9.0 HYDRAULIC MODEL DEVELOPMENT

9.1 PURPOSE

The purpose of this chapter is to outline details of the recycled water distribution system model construction and approach. This chapter also describes the model scenarios considered as part of this Master Plan representing various levels of development within the City.

This chapter is divided into the following sections:

- Model Approach
- Modeling Software
- Model Input and Components
- Model Development
- Model Calibration
- Modeled Scenarios

9.2 MODEL APPROACH

Hydraulic modeling is an important tool used to simulate and analyze water systems and their operation. There is a wide selection of software programs that have made network analysis modeling efficient and practical for virtually any water system. Modeling can simulate existing and future water system conditions, identify system deficiencies, analyze impacts of increased demands, and evaluate the effectiveness of proposed system improvements. Hydraulic models can provide both the engineer and water system operator with a better understanding of the water system operating and hydrodynamic conditions.

9.3 MODELING SOFTWARE

There are several software programs that are widely used to model pressurized distribution systems. The variety of the program capabilities and features makes the selection of a particular modeling software generally dependent upon three factors: user preference, the requirements of the particular water distribution system, and the costs associated with the software.

Although multiple software packages are available, WaterCAD by Bentley has been determined to best meet the City's modeling needs, as it is simple to operate and has relatively low costs. If the City were to want to operate their own model, this would be an efficient choice. The City's existing WaterCAD model was originally developed as part of the 30% Master Plan. The model simulates conditions in the recycled water distribution system and was updated for use with the development of this Master Plan.

9.4 MODEL INPUT AND COMPONENTS

A hydraulic model is composed of three main parts:

1. The data file that stores the geographic location of facilities. The geographic data file provides water system facility locations and is typically represented as an AutoCAD drawing file or GIS shapefile. Elements in this file represent model system facilities including pipes, junction nodes (connection points for pipes and locations of demands), control valves, pumps, tanks, and reservoirs.

2. The physical attribute database that defines the physical system properties, including things such as the facility size and geometry, operational characteristics, and production/consumption data.

3. A computer program "calculator" that solves a series of hydraulic equations based on the information contained in the database files to find and generate the performance of the water system in terms of pressure, flow, and operation status.

The key to maximizing the benefits of developing a hydraulic model is correctly interpreting the results so the user understands how the distribution system can be affected by the variables input into the model. This understanding enables the user to be proactive in developing solutions to existing and future water system goals and objectives. With this approach, the hydraulic model is not only used to identify the adequacy of system performance, but it is also used to find solutions for operating the water system according to established performance criteria.

Developing an accurate and reliable hydraulic model begins with entering system infrastructure information into the database and calibrating the model to match existing conditions observed in the field. Once the model is calibrated, it becomes an invaluable tool that can be used to solve system planning and operational issues. The model operates according to the operational and physical attributes assigned to each model component. This information is used to simulate flow and pressures within the system as predicted by the model's mathematical equations.

The hydraulic model used to develop the City's 30% Reclamation Master Plan was reconstructed using data provided by the City in the form of an ArcGIS geodatabase file:

- Reclamation.gdb (1/17/2018)

The file provides the physical attributes and location of the valves and pipelines within the existing reclamation system. Manufacturer pump curves and physical parameters of the reclamation booster pump station (RBPS) pumps were also used to create the hydraulic model.

9.5 MODEL DEVELOPMENT

The City's existing reclamation system model was updated with information provided by the City (as-built infrastructure and service area geography). After reviewing the information provided by City staff, the hydraulic model was updated to represent actual parameters associated with each system asset. Either a model link, node, pump, or valve is used to represent each system asset within the model. Associated physical and operational data for each component is stored as an attribute table assigned to each link or node.

Nodes are used to represent connections between links and may act as either a supply source, such as a tank, reservoir, hydrant, or a customer demand. Nodes define the boundaries of each link and separate links that may contain different attributes. Essential attributes input into the database associated nodes include elevation, flow demand, and pressure zone. Resulting node parameters calculated by the model include pressure and hydraulic grade line.

Pumps and valve elements are used to represent pumps, pump stations, and valves within the distribution system and require input of attributes associated with operational and physical data of the system component.

Links represent pipe segments and input of attributes such as diameter, length, and Hazen-Williams C-factor. Flow, velocity, headloss, and changes in hydraulic grade line are some of the reported output parameters for all link elements.

9.6 MODEL CALIBRATION

Once the model was redeveloped and updated, it was calibrated so that it provided a reasonable representation of actual field performance. Existing operation data was used to calibrate the model. During calibration, parameters in the computer model are adjusted so hydraulic results are similar to observed measurements in the field under identical conditions. Once calibrated, the model is an effective tool for predicting system performance under different demand or operational conditions.

