CITY OF West Linn

Memorandum

Date: March 31, 2010

To: Chris Jordan, City Manager

From: Gene Green, Public Works Director

Subject: Water Capital Improvement Project #65 – Transmission Main to Bolton Reservoir

Purpose:

Update on newly identified water system SDC project to increase transmission line size serving the Bolton Reservoir.

Background:

Last summer our water crew was monitoring water flow into the Bolton Reservoir. They realized that, even with low demand from the Bolton and Willamette pressure zones, the Bolton Reservoir was not refilling (recharging) as anticipated by the water system hydraulic model. The need for timely recharge will only increase as the Bolton Reservoir is replaced by a reservoir that either doubles or quadruples its current available storage and becomes the hub of the City's water system.

City staff shared this concern with our Water Master Plan (WMP) consultant, Murray, Smith and Associates (MSA), who concurred with the need to upgrade the feed to the reservoir from the 18-inch water transmission main. The City contracted with MSA to evaluate the situation and provide a technical report and recommendation to improve water flow to the Bolton Reservoir. MSA has completed their analysis and provided a technical report dated 3/18/2010.

As with the Water System Master Plan (WMP), attaining the required flow to the Bolton Reservoir is only to serve anticipated buildout requirements within the existing City's Urban Growth Boundary (UGB). With the exception of those few properties for which the City Council has approved extra-territorial water connection, no properties outside the City current UGB are included or considered in the water system analysis.

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

121 S.W. Salmon, Suite 900 ▪ Portland, Oregon 97204-2919 ▪ PHONE 503.225.9010 ▪ FAX 503.225.9022

TECHNICAL MEMORANDUM

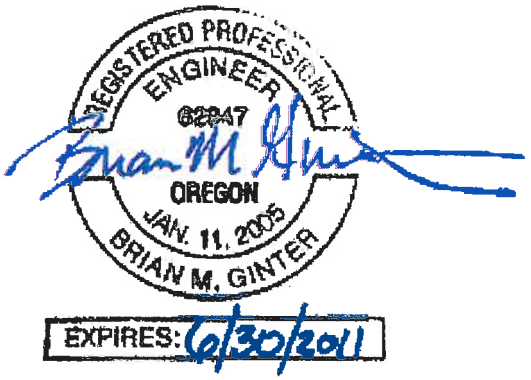
DATE: March 18, 2010

PROJECT: 09-1097.101

TO: Chris Jordan – City Manager
Gene Green – Public Works Director
Dennis Wright – City Engineer
City of West Linn, Oregon

FROM: Brian Ginter, P.E.
Chris Uber, P.E.
Murray, Smith & Associates, Inc.

RE: City of West Linn - South Fork Water Board Supply
Transmission Main Capacity Assessment



Introduction

The City of West Linn (City) has requested that Murray, Smith & Associates, Inc. (MSA) complete a hydraulic capacity analysis of the City's existing 24 to 18-inch diameter water transmission pipeline from the South Fork Water Board (SFWB) Division Street Pump Station across the Abernethy Bridge (I-205) over the Willamette River and through West Linn to the Bolton Reservoir.

The findings of this analysis confirmed the need for the construction of the City's water system capital improvements plan project CIP-65 to address capacity limitations in the SFWB transmission main.

Background and Understanding

The City's water system is supplied with treated Clackamas River water from the SFWB Water Treatment Plant (WTP) located in Oregon City. Finished drinking water flows from the SFWB WTP by gravity through a 30-inch diameter transmission main to the SFWB Division Street Pump Station. This pump station boosts water from the transmission main to the City of Oregon City's Mountainview Reservoir (overflow elevation of 490 feet) and to the City's Bolton Reservoir (overflow elevation of 440 feet). Supply to the City from the discharge of the pump station is transmitted through a master flow meter and two parallel 14-inch diameter ball valves that regulate flow and pressure in the City's transmission main. A 24-inch diameter transmission main extends from the discharge of the valve and meter vault, located adjacent to the Division Street Pump Station, west through Oregon City and across the I-205 bridge into the City. From the west side of the bridge, the transmission main continues as a 20-inch diameter main to the intersection of Buse Street and Broadway Street, and then continues on to the Bolton Reservoir as an 18-inch diameter transmission main. Figure 1 is an overview and schematic of this water supply system.

