NEW DOC

WATER MASTER PLAN
FOR
PAINT BRUSH HILLS METROPOLITAN DISTRICT

SEPTEMBER 2015

RGA JOB NO.: 1070.0004

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DEFINITIONS, ACRONYMS, AND ABBREVIATIONS (NOT ALL MAY BE FOUND IN THIS REPORT)

BOD_5	5-Day Biochemical Oxygen Demand
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
cm/sec	Centimeters per second
CY	Cubic Yards
DOLA	Department of Local Affairs
EA	Each
EDU	Equivalent Dwelling Unit
ECHO	Enforcement and Compliance History Online
EPA	Environmental Protection Agency
ft	Feet
gal	gallons
gpcd	Gallons per capita-day
gpd	Gallons per day
gpm	Gallons per minute
hp	Horsepower
HVAC	Heating, Ventilating and Air Conditioning
I&I	Inflow and Infiltration
kW	Kilowatts
lb/ac-day	Pounds per acre-day
lb/day	Pounds per day
LF	Linear Feet
LS	Lump Sum
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
N/A	Not available or applicable
O&M	Operations and Maintenance
OMB	Office of Management and Budget
PEL	Preliminary Effluent Limitations
PVC	Polyvinyl Chloride
PW	Present Worth
RAS	Return Activated Sludge
ref.	Reference
RGA	RG and Associates, LLC
RUS	Rural Utilities Services
SCADA	Supervisory Control and Data Acquisition
SFE	Single Family Equivalent
SF	Square Feet
SOG	Slab on Grade
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
VFD	Variable Frequency Drives
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant
YR	Year

1 EXECUTIVE SUMMARY

The purpose of the Paint Brush Hills Metropolitan District (PBHMD) Water Master Plan is to provide an overview of the District's water infrastructure, evaluate the District's water infrastructure based on current usage and future expansion, and to provide recommendations for future improvements and expansions to the District's water infrastructure.

This Master plan includes:

- Current and projected single family home development
- Current and future water demands
- Evaluation of Current Water System
- Water system improvements and expansions recommendations

This Document was developed for the use of the district in its planning process and evaluates both current and projected future conditions. It is intended to be a working document that is used as a guideline for planning decisions and represents a best approximation of future conditions.

1.1 Demands

To determine current water usage and estimate future demands, RGA obtained billing records for all taps served by PBHMD from September 2013 through June 2014 in addition to the 2013 Water Supply Report for the district By JDS-Hydro dated November 2013. RGA then calculated current Average Day Demand and a current Maximum Day Demand, which were then utilized to calculate the future demands of the district once all planned developments are constructed. These are as follows:

Current number of SFE: 824

Current average day demand: 0.26 MGD

Peaking factor used for max day / average day: 2.1

Current maximum day demand: 0.56 MGD

Future number of SFE (full buildout): 1,532

Future average day demand: 0.50 MGD

Future maximum day demand: 1.05 MGD

1.2 Water Treatment & Production

Raw water for the system is pumped from eleven wells from the Arapahoe and the Laramie-Fox Hills Aquifers. The Arapahoe and Laramie-Fox Hills Aquifers are part of the Denver Basin Aquifer, which is a non-renewable water source. In addition to these aquifer sources the district also utilizes contractual water from Meridian Service Metropolitan District through a metered interconnect with the Merdian Metropolitan District.

Groundwater pumped from the Arapahoe and the Laramie-Fox Hills Aquifers is disinfected at the wells using chlorination. Some of the wells do not have adequate contact time for disinfection. Also, many of the wells do not have sufficient land around them to allow for the installation of chlorine contact chambers to ensure that disinfection is achieved before the water enters the distribution system.

1.3 Water Rights

Through the analysis completed in this master plan utilizing information from the JDS-Hydro Report, it was determined that the district's existing water rights are sufficient to provide water to meet the current and future demands of the district.

1.4 Storage

The district should provide enough storage to satisfy the Maximum day Demand plus the required fire flow. In this analysis required fire flow is 3,500 gallons per minute for three hours and the Maximum Day Demand per SFE is 674 gallons per day. There are currently two existing tanks in the district's water supply system, one 1 million gallon tank and one 0.5 million gallon tank.

2 BACKGROUND & OVERVIEW

2.1 PROJECT SCOPE

The purpose of the Paint Brush Hills Metropolitan District (PBHMD) Water Master Plan is to provide an overview of the District's water infrastructure, evaluate the District's water infrastructure based on current usage and future expansion, and to provide recommendations for future improvements and expansions to the District's water infrastructure.

Specifically, this Master Plan evaluates the District's wells, treatment systems, booster pumps, and water storage based on current and projected water demands. Additionally, this Master Plan provides recommendations for future timing of upgrades and enhancements that will be necessary to meet future growth.

2.2 PAINT BRUSH HILL METROPOLITAN DISTRICT WATER SUPPLY SYSTEM OVERVIEW

The PBHMD water distribution system is a constant pressure system containing two storage tanks to meet fire flow and peak flow demands. Water supply for the district is provided primarily by the Denver Basin Aquifer, however, the district also utilizes purchased water from Meridian Service Metropolitan District during times of peak demand. The raw water wells are located throughout the district and are equipped with sodium hypochlorite disinfection equipment at each well house.

3 PROJECT AREA

3.1 LOCATION AND SERVICE AREA

Paint Brush Hills Metropolitan District is located north-east of Colorado Springs in unincorporated El Paso County. The District encompasses a total area of approximately 1.5 square miles and has a population of approximately 3,000 residents.

In total PBHMD's water distribution system consists of approximately 46,000 linear feet (LF) of 8-inch finished water pipe, 20,000 LF of 12-inch finished water pipe, 12,700 LF of raw water transmission pipe, eleven wells, and two water storage tanks. Figure 1 and Figure 2 show a general vicinity map of the area and a district boundary map, respectively.

