FINAL REPORT

City of Phoenix
Water Services Department
Water and Wastewater Facility Unit Cost Study Update

Prepared for

City of Phoenix

May 16th, 2019

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Acronyms and Abbreviations

‘	foot/feet
“	inch
AACE	Association for the Advancement of Cost Engineering
ASR	aquifer storage recovery
ATF	arsenic treatment facility
CCI	Construction Cost Index
CCP	concrete cylinder pipe
CH2M	CH2M HILL Engineers, Inc.
City	City of Phoenix
DIP	ductile iron pipe
ENR	Engineering New Record
HDPE	high-density polyethylene
PRV	pressure reducing valve
SCADA	supervisory control and data acquisition
VCP	vitrified clay pipe
WSD	Water Services Department
WSP	welded steel pipe

SECTION 1

Introduction

1.1 Background

The City of Phoenix (City) Water Services Department (WSD) periodically updates costs associated with water and wastewater facilities, which are then used to calculate and assess water and wastewater impact fees to pay for growth-related infrastructure. State regulations require that WSD go through the process of projecting future land use development and associated water demands and wastewater generation, identify necessary water and wastewater facilities necessary to serve that development, estimate the costs of providing those facilities, and then allocate those costs in a proportional manner to new residential and business customers. To accurately calculate the impact fee costs, WSD needs to know the costs of constructing new water and wastewater facilities.

The Water and Wastewater Facility Unit Cost Study has been used to validate and compile accurate facility costs through detailed costing tools. These costing tools incorporate design templates for each facility type developed based on WSD design standards, current pricing from manufacturers and suppliers, and actual bid data from construction projects within Phoenix and surrounding municipalities.

The Water and Wastewater Facility Unit Cost Study was last updated in 2012 as a full comprehensive report. A partial update was completed in 2014 as a standalone supplement that updated costs to reflect current market conditions and add well facilities to the cost model. In 2017, the City engaged the services of CH2M HILL Engineers, Inc. (CH2M) to update unit costs for water and wastewater remote facilities. The results of the study are summarized in this report.

1.2 Purpose

The purpose of this report is to summarize the results of Unit Cost Updates for water and wastewater remote facility infrastructure for the City. Unit costs computations are included in a spreadsheet submitted under a separate cover. The unit cost updates will assist WSD to calculate the water and wastewater infrastructure impact fees associated with future growth within the City with data based on actual construction costs from recent City projects.

1.3 Scope

The scope of this study includes updated unit cost estimates for water and wastewater remote facilities listed below. More specifically, this report addresses all large water transmission, wastewater distribution and associated facilities in the City's growth areas, and does not include water or wastewater treatment plant facilities.

Remote Facilities - Water

Boosters: *5 million gallons per day (MGD), 10 MGD, 13.5 MGD, 15 MGD, 20 MGD, 30 MGD, 35 MGD, 40 MGD, 60 MGD and 70 MGD (with adders for disinfection and phased facilities)*

Pressure Reducing Valves: *5 MGD, 10 MGD, 20 MGD, 30 MGD, 40 MGD, 60 MGD and 70 MGD (with adders for disinfection and phased facilities)*

Reservoirs: *1 million gallons (MG) steel, 2 MG steel AG, 2 MG concrete AG, 2 MG concrete PB, 3 MG steel AG, 3 MG concrete AG, 3 MG concrete PB, 5 MG concrete AG, 5 MG concrete PB, 10 MG concrete PB, 20 MG concrete PB, 30 MG concrete PB, 40 MG concrete PB (with adders for phased construction and disinfection).*

Water Mains: *12-inch (”) ductile iron, 16” ductile iron, 18” ductile iron, 20” PCCP and ductile iron, 24” PCCP and ductile iron, 30” PCCP and ductile iron, 36” PCCP and ductile iron, 42” PCCP and ductile iron, 48” PCCP and welded steel, 54” PCCP and welded steel, 60” PCCP and welded steel, 66” PCCP and welded steel, 72” PCCP and welded steel, 78” PCCP and welded steel, 84” PCCP and welded steel, and 90” welded steel (with adders for pavement removal and replacement, and extreme depth)*

Wells: *Different depths (1,300-1,550 feet [‘]), different casing diameters (14-18 inches) with adders for arsenic treatment facility*

Remote Facilities – Waste Water

Gravity Sewers: *12” VCP, 15” VCP, 16” VCP, 18” VCP, 20” VCP, 21” VCP, 24” VCP, 27” VCP, 30” RCP/PVC, 33” RCP/PVC, 36” RCP/PVC, 39” RCP/PVC, 42” RCP/PVC, 48” RCP/PVC, 54” RCP/PVC, 60” RCP/PVC, and 66”, 72”, 81”, 84”, 87” and 90” reinforced concrete gravity sewer pipe (with adders for extreme depth).*

Force Mains: *4” ductile iron, 6” ductile iron, 8” ductile iron, 10” ductile iron, 12” ductile iron, 14” ductile iron, 16” ductile iron, 20” ductile iron, 24” ductile iron, 30” ductile iron (single and dual for all sizes and adders for extreme depth and rock excavation).*

Lift Stations: *1 MGD, 2 MGD, 3 MGD, 3.5 MGD, 5 MGD, 8 MGD, 12 MGD, 15 MGD, 25 MGD and 40 MGD (with adders for acoustic enclosures).*

SECTION 2

Methodology

2.1 Facility Template and Design Requirements

Typical facility templates were developed for each of the water and wastewater remote facilities based on the City's design standards. WSD staff were engaged in the process through multiple workshops. The purpose of the collaboration workshops was to review and analyze the design templates, design standards and attributes associated with each type of facility to confirm that they are representative of current practices. Workshops included review of assumptions about the type of facilities and their attributes, and the specific quantities of materials, equipment, land and labor used in constructing those types of facilities. The facility design templates and design standards were updated based on workshop input and used to develop the cost models. Components that would not be considered typical for all facilities, or that would vary greatly depending on specific project field conditions or design alternatives, were categorized as "adder" cost components.

2.2 Cost Data Collection

Recent City of Phoenix bid tabulations, statements of value, change orders and job order contracts, were collected from the City of Phoenix and other municipalities. Approximately 35 bid tabs with construction dates from 2012 to 2017 were collected and sorted. Since the majority of the projects within this period in the Greater Phoenix area were rehabilitation or maintenance projects, the number of new build bids were very limited. The lack of bid data for new project construction is primarily attributed to the economic recession, limited residential and non-residential development, and absence of development-driven infrastructure construction that occurred between 2008 and 2016. Consequently, individual unit costs for which sufficient data was not available, costs were estimated based on extrapolation and reasonable analysis of the data available to the consultant. Further research and data collection were conducted using local community cost databases, and applicable construction indexes such as Engineering News Record (ENR).

2.3 Cost Model Update

The 2014 cost model was used as the basis for cost development. Cost model estimates are Association for the Advancement of Cost Engineering (AACE) Class 5 planning level costs. The facility templates and design assumptions in the cost model were verified against the information collected from the aforementioned workshops. Engineering News Record Construction Cost Indices (ENR CCI) for each of the facilities were updated to the April 2018 average of 10972. Cost estimates from the cost model were then compared against recent bid data and adjustments to base costs were made as needed.

2.4 City Design Standards

The following City design standards, which provide the basis for the typical facilities included in the cost model, were reviewed:

- "City of Phoenix, Design Standards Manual for Water and Wastewater Systems," 2017.
- "City of Phoenix, Design Guidance Manual for Drilling and Installation of Water Supply Wells," April 2016.
- "City of Phoenix, Water Remote Facilities Design Guidance Manual," August 2013.
- "City of Phoenix, Wastewater Lift Station Design Guidance Manual," December 2012.

- "City of Phoenix, Water Booster Pump Station, Pressure Reducing Station, and Well Head Design/ Equipment Standardization Guidance Manual," December 2005

Construction Costs – General

Each remote facility will include some of the same general costs. These costs include site and landscaping costs, supervisory control and data acquisition (SCADA) system costs, disinfection system costs, contractor's mobilization costs, facility phasing costs, and site security system costs. A description for each of these items and subsequent cost are described below.

3.1 Landscaping Costs

Landscape material and installation costs for pressure reducing valve (PRV) stations, booster stations, storage reservoirs, lift stations, and wells are based on data from the City. Landscaping costs are directly related to the size of the site. As such, a landscaping cost of $4.00 per square foot was assumed for all remote facilities. This cost includes landscaping costs for the facility interior and exterior. Interior landscaping requirements include a compacted aggregate base. The City requires that exterior landscaping match existing vegetation. Some remote facility sites may include additional costs due to native plant preservation requirements, especially for saguaros, which are protected by the state of Arizona. The City will need to address these preservation costs on a case-by-case basis; therefore, costs associated with native plant preservation are not included in the cost model.

3.2 Disinfection System Costs

Historically, the City has utilized chlorine tablet feeders and chlorine gas systems for chlorine disinfection at water remote facilities. Based on input from the City's Water Remote Facilities group, the cost model assumes bulk sodium hypochlorite (12.5% concentration) chemical storage and feed facilities to be installed at future water remote facilities for chlorine disinfection. These facilities include PRV stations, booster pump stations, reservoirs, and wells. However, not all remote facilities will include chlorine disinfection systems. The City will evaluate each project to determine whether chlorine disinfection facilities are required. Bulk sodium hypochlorite systems will be designed to be indoors. Tanks, pumps, and controls will be contained within a building as well. The building will be cooled with an evaporative cooler (i.e. an air conditioning system is not included). The bulk storage tank(s) will be sized to provide 30-day storage.