The City of West Linn's water system is configured around the Bolton Reservoir as the "hub" of the system with this facility serving as the terminal reservoir for the SFWB supply to the City. Transmission piping, booster pump stations that pump to higher elevation pressure zones and pressure reducing facilities that serve lower elevation pressure zones have been planned, designed and constructed to function optimally with supply from gravity storage at the Bolton Reservoir site. This operational configuration allows City Operations staff maximum control of the system and provides the greatest ability for continued water service in an emergency.

The hydraulic model of the City's supply transmission main has estimated main capacity to be approximately 9.0 per day (mgd); however, City Operations staff reports that the observed capacity of the transmission main appears to be significantly less than this under certain operational conditions, which will be discussed further below. The City's share of the capacity in the SFWB supply system is adequate to meet the City's projected maximum day water demand at saturation development of the existing Urban Growth Boundary (UGB), which is forecasted to be 10 mgd. Efficient operation of the system under these projected conditions requires the transmission capacity to deliver this flow rate to the Bolton Reservoir over a 24-hour period. The Water System Master Plan (WSMP) identified the potential limitations in the capacity of the transmission main and concluded that it may be feasible to operate the transmission main and ancillary control valving to transmit 10 mgd capacity to the City's system; however, further modeling has indicated that operation of the system in this fashion is inefficient and likely not workable.

While a model is a good approximation of system operation, field measurements are taken to calibrate the model and to verify conclusions. Subsequent field observations, including

preliminary investigation of the actual hydraulic capacity of the 18-inch diameter segment of the transmission main and the feasibility of operating the transmission main with flow diverted to the Willamette and Robinwood pressure zones for extended durations, have confirmed a limitation to the delivery capacity of the transmission main at less than the desired 10 mgd.

Based on the observed flow conditions, the planning criteria presented in the WSMP and a review of expected future system operational needs, addition of a new Capital Improvements Plan (CIP) project (CIP No. 65) was recommended to the City's water system CIP to address this deficiency. The recommended project is the replacement of approximately 4,200 linear feet of 18-inch diameter transmission main from Buse Street and Broadway Street to the Bolton Reservoir inlet.

The purpose of this assessment is to verify the actual hydraulic capacity of the transmission main under varying operational conditions including all SFWB supply delivered to the Bolton Reservoir through this transmission main. This analysis will also confirm the source of capacity limitations in the transmission main based on a section by section analysis of frictional head losses (energy losses) and validate current planning related to replacement of the 18-inch diameter section of the transmission main through the City. This analysis considers the planned changes to the receiving hydraulic grade of the system associated with the upcoming replacement of the Bolton Reservoir.

Data Gathering and Field Reconnaissance

To support this analysis, data gathered during the development of the WSMP was confirmed and refined. This data included: transmission main material, estimated age and actual inside pipe diameters; confirmation of transmission main lengths and alignment; elevation data for planned pressure measurement locations; and review of system operation to establish a flow testing protocol.

Based on the data provided, three flow/operational situations were developed to perform field flow testing and pressure measurements for analysis of system performance and calibration of a hydraulic model of the transmission system. The proposed flow testing protocol was reviewed with City Operations staff on February 10, 2010 to confirm the feasibility of performing the flow testing, to validate operational assumptions and to establish field measurement needs.

Transmission Main Flow Testing

On March 10, 2010, flow testing was performed by City staff under three operational scenarios. The three operating conditions during the flow testing were:

1. ***Static Conditions*** – No Flow from SFWB Division Street Pump Station (control valves closed at Division Street Pump Station) to West Linn. The purpose of this test condition is to establish baseline data related to system pressure under static conditions and to verify elevations at pressure measurement locations.