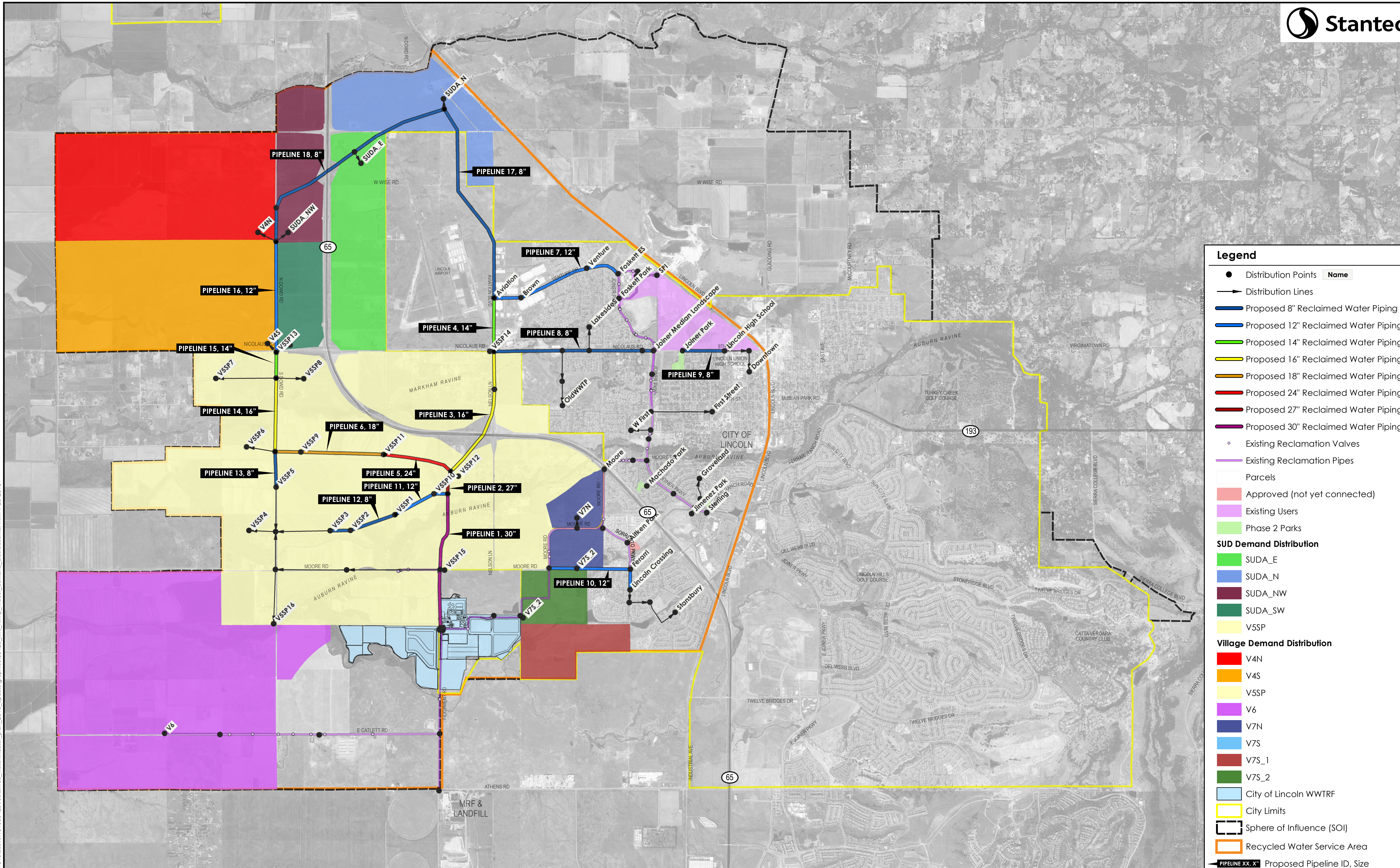
9.7 MODELED SCENARIOS

The calibrated model only represents the existing recycled water system infrastructure. However, the main purpose of the development of the hydraulic model is to create a tool that can be used to size future system expansions and develop the recommendations presented in this Master Plan. The existing system model was used as a basis to create model scenarios of the system under various levels of community development. To create the future system scenarios, new pipelines, nodes, user demands, and facilities were added to the system model. Controls from the existing calibrated model were imported and modified as necessary to create simulations of the future system.

The existing hydraulic model includes the following scenarios:

1. **Existing Level of Development Scenario**
   a. Existing Scenario – PHD
   b. Existing Scenario – MMD
   c. Existing Scenario – ADD
2. **Near-Term Level of Development Scenario**
   a. Near-Term Scenario – PHD
   b. Near-Term Scenario – PHD - 5p (all five pumps in operation)
   c. Near-Term Scenario – PHD – Remove County Leased Reclamation Area
   d. Near-Term Scenario – MMD
   e. Near-Term Scenario – ADD
3. **Buildout Level of Development Scenario**
   a. Buildout Scenario – PHD
   b. Buildout Scenario – MMD
   c. Buildout Scenario – ADD
4. **Long-Term Level of Development Scenario**
   a. Long-Term Scenario – PHD
   b. Long-Term Scenario – MMD
   c. Long-Term Scenario – ADD

Figure 9-1 depicts how the demands were distributed within the hydraulic model. Demands within Village 5/ SUD-B were distributed based on those presented in the Specific Plan. Demands to other service areas are assumed to be distributed uniformly and are collectively served by the nodes identified on the nearest distribution main.



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City of Lincoln
Reclamation Master Plan

Figure 9-1
Model Demand Distribution

10.0 RECLAMATION SYSTEM EVALUATION

10.1 PURPOSE

This chapter evaluates the existing reclaimed water system to identify issues that must be resolved for continued system operation and for preparation of future system expansions. This chapter also presents the proposed approach to phasing the construction of future recycled water distribution mains needed to provide reclamation service within the recycled water service area.

This chapter is divided into the following sections:

- Existing System Evaluation
- Future System Evaluation
- Phasing Approach

10.2 EXISTING SYSTEM EVALUATION

10.2.1 Existing Scenario

The hydraulic analysis of the existing reclaimed water system is based on the results of the calibrated model of the existing system. The hydraulic model was used to evaluate the existing reclamation system for possible deficiency corrections and optimization under the following demand conditions:

- Average Day Demand (ADD)
- Maximum Month Demand (MMD)
- Peak Hour Demand (PHD)

As explained in **Chapter 6.0**, Maximum Day Demand (MDD) conditions are assumed to be the same as MMD conditions. The goal of the hydraulic analysis is to identify system improvements required for efficient system operation and increased system utilization in future expansions. The model was run under ADD conditions to estimate the maximum pressure conditions that may occur in the existing system. Under ADD conditions two of the five RBPS pumps operate to supply demands. The pressure in the system ranges between 64 and 88 psi depending on location and elevation.

Based on discussions with WWTRF operators, existing agricultural demands are supplied on a continuous basis (multiple days of 24-hour use) during the maximum month of use. These users serve as large baseload demands, accounting for over 95% of the existing MMD. Because there is no hourly difference in these demands, the results of the MMD and PHD conditions models show little variation. System pressure ranges between approximately 52 and 74 psi with four of the five RBPS pumps running (reliable capacity). With all five pumps running, the pressure range increases to approximately 65 to 88 psi. No deficiencies within the existing system were predicted by the model. Model results are summarized in **Table 10-1**.

Table 10-1 Existing System Model Results Summary (1)

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	4	4
Demand (gpm)	1,820	4,550	4,590
Demand (MGD)	2.62	6.55	6.61
Annual Demand Volume (MG)	957	-	-
Maximum Pressure (psi)	88	74	73
Minimum Pressure (psi)	64	52	52
Maximum Headloss (ft/ft)	0.002	0.003	0.003
Maximum Velocity (fps)	1.79	4.47	4.47

1. Existing model results do not include demands associated with Foskett Regional Park, which was connect during the development of this Master Plan.

