Lidstone and Associates, Inc.
Engineering, Geology and Water Resource Consultants

January 9, 2014

Ms. Rachel Barkworth
Meadow Mountain Water Supply Company
P.O. Box 354
Allenspark, CO 80510

Re: Water Distribution System Operational and Infrastructure Improvements

As part of the initial scope of work for Meadow Mountain Water Supply Company system analysis and improvement plan, Lidstone and Associates, Inc. has developed recommendations for long-term water distribution system operational and infrastructure improvements. Information is also provided for financial planning for system operation and upgrades.

If you have any questions regarding the attached report, please contact me.

Sincerely,
LIDSTONE AND ASSOCIATES, INC.

Kari Sholtes, E.I.T
Project Engineer

KAS:rce

Attachment

Sent via: Email

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WATER DISTRIBUTION SYSTEM OPERATIONAL AND INFRASTRUCTURE IMPROVEMENTS

Prepared for:
Meadow Mountain Water Supply Company
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January 9, 2015

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1.0 INTRODUCTION

As part of the initial scope of work for Meadow Mountain Water Supply Company (MMWSC) system analysis and improvement plan, Lidstone and Associates, Inc. (LA) has developed recommendations for long-term water distribution system operational and infrastructure improvements. Information is also provided for financial planning for system operation and upgrades.

2.0 EXISTING DISTRIBUTION SYSTEM

The distribution system consists of over 3.5 miles of iron pipe and various levels of pumping control in the summer and winter (some houses are not occupied in the winter). Approximately 40 households are supplied during the summer.

Iron pipes in the distribution system are buried to the depth of bedrock, which varies between 0.5 to 9 feet. Therefore, pipe freezing is a seasonal risk mitigated by maintaining high flows through the system via pumps in one service area and bleed lines at the dead ends throughout the rest of the system. This results in approximately four times the water usage in the winter than in the summer and approximately four times more water consumption than the residential demand. Water main diameters vary between 2 and 2.5 inches. Approximately eight valves are located throughout the distribution mains. All valves exercised or replaced to date are gate valves.

It is estimated that the pipe network was installed in 1971; therefore, the age of the pipes is assumed to be over 40 years old. While the expected age of iron pipes can range from 60 to 100 years, corrosion, tuberculation, and freezing conditions can significantly reduce this life time. No records have been kept of previous distribution pipe replacement/repair. There are no looped water lines; they all end in dead ends. No as-builts exist for the system; however a system-wide depth analysis was performed on October 20, 2014—these results are discussed in the Long Term Distribution Recommendations section of this report.

From 2009 to 2013, unaccounted water fluctuated from less than 5% to 56% of the water conveyed to the treatment facility. However, finished water consumption cannot be verified due to the lack of metering of finished water leaving the facility and the lack of approximately 10% of household meters and all bleed line meters.

MMWSC is currently locating, exercising, and replacing (as needed) existing distribution system valves. Through this maintenance program, we have been able to inspect a small section (~2 feet) of pipe located on each side of a valve, which was replaced on Dale Drive on June 26, 2014. This section provides some insight regarding the condition of the system. However, there was only one section of pipe inspected, and any assumptions made regarding the condition of the system are limited. Below is a list of observations based on the inspection of the section of pipe:

- Corrosion of the pipe walls is minimal.
- There exists tuberculation inside the pipe. Fortunately, under the tubercles, the corrosion into the pipe wall was limited and is not anticipated to be a widespread source of failure. However, the tubercles do present various problems:
    - They increase the roughness of the pipe, making it harder for water to flow through the pipe. In the long term, this may begin to cause pressure and supply

issues in the distribution network. Furthermore, the slower the water is flowing, the more tubercles will form[1].

- Part of the tuberculation process includes the ongoing development of bacteria and biomass, which exerts a chlorine demand. This makes it difficult to provide adequate chlorine residual at the ends of the distribution system to protect public health.
- The two problems of biological growth and tuberculation development are interconnected and the slower the water is moving the more both problems are exacerbated[1]. Furthermore, the slower the water is flowing, the more susceptible it is to freezing.
- Discoloration of the water due to iron rust may stain household fixtures and/or clothing.

3.0 SHORT TERM DISTRIBUTION SYSTEM RECOMMENDATIONS

In the short term and as part of standard operations, we recommend an improved flushing program throughout the distribution system. Exercising or installing functional hydrants is critical in flushing the system to ensure safe water quality. All hydrants located at system dead-ends have been accessed, made functional, and exercised, and flushing has taken place at all dead-end locations as of September 2014. We recommend that the distal ends of the distribution system be well flushed on a regular schedule in accordance with the following guidance:

- Open valves fully;
- Flush for 15-30 minutes; and,
- Flush until residual of 1 mg/L is measured.

We also recommend that chlorination practices consider the distal ends of distribution to ensure adequate residual. This may require iterative experimentation to determine 1) if sufficient chlorine can be added at the treatment facility to provide detectible chlorine residual at the ends of the distribution system[2] and 2) needed concentrations to accomplish this.

