CDM

FINAL Report

City of Klamath Falls
Water Master Plan

March 2010

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Executive Summary
Klamath Falls Water Master Plan

Purpose of Study

The City of Klamath Falls undertook this master plan update to ensure adequate water system capacity for existing and future customers, and to plan for water system improvements in developing areas. The study area encompasses all lands within the Urban Growth Boundary (UGB), with the exception of areas served by private water systems including the Ridgewater and Southview developments and Skyline Water District.

Since the 2004 master plan, significant growth has occurred in the Stewart Lenox and Basinview areas, as well as anticipated and unanticipated growth in other locations throughout the study area. This master plan update more accurately reflects current and future development so City staff can respond effectively to new water system demands.

The planning timeframe extends to buildout within the UGB, which is anticipated to occur after approximately 50 years. To meet near-term needs, the plan addresses improvements for an intermediate timeframe of 10 years to approximately 2020.

Water Demands

Demand projections are estimated for existing, intermediate, and buildout land scenarios. Demands are based on existing and future land uses and unit water demands for each type of land use. Maps showing existing and future land uses within the UGB were prepared using information from City and County Planning Departments, and reviewed with planning staff for accuracy. Unit water demands are derived from historic usage data and reflect current consumption patterns.

Current average day demand is about 8 mgd and maximum day demand about 18 mgd, based on historic well production records. By 2020 (intermediate planning timeframe), average day demand is projected at 14 mgd, and maximum day demand at 32 mgd. At buildout, average day demand is projected to increase to 17 mgd, and maximum day demand to 40 mgd.

The largest future growth location is the Basinview area in the northeast part of the City. Other future growth areas include the northwest area near the hospital and Oregon Institute of Technology, the Stewart-Lenox area to the southwest, and the vicinity of the airport.

The master plan demand projections are representative of existing demand patterns, and do not include irrigation water for open space or large irrigated areas. The City should consider increasing conservation measures to reduce future maximum day and peak hour demands. This would reduce future infrastructure needs, as the water system must be sized to meet the high demand conditions.

Water System Evaluation

A conceptual water system expansion plan includes future waterline extensions to new areas and potential locations for other major facilities, such as storage reservoirs and pump stations. The overall ultimate system configuration is generally based on a typical approach used by other cities and water agencies with pressure zones at approximately 100-foot elevation intervals. This typical approach includes: supply provided from a lower zone, pumping up into the next zone including pass-through to higher zones, and storage within each zone. For small or isolated areas, alternate approaches may also be considered, such as supply from a higher zone through a pressure reducing valve station.

Water system evaluations determined the adequacy of the existing system to meet existing and future demands. The evaluations included well pumps, booster pump stations, storage reservoirs, pressure reducing stations, and the pipeline distribution system. Water rights for groundwater supply were not evaluated in this plan; the City should undertake this investigation in the near future.

Based on the evaluation results, required improvements were formulated to address identified deficiencies at the existing, intermediate, and buildout timeframes. The City's existing hydraulic model was reviewed and updated to reflect current and future conditions for use in the water system analysis. The recommended improvements consider buildout needs to ensure that pipe or other facility upgrades will be adequately sized to avoid multiple upsizing projects.

Future growth areas will be served by extending the existing distribution system. Future growth within the existing pressure zones will be served through new waterline extensions. Additional well supply, pumping and storage capacity will be required for these new areas. Improvements to existing pipelines will also be needed to provide adequate hydraulic capacity to convey supply from the Conger wellfield throughout the City.

Recommended Water System Improvements

The Capital Improvement Program (CIP) includes the costs of improvements required for all major facilities, including improvements to existing pipelines but excluding pipeline extensions to future areas.

The CIP does not include the cost of new pipeline extensions to areas that are currently undeveloped and not served by an existing pipeline. These pipeline extensions will be constructed by developers as part of the new developments. Developers may also be required to contribute to the cost for new water production, storage and pumping facilities as required by City standards.

Types of improvements included in the CIP are:

- New well pumping capacity;
- Improvements to existing pipelines;
- New reservoir storage and/or standby power at wells and booster stations for emergency storage;
- New pump stations (to replace or expand existing stations or to serve new areas); and
- Pressure reducing valve (PRV) station improvements.

Figure ES-1 shows recommended water system improvements to meet existing and future needs. Table ES-1 summarizes required capacities and costs. Future facility locations are conceptual and identify a general location or vicinity for master planning purposes.

CIP projects are staged by timeframe needed as a guideline for City staff in determining specific priorities and timing for project implementation based on future development requests and overall City needs. The timeframes include:

- Existing timeframe to correct existing deficiencies and provide some capacity for future growth;
- Intermediate timeframe to provide capacity for future growth within the next 10 years to year 2020 ; and
- Buildout of the remaining area within the Urban Growth Boundary which will occur after 2020 and will exceed the planning horizon of this study. The City will re-evaluate buildout demands and corresponding facilities needs in future master plan updates.

The master plan study addresses supply, storage, pumping, and major transmission system facilities only; and does not include analysis of smaller pipelines serving local areas. Therefore, the master plan does not identify all localized improvements that may be needed to provide the required fire flows throughout the existing system. In conjunction with new connection requests and main replacement upgrade projects, the City conducts detailed analyses of local areas to refine the master plan work and identify such localized improvements.

