MERRIMACK VILLAGE DISTRICT

MASTER PLAN UPDATE

November 2014

Submitted by: UNDERWOOD engineers

25 Vaughan Mall
Portsmouth, New Hampshire
99 North State Street
Concord, New Hampshire

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Executive Summary

Purpose and Objectives

The purpose of this Master Plan Update is to build off previous reports to complete a comprehensive evaluation of the Merrimack Village District (MVD) system. Objectives include:

- Review MVD's policies and standards and provide recommendations
- Evaluate current and future infrastructure needs
- Identify a ten year Capital Improvements Program (CIP)
- Develop an Asset Management (AM) Plan (provided under separate cover)

Overview of Existing System

The source for all of MVD's water is groundwater with the exception of emergency interconnects. There are six (6) active and one (1) inactive sand and gravel pack wells located in the Towns of Merrimack and Hollis. Water is distributed through approximately 877,000 LF (166 miles) of water main to approximately 6,553 metered service connections including over 85% of homes in the Town of Merrimack. Water is stored in two (2) active storage tanks, and a third tank is currently off line. The Turkey Hill Road Booster Pumping Station Water supplies water from the Main Pressure Zone to the High Pressure Zone. A smaller high pressure zone with hydropneumatic storage is served by the Belmont Avenue Booster Pumping Station.

Policy and Management

MVD's greatest assets are the groundwater supplies

- Our review shows significant watershed protection measures are in effect, but further steps can be done to mitigate impacts of continued development.
- Salt loading in the well head protection areas is a concern based on previous study. A mitigation plan has been developed. Additional monitoring is needed to see if current salt controls are effective.
- The "Odd/Even" policy for outside water restrictions have been reportedly successful in reducing maximum daily demands.
- An updated Emergency Management Plan should be submitted to DES in 2015

Water Demands

Current and projected water demands are summarized in Table ES-1. Continued monitoring is needed to confirm projected flow trends.

Table ES-1. Current and Projected Design Water Demands

	Current (2008 - 2014)	Design Year 2030 (UEI 2010 Report)
	(MGD)	(MGD)
Annual Average Day Demand	2.2 to 2.3	2.9
Summer Average Day Demand	2.7 to 3.2	4.1
Maximum Day Demand	4.3 to 5.4	5.9

Non-revenue water averages about 7% of total annual production but is significantly higher in the summer months. The seasonal peak does not appear accounted for by flushing or bulk water sales, and further investigation is required.

Supply Capacity Evaluation

MVD's existing wells are summarized below.

Table ES-2. Existing Groundwater Supply Capacity

Well	Notes	Capacity (Sustained Yield) (gpm)
Well #2	*Active* – Approved by NHDES for 1,500 gpm. Limited to 1,100 gpm by existing pump and MVD policy.	1,100
Well #3	*Active* – Has had Fe & Mn issues in the past	800
Wells #4 & #5	*Both Active* – Wells are pumped through a common station for treatment. Aquifer capacity is 625 gpm. Pumps capable of over 800 gpm combined.	625
Well #6	*Inactive* – Original capacity was 1,400 gpm. Not used due to VOC contamination	0
Well #7	*Active* – Fe and Mn issues; used only when necessary. Limited to 470 gpm by existing motor horsepower.	500
Well #8	*Active* - Treated commonly at Well #7 station. Effective existing capacity is zero due to Fe and Mn issues.	750
Total Capacity		**3,775 gpm (5.44 MGD)**

- Existing capacity with the largest well out of service (Well #2) meets existing summer ADF, but this assumes Well #8 is operated.
- Existing pump limitations and water quality constraints with Wells #7 and #8 limit what can be feasibly produced to about 4.3 MGD.
- The new Fe/Mn treatment plan will correct the issues at Wells #7 and #8 and provide capacity to meet current design flows when online (anticipated 2016).
- ***Additional supply of about 350 gpm (0.5 MGD) is needed to meet future design flows***.

Additional supply of 0.5 MGD is needed

Water Quality Evaluation

- Existing best water quality sources (Wells #2, #4, #5) barely meet winter time demands.
- MVD may be currently over pumping Wells #4 and #5 at times to avoid using lesser quality sources.
- The Well #7/8 Fe/Mn treatment plant will allow average summer demands to be met with high quality sources and reduce need to pump Wells #2, #4, and #5 at maximum rates.
- ***Future treatment at Well #3 (or development of an additional high quality source) may be needed to provide good water quality to meet maximum demands in all seasons.***
- The existing lime stations need replacement in the near term.
- Additional instrumentation is needed to monitor the long term performance and quality of the wells including aquifer level, conductivity, and SCADA links.

Future water quality goals need confirmation

Additional Supply Options

- Potential sources of additional supply have been identified which require further evaluation for cost effectiveness and feasibility (see Supply Flow Chart Figure 5, Appendix A).

Distribution Evaluation

- The existing distribution system is in relatively good condition, with no significant hydraulic issues or pattern of water main break occurrences.
- Asbestos cement mains make up 42% of the system and may need replacement over the next 30 to 40 years.
- Some redundant parallel mains may affect water quality and ease of operation.
- Some Town highway projects are anticipated in the near term which will impact the distribution system including certain bridge crossings.
- Hydraulic capacity is available to support a future expanded treatment plant capacity at Well#7/#8 of 1,850 gpm, but improvements may be needed if supplies from the south are greater.
- Sections of main that are more hydraulically limiting include the discharge from Well #7 (2,500 LF), the 12” AC section on Turkey Hill Road (1,000 LF), and portions of the 12” AC main on Route 3 between Greeley Street and Woodbury Street (5,000 LF).

90% of future 100 year replacement costs are for mains

Storage Evaluation

Long term maintenance of the Turkey Hill Tank needs further evaluation

- Existing storage is adequate for current and 20 year design flows.
- The Turkey Hill tank is difficult to remove from service for maintenance as it is the only tank serving the Main Pressure Zone.
- The Turkey Hill tank may require coating repairs in the near term and requires further evaluation.
- The Hutchinson tank requires some coating repairs to the roof in the near term.
- The tanks do not have mixing equipment per current design practice.
- Potential tank sites should be identified for long term planning.

Booster Pumping Station Evaluation

Turkey Hill Booster Station needs Replacement

- The Turkey Hill Booster Pumping Station is approaching the end of its useful life. The below grade installation has confined space/limited access issues, and the existing pumps are not available anymore and very costly to maintain.
- The Belmont Booster Pumping station lacks telemetry and may need pump/control renewals in the next 5 to 10 years.

Capital Improvements Plan (CIP)
The Ten Year Capital Improvement Plan for recommended projects below includes renewal of existing assets per the Asset Management Plan and the projects for growth or enhancement identified in the Master Plan.

Table 9-1. Ten Year Capital Improvements Plan.

Project	Amount	Priority	Year	Remarks
Current CIP Projects updated FY 2014-2015				
Increase production in Well 2	$0	3	-	“on hold”
New MVD office	$0	3	-	“on hold”
Iron and manganese treatment facility	$4,750,000	1	2014	In progress
Land purchase – site TBD	$400,000	2	2015	New supply
New well site development	$400,000	2	2015	New supply
Pipe replacement & eliminate parallel mains	$3,300,000 (note 1)	3	2020+	Distribution CIP
Proposed New Projects				
Naticook Lake water main extension	$300,000	2	2015	Town project
New well site installation	$1,500,000	2	TBD	Scope TBD depending on source
New well treatment	TBD	2	TBD	Scope TBD depending on source
Storage tank improvements (mixing)	$200,000	2	2016+-	Feasibility TBD
Turkey Hill Booster Station replacement	$1,200,000	1	2016+-	Feasibility TBD
Well 3 treatment	$4,500,000	3	TBD	Feasibility TBD
Well 5 pumps/controls	$200,000	2	2019	20 year replacement
Belmont Booster Station pumps/controls	$50,000	2	2020	20 year replacement
Lime station improvements (Wells 2, 3, 5)	$1,200,000	1	2016+-	Feasibility TBD
Well level monitoring, SCADA/GIS/IT improvements	$300,000	2	2016+-	Feasibility TBD
Total CIP	**$18,300,000**			

Note 1. $3,300,000 = 4-year pro-rated amount based on $8,250,000 for 2020 to 2029 per Distribution CIP.

Recommendations

Administrative recommendations are summarized in Table ES-3 and Capital Projects are summarized in Table ES-4. Note starred* items below are items related to MVD that were included in the 2013 Town Master Plan.

Table ES-3. Management/Administrative Recommendations

ID	Watershed Protection and Aquifer Management	Implementation Period	Remarks
WM1	Prepare a comprehensive *Well Management Plan*, including evaluation of operational control of the production wells to maximize water quality while protecting the long term yield of the aquifers.	Ongoing	
WM2	Reduce impervious surfaces in site design where appropriate.*	Ongoing	Coordinate with Town
WM3	Develop a design review checklist for subdivisions and site plans that incorporates recharge protection and water demand management practices.*	1-2 years	Coordinate with Town
WM4	Consider amending the subdivision and site plan regulations to limit the use of deicing compounds and regulate the use of pesticides or insecticides in new commercial, industrial, or multi-family residential projects.*	1-2 years	Coordinate with Town
WM5	Work with the State to address existing and future large quantity groundwater withdrawals in wellhead areas.*	3-5 years	Coordinate with State
WM6	Continue to work with residents and businesses to encourage individual water resource protection measures.*	Ongoing	
WM7	Develop a set of criteria for use of deicing materials throughout the Town.*	Ongoing	Coordinate with Town
WM8	Continue to implement and maintain the recommendations of the 2012 Salt Mitigation Plan.* Track status of the 24 Action Items and pursue grant funds for implementation.	1-2 years	Coordinate with Town

WM9	Update and submit Emergency Management Plan to NHDES.	Ongoing	
ID	**Water Conservation**	**Implementation Period**	**Remarks**
WC1	Consider updating the Conservation Plan and pursuing additional conservation measures as a way to offset the need for additional supplies.	3-5 years	
WC2	Evaluate the current water balance and non-revenue water, including why non-revenue water increases significantly in summer months. Complete an updated Water Audit.	1-2 years	
WC3	Continue to maintain the "odd/even" outside watering policy.* Evaluate the impact on peak and average demands.	Ongoing	
WC4	Use separate commercial and industrial irrigation meters to control demand.*	Ongoing	
WC5	Continue to expand homeowner education programs to reduce demand and encourage water conservation.*	Ongoing	
WC6	Work with all businesses to help keep outside watering in their facilities to a minimum.*	Ongoing	
ID	**Information Management**	**Implementation Period**	**Remarks**
IM1	Continue to update and expand the information in the GIS system.	Ongoing	
IM2	Provide additional training for personnel responsible for maintaining the GIS system.	Ongoing	
IM3	Establish or expand a server based computer network to increase reliability and the ability to share resources.	1-2 years	
IM4	Update the water model to the current WaterCAD version, using the current GIS base map and pipe inventory, including field work for calibration.	3-5 years	

ID	Asset Management and Financial Planning	Implementation Period	Remarks
AM1	Implement and maintain the Asset Management Plan developed in 2014.	Ongoing	
AM2	Provide additional capital reserve contributions as recommended in the AM plan for long term replacement of assets over their life cycle.	Ongoing	
AM3	Update rates and SDC every two years.	Ongoing	
AM4	Submit applications for SRF funding for potential near term projects.	Ongoing	

Table ES-4. Capital Improvements Recommendations

ID	Supply and Treatment	Implementation Period	Remarks
C1	Complete construction of the Fe/Mn treatment plant for Wells #7/#8.	1-2 years	
C2	Secure land rights for potential Mitchell Woods well.	1-2 years	
C3	Secure land rights for potential Bean Road well.	1-2 years	
C4	Secure land rights for potential Hollis source.	1-2 years	
C5	Evaluate scope and costs to complete installation, treatment systems, and connection of new sources and plan for implementation of most cost effective new source(s).	3-5 years	
C6	Evaluate options to replace the lime feed stations at Wells #2, #3, and #5.	1-2 years	
C7	Evaluate future Well 3 treatment based on experience with Well #7/#8 plant.	5-10 years	
C8	Install additional monitoring instruments including level monitoring and conductivity probes at each production well.	1-2 years	

C9	Plan and budget for other supply improvements including VFDs, surge control, and chlorinator replacements.	3-5 years	
C10	Evaluate increasing pumping capacity of Well #2 to 1,500 gpm.	5-10 years	
C11	Evaluate using only Well #5, without Well #4, to match the sustainable capacity of the aquifer.	3-5 years	
ID	**Distribution**	**Implementation Period**	**Remarks**
C12	Evaluate water distribution improvements in conjunction with anticipated near term Town road realignment and bridge replacement projects. Determine responsibilities and costs between the Town and MVD.	1-2 years	
C13	Construct other improvements in conjunction with Town paving projects where possible to reduce costs by digging the street once.	Ongoing	
C14	Plan for elimination of redundant parallel mains including those on Route 3 and Baboosic Lake Road.	5-10 years	
C15	Evaluate hydraulic capacity as future new sources are advanced.	5-10 years	
C16	Prioritize most hydraulically limiting mains for future improvements, if necessary to support future supply increases in South Merrimack.	Ongoing	
C17	Review and update construction standards.	Ongoing	

ID	Storage	Implementation Period	Remarks
C18	Evaluate tanking mixing improvements.	1-2 years	
C19	Evaluate coating repairs to the Turkey Hill Tank including how to maintain system pressure if tank must be taken out of service.	1-2 years	
C20	Plan for coating repairs to the Hutchinson Tank.	1-2 years	
C21	Identify site(s) for future additional storage for the Main Pressure Zone.	5-10 years	
C22	Obtain recorded easement for the future tank site at Merrimack Premium Outlets.	1-2 Years	
C23	Investigate sources of sediment that buildup in tanks.	3-5 years	
ID	**Booster Pumping Stations**	**Implementation Period**	**Remarks**
C24	Evaluate alternatives for replacement of the Turkey Hill Booster Pumping Station and secure land.	1-2 years	
C25	Evaluate telemetry/SCADA improvements with renewals to the Belmont Booster Pumping Station.	5-10 years	

1. Introduction

1.1. Purpose and Objectives

The purpose of this study is to build off previous reports to complete a comprehensive evaluation of the MVD system. Objectives include:

- Review MVD's policies and standards and provide recommendations
- Evaluate current and future infrastructure needs
- Identify a Capital Improvements Program (CIP)
- Develop an Asset Management (AM) Plan (provided under separate cover)

The Master Plan provides a framework for future management of the water system infrastructure, which provides a vital service to the Town of Merrimack. The Plan is intended to cover a time frame of about 10 years in coordination with other MVD planning documents.

1.2. History

The original MVD system was formed in 1955 and encompassed the area from Baboosic Brook on Route 3 to the Elbit Systems property in Thorton's Ferry. Customers of the Reeds Ferry System, which was developed around 1934, chose not to join with MVD at that time. However, the systems eventually did combine in 1974, though the two distribution systems remained hydraulically isolated (Town Master Plan, Draft 2013).

A number of improvements were implemented in the 1970's and 1980's based on recommendations in a 1975 study by Whitman and Howard. These included construction of the 4 million gallon tank on Turkey Hill Road, establishment of a high pressure zone, addition of transmission mains, installation of Well #6, and opening connections between the original systems. Lime feed stations were added at Wells #2, #3, #5, and #6 in approximately 1988.

Much of the current distribution system was constructed between 1960 and 1990. Expansion continued at a lesser pace in the 1990's and 2000's to serve residential development including Bean Road, Tinker Road, and near Baboosic Lake. MVD constructed new 16 inch transmission mains on Continental Boulevard, Camp Sargent Road, Amherst Road, and Turkey Hill Road in 2010 to 2012 to improve hydraulic connectivity with South Merrimack. Concurrently, the Merrimack Premium Outlets completed a 16 inch loop between Continental Boulevard and Camp Sargent Road.

Recent years have seen impacts to the supply sources. Well #6, located in south Merrimack, was taken offline in approximately 1988 due to contamination to the aquifer from a former adjacent industry (Merrimack Industrial Metals). Well #1 was removed from service in approximately 1995 due to failure of the well screen. To regain supply capacity, Wells #7 and #8 were installed in the late 1990s in Hollis just over the town line in South Merrimack. However, these new supplies became less favored as levels of iron and manganese increased with use. MVD is currently constructing a treatment plant for Wells #7/#8 to improve water quality. A program is ongoing to investigate potential sources for additional supply.

1.3. Overview of Existing System

1.3.1. Water Supply

The source for all of MVD's water is groundwater with the exception of emergency interconnects. There are six (6) active and one (1) inactive sand and gravel pack wells located in the Towns of Merrimack and Hollis. The water is treated for disinfection and corrosion control at each well site prior to pumping into the distribution system and storage.

1.3.2. Water Distribution

Water is distributed through approximately 877,000 LF (166 miles) of water main with diameters of 4 to 20 inches (see Figure 1, Appendix A). Fire protection is provided by approximately 889 hydrants and 154 fire sprinkler connections.

MVD provides water to approximately 6,553 metered service connections including over 85% of homes in the Town of Merrimack. Approximately 532 additional customers in the proximity of the system are billed for fire protection only.

1.3.3. Water Storage

Water is stored in two (2) active storage tanks, and a third tank is currently off line. The Turkey Hill Road tank was constructed in 1978 to serve the Main Pressure Zone with a capacity of 4 million gallons. The Hutchinson Tank and Lake Road Tank (inactive) were constructed in 1988 for the High Pressure Zone and can hold 1.0 and 0.75 million gallons, respectively.

1.3.4. Booster Pumping Stations

The High Pressure Zone is supplied by the Turkey Hill Road Booster Pumping Station. A smaller high pressure zone with hydropneumatic storage is served by the Belmont Avenue Booster Pumping Station.

1.4. Work Completed

This Master Plan update was a collaborative effort between Underwood Engineers and MVD staff. Information about the MVD water system was summarized in the Master Plan and AM Plan based on many sources including:

- Meetings with MVD staff, Town of Merrimack Department of Public Works, and NH Department of Environmental Services (NHDES) Water Supply Bureau.
- Site visits to MVD facilities.
- Review of MVD water quality and flow data.
- Review of previous reports and correspondence (Section 2).

2. Previous Studies and Reports

2.1. MVD Master Plan Update 2001

The last Master Plan Update for MVD was completed by Comprehensive Environmental Inc. in January 2001. The report was generally limited to future water demand projections and system capacity. Specific recommendations included:

- Continue to implement the odd/even water management.
- Put Well #6 back online as growth requires.
- Work with new industries to help keep outside watering in new facilities at a minimum.

2.2. Reports by Underwood Engineers

Several documents have been completed by Underwood Engineers since 2007 as summarized below:

- Water Supply Options, February 2007 (ESR 1)
    - Evaluated supply needs and recommended additional supply to meet current maximum day demands and future summer average day demands.
    - Compared five supply options and eliminated several from further consideration.
    - Recommended continuation of groundwater investigation and further study of blending Wells 6, 7 and 8. **See Blending Evaluation 2007**
- Water Rate Study and Lost Water Study, February 2007 (ESR 2)
    - Recommended rate increase to meet expenditures and increase capital reserves. **Implemented July 2007**
    - Recommended adjustments to fixed rate charges to balance rate structure between fixed and volumetric income. **Implemented July 2007**
    - Identified 17.25% "unaccounted for water" and recommended methods to reduce. **MVD tracking unmetered use**
- Blending Evaluation, June 2007 (ESR 3)
    - Desktop study to evaluate whether blending Wells 6, 7, and 8 was feasible to improve water quality.
    - Concluded blending could reduce sodium, chloride and VOCs in Well 6 and iron and manganese in Wells 7 and 8.
    - Recommended long-term **pumping** test of Well 6 and long-term pilot of blending to confirm. **See Pump Test and Blending Study 2008**

- Distribution System Hydraulic Evaluation, September 2007 (ESR 4)
  - Evaluated five hydraulic improvement scenarios to address system bottleneck from supply wells in the south.
  - Recommended 16-inch loop for proposed Premium Outlet Mall. **Constructed**
  - Recommended future distribution system improvements pending decisions on supply improvements. **See Hydraulic Verification 2009**
- Well 6, 7 and 8 Pump Test and Blending Study, October 2008 (ESR 6)
  - Long-term pumping test and blending pilot.
  - Confirmed conclusions and recommendations of 2007 Blending Evaluation.
  - Recommended implementation of blending infrastructure improvements (reactivate Well 6, add VFDs and controls to Wells 7 and 8).
  - **Infrastructure improvements were designed but not constructed because 1,4-Dioxane was discovered in Well 6 and the surrounding plume.**
- Memo - Comparison of Centralized versus Separate Treatment Facilities for Wells 3, 6, 7, and 8, October 2008
  - Evaluated cost-effectiveness of a centralized treatment facility to treat iron and manganese in Wells 3, 7, and 8 as compared to separate treatment facilities for Well 3 and Wells 7 and 8.
  - Separate treatment facilities determined to be cost effective because centralized treatment would require a long raw water transmission main between Wells 3 and 7. **Well 7/8 facility pursued**
- Hydraulic Verification, April 2009 (ESR 11)
  - Recommended Continental Boulevard as the first distribution system improvement project to address the hydraulic "bottleneck" between supplies in the south and the Turkey Hill Tank. **Constructed 16 inch DI improvements on Continental Boulevard, Camp Sargent Road, Amherst Road, and Turkey Hill Road 2010 – 2012.**
- Water Rate Study Update, May 2010 (ESR 7)
  - Recommended 2-step rate increase (2 x 8%) to continue capital reserve contributions and meet planned CIP expenditures (Continental Boulevard water main and Wells 6, 7, 8 blending). **8% rate increase July 2010**

- Water Supply Evaluation Update, and Nashua Source Evaluation, December 2010 (ESR 1-A-09, ESR 1-B-10)
    - Updated 2007 water supply study.
    - Confirmed need for additional supply.
    - Recommended increasing the pumping capacity of Well 2 from 1,100 gpm to 1,500 gpm (the permitted flow) and construction of an iron and manganese treatment facility for Wells 7 and 8 as the cost effective water supply program. **Well 2 Improvements on hold**
- Rate Review, May 2011 (ESR 10)
    - Confirmed continuation of the 2-step rate increase recommended in 2010. **8% rate increase July 2011**
- Distribution CIP Planning, November 2012 (ESR 14)
    - Prepared inventory and lifecycle costing of water main assets.
    - Recommended $700,000 annual contribution to capital reserves to cover 50% of projected replacement costs for years 2020 to 2070. **Future renewal projects added to long term CIP**
- Summary of Hydraulics Improvements, December 19, 2012 (ESR 11)
    - Evaluated hydraulic improvements due to completion of Continental Boulevard Water Main project.
    - Recommended no further improvements to support current production rates but further study needed if other potential sources exceed 2,000 gpm total. **No action**
- Wells 7 and 8 Iron and Manganese Treatment - Basis of Design, April 2013 (ESR 21)
    - Identified capacity (1.85 MGD) for an iron and manganese treatment facility to treat Wells 7 and 8 with provisions for future expansion to treat future sources. **Designed and under construction**
- Water Rate Study Update, April 2014 (ESR 20)
    - Recommended a 10% rate increase phased in over 2 or 3 years to support Wells 7 and 8 treatment debt service and additional capital reserves contributions. **Rate increase anticipated July 2015**
- Asset Management Plan, September 2014 (ESR 23)
    - Expanded Distribution CIP planning to include rest of system.
    - Recommended $420,000 to $840,000 in capital reserve contributions to cover future replacement costs, with the balance financed by future debt or other sources. **Action pending review**

2.3. Reports by Others

UE has also reviewed the following reports by others:

- "Naticook Brook Aquifer Model Project Summary and Results" by Emery & Garrett Groundwater Investigations, LLC, May 1998.
- "Merrimack Village District Master Plan Update" by Comprehensive Environmental Inc., January 2001.
- "Establishment of the Source Water Protection Area. Merrimack Village District Wells MVD-4 and MVD-5" by Emery & Garrett Groundwater Investigations, LLC, December 2003.
- "Well #6 Preliminary Engineering. Task 1 Evaluation of Iron and Manganese in Wells #7 and #8" by Prism Environmental, October 2006.
- "Supplemental Site Investigation. Merrimack Industrial Metals Site (DES # 198403082) Route 101A Merrimack, New Hampshire" by GZA GeoEnvironmental, Inc., March 2007.
- "Preliminary Hydrogeologic Investigation. Merrimack Village District (MVD). Groundwater Development at the Mitchell Woods and Bean Road Production Wells" by Emery & Garrett Groundwater Investigations, LLC, December 2009.
- "Final Report on 2011 Local Source Water Protection Grant SWP-223. Sodium and Chloride Loading Study of the Merrimack Village District Wellhead Protection Areas (WHPAs)" by Emery & Garrett Groundwater Investigations, LLC, May 2012.
- Letter report documenting the water level data collected by automated groundwater level monitoring equipment by Emery & Garrett Groundwater Investigations, LLC, November 7, 2012.
- "Long-Term Pumping Test to Assess Low Level 1,4-Dioxane Levels in the MVD-6 Production Well" by Emery & Garrett Groundwater Investigations, LLC, January 2013.
- "Review of Automated Groundwater Level Monitoring Data Collected Near MVD Production Wells (2013)" by Emery & Garrett Groundwater Investigations, LLC, January 2014.
- "Well MVD-2 1,4 Dioxane Monitoring Report – September 2013 Sampling" by Emery & Garrett Groundwater Investigations, LLC, November 2013.
- "2013 Master Plan Update Merrimack, New Hampshire" by Vanasse Hangen Brustlin, Inc., October 2013, amended by the Merrimack Planning Board January 2014.
- "Merrimack Village District Sanitary Survey 2013" by NHDES, August 26, 2014

3. MVD Policy and Resource Protection

3.1. Vision and Mission Statement

The following is published in MVD's Annual Report:

"Providing Water Services – All Night, All Day, Every Day"

MVD Mission Statement

"The Merrimack Village District will develop, operate and maintain our water system in a cost effective manner".