The bulk sodium hypochlorite system includes the following components:

- Chemical storage building, block construction with concrete roof
- Bulk chemical storage tank(s) with ultrasonic level controls and fill station
- Sodium hypochlorite solution storage tank(s)
- Peristaltic metering pumps
- Chlorine residual analyzers and pump
- Emergency eyewash / shower
- Water softener system
  - Includes a dual tank system and hardness monitor
- Local control panel and SCADA

3.3 Contractor's General Costs

Contractor's general costs including mobilization/demobilization and miscellaneous costs from several bid tabs were analyzed. Based on these bid tabs, it was determined that the average contractor general costs were typically 20 percent of the total construction costs for the project, which does not include design, administration, construction management, or property costs.

3.4 Phasing Costs

The City expects that some remote facilities may be constructed in phases. Phasing facilities allows infrastructure to be designed for current capacity while leaving space for future equipment needed to meet future demands. Phasing of facilities provides a long-term economic benefit to the City such that facilities can be easily expanded in the future with minimal additional capital investment. Phased facilities will include infrastructure sized for the ultimate capacity of the facility. As a result, the initial phase of these facilities will include additional costs. These costs include: land acquisition, facility fencing, landscaping, electrical equipment, and construction of all structural components. Structural components may include wet wells, equipment pads, containment areas, and buildings which will be sized to accommodate the ultimate facility size.

Subsequent phases will include costs for additional equipment, such as pumps and valves. Depending on the time that has elapsed since the first phase of the project, existing equipment may need to be replaced or upgraded during the facility expansion. Future phases will still include costs for electrical and SCADA changes, but these costs should be minimal as much of the required infrastructure will be built during the initial phase. For reservoirs, subsequent phases will include structural costs to construct additional storage tank(s) as needed. For booster stations, emergency generators are sized to meet the emergency power generation requirements of the initial phase only. Therefore, a second generator is added at facility build-out or expansion to meet additional power generation requirements. PRV stations and storage reservoirs do not require an emergency generator, although reservoir facilities are designed to accommodate a portable generator if needed.

3.5 Site Security Costs

Each water and wastewater remote facility will include a site security system. The site security system includes badge/ID access at entry gates and intrusion alarms on all building access points. The security system will monitor the site. If an intrusion alarm is triggered, the system will automatically notify the City's central security system. While the security system will vary by site, each system will include the same major components. Therefore, a standard cost of $105,000 was included for each remote facility.

3.6 Design, Construction Management and Admin Costs

Design, construction administration and management, permitting and City administrative and procurement costs have not been included in this cost model but are added to construction costs in the City's infrastructure improvement plans. Previous investigations by WSD staff produced an estimate of 25 percent of the construction cost, and the City will continue to use this number in the projection of total facility costs in the relevant infrastructure improvement plants prepared in 2019.

Remote Facilities – Water

4.1 Booster Stations

4.1.1 Design Requirements

Based on the Water Remote Facilities Design Guidance Manual - August 2013, and discussions with City staff a typical template was developed for water booster stations shown in **Figure 4-1**. Major features in the pump station include vertical turbine pumps, yard piping and surge control system, electrical gear and shade canopy, site instrumentation including flow meter and the site features. Booster stations sizes included in the cost model range from 5 MGD to 60 MGD. Stations are designed for the firm pumping capacity with the largest pump out of service. The design standards utilized in the cost model are shown in **Table 4-1**.

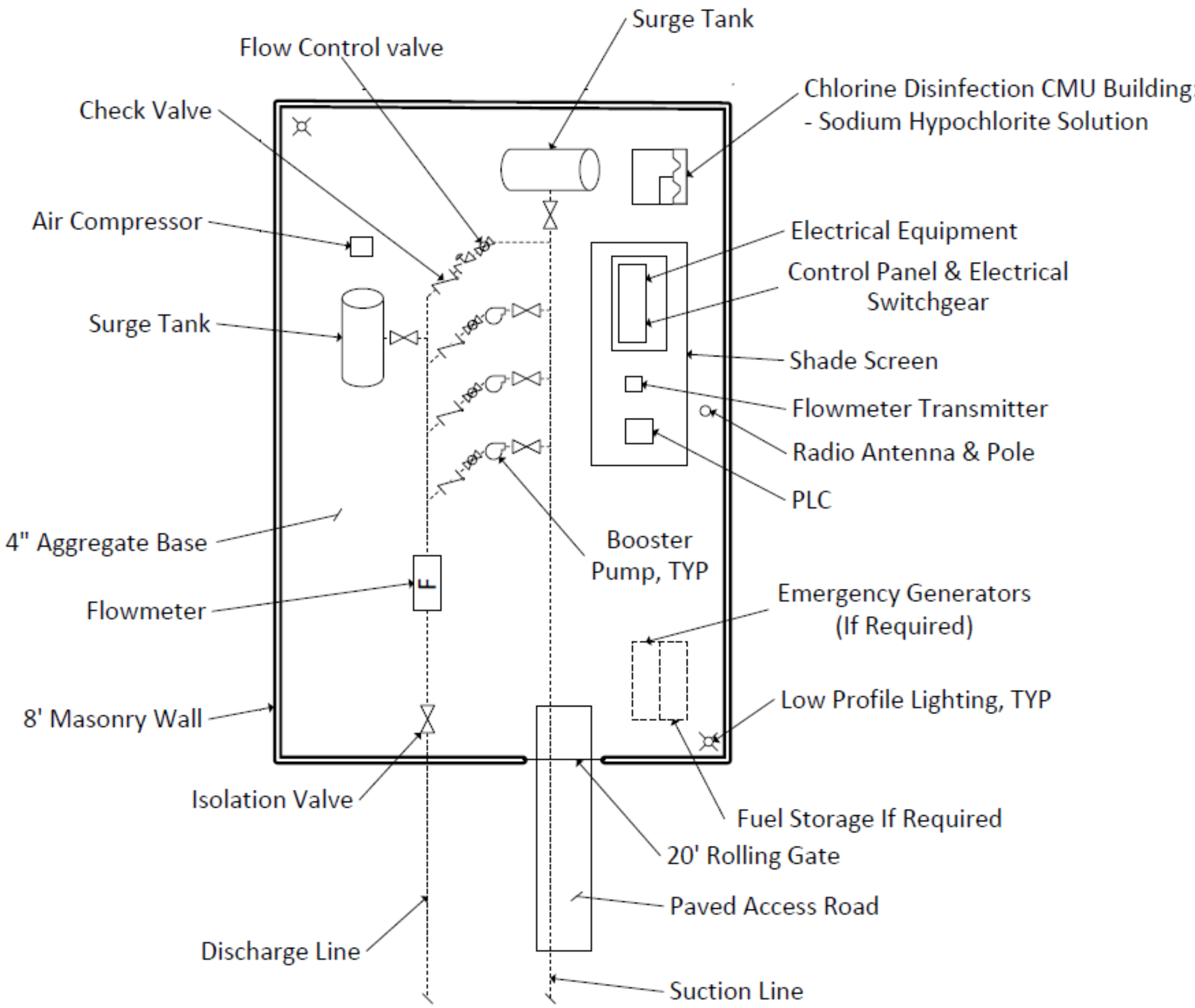

Figure 4-1. Typical Layout – Booster Stations

Table 4-1. Booster Station Design Standards

Asset/Design Condition		Design Standard/Cost Model	Specifications/Preferences/Notes
Hydraulics			
Capacity		5 pumps (5-15 MGD) 5 pumps (20-30 MGD) 6-7 pumps (40-60 MGD)	One redundant pump to maintain firm capacity
Mechanical Pumps & Tanks			
Pump		Can type, vertical turbine centrifugal pumps	Mechanical split case pumps not included in cost model
Hydro-Pneumatic Surge Tanks		Inlet and discharge 5000-gallon above grade steel hydro-pneumatic surge tank	Optional depending on transient analysis for each site; cost model includes two tanks per site
Sump Pump		Duplex, submersible sump pump of 50 gpm or higher capacity	Hard piped to a common discharge header. Double check valve and isolation plug valve shall be provided on horizontal run of each sump pump’s discharge line
Mechanical Piping			
Buried Pipe	</=16”	Flanged DIP w/ polyethylene encasement	Pipe: AWWA C110, C111,115,150,151 Encasement: ANSI/AWWA C150/A21.50
		Prefab. CML welded steel water pipe	ANSI/AWWA C200
	18”-42”	Prefab. CML welded steel water pipe	ANSI/AWWA C200
		Reinforced concrete steel cylinder pipe	ANSI/AWWA C301, C303, C304
	> 42”	CML reinforced welded steel pipe	ANSI/AWWA C301, C304
		Prefab. CML welded steel water pipe	ANSI/AWWA C200
Exposed Pipe	</=16”	CML flanged DIP	AWWA C150, C151, C104
	> 16”	Prefab. CML welded steel water pipe	ANSI/AWWA C200
	Chemical Piping	Schedule 80 CPVC	
Mechanical Valves			
Check Valves		Gravity operated swing check or cushioned check valve Silent check valves for pumps w/ VFD	MAG 15114 – Check Valves and Appurtenances
Pump Control Valves		Dual chamber control valves	City prefers </= 24“ valves be stainless steel; > 24” valves are not stainless-steel due to high cost
Isolation Valves		Butterfly or Gate upstream of FCV; require 2-4” bypass line inlet & outlet	Gate valve – non rising stem type
Air/Vacuum Release Valves		Sleeve, globe, butterfly, ball	

