KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT

2025 WATER MASTER PLAN

MARCH 2025

PREPARED BY:

PBI ENGINEERING CONSULTING™
A Verdantas Company

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KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT

33540 LOOP ROAD
KIRKWOOD, CA 95646

2025 WATER MASTER PLAN

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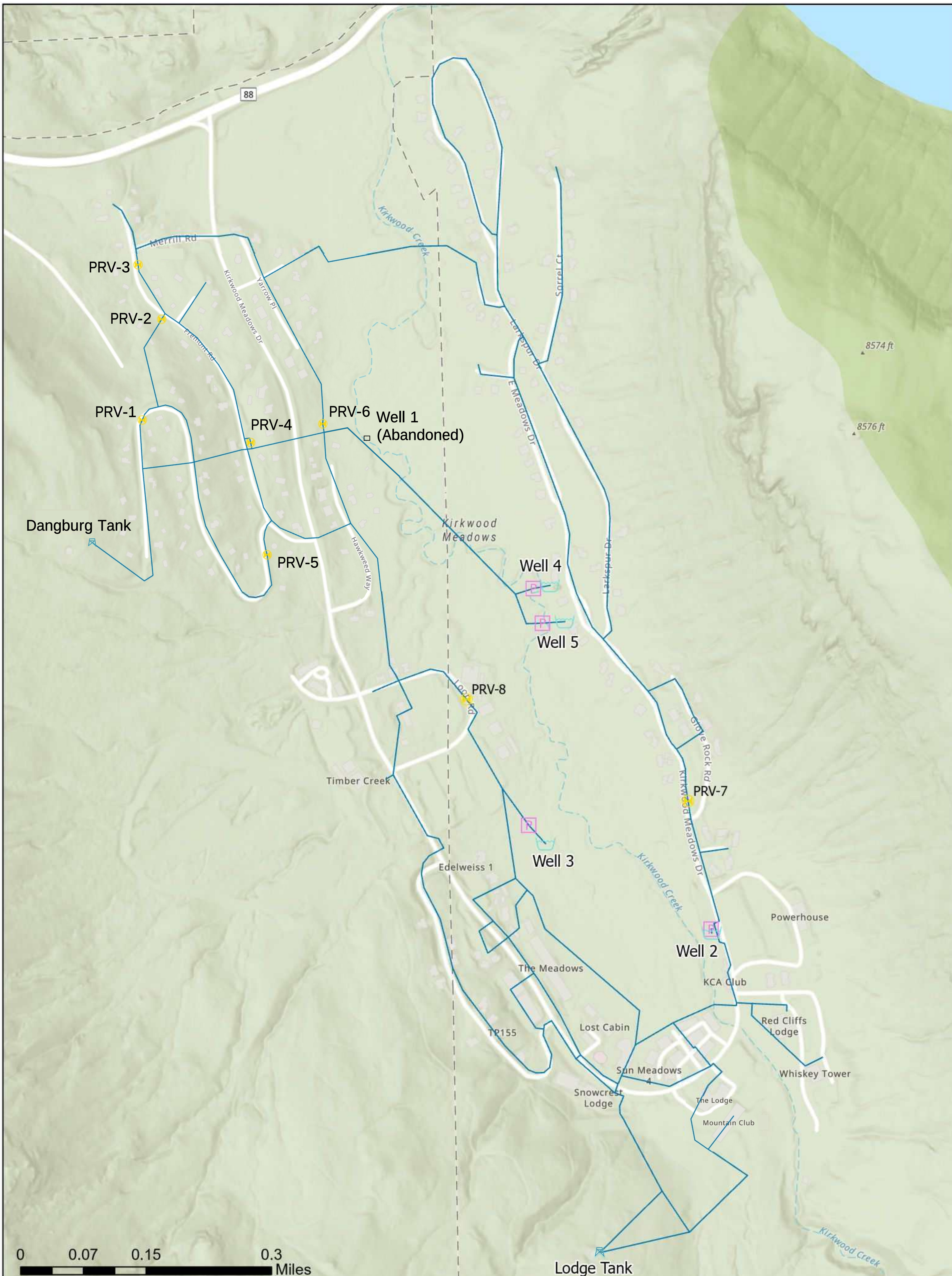
EXECUTIVE SUMMARY

The Kirkwood Meadows Public Utility District (District) is assembling a water master plan for its water system to support the development of a 5-year Capital Improvement Program (CIP) and 20-year asset management plan to ensure adequate funding for future improvements. The CIP incorporates input from District's staff based on institutional knowledge of the water system, along with the results of the distribution system hydraulic model. The District retained the services of PBI LLP, a Verdantas Company (PBI) to develop this master plan for their water system. The water master plan includes an evaluation of the water system's water supply, water demands, distribution system, and storage facilities.

The District's water system services approximately 864 active water connections in the counties of Alpine, Amador, and El Dorado. The water system consists of four active groundwater wells (one of the five existing wells, Well 1, was abandoned in 2013), two storage tanks, and approximately 8.4 miles of pipelines ranging from four to ten inches in diameter. The water is supplied entirely from the groundwater wells, which are located within the District's service area. The existing system also includes eight (8) PRVs; however, some PRVs are believed to be either bypassed or broken and the system has known areas of high pressure within the main pressure zone. Existing District's facilities are shown in Figure ES- 1.

The District provided five years of historical meter data from 2019 to 2023 to use for a basis of demand. The data provided included meter data for each month of the 5-year period, daily meter data for the peak month, and hourly meter data for the day with the highest usage. The average day demand (ADD) for each year was determined to be 21.6 gpm. The highest usage day over the 5-year span was February 20, 2023 at 117 gpm. The Maximum Dailey Demand (MDD) obtained from analyzing the historical data (117 gpm) was 5.4 times higher than the ADD. The wide range in demand estimations can be attributed to the large seasonal swing in occupancy experienced by the Kirkwood Mountain Ski Resort and, ultimately, the District's system.

The District's hydraulic model was updated to analyze different water demand scenarios throughout the distribution system. The original District's model did not include well facilities so only steady state analyses were available. The model was updated to include all four active well facilities based on data provided by the District. This allowed extended period simulations to be produced to aid in analyzing tank turnover and water age. The scenarios created for this master planning effort include average day demand (ADD), maximum day demand (MDD) with fire flow demand and peak hour demand (PHD). The scenarios were created for the existing distribution system and buildout demand based on the *Kirkwood Specific Plan (2003)* demand projections.



PBI ENGINEERING CONSULTING™ A Verdantas Company 80 Blue Ravine Rd., Suite 280 Folsom, CA 95630 Phone: (916) 608-2212	N	**Legend** Pressure P Pump Well PRV's Tank	KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT EXISTING FACILITIES	FIGURE ES-1

The District has noted that there are large pressure fluctuations in the system. The location of the existing PRVs is configured to accommodate four pressure zones. However, as it currently operates, the system has an interconnection between the upstream side of PRV 1, and the main pressure zone. Therefore, there are only three active pressure zones in the existing system, as shown in Figure ES-2. The main pressure zone has varied terrain, resulting in pressures over 120 psi. As part of the evaluation of improvement alternatives, the District has requested that operational strategy changes be considered as a way to mitigate high pressures in the system. Due to the varying terrain throughout the system, the best way to mitigate high pressures would be to add new pressure zones; however, the proximity of the existing groundwater supply wells and the two tanks prohibits the ability to create new pressure zones without dedicated transmission lines. Two operational strategies were analyzed using the hydraulic model:

1) Scenario 1: Open PRV's 1, 2, and 5 to create two pressure zones and a simplified version of current operations.
2) Scenario 2: Install dedicated transmission mains between the wells and both tanks so that any well could fill either tank.

The construction of dedicated transmission lines alone would not mitigate system pressures; however, the addition of a new PRV downstream of the Lodge tank that is set at a lower HGL which is reflected at existing PRVs 2 and 5 will help reduce the pressure within the main zone. Construction of dedicated transmission mains would require an upfront capital investment. Due to the existing configuration of the wells and the two tanks, adding additional PRVs to help reduce the pressure in the main zone would prohibit the ability for the Lodge Tank (the larger of the two tanks) to be filled by wells 4 and 5 (the higher capacity wells) which would result in over stressing wells 2 and 3. Alternatively, the District could further simplify system operations and eliminate the unnecessary lower Danburg zone by opening PRV's 1, 2, and 5. This would not reduce the high pressure areas in the main pressure zone, however, these areas are already equipped with PRVs on the service lines and would require minimal investment by the District.

Both scenarios comply with the District's maximum velocity and minimum pressure criteria and show improvements in available fireflow. However, there are areas where the maximum pressure is exceeded as anticipated.

Scenario 2 comes with a high implementation cost of just about $3M. Scenario 1 also provides operational improvements by allowing the tanks to float off each other and reduce water age but does not mitigate high pressures within the main zone. The customers that currently experience high pressure are already equipped with PRVs on their services. It can provide more control over system pressures, but it requires a significant investment from the District whereas the ultimate concern of high pressure is potential reduced useful life of assets. The assets can be instead maintained on an annual replacement program. Therefore, it is recommended that the District proceed with Scenario 1 and implement an annual pipeline replacement program. The hydraulic schematic for the Scenario 1 can be found in Figure ES-3

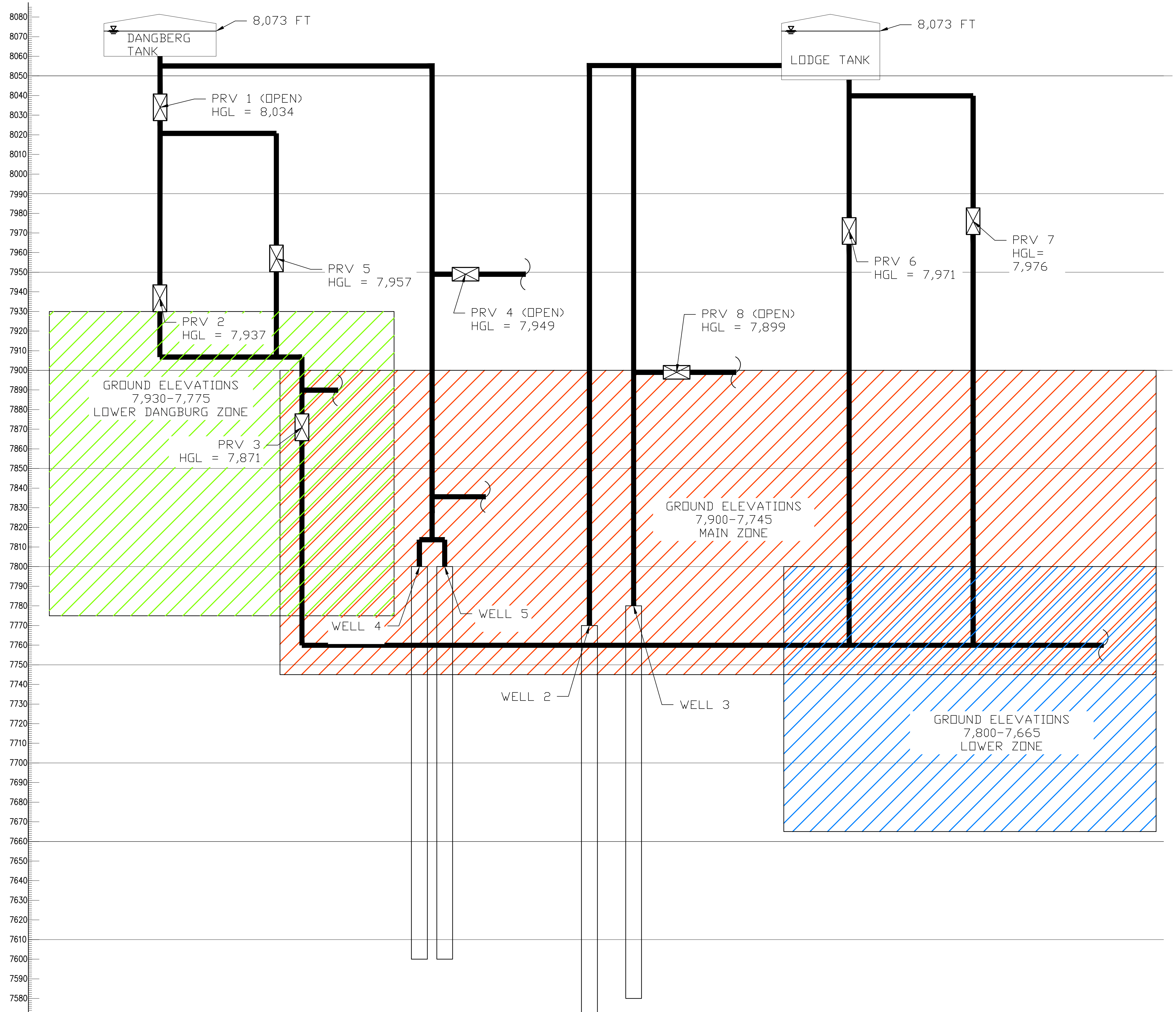


Figure ES-2. Existing System Hydraulic Schematic

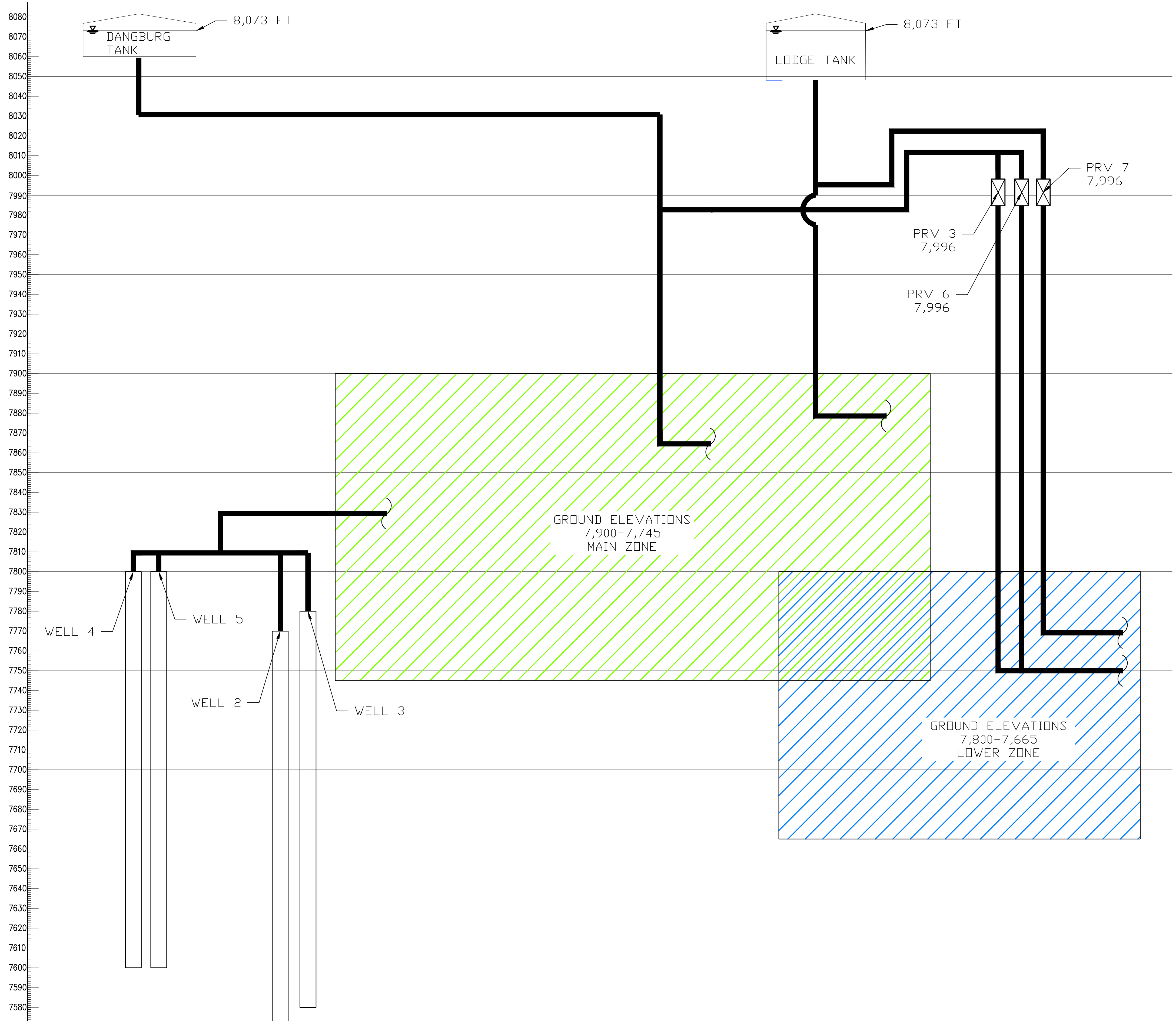


Figure ES-3. Proposed System Hydraulic Schematic

A condition assessment of critical facilities was performed resulting several recommended high priority rehabilitation projects. This includes recoating both tanks which have their original coatings and the addition of manganese treatment at Wells 4/5 for which the District has provided a corrective action plan to the California Division of Drinking Water (DDW) to mitigate the known water quality compliance concern. The District would also like to upgrade all facilities with PLC panels and SCADA but this is currently recommended on the 20 year planning horizon due to budget limitations.

Projects recommended to improve system operation, rehabilitate existing well facilities, and rehabilitate storage tank facilities are included in a 5-year CIP and 20-year asset management plan. The recommended 5-year and 20-year CIP includes 12 projects.

The 12 projects on the recommended 5-year and 20-year CIP include:

- Manganese Treatment Feasibility Study for Wells 4/5
- Wells 4/5 Improvement Project: Green Sand Filter and CMU Block Building.
- Wells 4/5 Improvement Project: PLC & Control Panels, Wireless Modems, Level Transducers.
- Well 2 Improvement Project: PLC & Control Panels, Wireless Modems, Level Transducers, CMU Block Building
- Well 3 Improvement Project: PLC & Control Panels, Wireless Modems, Level Transducers
- Dangburg Tank Rehabilitation Project: Interior Lining & Exterior Coating
- Dangburg Tank Rehabilitation Project: Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Minor structural repairs, Expansion joints, Transmission Line Upgrades
- New Dangburg Tank Access Road Project
- Lodge Tank Rehabilitation Project: Interior Lining & Exterior Coating
- Lodge Tank Rehabilitation Project: Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Expansion joints
- Operations Building SCADA System, Wireless Receiver, Programming
- PRV Field Assessments & Improvements

The total cost of the CIP is $3.2 million, in 2025 dollars, over the next 5 years and $8 million over the next 20 years. The recommended 5-year CIP and 20-year asset management plan is presented in Table ES-1.

Table ES- 1: Capital Improvement Program

Replacement Component	Construction Costs	Total Cost	Cycle	Priority Scale 1-6 1 = Critical	2025/2026	2026/2027	2027/2028	2028/2029	2029/2030	2030-2035	2035-2040	2040-2045
Manganese Treatment Feasibility Study		$30,000	One Time	1	$30,000							
Wells 4 + 5 Improvement Project: Green Sand Filter & CMU Block Building.	$1,370,280	$1,473,051	One Time	1		$102,771	$1,370,280					
Wells 4 + 5 Improvement Project: PLC & Control Panels, Wireless Modems, Level Transducers.	$360,000	$387,000	One Time	4						$387,000		
Well 2 Improvement Project PLC & Control Panels, Wireless Modems, Level Transducers, CMU Block Building	$976,560	$1,049,802	One Time	4						$1,049,802		
Well 3 Improvement Project PLC & Control Panels, Wireless Modems, Level Transducers	$315,000	$338,625	One Time	4							$338,625	
Dangburg Tank Improvement Project Interior Lining, Exterior Coating	$472,560	$508,002	Thirty Years	3				$508,002				
Dangburg Tank Improvement Project Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Minor structural repairs, Expansion joints	$619,920	$666,414	One Time	5							$666,414	
Dangburg Tank Access Road Project	$176,400	$189,630	One Time	3				$189,630				
Lodge Tank Improvement Project Interior Lining, Exterior Coating	$655,200	$704,340	Thirty Years	3					$704,340			
Lodge Tank Improvement Project Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Expansion joints	$569,520	$612,234	One Time	5							$612,234	
Operations Building SCADA System + Wireless Receiver + Programming	$243,000	$261,225	One Time	5								$261,225
PRV Field Assessments + Improvements	$231,960	$249,357	One Time	2		$249,357						
Annual Infrastructure Program			Yearly					$17,000	$17,000	$450,000	$450,000	$450,000
Total Water Capital Expense		**$7,853,680**			**$30,000**	**$352,128**	**$1,370,280**	**$714,632**	**$721,340**	**$1,886,802**	**$2,067,273**	**$711,225**

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CHAPTER 1 - INTRODUCTION

The Kirkwood Meadows Public Utility District (District) was established in 1985 as a special legislative district under the California Public Utilities Code, following its separation from the El Dorado Irrigation District. Situated in a remote region of the Sierra Nevada mountains, the District spans Alpine, Amador, and El Dorado Counties, covering an area of approximately 1.875 square miles. Since 1972, KMPUD has been operating water and wastewater systems, and since 2011, electric, and propane systems. Today, the District is dedicated to enhancing the quality and reliability of its infrastructure while providing essential services and maintaining financial sustainability for the community.

The District's system services approximately 864 active water connections in the counties of Alpine, Amador, and El Dorado. The water system consists of four groundwater wells with a combined peak production of 225 gallons per minute (one of the five existing wells, Well 1, was abandoned in 2013), two storage tanks with a total capacity of 950,000 gallons, and approximately 8.4 miles of pipelines ranging from four to ten inches in diameter. The water is supplied entirely from the groundwater wells, which are located within the District service area.

This document represents the findings and recommendations of the 2025 Kirkwood Meadows Public Utility District's (District) Water Master Plan (WMP).

1.1 Purpose of the Master Plan Update

The purpose of this 2025 WMP is as follows:

- Review water demands and supply and provide recommendations for meeting existing and ultimate water demands, including emergency scenarios.
- Evaluate the capacity of the existing water system such as distribution piping, storage requirements, pipe velocity requirements, and fireflow requirements.
- Update and calibrate the District's current hydraulic model.
- Provide detailed recommendations for Capital Improvement Projects that consider capacity, regulations, and maintenance costs.
- Prepare a list of recommended capital facilities improvements including estimated costs and implementation schedule for a 20-year CIP.

1.2 Background Documents & Data Collection

This 2025 WMP primarily relies on the following documents for information regarding the District's water use and potential infrastructure improvements:

- Kirkwood Specific Plan (2003)

- Kirkwood Meadows Public Utility District Water and Wastewater Rate Study (2020)
- Kirkwood Meadows Public Utility District Standard Design and Construction Specifications for Water Systems (2022)
- Kirkwood Meadows Public Utility District Approved Capital Improvement Program (2023-2028)
- Kirkwood Meadows Public Utility District System Analysis – Bailey Civil Engineering (2021)

1.3 Abbreviations

- **ADD**: Average Day Demand
- **CIP**: Capital Improvement Projects
- **CMU**: Concrete Masonry Unit
- **DDW**: Division of Drinking Water
- **EDU**: Equivalent Dwelling Units
- **fps**: Feet Per Second
- **GIS**: Geographic Information System
- **gpm**: Gallons Per Minute
- **HGL**: Hydraulic Grade Line
- **KMPUD**: Kirkwood Meadows Public Utility District
- **MDD**: Maximum Day Demand
- **PF**: Peaking Factor
- **PRV**: Pressure Reducing Valve
- **PHD**: Peak Hour Demand
- **PSI**: Pounds per Square Inch
- **WMP**: Water Master Plan

1.4 Report Organization

Following this introductory Chapter, the 2025 WMP includes the following chapters:

- Chapter 2 – Existing Water System: Describes the District's existing water service area and provides background information on the District's existing water system including water supply, storage and transmission/distribution facilities.
- Chapter 3 – Water Demands: Presents the existing water demands, population projections and projected future water demands
- Chapter 4 – Hydraulic Model Development: Discusses the process of updating and calibrating the current hydraulic model
- Chapter 5 – Distribution System Criteria: Presents the system design criteria used to evaluate the water system

- Chapter 6 – Distribution System Analysis: Presents results of hydraulic model evaluation of the existing and future water distribution system under the existing and projected future water demands
- Chapter 7 – Facility Condition Assessment: Summarizes information gathered from separate studies that assessed the condition of the distribution system piping, pump stations, and all District storage tanks.
- Chapter 8 – Recommended Capital Improvement Projects: Recommends projects based on the analysis of the existing and future water system and presents planning cost estimates and timelines for implementation of the recommended projects
- Chapter 9 – Recommended Capital Improvement Program: Presents the estimated costs and a prioritized implementation schedule for the recommended improvements.
- Appendices

CHAPTER 2 – EXISTING WATER SYSTEM

The Kirkwood Meadows Public Utility District operates using water from four active groundwater wells. Operators manually select which wells will pressurize the system and fill the two tanks: the Dangburg Tank and the Lodge Tank on the west side of the systems. The distribution system includes approximately 43,000 feet of 4-inch through 10-inch distribution mains. The following sections provide a detailed breakdown of the existing water facilities. Figure 2-4 shows a map of the existing facilities.

2.1 Existing Water Supply Facilities

2.1.1 *Wells and Water Treatment*

The District operates a network of wells that form the community's water supply system. Currently, four wells are active with a fifth abandoned. Operators manually select which wells to pressurize the system, ensuring that the community's water needs are met efficiently. Below is a detailed description of each well site and its specific features.

2.1.1.1 Well 1

Constructed in 1972, Well 1 is located on the west side of the meadow near the Dangburg tank fill line. This well was abandoned in 2013. Initially, the fill line was isolated from the distribution system by PRV 4, and it was only directly connected to the distribution system at the top of Dangburg Drive.

2.1.1.2 Well 2

Also constructed in 1972, Well 2 (Figure 2-1) is situated on the east side of the meadow below the powerhouse, just south of the entrance to the East Meadows. The equipment for Well 2 resides in a small wooden building. Based on data provided by the District, Well 2 is assumed to have a capacity of 120 gpm.

Figure 2-1: Well 2 Building

The piping on the outflow for Well 2 includes a flow meter, backflow preventer, air valve, and two chemical injection ports (see Figure 2-2).

Figure 2-2: Well 2 Piping

This well continues to serve as a critical component of the community's water supply infrastructure.

2.1.1.3 Well 3

Built in 1992, Well 3 is located south of the District's offices on the west side of the meadow. It features a secondary booster pump in addition to the well pump and features a CMU block building that encloses the well disinfection equipment(see Figure 2-3). The District has expressed a desire to install similar CMU block buildings for the other active wells. Based on data provided by the District, Well 3 is assumed to have a capacity of 85 gpm.

Figure 2-3: Well 3 Building

2.1.1.4 Well 4

Constructed in 1998, Well 4 is situated on the east side of the meadow, near lot 213, north of the Larkspur/East Meadows Drive intersections. Wells 4 & 5 combine and share the same chemical treatment building, while the well heads are located across the meadow. Based on data provided by the District, Well 4 is assumed to have a capacity of 64 gpm. High levels of manganese have been detected in this well, which exceeded state regulations. The California State Water Board's Division of Drinking Water (DDW) enforces Title 22 of the California Code of Regulations (CCR). Title 22 specifies various maximum contaminant levels (MCLs) that water systems must be monitored for. These MCLs are divided into primary and secondary MCLs, with primary MCLs addressing health concerns and secondary MCLs addressing esthetics such as taste and odor. Manganese is regulated in California as a secondary MCL; however, these standards are still enforceable and must be addressed. The current notification level for manganese is 0.5 milligram per liter (0.5 mg/L).

The District plans to install an oxidizing filtration system (green sand filter) to address this issue and lower the manganese levels to acceptable limits. Well 4, along with Well 5, are connected directly to the distribution system, which pressurize most of the system to fill the tanks, minimizing pressure zones and requiring the installation of pressure-reducing valves at most meters.

2.1.1.5 Well 5

Also constructed in 1998, Well 5 is south of Well 4. Based on data provided by the District, Well 5 is assumed to have a capacity of 85 gpm. Table 2-1 below includes the manganese monitoring results for Well 5 and shows that it, along with Well 4, have exceeded the secondary MCL standard provided by DDW. Together, Wells 4 and 5 have been instrumental in maintaining the water supply for the community despite challenges with elevated manganese levels.

Table 2-1: Wells 4 & 5 Manganese Monitoring Results

	Well 4 Monitoring Results (mg/L)	**Well 5 Monitoring Results (mg/L)**
3rd Quarter 2023	0.07	0.06
4th Quarter 2023	0.06	0.06
1st Quarter 2024	0.05	0.05
2nd Quarter 2024	0.05	0.06
Running Annual Average	**0.06**	**0.06**

2.1.2 Water Storage Tanks

The District currently has two aboveground water storage tanks: the 700,000 gallon Lodge Tank, and the 250,000 Dangburg Tank, for a total of 950,000 gallons of water storage. Originally, there was one 100,000 gallon tank in the system above the top of Dangburg Drive, which was filled by the now abandoned Well 1. Over time, as the valley developed, additional subdivisions necessitated expansion of the water system. The Lodge tank was constructed adjacent to chair 5 above the lodge in the village, and a new 250,000 gallon tank replaced the original Dangburg tank in 1992. A new 700,000 gallon tank also replaced the original Lodge tank in its original location. A fill line to the Dangburg tank was isolated from the distribution system by PRV 4 and was only directly connected to distribution at the top of Dangburg Drive. The system was gravity fed from the Dangburg Tank and the pressure was controlled by 5 pressure reducing stations. As the District grew, additional wells were drilled, and the Lodge Tank was constructed to provide

District grew, additional wells were drilled, and the Lodge Tank was constructed to provide additional storage. The Lodge Tank installation, in addition to the construction of Wells 4 & 5, created a system where the wells pressurized most of the system to fill the tanks, which minimized pressure zones and required the installation of individual pressure reducing valves at most meters.

2.1.2.1 *Dangburg Tank*

The Dangburg tank is a welded steel tank built in 1991. Dangburg tank is a 47 ft diameter tank with a capacity of 250,000 gal. The tank is at an elevation of 8,060ft, stands at 20 ft tall and typically operates at approximately 13ft to match the HGL of the Lodge Tank. The coatings are original and have not been recoated since installation. There is a shared 8" inlet and outlet pipe on the south side of the tank. The tank also has two manholes for entry. On the exterior there is a 6" overflow pipe. On the interior, there is a 6" floor drain that goes to the surrounding ditch.

2.1.2.2 *Lodge Tank*

The Lodge tank is a welded steel tank built in 1996. Lodge tank is a 60 ft diameter tank with a capacity of 700,000 gal. The tank is at an elevation of 8,048 feet, stands 35 feet tall, and usually operates at 25 feet to match the Dangburg tank's HGL. The coatings are original and have not been recoated since installation. There is a shared inlet and outlet pipe that splits into a 6" inlet on the south side of the tank, and a 12" outlet pipe on the west side. The 12" outlet pipe has a vault with check valves where the existing inlet and outlet bifurcate. The tank also has two manholes for entry. On the exterior there is a 6" overflow pipe. On the interior, there is a 6" floor drain that goes to the surrounding ditch.

2.1.3 *Transmission Main and Distribution Piping*

The District operates approximately 43,000 feet of 4", 6", 8", and 10" water mains. These mains are composed of various materials, including asbestos cement (AC), steel, ductile iron, and C900 PVC. The system also includes 8 PRV's and 99 fire hydrants.

2.1.4 *Pressure Reducing Stations*

The PRV's in the District's water system play a crucial role in maintaining the stability and efficiency of water pressure across different zones. Presently, the system is comprised of eight PRVs, yet several of these are either malfunctioning or being bypassed due to other operational issues. The Table 2-2 identifies the 8 PRVs in the District's system, their location, as well as their currently assumed settings based on the 2021 system analysis and their HGL based on provided elevations:

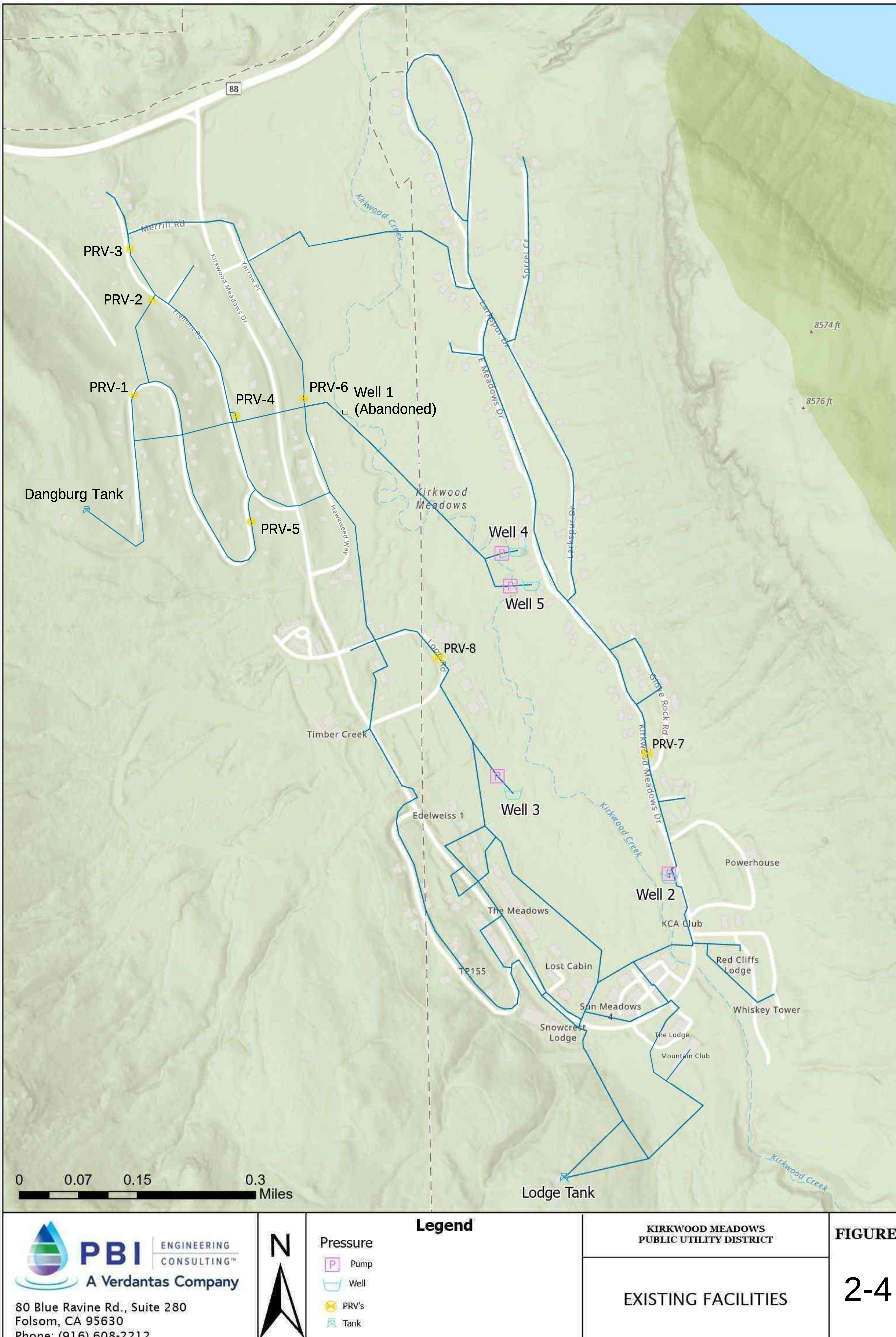

Figure 2-4: Existing Facilities

Table 2-2: Existing PRV Settings

PRV	Location	System Map Setting (PSI)	ELV (ft)	Observed System Pressures (PSI)	Head(ft) (System Map)	Head (ft) (Observed)	HGL (ft) (System Map)	HGL (ft) (Observed)
1	Top of Dangburg Drive, north end	45	7930	55	104.0	127.1	8057	8034
2	West of Fremont Rd, near Fremont Ct	70	7775	70	161.7	161.7	7937	7937
3	East of Fremont Road, South of Merrill Road	50	7755	10	115.5	23.1	7778	7871
4	East of Fremont Road, North of Dangburg	60	7810	115	138.6	265.7	8076	7949
5	East of Dangburg, ~200ft south of Fremont intersection	55	7830	55	127.1	127.1	7957	7957
6	Between Yarrow and Hawkweed	100	7740	100	231.0	231.0	7971	7971
7	West of E. Meadows Drive, near Glove Rock Road	85	7780	85	196.4	196.4	7976	7976
8	East end of Loop Road	60	7760	*	138.6	138.6	7899	7899

* Operational data for PRV 8 was indeterminable due to its location. For modeling purposes, the downstream pressure has been set to 60 psi to match the system map.

The District's distribution system does not currently function with well-defined pressure zones. This situation has developed over time due to several factors, including modifications to the system, the opening and breaking of pressure reducing valves (PRVs), and interconnection of transmission lines and distribution lines. The distribution system also spans terrain with variable elevations. As a result, certain areas within the system experience high operating pressures, reaching approximately 120 psi. Therefore, the District's customers that experience high pressure are now equipped with PRVs on their service lines.

The existing hydraulic schematic shows how the tanks and existing PRV hydraulic grade line compares to the ground elevations within the District's system (see Figure 2-5).

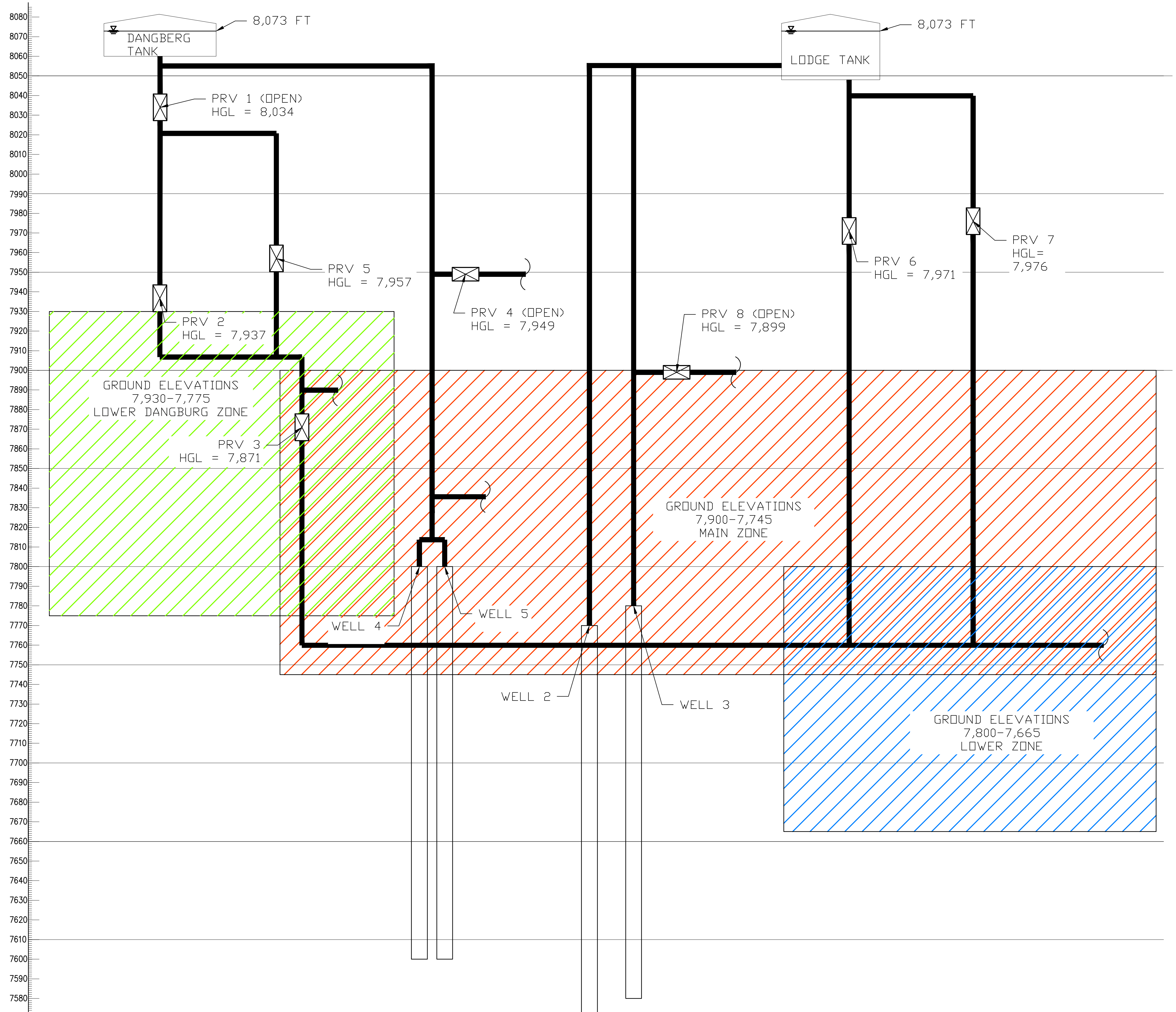

Figure 2-5. Existing System Hydraulic Schematic

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CHAPTER 3 – WATER DEMANDS

3.1 Existing Water Demand

The *Kirkwood Specific Plan* (2003) presents MDD and ADD values derived from meter data collected in 1997. For the purposes of this analysis, amore recent data provided by the District. The District provided five years of historical meter data from 2019 to 2023 to use for a basis of demand. The data provided included meter data for each month of the 5-year period, daily meter data for the peak month, and hourly meter data for the day with the highest usage. The average day demand (ADD) for each year was determined by dividing the annual total water usage by 365 days (366 for 2020), which can be seen below in Table 3-1. The average of the historical ADD data was 21.6 gpm.

Table 3-1: Historical Meter Data Demand

	MONTHLY DEMAND (MG)														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEARLY TOTAL (MG)	ADD (GPD)	ADD (GPM)
2023	0.98	1.68	1.40	1.14	0.69	0.41	0.94	0.65	0.49	0.48	0.65	1.51	11.01	30,160	20.9
2022	1.78	1.62	1.44	0.91	0.36	0.43	0.78	0.62	0.47	0.36	1.10	1.67	11.54	31,616	22.0
2021	1.38	1.69	1.44	0.75	0.42	0.76	1.00	0.75	0.32	0.79	0.82	1.44	11.56	31,672	22.0
2020	1.70	1.41	1.26	0.47	0.39	0.66	0.96	0.89	0.71	0.67	1.25	1.29	11.66	31,947	22.2
2019	1.82	1.32	1.41	0.72	0.26	0.36	0.75	1.05	0.67	0.39	0.72	1.51	10.99	30,101	20.9
													Average		21.6

The maximum day demand (MDD) for each year was taken to be the highest use day of the year. The highest usage day over the 5-year span was observed to be 117 gpm on February 20, 2023.

For comparison, the flow definition requirements for the District are detailed in Table 3-2. Based on these definitions, the Maximum Day Demand was derived by multiplying the Average Day Demand (ADD) of 21.6 gpm by a factor of 2.25, yielding a value of 48.6 gpm. The MDD obtained from analyzing the historical data (117 gpm) is 2.34 times higher than the MDD based on standard flow definitions for the District, which is shown in Table 3-3.

Table 3-2: District Flow Definitions

FLOW TYPE	DEFINITION	
Average Daily Demand (ADD)	(Design Population)*(Average per capita daily flow requirement) + (any commercial, industrial, school demand)	
Maximum Month Demand (MMD)	(ADD)* 1.5	
Maximum Day Demand (MDD)	(MMD)* 1.5	
Peak Hour Demand (PHD)	> (MDD)* 1.67, or the approved MDD to PHD factor, whichever is greater.	
Fire Flow (FF)	Fire Protection Districts set FF requirements. Minimum requirements listed below:	
	Residential Areas	≥ 1,000 gpm for 2 hours
	Commercial Areas	≥ 1,500 gpm for 2 hours
	Sprinklers	≥ 60 gpm for 2 hours

Table 3-3: Existing Demand Calculations

	FLOW DEFINITION PROJECTIONS (GPM)	2019 TO 2023 METER DATA (GPM)
ADD	21.60	21.60
MDD	48.60	117.00
ADD to MDD Factor	2.25	5.42

The wide range in demand estimations shown in Table 3-3 can be attributed to the large seasonal swing in occupancy experienced by the Kirkwood Mountain Ski Resort and, ultimately, the District's system. The more conservative MDD of 117 gpm was used in the hydraulic model analysis for this WMP.

3.2 Land Use Types

A variety of land use types exist within the District including residential, commercial, and utility zones. Figure 3-1 provides a summary of existing land use types that are within the District's water service area. The land use map from the 2003 Kirkwood Specific Plan was recreated in using GIS software and imported into the hydraulic model.

The District provided usage data for each land use type for the month of February 2023. The Data is summarized in Table 3-4. This data and the land use map were used to develop usage per square foot factors for the model to allocate demand throughout the system. The process and usage factors are discussed in *Section 4.4: Demand Allocation.*

Table 3-4: Summary of Usage Data by Land Use Type (February 2023)

REVENUE CODES	CODE DEFINITIONS	ZONE USE	USAGE (ft3)	USAGE (GAL)	USAGE (GPD)	USAGE (GPM)
CNDC	Condo Commercial (Restaurants, Stores - located in the common area of condominium buildings)	Multi-family Residential and Commercial Zone	6,946	51,956	1,856	1.3
CNDR	Condo Residential	Multi-family Residential Zone	61,049	456,647	16,309	11.3
COMM	Commercial (Ski Lifts, Office Buildings, Stand-alone Restaurants)	Open Space and Recreation Zone - Recreation Facilities Allowed	119,991	897,533	32,055	22.3
KMPD	KMPUD	Service - Utilities	25	187	7	0.005
RES	Residential	Single Family Duplex Residential Zone	38,138	285,272	10,188	7.1
	TOTAL USAGE		226,149	1,691,595	60,414	42

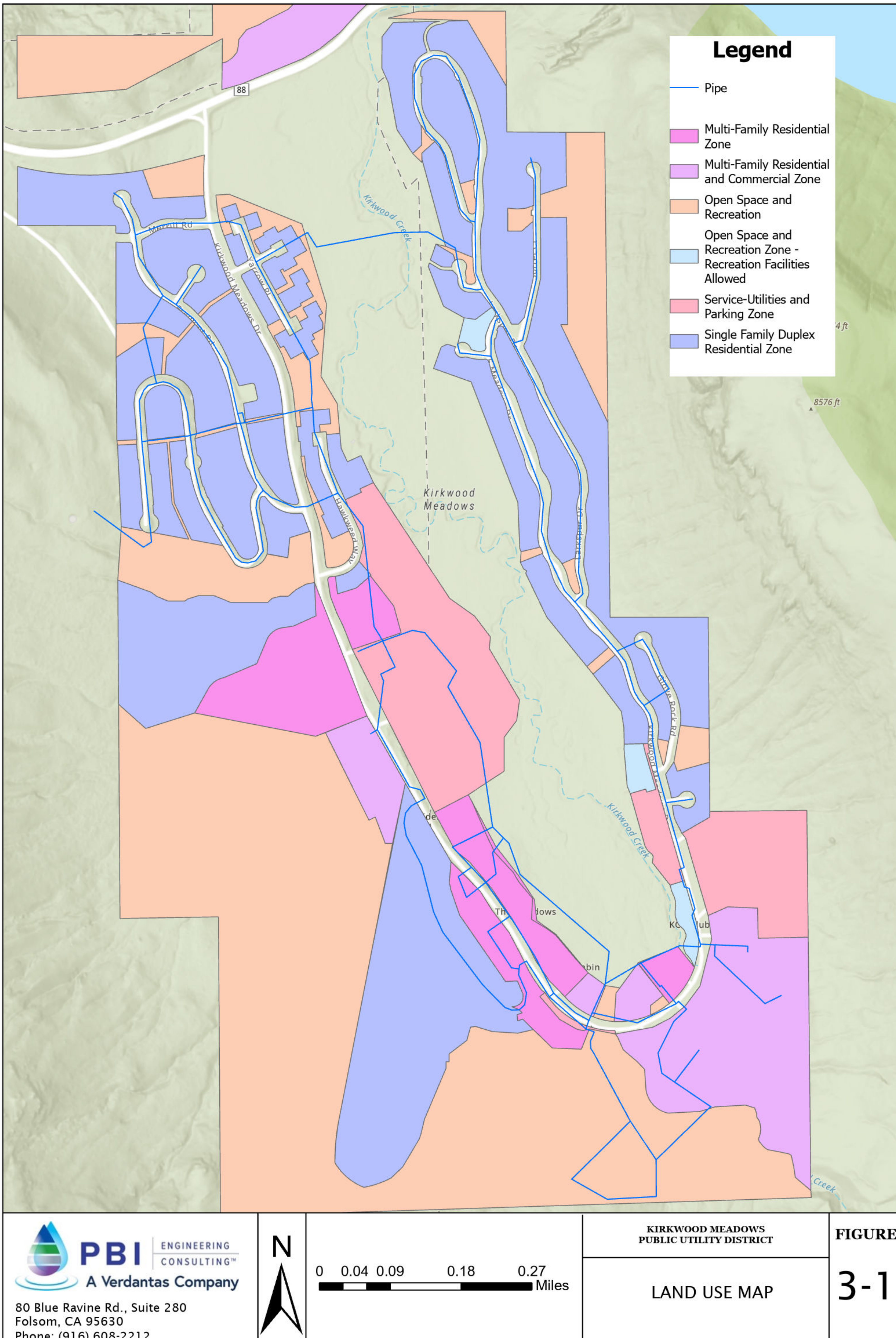

Figure 3-1: Existing Land Use within the District Water Service Area

3.3 Buildout Demand

The *Kirkwood Specific Plan (2003)* lists that under buildout conditions, 1,757 equivalent dwelling units (EDUs) should be assumed to be connected to the water system. The *2003 Kirkwood Specific Plan* states that the predicted ADD upon buildout will be 103.5 gpm and that the MDD will be 222.20 gpm. The Peaking Factor (PF) found from the diurnal curve (discussed in Section 3.4 Diurnal Demand Curve) was used to calculate a predicted PHD of 459.95 gpm. A comparison between the existing and projected demands can be found below in Table 3-5.

Table 3-5:Existing vs. Projected Demand

	EXISTING (GPM)	BUILDOUT (GPM)
ADD	21.60	103.5
MDD	117.00	222.20
ADD to MDD PF	5.42	2.15
PHD	242.19	459.95
MDD to PHD Factor	2.07	2.07

3.4 Diurnal Demand Curve

A diurnal demand curve was created utilizing data provided by the District. February 20, 2023 was identified as the basis for the diurnal curve pattern due to the peak demand during this day. The PHD factor was determined by dividing the hourly demand for each hour by the average hourly demand for the day – this produced demand factors for each hour over a 24-hour period. Table 3-6 presents the daily demand multipliers for this diurnal demand curve and Figure 3-2 shows this curve over a 24 hour period.

Table 3-6: Diurnal Demand Curve Multipliers

Hour	Daily Demand Multiplier	Hour	Daily Demand Multiplier	Hour	Daily Demand Multiplier
1	0.79	9	0.85	17	1.58
2	0.50	10	1.38	18	1.56
3	0.40	11	2.07	19	1.73
4	0.14	12	1.97	20	1.54
5	0.10	13	1.91	21	1.43
6	0.13	14	1.85	22	1.35
7	0.13	15	1.90	23	1.16
8	0.36	16	1.56	24	1.10

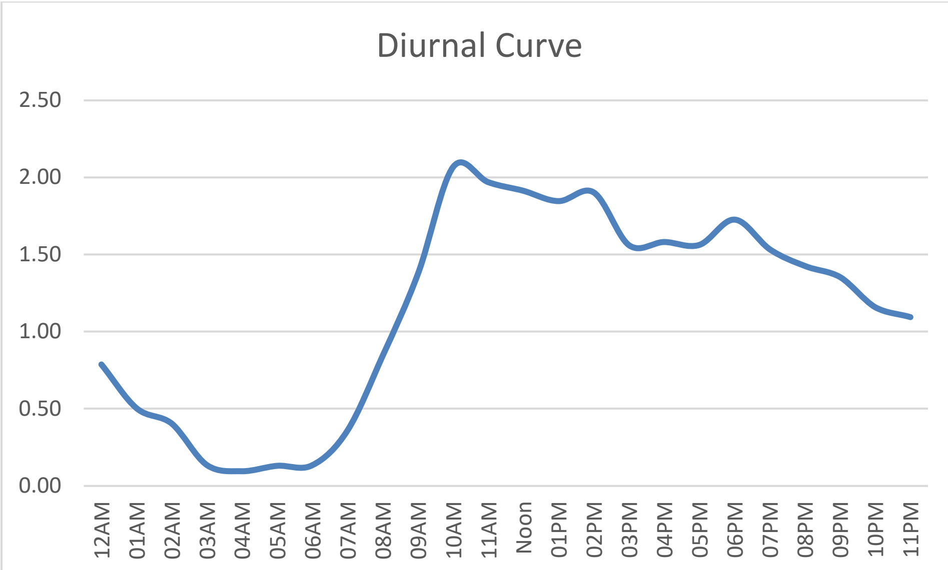

Figure 3-2: Diurnal Curve Pattern

The PHD was calculated by multiplying the MDD derived from the flow definitions (48.6 gpm) by 1.67, resulting in a value of 81.16 gpm. The diurnal curve presented in Figure 3-2 shows a peaking factor of 2.07 at 10 am. By multiplying this peaking factor by the MDD derived from the District's meter (117 gpm), a PHD of 242.19 gpm is obtained. These results are shown in Table 3-7 below. The hydraulic model analysis was performed using the more conservative PHD value of 242.19 gpm.

Table 3-7: Existing MDD & PHD – Calculated vs. Actual

	Table 1 Projection (GPM)	2023 Meter Data (GPM)
MDD	48.60	117.00
PHD	81.16	242.19
ADD to MDD Factor	1.67	2.07

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CHAPTER 4 – HYDRAULIC MODEL DEVELOPMENT

4.1 Background

The District provided their existing version of the hydraulic model - which was imported into InfoWater Pro - along with the following studies and miscellaneous documents:

- Kirkwood Specific Plan (2003)
- KMPUD Water and Wastewater Rate Study (2020)
- KMPUD Standard Design and Construction Specifications for Water Systems (2022)
- KMPUD Capital Improvement Program (2023-2028)

This information was used to determine parameters such as existing conditions, existing and buildout demands, and design requirements for the purposes of updating the hydraulic model for the development of this WMP.

4.2 Approach

The approach for updating the hydraulic model included:

- Incorporating updated demand scenarios for existing and buildout conditions based on the demand analysis presented in this WMP.
- Verifying all settings, facilities, and controls in the model with District operations staff and provided documentation.
- Identify proposed improvements to operational strategy.

4.3 Verifying Control Settings and Limitations

All system settings and characteristics for pressure reducing vales and existing storage tanks were verified with District staff and provided documentation and input into the model. The PRV settings and tank settings used for the existing conditions are outlined in Table 2-2 and Table 4-1, respectively. The existing hydraulic model did not have any well facilities incorporated and only provides steady state analysis.

Table 4-1: Hydraulic Model Tank Settings

STORAGE FACILITY	CAPACITY (GAL)	DIAMETER (FT)	GROUND ELEVATION (FT)	INITIAL WATER LEVEL (FT)	MINIMUM LEVEL (FT)	MAXIMUM LEVEL (FT)
Dangburg Tank	250,000	40	8060	13	0	13
Lodge Tank	700,000	60	8048	25	0	25

Currently, the District does not have any available information for the pumps operating at the existing wells. However, the District was able to provide information on pressure and flow based on pressure and flowmeter data. This information was used to add the four active wells into the model and provide an extended period simulation. The wells are currently activated manually but for the purposes of modeling, the well pumps were set to activate based on system pressure as presented in Table 4-2.

Table 4-2: Modeled Well Pump On and Off Settings

Pump	Downstream Node Pressure at Which Pump is Turned On (psi)	Downstream Node Pressure at Which Pump is Turned Off (psi)
Well 2	127	131
Well 3	127	122
Well 4	115	117
Well 5	115	117

4.4 Demand Allocation

The hydraulic model included ADD, MDD, and PHD demand scenarios for both existing and buildout conditions. Demand was allocated to each scenario by land use type.

4.4.1 *Demand Allocation by Land Use Type*

The general method of allocating water demand in the model is to identify land use types that surround each of the model nodes and apply unit demand factors (per acre) to each land use type. There are five land use types defined within the model:

(1) Condo Commercial – Multi-family residential and commercial zone

(2) Condo Residential – Multi-family residential zone

(3) Commercial – Open space and recreation zone (recreation facilities allowed)

(4) KMPUD – Service utilities

(5) Residential – Single family duplex residential zone

As previously discussed, the District provided 5 years of historical meter data from 2019 to 2023. The highest usage month over that 5-year span was February 2023. The District also provided the usage data for each land use type for the month of February, 2023.

A GIS shape file was created using the land use map provided in the *2003 Kirkwood Specific Plan*. This shapefile was uploaded into the hydraulic model. Each model node is assigned an area-weighted demand based on spatial distribution of land use types within a corresponding Thiessen polygon (Figure 4-1). Theissen polygons are created though a GIS function that identifies the area that is closest to each node relative to all other nodes.

Demands associated with each node were then multiplied by the appropriate peaking factor to achieve average day, maximum day, and peak hour conditions for each modeled demand scenario. Table 4-3 shows the unit factors used to allocate demand for each land use type.

Table 4-3: Usage Unit Factors

ZONE USE	Existing MDD Usage Unit Factor (GPM/SF)	Existing PHD Usage Unit Factor (GPM/SF)	BO MDD Usage Unit Factor (GPM/SF)	BO PHD Usage Unit Factor (GPM/SF)
Multi-family Residential and Commercial Zone	1.64E-06	3.39E-06	3.11022E-06	6.43816E-06
Multi-family Residential Zone	1.95E-05	4.03E-05	3.6949E-05	7.64844E-05
Open Space and Recreation Zone - Recreation Facilities Allowed	4.30E-04	8.90E-04	0.000815589	0.001688269
Service- Utilities and Parking Zone	6.57E-09	1.36E-08	1.24713E-08	2.58155E-08
Single Family Duplex Residential Zone	2.60E-06	5.38E-06	4.92803E-06	1.0201E-05

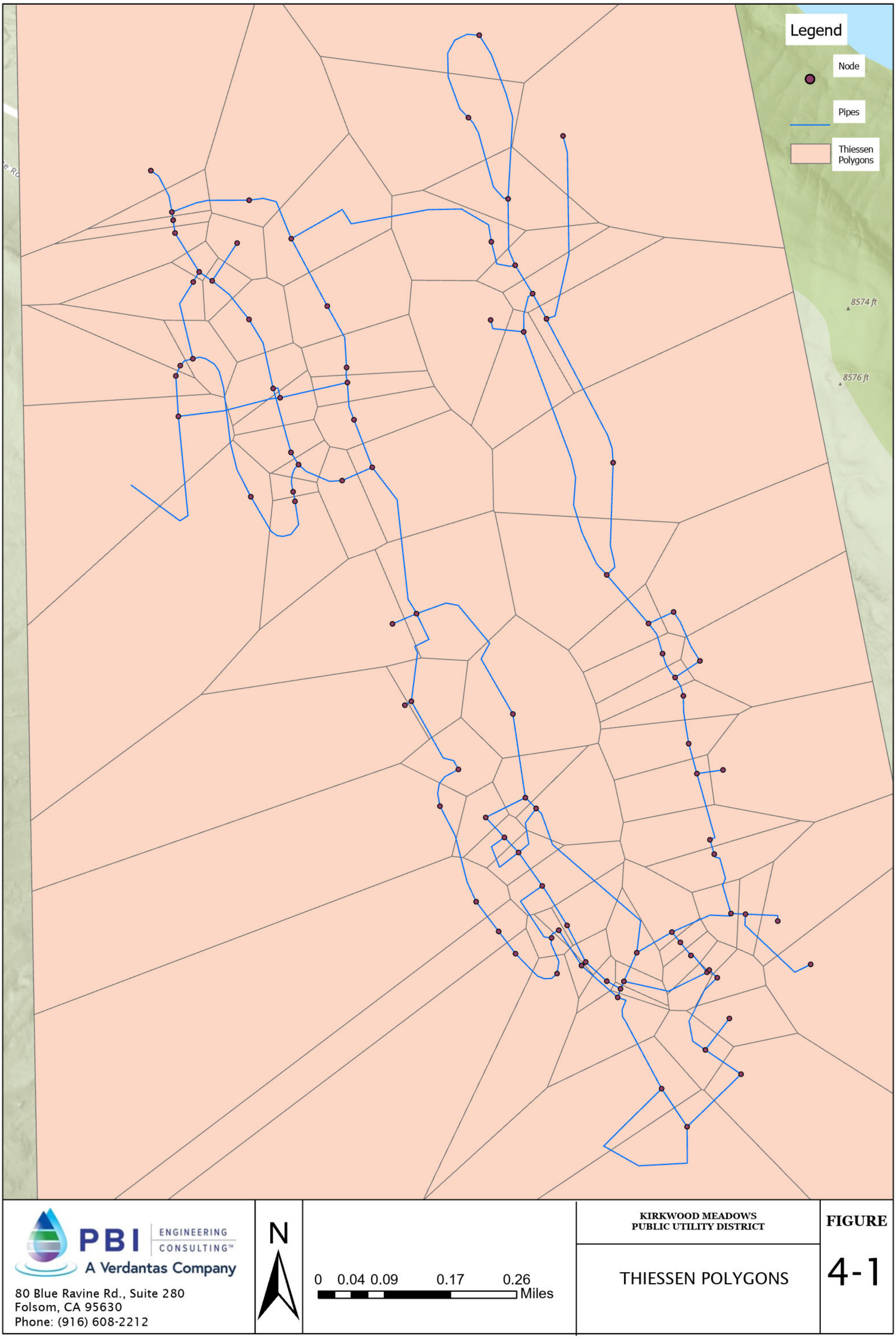

Figure 4-1:Thiessen Polygons used for demand allocation in the hydraulic model

4.5 Pump Control Settings

The model provided by the District initially did not include the existing wells that supply the system. The District currently operates the wells manually, without hydraulic controls. However, the District provided pressure and flow data for each well, which were utilized to model the wells and their respective pumps in the updated hydraulic model.