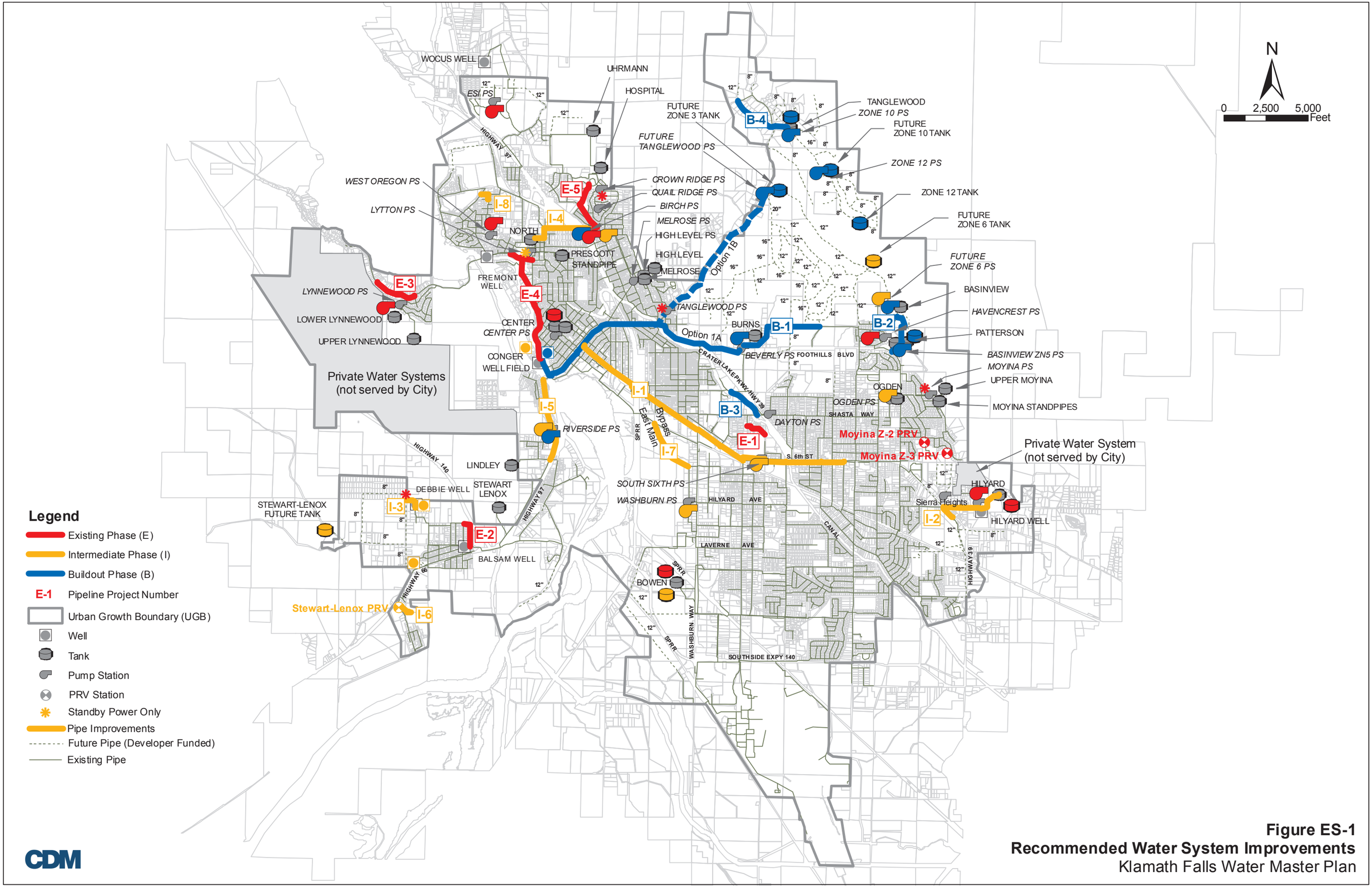

Figure ES-1
Recommended Water System Improvements
Klamath Falls Water Master Plan

Table ES-1
Summary of Recommended Improvements and Capital Costs

Timeframe Needed	Wells		Pipelines		Reservoirs		Pump Stations		PRVs		Total Capital Cost ($ Million)
	Capacity (mgd)	Capital Cost ($ Million)	Length (LF)	Capital Cost ($ Million)	Capacity (MG)	Capital Cost ($ Million)	Capacity (mgd)	Capital Cost ($ Million)	Number of Valves	Capital Cost ($ Million)	
Existing	0	$0.14	18,200	$4.71	4.0	$5.67	8.6	$3.11	2	$0.13	$13.76
Intermediate (by 2020)	11.7	$8.77	37,400	$11.10	2.3	$3.35	12.7	$3.46	1	$0.03	$26.70
Buildout (after 2020)	7.7	$6.93	28,400	$11.33	2.6	$3.84	15.2	$7.39	-	-	$29.50
GRAND TOTAL	**19.4**	**$15.84**	**84,000**	**$27.14**	**8.9**	**$12.86**	**36.5**	**$13.96**	**3**	**$0.16**	**$69.96**

Implementation Considerations

Sizing, location, and estimated costs of master plan projects are at a conceptual level. Project implementation will require predesign studies, including specific routing and siting studies, environmental review, and detailed design of specific projects. Timing for specific projects will be determined based on development needs, coordination with other construction projects, such as those for other utilities and street improvements, or for other City needs.

