Reservoir and Booster Pump Station Asset Management Plan

September 2011

SACRAMENTO SUBURBAN WATER DISTRICT

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EXECUTIVE SUMMARY

District staff has been taking a systematic approach to asset management. Previously completed asset management plans have addressed water meters, distribution mains, groundwater wells and transmission mains. Attention is now directed towards the District's reservoirs, tanks and booster pump stations.

The purpose of this *Reservoir and Booster Pump Station Asset Management Plan* (RBPSAMP) is to inventory the District's existing reservoirs, storage tanks, and booster pump stations in terms of size, type, and age and to discuss a plan for maintenance, repair and/or potential replacement. The District currently owns and operates seven (7) water storage tanks/reservoirs of different types and capacities. The total storage capacity for all seven tanks/reservoirs is 15,925,000 gallons. Four (4) are elevated steel tanks and three (3) are ground level steel storage reservoirs. Three (3) of the water storage reservoirs have associated booster pump stations and the District also owns and operates two other independent booster pump stations.

The District's four elevated tanks were all constructed in the 1950's and are older assets. However, they can provide decades of many more years of service as long as they continue to be properly maintained. The District's three ground level reservoir tanks are newer assets that were constructed between 1999 and 2006 and have many decades of service life remaining. These newer reservoir tanks also have cathodic protection systems for corrosion control to further increase their life expectancy.

When the four elevated tanks reach the end of their useful life, they may not be replaced. These tanks are no longer being used as originally designed because current water system hydraulic characteristics have made them useful only in extreme low pressure situations and other emergencies. In addition, for a mostly groundwater system like the one operated by the District, the groundwater basin itself acts as a large storage reservoir. As long as there is sufficient backup power at well sites to operate the wells in an emergency, this large underground storage reservoir is always available when needed.

This RBPSAMP is intended to be used as a tool for ongoing communication between the Board and staff to prioritize reservoir and tank repair, maintenance, improvements, and/or possible replacement. Furthermore, it is to be used as a planning tool during annual capital improvement program (CIP) budget discussions with the Board. This Plan does not represent a financial commitment by the Board, other than those CIP funds already approved and adopted.

The purpose and goals of the RBPSAMP are to:

- Provide for a safe and reliable water supply.
- Provide adequate emergency storage for fire protection and other needs.
- Inventory the District's existing reservoirs/tanks and booster pump stations by capacity, type, size and age.
- Provide a preliminary plan for reservoir/tank and booster pump station repair, rehabilitation and/or replacement that can be adapted and modified to incorporate new technologies, management practices, and District needs.
- Coordinate with the District's long term Capital Improvement Program (CIP).

The average useful life of steel reservoir tanks can range from 75 to 100 years or longer providing that adequate preventive maintenance is performed on a regular basis. The booster pump stations themselves will have a similar life expectancy but the pumps/motors and electrical equipment will require replacement at more frequent intervals during the facility's lifespan.

The District is currently on a schedule where the tanks and reservoirs are being inspected and cleaned every 2 (reservoirs) to 5 years (elevated tanks). Spot coating repairs are made each time the cleaning and inspections are performed. In addition, the steel tanks and reservoirs are being completely re-coated (interior and exterior) every 15 years. This schedule is subject to change depending on the findings and recommendations from the regular tank cleanings and inspections. Complete tank and reservoir re-coatings are estimated to cost between $300,000 (elevated tanks) and $550,000 (ground level reservoirs).

Based on current cost information that was obtained for this report, it is estimated that the cost to replace a 5 MG storage reservoir and associated booster pump station is approximately $8.7 million (2011 costs).

Similar to the District's other asset management plans, it is anticipated that the RBPSAMP will be amended periodically in the future. It is recognized that new information will be made available in the future that might affect the condition assessment and the need for repair and/or replacement. Therefore, review and reassessment of the RBPSAMP is recommended in 3 to 5 year intervals.

INTRODUCTION / BACKGROUND

Water utilities throughout the United States are currently facing the challenge of extensive rehabilitation and replacement of aging and deteriorated water mains and other water system infrastructure. In 2010, the American Society of Civil Engineers (ASCE) published a report card on America's infrastructure and their rating for drinking water systems was a D-[1]. As part of this study, ASCE estimated the 5-year funding requirement for drinking water and wastewater infrastructure at $255 billion.

The Sacramento Suburban Water District (SSWD) is no different in this regard. Of particular concern to SSWD in terms of water system infrastructure are the older water distribution mains that date back prior to the 1950s or even earlier. An ongoing water main replacement program is underway to replace aging distribution mains that have outlived their useful life. The next step is to evaluate and assess the District's reservoirs, tanks and booster pump stations.

All of the District's existing reservoirs/tanks are constructed of steel. The average useful life of steel reservoir tanks can range from 75 to 100 years or longer providing that adequate preventive maintenance is performed on a regular basis. In fact, some steel water tanks have been in service for over 100 years and are still in service today[2].

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[1] Source: *Report Card for American Infrastructure*, American Society of Civil Engineers, 2009.
[2] Source: *Steel Water Storage Tanks*, Manual of Water Supply Practices M42, American Water Works Association, 1998.

TYPES OF RESERVOIRS/TANKS

Storage tanks or reservoirs are an important part of any municipal water supply system. Water can be pumped into the tank during periods of low demand and then pumped out of the tank into the distribution system during periods of peak demand. Water in the tank or reservoir can also be used for emergency or fire protection purposes. In addition, storage tanks can be used to provide water pressure in the distribution system. The District utilizes two different types of reservoir tanks: ground level tanks and elevated tanks. These are briefly described below.

Ground Level Tanks/Reservoirs

In many cases, water is stored in reservoirs located at ground level due to a lower initial cost of construction, a lower maintenance cost, the ease with which water quality can be tested, greater safety, and a greater aesthetic value. The primary disadvantage of a ground tank is a lack of elevation. The water in ground level tanks is not under a significant amount of pressure unless the tank is located at a higher altitude, such as on top of a hill. Any pressure in a ground tank must be maintained through direct pumping of the water. However, pumping water from the tank can be costly.