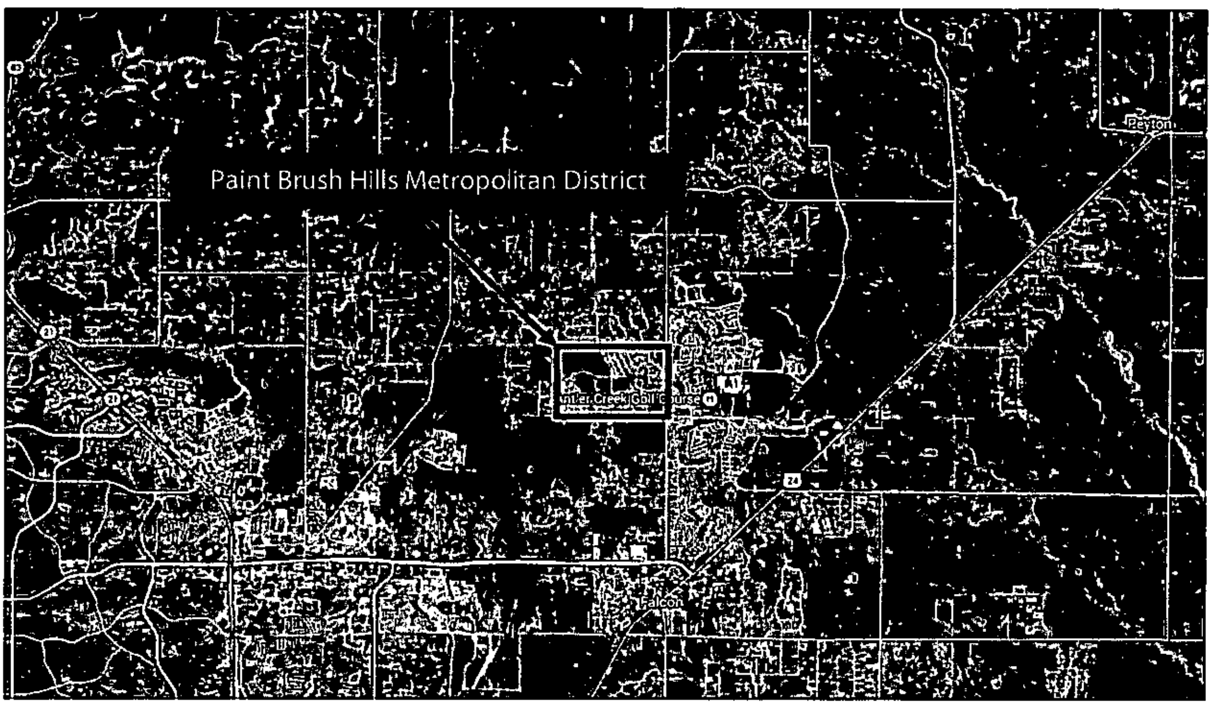

Figure 1: General Vicinity Map

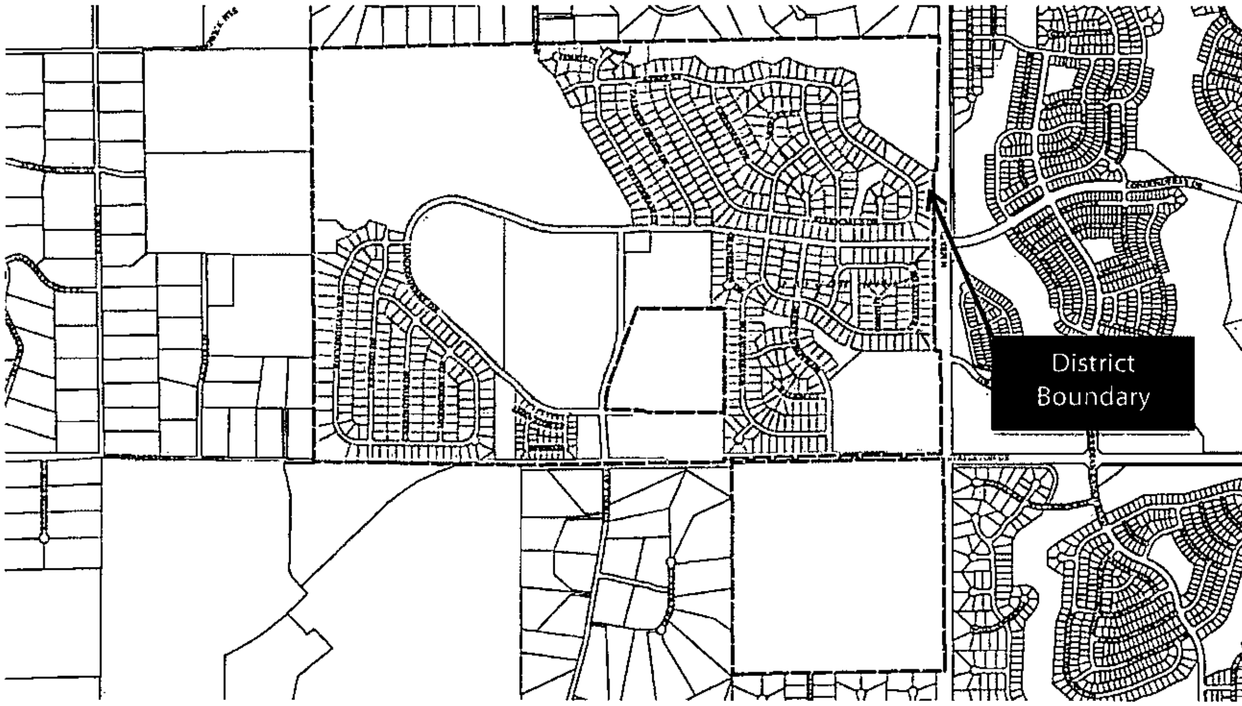

Figure 2: District Boundary Map

A detailed map showing the existing drinking water distribution system is attached as Appendix A.

3.2 WATER RESOURCES

The primary water source in the area is the Denver Basin aquifer. Specifically, PBHMD holds water rights to the Denver Aquifer, Laramie Fox-Hills Aquifer, and Arapahoe Aquifer. Currently the District only has wells drilled in the Arapahoe and Laramie-Fox Hills Aquifers.

3.3 PRECIPITATION AND TEMPERATURE

Data pertaining to the local environment has been obtained from the Western Regional Climate Center. Station 051778 – Colorado Springs Muni AP is the closest weather station to PBHMD and information from this station is used for this report and shown in Table 1.

Table 1: Annual Climate Data (1948-2010)

Average Monthly Temperature and Precipitation Station 051778 - Colorado Springs Muni AP, CO												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High Temp. (°F)	42.6	45.2	51.0	59.7	69.0	79.6	85.0	82.3	74.8	63.9	51.0	43.5
Avg. Low Temp. (°F)	16.6	19.3	24.8	32.9	42.5	51.5	57.1	55.5	47.3	36.3	24.9	17.9
Average Temp. (°F)	29.5	32.3	37.7	46.2	55.7	65.3	71.0	68.8	61.0	50.1	37.9	30.7
Avg. Precip. (in.)	0.3	0.3	0.9	1.3	2.1	2.2	2.9	2.9	1.3	0.8	0.5	0.3
Avg. Snowfalll (in.)	5.0	4.6	8.3	5.9	1.2	0.0	0.0	0.0	0.8	3.0	4.8	5.4
Source: Western Regional Climate Center												

Winters are relatively cold with an average temperature of 31 °F, December through January, while summers are warm with an average temperature of 68 °F, June through August. These averages are based on data from the Western Regional Climate Center data and is based on data collected from 1948-2010. Average total yearly precipitation over this time period is 16 inches, and the average total yearly snowfall is 44 inches.

