Water Transmission Main
Asset Management Plan

August 2011
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EXECUTIVE SUMMARY

In January 2008, the Sacramento Suburban Water District (SSWD) Board of Directors adopted an updated Water Main Replacement Plan (WMRP). This WMRP was an updated version of the adopted November 2005 plan. For the purpose of that report, water mains were defined as distribution water pipes between 4” and 12” in diameter that provide water service to commercial and residential properties. At that time, pipes 14-inches in diameter and larger were considered to be transmission mains and they were not included in the WMRP. [Note that it has now been decided that 14” diameter pipes will be included with the distribution mains the next time that the WMRP is updated.]

Attention is now directed toward the larger (16” in diameter and larger) transmission mains. The purpose of this Water Transmission Main Asset Management Plan (WTMAMP) is to inventory the District’s existing transmission mains in terms of size, type of pipe and age and to discuss a plan for monitoring and testing and potential repair, rehabilitation and/or replacement. This is the first attempt at identifying a program to address these larger pipeline assets in the long term. Fortunately, the District’s transmission mains are generally newer pipes within the system and they typically have cathodic protection for corrosion control to further increase their life expectancy. However, they are also the largest and most expensive pipes to replace when the need arises.

The reason that the majority of the transmission mains are newer pipes has to do with how the former Arcade and Northridge Water Districts were originally developed. As subdivisions were built in each district in the 1950’s (or earlier), the developer was typically required to provide a small lot or a portion of a lot for the construction of a groundwater well. As more and more wells were constructed a distribution system was constructed that resembles a “spider web” configuration with the larger diameter pipes in the vicinity of the wells and decreasing in size further away from the wells. There was no backbone transmission main system. In the 1990’s, as both former districts were pursuing conjunctive use opportunities, larger backbone transmission mains began to be constructed to move surface water throughout the District. The only exception is that the former Arcade Water District constructed a series of shallow infiltration wells along the American River in the 1960’s and a fairly substantial transmission
main system was constructed to move this surface water into the southeast portion of the District’s South Service Area. These are the oldest pipes in the current transmission main system.

Although District staff has considerable experience and information on the replacement of aging water distribution mains, staff has very limited experience with repair, rehabilitation, or replacement of the larger transmission mains. Therefore, for this report staff has relied on research information and the experiences of others. Cost estimates are considered as “ballpark” because they are based on a “best guess” set of assumptions in regards to pipe life expectancy, the ability to rehabilitate as opposed to replace the majority of the pipe when it reaches the end of its useful life, and the methods to be used for pipeline rehabilitation. Staff anticipates refining the assumptions and cost estimates going forward based on institutional experience and industry experience.

This WTMAMP is intended to be used as a tool for ongoing communication between the Board and staff to prioritize water transmission main assessment, rehabilitation or 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 in the District’s approved budget.

The purpose and goals of the WTMAMP are to:

- Provide for a safe and reliable water transmission system.
- Inventory the District’s existing transmission mains by size, type and age.
- Provide a preliminary plan for transmission main monitoring and condition assessment.
- Provide a preliminary plan for transmission main rehabilitation and/or replacement that can be adapted and modified to incorporate new technologies, management practices, and District needs.
- Provide a direction and framework for future plan revisions.
- Coordinate with the District’s WMRP.
- Coordinate with the District’s long term Water System Master Plan and Capital Improvement Program (CIP).
- Provide supporting information to address the District’s capital reserves going forward.

There are currently over 53 miles of 16” and larger transmission mains throughout the District. Fortunately, the majority (56.1%) of the transmission mains were constructed in the last 10 years and are still in excellent condition with a long useful life still remaining. And, approximately 80% of the transmission mains are less than 20 years of age. The District’s metallic transmission mains also generally include cathodic protection for protection from corrosion. The average useful life of the water transmission mains is estimated at between 70 and 120 years depending on the pipe material.

Various future transmission mains are also planned within the District. If these planned future transmission mains are funded and constructed, they will add approximately 20 miles of additional transmission mains to the District’s system.

Various methods are available for monitoring and testing the condition of the piping and performing condition assessments. Fortunately, the newer water transmission mains within the District were constructed to allow for electrical continuity between pipe sections. Test stations are available at various intervals to allow for the electrical continuity of the pipe and the pipe-to-soil (P/S) potential to be tested. The District has started a program to regularly test these transmission mains but more emphasis must be placed on this type of testing in the future. In addition, the District is considering an acoustic based testing method to perform condition assessment on other piping.

The majority of the District’s older distribution mains (pipes 12” and smaller) that are being replaced are presently located in back and side-yard easements. The new replacement water mains are typically being installed within the public right-of-way, and the existing back and side-yard water mains are being abandoned in place. However, the majority of the District’s transmission mains are already located within streets. As a result, their ultimate replacement becomes somewhat more complicated because their location is not changing. However, the fact that the transmission mains are in the preferred location (i.e., the street) allows for other
opportunities to extend the life of the mains through repair and/or rehabilitation. This could include relining the mains or other rehabilitation alternatives.

Various alternatives are available for pipeline rehabilitation and/or replacement. One of the most common methods for large pipe rehabilitation is known as sliplining. In 2011 dollars, the cost for rehabilitation can range from approximately 30 percent to 50 percent of the cost of replacement. Rehabilitation can extend the service life of the pipe by an estimated 50 years. Transmission main replacement costs are estimated to range from $1.1 million per mile for 16-inch diameter piping to $4.0 million per mile for 48-inch piping.

Over the next 100 years (2012 – 2111), costs have been estimated to rehabilitate and/or replace the District’s transmission mains and those in which the District owns capacity (SJWD and the City of Sacramento). These cost estimates assume that any transmission mains installed prior to 1985 will have an estimated service life of 70 years and any transmission mains installed in 1985 or later will have an estimated service life of 90 years. The life expectancy of these pipelines can of course vary greatly depending on many factors including construction methods, quality of pipe manufacturing, soil corrositivity, water quality, etc. Once the existing pipelines reach their estimated service life it is further estimated that 50 percent of the pipelines will be rehabilitated using localized repair and rehabilitation methods, 25 percent of the pipelines will be rehabilitated using the sliplining process, and 25 percent of the pipelines will be replaced. Based on these assumptions, it is estimated that the total cost to rehabilitate and/or replace existing transmission mains over the next 100 years is approximately $87 million (in 2011 dollars). Based on an economic analysis, the present value of estimated future transmission main rehabilitation and/or replacement costs is approximately $257 million.