3.2. Values and Level of Service

While removed from the Mission Statement in 2013, we suggest these goals remain to express the Values and Level of Service desired by the Merrimack Village District in developing this Master Plan:

Suggested MVD Values and Level of Service

- Providing quality services to our customers,
- Protecting and maintaining an adequate, uninterrupted and high quality water supply,
- Providing effective drinking water treatment and distribution and supporting fire protection,
- Making water available to as many residents in the Town of Merrimack as economically feasible,
- Developing and maintaining a safe, professional workforce, and
- Building alliances with communities and educating future generations about the importance of protecting our water resources.

3.3. MVD Organization

The MVD is a municipal corporation established and regulated under state law as a separate entity from the Town government. The District is governed by a five-member board of Commissioners, Clerk, Treasurer, Secretary, and Moderator elected at the Annual Meeting in March. The system is managed and operated by the Superintendent and three office staff, three treatment staff, and six distribution staff.

3.4. MVD Bylaws and Standards

MVD's governing rules and regulations are established in MVD's Bylaws. Additional administrative and Board policies are approved for specific issues. MVD also has written Standards for construction of water distribution improvements by the District or private developers.

3.5. MVD Rates

MVD has established a rate structure to raise revenues to fund operating expenses, debt service, and capital improvements. MVD has also established a system development charge (SDC) for new users as a "buy-in" fee for existing infrastructure. MVD's rates are comparable to or less than other systems providing similar services in New Hampshire. Rates are reviewed and updated typically every two years, with the most recent review completed in March 2014. The next rate increase is anticipated in FY 2016 (July 2015) to support future debt service for the water treatment plant project and fund additional capital reserve contributions from surpluses.

3.6. Conservation Restrictions

To reduce the maximum daily demand that occurs primarily during the summer months, MVD implemented an odd-even management policy effective in 1999. This policy allows residents with odd numbered houses to irrigate outside on odd numbered days and residents with even numbered houses to use water outside on even numbered days. The one exception to this rule is that all residents are allowed to water outside on the last day of the months of March, May, July, August and October, but only from 5AM to 8AM. These water restrictions have been reportedly successful in reducing maximum daily demands and the policy is expected to continue indefinitely.

When system capacities cannot meet demands (due to taking a well offline and/or increased summer water use), MVD has the ability to purchase water from Pennichuck Water Works. The interconnection is not generally used except for a brief period during annual flushing.

MVD prepared an updated Conservation Plan as part of the Preliminary Report for new development of new groundwater sources (EGGI, 1999). Ongoing conservation strategies noted in the plan include:

- Metering program
- Leak detection program

- Public outreach with information in Annual Report, mailings, and brochures.
- Odd/Even watering policy
- Landscape demonstration project for low water use
- Monitoring of water balance and non-revenue water.

3.7. Groundwater Resource Protection

Groundwater is a very important resource for MVD and the Town of Merrimack. MVD obtains its supply from stratified drift aquifers which yield large quantities of water and underlie approximately 57% of the Town (Figure 3-1).

There are many potential threats to groundwater quality and quantity. MVD formed the Naticook Aquifer Advisory Ad Hoc Committee in 1999 to address declining levels in the aquifer. The Committee developed the following recommendations as listed in the 2002 and 2013 Town of Merrimack Master Plan Updates:

- Address imperviousness in subdivision and site plan regulations.
- Develop a review checklist for subdivisions and site plans that incorporates recharge protection and demand management protections. The checklist would address best management practices (BMPs) for stormwater control and treatment.
- Identify opportunities to improve infiltration in existing impervious areas.
- Evaluate limitations on further sewering in the Naticook basin.
- Address existing and future large quantity withdrawals in the basin, especially by commercial and industrial users.
- Investigate the effectiveness and feasibility of raising Greens Pond for enhancing storage in the aquifer.

Some of the pollution issues discussed in the 2013 Town of Merrimack Master Plan Update include road salt, subsurface sanitary waste disposal, and stormwater runoff. The Town's Master Plan recommended changes to regulations and guidance that would:

- Leave more topsoil to reduce irrigation demands.
- Reduce impervious surfaces
- Require adequate treatment of stormwater
- Ensure development does not increase total stormwater runoff.

Current regulations in place to protect groundwater quality include the Town's Stormwater Management Standards. In addition, MVD distributes information for groundwater protection in their website and Annual Report including guidelines for hazardous waste disposal and alternative cleaning products. For over 12 years Merrimack has been awarded official Groundwater Guardian status from the National Groundwater Foundation in Lincoln, Nebraska. This program recognizes communities who are dedicated and committed to local groundwater protection to ensure a safe water supply for the future of the community. Merrimack is the only town in New Hampshire awarded this status.

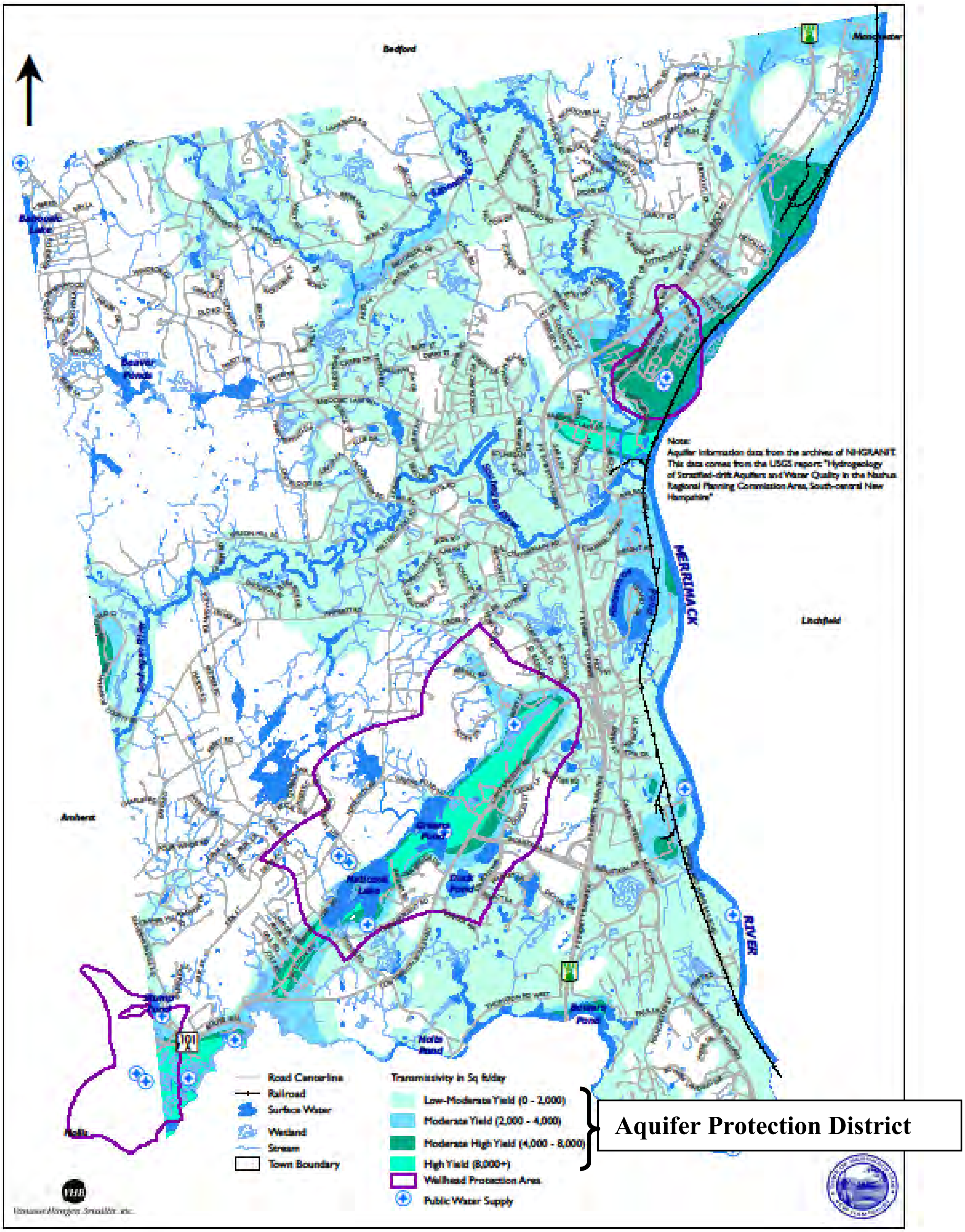

Figure 3-1. Merrimack Aquifer Map
(from Town of Merrimack Master Plan Update, prepared by VHB, 2013)

3.8. Aquifer Conservation District

The Town of Merrimack has adopted an aquifer conservation overlay district intended "to protect preserve, and maintain the existing potential groundwater supply and recharge areas within known aquifer and wellhead areas from adverse impacts that may results from inappropriate development or land use practices" (Merrimack Zoning Ordinance section 2.02.11). The Aquifer Conservation District is divided into two areas (Figure 3-1):

- Wellhead Protection Areas (WHPA)
- Balance of the Aquifer District (defined by maps referenced by the Zoning Ordinance)

The regulations control the types of uses allowed so that potential discharges of waste do not impact groundwater supplies. MVD reviews each plan for development within a WHPA and makes recommendations to the Planning Board. MVD's policy has been to provide engineering recommendations where appropriate to reduce the use of deicing materials and the potential impact of stormwater runoff.

3.9. Salt Controls

The Town of Merrimack adopted a reduced salt use policy in 1984 per the Town Master Plan. No salt routes are adjacent to MVD wells and other water supplies near roadways.

A detailed Sodium Chloride Mitigation Plan was developed by EGGI as part of the 2012 Study for MVD evaluating sodium chloride loading in the three well head protection areas. The Plan includes 24 specific action items for education, outreach, and monitoring in the following categories (see Table 1 of the Mitigation Plan):

- Pre-Construction and Project Design
- Private Parking Lots and Sidewalks
- Public Roads
- Public Policy, Education, and Outreach
- Evaluate and Monitor Groundwater

The 2013 Town Master Plan recommended that the Town and MVD implement these items. The ongoing status of these action items should be reviewed and documented, and Source Water Protection Grant funds should be pursued (e.g., GPS driven systems for tracking salt application).

3.10. Emergency Management Plan

DES regulations require a formal emergency plan to be submitted once every six years. In addition, the plan should be reviewed annually by the system and updated as necessary. Based on our review of MVD's current Emergency Management Plan dated March 2009, the following should be updated:

- List of current Staff and contact information.
- List of Service/Repair contractors.
- Add description of water treatment plant (under construction)

- Stated system production capacity and demands, based on this report.
- Status of new sources in development.
- Alternative power supplies should include the 230 KW portable generator and new generators to be added with the water treatment plant.
- Water Use Restrictions should include discussion of sudden or temporary water conservation notices; e.g. outside water bans.
- Vulnerability Assessment for various types of emergencies.

3.11. Sanitary Survey

The most recent Sanitary Survey by the Department of Environmental Services (NHDES) is documented in a letter dated August 6, 2014 from the Drinking Water and Groundwater Bureau. There were no deficiencies or noncompliance issues noted in the Survey. NHDES commended MVD for undertaking the iron and manganese treatment facility and developing an asset management plan.

4. Water System Demands

4.1. Existing Water Demands

Existing water demands were reviewed in the supply evaluation reports by UE in 2007 and 2010. To update existing and projected demands, UE reviewed production data through August 2014 (Table 4-1 and Appendix B):

Table 4-1. Summary of Annual Water Production

Year	Annual ADF MGD	Summer ADF MGD	MDF MGD
2004	2.35	3.36	4.10
2005	2.38	3.43	4.60
2006	2.38	2.92	4.72
2007	2.44	3.34	5.45
2008	2.31	3.03	5.43
2009	2.16	2.73	4.31
2010	2.32	3.17	5.32
2011	2.21	3.03	4.96
2012	2.26	3.10	4.94
2013	2.34	2.98	4.44
2014	2.29	2.95	4.72

Note: 2014 data is through August only.

Based on our review we note the following:

1. Demands continue to show a significant seasonal trend with higher demands in the summer, assumed to be primarily due to irrigation.
2. Demands are typically higher during drier summers due to more irrigation demands.
3. Winter demands range from < 2.0 MGD average to 2.8 MGD maximum.
4. Average demands have trended fairly flat the past few years, despite some new connections.
5. A major potential new water user, the Premium Outlet Mall, opened in June 2012. The design average day demand for the Mall was 137,000 gpd (UE letter dated May 21, 2008), but actual demands have been lower at 16,000 gpd average.
6. Approximately 69 new domestic and mercantile service connections were added from 2010 to 2013.

4.2. Customer Demographics and Consumption Trends

The average consumption per equivalent dwelling unit (EDU) is **266 gpd** (UE Rate Study March 2014). This consumption is higher than many communities in New Hampshire. The NHDES 2012 Water Rate Survey determined a state-wide average residential consumption of 185 gpd.

Each user class that MVD tracks is charged the same consumption rate while hydrant charges are applied differently. Based on FY 2013 revenue data, metered consumption is divided among user classes as follows.

- Domestic: 85%
- Mercantile: 10%
- Industrial: 5%

Historical production and consumption trends are charted in Figure 4-1.

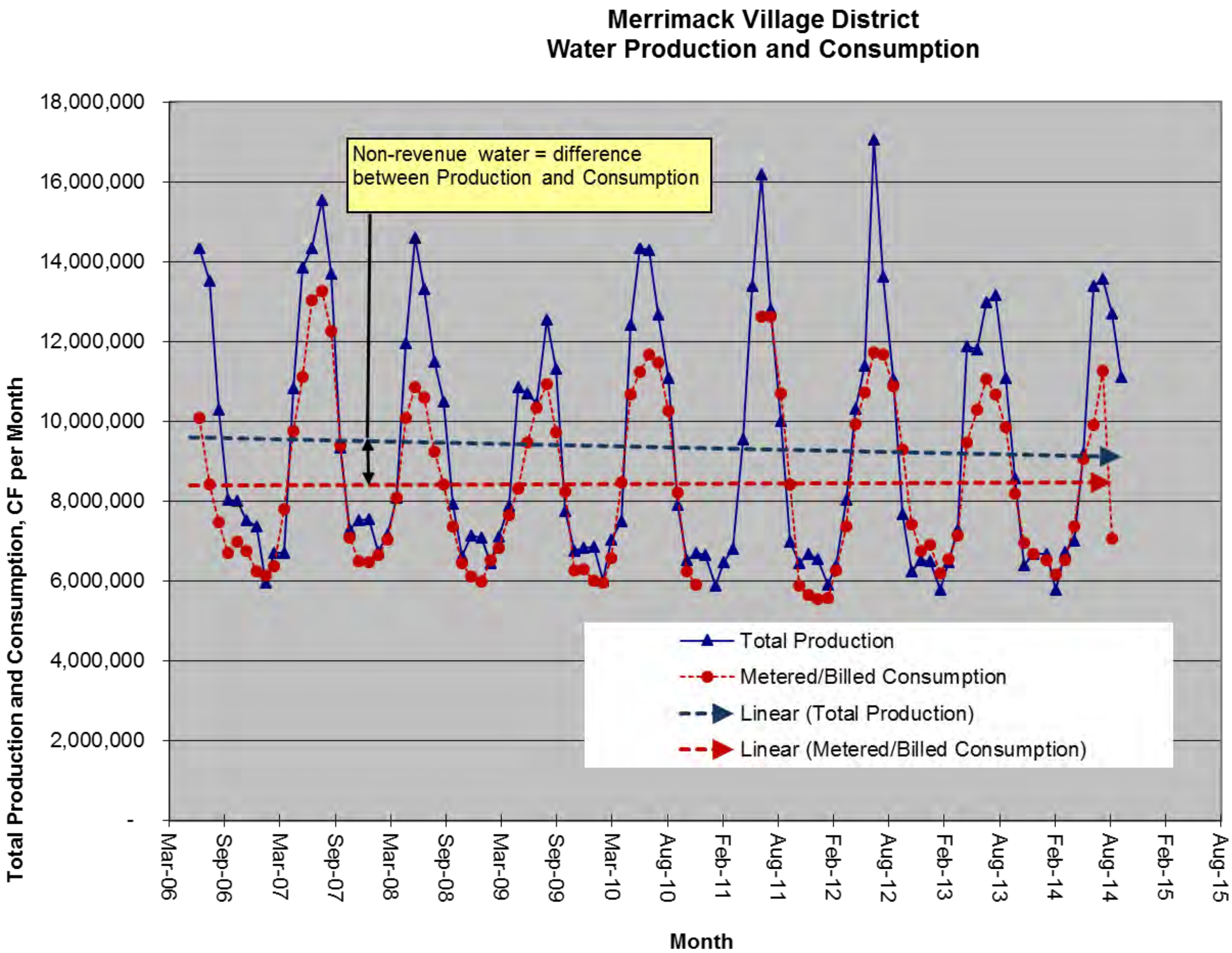

Figure 4-1. MVD Water Production and Consumption.

Note, Consumption in above chart does not include hydrant flushing, bulk water sales, fire suppression training, etc.

4.3. Non-Revenue Water

Non-revenue water is the difference in quantity between water produced from the wells and total metered consumption that is billed for. The amount of non-revenue water for MVD was estimated at 19% of total production in the 2007 Lost Water Study, higher than the typical standard of 15% for non-revenue water. More recent data suggests non-revenue water is reduced from earlier estimates; the average based on data from FY 2012 to FY 2014 is **7%** (Figure 4-2).

Non-revenue water is significantly higher in the summer months (Figure 4-1). System flushing, which is metered by MVD, accounts for about 34% of non-revenue water but does not significantly coincide with the summer peaks. Flushing is typically conducted for the whole system in April through July and again in September to October for South Merrimack.

An updated Water Audit is recommended to review the current water balance and evaluate the causes of the summer peaks in water losses.

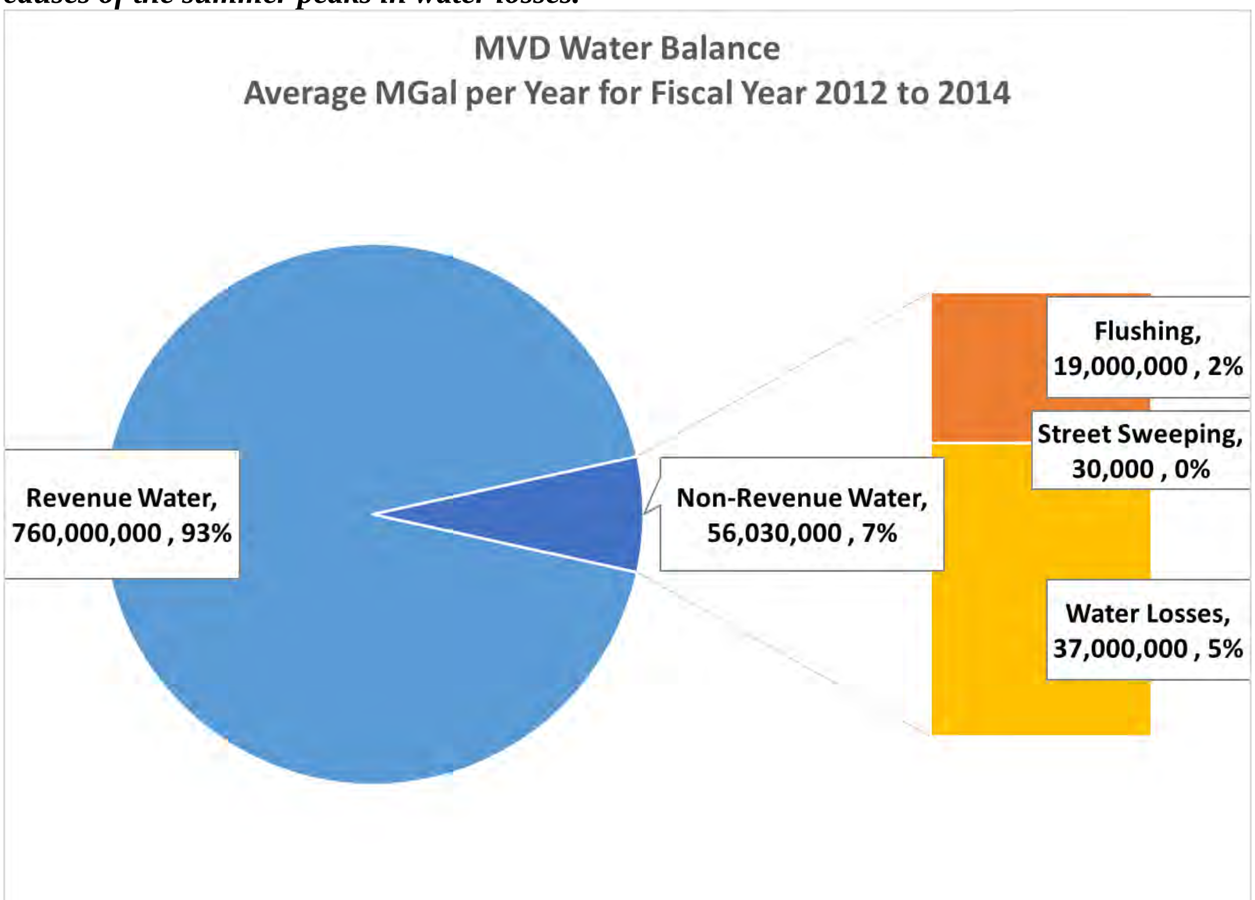

Figure 4-2. MVD Water Balance for Fiscal Years 2012 to 2014
(Revenue water includes metered connections and bulk water sales)

4.4. Projected Water Demands

The demand projections shown in the 2010 UEI report (Table 4-2) are assumed to be appropriate as the basis for evaluation of MVD's supply sources. Flow data should continue to be tracked to evaluate future trends and update design flow projections if necessary.

Table 4-2. Current and Projected Design Water Demands

	Current (2008 - 2014)	Design Year 2030 (UEI 2010 Report)
	(MGD)	(MGD)
Annual Average Day Demand	2.2 to 2.3	2.9
Summer Average Day Demand	2.7 to 3.2	4.1
Maximum Day Demand	4.3 to 5.4	5.9

4.5. Maximum Demands and Conservation Measures

MVD's By-laws allow outside watering on odd/even days for respective customer addresses, to conserve water during high use and generally dry periods. In the summer of 2010, all wells (except Well #8) were operated continuously for 12 days due to high demands. A complete outside watering ban was needed to recover tank levels. The maximum daily demand that occurred was 5.32 MGD.

There have been subsequent periods of high demands though not as great as in 2010. In July 2013, Wells #2, #3, #4, and #5 ran continuously for 9 days but a ban was avoided.

Instances this year also illustrate the occasional stress on MVD's supplies. In June 2014, the largest well was out of service when a motor failure caused Well #2 to be shutdown for about 3 days. Tank levels reportedly declined, since other online sources were not able to keep up with demands. MVD avoided bringing Well #7 or Well #8 online due to water quality concerns but briefly opened the Pennichuck interconnection.

Subsequently Well #7 was in production for July and August 2014 to meet peak summer demands. A maximum daily demand of 4.7 MGD occurred on July 2, 2014, requiring continuous production from all active wells except Well #8. MVD's records show the Turkey Hill tank level declined to 11 feet (tank is full at 32 feet) during this period then recovered as water demands eased.

4.6. Wholesale Customers

MVD supplies water to two systems owned by PWW which are not connected to PWW's core system. The connections to these PWW systems are on Pearson Road and Taconic Drive. These systems have a combined average day demand of approximately 100,000 gpd (2010 Water Supply Update Report).

5. Supply Evaluation

5.1. Supply Evaluation Criteria

MVD's water supply facilities were evaluated based on:

- Capacity
- Quality
- Reliability/Condition

On October 18, 2010, the MVD Board of Commissioners adopted the following water supply capacity criteria recommended by UEI (Letter dated October 15, 2010) based on NHDES regulations:

1. Meet all current and future Summer Average Day Demands (ADD) and as much of the Maximum Day Demands (MDD) as economically practicable using only groundwater sources controlled by MVD.
2. Meet Maximum Day Demands (MDD) with all sources on 24 hrs/day.
3. Meet Summer Average Day Demands (ADD) with all sources on 24 hrs/day & largest well off (i.e. out of service).

Proposed level of service statements related to water supply quality and reliability are included in the Asset Management Plan, including:

- Maintaining aesthetically high quality water within Secondary Standards as much as possible.
- Allowing outside watering per odd/even day policy to meet demands while conserving peaks.