2. ***All Supply to Bolton Reservoir*** – Maximum output from the SFWB Division Street Pump Station directed to the Bolton Reservoir. This condition was achieved with the Division Street Pump Station operating at full capacity with the City's supply control valves 100 percent open while simultaneously supplying Oregon City's Mountainview Reservoir. This test condition simulates actual operational conditions to be able to deliver sustained flow rates of up to 10 mgd from the SFWB supply to the Bolton Reservoir.

3. ***Maximum Supply to System*** –Under this test condition, the Willamette Falls Drive Pressure Reducing Valve (PRV) station and the PRV station located at the City's Emergency Intertie Pump Station, which supplies the Robinwood pressure zone, are fully opened to maximize the flow into the system. This test condition is used to assess the maximum supply available through the transmission main without consideration of operational conditions.

The field flow testing was conducted between 9:00 a.m. and 10:00 a.m., during a period of time of very low water usage to most accurately simulate static conditions and to minimize the impacts of water supply to customers served directly from the transmission main. City Operations staff located at key locations along the transmission main alignment, measured pressure during the testing and observed the water surface elevation in the Bolton Reservoir wetwell, on the inlet side of the reservoir. The flow rate in the transmission main from SFWB under each test condition are summarized in Table 1.

Table 1
Transmission Main Flow Rate Summary

Test Condition	Flow Rate	
	MGD	GPM
Static Conditions	0	0
All Supply to Bolton Reservoir	7.6	5,300
Maximum Supply to System	9.6	6,700

Additional field measurements gathered during the flow testing are included in the Appendix of this memorandum.

In addition to the measurements taken during the test, one additional condition was observed that is a major factor in limiting the sustainable flow available from the City's SFWB supply to the Bolton Reservoir. Supply to the Bolton Reservoir discharges into a small wetwell structure outside of and immediately adjacent to the reservoir and then flows by gravity through an 18-inch diameter pipe into the reservoir. This pipeline restricts the flow that can enter the reservoir and causes the level in the wetwell to rise above the level in the reservoir under peak flow conditions. This condition prevents the City from delivering supply at high flow rates to the Bolton Reservoir unless the reservoir is at a low level, thereby allowing greater flow between the wetwell and the reservoir.

Hydraulic Analysis

General

A hydraulic analysis was completed to identify specific capacity limitations in the transmission main and to verify recommended improvements to achieve a flow rate of approximately 10 mgd to the Bolton Reservoir. The hydraulic performance of the transmission main was assessed to determine if:

- Performance of the 24-inch diameter section of the transmission main is adequate to deliver 10 mgd without excessive head loss;
- Replacement of the 18-inch diameter sections of the transmission main with a new large diameter main will improve the hydraulic capacity of the whole system to approximately 10 mgd;
- Performance will be impacted by the anticipated future raise in overflow elevation associated with the replacement of the Bolton Reservoir

A discussion of each of these analysis goals is presented below. The hydraulic analysis focuses on the results of the "All Flow to Bolton" field testing scenario as this scenario represents the City's actual operating condition.

Performance of the 24-inch Diameter Section of the Transmission Main

The 24-inch diameter section of the transmission main extends from the Division Street Pump Station through Oregon City and across the Abernethy Bridge (I-205). Sections of this transmission main are located in inaccessible locations and steep terrain, and little is known about the specific condition of this segment of the transmission main that is made up of concrete cylinder pipe (CCP), welded steel and ductile iron segments. The first objective of this analysis was to verify that the performance of this section of the transmission main was adequate and that the condition of the transmission main is such that unexpected friction losses are not occurring. Table 2 summarizes pertinent data from the flow test, identifying pipeline flow rates, pressure measurements at key locations, and approximate velocities.