Other key actions for the City to consider in implementing the master plan include:

- Update current developer fees and water rates to incorporate the recommended improvements from the master plan, in order to allocate costs appropriately to existing and future users.
- Investigate existing and future groundwater supply availability to confirm its ability to meet future supply needs. This investigation should include groundwater yield, water quality, and water rights conditions of use.
- Update the Water Conservation and Management Plan to investigate potential reductions in future maximum day and peak hour demands that could be achieved through water conservation measures. Facility sizing is based on the ability of the system to meet maximum day and peak hour demands. If future maximum day and/or peak hour demands are reduced, future facilities requirements and costs may also be reduced.
- Update the master plan periodically, at approximately 5-year intervals, or more frequently if major land use or other changes occur. Keep the hydraulic model up-to-date and use on an ongoing basis as a tool to analyze localized improvements and evaluate developer proposals.

Section 1
Introduction

This section describes the purpose, organization and scope of the master plan; identifies acronyms and abbreviations used in the report; and lists acknowledgements.

1.1 Purpose of Master Plan

The City of Klamath Falls prepared this master plan update to ensure adequate water system capacity for existing and future customers, and to plan for water system improvements in developing areas. The study area for this master plan update encompasses all lands within the Urban Growth Boundary (UGB), with the exception of areas served by private water systems including the Ridgewater and Southview developments and Skyline Water District.

Since the last master plan in 2004, a significant amount of growth has occurred in Klamath Falls in the Basinview and Stewart Lenox areas, as well as anticipated and unanticipated growth in other locations throughout the study area. This master plan update includes current and future development information to more accurately reflect current levels of development and enable City staff to respond effectively to new water system demands. An up-to-date master plan enables the City to proactively set appropriate developer requirements/fees to address improvements needed for new development as it occurs.

The planning timeframe extends to buildout within the UGB, which is anticipated to occur after approximately 50 years. For immediate needs, the plan addresses improvements needed for an intermediate timeframe of 10 years to approximately 2020. Water demands projections were based on current planning information regarding future land uses during the planning horizon. Due to the long-range nature of buildout conditions, the buildout scenario will be re-evaluated in future master plan updates as more information becomes available.

1.2 Organization of Master Plan Report

Sections 2 through 5 of the master plan report describe the key study area and land use assumptions, existing water system facilities, water demand projections, and performance objectives for the water system analysis. Appendices A and B contain historical water production and usage data used for the water demand analysis.

Section 6 describes the water system evaluations conducted to determine required supply, pipeline, pumping, storage and pressure reducing valve capacities for existing and future demands. Appendix C describes the hydraulic model calibration and verification performed for this update. Appendix D shows results of the hydraulic model extended period simulation. Appendix E summarizes fire flow analysis results.

Finally, Section 7 identifies the required improvements to meet existing and future water system needs, including estimated costs and phasing. Appendix F provides a glossary of key terms used in the master plan.

1.3 Scope of Services

The City of Klamath Falls has retained Camp Dresser & McKee Inc. (CDM) to prepare the Water Master Plan. The following major elements comprise the scope of work for the master plan:

- **Existing and Future Demand Analysis –** Study area features and land use assumptions have been compiled for use in the overall master plan effort. Water demand projections have been developed based on existing, intermediate and buildout land use maps prepared with input from City staff. Unit water demand and peaking factors have been derived from historic usage data.

- **Existing Water System Features; Performance Objectives –** Information on existing water system facilities has been updated to use as a basis for the system analysis. Performance objectives have been established to define levels of service for the water system evaluation.

- **Hydraulic Model Update and Calibration –** The City's existing hydraulic model has been converted to a new software package, InfoWater, and updated to reflect current and future conditions for use in the water system analysis. The updated model of the existing system has been calibrated and verified using system operating data.

- **Water System Analysis and Recommended Improvements –** Water system evaluations have been conducted to determine adequacy of capacity of existing supply, pipeline, pumping, storage and pressure reducing facilities. Based on the analysis results, improvement recommendations have been formulated to address identified deficiencies.

- **Master Plan Report –** This report has been prepared to document the key assumptions, key findings, and recommendations of the master plan analyses.

In addition, a Geographic Information System (GIS) mapping task has been completed in conjunction with the master plan, as described in a separate report. The mapping task included development of a water utility GIS strategic plan, a water facility geodatabase, and preparation of up-to-date digital maps of the existing water system facilities in a common coordinate system. The geodatabase and mapping are in a common standard coordinate system. City staff improved the accuracy by conducting field surveys of key locations, e.g., valve locations using Geographic Position Survey (GPS) equipment. The geodatabase and mapping has been used for the master plan model and analysis described in the above scope of services. The GIS

tools are also available for ongoing use by City staff to support water facility management, development reviews, and other water system services.