The two most common types of ground level storage tanks are constructed either of steel or concrete. In general, steel tanks cost less initially to construct but have higher maintenance costs over the life of the tank due to the necessary coating systems that must be maintained. Concrete tanks on the other hand typically cost more to construct but have lower maintenance costs over the life of the tank. All three of the District's existing ground-level storage tanks are constructed of steel.

In addition to a tank foundation, tank shell, tank roof/supporting columns, and tank bottom, all ground level steel storage reservoirs come with various appurtenances, including: ladders (interior and exterior), inlet and outlet pipes, drain pipe/sump, overflow pipe, access man-way, roof hatch, roof vent(s), liquid level indicator, and a cathodic protection system.

Elevated Tanks/Reservoirs

All elevated steel water tanks consist of two primary components: the tank itself and its supporting structure. Elevated tanks come in various types and sizes. From an operational perspective, elevated water storage tanks can be very beneficial to water distribution systems. These "floating" storage tanks can reduce peak pumping rates, stabilize water pressures, and increase reliability. However, elevated storage can be significantly more costly to construct and operate and maintain than ground level storage and, if not designed and operated properly, can have a detrimental impact on water quality.

Elevated tanks or reservoirs do have certain advantages over ground level tanks. For example, elevated tanks do not require the continuous operation of pumps since the pressure is maintained by gravity. And the strategic location of the tank can equalize water pressures in the distribution system. However, precise water pressure can be difficult to manage in some elevated tanks.

Applicable Standards

All steel potable water storage tanks should be designed, constructed, operated and maintained in accordance with the most current standards published by the American Water Works Association (AWWA). Applicable AWWA standards include:

- AWWA D100, "Standard for Welded Steel Tanks for Water Storage"
- AWWA D101, "Standard for Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs and Elevated Tanks for Water Storage"
- AWWA D102, "Standard for Coating Steel Water Storage Tanks"
- AWWA D103, "Standard for Factory-Coated Bolted Steel Tanks for Water Storage"
- AWWA D104, "Standard for Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks"
- AWWA C652, "Standard for Disinfection of Water-Storage Facilities"

In addition, Article 6, of Chapter 16 of the *California Waterworks Standards*, as published by the State Department of Public Health (CDPH), also includes design requirements for distribution system reservoirs.

INVENTORY OF DISTRICT'S EXISTING RESERVOIRS/TANKS AND BOOSTER PUMP STATIONS

Storage Tank Facilities

The North Service Area (NSA) has six (6) active storage tanks. A 5 million gallon (MG) ground level storage tank and booster pump station, located at the Antelope reservoir site, stores both groundwater from nearby wells and treated water from the Peterson Water Treatment Plant (WTP) to meet peak hour demands and fire flows. The maximum pumping capacity from the Antelope reservoir is approximately 10,000 gpm. Another 5 MG capacity groundwater storage reservoir with an 8,000 gpm booster pump station is located near the intersection of Watt Avenue and Elkhorn Boulevard in the NSA. There is a 150,000 gallon elevated storage tank located in the Arbors at Antelope area (formerly known as Capehart) and a 125,000 gallon elevated storage tank located at the District's Walnut Corporation Yard. Finally, there are two active elevated storage tanks in the McClellan Business Park service area: Elevated Tank #216 with a capacity of 500,000 gallons and Elevated Tank #769 with a capacity of 150,000 gallons.

The SSA has one (1) active storage tank which was constructed in 2006. It is a 5 MG storage tank and booster pumping station located at Enterprise Drive and Northrop Avenue near an intertie with the City of Sacramento. The reservoir facilities, booster pump stations and their respective capacities are summarized in Table 1 and shown on Figure 1. Detailed descriptions of each storage and booster facility are provided below.