Table 4-1. Booster Station Design Standards

Asset/Design Condition	Design Standard/Cost Model	Specifications/Preferences/Notes
Site-Civil/Landscaping		
Booster Station Site	1 acre	
Booster Station Foundation	Helical piles	
Access Road	Minimum 16-foot width asphalt	
Facility Ground Surface Finish	4” thick compacted aggregate base	
Facility Landscaping	Exterior landscaping to match surrounding area	
Facility Storm Water Provisions	Storm retention basin sized to accommodate runoff from entire site	One drywell included
Structures & Appurtenances		
Booster Station Pad	Concrete slab on grade	
Pump Can	Cement-lined steel cans w/ bolt on flanges and AWWA specified coatings	
Chlorine Disinfection Building	CMU construction w/ concrete roof	
Flow Meter Vaults	72” Precast manhole	
Valve Vaults	Concrete precast/CIP, < 5’ deep, H-20 load rating, FRP grating with SS hardware	
Access Gate	Two 20-foot rolling access gates	One automated slide gate and one manual slide gate
Facility Fence	8’ block masonry wall with anti-climb barrier	
Fire Safety	Fire hydrant provided within facility	
Electrical		
Pump Motor	Electrical	High Efficiency Premium Motors
Facility Lighting	One manual/photo-electric operated light	
Electrical Equipment	Station equipped with enclosed electrical equipment and transformer	
Electrical Shade Canopy & Screen	Fire resistant shade canopy	
Back-up Power	Station equipped with standby generator hook-up with manual transfer switch	Diesel generator
Electrical		
VFD	To be provided by pump manufacturer	Not preferred by City. Not included in cost model
Flow Meters	Located on discharge line	Full port magnetic flowmeter Series ML-04-5G

Table 4-1. Booster Station Design Standards

Asset/Design Condition	Design Standard/Cost Model	Specifications/Preferences/Notes
Remote Monitoring	Station will be equipped with remote monitoring and control facilities (SCADA)	
Security	Site security system will be included	$105,000 lumpsum
Sodium Hypochlorite Disinfection		
Chemical Storage Building	Block construction with concrete roof with secondary containment	
Chemical Storage Tank	Linear fiberglass reinforced polyethylene designed for 30 days storage	One tank for sodium hypochlorite solution and one tank for batching
Storage Tank Level Control	Ultrasonic	
Chemical Pipe	SCH 80 CPVC	
Chemical Injection Eductor	PVC Venturi eductor	
Chemical Metering Pumps	Peristaltic Pulsafeeder pump	
Residual Analyzers	Online analyzer with sample pump	
Chemical Safety	Emergency eyewash/shower	

4.1.2 Unit Cost

4.1.2.1 Base Costs and Adders

Unit costs for booster stations include site work, pumps, flowmeters, site piping, electrical, instrumentation and security costs. The disinfection facility adder is included. Unit costs for various sizes including disinfection costs are shown in **Table 4-2**.

Table 4-2. Booster Pump Station Cost Summary

	Station Capacity						
Description	**5 MGD**	**10 MGD**	**15 MGD**	**20 MGD**	**30 MGD**	**40 MGD**	**60 MGD**
Booster Station	$4,274,000	$5,812,100	$7,198,500	$8,603,700	$10,349,700	$12,108,100	$14,724,700
Disinfection Facility Adder	$702,200	$866,800	$871,000	$877,000	$963,100	$1,049,300	$1,121,300
Total Cost	***$4,976,200***	***$6,678,900***	***$8,069,500***	***$9,480,700***	***$11,312,800***	***$13,157,400***	***$15,846,000***

4.1.2.2 Phased Facilities

The cost model has a few different options for phasing larger booster stations. The site features including equipment pads, piping, electrical and instrumentation, disinfection facilities and generators are sized for ultimate capacity. The cost of pumps in each phase is estimated based on the capacity required in that phase.

For the planned future booster stations the following phasing options are included in the cost model

- 10 MGD total capacity
  - Initial phase will provide 5 MGD capacity
  - Build-out will provide an additional 5 MGD capacity, for an ultimate capacity of 10 MGD
- 20 MGD total capacity
  - Initial phase will provide 10 MGD capacity
  - Build-out will provide an additional 10 MGD capacity, for an ultimate capacity of 20 MGD
- 30 MGD total capacity
  - There are two phasing approaches provided in the cost estimating tool with different initial phase capacities as described below.
    - Option 1
      - Initial phase will provide 5 MGD capacity
      - Build-out will provide an additional 25 MGD capacity, for an ultimate capacity of 30 MGD
    - Option 2
      - Initial phase will provide 15 MGD capacity
      - Build-out will provide an additional 15 MGD capacity, for an ultimate capacity of 30 MGD
- 40 MGD total capacity
  - There are two phasing approaches provided in the cost estimating tool, differing in the initial planned capacity of the station, as described below.
    - Option 1
      - Initial phase will provide 20 MGD capacity
      - Build-out will provide an additional 20 MGD capacity, for an ultimate capacity of 40 MGD
    - Option 2
      - Initial phase will provide 30 MGD capacity
      - Build-out will provide an additional 10 MGD capacity, for an ultimate capacity of 40 MGD
- 60 MGD total capacity
  - Initial phase will provide 20 MGD capacity
  - Build-out will provide an additional 40 MGD capacity, for an ultimate capacity of 60 MGD

Costs for phased booster stations are shown in **Table 4-3**.

Table 4-3. Phased Booster Pump Station Cost Summary

	Station Capacity					
	10 MGD		20 MGD		30 MGD - Option 1	
Description	**Phase 1**	**Build-out**	**Phase 1**	**Build-out**	**Phase 1**	**Build-out**
Booster Station	$2,045,400	$808,400	$2,881,200	$1,409,000	$2,792,700	$2,345,600
Disinfection Facility Adder	$866,800	$0	$877,000	$0	$914,000	$68,700
Phase Total Cost	$2,912,200	$808,400	$3,758,200	$1,409,000	$3,706,700	$2,414,300
Total Cost	***$3,720,600***		***$5,167,200***		***$6,121,000***	

	Station Capacity					
	30 MGD - Option 2		40 MGD - Option 1		40 MGD - Option 2	
Description	**Phase 1**	**Build-out**	**Phase 1**	**Build-out**	**Phase 1**	**Build-out**
Booster Station	$3,481,800	$1,850,900	$3,999,700	$1,603,400	$4,519,600	$665,200
Disinfection Facility Adder	$914,000	$68,700	$1,000,200	$68,700	$1,049,300	$0
Phase Total Cost	$4,375,800	$1,919,600	$4,999,900	$1,672,100	$5,568,900	$665,200
Total Cost	***$6,315,400***		***$6,672,000***		***$6,234,100***	

	Station Capacity	
	60 MGD	
Description	**Phase 1**	**Build-out**
Booster Station	$4,420,400	$2,634,400
Disinfection Facility Adder	$1,608,100	$74,500
Phase Total Cost	$5,488,500	$2,708,900
Total Cost	***$8,197,400***	

4.2 Pressure Reducing Valve (PRV) Stations

4.2.1 Design Requirements

Based on the design requirement listed in 'Water Remote Facilities Design Guidance Manual – August 2013' and discussions with City staff, the typical template for PRV stations shown in **Figure 4-2** was developed.