10.2.2 Near-Term Development Scenario

A near-term level of development scenario was considered within the existing system model. The near-term scenario provides an evaluation of the system upon connection of the City's planned or approved use areas. Demands added to the existing system model include the following park irrigation areas:

- Foskett Park – Approved for recycled water use
- Aitken Park – Approved for recycled water use
- Joiner Park – Phase II Reclamation Project
- Machado Park – Phase II Reclamation Project
- Peter Singer Park – Phase II Reclamation Project

The MMD of these parks adds an additional 565 gpm to the existing system demand, and 1,695 gpm to the total PHD. The total MMD and PHD exceed the current reliable pumping capacity (four pumps in operation) of the RBPS. The system pressure range is projected to fall to approximately 42 to 65 psi, under MMD conditions. Pressures are further reduced within the system under PHD conditions, falling to a minimum pressure of approximately 17 psi near Foskett Regional Park. Generally, lower pressures are projected along the 12-inch Joiner Parkway pipeline, and higher pressures are predicted at lower elevations in the system near the WWTRF.

The PHD exceeds the maximum pumping capacity of the RBPS (five pumps in operation). Existing demands can be met, but at the expense of system pressure and pump station redundancy. Based on discussions with City staff, the County Leased Reclamation Area may be removed from the reclamation system within the next five years. With the demand of the County Leased Reclamation Area removed from the model, system pressure range increases to approximately 45 to 77 psi with four of the RBPS pumps in operation. A summary of model results is presented in **Table 10-2**.

Table 10-2 Near-Term System Model Results Summary

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	4	4
Demand (gpm)	2,046	5,115	5,985
Demand (MGD)	2.95	7.37	8.62
Annual Demand Volume (MG)	1,075	-	-
Maximum Pressure (psi)	78	65	50
Minimum Pressure (psi)	54	42	17
Maximum Headloss (ft/ft)	0.001	0.003	0.003
Maximum Velocity (fps)	1.79	4.47	4.47

10.2.3 Existing and Near-Term System Recommendations

Condition Assessment – The City should perform a condition assessment of the existing reclamation system. The condition assessment should include a field evaluation of key system assets. Data from the condition assessment can be used in the implementation of asset management software, which can provide the City with automated evaluations of the most cost-effective means of maintaining the City's recycled water system and prioritizing potential rehabilitation and replacement (R&R) projects as the system ages.

Phase Out County Leased Reclamation Area – The City has identified that the County Leased Reclamation Area may be removed from the reclamation system by 2023. The near-term PHD falls within the existing reliable pumping capacity of the RBPS when the demand of the County Leased Reclamation Area is removed from the model. Alternatively, the City could install 6th RBPS pump to provide reliable pumping capacity during PHD conditions. Additional operational configurations include:

1. The 45-psi pressure is less than desirable, but suitable for sprinkler operation. The City could use the redundant pump to increase pressures and only drop to 45 psi when a pump is offline for service (don't retain the redundant pump off-line until needed).

2. The Machado irrigation system will take as much water as the City can send them. The City could send slightly less water to Machado to achieve the desired pressures in the City.

10.3 FUTURE SYSTEM EVALUATION

10.3.1 Buildout Development Scenario

Using information from previous chapters, the future system evaluation builds on the existing hydraulic model to develop potential system expansion alternatives that are within demand, supply, and evaluation criteria constraints. The existing system model was expanded to include demands associated future users within the City and proposed developments within the SOI. The demands of existing agricultural users are excluded from the buildout model because they will be phased out upon development of the SOI areas. The results of the simulations are used to size infrastructure required for future system expansions.

The first step in planning the future system is the development of the initial layout of the distribution system, which was previously considered as part of the 30% Reclamation Master Plan. The pipeline alignments were laid out to follow future roadway corridors presented in the City's General Plan and to maximize efficient supply and minimize cost. The future distribution system was adjusted to eliminate proposed facilities outside of the revised recycled water service area. The remaining pipelines were adjusted to support updated demand estimates and distribution needs. The revised system layout includes nineteen new pipeline segments. The future pipelines are shown on **Figure 10-1**. Pipeline diameter, length, and service area are presented in **Table 10-3**.

Table 10-3 Future System Pipelines

Pipeline ID	Length (ft)	Pipe Size (in)	Service Areas
1	7,000	30	V-4, V-5/SUD-B, SUD-A, Existing City
2	1,000	27	V-4, V-5/SUD-B, SUD-A, Existing City
3	7,000	16	V-5/SUD-B, SUD-A, Existing City
4	3,000	14	SUD-A, Existing City
5	3,000	24	V-4, V-5/SUD-B, SUD-A
6	5,000	18	V-4, V-5/SUD-B, SUD-A
7	6,000	12	Existing City
8	8,000	8	Existing City
9	2,000	8	Existing City
10	5,000	12	V-7, Existing City
11	3,000	12	V5/SUD-B
12	3,000	8	V5/SUD-B
13	2,000	8	V5/SUD-B
14	4,000	16	V-4, V-5/SUD-B, SUD-A
15	1,000	14	V-4, SUD-A
16	5,000	12	V-4, SUD-A
17	10,000	8	SUD-A
18	11,000	8	V-4, SUD-A
19	3,000	14	V-6
Total	**89,000**	-	-

The ultimate system shown on **Figure 10-1** consists of a looped system, which enhances the overall system reliability.