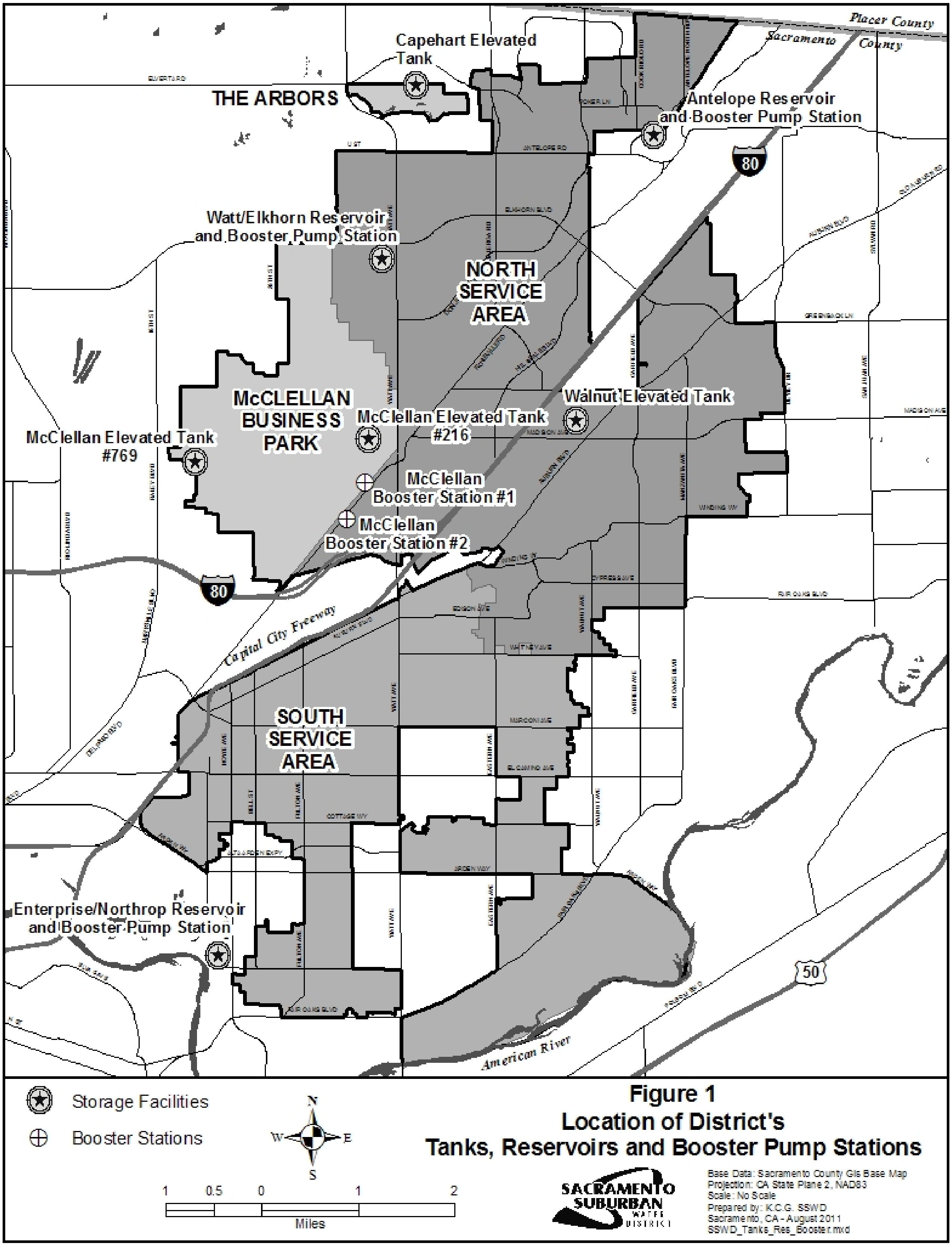

Placer County
Sacramento County
Capehart Elevated Tank
THE ARBORS
Antelope Reservoir and Booster Pump Station
80
Watt/Elkhorn Reservoir and Booster Pump Station
NORTH SERVICE AREA
McCLELLAN BUSINESS PARK
Walnut Elevated Tank
McClellan Elevated Tank #216
McClellan Elevated Tank #769
McClellan Booster Station #1
McClellan Booster Station #2
Capital City Freeway
SOUTH SERVICE AREA
Enterprise/Northrop Reservoir and Booster Pump Station
50
American River
Storage Facilities
Booster Stations
N
W
E
S
1 0.5 0 1 2
Miles
Figure 1
Location of District's
Tanks, Reservoirs and Booster Pump Stations
SACRAMENTO SUBURBAN WATER DISTRICT
Base Data: Sacramento County GIS Base Map
Projection: CA State Plane 2, NAD83
Scale: No Scale
Prepared by: K.C.G. SSWD
Sacramento, CA - August 2011
SSWD_Tanks_Res_Booster.mxd

Table 1. Inventory of District's Existing Storage Reservoirs and Tanks

Facility Name	Volume, MG	Year Constructed	Pump station capacity, gpm	Status
Antelope Ground Reservoir	5.0	1999	10,000 (8,000 gpm reliable capacity)	Active
Capehart Elevated Tank	0.150	1952	--	Active
Enterprise/Northrop Ground Reservoir	5.0	2006	13,900 (boosted directly from City to District system) 7,000 (from storage tank to District system)	Active
McClellan Business Park Elevated Tank #216	0.500	1953	--	Active. Tied to system, backup on low pressure situation-fire backup/ emergency.
McClellan Business Park Elevated Tank #769	0.150	1952	--	Active. Tied to system, backup on low pressure situation-fire backup/ emergency.
Walnut Yard Elevated Tank	0.125	1958	--	Active
Watt/Elkhorn Ground Reservoir	5.0	2000	8,000	Active

As indicated, the District's total storage capacity from all seven reservoirs and tanks is 15,925,000 gallons. To put this into perspective, the District supplies approximately 16 million gallons to its customers on an average winter day and approximately 50 million gallons on an average summer day.

A more detailed description of each reservoir, tank and booster pump station follows below.

Antelope Ground Reservoir and BPS – The 5 million gallon (MG) Antelope ground storage reservoir was constructed in 1999 and is located in the northeast corner of the NSA. The NSA surface water supply from San Juan Water District's (SJWD) Peterson WTP is delivered via the Cooperative Transmission Pipeline (CTP) and Antelope Transmission Pipeline (ATP) to the Antelope Pressure Reducing Valve (PRV) Station which is located near the reservoir. When available, surface water can be diverted directly into the tank. When surface water is not available, the tank can be filled with groundwater. The tank is used for emergency storage and the water in the tank is turned over on a bi-weekly basis for water quality purposes. See Appendix A for a current photo of the facility.

Capehart Elevated Tank – The 150,000 gallon Capehart elevated tank is located in the Arbors at Antelope service area, previously owned by the federal government. This tank was constructed in the 1950's. The District has operational issues with utilizing this storage tank because the height of the tank is lower than the hydraulic grade line (HGL) of the service area. The current service area pressures ranges from the high 70's psi to the low 80's psi. Therefore, at this time the tank is not being used as originally designed and it is reserved for extreme low pressure situations or other emergencies. This tank is periodically drained and refilled to ensure that water quality does not diminish. See Appendix A for a current photo of the facility.

Enterprise/Northrop Reservoir and BPS – The 5 million gallon (MG) Enterprise/Northrop ground storage reservoir and booster pump station (BPS) was constructed in 2006. The facility is located in the southwest corner of the District's South Service Area (SSA) on Enterprise Drive (near the intersection with Northrop Avenue) at the intertie with the City of Sacramento. When surface water is available, it is used to fill the tank. The surface water passes through the intertie with the City and through a flow meter vault and site piping before it enters directly into the reservoir tank. The booster pump station itself is designed for maximum operational flexibility. Two sets of booster pumps were constructed: one set to boost (pump) water from the City directly into the District's distribution system and a second set of lower capacity booster pumps dedicated to pumping water from the tank into the distribution system. The majority of the surface water received from the City is boosted directly into the District's system without entering the reservoir tank.