Similar to distribution mains, one other significant factor that affects scheduling and sequencing of any transmission main replacement is a County of Sacramento Ordinance that includes a moratorium which prohibits cuts in pavements on any streets within 3 years of being constructed or repaved. Any transmission main replacement projects will have to be coordinated with the County of Sacramento’s paving and overlay projects as it is prudent to install the new water main in a street or streets before they are overlaid and the moratorium takes effect.
Similar to the WMRP, it is anticipated that this WTMAMP 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. Review and reassessment of the WTMAMP is recommended in 3 to 5 year intervals. Future information that could change the plan include, but are not limited to: improved recordkeeping, information from leak detection surveys, information from condition assessment surveys and testing, infrastructure failures, catastrophic events, merger or consolidation with other water purveyors, and/or changes in District policies.
INTRODUCTION / BACKGROUND

Water utilities throughout the United States are currently facing the challenge of extensive rehabilitation and replacement of aging and deteriorated water transmission and distribution mains. In 2010, the American Society of Civil Engineers (ASCE) has 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 are the older water distribution mains that date back prior to the 1950s. Some portions of these pipelines have been in service since the mid-1920’s. 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 larger water pipes, or transmission mains. Transmission mains are larger pipes (16” in diameter and larger) which are designed to move large quantities of water from the source of supply, such as a treatment plant or groundwater well, and provide water to the smaller distribution mains. Service lines to homes and businesses are not normally connected to a transmission main, so ease of making service taps is not a major consideration in selecting the type of pipe to be used. Distribution mains are a network of smaller mains branching off from the transmission mains to which are connected the house service lines and meters, fire hydrants, and other appurtenances (blow-offs, etc.). Mainline valves are typically installed at pipe junctions (at street intersections) but certainly within quarter mile intervals to allow for a leaking or damaged section of pipe to be shut off with minimum interruption of water service to adjacent areas.

The likelihood of a transmission main failure is actually lower than for other piping systems because they are typically more substantial in design. In addition, transmission mains typically have no service connections which means there are significantly fewer locations where the pipe wall has been compromised. However, the consequences of failure for a transmission main are much greater than for a smaller distribution main. There is a greater chance of flooding and

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infrastructure failure (pavement, etc.) due to the larger volume of water that would be expected to escape from a leaking or ruptured pipe.
TYPES OF PIPE USED FOR DISTRICT TRANSMISSION MAINS

The five pipe materials used for water transmission mains within the District are asbestos cement pipe (ACP), concrete cylinder pipe (CCP), cement mortar lined and coated steel (CMLCS) pipe, ductile iron pipe (DIP), and polyvinyl chloride (PVC). Standards for the manufacture of each type of pipe are established and maintained by the American Water Works Association (AWWA). The CCP, CMLCS and DIP pipe types contain ferrous materials and as a result, they need to be protected from both internal and external corrosion and each type uses a different method to prevent corrosion. A brief description of each type of pipe follows below.

Asbestos Cement (AC) Pipe

Asbestos cement (AC) pipe is a concrete pipe made of a mixture of Portland cement and asbestos fibers. It is highly resistant to corrosion and it has historically been used for drainage systems, waterworks systems, and gas lines. AC pipe was used extensively in the mid-1900’s in potable water distribution systems, particularly in the Western United States.

The advantages of AC pipe include low initial cost, smooth interior walls and light weight which makes it easy to install. Principal disadvantages are that it breaks easily if not handled and installed properly, the need for special care in tapping, and the need for special safety precautions during installation and repair to prevent inhalation of asbestos dust. AC piping is rarely if ever installed in the United States today, both because of the fear of working with asbestos materials and because PVC pipe has taken its place as an inexpensive and lightweight piping material.

One of the most common issues that leads to AC pipe breaks within the District is the presence of tree roots. If trees are planted over the top or near the AC pipe, the tree roots can eventually spread out and cause the pipe to rupture. This is more common with the District’s AC distribution mains that are installed in back and side-yard easements where trees are more prevalent.

Over time, AC pipe may undergo gradual degradation (i.e., internal calcium leaching due to potable water chemistry and/or external leaching due to soil conditions or groundwater).
Leaching of calcium leads to a reduction in the effective cross-section, which results in pipe softening and loss of mechanical strength. Therefore, as the water distribution system ages, the number of AC pipe failures increases with time. In light of these risks, an AC pipe condition assessment is essential to determine the remaining useful service life and develop a replacement plan.

The Chrysotile Institute estimates the AC pipe lifespan at 70 years, but actual service life depends largely on water chemistry and the soil environment. Because thousands of miles of AC pipe installed in distribution systems in the U.S. is nearing the end of its useful life, AC pipe condition assessment and strategic replacement planning will need to be done in the coming decade.

**Concrete Cylinder Pipe (CCP)**

Concrete cylinder pipe (CCP) is a composite type of pipe that combines the adaptability of steel with the durability and corrosion inhibiting properties of concrete and cement mortar. CCP generally consists of a steel cylinder lined with concrete or cement mortar, then helically wrapped with a mild steel bar and coated with dense cement mortar. A watertight joint is provided by using bell and spigot steel joint rings welded to the ends of the cylinder and sealed with a rubber gasket.

The applicable AWWA standards for concrete cylinder pipe include C300 (Reinforced Concrete Pressure Pipe, Steel-Cylinder Type); C301 (either Lined-Cylinder Pipe or Embedded Cylinder Pipe); and C303 (Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type).

The advantages of CCP include good corrosion resistance, widespread availability, high strength, and excellent load supporting capacity. The disadvantages are that it requires careful handling and installation to avoid cracking, it is heavy and more difficult to install than other pipe types,

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2 The Chrysotile Institute is a trade group for the asbestos industry in Canada. In 2004, the group changed their name from the Asbestos Institute, but their mission has not changed. The non-profit organization, established in 1984, promotes the mining, application and use of a variety of asbestos called "chrysotile."
and it is more expensive than other types of pipe. Tapping the pipe is also difficult as special provisions are required to make connections and preserve the integrity of the lining systems.

**Cement Mortar Lined and Coated Steel (CMLCS) Pipe**
Steel pipe has been used for water pipelines since the 1850’s. It is frequently used where pressures are high and large diameter pipe is required. It is comparatively inexpensive, easy to install, and more easily transported than DIP; however, steel pipe cannot withstand the external loads that DIP can. Because it is metallic, steel pipe is subject to corrosion and the corrosion is oftentimes more severe in steel pipe than DIP.

Cement-mortar lining and coating is often used to protect both the interior and exterior of steel pipe. Special care must be taken to prevent damage to these protective coatings. Steel pipe can be joined together using different methods including welding.