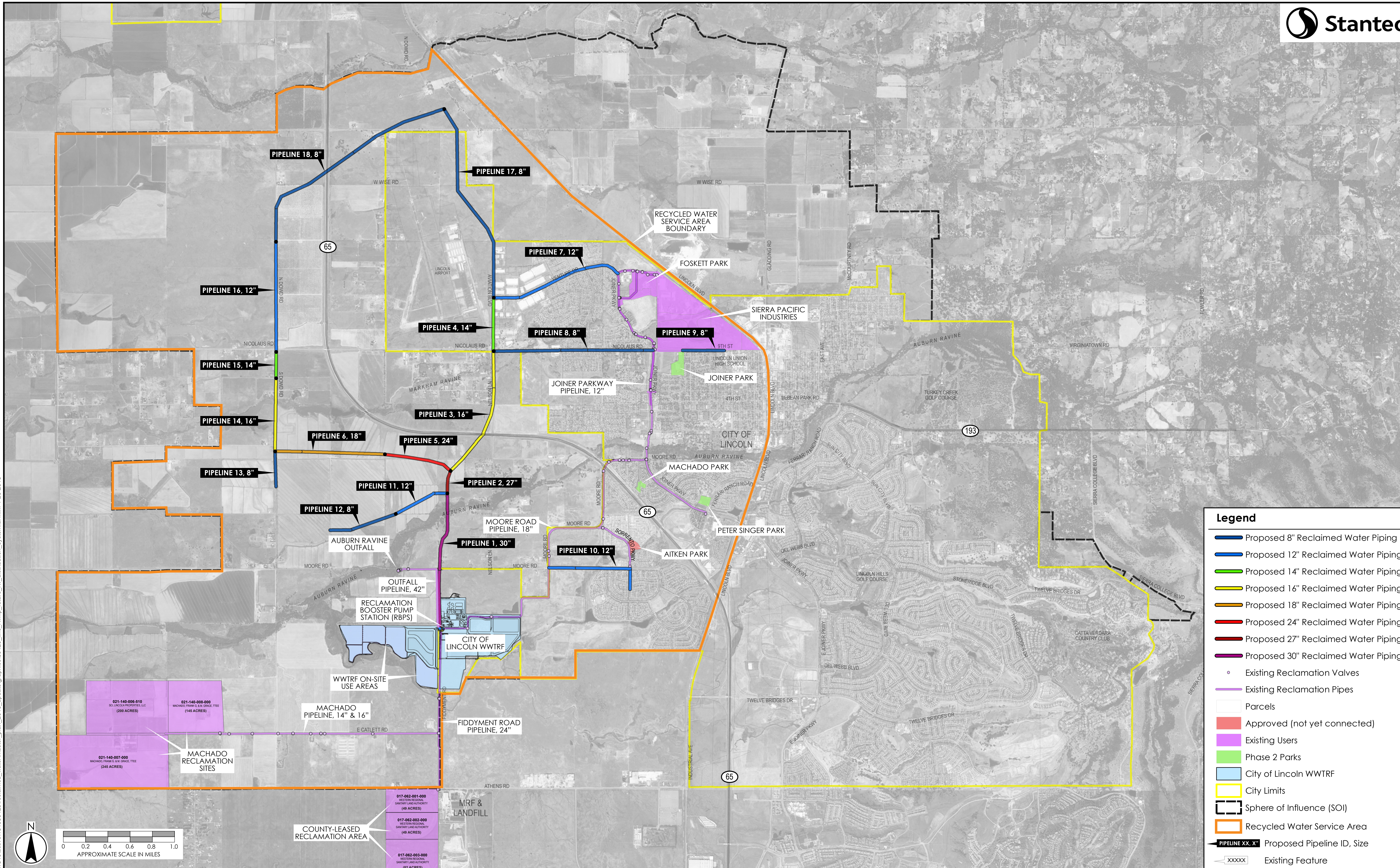

Figure 10-1
Future Recycled Water Distribution System

The future system has been sized to accommodate PHDs and will not require storage or pump stations within the distribution system, assuming demands do not exceed those estimated in this Master Plan. The requirements of the future distribution system should be revisited If the City chooses to supply additional demands or expand the proposed service area in the future.

Future demands within the City's recycled water service area reduce the total buildout MMD by 50 gpm and increase PHD by 8,350 gpm when compared to the existing system scenario. MMD is reduced, while PHD is increased due to the loss of large agricultural demands with 24-hour supply cycles and the addition of irrigation demands having shorter supply cycles. The existing RBPS was designed with future expansions in mind, reserving space for an additional wet-well to house six additional pumps. In future system scenarios, the RBPS is assumed to be expanded. Including this wet-well fora total of 12 RBPS pumps which match those currently installed. The reliable capacity of the expanded pump station is approximately 15.9 MGD, and the maximum capacity is approximately 19.0 MGD. A summary of model simulation results is provided in **Table 10-4**.

Table 10-4 Buildout System Model Results Summary

Item	AAD	MMD	PHD	PHD – New Pumps
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS Curve x 1.25, (25% more head and flow)
No. of Pumps Operating	2	4	11	10
Demand (gpm)	1,800	4,500	12,940	12,940
Demand (MGD)	2.59	6.48	18.63	18.63
Annual Demand Volume (MG)	946	-	-	-
Maximum Pressure (psi)	91	81	72	101
Minimum Pressure (psi)	59	49	30 (1)	59
Maximum Headloss (ft/ft)	0.001	0.001	0.004	0.004
Maximum Velocity (fps)	1.85	1.88	5.30	5.30

Expanding the RBPS is only required to meet PHDs under buildout conditions. The reliable pumping capacity of the existing RBPS can supply AAD and MMD at buildout, as they are less than those of the existing system. Similar to the existing system results, minimum system pressures exist at higher elevations, generally north of Nicolaus Road and east of Joiner Parkway. Under PHD conditions at buildout, the minimum pressure within the system is projected to drop to 30 psi, which is below minimum pressure criteria. Depending on the system pressure needs and actual demands within the service area, the City may choose to replace the existing RBPS pumps with higher head versions in the future.

The RBPS pump curves within the model were adjusted to consider the impacts of increasing the RBPS head and flow, the results of this simulation are also shown in **Table 10-4**. The operating point of the RBPS pumps was increased from 1,100 gpm at 180 TDH, to 1,375 gpm at 225 TDH within this scenario. The resulting maximum pipeline velocity and maximum headloss remain within the recommended operating range, occurring within the 18-inch Moore Road pipeline under PHD conditions. Therefore, no pipeline improvements are expected to be needed within the existing system in order to supply buildout reclamation demands with higher capacity pumps. Although, pipeline pressure classes and system operating conditions should be reconsidered when designing RBPS improvements.

10.3.2 Long-Term Development Scenario

To consider interim conditions and assess potential phasing strategies, a "long-term" level of development scenario was considered as part of the future system model. Demands associated with Village 4, SUD-A, and Village 6 were excluded from the model in this scenario. A summary of the long-term model results is presented in **Table 10-5**. The PHD under long-term development conditions exceeds the reliable capacity of the existing RBPS, requiring nine pumps to meet the estimated demand. The system pressure range is expanded by shifting demands to higher elevations.

Table 10-5 Long-Term System Model Results Summary

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	3	9
Demand (gpm)	1,482	3,285	9,295
Demand (MGD)	2.13	4.73	13.38
Annual Demand Volume (MG)	779	-	-
Maximum Pressure (psi)	102	82	85
Minimum Pressure (psi)	73	51	40 (1)
Maximum Headloss (ft/ft)	0.001	0.001	0.004
Maximum Velocity (fps)	1.79	1.84	5.17

1. Number of pumps shown to meet flow demanded assume more pumps of the existing pump capacity are added. This results in insufficient pressure indicating that the expanded pumps would require higher head. See **Section 10.3.1**.

10.3.3 Future System Recommendations

The buildout master plan recommendations are developed based on significant assumptions and general planning input, as they are projected to occur well into the future. As a result, the recommendations of the plan and the hydraulic model should be revisited periodically to assess specific plan information as it is developed and becomes available.