5.2. Existing Water Supply Sources

5.2.1. Overview

MVD’s normal sources of supply are sand and gravel pack wells located in three aquifers in the Towns of Merrimack and Hollis (Table 5-1). The location of each source is shown on the Distribution Map (Figure 1 in Appendix A). A detailed data sheet for each source is included in Appendix E.

Table 5-1. MVD Production Wells

Well	Aquifer	Year Installed	Status
Well #1	Naticook	1956	Decommissioned
Well #2	Naticook	1962	Active
Well #3	Naticook	1972	Active
Well #4	Merrimack - Merrimack River.	1956	Active
Well #5	Merrimack - Merrimack River.	1969	Active
Well #6	Witches Brook (South Merrimack)	1981	Inactive
Well #7	Witches Brook (South Merrimack)	1997	Active
Well #8	Witches Brook (South Merrimack)	1999	Active

5.2.2. Well #1

Well #1 is located near the MVD Warehouse off Continental Boulevard and is within the Naticook Brook Aquifer along with Wells #2 and #3. The well was discontinued from service in approximately 2004 or 2005 due to failure of the screen, and it has been permanently decommissioned.

5.2.3. Well #2

Well #2 located on Berry Lane is one of the best quality and is the highest producing of MVD's wells. The original well and pump house were constructed in approximately 1962. When the well packer was accidently damaged during pump re-installation in 1995, a new replacement well (#2A) was installed adjacently and the well house was expanded to house the new well pump. EGGI modeled the Naticook Brook Aquifer in which Wells #1, #2, and #3 are located and issued a report in May 1998. Per EGGI, the existing Well #2 screen is positioned near the bottom of the aquifer to have optimal access to the storage capacity in the Well #1/Well#2 area. Based on the recommendations of the report, at that time the Well #2 pump was replaced with a higher capacity pump at a lower depth to allow access to additional aquifer storage.

A variable frequency drive (VFD) was installed to control the Well #2 pump in 2001. When the VFD failed in approximately 2008, a new pump and soft start controls were installed. The current pump has a capacity of approximately 1,100 gpm, varying seasonally with changes in aquifer levels. This is less than the reported NHDES permitted production capacity of 1,500 gpm (2.16 MGD).

The 2010 Water Supply Evaluation Update by UE recommended hydrogeologic investigations and infrastructure improvements (pumps, piping, controls) to increase capacity. The lost volume from Well #1 of 400 gpm could be regained by increasing pumping from Well #2. The increased pumping rate would only be required infrequently to meet maximum day demands. The design would include a VFD to efficiently turn down the pumping rate to its current rate during normal operation. However, MVD has concern that increasing the production rate may negatively impact water quality by drawing in contaminants, particularly iron and manganese. Therefore, this recommendation has not been implemented.

5.2.4. Well #3

Well #3 is a highly productive well installed in approximately 1972 with a permitted production capacity of 800 gpm. The aquifer storage capacity that can be used for production depends on the minimum water level that is desired in Greens Pond, which recharges the aquifer. Well #3 was pumped at a rate as high as 1,100 gpm in 2009, a period which may have immediately followed cleaning.

There have been issues with iron and manganese in Well #3. Levels of iron and manganese initially declined following a rest period from approximately 1998 to 2000, but increased again when regular production was resumed. In recent years, MVD has limited operation of Well #3 when demands are lower in an effort to optimize water quality in the southern area.

There has been discussion of future Fe/Mn treatment for Well #3. A memo by UE dated October 22, 2008 evaluated central treatment for Wells #3, #7, and #8 compared to separate treatment facilities. UE determined the latter was more cost effective, and treatment for Wells #7 and #8 was a higher priority. Therefore, treatment for Well #3 is not currently being pursued.

5.2.5. Wells #4 and #5

Wells #4 and #5 are located off Front Street in the northeastern area of Town adjacent to the Merrimack River. Both wells draw from the Merrimack-Merrimack River aquifer which is a deposit spanning the River in North Merrimack and Litchfield. Well #4 was installed in 1956 for the Reeds Ferry Water District, which later merged with MVD. Well #5 was installed in 1969 a few hundred feet away from Well #4. The production from each well is combined and treated with facilities located at Well #5.

The capacity of Wells #4 and #5 were evaluated in a report by EGGI in December 2003. EGGI recommended the following limits to groundwater withdrawals:

- Annual: 220MGal/year or 600,000 gpd (420 gpm). This is the reported permitted production capacity.
- Maximum: 900,000 gpd (625 gpm) during short-term peak demand periods.

With current pumping capacities for Wells #4 and #5 at about 410 and 620 gpm, respectively, actual withdrawals have been possible in excess of the above limits when both wells are operated. The total withdrawal for 2013 was 273 million gallons (748,000 gpd average), and the maximum withdrawal was 1,180,000 gpd over a 7 day period in July 2013.

Over pumping of Wells #4 and #5 may have contributed to gradual lowering of the water table according to the long-term water level monitoring report issued by EGGI in January 2014. The report recommended monitoring water levels closely and maintaining the withdrawal cap of 220 million gallons per year. MVD has reportedly reduced withdrawals in 2014. One option being considered is to operate only Well #5, since its pumping capacity alone can reach the annual aquifer withdrawal limit.

Wells #4 and #5 are in regular use due to their high water quality. Iron and manganese are typically below detection limits. Nitrate is elevated in Well #4 (3.5 mg/L) but there is no indication of increasing results per EGGI, and levels remain below the MCL of 10 mg/L per.

The area around the well field along the Route 3 corridor has experienced continued residential and commercial development. The 2003 EGGI report delineated the Source Water Protection Area (SWPA) and recommended continued monitoring of development and water quality to protect this groundwater resource.

5.2.6. Well #6

Well #6 located in South Merrimack was installed in 1981 in the highly productive Witches Brook (South Merrimack) aquifer. This well has been offline since 1988 after it was contaminated with trace levels of volatile organic compounds (VOCs) from a former adjacent industry (Merrimack Industrial Metals). In addition, Well #6 has high concentrations of sodium and chloride, presumably from past salt storage near the well site. Past studies recommended aeration treatment to remove the VOCs but this was not pursued.

The option of blending water from Wells #6, #7, and #8 was investigated in previous reports by UEI. The goal was to dilute the sodium and chloride in Well #6 water and dilute the iron and manganese in Wells #7 and #8 water. Studies concluded blending may improve the overall quality of water but cannot increase the total capacity above 1,100 gpm without additional treatment (VOC's in Well #6 and/or iron and manganese in Wells #7 and #8).

Initial pumping tests for blending seemed to indicate VOCs are not drawn into Well #6 if it is pumped at rates at or below 600 gpm. Subsequent to these tests, NHDES conducted sampling for an emerging contaminant, 1,4-Dioxane, and detected it in nearby monitoring wells. The presence of this contaminant in the aquifer was confirmed during the 2010 blending investigations. 1,4-Dioxane is classified as a possible human carcinogen and is difficult and expensive to treat. The current NHDES ambient groundwater quality standard (AGQS) standard is 3.0 ug/L but a future standard of 0.35 ug/L may be set. A long term testing program conducted by EGGI (report dated January 2013) found Well #6 will continue to be impacted by the plume of Dioxane from the MIM site at levels of 0.5 to 0.95 ug/L. Blending or treatment would be required to maintain 1,4-Dioxane well below the AGQS.

MVD has instituted a no-tolerance policy towards VOCs and will not discharge water with detectable VOC levels into the distribution system. There are no plans in the near term to pursue bringing Well #6 online again.

5.2.7. Wells #7 and #8

Wells #7 and #8 are located in the Town of Hollis, just over the Town line in South Merrimack, and draw from the Witches Brook aquifer. Well #7 (500 gpm) came on line in 1997 followed by Well #8 (750 gpm) in 1999. The combined production from each well is treated by chemical addition facilities at Well #7. Although these wells have reliable capacity, there have been long running issues with iron and manganese levels above secondary standards that have limited their use. Well #7 is typically only operated during higher summertime demand periods, and Well #8 has not been operated since 2007.

In response to complaints from customers in the southern part of the system, MVD committed to improving water quality from supplies in that area, particularly Wells #7 and #8. Blending studies for Wells #6, #7, and #8 were conducted by UE as described above. A design was prepared but not implemented due to the subsequent detection of Dioxane in Well #6.

MVD elected to pursue design and construction of an iron and manganese treatment facility for Wells #7 and #8 as recommended by the "Water Supply Evaluation Update" report prepared by UE (December 2010). A design was completed and bid in 2014, and construction is anticipated to be substantially complete in early 2016.

A Basis of Design report prepared by UE (April 2013) recommended designing the plant for the combined permitted production volume of 1,250 gpm for Wells #7 and #8. The design includes provisions for future expansion to treat possible new sources (up to 600 gpm additional or 1,850 gpm total). A pressure filtration treatment method will be used. An oxidant (sodium hypochlorite) will be fed ahead of the filters to precipitate iron and manganese, which are then captured on the filter media.

The existing well house at Well #7 houses pumping and treatment facilities. Controls for the lime feed system were relocated to the upper level following an injector blowout and flood a few years ago. The pump discharge is throttled to about 470 gpm to avoid overloading the existing 50HP motor, which is reportedly undersized. The Well #8 well house has only limited space for pumping equipment (75 HP) and a tablet chlorinator (not used). Upgrades including new well pumps and VFDs will be installed as part of the water treatment plant improvements.

5.2.8. Emergency Power

The MVD facilities previously lacked emergency power in the event that normal utility power was down, except for the engine driven pump at Well #3. MVD reports that demands decrease during power outages, and experience shows they have been able to supply the system from storage during extended outages. To improve reliability, MVD recently acquired a 230 KW diesel generator mounted on a trailer for mobility. It is capable of powering any single well facility. The wells and the Turkey Hill booster station are equipped with manual switches or breakers to allow connection of the generator. In addition, the treatment plant project includes two new generators: one for the treatment plant and one to power Wells #7 and #8.

5.2.9. PWW Connection

MVD has an interconnection with Pennichuck Water Works (PWW) located on Route 101A in the southern area of Merrimack. The original formal agreement between MVD and PWW allowed MVD to use up to 1.0 MGD. We understand PWW considers this agreement void, but will sell water to MVD at the current volumetric rate upon written request. MVD currently uses this connection for a brief period annually during water main flushing.

In light of the MVD water supply criterion that demands be met using MVD-controlled groundwater sources where economically practical, the PWW connection has not been counted toward MVD's water supply capacity. In addition, PWW cannot guarantee supply without a long-term agreement. However, the PWW interconnection is available for emergencies.

The PWW hydraulic gradeline at the connection is close to MVD's hydraulic gradeline, depending on tank levels. When the MVD wells in the south are operating, MVD's pressure reportedly rises too high for flow to be possible from the PWW connection.

5.2.10. MWW Connection

The connection with Manchester Water Works (MWW) is on Route 3 in Merrimack just south of the Bedford/Merrimack town line. This is an emergency connection and is not intended to act as an additional supply source. The current agreement limits usage to ten consecutive days or less else a significant system development charge must be paid. Another limitation of this source is that chloramines used as a secondary disinfectant by MWW would impact the MVD distribution system. Finally, the hydraulic gradeline of MWW is lower than MVD's hydraulic gradeline so pumping would be necessary to supply MVD from MWW. A more feasible use of this connection would for MVD to supply MWW in an emergency.

5.3. Water Supply Capacity Evaluation

5.3.1. Existing Capacity

The existing well capacities are summarized in Table 5-2 based on the 2010 UEI Report with certain clarifications noted for Wells #7 and #8. Total capacity is 5.4 MGD based on the approved sustainable yields reported by EGGI. However, current capacity is limited at some sources as noted below.

Table 5-2. Existing Groundwater Supply Capacity

Well	Notes	Capacity (Sustained Yield) (gpm)
Well #2	*Active* – Approved by NHDES for 1,500 gpm. Limited to 1,100 gpm by existing pump and MVD policy.	1,100
Well #3	*Active* – Has had Fe & Mn issues in the past	800
Wells #4 & #5	*Both Active* – Wells are pumped through a common station for treatment. Aquifer capacity is 625 gpm. Pumps capable of over 800 gpm combined.	625
Well #6	*Inactive* – Original capacity was 1,400 gpm. Not used due to VOC contamination	0
Well #7	*Active* – Fe and Mn issues; used only when necessary. Limited to 470 gpm by existing motor horsepower.	500
Well #8	*Active* - Treated commonly at Well #7 station. Effective existing capacity is zero due to Fe and Mn issues.	750
Total Capacity		**3,775 gpm (5.44 MGD)**

Note: The 2010 Supply report assumed 1,100 gpm for Wells #7 & #8 combined.

The 2014 Sanitary Survey by NHDES lists the pumping capacity in gpm for each source. We note the pumping rate at some wells is higher than the reported sustainable yield.

5.3.2. Supply Capacity Needed

The total available supply capacity to meet design demands in Section 4 is summarized in Table 5-3 and illustrated in Figures 5-1 and 5-2. We note the following when available supply capacity is compared to demands:

- Existing capacity with the largest well out of service (Well #2) meets existing summer ADF, but this assumes Well #8 is operated.
- Existing pump limitations and water quality constraints with Wells #7 and #8 limit what can be feasibly produced to about 4.3 MGD.
- The new Fe/Mn treatment plan will correct the issues at Wells #7 and #8 and provide capacity to meet current design flows when online (anticipated 2016).
- ***Additional supply of about 350 gpm (0.5 MGD) is needed to meet future design flows***.

Table 5-3. Current and Future Groundwater Supply Capacity and Requirements.

	Existing Capacity[1] (MGD)	Current Summer Demands (MGD)	Design Year 2030 Demands (MGD)
Capacity to Meet **Average Day Demand** (largest well off)[2]	3.85	3.2	4.1
Capacity to Meet **Maximum Day Demand** (all wells on)	5.44	4.3 to 5.4	5.9

Notes:

1. Existing capacity assumes new Fe/Mn Treatment Plan online
2. The largest producing well is considered to be Well #2 at 1,100 gpm.

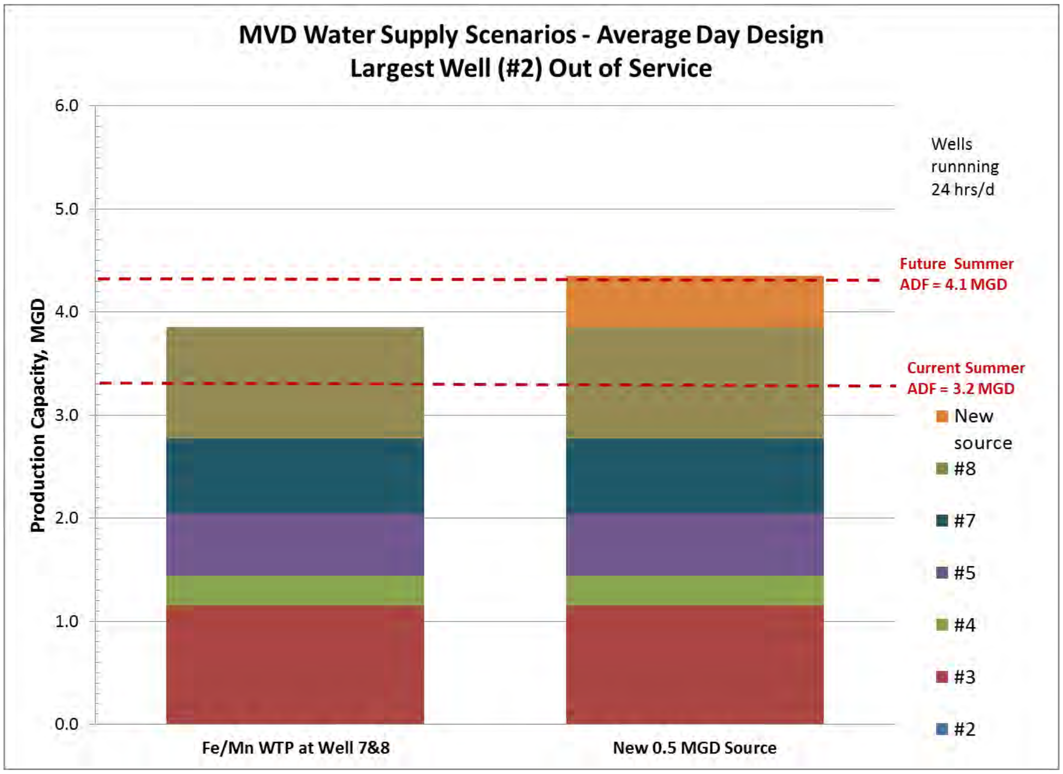

Figure 5-1. Supply Capacity Scenarios for Average Daily Flow

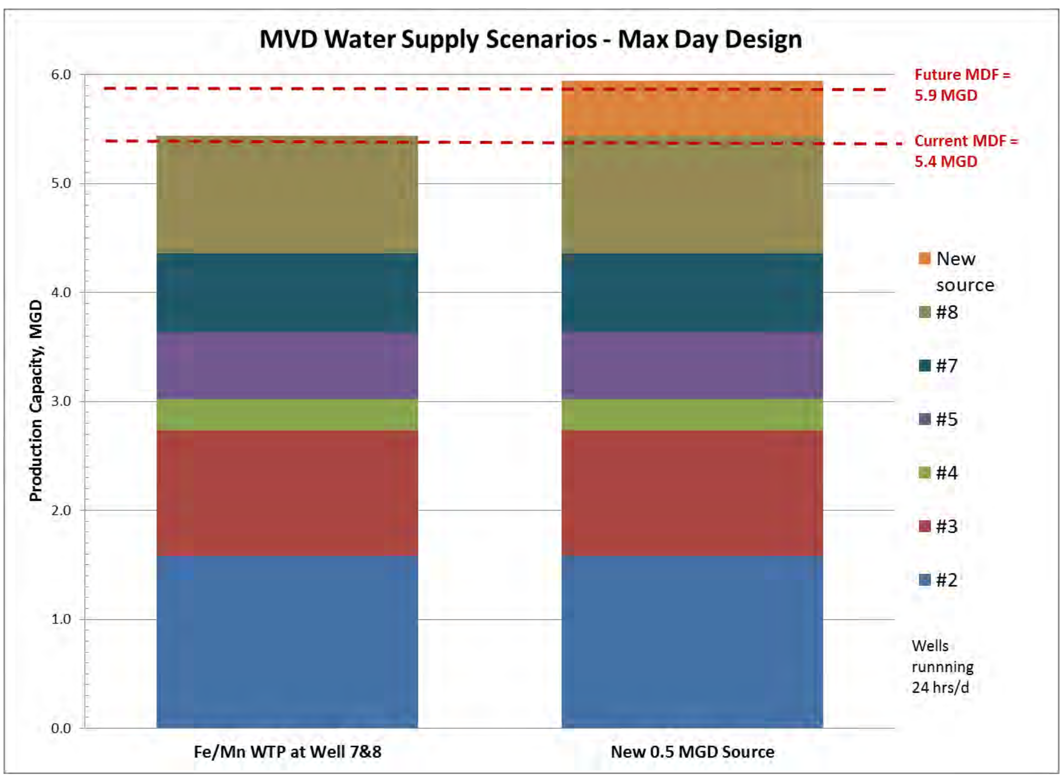

Figure 5-2. Supply Capacity Scenarios for Maximum Daily Flow

5.4. Water Quality

5.4.1. Existing Water Quality and Compliance

The MVD's groundwater is fairly typical of New Hampshire with low pH, alkalinity and hardness. The overall reputation for the MVD water supply is good quality, cold groundwater with minimal taste or odor issues. The exception is in the south area of town there have been colored water complaints when Well #3, Well #7 or Well #8 must be operated to meet demands. These wells typically exceed the secondary maximum contaminant limits for iron and manganese.

Average water quality data for each active source is summarized in Appendix C. Water quality monitoring records indicate the system is in general compliance with current water quality standards including bacteria monitoring and action levels for lead and copper. Regular system flushing had been practiced since 2005 or 2006 to maintain distribution quality.

5.4.2. Iron and Manganese

Graphs showing iron and manganese levels in Wells #3, #7, and #8 are included in Appendix C. Well #3 and Well #7 appear to show trends of increasing concentrations of iron and manganese generally corresponding to the operation of these wells. The more recent iron and manganese levels in Well #8 show a decline from the peaks seen when Well #8 was in production. Levels would be expected to rise again if Well #8 was placed back in service.

5.4.3. Sodium and Chloride Loading

Sodium chloride loading in the three well head protection areas was evaluated by EGGI (final report dated May 2012). Salt levels have trended upward in each WHPA over the past decade, primarily due to salt application to roads and parking lots for deicing. Two of MVD's production wells (#3 and #5) have exceeded the NHDES SMCL for chloride of 250 mg/L.

A detailed Mitigation Plan was developed by EGGI, including installing conductivity dataloggers for online monitoring. This recommendation has not yet been implemented. The dataloggers are needed to measure the variations in sodium and chloride levels which may occur between limited current sampling events.

5.4.4. 1,4 Dioxane

MVD's active wells were sampled for the emerging contaminant 1,4-Dioxane in 2011. Dioxane was detected in Well #2 at a concentration of 0.31 ug/L, just below the proposed drinking water standard of 0.35 ug/L. That prompted additional investigations by EGGI (letter reported November 13, 2013). Monitoring wells were installed down gradient of specific industries along Continental Boulevard where chlorinated solvents that contain Dioxane might have been used. Fortunately, no Dioxane or VOC's were detected in samples from the wells. EGGI recommended future low level Dioxane and VOC sampling testing when evaluating the feasibility of increasing the pumping rate for Well #2. Protecting MVD's supplies against Dioxane is critical because it is very difficult to treat.

5.5. Water Treatment

Each well source is treated with calcium hypochlorite or sodium hypochlorite for disinfection, lime for pH adjustment and corrosion control, and poly-orthophosphate for sequestering and corrosion control. Treatment is provided directly at the wellheads for Well #2, Well #3, Well #5, and Well #7. Well #4 flow is treated at the pump house for Well #5. There are facilities at Well #8 to treat with poly-orthophosphate and disinfectant, and lime is added at Well #7. With the construction of the new treatment facility, the chemical treatment for Well #7 and Well #8 will be modified.

Tablet chlorinators using calcium hypochlorite are used at Wells #2, #3, and #5. Well #7 is disinfected with sodium hypochlorite. When Well #8 has been disinfected at the wellhead in the past, there is reportedly no residual left by the time flow reaches Well #7 due to the iron and manganese demand.

The lime stations at Wells #2, #3, and #5 are in separate buildings from the well houses and are are nearly identical facilities, including storage, mixing, and feeding equipment. The lime station at Well #7 is located in the lower level of the pump house. The lime station at Well #6 is not in service, and parts have been removed for use at other stations. A lime de-scale agent is added to the lime batch tanks to help maintain a lime slurry flow.

Lime dust and increased labor for maintenance are typical concerns with lime treatment. MVD is one of the few water systems in NH using lime for treatment of well water according to NHDES, but the District has used this method successfully since about 1988. This can be attributed to the diligence of MVD's operators to maintaining the systems.

Concerns with the existing lime stations include:

- Existing precast concrete structures are deteriorated.
- Existing equipment, controls, and instrumentation are aged.
- Chemical storage and working space is inadequate except at Well #7.
- The lower levels of the lime stations (#2, #3, #5) have confined spaces and limited access.

5.6. Water Supply Operation

Management and operation of the wells is based on seasonal demands and water quality. A timeline of historical operation for each well is shown in Figure 5-3. Based on operating history and discussion with the treatment supervisor, we note the following:

- Wells #2, #4, and #5, the best quality wells, are generally operated year round.
- Well #3 and Well #7 are operated during the summer time to meet increased demands but have higher iron and manganese levels. One or both of these sources are shutdown in winter to improve water quality.

- Well #7 has been used every summer to meet increased demands, except 2009 and 2013.
- Well #3 was shut down in the winter of 2011/2012, instead of Well #7, since it had higher levels of iron and manganese than Well #7.
- Well #8 water quality is so poor it has not been operated since 2007 except in standby.
- Winter time demands in 2012/2013 and 2013/2014 (2.0 to 2.8 MGD) were met by running only the best quality wells, with both Wells #3 and #7 shut down. However, there may have been over pumping of Wells #4 and #5.
- Historically, chlorine residuals could not be maintained in the south area without running either Well #3 or Well #7 to serve the area directly. MVD has found with additional flushing of the south area in the fall, to reduce chlorine demand caused by iron and manganese, they can maintain residuals and feed with only Well #2.