The applicable AWWA standards for steel pipe include C200 (Steel Water Pipe 6 Inch and Larger); C205 (Cement-Mortar Protective Lining and Coating for Steel Water Pipe—4 Inch and Larger—Shop Applied); C206 (Field Welding for Steel Water Pipe Fittings); C207 (Steel Pipe Flanges); C208 (Dimensions for Fabricated Steel Water Pipe Fittings); and C602 (Cement-Mortar Lining of Water Pipelines—4 Inch and Larger—In Place).

**Ductile Iron Pipe (DIP)**
Ductile iron pipe (DIP) is generally recognized as an industry standard for modern water and wastewater piping systems. DIP has a high degree of dependability due to its high strength, durability, and impact and corrosion resistance. DIP can also be installed in a wide variety of soils and trench conditions and can be easily cut to length in the field. Disadvantages to DIP are that it is heavy and therefore more difficult to install than other types of pipe and it is also more expensive that other pipe types.

DIP is typically manufactured in 18- or 20-foot laying lengths and comes in sizes ranging from 3- to 64-inches in diameter in a range of pressure classes and wall thicknesses. DIP is furnished with several different types of joints and a wide variety of standard fittings are available. DIP is
usually furnished with cement-mortar lining for corrosion resistance. It also commonly receives a polyethylene wrap on the exterior of the pipe for external corrosion protection depending on soil corrosivity.

The applicable AWWA standards for DIP include C104 (Cement-Mortar Lining for Ductile-Iron Pipe and Fittings); C110 (Ductile-Iron & Gray-Iron Fittings); C111 (Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings); C150 (Thickness Design of Ductile-Iron Pipe); C151 (Ductile-Iron Pipe, Centrifugally Cast); and C153 (Ductile-Iron Compact Fittings for Water Service).

Polyvinyl Chloride (PVC) Pipe
Polyvinyl chloride (PVC) pipe is a plastic pipe made out of polyvinyl chloride or PVC. This type of pipe is most commonly used for water distribution or irrigation systems and wastewater collection systems. PVC pipe was first introduced in the United States around 1940 but was not commonly used until later in the century. PVC piping became more popular in the 1970’s and was used in nearly every house and building for plumbing purposes. It is also quite common in municipal water distribution systems in the United States and Canada.

In the larger sizes used for transmission mains (14” and larger), the PVC pipe must conform to the AWWA C905 specification for “Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14-inch through 48-inch, for Water Transmission and Distribution.” This specification establishes the general manufacturing and other requirements for PVC water transmission and distribution pipe in sizes 14-inch through 24-inch, with integral bell and spigot joints for the conveyance of water and other liquids.

Unlike metallic pipes, PVC pipes do not rust or corrode over time. It is also lightweight and therefore easier to handle and install than other types of pipe. The primary method of wear is by exposure to sunlight and heat, which begin to warp the pipe and cause damage. This is why PVC pipe is normally used underground or in basements where there is little light to damage the pipes. Another disadvantage is that careful attention must be paid during construction to avoid rocks or sharp objects coming into contact with the pipe.
INVENTORY OF DISTRICT’S EXISTING TRANSMISSION MAINS

Currently there are approximately 53 miles of water transmission mains within the District (pipelines 16-inches in diameter and larger). A breakdown by type of pipe, length in feet/miles and percentage of pipeline material in service in the District is shown in Table 1 below. Figure 1 is a map of the District showing the location of all transmission mains by size. Figure 2 is a map of the District showing the location of all transmission mains by type of pipe. See Appendices A and B for more detailed maps of the District showing the transmission mains by size and type respectively.

Table 1. Length of Transmission Mains by Size and Type of Pipe

<table>
<thead>
<tr>
<th>Diameter</th>
<th>AC Pipe (Feet)</th>
<th>CCP (Feet)</th>
<th>CMLC Steel (Feet)</th>
<th>DIP (Feet)</th>
<th>PVC Pipe (Feet)</th>
<th>Total (Feet)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16”</td>
<td>3,480</td>
<td>0</td>
<td>10,226</td>
<td>59,984</td>
<td>3,062</td>
<td>76,752</td>
<td>27.3</td>
</tr>
<tr>
<td>18”</td>
<td>0</td>
<td>0</td>
<td>10,833</td>
<td>112</td>
<td>0</td>
<td>10,945</td>
<td>3.9</td>
</tr>
<tr>
<td>20”</td>
<td>0</td>
<td>0</td>
<td>678</td>
<td>3,030</td>
<td>0</td>
<td>3,708</td>
<td>1.3</td>
</tr>
<tr>
<td>24”</td>
<td>0</td>
<td>0</td>
<td>85,524</td>
<td>13,875</td>
<td>0</td>
<td>99,399</td>
<td>35.4</td>
</tr>
<tr>
<td>30”</td>
<td>0</td>
<td>0</td>
<td>30,569</td>
<td>50</td>
<td>0</td>
<td>30,619</td>
<td>10.9</td>
</tr>
<tr>
<td>36”</td>
<td>0</td>
<td>0</td>
<td>19,142</td>
<td>187</td>
<td>0</td>
<td>19,329</td>
<td>6.9</td>
</tr>
<tr>
<td>48”</td>
<td>0</td>
<td>40,033</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40,033</td>
<td>14.3</td>
</tr>
<tr>
<td>Total</td>
<td>3,480</td>
<td>40,033</td>
<td>156,972</td>
<td>77,238</td>
<td>3,062</td>
<td>280,785</td>
<td>100.0</td>
</tr>
</tbody>
</table>

As indicated in Table 1, the majority of the District’s transmission mains are CMLC steel at 156,972 feet (29.7 miles) or 56 percent of all the District’s transmission mains. The second most prevalent type of pipe is DIP consisting of 77,238 feet (14.6 miles) or approximately 28 percent of the District’s transmission mains. The largest transmission mains are 48” diameter CCP which make up approximately 14 percent of the total footage. And finally, AC pipe and PVC pipe combined make up only 2.3 percent of all District transmission mains.
By size, the majority of the transmission mains are 24-inches in diameter with this size main making up 99,399 feet (18.8 miles) or approximately 35 percent of the District’s transmission mains. The next most prevalent size is 16-inch diameter making up 76,752 feet (14.5 miles) or approximately 27 percent of the District’s transmission mains.

The District’s transmission mains were broken down by age and type as shown in Table 2 below. Note the ages of some of the older transmission mains had to be estimated because this information was not available. Figure 3 is a map of the District showing the location of all transmission mains color coded by their age. See Appendix C for more detailed maps of the District showing the transmission mains by age.