When surface water is not available, groundwater can also be used to fill the tank. The tank is also used for emergency storage and the water in the tank is turned over on a bi-weekly basis for water quality purposes. See Appendix A for a current photo of the facility.

McClellan Business Park Elevated Tank #216 – The 500,000 gallon McClellan Business Park elevated tank #216 is located at Peacekeeper Way and Dudley Blvd. on the east side of the McClellan Business Park service area It was constructed in 1953. The elevation of this tank is lower than the current HGL of the service area and the District has difficulty emptying this tank. Therefore, at this time this tank is not being used as originally designed and it is reserved for extreme low pressure situations or other emergencies. This tank is periodically drained and refilled to ensure that water quality does not diminish. See Appendix A for a current photo of the facility.

McClellan Business Park Elevated Tank #769 – The 150,000 gallon McClellan Business Park elevated tank #769 is located on the west side of the McClellan Business Park service area. It was constructed in 1952. The elevation of this tank is lower than the current HGL of the service area and the District has difficulty emptying this tank. Therefore, at this time the tank is not being used as originally designed and it is reserved for extreme low pressure situations or other emergencies. This tank is periodically drained and refilled to ensure that water quality does not diminish. See Appendix A for a current photo of the facility.

Walnut Yard Elevated Tank – The 125,000 gallon Walnut Yard elevated tank is located in the NSA near Walnut Avenue and Auburn Blvd. It was constructed in 1958. Because the elevation of this tank is higher than the (HGL) of the NSA, the District utilizes a booster pump to boost water back into the tank from the distribution system during off-peak demand periods. As pressure drops in the system, an operational control valve will slowly open to allow the tank to provide supply to the system. This is done on a daily basis. See Appendix A for a current photo of the facility.

Watt/Elkhorn Ground Reservoir and BPS – The 5 MG Watt/Elkhorn ground reservoir and booster pump station (BPS) is located in the North Highlands sub zone of the NSA. It was constructed in 2001. This tank can be filled with either surface water or groundwater. When surface water is not available, and during peak demand periods, staff has difficulties maintaining reservoir level while also providing sufficient supply to meet demands. The tank is used for emergency storage and the water in the tank is turned over on a bi-weekly basis for water quality purposes. The Watt/Elkhorn Well (#31A) is located near the reservoir and is plumbed to pump either to the distribution system or to the reservoir. See Appendix A for a current photo of the facility.

Other Booster Pump Stations

There are two booster pump stations that are designed to boost water from the District's NSA into the McClellan Business Park service area. These booster pump stations are identical in configuration. The design flows for each booster pump station are shown in Table 2. The location of these booster pump stations is shown on Figure 1. These BPSs were constructed in 1988 to ensure adequate water supply during a flight line emergency at McClellan Air Force Base (when the base was still in operation). Backflow prevention valves are located at both BPSs to prevent flow within the McClellan Business Park service area from re-entering the NSA. As demand increases and the pressure decreases, the booster pumps start and maintain the pressure at a predetermined and desired set point. Because the pressure gradient for the McClellan Business Park service area does not differ significantly from the NSA, the booster pump stations rarely are required to operate, and sufficient flow is usually delivered by gravity.

Table 2. Inventory of District's Existing Booster Pump Stations

Facility Name	Design flow, gpm
McClellan Booster Station #1	
Booster 1A	2,000
Booster 1B	2,000
McClellan Booster Station #2	
Booster 2	2,000

INVENTORY OF DISTRICT'S EXISTING PRESSURE REDUCING VALVE (PRV) STATIONS AND METERED INTERCONNECTIONS

Note that staff is also planning on adding the District's Pressure Reducing Valve (PRV) stations and metered interconnections to this asset management plan but these assets have not yet been incorporated. These assets will be added in the next plan update.

PLANNED FUTURE RESERVOIRS/TANKS

If budgets are approved by the Board of Directors and/or possible grant funding can be secured, the District is planning on future reservoir tanks and booster pump stations in the following locations and sizes.

Verner Reservoir (3 MG) and Booster P.S.

Surface water is available to the District's NSA through a contract with Placer County Water Agency (PCWA) but this water is not always available. When surface water is not available, this area can experience lower water pressure. In addition, there can be poor water circulation in this area which can lead to secondary taste and odor problems.

This project would consist of the construction of a 3 million gallon (MG) reservoir tank and related facilities that will provide additional water supply storage capacity and increase water supply availability for fire protection. The District already owns a 2.5 acre site for the proposed project, located within the urban setting of the City of Citrus Heights. The proposed reservoir tank would provide water to customers during peak demand, fire-related flow periods and during power outages. By providing storage, the reservoir would also enhance conjunctive use capabilities in the NSA. When it is available, surface water could be stored in the reservoir and used in lieu of groundwater resources. The recently constructed Verner Well (#N36) could also be used to fill the tank with groundwater whenever surface water is not available.

McClellan Business Park Reservoir (3 MG) and Booster P.S.

The McClellan Business Park, formerly called McClellan Air Force Base, includes 2,888 acres of property, approximately 10.5 million square feet of building area and an industrial airfield. McClellan Business Park is one of the largest business parks in California and may ultimately employ up to 34,000 individuals. Because of the potential for growth in this service area, there is a future need for water storage to provide for fire protection and water supply reliability. The need for such a facility was identified in the District *2009 Water System Master Plan* as prepared by Brown and Caldwell. The proposed reservoir tank would provide water to customers during peak demand, fire-related flow periods and during power outages.

By providing storage, the reservoir tank would also enhance conjunctive use opportunities within the McClellan Business Park Service Area. Surface water is available to this service area through a contract with Placer County Water Agency (PCWA) but this water is not always available. When it is available, surface water could be stored in the reservoir and used in lieu of groundwater resources.

The proposed project consists of the construction of a 3 million gallon (MG) reservoir tank with booster pump station and related facilities that would provide additional water supply storage capacity and increase water supply availability and reliability for fire protection. The District already owns a 2± acre site for the proposed project, located within McClellan Business Park.