1.4 Acknowledgements

This report would not be possible without the valuable assistance and participation of the following City of Klamath Falls staff and County of Klamath Falls staff:

Don Wilcox	City Engineer
Mark Willrett	Public Works Director
Tom Del Santo	Development Coordinator
Justin Rodriguez	Consultant Project Manager and City Advisor
Steve Seratt	Water Division Manager
Randy Travis	Supervisor, Water Operations
Rod Denson	Supervisor, Water Infrastructure
Jeff Hansen	Engineering Design Specialist
Sandra Zaida	Community Development Department Director
Joe Slaughter	Associate Planner
Kelly O'Neill	Planner
Judy Goodin	Utility Billing Manager
Mindy Radford	Information Systems Manager
Les Wilson	Klamath County Planning Director

1.5 Acronyms and Abbreviations

Below are abbreviations and acronyms are used in this report. Appendix F contains a glossary of key terms used in the master plan.

ac	acre
ACP	Asbestos Cement Pipe
CDM	Camp Dresser & McKee Inc.
CIP	Capital Improvement Program, Cast Iron Pipe
DEM	Digital Elevation Model
DIP	Ductile Iron Pipe
EPS	Extended Period Simulation
ERU	Equivalent Residential Unit
fps	feet per second
ft	foot
GIS	Geographic Information System
gpd	gallons per day
gpm	gallons per minute
HGL	Hydraulic Gradeline

HP	Horsepower
in	inches
MG	million gallons
mg/l	milligrams per liter
mgd	million gallons per day
PRV	Pressure Reducing Valve
PS	Pump Station
psi	pounds per square inch
PVC	polyvinyl chloride
SCADA	Supervisory Control And Data Acquisition
SF	square foot
TDH	total dynamic head
UGB	Urban Growth Boundary
USGS	United States Geologic Survey

Section 2
Study Area

This section identifies the study area for the master plan, and describes the existing and future land uses within the study area.

2.1 Location and Characteristics

Figure 2-1 shows the general location of the City of Klamath Falls in Klamath County, in the south central region of Oregon. The City, which is the County seat, is in the Klamath Basin on the eastern slopes of the Cascade Mountains. It is on the southern shore of Upper Klamath Lake.

Figure 2-2 shows the study area for this master plan, as defined by the Urban Growth Boundary (UGB). The UGB encompasses the City of Klamath Falls incorporated area (shown dark on Figure 2-2), as well as a large unincorporated area.

