline crossing a freeway per linear foot (lf) for various pipe diameters. A pipe sleeve diameter of 12 inch on all sides of the pipe is assumed. The estimates do not cover the pipeline running inside the sleeve, which are included in Table 7.

Table 8 Costs for Pipeline crossing freeway

Diameter of the Pipe (in.)	Developed Costs for Single-Lane Pipeline Crossing a Freeway ($/lf)
16, 20, 21	$1,340
24, 27, 30 ,33 ,36 ,39 ,42	$2,680
48, 54, 60, 66	$4,830
72, 78, 81, 84, 87, 90	$5,360

4.2 Booster Pump Stations

The pump station layout is based on the template from the Design Guidance Manual with comments from City staff. Figure 1 presents the typical BPS layout from the Design Guidance Manual.



NOTE:
1. ON COMBINED BOOSTER PUMP PRV SITE USE 80'x100' FOR FACILITY DIMENSION AND 100'x130' OVERALL DIMENSION. FOR 30 MGD CAPACITY AND LESS USE 80'x120' FOR FACILITY DIMENSION AND 110'x150' OVERALL DIMENSION.

Figure 2 Typical Booster Pump Station Layout

4.2.1 Capacity

Pump station costs are calculated for 5, 10, 15, 20, 30, 40, and 60 mgd pump stations.

4.2.2 Assumptions for Cost Estimation

Table 9 presents the BPS design assumptions.

Table 9 Booster Pump Station Assumptions for Cost Estimation

Condition	Guideline/Assumption	
Hydraulics		
BPS Capacity	4 pumps (5 to 10 mgd)	
	5 pumps (15 to 30 mgd)	
	6 pumps (40 to 60 mgd)	
Mechanical Pumps and Surge Relief		
Pumps	Can type, vertical turbine centrifugal pump	
	80% Efficiency	
	145 feet TDH	
Hydropneumatic Surge Tank	Above grade steel hydropneumatic surge tank with a compressor and appurtenances	
	5,000-gallon suction (5 to 10 mgd) 10,000-gallon discharge (5 to 10 mgd)	
	10,000-gallon suction (15 to 20 mgd) 20,000-gallon discharge (15 to 20 mgd)	
	20,000-gallon suction (30 mgd) 30,000-gallon discharge (30 mgd)	
	30,000-gallon suction (40 mgd)	
	40,000-gallon discharge (40 mgd)	
	50,000-gallon suction (60 mgd) 60,000-gallon discharge (60 mgd)	
Mechanical Piping		
Pipe Material	<42 in. diameter	Flanged DIP with polyethylene encasement
	>42 in. diameter	Welded steel water pipe
Velocity	3 ft/sec suction header velocity	
	10 ft/sec pump train velocity	
	5 ft/sec discharge header velocity	
Mechanical Equipment		
Pipe Supports	Steel for pipes <= 30 in. Concrete for pipes > 30 in.	
Gate Valve	Resilient wedge gate valve Isolation valve	
Check Valve	250 psi swing check valve	
Butterfly Valve	150 psi Butterfly valve Isolation valve	
Air/Vac Valve	300 psi air/vac valve with shutoff	

Condition	Guideline/Assumption
Site Work	
Site Size	≤30 mgd, 80 ft. by 120-ft. site footprint
	>30 mgd, 125 ft. by 125-ft. site footprint
Access Road	20 feet minimum width asphalt
Access Gate	Double swing gate, chain link, 20-ft. opening
Facility Enclosure	8 ft. CMU block wall
Ground Surface Finish	2-in. thick compacted aggregate base
Storm Water Retention Basin	Basin sized to accommodate runoff from entire site
Structures	
Pump	12-in. thick concrete foundation
Surge Vessel	12-in. thick concrete foundation
Electrical/Chlorine Building	12-in. thick concrete foundation Precast concrete building
Valve Vault	5-ft. precast concrete valve box

TDH - total dynamic head; ft/sec - feet per second; psi - pounds per square inch; CMU - concrete masonry units

4.2.3 Unit Costs

Table 10 presents the BPS unit cost summary when the pump station is constructed in one phase.

Table 10 Booster Pump Station Cost Summary

Site Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
5	4,542,000	6,305,000	7,251,000
10	5,533,000	7,636,000	8,781,000
15	7,344,000	10,070,000	11,581,000
20	8,856,000	12,103,000	13,918,000
30	9,959,000	13,586,000	15,624,000
40	12,339,000	16,783,000	19,300,000
60	13,945,000	18,943,000	21,784,000

When a booster station is constructed in phases, the Phase 1 costs include the facility sized for buildout except for the pump trains that will be added or replaced at a later date. Phase 2 costs include upgrades to electrical equipment, additional pump trains, and upsized pumps. Table 11 presents the phased booster station costs.

Table 11 Phased Booster Pump Station Cost Summary

Site Capacity (mgd)	Initial or Buildout Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
5	(1 Initial)	3,573,000	5,001,000	5,751,000
	(5 Buildout)	956,000	1,485,000	1,708,000
30	(5 Initial)	7,162,000	9,826,000	11,300,000
	(30 Buildout)	4,196,000	5,840,000	6,716,000
40	(20 Initial)	10,350,000	14,110,000	16,227,000
	(40 Buildout)	5,420,000	7,484,000	8,607,000
60	(20 Initial)	12,103,000	16,466,000	18,936,000
	(60 Buildout)	5,714,000	7,879,000	9,061,000

4.3 Pressure Reducing Valve Station

Figure 2 presents a typical PRV Station layout from the Design Guidance Manual.