RESERVOIR TANK COATINGS AND/OR CATHODIC PROTECTION

Corrosion is a serious problem in steel water tanks. The metal walls break down due to an electrochemical reaction. Electrons flow from the walls of the tank (the anode) into the water (the cathode). The third component of the corrosion battery is a closure circuit - a surface linking the anode and cathode through which electrons can flow. A paint coating protects against corrosion by forming a physical barrier between the anode and the cathode. Another type of protection, cathodic protection, provides a replacement anode so that the tank walls do not corrode. Each type of corrosion protection can be used alone or in combination with each having unique advantages and disadvantages.

Coating Systems

When exposed to the environment, steel oxidizes and deteriorates. This is especially true if the environment includes both air (oxygen) and moisture. For steel water tanks, paints and other protective coatings are used on both the interior and exterior to prevent such deterioration. Properly applied protective coatings are cost-effective methods of protecting both the interior and exterior tank surfaces. Both the interior and exterior coatings must be carefully selected to provide the best protection based on coating life, effectiveness of protection, and ease of application.

Factors to consider when selecting an exterior coating for a tank include[2]:

- The type of atmosphere in which the tank will be located
- The area surrounding the tank
- The expected ambient temperatures and prevailing winds during the time of year when the coating project is scheduled to be performed
- Appearance of the coating

Interior tank coatings for potable water storage tanks must be able to withstand the following[3]:

- Constant immersion in water
- Varying water temperatures

[3] Source: *Steel Water Storage Tanks*, Manual of Water Supply Practices M42, American Water Works Association, 1998.

- Alternate wetting and drying periods
- High humidity and heat in the zones above the high water level
- Chlorine and mineral content of the water

In addition, the interior coatings must not impose a health risk on the general public and must be approved for potable water storage by the State Department of Public Health (CDPH).

Cathodic Protection Systems

The corrosion of steel in water is an electrochemical process in which a current flows and a chemical reaction occurs. A corrosion "cell" has four basic elements: anode, cathode, electrolyte, and closure path[4]. The anode is the metal that will corrode when metal ions leave its surface and enters the electrolyte. The cathode is a metal from which no metal ions enter the solution. In a steel water storage tank, some portion of the metal will be the anode and some portion will be the cathode. The electrolyte in this case is drinking water in the tank or reservoir that is capable of conducting electricity. The closure path, also called the return current path, is the electrical conductor, usually metal, that connects the anode and the cathode together. If any one of these four elements is missing, corrosion does not occur. Therefore, coating stops corrosion from occurring by providing a barrier to the current flowing between the metal and the electrolyte.

In addition to protective coatings, cathodic protection systems are used to prevent or retard the corrosion that would normally occur. There are both Galvanic (or "Passive") and Impressed-Current type systems. In a passive system, blocks of specially selected metal, typically magnesium, called sacrificial anodes, are hung from the roof of the storage tank and immersed in the water. With this system in place, the magnesium anodes corrode and the steel is protected. With an impressed current system, an outside source of electrical power forces current into the submerged anodes. The electrical current flows from the anodes, through the water (electrolyte) and onto the submerged walls of the tank, making the tank itself the cathode of the corrosion cell. Impressed current cathodic protection systems should be designed and constructed in

[4] Source: *Steel Water Storage Tanks*, Manual of Water Supply Practices M42, American Water Works Association, 1998.

accordance with AWWA Standard D104, "Standard for Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks"

Cathodic protection systems were included in the design and construction of the District's three ground level storage reservoirs. The Antelope storage tank has an impressed current cathodic protection system that is activated. The Enterprise/Northrop and Watt/Elkhorn Reservoirs have both passive and impressed current type systems in place and in both instances the impressed current systems are also turned on and working. However, only one of the elevated tanks (McClellan Business Park Elevated Tank #216) currently has a cathodic protection system.

RESERVOIR/TANK/PUMP MAINTENANCE AND REPAIRS

Purpose of Tank Maintenance

Every steel water tank must be periodically maintained in order to ensure long life of the tank and to maintain proper water quality within the tank. Tank maintenance can be considered a cost-saving measure. Periodic maintenance is usually much cheaper than the large repairs that will most likely become necessary in un-maintained tanks. The cost of inspection and maintenance is an insurance policy against premature failure of the tank. The tank should be inspected by an independent inspector at least every two or three years. Some utilities choose to hire an annual maintenance service to perform yearly inspections and maintenance. In either case, the inspector will determine what type of maintenance should be performed.

The tank's paint coating requires the most maintenance since it must be replaced periodically. When the coating is not well maintained, the tank will have to be repaired. Repairs can cost significantly more than the cost of the original coating.

Maintenance Inspections

Tanks must be inspected at regular intervals as the first step of the maintenance procedure. The purpose of the inspection is to determine if repairs are required and, if so, the exact nature and extent of the work required. Inspection of water tanks is expensive, but the cost is insignificant compared to the cost of premature failure of the tank. For steel tanks, inspection is considered to be an essential part of the maintenance process. Typically, a thorough inspection must be performed every two or three years on the entire tank structure. The District’s current schedule for tank cleanings and inspection is shown in Table 3.

Table 3. Reservoir and Tank Inspection Schedule

Reservoirs and Storage Tanks	Year Constructed	Current Status of Tank	Last Inspection and Cleaning[1]	Last Interior Coating	Last Exterior Coating	Last Cathodic Protection Test	Next Inspection and Cleaning Due	Comments
Antelope Reservoir	1999	Active	Oct. 2010	1999	1999	Oct. 2010	2012	Wet cleaning and inspection performed in 2010.
Capehart Elevated Tank	1952	Active	Aug. 2008	Nov. 2008	Nov. 2008	N/A	2013	Last inspection performed on November 7, 2008. Needs new cathodic protection (CP) equipment.
Enterprise / Northrop Reservoir	2006	Active	Feb. 2009	Dec. 2007	April 2008		2011	
McClellan Park Elevated Tank #216	1953	Active	Aug. 2009	Oct. 2010	Nov. 2003	Oct. 2010	2014	New CP equipment installed Oct. 2010.
McClellan Park Elevated Tank #769	1952	Active	Sept. 2006	Sept. 2006	Sept. 2006	N/A	2011	Needs new CP equipment.
Walnut Elevated Tank	1958	Active	April 2006	2011	2011	N/A	2011	Exterior "spot" repair May 2006. Tank interior and exterior being recoated starting in August 2011.
Watt / Elkhorn Reservoir	2000	Active	Oct. 2010	Nov. 2001	Nov. 2001	Oct. 2010	2012	Wet cleaning and inspection performed in 2010. Interior "spot" repair performed in October 2010

Notes:
[1] See Appendix B for copies of the most recent reservoir/tank inspection reports.