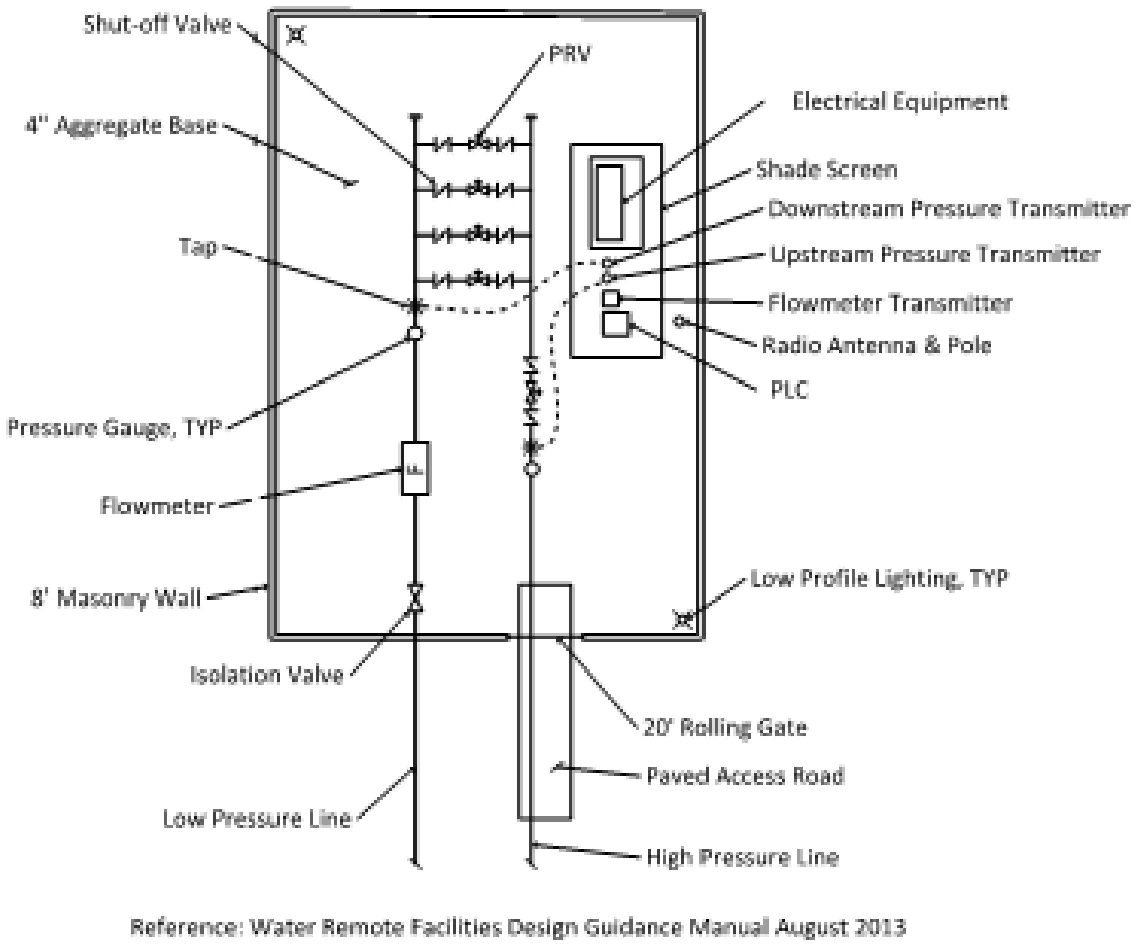

Figure 4-2. Typical Layout – PRV Stations

The cost model covers PRV stations with size ranging from 3 MGD to 70 MGD. Hydraulically operated, direct acting, single seated, pilot controlled diaphragm type globe valves with pressure sustaining feature are used. The cost model assumes multiple valves per station depending on firm capacity of the station with one redundant valve (using 8-inch (") valves for the 3 MGD station and 16" valves for all other capacities).

The design standards and assumptions used in the development of the base unit costs are shown in **Table 4-4**.

Table 4-4. PRV Design Standards

Asset	Design Standard/Cost Model	Preferences/Notes
Mechanical Valves and Piping		
PRV	Hydraulically operated, direct acting, single seated, pilot controlled diaphragm type globe valves w/ pressure sustaining feature	
Isolation Valves	Butterfly valves located upstream and downstream of each PRV	
Air/Vacuum Release Valves	Sleeve, globe, butterfly, ball	

Table 4-4. PRV Design Standards

Asset	Design Standard/Cost Model	Preferences/Notes
Station piping	DIP	
Electrical and I&C		
Back-up Power	Uninterruptable power supply for PLC, alarming system	
Electrical Equipment	Enclosed electrical equipment	
Electrical Shade Canopy & Screen	Fire resistant shade canopy	
Facility Lighting	One manual/photo-electric operated light.	
Flow Meters	Full port magnetic flowmeter located downstream of PRVs	
Remote Monitoring	Station will be equipped with remote monitoring and control facilities (SCADA)	
Security	Site security system will be included	$105K lump sum
Site-Civil		
Landscaping	Exterior landscaping to match surrounding area	
Site Area	1 acre	0.5 acre for 3 MGD site; all larger capacities are 1 acre.
Fence	8’ masonry wall w/ anti-climb barrier	
Access Road	20’ paved asphalt	
Potable Water	Potable water line with backflow preventer	
Access Gates	One 20-foot wide rolling access gate	Automated
Surface Finish	4” thick compacted aggregate base	
Storm Water Provisions	Retention basin sized for runoff from entire site	One drywell included

4.2.2 Unit Cost

4.2.2.1 Base Costs and Adders

Unit costs for PRV stations include site work, valves, site piping, electrical, instrumentation and security costs. Adders have been included for disinfection facilities and buried PRV stations. Disinfection facility details are discussed in Chapter 3. PRV stations are typically installed above grade. The buried PRV adder is for cases when above-grade PRV stations are not an option, where the valve is placed in a traffic-rated precast vault; valve depth is assumed as 9 feet.

Unit cost and adder costs for various facility sizes are listed in **Table 4-5**.

Table 4-5. PRV Station Cost Summary

Description	Station Capacity							
	3 MGD	5 MGD	10 MGD	20 MGD	30 MGD	40 MGD	50 MGD	60 MGD
PRV Station	$685,900	$771,700	$977,100	$1,030,600	$1,082,400	$1,167,900	$1,217,000	$1,286,400
Buried PRV Station Adder	$42,100	$42,100	$42,100	$42,100	$49,000	$56,000	$62,900	$69,900
Drywell Adder	$11,800	$11,800	$11,800	$11,800	$11,800	$11,800	$11,800	$11,800
Total Cost	***$739,900***	***$825,700***	***$1,031,100***	***$1,084,600***	***$1,143,300***	***$1,235,700***	***$1,291,800***	***$1,368,100***

4.2.2.2 Phased Facilities

The cost model has a few different options for phasing larger PRV stations. The site features including equipment pads, piping, electrical and instrumentation, and disinfection facilities are sized for ultimate capacity. The cost of valves in each phase is estimated based on the capacity required in that phase.

Phasing options included in cost model are as follows:

- 20 MGD total capacity
  - initial phase will provide 10 MGD capacity.
  - build-out will provide an additional 10 MGD capacity, for an ultimate capacity of 20 MGD.
- 40 MGD total capacity
  - Two phasing approaches are provided in the cost estimating tool. Under Option 1, the facility will be built in three phases, while under Option 2, the facility will be built in two phases.
    - Option 1:
      - Initial phase will provide 10 MGD capacity
      - Second phase will provide additional 20 MGD capacity, with a total capacity of 30 MGD.
      - Build-out will provide an additional 10 MGD capacity, with a total capacity of 40 MGD.
    - Option 2:
      - Initial phase will provide 20 MGD capacity.
      - Build-out will provide an additional 20 MGD capacity, with a total capacity of 40 MGD.

The phased PRV station cost summary is shown in **Table 4-6**.

Table 4-6. Phased PRV Station Cost Summary

Description	Station Capacity – 20 MGD		
	Phase 1	Build-out	Total
PRV Station	$943,100	$95,200	$1,038,400
Disinfection Facility Adder	$877,000	–	–
Buried PRV Station Adder	–	–	–
Total Cost	***$1,820,100***	***$95,200***	***$1,915,300***

Table 4-6. Phased PRV Station Cost Summary

Description	Station Capacity – 20 MGD		
	Phase 1	Build-out	Total

Description	Station Capacity – 40 MGD, Option 1			
	Phase 1	Phase 2	Build-out	Total
PRV Station	$971,800	$145,400	$93,200	$1,210,300
Disinfection Facility Adder	$1,049,300	–	–	–
Buried PRV Station Adder	–	–	–	–
Total Cost	***$2,0210,100***	***$145,400***	***$93,200***	***$2,259,600***

Description	Station Capacity – 40 MGD, Option 2		
	Phase 1	Build-out	Total
PRV Station	$1,020,900	$147,100	$1,168,000
Disinfection Facility Adder	$1,049,300	–	–
Buried PRV Station Adder	–	–	–
Total Cost	***$2,070,200***	***$147,100***	***$2,217,300***

4.3 Storage Reservoirs

4.3.1 Design Requirements

The cost model includes both steel and concrete tanks ranging from 1 MG to 40 MG. Options for above-grade and partially buried tanks are available in the cost model. A summary of the cost model materials and sizing is shown in **Table 4-7**.

Table 4-7. Steel and Concrete Tanks

Capacity	Material and Dimensions
1 MG	Steel – above grade tank
2-3 MG	Material: Steel – above grade tank Concrete – above grade or partially buried tank Dimensions: Diameter ≤ 165 ft Depth = 16 ft
5 MG	Material: Concrete – above grade or partially buried tank Dimensions: Diameter ≤ 165 ft Depth ≤ 30 ft with 2 ft freeboard & 5 ft stem wall
10-40 MG	Material: Concrete – partially buried rectangular tank Dimensions: Depth = 25 ft with 5 ft freeboard

Steel tanks are epoxy-coated welded steel with concrete mat foundation, fixed roof and cathodic protection. Cast-in-place concrete reservoirs are either prestressed concrete with cast-in-place core wall, vertical post-tensioned tendons and circumferential prestressed strands (AWWA D110 Type I) or prestressed concrete with precast core wall, vertical post-tensioned tendons and circumferential prestressed strands (AWWA D110 Type III). The cost model assumes prestressed tanks at 2-5 MG tank capacity; cast-in-place for 10 to 40 MG tank capacity. All reservoirs have an active tank mixing system consisting of recirculation pumps. The mixing system uses system pressure as flow enters the reservoir during a fill period to mix the influent water with the tank contents and is sized to completely mix the reservoir over a 24-hour period. All design standards and assumptions used in the cost model are shown in **Table 4-8**.