Furthermore, it is our understanding and our recommendation that MMWSC will continue with the valve operation and replacement plan. All valves are being checked for operation and replaced if not functional. For those valves which are replaced, it is recommended that the condition of the pipe be well documented (including photographically). Once accessible and functional, a valve exercising schedule will be implemented. The installation of functional valves on water mains is critical for protection of consumers in the event of pipe leaks, breaks, or other service interruptions. Of the eight valves in the distribution system, five have been located, exercised, and made accessible with a new access pipe, and one was replaced and also made accessible with a new access pipe as of September 2014. One of the remaining valves is located in a non-beneficial

[1] http://www.sws.uiuc.edu/pubdoc/C/ISWSC-82.pdf Larson, Thurston E. Loss in Pipeline Carrying Capacity Due to Corrosion and Tuberculation. J Am Water Works Assoc. Vol 52, No 10, Oct 1960.
http://nepis.epa.gov/Exe/ZyPDF.cgi/10003FIW.PDF?Dockey=10003FIW.PDF USEPA Corrosion Manual for Internal Corrosion of Water Distribution Systems. April 1984.

[2] Chlorine residual at the entry point testing tap must be between 1.2 mg/L and 4.0 mg/L while chlorine at the endpoint of distribution must be detectible in 95% of samples.
https://www.colorado.gov/pacific/sites/default/files/Regulation-11.pdf CPDHE Primary Drinking Water Regulations.

location and will be abandoned. The last valve on lot 33 will be located, accessed, and exercised if possible or replaced during 2015.

4.0 LONG TERM DISTRIBUTION SYSTEM RECOMMENDATIONS

There are numerous challenges inherent in the distribution system including the following:

- Vulnerability to freezing: pipe breaks with loss of system pressure and/or infiltration
    - Consequence: High water consumption and high treatment costs due to bleeding; expensive maintenance which will likely weaken the pipes over time (corrosion induced by electricity applied to thaw lines); expensive repairs with limited long term planning in mind; or due in part to limited metering and system control, the inability to locate a freeze-related break and the high cost associated with such a situation (i.e., other sections of pipe freezing as a consequence, limited water access and possible water hauling needs in winter, etc.).
- Dead ends: stagnant water at dead ends with high chlorine demand due to biological growth associated with tuberculation/corrosion
    - Consequence: High chlorine demand, accelerated corrosion, high water consumption due to bleeding, and high risk of health impacts due to poor water quality. Also, dead ends amplify the freezing vulnerabilities.
- Tuberculation/corrosion: stagnant water at dead ends, low-use areas, or low pressure areas with high chlorine demand due to biological growth associated with tuberculation/corrosion
    - Consequence: Decreased pressure, high chlorine demand, staining, and high risk of health impacts due to poor water quality. Also, tuberculation/corrosion amplifies the freezing vulnerabilities due to decreased pressure and flow.

In the long term, we recommend a schedule and financial plan for pipe replacement at a freeze-protected depth. It is anticipated that the system will experience increased interruptions in service due to both freezing pipes and tuberculation which will impact freeze-prone areas and distal ends of the system as it continues to age. Financial planning and saving for future improvements will ensure that MMWSC will be better positioned to implement improvements and will improve eligibility for grants and loans. A phased approach for water distribution system improvements is recommended with the ultimate goal of complete distribution system replacement with 4 inch PVC mains placed below frost depth and the elimination of dead-ends (current CDPHE regulations require a minimum 4 inch main diameter) at a freeze-protected depth of 8 to 9 feet. The current value of the distribution system replacement at a freeze-protected depth with looping of the dead ends is estimated to cost $2.6M or $115 per linear foot of pipe (current value). These costs do not include the possible import of non-native material for pipe bedding if needed.

LA has developed a preliminary conceptual plan for long-term distribution system replacement. This plan is based on the following information:

1) Measured-in-place pipeline depth analysis survey completed by American Leak Detection located in Firestone, CO on October 20, 2014 which included the following:
    a. Approximately 2/3 the length of the high pressure distribution system (from treatment facility to the turn off of Meadow Mountain Drive).

   b. The low pressure distribution system (South Skinner Road from the treatment facility to North Skinner Road and Dale Drive).
   c. However, the medium pressure distribution line (the southern extent of South Skinner Road) depth survey was inconclusive due to the phone line interference.
2) Anecdotal information regarding areas of high freeze risk and low pressure.
3) Level of importance, construction planning, and logistical simplicity.

It is critical to note that no hydraulic pipe network analysis has been performed to date. A pipe network analysis is an essential design element in that it allows the engineer to look at design alternatives, prioritization and sequencing, system pressures, flow capabilities among numerous other factors. System upgrades must be considered in the context of the functionality of the whole system, and prioritization may shift if a proposed upgrade in one section would negatively impact the functionality of another part of the pipe network. It is possible that pressure relief valves or other infrastructure may be needed in lower priority sections to maintain functionality as improvements are made in higher priority sections; however, improvement prioritization detailed below attempts to incorporate and optimize these possible impacts. It is recommended that prior to any system improvements, a hydraulic pipe network model be developed and analysis be performed for existing and proposed future conditions.