In the model, a Fixed Head Reservoir was used to represent each well. Since the District could not verify the depth of the existing wells, a well depth of 200 feet below ground elevation was entered into the settings as an estimation. The District was unable to provide pump curves for the existing well pumps; however, pressure and flow readings at each well were supplied by District staff. This data, along with existing ground elevation, was used to model the well pumps as Design Point Curve pumps with a design head and design flow. Table 4-4 summarizes the well and pump information used in the hydraulic model.

Table 4-4: Well and Pump Information

	Ground Elevation (ft)	Well Head (ft)	Pump Design Head (ft)	Pump Design Flow (gpm)
Well 2	7,770	7,570	601	120
Well 3	7,780	7,580	591	85
Well 4	7,800	7,600	593	64
Well 5	7,800	7,600	593	85

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CHAPTER 5 – DISTRIBUTION SYSTEM CRITERIA

5.1 Evaluation Criteria

The District's *Standard Design and Construction Specifications for Water Systems* (May 2022) established the system evaluation criteria presented in Tables 5-1 to 5-6.

5.1.1 *Flow Definitions and Minimum Fire Flow*

Table 5-1 presents the flow requirements established in the District's standards. In addition, the 2022 California Fire Code (CFC), Section B105, lists the minimum fire flow for single family dwellings as 1,000 gpm and the minimum fire flow for buildings other than single family dwellings as 1,500 gpm.

Table 5-1: District's Flow Definitions

<table>
<tr><th>FLOW TYPE</th><th colspan="2">DEFINITION</th></tr>
<tr><td>Average Daily Demand (ADD)</td><td colspan="2">(Design Population) * (Average per capita daily flow requirement) + (any commercial, industrial, school demand)</td></tr>
<tr><td>Maximum Daily Demand (MDD)</td><td colspan="2">(ADD)* 1.5</td></tr>
<tr><td>Peak Hour Demand (PHD)</td><td colspan="2">(MMD)* 1.5</td></tr>
<tr><td rowspan="4">Fire Flow (FF)</td><td colspan="2">Fire Protection Districts set FF requirements. Minimum requirements listed below:</td></tr>
<tr><td>Residential Areas</td><td>≥ 1,000 gpm for 2 hours</td></tr>
<tr><td>Commercial Areas</td><td>≥ 1,500 gpm for 2 hours</td></tr>
<tr><td>Industrial</td><td>To be determined</td></tr>
</table>

Table 5-2: California Fire Code Minimum Fire Flows

FLOW TYPE	MINIMUM REQUIREMENT
Single Family	1,000 gpm
Buildings other than Single Family Dwellings	1,500 gpm

5.2 Performance Criteria

Table 5-3 presents the District's pressure requirements within the system.

Table 5-3: District's Pressure Requirements

SCENARIO	REQUIRED PRESSURE (PSI)
Distribution & Transmission Design Operating Pressures	40-100
Minimum service pressure during Maximum Day Demand (MDD)	50
Minimum pressure in any point in system during periods of Peak Hour Demand (PHD) + Fire Flow	20
Minimum during periods of Peak Hour Demand (PHD)	40
Maximum pressure regulator setting at services with >80 psi Static Pressure	80

The District's standards also describe distribution line requirements. Table 5-4 presents the District's requirements for pipe velocities. These standards were used to evaluate the model results. Water industry standard criteria for pipe velocity is to maintain a minimum velocity that will not generate sedimentation and a maximum velocity that will not erode the pipe walls. The California Title 22 Requirements identify 2.5 ft/s as the minimum velocity for pipes and anything below this criterion would require a flushing program. Distribution pipes with velocities below 2.5 ft/s will require a flushing program to remove sediment accumulation.

Table 5-4: District's Distribution Line Pipe Velocity Requirements

SCENARIO	MAXIMUM ALLOWABLE VELOCITY (FPS)
Peak Day Demand	7
Peak Day Demand + Fire Flow	11
MINIMUM CONTINUOUS FLUSHING VELOCITY (FPS)	
Water mains, hydrants, hydrant laterals, flushing appurtenances	2.5

Table 5-5 presents the minimum distribution line sizes for different areas in the District's system.

Table 5-5: Minimum Distribution Line Sizes

CATEGORY	MINIMUM PIPE SIZE (IN)
Transmission Pipe	8
Distribution Pipe	8
Distribution Pipe (if fully looped)	6
Fire Hydrant Service (two-way feed)	6
Fire Hydrant Service (single feed)	8

The maximum day demand scenario was simulated for existing and buildout demand conditions to evaluate the supply facilities, and distribution system performance.

5.3 Treated Water Storage Criteria

According to the District's standards, system storage capacity shall equal the sum of the maximum day demand (emergency storage), plus thirty three percent maximum day demand (operational storage), twelve percent maximum day demand (system losses), and maximum required fire flow plus sprinkler fire flow. Table 5-6 presents the District's individual component storage requirements.

Table 5-6: District's Storage Requirements

STORAGE TYPE
Operational Storage (0.33 of MDD)
Required Fire Flow Storage
Sprinkler Fire Flow Storage
Maximum Day Demand (Emergency Storage)
System Losses (0.12 of MDD)

CHAPTER 6 – DISTRIBUTION SYSTEM ANALYSIS

The performance of the existing water system was simulated using the modeling software. The following scenarios were simulated to perform the assessment on the exiting distribution system:

- Existing PHD
- Existing MDD + Fire Flow
- Existing ADD
- Buildout PHD with existing facilities
- Buildout MDD + Fire Flow with existing facilities
- Buildout ADD with existing facilities
- Buildout PHD with proposed improvements (Scenario 1 and 2)
- Buildout MDD + Fire Flow with proposed improvements (Scenario 1 and 2)
- Buildout ADD + Fire Flow with proposed improvements (Scenario 1 and 2)

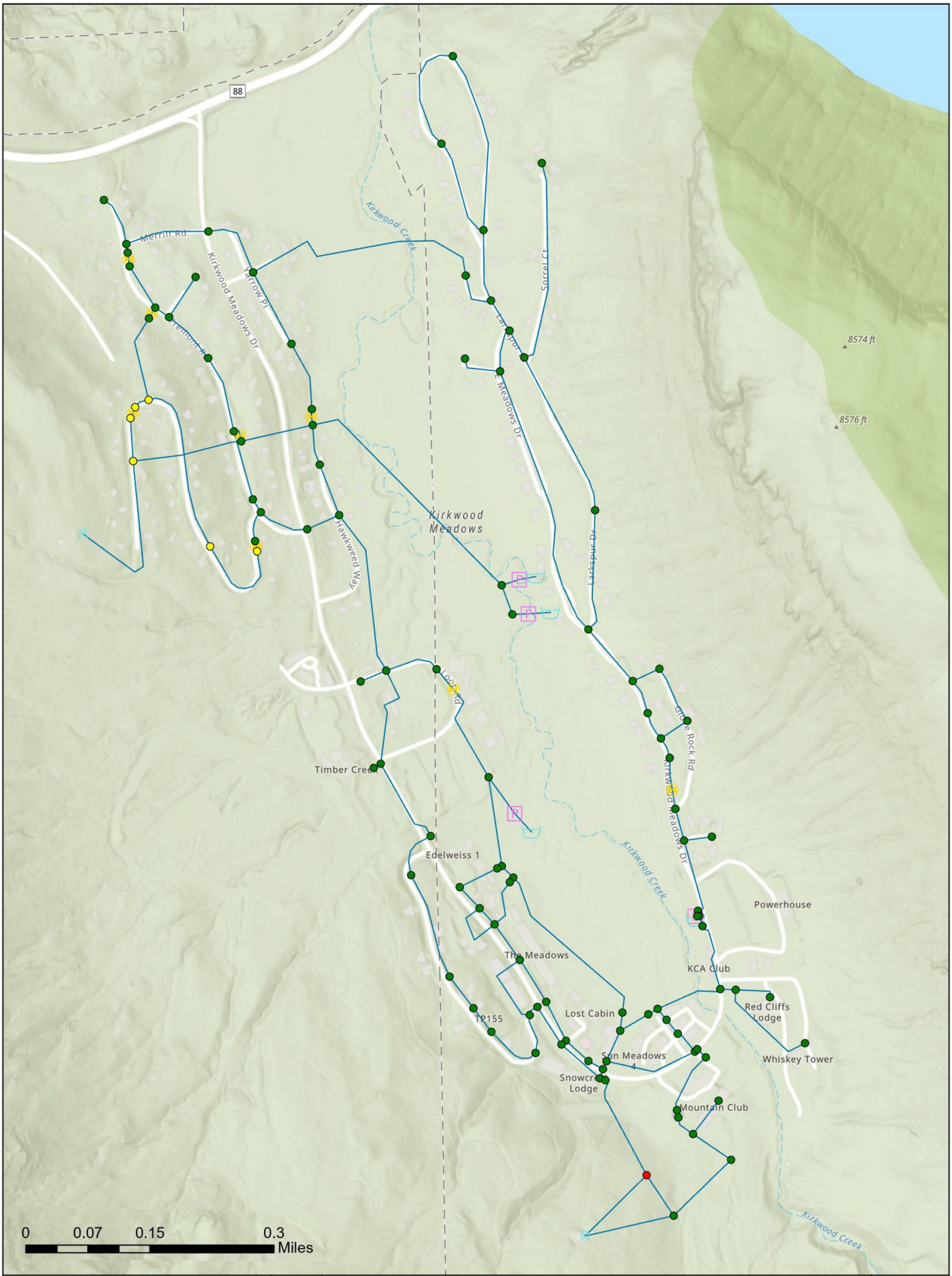
6.1 Existing System Analysis

Fire flow and PHD simulations were used to analyze the existing system as these conditions represent the worst-case scenarios.

6.1.1 *Fire flow Analysis*

A fire flow analysis was performed on the hydraulic model, calculating the available fire flow during MDD with a minimum residual pressure of 20 psi at the hydrant (node) and a minimum pressure of 20 psi anywhere in the system. The fire flow analysis included the four existing wells in the simulation.

Figure 6-1 presents the available fire flow during existing system MDD on the existing distribution system. The modelling results indicate that only seven of the nodes cannot serve their assigned fire flow demand of 1,500 gpm. The main area with the fire flow deficiency is near the Dangburg tank on the northwest portion of the system. There is an additional node with fire flow deficiency on the south side of the system, near Lodge Tank.



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Available Fire Flow
- 1000-1500 gpm
- < 1000 gpm
- > 1500 gpm

- Pipes
- Tanks
- Wells
- Pumps
- PRV'S

KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT

EXISTING FIRE FLOW

FIGURE 6-1

Figure 6-1: Existing Fire Flow

6.1.2 *Peak Hour Demand Analysis*

Figure 6-2 shows the existing PHD pressure and velocity maps. The existing model assumes the pressure zoning according to the HGL's presented in *Chapter 2: Existing Water System*. The District standard for maximum pressure is identified as 100 psi, however, the majority of the system exceeds 100 psi, and in select locations it exceeds 120 psi. The analysis did not identify any areas with pressures lower than 40 psi. The high pressures are due to the wide range of terrain within the main pressure zone. As it currently operates, the system has an interconnection between the upstream side of PRV 1, and the main pressure zone. In this scenario, PRV's 1, 2, and 5 are creating an unnecessary additional pressure zone (identified as the lower Dangburg zone). Table 2-2 illustrates that the current PRV settings create two primary pressure zones, leading to large variations in system pressure due to the varying terrain within the two zones.

The existing system velocities are all below 2.5 ft/s. This indicates that the implementation of a flushing program should be implemented remove accumulated sedimentation. The results do not show pipe velocities exceeding the District maximum of 7 ft/s.

6.1.3 *Tank Turnover and Water Age Analysis*

An extended period simulation over 10 days was run on the existing model under the MDD scenario. Figure 6-3 and Figure 6-4 show the tank turnover for Danburg Tank and Lodge Tank, respectively. The figures show that neither tank is currently able to fully fill or empty when the pumps are operating on system pressure. To simulate the worst-case scenario for water age, the model was also run under the ADD condition. Figure 6-5 and Figure 6-6 show the water age over the extended period simulations on the Dangburg Tank and Lodge Tank, respectively. The water age at Dangburg Tank reaches a maximum of 123 hours (5.2 days) at 8.7 days into the simulation period. The water age at Lodge Tank increases at a constant rate throughout the simulation, reaching approximately 209 hours (8.7 days) by the end of the 10-day simulation. This indicates that Lodge tank may have a current water age issue.

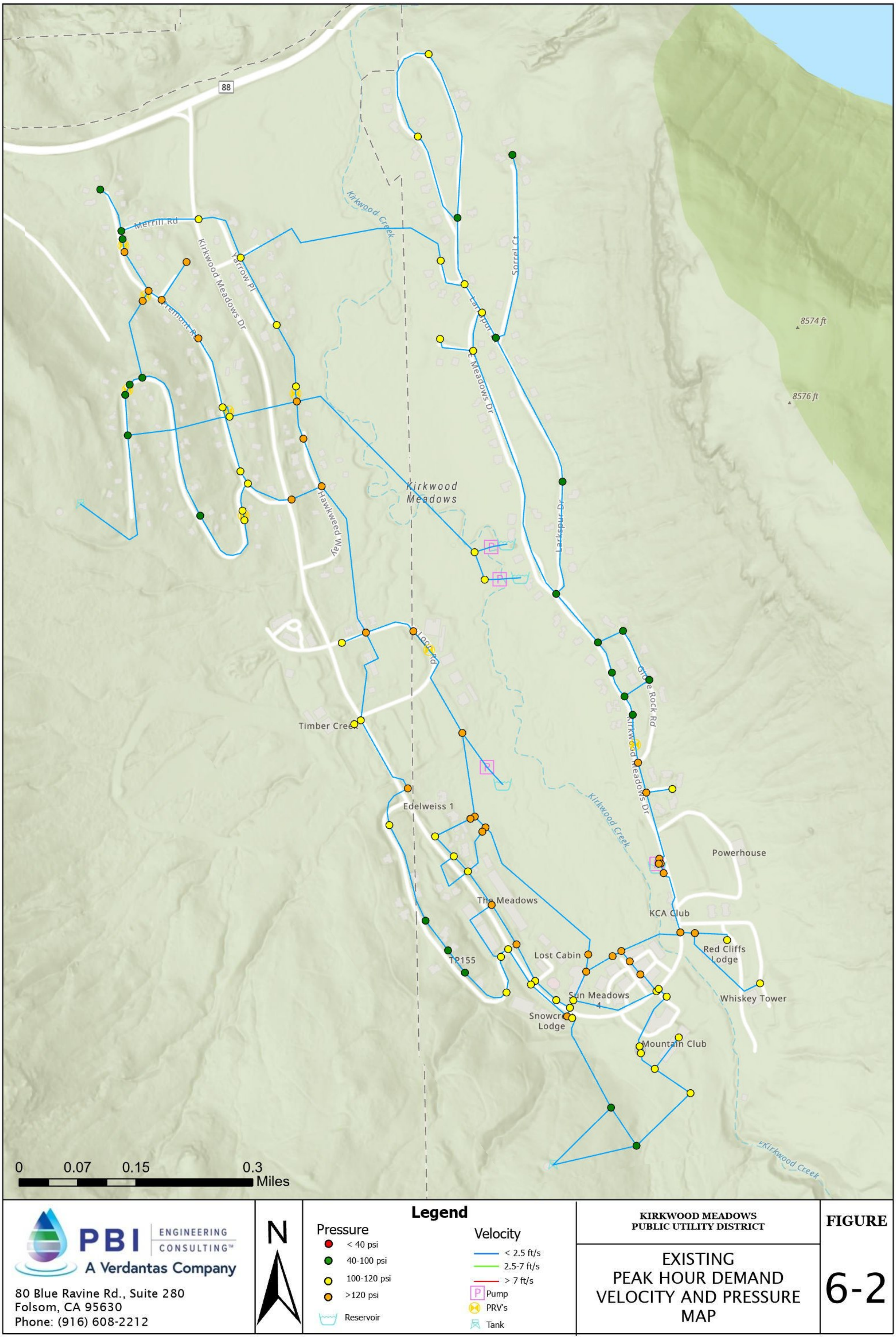


Figure 6-2: Existing Peak Hour Demand Velocity and Pressure Map

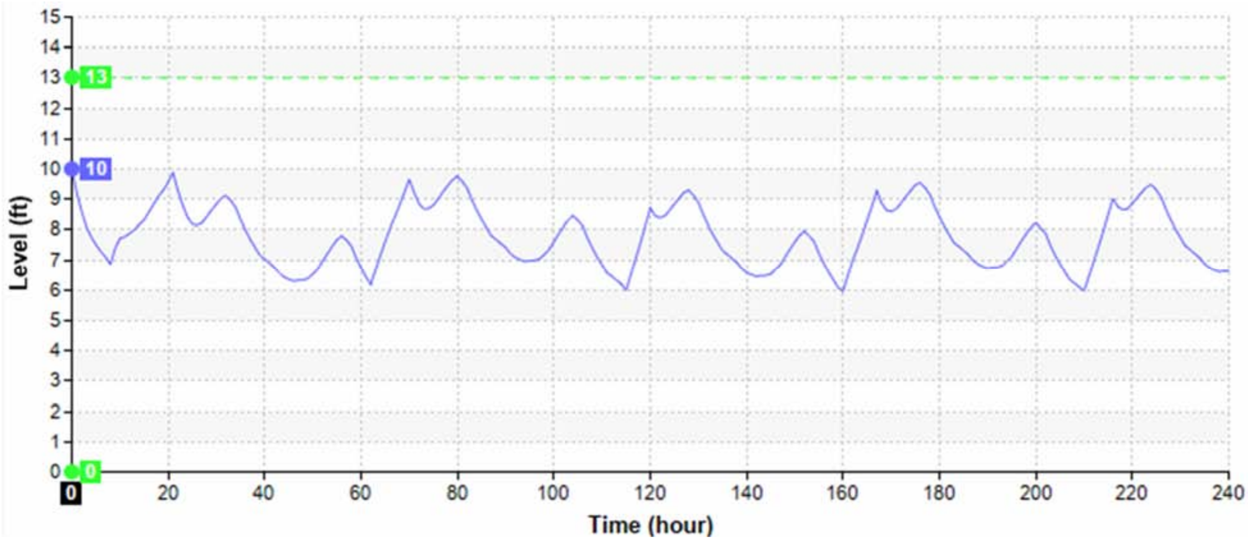


Figure 6-3: Dangburg Tank Turnover

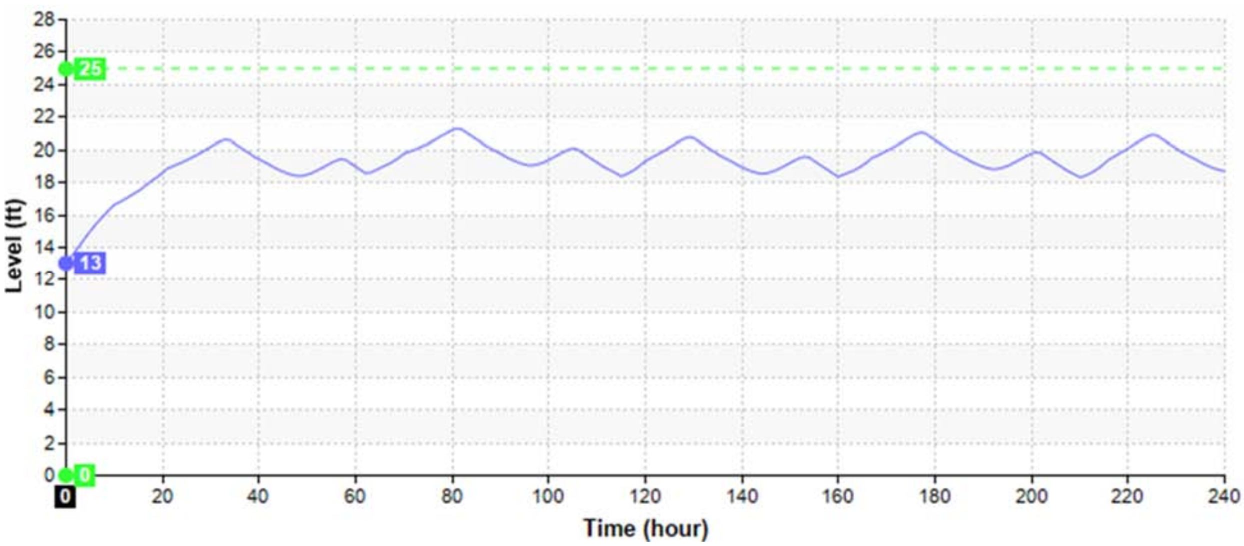


Figure 6-4: Lodge Tank Turnover

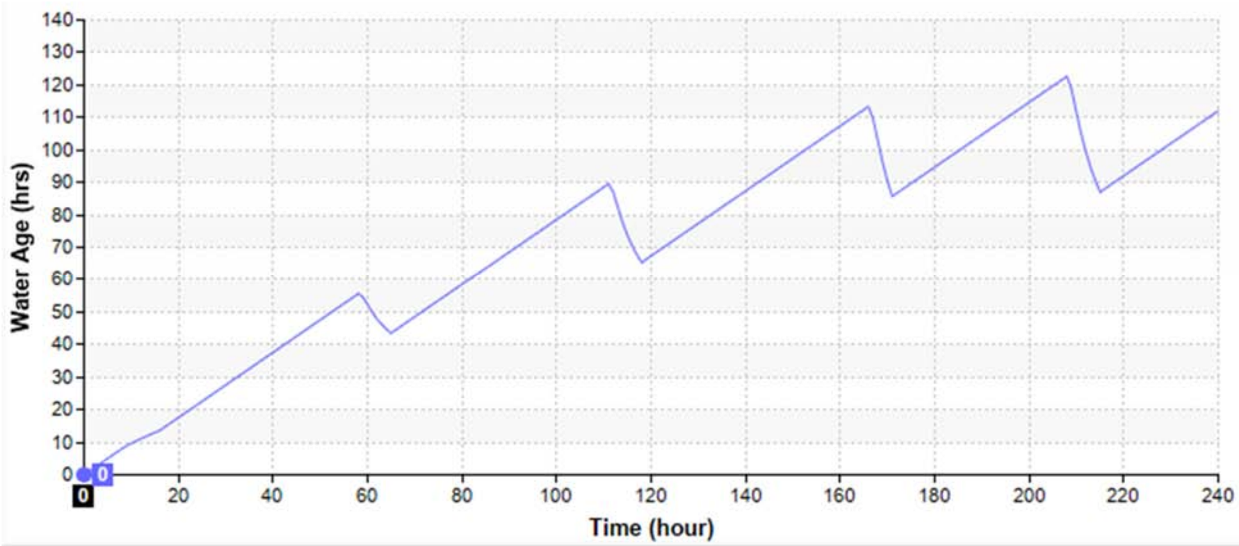


Figure 6-5: Dangburg Tank Water Age

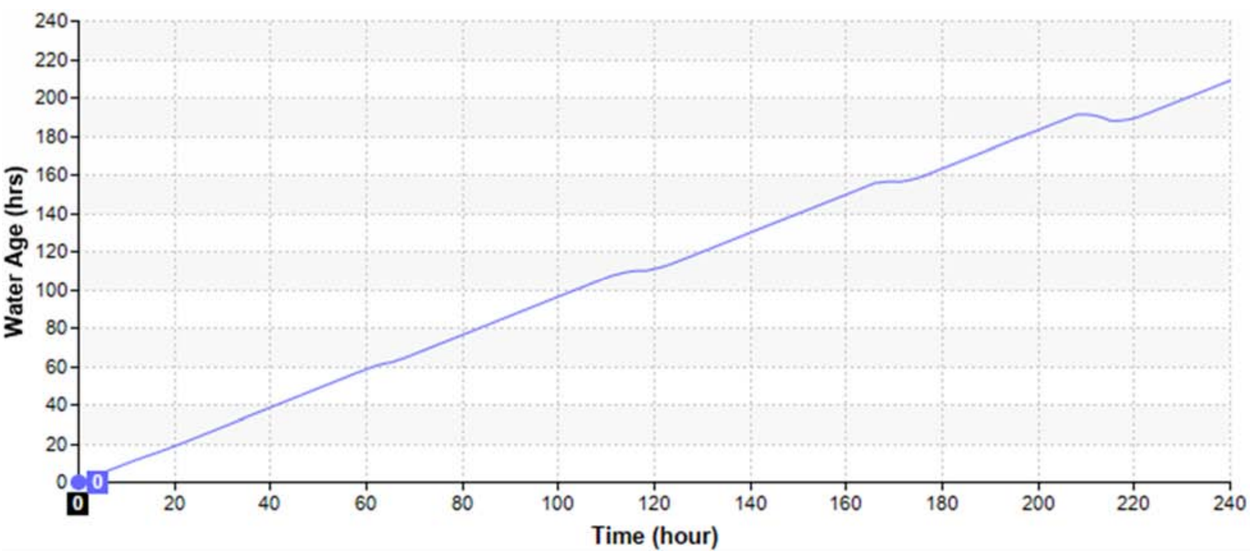


Figure 6-6: Lodge Tank Water Age

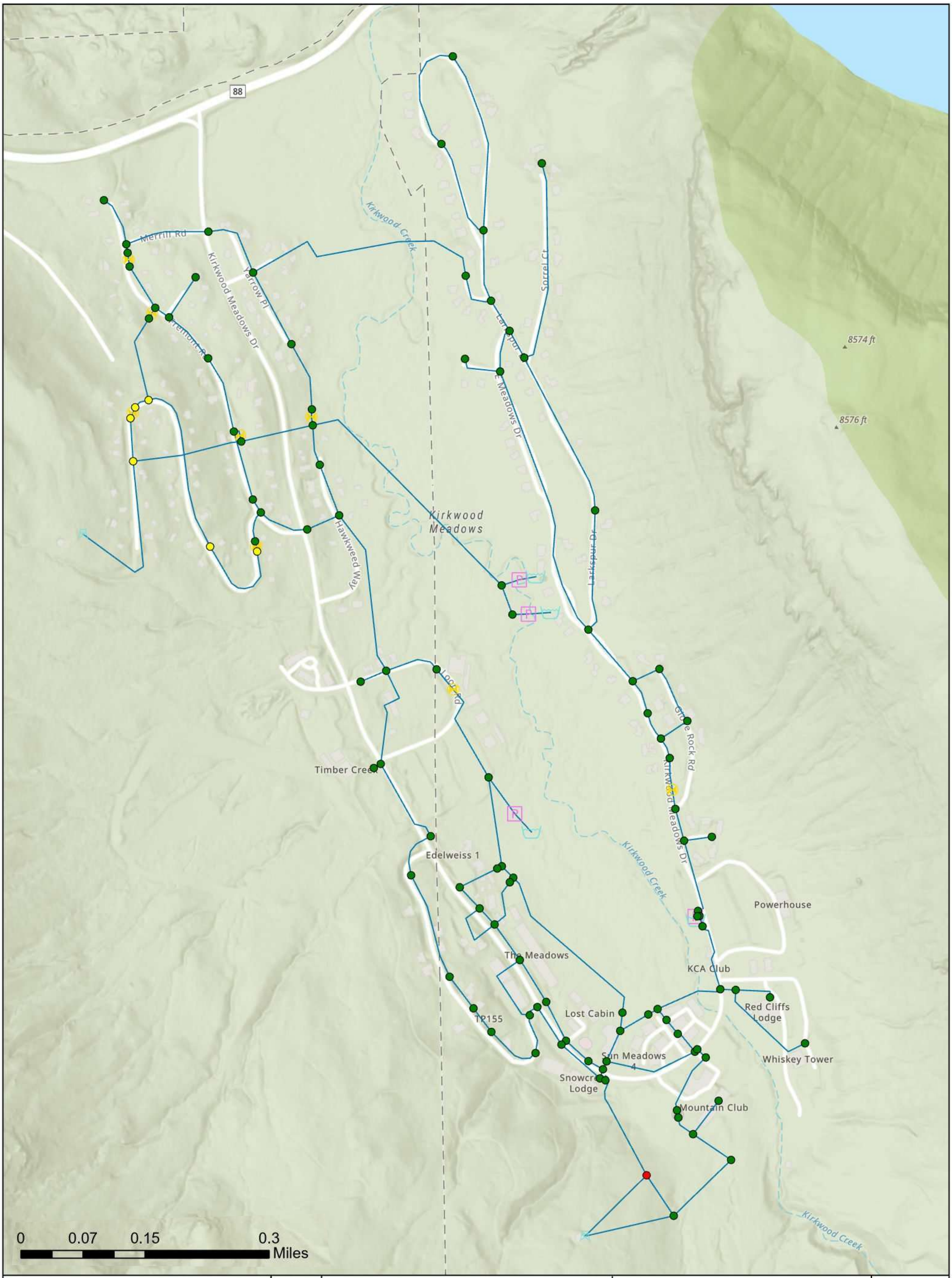
6.2 Buildout System Analysis

Fire flow and PHD simulations were performed under buildout demand conditions to evaluate the existing system's performance with future demands.

6.2.1 *Fire flow Analysis with Existing Facilities*

A fire flow analysis was performed on the hydraulic model, calculating the available fire flow during Buildout MDD with a minimum residual pressure of 20 psi at the hydrant (node) and a minimum pressure of 20 psi anywhere in the system. The fire flow analysis included the four existing wells in the simulation.

Figure 6-7 shows the available fire flow during buildout MDD on the existing distribution system. The modeling results for the buildout fire flow simulation are similar to those of the existing fire flow simulation. The analysis indicates that seven nodes cannot serve their assigned fire flow demand of 1,500 gpm. The area with the fire flow deficiency is located near the Dangburg tank in the northwest portion of the system, and an additional deficient node in the southwest portion of the system near Lodge Tank. This is generally anticipated near tank sites and dead-end mains, which is generally acceptable.



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Available Fire Flow
- 1000-1500 gpm
- < 1000 gpm
- > 1500 gpm

- Pipes
- Tanks
- Wells
- Pumps
- PRV'S

KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT

BUILDOUT AVAILABLE FIRE FLOW - EXISTING FACILITY

FIGURE 6-7

Figure 6-7: Buildout Available Fire Flow – Existing Facility

6.2.2 *Buildout Peak Hour Demand Analysis with Existing Facilities*

Figure 6-8 displays the buildout PHD pressure and velocity maps. The buildout model assumes the pressure zoning according to the HGLs presented in *Chapter 2: Existing Water System*. The analysis results indicate pressures exceeding 120 psi throughout the system. No areas were identified with pressures below 40 psi. High pressures can be addressed by adjusting the current pressure zones.

System velocities are under 2.5 ft/s for buildout demands, indicating the need for a flushing program to clear sediment. No pipe velocities exceed the District's 7 ft/s maximum criteria.

6.2.3 *Buildout Tank Turnover and Water Age Analysis*

An extended period simulation over 10 days was run on the existing model under the Buildout MDD scenario. Figure 6-9 and Figure 6-10 show the tank turnover for Danburg Tank and Lodge Tank, respectively. The figures show that neither tank is currently able to fully fill or empty.

To simulate the worst-case scenario for water age, the model was also run under the Buildout ADD condition. Figure 6-11 and Figure 6-12 show the water age over the extended period simulations on the Dangburg Tank and Lodge Tank, respectively. The water age at Dangburg Tank reaches a maximum of 90 hours (3.75 days) at 9.4 days into the simulation period. The water age at Lodge Tank increases at a constant rate throughout the simulation, reaching approximately 181 hours (7.5 days) by the end of the 10-day simulation. This indicates that Lodge tank may also encounter a water age issue under the buildout condition.

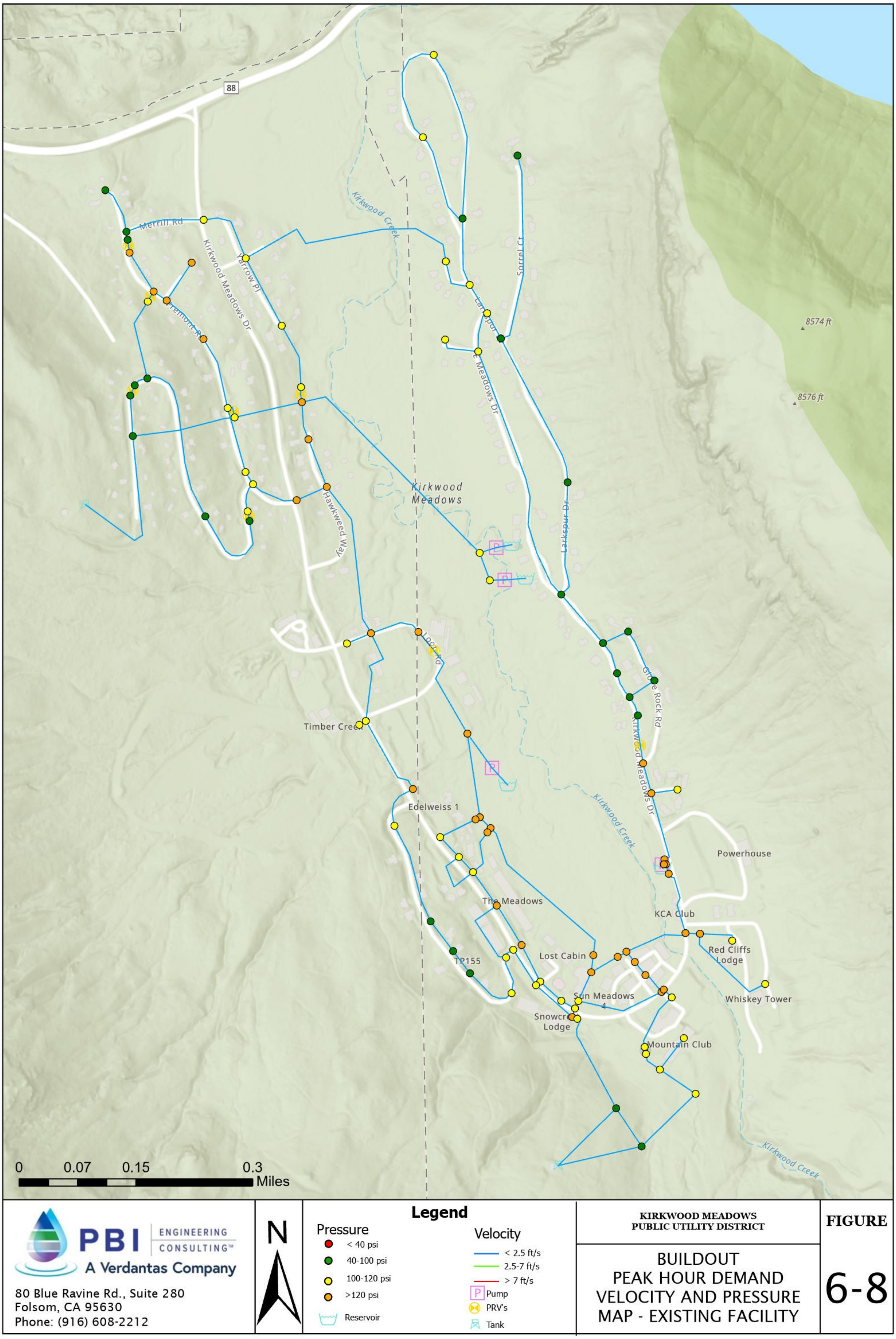

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Figure 6-8: Buildout Peak Hour Demand Velocity and Pressure Map – Existing Facility

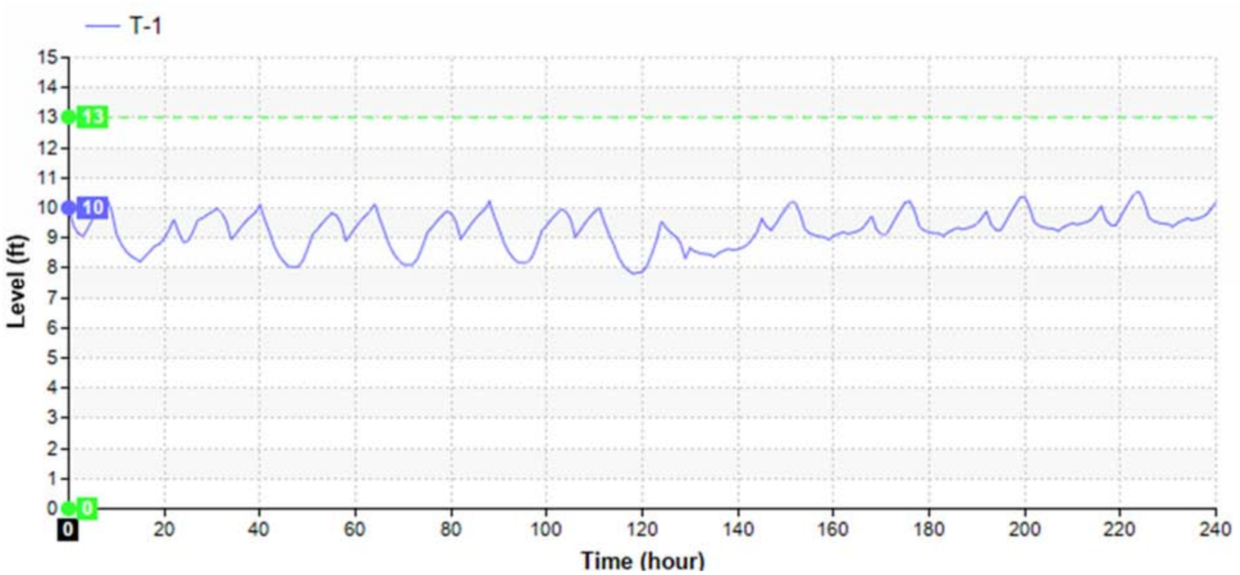


Figure 6-9: Dangburg Tank Turnover - Buildout Demand

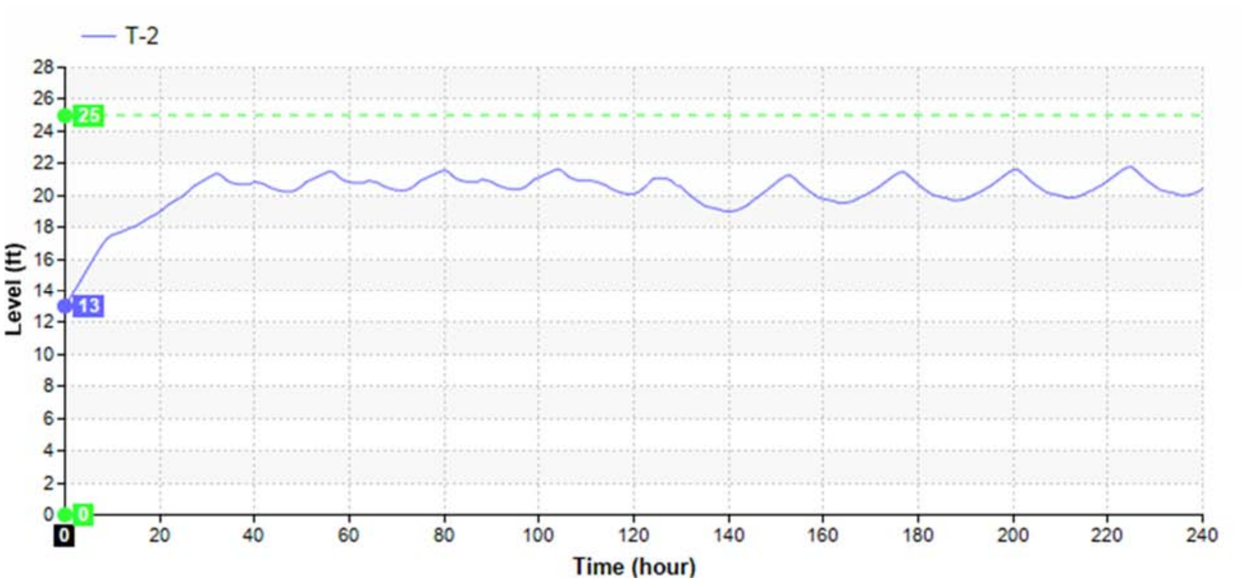


Figure 6-10: Lodge Tank Turnover - Buildout Demand

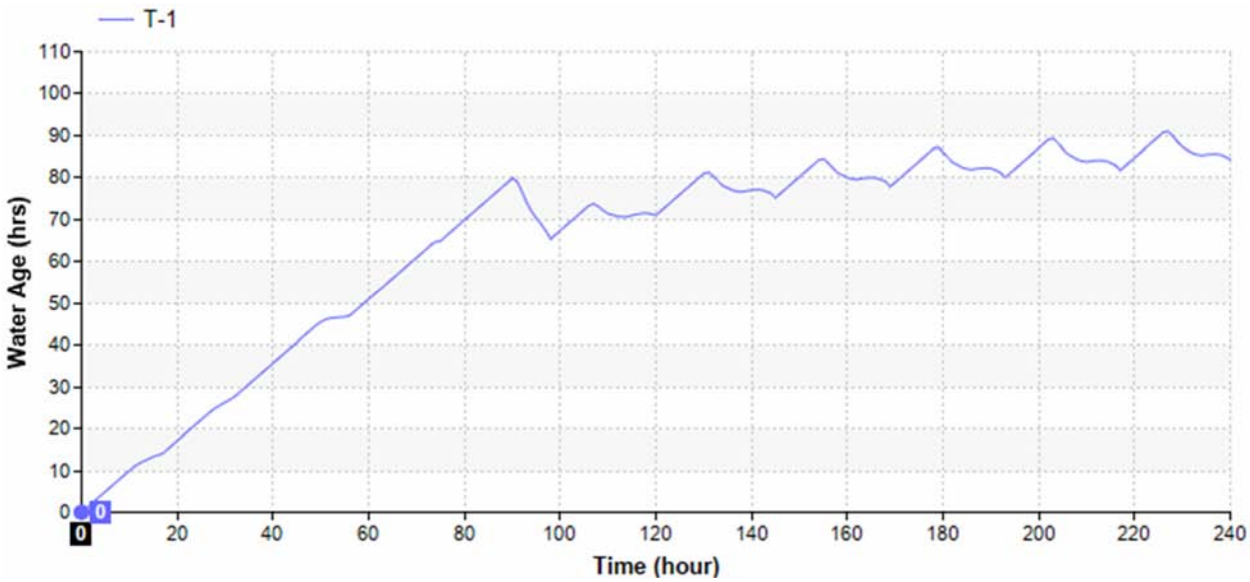


Figure 6-11: Dangburg Tank Water Age - Buildout Demand

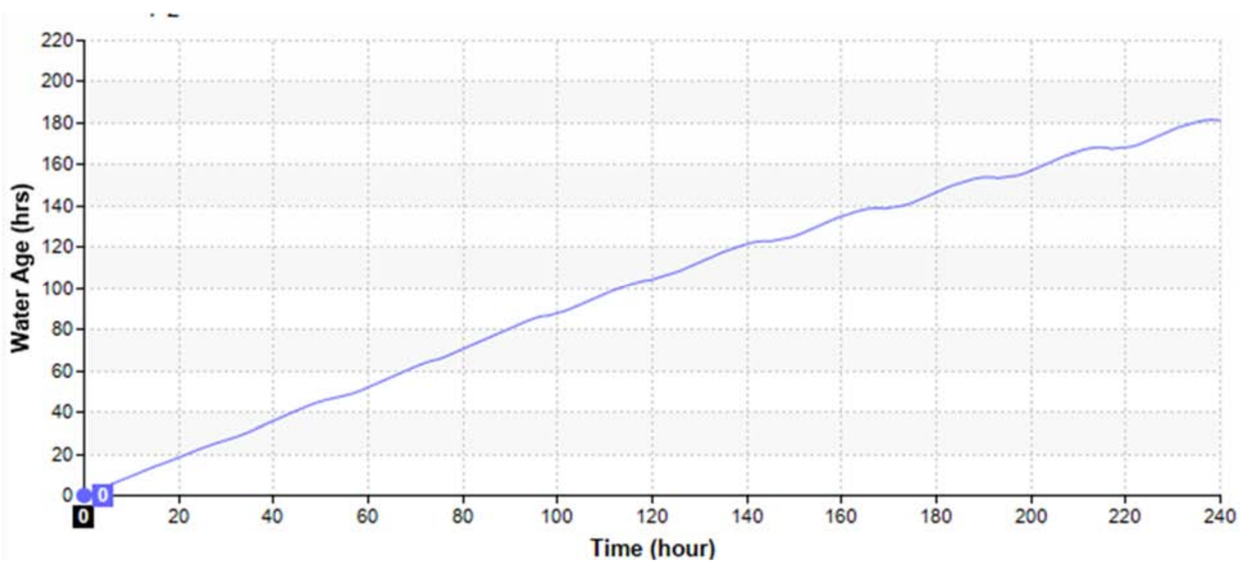


Figure 6-12: Lodge Tank Water Age - Buildout Demand

6.3 Proposed Facility Improvements

As part of the evaluation of improvement alternatives, the District has requested that operational strategy changes be considered as a way to mitigate high pressures in the system. The 2021 System Analysis recommended that the District consider construction of dedicated transmission mains from the wells to the tanks. The construction of dedicated transmission lines alone would not mitigate system pressures; however, the addition of a new PRV downstream of the Lodge tank that is set at a lower HGL that is mirrored at existing PRVs 2 and 5 could help reduce the pressure within the main zone. Construction of dedicated transmission mains would require an upfront capital investment. Due to the existing configuration of the wells and the two tanks, adding additional PRVs to help reduce the pressure in the main zone would prohibit the ability for the Lodge Tank (the larger of the two tanks) to be filled by wells 4 and 5 (the higher capacity wells) which would result in over stressing wells 2 and 3. Alternatively, the District could operate the system similar to today and eliminate the unnecessary lower Danburg zone by opening PRV's 1, 2, and 5. This would not reduce the high pressure areas in the main pressure zone, however, these areas are already equipped with PRVs on the service lines and would require minimal investment by the District. Two operational strategies were analyzed using the hydraulic model:

1) Scenario 1: Open PRV's 1, 2, and 5 to create two pressure zones and a simplified version of current operations.
2) Scenario 2: Install dedicated transmission mains between the wells and both tanks so that any well could fill either tank.

6.3.1 *Buildout Operational Scenario 1: Open PRV's 1, 2, and 5 to Create Two Pressure Zones*

The model was run under the buildout scenarios with the PRV's 1, 2, and 5 set as "initially open". PRVs 4 and 8 are assumed to be open as they are today, and PRVs 6 and 7 are set to the existing pressure setting listed in Table 2-2.

6.3.1.1 Fire Flow Analysis

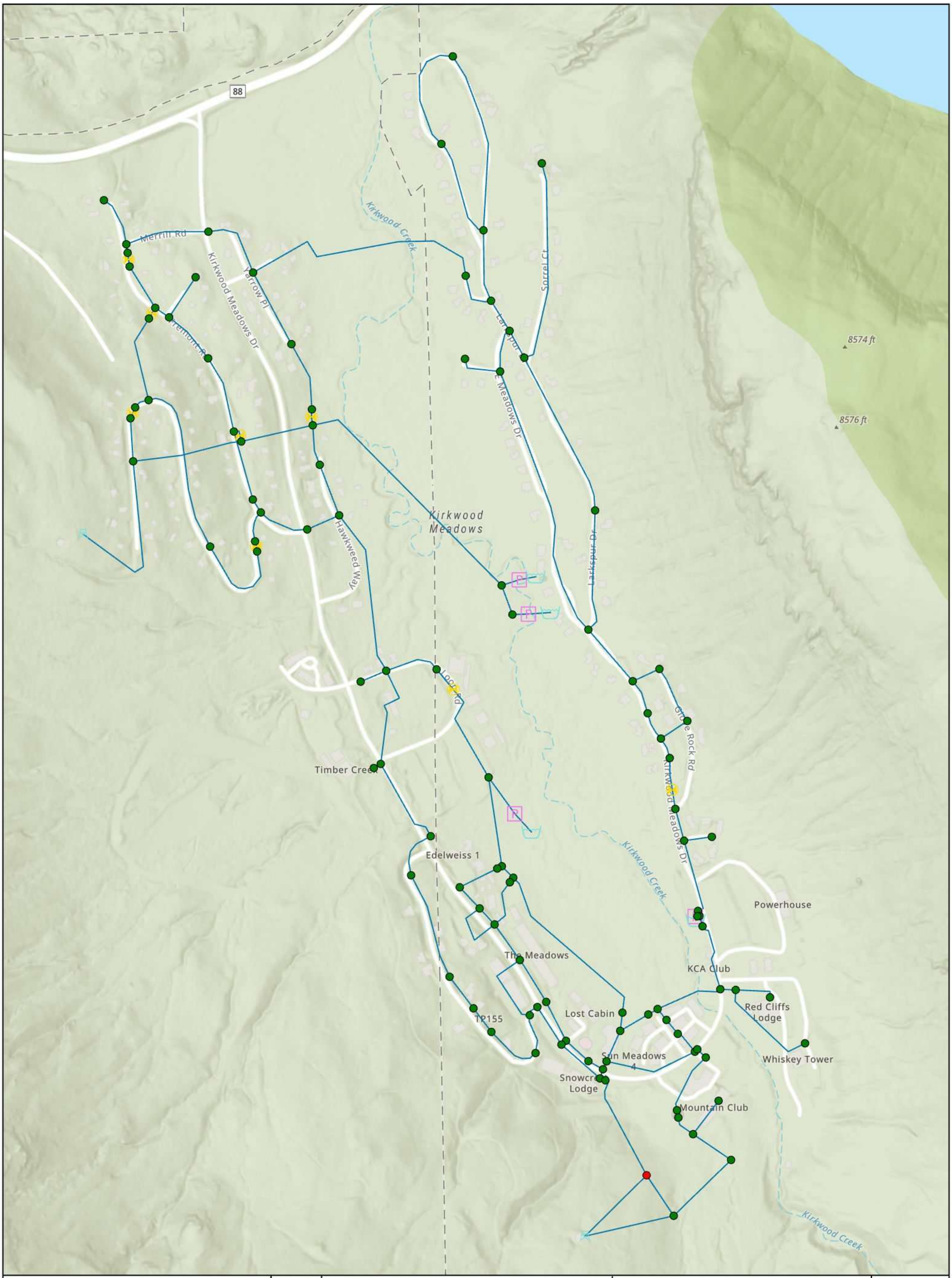
A fire flow analysis was performed on the hydraulic model, calculating the available fire flow during Buildout MDD with a minimum residual pressure of 20 psi at the hydrant (node) and a minimum pressure of 20 psi anywhere in the system. The fire flow analysis included the four existing wells in the simulation.

Figure 6-13 shows the available fire flow for this scenario. The only node that does not meet its designated fire flow requirements is the node located on the inlet side of Lodge Tank – this is likely due to its proximity to the tank. The results under this operational strategy show improvements from the seven deficient nodes under the existing condition. When PRV's 1, 2, and 5 are active, the system pressures do not require them to open – this creates dead ends in the system which leads to deficient fire flow in those areas. When PRV's 1, 2, and 5 are open, those dead ends are eliminated.

6.3.1.2 Peak Hour Demand Analysis

Figure 6-14 displays the buildout PHD pressure and velocity maps under Operational Scenario 1. The analysis results indicate pressures exceeding 120 psi throughout the system. No areas were identified with pressures below 40 psi. High pressures can be addressed by adjusting the current pressure zones.

System velocities are under 2.5 ft/s for buildout demands, indicating the need for a flushing program to clear sediment. No pipe velocities exceed the District's 7 ft/s maximum criteria.



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Folsom, CA 95630
Phone: (916) 608-2212

Legend

Available Fire Flow
- 1000-1500 gpm
- < 1000 gpm
- > 1500 gpm
- Inactive Pipe
- Pipes
- Tanks
- Wells
- Pumps
- PRV'S

KIRKWOOD MEADOWS PUBLIC UTILITY DISTRICT

BUILDOUT SCENARIO 1 - AVAILABLE FIRE FLOW

FIGURE 6-13

Figure 6-13: Buildout Scenario 1 - Available Fire Flow

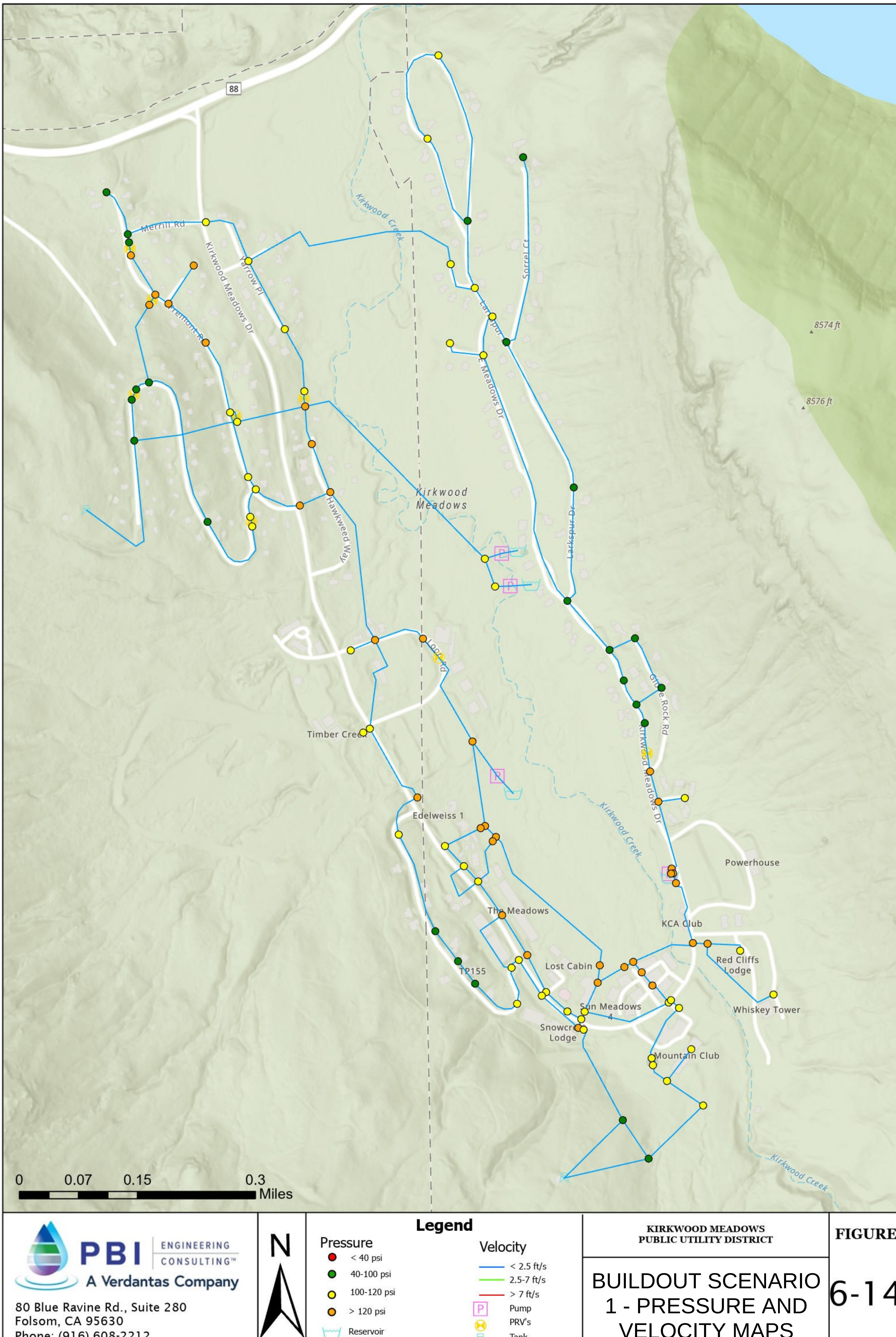

Figure 6-14: Buildout Scenario 1 - Pressure and Velocity Maps

6.3.1.3 Tank Turnover and Water Age Analysis

Figure 6-15 and Figure 6-16 show the tank turnover for Dangburg Tank, and Lodge Tank, respectively. The figures show that the tanks in this condition do not completely fill or empty similar to the turnover in the existing condition.

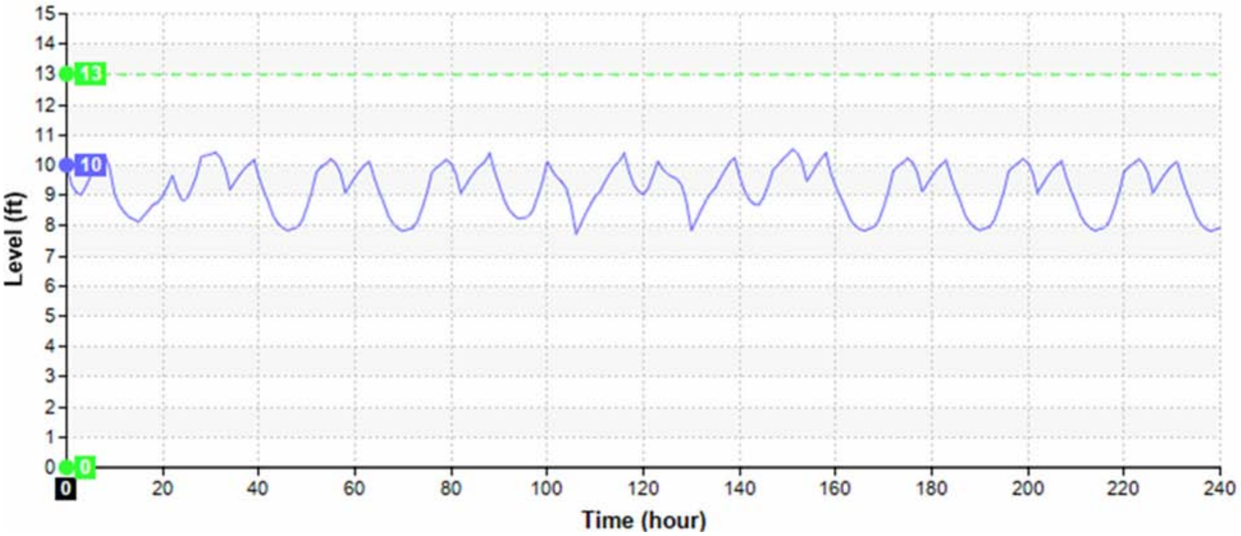

Figure 6-15: Dangburg Tank Turnover - Scenario 1

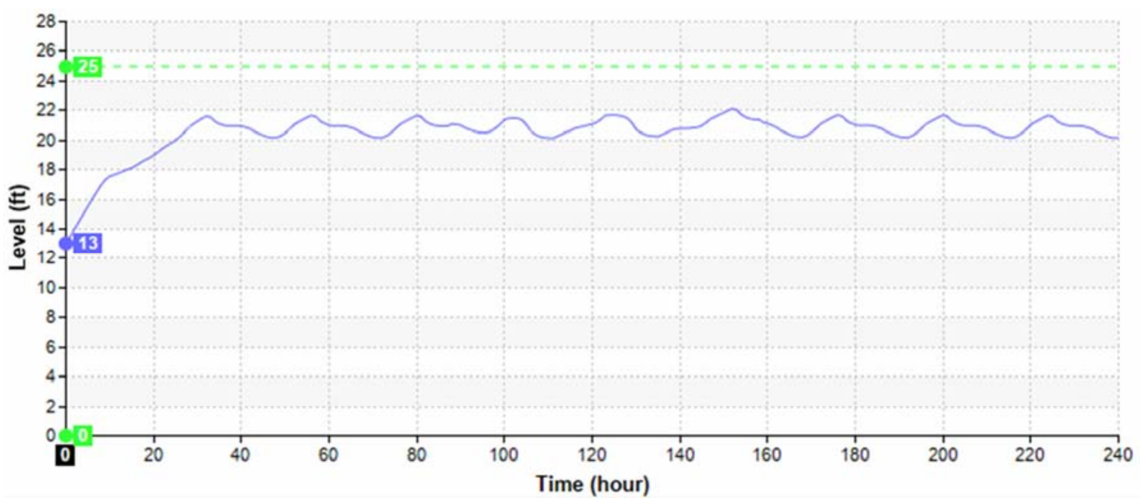

Figure 6-16: Lodge Tank Turnover - Scenario 1

To simulate the worst-case scenario for water age, the model was also run under the buildout ADD condition. Figure 6-17 and Figure 6-18 show the Dangburg Tank and Lodge Tank water age, respectively. The water age in Dangburg Tank increases to 84 hours (3.5 days) by day 9.5 of the simulation, then stabilizes. The water age at the Lodge Tank increases at a constant rate throughout the simulation, reaching approximately 170 hours (7 days) at the end of the 10-day simulation period.