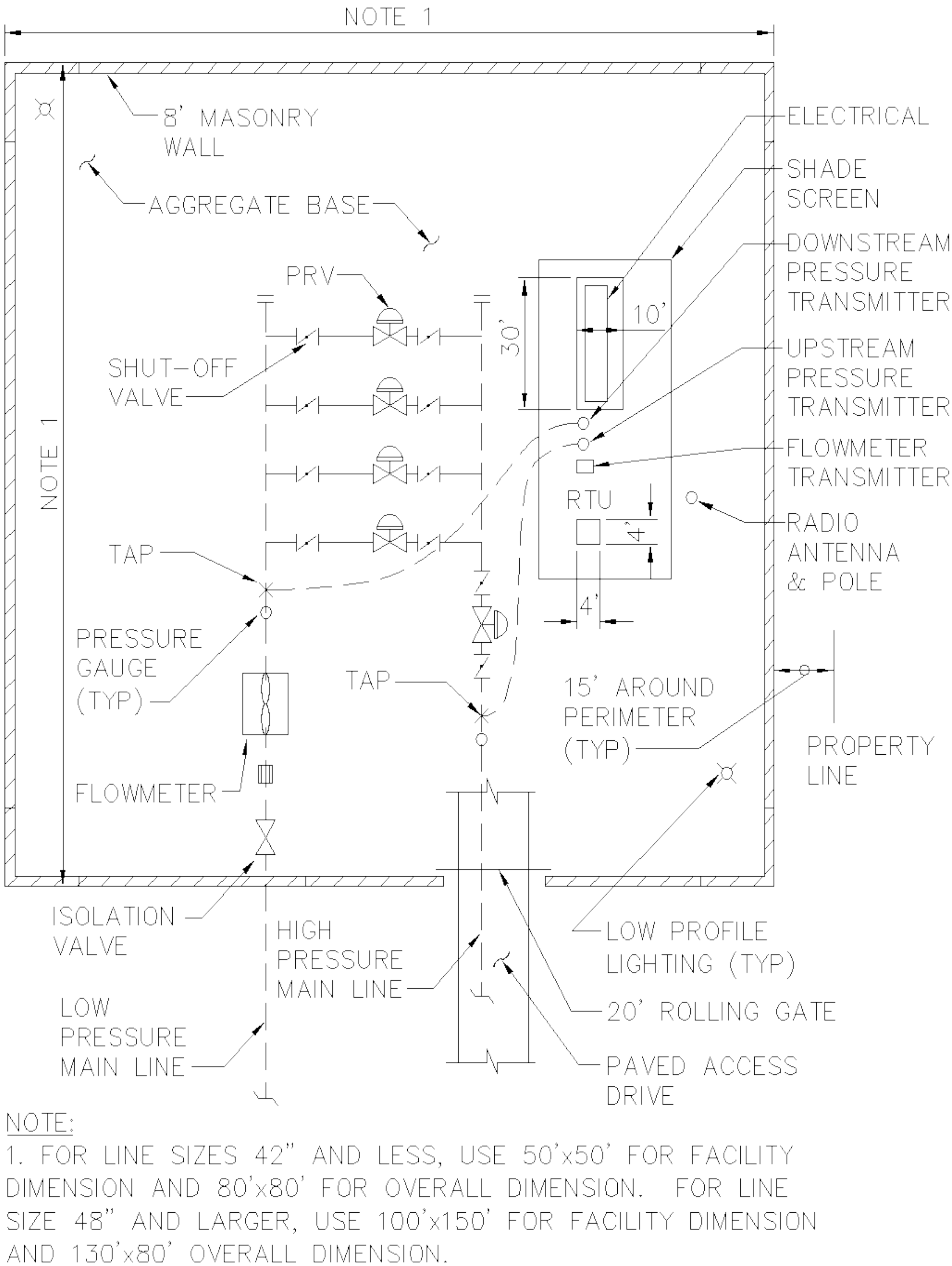


Figure 3 Typical PRV Station Layout

4.3.1 Capacity

Unit costs have been created for 1, 3, 5, 10, 20, 30, 40, 50, 60, and 70 mgd PRV stations.

4.3.2 Assumptions for Cost Estimation

Table 12 presents the assumptions for cost estimation for PRV stations.

Table 12 Pressure Reducing Valve Station Assumptions for Cost Estimation

Condition	Guideline/Assumption	
Hydraulics		
PRV Capacity	2 trains (1 to 5 mgd)	
	3 trains (10 to 30 mgd)	
	5 trains (40 to 70 mgd)	
Mechanical		
PRV	Steel PRV Hydraulically operated, direct acting, single seated. Up to 10 ft/sec is allowed through PRV lines.	
Mechanical Piping		
Pipe Material	<42 in. diameter	Flanged DIP with polyethylene encasement
	>42 in. diameter	Welded steel water pipe
Velocity	3 ft/sec suction header velocity	
	10 ft/sec PRV train velocity	
	5 ft/sec discharge header velocity	
Mechanical Equipment		
Pressure Reducing Valve	150 psi pressure reducing valve	
Flow Control Valve	250 psi swing check valve	
Butterfly Valve	150 psi Butterfly valve Isolation valve	
Air/vac Valve	300 psi air/vac valve with shutoff	
Site Work		
Site Size	Line size ≤ 42 in., 50 ft. by 50 ft. site footprint	
	Line size > 42 in., 100 ft. by 150 ft.	
Access Road	20 ft. minimum width asphalt	
Access Gate	Double swing gate, chain link, 20 ft. opening	
Facility Enclosure	8 ft. CMU block wall	
Ground Surface Finish	2-ft. thick compacted aggregate base	
Storm Water Retention Basin	Basin sized to accommodate runoff from entire site	
Structures		
Electrical/Chlorine Building	8-in. thick concrete foundation Precast concrete building	

4.3.3 Unit Costs

Table 13 presents the unit costs for PRV stations.

Table 13 PRV Station Cost Summary

Site Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
1	931,000	1,451,000	1,669,000
3	1,044,000	1,603,000	1,843,000
5	1,109,000	1,691,000	1,945,000
10	1,524,000	2,247,000	2,584,000
20	2,273,000	3,254,000	3,742,000
30	2,982,000	4,207,000	4,838,000
40	4,146,000	5,773,000	6,639,000
50	5,304,000	7,328,000	8,427,000
60	5,306,000	7,332,000	8,432,000
70	5,448,000	7,523,000	8,651,000

When PRV stations are constructed in phases, the Phase 1 costs include total site work for buildout capacity, piping and appurtenances sized for buildout capacity, PRVs for the Phase 1 capacity, equipment, and structures. The Phase 2 costs include upgrades to electrical equipment, additional PRV trains, and PRV upgrades. Table 14 presents the unit costs for phased PRV stations.

Table 14 Phased PRV Station Cost Summary

Site Capacity (mgd)	Initial or Buildout Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
5	(1 Initial)	1,166,000	1,768,000	2,033,000
	(5 Buildout)	300,000	603,000	693,000
20	(10 Initial)	2,059,000	2,968,000	3,413,000
	(20 Buildout)	366,000	693,000	797,000
40	(10 Initial)	3,425,000	4,805,000	5,526,000
	(40 Buildout)	1,251,000	1,881,000	2,163,000

4.4 Wells

The well site layout is based on the template from the Design Guidance Manual, with comments from workshops with the Remote Facilities group. Figure 3 presents a typical well site layout from the Design Guidance Manual.