Figure 2-1
Location Map

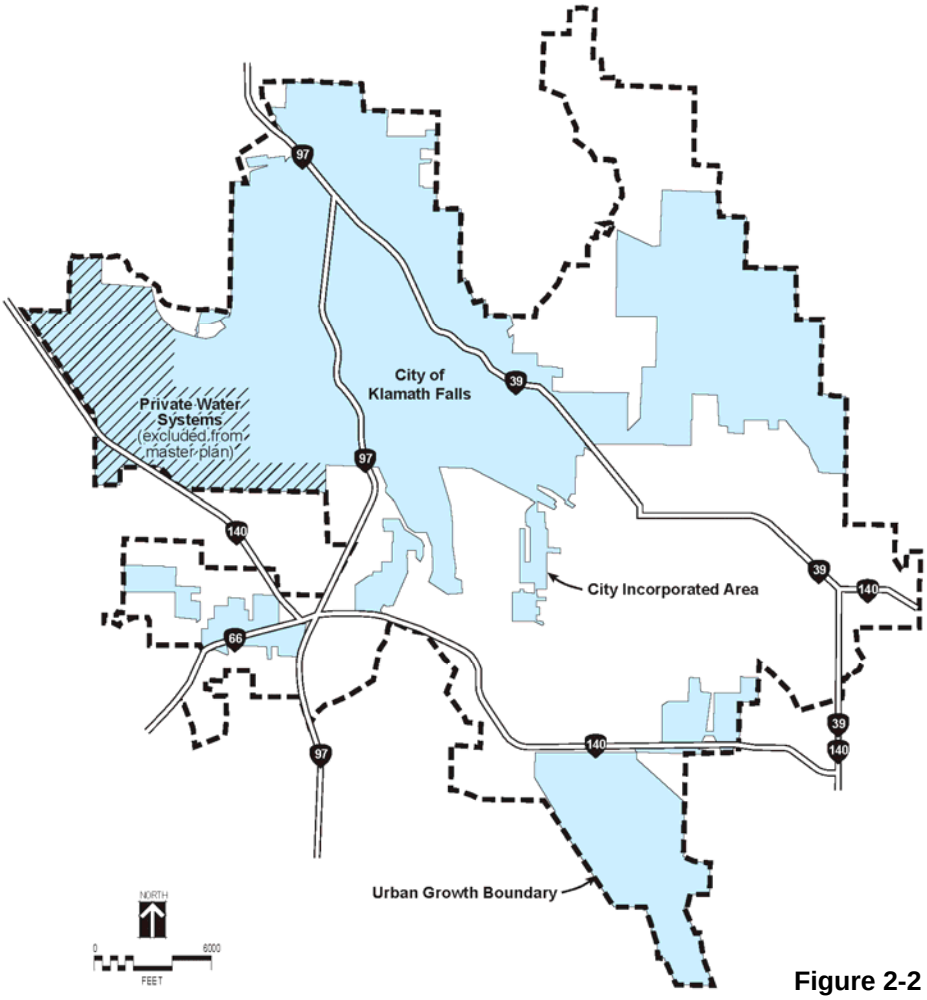

Figure 2-2
Study Area

The study area includes all lands within the Urban Growth Boundary, except for the Southview and Ridgewater planned developments located on the west side of the UGB, and the Skyline Water District just north of Sierra Heights on the east side of the UGB (small area of about 30 homes). These areas have private water systems and will not be served by the City.

In addition, the Oregon Institute of Technology (OIT) currently has its own water system and is not served by the City. However, it may be served in the future due to potential water quality issues; and is therefore included as part of the master plan study area. Service to existing private water systems could require substantial costly upgrades and would be evaluated on a case-by-case basis when request for service is made, with costs borne by those requesting service.

The center of the study area is relatively flat with gentle slopes. Ground elevations increase significantly toward the study area boundaries. Ground elevations range from about 4100 feet in the central area to over 5000 feet in the hills.

The climate is classified as high desert, with low humidity. Rainfall averages 14.2 inches annually, and snowfall averages 38.5 inches annually. Temperatures seldom rise above 100 degrees Fahrenheit. In July, the average daily temperature ranges from a high of about 85 degrees to a low of about 50 degrees. In January, the average daily temperature ranges from a high of about 40 degrees to a low of about 20 degrees.

The current population within the study area is about 46,000 residents, with about 21,000 within the City limits and another 25,000 in the unincorporated areas.

2.2 Land Uses for Master Plan

A land-use based approach was used for developing water demand projections for the master plan, as discussed in Section 4. Land use maps were prepared showing ultimate (buildout) land uses within the study area (Figure 2-3), and phasing scenarios for intermediate and ultimate development (Figure 2-4).

The land use information for these maps was obtained from the City Community Development Department and from the Klamath County Planning Department. The City's adopted zoning and general plan and the County's adopted zoning and assessor parcel information, was used as the starting point for developing the maps, supplemented with more specific development information where available. Two meetings were held with key City and County staff to discuss and review the land use information and maps. The attendees based the land use projections on the best available information regarding growth trends, and approved and submitted plans.

The discussion below regarding ultimate (buildout) land uses and phasing of future growth is based on meetings and information provided by City and County staff.

2.2.1 Ultimate Land Use

Figure 2-3 shows ultimate land uses in the study area. Buildout of ultimate uses within the Urban Growth Boundary is expected to exceed the planning horizon for this study. At buildout, the master plan assumes that the City will serve all area within the Urban Growth Boundary, except for the Southview and Ridgewater planned developments located on the western side of the UGB and the small Skyline