Two water system industry professional organizations, the American Water Works Association (AWWA) and American Society of Civil Engineers (ASCE) recommend a maximum flow velocity in transmission mains of 4 to 5 fps, to minimize friction losses and to reduce the risk of harmful hydraulic transient (surge) conditions. While this segment of the transmission main will experience velocities slightly in excess of 5 fps, the velocity in the transmission main will only rise above this level and only for a short duration under maximum day demand conditions.

Table 2
24-inch Diameter Transmission Main Segment Analysis

Measured / Calculated Data	Value
Pipeline Segment Length	6,831 ft.
24" CCP (ID ~23.25 in.)	*3, 498 ft.*
24" DI (ID = 24.92 in.)	*596 ft.*
24" Steel (ID ~ 23.25 in.)	*2,737 ft.*
Upstream Hydraulic Grade (Division St. PS)	506.7 ft.
Downstream Hydraulic Grade (West Linn side of I-205 Bridge)	490.6 ft
Approximate Segment Velocity @ 5,300 gpm (7.6 mgd)	4 fps
Friction loss per 100 Linear Feet	0.23 ft
Approximate Segment Velocity @ 10 mgd (6,950 gpm)	5.3 fps

Note: ID = Estimated inside diameter of transmission main segment.

The results of the analysis, the key elements of which are summarized in Table 2, indicate that the 24-inch diameter segments of the transmission main are adequate and the hydraulic performance of this segment of the main is consistent with the expected performance of a similar sized and configured new transmission main.

Performance of the 18-inch Diameter Section of the Transmission Main

From the West Linn side of the Abernethy Bridge, the transmission main extends approximately 1,500 feet towards the Bolton Reservoir as a 20-inch diameter welded steel main. From the end of this 20-inch diameter main, near the intersection of Buse Street and Broadway Street, the transmission main is 18-inch diameter welded steel pipe between that point and the Bolton Reservoir.

- The transmission main is estimated to be approximately 40 years old, with construction dating to the 1970s. The pipe is unlined, spiral welded steel pipe buried in oil soaked sand backfill to protect the pipe from external corrosion.

- The transmission main is "OD steel pipe", meaning that the outside diameter of the pipe is 18-inches. Assuming a wall thickness of 3/8-inches, which is typical for pipelines of this age, size and service condition, the inside diameter of the pipeline is estimated to be 17.25 inches.

As with the 24-inch diameter segments, the hydraulic performance of this section of the transmission main was documented during the flow testing. Table 3 summarizes pertinent data from the flow test, identifying pipeline flow rates, pressure measurements at key locations, and approximate velocities.

Table 3
18-inch Diameter Transmission Main Segment Analysis

Measured/Calculated Data	Value
Pipeline Segment Length	4,071 ft.
Upstream Hydraulic Grade (Hydrant @ Buse and Broadway)	485.8 ft.
Downstream Hydraulic Grade (Bolton Reservoir Wetwell)	445.1 ft
Approximate Segment Velocity @ 5,300 gpm (7.6 mgd)	7.3 fps
Friction loss per 100 Linear Feet	1.0 ft
Approximate Segment Velocity @ 10 mgd	9.5 fps

The results of this analysis indicate that this segment of the transmission main system is inadequate to transmit 10 mgd supply to the Bolton Reservoir. Furthermore, under existing peak flow conditions of 7.6 mgd, the velocity in this segment of the pipeline, 7.3 fps, which is much higher than the recommended maximum velocity for a transmission main. Velocities well above 5 fps that occur on a routine basis will result in excessive friction losses and may put the transmission system at risk of harmful hydraulic transient (surge) conditions.

A hydraulic grade line analysis was performed for the entire transmission to graphically depict the findings of the analysis. This illustration is presented as Figure 2. As Figure 2 shows, the hydraulic grade line in the existing transmission main drops below the water surface elevation in the Bolton Reservoir at a flow rate of 10 mgd, making supply to Bolton Reservoir at this flow rate infeasible. These figures also show that the greatest friction losses occur in the 18-inch diameter segment of the transmission main, as expected as it has the smallest diameter segments of the system.