4 WATER USAGE

4.1 Current Water Demand

The current water demand in the PBHMD was determined using billing data provided to RGA by the district spanning from August 2013 through June 2015. The data was separated into four categories: residential, school, irrigation, and commercial as shown in Table 2, Table 3, Table 4, and Table 5 respectively. Residential usage in the District accounts for the majority of the water usage across the three categories.

Table 2: Monthly Residential Water Usage (in Million Gallons (MG))

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	-	-	-	-	-	-	-	-	5.00	5.55	3.65	3.10	
2014	3.38	3.39	2.81	2.88	3.68	6.10	6.93	8.32	5.20	6.27	5.39	2.97	
2015	3.66	3.11	2.73	2.94	4.46	3.72	-	-	-	-	-	-	Average
Average	3.52	3.25	2.77	2.91	4.07	4.91	6.93	8.32	5.10	5.91	4.52	3.03	4.33

Table 3: Monthly School Water Usage (in MG)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	-	-	-	-	-	-	-	-	0.52	0.76	0.27	0.11	
2014	0.09	0.08	0.05	0.06	0.05	0.89	0.00	1.03	0.40	0.89	0.81	0.06	
2015	0.05	0.04	0.05	0.06	0.47	0.21	-	-	-	-	-	-	Average
Average	0.07	0.06	0.05	0.06	0.26	0.55	0.00	1.03	0.46	0.82	0.54	0.08	0.33

Table 4: Monthly Irrigation Water Usage (in MG)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	-	-	-	-	-	-	-	-	0.40	0.72	0.21	0.00	
2014	0.00	0.09	0.00	0.00	0.02	0.48	0.60	0.80	0.53	0.60	0.36	0.00	
2015	0.00	0.00	0.00	0.00	0.07	0.16	-	-	-	-	-	-	Average
Average	0.00	0.04	0.00	0.00	0.04	0.32	0.60	0.80	0.46	0.66	0.29	0.00	0.27

Table 5: Monthly Commercial Water Usage (in MG)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	-	-	-	-	-	-	-	-	0.010	0.012	0.004	0.006	
2014	0.001	0.001	0.012	0.001	0.002	0.001	0.010	0.035	0.009	0.024	0.019	0.003	
2015	0.004	0.003	0.003	0.003	0.004	0.003	-	-	-	-	-	-	Average
Average	0.003	0.002	0.008	0.002	0.003	0.002	0.010	0.035	0.009	0.018	0.012	0.005	0.009

Water usage for all categories is totaled in Table 6.

Table 6: Total Water Usage (in MG)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	-	-	-	-	-	-	-	-	5.92	7.05	4.14	3.22	
2014	3.47	3.56	2.86	2.94	3.75	7.46	8.60	10.19	6.13	7.79	6.58	3.02	
2015	3.71	3.16	2.79	3.00	5.00	4.09	-	-	-	-	-	-	Total
Average	3.59	3.36	2.82	2.97	4.38	5.78	8.60	10.19	6.03	7.42	5.36	3.12	63.61

The MDD is an important factor in the analysis of treatment and pumping facilities as these facilities must be designed to handle the MDD to ensure that the district can adequately supply enough water to meet that demand. The MDD can be calculated by dividing the month with the maximum demand by 30. The maximum monthly demand of 10.19 MG occurred in August of 2014. Dividing this by 30 equates to a MDD of 0.34 MG/day.

The number of taps throughout the district was calculated based on the number of residential customers on the monthly billing information provided by the district. It is assumed that each residential customer billed equates to one single family equivalent (SFE).

A SFE is a unit of measure which standardizes all land use categories (residential, commercial, etc.) to the level of water demand created by one single family household. Typically, all single family taps within a district are assigned a total of one (1) SFE. From September 2013 through June 2015 there was an average of 724 single family residential customers billed. The average monthly residential water demand for this time period was 4.33 MG, which corresponds to an average day demand (ADD) of 0.14 MG/day (144,315 gpd). By dividing the (ADD) by the number of residential customers, we can calculate the daily demand per SFE of 199 gpd.

For the period from September 2013 through June 2015 the average daily demand per SFE was approximately 199 gallons/day. Using this flow per SFE we can then calculate the number of SFEs for non-residential development (school, irrigation, and commercial). Table 7 displays the conversion of the non-residential development into SFE. In total, there are a calculated 825 SFE currently served by the district.

Table 7: SFE for Residential, School, Irrigation, and Commercial Water Demands

	Daily Flow (gallons/day)	Flow Per SFE (gallons/day)	SFE
Residential	144,315	199	724
School	12,084	199	61
Irrigation	7,637	199	38
Commercial	244	199	1
Total	164,280	199	824

The average daily water demand per SFE calculated in this master plan is significantly less than that calculated in the JDS-Hydro Report of 321 gallons/day. The JDS-Hydro Report uses data from the district that extends back through 2002 and incorporates data from dryer years where residents and the district would have had to irrigate more.

The data utilized above to calculate SFE only uses data from September 2013 through June 2015, which were all relatively wet years. The JDS-Hydro SFE of 321 gallons/day will be used for the analysis in the remainder of this report as this is a more conservative approach. The corresponding MDD to the 321 gallons per day per SFE can be calculated by multiplying the average day SFE of 321 gallons/day by a peaking factor for the district.

The peaking factor is calculated by dividing the average day demand of the maximum month demand (the demand during August 2014) by the average day demand of the year (199 gpd/SFE). This calculation results in a peaking factor of 2.1. Using the calculated peaking factor, the MDD per SFE was found to be 674. The MDD per SFE and ADD per SFE were used to calculate the MDD, ADD, and the average yearly demand for the district, as shown in Table 8.

Table 8: Existing MDD, ADD, and Yearly Demand

	SFE	MDD (gpd)	ADD (gpd)	Yearly Demand (AF/year)
Residential	724	488,048	232,404	260.3
School	61	41,120	19,581	21.9
Irrigation	38	25,616	12,198	13.7
Commercial	1	674	321	0.4
Total	824	555,458	264,504	296.3

4.2 FUTURE WATER DEMAND

Future plans for development in the PBHMD service area include Filing 13A, Filing 13B, Scenic View, and Falcon Reserve developments and are shown in Figure 3. These four developments would add approximately 700 single family equivalents (SFE) of water demand to the district plus additional water for any public owned land that would need irrigation.