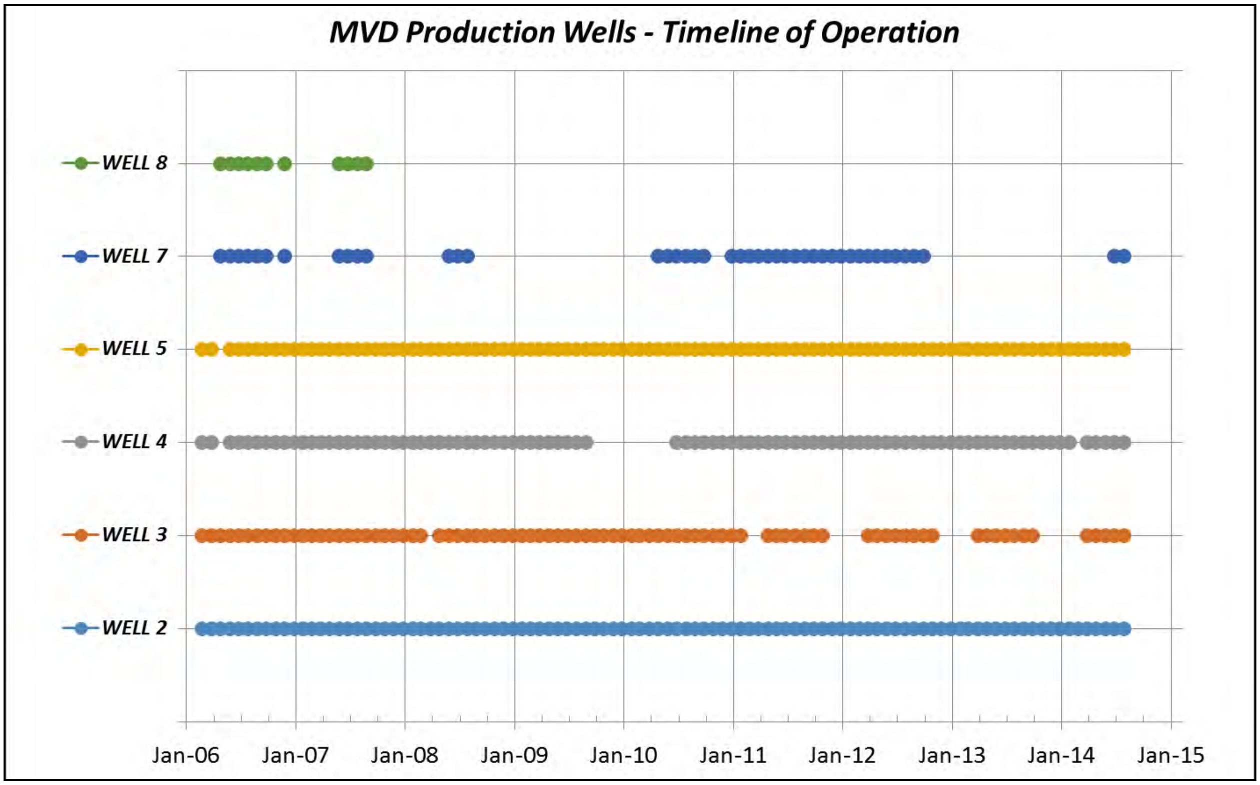

Figure 5-3. Timeline of Operation for MVD Production Wells

5.7. Production Well Management

Water quality generally improves in MVD's production wells after they are rested. Water production rates vary seasonally with aquifer levels. When the aquifer levels are higher, the pump head is lower and a greater flow rate is possible for a given pump speed. Well yield tends to decline with usage until the well is cleaned or surged. Cleaning of each well is generally targeted for every 5 to 7 years, depending on the need for other maintenance.

MVD has implemented practices to improve aquifer management. For about the past 10 years, drawdown levels have been monitored by manually sounding the level in adjacent monitoring wells adjacent to each production well every one to two weeks. In addition, a total of 12 automatic water level recorders have been installed since 2011 in close proximity to the seven MVD production wells, additional observation wells, and Greens Pond (near MVD-3).

Data from 2012 showed groundwater levels are generally highest during the spring, declining steadily with summer demands until late summer/early fall rain events, along with lower demands, allowed aquifers to recharge. The most recent report issued by EGGI in January 2014 indicated the MVD production wells are currently operating on a sustainable basis and that groundwater levels within the aquifers recover seasonally. However, additional monitoring is required to evaluate if the current withdrawals from Well #4 and Well #5 exceed available annual recharge. EGGI reiterated its recommended withdrawal cap of 220Mgal (0.6 MGD) from these wells.

5.8. Water Quality Improvements

Based on our review of current operation, we note:

- The new Well #7/#8 Fe/Mn Treatment Plant will reduce the need to pump Wells #2, #4, and #5 at maximum rates to meet summer demands with high quality sources.
- Well #3 is needed to meet maximum demands but has water quality issues.
- Further evaluation is needed to determine if blending of Well #3 water with treated water from Wells #7 and #8 will lower iron and manganese concentrations sufficiently for all users.
- ***Future treatment at Well #3 (or development of an additional high quality source) may be needed to provide enough high water quality to meet maximum demands.***

5.9. Alternatives for Additional Supply

Past groundwater investigations by EGGI have indicated there is little potential left in Merrimack to develop new high-yielding wells in sand and gravel deposits. Recent studies have concentrated on fractured bedrock aquifers and remaining potential sand and gravel aquifers in Merrimack and neighboring communities. Based on the 2010 Water Supply Update report by UE and recent information from EGGI, alternatives for additional supply are summarized in Table 5-4 and located as shown on Figure 2 (Appendix A).

Table 5-4. Summary of Additional Supply Alternatives.

Water Supply Option	Water Quality	Potential Capacity	Remarks
Treatment Plant for Wells #7 & #8	Iron and manganese removal will provide high quality water	1,250 gpm, expandable in future	Under construction, expected online early 2016
Increase Capacity Well #2	Good quality	400 gpm additional	On hold due to MVD concerns for impacting water quality
Mitchell Woods Well (sand and gravel aquifer)	Good quality	300 gpm (0.432 MGD) 45 MGal/year per pump test	Conditionally approved by DES. Land control and long term monitoring program required. Would supply high pressure zone
Bean Road Well (fractured bedrock)	Good quality	100 – 125 gpm sustained, 150 gpm maximum per EGGI	Preliminary report by EGGI in 2009. Not cost effective per 2010 UE report. Would supply high pressure zone.
Nashua Source (sand and gravel aquifer)	Need more testing to confirm quality. Risk due to proximity to contaminated MIM site.	300 gpm	City of Nashua and PWW oppose. Not feasible without land rights. MVD not pursuing.
Hollis Source (sand and gravel)	Possible high Fe/Mn would require expansion of treatment plant	300 to 400 gpm or possibly higher?	Proposed 8" test well and pump test pending property negotiations
Purchase from Pennichuck Water Works.	Surface water treated to standards. Past complaints of taste and odor.	Assume 700 gpm (1.0 MGD)	Not owned or controlled by MVD. Considered emergency source only.
Well #6 (inactive)	1, 4 dioxane contamination; high Sodium chloride	600 gpm	Treatment required. MVD not currently pursuing.

5.10. Supply Improvements

Projects identified for supply and treatment improvements are summarized in Table 5-5.

Table 5-5. Supply Improvements Projects.

Project	Description
New Groundwater Source(s)	• Land acquisition/easements. • Preliminary and final well siting approvals. • Design and construction of well house, controls, and piping connection to system. • Treatment improvements, if necessary (e.g. expand Well#7/8 WTP).
Well #2 Upgrade	• Increase production capacity to 1,500 gpm. • Pump, controls, piping upgrade. • Hydrogeological and water quality evaluations.
Well #3 Treatment	• Iron and manganese treatment facility similar to the plant under construction for Wells #7 and #8.
Lime Stations Upgrade	• Evaluate replacement or refurbishment of stations. • Evaluate replacement with other treatment options. • New equipment and structures to adequately store and feed treatment chemicals at Wells #2, #3, #5. • Upgrade system at Well #7 if not done under treatment plant project.
Well Monitoring	• Installation of access tubes in each production well when pumps are removed for maintenance. • Instrumentation including transducers, data loggers, and SCADA connections. • Conductivity dataloggers to monitor salt loading.
Other Supply Improvements	• Provide surge controls where Parco valves have been discontinued or soft starts do not ramp down (e.g. VFDs, relief valves). • Replacement of aging chlorinators as needed. • Well #3 gate widening for chemical deliveries.
Supply Management	• Develop and update a comprehensive well management plan for all sources.

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6. Distribution System Evaluation

6.1. Introduction

MVD owns and operates approximately 877,000 LF (166 miles) of water main with diameters of 4 to 20 inches (See Figure 1, Appendix A). Asbestos cement (AC) pipe was the primary material used for distribution piping from approximately 1956 to 1979. Newer mains are constructed of primarily ductile iron (DI) pipe, with some polyvinyl chloride (PVC) installed in the 1990's.

Recent improvements focused on reducing the hydraulic "bottleneck" between the supply sources in the south and the demand areas in the north. Projects constructed in 2010 to 2012 include approximately 17,000 LF of 16" ductile iron water main on Continental Boulevard, Camp Sargent Road, and Turkey Hill Road and approximately 7,700 LF of 16" ductile iron water main at the Merrimack Premium Outlets to create a loop (Distribution CIP Report, UE 2012). MVD also participated in the Town's Turkey Hill Bridge replacement project to replace the two 16" water main crossings.

6.2. Distribution System Inventory

A general inventory and review of the distribution system for capital planning purposes was performed by UE in 2012. Since the 2012 report, MVD has continued to update distribution information in the GIS database, including estimated pipe installation dates. The current inventory of pipes in the MVD distribution system are summarized by material, diameter, and age in Tables 6-1, 6-2, and 6-3, respectively.

Table 6-1. Water Mains Summarized by Material

Material	Length (Feet)	Percent of System	Installation Period Approximate
AC	368,061	42.0%	1950's to 1970's
CI	2,685	0.3%	1970's
DI	307,495	35.1%	1980's to present
PVC	117,412	13.4%	1990's
Unknown	81,057	9.2%	-
Total	**876,959**	**100%**	**-**

Table 6-2. Water Mains Summarized by Size

Size	Length (Feet)	Percent of System
2"	22,601	2.6%
4"	5,608	0.6%
6"	122,513	14.0%
8"	397,966	45.4%
10"	17,709	2.0%
12"	235,873	26.9%
16"	51,535	5.8%
20"	18,944	2.2%
24"	61	0.0%
Unknown	4,550	0.5%
Total	**876,959**	-

Table 6-3. Water Mains Summarized by Age

Decade	Length (Feet)	Percent	Primary Material
1950's	31,327	3.6%	AC
1960's	88,178	10.1%	AC
1970's	259,378	29.6%	AC / DI
1980's	245,790	28.0%	DI
1990's	87,253	9.9%	PVC
2000's	125,962	14.4%	DI / PVC
2010's	27,829	3.2%	DI
Unknown	11,241	1.3%	-
Total	**876,959**	**100%**	**-**

6.3. Distribution Evaluation Criteria

MVD's distribution system was evaluated based on:

- Condition and reliability
- Hydraulic capacity for design demands and fire flow

6.4. Distribution System Condition

MVD's existing distribution system is generally in good condition with no significant break history or hydraulic issues. The mains are relatively new compared to systems in some other New Hampshire communities.

Asbestos cement (AC) pipe represents a significant portion of the system (about 40%). AC pipe was extensively used in the US in the mid 1900's but phased out of production in the 1970's.

AC pipe's advantages are its resistant to corrosion, light weight for handling, and low cost. However, it is more prone to breakage due to its brittle nature and working with asbestos dust is a potential health hazard. AC pipe may undergo gradual degradation over time depending on potable water chemistry and soil conditions.

A general schedule and financial plan for future replacement of mains as they reach end of life is provided in the Asset Management Plan. The oldest sections of AC main are assumed to have a replacement cycle beginning in 2020 to 2030, based on a 70 year estimated life. The actual useful life will depend on future monitoring and experience.

Ductile iron (DI) is used for new mains constructed by the District, in accordance with modern industry standards, due to its high strength, durability, and corrosion resistance. Polyvinyl chloride (PVC) and high density polyethylene (HDPE) are acceptable alternatives if proper installation procedures are followed.

One concern noted by MVD personnel is the existence of parallel mains on certain sections of Route 3 (D. W. Highway) and Baboosic Lake Road. Water quality and maintenance issues are reportedly associated with these redundant mains. Correction would include hydraulic evaluation, relocating service connections, and eliminating unnecessary mains and "dogleg" connections.

6.5. GIS System

6.5.1. Existing GIS System

MVD has been working for several years to create and update a geographic information system (GIS) database of their water system. The GIS database was developed in the ArcGIS software platform (ESRI) building off the Town of Merrimack's GIS base mapping with the assistance of the Nashua Regional Planning Commission. MVD's GIS is now maintained by MVD staff. MVD owns two stand-alone licenses for ArcGIS for Desktop Basic (formerly ArcView) which provides geographic data mapping and editing capabilities.

MVD's GIS database includes water mains, hydrants, valves, curb stops, service laterals, and meter pits. Scanned documents are being added such as tie cards and record drawings.

6.5.2. GIS Improvements

Suggested GIS improvements based on discussion with MVD staff include:

- Central, server based storage of GIS database to improve sharing and data backup capabilities.
- Link customer information such as account numbers, addresses, and phone numbers that is currently available only through MVD's billing software.
- Combine the over 3,000 pipe elements into logical segments between isolation valves or fittings.
- Provide more GIS training for MVD staff.

6.6. Hydraulic Model

6.6.1. Existing Hydraulic Model

MVD's hydraulic computer model is an important tool for analyzing the performance of the distribution system under existing and alternative scenarios. For the model to accurately simulate the system the pipe data must be correct and calibrated. The original model in WaterCAD Version 7 (Haestad Methods, acquired by Bentley) was set up by Prism Environmental in approximately 2004. The model calibration was checked by UE using limited field flow testing in 2007 and minor corrections were made. The model was also updated by UE for distribution improvements constructed in 2010 to 2012. The current model is adequate for general evaluations but still has significant limitations.

6.6.1. Hydraulic Model Improvements

Creating a new hydraulic model in the latest WaterCAD version is recommended. Conversion tools are available to develop the water model from the current GIS database. As future updates are made to the GIS database they should be done concurrently to the model. Alternatively, the model can be linked to the GIS database, but this may add unnecessary complication. Additional field flow testing should be performed to verify the model calibration. The updated model will facilitate future evaluations such as additional supply sources, new booster station locations, or proposed development.

The model should be updated as follows:

- Upgrade to current software Version 8i.
- Provide an accurate base or background map (none currently available).
- Draw to scale with current MVD/Town base mapping (existing is not scaled).
- Add smaller water mains not included in current model.
- Update pipe inventory to correspond with the current GIS database.
- Update pump curves in model to accurately reflect existing production well pumps.
- Obtain additional calibration data to confirm friction coefficients.

6.7. Hydraulic Analysis

The hydraulic model was run under various scenarios for general system evaluations as follows.

6.7.1. Pressure Analysis

System wide pressures were analyzed under the following conditions:

- Active storage tank levels: 5 feet below overflow elevation.
- Demands: Design MDF
- Supply: Production Wells off.

Model results are shown color coded in Figure A, Appendix D:

- System pressure typically meets the standard of 45 to 80 psi at almost all locations.
- The lowest pressure location is at the top of Lamson Drive (40 psi).

- At locations near the Premium Outlets, Belmont Drive, and the Hutchinson Tank, pressures range 40 to 42 psi.
- High pressures above 80 to 100 psi exist along portions of DW Highway and the south end of the High Pressure Zone (HPZ). Services at these locations should have pressure reducing valves if not currently installed.

6.7.2. Fire Flow Analysis

Available fire flows were analyzed under the following conditions.

- Active storage tank levels: 5 feet below overflow elevation.
- Demands: summer ADF
- Supply: Wells #1, #2, #5, #7 in operation.
- Residual pressure: 20 psi minimum at any location

Model results are shown color coded in Figure B, Appendix D:

- Available fire flows in the Main Pressure Zone (MPZ) are greater than 5,000 gpm at most locations.
- The north end of D.W. Highway has available fire flows of 2,000 to 3,000 gpm.
- The Route 101A area has available fire flows of 3,000 to 4,000 gpm.
- The northern HPZ area has fire flows of 2,000 to 3,000 gpm
- The southern HPZ area has fire flows of 1,000 to 2,000 gpm
- All locations appear above ISO residential minimum fire flows of 500 to 1,500 gpm depending on spacing between homes.

The most recent survey (October 2005) by Insurance Services Office (ISO) indicates needed and available fire flows. Note that needed fire flows greater than 3,500 gpm are not considered by ISO in determining the Public Protection Classification (PPC). Buildings needing greater than 3,500 gpm or protected by automatic sprinkler systems are individually graded by ISO.

In general, the water system scored well in the 2005 ISO survey (actual score = 35.2%, maximum possible = 40.0 %). Available fire flows today should be higher in some locations due to the distribution improvements completed after the 2005 survey. A new survey is expected in 2015.

The highest needed fire flows were at commercial locations (Table 6-4). At most locations, predicted available fire flows exceed the ISO available flows and meet the needed ISO flows. Additional field testing is needed to confirm the calibration of the current model and actual available fire flows. Some locations may be more limited by existing hydrant spacing than by the capacity of the water mains.

Table 6-4. Highest Needed Fire Flows per 2005 ISO Survey

ISO Test No.	Test Location	ISO Flow needed (gpm)	ISO Flow available (GPM)	Model predicted fire flow (gpm)
1	Elm @ D.W. Highway	9.000	3,900	>5,000
2	D.W. Highway @ Crosswoods Path Blvd.	6,000	**3,300**	**2,970**
3	Lyons Rd @ Pearson	3,000	**2,400**	4,620
7	O'Gara Dr. @ High School	5,000	**1,700**	>5,000
8	Railroad Ave. @ D.W. Highway	4,500	**2,200**	> 5,000
10	Baboosic Lake Rd @ Church	5,000	4,200	> 5,000
11	Camp Sargent @ Castleton	3,000	**2,300**	4,080

Notes:

1. Model predictions are at nearest model node to actual location.
2. Needed fire flows greater than 3,500 gpm are not considered in the rating score.
3. Predicted fire flows greater than 5,000 gpm are not shown since actual fire flows depend on type and quantity of hydrants available.
4. Bold indicates needed fire flow not met.

6.7.3. Hydraulic Capacity

Hydraulic capacity was analyzed under the following conditions.

- Active storage tank levels: 5 feet below overflow elevation.
- Demands: summer ADF
- Supply: Wells #1, #2, #5, #7, #8 plus a future south source in operation (1,850 gpm total from south assuming expanded water treatment plant).

Model results are color coded for hydraulic gradient (headloss per unit length) in Figure C (Appendix D):

- Well #7/#8 discharge line (2,500 LF) and 12 inch AC section on Turkey Hill Road (3,000 LF) are more limiting. This section on Turkey Hill Road, between the intersections with Summit Drive and Chamberlain, was not prioritized previously because it has a parallel loop.
- Certain sections along DW Highway between Greely Street and Woodbury Street are more limiting (6,000 LF). These probably also limit available fire flows.
- Transmission capacity is available for a total flow from south supplies of 1,850 gpm with a maximum pressure of about 94 psi at Route 101A.

These results correspond findings in the Summary of Hydraulics Improvements letter report by UE dated December 19, 2012. That report concluded the 16 inch DI water main improvements constructed in 2010 to 2012 in the Continental Boulevard and Turkey Hill Road areas sufficiently reduced the hydraulic "bottleneck".

6.8. Town Highway Projects

Based on the Town's highway capital improvements plan, the following projects may impact the existing water system (see Figure 3, Appendix A):

- Bridge Replacement - Bedford Road/Baboosic Brook - 2014/15
- Wire Road intersection - 2014/15
- Turkey Hill Road/Baboosic Road Intersection - 2014/15
- Sunset Shores Sewer Extension - 2014/15. MVD is considering extending water mains as part of this project near Naticook Lake on Sunset Dr, Dawn Ave, and High Noon Rd.
- McGaw Bridge Road - 2016/17 or may be earlier
- Paving - Schedule is determined each spring depending on available funds.

Planning water improvements where needed in conjunction with Town projects is more cost effective and "digs the street" once.

6.9. Potential Areas of Expansion

Most of the Town is currently served, and areas for consideration of expansion are limited. The following are identified at this time:

- Proposed Blood Road subdivision: MVD is requiring the developer to construct an 8 inch loop from Madeline Drive to Wilson Hill Road to serve approximately 75 homes.
- Proposed FW Webb Warehouse: 1,000,000 SF warehouse proposed off Route 3, which is currently served by a single 12 inch main. MVD intends to evaluate looping options to increase reliability of service.

6.10. Distribution Improvements

Based on our review, the following distribution improvements are summarized (See Figure 3, Appendix A):

- Evaluate distribution improvements in conjunction with near term Town road projects.
- As future supply sources are refined, evaluate the need for hydraulic improvements.
- Plan for improvements to the most hydraulically limiting sections of main first, if necessary to support additional supply or fire flows.
- Plan for elimination of redundant parallel mains including those on Route 3 and Baboosic Lake Road.

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7. Water Storage Evaluation

7.1. Existing Storage

MVD owns, operates, and maintains three water storage facilities (Table 7-1). Currently only the Hutchinson and Turkey Hill Tanks are in use.

Table 7-1. Water Storage Facility Summary.

Tank	Pressure Zone	Cap. (Mgal)	HGL (overflow, ft. MSL)	Type	Year Built	Diameter	Height
Turkey Hill Tank	MPZ	4.0	391'	Pre-stressed Concrete	1978	150'	32'
Hutchinson Tank	HPZ	1.0	538'	Welded Steel	1987	58'	53.6'
Lake Road Tank	HPZ	0.75	538'	Fluted Steel Elevated	1988	64'	53'

7.2. Storage Evaluation Criteria

The purposes of water storage include:

- Maintenance of stable pressure in the water system.
- Equalization of constant source production rates with varying water demands by allowing tanks to drain and fill.
- Provision of water for fire suppression.
- Provision of water for emergencies such as power outages and water main breaks.

The hydraulic gradeline, capacity, and condition of MVD's storage tanks are evaluated in the following sections.

7.3. Hydraulic Gradeline Review

The hydraulic gradeline (HGL) established by storage tank level maintains water pressure in the system depending on the elevation at each service location. The recommended range for operating pressure is typically 35 psi to 80 psi, with pressure no less than 20 psi under all conditions. HGLs and static service pressures are summarized in Table 7-2 and Figure 4 (Appendix A). Static service pressures were calculated using tank overflow elevations. Actual static pressures range a few psi lower depending on the daily variation in tank levels.

Table 7-2. Hydraulic Grade Lines (HGLs) and Service Pressure Summary

	HGL (Tank Overflow) (ft. AMSL)	Service Elevation Range (ft. AMSL)	Static Pressure Range
Main Pressure Zone (MPZ)	391’	120’ to 295’	42 to 117 psi
High Pressure Zone (HPZ)	538’	200’ to 440’	42 to 146 psi

The following can be concluded regarding tank elevations and HGLs:

1. Existing minimum static pressures are adequate (above the 35 psi minimum recommended).
2. Existing maximum static pressures exceed recommended standards at some locations. Individual pressure reducing valves (PRVs) are reportedly installed at some services.
3. The entire storage volume in the Hutchinson and Turkey Hill Tanks is considered “useable” storage because the base elevations of both tanks are high enough to provide 20 psi at the highest service elevation.

7.4. Storage Capacity Evaluation

The total system storage requirement described in AWWA Manual of Practice M32 is the sum of equalization storage, fire suppression storage, and emergency storage. Underwood Engineers calculated the required storage for each pressure zone under current and future Summer Average Daily Flow (ADF) conditions of 3.2 and 4.1 MGD, respectively. The High Pressure Zone summer demand is an average of 20% of total demands based on Turkey Hill Booster Station pumping records for 2010 to 2013.

7.4.1. Equalization Storage

Equalization Storage is the storage needed to meet system demands in excess of the delivery capability of the water supply system. While supply systems are typically designed to provide up to the maximum daily flow rate, water storage facilities provide additional water to meet peak demands. For a high pressure zone within a larger system, a booster pump station is needed to fill the tank. The booster pumps are commonly sized to meet the maximum day demand of the pressure zone, and the tank’s equalization volume is used to meet peak demands. Typical values of equalization storage are 20% of average daily demand.

7.4.2. Fire Protection Storage

Fire Protection Storage was evaluated based on Insurance Services Office (ISO) recommendations, per the latest ISO survey dated October 2005. The maximum fire flow ISO considers in determining the public fire protection classification is 3,500 gpm for 3 hours. Therefore, for the purpose of this evaluation, the MPZ is assumed to require 630,000 gal (3,500 gpm x 3 hours) for fire protection storage.

For flow rates above 3,500 gpm, ISO recommends 4 hours of storage at the recommended flow rate. The highest rate identified in the 2005 ISO survey of 9,000 gpm requires 2,160,000 gallons of storage. Although MVD is not required to, this can be met from available emergency storage in the Main Pressure Zone (see below). A proposed one million square foot warehouse on D.W. Highway may require re-evaluation of fire protection requirements.

The highest fire flow for the HPZ listed in the ISO survey is 500 gpm. For planning purposes, we assumed a maximum residential fire flow of 1,500 gpm which corresponds to 180,000 gallons recommended fire protection storage (1,500 gpm x 2 hours).

7.4.3. Emergency Storage

Emergency Storage is intended to provide water during instances such as power outages, water main breaks, and unexpected equipment failures. The amount of emergency storage required is a judgment of perceived vulnerability of the system. MVD has multiple supply sources in different aquifers with backup power; therefore, a system failure that impacts all supply sources from providing water is unlikely. In addition, the PWW emergency connection is available.