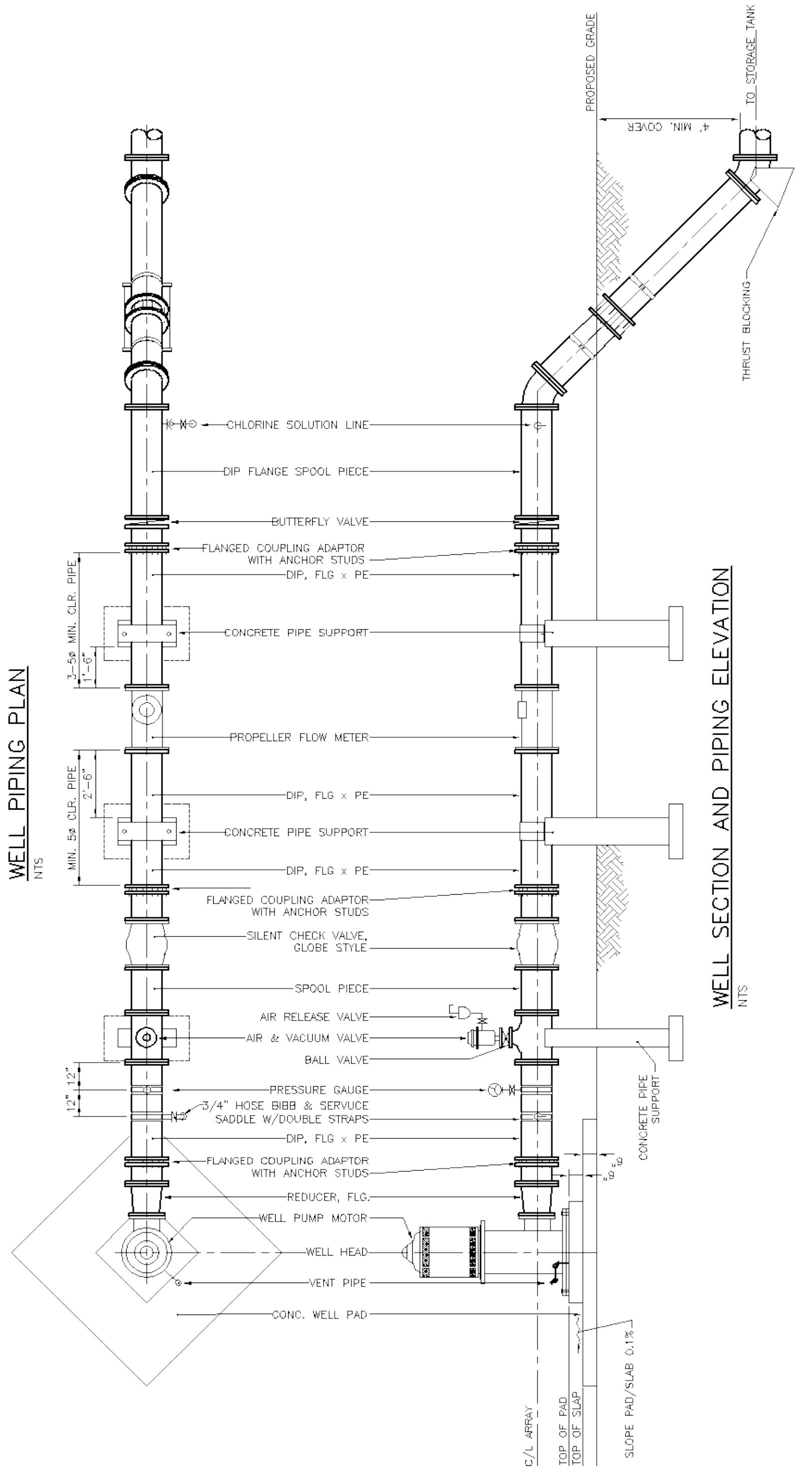


Figure 4 Typical Well Site Layout

4.4.1 Capacity and Depth

Capacities, depths, and diameters for each well were decided in the remote facilities workshop group. Table 15 presents the well capacities and depths for which unit costs have been prepared.

Table 15 Well Capacity, Diameter, and Depth

Capacity (mgd)	Diameter (in.)	Depth (ft.)
1	14	1,200
1	14	1,300
1	14	1,400
1	14	1,450
1	14	1,500
1	14	1,550
1.5	16	1,200
1.5	16	1,300
1.5	16	1,400
1.5	16	1,450
1.5	16	1,500
1.5	16	1,550
3	18	1,200
3	18	1,300
3	18	1,400
3	18	1,450
3	18	1,500
3	18	1,550

4.4.2 Assumptions for Cost Estimation

Table 16 presents assumptions for cost estimation used to calculate unit costs for the well.

Table 16 Assumptions for Cost Estimation for the Well

Condition	Guideline/Assumption
Hydraulics	
Well Capacity	1 mgd (at 1,200-ft. depth) 16-in. casing
	1.5 mgd (at 1,200-ft. depth) 16-in. casing
	3 mgd (at 1,200-ft. to 1,550 depth) 18-in. casing
Mechanical	
Pump	694 to 2,082 gallons per minute 80% efficiency
Mechanical Piping	
Pipe Material	Flanged DIP
	5 ft/sec discharge velocity
Mechanical Equipment	
Flow Control Valve	250 psi swing check valve
Isolation Valve	150 psi butterfly valve
Air/vac Valve with Air Release	300 psi air/vac valve with shutoff
Site Work	
Site Size	50 ft. by 50 ft. site footprint
Access Road	20 ft. minimum width asphalt
Access Gate	Double swing gate, chain link, 20-ft. opening
Facility Enclosure	8 ft. CMU block wall
Ground Surface Finish	2 ft. thick compacted aggregate base

4.4.3 Unit Costs

Table 17 presents unit costs for wells.

Table 17 Well Cost Summary

Capacity (mgd)	Well Depth (ft.)	Well Diameter (in.)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
1	1200	14	3,142,000	4,423,000	5,086,000
	1300		3,149,000	4,433,000	5,098,000
	1400		3,288,000	4,619,000	5,312,000
	1450		3,434,000	4,814,000	5,536,000
	1500		3,464,000	4,855,000	5,583,000
	1550		3,493,000	4,894,000	5,628,000
1.5	1200	16	3,293,000	4,626,000	5,320,000
	1300		3,300,000	4,635,000	5,330,000
	1400		3,440,000	4,823,000	5,546,000
	1450		3,586,000	5,020,000	5,773,000
	1500		3,615,000	5,060,000	5,819,000
	1550		3,645,000	5,100,000	5,865,000
3	1200	18	3,628,000	5,077,000	5,839,000
	1300		3,638,000	5,090,000	5,854,000
	1400		3,777,000	5,277,000	6,069,000
	1450		3,932,000	5,484,000	6,307,000
	1500		3,985,000	5,557,000	6,391,000
	1550		4,038,000	5,627,000	6,471,000

4.5 Wellhead Treatment

The wellhead treatment is for arsenic. The treatment method is ion exchange which has a higher cost than other methods and therefore provides a more conservative cost estimate.

The design includes a pressure vessel, backwash tank, storage tank, brine tank, piping, valves, pumps, and mixers.

The design does not include a bypass flow.

4.5.1 Capacity

Unit costs have been created for treatment capacities of 1, 1.5, and 3 mgd.

4.5.2 Unit Costs

Table 18 presents the wellhead arsenic treatment unit cost summary.

Table 18 Wellhead Arsenic Treatment Cost Summary

Capacity (mgd)	Capacity		
	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
1	3,226,000	4,337,000	4,988,000
1.5	3,361,000	4,517,000	5,195,000
3	5,543,000	7,450,000	8,568,000

4.6 Steel Ground Storage Tanks

4.6.1 Capacity

Unit costs are for 2- and 3-MG steel tank sites.

4.6.2 Assumptions for Cost Estimation

Table 19 presents the assumptions for cost estimation for steel tank ground storage facilities.

Table 19 Assumptions for Cost Estimation for the Steel Tank

Condition	Guideline/Assumption
Steel Tank	
2 mgd	Steel tank, above grade Diameter = 165 ft. Depth = 16 ft.
3 mgd	Steel tank, above grade Diameter = 165 ft. Depth = 16 ft.
Isolation Valve	Butterfly valve
Backflow Prevention	Swing check valve
Tank Mixing	Included
Site Work	
Site Size	2 and 3 mgd, 150 ft. by 150 ft. site footprint
Access Road	20 ft. minimum width asphalt
Access Gate	Double swing gate, chain link, 20-ft. opening
Facility Enclosure	8-ft. CMU block wall
Ground Surface Finish	2-in. thick compacted aggregate base

4.6.3 Unit Costs

Table 20 presents the steel ground storage tank unit costs.