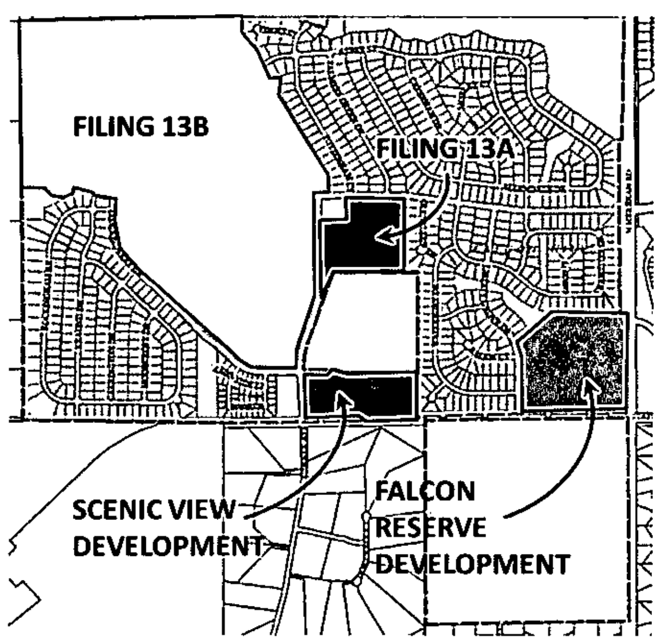

Figure 3: Map of Future Developments in the Paint Brush Hills Metropolitan District

Filing 13 B is broken up into four separate phases of construction as shown in Figure 4.

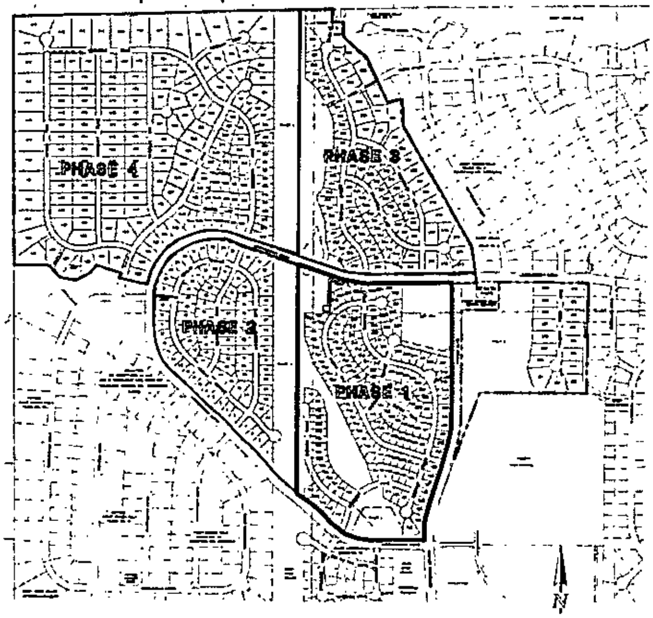

Figure 4: Filing 13 B Phase Map

The additional water demand that each new development will require is calculated based on the MDD per SFE previously developed. The MDD of 674 gpd per SFE is multiplied by the number of potential lots that each development.

PBHMD also has public land across the district that it irrigates. The potential irrigation area of future developments is unknown. However, the future irrigation acreage can be estimated based on the ratio of irrigation demand to total acreage of existing developments. To account for additional public land that will need to be irrigated, the maximum irrigation demand per acre was calculated based on the maximum month irrigation demand. This maximum month demand was then divided by the current acreage of land developed, approximately 470 acres.

The irrigation water demand per acre can then be used to estimate how much water the district will need to supply for the irrigation needs of future developments as they are built. The maximum month irrigation demand of 781,130 gallons occurred in August of 2014, which corresponds to a demand of 1,662 gallons per acre per month, or a daily demand of 55.4 gallons per acre per day. To determine the future irrigation demand the existing demand of 55.4 gallons per acre per day is multiplied by the area, in acres, of each future development. The future irrigation and single family residential demand associated with future developments is shown in Table 9.

Table 9: Calculated Maximum Day Water Demand by Development

Development	SFE	MDD per SFE	Additional Residential MDD (gpd)	Area (acres)	Irrigation MDD Per Acre (gpd)	Additional Irrigation Demand (gpd)	Total Additional Demand (gpd)
Falcon Reserve	64	674	43,136	38.5	55.4	2,133	45,269
Scenic View	90	674	60,660	18	55.4	997	61,657
Filing 13 A	17	674	11,458	10	55.4	554	12,012
Filing 13 B - P1	157	674	105,818	62	55.4	3,435	109,253
Filing 13 B - P2	97	674	65,378	45	55.4	2,493	67,871
Filing 13 B - P3	102	674	68,748	48	55.4	2,659	71,407
Filing 13 B - P4	181	674	121,994	127	55.4	7,036	129,030
Total	**708**	**674**	**477,192**	**348.5**	**55.4**	**19,307**	**496,499**

Table 10 shows the calculated average day water demands for each development. The total additional daily water demand once all developments are constructed is approximately 233,890 gpd.

Table 10: Calculated Average Day Water Demand By Development (in Gallons)

Development	SFE	ADD per SFE	Additional Residential Flow	Area	ADD Per Acre	Additional Irrigation Flow	Total Additional Flow
Falcon Reserve	64	321	20,544	38.5	19	732	21,276
Scenic View	90	321	28,890	18	19	342	29,232
Filing 13 A	17	321	5,457	10	19	190	5,647
Filing 13 B - P1	157	321	50,397	62	19	1,178	51,575
Filing 13 B - P2	97	321	31,137	45	19	855	31,992
Filing 13 B - P3	102	321	32,742	48	19	912	33,654
Filing 13 B - P4	181	321	58,101	127	19	2,413	60,514
Total	708	321	227,268	348.5	55.4	19,307	233,890

The MDD, ADD, and average yearly demand currently for the district along with the demands for future developments are shown in Table 11. The total MDD once all of the proposed developments are constructed is approximately 1 MGD and the ADD is approximately 0.5 MGD, which corresponds to an average yearly demand of 558 AF/year.

Table 11: Calculated MDD, ADD, and Yearly Demand by Area

	MDD (gpd)	ADD (gpd)	Yearly Demand (AF/year)
Current	555,458	264,504	296.3
Falcon Reserve	45,269	21,276	23.8
Scenic View	61,657	29,232	32.7
Filing 13 A	12,012	5,647	6.3
Filing 13 B - P1	109,253	51,575	57.8
Filing 13 B - P2	67,871	31,992	35.8
Filing 13 B - P3	71,407	33,654	37.7
Filing 13 B - P4	129,030	60,514	67.8
Total	1,051,957	498,394	558.3

5 WATER SYSTEM EVALUATION

5.1 Evaluation Criteria

The water system in PBHMD will be evaluated based on the ability of the system to meet current demands along with the future demands of the proposed developments listed in Section 4.2. These evaluations will then be used to make recommendations for further expansions of the system to meet the future water demands of the district.