Impacts of Future Bolton Reservoir Configuration

One key recommendation of the Water System Master Plan is the replacement of the Bolton Reservoir. The construction of the new reservoir will accomplish several goals including:

- Replacement of the aging Bolton Reservoir. The condition of this reservoir is deteriorating, as documented over the past 10 years and confirmed in the Water System Master Plan, and will require increasingly significant investment of capital maintenance funds to maintain this storage facility in service until replaced.

- Addressing the capacity limitation of the 18-inch diameter piping restriction of the current reservoir wetwell configuration, as discussed above.

- Improving suction supply for the Bolton Pump Station. As documented in the Water System Master Plan, the configuration of the Bolton Pump Station limits the volume of the existing Bolton Reservoir available as suction supply for the pump station.

In order to achieve the third objective, it has been recommended in the WSMP that the City configure the new reservoir with an overflow elevation approximately 10 feet higher than the existing Bolton Reservoir, which is approximately 440 feet. This configuration will further reduce the supply capacity of the existing transmission main.

Hydraulic Analysis Findings

As Figure 2 illustrate, the capacity of the existing 18-inch diameter segments of the transmission main are inadequate to deliver the City's SFWB supply capacity to the Bolton Reservoir. Replacement of the 18-inch diameter segment of the transmission main to the Bolton Reservoir will address this hydraulic limitation and allow the City to receive the full supply capacity currently owned by the City in the SFWB system to the Bolton Reservoir under existing and future conditions.

The 20-inch diameter segment of the transmission main extending approximately 1,500 feet from the I-205 bridge towards the Bolton Reservoir will operate at velocities higher than recommended during maximum day demand conditions; however, these conditions will not occur routinely. The results of the flow test and the findings of the hydraulic analysis indicate that the head loss in this segment of pipe is acceptable and that there would be limited hydraulic benefit by upsizing this segment of the transmission main. It is not recommended that the City upsize this segment of the transmission main at this time due to the limited hydraulic benefit and high capital cost of such an improvement.