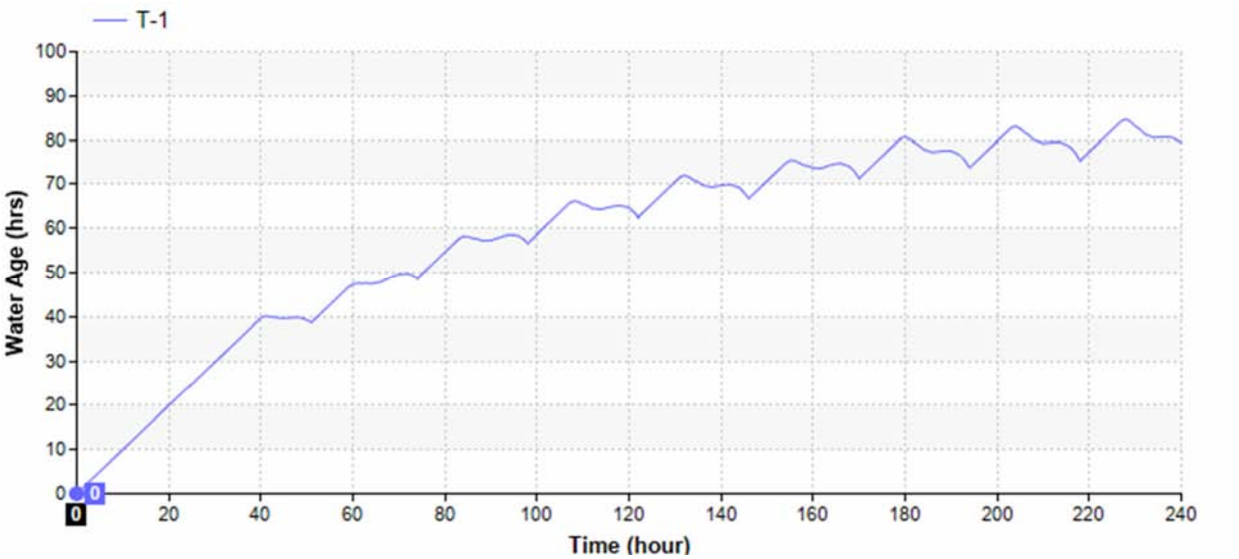

Figure 6-17: Dangburg Tank Water Age - Scenario 1

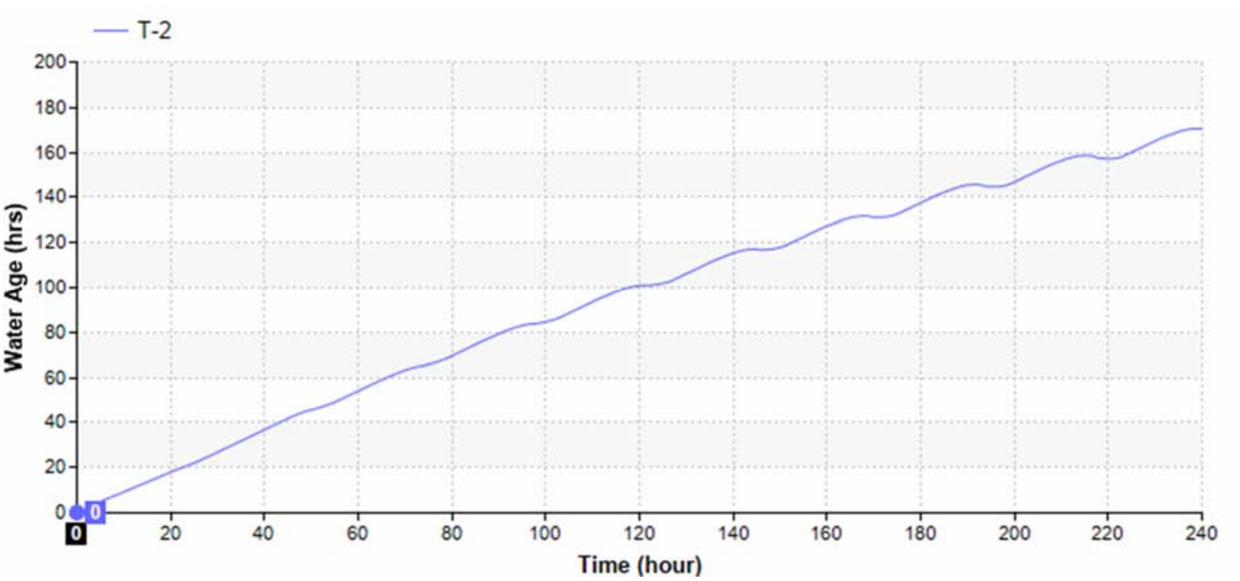

Figure 6-18: Lodge Tank Water Age - Scenario 1

This operational strategy allows for the tanks to still flow off each other, while eliminating the unnecessary pressure zone that is being created by PRV's 1, 2, and 5. Figure 6-19 shows the hydraulic schematic for this operational scenario. The cost to implement this strategy is minimal as it will involve only the maintenance of the exiting PRV's. The water age under this operational scenario is also slightly improved compared to the water age under the existing operational strategy. Under this condition, the system is still experiencing pressures above the District limit of 100 psi. However, the District's customers are already equipped with PRV's on their service lines, which mitigates this issue. The primary concern with elevated pressures in the system is the potential for diminishing the lifespan of the District's assets.

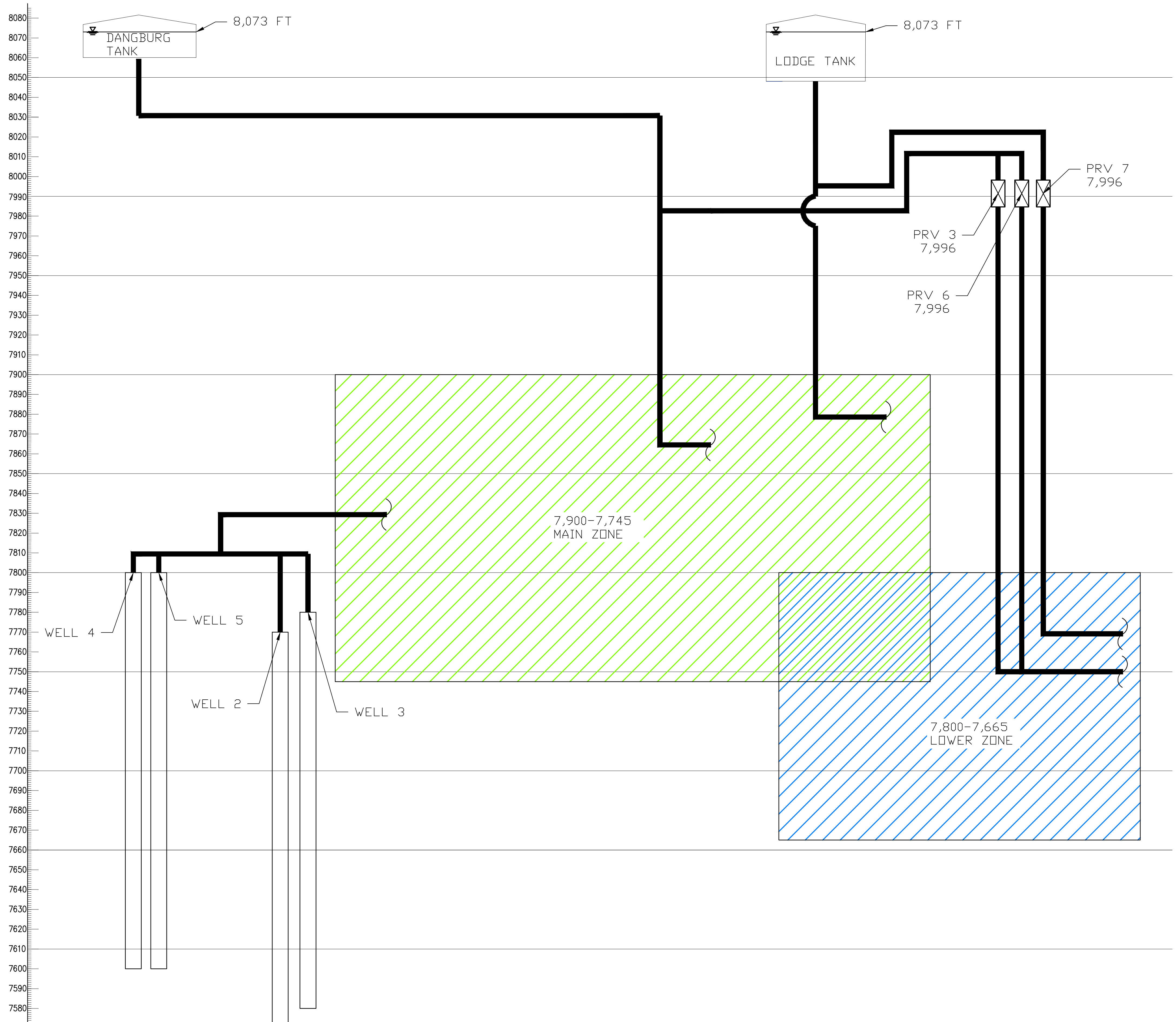

Figure 6-19: Scenario 1 Hydraulic Schematic

6.3.2 *Buildout Operational Scenario 2: Create and maintain 4 distinct pressure zones, and install transmission mains to strictly feed the wells*

The second alternative scenario involves installing approximately 5,200 LF of 10-inch transmission main, and approximately 645 LF of 8-inch water main to act as an intertie between the wells. These additional water mains will serve as dedicated fill lines that are interconnected, allowing each tank to be filled by any of the four existing wells. The intertie between Wells 4/5 and Well 2 will be located on Loop Rd, near PRV 8. This connection will prevent overloading Wells 2 and 3 while trying to fill the Lodge Tank which is almost three times the size of Dangburg Tank.

In addition to the new transmission mains, this scenario includes defining four distinct pressure zones. This is achieved by adding a new PRV A that is set at an HGL of 8010 and adjusting the pressure settings of PRVs 2 and 5 to match. PRVs 4 and 8 are not necessary and can be removed. Table 6-1 shows the new PRV settings that are proposed to create four independent pressure zones in the system, and Figure 6-20 illustrates the resulting hydraulic schematic.

Table 6-1: Scenario 2 PRV Settings

PRV	Location	Setting (PSI)	Head(ft)	ELV (ft)	HGL (ft)
1	Top of Dangburg Drive, north end	45	127.0	7930	8057
2	West of Fremont Rd, near Fremont Ct	102	235.0	7775	8010
3	East of Fremont Road, South of Merrill Road	104	241.0	7755	7996
5	East of Dangburg, ~200ft south of Fremont intersection	78	180.0	7830	8010
6	Between Yarrow and Hawkweed	111	256.0	7740	7996
7	West of E. Meadows Drive, near Glove Rock Road	94	216.0	7780	7996
A	Downstream of Lodge Tank	84	193	7817	8010

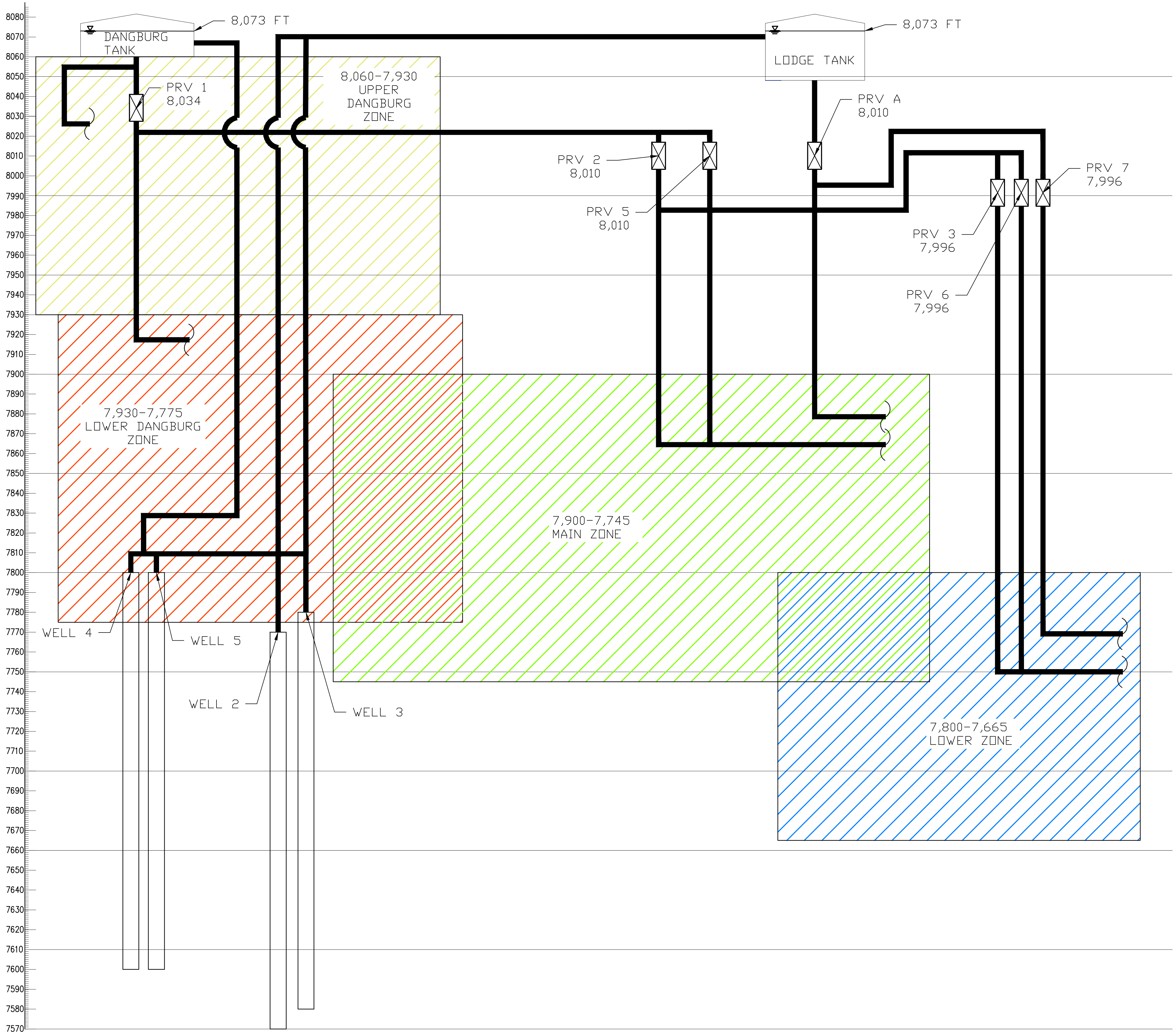

Figure 6-20: Hydraulic Schematic - Buildout Scenario 2

6.3.2.1 Fire Flow Analysis

A fire flow analysis was performed on the hydraulic model, calculating the available fire flow during Buildout MDD with a minimum residual pressure of 20 psi at the hydrant (node) and a minimum pressure of 20 psi anywhere in the system. The fire flow analysis included the four existing wells in the simulation.

Figure 6-21 shows the available fire flow under this operational scenario. These results are like the fire flow results of the existing scenario, with only a handful of nodes near the Dangburg and Lodge Tanks have fire flow deficiencies. However, this is generally anticipated near tank sites and dead-end mains, which is generally acceptable. Transmission lines typically do not include hydrants; therefore, the nodes along the transmission mains were excluded from the fire flow analysis.

6.3.2.2 Peak Hour Demand Analysis

Figure 6-22 shows the pressure and velocity map of operational scenario 2 under Buildout MDD conditions. The figure shows that operating the system with the modified pressure zones - created by PRV’s A, 2, and 5 - as well as adding the dedicated transmission lines, helps to reduce the high pressures experienced by the system in the main pressure zone to a maximum of 119 psi. There are no pressures below 40 psi.

System velocities are under 2.5 ft/s for buildout demands, indicating the need for a flushing program to clear sediment. No pipe velocities exceed the District's 7 ft/s maximum criteria.

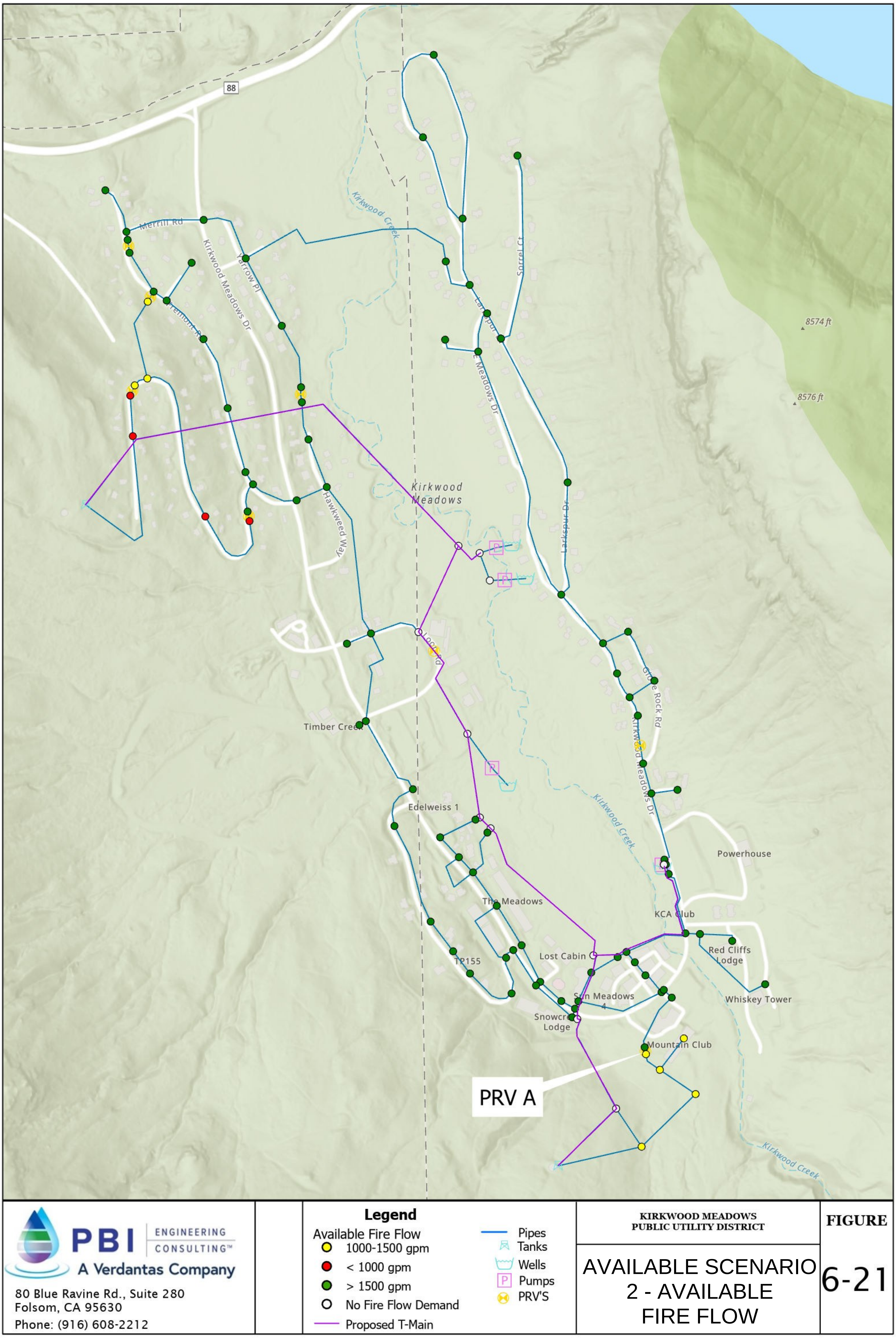

Figure 6-21: Available Scenario 2 - Available Fire Flow

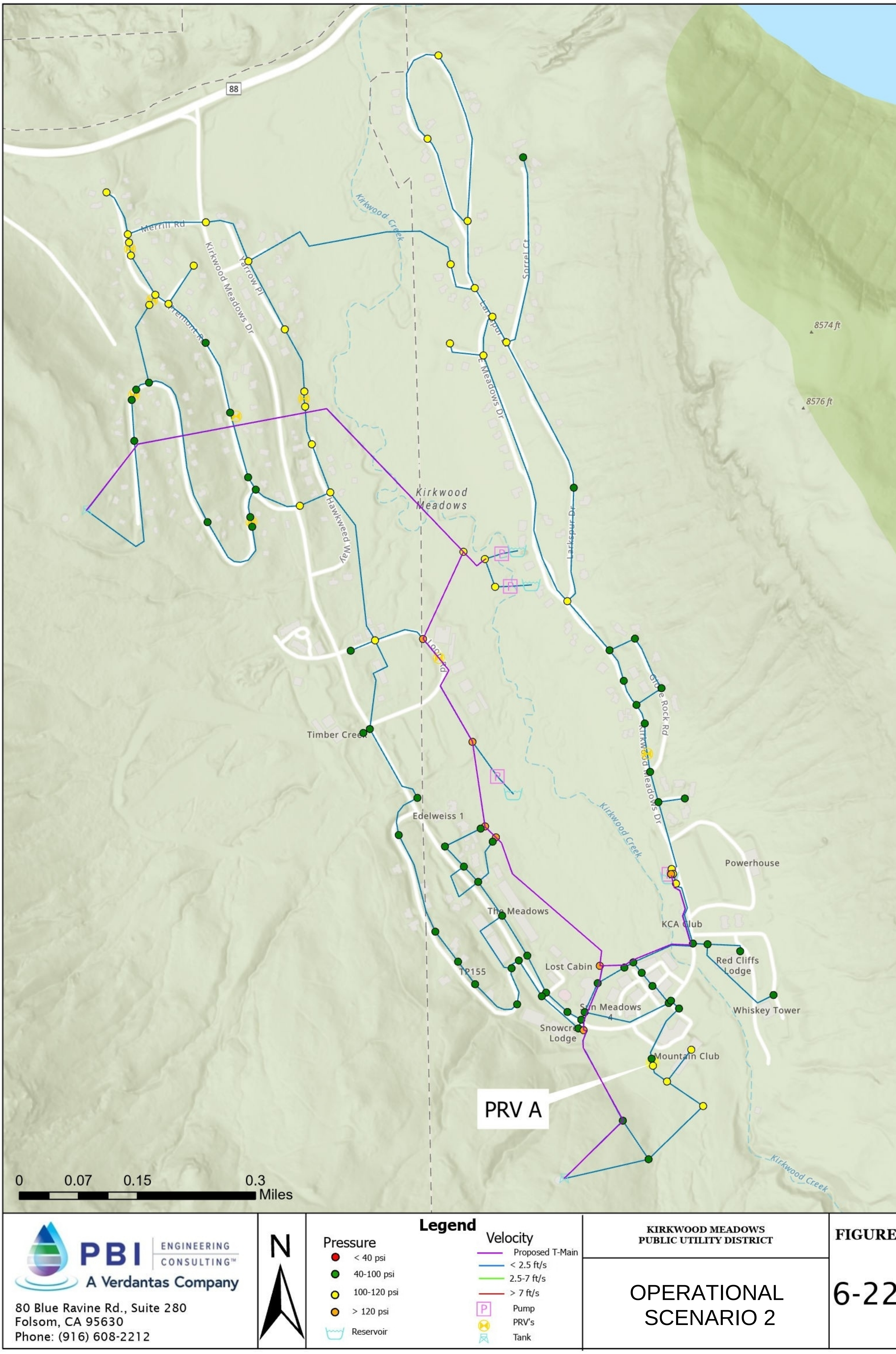

Figure 6-22: Operational Scenario 2

6.3.2.1 Tank Turnover and Water Age Analysis

Figure 6-23 and Figure 6-24 show that the tank Turnover for both Dangburg and Lodge Tanks is improved under this scenario. Both tanks experience full fill and empty cycles throughout the simulation.

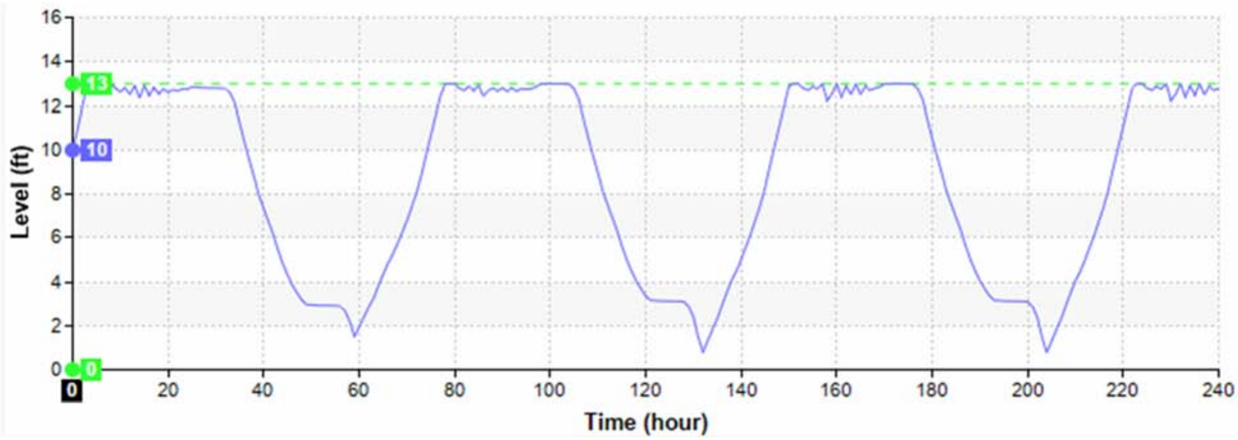

Figure 6-23: Dangburg Tank Turnover Scenario 2

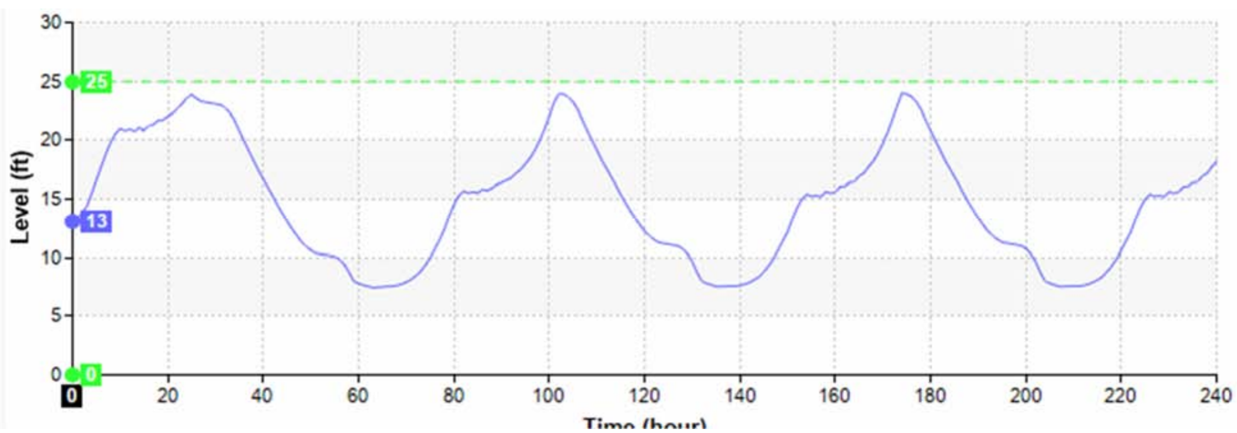

Figure 6-24: Lodge Tank Turnover Scenario 2

To simulate the worst-case scenario for water age, the model was also run under the Buildout ADD condition. Figure 6-25 shows that the water age at the Dangburg Tank peaks at 119 hours (5 days) around 8.8 days into the 10-day simulation. This water age is higher than the water age at the Dangburg Tank under Scenario 1 (3.5 days). Figure 6-26 shows that the water age at Lodge Tank Peaks is improved by the increased turnover in the tank. The water age cycles throughout the simulation and experiences a peak of 83 hours (3.5 days) at approximately 8.8 days into the 10-day simulation period. The water age for Lodge Tank shows a significant improvement under this operational scenario.

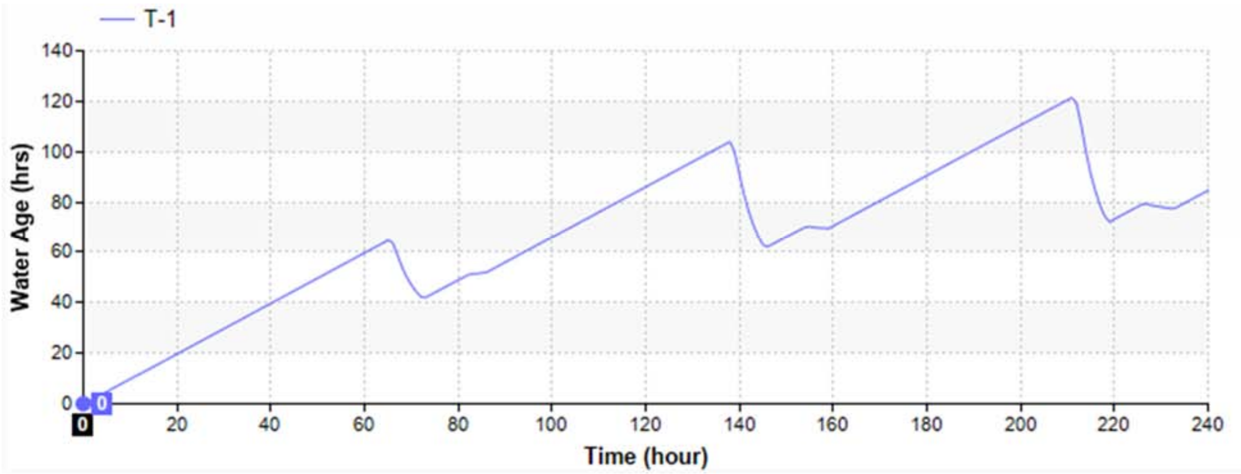

Figure 6-25: Dangburg Tank Water Age Scenario 2

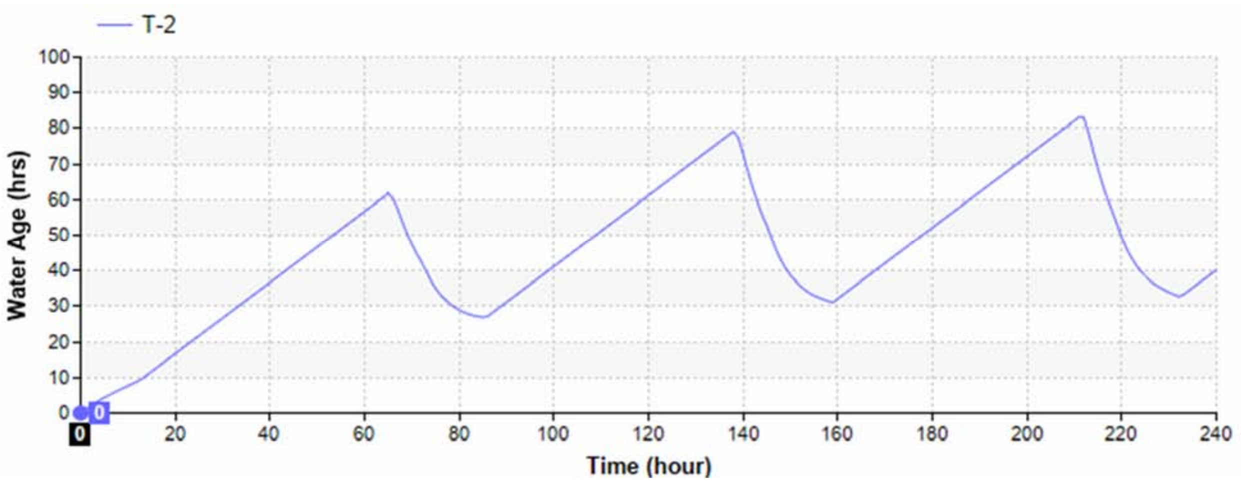

Figure 6-26: Lodge Tank Water Age Scenario 2

As shown in Figures 6-21 and 6-22, the implementation of this scenario requires the installation of approximately 5,200 LF of 10-inch PVC transmission main, and approximately 645 LF of 8-inch PVC water main. Assuming a unit cost of $280/LF and $240/LF for 10-inch and 8-inch main respectively, the entire effort to implement these improvements is estimated to cost approximately $2.7 million.

Both Scenario 1 and Scenario 2 come with their own advantages and disadvantages. See Table 6-2 below for a list of pros and cons for each scenario:

Table 6-2 Scenario Pros & Cons

	Pros	Cons
Scenario 1: Open PRVs 1,2, and 5 to create two pressure zones.	Simplifies current operations.	Does not mitigate high pressures within the main zone.
	Minimal investment required.	
Scenario 2: Install dedicated transmission mains between the wells and both tanks.	Reduces high pressures within the main zone.	High implementation cost of approximately $3 million.
	Improves tank turnover and significantly reduces water age.	

Operating the system as described in Scenario 2 would mitigate high pressures, improve tank turnover, and reduce water age, however it has a high implementation cost of nearly $3M. Scenario 1 allows tanks to float off each other and can be implemented with minimal investment. It does not address high pressures in the main zone; however, existing customers are already equipped with PRVs on their service line to mitigate this issue. The only issue not mitigated is the potential reduction in useful life of the pipeline that experiences high pressure. Scenario 1 can be implemented with minimal investment and an annual pipeline replacement program can be implemented to ensure assets are replaced prior to reaching the end of their useful life. Therefore, it is recommended that the District proceed with Scenario 1 and implement an annual pipeline replacement program.

6.3.3 *Minimum Pipe Size Improvements*

The District requires that any distribution piping that is not fully looped be a minimum of 8-inches in diameter. Several dead-end portions of the existing system are composed of 6-inch diameter piping. To correct this, it is recommended that these portions of the distribution system be upsized to 8-inch diameter pipe. Analysis of the system shows that approximately 1,400 linear feet of existing 6-inch pipe will need to be upsized to bring the system into compliance with District requirements. While the upsizing of this pipe is not urgent, it should be included in the maintenance plan and addressed gradually.

6.4 Storage Tank Capacity

The storage tank requirements for the system were determined by using the requirements outlined in the *District Construction Specifications* (May 2022) under buildout demand conditions. These standards were used to evaluate system capacity. The standards are:

- Operational Storage: 33% of MDD
- Required Fire Flow Storage: 1,500 gpm for 4 hours
- Sprinkler Fire Flow Storage: 60 gpm for 2 hours
- Emergency Storage: MDD
- System Losses: 12% of MDD

Table 6-2 shows the District's required tank capacity per their listed standards, and Table 6-3 lists the existing tank storage capacity.

Table 6-3: Required Tank Capacity

STORAGE TYPE	FLOW (GPM)	STORAGE CAPACITY (GAL)
Operational Storage (0.33 of MDD)	222.2 (7.92 hours)	105,590
Required Fire Flow Storage	1,500 (4 hours)	360,000
Sprinkler Fire Flow Storage	60 (2 hours)	7,200
Maximum Day Demand (Emergency Storage)	222.2 (24 hours)	319,970
System Losses (0.12 of MDD)	222.2 (2.88 hours)	38,400
Total Required Storage Capacity		**831,160**

Table 6-4: Existing Tank Storage

STORAGE FACILITY	CAPACITY (GAL)
Dangburg Tank	250,000
Lodge Tank	700,000
TOTAL	950,000

The system requires approximately 832,000 gallons of storage. The existing tank storage capacity of 950,000 gallons exceeds this requirement. No additional storage improvements are needed at this time.

CHAPTER 7 – FACILITY CONDITION ASSESSMENT

The following sections present a summary of information gathered during site visits to the main components of the District's water system.

7.1 Wells

The District currently has four active wells in their system: Wells 2, 3, 4 and 5. Well 1 was previously abandoned in 2013.

7.1.1 *Well 2*

Well 2 was constructed in 1972 and sits inside a wooden building. Currently, this well is operated manually and has no automatic controls. Operational upgrades are recommended for this well site, including the installation of a PLC and control panel, a wireless modem, and a level transducer. The existing wooden building is aging and in poor condition. The District would like to upgrade the building to be a CMU block building similar to the one used for Well 3. Further details on these improvements can be found in Chapter 8 – Recommended Capital Improvement Projects.

7.1.2 *Well 3*

Well 3 was constructed in 1992 and is located south of the District offices on the west side of the meadow. The well is outfitted with treatment and a secondary booster pump that rest inside an existing CMU block building (see Figure 7-1). Currently, this well is operated manually and has no automatic controls. Operational upgrades are planned for this well site, including the installation of a PLC and control panel, a wireless modem, and a level transducer. Further details on these improvements can be found in Chapter 8 – Recommended Capital Improvement Projects.

Figure 7-1: Well 3 Treatment and Booster Pump CMU Block Building

7.1.3 *Well 4 & 5*

Wells 4 & 5 were constructed in 1998 and pump to a common treatment building before connecting to the distribution system. Currently, these wells are operated manually and have no automatic controls. Operational upgrades are planned for this well site, including the installation of a PLCs and control panels, wireless modems, and level transducers. Additionally, the District intends to install a new CMU block building like the one currently used for Well 3. This will replace the existing wood building (see Figure 7-2 below).

Wells 4 & 5 have also been found to have high levels of manganese above the State's maximum contaminant level. Per the District's corrective action plan provided to the Division of Drinking Water, a feasibility study must be conducted for the implementation of a green sand filter that would effectively reduce manganese levels in the before entering the system. Preliminary filter sizing and backwash disposal estimates can be found in Chapter 8 – Recommended Capital Improvements Projects.

Figure 7-2: Wells 4 & 5 Wooden Treatment Building

7.2 Lodge Tank

The field work for the Lodge Tank inspection was completed on August 29, 2024, with a tank water level of 30 ft. The interior inspection was done using special underwater diving equipment and techniques. The exterior shell observations were made mostly from grade level, while the exterior of the roof was examined closeup. The exterior coating of the tank was determined to be in overall fair condition, while the interior coating is in poor condition above water, and good condition below water. Appendix A presents a copy of this report.

7.2.1 *Tank Interior*

The coating on the underside of the roof plates was determined to be in overall poor condition and worse than the rest of the interior. Corrosion was found common to the edges of the support member flanges and roof plates. Spot peeling and cracking was observed throughout. Although the shell surfaces are covered with a dark sediment, spot checking revealed the lining of the shell to be in good condition with minor areas of dark rust mainly found below the high-water level. The floor had a moderate load of sediment upon it, but spot checking revealed an epoxy system that was estimated to be in good condition. Corrosion pitting locations were uncovered on the floor and were patched during the inspection by CSI. Prior patches identified were observed to be performing properly. Figure 7-3 and Figure 7-4 present examples of the tank's roof and floor condition.

Figure 7-3: Lodge Tank Interior Roof

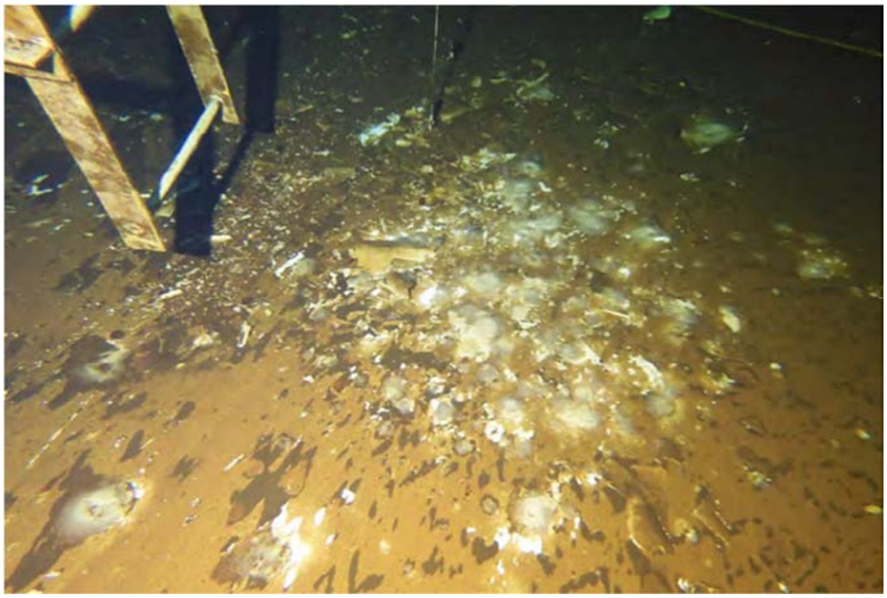

Figure 7-4: Lodge Tank Interior Floor

Is it recommended that within the three to five years, the interior lining should be removed and replaced. This work should include the following:

1) Cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 10 "Near-White Metal Blast Cleaning" (SSPC-SP10) followed by three 4 to 6 mil coats of an NSF Certified epoxy lining.
2) Caulk all crevices in the tank such as roof lap seams.
3) Anticipate the need for structural repairs (welding, grinding, etc.)
4) Eliminate all dissimilar metal connections within the tank by electrically isolating these connections with phenolic washers, nylon inserts, neoprene or Teflon buffers.

7.2.2 *Tank Exterior*

The exterior roof is highly weathered and was determined to be in overall fair condition. The exterior shell is in good condition. There is moderate chalking present on the entire tank as well as dark rust in areas that have been mechanically damaged from operations or vandalism. Figure 7-5 and Figure 7-6 show examples of the condition of the tank's exterior roof and the thickness of the paint on the tank's shell.

Figure 7-5: Lodge Tank Exterior Roof

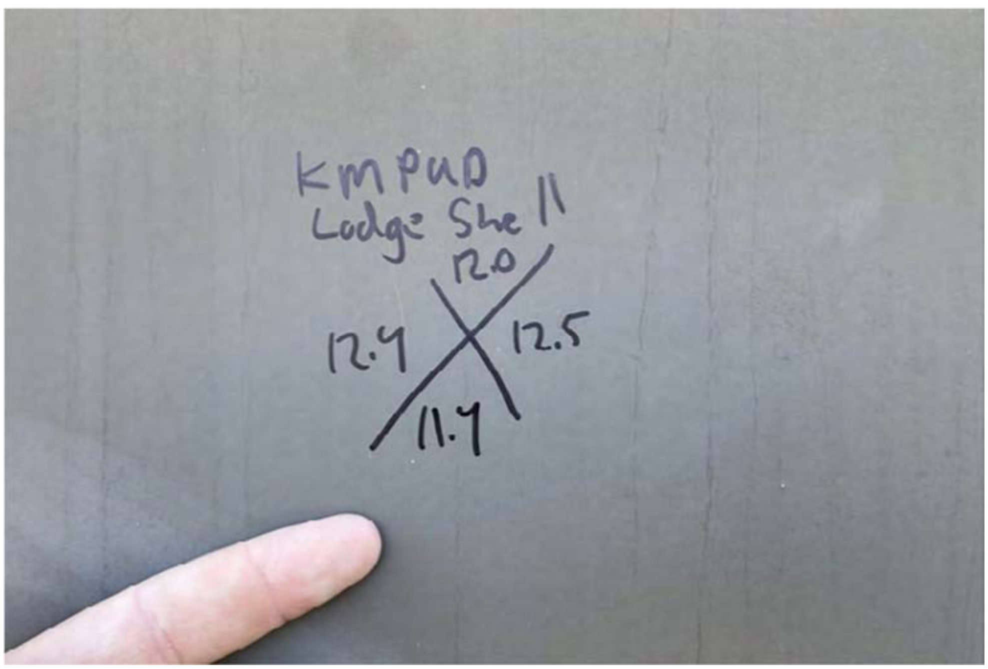

Figure 7-6: Lodge Tank Shell Paint Thickness

It is recommended that within the three to five years, spot repair and overcoat the exterior coating. This work should include the following:

1) This work should include cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 15, "Commercial Power Tool Cleaning" followed by 4-6 mils of an industrial epoxy primer and 3-5 mils of a polyurethane finish coat.
2) Test the paint system for heavy metals to determine if any special actions are required to protect workers and the environment during paint disturbance.

Additionally, the existing tank piping is not seismically isolated from the rest of the tank. Per AWWA D100, piping connections to the tank shall provide for minimum design displacements. The District should consider retrofitting the tank piping to include flexible couplings.

7.3 Dangburg Tank

The field work for the Dangburg Tank inspection was completed on August 29, 2024, with a tank water level of 19 ft. The interior inspection was done using special underwater diving equipment and techniques. The exterior shell observations were made mostly from grade level, while the exterior of the roof was examined closeup. The exterior coating of the tank was determined to be in overall fair condition, while the interior coating is in poor condition above water, and good condition below water. Appendix A presents a copy of this report.

7.3.1 *Tank Interior*

The coating on the underside of the roof plates was determined to be in overall poor condition and worse than the rest of the interior. Corrosion was found common to the edges of the support member flanges and roof plates. Spot peeling, cracking, exfoliation and structural loss was observed throughout. Although the shell surfaces are covered with a dark sediment, spot checking revealed the lining of the shell to be in good condition with minor areas of dark rust mainly found below the high-water level. The floor had sediment upon it, but spot checking revealed an epoxy system that was estimated to be in good condition. Corrosion pitting locations were uncovered on the floor and were patched during the inspection by CSI. Prior patches identified were observed to be performing properly. Figure 7-7 and Figure 7-8 present examples of the tank's roof and floor condition.

Figure 7-7: Dangburg Tank Roof Interior

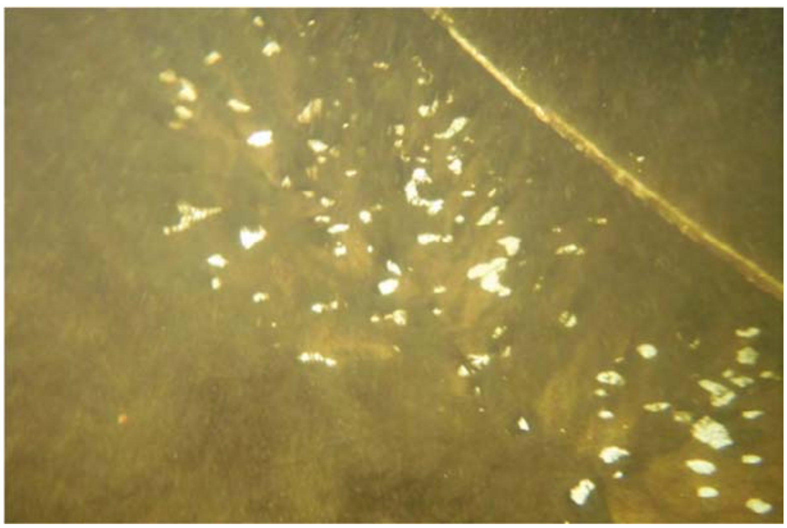

Figure 7-8: Dangburg Tank Interior Floor

It is recommended that within the three to five years, the interior lining should be removed and replaced. This work should include the following:

5) Cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 10 "Near-White Metal Blast Cleaning" (SSPC-SP10) followed by three 4 to 6 mil coats of an NSF Certified epoxy lining.
6) Caulk all crevices in the tank such as roof lap seams.
7) Anticipate the need for structural repairs (welding, grinding, etc.)
8) Eliminate all dissimilar metal connections within the tank by electrically isolating these connections with phenolic washers, nylon inserts, neoprene or Teflon buffers.

7.3.2 *Tank Exterior*

The exterior roof is highly weathered and was determined to be in overall poor condition. The exterior shell is in good condition. There is moderate chalking present on the entire tank as well as dark rust in areas that have been mechanically damaged from operations or vandalism. The paint thickness was found to range from 7.0 to 8.0 mils on the roof and 11 mils on the shell, and the paint was estimated to exhibit satisfactory adhesion. Figure 7-9 and Figure 7-10 show examples of the condition of the tanks exterior roof and the thickness of the paint on the tank's shell.

Figure 7-9: Dangburg Tank Roof

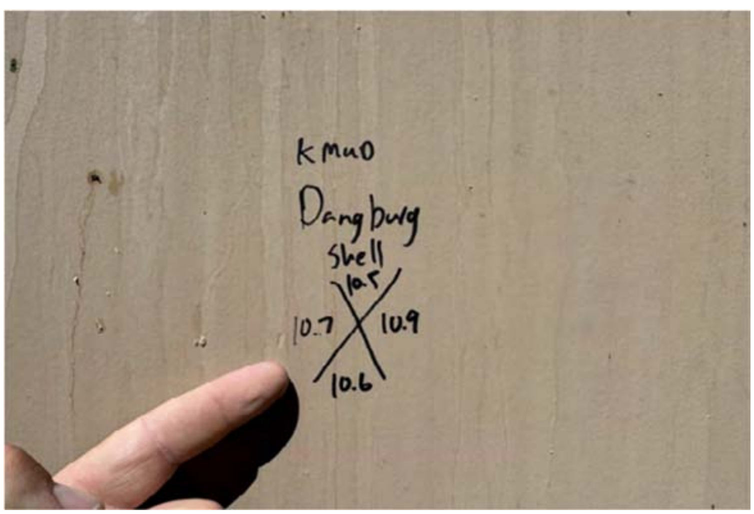

Figure 7-10: Dangburg Tank Shell Paint Thickness

It is recommended that within the three to five years, spot repair and overcoat the exterior coating. This work should include the following:

1) This work should include cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 15, "Commercial Power Tool Cleaning" followed by 4-6 mils of an industrial epoxy primer and 3-5 mils of a polyurethane finish coat.
2) Test the paint system for heavy metals to determine if any special actions are required to protect workers and the environment during paint disturbance.

Additionally, the existing tank piping is not seismically isolated from the rest of the tank. Per AWWA D100, piping connections to the tank shall provide for minimum design displacements. The District should consider retrofitting the tank piping to include flexible couplings.

7.3.3 *Dangburg Tank Access Road*

The Dangburg Tank currently faces accessibility challenges due to the lack of an adequate access road. The District has identified the need for an improved access road to facilitate vehicle movement to and from the tank site. The importance of this infrastructure upgrade is highlighted in Chapter 8 of the Recommended Capital Improvement Projects, which details the specifications and anticipated benefits of the new road.

7.4 Pressure Reducing Valves

The Pressure Reducing Valves (PRVs) in the District's water system play a crucial role in maintaining the stability and efficiency of water pressure across different zones. Presently, the system is comprised of eight PRVs, yet several of these are either malfunctioning or being bypassed due to other operational issues.

In February 2021, Bailey Civil Engineering (Bailey) conducted a comprehensive system analysis and identified potential pressure zones that could be effectively managed by the PRVs. Bailey identified that some of these older PRVs are particularly problematic and are no longer serviceable. Bailey also identified that PRV 3 has broken gauges and bypass piping that is not in use, while PRVs 2, 5, and 7 are the only ones operating as intended. However, the observed pressure recordings presented in the system analysis (see Table 2-2) revealed inconsistencies in the system hydraulic grade line which implies the observed pressures may be inaccurate.

To address these discrepancies and improve the water system, field assessments should be scheduled to determine the precise status and functionality of each PRV. Following the assessments, the PRV's should be modified as outlined in Chapter 6 omit unnecessary PRV's from the system.

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CHAPTER 8 – RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

The District had originally adopted a comprehensive Capital Improvements Plan (CIP) during their 2023/2024 fiscal year to address critical infrastructure needs. Under the "water" section, several high-priority projects have been identified to ensure the continued reliability and safety of the community's water supply. The projects are assigned a priority number from 1 to 5, with 1 indicating the most critical needs.

The recommended CIP list and schedule, integrate both the priority projects from the District's Capital Improvement Program and those discussed during the initial Water Master Plan kickoff meeting. Adjustments were made to some project's priorities, such as elevating the work on Wells 4 and 5 due to the high levels of manganese detected in the water. A feasibility study for Wells 4 and 5 is also considered, to ensure that the elevated manganese levels are addressed appropriately. This approach ensures that the District can continue to meet regulatory standards and the community's needs effectively.

The CIP list addresses five different facilities requiring improvements:

- Wells
- Tanks
- PRVs
- Operations Building
- Pipeline Improvements

8.1 Wells

8.1.1 *Manganese Treatment Feasibility Study*

The priority project to complete will be the Feasibility Study for Wells 4 & 5 to address the high levels of manganese, per the District's corrective action plan. This is a priority 1 project.

8.1.2 *Operational Upgrades*

Several operational upgrades have been proposed for Wells 2, 3, 4, and 5. These upgrades include adding PLCs, control panels, wireless modems, and level transducers. The system is currently able to operate with manual controls. The high priority treatment equipment at Wells 4/5 can likely be operated with local controls. Due to CIP funding constraints, PLC upgrades for the well sites are considered priority 4 projects.

8.1.3 *CMU Block Buildings*

The District wants to replace existing wooden water treatment buildings with CMU block buildings similar to Well 3. The installation of CMU block buildings for Wells 2, 4, and 5 will be coordinated with any operational improvements.

8.2 Tanks

8.2.1 *Dangburg Tank*

A recoating and relining of the Dangburg Tank is recommended and has been put on the CIP schedule as a priority 2 project. Based on the CSI report, it is also expected that minor structural repairs will be required. Operational upgrades will also be made at the Dangburg Tank, including a new tank mixer, a PLC and control panel, wireless modem, and level transducer.

The Dangburg tank lacks dedicated access to the site. It is recommended to construct a 650-ft access road beyond the end of Dangburg Drive to the tank site. This work will be coordinated to occur simultaneously with the other site improvements. The site improvements to this tank are considered a priority 3 project.

8.2.2 *Lodge Tank*

A recoating and relining of the Lodge Tank is recommended and has been put on the CIP schedule as a priority 2 project . Based on the CSI report, it is also expected that minor structural repairs will be required. Operational upgrades will also be made at the Lodge Tank, including a new tank mixer, a PLC and control panel, wireless modem, level transducer, and expansion joints. These improvements to this tank are considered a priority 3 project.

8.3 Operations Building

The District's Operations Building, which manages all facilities, will eventually have a fully automated control system. A new SCADA system and wireless receiver will be installed to control the wells and tanks. It is recommended that this should happen after tank and well improvements. Thus, this project is considered a priority 4 project.

8.4 Distribution Improvements

8.4.1 *PRV Improvements*

Multiple PRV’s within the distribution system have been identified to either be functioning incorrectly or are not working at all. To update the system operations consistent with recommendations from Chapter 6, it is recommended to remove PRV's 1, 2, 4, 5, and 8 and assess the remaining PRVs for functionality or replacement. These assessments and improvements are considered priority 2 projects.

8.5 Annual Infrastructure Program

An annual infrastructure program can be used to address on-going maintenance, repair, and replacement costs to maintain the system. The following sections describe anticipated costs to maintain District assets.

8.5.1 *Pipeline Replacement*

Due to various pipe segments within the District's system being undersized due to being dead ends, pipeline upgrade projects have been planned in order to bring up these distribution line to the proper size. These can be addressed as part of an annual infrastructure program.

It is assumed that all pipes will be at the end of their useful life within the next 50 years and will need replacement. It is therefore recommended to replace 1% of the distribution system piping per year.

To determine the construction budget for replacing the existing system piping over the next 50 years, the current value of all the pipe in the system was estimated. Table 8-1 presents the total value of the transmission and distribution system piping in 2025 dollars along with the annual 1% construction cost.

Table 8-1: Annual Construction Cost for 1% Replacement of Existing System Piping

New Pipe Diameter (in)	Planning Level Construction Cost (2025 Dollars/LF)	Existing System Pipe Length (LF)	Total Cost to Replace Existing System (2025 Dollars)	1% Annual Cost of Construction (2025 Dollars/yr)
6	$198.00	13996	$2,800,000	$28,000
8	$220.00	15815	$3,500,000	$35,000
12	$250.00	10614	$2,700,000	$27,000
		Total	**$9,000,000**	**$90,000**

8.5.2 *Greensand Filter O&M Costs*

With the implementation of the new greensand filtration system at the Well 4 & 5 site, there will be associated operation and maintenance costs that need to be considered. The costs associated with the operation of this system can be broken down into greensand media costs and backwash costs.

For the greensand media, it is assumed that the unit cost is $95 per cubic foot. With an estimated media volume of 175 cubic feet, this results in a replacement cost of $16,700. The media is expected to be replaced every 7-10 years. This would lead to a maximum annualized cost of $2,400 per year (in 2025$).

When considering the backwash costs, it is important to start with the volume of the backwash tank. The backwash tank for this application is estimated to be 5,000 gallons, with an estimated backwash volume of 3,500 gallons. Based on an estimated cost of $5.68 per 100 gallons of wastewater and a frequency of backwash of once every 5 days, this leads to an estimated cost of $200 every 5 days, or $14,600 per year (in 2025$).

Overall, an estimated O&M cost of $17,000 should be assumed for the new greensand filtration system. In addition to the $90,000 annual cost of construction associated with pipeline replacements in the District's system, this would result in a total of approximately **$107,000 per year** ($2025) in additional costs.

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CHAPTER 9 – RECOMMENDED CAPITAL IMPROVEMENT PROGRAM

Recommendations for a capital improvement program (CIP) were developed based on the assessment of the District’s water system that was described in Chapters 6 and 7 and summarized in Chapter 8. The following section presents the estimated costs and a prioritized implementation schedule for the recommended improvements.

9.1 Approach

Planning level cost estimates were made for each of the recommended capital improvements.

The following contingencies and allowances were added to the base construction cost:

- 20% Estimating Contingency
- 7.5% Allowance for Engineering/Design Cost
- 7.5% Allowance for Construction Management
- 5% Allowance for Bonds/Insurance/Mobilization

The recommended projects, estimated costs, and proposed schedule were developed through a planning-level of analysis that was appropriate for the 2024 Master Plan and should be re-evaluated in further detail prior to implementation.

9.2 Implementation Schedule

The proposed District Capital Improvements Plan (CIP) is set on a 5-year schedule for the short range and 20-year schedule for the long range, starting with a feasibility study for Wells 4 and 5 in the first year (2025/2026), and finishing in the 2045/2046 fiscal year.

9.3 Recommended Capital Improvement Program (CIP)

Table 9-1 Presents the recommended CIP for the District’s water system including short range (1-5 years) and long range (6-20 years) planning.

Table 9-1 presents the recommended CIP for the District's water system including short range (1-5 years) and long range (6-20 years) planning.