Table 2. Age of Transmission Mains by Type of Pipe

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>AC Pipe (Feet)</th>
<th>CCP (Feet)</th>
<th>CMLC (Feet)</th>
<th>DIP (Feet)</th>
<th>PVC Pipe (Feet)</th>
<th>Total (Feet)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>0</td>
<td>0</td>
<td>128,556</td>
<td>26,676</td>
<td>2,214</td>
<td>157,446</td>
<td>56.1</td>
</tr>
<tr>
<td>11 – 20</td>
<td>0</td>
<td>40,033</td>
<td>11,242</td>
<td>15,140</td>
<td>848</td>
<td>67,263</td>
<td>24.0</td>
</tr>
<tr>
<td>21 – 30</td>
<td>1,529</td>
<td>0</td>
<td>10</td>
<td>31,681</td>
<td>0</td>
<td>33,220</td>
<td>11.8</td>
</tr>
<tr>
<td>31 – 40</td>
<td>1,951</td>
<td>0</td>
<td>744</td>
<td>3,741</td>
<td>0</td>
<td>6,436</td>
<td>2.3</td>
</tr>
<tr>
<td>41 – 50</td>
<td>0</td>
<td>0</td>
<td>16,420</td>
<td>0</td>
<td>0</td>
<td>16,420</td>
<td>5.8</td>
</tr>
<tr>
<td>Total</td>
<td>3,480</td>
<td>40,033</td>
<td>156,972</td>
<td>77,238</td>
<td>3,062</td>
<td>280,785</td>
<td>100.0</td>
</tr>
<tr>
<td>Percent of Total</td>
<td>1.2</td>
<td>14.3</td>
<td>55.9</td>
<td>27.5</td>
<td>1.1</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

As indicated by Table 2 above, the majority (56.1%) of the District’s transmission mains are less than 10 years old and are still in excellent condition with a long useful life still remaining. And, approximately 80% of the transmission mains are less than 20 years of age.
Figure 3
Transmission Mains by Age
Base Data: Sacramento County GIS Base Map
Projection: CA State Plane 2, NAD83
Scale: No Scale
Prepared by: KCG, SSWD
Date: 4/22/2011
TMain_by_Age.mxd
Each type of pipe is also broken down by size starting with the 16-inch diameter transmission mains as shown in Table 3 below. Also, see Appendix D for a map showing the location of all 16-inch transmission mains, by pipe type, within the District.

### Table 3. Percentage of 16” Diameter Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length (Feet)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>3,480</td>
<td>4.5</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>10,226</td>
<td>13.3</td>
</tr>
<tr>
<td>DIP</td>
<td>59,984</td>
<td>78.2</td>
</tr>
<tr>
<td>PVC</td>
<td>3,062</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76,752</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The 18-inch diameter transmission mains are broken down by type as shown in Table 4 below. Also, see Appendix D for a map showing the location of all 18-inch transmission mains, by pipe type, within the District.

### Table 4. Percentage of 18” Diameter Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length (Feet)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>10,833</td>
<td>99.0</td>
</tr>
<tr>
<td>DIP</td>
<td>112</td>
<td>1.0</td>
</tr>
<tr>
<td>PVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,945</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The 20-inch diameter transmission mains are broken down by type as shown in Table 5 below. Also, see Appendix D for a map showing the location of all 20-inch transmission mains, by pipe type, within the District.
### Table 5. Percentage of 20” Diameter Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>678</td>
<td>18.3</td>
</tr>
<tr>
<td>DIP</td>
<td>3,030</td>
<td>81.7</td>
</tr>
<tr>
<td>PVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,708</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The 24-inch diameter transmission mains are broken down by type as shown in Table 6 below. Also, see Appendix D for a map showing the location of all 20-inch transmission mains, by pipe type, within the District.

### Table 6. Percentage of 24” Diameter Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>85,524</td>
<td>86.0</td>
</tr>
<tr>
<td>DIP</td>
<td>13,875</td>
<td>14.0</td>
</tr>
<tr>
<td>PVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99,399</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The 30-inch diameter transmission mains are broken down by type as shown in Table 7 below. Also, see Appendix D for a map showing the location of all 24-inch transmission mains, by pipe type, within the District.

### Table 7. Percentage of 30” Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length (Feet)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The 36-inch diameter transmission mains are broken down by type as shown in Table 8 below. Also, see Appendix D for a map showing the location of all 30-inch transmission mains, by pipe type, within the District.

### Table 8. Percentage of 36” Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length (Feet)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>19,142</td>
<td>99.0</td>
</tr>
<tr>
<td>DIP</td>
<td>187</td>
<td>1.0</td>
</tr>
<tr>
<td>PVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19,329</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The 48-inch diameter transmission mains are broken down by type as shown in Table 9 below. These are the largest diameter transmission mains in the District. Also, see Appendix D for a map showing the location of all 48-inch transmission mains, by pipe type, within the District.

### Table 9. Percentage of 48” Pipe by Type

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Length (Feet)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>40,033</td>
<td>100.0</td>
</tr>
<tr>
<td>CMLC Steel</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40,033</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
CAPACITY IN TRANSMISSION MAINS OWNED BY OTHERS

The District owns capacity in two transmission mains that are owned by other agencies. These co-owned transmission mains are discussed below. [Note that the physical assets included in these transmission mains, since they are owned and operated by others, are not included in the inventory of existing transmission mains in the previous section of this report.]

**Antelope Transmission Pipeline (ATP)**

In 1994, the former Northridge Water District (Northridge) constructed Phase 1 of the Antelope Transmission Pipeline. The first phase placed approximately 8,000 linear feet (LF) of 48-inch concrete wire wrap steel cylinder pipeline (C303 Pipe). The placement of the pipeline was on Antelope Road from Auburn Blvd. east to Old Auburn Blvd. In 1995, Northridge constructed Schedule A of the Antelope Transmission Pipeline. The project continued the 48-inch pipeline another 6,000 LF. The pipeline was placed in Old Auburn Boulevard east to Fair Oaks Boulevard south to Villa Oak Drive east to C-Bar-C Park and south through the park to Oak Avenue connecting into the San Juan Water District’s Cooperative Transmission Pipeline. The last phase was constructed in 1996 (Schedules B, C, D, E, and F) and the 48-inch pipeline was extended another 33,500 LF. The project continued the 48-inch pipeline from the end of Phase 1 at Auburn Blvd. west on Antelope Road crossing the I-80 Freeway under the Union Pacific railroad tracks into the District’s Antelope Reservoir to Antelope Road North. At that point the 48-inch pipeline proceeded south on Antelope Road North to Antelope Road and along Antelope Road west terminating at Walerga Road. The total length of the project is approximately 9 miles.