In support of expanding reclamation services, the RBPS capacity should be regularly assessed to ensure that reliable capacity is sufficient and maintained at all times. The operation of the

WWTRF should also be evaluated to ensure that PHDs can be met using TSBs and DAFTs or through metered operation of the maturation pond effluent.

For near-term reclamation planning purposes, using Placer County's portion of reclaimed water from the SMD1 wastewater flow contribution can aid in the delivery of PHDs within the service area. However, long term effluent management will become more difficult as flows increase upon future development within the City. Therefore, in the future the City would benefit by having Placer County use their reclaimed water within the County. This possibility should be explored and discussed with the County over time, as it is already a possible provision in the current COJA.

10.4 PHASING APPROACH

The following phasing strategy has been developed considering areas of the City that are currently in development and/or planning and the projected order in which SUDs and Villages may develop. The phasing strategy is subject to change as development occurs and plans become more refined. The actual layout and phasing of the future distribution system will likely be driven by the locations of high demand customers and planned transportation corridors, and the timing of recycled water use commitments. Partnering with users beyond the City's planning area could also influence the layout and stages of construction, although not considered in this Master Plan.

Reclamation phases are numbered in the order in which they are assumed to occur, lettering indicates that phases could occur in either order depending on actual development conditions. The anticipated phases and the corresponding level of development, recommended improvements, demands served, and other recommendations are summarized in **Table 10-6.** The future reclamation system phasing approach is depicted in **Figure 10-2**.

As previously discussed, Phase I improvements have already been completed and Phase II improvements are currently in development and additional users along the existing Joiner Parkway pipeline may also be connected. Phases listed under near-term development conditions support the demands of Village 5/ SUD-B, (currently planning development). Although the recommended projects support demands of areas that were evaluated within the long-term development model, they also support the addition of existing system demands and the first step in providing service to the undeveloped portions of the recycled water service area. Phase 3A pipelines will serve as the primary transmission main for the portion of the service area that is currently undeveloped and provide service to users within Village 5/ SUD-B.

Phase 3B will provide reclaimed water service to users in Village 7 (currently planned for development and recently annexed into city limits) and the existing Lincoln Crossings development. These phases could happen in either order but are considered as the next steps in further expanding the existing system. Along with the construction of the Phase 3B pipelines the City should provide an allowance for the development of an effluent management plan, begin phasing out agricultural users, add the final pump to the existing RBPS wet-well, and conduct an existing system condition assessment.

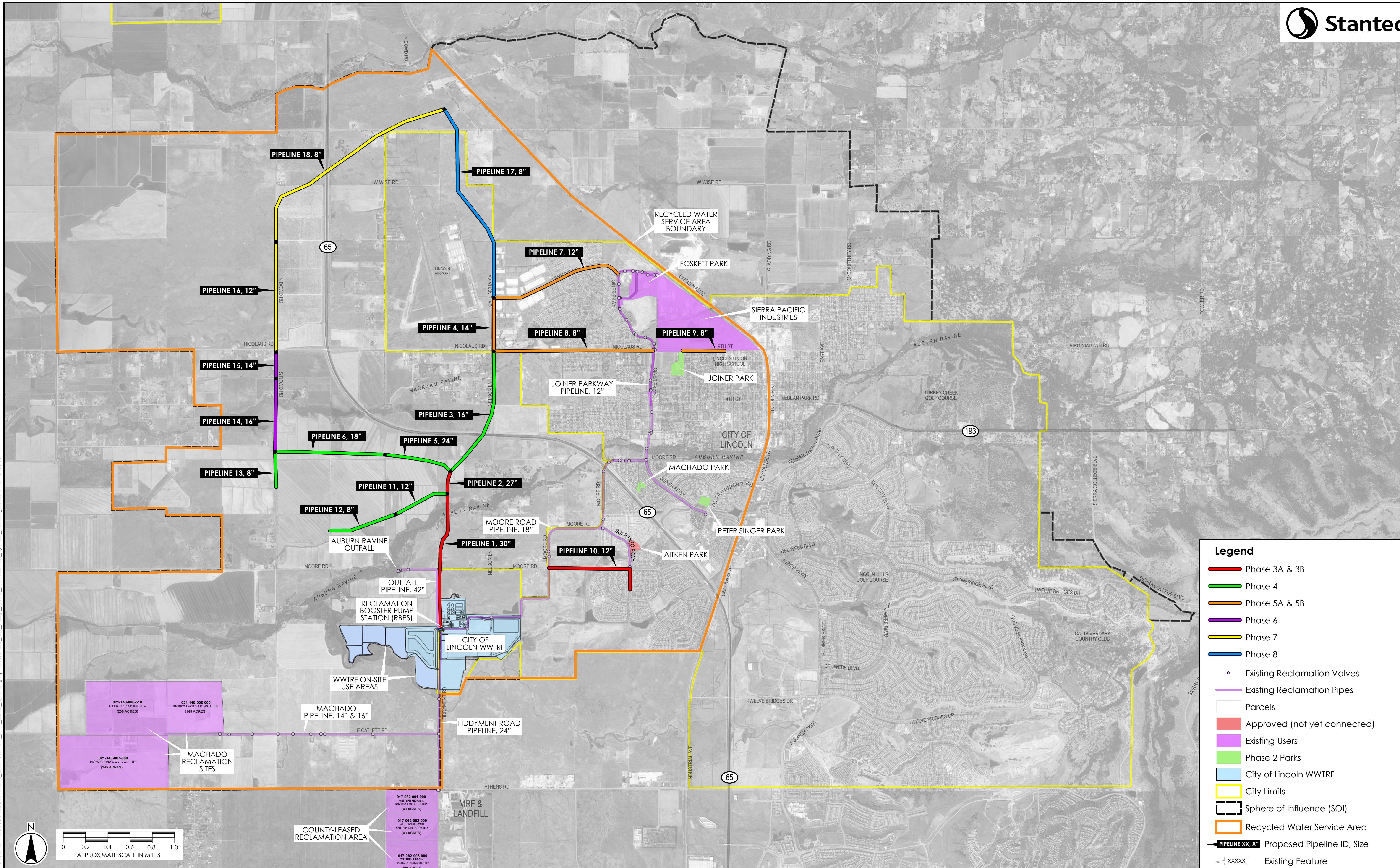

Figure 10-2
Future Reclamation System Phasing Approach

Table 10-6 Phasing Recommendations

Development Condition	Phase (1)	Improvements	Demands	Additional Items & Recommendations
Existing	1	Existing Pipelines	City Demands	• Continue to connect users along existing pipelines (potential of 684 AF)
Near-Term	2	Phase II Park branches	City Demands	• Phase out County Leased Reclamation Area or increase RBPS capacity with second wet-well • Add 6th RBPS pump to existing wet-well • Effluent Management Planning • Condition Assessment
	3A	Pipelines 1 & 2	Village 5/SUD-B (1st phase of development)	
	3B	Pipeline 10	Village 7, Lincoln Crossing	
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	Village 5/SUD-B (2nd phase of development)	• The RBPS expansion should be completed with one of the long-term phases depending on demand conditions • Phase out or limit the PHD of the Machado Farm.
	5A	Pipelines 8 & 9	Loop City System	
	5B	Pipelines 4 & 7	Loop City System	
		RBPS Expansion	PHD – Long-Term	
Buildout	6	14, 15	V4/SUD-A (1st phase of development)	• Connect V-6 to Machado Pipeline • Add additional pumps to RBPS to meeting PHD as they are added.
	7	16, 18	V4/SUD-A (2nd phase of development)	
	8	17	SUD-A/ Expand system	