The loss of MVD's largest source Well #2 would reduce total system capacity (5.4 MGD) by about 1.6 MGD or 30%. Based on Maximum Daily Flow demand (5.4 MGD) and drawing from emergency storage while Well #2 was out of service for up to two days, a volume of 3.2 MGD is suggested for emergency storage. If the time needed to resolve an emergency is longer, average demands may be assumed which can be met by remaining supply sources without increasing the emergency storage requirement.

Another potential emergency that could impact the High Pressure Zone is a loss of the Turkey Hill Booster Pumping Station. In this case, the recommended volume of emergency storage is equal to the Average Daily Flow for the High Pressure Zone (640,000 GPD existing).

Other emergencies could involve industrial demands. For example, GT Solar located on D.W. Highway has requested up to 1,100 gpm for up to 8 hours from MVD's system as an emergency backup for cooling water to protect worker safety (letter to MVD dated July 19, 2011). This corresponds to 528,000 gallons and is within MVD's existing emergency storage capacity.

7.4.4. Total Recommended Storage

Tables 7-3 and 7-4 summarize existing and future storage requirements, respectively. We note the following based on the assumptions for required storage:

1. Existing Conditions
   - Existing storage volume is adequate for both pressure zones and system-wide.
2. Future Conditions
   - Existing storage volume is adequate in the Main Pressure Zone and system-wide.
   - Existing storage volume would have a deficit in the High Pressure Zone.
   - The HPZ deficit could be addressed by:
     - Placing the Lake Road Tank in service to provide additional storage.
     - Connecting new supplies directly to the High Pressure Zone to reduce the emergency storage requirement.

Table 7-3. Recommended Storage for Existing Demands

	Main Pressure Zone (MPZ)	High Pressure Zone (HPZ)		System-Wide
Recommended Storage				
Equalization gal (ADF x 20%)	512,000	128,000		640,000
Fire flow, gal (ISO values)	630,000	180,000	(Note 1)	630,000
Emergency, gal	2,560,000	640,000		3,200,000
Total, gal	**3,702,000**	**948,000**		**4,470,000**
Existing Storage Capacity				
Hutchinson Tank, gal	-	1,000,000		1,000,000
Lake Road Tank, gal (Note 1)	-	0	(Note 2)	0
Turkey Hill Tank, gal	4,000,000	-		4,000,000
Total, gal	**4,000,000**	**1,000,000**		**5,000,000**
Surplus/(Deficit)	**298,000**	**52,000**		**530,000**

Note 1. Fire flows for each zone are not additive.
Note 2. Lake Road Tank currently offline. Would add 750,000 gallons to HPZ if activated.

Table 7-4. Recommended Storage for Future (20 Year Design)

	Main Pressure Zone (MPZ)	High Pressure Zone (HPZ)		System-Wide
Recommended Storage				
Equalization gal (ADF x 20%)	656,000	164,000		820,000
Fire flow, gal (ISO values)	630,000	180,000	(Note 1)	630,000
Emergency, gal	2,560,000	820,000	(Note 3)	3,380,000
Total, gal	**3,846,000**	**1,164,000**		**4,830,000**
Existing Storage Capacity				
Hutchinson Tank, gal	-	1,000,000		1,000,000
Lake Road Tank, gal (Note 1)	-	0	(Note 2)	0
Turkey Hill Tank, gal	4,000,000	-		4,000,000
Total, gal	**4,000,000**	**1,000,000**		**5,000,000**
Surplus/(Deficit)	**154,000**	**(164,000)**		**170,000**

Note 1. Fire flows for each zone are not additive.
Note 2. Lake Road Tank currently offline. Would add 750,000 gallons to HPZ if activated.
Note 3. HPZ emergency storage needs are less if a future supply is connected to the zone.

7.5. Tank Condition Assessments

7.5.1. Turkey Hill Tank

The tank was recently cleaned and inspected by Underwater Solutions. The inspection report dated September 11 & 12, 2014 noted:

- Tight surface cracks on the exterior walls.
- Four areas of reinforcement steel exposure on the roof dome exterior.
- Tight surface cracks on the interior walls.
- Eight foot band of ice scour on interior wall is non-structural but should be monitored.
- Recoating of entire exterior and interior surfaces is recommended.

Sediment accumulation has been an ongoing concern. Over eight inches of sediment was removed from the floor during the recent cleaning. The last cleaning in September 2010 found approximately eleven inches of sediment.

Theoretical turnover time for the tank is less than two days at average daily flow but residence time may be longer if stratification is occurring.

Current issues with the 36 year old Turkey Hill Tank include:

- Removing the Turkey Hill Tank from service for maintenance is very difficult since it is the only tank on the MPZ.
- Recoating of surfaces needs further evaluation by a specialty contractor for this work.
- A plan for operating the system with the tank out of service is needed.
- Sediment buildup; may increase chlorine demand and impact water quality.
- No mixing provided; potential for stratification to impact water quality.

7.5.2. Hutchinson Tank

The most recent inspection completed by Underwater Solutions in September of 2011 noted the following:

- The exterior walls showed no signs of metal fatigue with the coating still providing good protection of the steel.
- Exterior roof coating had declined in film thickness (nearly expired). However, the roofing panels did not show signs of fatigue, nor exposure of the primer or steel.

The tank was last blast cleaned and recoated (interior and exterior) in 2005, and the exterior was pressure washed in 2013. The next inspection is anticipated in FY 2015.

Theoretical residence time is less than two days at current average flow. Current known issues with the Hutchinson Tank include:

- Needs new exterior roof coating.
- No mixing provided; potential for stratification to impact water quality.

7.5.3. Lake Road Tank

The Lake Road Tank was intended to meet anticipated demands in the Baboosic Lake area that did not occur because the sewer was not expanded. The tank was originally used in the summer but has been offline (with one exception) since 2001 due to water quality issues. Hydraulics and limited demand do not allow adequate drawdown and turnover in the tank.

The Lake Road Tank currently provides the following:

- Active storage when the Hutchinson Tank is out of service (last recoat in 2005).
- Equipment storage in tank pedestal including portable emergency generator.
- Antenna mounting space to outside parties per lease agreements with MVD.

7.5.4. Stored Water Quality and Mixing

In water storage tanks, water age and quality can be impacted by stratification where warmer water remains at the top and only cooler water turns over at the bottom. Eventually a significant change in water temperature or large tank drawdown may result in “tank turnover” where the older water moves out of the tank and into the distribution system. This older water is often associated with water quality issues such loss of disinfectant residual, increased concentrations of disinfection byproducts (DBPs), and bacteria regrowth.

Although MVD has not detected water quality violations in its tanks, stratification may be occurring. Unless samples are taken from stagnant areas of the tanks or at the time of a "tank turnover" event, water quality changes may not be observed.

Mixers can be added to tanks to prevent stratification and promote consistent water and quality. They also minimize the formation of ice in winter. Unfortunately, tank mixers are not typically effective against sedimentation.

Tank mixers fall into one of two major categories: active or passive. Passive mixers obtain energy from inflow to form jets, typically using rubber duckbill check valves. Active mixers use a motor to mechanically mix water inside the tank. They require a power source (either grid or solar panels) and typically require more maintenance than passive mixers. Some types of active mixers are designed to be installed in tanks while in service.

We recommend MVD plan and budget to install mixers in the Turkey Hill and Hutchinson Tanks. Further study is recommended to evaluate the cost and benefits of adding mixing and the appropriate mixer type for each tank.

7.6. Proposed Storage Improvements

1. Perform preventive maintenance as recommended by recent tank inspections:
    a. Turkey Hill Tank: evaluate interior and exterior recoating.
    b. Hutchinson Tank: Recoat exterior roof.
2. Plan for installation of tank mixers in Turkey Hill and Hutchinson Tanks. Conduct further study to evaluate potential benefits and appropriate mixer type.
3. Maximize available storage by providing ability to return water from the High Pressure Zone to the Main Pressure Zone at the booster station or elsewhere.
4. Investigate sediment buildup and ways to mitigate.
5. Maintain the Lake Road Tank for alternate storage or future use, if necessary.
6. Plan for an additional storage tank twenty plus years out, depending on future demands and need for redundancy.
    a. Budget $2M (2014 dollars) for a 1.0 MGal tank including construction, engineering and contingency.
    b. Construct the tank in the Main Pressure Zone to provide redundancy for the Turkey Hill Tank.
    c. Identify and confirm potential sites. MVD has rights to potential sites at the Merrimack Premium Outlets (MPO) and at Belmont Hill.

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8. Booster Pumping Stations Evaluation

8.1. Pumping Station Evaluation Criteria

The booster pumping stations were evaluated on the basis of capacity, reliability, and maintenance concerns.

8.2. Turkey Hill Booster Pumping Station

The Turkey Hill Booster Pumping Station is located near the Turkey Hill Road tank at the access road entrance. The factory built (Dakota) packaged station built in 1988 is installed below grade in a steel can. The station serves to transfer water from the Main Pressure Zone to the High Pressure Zone and maintain level in the Hutchinson Water Storage Tank.

The station is equipped with two 100 HP vertical split case pumps by Allis Chalmers with soft start controls and capable of about 1,400 gpm each. The pumps and motors were rebuilt in approximately 2009 including new custom made impellers. The pumps were subsequently damaged by sand that entered the piping from distribution construction work in 2010, requiring removal for repairs again. These pump models are not built anymore and are expensive to maintain since parts are not available. Instrumentation includes a 12" magnetic meter, circular chart recorder, and remote telemetry unit to monitor the station on SCADA.

The station capacity is adequate to meet High Pressure Zone demands, which are summarized in Table 8-1 based on pumping station records.

Table 8-1. High Pressure Zone Water Demands

	HPZ Demand (MGD)	Remarks
Average Daily Flow	0.4	17% of total annual ADF
Summer Average Flow	0.6	20% of total summer ADF
Maximum Day Demand	1.45	Maximum occurred July 6, 2010

Significant issues with the existing Turkey Hill station include:

- Confined space and limited access.
- Control panel issues have required recent repairs.
- Pumps are aged and no longer manufactured.
- No space for future chemical feed system (hypochlorite), if necessary.
- Site size is very limited.
- No ability to back feed High Pressure Zone to Main Pressure Zone.
- No dedicated emergency power source.
- Single main only supplies HPZ.

8.3. Belmont Booster Pumping Station

This booster pumping station located on Belmont Drive serves 42 homes in a small pressure zone fed through three swing check valves. The packaged pumping station (Flowtronex) includes duplex 3HP pumps rated for 80 gpm each, two pneumatic pressure tanks, and controls in a small wood frame building. The station was installed in 2000 to address customer complaints of low water pressure. There is no backup power in the event of a power outage, but pressures reportedly do not drop below 20 to 30 psi since the area is below the hydraulic gradeline of the Turkey Hill Tank. There is a flowmeter installed but no radio telemetry for alarms or flow indications. Fire flow can be supplied to this area as a high demand causes the check valves to open.

8.4. Booster Pumping Improvements

A new booster station is necessary to address the issues with the existing Turkey Hill Booster Station. A building to house new pumps and controls with above grade access is recommended. The new station (or stations) could be potentially located where large diameter mains for each pressure zone are in close proximity to each other:

- Baboosic Lake Road
- McQuestion Road
- Turkey Hill Road
- Amherst Road
- Route 101A.

We recommend further review and hydraulic analysis be done now to identify potential sites and acquire land if necessary.

Suggested improvements for the Belmont Booster Station include telemetry/SCADA. These could be implemented with the next major pump/control upgrade as the existing systems near end of life in the next 5 to 10 years.

9. Recommended Capital Improvements Summary

9.1. Phasing of Improvements

The Master Plan relates to other financial planning documents for MVD as illustrated in Figure 9-1. The projects identified in the Master Plan, Asset Management Plan and other planning studies are summarized in the Capital Improvements Plan. The near term (up to 5 year) funding strategy for the CIP was considered in the latest Rate Update (April 2014). The Rate Model should continue to be updated as the CIP is further refined.

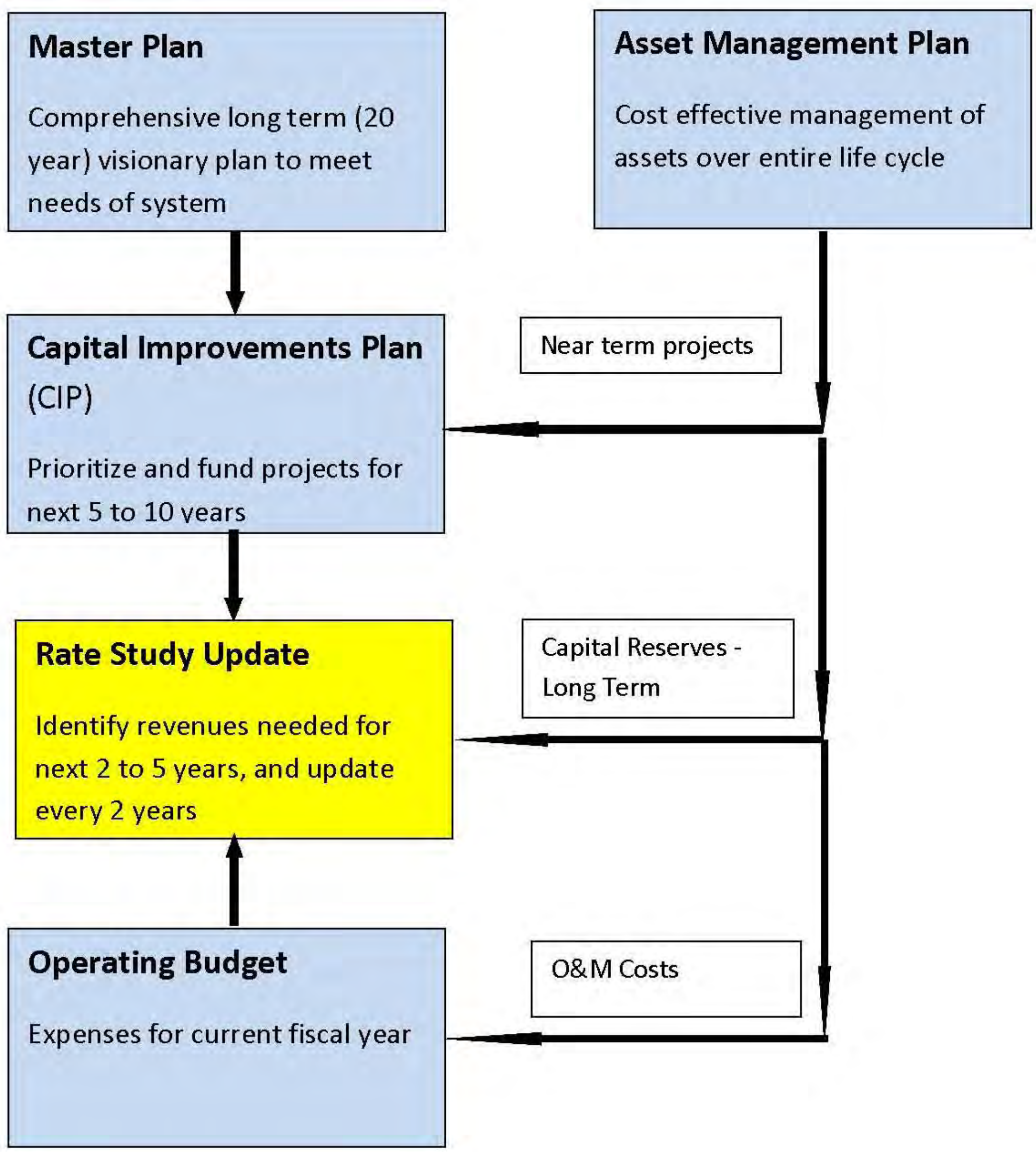

Figure 9-1. Financial Planning Flow Chart

9.2. Capital Improvements

Recommended projects for the Ten Year Capital Improvements Plan (CIP) are summarized in Table 9-1. These include renewals of existing assets per the Asset Management Plan and the projects for growth or enhancement identified in the Master Plan.

The CIP should be updated as the scope, cost, and schedule of these projects are further refined. The highest priority projects in the CIP should receive further evaluation first. Basic levels of priority were assigned in discussion with MVD staff, as follows:

1 = High priority; needed now to maintain level of service.
2 = Medium priority; needed in next 5 to 10 years to maintain service.
3 = Low priority; not critical in near to mid-term to maintain service.

An expanded Ten Year CIP Worksheet is included in Appendix A to review and establish the schedule for projects by fiscal year.

MVD has identified certain long term (>10 year) projects in their current CIP, including future source development and distribution replacements per the 2102 Distribution CIP. While beyond the window for the Ten Year CIP in this report, these long term projects are summarized for reference in Table 9-2. UE has included facility asset renewals based on the 2014 Asset Management Plan; these assets include supply, pumping, storage, and other structures.

Table 9-1. Ten Year Capital Improvements Plan.

Project	Amount	Priority	Year	Remarks
Current CIP Projects updated FY 2014-2015				
Increase production in Well 2	$0	3	-	"on hold"
New MVD office	$0	3	-	"on hold"
Iron and manganese treatment facility	$4,750,000	1	2014	In progress
Land purchase – site TBD	$400,000	2	2015	New supply
New well site development	$400,000	2	2015	New supply
Pipe replacement & eliminate parallel mains	$3,300,000 (note 1)	3	2020+	Distribution CIP
Proposed New Projects				
Naticook Lake water main extension	$300,000	2	2015	Town project
New well site installation	$1,500,000	2	TBD	Scope TBD depending on source
New well treatment	TBD	2	TBD	Scope TBD depending on source
Storage tank improvements (mixing)	$200,000	2	2016+-	Feasibility TBD
Turkey Hill Booster Station replacement	$1,200,000	1	2016+-	Feasibility TBD
Well 3 treatment	$4,500,000	3	TBD	Feasibility TBD
Well 5 pumps/controls	$200,000	2	2019	20 year replacement
Belmont Booster Station pumps/controls	$50,000	2	2020	20 year replacement
Lime station improvements (Wells 2, 3, 5)	$1,200,000	1	2016+-	Feasibility TBD
Well level monitoring, SCADA/GIS/IT improvements	$300,000	2	2016+-	Feasibility TBD
Total CIP	**$18,300,000**			

Note 1. $3,300,000 = 4-year pro-rated amount based on $8,250,000 for 2020 to 2029 per Distribution CIP.

Table 9-2. Long Term (>10 Year) Capital Improvements Plan.

Project	Amount	Years in Future	Remarks
Future Projects			
Well #6 treatment facility	$2,600,000	20	Subject to water quality and needs
New Well Mitchell Woods – engineering and construction	1,500,000	20	For engineering and construction for new well and pump station
Distribution assets replacement	$149,000,000	20 to 100	Per 2012 Distribution CIP Report
Facility assets replacement	$26,400,000	20 to 100	Per 2014 Asset Management Plan
Future storage tank	$2,000,000	20 plus	Reserve land now for future use if necessary

9.3. Funding Sources

Potential funding sources include:

- Revenues: Water Rates, System Development Charges (SDC)
- Capital Reserve Funds: Set aside by budget or surpluses.
- Debt: Bonds or State Revolving Funds (SRF)
- Grants: e.g., Asset Management, Source Water Protection

The current water plant project is primarily funded by a low interest loan through the State drinking water SRF program. A rate increase of 10% to support future debt service for the SRF loan was identified for FY 2016 in the 2014 rate study update. MVD should apply for additional low interest SRF loans to fund other large capital projects that are near term, and rates should be adjusted as necessary as projects are refined and implemented.

The next rate increase will also allow the option to increase capital reserve contributions above the current budget of $200,000/year by an additional $350,000/year. Smaller projects and future asset renewals per the Asset Management Plan are anticipated to be funded from these Capital Reserves.

10. Summary

Our findings are summarized below:

10.1. Policy and Management

> *MVD's greatest assets are the groundwater supplies*

- Significant watershed protection measures are in effect, but further steps can be done to mitigate impacts of continued development.
- Salt loading in the Well Head Protection Areas is a concern based on previous study. A mitigation plan has been developed. Additional monitoring is needed to see if current salt controls are effective.
- The "Odd/Even" policy for outside water restrictions have been reportedly successful in reducing maximum daily demands.
- An updated Emergency Management Plan should be submitted to DES in 2015.

10.2. Demands

- Current annual average demand is 2.3 MGD, trending flat the past few years.
- Seasonal demands are 3.2 MGD (Summer average) and up to 5.4 MGD (Maximum Day).
- Projected design flows are 4.1 MGD (Summer average) and 5.9 MGD (Maximum Day)
- Non-revenue water averages about 7% of total annual production but is significantly higher in the summer months.

10.3. Supply

Production Capacity

> *Additional supply of 0.5 MGD is needed*

- Existing capacity with the largest well out of service (Well #2) meets existing summer ADF, but this assumes Well #8 is operated.
- Existing pump limitations and water quality constraints with Wells #7 and #8 limit what can be feasibly produced to about 4.3 MGD.
- The new Fe/Mn treatment plant will correct the issues at Wells #7 and #8 and provide capacity to meet current design flows when online (anticipated 2016).
- ***Additional supply of about 350 gpm (0.5 MGD) is needed to meet future design flows***.

Water Quality

> *Future water quality goals need confirmation*

- Existing best water quality sources (Wells #2, #4, #5) barely meet winter time demands.
- MVD may be currently over pumping Wells #4 and #5 at times to avoid using lesser quality sources.
- The Well #7/8 Fe/Mn treatment plant will allow average summer demands to be met with high quality sources and reduce need to pump Wells #2, #4, and #5 at maximum rates.

- ***Future treatment at Well #3 (or development of an additional high quality source) may be needed to provide good water quality to meet maximum demands in all seasons.***
- The existing lime stations need replacement in the near term.
- Additional instrumentation is needed to monitor the long term performance and quality of the wells including aquifer level, conductivity, and SCADA links.

Additional Supply Options

- Potential sources of additional supply have been identified, and MVD is pursuing cost effective and feasible alternatives (see Table 5-4, Map Figure 2, and Supply Flow Chart Figure 5, Appendix A).

10.4. Distribution

90% of long term replacement costs are for mains

- The existing distribution system is in relatively good condition, with no significant hydraulic issues or pattern of water main break occurrences.
- Asbestos cement mains make up 42% of the sytem and may need replacement over the next 30 to 40 years depending on actual usual life.
- Some redundant parallel mains may affect water quality and ease of operation.
- Areas for anticipated future expansion of service are limited.
- Some Town highway projects are anticipated in the near term which will impact the distribution system including certain bridge crossings.
- Hydraulic capacity is available to support a future expanded treatment plant capacity at Well#7/#8 of 1,850 gpm, but improvements may be needed if supplies from the south are greater.
- Sections of main that are more hydraulically limiting include the discharge from Well #7 (2,500 LF), the 12” AC section on Turkey Hill Road (1,000 LF), and portions of the 12” AC main on Route 3 between Greeley Street and Woodbury Street (5,000 LF).
- MVD has developed a GIS based inventory of distribution system assets. Additional training and networked based sharing would improve the utility of this tool.
- Existing water model is out of date and not aligned with current GIS mapping.

10.5. Storage

Long term maintenance of the Turkey Hill Tank needs further evaluation

- Existing storage is adequate for current and 20 year design flows, based on the criteria assumed for storage capacity including emergency storage.
- The Turkey Hill tank is difficult to remove from service for maintenance as it is the only tank serving the Main Pressure Zone.
- The Turkey Hill tank may require coating repairs in the near term and requires further evaluation.
- The Lake Road tank cannot be used normally since it does not turnover, but it serves as an alternate storage facility for the High Pressure Zone when the Hutchinson tank must be removed from service.

- The Hutchinson tank requires some coating repairs to the roof in the near term.
- The tanks do not have mixing equipment per current design practice.
- Potential tank sites should be identified for long term planning.

10.6. Booster Pumping Stations

Turkey Hill Booster Station needs Replacement

- The Turkey Hill Booster Pumping station is approaching the end of its useful life. The below grade installation has confined space/limited access issues, and the existing pumps are not available anymore and very costly to maintain.
- The Belmont Booster Pumping station lacks telemetry and may need pump/control renewals in the next 5 to 10 years.

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11. Recommendations

Administrative recommendations are summarized in Table 11-1 and Capital Projects are summarized in Table 11-2. The current CIP should be reviewed and updated based on the recommended projects in this report. Note starred* items below are items related to MVD that were included in the 2013 Town Master Plan.