Sacramento Suburban Water District (District) owns the Antelope Transmission Pipeline and 59.2 million gallons per day (MGD) of capacity in the San Juan Water District Cooperative Transmission Pipeline (CTP). This represents approximately 50 percent of the capacity in the CTP. See Figure 4 for a map showing the location of the Cooperative Transmission Pipeline in which the District owns capacity.
Per the “Agreement for Ownership, Utilization, Operation and Maintenance of the Cooperative Transmission Pipeline” dated July 1, 1997, the District is obligated to pay for its share of maintenance costs and capital replacement and capital improvement costs for the CTP. Section 4.C., Maintenance Costs, of the agreement states that “Maintenance Costs are defined as costs incurred for routine maintenance of the pipeline, valves, appurtenances, cathodic protection stations, telemetry equipment, and the cost of administration and professional consultants related thereto. All Maintenance Costs of SJWD’s routine Project maintenance shall be allocated to and paid by the Participants on a pro rata basis based upon the percentage each Participant is entitled to of the total capacity of the Project as set forth in Exhibit D.” Furthermore, the agreement states that these maintenance costs will be assessed annually.

Likewise, Section 5.B. of the agreement discusses capital replacement costs. This section of the agreement states that “The cost of Capital Replacements shall be allocated and paid by the Participants on a pro rata basis based upon the percentage each Participant is entitled to of the capacity of a particular Project pipeline segment (as set forth in Exhibit C) for which such costs were incurred.” Furthermore the agreement states that “The payment for Capital Replacements shall be made by Participants within the deadline set by SJWD, reasonably taking into consideration the potential need for a Participant to arrange for financing of its share of the cost.”

Finally, Section 6 of the agreement discusses capital improvements. A “Capital Improvement” is defined as “an improvement or betterment to the SJWD-owned portions of the Project that SJWD recommends to enhance the operating design capability or capacity of the Project.” The agreement also states that “SJWD shall determine the need for, administer and carry out any Project Capital Improvement that has been approved by the Participants.” Similar to capital replacements, the agreement further states that “The cost of a Capital Improvement shall be allocated to and paid for by the Participants on a pro rata basis based upon the percentage each Participant is entitled to of the capacity in a particular Project pipeline segment (as set forth in Exhibit C) for which such costs were incurred, unless the Participants approve a different cost allocation method.” Furthermore the agreement states that “SJWD shall in all instances provide notice to Participant(s) having capacity within the affected Project pipeline segment as soon as possible as to the need for the Capital Improvement.”
City of Sacramento’s Transmission Main

Plans for the former Arcade Water District to purchase treated surface water from the City of Sacramento were in the works back in the early 1990’s. The District agreed to purchase capacity in a planned 54-inch transmission main to be constructed by the City from their Fairbairn Water Treatment Plant (WTP) north to a turnout with the District located near the intersection of Northrop Avenue and Enterprise Drive (916 Enterprise Drive).

The first segment (approximately 4,200 feet) of the City’s 54-inch transmission main was constructed in 1993 between University Avenue and Enterprise Drive. As part of this same project, the City constructed (for Arcade) approximately 1,200 feet of 36-inch transmission main from Enterprise Drive south to Northrop Avenue and then east on Northrop Avenue across Howe Avenue (to a point approximately 400 feet east of Howe Avenue). This 36-inch waterline was constructed solely for the future use of the District (and this pipe is included in the inventory of transmission mains in the previous section of this report). The second segment of the City’s 54-inch transmission main was constructed in 2003/2004 and consists of 1.2 miles of a 54-inch diameter water transmission main from the Fairbairn WTP under the American River to University Avenue, and in the right-of-way of University Avenue north to Howe Avenue. See Figure 4 for a map showing the location of the City’s Transmission Main in which the District owns capacity.

The District’s agreed upon share of the design and construction cost for both segments of the City’s 54-inch transmission main is 32.26 percent. This is based on a formula that factors in the capacity of the 54-inch transmission main (62 mgd), the City’s anticipated maximum day water demand from this pipeline (42 mgd), and the amount of water that the District could divert (up to 20 mgd). Therefore, the District’s share is 20 mgd ÷ 62 mgd or 32.26 percent.

The District’s agreement with the City of Sacramento is different that the agreement with SJWD with respect to how the District’s share of O&M and capital improvement costs will be paid. The applicable agreement is the “Wholesale Water Supply Agreement Between the City of Sacramento and Sacramento Suburban Water District” dated January 20, 2004. Section 9 of the agreement, titled Cost Allocation and Payment” addresses the cost allocation terms and
conditions. In Paragraph 9.a. is it stated that “The District will be charged a Wholesale Water Rate for diversion, treatment and conveyance of water.” Furthermore it is stated that “In no event, however, will the unit cost of water delivered exceed the City’s annual operating, maintenance and applicable capital improvement costs for surface water treatment and conveyance divided by the number of gallons produced. Operating, maintenance and capital improvement costs included in the Unit Rate will include but not be limited to costs for operating, maintenance, personnel, services and supplies, and an equitable portion of appropriate overhead distribution.”
PLANNED FUTURE TRANSMISSION MAINS

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

- **Indian River/Flaming Arrow Pipeline** – This would include new transmission pipelines to be constructed south from the intersection of Verner Avenue and Flaming Arrow Drive. The proposed pipelines would connect with a tee to an existing 30-inch transmission main at this location. One branch would be a 16-inch pipeline that heads southeast, parallel to and east of an existing 12-inch distribution main in Flaming Arrow Drive. It then turns south and parallels the existing 12-inch line and ties into an existing 14-inch water line in Indian River Drive at the southerly intersection with Faming Arrow Drive. The other proposed branch would be a 24-inch transmission pipeline which heads southwest on the west side of Verner Avenue parallel to an existing 16-inch water line. It then ties into that 16-inch line as it crosses Verner Avenue. The total proposed length of these new transmission mains is 5,480 feet (1.0 miles).

These new transmission mains would improve the distribution of surface water from the Cooperative Transmission Pipeline (CTP) into the NSA. This pipeline would also solve low-pressure and circulation problems which exist in this area. More surface water could be taken via the CTP which would further conjunctive use and lessen the use of groundwater when surface water is available. Therefore, this pipeline will improve water distribution and system pressures, improve the flow and distribution of surface water into the system and minimize groundwater overdraft on the basin.