Table 4-8. Reservoir Design Standards

Asset	Design Standard/Cost Model	Preferences/Notes
Mechanical Piping and Valves		
Altitude valves	1-2 MG: Diaphragm type globe pattern ≥ 3 MG: motor actuated butterfly valves	Valves sized for 24-hr turnaround and 3 fps velocity
Inlet/Outlet Pipe	Ductile Iron or Steel mortar lined and coated	
Isolation Valves	Butterfly or gate type	Gate valve – non rising stem type
Overflow Pipe	Gravity drain pipe sized for maximum flow with flapper check valve and air gap	
Circulation Pump Station Type	Vertical turbine can pump station or horizontal centrifugal pump station	
Electrical and I&C		
Facility Lighting	One manual/photo-electric operated light. Task lighting for electrical equipment, odor control.	
SCADA	Station shall include a PLC tied to City SCADA system.	
Security	Badge access, automated gates, site intrusion alarms, reservoir door and hatch intrusion alarms	
Flow Meters	In-line magnetic flow meter	
Level Monitoring	2 ultrasonic level transmitters (1 primary, 1 backup)	
Site-Civil		
Landscaping	Exterior landscaping to match surrounding area	
Fence	8’ masonry wall w/ anti-climb barrier	
Access Road	Asphalt paved ≥ 20-foot wide	
Potable Water	Potable water line with backflow preventer	
Access Gates	One 20-foot wide automated rolling gate	
Surface Finish	4” thick compacted aggregate base	
Storm Water	Retention basin sized for runoff from entire site	Drywell included
Overflow	Concrete weir box located inside reservoir	

Table 4-8. Reservoir Design Standards

Asset		Design Standard/Cost Model	Preferences/Notes
Overflow Basin		Sized for 100-year, 2-hour storm event plus 1 hour reservoir overflow event at maximum fill rate.	
Site Area	1-5 MG	Facility Dimensions: 400’ x 400’ Land: 3.7 acres	
	10 MG	Facility Dimensions: 250’ x 450’ Land: 2.6 acres	
	15 MG	Facility Dimensions: 280’ x 520’’’ Land: 3.3 acres ’’	
	20 MG	Facility Dimensions: 310’ x 590’ Land: 4.2 acres	
	30 MG	Facility Dimensions: 370’ x 730’ Land: 6.2 acres	
	40 MG	Facility Dimensions: 430’ x 870’ Land: 8.6 acres	

4.3.2 Unit Cost

4.3.2.1 Base Costs and Adders

The summary of the base unit cost for reservoirs is shown in **Table 4-9**.

Table 4-9. Reservoir Base Unit Cost Summary

Storage Capacity (MG)	Reservoir Type	Total Reservoir Cost	Cost per gallon
2	steel, above grade	$5,308,600	$2.65
2	concrete, above grade	$5,389,900	$2.69
3	concrete, above grade	$5,567,400	$2.78
5	concrete, above grade	$5,691,600	$1.90
2	concrete, partially buried	$5,869,100	$1.96

Table 4-9. Reservoir Base Unit Cost Summary

Storage Capacity (MG)	Reservoir Type	Total Reservoir Cost	Cost per gallon
3	concrete, partially buried	$6,314,700	$1.26
5	concrete, partially buried	$6,536,600	$1.31
10	concrete, partially buried	$14,906,400	$1.49
15	concrete, partially buried	$17,705,200	$1.18
20	concrete, partially buried	$22,355,700	$1.12
30	concrete, partially buried	$30,651,800	$1.02
40	concrete, partially buried	$38,939,000	$0.97

4.3.2.2 Phased Facilities

The cost model has a few different options for phasing larger reservoirs. The site features including equipment pads, yard piping, electrical and instrumentation are sized for ultimate capacity. Costs for phased facilities are shown in **Table 4-10**.

For the planned future storage reservoirs, phased facilities are:

- 10 MG total capacity
  - Initial phase will provide 5 MG capacity
  - Build-out will provide an additional 5 MG capacity, for a total capacity of 10 MG
- 20 MG total capacity
  - Initial phase will provide 10 MG capacity
  - Build-out will provide an additional 10 MG capacity, for a total capacity of 20 MG
- 30 MG total capacity
  - Initial phase will provide 15 MG capacity
  - Build-out will provide an additional 15 MG capacity, for a total capacity of 30 MG
- 40 MG total capacity
  - Initial phase will provide 20 MG capacity.
  - Build-out will provide an additional 20 MG capacity, for a total capacity of 40 MG

Table 4-10. Phased Facility Cost Summary

Total Storage Capacity and Phase	Storage Capacity (MG)	Reservoir Type	Total Reservoir Cost	Cost per gallon
10 MG – Phase 1	5		$4,574,800	$0.91
10 MG – Phase 2	5	concrete above grade	$3,802,200	$0.76
Total	10		$8,377,100	$0.84
20 MG – Phase 1	10		$13,004,000	$1.30
20 MG – Phase 2	10	concrete partially buried	$12,063,200	$1.21
Total	20		$25,067,200	$1.25
30 MG – Phase 1	15		$15,593,200	$1.04
30 MG – Phase 2	15	concrete partially buried	$14,480,000	$0.97
Total	30		$30,073,200	$1.00
40 MG – Phase 1	20		$19,982,400	$1.00
40 MG – Phase 2	20	concrete partially buried	$18,692,700	$0.93
Total	40		$38,675,200	$0.97

4.4 Pipelines

4.4.1 Materials and sizes

Materials and sizes are included in the cost model as compared to City standards are listed in **Table 4-11**. City staff confirmed that 12" – 18" pipes are typically Ductile Iron Pipe (DIP); 20" – 42" will be either DIP or Concrete Cylinder Pipe (CCP); 48" – 84" will be either PCCP or Welded Steel Pipe (WSP); and mains 90" and larger will be WSP.

Table 4-11. Water Mains Pipe Material

Material	Ductile Iron Pipe		Concrete Cylinder Pipe		Welded Steel Pipe	
Pipe Size	**Standard**	**Cost Model**	**Standard**	**Cost Model**	**Standard**	**Cost Model**
6"	X					
12"	X	X				
16"	X	X	X			
18"	x	X	X			
20"	X	X	X	X		
24"	X	X	X	X		
30"	X	X	X	X		
36"	X	X	X	X		
42"	X	X	X	X		
48"	X			X	X	X

Table 4-11. Water Mains Pipe Material

Material	Ductile Iron Pipe		Concrete Cylinder Pipe		Welded Steel Pipe	
Pipe Size	**Standard**	**Cost Model**	**Standard**	**Cost Model**	**Standard**	**Cost Model**
54”	X			X	X	X
60”	X			X	X	X
66”	X			X	X	X
72”	X			X	X	X
78”	X			X	X	X
84”	X			X	X	X
90”	X				X	X

4.4.2 References and assumptions

The following City standards were used as primary references for defining the design requirements for the cost model development:

- City of Phoenix Design Standards Manual for Water and Wastewater Systems – 2017
- City of Phoenix Supplement to the 2015 Edition of the Maricopa Association of Governments Uniform Standard Specifications for Public Works Construction - 2015

The design standards and assumptions used in the development of the base unit costs are shown in **Table 4-12**.

Table 4-12. Water Main Design Standards

Asset	Design Standard	Cost Model Preferences/Notes
Minimum Pipe Cover		
Distribution Mains (12”-16”)	4 ft	Conservative assumption of 8 ft in cost model
Transmission Mains (> 16”)	6.5 ft	Conservative assumption of 8 ft in cost model
Valves		
Line Valves (12”-36”)	Direct-bury Gate or Butterfly Valves	Butterfly valve
Line Valves (> 36”)	Butterfly Valves with bypass assemblies	
Access Outlets with Manhole	Installed on water lines on each side of line valve.	
Line Valve Spacing		
Distribution Main (12”-16”)	600 ft	
Transmission Main (16”-30”)	2,640 ft	
Transmission Main (> 30”)	5,280 ft	

Table 4-12. Water Main Design Standards

Asset	Design Standard	Cost Model Preferences/Notes
Line Valve Spacing		
Distribution Main Thrust Restraint	Joint restraint at all bends and fittings (MAG Standard Detail 303)	
Transmission Main Thrust Restraint	Joint restraint at all bends, fittings, line valves, and bulkheads with system compatible with type of pipe	
Line Valve Spacing		
Fire Hydrants – Distribution	Installed on 12” distribution lines at 300 ft spacing	
Fire Hydrants – Transmission	Installed at high points on water mains 16” and larger at 1,320 ft spacing	

4.4.3 Unit Cost Development

4.4.3.1 Base Costs

The unit cost model includes material and installation costs for pipelines, trenching, subgrade excavation, backfill with Class B material, valves and structures and hydrants in distribution mains. The model includes a 25 percent addition to base costs to cover general requirements including mobilization, demobilization and other miscellaneous items.

Table 4-13 to **Table 4-15** provide a summary of the results from the cost model for water pipelines.

Table 4-13. Ductile Iron Pipeline Cost Summary

Pipe Diameter (inch)	Total cost per linear foot	Total cost per mile
12	$182.00	$960,960
16 (Distribution)	$196.00	$1,034,880
16 (Transmission)	$195.00	$1,029,600
18	$212.00	$1,119,360
20	$221.00	$1,166,880
24	$267.00	$1,409,760
30	$356.00	$1,879,680
36	$404.00	$2,133,120
42	$481.00	$2,539,680

Table 4-14. Welded Steel Pipeline Cost Summary

Pipe Diameter (inch)	Total cost per linear foot	Total cost per mile
48	$519.00	$2,740,320
54	$584.00	$3,083,520
60	$651.00	$3,437,280
66	$745.00	$3,933,600
72	$814.00	$4,297,920
78	$888.00	$4,688,640
84	$963.00	$5,084,640
90	$1,036.00	$5,470,080

Table 4-15. Concrete Cylinder Pipeline Cost Summary

Pipe Diameter (inch)	Total cost per linear foot	Total cost per mile
20	$198.00	$1,045,440
24	$247.00	$1,304,160
30	$323.00	$1,705,440
36	$379.00	$2,001,120
42	$418.00	$2,207,040
48	$472.00	$2,492,160
54	$531.00	$2,803,680
60	$591.00	$3,120,480
66	$677.00	$3,574,560
72	$739.00	$3,901,920
78	$805.00	$4,250,400
84	$871.00	$4,598,880

4.4.3.2 Cost Adders

Cost adders are features in the cost model to include non-standard conditions for projects. Cost adders included to water mains in the current cost model are:

- Pavement removal and replacement
- Extreme buried depth

Pavement Removal and Replacement

City Code, Chapter 31 Streets and Sidewalks, Section 31-49.1 was recently updated requiring resurfacing of pavement extending 25 feet on either side of the cut. The current cost model reflects this change. The cost model also assumes 1 foot of pavement removal and replacement on either side of the pipe trench. Additional cost for pavement removal and replacement is shown in **Table 4-16**.