Table 9-1. 2025/2026 Capital Improvement Program

Replacement Component	Construction Costs	Total Cost	Cycle	Priority Scale 1-6 1 = Critical	2025/2026	2026/2027	2027/2028	2028/2029	2029/2030	2030-2035	2035-2040	2040-2045
Manganese Treatment Feasibility Study		$30,000	One Time	1	$30,000							
Wells 4 + 5 Improvement Project: Green Sand Filter & CMU Block Building.	$1,370,280	$1,473,051	One Time	1		$102,771	$1,370,280					
Wells 4 + 5 Improvement Project: PLC & Control Panels, Wireless Modems, Level Transducers.	$360,000	$387,000	One Time	4						$387,000		
Well 2 Improvement Project PLC & Control Panels, Wireless Modems, Level Transducers, CMU Block Building	$976,560	$1,049,802	One Time	4						$1,049,802		
Well 3 Improvement Project PLC & Control Panels, Wireless Modems, Level Transducers	$315,000	$338,625	One Time	4							$338,625	
Dangburg Tank Improvement Project Interior Lining, Exterior Coating	$472,560	$508,002	Thirty Years	3				$508,002				
Dangburg Tank Improvement Project Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Minor structural repairs, Expansion joints	$619,920	$666,414	One Time	5							$666,414	
Dangburg Tank Access Road Project	$176,400	$189,630	One Time	3				$189,630				
Lodge Tank Improvement Project Interior Lining, Exterior Coating	$655,200	$704,340	Thirty Years	3					$704,340			
Lodge Tank Improvement Project Tank Mixer, PLC & Control Panel, Wireless Modems, Level Transducers, Expansion joints	$569,520	$612,234	One Time	5							$612,234	
Operations Building SCADA System + Wireless Receiver + Programming	$243,000	$261,225	One Time	5								$261,225
PRV Field Assessments + Improvements	$231,960	$249,357	One Time	2		$249,357						
Annual Infrastructure Program			Yearly					$17,000	$17,000	$450,000	$450,000	$450,000
Total Water Capital Expense		**$7,853,680**			**$30,000**	**$352,128**	**$1,370,280**	**$714,632**	**$721,340**	**$1,886,802**	**$2,067,273**	**$711,225**

Appendix A

Storage Tank Inspection Reports

(CSI Services, 2024)

P. O. Box 801357
Santa Clarita, CA 91380-2316
Phone: 877.274.2422
Fax: 661.775.7628
www.CSIServices.biz

Providing Quality Technical Services to the Coating Industry

November 19, 2024

Via Email: asmith@pbieng.com

Ashley Smith, PE
Peterson Brustad Inc.
80 Blue Ravine Road, Suite 280
Folsom, CA 95630

Office: 916.608.2212
Cell: 530.200.6309

Subject: **Final Report - Maintenance Inspection**

Re: **Kirkwood Medows PUD – Danburg Reservoir**

Dear Ashley:

Please find attached the final report for the evaluation that was completed on the above referenced tank. Also attached is our invoice.

Thank you for your business and please let me know if you have any questions or comments about our findings. I can always be reached by cell at 951.609.6991 or by e-mail at rgordon@csiservices.biz.

Sincerely,
CSI Services, Inc.

N. Randy Gordon

N. Randy Gordon, PCS
Technical Services Manager

P. O. Box 801357, Santa Clarita, CA 91380 877.274.2422

Final Report
Maintenance Inspection
Danburg Reservoir
Kirkwood Medows Public Utility District

Prepared for:
Ashley Smith, PE
Peterson Brustad Inc.
80 Blue Ravine Road, Suite 280
Folsom, CA 95630

PROTECTIVE COATING SPECIALIST
N. RANDY GORDON
No. 2018-621-011
Exp. 12-31-26
PCS
STATE OF CALIFORNIA

Prepared by:
CSI Services, Inc.

N. Randy Gordon, PCS
Technical Services Manager

November 19, 2024

Hawaiian Office: P.O. Box 671, Aiea, HI 96701
Northern California Office: P.O. Box 371, Sonoma, CA 95476

Coating Specialists and Inspection Services, Inc.

Consulting Evaluations Tank Diving Inspection

Table of Contents

Attachments

Introduction

Peterson Brustad Inc. authorized CSI Services, Inc. (CSI) to conduct a maintenance inspection on the Kirkwood Meadows Public Utility District, Danburg Reservoir located at the Kirkwood Mountain Resort, Pioneer, CA. This report documents the findings of the inspection and services performed.

Any recommendations have been made in accordance with the applicable requirements of American Water Works Association's Standard (AWWA) D102 "Coating Steel Water Storage Tanks," AWWA Standard M42 "Steel Water Storage Tanks," and CSI's experience with evaluating over a thousand water storage facilities. A photo summary and narrated video are also included to document the condition of the tank.

The field-work was completed on August 29, 2024 by a team primarily comprised of Anthony Jackson, Steven Metcalf and Steven Metcalf Jr. The exterior shell observations were made mostly from grade level, while the exterior of the roof was examined close-up. The interior inspection was carried out with the tank's water level at approximately 19 feet using special underwater diving equipment and techniques. Steve Metcalf was the site supervisor and Anthony Jackson was the lead diver. Mr. Randy Gordon, Technical Services Manager, reviewed the results of the field data and prepared recommendations for maintenance work. Mr. Gordon has over 35 years of experience through the evaluation of thousands of storage tanks and other structures. He is certified as an SSPC Protective Coating Specialist (PCS) and NACE/SSPC Level 3 Coating Inspector.

Summary

The estimated 33 year old coating system on the tank is in overall fair condition with widespread and pervasive corrosion on the roof while the shell is largely unimpacted by corrosion. The exterior paint system is severely weathered but has satisfactory adhesion, making it an ideal candidate for future overcoating strategies. The exterior paint is believed to be the original system applied from 1991 and although it should not have high concentrations of heavy metals (e.g. lead, chromium, etc.) the paint system should be further analyzed prior to any work that would disturb the paint system as special precautions to protect the workers and environment may be required if it is disturbed.

The lining in the tank is in an overall unsatisfactory condition with widespread rust including undercutting, pitting, and exfoliation. Blistering of the lining below the MWL is extensive and widespread. The most advanced corrosion spots below the CWL were patched during this inspection using an NSF certified underwater curing epoxy. The existing lining conditions dictate that the existing exterior paint and interior lining systems should be removed and replaced within the next 1 to 2 years to prevent any further structural loss.

Background

The Danburg Reservoir is a welded steel on grade structure where the year of construction is 1991. The tank is approximately 47 feet in diameter by 20 feet high providing a nominal capacity of 250,000 gallons.

The tank shell has two 10 foot courses that are connected to a conical roof with rafters, girders and one center column. The tank has one roof vent, one roof hatch, and two shell manways. There is one interior ladder and one exterior ladder. The exterior ladder has fall protection and a vandal deterrent. The tank is not seismically anchored to its gravel grade band foundation. There is no internal or external cathodic protection (CP) system associated with this tank. The tank has a half-travel water level indicator, rigid piping connections, and the overflow is internal.

It is believed that the interior linings are the original coatings applied. The interior steel surfaces, including the roof and roof support members and tank bottom are coated with a thin-film, multi coat epoxy system. The exterior roof, shell, and appurtenances are painted with what appears to be an alkyd system. The internal roof lap seams are not caulked.

Field Evaluation

The purpose of this survey was to assess the condition of the existing coatings and recommend maintenance coating work, where needed. The evaluation mainly involved visual observations, but also involved various testing procedures. Photographs and video were taken to document the field inspections, and a photo summary and narrated video is included within this report.

For survey purposes, the tank has been segmented into defined areas: exterior roof, exterior shell, interior roof, interior shell, and interior floor. The various appurtenances within each of these areas have also been evaluated. A rating system has been developed to quantify the condition of these various tank areas. Each of the rating criteria is found in the Attachments (Charts 1 through 6).

The condition of the coating systems was rated as being poor, fair, good, or excellent (Chart 1). The extent of any rust defects identified within each of the areas was generally determined using the guidelines set forth in ASTM D610 “Standard Test

Method for Evaluating the Degree of Rusting of Painted Steel Surfaces" (Chart 2). Where applicable, the characteristic or stage of corrosion was determined in accordance with CSI Corrosion Grade criteria (Chart 3). The degree of paint chalking was determined in accordance with ASTM D4214 "Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films," Test Method D659, Method C (Chart 4). Coating adhesion was assessed in accordance with ASTM D3359 "Standard Test Method for Evaluating Adhesion by Tape Test, modified Method A and/or a modified version of ASTM D6677 "Standard Test Method for Evaluating Adhesion by Knife" (Chart 5). The modified version of ASTM D6677 was used in areas where destructive testing was not found to be practical. Any blistering that may have been present was rated in accordance with ASTM D714 "Standard Test Method for Evaluating the Degree of Blistering in Paints" (Chart 6), and the paint dry film thickness was measured with a Positector 6000FN3 Type II gage in accordance with the applicable guidelines set forth SSPC PA2. The visual observations and data collected from the various areas of the tank are found in the charts below:

Exterior

Close-up visual examination of the coating was limited to the first (lowest) shell course, upper shell areas adjacent to the ladder, and the roof. The exterior paint on the heavily weathered roof is in poor condition and the shell was in good condition, both with moderate chalking (ASTM D4214, No. 8). Dark rust (CSI Corrosion Grade 2, 3) was present in areas that had been mechanically damaged from operations or vandalism and areas where paint was peeling. The amount of rust on the roof was less than 33 percent of the overall surface area (ASTM D610, 8). Areas where paint was found to be cracking were rated a 2 in accordance with ASTM D661. The paint thickness was found to range from 7.0 to 8.0 mils on the roof and 11 mils on the shell. The paint was estimated to exhibit satisfactory adhesion (ASTM D6677, 3A).

Some of the specific data collected follows:

Exterior Paint				**Overall Condition**		Fair						
Paint Defects	**Roof Quadrant**				**Shell Quadrant**				**Tank Support**			
	Exterior		Poor		Exterior		Good		Exterior		Good	
	S	**W**	**N**	**E**	**S**	**W**	**N**	**E**	**S**	**W**	**N**	**E**
Rust spots (ASTM D610)	2	2	2	2	9	9	9	9	9	9	9	9
Corrosion Grade	2	2	2	2	2	2	2	2	2	2	2	2
Rusting at crevices	Yes	Yes	Yes	Yes								
Spot peeling	Yes	Yes	Yes	Yes								
Delamination												
Cracking (ASTM D661)												
Checking (ASTM D660)												
Chemical staining												
Chalking	8	8	8	8	8	8	8	8	8	8	8	8

Interior

The roof area is defined as those surfaces above the highest water level (HWL). Close-up visual examinations were made to all areas below the waterline and all other areas were assessed from the water level. The coating on the underside of the roof plates and roof support structure is in poor condition with corrosion common to the edges of the support member flanges and roof plates (CSI Corrosion Grade 2, 3, 4). Spot peeling, cracking, exfoliation and structural loss was observed throughout. The total amount of corrosion on the roof was rated to be approximately one third of the total surface area (ASTM D610, 2), and there was a minor amount of rust staining present at the faying surfaces of the roof structure.

The shell surfaces are covered with a dark sediment, but spot checking revealed the lining on the shell was found to be in good condition with areas of dark rust (CSI Corrosion Grade 2), especially below the high-water level segment of the shell. The total amount of corrosion on the shell was rated to be excessive but less than 0.03 percent of the total surface area (ASTM D610, 9). Fields of intact and broken, medium dense blisters were observed (ASTM 714, 2-few).

The floor had sediment upon it, but spot checking revealed an epoxy system that was estimated to be in good condition, (ASTM D610, 9) with fields of small, medium-dense blisters (ASTM 714, 2-few). Some pitting uncovered upon the floor was patched during the inspection and the prior patches were observed to be performing properly.

The data collected from the underwater inspection follows:

Interior Paint					Above Water Condition			Poor		Below Water Condition			Good
Paint Defects/Overall Grade	**Roof Quadrant**				**Shell Quadrant**				**Floor Quadrant**				
	Interior		Poor		Interior		Good		Interior		Good		
	S	**W**	**N**	**E**	**S**	**W**	**N**	**E**	**S**	**W**	**N**	**E**	
Rust spots (ASTM D610)	3	3	3	3	9	9	9	9	9	9	9	9	
Rust areas (ASTM D610)													
Corrosion Grade	2,3,4	2,3,4	2,3,4	2,3,4	2	2	2	2	2	2	2	2	
Rust staining	Minor	Minor	Minor	Minor									
Rusting at crevices	Yes	Yes	Yes	Yes									
Spot peeling	Yes	Yes	Yes	Yes									
Delamination													
Cracking (ASTM D661)	2	2	2	2									
Blistering (ASTM 714) Size/Density					2/Few	2/Few	2/Few	2/Few	2/Few	2/Few	2/Few	2/Few	
Pitting (Estimated Amount)													
Pitting (Estimated Deepest Mils)													

Dive Inspection Video

Click on link or cut and paste the external link: https://youtu.be/HALSaerd-ic

Discussion

The paint system on the exterior was found to be very thin and in poor condition on the roof and good condition at the shell. Although these surfaces have spot rust and areas of peeling, the paint system was found to have significantly weathered from chalking.

Generally speaking, there are four possible approaches to maintenance coating work. The coatings can be either completely removed and replaced (repainted), spot repaired, spot repaired and overcoated, or simply overcoated. In evaluating the condition of a coating to determine the best approach there are a number of different factors to consider. The first set of factors includes the determination of the coating's ability to withstand the added stress of an additional coat(s). Attributes impacting this decision include film thickness and adhesion. If a film is too thick or has poor adhesion, the tension from the curing stresses and/or the weight of the additional paint can cause the existing system to disbond. The second set of factors to consider when determining what maintenance coating approach to take is the amount of surface area requiring repair, the overall difficulty in providing access to the structure, and whether the coating system contains heavy metals. The final factor is the condition of the substrate.

When considering whether a spot repair approach is a viable option, a good rule of thumb is that up to 10 percent of the surface area requiring repair is the point at which making spot repairs with overcoat becomes a diminishing return. With 10 percent rusting, overcoating may be an option if the adhesion is better than fair. If there is more than 10 percent rusting and the substrate is free of mill scale, overcoating may be considered an option if the adhesion is satisfactory. Once the amount of surface area exceeds this range, the cost of cleaning and coating the individual rust spots approaches (or exceeds) the total cost of removal and replacement.

Chalking is the term for the powdery characteristic of an aged coating that may also have a faded finish. Chalking is a result of the natural breakdown of a paint system's binder when it is exposed to sunlight. The binder (or resin) degrades in ultraviolet light, which leaves behind the unbound pigment or chalk. Aside from a faded appearance, chalking can result in corrosion as the film weathers (thins) away through cycles of wind and rain. As the paint endures years of direct sunlight, it begins to weather away, which results in the paint no longer providing enough barrier protection from corrosion.

Peeling or delaminating coating is a symptom of an adhesion problem between the coating and substrate or from within layers of coating system. Adhesion is a function of a coating system's strength. Peeling is often a result of coated over contamination, incompatibility between coats, or from an undercoat being coated after its recoat window had closed. Catalyzed coatings, such as epoxies and urethanes continue to dry and then cure to a point where they become too hard for topcoats to chemically adhere. Once the window for a chemical bond is closed, special procedures such as scarification are required to allow for a mechanical bond.

Industrial paint systems such as those applied to industrial facilities (i.e. piping, structural steel, storage tanks) typically have a life expectancy of 25 to 35 years before any spot maintenance coating repairs are required. The exterior paint system is aged yet remains suitable for overcoating. Therefore, it is recommended that the paint system on the tank be spot repaired and overcoated with a new epoxy urethane system within the next 2 to 3 years.

Overall, the tank interior lining is in poor condition in the area above the highest water level (HWL), and in good condition below the HWL. The vapor area is replete with corrosion and has advanced to exfoliation, primarily at the roof structure. The lining on the underwater areas of the tank is mostly free of widespread corrosion, but there are many rust spots that were patched during the course of the inspection. Many groupings of blisters were encountered at the shell and at the tank bottom.

A tank roof, including its roof support structure has many open, unsealed areas by design. These open areas are primarily at the inaccessible crevices that are between the top of the roof beam flanges and the roof plate. The cost of properly sealing these areas becomes a diminishing return, notably when one considers that small crevice areas often develop into dead-air space. Since corrosion requires oxygen to advance and the initial development of corrosion depletes the majority of the available oxygen, the rate of corrosion is very low. The side effect of this design is rust staining that runs from these areas as they initiate corrosion. Unsealed areas can also include lapped, un-welded roof plates. However, these lapped seams areas can be sealed with caulking at a very cost-effective cost.

Cracking is the result of some form of stress within the coating system that extends through a complete layer of coating. The stress is often a result of some internal coating pressure or from some form of structural movement. The internal pressures can result from a shrinking film when it is applied too thick or if coating a coating does not have the elongation properties required to bridge existing breaks. Checking is related to cracking, but the coating breaks do not extend through the entire system.

Exfoliation corrosion is a form of intergranular corrosion which involves selective attack of a metal at or adjacent to grain boundaries. In this process, corrosion products force metal to move away from the body of the material, giving rise to a layered, laminar appearance. Exfoliation corrosion is also known as layer corrosion or lamellar corrosion.

Undercutting is a characteristic of corrosion when it travels laterally up under a coating that has inadequate adhesion. A coating with an excellent bond to the substrate inhibits the exponential advancement of rust from growing from a small rust spot.

Since all of the blisters were underwater and below the common water level, it is presumed that the blisters are a result of osmotic forces. Osmotic blistering is typically caused when coatings that are to be placed into immersion service are applied too thick, overcoated too soon, under colder weather conditions, and/or over contaminated surfaces. One form of osmotic blistering is solvent entrapment. Solvents are added to coatings to act as a vehicle during application. When coatings are applied too thick the coating solvents that were designed to be released during application are locked in-place when the catalyzed coating reaches a full chemical cure. Additionally, if coatings are applied under cold or cooler conditions, the solvents have a difficult time escaping from the film before it gets hard. Blisters that result from solvent entrapment tend to be localized to the coolest and lowest areas of a tank. Solvent vapors are typically heavier than air, and the lowest portion of a tank tends to become saturated with these gases without proper ventilation at the time of application. Coated over contamination creates a source for osmotic forces. This contamination attracts fluid that creates pressures that exceed the film's ability to bond, creating blisters.

The surfaces below the HWL waterline had areas of coating defects in the form of small, isolated rust spots, but it should be noted that the most advanced coating defects below the HWL were patched during this inspection using NSF certified underwater curing epoxy.

There are many areas that have been patched underwater and it is believed that these maintenance activities will extended the life of the lining by preventing widespread undercutting corrosion from developing below the highest water level (HWL). It should be noted that underwater patches were applied during this inspection using underwater curing NSF 61 certified underwater curing epoxy. This process will prevent any coating breaks from exponentially growing in the form of undercutting.

Isolated corrosion pits can develop within a coating system that may have only a few small breaks that were not corrected through periodic maintenance repairs. If the remaining, adjacent coating has excellent adhesion, it will inhibit undercutting corrosion. As a result, the corrosion forces will have a tendency to concentrate on the exposed bare metal, which results in pitting. Pitting can be critical in some instances. The maximum corrosion rate for steel in fresh water is typically no more than 30 mils per year (MPY). As a result, the pitting can develop into a perforation if not repaired. If a thru-hole develops within a tank bottom, the isolated issue can develop into a much larger corrosion problem. Corrosion requires oxygen to advance, and the underside of the tank bottoms are considered a dead-air space. As a result, the bottom of tank floors are typically not coated. A perforation or thru-hole with even a small trickle of water will reintroduce oxygen into the environment creating active corrosion that is difficult to identify until the steel floor plate requires replacement.

Thin film epoxy systems are typically designed for 25 to 30 years of service, and the interior lining, at an estimated 33+ years of age, appears to have reached the end of its serviceable lifespan. Therefore, it is recommended that the tank interior lining be removed and replaced within the next 1 to 2 years.

The tank ventilation was found to have screening installed without gaps or penetrations.

Recommendations

The following activities are recommended for remedial work:

Exterior:

Within the next two to three years, spot repair and overcoat the exterior coating. This work should include the following:

1) This work should include cleaning all active rust sites in accordance with SSPC's Surface Preparation Standard No. 15, "Commercial Power Tool Cleaning" followed by 4-6 mils of an industrial epoxy primer and 3-5 mils of a polyurethane finish coat.

2) Test the paint system for heavy metals to determine if any special actions are required to protect workers and the environment during paint disturbance.

Interior:

Within the next 1 to 2 years, remove and replace the interior lining. This work should include the following:

3) Remove and replace the lining system at all interior surfaces. This work should include cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 10 "Near-White Metal Blast Cleaning" (SSPC-SP10) followed by three 4 to 6 mil coats of an NSF Certified epoxy lining.

4) Caulk all crevices in the tank such as roof lap seams.

5) Anticipate the need for minor structural repairs (welding, grinding, etc.)

6) Consider retrofitting the tank piping to include flexible couplings.

P.O. Box 801357, Santa Clarita, CA 91380
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Fax: 661.755.7628
www.CSIServices.biz

Page	1	of	1
Date	08/29/24		Thursday
CSI Job No.	240221		
Completed By	Metcalf		

Field Water Tank Dive Inspection Report

Tank Name:	Danburg	**Dive Supervisor:**	Steven Metcalf
Tank Owner/Client:	Kirkwood Medows PUD	**Dive Leader:**	Anthony Jackson
Client Contact:	Ashley Smith	**Dive Tender**	Steven Metclaf Jr.

Scope Maintenance Inspection

Site Information

Item	Description
Cross Street	Danburg Dr
Tank Location	Kirkwood Mountain Resort, Pioneer CA
GPS Coordinates	38.69315 -120.08071
Nearest Structures	None
Surrounding Site	Dirt

Item		Notes
Perimeter Fencing	No	None
Site secured on arrival	Yes	Tank Secured
Overhead Power Lines	No	None
Antenna on Tank	No	None
Roof Accessible	Yes	No Comments

Interior Structural Characteristics

Item	Data	
Roof Structure	Rafters and Center Column	
Column Design	Pipe	
Upper Center Column	Cone	
Column Base Design	Cone	
Connections	Welded	
Overflow Design	Through Floor	
Inlet Interior Design	Flor Stub	
Lining Type/Original	Epoxy	Yes

Item	Data			
Outlet Design	Floor Stub			
No. Interior Ladder	No	N/A		
CP System/Type	No	None		
Water Depth	19			
Water Agitator	No	None		
Barrier Walls	No			
No. of Columns	One Column			
Caulking	Roof	No	Columns	No

Exterior Structural Characteristics

Item	Data	
Capacity (gallons)	250,000	
Diameter (feet)	47	
Height (feet)	20	
Erection Year	1991	
Contract No.	3219	
Tank Type	Welded Steel	
Tank Profile	on grade	
Tank Geometry	Cylinder	
Number of Courses	Two	
Height of Each Course	10 Ft	
Roof Design	Pitched Roff with Drip Ring	
No. Shell Manways	Two Shell Manways	
Type of Manways	Round	
Manway Cover Design	Bolted Circle	
Diameter of Manways	20 in	
No. Roof Hatches/Location	One	Near Edge
Hatch Design	Round	
Size of Roof Hatch	24 in	
No. Roof Vents/Location	Two	Near Edge
Roof Vent Design	Bent Pipe	
Construction Co.	San Louis Tank	

Item	Data	
Center Roof Vent Size	4 in	
Roof Vent Sealed	Yes	Satisfactory
Roof Rail System	Yes	Corral
Roof Rail Satisfactory	Yes	No Comments
Rail Location	Top Of Ladder	
No. & Type Roof Access	One	Ladder
Exterior Vandal Deterrent	Yes	
Ext Ladder Satisfactory	One	Yes
Ext Ladder Fall Prevent	Yes	
Roof Tie-Off Present	Yes	
Tank Piping	Floor Inlet and Outlet	
Inlet Diameter	8 in	
Outlet Diameter	8 in	
Flexible Pipe Coupling	N/A	
Overflow Pipe Diameter	8 in	
Overflow Exterior Design	Through Floor	
Drain Location	Floor	
Tank Foundation	Gravel Ring Wall	
Water Level Indicator	Yes	
Tank Type	Potable	
Lining Type/Original	Polyurethane	Yes

Miscellaneous Notes

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -001

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -002

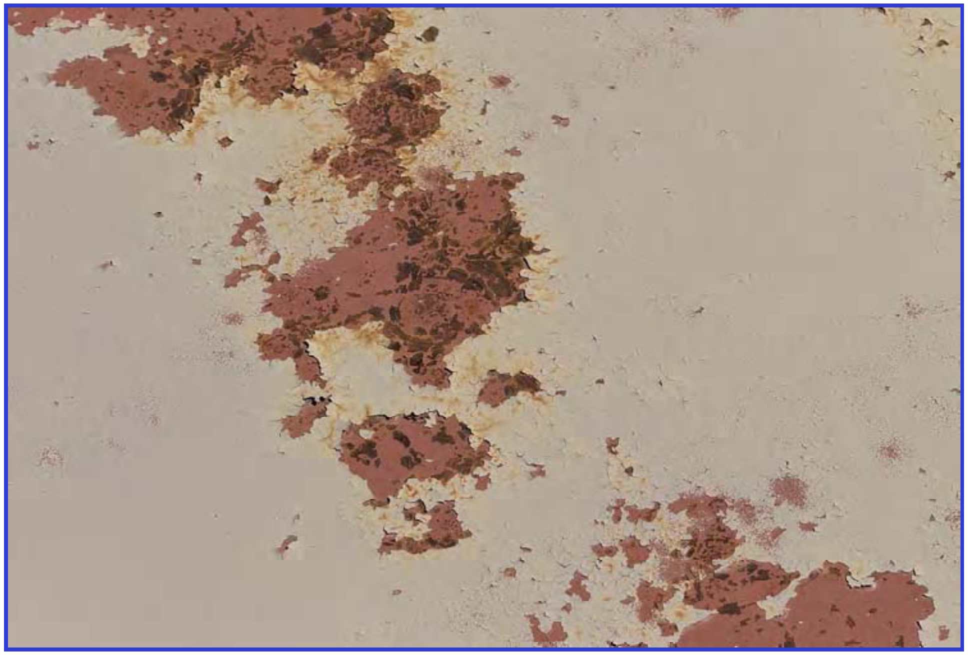
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -003

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -004

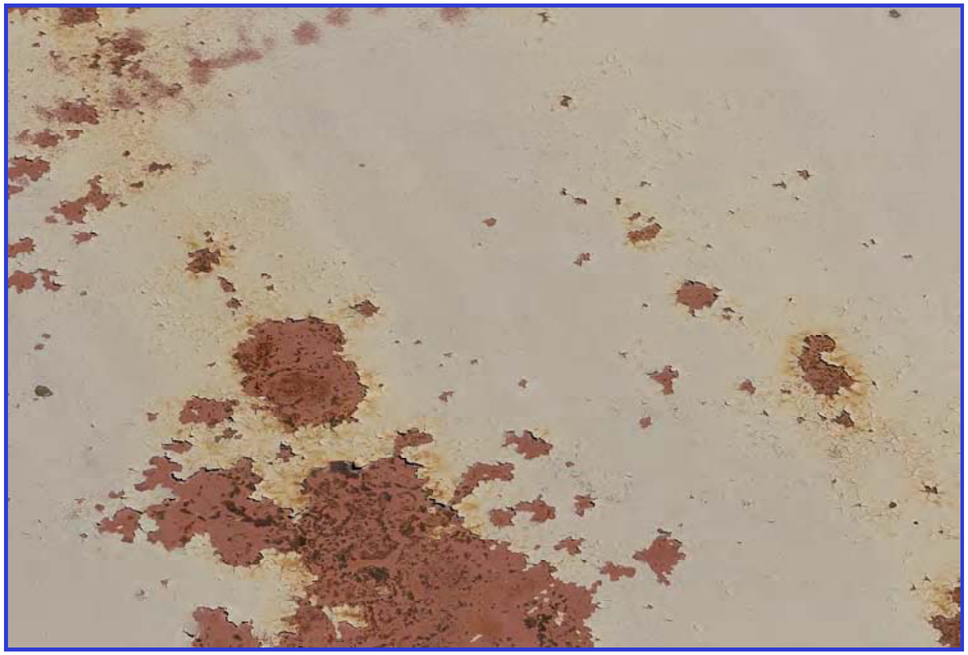
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -005

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -006

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -007



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -008



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -009

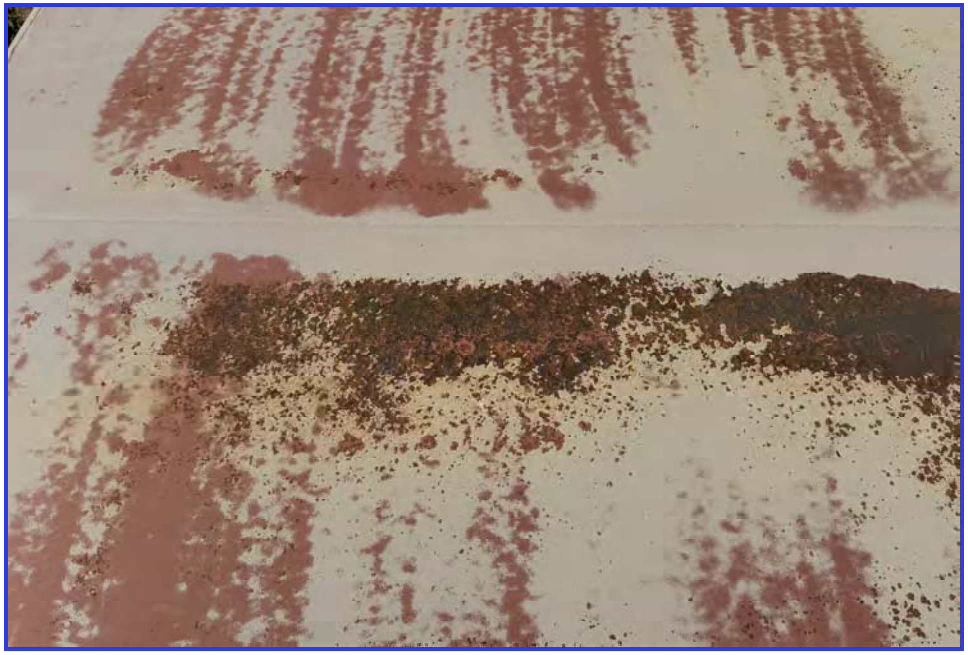
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -010

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -011

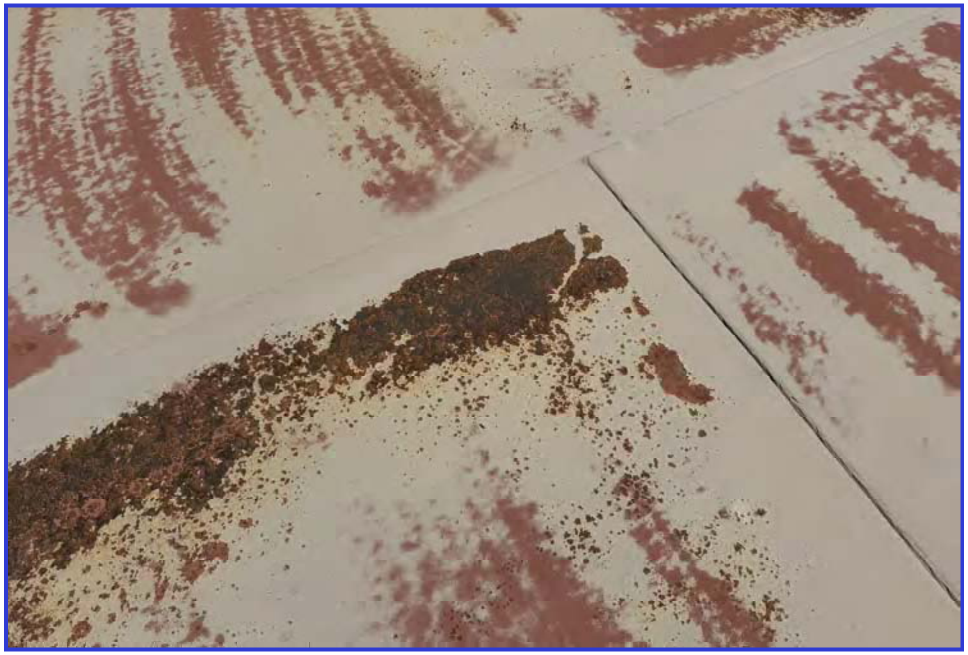
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -012

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -013

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -014



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -015



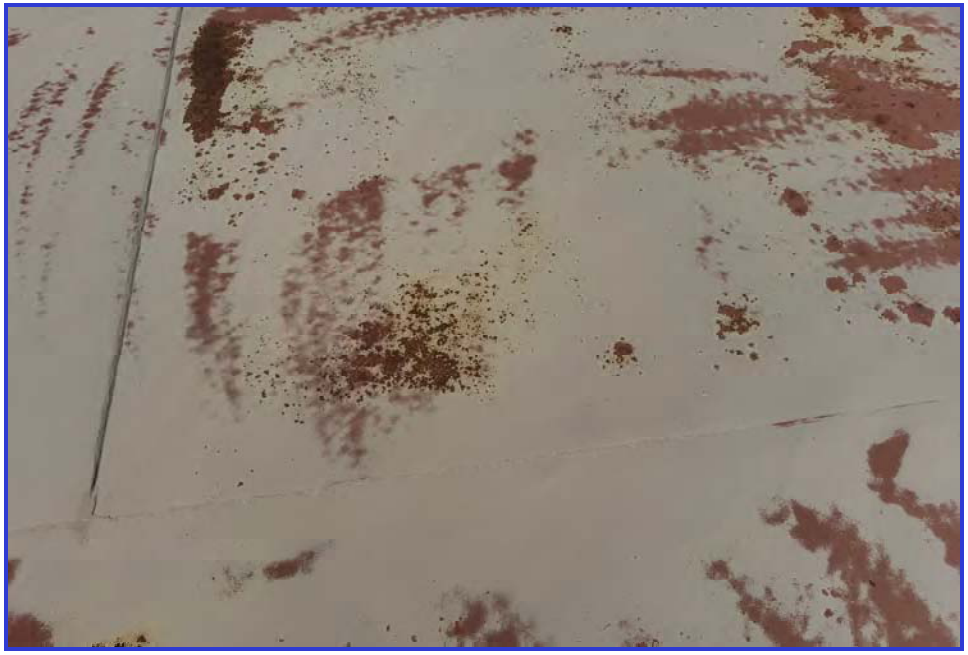
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -016

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -017

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -018

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -019

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -020



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -021

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -022

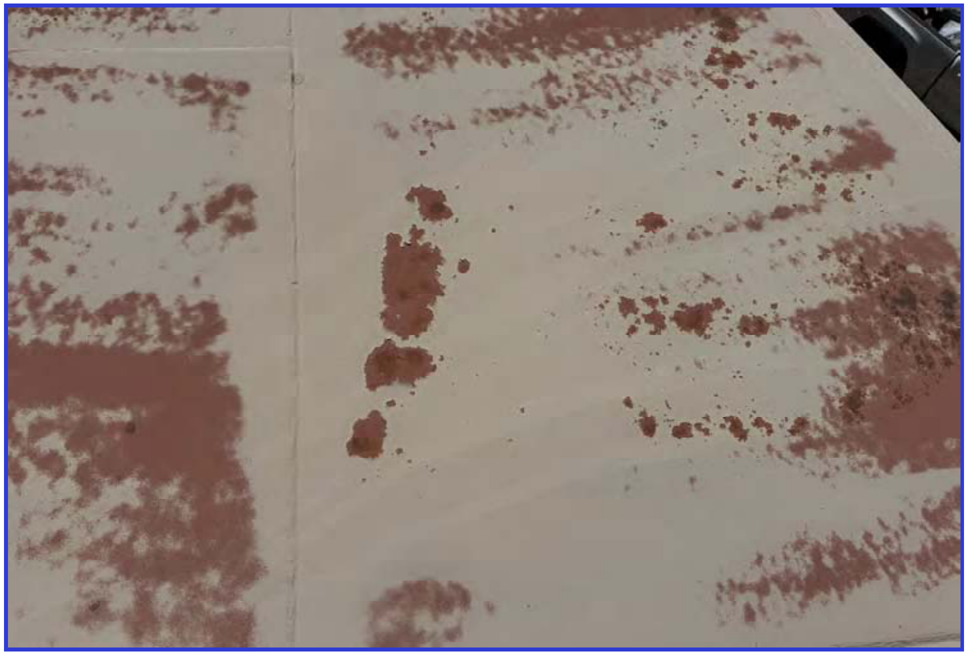
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -023

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -024

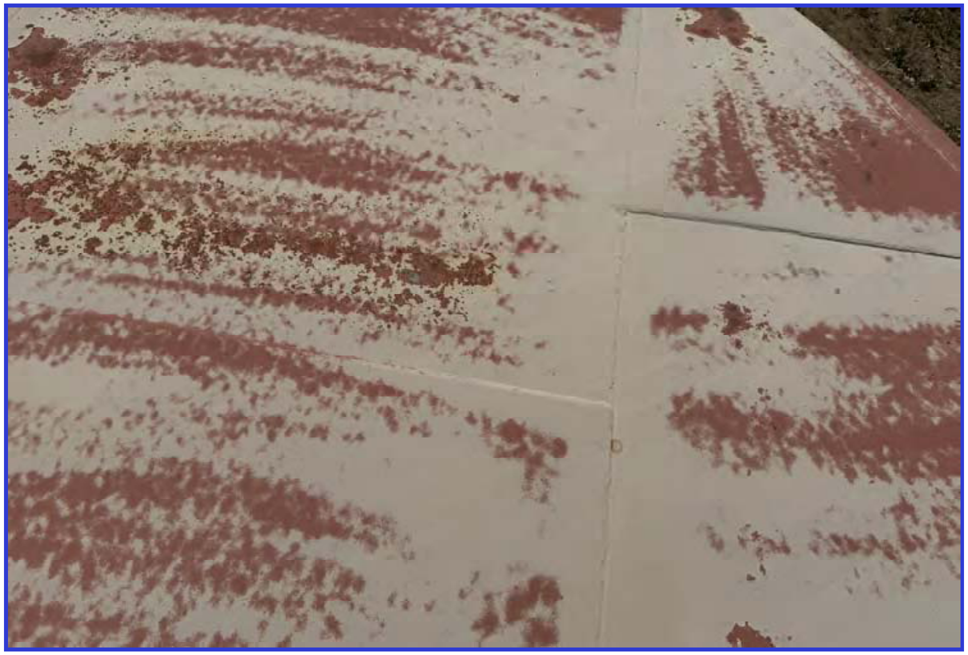
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -025

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -026

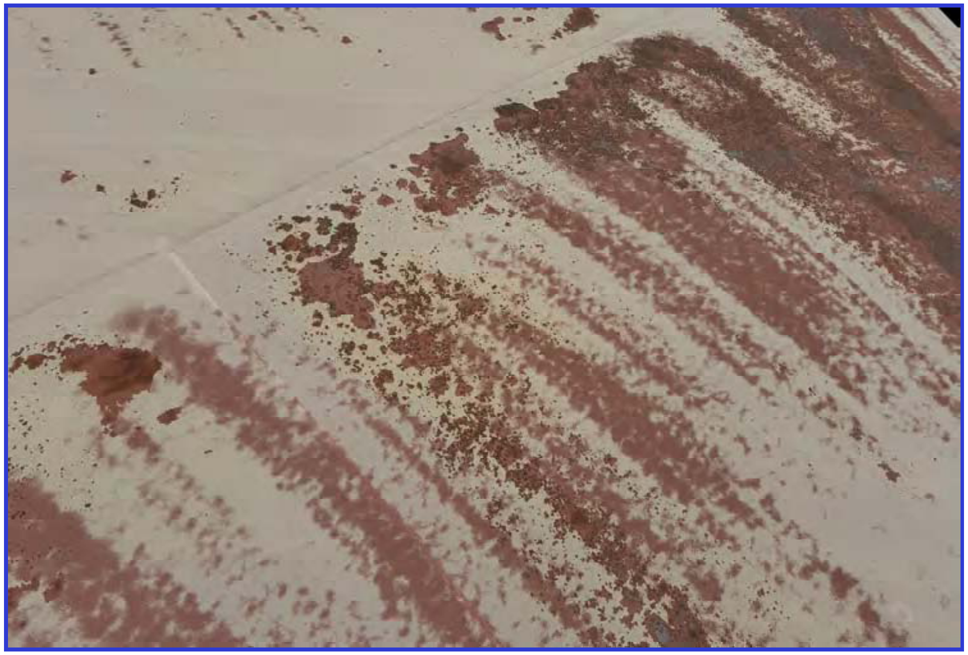
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -027



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -028



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -029



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -030

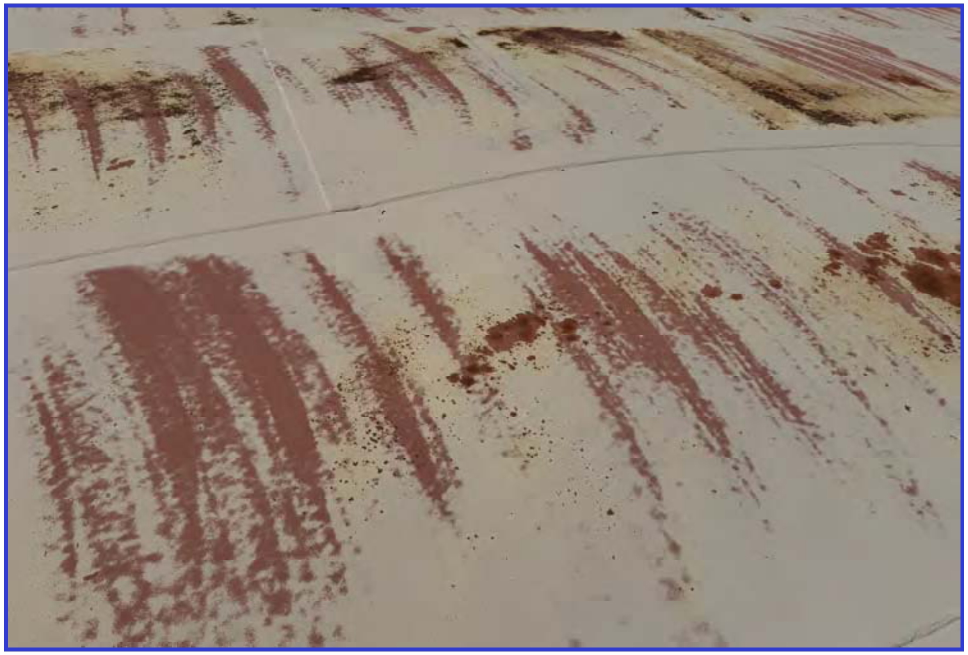
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -031

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -032

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -033

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -034

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -035



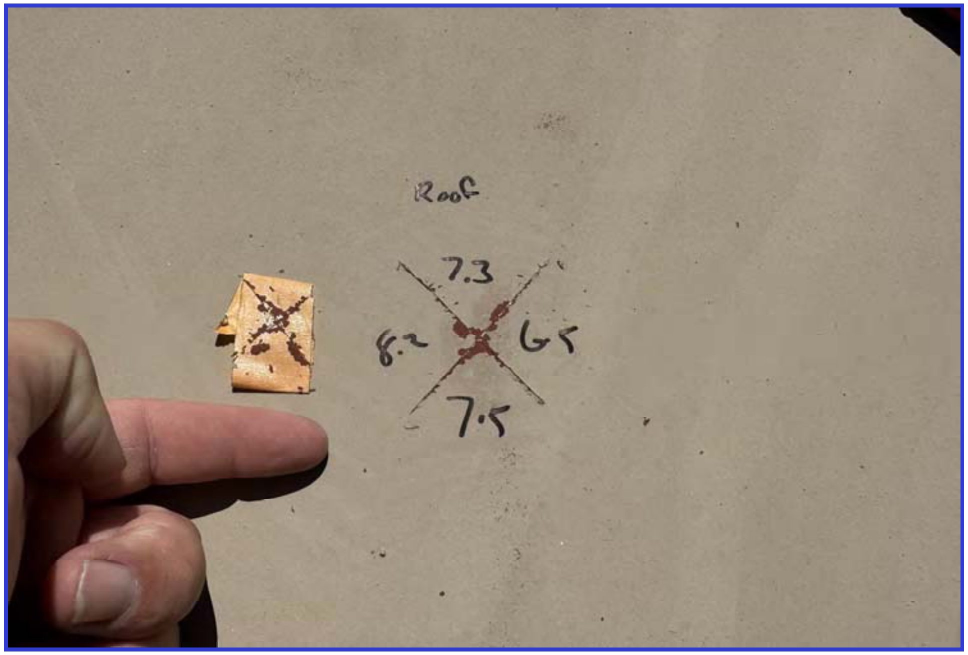
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -036

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -037

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -038

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -039

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -040



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -041

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -042

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -043

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -044

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -045

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -046

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -047

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -048

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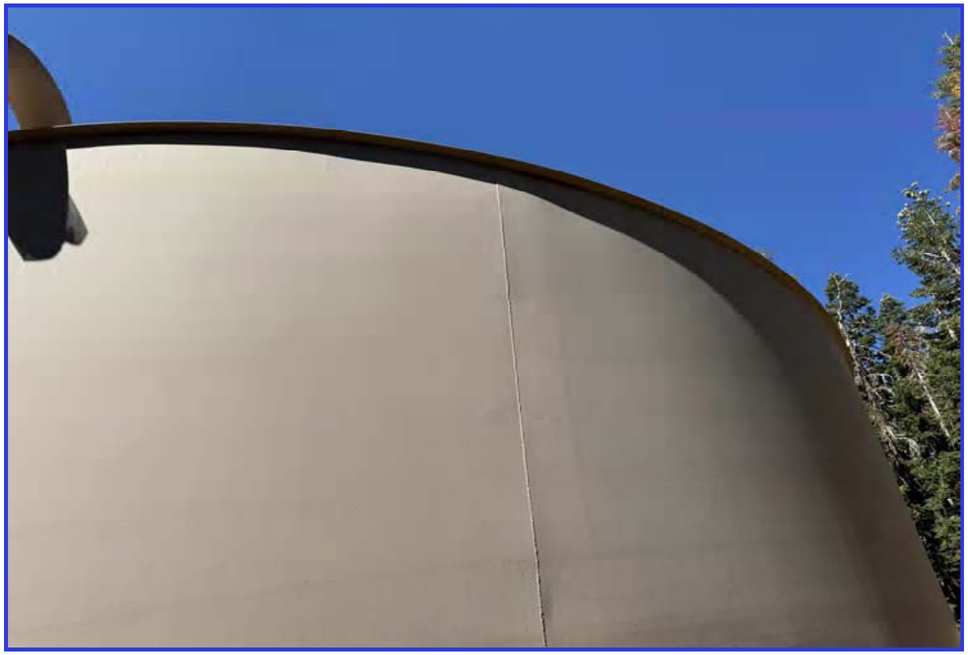
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -050



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -051

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -052

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -053

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -054

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -055

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -056

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -057

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -058

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -059

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -060

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -061

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -062

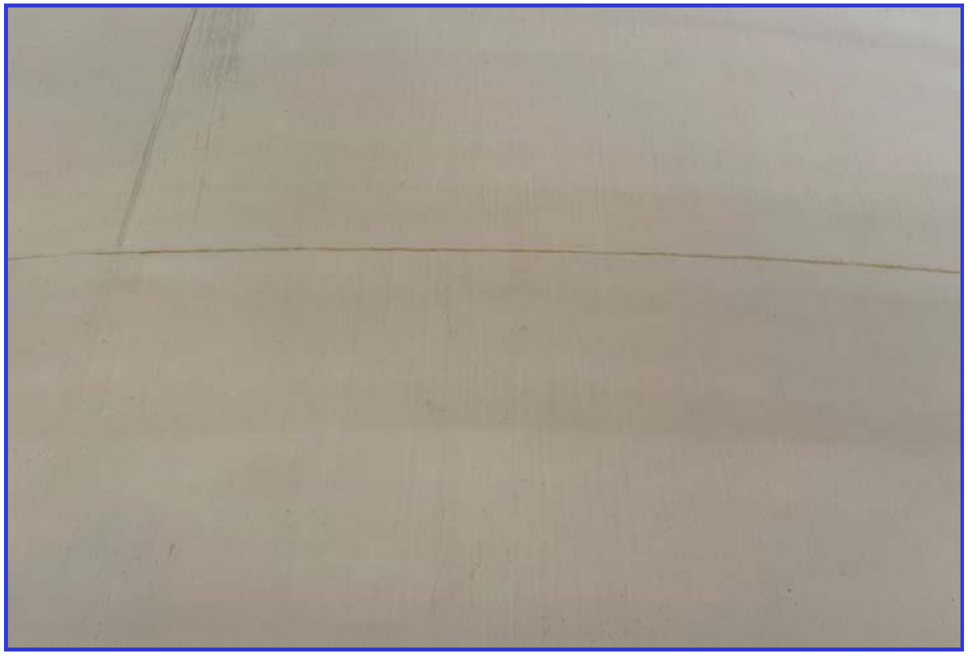
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -063

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -064

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -065

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -066

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -067



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -068

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -069

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -070

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -071

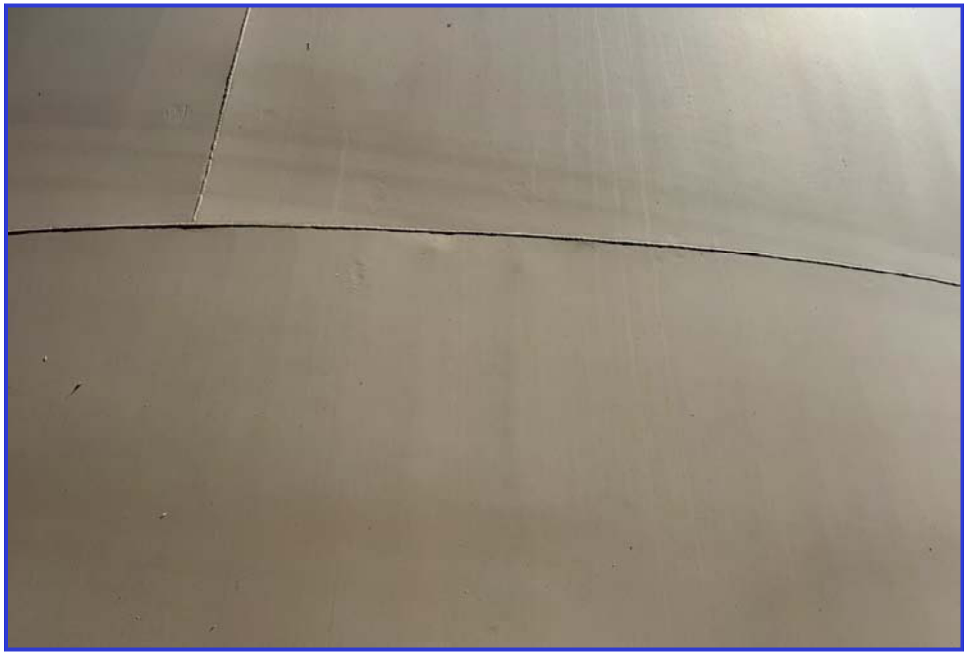
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -072

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -073

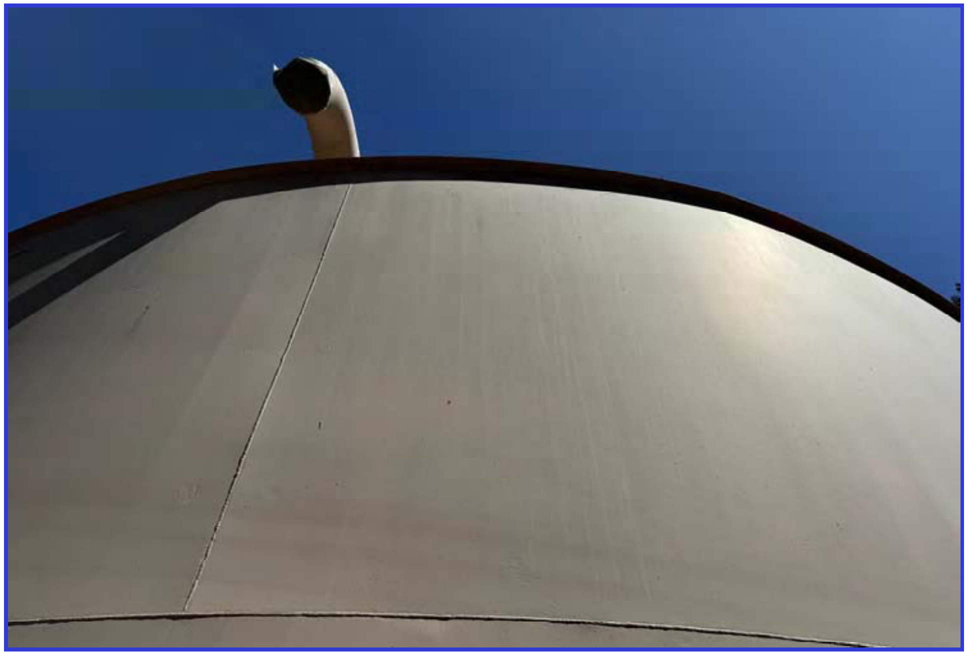
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -074

EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -075

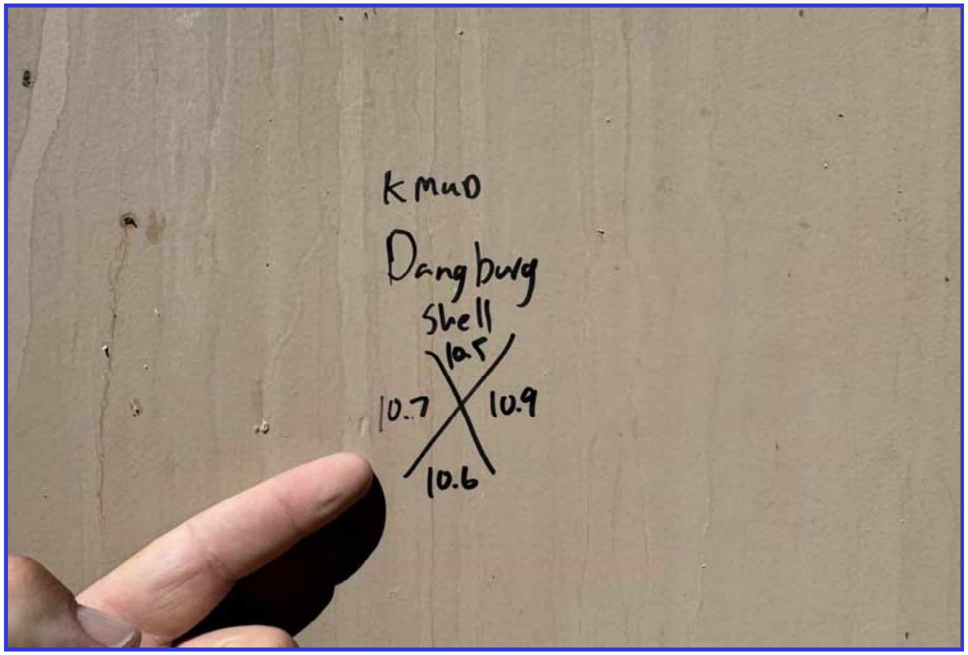
EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -076



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -077



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -078



EXTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -079

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -001

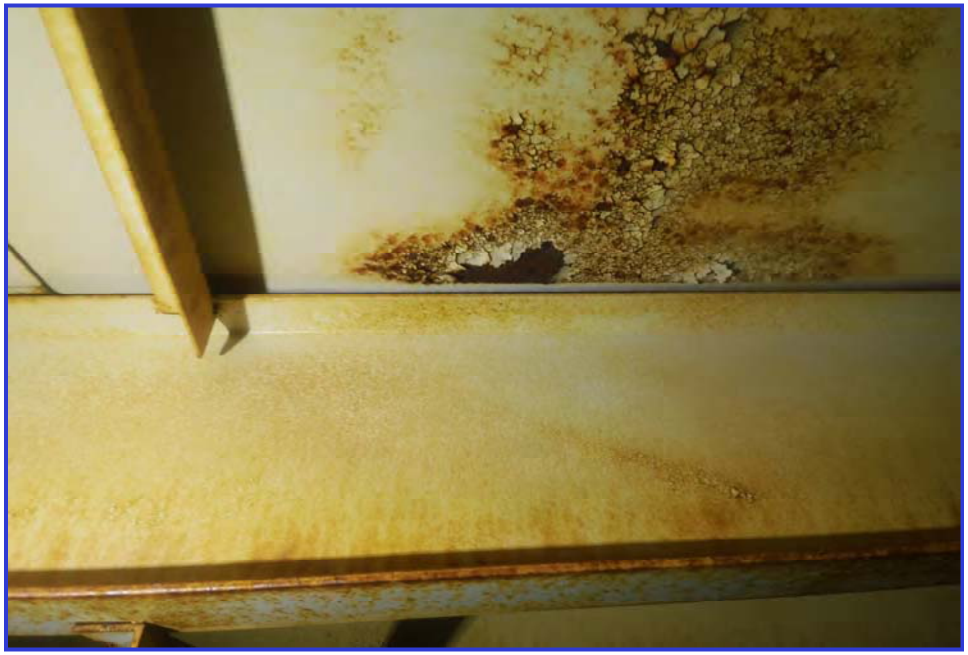
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -002

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -003

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -004

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -005

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -006



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -007

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -008

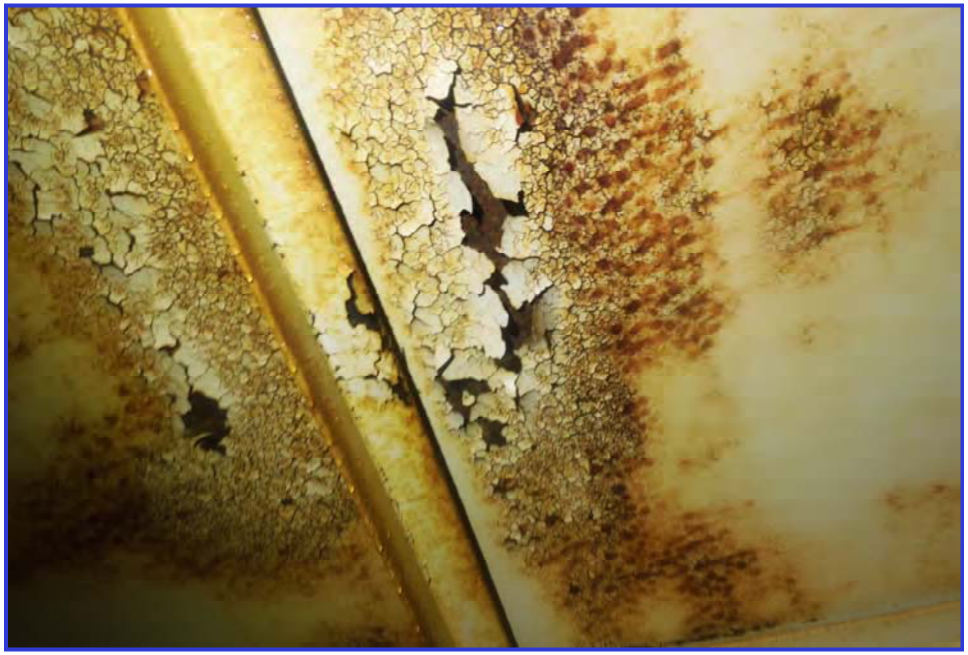
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -009