1. Phases are numbered in the order in which they are anticipated occur; lettering indicates that the project could be done in either order depending on actual development conditions

To support long-term development conditions, three improvement phases have been recommended. The first phase of these improvements, (Reclamation Phase 4) will include the construction of the remaining pipelines needed to provide service to Village 5/SUD-B and will extend a new transmission main along Nelson Lane north to Nicolaus Road. After the construction of this pipeline, the two main system branches providing service to the City can be looped, providing additional reliability for users. Looping the existing system can be accomplished by implementing either Phase 5A or 5B, although the City may elect to implement both projects at the same time. In addition to these pipeline improvements, it is recommended that an additional reclamation pump station or wet well is added to support PHDs of long-term development. Improvements to the RBPS should be included as a part of one of the proposed phases.

The remaining three phases of improvements support full buildout development, providing service to Village 4, SUD-A, and Village 6. Phase 6 includes construction of pipelines 14 and 15 to supply the initial development of Village 4 and SUD-A. The existing Machado Pipeline can be used to supply Village 6; the connection of this Village should be made upon development and isn't impacted by prior or subsequent phasing. Phase 7 includes the construction of pipelines 16 and 18 to provide service to further development within Village 4 and SUD-A, the City may wish to divide this into two separate projects depending on actual development within these areas. The final recommended phase includes the construction of Pipeline 17 along Aviation Drive, providing an additional loop to the future system, adding capacity, redundancy and helping the system meet pressure requirements at buildout. This pipeline provides reliability to Village 4 and SUD-A users and could support additional demands within the City's SOI, outside of the recycled water service area. The RBPS will have to be expanded as demands increase, and RBPS improvements should be reconsidered if demands exceed those projected herein.

11.0 COST ESTIMATES

11.1 PURPOSE

The purpose of this chapter is to present opinions of probable cost for the capital improvements projects (CIPs) recommended as part of this Reclamation Master Plan. Planning level opinions of probable costs have been developed for repair and replacement (R&R) of existing pipelines, proposed CIPs needed to supply recycled water to future users under buildout development conditions, and reclamation system operation and maintenance (O&M) costs.

It should be noted that the cost parameters presented herein provide appropriate budgets for the reclamation project elements as standalone projects. If they are implemented as part of a larger development project, whereby environmental services, design, management, inspection and road and traffic impacts and details are spread across other project components, these budgets provide conservative cost estimates.

This chapter is divided into the following sections:

- Cost Basis and Assumptions
- Future Growth CIP Costs
- Reclamation O&M Costs
- On-going R&R Program
- Summary

11.2 COST BASIS AND ASSUMPTIONS

The level of accuracy for cost estimates varies depending on the level of detail to which the project has been defined. Master planning represents the lowest level of accuracy, while pre-bid estimates represent a much higher level of accuracy. The American Association of Cost Engineers (AACE) has developed a cost estimate classification system used to define the anticipated level of accuracy of cost estimates based on project maturity.

The cost estimates presented in this Master Plan should be considered order-of-magnitude estimates and have been prepared as Class 4 estimates in accordance with AACE guidelines. As Class 5 estimates, the accuracy ranges from -30 to +50 percent. These costs have been estimated in December 2019 dollars consistent with the Engineering News Record construction cost index (ENRCCI, 20-Cities Average) of 11,381. Future adjustments of cost estimates can be projected by increasing the estimated capital cost by the ratio of the future ENR to 11,381.

11.2.1 Capital Costs

Cost estimates for each system expansion segment is a combination of construction costs and project costs. Construction costs account for the budget required for a contractor to install the proposed infrastructure. Project costs account for project contingencies, administration, engineering, planning, and environmental documentation. Capital cost estimates include the base construction costs, a 35 percent estimating contingency, and a 25 percent allowance for engineering, environmental services, and administration.

The pipeline costs estimates represent those associated with primary transmission mains in the future distribution system. The cost of pipelines less than 8-inches in diameter (distribution mains) are not included. The unit costs for transmission pipelines is based on $18/diameter-inch/linear-foot of pipe, including all construction cost elements. Pump station improvement costs were developed by scaling the pre-bid estimate and actual construction costs of the existing RBPS and improvements thereto.

11.2.2 O&M Costs

O&M costs consider purchased power for pumping, labor for WWTRF staff to operate and maintain the reclamation system and assist City staff at use areas, and ongoing material costs. The average pumping capacity was used to estimate power consumption. The existing average pumping capacity was determined to be approximately 25% of peak pumping capacity and it was assumed to increase to 33% under buildout conditions. The costs for electricity are based on a unit price of $0.10 per kilowatt-hour (kWh).

Labor costs were approximated based on discussions with WWTRF staff concluding that approximately 4-hours per day is spent operating and maintaining the reclamation system. This amount of time was assumed to increase by 50% under buildout conditions. An hourly rate of $120 was assumed for WWTRF operating staff.

Ongoing material costs include those for chemicals and general equipment parts replacement.

11.2.3 R&R Program Costs

The R&R cost estimates equate to the amount of money the City would need to save each year for a complete replacement of the distribution system component over the remaining years of its useful life. It was assumed that new pipelines will have a useful life of approximately 60 years. The existing system pipelines are assumed to have a reduced useful life to reflect their time of installation and account for portions of the system consisting of repurposed wastewater forcemains. An estimated cost of $280,000 was approximated to replace the existing five RBPS pumps. The expected useful life for the existing pumps is approximately 10-years.