A pre-design report and cost-estimate for this project was prepared in 2005 by Eco:Logic Engineering. Figure 5 is a map showing the location of proposed future transmission mains in this area.
- **Crestview Transmission Main** - Since the early 1990’s, the District has made improvements to mitigate problems in the old Arvin system located east of Manzanita Avenue in the NSA. One such improvement was to construct and install new transmission mains to assist in circulating water from north to south and west to east. To provide the necessary facilities the District developed a six-phase project to construct transmission mains capable of providing sufficient flows throughout the area. Since the 1990’s the District has constructed five of the six-phases. The remaining phase is the design and construction of approximately 9,200 linear feet of new transmission and distribution pipelines. Of this amount, 5,300 linear feet of 16-inch transmission pipeline is proposed. (An additional 2,700 linear feet of 12-inch distribution pipeline and 1,200 linear feet of 8-inch distribution pipeline are included in the total.) Included with the project would be miscellaneous tie-ins to the existing distribution system and fire hydrants spaced to meet local fire agency guideline standards. The new transmission pipeline would also connect to a pipeline installed as part of phase five, then proceed south through residential streets and connect to an existing pipeline of adequate size. Along the pipeline route the new pipeline will be connected to the existing distribution system to provide flows, pressure and circulation throughout the system. The installation of this pipeline will provide the District with water transmission facilities from Greenback Lane to Winding Way.

Figure 5 is a map showing the location of proposed future transmission mains in the Crestview area.

- **McClellan Business Park Transmission Mains** - As part of the 2009 *Water System Master Plan*, an analysis of the McClellan Business Park Service Area (MBPSA) needs was conducted by Brown and Caldwell to evaluate the water system facilities needed to supply the McClellan Business Park at buildout. A MBPSA buildout water demand estimate of 4,183 acre-feet (ac-ft) was used for buildout infrastructure sizing. A separate technical memorandum dated January 8, 2010, was later prepared by B&C to layout a backbone water transmission and distribution system for McClellan Business Park at
buildout. A total of 92,903 linear feet (17.6 miles) of 16-inch and 20-inch transmission pipelines are proposed at buildout.

Figure 5 is a map showing the location of proposed future transmission mains in the McClellan Park Service Area.
TRANSMISSION MAIN MONITORING, TESTING AND CONDITION ASSESSMENT

There are major costs associated with maintaining and replacing transmission mains. A key question is how do you know that the pipeline material is deteriorating or nearing the end of its useful life? Over time, metallic pipes lose wall thickness as a result of both internal and external corrosion. Cement-based pipe types lose “effective” wall thickness and are weakened by the leaching out of the cement by aggressive water. For planning purposes, information about the actual condition of pipes is needed. But gaining access to inspect buried pipes is difficult, disruptive and costly. However, there are ways to monitor and test the condition of the piping and methods of performing condition assessment.

Monitoring and Testing

Methods for external corrosion protection for metallic water mains include passive (coatings, wraps, etc.), active (cathodic protection) or a combination of both. Cathodic protection (CP) is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell. CP has been proven to be an excellent and cost-effective method for corrosion control for dielectrically coated, electrically continuous pipe.

Fortunately, the newer metallic (CCP, CMLC steel and DIP) water transmission mains within the District were constructed with “joint bonds” to insure electrical continuity between pipe sections for cathodic protection. Joint bonds are simply straps across the pipe joints to allow for electrical continuity which would otherwise not be possible because of the use of rubber gaskets within the pipe joints. Test stations are then installed at various intervals to allow for the electrical continuity of the pipe to be tested. With this type of CP system, it is recommended that the pipe-to-soil (P/S) potential be measured on a regular basis at each test station. A major corrosion testing company, Corrpro, recommends that this type of testing be conducted each year if at all possible.

At the time that the newer transmission mains were constructed, a national corrosion protection company, Corrpro, was hired as a subcontractor to perform an initial corrosion monitoring
system survey. Pipe-to-soil potentials at each test station were measured and documented by Corrpro. This procedure is used to determine if the corrosion monitoring system is properly installed. This initial testing also forms a “baseline” for future testing that is recommended on a regular basis by Corrpro. Initial corrosion system monitoring system survey test reports from Corrpro are available in the District’s files as described below.

- April 6, 2001. Corrosion Monitoring System Survey for 48-Inch Concrete Cylinder Pipeline, Schedules A – F & Antelope Road Widening Project (Northridge Water District)

Corrpro was hired by the District in 2008 to test the cathodic protection systems on four of the District's transmission mains and prepare a report on the findings. Corrpro was also asked to locate the test stations in the field using a GPS locator so that this information could be transferred to the District’s facility maps. The total amount of Corrpro’s contract was $21,254. Corrpro was able to complete about 50 percent of the testing. The remaining testing requires traffic control in order to safely obtain the test data. Traffic control plans were prepared and approved by the County for the various locations encountered. However, rather than paying
Corrpro to provide the traffic control, District staff suggested waiting until the District purchased a traffic control trailer with associated traffic control equipment. A traffic control trailer was purchased in late-2010 and the remaining testing work can now be scheduled with Corrpro.

**Condition Assessment**

It is difficult but not impossible to monitor the condition of buried utilities such as transmission mains. Condition assessment is a process that helps to establish a record of the state of water pipelines. It’s essential for cost-efficient repair and replacement programs. Condition assessment methods for pipes can generally be classified into direct or indirect methods. Both methods are discussed below.

**Direct Methods**

- Visual inspection, including closed circuit television (CCTV)
- Sampling programs (where sections of pipe or “coupons” are sent to a laboratory to have remaining wall thickness measured and a variety of material tests and analyses performed)
- Various non-destructive testing methods:
  - Acoustic emission
  - Acoustic leak detection
  - Remote field eddy current
  - Magnetic flux leakage
  - Ultrasonic pulse echo and guided Lamb waves

**Indirect Methods**

- Analysis of pipe failure history
- Water audits and leak detection to determine leakage levels
- Flow testing
- Measurement of soil resistivity to determine the risk of corrosion
A few of the available methods for monitoring, testing and performing condition assessments are discussed below.

- **Direct Testing of Pipe Material (“Sampling Program”)** – It is possible to take wafers from the walls of excavated pipes and to test the condition of the pipe material in a laboratory. An opportunity to do so occurs if a pipe repair is made and a section of existing pipe must be cut out of the system to make the repair.

- **Acoustic Testing** - Unlike conventional methods, it is possible to accurately perform a water pipe assessment to determine remaining pipe wall thickness without digging. This is especially effective with AC pipe that conventional leak detection testing would be unable to evaluate. New technology is used that measures the remaining wall thickness of buried water pipes in a non-destructive way, and without taking pipes out of service, using acoustic waves. Using this technology with ongoing monitoring, can even accurately estimate the service life of pipes. A schematic of the measurement setup is shown below in Figure 6. District staff have met with representatives of a company, Echologics, that provides this type of testing and a pilot program is currently being considered.