Summary

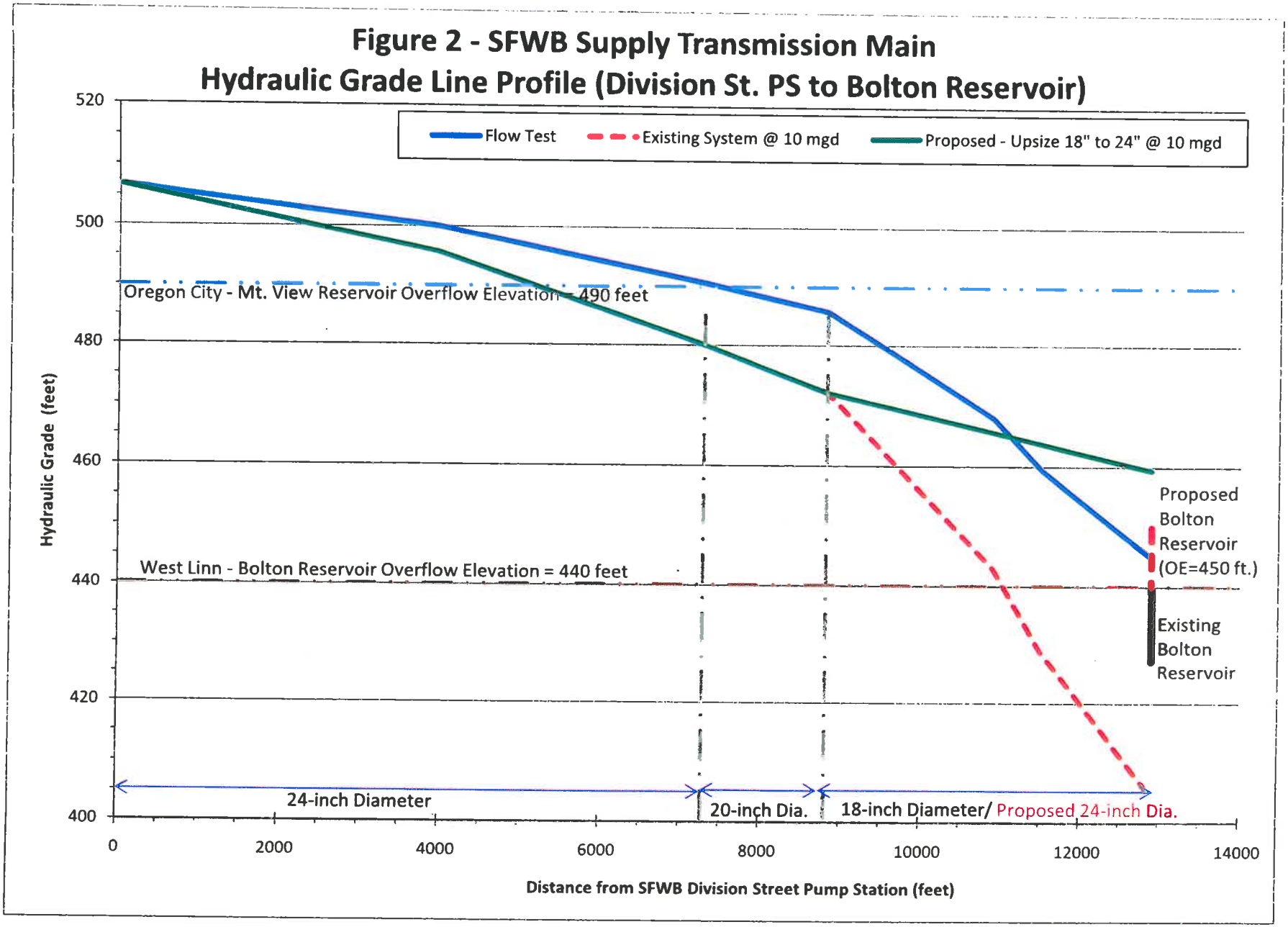
This technical memorandum presents the findings of an analysis of the hydraulic capacity of the City of West Linn's SFWB supply transmission main. The analysis included a review of the transmission main configuration, system operations, performance of detailed flow testing to verify current conditions and calibration of the transmission main elements of the water system hydraulic model to verify recommended improvements. The findings of the analysis confirmed the recommendation that replacement of an undersized 18-inch diameter segment of the transmission main near the Bolton Reservoir with a 24-inch diameter pipe is needed to meet future water supply transmission needs within the current UGB.

cc: Mr. Jimmy Whynot – Operations Supervisor
City of West Linn, Oregon

INSERT

Figure 1

Figure 2 - SFWB Supply Transmission Main
Hydraulic Grade Line Profile (Division St. PS to Bolton Reservoir)



City of West Linn
SFWB Supply Transmission Main Analysis
Flow Test - March 10, 2010

Measurements	Scenario		
	(1) Static Conditions	(2) All Flow to Bolton	(3) Maximum Flow
Time of Test			
Start	9:00 a.m.	9:15 a.m.	9:30 a.m.
End	9:05 a.m.	9:25 a.m.	9:35 a.m.
Flow Rate (gpm)			
Division St. PS	0	14.6 mgd	14.9 mgd
West Linn Supply	0	5,300 gpm	6,700 gpm
Bolton PS	0	0	0
Reservoir Level (ft)			
Bolton	11.7	11.8	12.1
Bolton Wetwell (measured from floor)	8'-1"	5'-2"	6'-6"
Willamette	30.6	30.1	30.7
View Drive	19.9	19.8	20.0
Oregon City - Mountainview	23.8	23.8	23.8
Valve Position (% Open)			
SFWB Supply	0	100%	100%
Willamette Supply	0	0	35%
Robinwood Supply	0	0	25%
Pressure (psi)			
Division St. PS (Upstream/Downstream of Control Valves)	106/83	115/112	111.5/108
Willamette Falls Dr PRV Upstream	105	129	119
Willamette Falls Dr PRV Downstream	63	63	94
Robinwood PRV Upstream	115	124	115
Robinwood PRV Downstream	64	64	77
Oregon City side of I-205 Bridge	160	184	177
West Linn side of I-205 Bridge	140	160	155
Hydrant 03-FH-0024 - Buse and Broadway	107	125	119
Hydrant 03-FH-0041 - West A and Webb	89	100	94
Hydrant 03-FH-0043 - Webb at Skyline	43	50	46