Table 11-1. Management/Administrative Recommendations

ID	Watershed Protection and Aquifer Management	Implementation Period	Remarks
WM1	Prepare a comprehensive *Well Management Plan*, including evaluation of operational control of the production wells to maximize water quality while protecting the long term yield of the aquifers.	Ongoing	
WM2	Reduce impervious surfaces in site design where appropriate.*	Ongoing	Coordinate with Town
WM3	Develop a design review checklist for subdivisions and site plans that incorporates recharge protection and water demand management practices.*	1-2 years	Coordinate with Town
WM4	Consider amending the subdivision and site plan regulations to limit the use of deicing compounds and regulate the use of pesticides or insecticides in new commercial, industrial, or multi-family residential projects.*	1-2 years	Coordinate with Town
WM5	Work with the State to address existing and future large quantity groundwater withdrawals in wellhead areas.*	3-5 years	Coordinate with State
WM6	Continue to work with residents and businesses to encourage individual water resource protection measures.*	Ongoing	
WM7	Develop a set of criteria for use of deicing materials throughout the Town.*	Ongoing	Coordinate with Town
WM8	Continue to implement and maintain the recommendations of the 2012 Salt Mitigation Plan.* Track status of the 24 Action Items and pursue grant funds for implementation.	1-2 years	Coordinate with Town

WM9	Update and submit Emergency Management Plan to NHDES.	Ongoing	
ID	**Water Conservation**	**Implementation Period**	**Remarks**
WC1	Consider updating the Conservation Plan and pursuing additional conservation measures as a way to offset the need for additional supplies.	3-5 years	
WC2	Evaluate the current water balance and non-revenue water, including why non-revenue water increases significantly in summer months. Complete an updated Water Audit.	1-2 years	
WC3	Continue to maintain the "odd/even" outside watering policy.* Evaluate the impact on peak and average demands.	Ongoing	
WC4	Use separate commercial and industrial irrigation meters to control demand.*	Ongoing	
WC5	Continue to expand homeowner education programs to reduce demand and encourage water conservation.*	Ongoing	
WC6	Work with all businesses to help keep outside watering in their facilities to a minimum.*	Ongoing	
ID	**Information Management**	**Implementation Period**	**Remarks**
IM1	Continue to update and expand the information in the GIS system.	Ongoing	
IM2	Provide additional training for personnel responsible for maintaining the GIS system.	Ongoing	
IM3	Establish or expand a server based computer network to increase reliability and the ability to share resources.	1-2 years	
IM4	Update the water model to the current WaterCAD version, using the current GIS base map and pipe inventory, including field work for calibration.	3-5 years	

ID	Asset Management and Financial Planning	Implementation Period	Remarks
AM1	Implement and maintain the Asset Management Plan developed in 2014.	Ongoing	
AM2	Provide additional capital reserve contributions as recommended in the AM plan for long term replacement of assets over their life cycle.	Ongoing	
AM3	Update rates and SDC every two years.	Ongoing	
AM4	Submit applications for SRF funding for potential near term projects.	Ongoing	

Table 11-2. Capital Improvements Recommendations

ID	Supply and Treatment	Implementation Period	Remarks
C1	Complete construction of the Fe/Mn treatment plant for Wells #7/#8.	1-2 years	
C2	Secure land rights for potential Mitchell Woods well.	1-2 years	
C3	Secure land rights for potential Bean Road well.	1-2 years	
C4	Secure land rights for potential Hollis source.	1-2 years	
C5	Evaluate scope and costs to complete installation, treatment systems, and connection of new sources and plan for implementation of most cost effective new source(s).	3-5 years	
C6	Evaluate options to replace the lime feed stations at Wells #2, #3, and #5.	1-2 years	
C7	Evaluate future Well 3 treatment based on experience with Well #7/#8 plant.	5-10 years	
C8	Install additional monitoring instruments including level monitoring and conductivity probes at each production well.	1-2 years	

C9	Plan and budget for other supply improvements including VFDs, surge control, and chlorinator replacements.	3-5 years	
C10	Evaluate increasing pumping capacity of Well #2 to 1,500 gpm.	5-10 years	
C11	Evaluate using only Well #5, without Well #4, to match the sustainable capacity of the aquifer.	3-5 years	
ID	**Distribution**	**Implementation Period**	**Remarks**
C12	Evaluate water distribution improvements in conjunction with anticipated near term Town road realignment and bridge replacement projects. Determine responsibilities and costs between the Town and MVD.	1-2 years	
C13	Construct other improvements in conjunction with Town paving projects where possible to reduce costs by digging the street once.	Ongoing	
C14	Plan for elimination of redundant parallel mains including those on Route 3 and Baboosic Lake Road.	5-10 years	
C15	Evaluate hydraulic capacity as future new sources are advanced.	5-10 years	
C16	Prioritize most hydraulically limiting mains for future improvements, if necessary to support future supply increases in South Merrimack.	Ongoing	
C17	Review and update construction standards.	Ongoing	

ID	Storage	Implementation Period	Remarks
C18	Evaluate tanking mixing improvements.	1-2 years	
C19	Evaluate coating repairs to the Turkey Hill Tank including how to maintain system pressure if tank must be taken out of service.	1-2 years	
C20	Plan for coating repairs to the Hutchinson Tank.	1-2 years	
C21	Identify site(s) for future additional storage for the Main Pressure Zone.	5-10 years	
C22	Obtain recorded easement for the future tank site at Merrimack Premium Outlets.	1-2 Years	
C23	Investigate sources of sediment that buildup in tanks	3-5 years	
ID	**Booster Pumping Stations**	**Implementation Period**	**Remarks**
C24	Evaluate alternatives for replacement of the Turkey Hill Booster Pumping Station and secure land.	1-2 years	
C25	Evaluate telemetry/SCADA improvements with renewals to the Belmont Booster Pumping Station.	5-10 years	

APPENDIX A

MAPS AND FIGURES

WATER MAIN LENGTH BY DIAMETER

DIAMETER	LENGTH (FEET)	LENGTH (MILES)	PERCENT
2"	22,601	4.3	2.6%
4"	5,608	1.1	0.6%
6"	122,513	23.2	14.0%
8"	397,966	75.4	45.4%
10"	17,709	3.4	2.0%
12"	235,873	44.7	26.9%
16"	51,135	9.7	5.8%
20"	18,944	3.6	2.2%
24"	61	0.01	0.0%
UNKNOWN	4,550	0.9	0.5%
TOTAL	876,959	166.1	-

NOTES:
1. BASE PLAN AND WATER MAIN INFORMATION COMPILED FROM GIS SHAPE FILES PROVIDED BY NASHUA REGIONAL PLANNING COMMISSION (NRPC) 3/27/2012. WATER MAIN INFORMATION UPDATED APRIL, 2014, BASED ON INFORMATION PROVIDED BY MERRIMACK VILLAGE DISTRICT.
2. BASE PLAN DATUM IS NEW HAMPSHIRE STATE PLANE NAD 83 US FOOT.

DATE 11/12/14
PROJECT 1786

UNDERWOOD engineers
25 Vaughan Mall, Portsmouth, N.H. 03801
Tel. 603-436-6192 Fax. 603-431-4733

EXISTING DISTRIBUTION MAINS
-SIZE-
MERRIMACK VILLAGE DISTRICT
MERRIMACK, NEW HAMPSHIRE

FIG. 1

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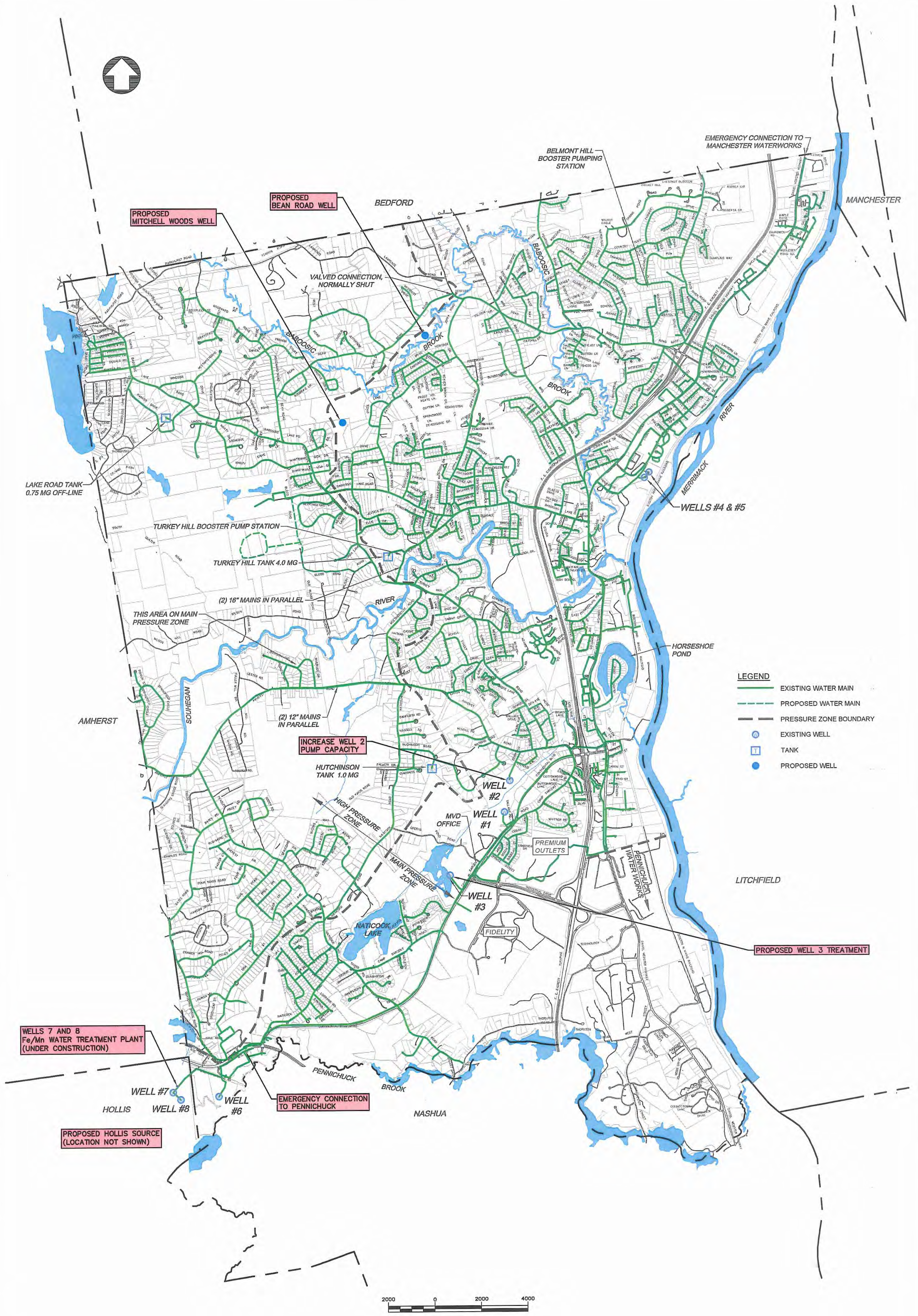

NOTES:
1. BASE PLAN AND WATER MAIN INFORMATION COMPILED FROM GIS SHAPE FILES PROVIDED BY NASHUA REGIONAL PLANNING COMMISSION (NRPC) 3/27/2012. WATER MAIN INFORMATION UPDATED APRIL, 2014, BASED ON INFORMATION PROVIDED BY MERRIMACK VILLAGE DISTRICT.
2. BASE PLAN DATUM IS NEW HAMPSHIRE STATE PLANE NAD 83 US FOOT.

DATE			FIG.
11/12/14	UNDERWOOD engineers	POTENTIAL SUPPLY IMPROVEMENTS	2
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	MERRIMACK VILLAGE DISTRICT	
1786	Tel. 603-436-6192 Fax. 603-431-4733	MERRIMACK, NEW HAMPSHIRE	

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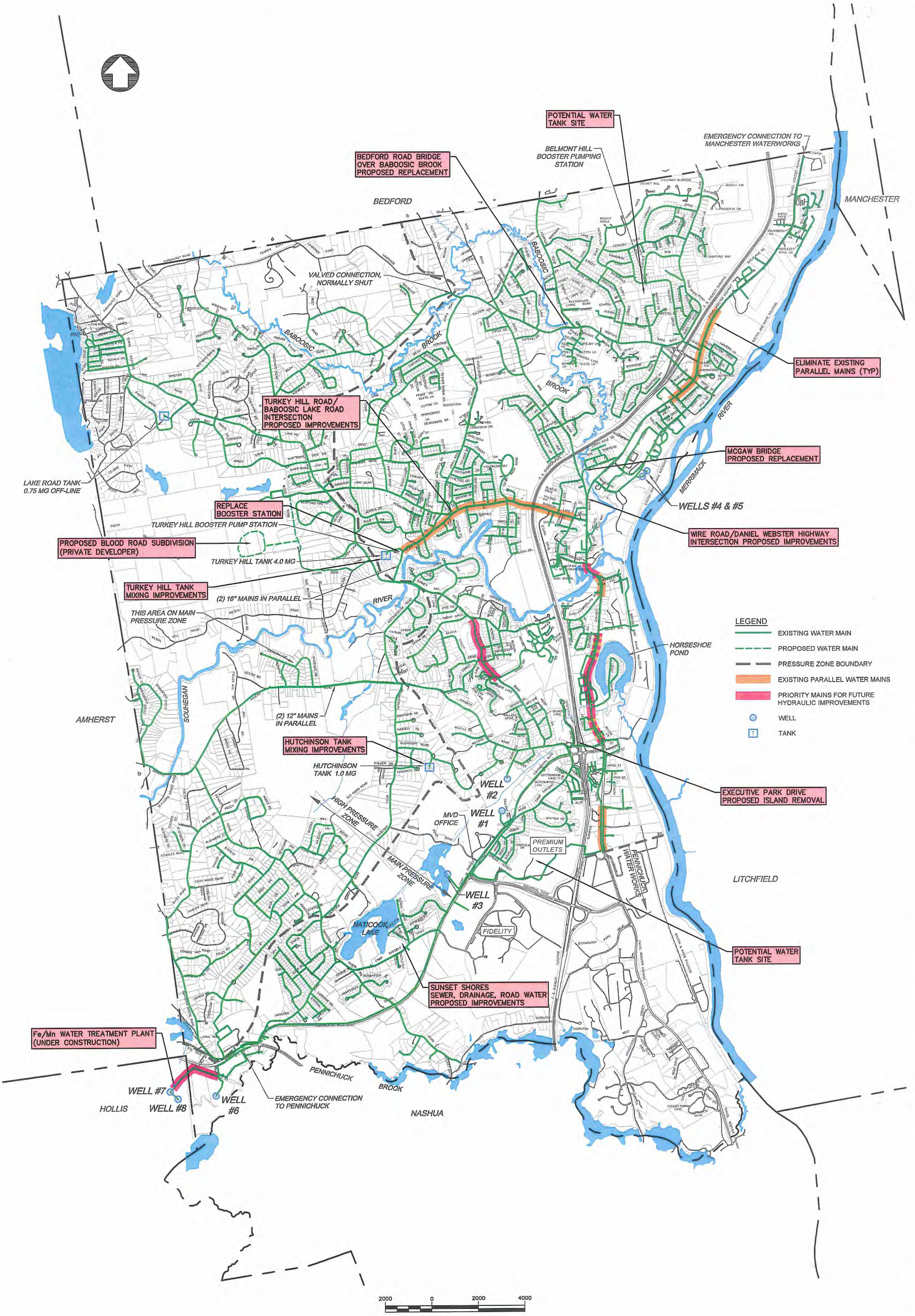

NOTES:
1. BASE PLAN AND WATER MAIN INFORMATION COMPILED FROM GIS SHAPE FILES PROVIDED BY NASHUA REGIONAL PLANNING COMMISSION (NRPC) 3/27/2012. WATER MAIN INFORMATION UPDATED APRIL, 2014, BASED ON INFORMATION PROVIDED BY MERRIMACK VILLAGE DISTRICT.
2. BASE PLAN DATUM IS NEW HAMPSHIRE STATE PLANE NAD 83 US FOOT.

DATE		PROPOSED WATER SYSTEM PROJECTS MERRIMACK VILLAGE DISTRICT MERRIMACK, NEW HAMPSHIRE	FIG.
11/12/14	UNDERWOOD engineers		3
PROJECT 1786	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733		

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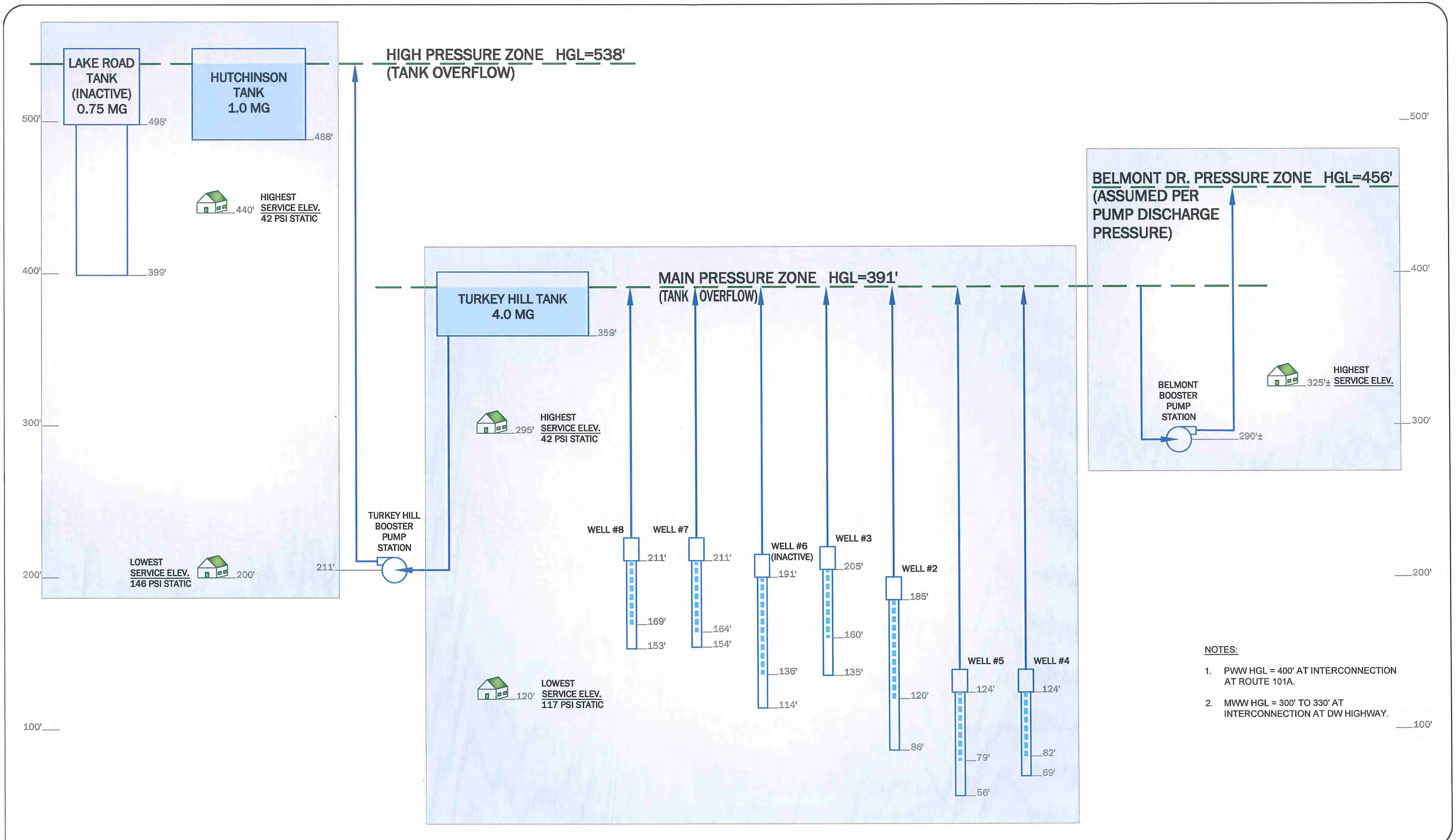

DATE			FIG.
11/12/14	UNDERWOOD engineers	HYDRAULIC GRADELINE SCHEMATIC MERRIMACK VILLAGE DISTRICT MERRIMACK, NEW HAMPSHIRE	4
PROJECT 1786			

25 Vaughan Mall, Portsmouth, N.H. 03801
Tel. 603-436-6192 Fax. 603-431-4733

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11/4/2014

Updated: November 4, 2014

MVD Supply Options and Distribution Improvements

CIP

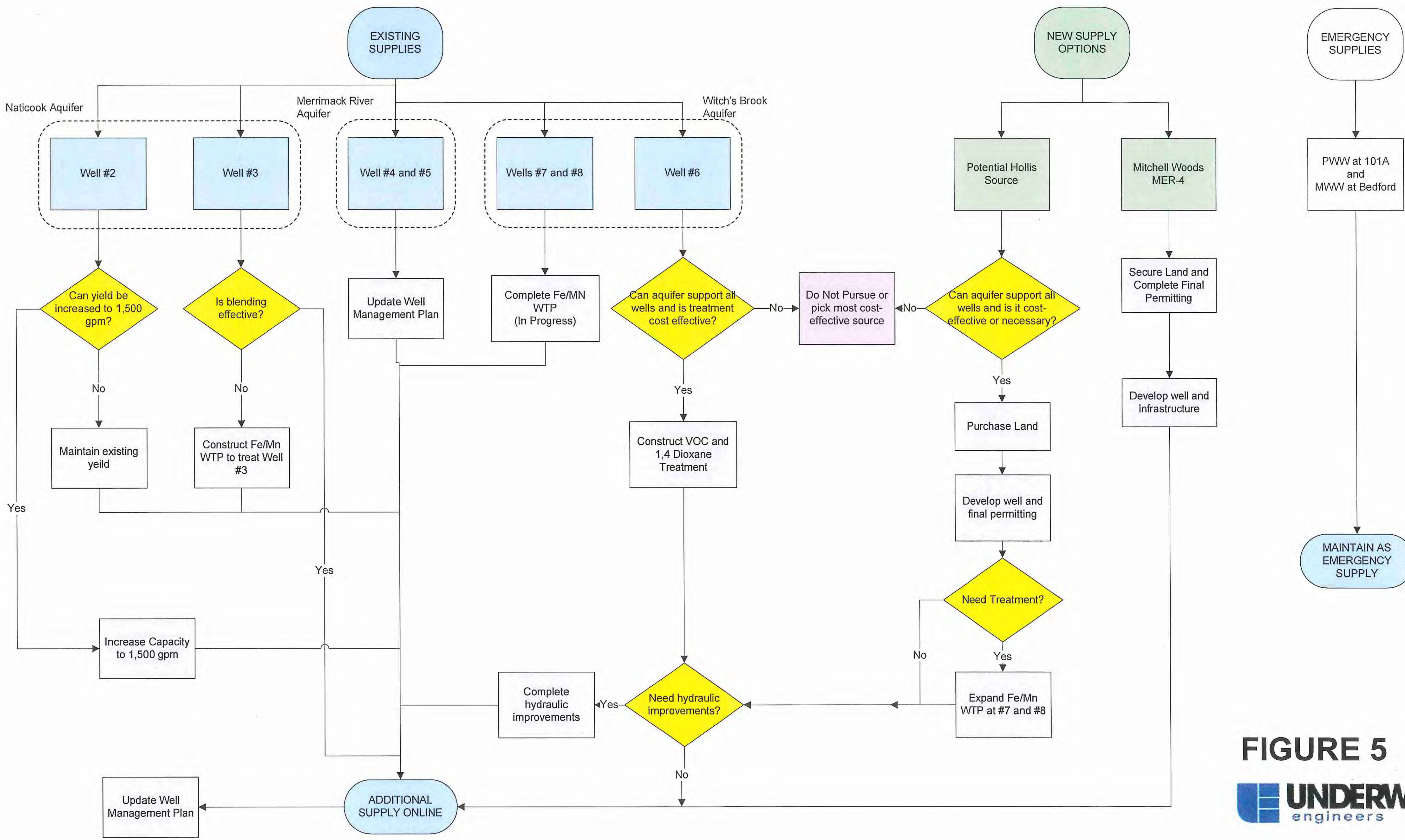


FIGURE 5

UNDERWOOD engineers

6. Ten Year CIP Worksheet

Merrimack Village District, Merrimack, New Hampshire

Date Worksheet Updated	11/4/2014

Current Year	2014

Schedule and Costs by Fiscal Year

Project	Amount	Funding Source	Type	Growth/Enhancement Cost not in AM Plan	Priority	Year Action Required	Remarks	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Current CIP Projects updated FY 2014-2015																	
Increase production in Well #2	$0	Capital Reserves	Enhancement		3	on hold	$300,000 "on hold"										
New MVD Office	$0	Capital Reserves	Enhancement		3	on hold	$600,000 "on hold"										
Final Design and Construction for Iron and Manganese Treatment Facility	$4,750,000	Debt (SRF)	Enhancement	$4,750,000	1	2014-2016	In progress	$4,750,000									
Land Purchase - site TBD	$400,000	Capital Reserves	Growth	$400,000	2	2015	New supply		$400,000								
New well site development	$400,000	Capital Reserves	Growth	$400,000	2	2015	New supply		$400,000								
Pipe Replacement; (may include Dogleg/parallel pipe Removal)	$3,300,000	Capital Reserves/Debt	Renewal		3	2020+	2020's Replacement Period per Distribution CIP. Schedule, locations TBD. Dog							$825,000	$825,000	$825,000	$825,000
Proposed New Projects for 10 Year CIP																	
Naticook Lake water main extension	$300,000	Capital Reserves	Growth	$300,000	2	2014	with Town sewer/road project		$300,000								
New Well Site Installation	$1,500,000	Capital Reserves/debt	Growth	$1,500,000	2	tbd	Scope, feasibility TBD. Schedule?				$1,500,000						
New Well Treatment	TBD	Capital Reserves/debt	Growth	TBD	2	tbd	Scope, feasibility TBD. Schedule?				TBD						
Storage Tank Improvements (Mixing)	$200,000	Capital reserves	Renewal/Enhancement		1	tbd	Feasibility TBD			$200,000							
Turkey Hill Booster Station Replacement	$1,200,000	Capital Reserves/debt	Renewal/Enhancement		1	tbd	Location, feasibility TBD			$1,200,000							
Well 3 Treatment	$4,500,000	Capital Reserves/debt	Enhancement	$4,500,000	3	tbd	Feasibility TBD							$4,500,000			
Well 5 Pump/Controls Replacement	$200,000	Capital reserves	Renewal		2	2019	Replace at 20 year life approx 2019						$200,000				
Belmont Booster Station Pumps/Controls Replacement	$50,000	Capital reserves	Renewal		2	2020	Replace at 20 year life approx 2020							$50,000			
Lime Station Improvements? (Wells 2, 3 and 5)	$1,200,000	Capital Reserves/debt	Renewal		1	tbd	Feasibility TBD. Replace or refurbish? Alternative treatment?				$1,200,000						
Well level monitoring, SCADA/GIS/IT Improvements (Wells 2, 3, 5; booster stations, tanks)?	$300,000	Capital reserves	Renewal/Enhancement	$300,000	2	tbd	Scope, feasibility TBD. Wells 7, 8 included in WTP project				$300,000						
Total CIP	**$18,300,000**			**$12,150,000**				$4,750,000	$1,100,000	$1,400,000	$3,000,000	$0	$200,000	$5,375,000	$825,000	$825,000	$825,000

Total in AM Plan

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
Capital Reserves	$450,000	$1,100,000	$200,000	$300,000	$0	$200,000	$875,000	$0	$825,000	$0	$3,950,000
Debt	$4,300,000	$0	$1,200,000	$2,700,000	$0	$0	$4,500,000	$825,000	$0	$825,000	$14,350,000
											$18,300,000

Notes

1. Project types may be renewal, growth, or enhancement.
2. Conceptual costs are for initial planning only and require further study and refinement
3. Priority rankings are:
   - 1 = necessary now or in near term to maintain level of service
   - 2 = recommended to plan in next 5 -10 years
   - 3 = low priority
4. Funding sources are preliminary, to be confirmed.