![Figure 6. Acoustic Testing with Measurement of Acoustic Propagation Velocity](image)

Wave propagation velocity \( (v) = \frac{D}{\Delta T} \), where \( \Delta T \) is time delay between signals 1 and 2.

**Figure 6. Acoustic Testing with Measurement of Acoustic Propagation Velocity**

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To track monitoring, testing and/or condition assessment work on the District’s transmission mains, each segment of existing pipe has been identified with an asset identification number and this information is now included in the District’s Graphical Information System (GIS). Using this information, staff will be able to track whenever any piping is tested or if any condition assessment is performed and the results of the testing and/or condition assessment.
TRANSMISSION MAIN REHABILITATION AND/OR REPLACEMENT OPTIONS AND COST ESTIMATES

The rehabilitation and/or replacement of aging and deteriorated water transmission and distribution mains is expensive. It is very unlikely that water utilities in general will have huge funds set aside to meet expected replacement needs in the future. Therefore, pipe replacement has to be done selectively and rehabilitation options need to be considered when feasible. Rehabilitation is defined as improvement of the functional service of an existing pipeline by repairing and/or lining the interior. It typically involves placing a water tight liner or material inside of an existing pipe without requiring extensive excavation of the soil. Replacement of course means installing a new pipeline by either open cut or trenchless construction methods. Both rehabilitation and trenchless replacement reduce the amount of excavation required but neither eliminates it completely.

**Pipeline Rehabilitation**

Pipeline rehabilitation methods oftentimes use the existing pipe to form part of the new pipeline or to support a new lining. Rehabilitation must be preceded by cleaning the pipe to remove scale, tuberculation, corrosion and other foreign materials.

Pipeline rehabilitation methods can also include joint welding rehabilitation, repair of internal corroded areas of the pipeline, repair of internal corroded areas of pipe connections, installing an impressed current corrosion protection system and/or joint test welding. For the purpose of this report, this is referred to as the “Method A” type of pipeline rehabilitation. The San Juan Water District (SJWD) is currently using some of these methods to rehabilitate a 40-inch transmission main installed in 1956 that supplies surface water to the Fair Oaks Water District (referred to as the “Fair Oaks 40”). After reviewing nine different plans for rehabilitation, SJWD and their consultant picked a rehabilitation program that will weld the joints of the entire pipeline to eliminate the largest source of leakage\(^4\). In addition to joint welding, spot lining rehabilitation and repair will be performed and selected segments of the pipeline will also be replaced. SJWD has estimated that through this rehabilitation process the service life of the existing Fair Oaks 40

pipeline will be extended by 50 years. A similar assumption is being made for the District’s pipelines. The estimated cost of this type of rehabilitation is estimated to be 30 percent of the cost of complete pipeline replacement.

Sliplining is one of the oldest methods for trenchless rehabilitation of existing pipelines. For the purpose of this report, this is referred to as the “Method B” type of pipeline rehabilitation. Sliplining is used to repair leaks or restore the structural stability of an existing pipeline. Sliplining is completed by installing a smaller, "carrier pipe" into a larger "host pipe," grouting the annular space between the two pipes, and sealing the ends. Sliplining has been used since the 1940s. The most common material used to slipline an existing pipe is high density polyethylene (HDPE), but fiberglass reinforced pipe (FRP) and PVC are also common. The most common pipe sizes for sliplining are 8"- 60", but sliplining can occur in any size given appropriate access and a new pipe small or large enough to install. The HDPE pipe has an outside diameter (OD) slightly larger than the inside diameter (ID) of the pipe to be lined. The tight-fitting HDPE liner results in a flow capacity close to the original pipeline design. The rapid installation of the liner and a small footprint means minimum impact on local businesses, traffic, and pedestrians.

The ballpark cost of the sliplining rehabilitation method is approximately $5 to $7 per inch diameter per foot of piping. Therefore, for 16-inch through 48-inch diameter piping, the cost of sliplining would range from $80 to $112 per foot ($422,000/mile to $591,000 per mile) for 16-inch diameter piping to $240 to $336 per foot ($1.27 million/mile to $1.77 million per mile) for 48-inch diameter piping. For this report, the estimated cost of this type of rehabilitation is assumed to be 50 percent of the cost of complete pipeline replacement.

**Pipeline Replacement**

Pipeline replacement is obviously an option to be considered as transmission mains reach the end of their useful life. Trenchless replacement involves inserting new pipe along or near the existing pipe without requiring extensive excavation of soil. As compared to open trenching, trenchless pipe replacement can be accomplished with minimal disruption to businesses, traffic,

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and pedestrians. The best known trenchless replacement techniques are pipe bursting, microtunneling and horizontal directional drilling.

Open trench construction is the most commonly used method for replacement of water mains. It involves placing a new pipe in a trench cut along or near the path of the existing pipe. Open trench replacement in developed areas is costly and has the expected problems of working beneath streets, sidewalks, customer landscapes, utility poles, and near other utilities. Estimated open trench transmission main replacement costs are provided in Table 10. These cost estimates are based on the following assumptions:

- Costs are in 2011 dollars.
- Costs include engineering (design and construction management) and contingencies.
- For pipe sizes 16 inches through 24 inches, pipe is ductile iron pipe (AWWA C150 and C151) suitable for 150 psi service.
- For pipe sizes 30 inches through 78 inches, pipe is concrete pressure pipe, bar-wraped, steel-cylinder type (AWWA C303) suitable for 150 psi service.
- Trench excavation and backfill for 3 feet of cover with imported backfill and thrust blocks.
- Buried shutoff valves at 1,000 foot intervals for 16-inch pipelines and 2,000 foot intervals for 20-inch and larger pipelines.
- Air valves and blow-offs each at 2,000 foot intervals.
- Surface restoration of asphalt cement (AC), 12 feet wide for trenches under or crossing streets for improved areas. Traffic control is included.
- No service connections.
- Cathodic protection as required.
Table 10. Estimated Transmission Main Replacement Costs (Open Trench Construction)