The annual R&R budget presented for each distribution system component represents the amount of money the City would need to save each year of its remaining useful life to replace it assuming 3-percent interest and 3-percent inflation. The total reclamation system R&R budget equates to the sum of the annual costs presented for each installed component of the system. The cost estimate assumes that total annual R&R budget will be inflated each year to represent the current ENR and increased to include replacement allowances for any reclamation system improvements constructed in that year.

11.2.4 Additional Cost Considerations

The cost estimates presented herein do not include customer connection costs, which may include retrofitting the intended use area for Title 22 compliance, tapping the distribution mains, and installing service laterals, meters, pressure reducing valves, and backflow prevention devices. It is assumed that these costs will be the responsibility of the recycled water user. Costs associated with right-of-way land acquisition and construction of distribution pipes less than 8-inches in diameter are not included in the costs presented in this Master Plan.

11.3 FUTURE GROWTH CIP COSTS

Opinions of probable costs associated the CIPs recommended to support future growth and phased expansion of the reclamation system have been established as part of this Master Plan.

11.3.1 RBPS Improvements

Improvements to the RBPS were scaled from previous design estimates and actual improvement costs. The actual RBPS project costs used to develop this estimate were indexed to the current ENRCCI and scaled proportionally to the projected total dynamic head (TDH) and pumping capacity requirements of the RBPS at buildout. This estimate assumes that the City will replace the existing RBPS pumps with higher head pumps over time. Based on the demands identified in this master plan and the reclamation system model, a TDH of 225 feet and a reliable capacity of 19.8 MGD will be necessary to supply the needs of the buildout system. The probable cost of the pump station improvements was approximated as $11,000,000.

11.3.2 New Pipelines

As discussed in preceding chapters, new transmission pipelines are needed to provide service to the City's recycled water service area. Eighteen new pipelines have been proposed, the opinion of probable cost for each is presented in **Table 11-1**.

Table 11-1 Opinion of Probable Cost, New Pipelines

Pipe ID	Description	Pipe Length (ft)	Pipe Size (in)	Construction Cost	Estimating Contingency (35%)	Engineering and Environmental (25%)	Total Project Cost (rounded)
1	Pipeline 1	7,000	30	$3,780,000	$1,323,000	$1,276,000	$6,379,000
2	Pipeline 2	1,000	27	$486,000	$170,000	$164,000	$820,000
3	Pipeline 3	7,000	16	$2,016,000	$706,000	$681,000	$3,403,000
4	Pipeline 4	3,000	14	$756,000	$265,000	$255,000	$1,276,000
5	Pipeline 5	3,000	24	$1,296,000	$454,000	$438,000	$2,188,000
6	Pipeline 6	5,000	18	$1,620,000	$567,000	$547,000	$2,734,000
7	Pipeline 7	6,000	12	$1,296,000	$454,000	$438,000	$2,188,000
8	Pipeline 8	8,000	8	$1,152,000	$403,000	$389,000	$1,944,000
9	Pipeline 9	2,000	8	$288,000	$101,000	$97,000	$486,000
10	Pipeline 10	5,000	12	$1,080,000	$378,000	$365,000	$1,823,000
11	Pipeline 11	3,000	12	$648,000	$227,000	$219,000	$1,094,000
12	Pipeline 12	3,000	8	$432,000	$151,000	$146,000	$729,000
13	Pipeline 13	2,000	8	$288,000	$101,000	$97,000	$486,000
14	Pipeline 14	4,000	16	$1,152,000	$403,000	$389,000	$1,944,000
15	Pipeline 15	1,000	14	$252,000	$88,000	$85,000	$425,000
16	Pipeline 16	5,000	12	$1,080,000	$378,000	$365,000	$1,823,000
17	Pipeline 17	10,000	8	$1,440,000	$504,000	$486,000	$2,430,000
18	Pipeline 18	11,000	8	$1,584,000	$554,000	$535,000	$2,673,000
						Total:	**$34,800,000**

In addition to these improvements, the reclamation system improvement budget should include allowances for the recommendations provided in **Chapter 10.0** for each level of development.

11.3.3 Total Capital Cost Summary

A summary of the total capital cost for the proposed future reclamation system including the pump station improvements and future pipelines is presented as **Table 11-2**.

Table 11-2 Total Cost for New Infrastructure

Item	Description	Cost
1	Future Pipelines	$34,800,000
2	Pump Station Improvements	$11,000,000
	Total:	**$45,800,000**

A summary of the project costs associated with each recommended improvement phase is presented as **Table 11-3**. The table also includes the total capital cost per AF served annually ($/AF) at buildout for each pipeline. These pipelines will supply more than the projected annual buildout supply over their expected useful life. Therefore $/AF ratio does not represent the actual value of each AF of reclaimed water supplied by each pipeline over its expected lifetime but does provide a relative comparison of the cost to supply the demands associated with each pipeline and the value of each improvement with respect to the buildout system.

The annual volume of reclaimed water supplied at buildout for each pipeline was determined from projected flow through each pipeline within the hydraulic model. The $/AF associated with each phase of development increases as the distribution system is extended further from the RBPS. Pipelines recommended with phases 5A, 5B, 7, and 8 will create loops within the distribution system, which provides additional value to system redundancy and reliability not represented by the $/AF ratio.

Table 11-3 Phased Improvement Costs

Development Condition	Phase	Improvements	Capital Cost Estimate	$/AF Supplied (1)
Existing	1	Existing Pipelines	-	-
Near-Term	2	Phase II Park Branches	$900,000	$14,800
	3A	Pipelines 1 & 2	$7,200,000	$4,200
	3B	Pipeline 10	$1,800,000	$5,400
		Subtotal Near-Term:	**$9,900,000**	**$4,700**
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	$10,600,000	$12,700
	5A	Pipelines 8 & 9	$2,400,000	$17,800
	5B	Pipelines 4 & 7	$3,500,000	$7,700
		RBPS Expansion (2)	$11,000,000	$3,500
		Subtotal Long-Term:	**$27,500,000**	**$11,600 (3)**
Buildout	6	14, 15	$2,300,000	$5,600
	7	16, 18	$4,500,000	$21,700
	8	17	$2,400,000	$71,200
		Subtotal Buildout:	**$9,200,000**	**$14,200 (4)**
		Total:	**$46,600,000**	**$14,700**

1. $/AF supplied represents the total project cost divided by the approximate volume of recycled water supplied through the pipelines annually, under buildout conditions.
2. Pump Station costs may be spread over multiple improvement projects to Long-Term buildout.
3. $/AF excludes RBPS expansion costs, representing pipeline improvements only.
4. The additional value of system reliability and redundancy provided by looping the distribution system is not represented in the $/AF of improvements associated with buildout phases.