5.2 Existing Water Facilities

The PBHMD water distribution system is constant pressure system containing two storage tanks (a 1 million gallon (MG) tank and a 0.5 MG tank) to meet fire flow and peak a flow demands. Water supply for the district comes primarily from the Denver Basin Aquifer, however, the district also utilizes contractual water from Meridian Service Metropolitan District (MSMD) as a peaking supply.

The raw water wells are located throughout the district and treatment consists of chlorination, which is done at the well site. In total PBHMD's water distribution system consists of approximately 46,000 linear feet (LF) of 8-inch finished water pipe, 20,000 LF of 12-inch finished water pipe, 12,700 LF of raw water transmission pipe, eleven wells, and two water storage tanks.

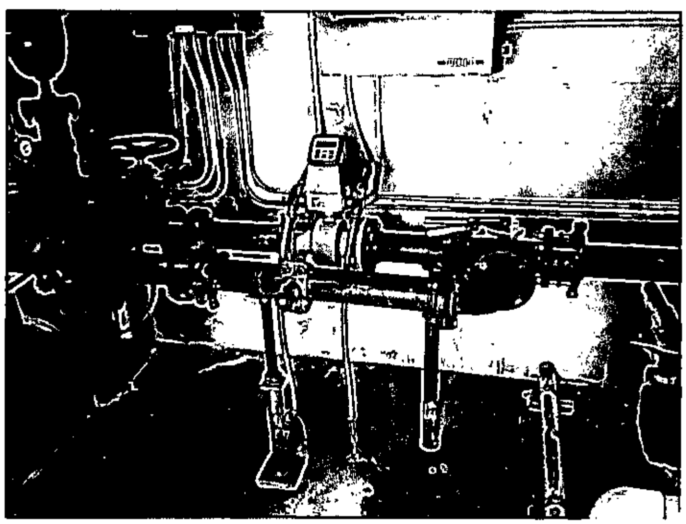

Figure 5: Piping inside Well House 6

5.2.1 Raw Water Supply

Raw water for the system is pumped from eleven wells across the district from the Arapahoe and the Laramie-Fox Fills Aquifers. All well pumping and well house equipment appears to be in good working order. The Arapahoe and Laramie-Fox Hills Aquifers are part of the Denver Basin Aquifer, which is a non-renewable water source. In their 2013 Water Supply Report for the District, JDS-HYDRO found that the current total annual legal supply for the District to be 1,194.5 AF/year.

The calculations of current and future water demands done in Section 4.1 and Section 4.2

show that currently the districts yearly demand is approximately 297 AF/year and that demand once all the proposed developments are constructed will be approximately 560 AF/year (Table 11). These demands are well below the districts permitted annual allocation of 1,010 AF/year.

Table 12 shows the current physical water supply inventory for the district, detailing the volume of water allocated from the Laramie-Fox Hills, Arapahoe, and Denver aquifers along with the Districts contractual rights from MSMD. The district currently has an annual allocation of 1,010 AF-year. Additionally, PBHMD has contingent water supply sources, detailed in Table 13, which may be utilized if needed in the future. As shown, the district currently has adequate water rights to meet its future obligations.

Table 12: Current Physical Water Supply Inventory

Land Formation or Aquifer	Finding, Dermination, or Decree	Tributary Status	Total Volume (AF)	Annual Allocation (AF/yr)	Well Permits
Larimie-Fox Hills	47813-F	NT	38,800	388.0	LFH-1 (47813-F)
					LFH-2 (50877-F)
					LFH-3 (55192-F)
					LFH-4 (63429-F)
					LFH-5 (64084-F)
Arapahoe	17048-F	NT	13,070	130.7	A-1 (17048-F)
	30593-F	NT	11,300	113.0	A-2 (30593-F)
	46553-F	NT	18,200	182.0	A-3 (46553-F)
					A-4 (55193-F)
					A-5 (60862-F)
					A-6 (64086-F)
Denver	17048-F	NT	11,130	111.3	
85 AF Contractural Right	Contrac MSMD	UBSC Alluvium	25,500	85.0	UBSC non-specific source
					Alluvial Water
Current Total Legal Supply			118,000	1,010.0	

Source: JDS-HYDRO 2013 Water Supply Report

Table 13: Contingent Water Supply Inventory

Land Formation or Aquifer	Finding, Determination, or Decree	Tributary Status	Total Volume (AF)	Annual Allocation (100 yr supply) (AF/yr)	Annual Allocation (300 yr supply) (AF/yr)	Well Permits
Dawson	719-BD	NNT	23,700	237.0	79.0	
	Unappropriated	NNT	2,000	20.0	-	
Denver	Unappropriated	NT	2550	25.5	-	
Arapahoe	214-BD	NNT 4%	29750	297.5	99.2	
Surface Water Diversion	**Finding, Determination, or Decree**	**Tributary Status**	**Comments**			
Return Flows 02CW016	05CW043	2 cfs	Allocation is 25%, Unavailable for potable supply			

Source: JDS-HYDRO 2013 Water Supply Report

The wells in the district need to be able to produce enough water to meet the MDD. The current MDD for the district is 386 gpm, which is 163 gpm less than the net instantaneous flow at 90% (10% subtracted for system losses). This indicates that the district would be capable of producing enough water to meet the current MDD plus the MDD for the Falcon Reserve, Scenic View, Filing 13 A, and Filing 13 B- P1 before needing to drill more wells. However, in order to meet the current MDD and the MDDs of all the future planned developments, the district would need an additional 182 gpm of net instantaneous demand.

Table 14 shows the permit number and permitted pumping rate for each individual well and activity of the well along with the instantaneous flow rate from the JDS-HYDRO report for each well and the contracted water from MSMD. The total instantaneous flow for all the currently active wells combined, as reported by JDS-Hydro, is 610 gallons per minute (gpm). Assuming a 10 percent loss of water in the system, the net instantaneous flow corresponds to a flow rate of 549 gpm.

Table 14: Well Permits, Permitted Pumping Rates, and 2013 Instantaneous Flow-Rates

Land Formation or Aquifer	Well Number	Well ID	Well Permit	Permitted Pump Rate	2013 Instantaneous Flow-Rate (JDS-HYDRO)	Acitvity
				gpm	gpm	
Larimie-Fox Hills	4	LFH-1	47813-F	100	30-40	Inactive
	5	LFH-2	50877-F	70	45	Inactive
	7	LFH-3	55192-F	100	60	Active
	9	LFH-4	63429-F	-	125	Active
	11	LFH-5	64084-F	-	100	Active
Arapahoe	1	A-1	17048-F	150	60	Active
	2	A-2	30593-F	70	60	Active
	3	A-3	46553-F	53	55	Inactive
	6	A-4	55193-F	76	75	Active
	8	A-5	60862-F	85	75	Active
	10	A-6	64086-F	-	55	Active
Transfer Station	N/A	N/A	N/A	N/A	90-200	Active
Total Instantaneous Flow of Active Wells (gpm)					610	
Net Instantaneous Flow @ 90% (gpm)					549	
Net Instantaneous Flow @ 90% (gpd)					790,560	

5.2.2 Treatment Systems

Currently the only treatment done on the raw water is disinfection. Sodium hypochlorite is injected at each of six well houses in the district before the water passes into the distribution lines. The chlorinated water from Pump House 1 (which houses Well 1) and Pump House 2 (which houses Wells 2 & 5) is fed directly into the distribution system after chlorination. There is no contact time provided for wells at these pump houses. Chlorinated water from Pump House 3, (which houses Wells 3 & 4), Pump House 4 (which houses Wells 6 & 7), Pump House 5 (which houses Wells 8 & 9), and Pump House 6 (which houses Wells 10 & 11) is piped to the two storage tanks before it is pumped into the distribution system. This piping and the storage tanks provide the required contact time for disinfection.