Table 20 Steel Storage Tank Cost Summary

Capacity (MG)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)	Construction Cost Including CMAR ($) per Gallon
2	$4,897,000	$6,582,000	$7,569,000	3.78
3	$6,205,000	$8,340,000	$9,591,000	3.20

4.7 Concrete Reservoirs

4.7.1 Capacity

Unit costs for above grade concrete storage tanks have been calculated for 2, 3, 5, 10, 15, 20, 30, and 40 MG.

4.7.2 Assumptions for Cost Estimation

Table 21 presents the assumptions for cost estimation for prestressed concrete tanks.

Cast-in-place concrete reservoirs are either prestressed concrete with cast-in-place core wall, vertical post-tensioned tendons, and circumferential prestressed strands (American Water Works Association [AWWA] D110 Type I) or prestressed concrete with precast core wall, vertical post-tensioned tendons, and circumferential prestressed strands (AWWA D110 Type III). Two to 5 MG are prestressed tanks, 10 to 40 MG are cast in place.

The cost includes an active mixing system, isolation valves, piping, site work, and overflow retention basin.

Table 21 Concrete Reservoir Cost Estimation Assumptions

Condition	Guideline/Assumption
Mechanical Equipment and Valves	
Inlet/outlet Pipe	Ductile iron pipe
Overflow Pipe	Ductile iron pipe
Isolation Valve	Butterfly valve
Backflow Prevention	Swing check valve
Recirculation	Included
Concrete Reservoir	
2 mgd	Concrete reservoir, above grade Diameter = 107 ft. Depth = 32 ft., 2 ft. freeboard
3 mgd	Concrete reservoir, above grade Diameter = 127 ft. Depth = 34 ft., 2 ft. freeboard
5 mgd	Concrete reservoir, above grade Diameter = 156 ft. Depth = 37 ft., 2 ft. freeboard
10 mgd	Concrete reservoir, above grade Diameter = 221 ft. Depth = 37 ft., 2 ft. freeboard
15 mgd	Concrete reservoir, above grade Diameter = 253 ft. Depth = 42 ft., 2 ft. freeboard
20 mgd	Concrete reservoir, above grade Diameter = 292 ft Depth = 42 ft., 2 ft. freeboard
30 mgd	Concrete reservoir, above grade Diameter = 358 ft. Depth = 42 ft., 2 ft. freeboard
40 mgd	Concrete reservoir, above grade Diameter = 413 ft. Depth = 47 ft., 2 ft. freeboard
Site Work	
Site Size	2 mgd, 157 ft. by 157 ft. site footprint 3 mgd, 177 ft. by 177 ft. site footprint 5 mgd, 206 ft. by 206 ft. site footprint 10 mgd, 271 ft. by 271 ft. site footprint 15 mgd, 303 ft. by 303 ft. site footprint 20 mgd, 342 ft. by 342 ft. site footprint 30 mgd, 408 ft. by 408 ft. site footprint 40 mgd, 463 ft. by 463 ft. site footprint
Access Road	20 ft. minimum asphalt width
Access Gate	Double swing gate, chain link, 20-ft. opening
Facility Enclosure	8-ft. high CMU block wall
Ground Surface Finish	2-in. thick compacted aggregate base

4.7.3 Unit Cost

Table 22 presents the concrete reservoir unit cost summary.

Table 22 Concrete Reservoir Cost Summary

Site Capacity (MG)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)	Construction Cost Including CMAR ($) per Gallon
2	5,118,000	6,879,000	7,911,000	3.96
3	6,307,000	8,477,000	9,749,000	3.25
5	8,439,000	11,342,000	13,043,000	2.61
10	14,487,000	19,471,000	22,392,000	2.24
15	20,288,000	27,267,000	31,357,000	2.09
20	26,261,000	35,295,000	40,589,000	2.03
30	39,617,000	53,246,000	61,233,000	2.04
40	51,835,000	69,667,000	80,117,000	2.00

SECTION 5 WASTEWATER FACILITIES

5.1 Gravity Sewer Main

5.1.1 Pipe Diameter and Materials

Vitrified clay pipe (VCP) is the most common material used by the City for gravity sewer pipe. Reinforced concrete pipe (RCP) is typically used for larger diameter sewers greater than 30 inches. The City is transitioning to Hobas pipe for sewers, and this pipe is available for a large range of pipe diameters. Pipe materials and where costs are provided are presented in Table 23.

Table 23 Gravity Sewer Pipeline Material, Diameter, and Excavation Information

Diameter (in.)	Material			Excavation	
	VCP	RCP	Hobas	Trench Depth (ft.)	Trench Width (ft.)
8	✓			6.0	4.00
12	✓			6.0	4.33
15	✓			8.0	4.58
16	✓		✓	8.0	4.67
18	✓		✓	8.0	5.08
20	✓		✓	8.0	5.25
21	✓		✓	8.0	5.33
24	✓		✓	8.0	5.58
27	✓		✓	10.0	6.58
30	✓	✓	✓	10.0	6.83
33	✓		✓	10.0	7.08
36	✓	✓	✓	10.0	7.33
39	✓		✓	10.0	7.58
42	✓	✓	✓	12.0	8.00
48		✓	✓	12.0	8.50
54		✓	✓	12.0	9.00
60		✓	✓	12.0	9.50
66		✓	✓	14.0	11.00
72		✓	✓	14.0	11.50
81			✓	16.0	12.92
84		✓	✓	16.0	13.17
87			✓	17.0	13.42
90		✓	✓	17.0	13.67

5.1.2 Assumptions for Cost Estimation

Table 24 presents the assumptions for cost estimation for the gravity sewer pipe unit cost.

Table 24 Gravity Sewer Pipe Cost Estimation Assumptions

Condition	Guideline/Assumption
Minimum Pipe Cover	Excavation depth ranges from 4 ft. to 17 ft. depending on sewer diameter
Pavement Replacement	Pavement replacement for the trench and micro seal for the street width
Excavation Type	Hard digging
Manholes	
MH Spacing	400 ft. (diameters < 15 in.) 500 ft. (diameters between 15 in. and 24 in.) 600 ft. (diameters greater than 24 in.)
MH Sizing	4-ft. MH diameter (pipes up to 48 in.) 5-ft. MH diameter (pipes up to 60 in.) 6-ft. MH diameter (pipes up to 72 in.) 7-ft. MH diameter (pipes up to 90 in.)
MH Cover	24-in. diameter cover (pipes < 36 in.) 36-in. diameter cover (pipes > 36 in.)

5.1.3 Unit Costs

Costs for easy, medium, hard, and hard rock excavation are in the unit cost spreadsheet. Hard excavation is assumed for the cost tables in this report. Table 25 and Table 27 present the unit costs for gravity sewers constructed of VCP, RCP, and Hobas, respectively. Table 26 and Table 28 illustrate the unit costs for gravity sewers constructed of VCP, RCP, and Hobas, respectively without pavement costs.