<table>
<thead>
<tr>
<th>Pipeline Diameter</th>
<th>Estimated Replacement Cost Per Foot</th>
<th>Estimated Replacement Cost Per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-inch</td>
<td>$210</td>
<td>$1.1 million</td>
</tr>
<tr>
<td>18-inch</td>
<td>$235</td>
<td>$1.25 million</td>
</tr>
<tr>
<td>20-inch</td>
<td>$260</td>
<td>$1.4 million</td>
</tr>
<tr>
<td>24-inch</td>
<td>$315</td>
<td>$1.65 million</td>
</tr>
<tr>
<td>30-inch</td>
<td>$470</td>
<td>$2.5 million</td>
</tr>
<tr>
<td>36-inch</td>
<td>$560</td>
<td>$3.0 million</td>
</tr>
<tr>
<td>48-inch</td>
<td>$750</td>
<td>$4.0 million</td>
</tr>
<tr>
<td>54-inch (City of Sacramento)</td>
<td>$840</td>
<td>$4.45 million</td>
</tr>
<tr>
<td>72-inch (CTP)</td>
<td>$1,125</td>
<td>$6.0 million</td>
</tr>
<tr>
<td>78-inch (CTP)</td>
<td>$1,220</td>
<td>$6.4 million</td>
</tr>
</tbody>
</table>

Cost Estimates

Over the next 100 years (2012 – 2111), costs have been estimated to rehabilitate and/or replace the District’s transmission mains and those in which the District owns capacity (SJWD and the City of Sacramento). These cost estimates assume that any transmission mains installed prior to 1985 will have an estimated service life of 70 years and any transmission mains installed in 1985 or later will have an estimated service life of 90 years. A longer life for newer pipe is an assumption based on better pipe manufacturing standards, improved methods of construction and the more common use of corrosion protection. The life expectancy of these pipelines can of course vary greatly depending on many factors including construction methods, quality of pipe manufacturing, soil corrosivity, water quality, etc. The projected year when existing transmission mains reach either 70 or 90 years of service life is shown in Figure 7 (note that this figure shows only District transmission mains).
Year When Transmission Mains Reach Age of 70/90 Years by Size

Notes:
1 Does not include transmission mains owned by others in which the District owns capacity.
2 Service Life (estimated) for transmission mains installed prior to 1985.
3 Service Life (estimated) for transmission mains installed in 1985 or later.
Once the existing pipelines reach their estimated service life it is further estimated that 50% of the pipelines will be rehabilitated using localized repair and rehabilitation methods (Method A), 25% of the pipelines will be rehabilitated using the sliplining process (Method B), and 25% of the pipelines will be replaced. These are gross assumptions that are based on research and the findings of others and not direct District experience. Using these assumptions, pipeline rehabilitation and/or replacement costs have been estimated for the next 100 years (2012 through 2111) and are shown in Appendix E. These future estimated costs are also shown in Figure 8.

As noted above, pipelines being rehabilitated are assumed to have their service life extended by 50 years. Therefore, as noted on Figure 8, those existing transmission mains that are being rehabilitated during the 2036 to 2054 timeframe will reach the end of their extended service life by the years 2086 through 2104 respectively. At that point in time it is assumed that these pipelines will need to be replaced and appropriate costs have been included in this analysis for their replacement.

Based on these assumptions, it is estimated that the total cost to rehabilitate and/or replace existing transmission mains over the next 100 years is approximately $87 million (in 2011 dollars). Based on the expected annual cash flow schedule shown in Appendix E and Figure 8, an economic analysis was performed by the District’s Director of Finance, Mr. Dan Bills, to calculate the present value of future costs both on a lump sum and an annuity basis. For this analysis, the value of the dollar in future periods was calculated assuming a long-term Consumer Price Index of 3.0 percent6. Furthermore, a 1.5 percent discount rate (short-term rate) was used to evaluate the present value of the estimated future annual cash flows. From this analysis, the present value of estimated future transmission main rehabilitation and/or replacement costs is approximately $257 million.

6 Source: Bloomberg historical year-over-year CPI index (1920 to present) and CalPERS long-term CPI estimate.
Transmission Main Rehabilitation/Replacement Costs from 2012-2111

Note: This figure does not show $150,000/Year for ongoing testing/monitoring/condition assessments and the District's share of capital improvements to the CTP and the City of Sacramento's transmission mains.
PLAN UPDATES

Review and reassessment of the Water Transmission Main Asset Management Plan is recommended in at least 3 to 5 year intervals. 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. Future information could include, but not be limited: improved recordkeeping systems, information from leak detection surveys, information from condition assessment surveys and testing, infrastructure failures, catastrophic events, merger or consolidation with other water purveyors, and/or changes in District policies.
CONCLUSIONS AND RECOMMENDATIONS

- This *Water Transmission Main Asset Management Plan* provides an inventory of the District’s existing transmission mains sized 16-inches in diameter and larger.

- There are currently over 53 miles of 16” and larger transmission mains throughout the District. The most common pipe type is CMLC steel at 157,155 feet (29.8 miles) or approximately 56 percent of all of the District’s transmission mains.

- The majority (56.1%) of the District’s transmission mains were constructed in the last 10 years and are still in excellent condition with a long useful life still remaining. And, approximately 80% of the transmission mains are less than 20 years of age.

- Out of 53 total miles of existing transmission mains, approximately 3.1 miles consist of pipe that is 40 years of age or older. These older transmission mains are in the greatest need of repair and/or replacement.

- Proposed future transmission mains (Indian River/Flaming Arrow, Crestview and McClellan) could add another 20 miles or so of transmission mains to the District’s system.

- This *Water Transmission Main Asset Management Plan* provides a tool for communication between the Board and Staff to identify pipelines in need of repair, rehabilitation and/or replacement.

- The District must get caught up on a program to monitor the existing transmission mains by testing the electrical continuity through use of test stations.

- This Plan identifies probable costs associated with water transmission main rehabilitation and/or replacement but does not prescribe any funding mechanisms.
Based on current cost information that was obtained for this report, it is estimated that the cost to replace 1 mile of existing transmission main (using open trench construction) ranges from $1.1 million per mile for 16-inch diameter piping to $4.0 million per mile for 48-inch piping. The estimated cost of pipeline rehabilitation ranges from approximately 30 to 50 percent of the replacement cost.

It is estimated that the total cost to rehabilitate and/or replace existing transmission mains over the next 100 years is approximately $87 million (in 2011 dollars). The present value (lump sum) of estimated future transmission main rehabilitation and/or replacement costs is approximately $257 million.

This Plan will be reviewed and revised periodically as additional field and other information becomes available.
Appendix A

Detailed Maps of District Showing Transmission Mains by Size
Appendix B

Detailed Maps of District Showing Transmission Mains by Type
Appendix C

Detailed Maps of District Showing Transmission Mains by Age
Appendix D

Separate Maps Showing Location of All Transmission Mains by Size
(16-Inch through 48-Inch Diameter)
Appendix E

Detailed Cost Estimates for Transmission Main Rehabilitation and/or Replacement (2012 – 2111)