Initial System Configuration for Tests: Bolton PS off.
Scenario 1: No Flow from SFWB.
Scenario 2: Max Flow from Division St. PS. Willamette Falls Drive and View Drive PRVs Closed.
Scenario 3: Max Flow from Division St. PS. Willamette Falls Drive and View Drive PRVs Open.

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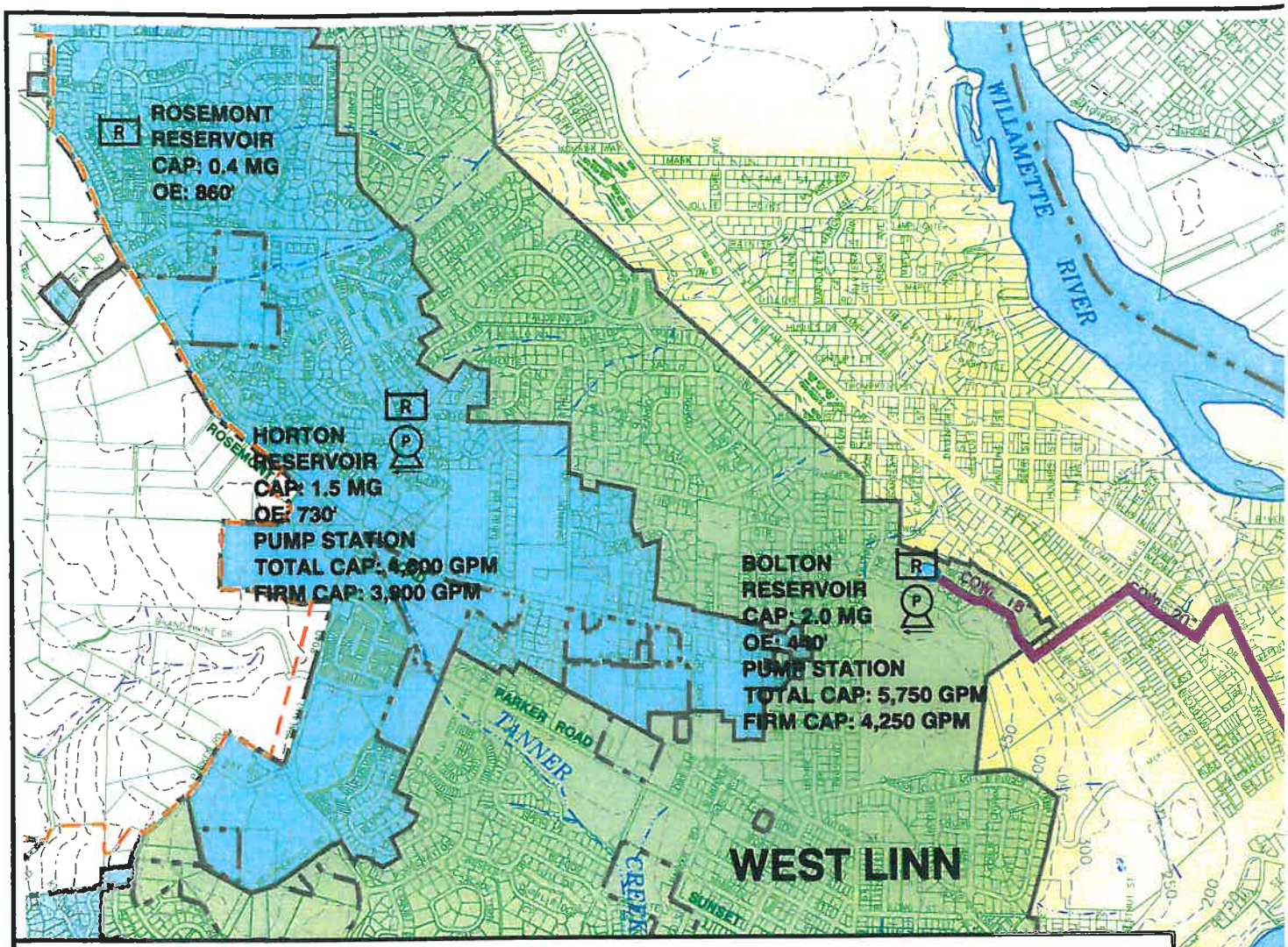