Table 25 VCP Gravity Sewer Cost Summary

Diameter (in.)	Vitrified Clay Pipe	
	Construction Cost/ft. ($)	CMAR Cost/ft.($)
8	350	400
12	430	490
15	500	580
16	580	670
18	610	700
20	660	760
21	740	850
24	770	890
27	950	1,090
30	1,070	1,230
33	1,120	1,290
36	1,230	1,410
39	1,500	1,730
42	1,660	1,910

Table 26 VCP Gravity Sewer Cost Summary without Pavement Costs

Diameter (in.)	Vitrified Clay Pipe	
	Construction Cost/ft. ($)	CMAR Cost/ft.($)
8	290	330
12	320	370
15	430	490
16	480	550
18	510	590
20	580	670
21	620	710
24	660	760
27	880	1,010
30	950	1,090
33	1,060	1,220
36	1,110	1,280
39	1,390	1,600
42	1,540	1,770

Table 27 RCP and Hobas Gravity Sewer Cost Summary

Diameter (in.)	Reinforced Concrete Pipe		Hobas Pipe	
	Construction Cost(1)/ft. ($)	CMAR Cost/ft. ($)	Construction Cost(1)/ft. ($)	CMAR Cost/ft. ($)
16	-	-	620	710
18	-	-	730	840
20	-	-	760	870
21	-	-	770	890
24	-	-	820	940
27	-	-	1,080	1,240
30	1,880	2,160	1,120	1,290
33	-	-	1,230	1,410
36	2,310	2,660	1,350	1,550
39	-	-	1,400	1,610
42	3,060	3,520	1,510	1,740
48	3,750	4,310	1,800	2,070
54	4,580	5,270	2,030	2,330
60	4,960	5,700	2,290	2,630
66	6,050	6,960	2,670	3,070
72	6,740	7,750	2,930	3,370
81	-	-	3,730	4,290
84	8,810	10,130	3,850	4,430
87	-	-	4,060	4,670
90	9,990	11,490	4,330	4,980

Notes:
(1) Construction cost does not include the CMAR cost.

Table 28 RCP and Hobas Gravity Sewer Cost Summary without Pavement Costs

Diameter (in.)	Reinforced Concrete Pipe		Hobas Pipe	
	Construction Cost(1)/ft. ($)	CMAR Cost/ft. ($)	Construction Cost(1)/ft. ($)	CMAR Cost/ft. ($)
16	-	-	560	640
18	-	-	610	700
20	-	-	650	750
21	-	-	670	770
24	-	-	750	860
27	-	-	970	1,120
30	1,820	2,090	1,060	1,220
33	-	-	1,100	1,270
36	2,200	2,530	1,250	1,440
39	-	-	1,330	1,530
42	2,940	3,380	1,400	1,610
48	3,680	4,230	1,690	1,940
54	4,460	5,130	1,960	2,250
60	4,900	5,640	2,190	2,520
66	5,960	6,850	2,590	2,980
72	6,630	7,620	2,820	3,240
81	-	-	3,660	4,210
84	8,740	10,050	3,740	4,300
87	-	-	3,990	4,590
90	9,870	11,350	4,210	4,840

Notes:
(1) Construction cost does not include the CMAR cost.

5.1.4 Costs for Pipeline Crossing a Freeway

Table 29 shows the additional costs associated with a single-line pipeline crossing a freeway per linear foot for various pipe diameters. A pipe sleeve diameter of 12 inches on all sides of the pipe is assumed.

The estimates do not cover the pipeline running inside the sleeve, which are included in Table 25 through Table 28.

Table 29 Costs for Pipeline Crossing Freeway

Diameter of the Pipe (in.)	Developed Costs for Single-lane Pipeline Crossing a Freeway ($/lf)
16,20,21	$1,340
24, 27,30 ,33 ,36 ,39 ,42	$2,680
48, 54, 60, 66	$4,830
72, 78, 81, 84, 87, 90	$5,360

5.2 Force Main

5.2.1 Pipe Materials and Sizing

The City accepted force main material is DIP and high-density polyethylene (HDPE) pipe.

HDPE and DIP are included in the cost model.

Table 30 Force Main Diameter, Material, and Excavation Information

Diameter (in.)	Material		Excavation	
	DIP	HDPE	Trench Depth (ft.)	Trench Width (ft.)
4	✓	✓	6.0	9.00
6	✓	✓	6.0	9.33
8	✓	✓	6.0	9.67
10	✓	✓	6.0	10.00
12	✓	✓	6.0	10.33
14	✓	✓	8.0	10.67
16	✓	✓	8.0	11.00
20	✓	✓	8.0	11.92
24	✓	✓	8.0	12.58
30	✓	✓	10.0	13.58

Notes:
(1) Trench width is the same as width of pavement replacement.

5.2.2 Assumptions for Cost Estimation

Table 31 presents the assumptions for cost estimation for the force mains.

Table 31 Assumptions for Cost Estimation for the Force Main

Condition	Guideline/Assumption
Piping	Dual force mains have been assumed.
Minimum Pipe Cover	Assuming 6-ft. depth.
Thrust Restraint	Joint restraint at all bends, fitting and appurtenances with system compatible with pipe material.
Excavation Type	Hard digging.
Valves	
Isolation Valve	Full port eccentric plug valve.
Air Release Valve	Required at all high points.

5.2.3 Unit Cost

Costs for easy, medium, hard, and hard rock excavation are in the unit cost spreadsheet. Hard excavation is assumed for the cost tables in this report. Table 32 presents the unit costs for DIP and HDPE dual force mains. Table 33 presents the unit costs for DIP and HDPE dual force mains without pavement costs.

Table 32 DIP and HDPE Force Main Cost Summary

Diameter (in.)	Ductile Iron Pipe		High Density Polyethylene Pipe	
	Construction Cost/ft. ($)	CMAR Cost/ft. ($)	Construction Cost/ft. ($)	CMAR Cost/ft ($)
4	870	1,000	790	910
6	930	1,070	890	1,020
8	1,020	1,170	940	1,080
10	1,050	1,210	960	1,110
12	1,100	1,270	1,070	1,230
14	1,270	1,460	1,250	1,440
16	1,490	1,710	1,660	1,910
20	1,710	1,970	1,960	2,250
24	2,010	2,310	2,260	2,600
30	2,980	3,430	3,130	3,600

Table 33 DIP and HDPE Force Main Cost Summary without Pavement Costs

Diameter (in.)	Ductile Iron Pipe		High Density Polyethylene Pipe	
	Construction Cost/ft. ($)	CMAR Cost/ft. ($)	Construction Cost/ft. ($)	CMAR Cost/ft. ($)
4	580	670	510	590
6	650	750	600	690
8	740	850	660	760
10	760	870	720	830
12	820	940	780	900
14	1,020	1,170	960	1,100
16	1,200	1,380	1,370	1,580
20	1,430	1,640	1,660	1,910
24	1,720	1,980	1,980	2,280
30	2,740	3,150	2,890	3,320

5.2.4 Costs for Pipeline Crossing a Freeway

Table 34 shows the additional costs associated with a single-line pipeline crossing a freeway per linear foot for various pipe diameters. A pipe sleeve diameter of 12 inches on all sides of the pipe is assumed.

The estimates do not cover the pipeline running inside the sleeve, which are included in Table 32 and Table 33.

Table 34 Costs for Pipeline crossing freeway

Diameter of the Pipe (in.)	Developed Costs for Single-lane Pipeline Crossing a Freeway ($/lf)
16,20,21	$1,340
24, 27,30 ,33 ,36 ,39 ,42	$2,680
48, 54, 60, 66	$4,830
72, 78, 81, 84, 87, 90	$5,360

5.3 Lift Stations

The template for lift stations was developed based on City guidelines and meetings with the City. A typical lift station layout is taken from the Lift Station Design Guidance Manual and presented in Figure 4.