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -010

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -011

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -012

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -013



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -014

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -015

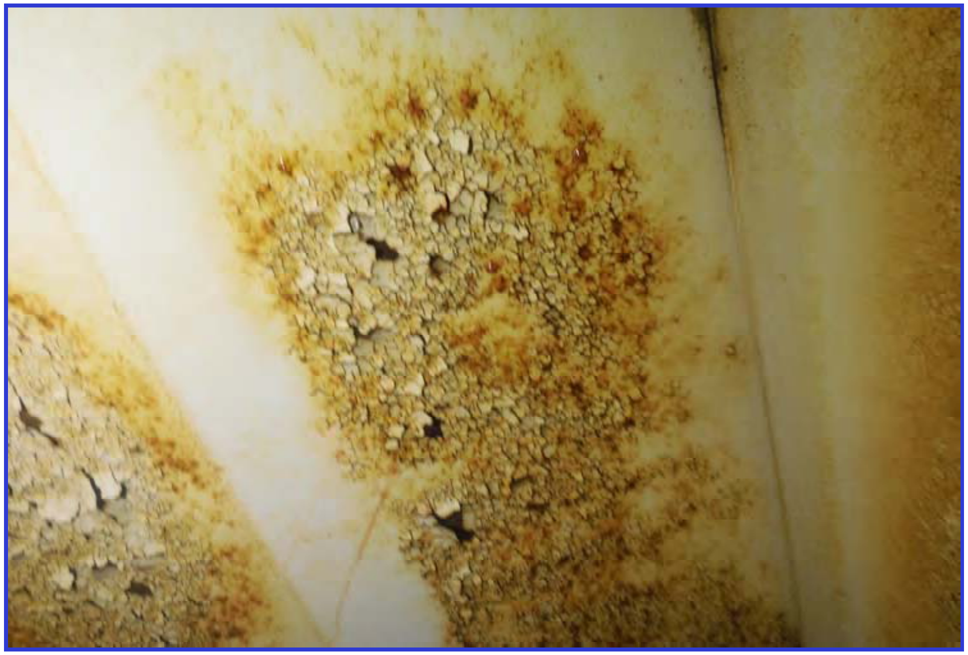

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -016


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -017


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -018


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -019


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -020


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -021

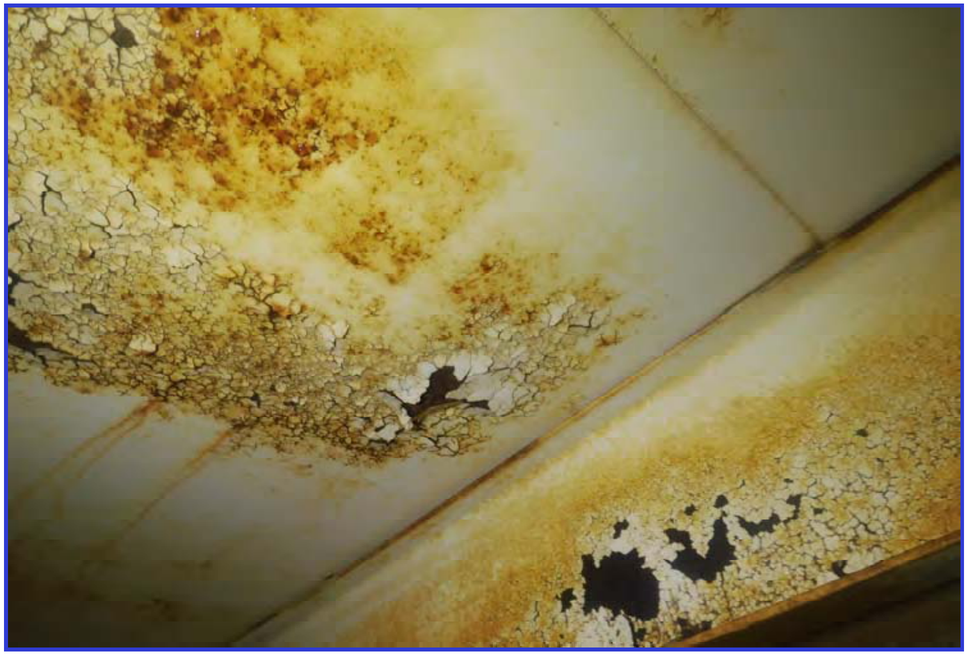

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -022


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -023

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -024

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -025

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -026



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -027


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -028


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -029


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -030


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -031

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -032

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -033

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -034

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -035

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -036

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -037

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -038

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -039

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -040

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -041

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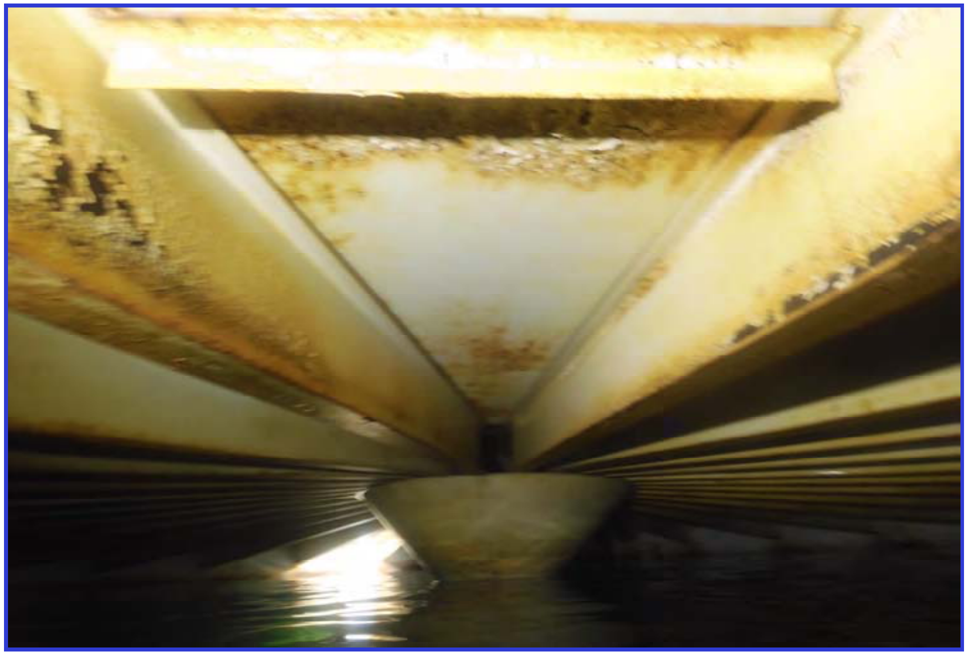

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -044

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -045

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -046

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -047

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -048

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -049

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -050

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -051

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -052

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -053

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -054

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -055

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -056

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -057

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -058

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -059

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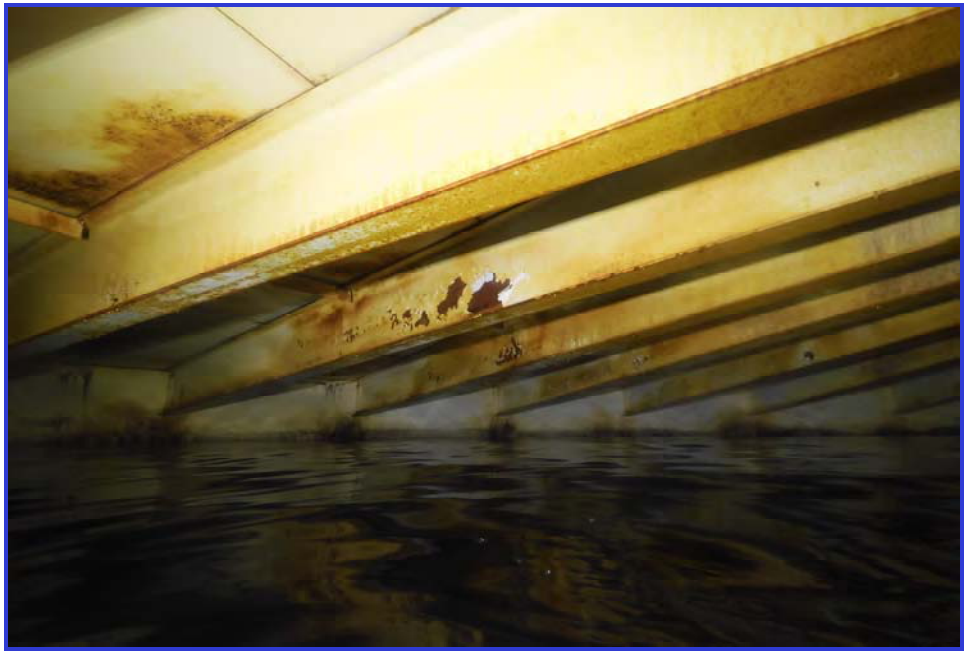
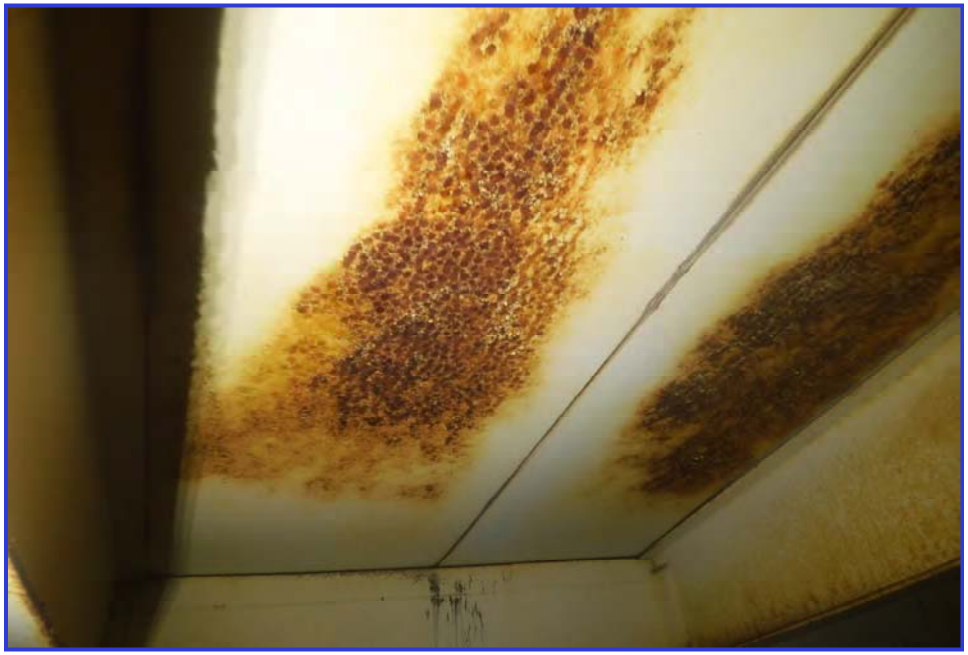
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -061



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -062

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -063

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -064



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -065

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -066

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -067

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -068

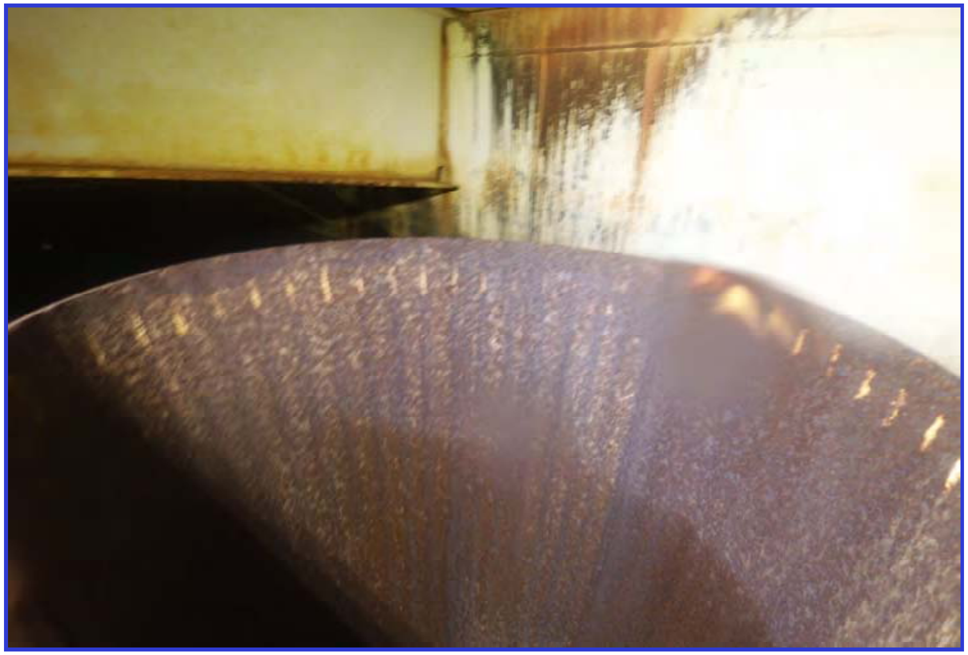
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -069

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -070

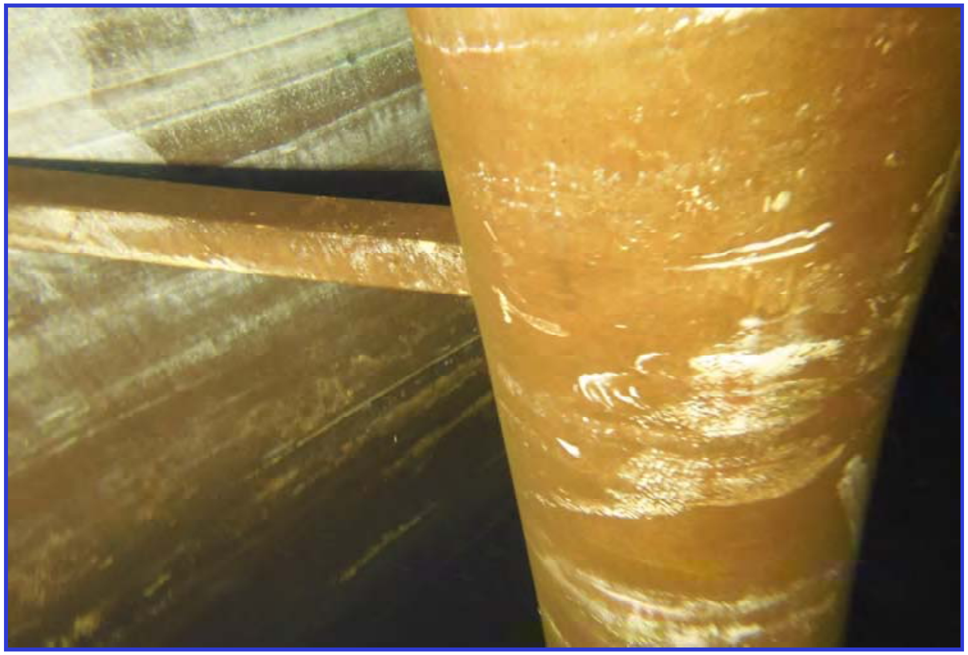
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -071

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -072

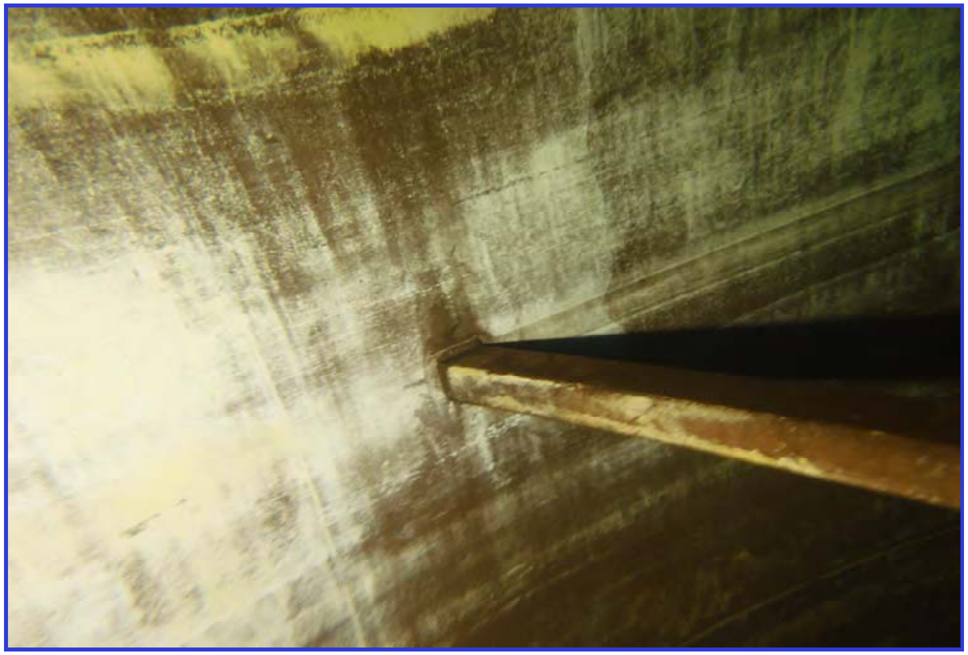
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -073



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -074

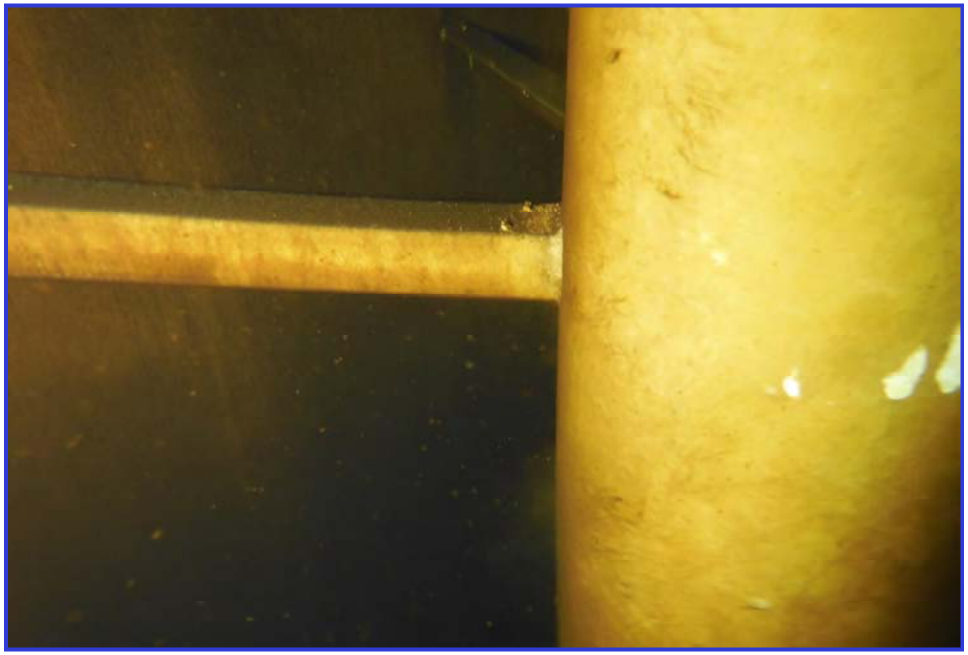


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -075



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -076

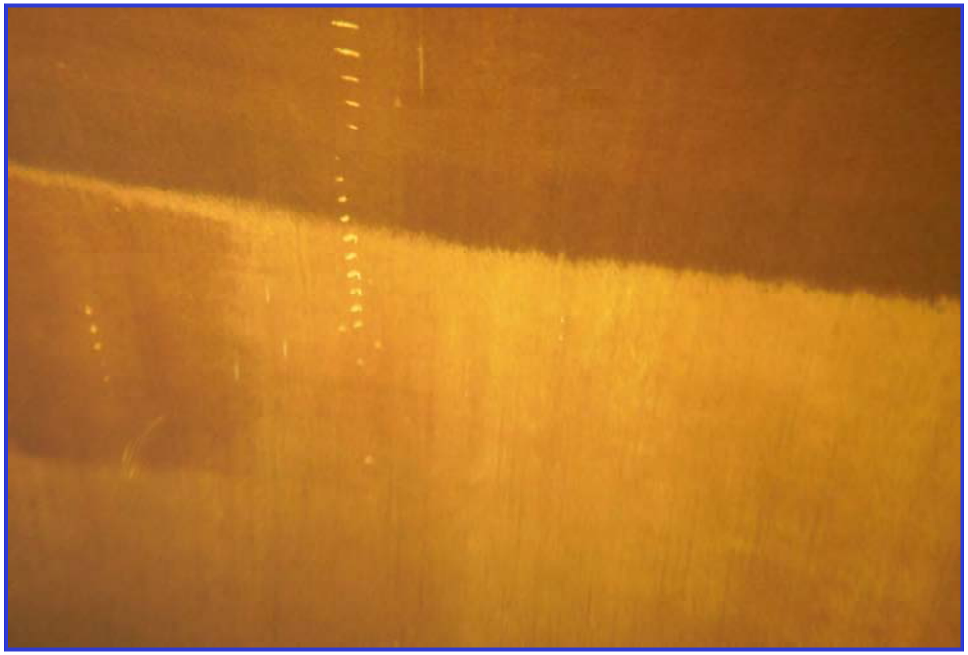
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -077



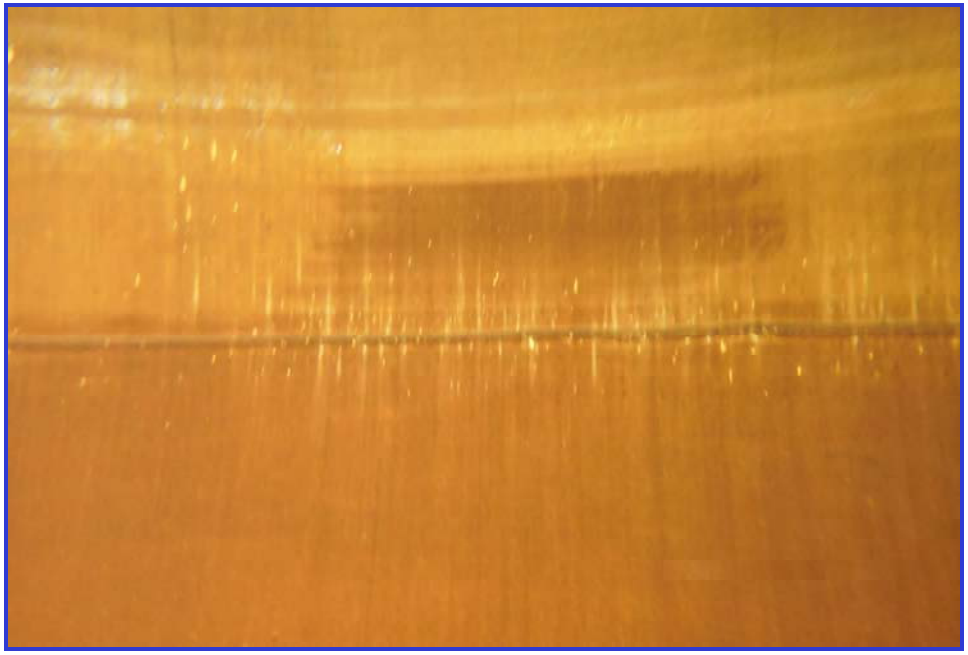
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -078

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -079

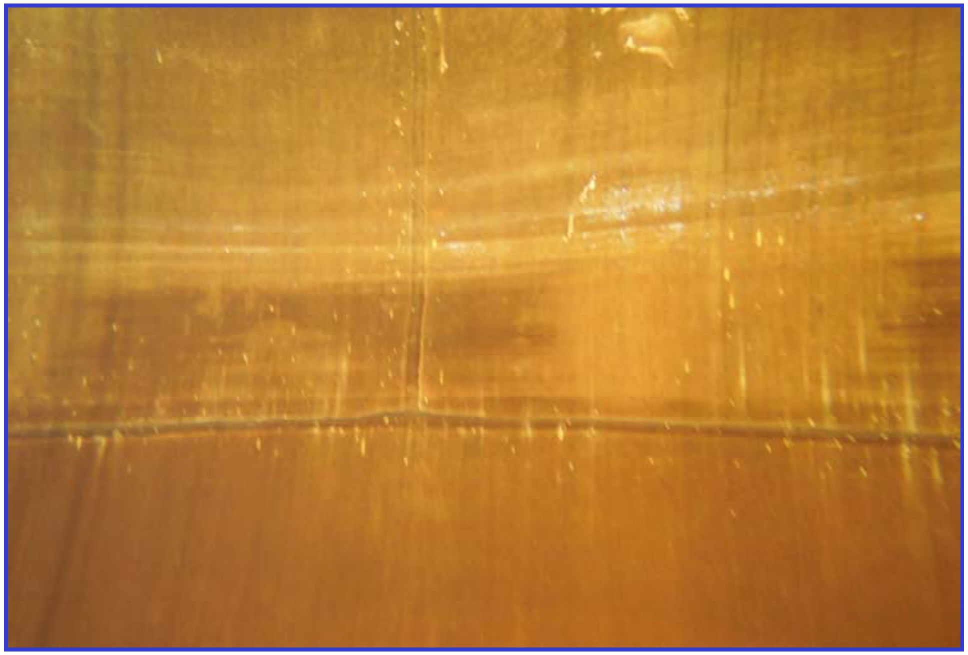
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -080



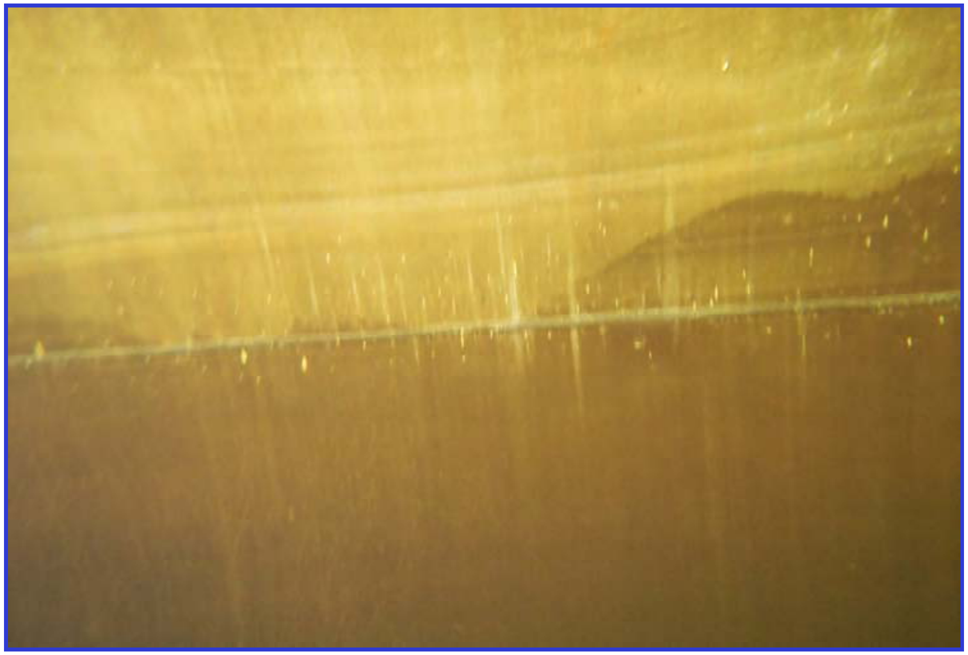
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -081

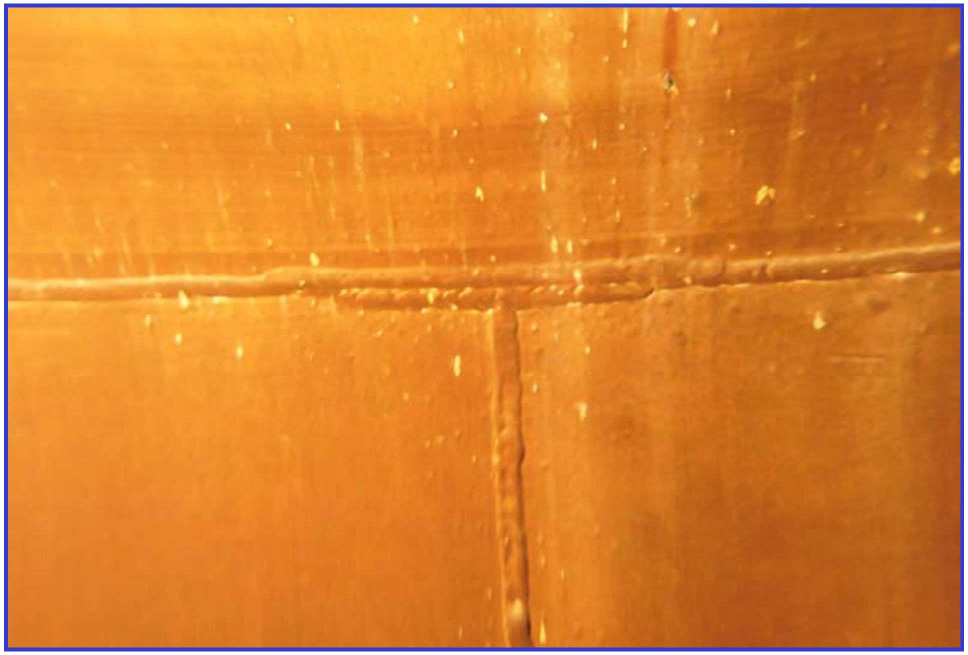


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -082



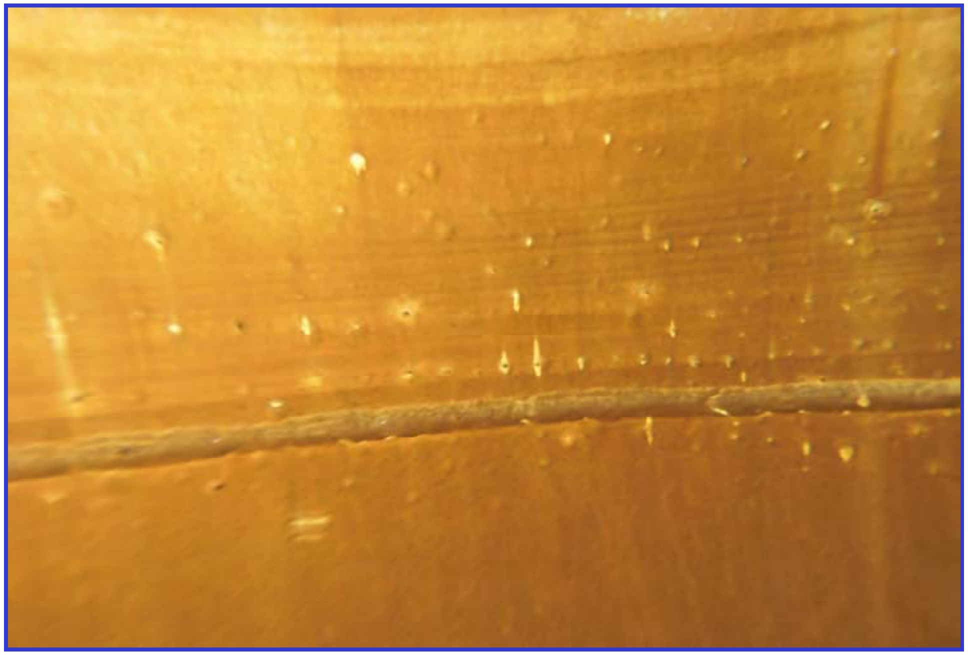
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -083


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -084

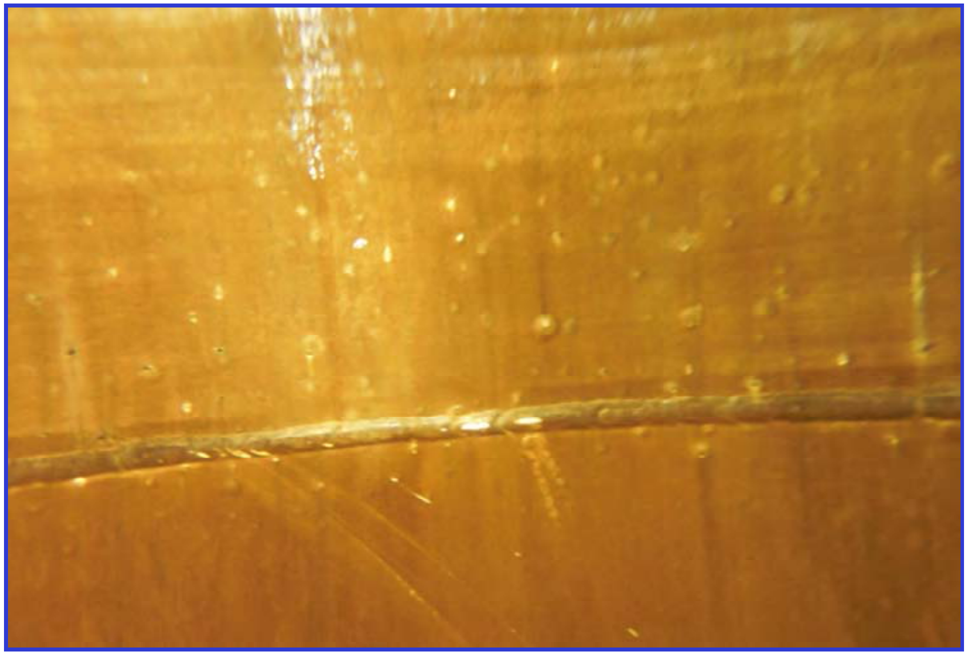

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -085


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -086

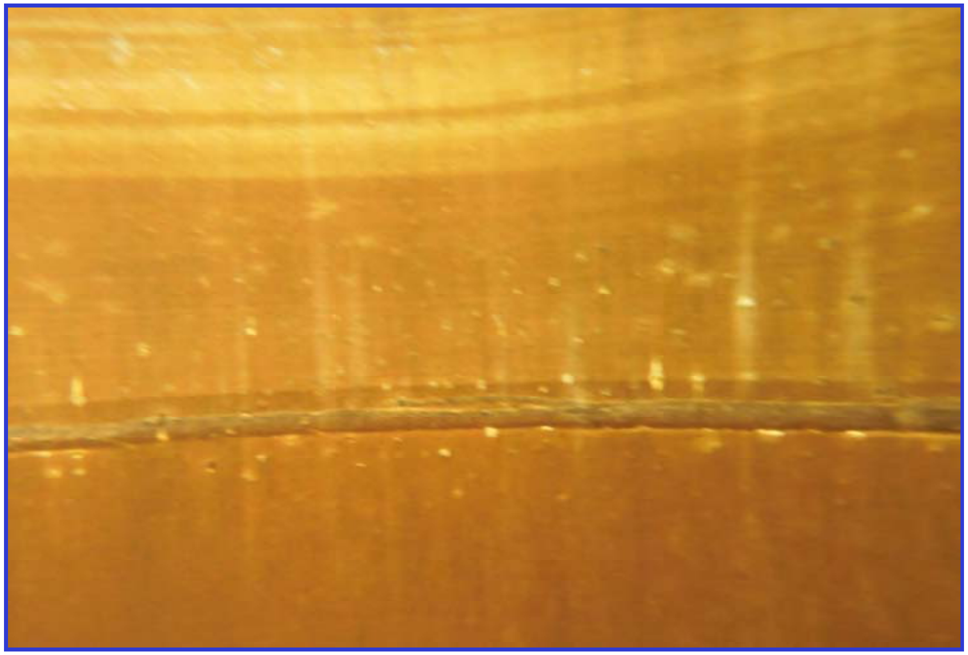

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -087



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -088

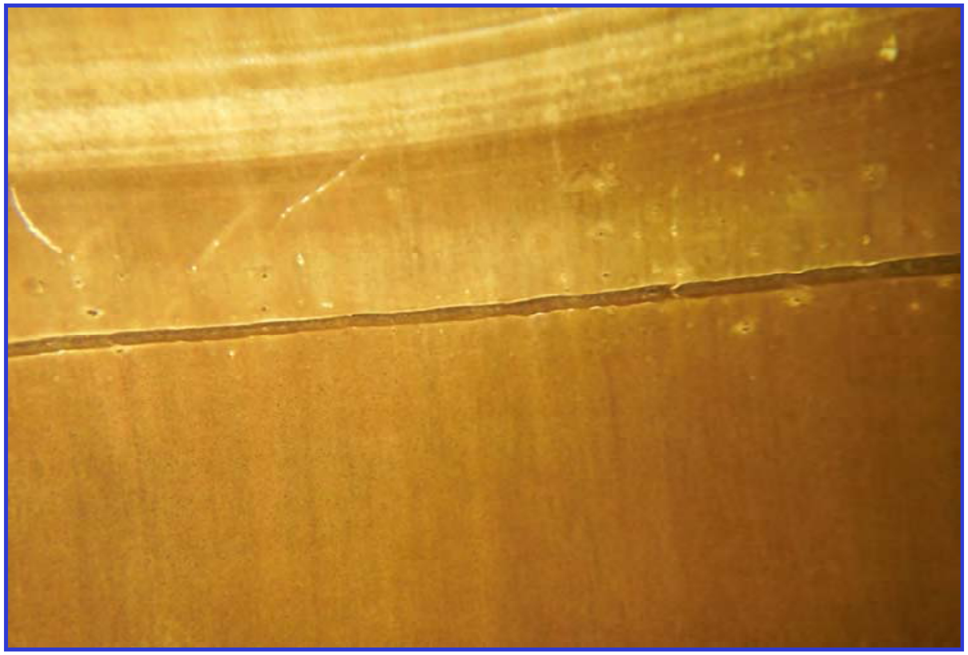


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -089



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -090

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -091



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -092

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -093

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -094

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -095

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -096

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -097

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -098

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -099

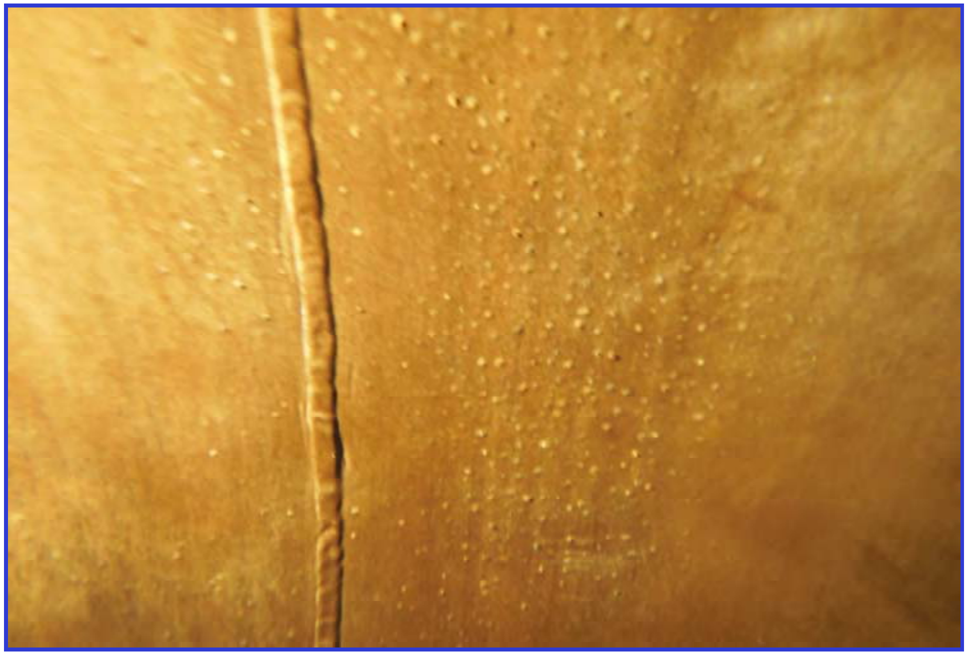
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -100

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -101

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -102

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -103

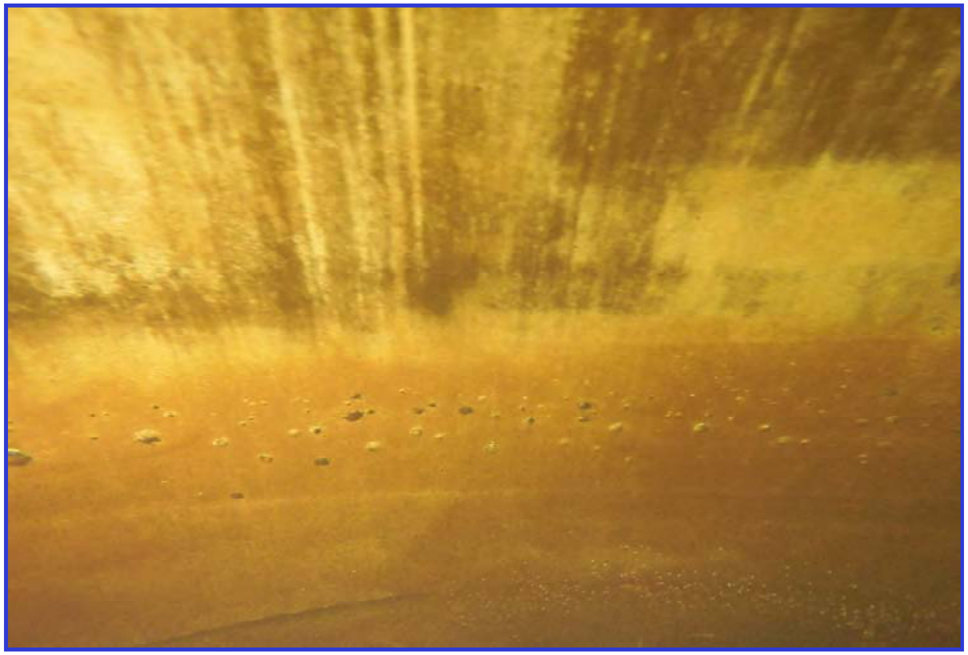
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -104



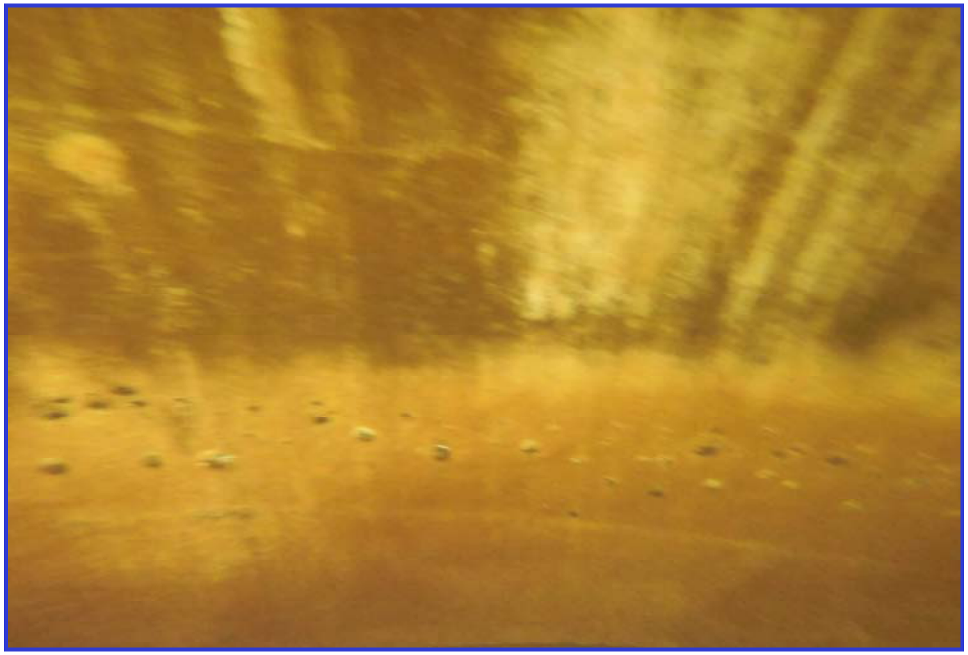
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -105

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -106

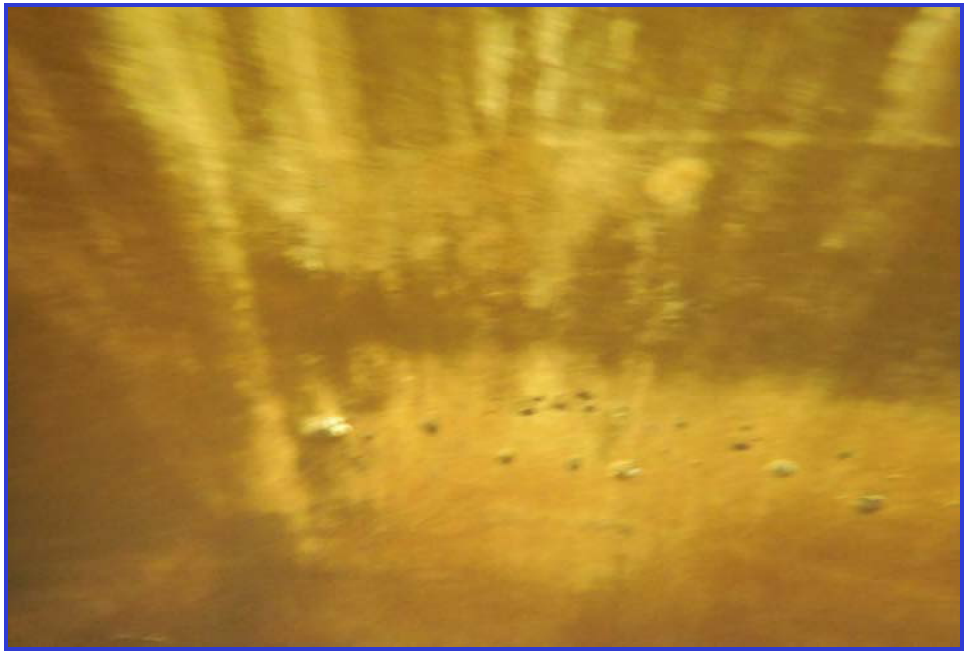
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -107



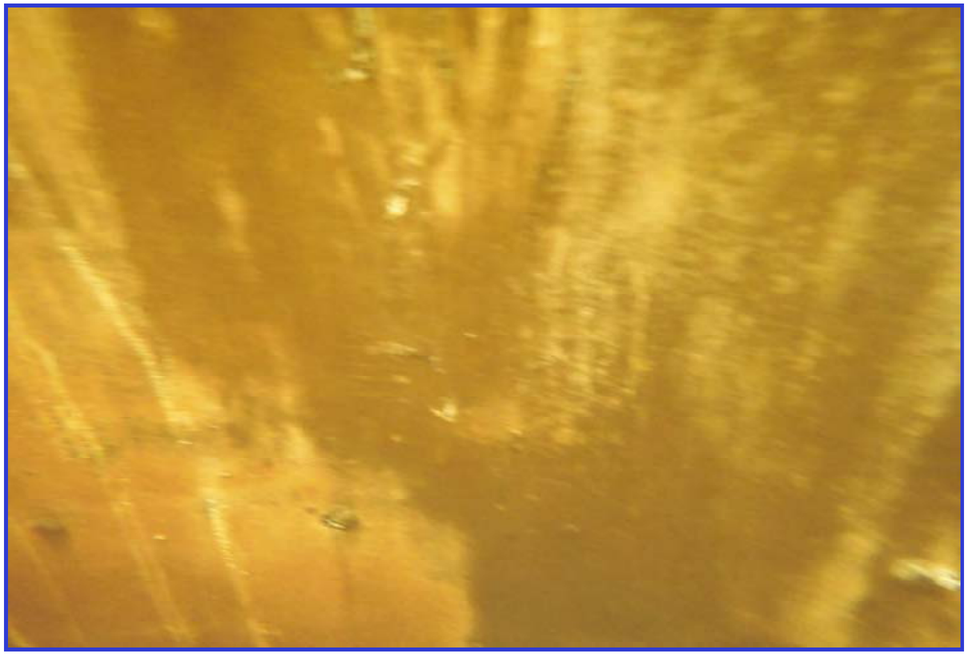
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -108



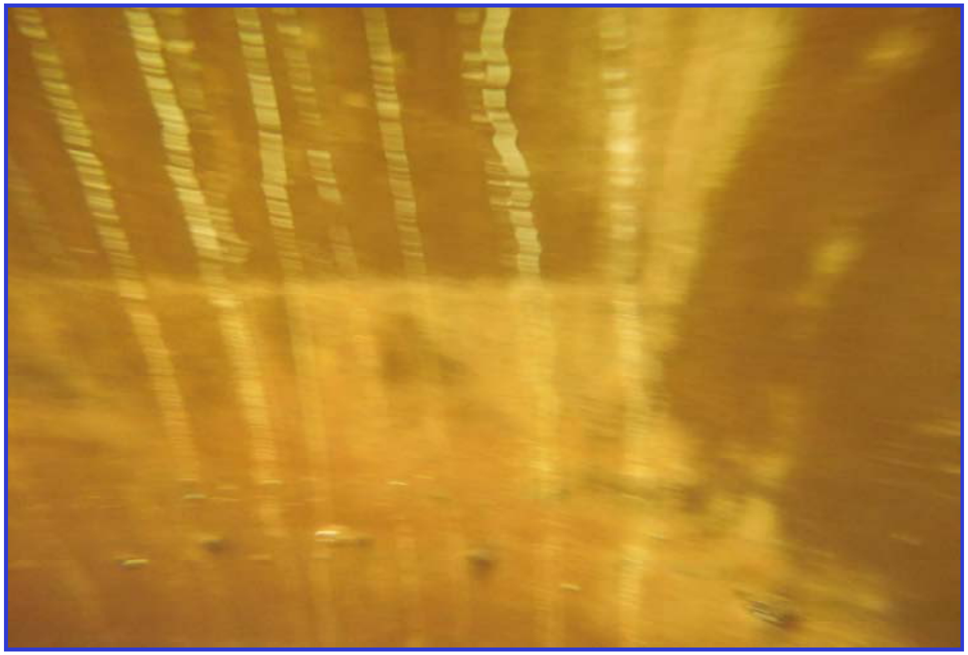
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -109



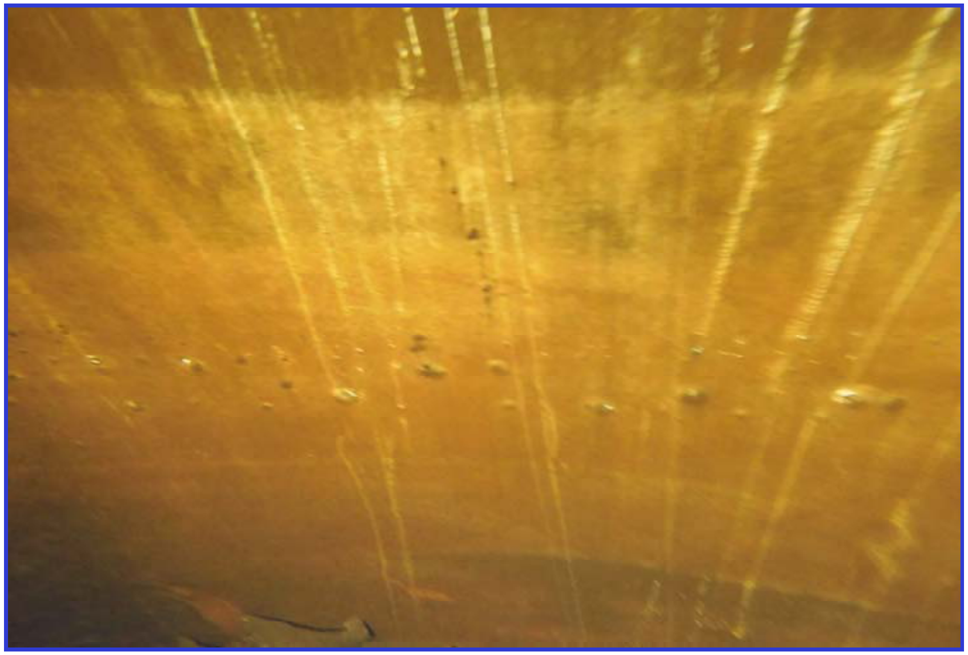
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -110



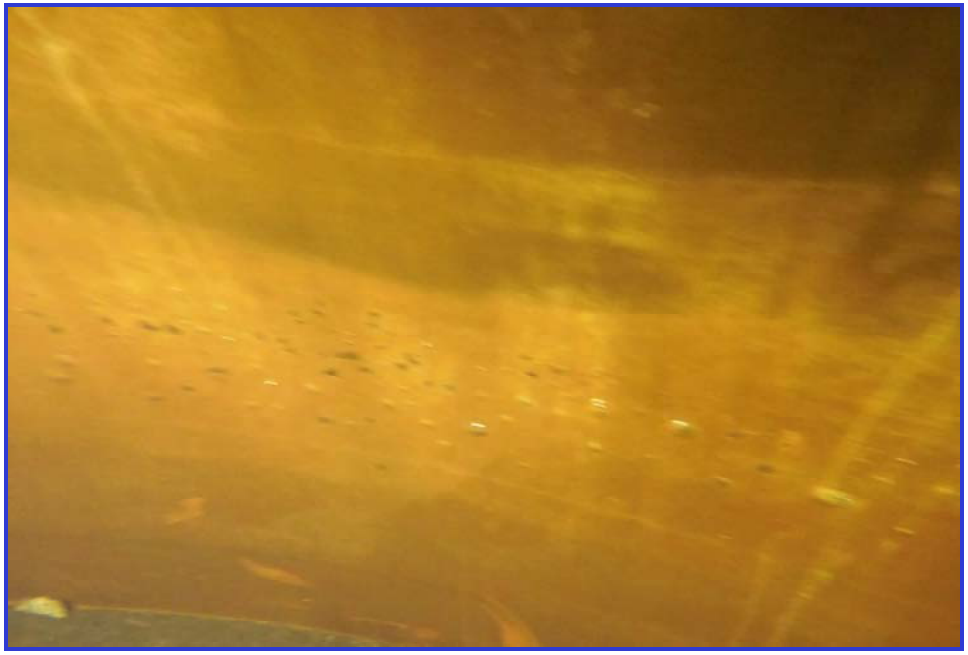
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -111



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -112



INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -113



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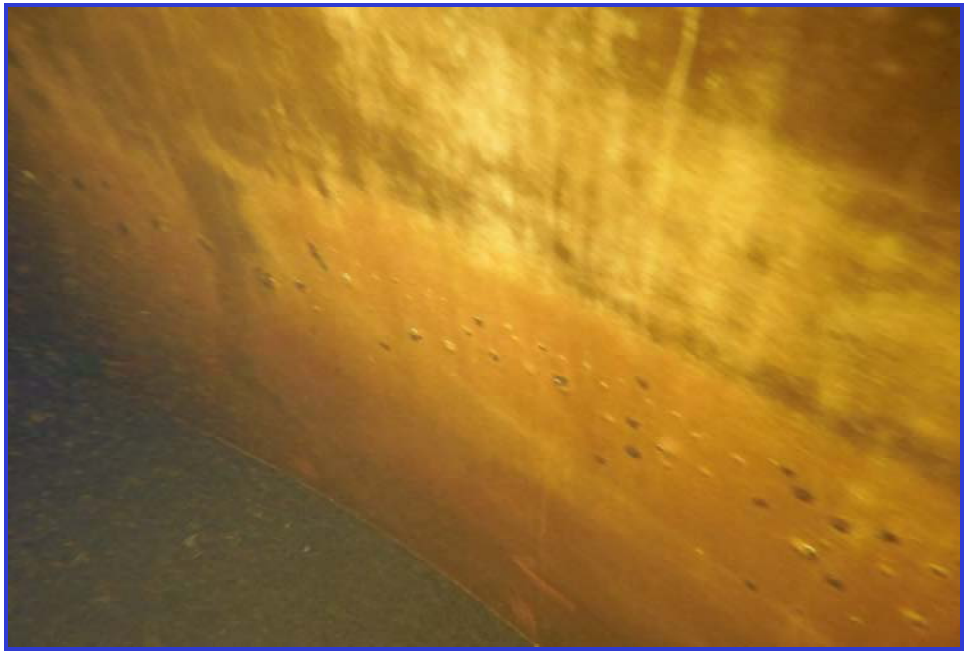
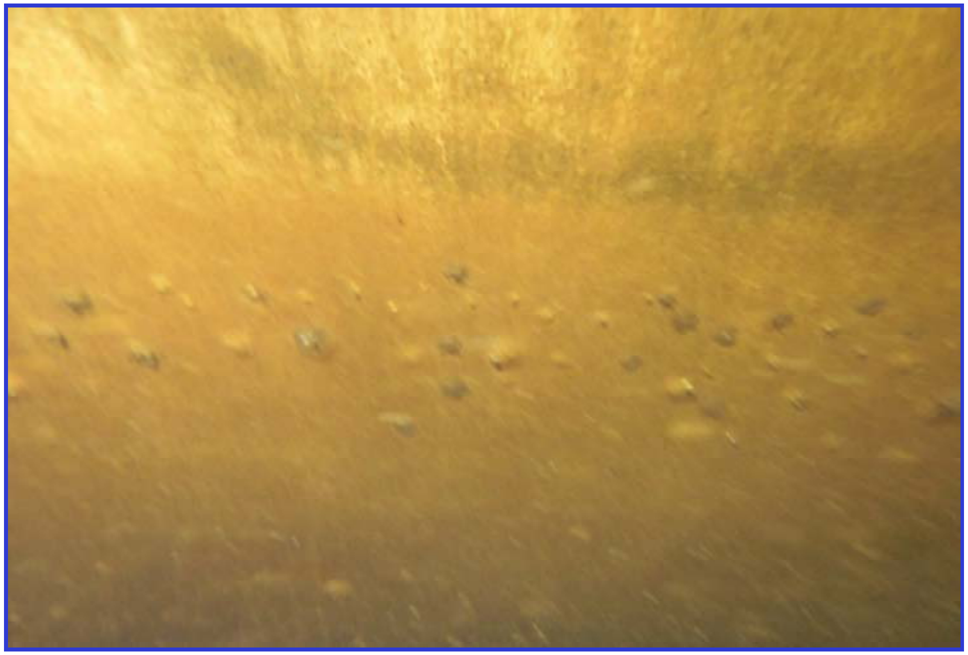


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -115



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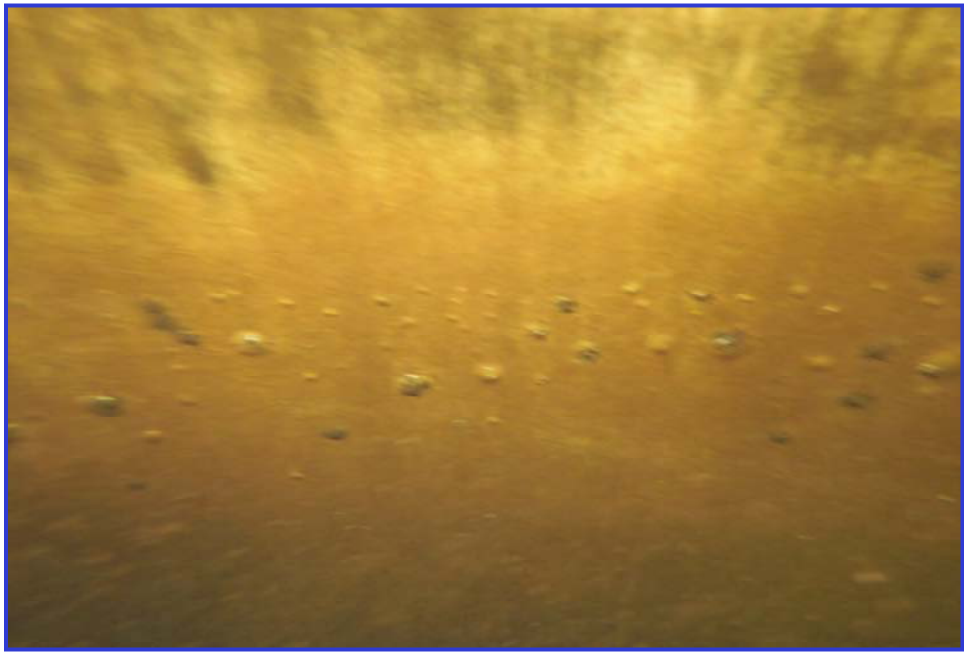

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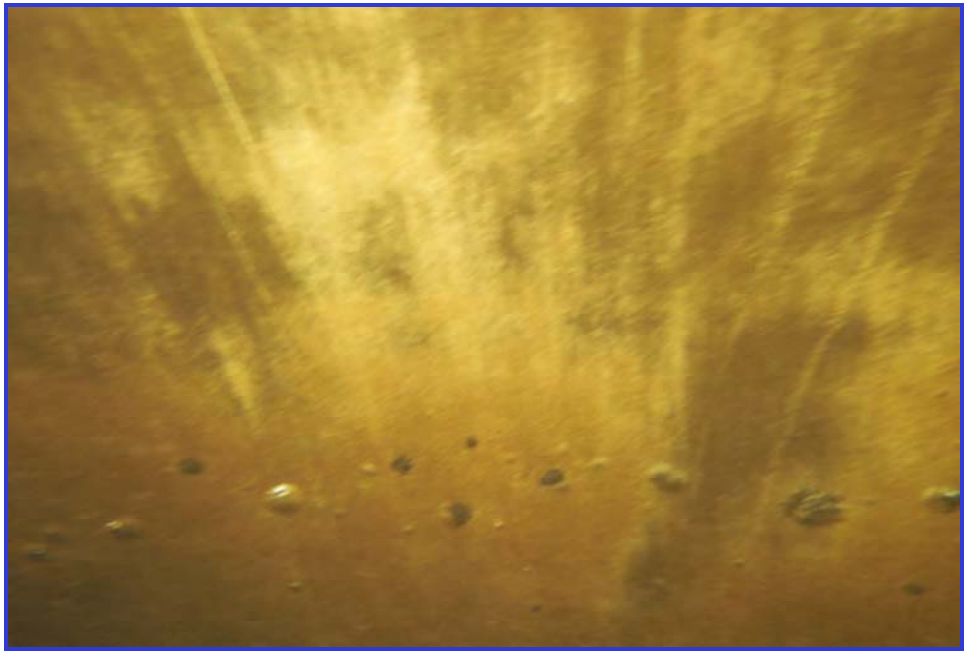