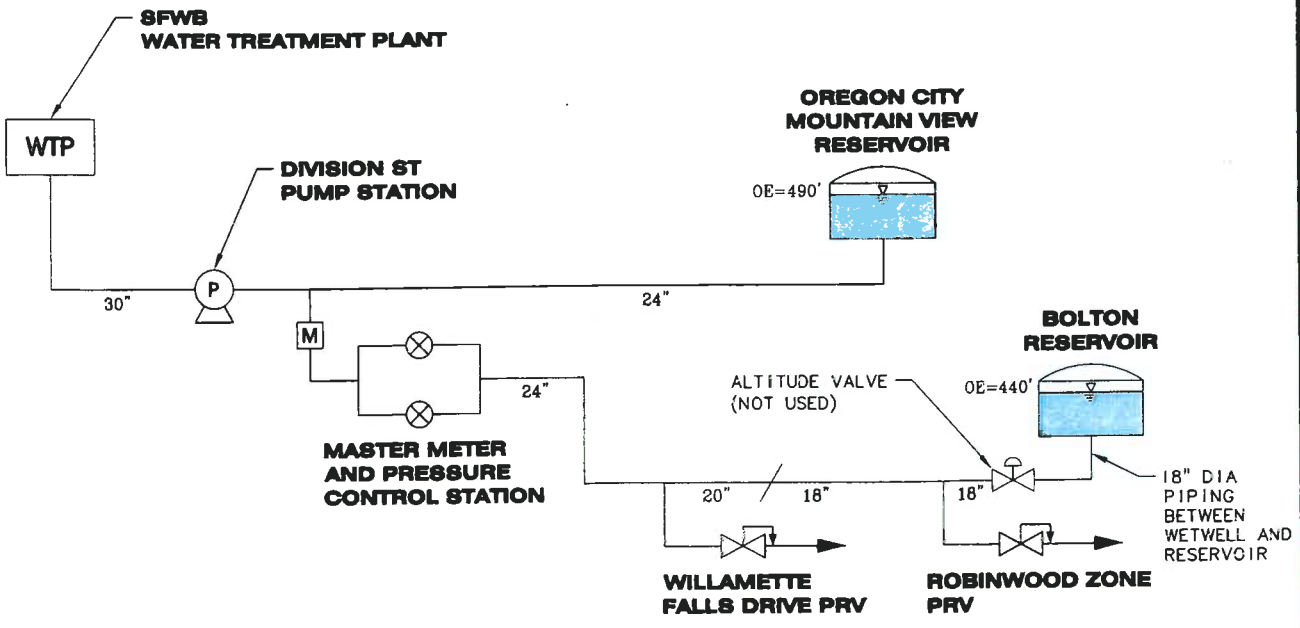

SFWB SUPPLY SCHEMATIC

SCALE: NTS

G:\09\1097\101\CAD\09-1097-101-OR-FIGURE 1.dwg FIG 1 3/16/10 17:16 (mbe)