Based on the information available to date, LA recommends replacing all existing distribution and intake pipes with 4 inch PVC laid at a freeze-protected depth of 8 to 9 feet deep (note: if MMWSC decides to develop a system capable of residential fire protection, LA recommends 6 to 8 inch ductile iron pipes). All of the pipe lines had sections that had shallow bury depths and present a significant freezing hazards; See **Table 1** for depth analysis results for the percent of pipe length determined to be shallower than 3, 4, 5, 6, and 8 feet. LA recommends considering the following long-term distribution system replacement plan (see **Figure 1** for a system-wide map with priority areas highlighted). Detailed explanations of the below recommendations are provided on Pages 7-11 of this report. The replacement plan has been divided into multiple priority areas to address the highest hazard segments first.

1) Replace and combine the high pressure and medium pressure systems, each originating at the treatment facility, into one looped pipe system.
   a. Replace intake pipes
2) Replace the low pressure distribution system pipe from the treatment facility along South Skinner Road to the junction with North Skinner Road.
3) Replace the low pressure distribution system pipe along North Skinner Road from South Skinner Road to Dale Drive South. Continue replacement of low pressure distribution system pipe along Dale Drive South to Lot 11.
   a. Loop this pipe to Dale Drive North pipe or other, depending on hydraulic analysis.
4) Replace the low pressure distribution system pipe along Dale Drive North from North Skinner Road to Lot 8 or to loop with Dale Drive South.
5) Replace the low pressure distribution system pipe along North Skinner Road from Dale Drive South to Lot 7.
   a. Loop connection from Lot 7 to Dale Drive North pipe.

6) Eliminate remaining dead ends by looping pipes in and around Lot 32.

Table 1 Pipe Depth for Each Priority Area

Priority	Percent Pipe Length Above Depth (ft)				
	<3	<4	<5	<6	<8
1	38	55	83	86	97
2	16	30	54	78	95
3	0	15	48	88	98
4	0	3	22	59	97
5	0	3	15	51	90

Priority 1) Replace and combine the high pressure and medium pressure systems, each originating at the treatment facility, into one looped pipe system. This upgrade will consist of approximately 1.25 miles of 4-inch PVC pipe laid at 8 to 9 feet (final depth, pumping needs, and associated controls to be determined). Intake pipes can also be replaced at this time (approximately 3,500 feet of 4-inch PVC pipe). Replacing the intake pipes will be important for various reasons: 1) bleeding of the intake lines can be stopped or reduced, 2) treatment costs can be reduced due to less water wastage, and 3) as the facility requires less water due to reduced distribution system bleeding (as subsequent improvements are made), less water will be used by the system, making the intakes pipes more vulnerable to freezing without proper depth protection.

Depth analysis survey results were too limited to provide associated depth to pipe charts. However, the available data indicate the following percentage of the pipe length buried to the associated depths:

- 38% buried to a depth of less than 3 feet.
- 55% buried to a depth of less than 4 feet.
- 85% buried to a depth of less than 5 feet.

Segments of the distribution pipe were as deep as 6 feet, but this was not common. Note: the pipe depth analysis cannot distinguish between water delivery pipes, intake pipes, other infrastructure, and native or other metal in ground. Efforts were taken by Mr. Parrish and MMWSC to identify and trace only distribution pipes. Based on historical freezing problems throughout both the high and medium pressure systems, conditional supply issues experienced at the distal end of the medium pressure system, and the relative close proximity of the high and medium distribution system pipes, LA recommends combining these systems into one looped system and laying the 4-inch PVC pipe at a freeze protected depth.

Priority 2) Replace the low pressure distribution system pipe from the treatment facility along South Skinner Road to the junction with North Skinner Road (3,700 feet of 4-inch PVC pipe). Based on the depth analysis survey (see **Figure 2**), this section of the low pressure distribution system appears to represent the highest risk of freezing due to the shallow depth of bury. **Figures 2-5** translate measured-in-place depth survey information to elevations based on USGS 5 ft contour topographic data.

The available data indicate the following percentage of the pipe length buried to the associated depths:

- 30% buried to a depth of less than 4 feet.
- 54% buried to a depth of less than 5 feet.
- 78% buried to a depth of less than 6 feet.

Priority 3) Replace the low pressure distribution system pipe along North Skinner Road from South Skinner Road to Dale Drive South (approximately 500 feet). Continue replacement of low pressure distribution system pipe along Dale Drive South to Lot 11 (approximately 1,500 feet of 4-inch PVC pipe). It would be preferable to loop this pipe to the Dale Drive North pipe, depending on hydraulic analysis (length, placement, and possible pumping requirements to be determined).

Based on the depth analysis survey (see **Figure 3**), this section of the low pressure distribution system appears to represent the second highest risk of freezing due to the shallow depth of bury. The available data indicate the following percentage of the pipe length buried to the associated depths:

- 15% buried to a depth of less than 4 feet.
- 48% buried to a depth of less than 5 feet.
- 88% buried to a depth of less than 6 feet.

Priority 4) Replace the low pressure distribution system pipe along Dale Drive North from North Skinner Road to Lot 8 (1,700 feet of 4-inch PVC pipe). Complete pipe loops as necessary (length and possible pumping needs to be determined). The available depth analysis survey results (see **Figure 4**) indicate the following percentage of the pipe length buried to the associated depths:

- 22% buried to a depth of less than 5 feet.
- 59% buried to a depth of less than 6 feet.