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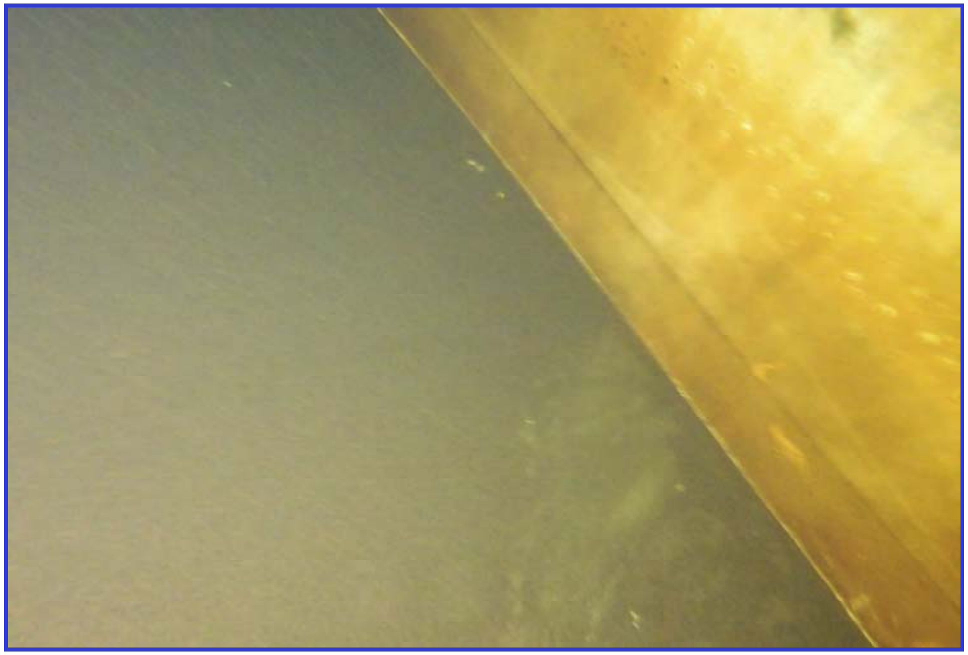

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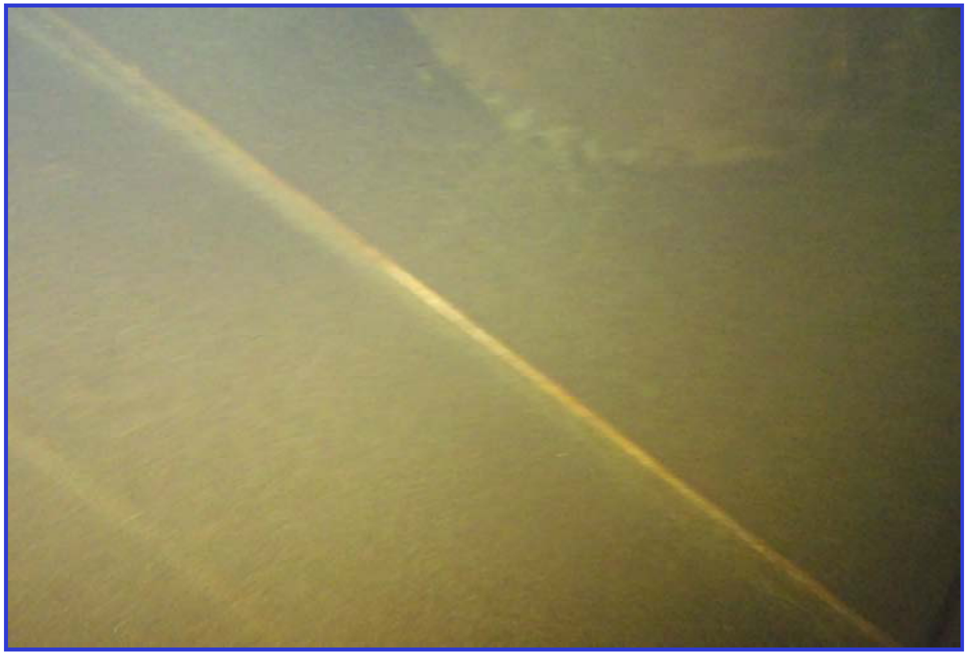
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -123



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INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -125

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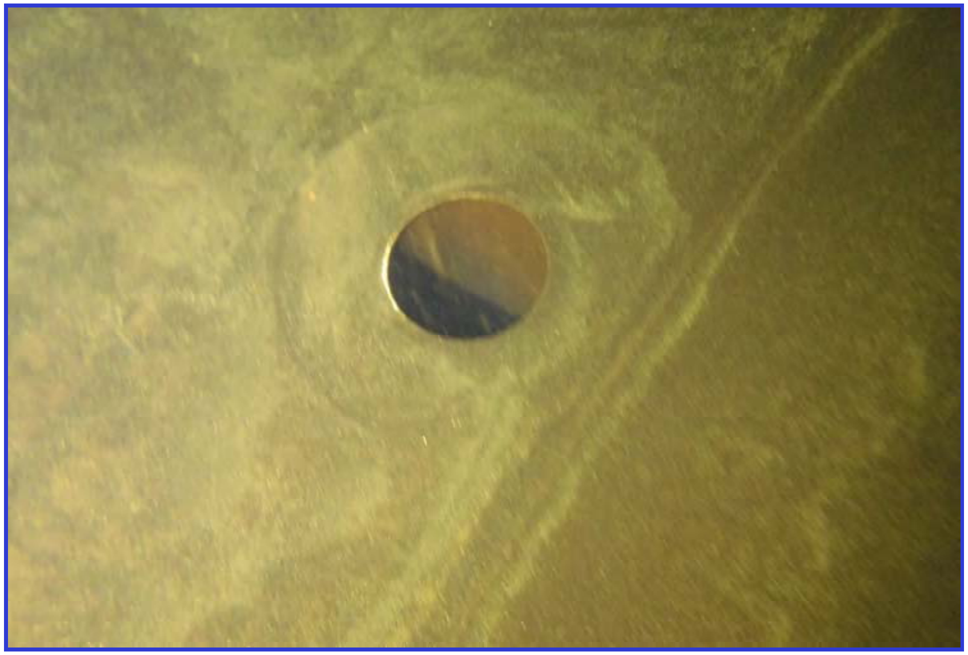
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -127

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -128



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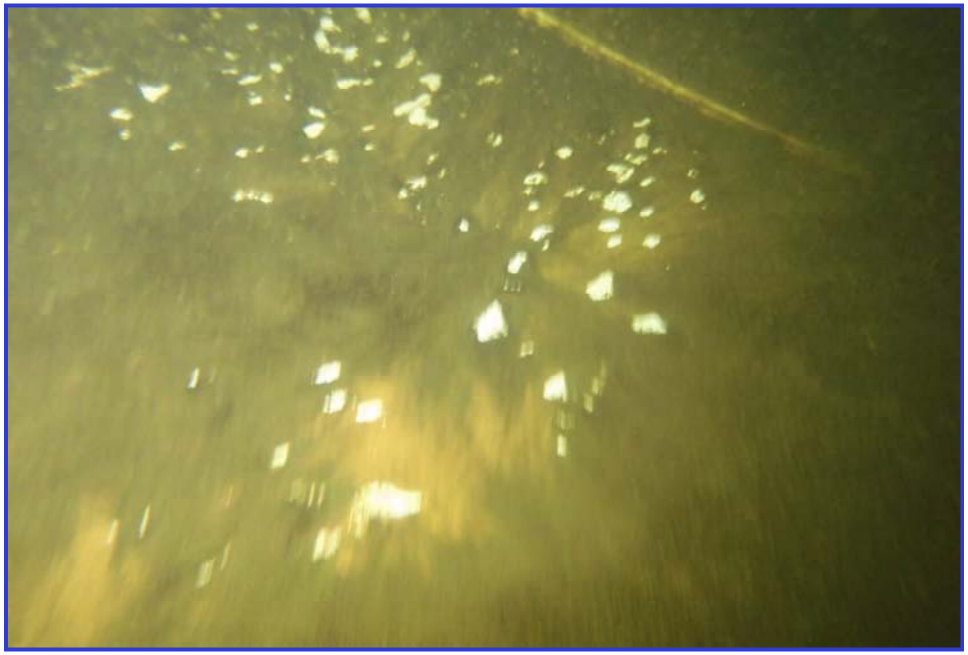

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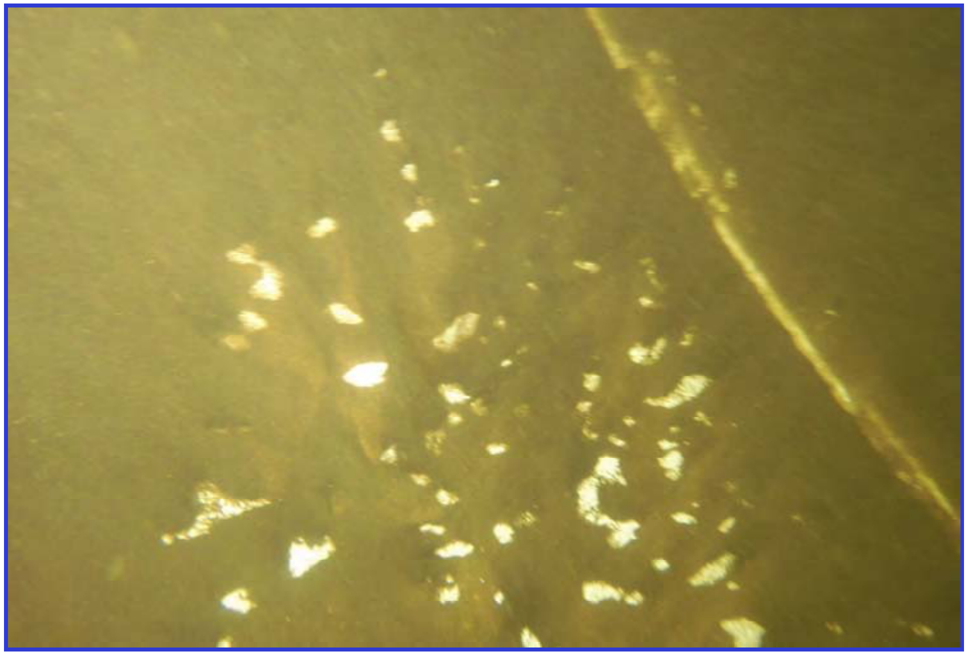

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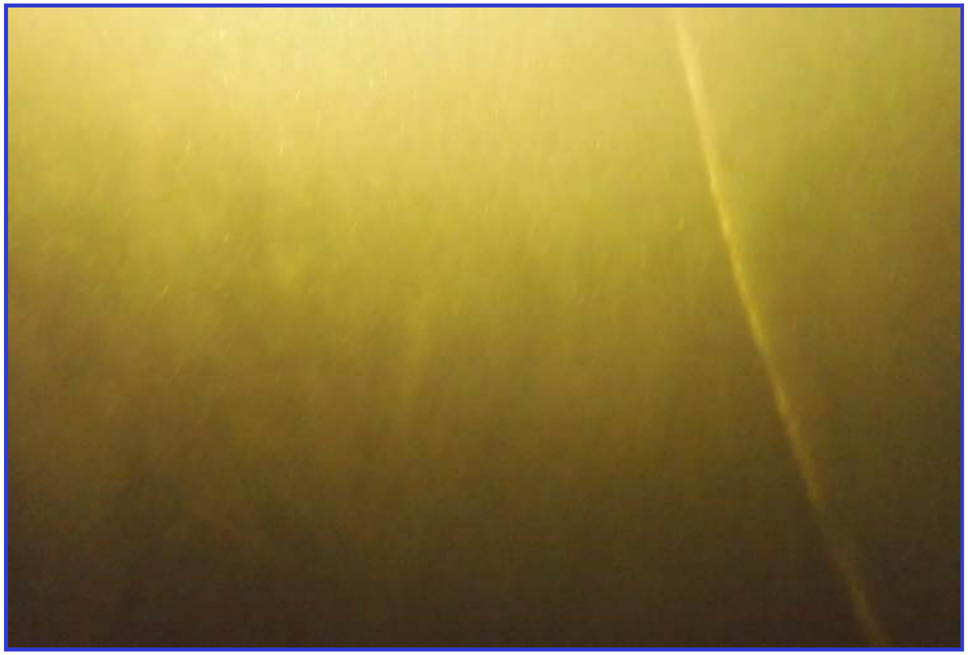

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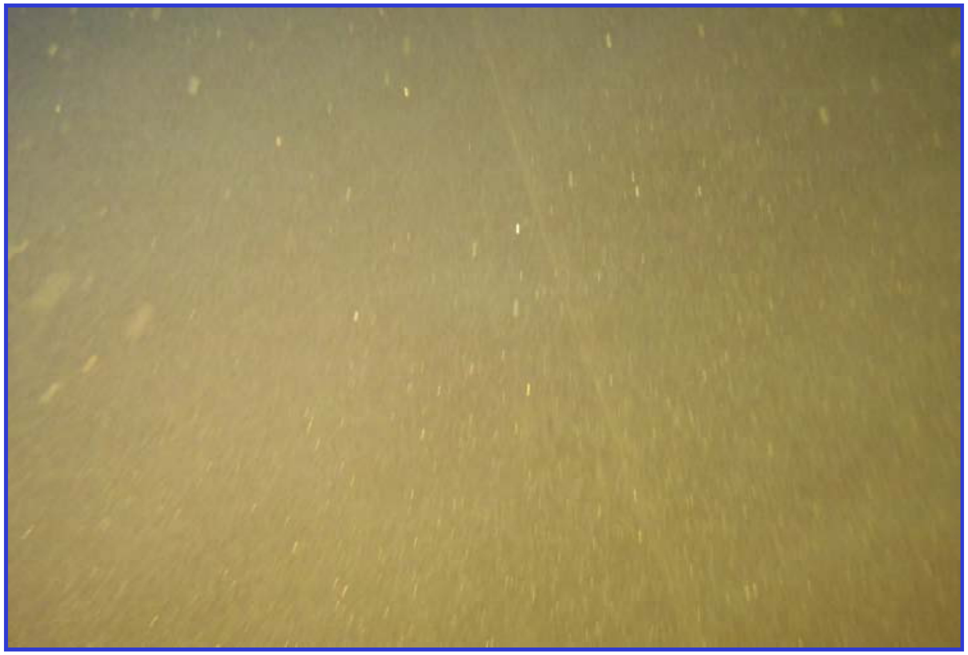

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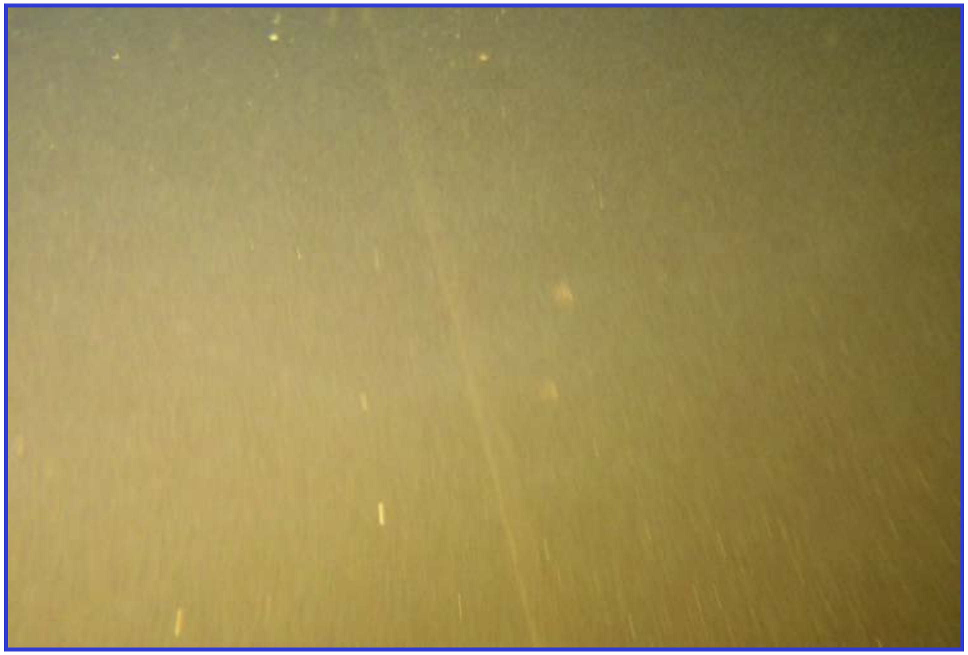

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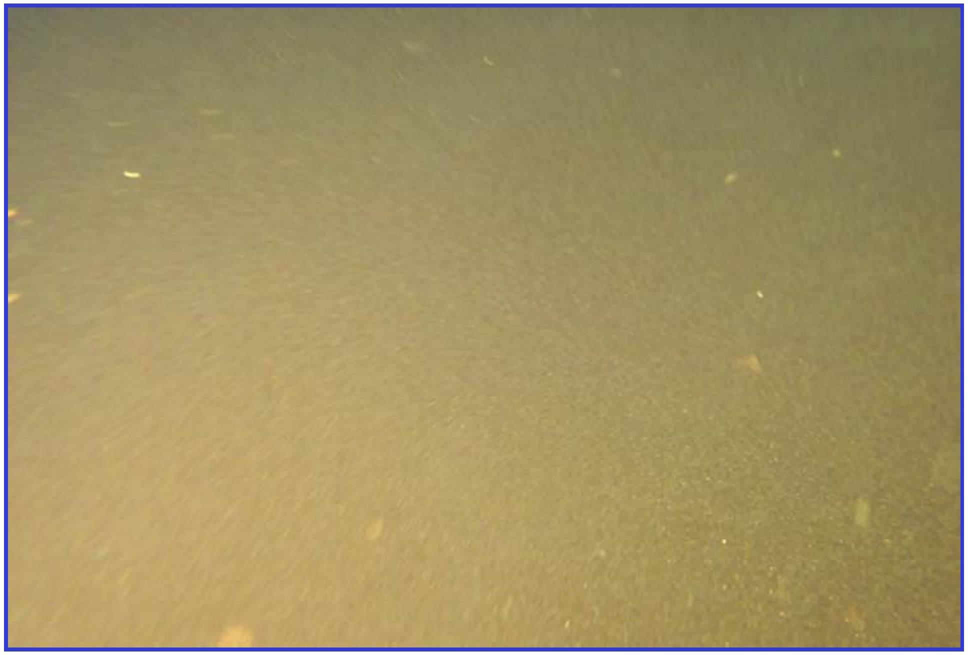

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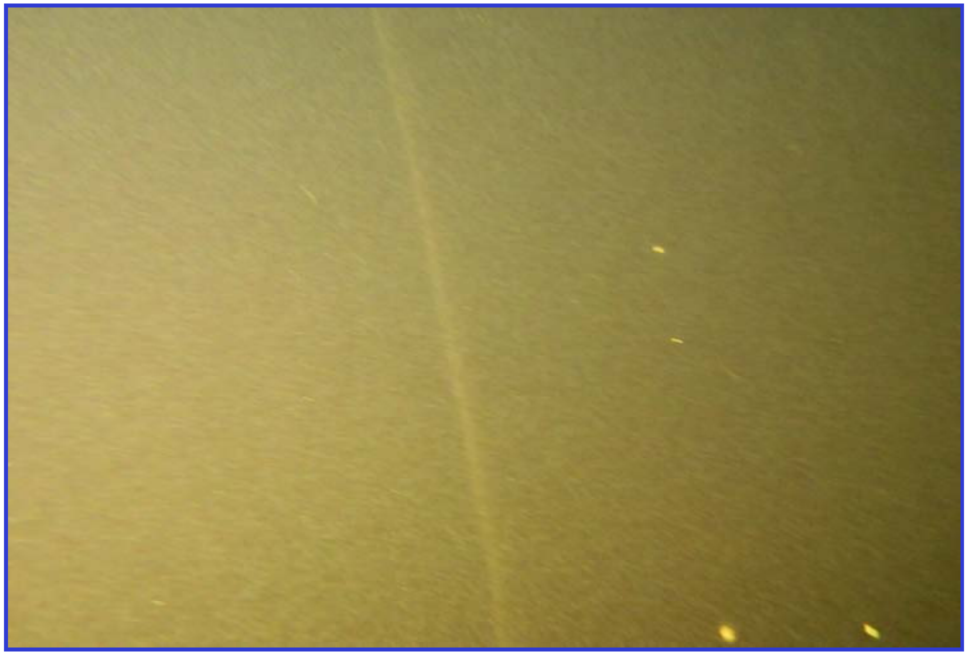

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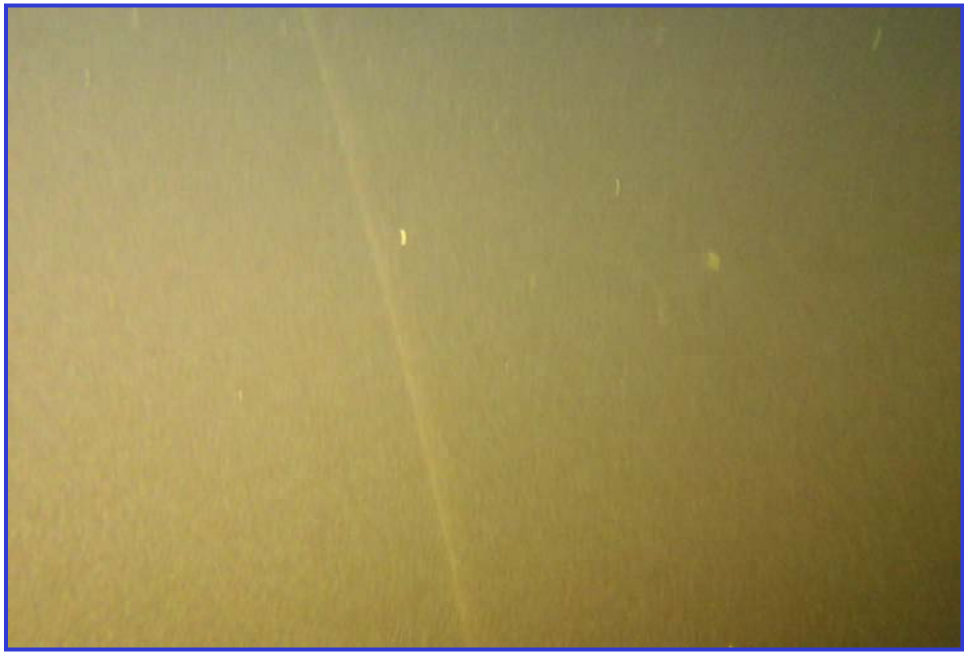

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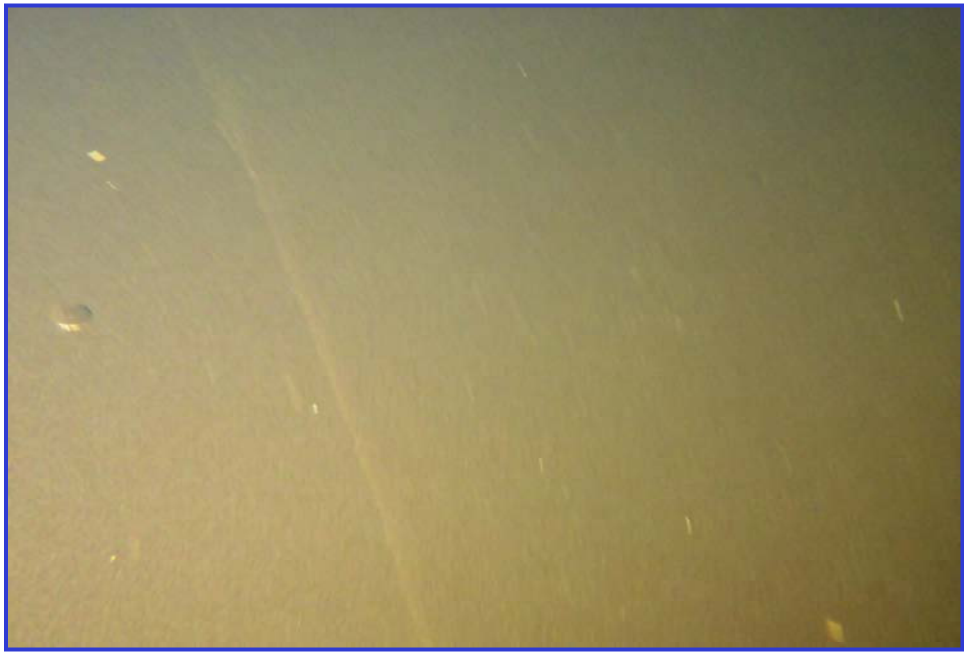


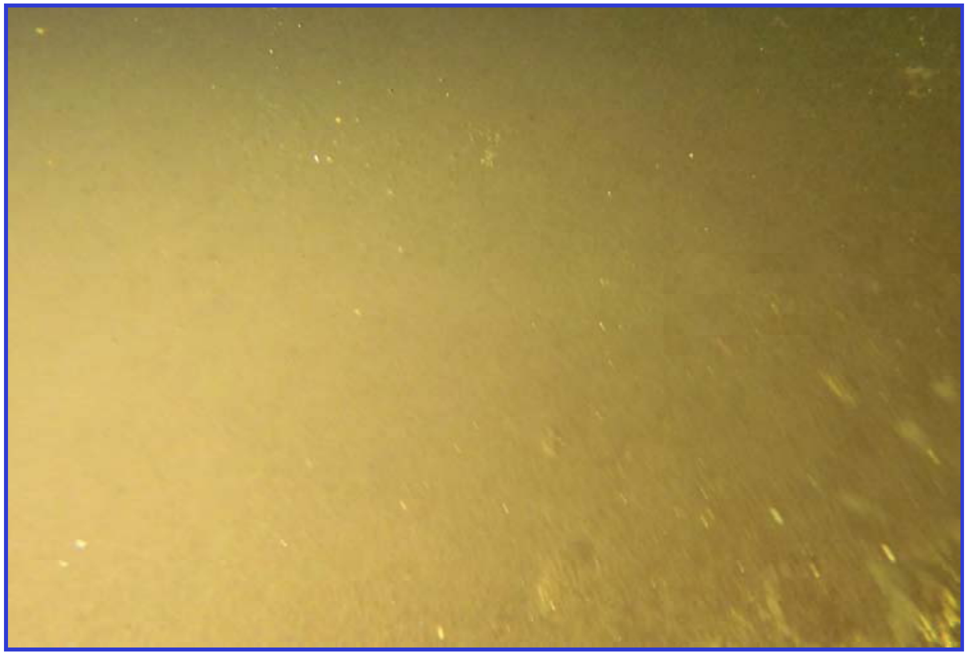
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -139


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -140


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -141


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -142


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -143



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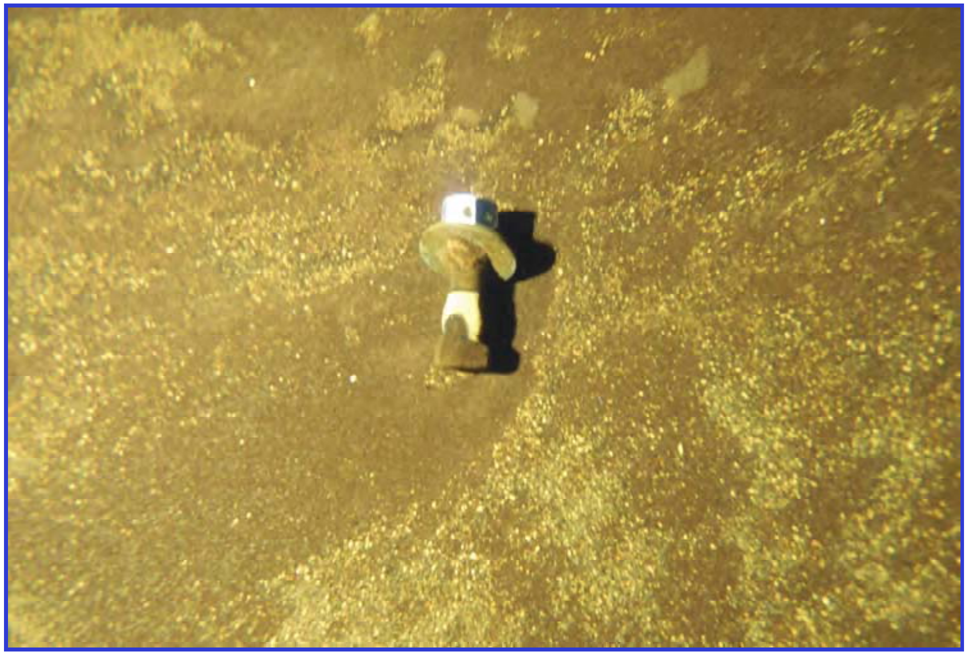

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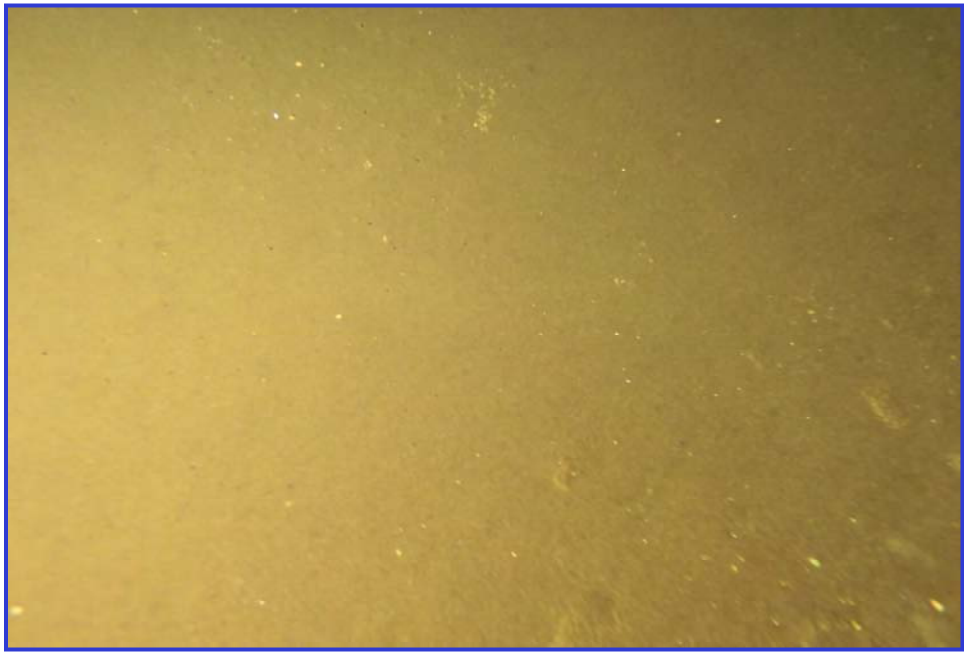

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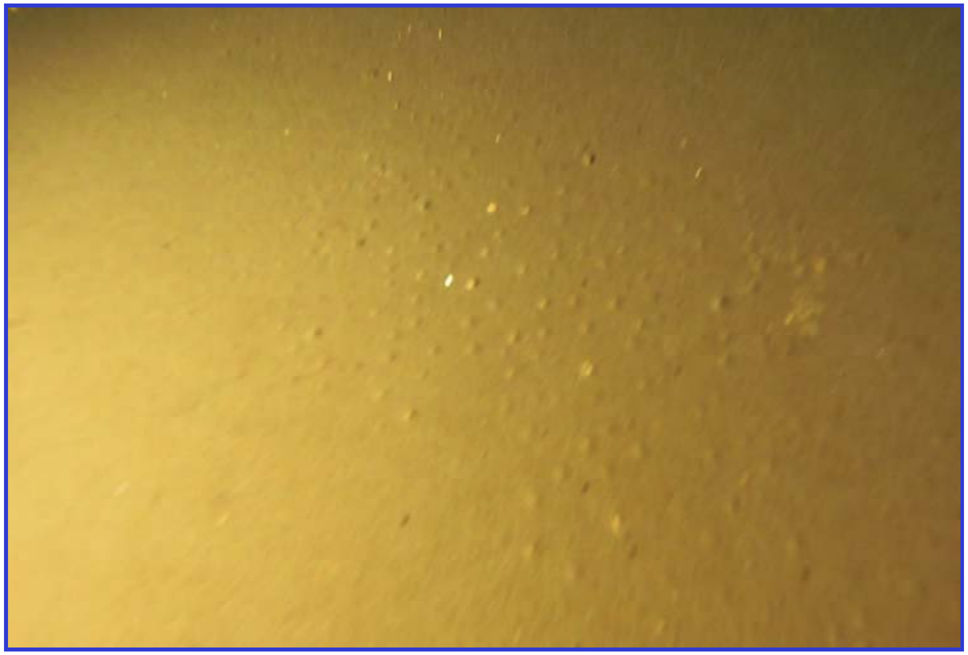

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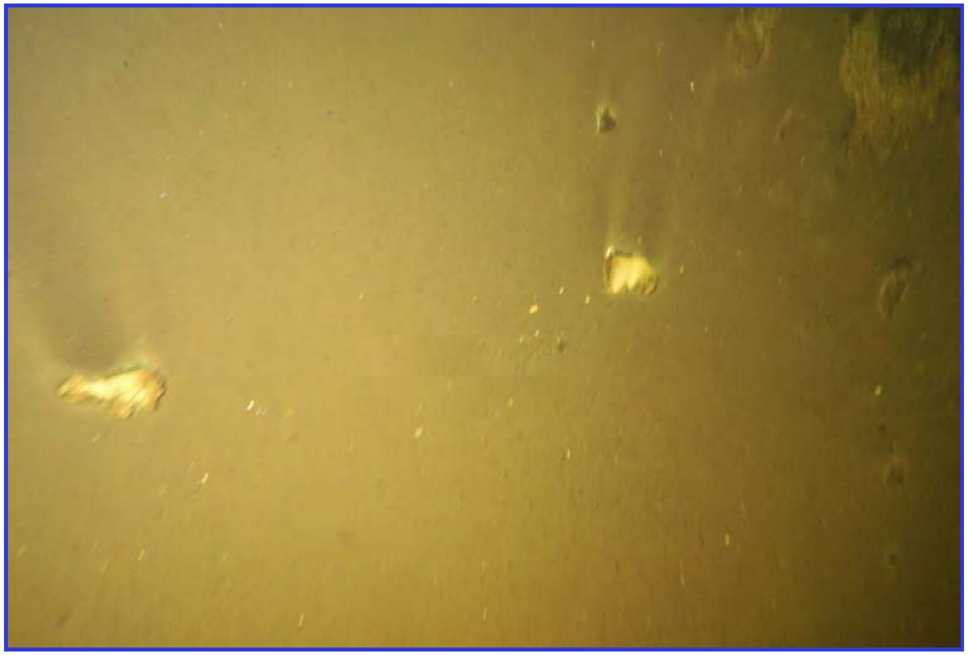
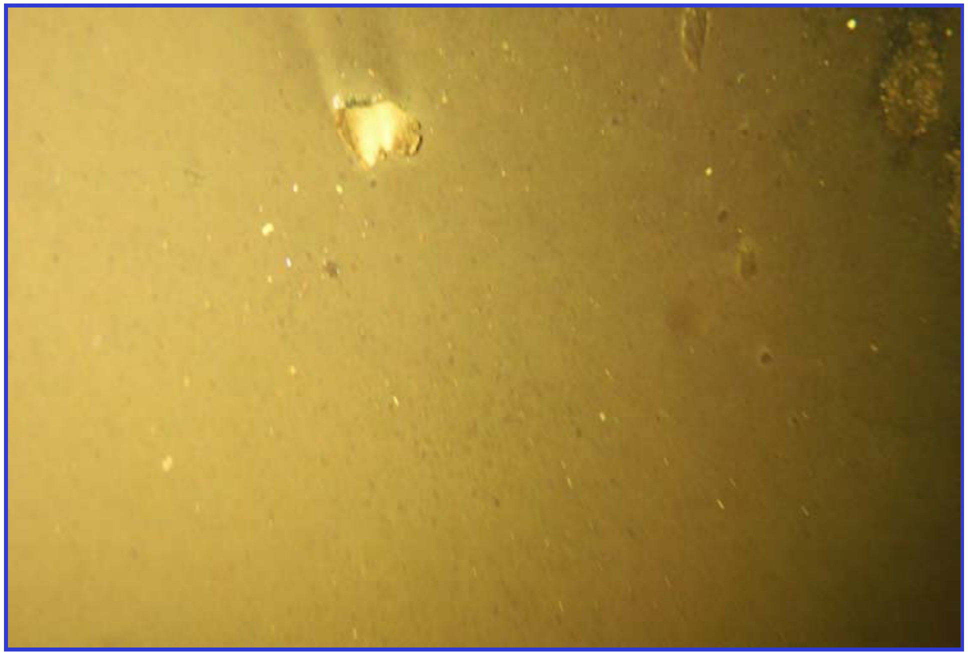
INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -148


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -149


INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -150

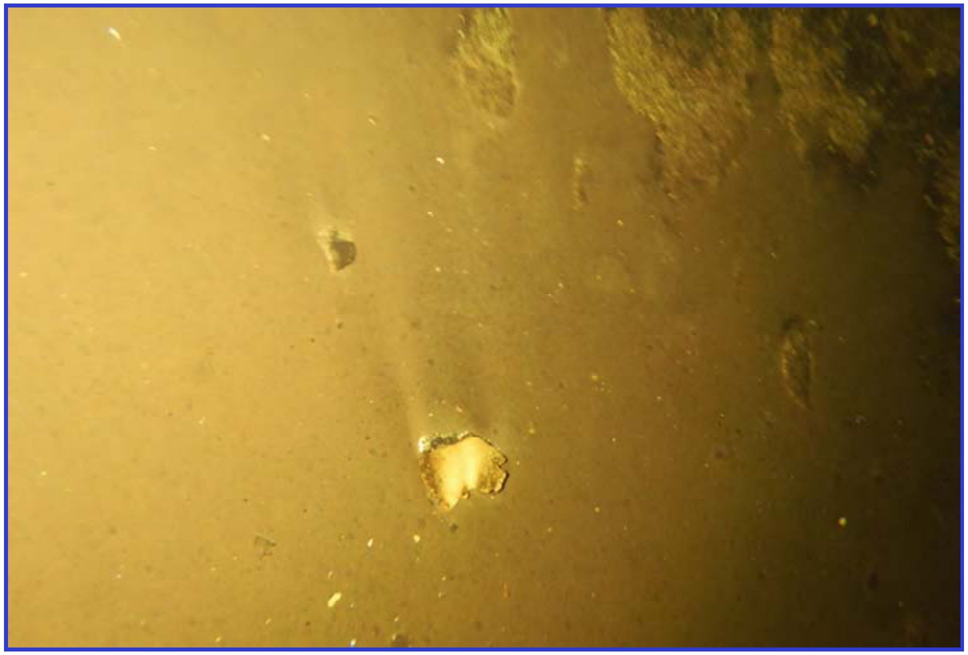
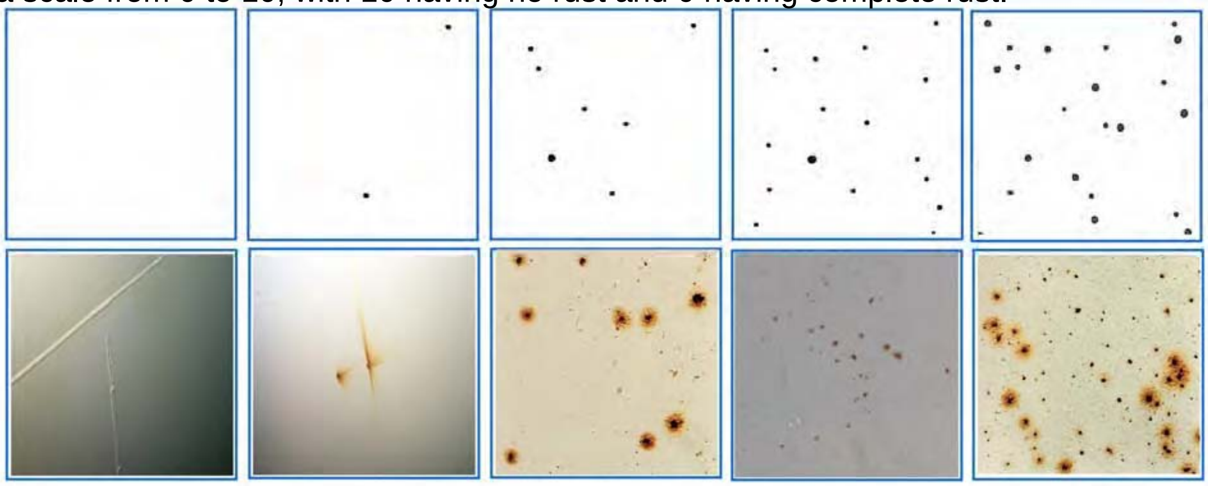

INTERIOR - Kirkwood Medows PUD - Danburg Tank - Maintenance Inspection -151

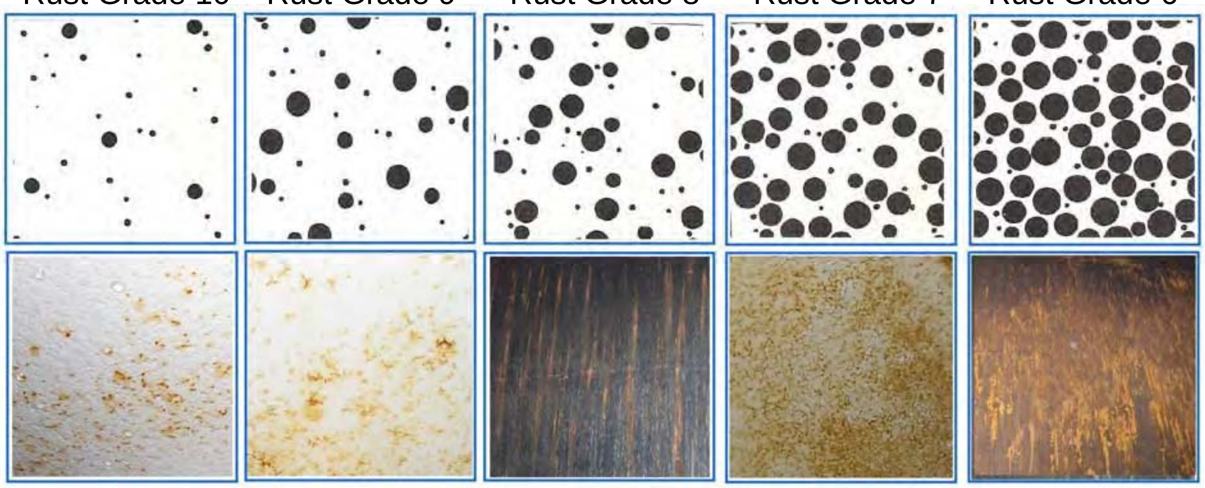
Chart 1 - Condition Rating The table below gives a basic description of the four different categories that CSI Services, Inc. uses to provide a general depiction of the condition of each defined area of a structure. The categories are Poor, Fair, Good, or Excellent. The development of these categories is based on historical knowledge and experience of various paint and lining systems over given periods of time in certain service environments. Basically, the rating is determined based on what should be expected of the paint or lining system at that point in its life cycle. As a result, different determinations are made for maintenance inspection versus warranty inspections. A detailed description of each rating with relative consideration addressed follows:

Rating	General Description of Conditions	
	Maintenance Inspection	**Warranty Inspection**
Poor	This condition is usually prioritized for rework in the short-term. Typically, these surfaces have considerably more coating defects and/or corrosion than what is expected for the age of the system.	This condition identifies an area with wholesale coating defects or corrosion concerns that will typically require significant removal and replacement of the coatings in the area.
Fair	Typically, these surfaces have a level of coating defects and/or corrosion that is slightly worse than what should be expected for the age of the system. This condition is placed on a short-term monitoring schedule.	This condition identifies an area with partial coating defects or corrosion concerns that will require significant rework.
Good	This condition is rated for areas without any considerable coating defects or corrosion. These surfaces are in a condition that is typical for the age of the coating system.	This condition identifies areas with coating defects or corrosion that is typically seen in one-year warranty inspections. Typically, only minor spot repairs are required.
Excellent	This condition is for areas without any considerable coating defects or corrosion. Typically, these surfaces are in a condition that is better than expected for the age of the system.	This condition identified areas that typically are in perfect condition and require no repair work.

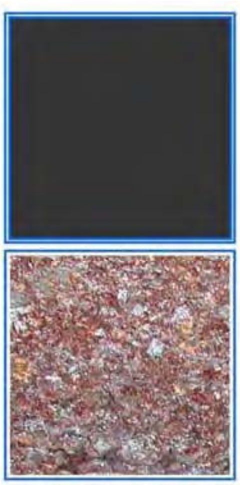
Chart 2 -Rust Grade The black and white figures below depict the standards referenced in ASTM D610 “Standard Test Method for Evaluating Degree of Rusting on Painted Surfaces.” Below each standard is a photographic depiction of each level of corrosion, as used by CSI Services, Inc. The standards depict the percentage of rust on a scale from 0 to 10, with 10 having no rust and 0 having complete rust.



Rust Grade 10 Rust Grade 9 Rust Grade 8 Rust Grade 7 Rust Grade 6



Rust Grade 5 Rust Grade 4 Rust Grade 3 Rust Grade 2 Rust Grade 1



Rust Grade 0

Rust Grade	Description
10	No rusting or less than 0.01% of surface rusted
9	Minute rusting, less than 0.03% of surface rusted
8	Few isolated rust spots, less than 0.1% of surface rusted
7	Less than 0.3% of surface rusted
6	Excessive rust spots, but less than1% of surface rusted
5	Rusting to the extent of 3% of surface rusted
4	Rusting to the extent of 10% of surface rusted
3	Approximately one-sixth of the surface rusted
2	Approximately one-third of the surface rusted
1	Approximately one-half of the surface rusted
0	Approximately 100% of the surface rusted

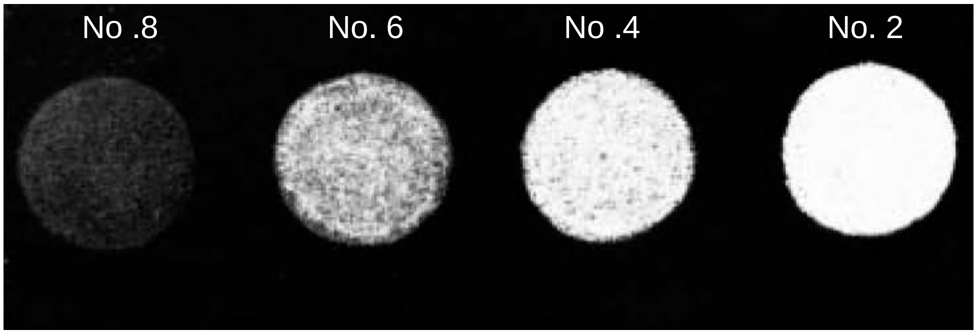
Chart 3 - Corrosion Grade The figure below depicts the photographic standards referenced by CSI Services, Inc. in the determination of the characteristics and stages of corrosion progression. This standard is used to better quantify the level of corrosion once it has progressed to Rust Grades 3, 2, 1, or 0 (see Chart 2). When applicable, CSI classifies an area as one or more of the five different Corrosion Grades. Corrosion Grades 1 through 5 are described below:

Grade	Description	Photo Examples
1	Light Rust - This condition involves relatively light colored rust that does not have any significant metal loss.	 
2	Dark Rust -This condition involves relatively dark colored, thicker rust that is progressing towards the next phase, significant metal loss.	 
3	Pitting - This condition involves isolated or widespread deep spot corrosion (pitting).	  
4	Scale - Also known as lamellar or exfoliation corrosion. The edges of the affected area are leaf like and resemble the separated pages of a wetted book.	 
5	Structural Loss - This condition involves metal loss or failure where components will require structural consideration	 

The photos depicted are examples and were not taken on this project.

Chart 4 - Chalking The figure below depicts the photographic standards referenced in ASTM D4214 "Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films," Method D659, Method C. Generally speaking, chalking is the degradation of a paint's binder leaving behind loose pigments as the binder reacts with the environment, primarily ultraviolet light and oxygen. Evaluating chalking is a means to measure the performance of a coating system and its life cycle projection. It is also important to quantify for consideration of future overcoating options. This test uses these pictorial standards to quantify the amount of chalking present on paint films. The depictions below represent the mount of colored chalk removed onto a cloth during the test. The scale ranges from 2 to 8 with the rating 2 having the most chalk.

Light Colored Paints



Dark Colored Paints

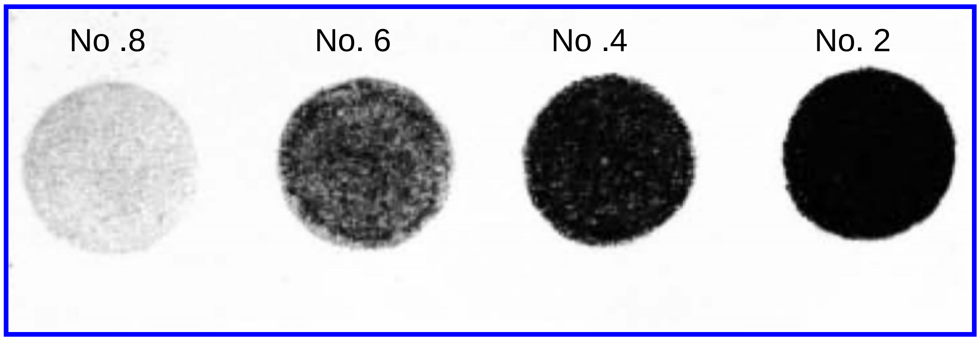
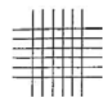
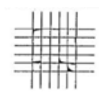
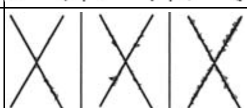
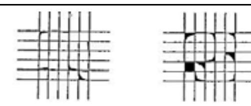
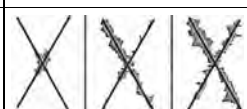
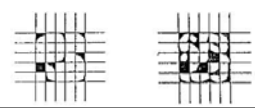
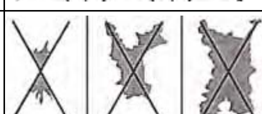
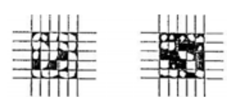
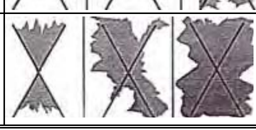
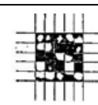


Chart 5 - Adhesion Rating The figures below depict the photographic standards and criteria referenced in ASTM D3359 “Standard Test Method for Evaluating Adhesion by Tape Test” and ASTM D6677 “Standard Test Method for Evaluating Adhesion by Knife.” Both Standards are used to assess the condition of a paint system for life-cycle projections. It is also used to evaluate an existing paint system’s ability to withstand the added stress that any overcoating strategies can create. Depending upon the thickness of the paint system, ASTM D3359 has two different test methods. The rating criteria for both standards follow:

ASTM D3359					
Method A			Method B		
Rating	**Observation**	**Surface of X-cut from which flaking/peeling has occurred**	**Rating**	**Percent Area Removed**	**Surface of cross-cut area from which flaking has occurred for six parallel cuts and adhesion range by percent**
5A	No peeling or removal	None	5B	0% none	
4A	Trace peeling or removal along incisions or their intersection		4B	Less than 5%	
3A	Jagged Removal along incisions up to 1/16” on either side		3B	5 – 15%	
2A	Jagged removal along most of incisions up to 1/8” on either side		2B	15 – 35%	
1A	Removal from most of the area of the X under the tape		1B	35-65%	
0A	Removal beyond the area of the X		0B	Greater than 65%	

ASTM D6677	
Rating	Description
10	Fragments no larger than $\frac{1}{32}$” x $\frac{1}{32}$” can be removed with difficulty
8	Chips up to $\frac{1}{8}$” x $\frac{1}{8}$” can be removed with difficulty
6	Chips up to $\frac{1}{4}$” x $\frac{1}{4}$” can be removed with slight difficulty
4	Chips larger than $\frac{1}{4}$” x $\frac{1}{4}$” can be removed with slight pressure
2	Once coating removal is initiated by knife, it can be peeled at least $\frac{1}{4}$”
0	Coating can be peeled easily to length greater than $\frac{1}{4}$”

Chart 6 – Blistering Rating The figure below depicts the photographic standards referenced in ASTM D714 “Standard Test Method for Evaluating Degree of Blistering of Paints”. This test uses these pictorial standards to quantify both the size and density of blisters that may develop in linings. Although the standard uses a blister size scale of 0 to 10 this chart uses the most common sizes of blisters found in the field. The standard does not use a reference for the size of each of the blisters depicted. CSI used this scale as a means for further quantification by qualifying the largest blister depicted as being 1 inch in width (Blister Size No. 2) and the smallest blister being 1/32 of an inch in width (Blister Size No. 8).

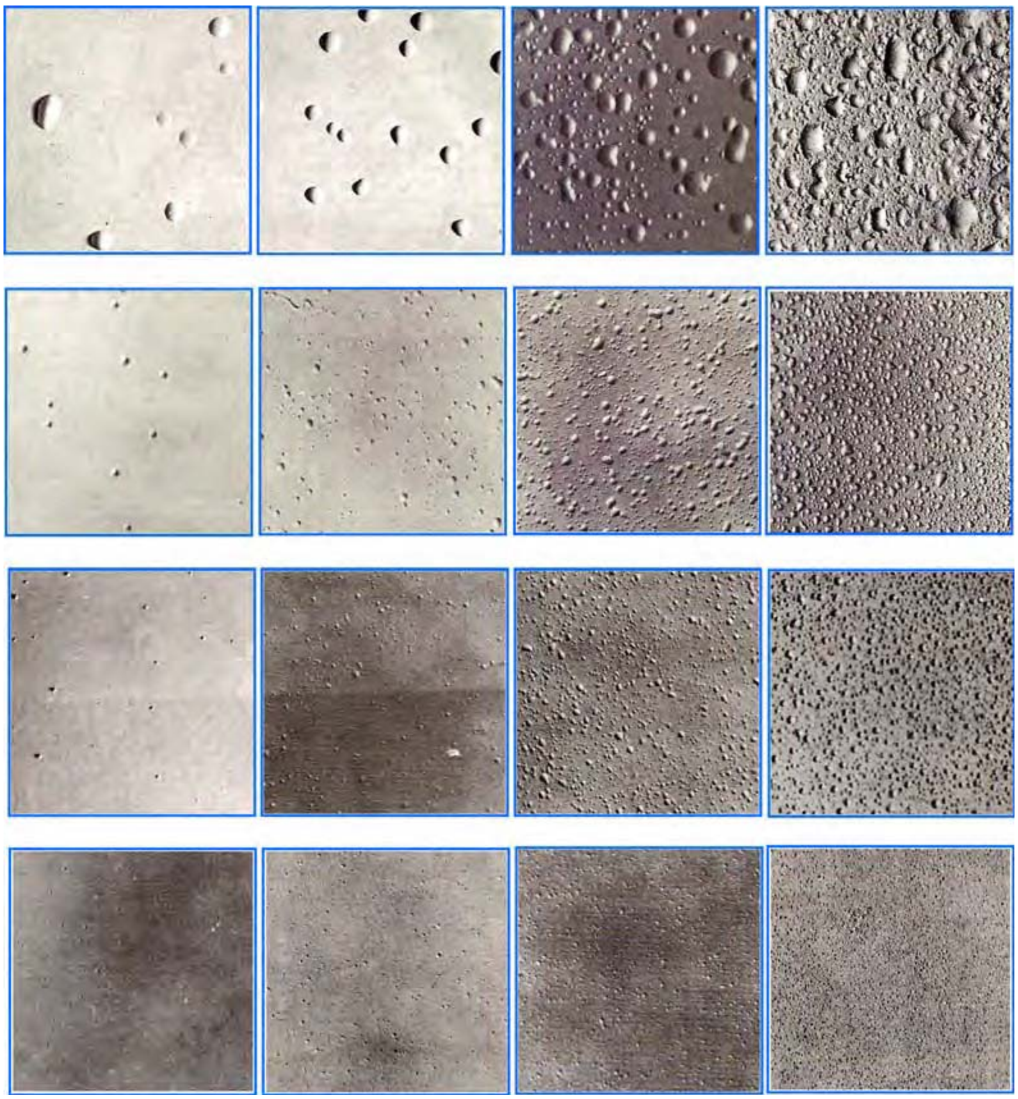
Few **Medium** **Medium Dense** **Dense**

Blister Size No. 2

Blister Size No. 4

Blister Size No. 6

Blister Size No. 8



P. O. Box 801357
Santa Clarita, CA 91380-2316
Phone: 877.274.2422
Fax: 661.775.7628
www.CSIServices.biz

Providing Quality Technical Services to the Coating Industry

November 19, 2024 ***Via Email:*** asmith@pbieng.com

Ashley Smith, PE
Peterson Brustad Inc.
80 Blue Ravine Road, Suite 280
Folsom, CA 95630

Office: 916.608.2212
Cell: 530.200.6309

Subject: Final Report - Maintenance Inspection

Re: Kirkwood Medows PUD – Lodge Reservoir

Dear Ashley:

Please find attached the final report for the evaluation that was completed on the above referenced tank. Also attached is our invoice.

Thank you for your business and please let me know if you have any questions or comments about our findings. I can always be reached by cell at 951.609.6991 or by e-mail at rgordon@csiservices.biz.

Sincerely,
CSI Services, Inc.

N. Randy Gordon

N. Randy Gordon, PCS
Technical Services Manager

P. O. Box 801357, Santa Clarita, CA 91380 877.274.2422

Final Report
Maintenance Inspection
Lodge Reservoir
Kirkwood Medows Public Utility District

Prepared for:
Ashley Smith, PE
Peterson Brustad Inc.
80 Blue Ravine Road, Suite 280
Folsom, CA 95630

Prepared by:
CSI Services, Inc.

N. Randy Gordon, PCS
Technical Services Manager

PROTECTIVE COATING SPECIALIST
N. RANDY GORDON
No. 2018-621-011
Exp. 12-31-26
PCS
STATE OF CALIFORNIA

November 19, 2024

Hawaiian Office: P.O. Box 671, Aiea, HI 96701
Northern California Office: P.O. Box 371, Sonoma, CA 95476
Coating Specialists and Inspection Services, Inc.
Consulting Evaluations Tank Diving Inspection

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- Exterior Photos
- Interior Photos
- CSI Chart 1 – General Description of Conditions
- CSI Chart 2 – Rust Grade Criteria
- CSI Chart 3 – Corrosion Grade Criteria
- CSI Chart 4 – Coating Chalking Criteria
- CSI Chart 5 – Coating Adhesion Criteria
- CSI Chart 6 – Coating Blistering Criteria

Introduction

Peterson Brustad Inc. authorized CSI Services, Inc. (CSI) to conduct a maintenance inspection on the Kirkwood Meadows Public Utility District, Lodge Reservoir located at the Kirkwood Mountain Resort, Pioneer, CA. This report documents the findings of the inspection and services performed.

Any recommendations have been made in accordance with the applicable requirements of American Water Works Association's Standard (AWWA) D102 "Coating Steel Water Storage Tanks," AWWA Standard M42 "Steel Water Storage Tanks," and CSI's experience with evaluating over a thousand water storage facilities. A photo summary and narrated video are also included to document the condition of the tank.

The field-work was completed on August 29, 2024 by a team primarily comprised of Anthony Jackson, Steven Metcalf and Steven Metcalf Jr. The exterior shell observations were made mostly from grade level, while the exterior of the roof was examined close-up. The interior inspection was carried out with the tank's water level at approximately 30 feet using special underwater diving equipment and techniques. Steve Metcalf was the site supervisor and Anthony Jackson was the lead diver. Mr. Randy Gordon, Technical Services Manager, reviewed the results of the field data and prepared recommendations for maintenance work. Mr. Gordon has over 35 years of experience through the evaluation of thousands of storage tanks and other structures. He is certified as an SSPC Protective Coating Specialist (PCS) and NACE/SSPC Level 3 Coating Inspector.

Summary

The coating system on the tank is in overall fair condition with widespread and peeling of the topcoat and localized corrosion on the roof while the shell is largely unimpacted by corrosion. The exterior paint system is severely weathered and has marginal adhesion, making it a potential candidate for future overcoating strategies. The exterior paint should not have high concentrations of heavy metals (e.g. lead, chromium, etc.) yet the paint system should be further analyzed prior to any work that would disturb the paint system as special precautions to protect the workers and environment may be required if it is disturbed.

The lining in the tank is in an overall unsatisfactory condition with widespread rust including undercutting and pitting impacting knuckle bracing and roof structural elements. The most advanced corrosion spots below the CWL were patched during this inspection using an NSF certified underwater curing epoxy and prior patch repairs were performing properly. The existing lining conditions dictate that the interior lining system

should be removed and replaced within the next 3 to 5 years to prevent any further structural loss.

Background

The Lodge Reservoir is a welded steel on grade structure where the year of construction is unknown but historical satellite imagery shows a tank at this site as far back as 1992. The tank is approximately 50 feet in diameter by 32 feet high providing a nominal capacity of 500,000 gallons.

The tank shell has four 8 foot courses that are connected to a knuckle radiused, conical roof with rafters, girders and one center column. The tank has two roof vents, one roof hatch, and two shell manways. There is one interior ladder and one exterior ladder. The exterior ladder has fall protection and a vandal deterrent. The tank is seismically anchored to its concrete ring wall foundation. There is no internal or external cathodic protection (CP) system associated with this tank. The tank has a half-travel water level indicator, rigid piping connections, and the overflow is external.