Well 6 and Well 7 have elevated levels of hydrogen sulfide, which have raised aesthetic concerns about the water in PBHMD. Hydrogen sulfide in water does not typically pose a health risk although it does create aesthetic problems such as bad taste and rotten egg odor at levels as low as 0.5 milligrams per liter (mg/L). Hydrogen sulfide is not regulated by the EPA. RGA recommended using an activated carbon filtration system to mitigate the aesthetic concerns from the hydrogen sulfide in the water. A pilot test aimed at testing the efficacy of removing hydrogen sulfide using an activated carbon filter is currently underway.

The two-phase pilot test is being conducted at Well 6 and Well 7. Activated carbon filters are being used to treat the water through adsorption, a process in which the hydrogen sulfide in the water will attach to the surface of the carbon particles in the filter. Phase 1 of the pilot test was a bench-scale test aimed at determining if the carbon removes sufficient hydrogen sulfide from the water and if different types of carbon are more effective at removing hydrogen sulfide than others. However, due to the small scale of the filters at this phase, no reduction in odor and taste from the hydrogen sulfide was detected. This was likely because the proper contact time could not be targeted at this small of a scale. Phase 2 of the pilot test employs a 10" diameter filter vessel filled with activated carbon. Initial results indicate that the activated carbon filter can remove the odor and taste due to hydrogen sulfide in the water. The test was run at 5 gpm to allow for sufficient contact time in the filter. This small scale pilot test has shown promising results and no odor has been detected post filtration.

RGA is currently working with the district in planning a full-scale, in-place pilot test to allow the district to pump treated water to the distribution system.

Additionally, RGA has evaluated the option of centralizing treatment or leaving treatment decentralized in each of the well houses. This evaluation along with a cost estimate and a recommendation are discussed in Section 6.1.2.

5.2.3 Water Storage

The PBHMD water distribution system contains two welded steel water storage tanks, a 1 MG tank and a 0.5 MG tank, which are also located on District owned land on the corner of Londonderry Drive and Towner Avenue. Both storage tanks are in relatively good condition and are not in need of any repairs. Chlorinated raw water from Pump House 3, (which houses Wells 3 & 4), Pump House 4 (which houses Wells 6 & 7), Pump House 5 (which houses Wells 8 & 9), and Pump House 6 (which houses Wells 10 & 11) is piped and stored in the tanks. The storage is used to meet fire flow demand and peak demand during summer months.

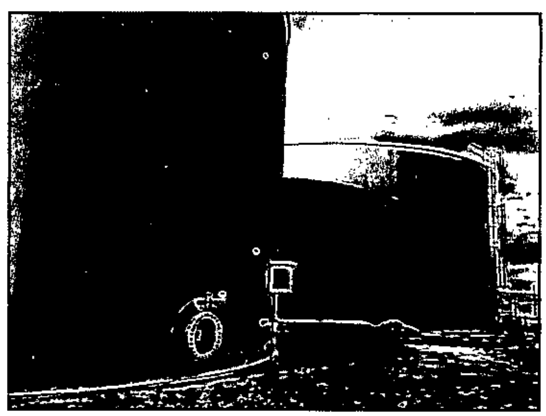

Figure 6: PBHMD 1 MG Water Storage Tank (left) and 0.5 MG Water Storage Tank (Right)

The district must have enough water storage to hold the maximum day demand (MDD) for the district plus three hours of fire flow at 3,500 gpm. The required storage for the fire flow demand is a volume of 630,000 gallons. The storage required to meet the current MDD and the storage required to meet MDD of each planned development are listed in Table 15.

Table 15: Required Storage to Meet Current MDD, Future MDD, and Fire Flow

	Required Storage (gallons)
Current	555,458
Falcon Reserve	45,269
Scenic View	61,657
Filing 13 A	12,012
Filing 13 B - P1	109,253
Filing 13 B - P2	67,871
Filing 13 B - P3	71,407
Filing 13 B - P4	129,030
Fire Flow	630,000
Total	1,681,957

The total volume of storage required to meet all MDDs once all developments are constructed and fire flow in the district is approximately 1.7 MG, which is above the district's current capacity of 1.5 MG. Although the districts storage capacity is sufficient to meet the current storage requirements, as the future developments are constructed, the district will need to construct additional storage to meet the storage requirements for the future developments. RGA recommends constructing an additional storage tank to meet future storage requirements and adding mixing systems to the storage tanks. This recommendation will be further discussed in Section 6.1.3.

5.2.4 Booster Pump Station

The booster pump station is located on District owned land on the corner of Londonderry Drive and Towner Avenue adjacent to the storage tanks. The pump station is below grade and houses four pumps used to pressurize the distributions system with water from the storage tanks. A photo of the pump station is shown in Figure 7.

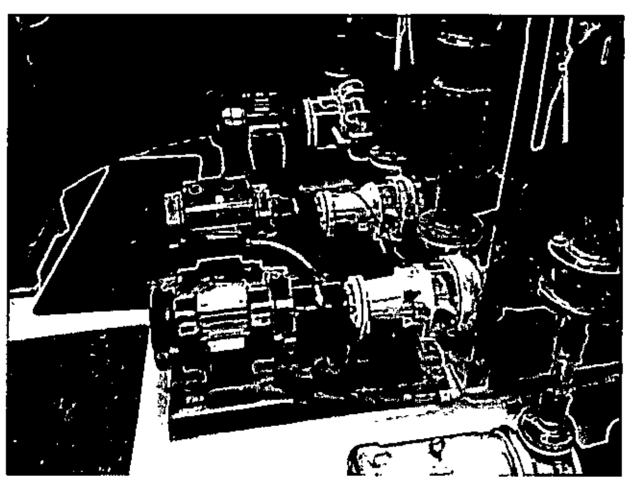

Figure 7: PBHMD Booster Pumps

Pump and motor information is shown in Table 16. Additionally, the booster pump station contains a sump pump to allow for the removal of any water in the dry pit to be removed.