Priority 5) Replace the low pressure distribution system pipe along North Skinner Road from Dale Drive South to Lot 7 (2,700 feet of 4-inch PVC pipe). Loop connection from Lot 7 to Dale Drive North pipe (length and possible pumping needs to be determined). The available depth analysis survey results (see **Figure 5**) indicate the following percentage of the pipe length buried to the associated depths:

- 15% buried to a depth of less than 5 feet.
- 51% buried to a depth of less than 6 feet.

While “only” 51% of the length of this pipe section is shallower than 6 feet deep, it is important to note that more than 90% of this section’s pipe length is buried to a depth of less than 8 feet.

Priority 6) Eliminate any remaining dead ends by looping pipes in and around Lot 32 (pipe length and pumping needs to be determined based on hydraulic analysis).

Figure 1 System Map with Priority Areas Highlighted

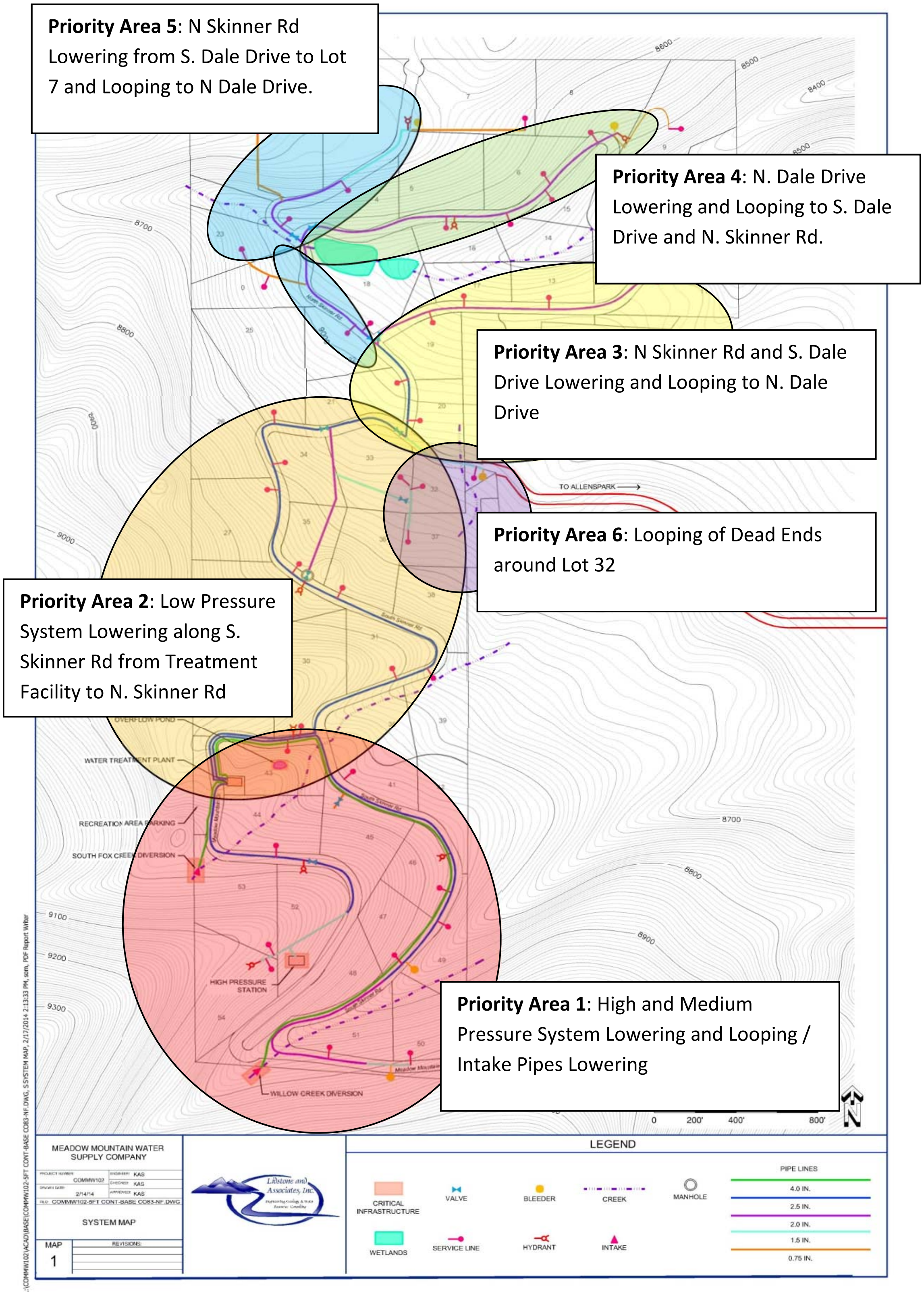


Figure 2   Depth Analysis for Priority 2

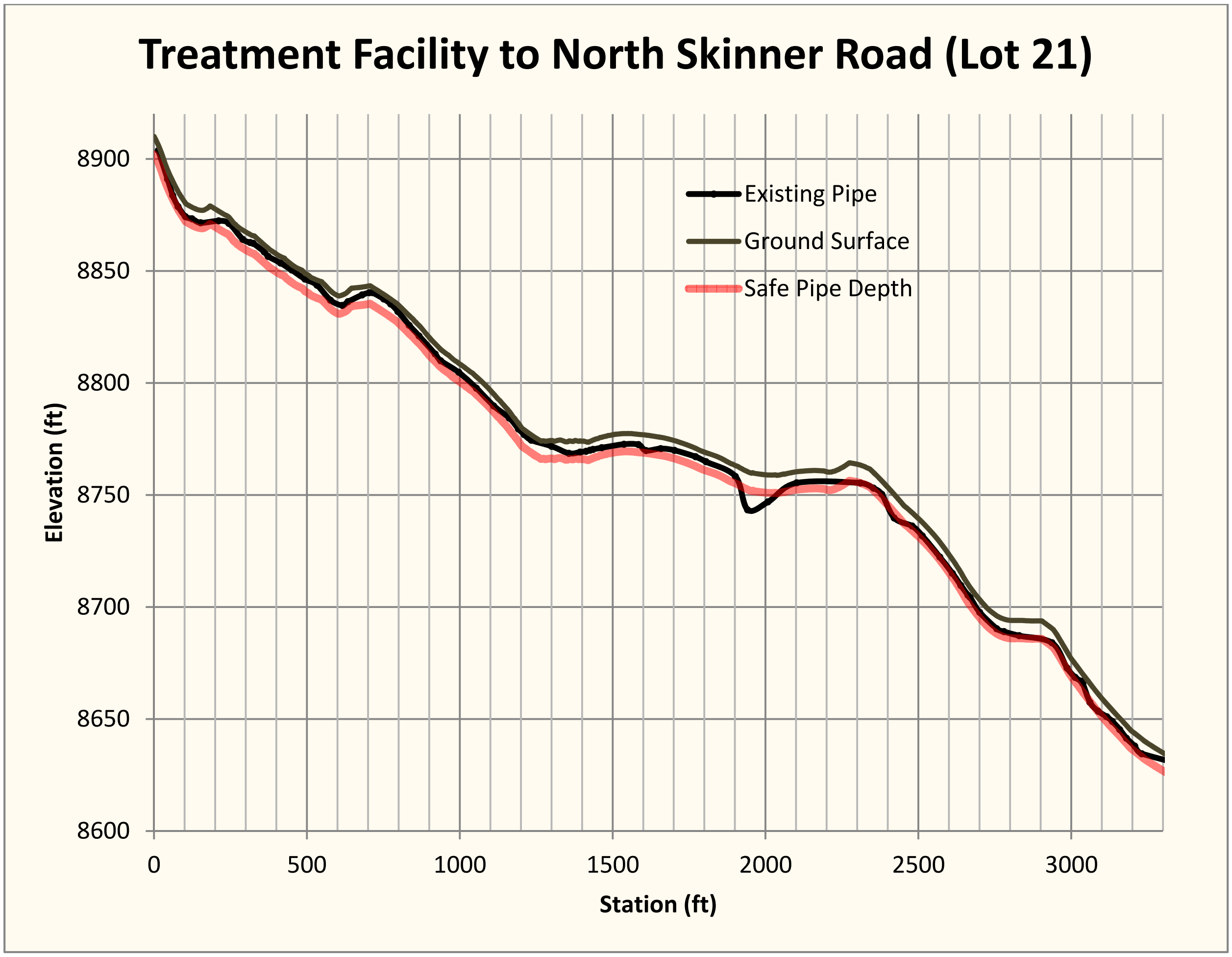


Figure 3 Depth Analysis for Priority 3

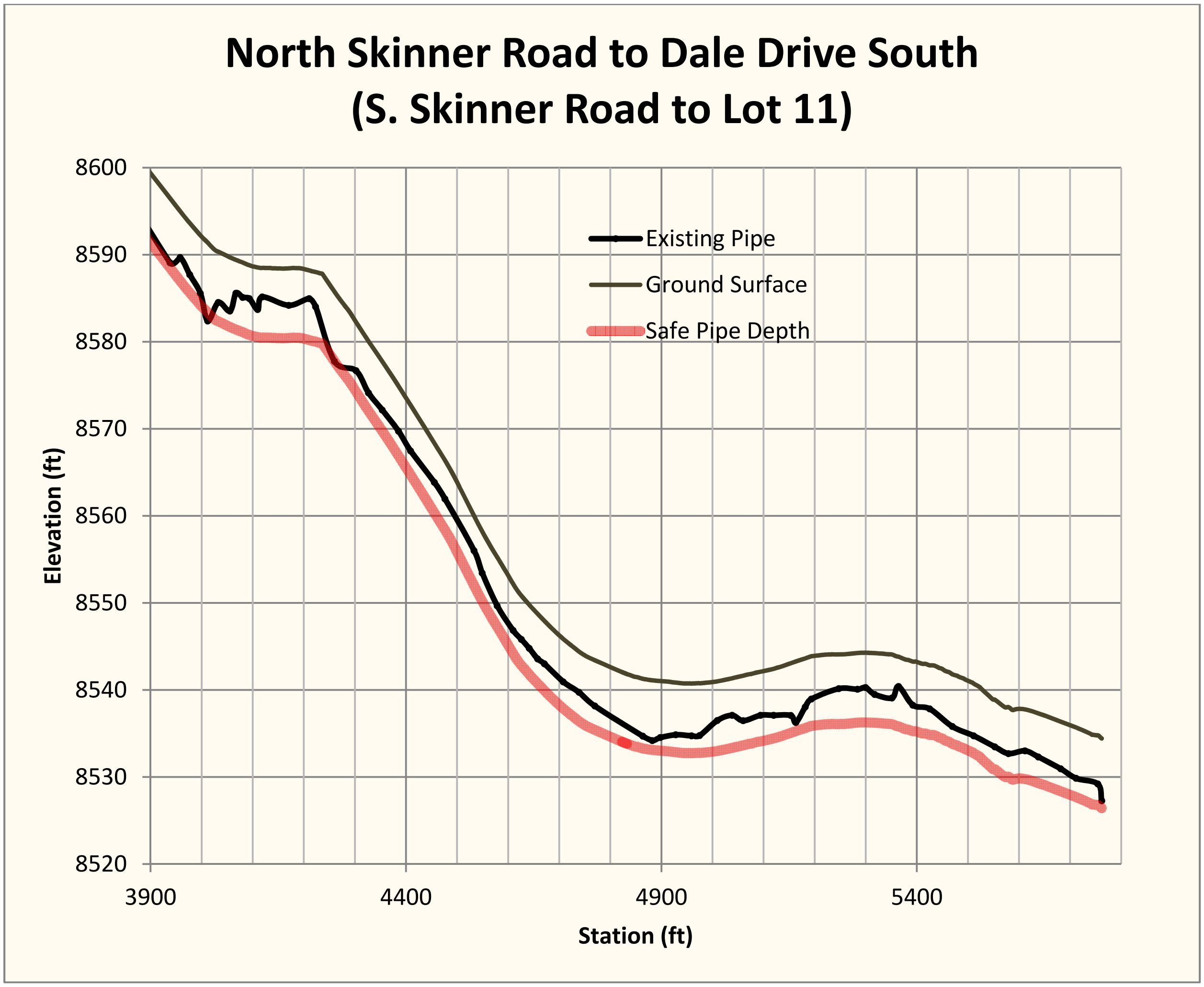


Figure 4 Depth Analysis for Priority 4

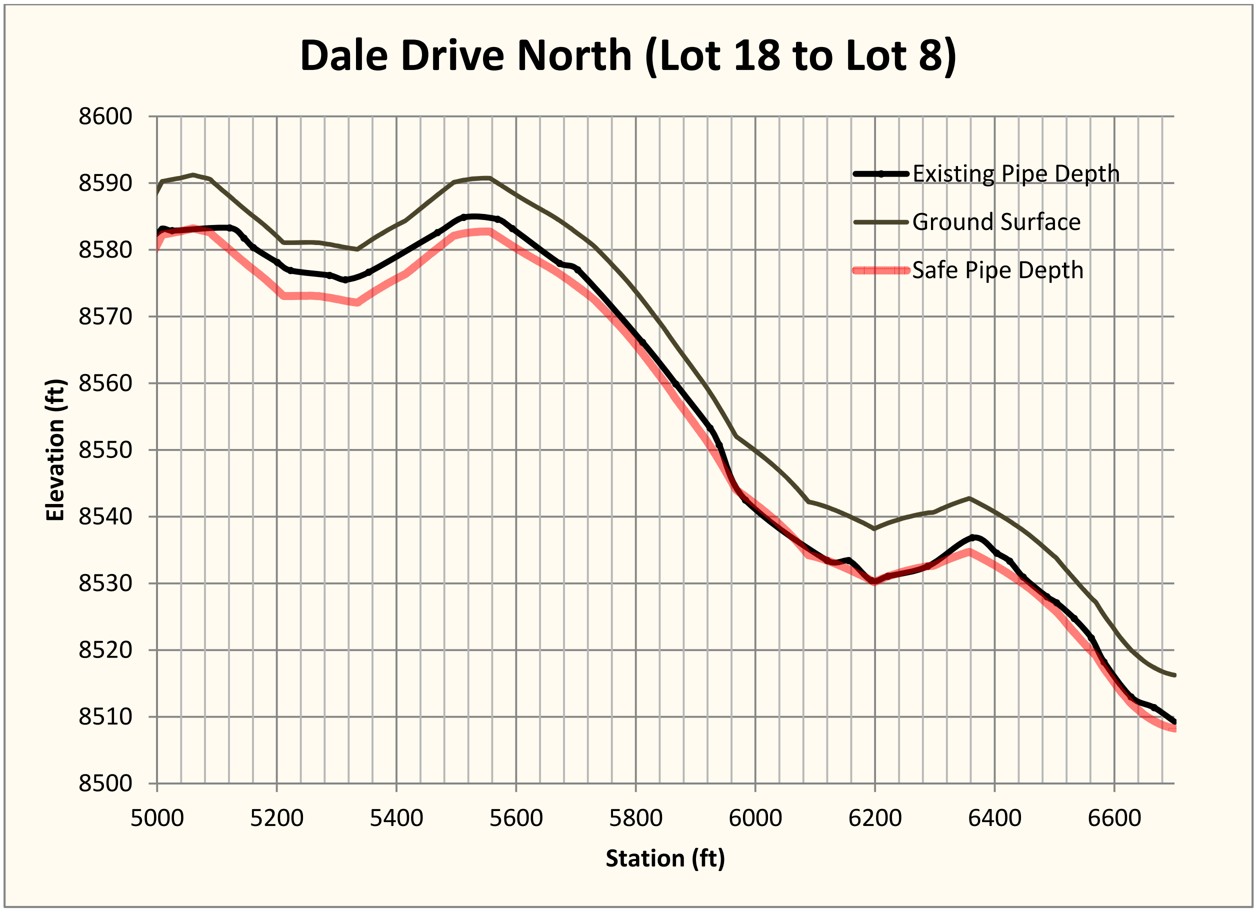
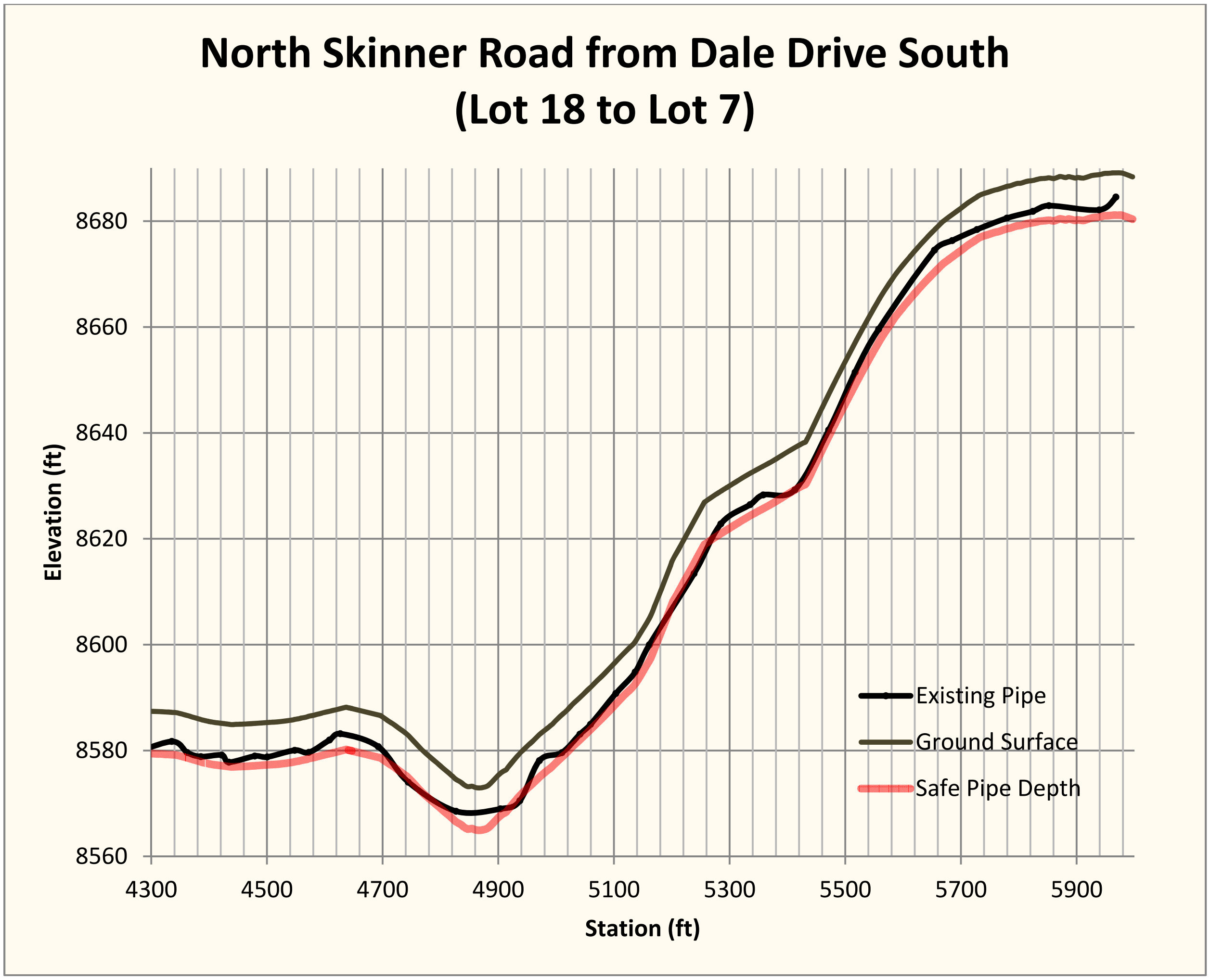


Figure 5 Depth Analysis for Priority 5



4.1 Financial Recommendations

Below is an expansion on the financial recommendations as initially detailed in the December 2013 Preliminary Engineering Report (PER) Long Term Recommendations Section (Chapter 7) as submitted to MMWSC (Note: Chapter 7 of the PER was submitted only to MMWSC, not to CDPHE). The financial recommendations have been updated based on the improvements and cost estimates as detailed in this report.