APPENDIX B

WATER PRODUCTION DATA

Merrimack Village District- Monthly Well Production Totals

	Well 2 Mgal	Well 3 Mgal	Well 4 Mgal	Well 5 Mgal	Well 7 Mgal	Well 8 Mgal	Total Mgal	Average Mgd	Max Day Mgd
Jan-04	(monthly data for each well not available for 2004 - 2005)							1.83	
Feb-04								1.88	
Mar-04								1.88	
Apr-04								2.02	
May-04								2.77	
Jun-04								3.42	
Jul-04								3.50	
Aug-04								3.16	
Sep-04								2.65	
Oct-04								1.98	
Nov-04								1.77	
Dec-04								1.74	
Jan-05								1.85	
Feb-05								1.81	
Mar-05								1.81	
Apr-05								2.06	
May-05								2.33	
Jun-05								3.31	
Jul-05								3.48	
Aug-05								3.50	
Sep-05								3.16	
Oct-05								2.21	
Nov-05								1.93	
Dec-05								1.90	
Jan-06	24.79	14.11	4.03	13.50	0.00	0.00	56.42	1.82	2.14
Feb-06	20.73	14.92	3.35	11.44	0.00	0.00	50.44	1.80	2.38
Mar-06	23.94	17.27	3.80	13.18	0.00	0.00	58.20	1.88	2.35
Apr-06	32.52	23.81	1.46	5.06	0.00	0.00	62.85	2.10	3.16
May-06	29.07	21.44	0.00	0.00	10.29	17.78	78.58	2.53	4.72
Jun-06	27.53	19.89	1.47	5.02	11.21	18.97	84.09	2.80	4.71
Jul-06	30.94	21.62	5.31	18.41	11.87	20.46	108.62	3.50	4.49
Aug-06	28.24	20.33	4.82	16.95	10.64	19.22	100.20	3.23	4.12
Sep-06	21.57	15.74	3.69	13.14	7.59	14.15	75.88	2.53	3.51
Oct-06	20.80	16.77	3.56	12.73	2.15	3.99	60.00	1.94	2.79
Nov-06	23.63	18.45	3.93	13.99	0.00	0.00	60.00	2.00	2.51
Dec-06	21.91	17.18	3.54	12.53	6.59	12.35	74.10	2.39	3.68
Jan-07	22.82	17.86	3.28	11.21	0.00	0.00	55.18	1.78	2.23
Feb-07	15.12	14.89	3.45	11.45	0.00	0.00	44.90	1.60	1.83
Mar-07	16.99	16.70	3.60	12.86	0.00	0.00	50.15	1.62	2.01
Apr-07	18.22	13.22	4.01	14.61	0.00	0.00	50.06	1.67	2.13
May-07	25.10	28.02	6.05	21.77	0.00	0.00	80.95	2.61	3.81
Jun-07	28.80	25.91	5.82	21.12	8.15	13.73	103.52	3.45	5.45
Jul-07	26.67	23.03	5.14	18.98	12.34	21.04	107.20	3.46	4.78
Aug-07	28.35	24.28	5.64	20.28	13.80	24.09	116.44	3.76	4.59
Sep-07	33.90	24.25	5.33	20.03	6.74	12.24	102.49	3.42	5.45
Oct-07	27.72	21.54	4.28	16.41	0.00	0.00	69.95	2.26	3.47
Nov-07	22.54	16.19	3.25	12.50	0.00	0.00	54.48	1.82	2.20
Dec-07	22.65	16.80	3.44	13.23	0.00	0.00	56.12	1.81	2.18
Jan-08	22.83	16.99	3.45	13.25	0.00	0.00	56.51	1.82	2.23
Feb-08	20.77	15.24	2.95	11.38	0.00	0.00	48.51	1.73	2.15
Mar-08	25.19	10.50	3.78	14.19	0.00	0.00	53.66	1.73	1.95
Apr-08	35.25	0.00	5.27	19.89	0.00	0.00	60.41	2.01	2.92
May-08	44.49	12.63	6.75	25.56	0.00	0.00	89.43	2.88	4.65
Jun-08	32.53	36.28	5.26	20.32	14.80	0.00	109.19	3.64	5.43
Jul-08	49.35	24.71	2.98	11.61	10.96	0.00	99.61	3.21	5.21
Aug-08	49.57	19.29	2.20	8.51	6.38	0.00	85.94	2.77	3.49
Sep-08	48.32	16.15	3.43	10.68	0.00	0.00	78.57	2.62	3.71
Oct-08	31.92	15.37	2.59	10.03	0.00	0.00	59.92	1.93	2.98
Nov-08	23.73	8.92	3.38	13.57	0.00	0.00	49.60	1.65	2.06
Dec-08	25.92	15.22	2.51	9.79	0.00	0.00	53.45	1.72	3.22
Jan-09	19.25	19.48	2.93	11.41	0.00	0.00	53.07	1.71	2.24
Feb-09	17.83	17.79	2.56	10.09	0.00	0.00	48.27	1.72	2.08
Mar-09	19.90	19.56	2.79	10.96	0.00	0.00	53.21	1.72	2.31
Apr-09	22.14	20.46	3.34	12.97	0.00	0.00	58.90	1.96	2.68
May-09	29.74	29.33	4.52	17.52	0.00	0.00	81.11	2.62	3.67

Jun-09	27.73	30.14	4.51	17.60	0.00	0.00	79.97	2.67	4.29
Jul-09	29.52	28.24	4.20	16.15	0.00	0.00	78.10	2.52	3.49
Aug-09	35.77	33.81	5.02	19.20	0.00	0.00	93.79	3.03	4.31
Sep-09	33.45	30.43	2.04	18.68	0.00	0.00	84.60	2.82	3.84
Oct-09	27.28	15.49	0.00	15.24	0.00	0.00	58.01	1.87	2.41
Nov-09	20.51	18.61	0.00	11.35	0.00	0.00	50.47	1.68	2.04
Dec-09	20.58	18.06	0.00	12.52	0.00	0.00	51.16	1.65	1.91
Jan-10	21.20	18.46	0.00	11.64	0.00	0.00	51.30	1.65	2.22
Feb-10	18.79	16.11	0.00	9.97	0.00	0.00	44.87	1.60	2.13
Mar-10	23.48	20.24	0.00	8.90	0.00	0.00	52.61	1.70	2.96
Apr-10	19.32	21.64	0.00	15.07	0.00	0.00	56.03	1.87	2.36
May-10	38.69	32.63	0.00	19.11	2.35	0.00	92.78	2.99	4.18
Jun-10	35.18	30.18	0.00	19.74	22.10	0.00	107.20	3.57	4.80
Jul-10	34.38	25.25	4.32	20.24	22.73	0.00	106.93	3.45	5.32
Aug-10	28.57	23.69	5.63	15.79	21.05	0.00	94.73	3.06	3.85
Sep-10	25.10	19.74	4.75	14.14	19.21	0.00	82.94	2.76	3.58
Oct-10	20.98	17.34	4.18	10.97	5.67	0.00	59.14	1.91	2.53
Nov-10	18.86	15.37	4.08	10.39	0.00	0.00	48.71	1.62	2.06
Dec-10	25.51	19.50	1.39	3.64	0.00	0.00	50.04	1.61	2.55
Jan-11	17.03	14.09	3.67	11.01	3.95	0.00	49.76	1.61	2.07
Feb-11	20.51	1.77	3.25	9.74	8.69	0.00	43.97	1.57	2.12
Mar-11	24.39	0.00	3.68	11.15	9.24	0.00	48.46	1.56	2.12
Apr-11	23.67	0.00	4.73	13.47	9.08	0.00	50.95	1.70	2.81
May-11	26.92	14.74	5.29	15.11	9.32	0.00	71.39	2.30	3.73
Jun-11	32.42	29.06	6.64	18.95	13.06	0.00	100.13	3.34	4.85
Jul-11	40.46	34.80	7.92	22.60	15.25	0.00	121.02	3.90	4.96
Aug-11	32.04	26.87	6.32	18.09	12.35	0.00	95.67	3.09	4.74
Sep-11	25.92	19.20	5.08	14.58	10.06	0.00	74.85	2.49	3.35
Oct-11	17.00	14.86	3.29	9.49	7.66	0.00	52.29	1.69	2.52
Nov-11	18.21	8.17	3.29	9.52	8.97	0.00	48.17	1.61	2.32
Dec-11	23.58	0.00	4.17	12.08	10.06	0.00	49.89	1.61	2.45
Jan-12	22.92	0.00	4.36	12.67	8.94	0.00	48.88	1.58	2.00
Feb-12	20.47	0.00	3.87	11.28	8.61	0.00	44.22	1.52	1.99
Mar-12	24.45	0.00	3.62	10.56	9.24	0.00	47.87	1.54	1.95
Apr-12	26.19	2.96	5.25	15.53	10.25	0.00	60.18	2.01	2.68
May-12	28.23	16.83	5.43	16.07	10.65	0.00	77.20	2.49	3.83
Jun-12	27.94	23.24	5.18	15.41	13.43	0.00	85.20	2.84	4.85
Jul-12	42.52	35.15	7.82	23.13	18.94	0.00	127.56	4.11	4.94
Aug-12	33.72	27.63	5.42	16.14	18.95	0.00	101.85	3.29	4.65
Sep-12	26.43	18.94	4.73	14.40	18.20	0.00	82.69	2.76	3.63
Oct-12	21.19	15.90	3.47	10.86	6.08	0.00	57.50	1.85	2.85
Nov-12	18.48	14.32	3.36	10.54	0.00	0.00	46.70	1.56	2.05
Dec-12	28.28	0.00	4.96	15.54	0.00	0.00	48.78	1.57	2.11
Jan-13	28.17	0.00	4.92	15.45	0.00	0.00	48.54	1.57	2.02
Feb-13	25.22	0.00	4.36	13.71	0.00	0.00	43.28	1.55	2.32
Mar-13	28.34	0.00	4.86	15.28	0.00	0.00	48.48	1.56	2.40
Apr-13	26.70	7.75	5.24	14.92	0.00	0.00	54.61	1.82	2.78
May-13	35.95	27.36	6.86	18.77	0.00	0.00	88.93	2.87	4.15
Jun-13	35.74	26.93	6.86	18.75	0.00	0.00	88.28	2.94	4.44
Jul-13	39.09	29.58	7.64	20.82	0.00	0.00	97.12	3.13	4.24
Aug-13	40.06	29.64	7.71	21.07	0.00	0.00	98.48	3.18	3.99
Sep-13	33.85	24.59	6.53	17.89	0.00	0.00	82.86	2.76	3.80
Oct-13	26.75	15.86	5.74	15.71	0.00	0.00	64.05	2.07	2.83
Nov-13	28.79	0.00	5.07	13.89	0.00	0.00	47.76	1.59	2.01
Dec-13	29.00	0.00	5.61	15.41	0.00	0.00	48.38	1.61	2.32
Jan-14	29.23	0.00	5.63	15.00	0.00	0.00	49.86	1.61	2.26
Feb-14	29.26	0.00	1.60	13.02	0.00	0.00	43.89	1.57	2.30
Mar-14	36.83	0.00	0.00	13.44	0.00	0.00	50.27	1.62	2.26
Apr-14	27.20	6.74	3.97	14.45	0.00	0.00	52.37	1.75	2.37
May-14	27.00	21.31	4.88	15.60	0.00	0.00	68.79	2.22	3.28
Jun-14	34.51	32.26	7.42	23.61	0.00	0.00	97.80	3.26	4.37
Jul-14	32.41	25.89	5.98	19.19	18.01	0.00	101.48	3.27	4.72
Aug-14	30.14	25.12	5.35	17.18	17.19	0.00	94.97	3.06	4.64
Sep-14									
Oct-14									
Nov-14									
Dec-14									

APPENDIX C

WATER QUALITY DATA

Merrimack Village District
Average Raw Water Quality of Existing Wells (March 2010 - through July 2014)
Updated September 2014

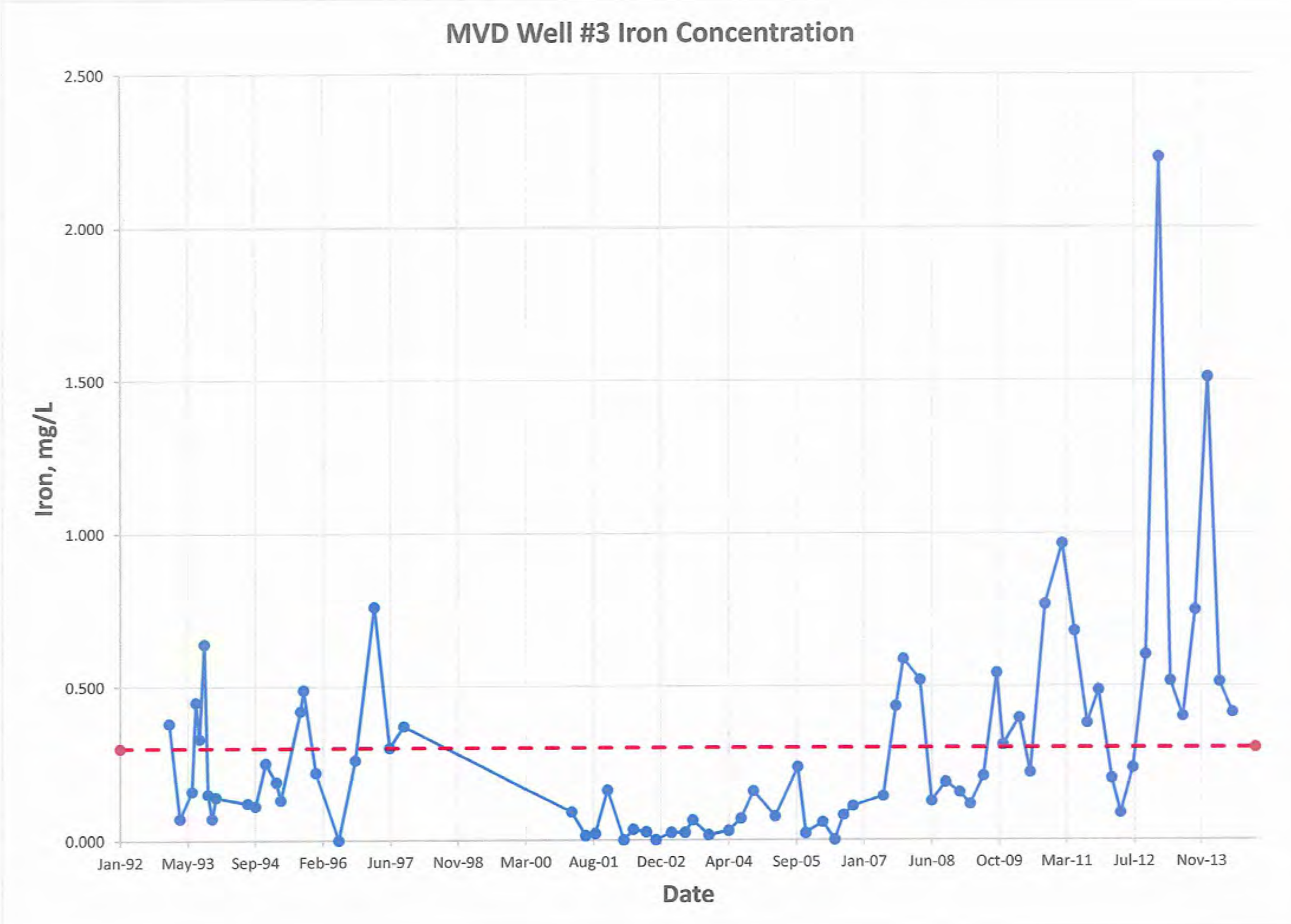
Parameter	Units	MCL/SMCL*	Well #2	Well #3	Well #4	Well #5	Well #7	Well #8
pH	Units	6.5-8.5*	6.01	5.85	5.87	5.92	6.00	5.89
Turbidity	NTU	1	<.5	<.5	<.5	<.5	<.5	<.5
Copper**	mg/L	1.3	<.01	<0.1	<.01	<.01	<.01	<.01
Iron	mg/L	0.3	<.05	**0.63**	<.01	<.05	**0.90**	**0.63**
Manganese	mg/L	0.05	<.01	**0.35**	<.01	<.01	**0.30**	**0.10**
Sodium	mg/L	100-250	30.0	**118.0**	55.2	96.3	56.4	53.2
Lead**	mg/L	0.015	<.01	<.01	<.01	<.01	<.01	<.01
Chloride	mg/L	250	62	234	106	201	119	128
Nitrate	mg/L	10	<1	<1	3.4	1.7	<1	<1
Hardness	mg/L		38	76	53	74	52	71

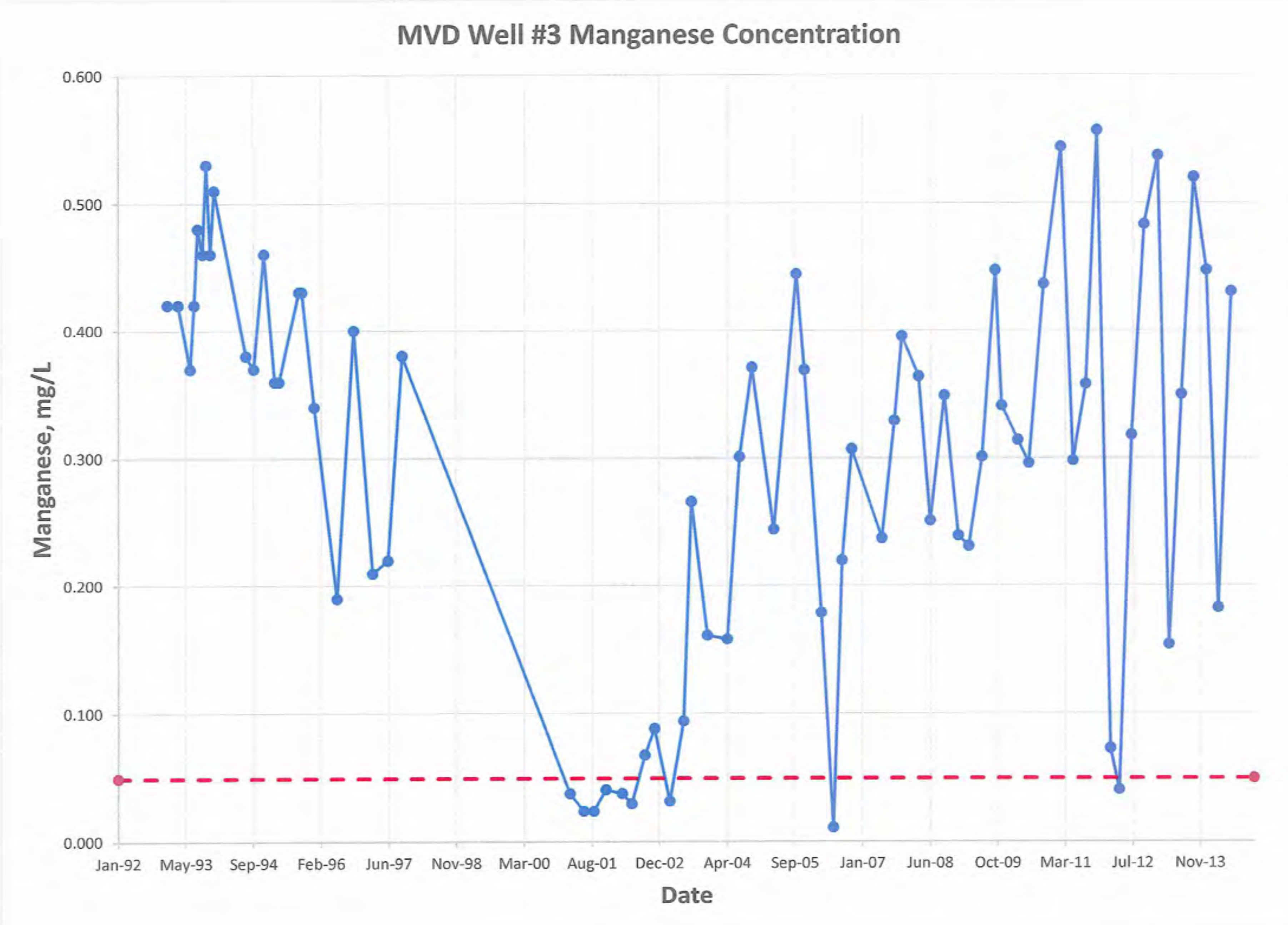
*Standard (MCL) or recommendation (SMCL) for treated water.

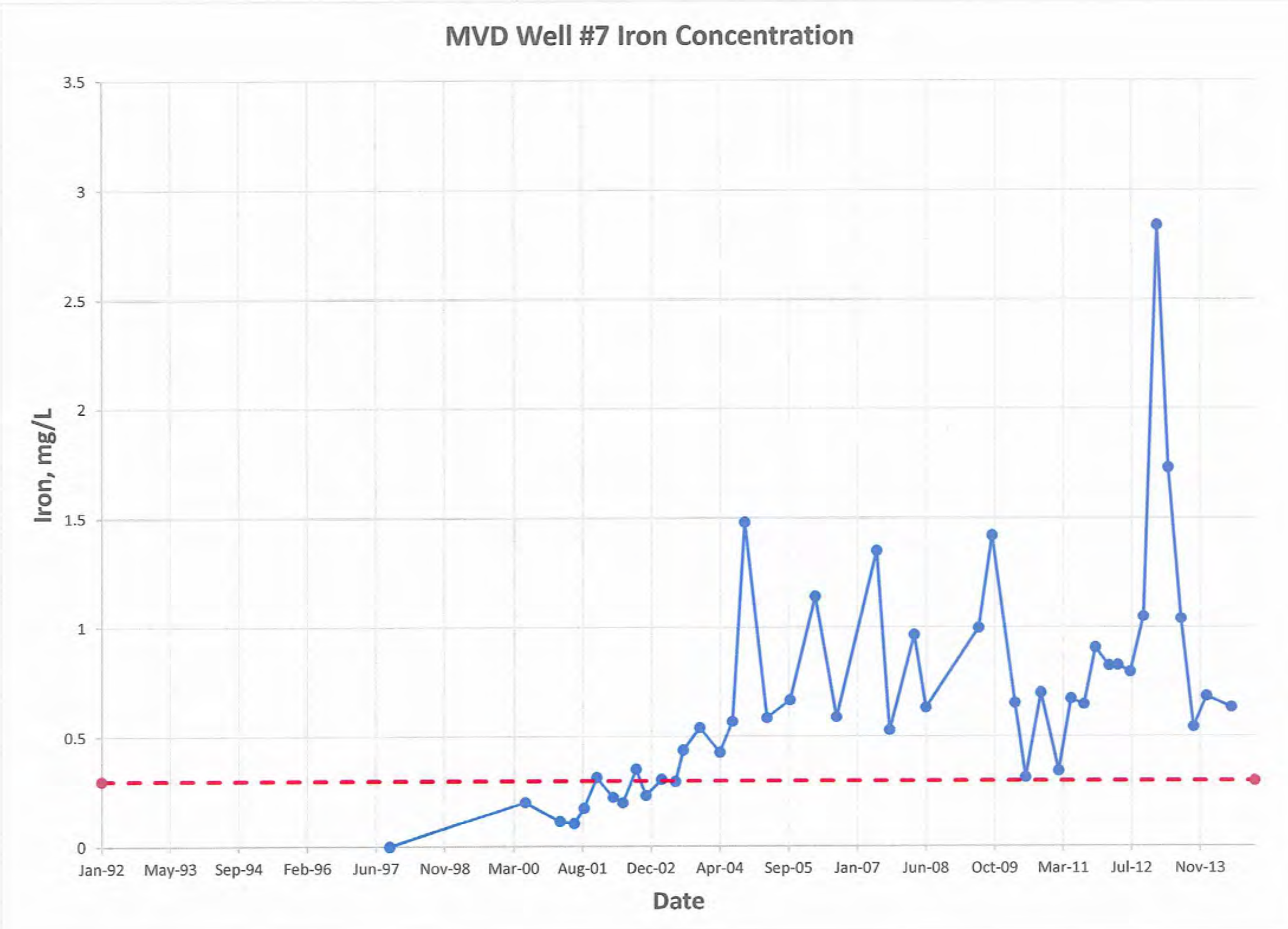
**Lead and Copper compliance determined by sampling in the distribution system, not at sources.