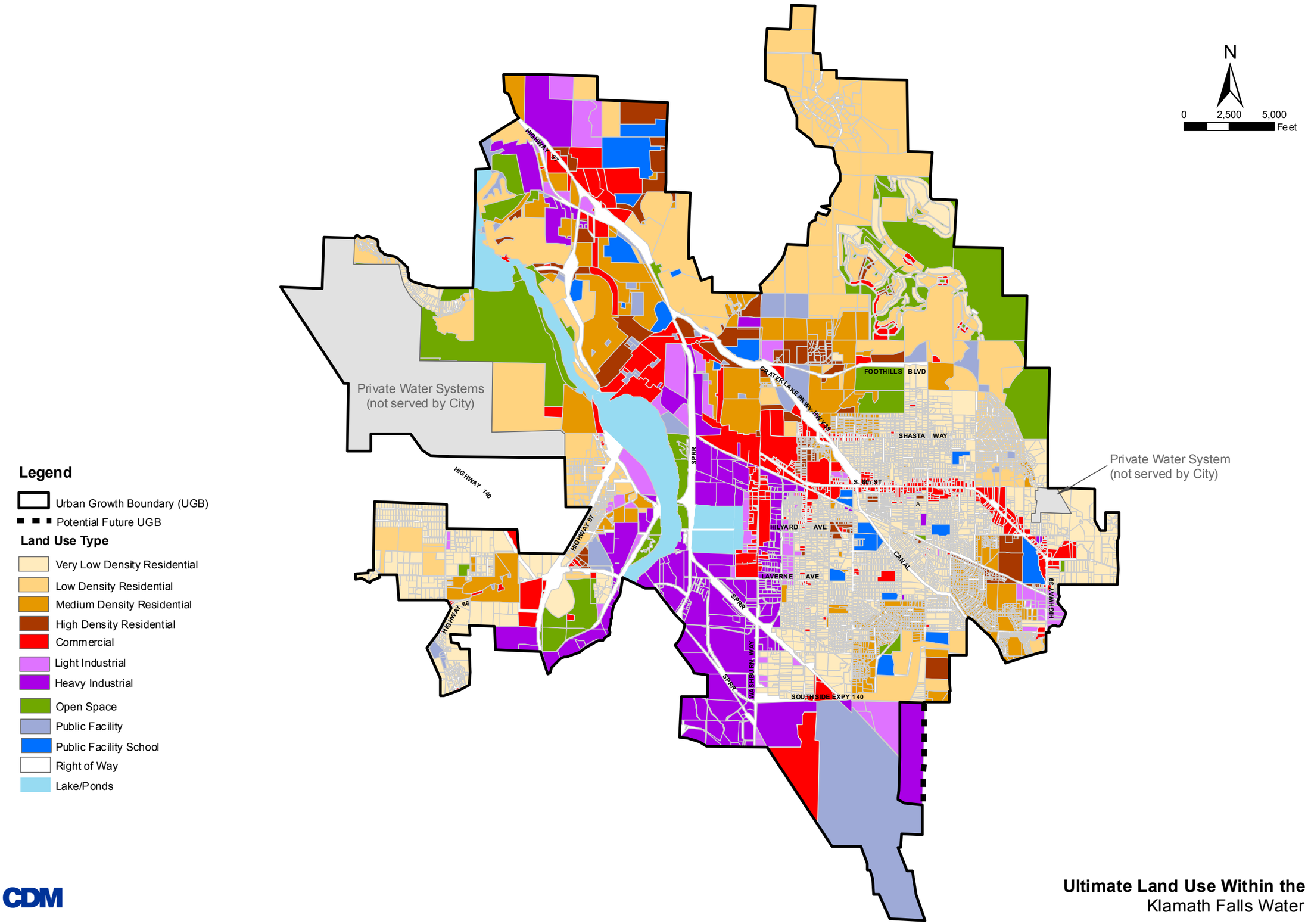

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Figure 2-3
Ultimate Land Use Within the Study Area
Klamath Falls Water Master Plan