Planned Cleaning / Inspection Interval	
Reservoirs	**Every 2 Years**
Elevated Tanks	**Every 5 Years**

Inspection should be considered a mandatory part of the maintenance procedure and should be conducted by an independent and well trained expert who will receive no benefit from any maintenance performed on the tank. The practice of inspecting reservoirs and tanks on a regular basis is a Best Management Practice (BMP) encouraged by CDPH's Sanitary Engineer. A qualified inspector or professional engineer (see AWWA Standard D101, "*Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs and Elevated Tanks for Water Storage*") will be able to evaluate the structure, the welds, the formulations, the structural alignment, paint condition (interior and exterior), leakage, and any settling, and successfully complete a corrosion evaluation in accordance with D101. The AWWA Standard D102, "*Coating Steel Water Storage Tanks,*" includes a brief section on inspection which should be followed but which is not adequate as a basis for the entire inspection. Tank inspections should always be performed by an independent contractor.

The inspector should outline specific maintenance needed to restore the structure. This inspection should be the basis for all maintenance of the structure - only maintenance required by the inspector should be performed. In addition, a complete record of inspections and maintenance should be kept. Following the proper guidelines and selecting a qualified engineer to perform regular inspections will help avoid serious maintenance problems in the future. Formal coating inspections and the associated maintenance will vastly increase the probability of achieving a successful coating application that will protect for the design life of the system. They will prevent costly repairs and are financially responsible in the long run.

The District employs two methods of tank inspection, "dry" inspections and "wet" or submerged inspections. The method of inspection utilized is based on conditions specific to the reservoir or tank being inspected.

Dry inspections consist of isolating the reservoir/tank from the distribution system and dewatering completely. The tank is then inspected per AWWA Standard D101 for structural integrity and coating condition. If repairs are required, these are completed while the reservoir/tank is empty and dry. Before the reservoir/tank is placed back into service after a dry inspection, it must be disinfected in accordance with AWWA Standard C652 (see further discussion below).

Wet or submerged inspections consist of filling the vessel to its maximum capacity, then isolating it from the distribution system to ensure the safety of the inspector. The inspector then dons fully contained divers dry suit, is disinfected with a 200 parts per million (ppm) solution of sodium hypochlorite, and bodily enters the reservoir/tank to perform the inspection. These inspections are often more thorough as a submerged diver can cover the vertical surfaces of the vessel much more thoroughly than viewing from ground level in a dry tank. If pitting or holidays are found in the coating, minor spot repairs can be done below the water line with NSF approved wet location epoxy paste. Another advantage to wet inspections is the lack of having to disinfect the entire reservoir/tank before placing it back into normal service.

Painting

Inspections determine the need for maintenance and painting. Then the tank must be dewatered and the surface prepared for painting. The first step during many maintenance procedures is to drain all of the water out of the tank. Before dewatering any potable water storage tank/reservoir, notice must be given to the State Department of Public Health (CDPH). Insurance carriers should also be notified before dewatering and inspection occurs.

Next the structure must be prepared for painting. This preparation is a very important part of the process. If preparation is poor, the painting job will be poor. The interior and exterior surfaces of the tank must be cleaned of all rust scale, paint scale, blisters, rust, dirt, and growths. This cleaning can be achieved through any of several methods - using wire scrapers, sand blasting, flame cleaning, and so on. After cleaning the surface, loose rivets must be replaced and damaged seams must be welded.

To prevent rust, painting should begin as soon as possible after the tank structure is cleaned and repaired. A coat of rust-inhibitive primer should be painted on all bare surfaces first. If the surface preparation resulted in an extensive removal of old paint, then the primer coat should cover the entire surface. A protective coating is then applied on top of the primer coat. This protective coating is applied in a thickness ranging from five to fifteen thousandths of an inch and serves to protect the tank surface from the environment. The protective coating is composed of a system containing solvents, resins, pigment and inert ingredients. The pigments add color, but may also perform a variety of other functions. The pigments may provide resistance to the sun's ultraviolet light and may enhance the physical properties of the paint and the gloss.

The tank must be allowed to dry, or to cure, before being refilled with water and placed back into service. The paint on the inside of the tank may take longer to cure, especially during the winter. Some types of paint, such as high build epoxies, will be problematic if applied during the winter. Instead, high solid vinyl should be used during these months since they will cure more reliably.

Currently, the District is on a schedule where the steel tanks, both ground level and elevated, are being completely re-coated, interior and exterior, every 15 years. Of course, this schedule is subject to change depending on the findings and recommendations from the regular tank cleanings and inspections. In addition, spot repairs are performed each time that the regular cleanings and inspections are performed. The District's current schedule for tank re-coatings is shown in Table 4.