Table 4-16. Pavement Removal and Replacement Adder

Pipe Diameter (inch)	Pavement Width (ft)	Total Cost per Linear Foot	Total Cost per Mile
12	3.67	$353.00	$1,863,840
16	4.00	$355.00	$1,874,400
20	4.83	$361.00	$1,906,080
24	5.17	$362.00	$1,911,360
30	7.17	$376.00	$1,985,280
36	7.67	$379.00	$2,001,120
42	7.83	$380.00	$2,006,400
48	8.00	$381.00	$2,011,680
54	9.00	$388.00	$2,048,640
60	10.00	$394.00	$2,080,320
66	11.50	$405.00	$2,138,400
72	12.00	$407.00	$2,148,960
78	12.50	$411.00	$2,170,080
84	13.00	$414.00	$2,185,920

Extreme Buried Depth

The City's standard for minimum pipe cover is 4' for distribution mains smaller than 12" diameter; 4' for distribution mains 12" to 16" diameter; and 6.5' for transmission mains larger than 16" diameter. However, the cost model uses a conservative assumption of 8' cover for all pipelines as this could vary significantly from project to project depending on the location of other utilities. The cost model also has an 'extreme depth' option for vertical walled trench with buried pipe depth of 20'. Dewatering is not included. Costs for extreme buried depth are shown in **Table 4-17 to Table 4-19**.

Table 4-17. Ductile Iron Pipeline Cost Summary (Extreme Buried Depth)

Pipe Diameter (inch)	Total Cost per Linear foot	Total Cost per Mile
12	$405.00	$2,138,400
16 (Distribution)	$436.00	$2,302,080
16 (Transmission)	$431.00	$2,275,680
18	$363.00	$1,916,640
20	$374.00	$1,974,720
24	$403.00	$2,127,840
30	$492.00	$2,597,760
36	$534.00	$2,819,520
42	$571.00	$3,014,880

Table 4-18. Welded Steel Pipeline Cost Summary (Extreme Buried Depth)

Pipe Diameter (inch)	Total Cost per Linear foot	Total Cost per Mile
48	$818.00	$4,319,040
54	$898.00	$4,741,440
60	$979.00	$5,169,120
66	$1,096.00	$5,786,880
72	$1,173.00	$6,193,440
78	$1,254.00	$6,621,120
84	$1,337.00	$7,059,360
90	$1,417.00	$7,481,760

Table 4-19. Concrete Cylinder Pipeline Cost Summary (Extreme Buried Depth)

Pipe Diameter (inch)	Total Cost per Linear foot	Total Cost per Mile
20	$504.00	$2,661,120
24	$588.00	$3,104,640
30	$721.00	$3,806,880
36	$812.00	$4,287,360
42	$877.00	$4,630,560
48	$975.00	$5,148,000
54	$1,074.00	$5,670,720
60	$1,175.00	$6,204,000
66	$1,314.00	$6,937,920
72	$1,417.00	$7,481,760
78	$1,525.00	$8,052,000
84	$1,633.00	$8,622,240

4.5 Wells

4.5.1 Assumed Design Requirements

Based on the design requirement listed in 'Water Remote Facilities Design Guidance Manual – August 2013' and discussions with City staff, the typical template for well facilities shown in **Figure 4-3** was developed.

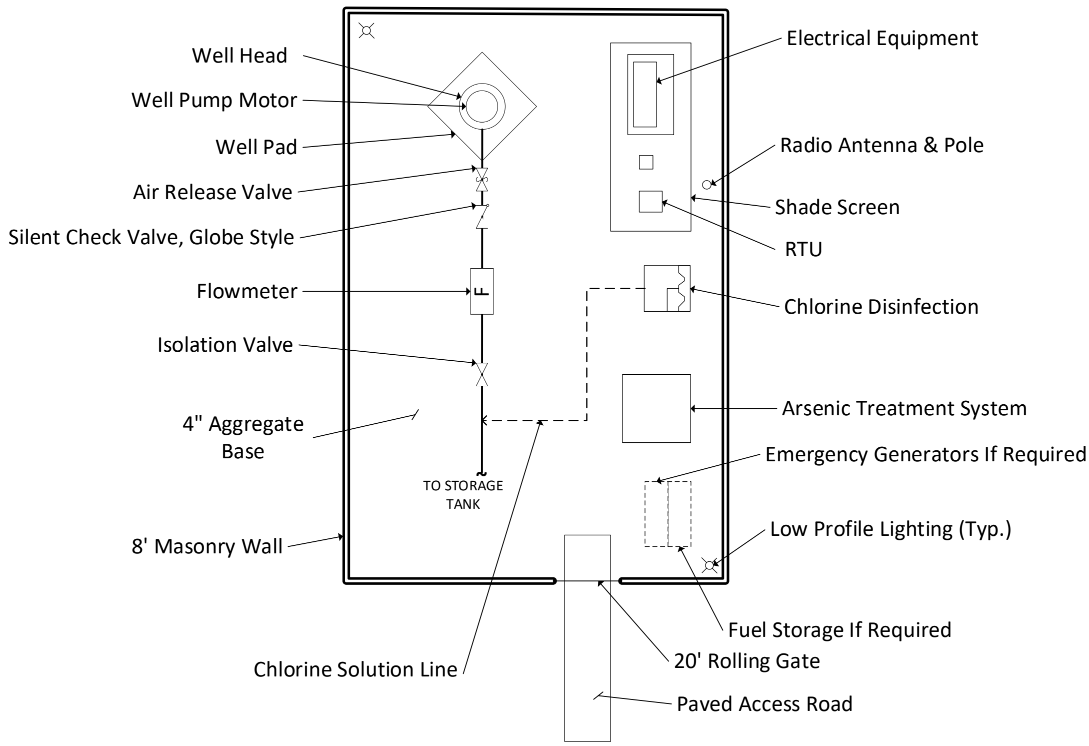

Figure 4-3. Typical Layout – Well Facilities

The costs developed for production wells and aquifer storage recovery (ASR) wells are based on City design standards and typical industry practices. Assumed design requirements for development of the base unit cost are presented in **Table 4-20**.

Table 4-20. Well Design Standards

Asset		Design Standard/Cost Model	Preferences/Notes
Casing			
Capacity	1.5 MGD	Diameter: 16” or 14” Depth: 1200 ft or 1300 ft	
	3 MGD	Diameter: 18” Depth: 1450-1550 ft	
Material		High strength low alloy (HSLA) steel	
Piping			
Well Site		In-line or down-hole submersible vertical turbine pipes will be included	
Well Head		Flanged DIP	
Valves			
Flow Control Valves		Silent globe-style check valves and butterfly isolation valves	
Well Head Valves		Air/vacuum release valves	
Screens			
Material		Wells will include stainless steel type 304L full-flow louvered screens	
Site-Civil/Landscaping			
Well Site		1 acre	
Foundation		The interior facility will be surfaced with a compacted aggregate base, 4” thick	
Access Road		Paved and 20-foot width	
Facility Landscaping		Exterior landscaping will match the surrounding area	
Structures & Appurtenances			
Well Head Pad		Concrete slab on grade	
Storm Retention Basin		Sized to handle the storm water capacity and well pumping at full capacity for 15 minutes	
Access Gate		20-foot automated rolling gate and additional non-automated 20-foot rolling gate	
Facility Fence		8-foot concrete masonry unit (CMU) wall	
Electrical			
Electrical Equipment		Station equipped with enclosed electrical equipment and transformer	
Electrical Shade Canopy		Metal roof with fabric shades.	

4.5.2 Unit Cost

4.5.2.1 Base Costs and Adders

The base cost shown in **Table 4-21** include drilling and installation. An adder for arsenic treatment facility (ATF) is provided. Arsenic treatment is accomplished using a split stream adsorptive media system. The arsenic treatment facilities are packaged systems and include a shade structure. The ATF is sized to treat 50 percent of the well capacity.

Table 4-21. Well Cost Summary

Description	Cost	Arsenic Treatment Cost	Total Cost
16" Casing at 1200 ft depth	**$3,364,180**	**$580,560**	**$3,944,740**
14" Casing at 1300 ft depth	**$3,342,940**	**$580,560**	**$3,923,500**
18" Casing at 1450 ft depth	**$3,847,390**	**$1,291,109**	**$5,138,499**
18" Casing at 1500 ft depth	**$3,906,390**	**$1,291,109**	**$5,197,499**
18" Casing at 1550 ft depth	**$3,965,390**	**$1,291,109**	**$5,256,499**

Construction Costs – Wastewater Facilities

Wastewater remote facilities covered in the cost model are gravity sewers, force mains, and lift stations. The design assumptions for each of these facilities and results of the unit cost update are summarized in this report.

5.1 Gravity Sewers

5.1.1 Materials and sizes

Materials and sizes are included in the cost model as compared to City standards presented in **Table 5-1**. Vitrified Clay Pipe (VCP) is the preferred and most commonly used gravity sewer pipe material. The City typically discourages use of DIP due to on-going corrosion issues with older DIP sewer installations. However, DIP remains in the City's standard because there are certain situations where DIP may be required (i.e. railroad crossings). DIP is not included in the cost model.