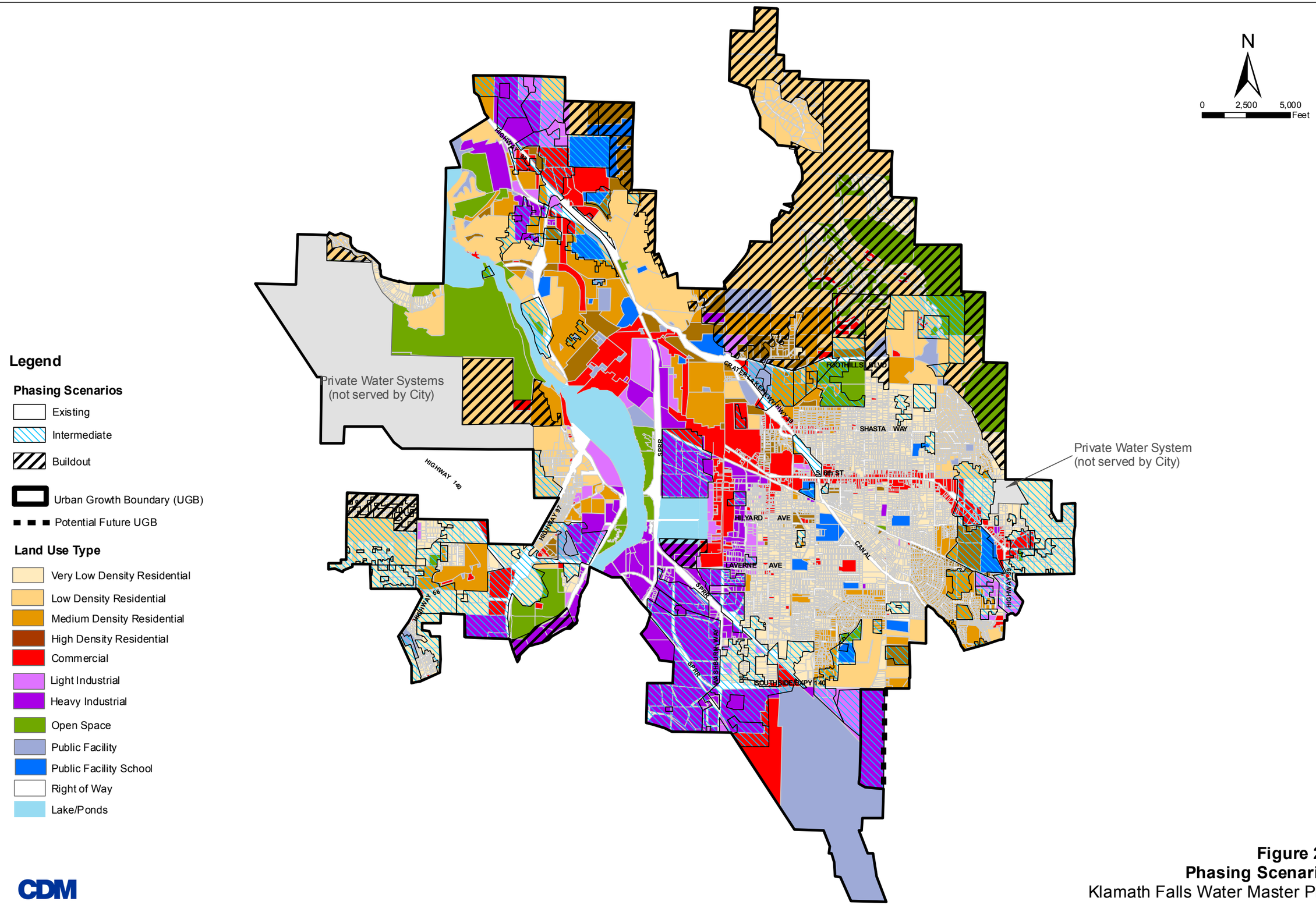


Figure 2-4
Phasing Scenarios
Klamath Falls Water Master Plan

Water District on the eastern side. As shown on Figure 2-3, the Southview and Ridgewater areas have private water systems and will not be served by the City.

Ultimate land uses were obtained from: the current City zoning map for the area within the City limits; the County adopted zoning and tax assessor parcel database for the unincorporated area; and from the Basinview Specific Plan. The zoning categories used by the City and County were grouped into simplified land use types to facilitate the master plan analysis. Table 2-1 shows the master plan land use types and the corresponding City and County zoning categories.

Figure 2-3 shows a potential change to the UGB identified by City Planning staff (shown as potential future UGB at the southeast boundary). This potential change would add some additional industrial area east of Kingsley Field. This additional area is included in the master plan demand projections.

Table 2-1
Master Plan Land Use Types Within Study Area

Master Plan Land Use Type	*Corresponding City Zoning Categories*	*Corresponding County Zoning Categories*
Residential		
Very Low Density Residential	Single family residential (County)	RS (suburban residential) – 10,000 SF minimum lots
Low Density Residential	Single family residential	RL (low density residential) – 7,000 SF minimum lots
Medium Density Residential	Medium density residential	RM (medium density residential) – 5,000 SF minimum lots
High Density Residential	Apartment residential	RH (high density residential) – 10,000 SF for 10 – 24 units per acre
Non-Residential		
Commercial	Office, neighborhood commercial, general commercial, mixed use	All commercial categories (C - commercial, CG – commercial general, CN – commercial neighborhood, CR – commercial recreation, CT – commercial transportation)
Light Industrial	Light industrial	IL (industrial light)
Heavy Industrial	Industrial	IH (industrial heavy)
Public Facility, Public Facility-School	Public	N/A
Open Space, Special Reserve, No City Water Service	Special reserve, open space	NR (non-resource), EFU (exclusive farm use), F and FR (forestry, range)
Lake, Ponds	N/A	N/A
Street Right-of-Way	N/A	N/A

2.2.2 Existing Development Served by City

Figure 2-4 shows the developed areas within the Urban Growth Boundary that are currently served by the City water system. The figure shows currently served areas without cross-hatching, which is the existing scenario for the master plan.

Areas that are not currently served are cross-hatched on the figure including large vacant parcels within currently served areas, or existing developed areas that have another water supply, e.g., private wells. The areas with private water systems not included in the master plan analysis are the Southview and Ridgewater development

areas on the western side of the UGB and the Skyline Water District just north of Sierra Heights on the eastern side of the UGB (small area of about 30 homes), which are shaded solid gray in Figure 2-4.

The existing scenario includes some anticipated developments that the City has agreed to serve, although the customers may not yet be on-line. Table 2-2 shows specific developments within the UGB that have plans and/or tentative approval from either the City or County, as of the time of this Master Plan. The table shows the total number of approved lots, and the number of lots that are included in the existing and intermediate scenarios.

Table 2-2
Anticipated Developments With Plans and/or Tentative Approval
(as of the time of this Master Plan)

Subdivision Name (1) (2)	Total Lots	Development Phasing		
		Existing Scenario		Intermediate
		Developed Lots	Undeveloped Lots	Undeveloped Lots
Clover Falls	200	0	200	0
Cregan Park	70	0	70	0
Dove Hollow	18	2	16	0
Eden Gardens	20	0	0	20
Emerald Meadows	34	0	0	34
Grandview	30	0	0	30
Hacienda Heights	24	0	0	24
Harbor View Phase 1	46	0	46	0
Juniper Ridge	36	0	0	36
Keiger Heights	13	0	0	13
Kerns Tracts	63	0	0	63
Klamath Industrial Park	8	0	8	0
Link River Estates	50	0	50	0
Madsen Corner	19	0	19	0
Partridge Hill	58	0	58	0
Pheasant Run	87	10	77	0
Prairie Meadows	47	20	27	0
Ross Ranch/Credenda/Westwind	163	0	0	163
Sage Meadows Phase 2	22	10	12	0
Sherwood Forest	11	0	11	0
Sierra Heights 1st Addition	96	0	0	96
Sky Ridge Estates	204	26	36	116
Summerfield	63	30	33	0
Sunset Village	24	0	24	0
Timbermill Shores – Mixed Use	14	1	13	0
Valley Vista	158	0	0	158
TOTAL	**2044**	**99**	**818**	**1127**

(1) The Klamath Heights subdivision is not shown on this table, as the City is not anticipating development at this time (impractical at this time).