11.4 RECLAMATION O&M COSTS

The O&M costs associated with the reclamation system were prepared to consider the on-going costs associated with operating the reclamation system. These costs represent those associated with the WWTRF. Additional costs associated with management of city parks and other use areas are not reflected in these O&M cost estimates.

O&M costs have been approximated for existing and future buildout development conditions using 2019 dollars. It is expected that additional O&M costs will be incurred as each phase of the distribution system expansion is implemented. O&M cost estimates under existing conditions are presented in **Table 11-4** and O&M cost estimates under buildout conditions are presented in **Table 11-5**.

Table 11-4 Existing Reclamation System O&M Costs

Item	Description	Quantity	Units	Unit Price	Total Cost
1	Power (RBPS)	610,974	kWh/ year	$0.10	$61,000
2	Labor (WWTRF Staff)	1,460	hours/ year	$130.00	$190,000
3	Chlorine	8	Tote of Chlorine	$600	$5,000
4	Maintenance and Replacement Parts				$2,500
				Total:	**$256,000**

Table 11-5 Future Reclamation System O&M Costs

Item	Description	Quantity	Units	Unit Price	Total Cost
1	Power (RBPS)	2,150,628	kWh/ year	$0.10	$215,000
2	Labor (WWTRF Staff)	2,190	hours/ year	$130.00	$285,000
3	Chlorine	32	Tote of Chlorine	$600	$19,000
4	Maintenance and Replacement Parts				$5,000
				Total:	**$524,000**

11.5 ON-GOING R&R PROGRAM

No hydraulic deficiencies were identified within the existing distribution system and as a result no CIPs are recommended for the existing system as part of this Master Plan. Although no improvements to the existing system are recommended, funding will be needed to support the City's on-going repair and replacement (R&R) program. A robust R&R program is a key element of any properly managed public infrastructure system and includes an annual expenditure for the replacement of older, aging infrastructure. The annual R&R allocation is intended to reduce the impact of repairing and replacing critical portions of the City's reclamation system by stretching them out over time.

The cost estimates to replace the existing reclaimed water distribution pipelines are presented in **Table 11-6**. The replacement costs for existing pipelines in the reclamation system have been estimated to be incorporated into an on-going R&R program.

Table 11-6 Existing Reclaimed Pipeline Replacement Costs

Item	Description	Pipe Length (ft)	Pipe Size (in)	Construction Cost	Estimating Contingency (35%)	Engineering and Environmental (25%)	Total Project Cost (rounded)
1	Fiddyment Road	8,000	24	$3,456,000	$1,210,000	$1,167,000	$5,833,000
2	Foskett Park	2,000	8	$288,000	$101,000	$97,000	$486,000
3	Joiner Parkway	15,000	12	$3,240,000	$1,134,000	$1,094,000	$5,468,000
4	Machado - Part 1	7,000	14	$1,764,000	$617,000	$595,000	$2,976,000
5	Machado - Part 2	6,000	16	$1,728,000	$605,000	$583,000	$2,916,000
6	Moore Road	18,000	18	$5,832,000	$2,041,000	$1,968,000	$9,841,000
7	Sorrento	3,000	8	$432,000	$151,000	$146,000	$729,000
8	SPI Supply Line	1,000	8	$144,000	$50,000	$49,000	$243,000
9	At WWTRF	100	30	$54,000	$19,000	$18,000	$91,000
						Total:	**$28,600,000**

The total annual R&R budget equates to the sum of the annual R&R presented for installed components. The current annual R&R budget equates to approximately $675,000. This value should be indexed annually using the ENRCCI, 20-Cities Average. Future adjustments of cost estimates should be estimated by increasing the annual replacement budget or capital cost estimate by the ratio of the future ENRCCI, 20-Cities Average to 11,381 (December 2019). After completing the Phase II reclamation project, the R&R budget will increase to $690,000 and inflated by the ENR ratio at the time of project completion.

Table 11-7 On-going R&R Costs Budget

Development Condition	Phase	Improvements	Capital Cost Estimate	Remaining Years Useful Life	Annual Replacement Budget Starting at Time of Construction
Existing	1	Existing Pipelines	$28,200,000	45	$646,000
	1	Existing Pumps	$280,000	10	$29,000
		Subtotal Existing:	**$28,480,000**		
Near-Term	2	Phase II Park branches	$900,000	60	$15,000
	3A	Pipelines 1 & 2	$7,200,000	60	$124,000
	3B	Pipeline 10	$1,800,000	60	$31,000
		Subtotal Near-Term:	**$9,900,000**		
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	$10,600,000	60	$182,000
	5A	Pipelines 8 & 9	$2,400,000	60	$41,000
	5B	Pipelines 4 & 7	$3,500,000	60	$60,000
		RBPS Expansion (2)	$11,000,000	30	$378,000
		Subtotal Long-Term:	**$27,500,000**		
Buildout	6	14, 15	$2,300,000	60	$39,000
	7	16, 18	$4,500,000	60	$77,000
	8	17	$2,400,000	60	$41,000
		Subtotal Buildout:	**$9,200,000**		
		Total Capital Costs:	**$75,080,000**		

1. To be cumulatively added to annual reclamation R&R budget at time of construction.
2. Index costs with CCI annually to bring values to present worth at time of construction.

11.6 SUMMARY

The existing system R&R costs, capital improvement costs, and O&M cost estimates developed as part of this Master Plan are summarized in **Table 11-8**.

Table 11-8 Summary of Cost Estimates

Cost Estimate Type	Improvements	Cost Estimate	Recommendations
Existing System R&R	Existing Pipelines	$28,200,000	• Continue to connect users along existing pipelines. • Monitor pump station performance add sixth pump to existing RBPS to meet demands and pressure requirements.
	Existing Pumps	$280,000	
	Subtotal Existing System R&R:	**$28,480,000**	
Capital Impartments Project Cost	Near-Term	$9,900,000	• Phase out of County Leased Reclamation Area and/or increase RBPS capacity to meet demands. • Effluent Management Planning • Perform condition assessment on existing infrastructure. • Continue discussion with Placer County regarding their portion of effluent, per COJA.
	Long-Term	$27,500,000	• RBPS expansion project should occur with one of the long-term phases depending on demand conditions, pumps can be added as demand increases. • Phase out or limit the PHD of the Machado Farm.
	Buildout	$9,200,000	• Add pumps to the RBPS to meet PHD as they increase. • Utilize the existing Machado Pipeline to serve Village 6.
	Subtotal CIP Costs:	**$46,600,000**	•
O&M Costs (WWTRF)	Existing System	$256,000	•
	Buildout System	$524,000	•