PVC pipe is currently being reviewed by the City for potential sewer installations. Historically, PVC has not been allowed in the City of Phoenix because of concerns about PVC pipe failing due to high water temperatures in the distribution and collection system, water pressure transients, and a lack of full time inspection of bedding and cover (which are critical for flexible pipe). PVC will not be included in the cost model.

Table 5-1. Gravity Sewer Pipe Material

Material	VCP		RCP, RCP/PVC Lined		DIP	
Pipe Size	Standard	Cost Model	Standard	Cost Model	Standard	Cost Model
8"	X				X	
10"	X				X	
12"	X	X			X	
15"	X	X			X	
16"	X	X			X	
18"	X	X			X	
20"	X	X			X	
21"	X	X			X	
24"	X	X			X	
27"	X	X			X	
30"	X		X	X	X	
33"	X		X	X	X	
36"	X		X	X	X	
39"	X		X	X	X	
42"	X		X	X	X	

Table 5-1. Gravity Sewer Pipe Material

Material	VCP		RCP, RCP/PVC Lined		DIP	
Pipe Size	**Standard**	**Cost Model**	**Standard**	**Cost Model**	**Standard**	**Cost Model**
48”			X	X	X	
54”			X	X	X	
60”			X	X		
66”			X	X		
72”			X	X		
78”			X			
81”			X	X		
84”			X	X		
87”			X	X		
90”			X	X		
96”			X			
108”			X			
120”			X			

5.1.2 Design Requirements

The design assumptions used in the cost model for unit cost development are shown in **Table 5-2**.

Table 5-2. Gravity Sewer Design Standards

Asset		Design Standard/Cost Model	Preferences/Notes
Gravity Sewers			
Minimum Pipe Cover		7 ft	Cost Model assumes a minimum cover of 12.5 ft
Thrust Restraint		Joint restraint at all bends, fittings, line valves, and bulkheads with system compatible with type of pipe	
Manholes	< 15”	400 ft	
	15”-24”	500 ft	
	> 24”	600 ft	

5.1.3 Cost Development

5.1.3.1 Base Costs

The unit cost model includes material and installation costs for pipelines, trenching, subgrade excavation, backfill with Class B material, structures and manholes. The model includes a 25 percent addition to base costs to cover general requirements including mobilization, demobilization and other miscellaneous items.

Table 5-3 provides a summary of the results from the cost model for gravity sewers.

Table 5-3. Gravity Sewer Pipeline Cost Summary

Pipe Diameter (inch)	Total cost per linear foot	Total cost per mile
12	$207.00	$1,092,960
15	$235.00	$1,240,800
18	$278.00	$1,467,840
21	$306.00	$1,615,680
24	$343.00	$1,811,040
27	$401.00	$2,117,280
30	$457.00	$2,412,960
33	$496.00	$2,618,880
36	$535.00	$2,824,800
39	$566.00	$2,988,480
42	$594.00	$3,136,320
48	$646.00	$3,410,880
54	$717.00	$3,785,760
60	$826.00	$4,361,280

5.1.3.2 Cost Adders

Cost adders are features in the cost model to include non-standard conditions for projects. Cost adders included for gravity sewers in the current cost model are:

- Pavement removal and replacement
- Extreme buried depth

Pavement Removal and Replacement

City Code, Chapter 31 Streets and Sidewalks, Section 31-49.1 was recently updated requiring resurfacing of pavement extending 25 feet on either side of the cut. The current cost model reflects this change. The cost model also assumes 1 foot of pavement removal and replacement on either side of the pipe trench. Additional cost for pavement removal and replacement is shown in **Table 5-4**.

Table 5-4. Gravity Line Pavement Replacement Cost Adder

Pipe Diameter (inch)	Pavement Width (ft)	Total cost per linear foot	Total cost per mile
12	3.67	$353.00	$1,863,840
15	3.92	$355.00	$1,874,400
18	4.67	$360.00	$1,900,800
21	4.92	$361.00	$1,906,080

Table 5-4. Gravity Line Pavement Replacement Cost Adder

Pipe Diameter (inch)	Pavement Width (ft)	Total cost per linear foot	Total cost per mile
24	5.17	$362.00	$1,911,360
27	6.92	$374.00	$1,974,720
30	7.17	$376.00	$1,985,280
33	7.42	$377.00	$1,990,560
36	7.67	$379.00	$2,001,120
39	7.83	$380.00	$2,006,400
42	7.83	$380.00	$2,006,400
48	8.00	$381.00	$2,011,680
54	9.00	$388.00	$2,048,640
60	10.00	$394.00	$2,080,320

Table 5-5 provides a summary of the results from the cost model for gravity sewer pipeline for extreme buried depths.

Table 5-5. Gravity Sewer Pipeline Cost Summary (Extreme Buried Depth)

Pipe Diameter (inch)	Total cost per linear foot	Total cost per mile
12	$557.00	$2,940,960
15	$590.00	$3,115,200
18	$647.00	$3,416,160
21	$680.00	$3,590,400
24	$724.00	$3,822,720
27	$808.00	$4,266,240
30	$870.00	$4,593,600
33	$915.00	$4,831,200
36	$960.00	$5,068,800
39	$1,001.00	$5,285,280
42	$1,037.00	$5,475,360
48	$1,107.00	$5,844,960
54	$1,210.00	$6,388,800
60	$1,352.00	$7,138,560

5.3 Force Mains

5.3.1 Materials and sizes

The City's standard for force mains is currently DIP. Due to corrosion issues, the City is installing HDPE. The City expects that HDPE could be listed as a standard material in the future; however, HDPE is not included in the current cost model update.

The materials and sizes used for force main unit cost is shown in **Table 5-6**. Single force mains and dual force mains with 5-foot barrel-to-barrel spacing are included in the cost model.

Table 5-6. Force Main Pipe Material

Material	DIP	
Pipe Size	**Standard**	**Cost Model**
4"	X	X
6"	X	X
8"	X	X
10"	X	X
12"	X	X
14"	X	X
16"	X	X
20"	X	X
24"	X	X
30"	X	X

5.3.2 Design Requirements

The design assumptions used in the cost model for unit cost development are shown in **Table 5-7**.

Table 5-7. Force Main Design Standards

Asset	Design Standard/Cost Model	Preferences/Notes
Force Mains		
Minimum Pipe Cover	Not specified	2014 Cost Model assumes a minimum cover of 7 ft
Force Main Thrust Restraint	Joint restraint at all bends and fittings (MAG Standard Detail 303)	
Isolation Valves	Full-port eccentric plug valves	2,640 ft
Air Release Valves	Required at all high points	2,640 ft
Air Release Manholes		2,640 ft
Blow-off Manholes		2,640 ft

5.3.3 Cost Development

5.3.3.1 Base Costs

The unit cost model includes material and installation costs for pipelines, trenching, subgrade excavation, backfill with Class B material, structures and manholes. The model includes a 25 percent addition to base costs to cover general requirements including mobilization, demobilization and other miscellaneous items.

Table 5-8 and **Table 5-9** provide a summary of the results from the cost model for single and dual force mains at typical depths.

Table 5-8. Single Force Main Pipeline Cost Summary

Pipe Diameter (inch)	Total Cost per Linear Foot	Total Cost per Mile
4	$102.00	$538,560
6	$106.00	$559,680
8	$133.00	$702,240
10	$150.00	$792,000
12	$160.00	$844,800
14	$177.00	$934,560
16	$208.00	$1,098,240
20	$241.00	$1,272,480
24	$294.00	$1,552,320
30	$382.00	$2,016,960

Table 5-9. Dual Force Main Pipeline Cost Summary

Pipe Diameter (inch)	Total Cost per Linear Foot	Total Cost per Mile
4	$177.00	$934,560
6	$188.00	$992,640
8	$235.00	$1,240,800
10	$263.00	$1,388,640
12	$282.00	$1,488,960
14	$310.00	$1,636,800
16	$363.00	$1,916,640
20	$431.00	$2,275,680
24	$523.00	$2,761,440
30	$689.00	$3,637,920

5.3.3.2 Cost Adders

Cost Adders are features in the cost model to include non-standard conditions for projects. Cost adders included for force mains in the current cost model are:

- Pavement removal and replacement
- Hard rock excavation

Pavement Removal and Replacement

City Code, Chapter 31 Streets and Sidewalks, Section 31-49.1 was recently updated requiring resurfacing of pavement extending 25 feet on either side of the cut. The current cost model reflects this change. The cost model also assumes 1 foot of pavement removal and replacement on either side of the pipe trench. Additional cost for pavement removal and replacement is shown in **Table 5-10** and **5-11**.

Table 5-10. Single Force Main Pavement Replacement Adder

Pipe Diameter (inch)	Pavement Width (ft)	Total Cost per Linear Foot	Total Cost per Mile
4	4.17	$356.00	$1,879,680
6	4.17	$356.00	$1,879,680
8	4.33	$357.00	$1,884,960
10	4.58	$359.00	$1,895,520
12	4.75	$360.00	$1,900,800
14	5.00	$362.00	$1,911,360
16	5.33	$363.00	$1,916,640
20	5.58	$366.00	$1,932,480
24	6.00	$368.00	$1,943,040
30	7.08	$375.00	$1,980,000

Table 5-11. Dual Force Main Pavement Replacement Adder

Pipe Diameter (inch)	Pavement Width (ft)	Total Cost per Linear Foot	Total Cost per Mile
4	7.67	$379.00	$2,001,120
6	8.00	$381.00	$2,011,680
8	8.33	$383.00	$2,022,240
10	8.67	$386.00	$2,038,080
12	9.00	$388.00	$2,048,640
14	9.33	$390.00	$2,059,200
16	9.67	$392.00	$2,069,760
20	10.83	$400.00	$2,112,000
24	11.50	$405.00	$2,138,400
30	14.00	$421.00	$2,222,880

Hard Rock Excavation

Hard rock excavation may be encountered in some portions of the City. The rock excavation cost adder includes the additional cost and time for the excavation and hauling the rock for disposal and replacement of the rock with backfill material.