It is believed that the interior linings are not the original coatings applied. The interior steel surfaces, including the roof and roof support members and tank bottom are coated with a thin-film, multi coat epoxy system. The exterior roof, shell, and appurtenances are painted with what appears to be an alkyd system. The internal roof lap seams are not caulked.

Field Evaluation

The purpose of this survey was to assess the condition of the existing coatings and recommend maintenance coating work, where needed. The evaluation mainly involved visual observations, but also involved various testing procedures. Photographs and video were taken to document the field inspections, and a photo summary and narrated video is included within this report.

For survey purposes, the tank has been segmented into defined areas: exterior roof, exterior shell, interior roof, interior shell, and interior floor. The various appurtenances within each of these areas have also been evaluated. A rating system has been developed to quantify the condition of these various tank areas. Each of the rating criteria is found in the Attachments (Charts 1 through 6).

The condition of the coating systems was rated as being poor, fair, good, or excellent (Chart 1). The extent of any rust defects identified within each of the areas was generally determined using the guidelines set forth in ASTM D610 “Standard Test

Method for Evaluating the Degree of Rusting of Painted Steel Surfaces" (Chart 2). Where applicable, the characteristic or stage of corrosion was determined in accordance with CSI Corrosion Grade criteria (Chart 3). The degree of paint chalking was determined in accordance with ASTM D4214 "Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films," Test Method D659, Method C (Chart 4). Coating adhesion was assessed in accordance with ASTM D3359 "Standard Test Method for Evaluating Adhesion by Tape Test, modified Method A and/or a modified version of ASTM D6677 "Standard Test Method for Evaluating Adhesion by Knife" (Chart 5). The modified version of ASTM D6677 was used in areas where destructive testing was not found to be practical. Any blistering that may have been present was rated in accordance with ASTM D714 "Standard Test Method for Evaluating the Degree of Blistering in Paints" (Chart 6), and the paint dry film thickness was measured with a Positector 6000FN3 Type II gage in accordance with the applicable guidelines set forth SSPC PA2. The visual observations and data collected from the various areas of the tank are found in the charts below:

Exterior

Close-up visual examination of the coating was limited to the first (lowest) shell course, upper shell areas adjacent to the ladder, and the roof. The exterior paint on the heavily weathered roof is in fair condition and the shell was in good condition, both with moderate chalking (ASTM D4214, No. 8). Dark rust (CSI Corrosion Grade 2) was present in areas that had been mechanically damaged from operations or vandalism and areas where paint was peeling. The amount of rust on the roof was less than 0.03 percent of the overall surface area (ASTM D610, 9). The paint thickness was found to range from 11.0 to 14.0 mils on the roof and 11 to 13 mils on the shell. The paint was estimated to exhibit marginal adhesion (ASTM D6677, 3A).

Some of the specific data collected follows:

Exterior Paint					**Overall Condition**		Fair					
Paint Defects	**Roof Quadrant**				**Shell Quadrant**				**Tank Support**			
	Exterior		Poor		Exterior		Good		Exterior		Good	
	S	**W**	**N**	**E**	**S**	**W**	**N**	**E**	**S**	**W**	**N**	**E**
Rust spots (ASTM D610)	9	9	9	9	9	9	9	9	9	9	9	9
Corrosion Grade	2	2	2	2								
Rusting at crevices												
Spot peeling	Yes	Yes	Yes	Yes								
Delamination												
Cracking (ASTM D661)												
Checking (ASTM D660)												
Chemical staining												
Chalking	8	8	8	8	8	8	8	8	8	8	8	8

Interior

The roof area is defined as those surfaces above the highest water level (HWL). Close-up visual examinations were made to all areas below the waterline and all other areas were assessed from the water level. The coating on the underside of the roof plates and roof support structure is in poor condition with corrosion common to the edges of the support member flanges and roof plates (CSI Corrosion Grade 2). Spot peeling and cracking was observed throughout. The total amount of corrosion on the roof was rated to be approximately one percent of the total surface area (ASTM D610, 6), and there was a minor amount of rust staining present at the faying surfaces of the roof structure.

The shell surfaces are covered with a dark sediment, but spot checking revealed the lining on the shell was found to be in good condition with areas of dark rust (CSI Corrosion Grade 2), especially below the high-water level segment of the shell. The total amount of corrosion on the shell was rated to be excessive but less than 0.03 percent of the total surface area (ASTM D610, 9).

The floor had a moderate load of sediment upon it, but spot checking revealed an epoxy system that was estimated to be in good condition, (ASTM D610, 9). Some pitting uncovered upon the floor was patched during the inspection and the prior patches were observed to be performing properly.

The data collected from the underwater inspection follows:

Interior Paint			Above Water Condition		Poor			Below Water Condition			Good	
Paint Defects/Overall Grade	Roof Quadrant				Shell Quadrant				Floor Quadrant			
	Interior		Poor		Interior		Good		Interior		Good	
	S	W	N	E	S	W	N	E	S	W	N	E
Rust spots (ASTM D610)	6	6	6	6	9	9	9	9	9	9	9	9
Rust areas (ASTM D610)												
Corrosion Grade	2	2	2	2		2						
Rust staining												
Rusting at crevices												
Spot peeling	Yes	Yes	Yes	Yes								
Delamination												
Cracking (ASTM D661)	2	2	2	2								
Blistering (ASTM 714) Size/Density												
Pitting (Estimated Amount)												
Pitting (Estimated Deepest Mils)												

Dive Inspection Video

Click on link or cut and paste the external link: https://youtu.be/23AKmo5uD8A

Discussion

The paint system on the exterior was found to be very thin and in poor condition on the roof and good condition at the shell. Although these surfaces have spot rust and areas of peeling, the paint system was found to have significantly weathered from chalking.

Generally speaking, there are four possible approaches to maintenance coating work. The coatings can be either completely removed and replaced (repainted), spot repaired, spot repaired and overcoated, or simply overcoated. In evaluating the condition of a coating to determine the best approach there are a number of different factors to consider. The first set of factors includes the determination of the coating's ability to withstand the added stress of an additional coat(s). Attributes impacting this decision include film thickness and adhesion. If a film is too thick or has poor adhesion, the tension from the curing stresses and/or the weight of the additional paint can cause the existing system to disbond. The second set of factors to consider when determining what maintenance coating approach to take is the amount of surface area requiring repair, the overall difficulty in providing access to the structure, and whether the coating system contains heavy metals. The final factor is the condition of the substrate.

When considering whether a spot repair approach is a viable option, a good rule of thumb is that up to 10 percent of the surface area requiring repair is the point at which making spot repairs with overcoat becomes a diminishing return. With 10 percent rusting, overcoating may be an option if the adhesion is better than fair. If there is more than 10 percent rusting and the substrate is free of mill scale, overcoating may be considered an option if the adhesion is satisfactory. Once the amount of surface area exceeds this range, the cost of cleaning and coating the individual rust spots approaches (or exceeds) the total cost of removal and replacement.

Chalking is the term for the powdery characteristic of an aged coating that may also have a faded finish. Chalking is a result of the natural breakdown of a paint system's binder when it is exposed to sunlight. The binder (or resin) degrades in ultraviolet light, which leaves behind the unbound pigment or chalk. Aside from a faded appearance, chalking can result in corrosion as the film weathers (thins) away through cycles of wind and rain. As the paint endures years of direct sunlight, it begins to weather away, which results in the paint no longer providing enough barrier protection from corrosion.

Peeling or delaminating coating is a symptom of an adhesion problem between the coating and substrate or from within layers of coating system. Adhesion is a function of a coating system's strength. Peeling is often a result of coated over contamination, incompatibility between coats, or from an undercoat being coated after its recoat window had closed. Catalyzed coatings, such as epoxies and urethanes continue to dry and then cure to a point where they become too hard for topcoats to chemically adhere. Once the window for a chemical bond is closed, special procedures such as scarification are required to allow for a mechanical bond.

Industrial paint systems such as those applied to industrial facilities (i.e. piping, structural steel, storage tanks) typically have a life expectancy of 25 to 35 years before any spot maintenance coating repairs are required. The exterior paint system is aged yet remains suitable for overcoating. Therefore, it is recommended that the paint system on the tank be spot repaired and overcoated with a new epoxy urethane system within the next 3 to 5 years.

Overall, the tank interior lining is in poor condition in the area above the highest water level (HWL), and in good condition below the HWL. The vapor area is replete with corrosion and has advanced to pitting, primarily at the roof structure. The lining on the underwater areas of the tank is mostly free of widespread corrosion, but there are many rust spots that were patched during the course of the inspection.

A tank roof, including its roof support structure has many open, unsealed areas by design. These open areas are primarily at the inaccessible crevices that are between the top of the roof beam flanges and the roof plate. The cost of properly sealing these areas becomes a diminishing return, notably when one considers that small crevice areas often develop into dead-air space. Since corrosion requires oxygen to advance and the initial development of corrosion depletes the majority of the available oxygen, the rate of corrosion is very low. The side effect of this design is rust staining that runs from these areas as they initiate corrosion. Unsealed areas can also include lapped, un-welded roof plates. However, these lapped seams areas can be sealed with caulking at a very cost-effective cost.

Cracking is the result of some form of stress within the coating system that extends through a complete layer of coating. The stress is often a result of some internal coating pressure or from some form of structural movement. The internal pressures can result from a shrinking film when it is applied too thick or if coating a coating does not have the elongation properties required to bridge existing breaks. Checking is related to cracking, but the coating breaks do not extend through the entire system.

The surfaces below the HWL waterline had areas of coating defects in the form of small, isolated rust spots, but it should be noted that the most advanced coating defects below the HWL were patched during this inspection using NSF certified underwater curing epoxy.

There are many areas that have been patched underwater and it is believed that these maintenance activities will extended the life of the lining by preventing widespread undercutting corrosion from developing below the highest water level (HWL). It should be noted that underwater patches were applied during this inspection using underwater curing NSF 61 certified underwater curing epoxy. This process will prevent any coating breaks from exponentially growing in the form of undercutting.

Isolated corrosion pits can develop within a coating system that may have only a few small breaks that were not corrected through periodic maintenance repairs. If the remaining, adjacent coating has excellent adhesion, it will inhibit undercutting corrosion. As a result, the corrosion forces will have a tendency to concentrate on the exposed bare metal, which results in pitting. Pitting can be critical in some instances. The maximum corrosion rate for steel in fresh water is typically no more than 30 mils per year (MPY). As a result, the pitting can develop into a perforation if not repaired. If a thru-hole develops within a tank bottom, the isolated issue can develop into a much larger corrosion problem. Corrosion requires oxygen to advance, and the underside of the tank bottoms are considered a dead-air space. As a result, the bottom of tank floors are typically not coated. A perforation or thru-hole with even a small trickle of water will reintroduce oxygen into the environment creating active corrosion that is difficult to identify until the steel floor plate requires replacement.

Thin film epoxy systems are typically designed for 25 to 30 years of service, and the interior lining, at an estimated 20+ years of age, appears to be reaching the end of its serviceable lifespan. Therefore, it is recommended that the tank interior lining be removed and replaced within the next 3 to 5 years.

The tank ventilation was found to have screening installed without gaps or penetrations.

Recommendations

The following activities are recommended for remedial work:

Exterior:

Within the next three to five years, spot repair and overcoat the exterior coating. This work should include the following:

1) This work should include cleaning all active rust sites in accordance with SSPC's Surface Preparation Standard No. 15, "Commercial Power Tool Cleaning" followed by 4-6 mils of an industrial epoxy primer and 3-5 mils of a polyurethane finish coat.

2) Test the paint system for heavy metals to determine if any special actions are required to protect workers and the environment during paint disturbance.

Interior:

Within the next three to five years, remove and replace the interior lining. This work should include the following:

3) Remove and replace the lining system at all interior surfaces. This work should include cleaning all surfaces in accordance with SSPC's Surface Preparation Standard No. 10 "Near-White Metal Blast Cleaning" (SSPC-SP10) followed by three 4 to 6 mil coats of an NSF Certified epoxy lining.

4) Caulk all crevices in the tank such as roof lap seams.

5) Anticipate the need for minor structural repairs (welding, grinding, etc.)

6) Consider retrofitting the tank piping to include flexible couplings.

P.O. Box 801357, Santa Clarita, CA 91380
Phone: 877.274.2422 (toll free)
Fax: 661.755.7628
www.CSIServices.biz

Field Water Tank Dive Inspection Report

Tank Name:	Lodge	**Dive Supervisor:**	Steven Metcalf
Tank Owner/Client:	Kirkwood Medows PUD	**Dive Leader:**	Anthony Jackson
Client Contact:	Ashley Smith	**Dive Tender**	Steven Metclaf Jr.

Scope: Maintenance Inspection

Site Information

Item	Description
Cross Street	Kirkwood Medows Dr
Tank Location	Kirkwood Mountain Resort, Pioneer CA
GPS Coordinates	38.68084 -120.06948
Nearest Structures	None
Surrounding Site	Dirt

Item		Notes
Perimeter Fencing	No	None
Site secured on arrival	Yes	Tank Secured
Overhead Power Lines	No	None
Antenna on Tank	No	None
Roof Accessible	Yes	No Comments

Interior Structural Characteristics

Item	Data	
Roof Structure	Rafters, Girders and Seven Columns	
Column Design	Pipe	
Upper Center Column	Free Plate	
Column Base Design	Free Plate with Clips	
Connections	Welded	
Overflow Design	Through Floor	
Inlet Interior Design	Flor Stub	
Lining Type/Original	Epoxy	Yes

Item	Data			
Outlet Design	Floor Stub			
No. Interior Ladder	No	N/A		
CP System/Type	No	None		
Water Depth	30			
Water Agitator	No	None		
Barrier Walls	No			
No. of Columns	Seven Columns			
Caulking	Roof	No	Columns	No

Exterior Structural Characteristics

Item	Data	
Capacity (gallons)	500,000	
Diameter (feet)	50	
Height (feet)	32	
Erection Year	Unknown	
Contract No.	Unknown	
Tank Type	Welded Steel	
Tank Profile	on grade	
Tank Geometry	Cylinder	
Number of Courses	Four	
Height of Each Course	8 Ft	
Roof Design	Pitched Roff with Nckle	
No. Shell Manways	Two Shell Manways	
Type of Manways	Round	
Manway Cover Design	Bolted Circle	
Diameter of Manways	20 in	
No. Roof Hatches/Location	One	Near Edge
Hatch Design	Square Shoebox	
Size of Roof Hatch	24 in	
No. Roof Vents/Location	Two	Center and Near Edge
Roof Vent Design	Bent Pipe and Round Hood	
Construction Co.	Unknown	

Item	Data	
Center Roof Vent Size	18 in	
Roof Vent Sealed	Yes	Satisfactory
Roof Rail System	Yes	Corral
Roof Rail Satisfactory	Yes	No Comments
Rail Location	Top Of Ladder	
No. & Type Roof Access	One	Ladder
Exterior Vandal Deterrent	Yes	
Ext Ladder Satisfactory	One	Yes
Ext Ladder Fall Prevent	Yes	
Roof Tie-Off Present	Yes	
Tank Piping	Floor Inlet and Outlet	
Inlet Diameter	8 in	
Outlet Diameter	8 in	
Flexible Pipe Coupling	N/A	
Overflow Pipe Diameter	8 in	
Overflow Exterior Design	To Ground	
Drain Location	Floor	
Tank Foundation	Concrete Ringwall with Anchors	
Water Level Indicator	Yes	
Tank Type	Potable	
Lining Type/Original	Polyurethane	Yes

Miscellaneous Notes

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -001

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -002

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -003

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -004

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -005

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -006

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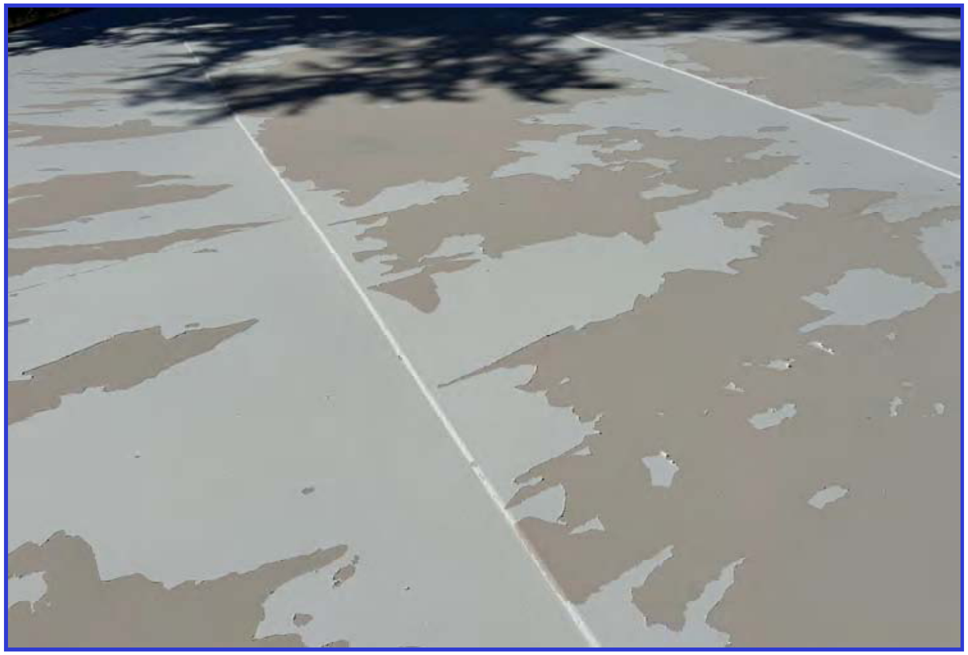
EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -009

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -010

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -011

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -012

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -013



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EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -021

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -022

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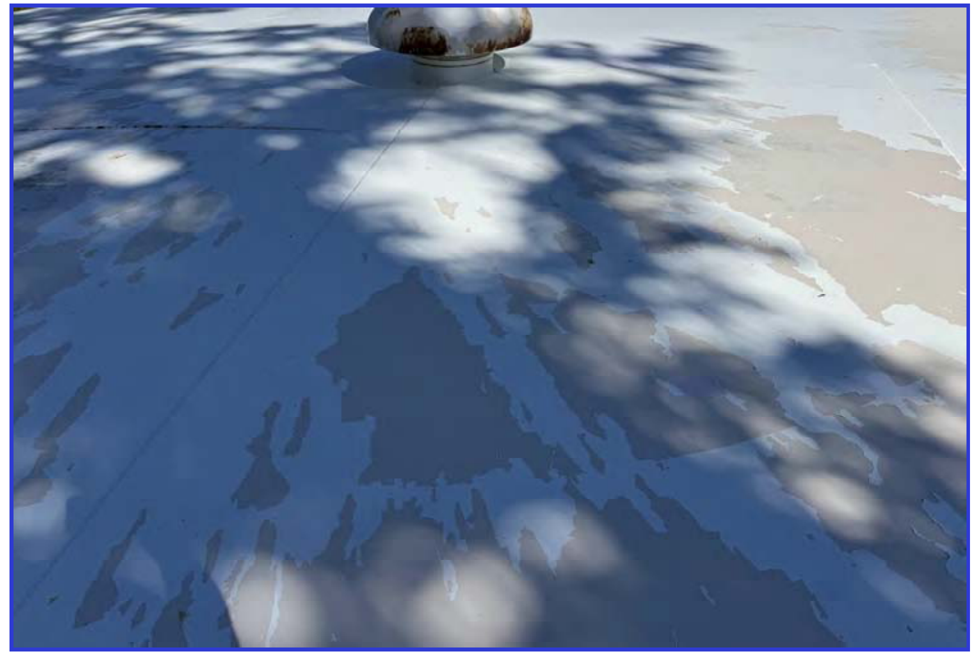
EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -024



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EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -028

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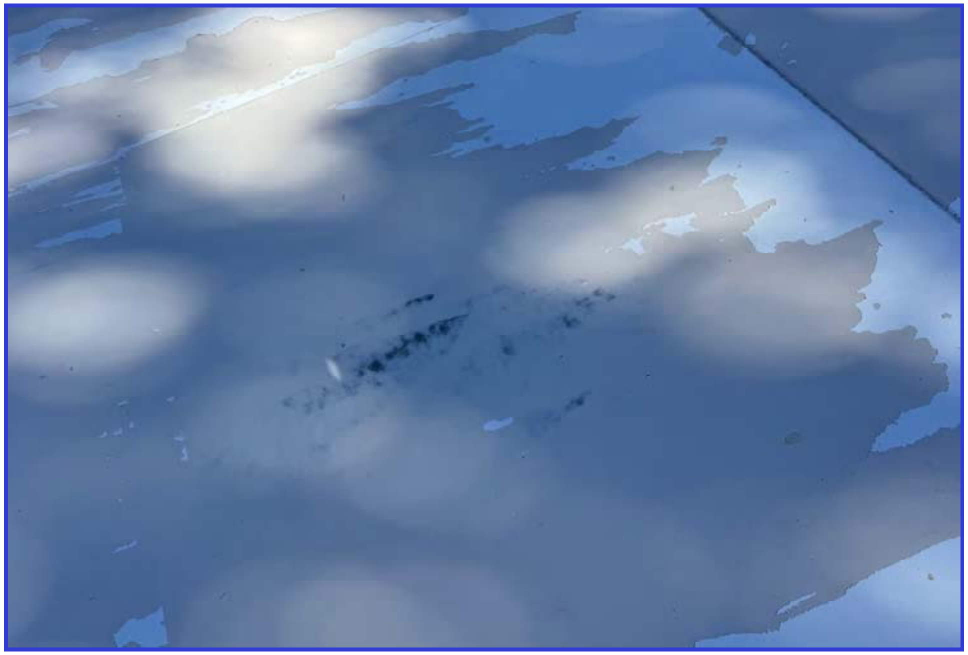
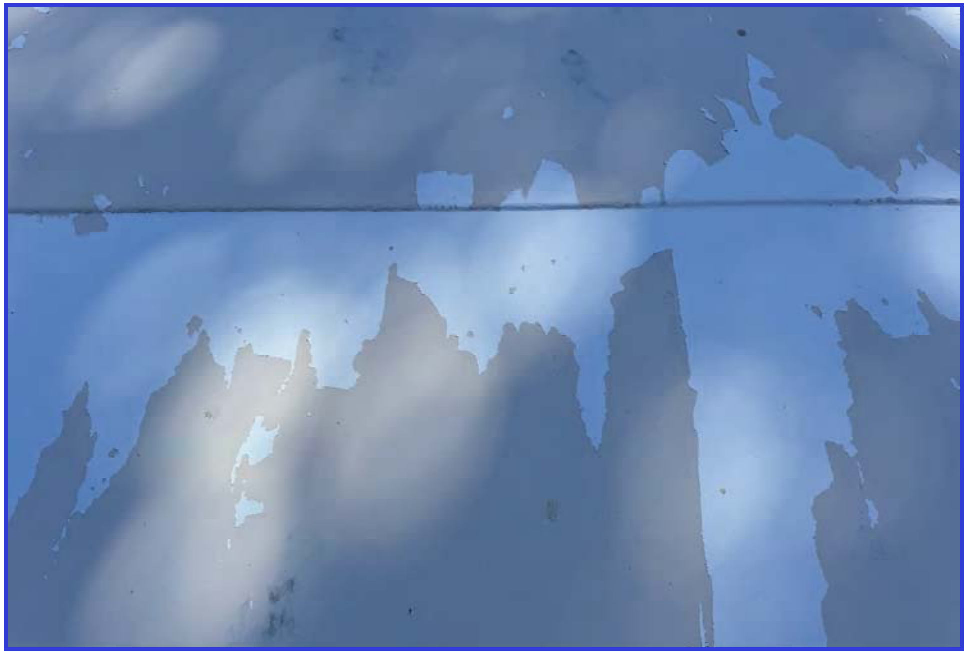
EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -030



EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -031



EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -032

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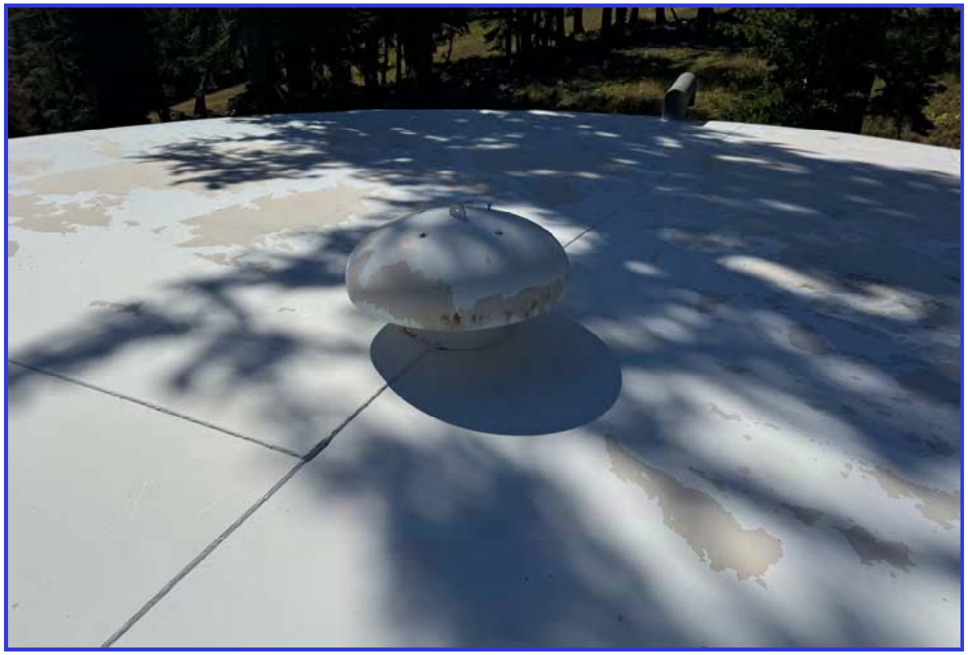
EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -037



EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -038

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EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -041


EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -042


EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -043

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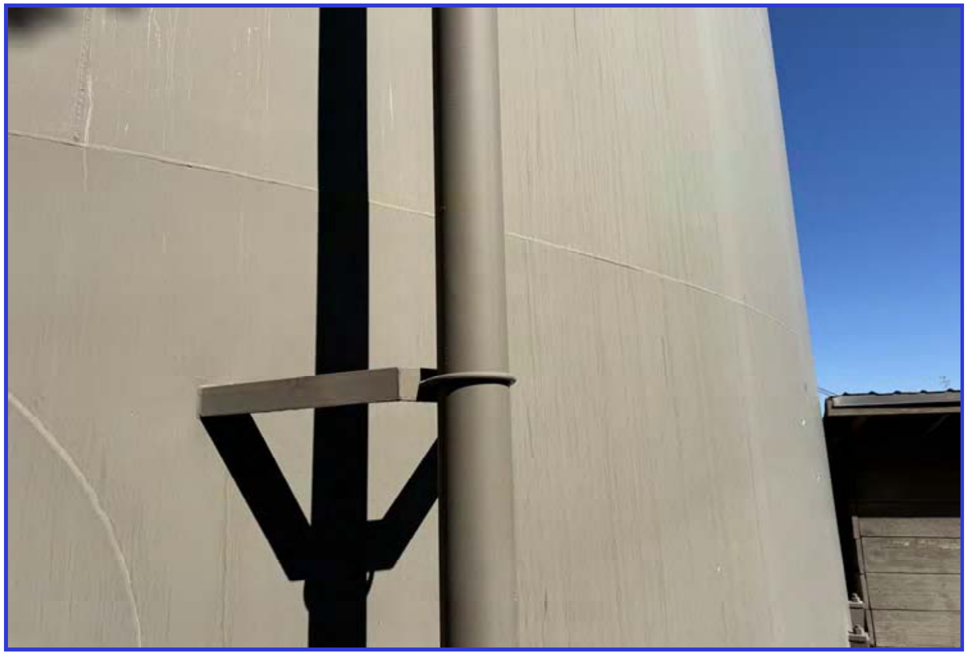

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -060

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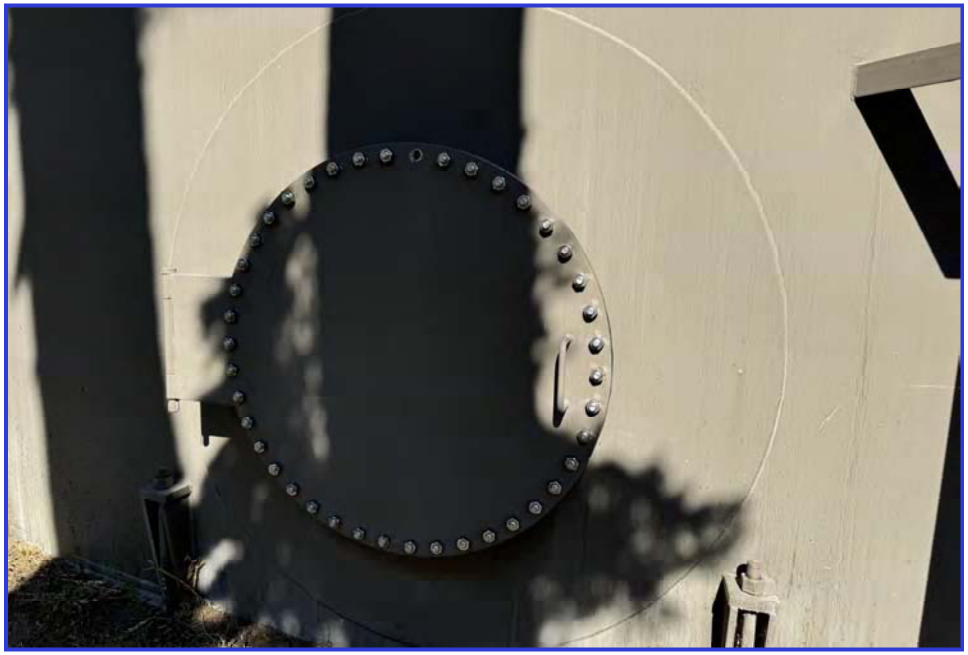

EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -063


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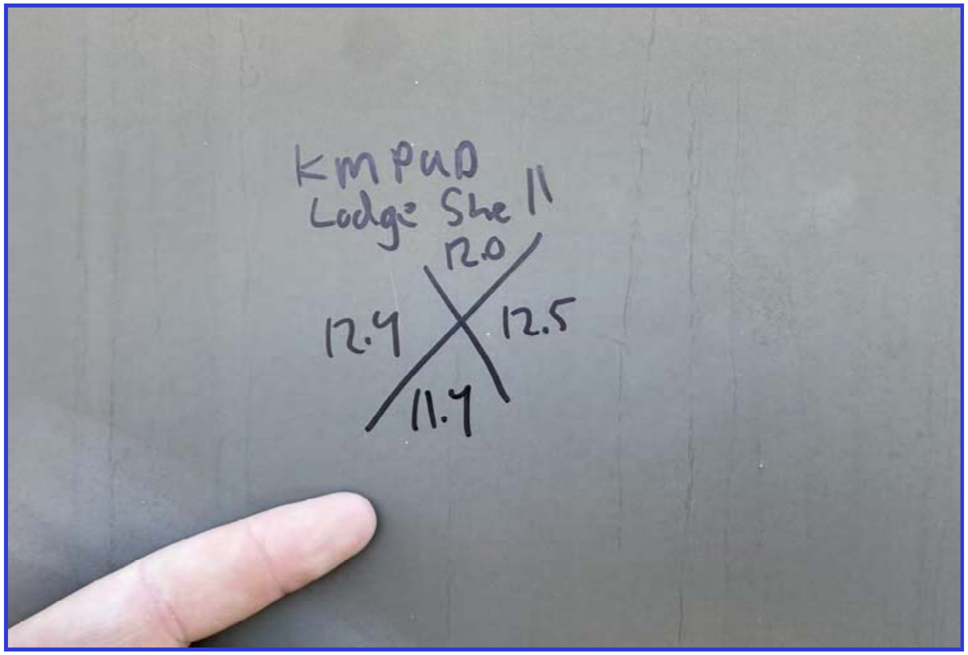
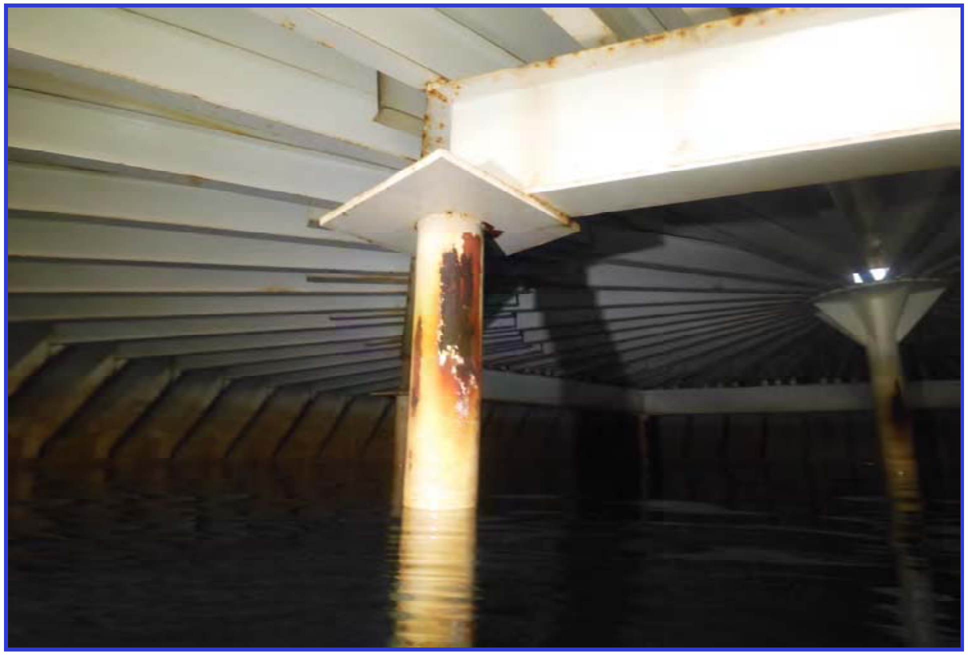


EXTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -087

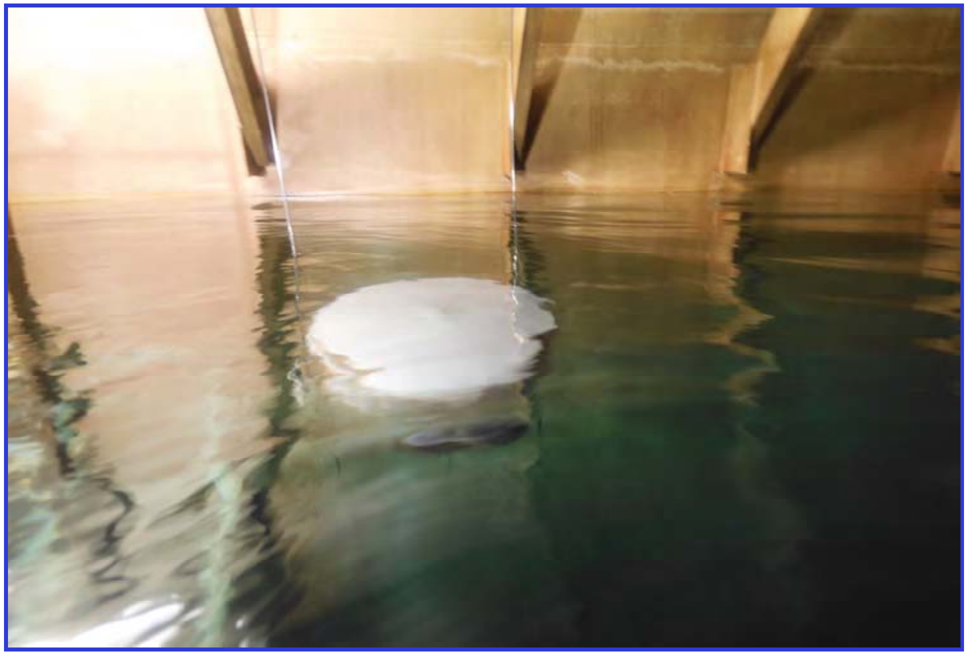
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -001

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -002

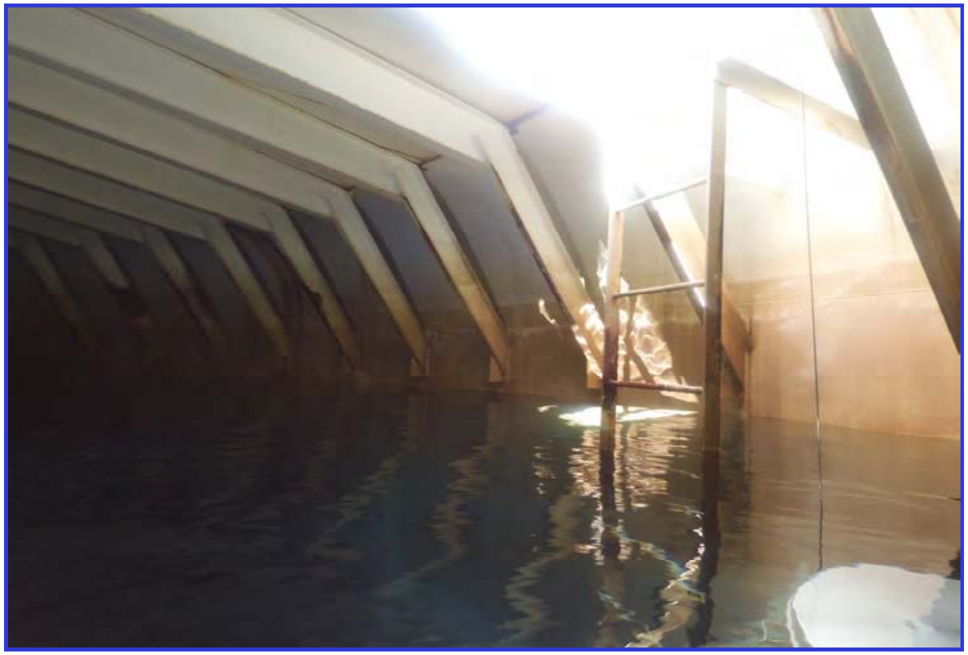


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -003



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -004

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -005



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -006

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -007

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -008

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -009

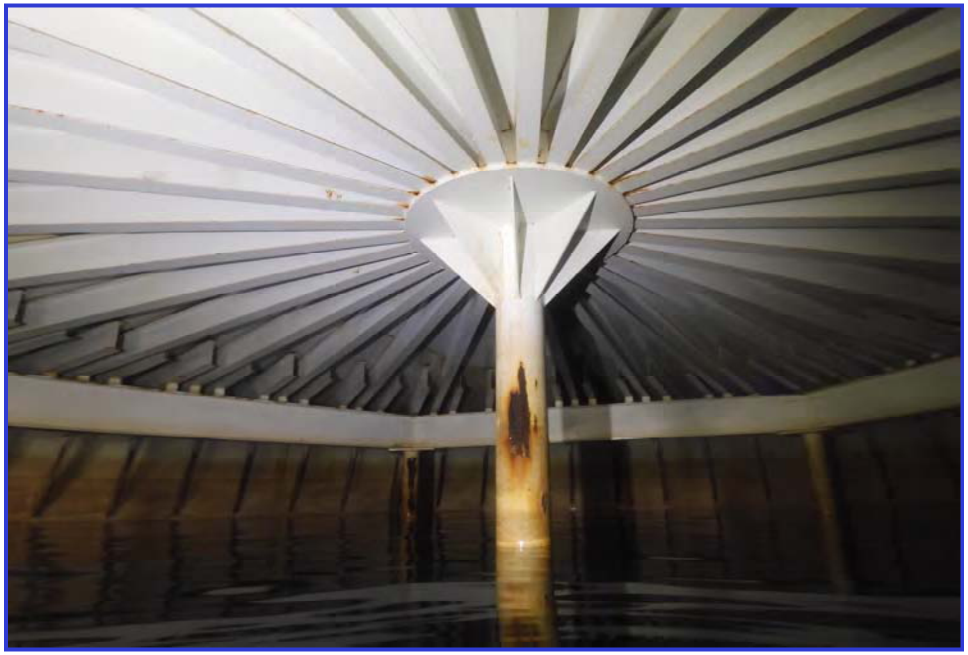
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -010

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -011

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -012

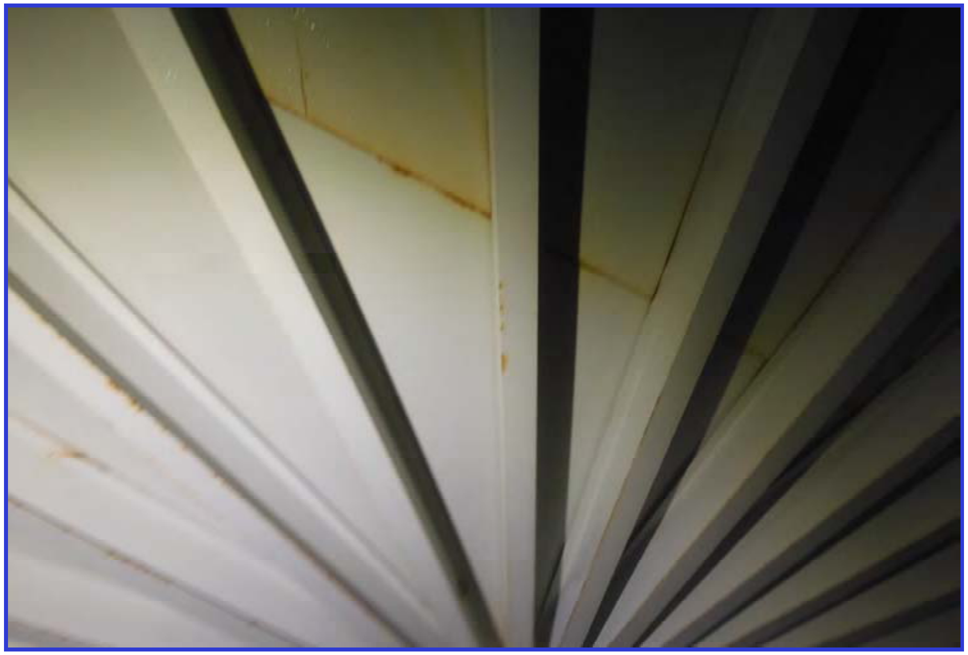
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -013

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -014



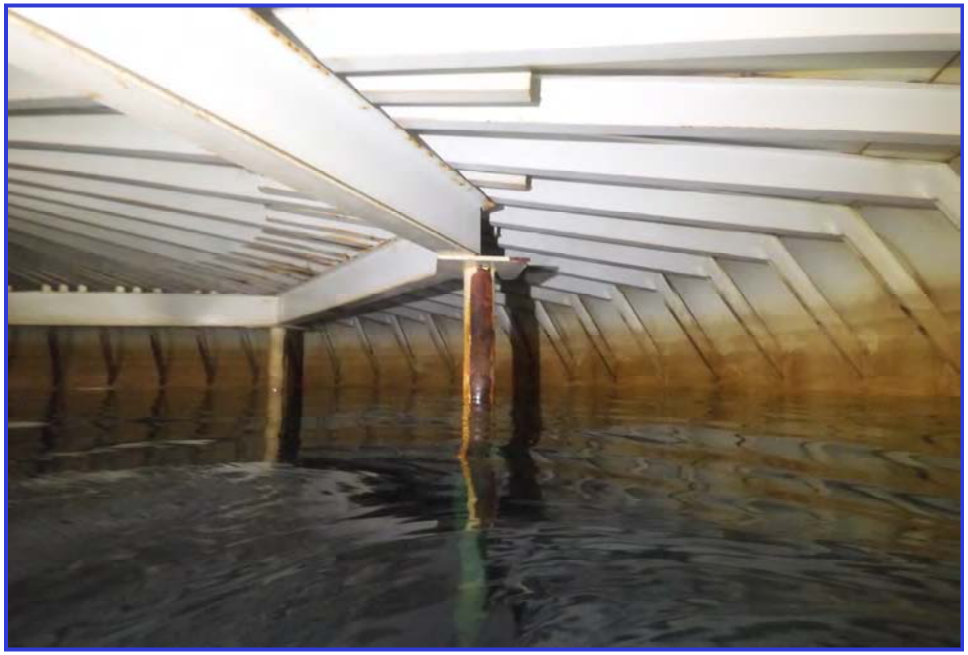
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -015

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -016



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -017

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -018



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -019

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -020

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -021

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -022

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -023

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -024

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -025

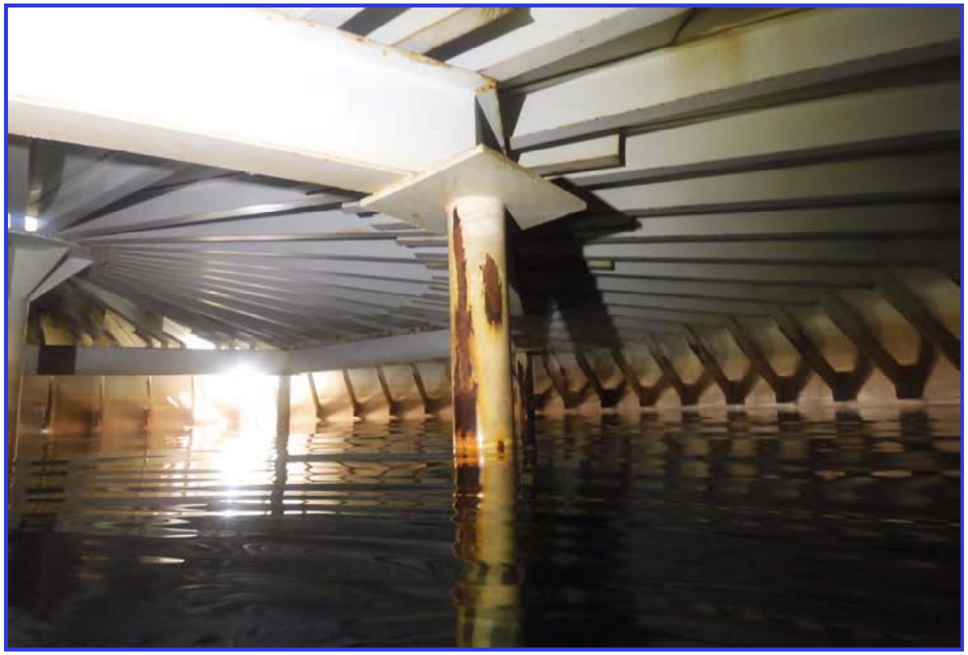
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -026

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -027

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -028

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -029

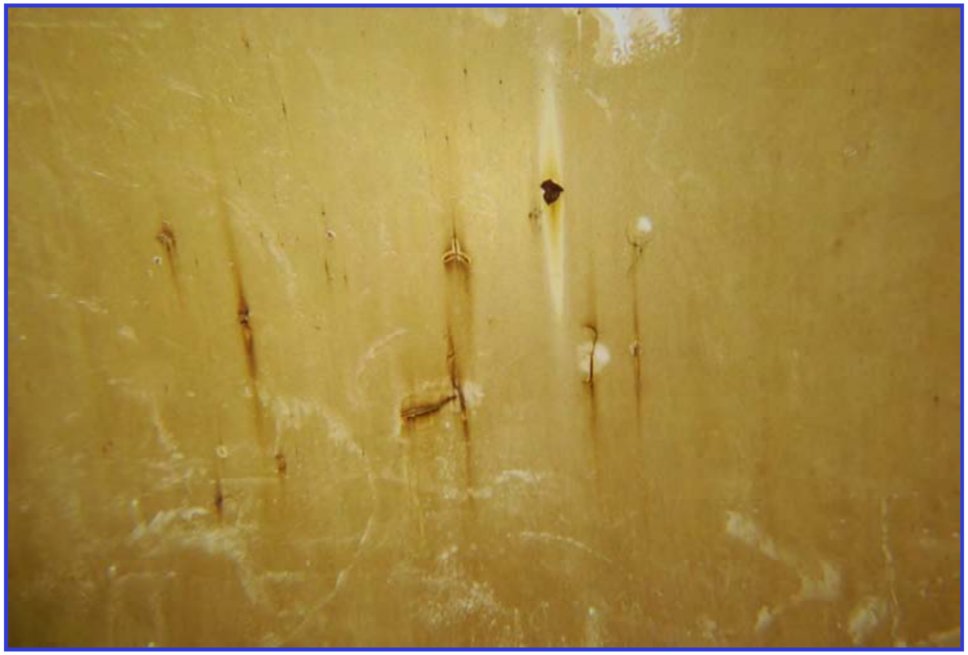
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -030



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -031

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -032

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -033

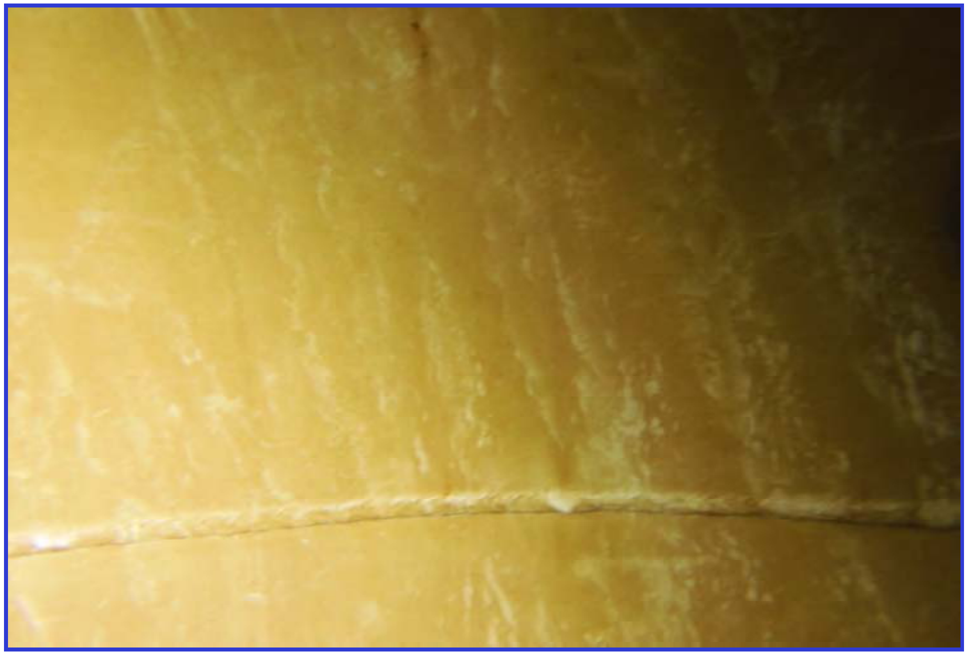


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -034

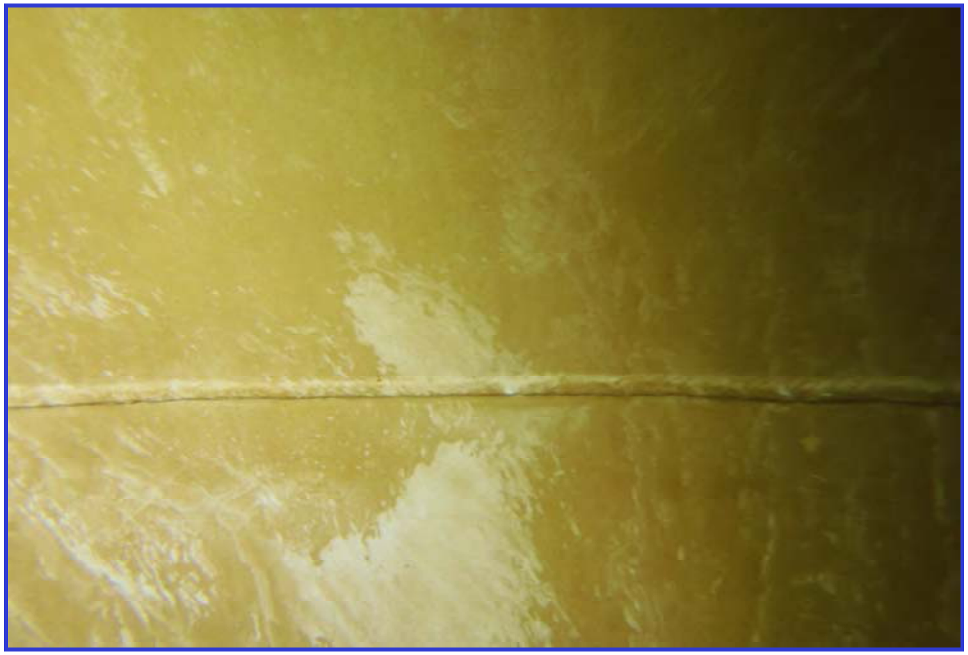
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -035

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -036

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -037



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -038

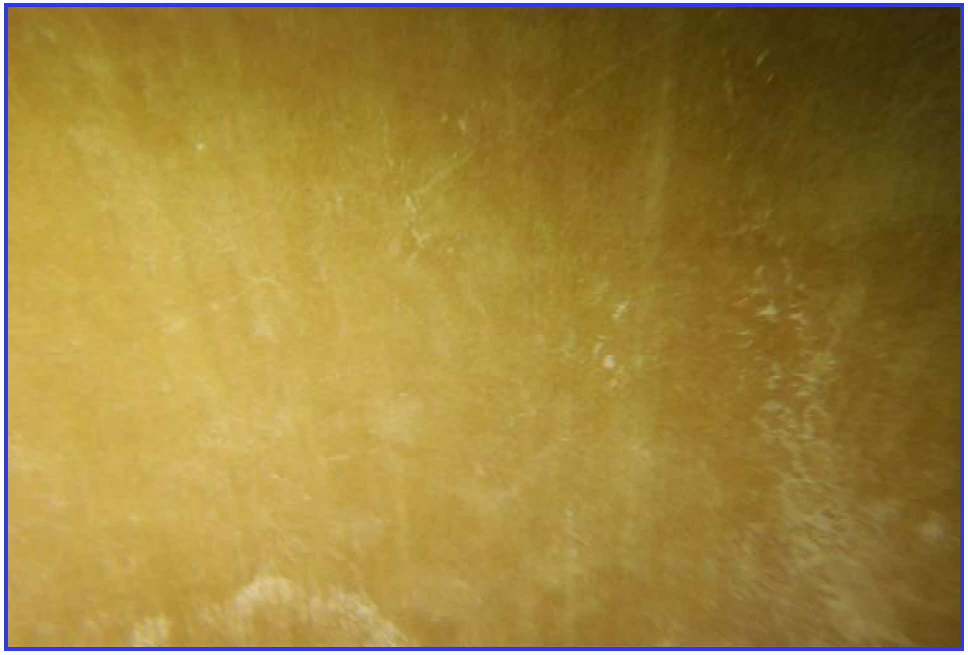


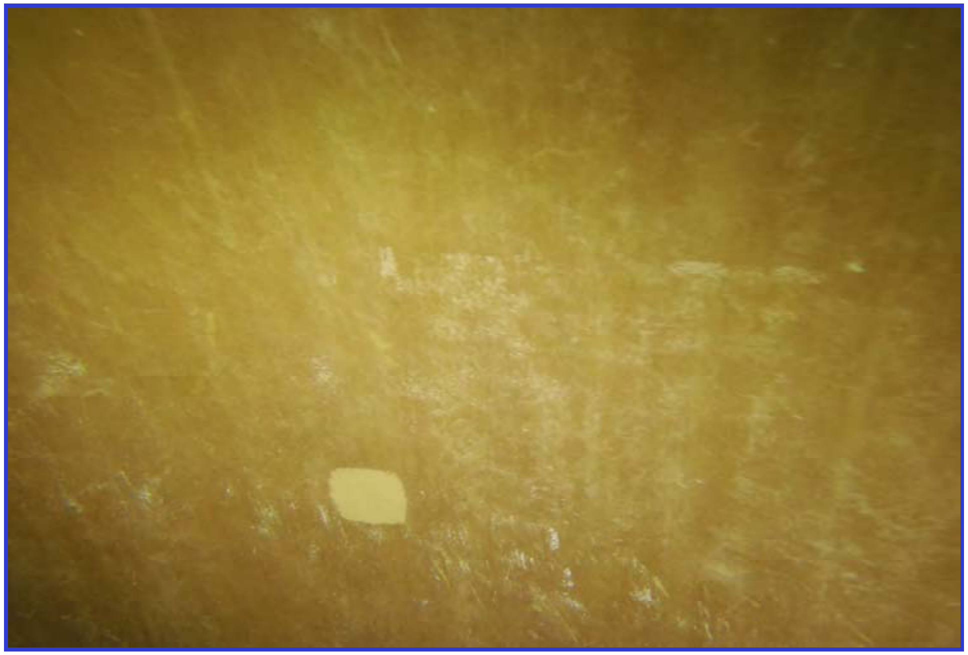
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -039


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -040


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -041


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -042

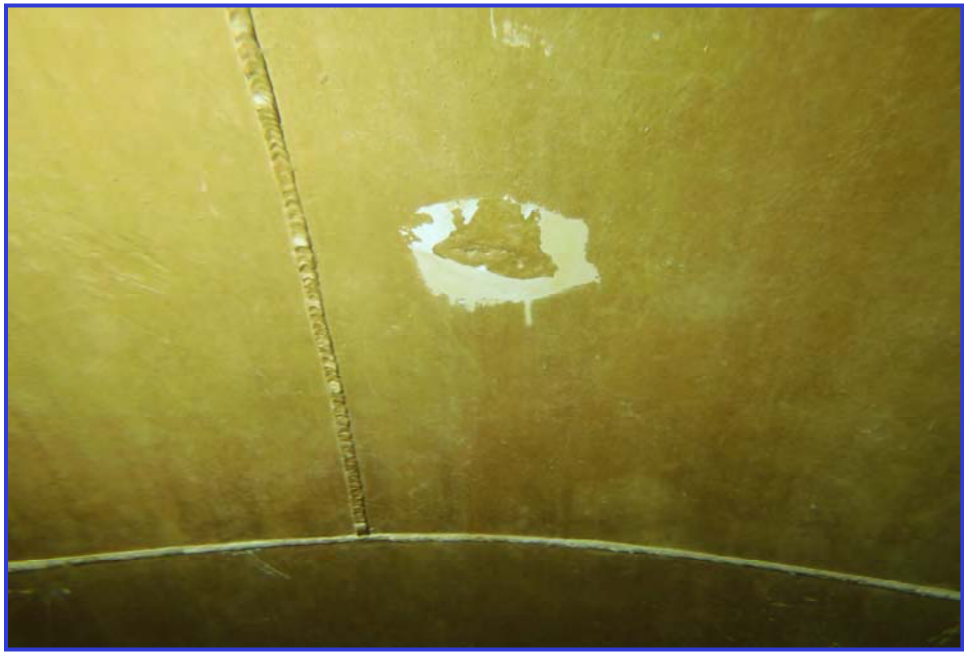

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -043



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -044

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -045

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -046



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -047

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -048

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -049

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -050

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -051

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -052

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -053

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -054

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -055

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -056

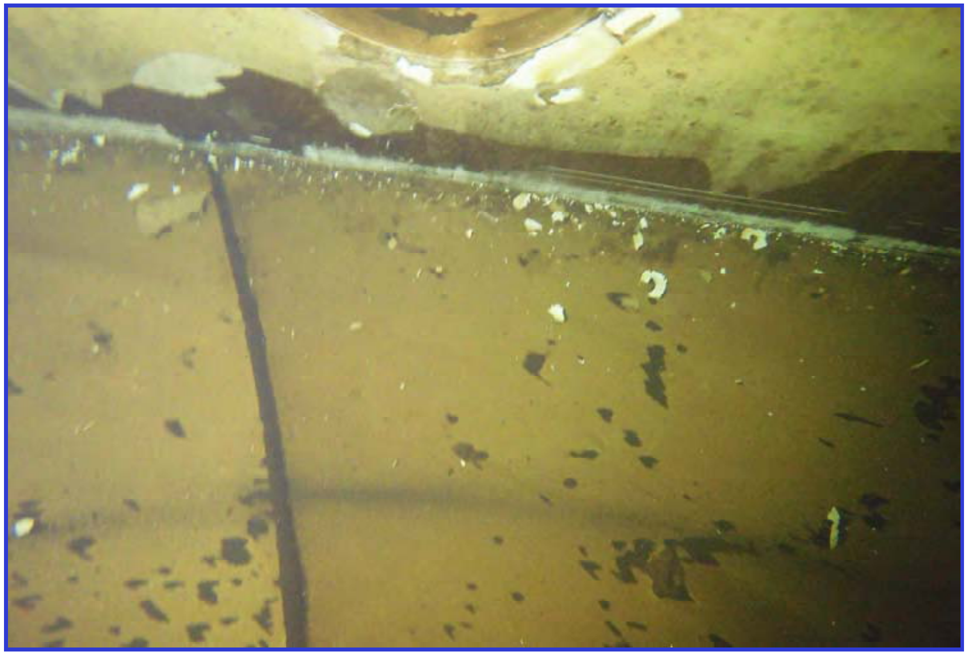
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -057