A thorough analysis has been made of the expenses of the company over the past 10 years (2003-2013), and the average annual cost of operating the plant has been $32,200. Operating costs included the cost of filters, laundry of pre-filters, chlorine, water testing, heating and electricity, communications, licenses and fees, insurance, water augmentation, trash disposal, and winter maintenance such as snow plowing and heating the distribution lines when pipes freeze. Maintenance costs included replacement of parts, materials, and labor. However, prior to 2013, a maintenance schedule has not been utilized for maintenance of sedimentation basin or clearwell, pumps, distribution or intake components, etc. In 2013, MMWSC developed an operations and maintenance plan, and its implementation will begin soon. MMWSC does not have any existing debt.

Future operating costs for the system will be higher than past operating costs. It is estimated that the current microfiltration system annual operating costs will be approximately $50,000 as estimated in the PER to MMWSC in December 2013. This includes the cost and laundry of pre-filters; microfilter replacement (estimated 10 year lifetime); chlorine; water testing; heating and electricity; communications; licenses and fees; insurance; water augmentation; trash disposal; pond, sedimentation basin, intake, and clearwell cleaning; distribution system maintenance including hydrant flushing, pump maintenance, etc.; calibration and monitoring equipment standards; and winter maintenance such as snow plowing and heating the distribution lines when pipes freeze.

It is recommended that MMWSC maintain reserves of not less than 15% of annual operating costs; this equates to approximately 60 days of operations. Annual operating costs are projected to be approximately $50,000 with the new microfiltration system; however, those values will not be well understood until a couple of years of operational cost data are collected and analyzed. As discussed in the long-term distribution system planning section, it is recommended that MMWSC build a distribution system improvement fund to contribute to the cost of each distribution system improvement phase.

Fortunately, MMWSC could be (and is currently considered) eligible for various funding opportunities including the State of Colorado Small Community Drinking Water Grant Project (SCDW Grant)[3] and a USDA Rural Utility Service Water and Waste Revolving Loan Fund Grant (RUS RF)[4]. The criteria and priorities under which MMWSC is most competitive are the following:

- Potential Acute Health Hazard
  - Difficulty in maintaining sufficient chlorine residual at ends of distribution makes system vulnerable to potential contamination.
  - Potential contamination introduction due to main breaks from freezing conditions.
- Future Needs
  - Distribution system useful life has been exceeded and is in need of replacement or repair in order to maintain compliance and health goals.
- Water Conservation
  - Reduced bleeding year-round and especially during the winter will conserve significant amounts of water and will reduce treatment costs;
- Population
  - MMWSC currently serves 41 households which means that consumers have a difficult time funding large projects and are dependent on external funding mechanisms.

Other considerations which will improve the grant and loan funding prospects include the percent of local match contribution, the condition of the other related infrastructure (i.e., 100% meter coverage, compliance with drinking water regulations, etc.), and a low ratio of overhead to project costs. Because a local match is critical in acquiring significant funding, we recommend that MMWSC plan to pay for 25% of the projected future improvement costs. Projects and applications that meet

[3] http://www.colorado.gov/cs/ search "2015 Small Community Drinking Water Grant Project Ranking Criteria"
[4] http://www.rurdev.usda.gov/SupportDocuments/UWP_AppGuide_RevolvingLoanFY14.pdf

these criteria are ranked better and will be more successful in obtaining approval for funding. Short-term improvement costs have been and will be paid for by current reserves. Long-term improvement costs cumulatively are estimated at approximately $2.6M or $115 per linear foot of pipe (current value). Twenty five percent (25%) of the long-term improvement costs are approximately $650,000 or $29 per linear foot of pipe, current value.

We recommend that the next five years of operational cost data be collected and analyzed to determine if the $50,000/year (current value) operational cost estimate is accurate. Rates may need to be adjusted to ensure that operating expenses, reserve, and savings are sufficient to cover operating costs, planned capital improvements, and matching contributions for loans and grants as needed.

5.0 ADDITIONAL RECOMMENDATIONS

In addition to the above recommendations, LA recommends numerous immediate expenditures listed below. Additionally, operations, maintenance, record keeping, and management recommendations are made below.

5.1 Immediate recommendations/Capital Expenditures

- Install functional valves on all functional bleed water lines and at existing main valve locations.
- Improve sedimentation basin: strip and paint, eliminate short-circuiting at a cost estimate of $7,000.
- Utilize proper pre-filtration bag pore sizes </=20 um of food grade quality as per sanitary survey requirement.

5.2 Operational Recommendations

Distribution system recommendations

- Install functional meters at all residences and all functional bleed lines.
- Begin meter testing/replacement schedule.
- Implement hydrant flushing schedule.
- Optimally operate infiltration galleries (no boards placed in stream during normal and high flow conditions).
- Discontinue or optimize bleed line usage during periods of no freeze risk (flushing schedule can be increased in summer months if needed to maintain chlorine residual at distal ends of distribution or data can be collected to determine optimal flow rate at bleed line if necessary).

Treatment system recommendations

- Ensure proper functioning of system alarms.
- Determine proper cleaning frequency of sedimentation basin during periods of low turbidity and during periods of high turbidity, implement cleaning schedule.
- Develop calibration curve for chlorine pump.
- Determine chlorine demand within distribution system to provide sufficient chlorine residual at endpoints to protect public health.

- Determine chlorine dose needed for clearwell in the case of zero chlorine residual at testing tap.
- Follow manufacturer's recommendations for ultrafiltration system maintenance including regular Clean in Place procedures.