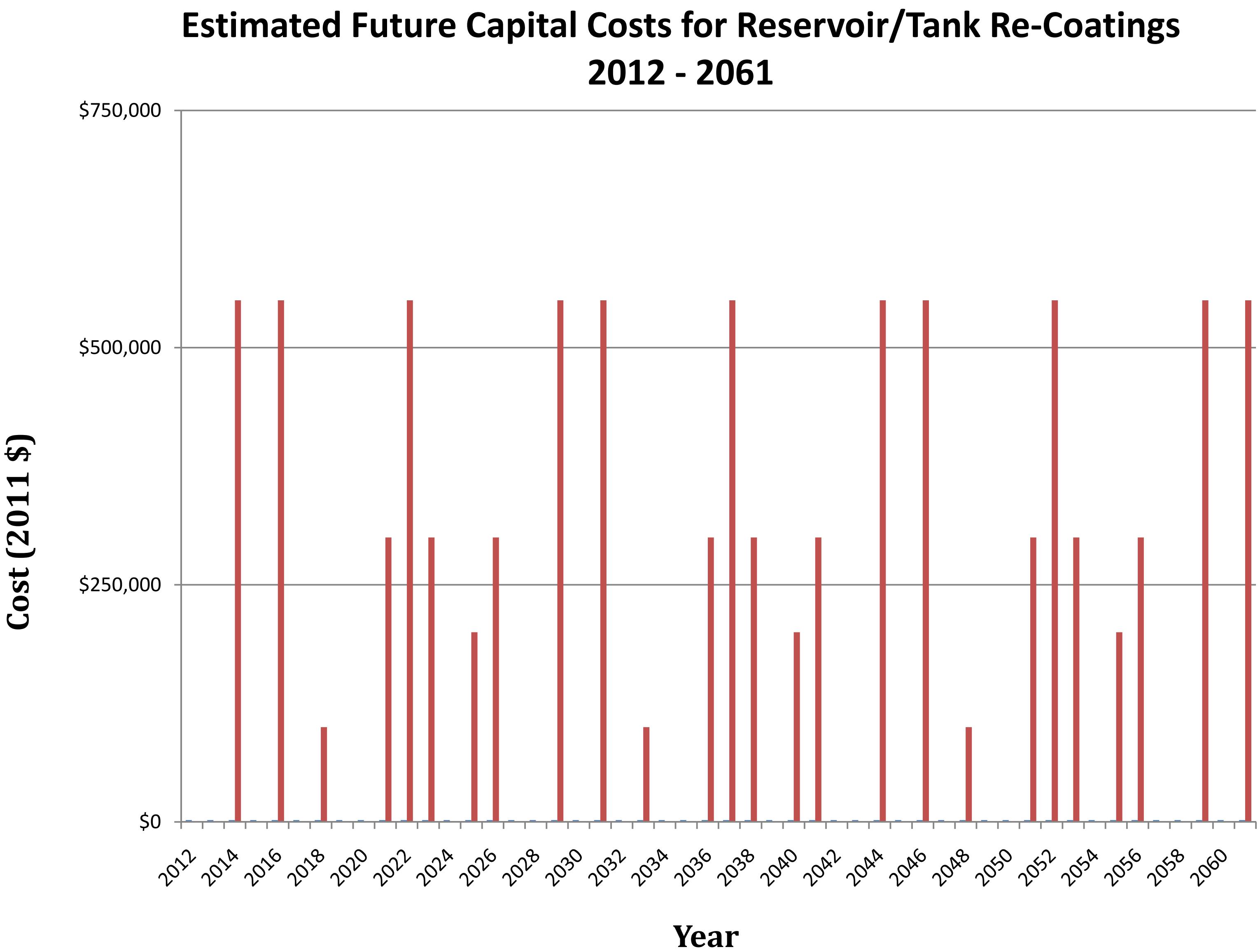
Complete tank and reservoir re-coatings are estimated to cost between $300,000 (elevated tanks) and $550,000 (ground level reservoirs). The estimated cost for an elevated tank re-painting is based on the low bid for a complete re-coating of the Walnut Yard Elevated Tank received in June 2011 by River City Painting, Inc. of Sacramento. The estimated cost for an entire re-coating of a 5 MG ground level reservoir is based on an estimate provided in August 2011 by River City Painting. This estimate assumes that existing coatings on the interior of the reservoir tank would be completely removed by sand blasting to bare metal. New coatings would then be applied to the interior. The estimated cost of re-coating the tank interior is $430,000 to $480,000. The estimated cost for re-coating the reservoir tank exterior assumes that the entire exterior of the tank would be sanded to roughen the existing finish to receive new paint. New coatings would then be applied to the tank exterior. No sand blasting is assumed for the tank exterior. Therefore, the estimated total cost for a complete re-coating, interior and exterior, for a 5 MG steel ground level reservoir tank is $550,000 in 2011 dollars.

Table 4. Reservoir and Tank Re-Coating Schedule

Reservoirs and Storage Tanks	Year Constructed	Current Status of Tank	Last Interior Coating	Last Exterior Coating	Next Tank Re-Coating Due	Comments
Antelope Reservoir	1999	Active	1999	1999	2014	
Capehart Elevated Tank	1952	Active	Nov. 2008	Nov. 2008	2023	
Enterprise / Northrop Reservoir	2006	Active	Dec. 2007	April 2008	2022	
McClellan Park Elevated Tank #216	1953	Active	Oct. 2010	Nov. 2003	2018 (Exterior) 2025 (Interior)	Exterior and interior of tank will be on different schedules.
McClellan Park Elevated Tank #769	1952	Active	Sept. 2006	Sept. 2006	2021	
Walnut Elevated Tank	1958	Active	2011[1]	2011[1]	2026	[1]Tank interior and exterior are being recoated starting in August 2011.
Watt / Elkhorn Reservoir	2000	Active	Nov. 2001	Nov. 2001	2016	

Planned Interior/Exterior Re-Coating Interval	
Reservoirs	**Every 15 Years**
Elevated Tanks	**Every 15 Years**

Capital costs for reservoir/tank re-coatings have been projected out 50 years (2012 – 2061) and are shown in Figure 2.



Note: Routine tank cleanings/inspections/spot repairs and pump/motor repair and maintenance would be included in the District's annual O&M budgets.