Table 16: Pump Station Pump Data

Pump	Type	Manufacturer	Model NO.	Capacity	Motor	Motor Manufacturer
No. 1 Jockey Pump	Horizontal, Close Coupled, End Suction, Centrifugal	Goulds	SST A45#1L5AO EOO	-	10 HP 3490 RPM	Baldor
No. 2 Service Pump		-	Type 344 8F No-71-91450-2	540 gpm	30 HP 3540 RPM	WEG
No. 3 Service Pump		-	Type 344 8F No-71-91450-2	540 gpm	30 HP 3540 RPM	WEG
No. 4 High Service Pump		Cornell	5RB 60-4	2200 gpm	60 HP 1775 RPM	Marathon Electric

To evaluate the pumps and ensure that the district has enough pumping capacity, the peak hour flow (PHF) for the district is calculated. The PHF is calculated from the ADD using a peaking factor (PF), which can be calculated using the following population based equation from the State of Colorado Design Criteria for Domestic Wastewater Treatment Works (2012):

$$PF = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$$

where P is population in thousands.

Assuming an average of 2.5 persons per single family household, the total population for the district can be estimated by multiplying the SFE of the district by 2.5. This was done for the total SFE of the district currently and the total SFE of the district once all future developments are constructed.

The peaking factor was found to be 3.6 and 3.4 for current and future development respectively, as shown in Table 17. The PHF was then calculated by multiplying the ADD for the district by the peaking factor. The PHF for the district was found to be 584 gpm and 1,078 gpm for the current and future developments respectively (Table 17).

Table 17: District Peaking Factor and PHF For Current and Future Development

	Total SFE	PF	ADD gpd	PHF gpm
Current	724	3.6	321	584
Future	1432	3.4	321	1,078

The district has adequate pumping capacity to meet the current and future demand with the two service pumps; however, RGA recommends the district add an additional service pump as the proposed future developments are constructed to allow for redundancy. This recommendation is discussed further in Section 6.1.4.

The fire flow demand for the district is 3,500 gpm. Although, the district has a total capacity to meet this demand with the one existing high service pump, RGA recommends the addition of an additional high service pump for redundancy. This recommendation is discussed further in Section 6.1.4.

6 RECOMMENDATIONS & COST ESTIMATES

6.1 System Improvements

6.1.1 Raw Water Supply

The analysis performed in Section 5.2.1 indicates that the district has sufficient annually allocated raw water supply to meet current demands, however the district will need an additional 182 gpm of raw water to meet the demands of the proposed future developments once they are constructed.

RGA recommends that the district construct enough additional wells to allow for an additional 182 gpm of net flow of raw water to be pumped from existing water rights. The district should also drill back up wells to ensure they have enough pumping capacity in the event that a well goes down. Table 18 shows a construction cost estimate for a single well.

Table 18: Construction Cost Estimate – Single Raw Water Well

Item	Description	Qty	Unit	Unit Price	Subtotal
1	Drill Well, Well Pump, Well Pump Installation	1	LS	$750,000	$750,000
2	Well Building and Process Piping	1	LS	$100,000	$100,000
3	Sodium Hypochlorite Feed System	1	LS	$15,000	$15,000
4	Misc. Yard Piping	1	LS	$30,000	$30,000
5	Chlorine Contact Chamber	1	LS	$50,000	$50,000
				Subtotal	**$945,000**
Mobilization, Demobilization, Bonds & Insurance (5% Overall Construction Cost)					$47,250
Electrical and Controls (5% of Treatment Facility Cost)					$47,250
Erosion Control					$10,000
Construction Survey					$15,000
Engineering, Survey, Geotechnical Anlysis & Permitting (10%)					$94,500
Construction Management (10%)					$94,500
				SUBTOTAL NON-EQUIPMENT/MATERIAL COSTS	**$308,500**
				TOTAL PROJECT COST	**$1,253,500**
				CONTINGENCY (20% OF TOTAL PROJECT COST	**$250,700**
TOTAL PROJECT COST + CONTINGENCY					**$1,504,200**

Assuming the new wells have a production of 75 gpm, three (3) wells will be required. Adding one for redundancy equates to four (4) total wells.

6.1.2 Treatment Systems

Two options for raw water treatment have been proposed. These are: 1) centralized treatment and 2) decentralized treatment. Centralizing the water treatment system would require tying all existing and future pumps into the storage tanks. Currently only Pump House 1 and Pump House 2 are not tied into the storage tank. In addition a chorine contact basin would be necessary to allow sufficient contact time for chlorination of the raw water. Additionally, the district may add an activated carbon filter to address any taste and odor issues due to hydrogen sulfide. Table 19 details a cost estimate for a centralized system.

Table 19: Construction Cost Estimate – Centralized Treatment

Item	Description	Qty	Unit	Unit Price	Subtotal
1	Sawcut, Remove & Replace Asphalt Pavement	4,538	SY	$45	$204,210
2	Removal & Replacement of Unsuitable Subgrade Material	2,079	CY	$25	$51,975
3	Furnish and Install 6" Water Main w/ all Appurtenances	5,834	LF	$70	$408,380
4	Connect to Existing System	4	EA	$3,000	$12,000
5	Treatment Building (Site Work, Building, HVAC, Etc.)	3,500	SF	$125	$437,500
6	Treatment Equipment and Piping (Granular Activated Carbon Pressure Vessels)	1	LS	$650,000	$650,000
7	Process Piping and Valves	1	LS	$50,000	$50,000
8	Chlorine Contact Basin (Concrete, Baffle Walls, Etc.)	130	CY	$700	$91,000
9	Chlorine Feed Equipment	1	LS	$20,000	$20,000
10	Clearwell Booster Pump Station (To Tank)	2	EA	$65,000	$130,000
				Subtotal	**$2,055,065**
Mobilization, Demobilization, Bonds & Insurance (5% Overall Construction Cost)					$102,753
Electrical and Controls (5% of Treatment Facility Cost)					$21,875
Erosion Control					$10,000
Construction Survey					$15,000
Engineering, Survey, Geotechnical Anlysis & Permitting (10%)					$205,507
Construction Management (10%)					$205,507
				SUBTOTAL NON-EQUIPMENT/MATERIAL COSTS	**$560,641**
				TOTAL PROJECT COST	**$2,615,706**
				CONTINGENCY (20% OF TOTAL PROJECT COST	**$523,141**
TOTAL PROJECT COST + CONTINGENCY					**$3,138,848**

The decentralized option would entail leaving the chlorine treatment in each individual pump house with the option to add and activated carbon filter to the well houses that have significant hydrogen sulfide issues. This option would leave the system relatively unchanged, however currently Pump 1 and Pump 2 pump directly into the distribution system without any chlorination contact time for disinfection.