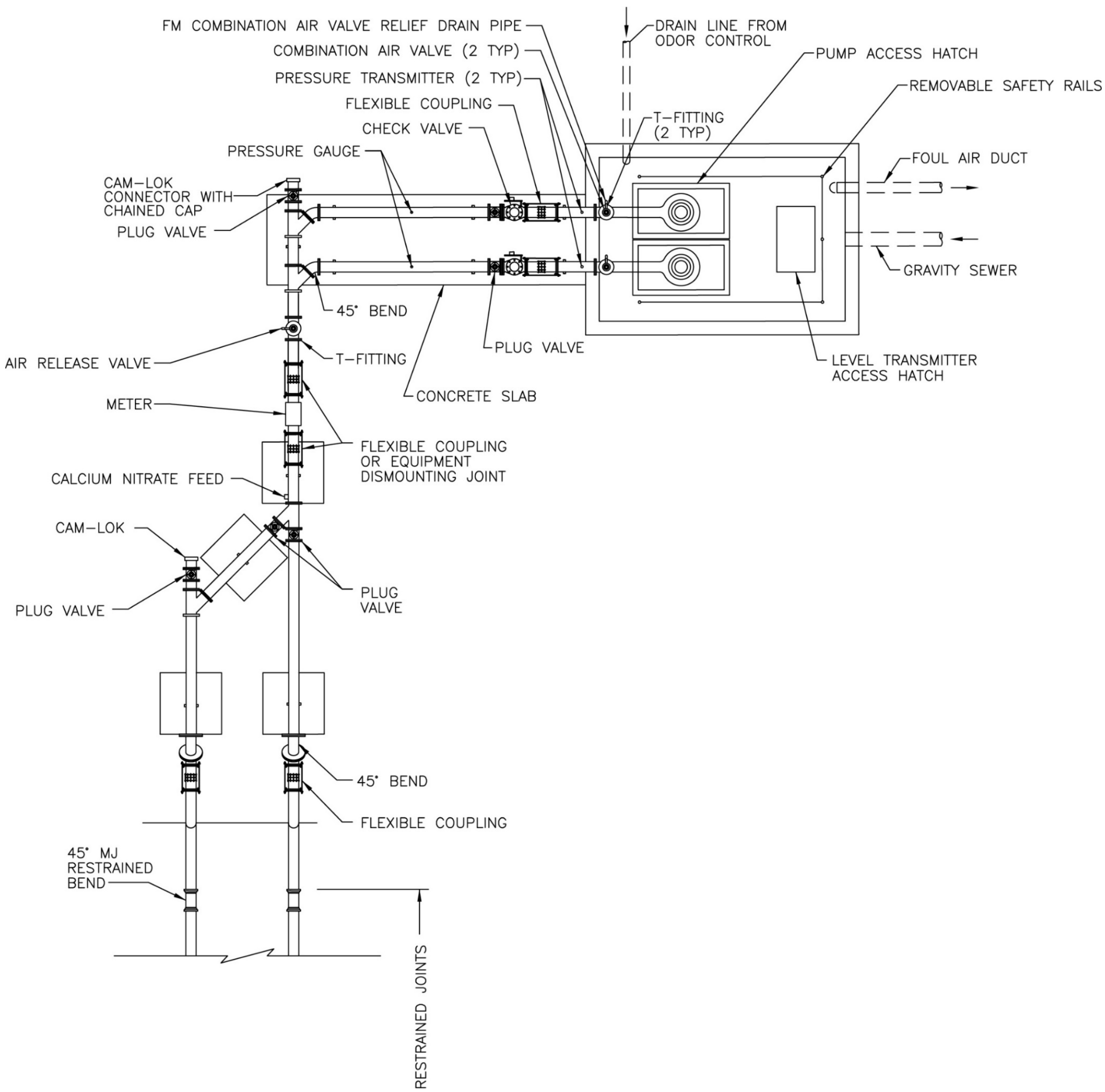


Figure 5 Typical Lift Station Layout

5.3.1 Capacity

Lift station unit costs are provided for firm pumping capacities of 1, 3, 3.5, 5, 8, 12, 16, 25, and 40 mgd.

5.3.2 Assumptions for Cost Estimation

Table 35 presents the assumptions for cost estimation for the lift stations.

Table 35 Lift Station Cost Estimation Assumptions

Condition	Guideline/Assumption
Hydraulics	
Lift Station Capacity	2 pumps (1 mgd)
	3 pumps (3 to 5 mgd)
	4 pumps (8 to 12 mgd)
	6 pumps (16 mgd to 40 mgd)
Pumps	
Pump	Submersible wastewater pump
	70% Efficiency
	50 ft. TDH
Mechanical Piping	
Pipe Material	HDPE
Velocity	10 ft/sec pump train velocity
	5 ft/sec discharge header velocity
	5 ft/sec force main velocity
Mechanical Equipment	
Check Valve	125 psi swing check valve
Plug Valve	Full port eccentric plug valve
Air Release Valve	300 psi combination air release valve
Site Work	
Site Size	≤5 mgd, 75 ft. by 75 ft. site footprint
	≤12 mgd, 150 ft. by 150 ft. site footprint
	≤40 mgd, 200 ft. by 200 ft. site footprint
Access Road	20 ft. minimum width asphalt
Access Gate	Double swing gate, chain link, 20-foot opening
Facility Enclosure	8-ft. CMU block wall
Ground Surface Finish	2-in. thick compacted aggregate base
Storm Water Retention Basin	Basin sized to accommodate runoff from entire site
Structures	
Pump Train	18-in. thick concrete foundation
Electrical/Chlorine Building	12-in. thick concrete foundation
	Precast concrete building
Valve Vault	5 ft. precast concrete valve box
Wet Well	≤1 mgd, precast concrete wet well
	>1 mgd, cast-in-place concrete wet well

5.3.3 Unit Costs

Table 36 presents lift station unit costs.

Table 36 Sewer Lift Station Cost Summary

Site Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
1	1,103,000	1,792,000	2,061,000
3	2,319,000	3,549,000	4,081,000
3.5	2,348,000	3,591,000	4,130,000
5	2,444,000	3,728,000	4,287,000
8	3,336,000	5,018,000	5,771,000
12	3,864,000	5,779,000	6,646,000
16	4,072,000	6,079,000	6,991,000
25	5,141,000	7,623,000	8,766,000
40	10,068,000	14,739,000	16,950,000

When a lift station is constructed in phases, the Phase 1 costs include the facility sized for buildout, except for the pump trains that will be added or replaced at a later date. Phase 2 costs include upgrades to electrical equipment, additional pump trains, and upsized pumps. Table 37 presents phased lift station costs.