Figure 2

Disinfection

A newly-installed reservoir/tank or a reservoir/tank that has been taken out of service for repair or inspection shall be thoroughly disinfected and sampled for bacteriological quality in accordance with AWWA Standard C652-02, Disinfection of Water Storage Facilities," before being placed back into service. Outside demands should never be allowed to force a tank back into service before it is properly cured and disinfected. If the results of the bacteriological sampling are positive for coliform bacteria, the reservoir shall be re-sampled for bacteriological quality and the test results shall be submitted to CDPH for review and approval before the reservoir is placed into service.

Pump/Motor Maintenance, Repair and Replacement

The pumps and motors in service at the ground level reservoir booster pump stations and the independent booster pump stations need to be repaired, rebuilt and or replaced on a somewhat frequent basis. Typically the pumps should be removed and disassembled for inspection every 7 years to determine the amount of wear on the impellers, bowls, and wear rings, as well as to determine the condition of the bearings. When the pumps show significant wear, usually every 15 years on average (at the time of the second 7 year inspection) they should be rebuilt or replaced, whichever is more cost effective at the time. The costs for the regular maintenance of the pumps is assumed to be included in the District's annual Operation and Maintenance (O&M) budget and is not a capital cost item.

Assuming the pump motors are installed and operated properly they typically have a life expectancy of 40,000 to 50,000 hours before needing to be rebuilt, rewound or replaced. This is equal to approximately 4-½ years of continuous service. Since the District's booster pumps are not used continuously, it is expected that the motors will last an estimated 15 to 20 years before needing attention. The costs for motor rebuilding, re-winding or replacement are also assumed to be included in the District's annual Operation and Maintenance (O&M) budget.

RESERVOIR REHABILITATION AND/OR REPLACEMENT COSTS

Tank/Reservoir Rehabilitation

The most common areas where a ground level steel water storage reservoir will fail are the floor and the roof. However, if the tank shell is still in good condition, the floor and/or roof can be replaced as part of a rehabilitation process.

A large ground level storage reservoir will actually have some movement due to expansion and contraction. This movement is lessened if the tank is kept full of water the majority of the time. This movement places stresses on the floor of the tank where the center and intermediate support columns are located. The roof of the reservoir is subject to failure because the area above the normal water level is subject to high humidity and moisture buildup which can result in corrosion. If a failure occurs at the tank roof, it is generally at the bolted connection points.

Fortunately, the reservoir roof or floor can be completely replaced if the shell is still in good condition. Estimated labor for floor or roof replacement would be on the order of 5 to 6 weeks for a crew with another 3 weeks for coating the new floor or roof. For a reservoir tank the size of the District's three ground level storage reservoirs (approx. 160' diameter x 32' in height at the knuckle), the estimated ballpark cost of a complete floor or roof replacement is on the order of $500,000 to $600,000.[5]

Replacement Costs

Costs to construct steel water storage tanks have risen sharply in the last decade as the price of steel has increased dramatically. The current ballpark cost to construct ground level steel water storage tanks is approximately $1 per gallon of capacity. Therefore, a new 5 MG steel storage tank with foundation and all appurtenances would cost on the order of $5 million to construct. Elevated steel tanks are more expensive and current ballpark costs of these types of tanks can range from $3 up to as high as $5 or $6 per gallon of capacity. Therefore, a 150,000 gallon elevated tank could cost up to $900,000 to construct.

[5] Source: Phone conversation with Mr. Keith Bowers, Pacific Tank, August 18, 2011.

For better cost estimating, the District has fairly recent cost information on the design and construction of the 5 MG Enterprise/Northrop Reservoir and Booster Pump Station. The booster pump station has a pumping capacity of 20 mgd. This facility was constructed in 2005/2006. The total cost for this facility, including design, environmental review, construction, and construction management was approximately $7.4 million (not including land acquisition). To project this cost to today (2011), a construction cost index was used. Every month, *Engineering News Record* (ENR), a professional magazine in the construction industry, publishes their Construction Cost Index (CCI). The CCI is a weighted aggregate index of average prices for raw construction materials and labor for 20 large cities throughout the U.S. By applying the current CCI to the CCI when the Enterprise facility was constructed, it can be determined that construction costs have increased by approximately 18 percent due to inflation. Therefore, the total cost of the Enterprise/Northrop Reservoir and Booster Pump Station facility in today’s dollars is estimated at $8.7 million.

PLAN UPDATES

Review and reassessment of the RBPSAMP is recommended in at least 3 to 5 year intervals. It is recognized that new information may be made available in the future that might affect the condition assessment and the need for reservoir/tank repair, rehabilitation and/or replacement.

CONCLUSIONS AND RECOMMENDATIONS

- This *Reservoir and Booster Pump Station Asset Management Plan* provides an inventory of the District's existing reservoirs, tanks and booster pump stations.
- This Plan provides a tool for communication between the Board and Staff to identify areas in need for repair and/or replacement.
- This Plan identifies probable costs associated with reservoir tank repair, maintenance and/or replacement but does not prescribe any funding mechanisms.
- Out of seven (7) total reservoirs and tanks, four are elevated tanks that are all over 50 years of age. There are also three (3) ground level steel water storage tanks that are all less than 15 years of age. Steel water storage tanks have been known to provide service for 100 years or longer provided that they are properly maintained.
- Tank/reservoir cleaning and inspection is currently being performed every 2 years (reservoirs) and 5 years (elevated tanks). Spot coating repairs are being performed at the same time as the regular cleanings and inspections.
- Complete tank and reservoir re-coatings (interior and exterior) are being scheduled every 15 years. This is subject to change depending on the findings from the regular cleanings and inspections.
- Complete tank and reservoir re-coatings are estimated to cost between $300,000 (elevated tanks) and $550,000 (ground level reservoirs).
- If a reservoir tank shell is still in good condition, the floor and/or roof can be replaced as part of a tank rehabilitation process. The estimated ballpark cost of a complete floor or roof replacement is on the order of $500,000 to $600,000.
- Based on current cost information that was obtained for this report, it is estimated that the cost to replace a 5 MG ground level storage reservoir and associated booster pump station is approximately $8.7 million (2011 costs).
- This Plan will be reviewed and revised periodically as additional field and other information becomes available.