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -058

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -059

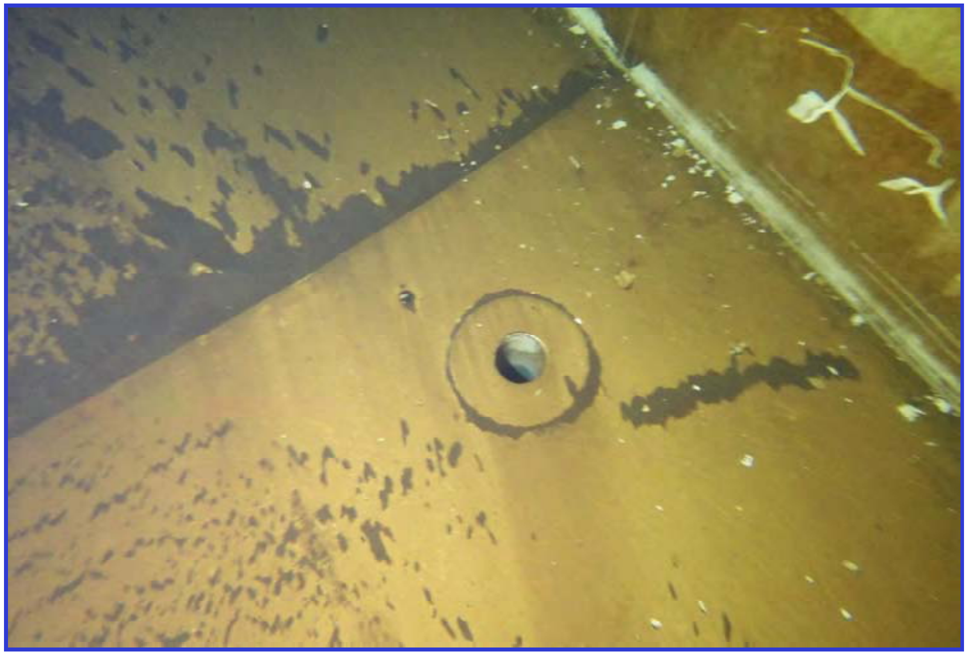
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -060

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -061



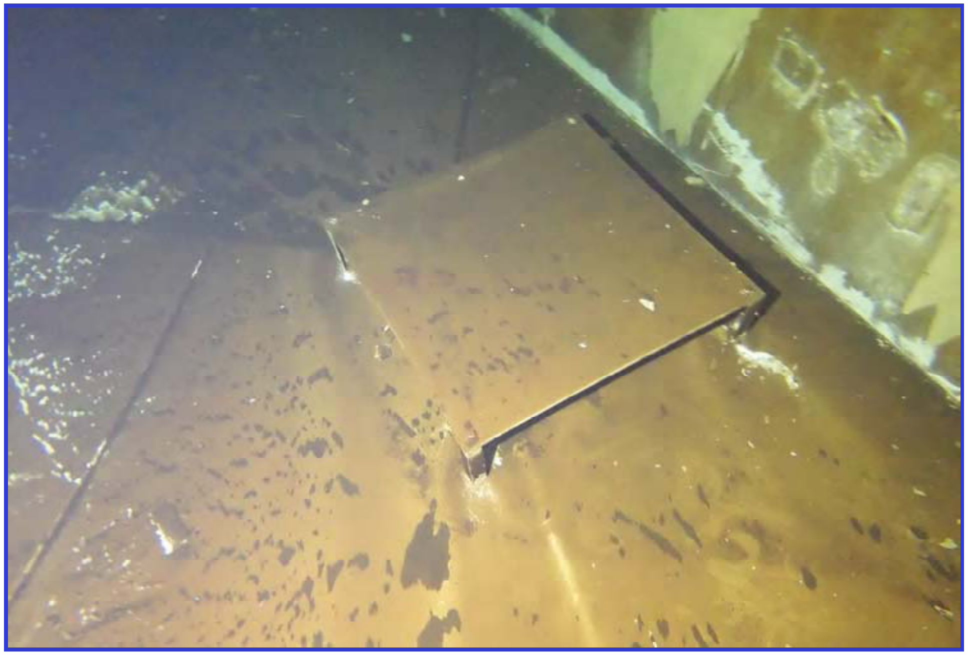
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -062

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -063



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -064

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -065



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -066

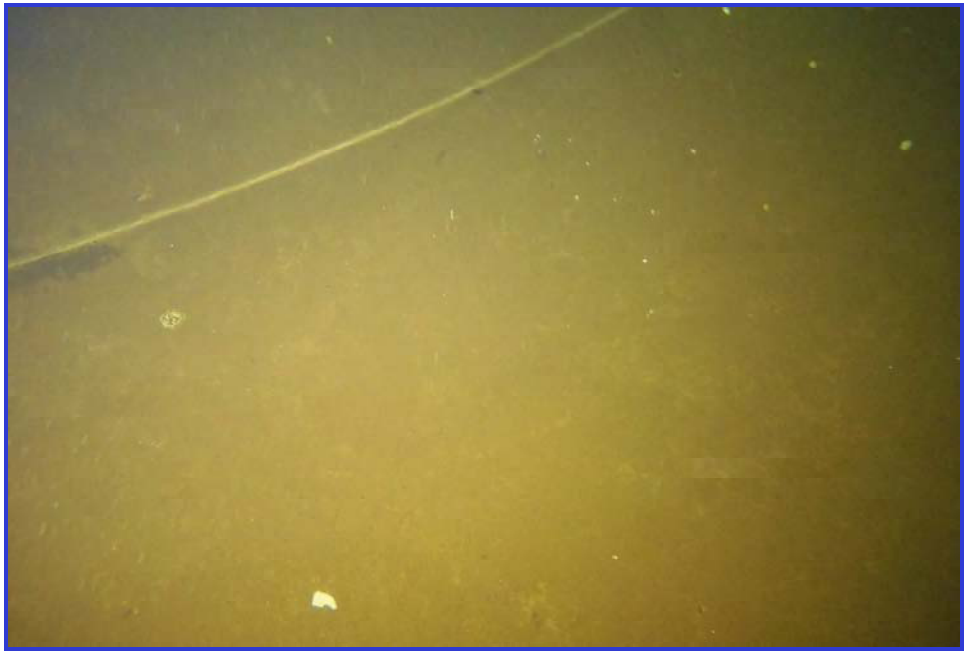
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -067

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -068

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -069

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -070

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -071

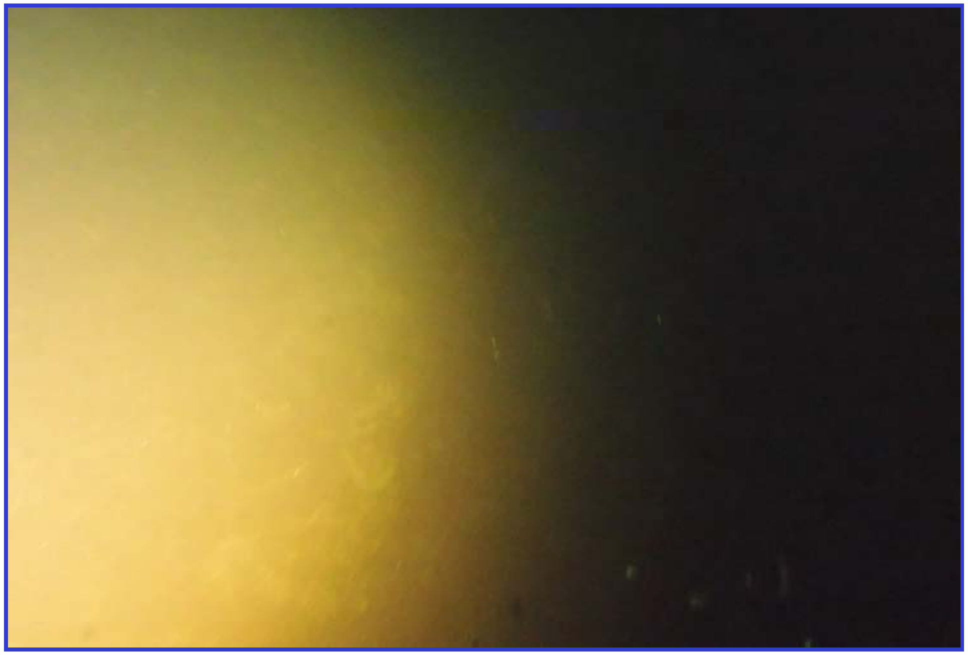


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -072

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -073

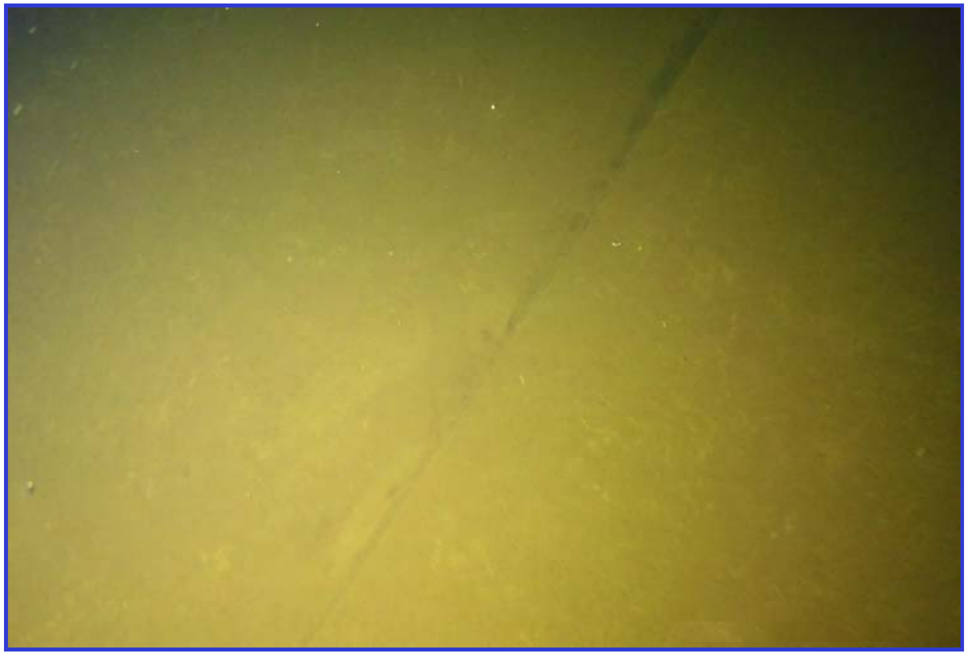
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -074

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -075

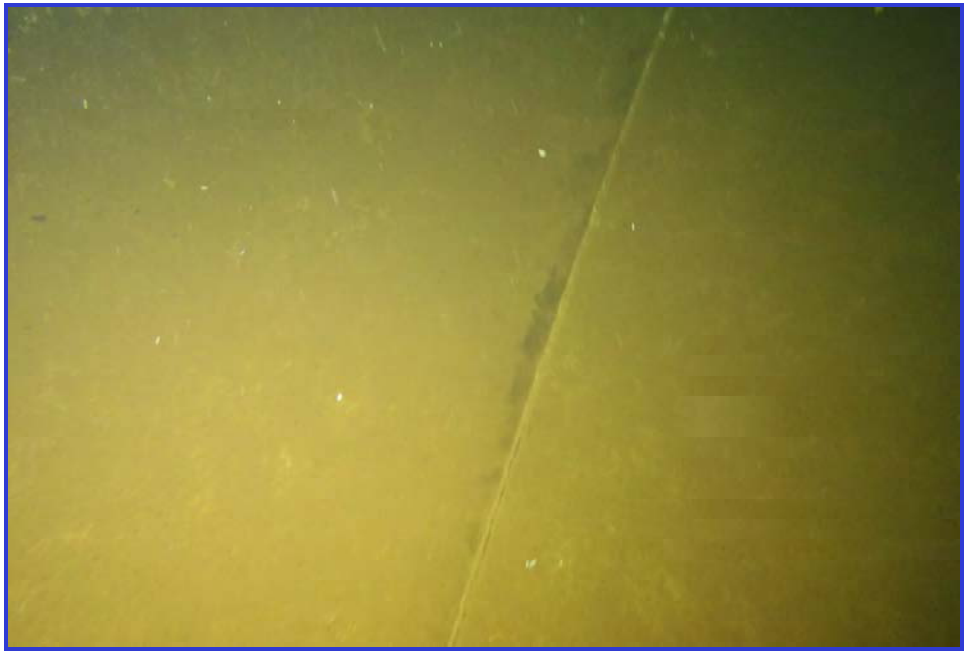


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -076

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -077

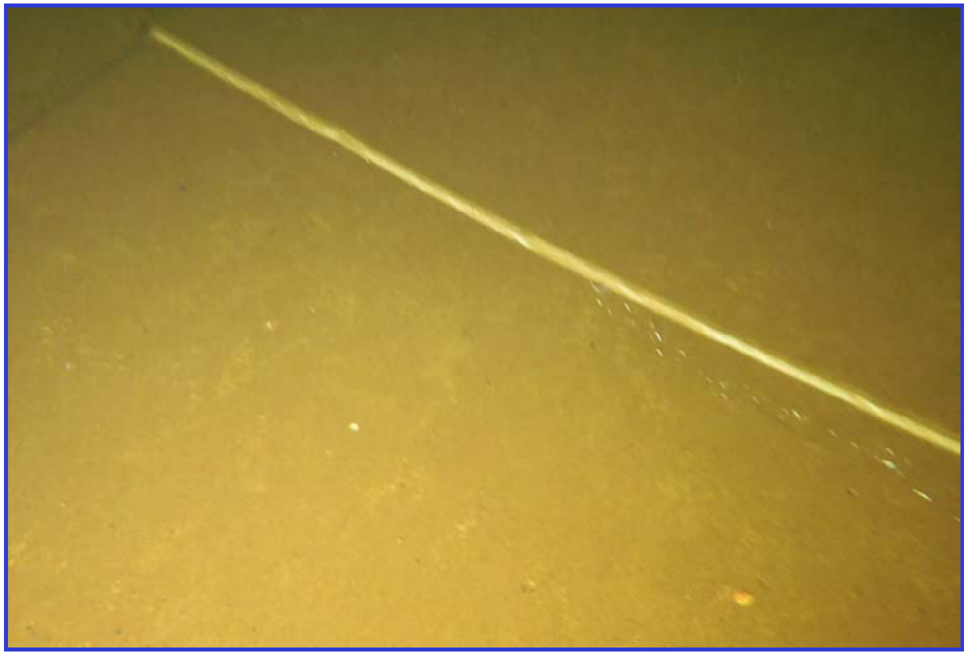


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -078



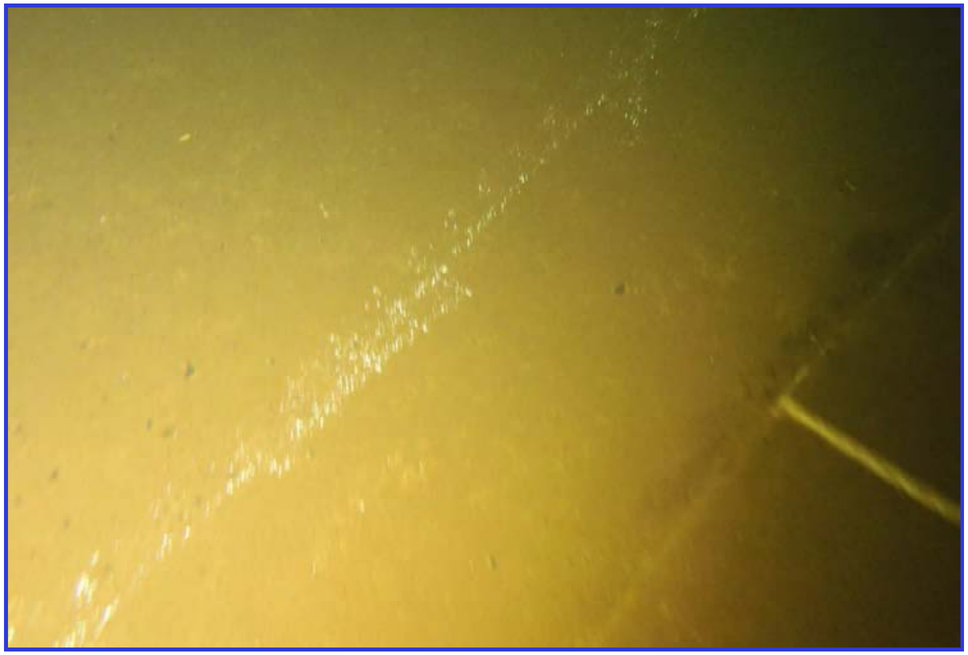
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -079

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -080

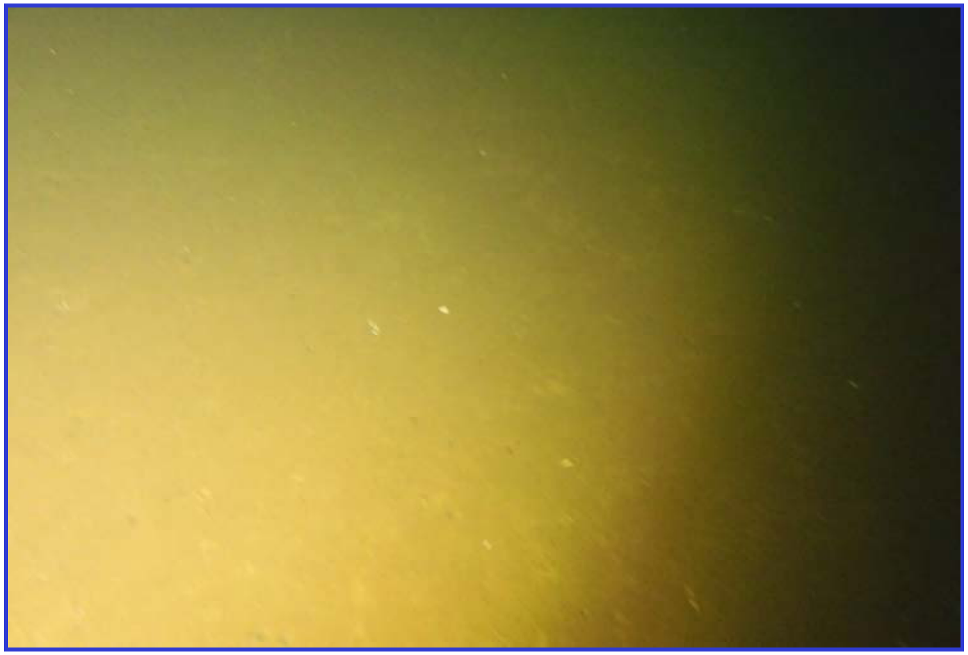


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -081

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -082



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -083



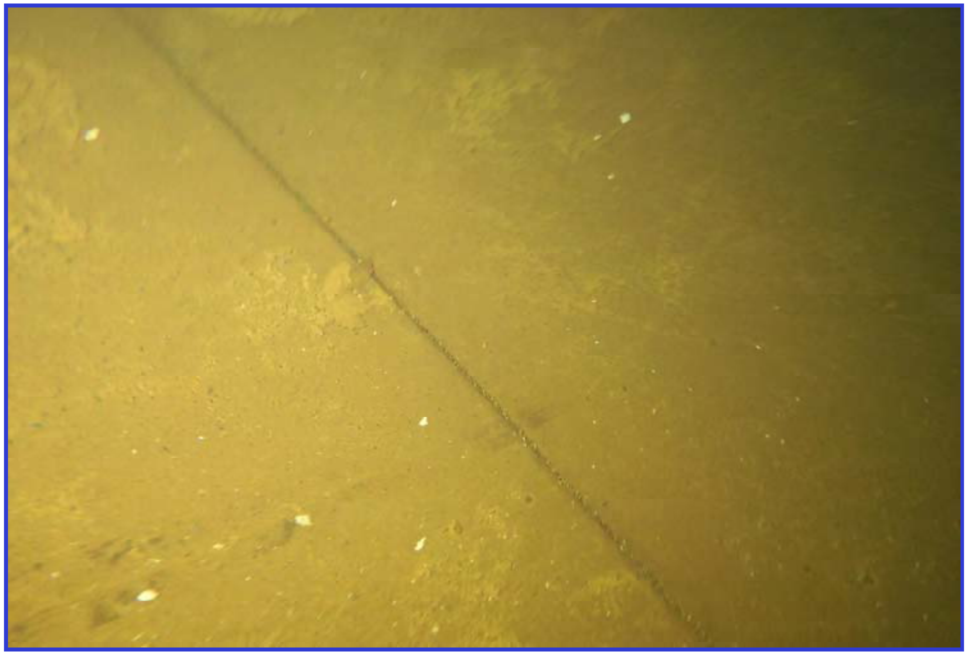
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -084

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -085

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -086

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -087

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -088

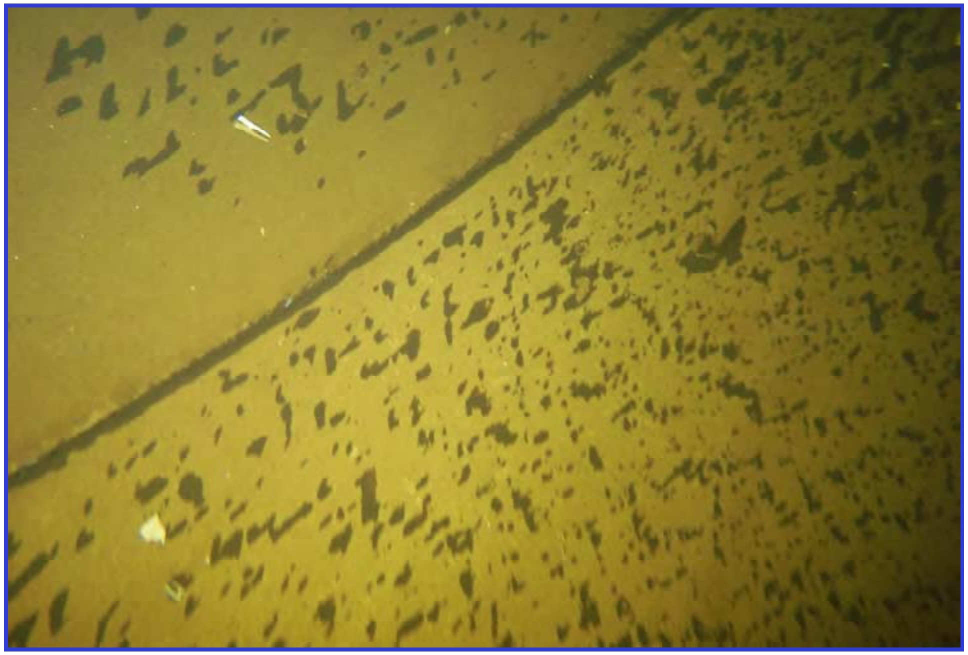


INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -089

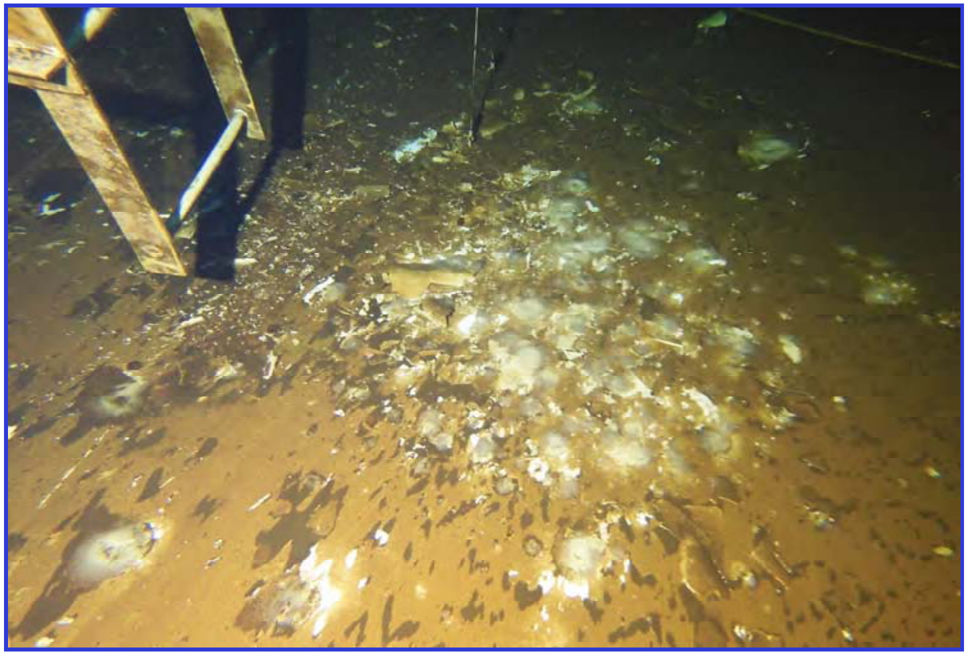
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -090

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -091

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -092



INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -093



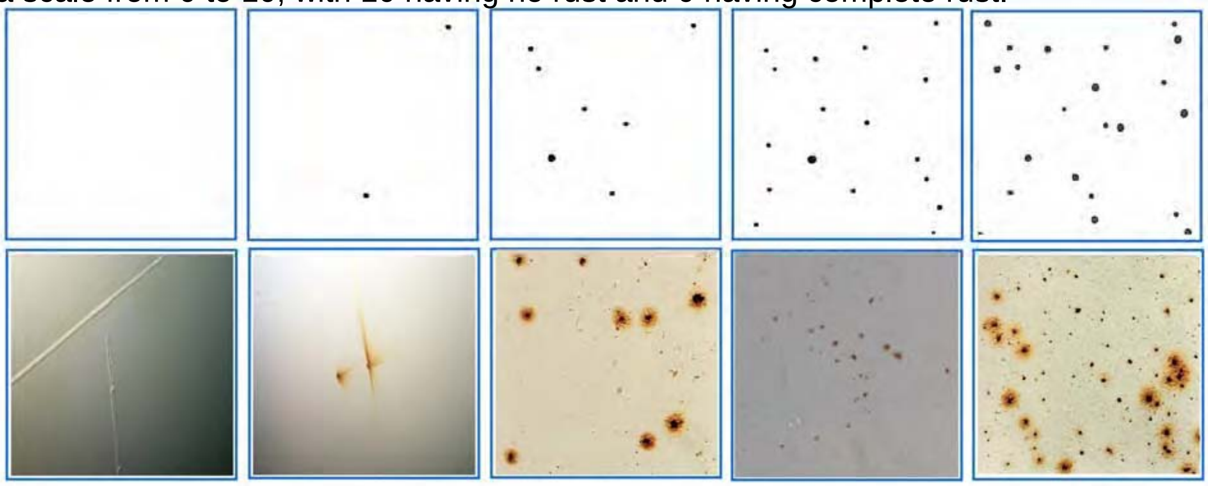
INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -094

INTERIOR - Kirkwood Medows PUD - Lodge Tank - Maintenance Inspection -095

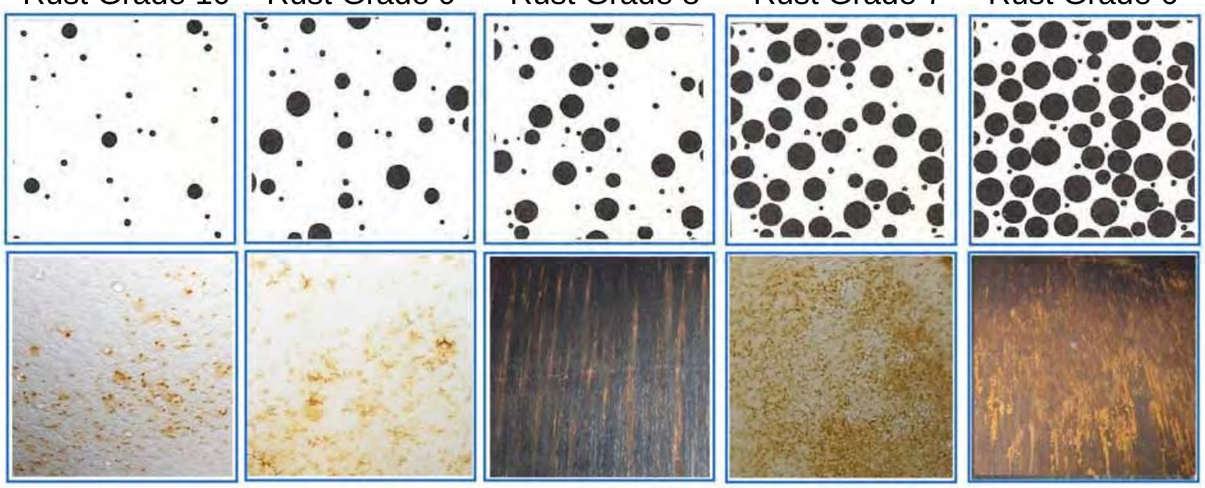
Chart 1 - Condition Rating The table below gives a basic description of the four different categories that CSI Services, Inc. uses to provide a general depiction of the condition of each defined area of a structure. The categories are Poor, Fair, Good, or Excellent. The development of these categories is based on historical knowledge and experience of various paint and lining systems over given periods of time in certain service environments. Basically, the rating is determined based on what should be expected of the paint or lining system at that point in its life cycle. As a result, different determinations are made for maintenance inspection versus warranty inspections. A detailed description of each rating with relative consideration addressed follows:

Rating	General Description of Conditions	
	Maintenance Inspection	Warranty Inspection
Poor	This condition is usually prioritized for rework in the short-term. Typically, these surfaces have considerably more coating defects and/or corrosion than what is expected for the age of the system.	This condition identifies an area with wholesale coating defects or corrosion concerns that will typically require significant removal and replacement of the coatings in the area.
Fair	Typically, these surfaces have a level of coating defects and/or corrosion that is slightly worse than what should be expected for the age of the system. This condition is placed on a short-term monitoring schedule.	This condition identifies an area with partial coating defects or corrosion concerns that will require significant rework.
Good	This condition is rated for areas without any considerable coating defects or corrosion. These surfaces are in a condition that is typical for the age of the coating system.	This condition identifies areas with coating defects or corrosion that is typically seen in one-year warranty inspections. Typically, only minor spot repairs are required.
Excellent	This condition is for areas without any considerable coating defects or corrosion. Typically, these surfaces are in a condition that is better than expected for the age of the system.	This condition identified areas that typically are in perfect condition and require no repair work.

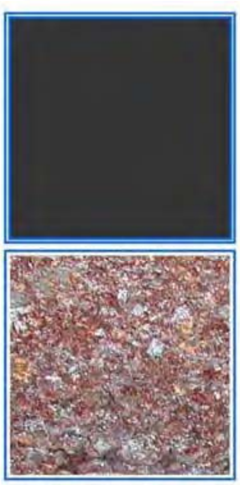
Chart 2 -Rust Grade The black and white figures below depict the standards referenced in ASTM D610 “Standard Test Method for Evaluating Degree of Rusting on Painted Surfaces.” Below each standard is a photographic depiction of each level of corrosion, as used by CSI Services, Inc. The standards depict the percentage of rust on a scale from 0 to 10, with 10 having no rust and 0 having complete rust.



Rust Grade 10 Rust Grade 9 Rust Grade 8 Rust Grade 7 Rust Grade 6



Rust Grade 5 Rust Grade 4 Rust Grade 3 Rust Grade 2 Rust Grade 1



Rust Grade 0

Rust Grade	Description
10	No rusting or less than 0.01% of surface rusted
9	Minute rusting, less than 0.03% of surface rusted
8	Few isolated rust spots, less than 0.1% of surface rusted
7	Less than 0.3% of surface rusted
6	Excessive rust spots, but less than1% of surface rusted
5	Rusting to the extent of 3% of surface rusted
4	Rusting to the extent of 10% of surface rusted
3	Approximately one-sixth of the surface rusted
2	Approximately one-third of the surface rusted
1	Approximately one-half of the surface rusted
0	Approximately 100% of the surface rusted

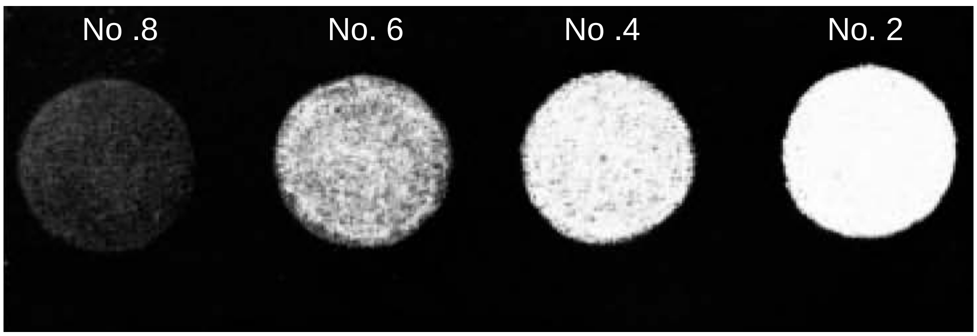
Chart 3 - Corrosion Grade The figure below depicts the photographic standards referenced by CSI Services, Inc. in the determination of the characteristics and stages of corrosion progression. This standard is used to better quantify the level of corrosion once it has progressed to Rust Grades 3, 2, 1, or 0 (see Chart 2). When applicable, CSI classifies an area as one or more of the five different Corrosion Grades. Corrosion Grades 1 through 5 are described below:

Grade	Description	Photo Examples
1	Light Rust - This condition involves relatively light colored rust that does not have any significant metal loss.	 
2	Dark Rust -This condition involves relatively dark colored, thicker rust that is progressing towards the next phase, significant metal loss.	 
3	Pitting - This condition involves isolated or widespread deep spot corrosion (pitting).	  
4	Scale - Also known as lamellar or exfoliation corrosion. The edges of the affected area are leaf like and resemble the separated pages of a wetted book.	 
5	Structural Loss - This condition involves metal loss or failure where components will require structural consideration	 

The photos depicted are examples and were not taken on this project.

Chart 4 - Chalking The figure below depicts the photographic standards referenced in ASTM D4214 “Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films,” Method D659, Method C. Generally speaking, chalking is the degradation of a paint’s binder leaving behind loose pigments as the binder reacts with the environment, primarily ultraviolet light and oxygen. Evaluating chalking is a means to measure the performance of a coating system and its life cycle projection. It is also important to quantify for consideration of future overcoating options. This test uses these pictorial standards to quantify the amount of chalking present on paint films. The depictions below represent the mount of colored chalk removed onto a cloth during the test. The scale ranges from 2 to 8 with the rating 2 having the most chalk.

Light Colored Paints



Dark Colored Paints

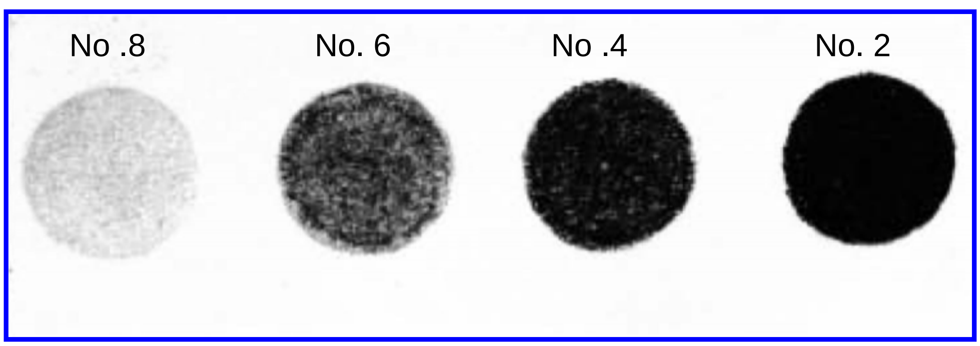
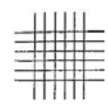
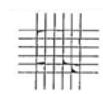
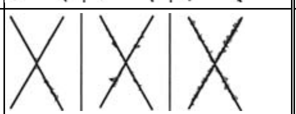
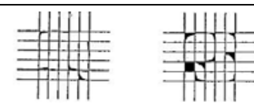
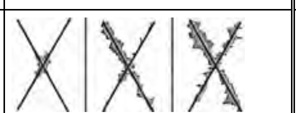
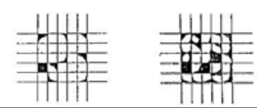
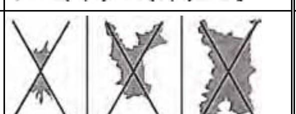
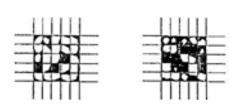
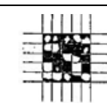
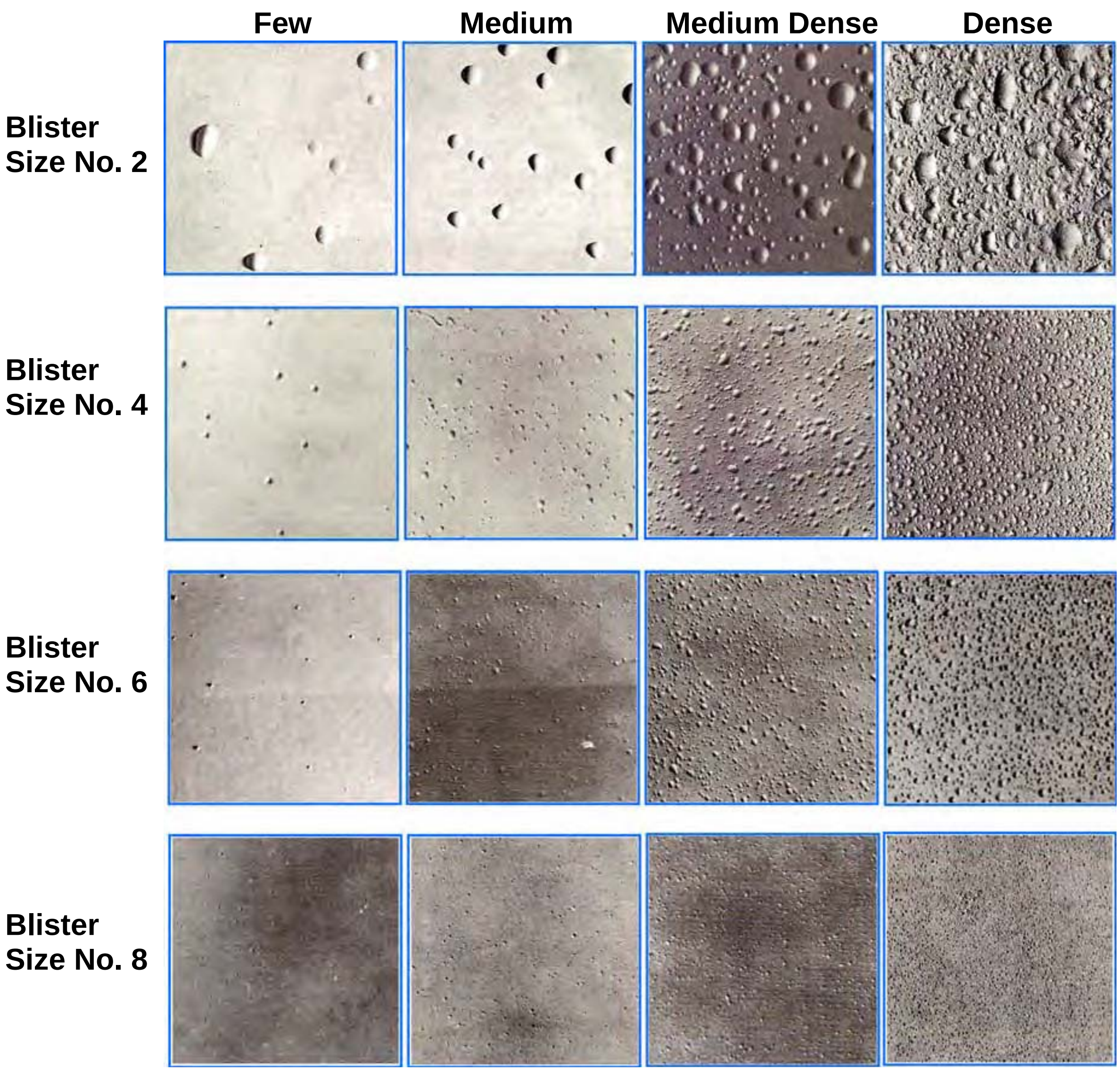


Chart 5 - Adhesion Rating The figures below depict the photographic standards and criteria referenced in ASTM D3359 “Standard Test Method for Evaluating Adhesion by Tape Test” and ASTM D6677 “Standard Test Method for Evaluating Adhesion by Knife.” Both Standards are used to assess the condition of a paint system for life-cycle projections. It is also used to evaluate an existing paint system’s ability to withstand the added stress that any overcoating strategies can create. Depending upon the thickness of the paint system, ASTM D3359 has two different test methods. The rating criteria for both standards follow:

ASTM D3359					
Method A			Method B		
Rating	**Observation**	**Surface of X-cut from which flaking/peeling has occurred**	**Rating**	**Percent Area Removed**	**Surface of cross-cut area from which flaking has occurred for six parallel cuts and adhesion range by percent**
5A	No peeling or removal	None	5B	0% none	
4A	Trace peeling or removal along incisions or their intersection		4B	Less than 5%	
3A	Jagged Removal along incisions up to 1/16” on either side		3B	5 – 15%	
2A	Jagged removal along most of incisions up to 1/8” on either side		2B	15 – 35%	
1A	Removal from most of the area of the X under the tape		1B	35-65%	
0A	Removal beyond the area of the X		0B	Greater than 65%	

ASTM D6677	
Rating	Description
10	Fragments no larger than $\frac{1}{32}$” x $\frac{1}{32}$” can be removed with difficulty
8	Chips up to $\frac{1}{8}$” x $\frac{1}{8}$” can be removed with difficulty
6	Chips up to $\frac{1}{4}$” x $\frac{1}{4}$” can be removed with slight difficulty
4	Chips larger than $\frac{1}{4}$” x $\frac{1}{4}$” can be removed with slight pressure
2	Once coating removal is initiated by knife, it can be peeled at least $\frac{1}{4}$”
0	Coating can be peeled easily to length greater than $\frac{1}{4}$”

Chart 6 – Blistering Rating The figure below depicts the photographic standards referenced in ASTM D714 "Standard Test Method for Evaluating Degree of Blistering of Paints". This test uses these pictorial standards to quantify both the size and density of blisters that may develop in linings. Although the standard uses a blister size scale of 0 to 10 this chart uses the most common sizes of blisters found in the field. The standard does not use a reference for the size of each of the blisters depicted. CSI used this scale as a means for further quantification by qualifying the largest blister depicted as being 1 inch in width (Blister Size No. 2) and the smallest blister being 1/32 of an inch in width (Blister Size No. 8).



Appendix B

Existing Available Fire Flow Results

Existing Fireflow Results

ID	Static Demand (gpm)	Static Pressure (p	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)
0 J-1	0.4	42.71	8,068.76	1,500.00	9.37	1,218.48	20
0 J-10	0.05	95.80	7,976.55	1,500.00	81.70	2,815.58	20
0 J-11	0.11	95.80	7,976.55	1,500.00	85.46	2,978.84	20
0 J-12	0.56	98.83	7,976.55	1,500.00	66.22	2,228.19	20
0 J-13	0.25	100.13	7,976.55	1,500.00	94.42	3,282.88	20
0 J-14	0.05	141.72	8,067.73	1,500.00	109.40	3,461.68	20
0 J-15	0.17	143.88	8,067.71	1,500.00	112.43	3,558.52	20
0 J-16	0.51	119.13	8,067.48	1,500.00	84.41	2,872.18	20
0 J-17	0.31	104.85	8,067.46	1,500.00	69.98	2,611.71	20
0 J-18	0.9	78.88	8,067.40	1,500.00	44.79	2,099.18	20
0 J-19	0.68	110.85	8,067.34	1,500.00	79.38	2,802.71	20
0 J-2	0.08	57.16	8,057.19	1,500.00	7.33	1,285.36	20
0 J-20	1.84	118.61	8,067.28	1,500.00	84.18	2,751.29	20
0 J-21	0.95	117.76	8,067.33	1,500.00	85.73	2,853.22	20
0 J-22	1.61	117.76	8,067.33	1,500.00	86.46	2,902.32	20
0 J-23	1.24	117.76	8,067.33	1,500.00	84.49	2,795.99	20
0 J-26	1.46	126.53	8,067.61	1,500.00	95.45	3,263.45	20
0 J-27	0.26	122.10	8,067.35	1,500.00	93.11	3,032.90	20
0 J-28	0.93	117.73	8,067.24	1,500.00	87.85	2,958.65	20
0 J-29	0	117.72	8,067.23	1,500.00	88.17	2,964.21	20
0 J-3	0.2	61.49	8,057.19	1,500.00	4.70	1,274.39	20
0 J-30	0.42	119.01	8,067.20	1,500.00	88.84	2,949.90	20
0 J-31	0.09	122.12	8,067.39	1,500.00	92.47	2,966.57	20
0 J-32	0.06	117.78	8,067.36	1,500.00	91.55	3,024.22	20
0 J-33	0.15	117.78	8,067.36	1,500.00	91.80	3,022.47	20
0 J-34	0.12	115.61	8,067.36	1,500.00	89.70	2,988.01	20
0 J-35	0.17	102.05	8,061.00	1,500.00	13.98	1,443.92	20
0 J-36	0.23	106.81	8,061.00	1,500.00	14.25	1,449.16	20
0 J-37	0.39	99.89	8,061.00	1,500.00	13.74	1,440.50	20
0 J-38	10.06	120.00	8,067.50	1,500.00	82.90	2,561.12	20
0 J-39	0.1	117.84	8,067.50	1,500.00	79.07	2,458.10	20
0 J-4	1.42	83.11	8,057.19	1,500.00	-48.79	1,045.85	20
0 J-40	0.4	111.35	8,067.50	1,500.00	61.53	2,092.77	20
0 J-41	0	128.67	8,067.56	1,500.00	87.82	2,528.95	20
0 J-42	8.19	128.67	8,067.55	1,500.00	89.08	2,592.42	20
0 J-43	0.06	124.35	8,067.55	1,500.00	80.73	2,382.61	20
0 J-44	0.14	113.53	8,067.55	1,500.00	57.76	1,991.57	20
0 J-45	15.33	124.33	8,067.50	1,500.00	63.82	2,035.76	20
0 J-46	0.11	89.32	7,976.56	1,500.00	83.00	2,934.51	20
0 J-47	0.24	72.03	7,976.56	1,500.00	59.40	2,387.95	20
0 J-48	0.13	87.16	7,976.56	1,500.00	80.84	2,908.82	20
0 J-49	0.42	91.48	7,976.56	1,500.00	84.97	2,969.55	20
0 J-5	0.07	109.31	8,067.79	1,500.00	70.05	2,805.94	20
0 J-50	0.93	68.56	7,976.55	1,500.00	58.18	2,487.19	20
0 J-51	0.47	93.64	7,976.55	1,500.00	85.69	2,978.97	20
0 J-52	0.19	111.35	8,067.50	1,500.00	54.84	1,961.72	20
0 J-53	2.49	104.45	7,976.55	1,500.00	91.98	2,903.25	20
0 J-54	6.67	110.94	7,976.55	1,500.00	84.20	2,500.41	20
0 J-55	5.04	102.29	7,976.55	1,500.00	95.52	3,180.31	20
0 J-56	0.52	61.21	7,976.55	1,500.00	28.07	1,679.59	20
0 J-57	0.28	104.45	7,976.55	1,500.00	97.67	3,218.16	20
0 J-58	0.13	108.78	7,976.55	1,500.00	102.03	3,287.92	20
0 J-59	0.39	91.48	7,976.55	1,500.00	81.69	2,896.57	20
0 J-6	0.22	104.57	8,067.81	1,500.00	64.66	2,669.61	20
0 J-60	1.28	102.29	7,976.55	1,500.00	85.68	2,749.33	20
0 J-61	0.24	111.53	8,067.91	1,500.00	75.57	2,929.53	20

0	J-62	0.2	111.54	8,067.93	1,500.00	78.26	2,983.33	20
0	J-63	0.09	57.84	8,068.76	1,500.00	8.17	1,278.85	20
0	J-64	0.16	119.86	8,057.19	1,500.00	25.16	1,548.24	20
0	J-65	0.13	135.31	8,067.91	1,500.00	57.08	2,089.56	20
0	J-66	0.32	98.24	8,057.19	1,500.00	-78.68	998.62	20
0	J-67	0.06	102.83	8,067.79	1,500.00	54.97	2,443.10	20
0	J-68	0.2	133.15	8,067.91	1,500.00	54.25	2,075.35	20
0	J-69	0.26	108.78	7,976.55	1,500.00	101.08	3,546.79	20
0	J-7	0.37	121.47	8,067.91	1,500.00	63.63	2,565.73	20
0	J-70	0.11	126.58	8,067.71	1,500.00	94.42	3,265.13	20
0	J-71	7.21	117.89	8,067.61	1,500.00	85.80	3,071.92	20
0	J-73	0.12	141.72	8,067.72	1,500.00	109.74	3,486.74	20
0	J-74	1.49	87.51	8,067.36	1,500.00	54.64	2,277.62	20
0	J-75	0.03	117.74	8,067.27	1,500.00	88.93	2,988.47	20
0	J-77	0.43	119.94	8,067.36	1,500.00	92.57	3,009.57	20
0	J-78	0.27	117.73	8,067.24	1,500.00	87.79	2,954.96	20
0	J-79	0	60.97	8,061.00	1,500.00	15.14	1,411.85	20
0	J-8	0.09	126.66	8,067.91	1,500.00	68.63	2,530.56	20
0	J-82	0.15	117.07	8,067.31	1,500.00	86.47	2,947.67	20
0	J-83	2.09	118.17	8,067.32	1,500.00	87.78	2,968.05	20
0	J-84	0.64	115.60	8,067.32	1,500.00	85.34	2,948.00	20
0	J-85	0.07	117.85	8,067.54	1,500.00	84.25	2,930.84	20
0	J-86	2.43	113.53	8,067.54	1,500.00	76.43	2,685.38	20
0	J-87	0.68	78.87	8,067.38	1,500.00	45.41	2,113.81	20
0	J-89	0.36	121.16	8,067.38	1,500.00	91.88	2,956.10	20
0	J-9	0.06	126.66	8,067.91	1,500.00	69.52	2,524.09	20
0	J-90	0.25	117.72	8,067.23	1,500.00	87.72	2,941.22	20
0	J-91	0.29	67.70	7,976.56	1,500.00	54.81	2,277.73	20
0	J-92	2.13	87.16	7,976.56	1,500.00	81.11	2,913.81	20
0	J-93	0.06	87.16	7,976.56	1,500.00	81.01	2,910.37	20
0	J-95	0.46	110.94	7,976.55	1,500.00	95.66	2,907.02	20
0	J-96	0.25	102.29	7,976.55	1,500.00	97.38	3,370.75	20
0	J-98	0.05	102.29	7,976.55	1,500.00	98.31	3,429.88	20
0	J10	0	105.09	8,061.00	1,500.00	13.10	1,438.12	20
0	J12	0	108.72	8,067.36	1,500.00	83.43	2,844.80	20
0	J14	0	128.67	8,067.56	1,500.00	88.52	2,558.77	20
0	J22	0.99	123.55	8,067.34	1,500.00	87.04	2,738.89	20
0	J24	0.28	123.60	8,067.34	1,500.00	86.75	2,722.55	20
0	J26	0	122.11	8,067.37	1,500.00	92.59	2,978.76	20

Appendix C

Buildout Available Fire Flow Results

APPENDIX C - BUILDOUT FIREFLOW WITH PROPOSED IMPROVEMENTS

	ID	Static Demand (gpm)	Static Pressure (p	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)
0	J-1	0.76	43.47	8,070.52	1,500.00	12.20	1,141.99	20
0	J-10	0.09	104.79	7,997.33	1,500.00	100.28	3,243.17	20
0	J-11	0.2	104.79	7,997.33	1,500.00	101.19	3,301.37	20
0	J-12	1.06	107.82	7,997.33	1,500.00	81.94	2,434.52	20
0	J-13	0.47	109.12	7,997.33	1,500.00	106.90	3,470.30	20
0	J-14	0.1	143.04	8,070.78	1,500.00	111.25	3,401.56	20
0	J-15	0.32	145.16	8,070.68	1,500.00	114.33	3,495.12	20
0	J-16	0.96	120.33	8,070.26	1,500.00	85.15	2,816.33	20
0	J-17	0.58	106.03	8,070.20	1,500.00	70.74	2,586.07	20
0	J-18	1.71	80.03	8,070.06	1,500.00	45.48	2,157.44	20
0	J-19	1.29	111.97	8,069.92	1,500.00	79.82	2,774.31	20
0	J-2	0.16	62.95	8,070.56	1,500.00	25.39	1,696.26	20
0	J-20	3.5	119.69	8,069.78	1,500.00	84.39	2,723.38	20
0	J-21	1.81	118.87	8,069.89	1,500.00	86.00	2,824.68	20
0	J-22	3.05	118.87	8,069.89	1,500.00	86.74	2,861.51	20
0	J-23	2.36	118.87	8,069.90	1,500.00	84.76	2,767.38	20
0	J-26	2.77	127.81	8,070.57	1,500.00	96.93	3,198.43	20
0	J-27	0.5	123.14	8,069.77	1,500.00	93.07	2,984.37	20
0	J-28	1.77	118.79	8,069.70	1,500.00	88.04	2,912.70	20
0	J-29	0.01	118.77	8,069.66	1,500.00	88.33	2,918.50	20
0	J-3	0.39	67.28	8,070.58	1,500.00	29.16	1,808.68	20
0	J-30	0.8	120.05	8,069.62	1,500.00	89.01	2,908.05	20
0	J-31	0.17	123.14	8,069.77	1,500.00	92.21	2,930.39	20
0	J-32	0.11	118.81	8,069.75	1,500.00	91.48	2,989.20	20
0	J-33	0.29	118.81	8,069.75	1,500.00	91.74	2,987.77	20
0	J-34	0.23	116.65	8,069.75	1,500.00	89.64	2,953.00	20
0	J-35	0.32	102.05	8,061.00	1,500.00	13.91	1,443.37	20
0	J-36	0.43	106.81	8,061.00	1,500.00	14.17	1,448.69	20
0	J-37	0.74	99.89	8,061.00	1,500.00	13.67	1,440.14	20
0	J-38	19.12	120.99	8,069.79	1,500.00	82.85	2,592.41	20
0	J-39	0.19	118.83	8,069.79	1,500.00	79.02	2,486.81	20
0	J-4	2.69	88.91	8,070.61	1,500.00	37.91	1,876.54	20
0	J-40	0.77	112.34	8,069.79	1,500.00	61.47	2,102.11	20
0	J-41	0	129.65	8,069.81	1,500.00	87.80	2,554.11	20
0	J-42	15.55	129.65	8,069.81	1,500.00	89.04	2,611.35	20
0	J-43	0.12	125.31	8,069.78	1,500.00	80.17	2,402.52	20
0	J-44	0.26	114.50	8,069.78	1,500.00	57.19	1,994.82	20
0	J-45	29.13	125.25	8,069.63	1,500.00	62.97	2,049.47	20
0	J-46	0.2	98.32	7,997.36	1,500.00	90.37	2,968.16	20
0	J-47	0.46	81.02	7,997.36	1,500.00	66.80	2,462.03	20
0	J-48	0.26	96.16	7,997.36	1,500.00	88.32	2,944.17	20
0	J-49	0.79	100.48	7,997.35	1,500.00	92.76	3,014.55	20
0	J-5	0.13	110.55	8,070.65	1,500.00	75.21	2,753.81	20
0	J-50	1.76	77.55	7,997.34	1,500.00	66.92	2,553.43	20
0	J-51	0.89	102.63	7,997.33	1,500.00	95.05	3,057.93	20
0	J-52	0.36	112.34	8,069.79	1,500.00	54.79	1,966.30	20
0	J-53	4.74	113.44	7,997.33	1,500.00	100.67	2,961.43	20
0	J-54	12.67	119.92	7,997.32	1,500.00	92.79	2,551.96	20
0	J-55	9.58	111.28	7,997.33	1,500.00	105.45	3,286.54	20

0	J-56	0.99	70.20	7,997.33	1,500.00	37.42	1,860.42	20
0	J-57	0.53	113.44	7,997.33	1,500.00	108.01	3,330.50	20
0	J-58	0.25	117.76	7,997.33	1,500.00	112.69	3,411.56	20
0	J-59	0.75	100.47	7,997.33	1,500.00	92.02	2,982.06	20
0	J-6	0.42	105.80	8,070.65	1,500.00	69.18	2,619.83	20
0	J-60	2.44	111.28	7,997.33	1,500.00	96.00	2,823.77	20
0	J-61	0.46	112.71	8,070.65	1,500.00	78.86	2,876.36	20
0	J-62	0.37	112.71	8,070.65	1,500.00	79.80	2,928.53	20
0	J-63	0.18	58.62	8,070.55	1,500.00	21.95	1,578.42	20
0	J-64	0.31	125.66	8,070.60	1,500.00	78.98	2,538.08	20
0	J-65	0.25	136.48	8,070.60	1,500.00	68.36	2,127.84	20
0	J-66	0.62	104.06	8,070.64	1,500.00	60.89	2,348.55	20
0	J-67	0.12	104.06	8,070.64	1,500.00	62.49	2,402.02	20
0	J-68	0.39	134.32	8,070.61	1,500.00	66.27	2,106.79	20
0	J-69	0.49	117.76	7,997.33	1,500.00	114.97	3,546.85	20
0	J-7	0.71	122.65	8,070.62	1,500.00	77.48	2,544.26	20
0	J-70	0.21	127.86	8,070.68	1,500.00	96.47	3,203.22	20
0	J-71	13.7	119.17	8,070.57	1,500.00	87.27	3,014.22	20
0	J-73	0.24	143.02	8,070.74	1,500.00	111.61	3,425.39	20
0	J-74	2.83	88.64	8,069.98	1,500.00	55.20	2,344.40	20
0	J-75	0.06	118.79	8,069.70	1,500.00	89.05	2,942.88	20
0	J-77	0.83	120.97	8,069.75	1,500.00	92.47	2,975.18	20
0	J-78	0.5	118.79	8,069.70	1,500.00	87.98	2,908.89	20
0	J-79	0	60.97	8,061.00	1,500.00	15.10	1,411.14	20
0	J-8	0.17	127.83	8,070.61	1,500.00	80.65	2,545.93	20
0	J-82	0.28	118.17	8,069.87	1,500.00	86.79	2,894.24	20
0	J-83	3.97	119.27	8,069.87	1,500.00	88.05	2,915.63	20
0	J-84	1.22	116.70	8,069.88	1,500.00	85.68	2,893.33	20
0	J-85	0.14	119.09	8,070.40	1,500.00	85.21	2,871.13	20
0	J-86	4.61	114.77	8,070.40	1,500.00	77.38	2,651.41	20
0	J-87	1.29	80.01	8,070.02	1,500.00	46.03	2,171.07	20
0	J-89	0.68	122.19	8,069.76	1,500.00	91.70	2,921.24	20
0	J-9	0.11	127.83	8,070.60	1,500.00	80.81	2,552.61	20
0	J-90	0.48	118.78	8,069.67	1,500.00	87.90	2,899.57	20
0	J-91	0.55	76.70	7,997.37	1,500.00	62.22	2,392.20	20
0	J-92	4.05	96.16	7,997.37	1,500.00	88.31	2,944.45	20
0	J-93	0.12	96.16	7,997.37	1,500.00	88.31	2,941.10	20
0	J-95	0.88	119.93	7,997.33	1,500.00	105.98	2,980.59	20
0	J-96	0.47	111.28	7,997.33	1,500.00	109.01	3,503.70	20
0	J-98	0.09	111.28	7,997.33	1,500.00	109.42	3,516.83	20
0	J10	0	105.09	8,061.00	1,500.00	13.02	1,437.45	20
0	J12	0	109.75	8,069.75	1,500.00	82.87	2,839.01	20
0	J14	0	129.65	8,069.81	1,500.00	88.49	2,576.60	20
0	J22	1.88	124.67	8,069.93	1,500.00	87.33	2,712.52	20
0	J24	0.54	124.71	8,069.91	1,500.00	87.02	2,695.56	20
0	J26	0	123.14	8,069.77	1,500.00	92.42	2,943.71	20