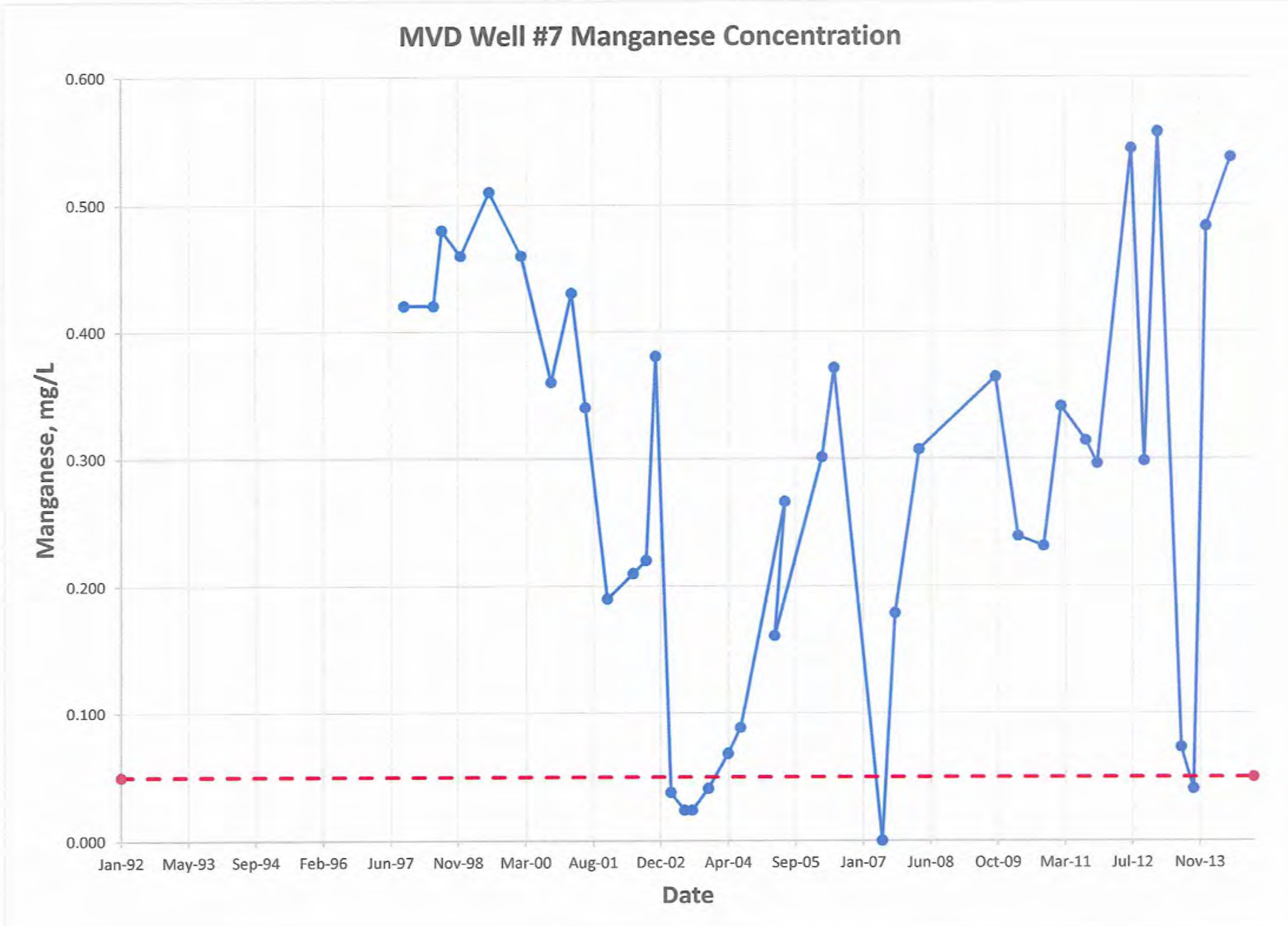
Bold indicates raw water concentrate exceeds finished MCL or SMCL.

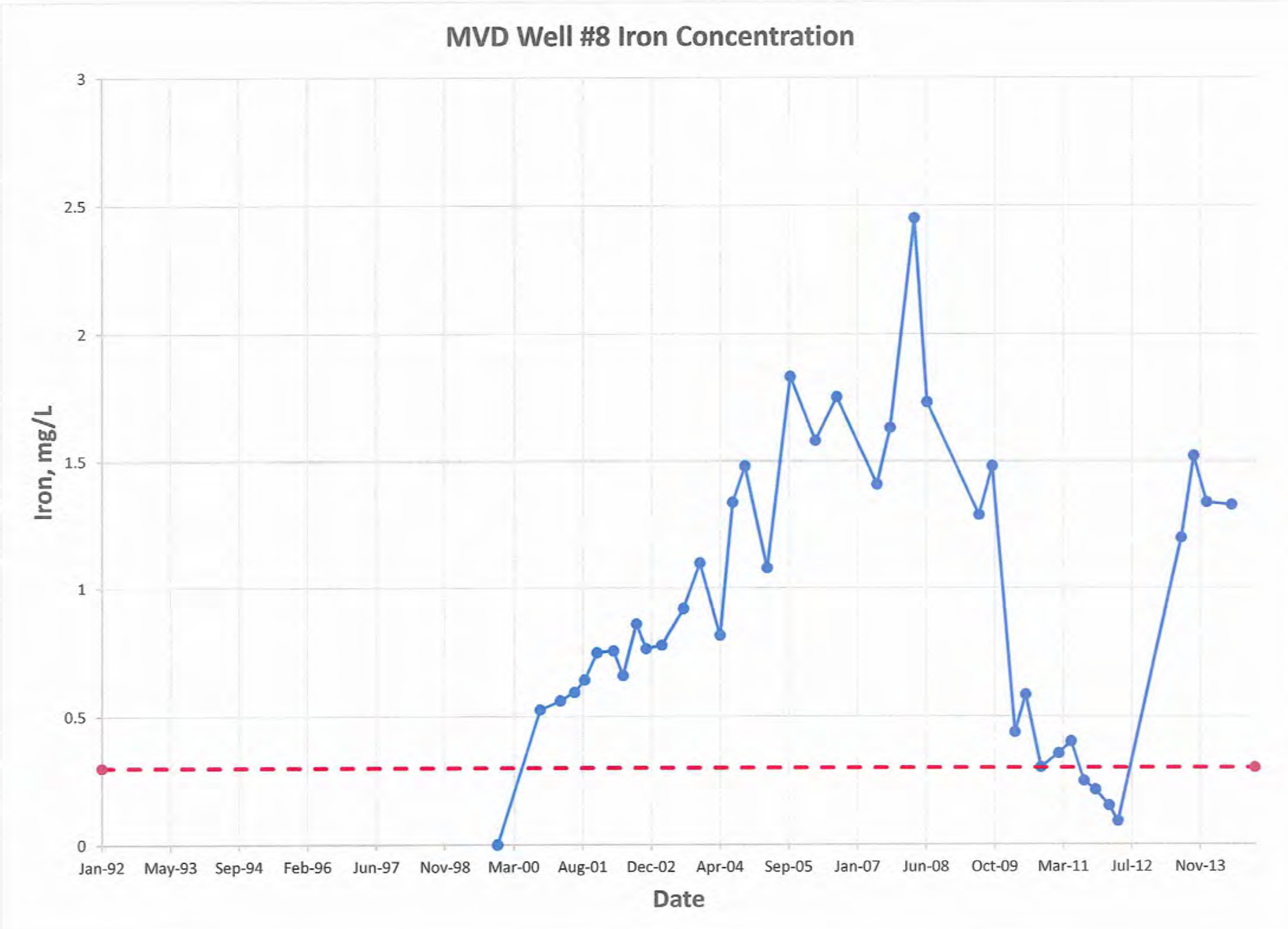
Note, Well#8 has not been in regular production since 2007. Well #8 Iron reached a peak of 2.45 mg/L in 2008.
Well #8 Iron averaged 1.2 mg/L in the period Sept 2007 to March 2010, per the 2010 Supply Update Report

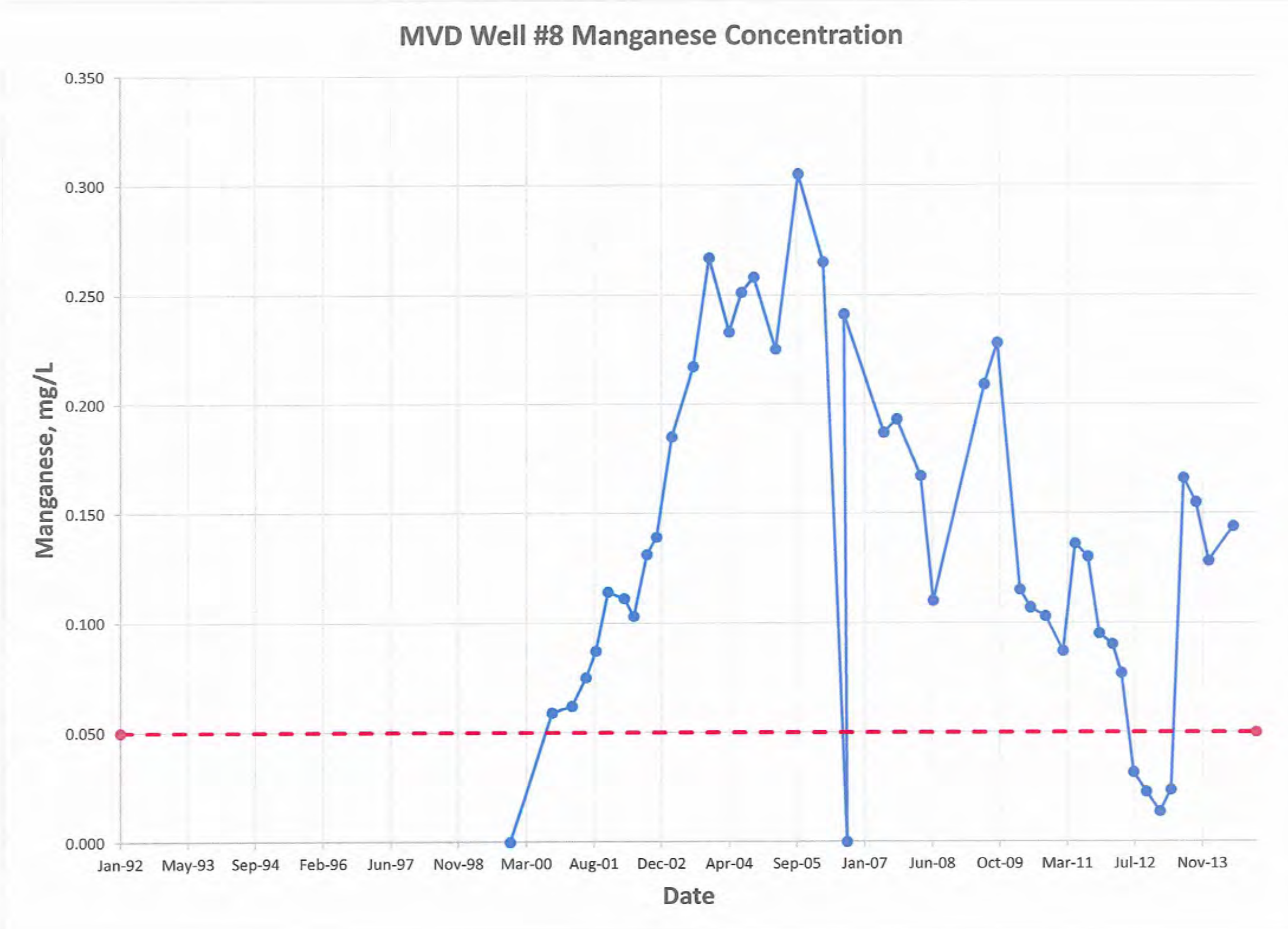

MVD Well #3 Iron Concentration
Iron, mg/L
2.500
2.000
1.500
1.000
0.500
0.000
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date


MVD Well #3 Manganese Concentration
Manganese, mg/L
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date


MVD Well #7 Iron Concentration
Iron, mg/L
3.5
3
2.5
2
1.5
1
0.5
0
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date


MVD Well #7 Manganese Concentration
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Manganese, mg/L
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date


MVD Well #8 Iron Concentration
Iron, mg/L
3
2.5
2
1.5
1
0.5
0
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date


MVD Well #8 Manganese Concentration
Manganese, mg/L
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Jan-92
May-93
Sep-94
Feb-96
Jun-97
Nov-98
Mar-00
Aug-01
Dec-02
Apr-04
Sep-05
Jan-07
Jun-08
Oct-09
Mar-11
Jul-12
Nov-13
Date

APPENDIX D

WATER MODEL RESULTS

Scenario: 2025 MDF Wells Off

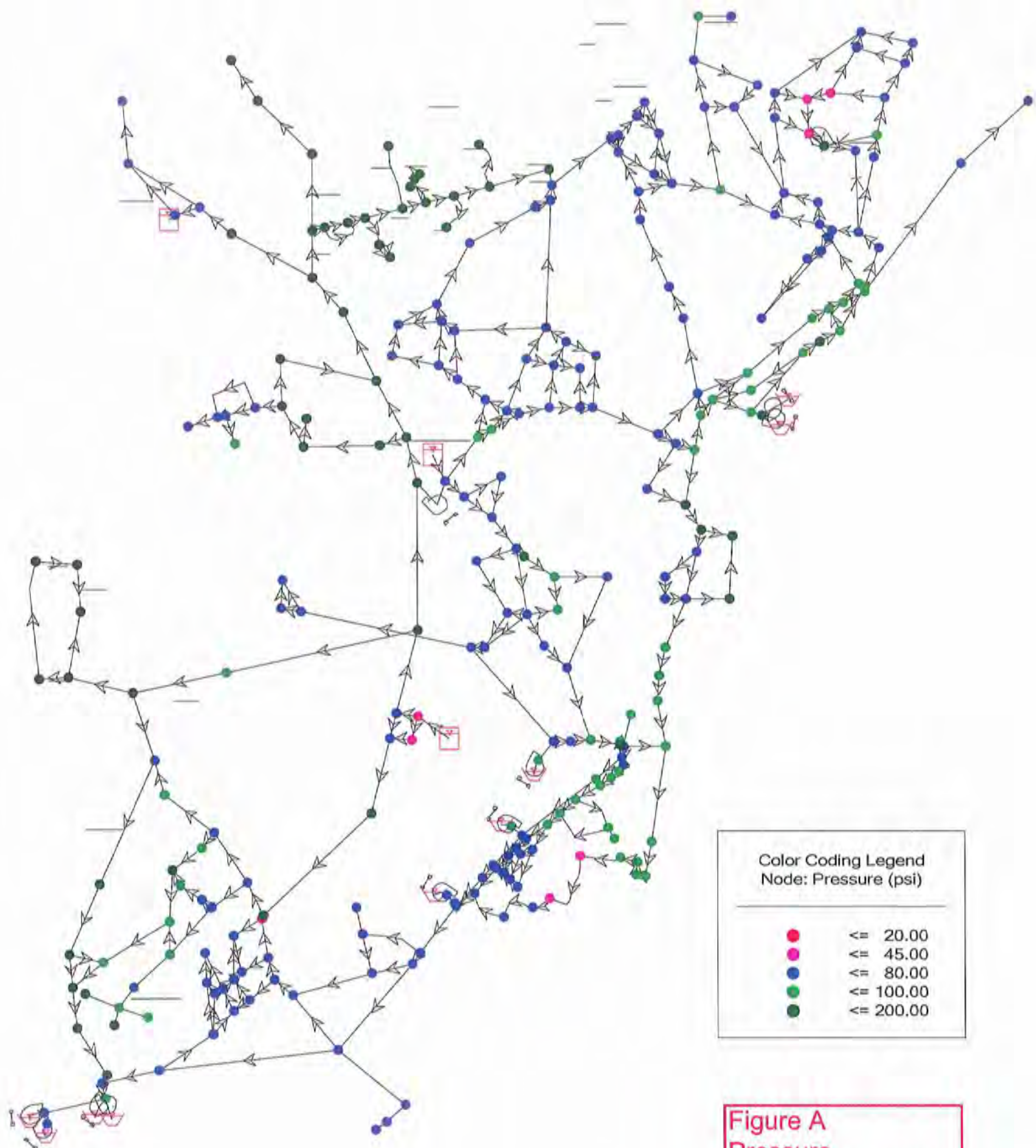


Figure A
Pressure
MVD Water Model

Scenario: Summer ADF Wells 2,3,4,5,7 ON

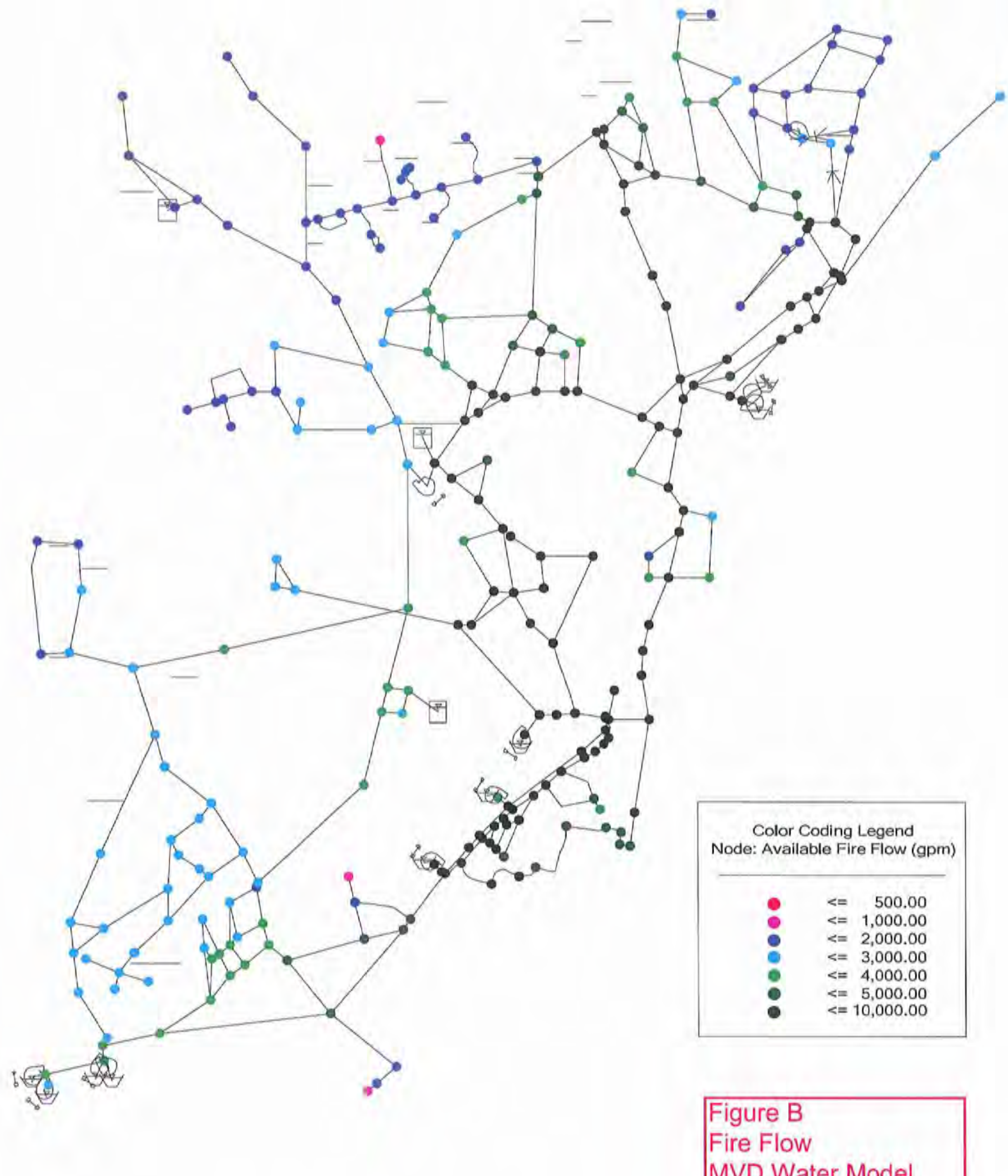


Figure B
Fire Flow
MVD Water Model

Scenario: WTP 1850 gpm

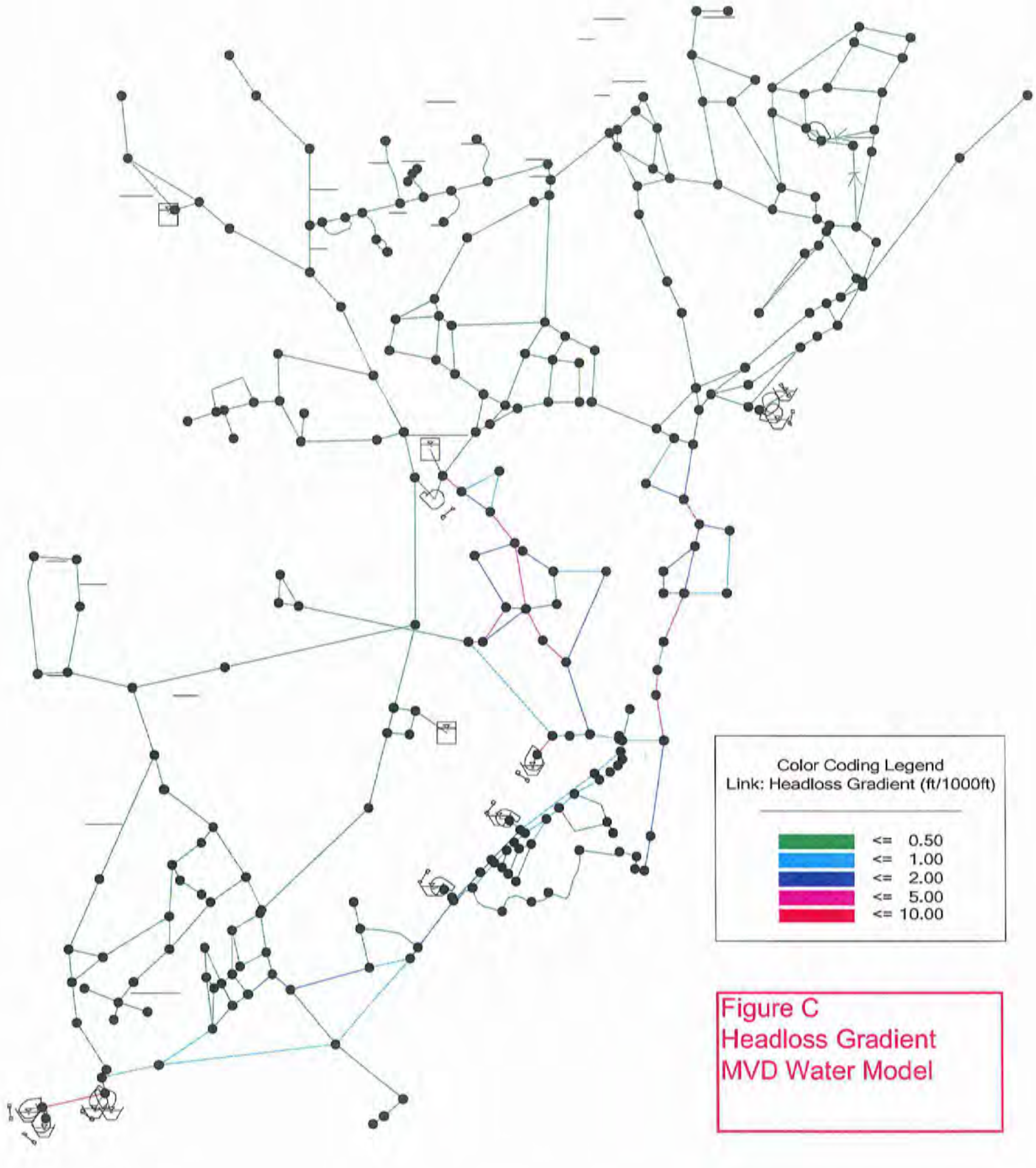


Figure C
Headloss Gradient
MVD Water Model