If the district chooses to leave the system decentralized, RGA recommends tying Pump House 1 and Pump House 2 into the storage tanks as opposed to tying directly into the distribution system. This would allow for adequate contact time necessary for disinfection. Also, dedicated chlorine contact chamber should also be installed at the tank site with adequate pumping to fill the tanks. This will ensure the tank storage volume is reserved for system demand and fire flow. Table 20 details a cost estimate for a decentralized system.

Table 20: Construction Cost Estimate – Decentralized Treatment

Item	Description	Qty	Unit	Unit Price	Subtotal
1	Sawcut, Remove & Replace Asphalt Pavement	4,538	SY	$45	$204,210
2	Removal & Replacement of Unsuitable Subgrade Material	2,079	CY	$25	$51,975
3	Furnish and Install 6" Water Main w/ all Appurtenances	5,834	LF	$70	$408,380
4	Connect to Existing System	4	EA	$3,000	$12,000
5	Treatment Equipment and Piping (Granular Activated Carbon Pressure Vessels)	1	LS	$200,000	$200,000
6	Process Piping and Valves	1	LS	$5,000	$5,000
7	Chlorine Contact Basin (Concrete, Baffle Walls, Etc.)	130	CY	$700	$91,000
8	Clearwell Booster Pump Station (To Tank)	2	EA	$65,000	$130,000
				Subtotal	**$1,102,565**
	Mobilization, Demobilization, Bonds & Insurance (5% Overall Construction Cost)				$55,128
	Electrical and Controls (5% of Treatment Facility Cost)				$25,000
	Erosion Control				$10,000
	Construction Survey				$15,000
	Engineering, Survey, Geotechnical Anlysis & Permitting (10%)				$110,257
	Construction Management (10%)				$110,257
				SUBTOTAL NON-EQUIPMENT/MATERIAL COSTS	**$325,641**
				TOTAL PROJECT COST	**$1,428,206**
				CONTINGENCY (20% OF TOTAL PROJECT COST	**$285,641**
	TOTAL PROJECT COST + CONTINGENCY				**$1,713,848**

6.1.3 Water Storage

The calculations performed in Section 5.2.3 indicate that the districts storage capacity is sufficient to meet the current storage requirements, as the future developments are constructed, the district will need to construct additional storage to meet the storage requirements for the future developments. RGA recommends constructing an additional 0.5 MG storage tank to meet future storage requirements and adding mixing systems to the storage tanks.

The construction of an additional 0.5 MG storage tank would allow for the district to meet its storage requirements once all proposed developments are constructed. It would increase its total storage capacity to 2 MG, providing approximately 0.3 MG more storage than the district need to meet peak day demand plus fire flow.

Additionally, RGA recommends the addition of mixing systems to all three storage tanks to prevent excessive water age and ice formation. Without a water mixing system in a storage tank, the first water in the tank is the last water to be taken from the tank. The excess water age is conducive to microbial growth and chemical changes and can reduce water quality parameters. Additionally, in winter months ice can form on the top of the water inside the storage tank. As the water level inside the tank rises and falls with residential water use, the ice moves up and down the tank walls and can cause damage to the tank. By installing a mixing system into all of the districts tanks, excess water age and ice formation can be reduced significantly. Table 21 details a cost estimate for a 500,000 gallon water storage tank.

Table 21: Construction Cost Estimate – 500,000 Gallon Water Storage Tank

Item	Description	Qty	Unit	Unit Price	Subtotal
1	500,000 Gallon Water Storage Tank and Foundation	1	LS	$650,000	$650,000
2	Tank Mixing System	3	LS	$25,000	$75,000
3	Misc. Yard Piping	1	LS	$40,000	$40,000
				Subtotal	**$765,000**
	Mobilization, Demobilization, Bonds & Insurance (5% Overall Construction Cost)				$38,250
	Erosion Control				$10,000
	Construction Survey				$15,000
	Engineering, Survey, Geotechnical Anlysis & Permitting (10%)				$76,500
	Construction Management (10%)				$76,500
				SUBTOTAL NON-EQUIPMENT/MATERIAL COSTS	**$216,250**
				TOTAL PROJECT COST	**$981,250**
				CONTINGENCY (20% OF TOTAL PROJECT COST	**$196,250**
	TOTAL PROJECT COST + CONTINGENCY				**$1,177,500**

6.1.4 Booster Pump

The calculations performed in Section 5.2.4 indicate that the district has enough pumping capacity to meet current PHF and to meet the PHF once all of the planned future developments are constructed. RGA recommends the district add an additional service pump for redundancy as the proposed future developments are constructed.

The district is also able to meet the fire flow demand using a combination of its high capacity pump and its service pumps; however, RGA recommends the addition of another high capacity pump for redundancy. The addition of an additional high service pump will allow the district to meet fire flow demand without the use of the service pumps and allow the district to meet the fire flow demand in the event that the current high service pump goes out. Table 22 presents a cost estimate to provide redundant pumping capabilities.

Table 22: Construction Cost Estimate – Distribution System Pumping

Item	Description	Qty	Unit	Unit Price	Subtotal
1	Jockey Pump and Service Pumps	1	LS	$65,000	$65,000
2	Pump Basin (Dry Well) and Piping	1	LS	$85,000	$85,000
3	Misc. Yard Piping	1	LS	$30,000	$30,000
				Subtotal	**$180,000**
	Mobilization, Demobilization, Bonds & Insurance (5% Overall Construction Cost)				$9,000
	Electrical and Controls (5% Overall Construction Cost)				$9,000
	Erosion Control				$10,000
	Construction Survey				$15,000
	Engineering, Survey, Geotechnical Anlysis & Permitting				$35,000
	Construction Management (10%)				$18,000
				SUBTOTAL NON-EQUIPMENT/MATERIAL COSTS	**$96,000**
				TOTAL PROJECT COST	**$276,000**
				CONTINGENCY (20% OF TOTAL PROJECT COST	**$55,200**
	TOTAL PROJECT COST + CONTINGENCY				**$331,200**

6.2 TIMING OF IMPROVEMENTS

The exact timing of improvements is unknown as it is based on when each remaining development. It is possible, however, to determine the needs based on number of SFE constructed. Recommended improvements based on additional SFEs are shown in Table 23.

Table 23: Improvement Schedule

Improvement	Additional SFEs Until Required	Notes
Raw Water Well 1	541	
Raw Water Well 2	160	
Raw Water Well 3	160	
Raw Water Well 4	N/A	Redundancy Only
500,000 Gallon Storage Tank	466	
Water Treatment - Centralized	See Note	
Water Treatment - Decentralized	See Note	
Booster Pumping Station	N/A	Redundancy Only
Note: Currently water treatment for odor issues is required.		
Assumes all current wells are active.		