Table 5-12 and **Table 5-13** provide a summary of the results from the cost model for single and dual force main rock excavations.

Table 5-12. Single Force Main Rock Excavation Cost Summary

Pipe Diameter (inch)	Excavated Volume (cubic yard)	Total Cost per Linear Foot	Total Cost per Mile
4	1.65	$169.00	$892,320
6	1.72	$177.00	$934,560
8	1.84	$189.00	$997,920
10	1.99	$205.00	$1,082,400
12	2.12	$218.00	$1,151,040
14	2.28	$235.00	$1,240,800
16	2.47	$255.00	$1,346,400
20	2.74	$282.00	$1,488,960
24	3.08	$317.00	$1,673,760
30	3.84	$395.00	$2,085,600

Table 5-13. Dual Force Main Rock Excavation Cost Summary

Pipe Diameter (inch)	Excavated Volume (cubic yard)	Total Cost per Linear Foot	Total Cost per Mile
4	2.63	$271.00	$1,430,880
6	2.82	$290.00	$1,531,200
8	3.01	$310.00	$1,636,800
10	3.21	$330.00	$1,742,400
12	3.42	$351.00	$1,853,280
14	3.63	$374.00	$1,974,720
16	3.85	$396.00	$2,090,880
20	4.47	$460.00	$2,428,800
24	4.96	$511.00	$2,698,080
30	6.36	$654.00	$3,453,120

5.4 Submersible Lift Stations

5.4.1 Design Requirements

Based on the City's Wastewater Lift Station Design Guidance Manual – December 2012 and discussions with City staff, a typical template for lift stations shown in **Figure 5-1** was developed. Major features in the pump station include vertical turbine pumps, yard piping and odor control system, electrical gear and shade canopy, site instrumentation including flow meter and the site features. Lift station sizes included in the cost model range from 1 MGD to 40 MGD. Stations are designed to meet firm pumping capacity with the largest pump out of service.

Current City standard requires DIP for force mains. Due to problems with corrosion, the City is specifying HDPE in certain locations. The force main material is typically DIP on the lift station site but transitions to HDPE outside of the lift station site. The cost model assumes DIP within the lift stations.

The design standards utilized in the cost model are shown in **Table 5-14**.

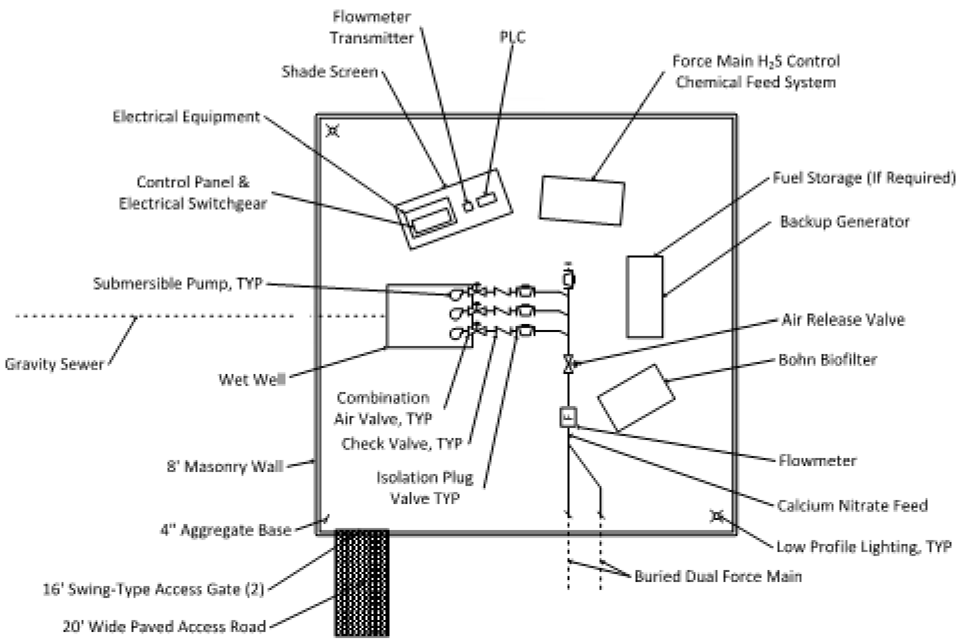

Figure 5-1. Typical Layout – Lift Stations

Table 5-14. Lift Station Design Standards

Asset/Design Condition	Design Standard/Cost Model	Preferences/Notes
Capacity	2 pumps (1 MGD) 3 pumps (3-5 MGD) 4 pumps (8-10 MGD) Up to 6 pumps (10-40 MGD)	
Pump	Close coupled, submersible, radial flow centrifugal pumps	Constant speed pumps ($\leq$ 5 MGD) VFDs ($\geq$ 5MGD)
Discharge Pipe (force main)	Lined flanged ductile iron pipe (AWWA C150, C151, C104)	
Check/Control Valves	Air-cushioned swing check valve	Electric actuators preferred

Table 5-14. Lift Station Design Standards

Asset/Design Condition	Design Standard/Cost Model	Preferences/Notes
	(Automatic or pneumatic check valves considered for lift stations $\geq$ 5 MGD)	
Isolation Valves	Full-port eccentric plug valves	
Force Main H2S Control	Calcium nitrate addition to force main	City is has used ferrous chloride in larger interceptors
Wet Well Odor Control	Biofilters with Wet Chemical Scrubber	
Chemical Containment	Concrete containment w/ chemical resistant non-slip, non-porous coating Able to contain 100% of chemical tank volume w/ 6" freeboard	
Calcium Nitrate	Tank: FRP, HDPE Piping: Schedule 80 CPVC, HDPE, FRP	
Sodium Hydroxide	Tank: FRP Piping: Schedule 80 CPVC	
Sodium Hypochlorite	Tank: FRP Piping: Schedule 80 CPVC	
Back-up Power	Natural gas/diesel-fueled engine generator w/ Automatic Transfer Switch. Uninterruptable power supply for PLC, alarming system, some I&C	Diesel Generator
Electrical Equipment	Enclosed electrical equipment and transformer	
Electrical Shade Canopy & Screen	Fire resistant shade canopy	
Facility Lighting	One manual/photo-electric operated light. Task lighting for electrical equipment, odor control.	
SCADA	Station shall include a PLC tied to City SCADA system.	
Security	Badge access, automated gates, intrusion alarms	
Flow Meters	In-line magnetic flow meter	
Wet well level control	2 ultrasonic level transmitters (1 primary, 1 backup)	
SCADA	Station shall include a PLC tied to City SCADA system.	
Temperature Sensor	Location: Field Equipment: Pump	
Moisture Sensor	Location: Field Equipment: Pump	
Level Element	Location: Field Equipment: Wet Well, Chemical Tanks	

Table 5-14. Lift Station Design Standards

Asset/Design Condition	Design Standard/Cost Model	Preferences/Notes
Pressure Transmitter	Location: Field Equipment: Force Main	
Pressure Gauge	Location: Field Equipment: Force Main	
Flow Element	Location: Field Equipment: Force main	
Level Transmitter	Location: Field/PCP Equipment: Tank Level Element/Wet Well Level Element	
Flow Totalizing Transmitter	Location: PCP	
Flow Totalizer	Location: PCP Equipment: Flow Totalizing Transmitter	
Transient Voltage Surge Suppressor	Location: MCC Equipment: MCC	
Temperature Transmitter	Location: PLC Equipment: PLC	
Site	1 acre	
Landscaping	Exterior landscaping to match surrounding area	
Fence	8’ masonry wall w/ anti-climb barrier	
Access Road	Paved min. 20-foot width	Asphalt
Potable Water	Potable water line with backflow preventer	
Access Gates	Two 16-foot wide double swing-type gates	One automated and one manual
Surface Finish	4” thick compacted agg. base	
Foundation	Helical piles	
Storm Water Provisions	Retention basin sized for runoff from entire site	Dry wells included in cost model
Wet Well	Circular or rectangular cast-in-place or pre-cast concrete sections w/ anti-corrosion coating.	
Pump Station, Storage, Generator, Equipment Station, Transformer, Odor Control Concrete Pads	Slab on grade	
Fire Safety	Fire hydrant provided within facility	

5.4.2 Unit Cost

5.4.2.1 Base Costs and Adders

Unit Costs for lift stations include site work, pumps, flowmeters, site piping, odor control systems, pigging facility, electrical, instrumentation and security costs. Acoustic enclosure adder is included where noise protection is needed in residential areas. Unit costs for various sizes including acoustic enclosure are shown in **Table 5-15**.

Table 5-15. Lift Station Cost Summary

Description	Station Capacity			
	1 MGD	**3 MGD**	**3.5 MGD**	**5 MGD**
Lift Station	$2,125,700	$2,899,700	$3,441,300	$3,804,000
Acoustic Enclosure	$45,500	$45,500	$45,500	$50,000
Total	$2,171,200	$2,945,200	$3,486,800	$3,854,000
Description	**Station Capacity**			
	8 MGD	**12 MGD**	**25 MGD**	**40 MGD**
Lift Station	$4,830,700	$5,812,600	$8,648,400	$11,727,600
Acoustic Enclosure	$60,000	$70,000	$80,000	$80,000
Total	$4,890,700	$5,882,600	$8,728,400	$11,807,600