Table 37 Phased Lift Station Cost Summary

Site Capacity (mgd)	Initial or Buildout Capacity (mgd)	Direct Cost ($)	Construction Cost ($)	Construction Cost Including CMAR ($)
5	(1 Initial)	2,027,000	2,925,000	3,364,000
	(5 Buildout)	644,000	1,065,000	1,225,000
40	(20 Initial)	7,540,000	10,333,000	11,883,000
	(40 Buildout)	3,499,000	4,903,000	5,638,000

SECTION 6 TREATMENT COSTS

6.1.1 Wastewater Treatment

The City plans to construct, the Northwest Gateway WRP, expand the 91st Avenue WWTP to include advanced treatment for direct potable reuse (DPR), and bring the Cave Creek WRF back into service and expand the capacity of the plant as well as construct DPR treatment capabilities in the future. The cost to construct or expand each of these facilities is unique to each facility. A detailed component by component cost for expanding each of these plants is not included in this study. However, the costs that were prepared by others at the time this report was prepared is included so that the cost of these WRF improvements can be included in capital planning. Table 38 presents the cost to construct or expand each facility, grouped by major process. Table 39 presents the cost to construct or expand each facility on a cost per gallon of treatment capacity.

Table 38 City of Phoenix Wastewater Treatment Costs Including Advanced Treatment

Capital Costs in October 2023 Dollars ($M)						
Treatment Location	North Gateway WRP(1,2)		Cave Creek WRP(3)		91st Avenue WWTP(5)	
Phase	Phase I	Buildout	Phase I	Buildout	Phase I	Buildout
Capacity (mgd)	8	16	8	16	27.3	43.7
Cost Category	**Cost ($M)**					
Wastewater Collection Conveyance	140(1)		N/A	N/A	N/A	N/A
Wastewater Treatment	297(1)	594(1)	183	374	TBD(6)	TBD(6)
Advanced Water Treatment	164(2)	263(2)	116	227	418	613
Concentrate Management	360(2)	456(2)	N/A(3)	N/A(3)	103 to 335(7)	173 to 558(7)
Treated Water Conveyance	109(1)	143(1)	TBD(4)	TBD(4)	517	693
Total	**1,070**	**1,595**	**299**	**601**	**1,038 to 1,270(7)**	**1,479 to 1,864(7)**

Notes:
$M - million dollars; WWTP - wastewater treatment plant; N/A - not available; TBD - to be determined; UF - ultrafiltration; RO - reverse osmosis; BAF - biological aerated filter; UV AOP - ultraviolet advanced oxidation process; GAC - granular activated carbon

(1) AACE Class 5 cost opinion from Biscuit Flat South Cost Allocations, Figure 5 and Figure 6.
(2) AACE Class 5 cost opinion from 2022 Advanced Purified Water Plan. The advanced water treatment train assumes Ozone, BAF, side stream UF and RO, UV AOP and GAC.
(3) 60 percent design cost estimate from Black & Veatch (B&V), concentrate is sent to 91st Avenue WWTP. The advanced water treatment train assumes full-stream RO, UV AOP, decarbonator and chlorination.
(4) Hydraulic modeling and further analysis needed.
(5) AACE Class 5 cost opinion from 2023 AWPF Pre-Feasibility Study, Phoenix only cost. The advanced treatment train assumes side stream RO assumes Ozone, BAF, UF, side stream RO, UV AOP, GAC, chlorination.
(6) Costs to be determined after the ongoing 91st Avenue WWTP MP study is completed.
(7) AACE Class 5 cost opinion from 2023 AWPF Pre-Feasibility Study for the two brine management options, Phoenix only cost. The 2023 study assumed two potential brine management options: (1) partnering with Arizona Public Service (APS) for brine disposal by discharging primary RO brine from the AWPF to the existing effluent pipeline to PVNGS; (2) onsite brine management, essentially zero liquid discharge where RO brine is treated onsite at the AWPF using mechanical vapor recompression and evaporation ponds. The estimated footprint for the AWPF is located north of the 91st Avenue WWTP on

a parcel owned by the City of Phoenix. The estimated acreage for the AWPF is as follows: 48 acres for the facility itself, 22 acres for onsite brine management, and 55 acres for evaporation ponds.

Table 39 City of Phoenix Wastewater Treatment Unit Costs Including Advanced Treatment

Unit Treatment Costs in October 2023 Dollars						
Treatment Location	North Gateway WRP(1,2)		Cave Creek WRP(3)		91st Avenue WWTP(4)	
Phase	Phase I	Buildout	Phase I	Buildout	Phase I	Buildout
Capacity (mgd)	8	16	8	16	27.3	43.7
Purified Water (mgd)	7.8	15.6	6.7	13.4	24.7 to 27.2	39.5 to 43.6
Cost Category	**Unit Cost Based on Capacity ($/gpd)**					
Wastewater Treatment	37	37	23	23	N/A(5)	N/A(5)
Advanced Water Treatment	19	16	14	14	15	15
Concentrate Management	45	29	N/A(3)	N/A(3)	4 to 12(6)	4 to 13(6)
Solids Handling	3 to 4.5(7)					

Notes:
gpd - gallons per day
(1) AACE Class 5 cost opinion from Biscuit Flat South Cost Allocations, Figure 5 and Figure 6.
(2) AACE Class 5 cost opinion from 2022 Advanced Purified Water Plan. The advanced water treatment train assumes Ozone, BAF, side stream UF and RO, UV AOP and GAC.
(3) 60-percent design cost estimate from B&V, concentrate is sent to 91st Avenue WWTP. The advanced water treatment train assumes full-stream RO, UV AOP, Decarbonator and Chlorination.
(4) AACE Class 5 cost opinion from 2023 AWPF Pre-Feasibility Study, Phoenix only cost. The advanced treatment train assumes side stream RO assumes Ozone, BAF, UF, side stream RO, UV AOP, GAC, chlorination.
(5) Costs to be determined after the ongoing 91st Avenue WWTP MP study is completed.
(6) AACE Class 5 cost opinion from 2023 AWPF Pre-Feasibility Study for the two brine management options, Phoenix only cost. The 2023 study assumed two potential brine management options: (1) partnering with APS for brine disposal at the PVNGS by discharging primary RO brine from the AWPF to the existing effluent pipeline to PVNGS; (2) onsite brine management, essentially zero liquid discharge where RO brine is treated onsite at the AWPF using mechanical vapor recompression and evaporation ponds. The estimated footprint for the AWPF is located north of the 91st Avenue WWTP on a parcel owned by the City of Phoenix. The estimated acreage for the AWPF is as follows: 48 acres for the facility itself, 22 acres for onsite brine management, and 55 acres for evaporation ponds.
(7) AACE Class 5 cost opinion from 2023 AWPF Pre-Feasibility Study, non-SROG flows only for a solids handling capacity for an existing WWTP, 50 percent contingency range per Class 5 cost opinion was assumed for the range. The treatment train assumed thickening facility, centrifuge, and digestors.

6.1.2 Water Treatment

The City plans to expand the Deer Valley WTP and the 24th Street WTP in the future, the timing has not been determined. The cost estimate for the 24th Street WTP expansion considers the current 24th Street WTP Rehabilitation 2021 project, which includes hydraulic upgrades to reduce head loss and additional solids handling capacity.

Upgrades to the 24th Street WTP in the next expansion that are included in the cost estimate are as follows:

- Plant 3, 60 mgd expansion includes conventional treatment plus post filter GAC contactors. The costs are based on conventional treatment.
- Treatment trains will be like the existing Plant 2 treatment trains and include:
  - Flocculation.
  - Sedimentation.
  - GAC filter.
  - Raw water pump station upgrades.
  - Chemical feed and storage upgrades.
  - Solids Handling upgrades (centrifuge, equalization basin.
- Yard piping extending from Plant 3 to GAC contactors and from there to Reservoir 2.
- Break-tank and pump station for GAC treated water.
- Backwash equalization system.
- Maintenance building.

Table 40 presents the 24th Street WTP treatment expansion costs.

Table 40 24th Street WTP Treatment Expansion Costs

Cost Parameter	Plant 3 + GAC
Expansion Capacity (mgd)	60(1,2,3)
Total Estimated Construction Cost with Contingency, October 2023 Dollars ($M)(4)	457
Unit Cost ($/gpd)	7.6

Notes:
(1) Data is from the 24th Street WTP New Technologies Evaluation 2021 TM.
(2) 60 mgd of post-filter GAC contactors is assumed.
(3) The hydraulic improvements of existing plant are part of a different project with an expansion capacity of 20 mgd.
(4) Cost opinion is AACE Class 5.

The Deer Valley WTP expansion includes the following:

- Three potential expansion capacities: 40-, 50-, and 80-mgd of treatment capacity in the West Plant.
- New pre-sedimentation, ballasted flocculation, GAC filters.
- Post-filter GAC contactors for PFAS removal; 40 mgd initial expansion with room for up to additional 120 mgd, if needed.
- Chemical feed upgrades.
- Expanded solids handling.

- Expanded raw and finished water pump stations.
- Offsite piping across the Arizona Canal Diversion Channel (ACDC) Canal.

Table 41 presents the Deer Valley WTP treatment expansion costs. Table 42 presents the cost of the 66-inch pipeline across the ACDC canal.

Table 41 Deer Valley WTP Treatment Expansion Costs

Cost Parameter	West Plant Replace + GAC (Phase I)	West Plant Replace + GAC (Phase II)	West Plant Replace + GAC (Buildout)
Expansion Capacity (mgd)(2)	40	50	80
Total Estimated Construction Cost with Contingency in October 2023 Dollars(1) ($M)	264	330	528
Unit Cost ($/gpd)	6.6	6.6	6.6

Notes:
(1) AACE class 5 cost opinion.
(2) 40, 50, and 80-mgd of post-filter GAC contactors assumed.

Table 42 66-inch Pipeline Across the ACDC Canal

Cost Parameter	66-inch Pipeline Cost
66-inch Pipeline from the Deer Valley WTP to across the ACDC Canal (Length, feet)	3,400
Total Estimated Construction Cost with Contingency in October 2023 Dollars(1) ($M)	16.4
Unit Cost ($/lf)	4,830

APPENDIX A

UNIT COST SPREADSHEET INSTRUCTIONS

UNIT COST SPREADSHEET INSTRUCTIONS

The Unit Cost Spreadsheet that contains unit costs for the City's water and wastewater facilities is designed with the flexibility to adjust unit costs for project specific conditions by providing a way for costs to be changed based on specific conditions of an individual project. The cost of components used to develop the unit costs can also be updated due to inflation or other factors. The process of changing costs for specific project parameters and for updating component costs is intuitive. However, this appendix contains the instructions to guide the user in applying the spreadsheet.

In the spreadsheets for each type of infrastructure, cells that can be changed are colored as follows:

(orange)	Cells with this color have a pull-down menu where options can be selected.
(light blue)	Cells with this color have a default value that can be overridden to satisfy project specific requirements.

The following cells have default values and can be edited to satisfy project specific requirements for all types of infrastructure. The percentages in these cells are multiplied by the Total Direct Cost, then added to the Total Direct Cost to obtain the Construction Cost:

1. Contractor overhead.
2. Construction profit.
3. Sales tax.
4. General conditions.

Explanations below are organized by the infrastructure unit cost sheets in the spreadsheet, with similar infrastructure types being grouped together conciseness where appropriate.

1. **Project Summary:** This sheet can be used to document project specific information when the spreadsheet is being adapted to the needs of a specific project.
2. **Unit Cost Database:** This sheet contains the costs of individual infrastructure components that are used to develop the unit costs. The costs in this sheet are linked to the rest of the sheets with the Item No. The item numbers should not be edited, although additional rows of components with unit costs can be added to this sheet. If the cost of an item becomes outdated, a revised cost can be entered into the row of the item that is outdated, and the cost of this component will be automatically updated in every sheet where the component is used.

3. **Water Pipelines, Gravity Sewer Pipelines, and Force Mains:**
    a. Water and wastewater pipeline costs are developed as a unit cost per linear foot and then as a unit cost per mile.
    b. Material, diameter and length can be selected at the top of the spreadsheet. The corresponding components and costs will update automatically in the cells below with the correct size and cost for each component. By taking this approach there is only one sheet for every diameter and material combination of water pipes. If a material/diameter combination does not exist in the spreadsheet, the cells will be blank.
    c. The following parameters can be changed interactively for pipes by selecting an option with the down arrow at a cell or entering a new value into the cell:
        i. Default excavation depth. The depth can be changed by checking the "User Enter Excavation Depth" box, and a cell that allows an excavation depth input will appear where the new depth can be entered.
        ii. Costs for different digging conditions can be obtained by selecting easy, medium, hard, or hard rock digging conditions.
        iii. Box shoring rental period and cost.
        iv. The thickness and width of asphalt replacement.
        v. The number of valves, air release and manholes.
        vi. Traffic control.
4. **Remote Facilities:** Consist of BPSs, pressure reducing valve stations, wells, steel storage tanks, concrete reservoirs, and sewer lift stations:
    a. The capacity of each facility is selected in the drop-down menu, and the costs are automatically updated with the selection.
    b. The following costs are calculated as a percentage of the direct cost and can be modified:
        i. Electrical and instrumentation.
        ii. Painting and coating.
        iii. Disinfection, for water infrastructure.
        iv. Odor control for lift stations.
5. **Phased Remote Facilities:** Consist of BPSs, pressure reducing valve stations, and sewer lift stations:
    a. The phase is selected and costs for the phase are automatically updated, and the infrastructure cost is associated with each phase. Phase 2 costs assume that the Phase 1 infrastructure is already in place.
    b. The incremental costs of Phase 2 assume that Phase 1 installed infrastructure is for the buildout capacity.
    c. If a capacity and phasing selection is made that doesn't correspond with the selected phasing, all cells will be blank, and a correct phase will need to be selected.
6. **Well Head Treatment for Arsenic:**
    a. The desired capacity is selected from the pull-down menu, then costs for the desired capacity is displayed.
    b. Electrical and instrumentation costs are calculated as a percentage of the direct cost.

7. **Updating Unit Costs:** Cost estimates in the UCS can be adjusted on an annual basis by the rate of inflation. Current inflation rates are approximately 5 percent per year, but the City can adjust the escalation rate based on actual cost increases. To adjust the unit cost, edit Phoenix_Unit_Cost_Template spreadsheet in the Unit Cost Database sheet by replacing the Material Unit Cost, Labor unit Cost, Const. Equip Cost, Sub Unit Cost and Other Unit Cost (Columns E through I) using the equation:

   Updated cost = Original cost(1+annual escalation rate)^years after 2024*

   Leave the equations in the Total Direct Unit Cost (Column J) and the values in this column will update automatically with the other updates. All the costs in each unit cost infrastructure sheet are taken from the Total Direct Unit Cost column in the Unit Cost Template spreadsheet so the unit costs are automatically updated when the Total Direct Unit Cost is updated.