(2) Inclusion in this table does not guarantee capacity or availability of water or signify current plan approval.

2.2.3 Intermediate Phasing

The City does not anticipate that buildout will occur within the planning horizon for this study. Therefore, it is necessary to establish an intermediate land-use scenario for planning for the capital improvement program. Based on discussion with City and County staff, a planning horizon of 10 years was selected as an appropriate intermediate scenario for capital improvement planning.

The master plan will identify improvements needed within the next 10 years in more detail for capital improvement planning. In addition, conceptual improvements will be identified for future implementation after the initial 10-year timeframe to buildout of the City. The buildout timeframe recommendations will be re-evaluated in future master plan updates, as more information becomes available over time.

Figure 2-4 shows areas within the Urban Growth Boundary that are not currently served by the City, but are anticipated to be served within the next 10 years. These intermediate phasing areas are shown as blue cross-hatched areas on the figure. Table 2-2 shows the number of lots anticipated to be developed in the intermediate timeframe for specific developments that have plans and/or tentative approval.

Black cross-hatched areas shown on Figure 2-4 are expected to be developed between the intermediate and ultimate timeframes. At buildout, whenever it occurs, it is assumed that all the black cross-hatched areas will have been developed.

As discussed further in Section 4, some existing rural residential areas in the southern portion of the study area are currently developed at a lower density than allowed by zoning, and may ultimately redevelop at higher allowable densities by buildout. Key assumptions regarding buildout demands for redevelopment areas are discussed further in Section 4.

2.2.4 Summary of Master Plan Land Uses

Table 2-3 summarizes acreages of various land uses within the study area for existing, intermediate, and ultimate buildout scenarios. These acreages were obtained using GIS tools from the land use database information illustrated on Figures 2-3 and 2-4.

Table 2-3
Summary of Land Use Acreages within Master Plan Study Area

Land Use Type	Area (acres)		
	Existing [1]	Intermediate	Buildout
Residential			
Very Low Density Residential	2,354	3,732	4,060
Low Density Residential	1,974	2,364	4,407
Medium Density Residential	1,640	1,931	2,332
High Density Residential	456	609	836
Subtotal - Residential	*6,424*	*8,636*	*11,635*
Non-Residential			
Commercial	1,268	1,594	1,649
Light Industrial	347	674	702
Heavy Industrial	969	2,392	2,527
Public Facility - School	247	312	320
Public Facility	1,672	1,936	2,193
Subtotal - Non-Residential	*4,503*	*6,908*	*7,391*
Others (no City Water Service is planned for these land uses)			
Water Bodies (Lake, Ponds)	904	904	904
Open Space, Special Reserve, No City Water Service, Right of Way (Freeways, Railroads)	1,626	1,828	2,616
Private Water Systems (e.g., Southview, Ridgewater)	1,795	1,795	1,795
Subtotal - Others	*4,325*	*4,527*	*5,315*
Total	***15,252***	***20,071***	***24,341***

[1] Existing Scenario acreages include some anticipated developments with plans and/or tentative approval, although the customers may not yet be on-line (as shown on Table 2-2).

Section 3
Existing Water System

This section describes key features of the City's existing water system.

3.1 Groundwater Wells

Groundwater wells provide the entire supply for the City's water system. Table 3-1 summarizes key information obtained from the City about the existing wells.

The Conger Avenue well field, which has 5 production wells, is the largest centralized supply location. These wells provide over 75 percent of the existing supply capacity. Other wells located throughout the City's system provide the remaining 25 percent of existing supply capacity. In the future, the City intends to keep the existing wells in service and add new wells as needed.

The overall quality of the groundwater basin is excellent. The City's ground water supply meets all state water quality requirements. If aesthetic (secondary) water quality issues should be encountered at a specific well site, such as manganese, the City will evaluate the potential need for wellhead treatment. The master plan scope does not include water quality evaluations.

Cities and other water users must obtain authorization from the State of Oregon Water Resources Department to use water from any groundwater or surface water source. For allowable water uses, the Department issues a permit that provides permission to begin using the water beneficially. After a permitted water right has been fully developed and put to beneficial use, the Department determines if a water right certificate can be issued. A water right certificate is a permanent water right that will be valid as long as the water is used at least once every five years in accordance with the provisions of the water right.

According to City-provided information, the City has certified rights to 10.64 mgd of well capacity based on proven beneficial use, and permitted rights to an additional 26.31 mgd capacity, for total water rights of 36.95 mgd. The City is in the process of proving beneficial use for their permitted rights to certify all rights. The City has indicated that it has the option of transferring water rights within the same aquifer, which may allow locating new wells in other areas if needed for future system service and hydraulics.

3.2 Distribution System

The City's existing water distribution system includes 227 miles of distribution pipelines ranging in size from 2-inch to 20-inch in diameter, 22 storage reservoirs, 23 booster pump stations, and 18 pressure regulating station locations. Figure 3-1 presents a schematic map of the City's existing distribution system with the pipes color coded by pressure zone. The figure also shows ground elevation contours from the City's mapping data for determination of zone boundaries.

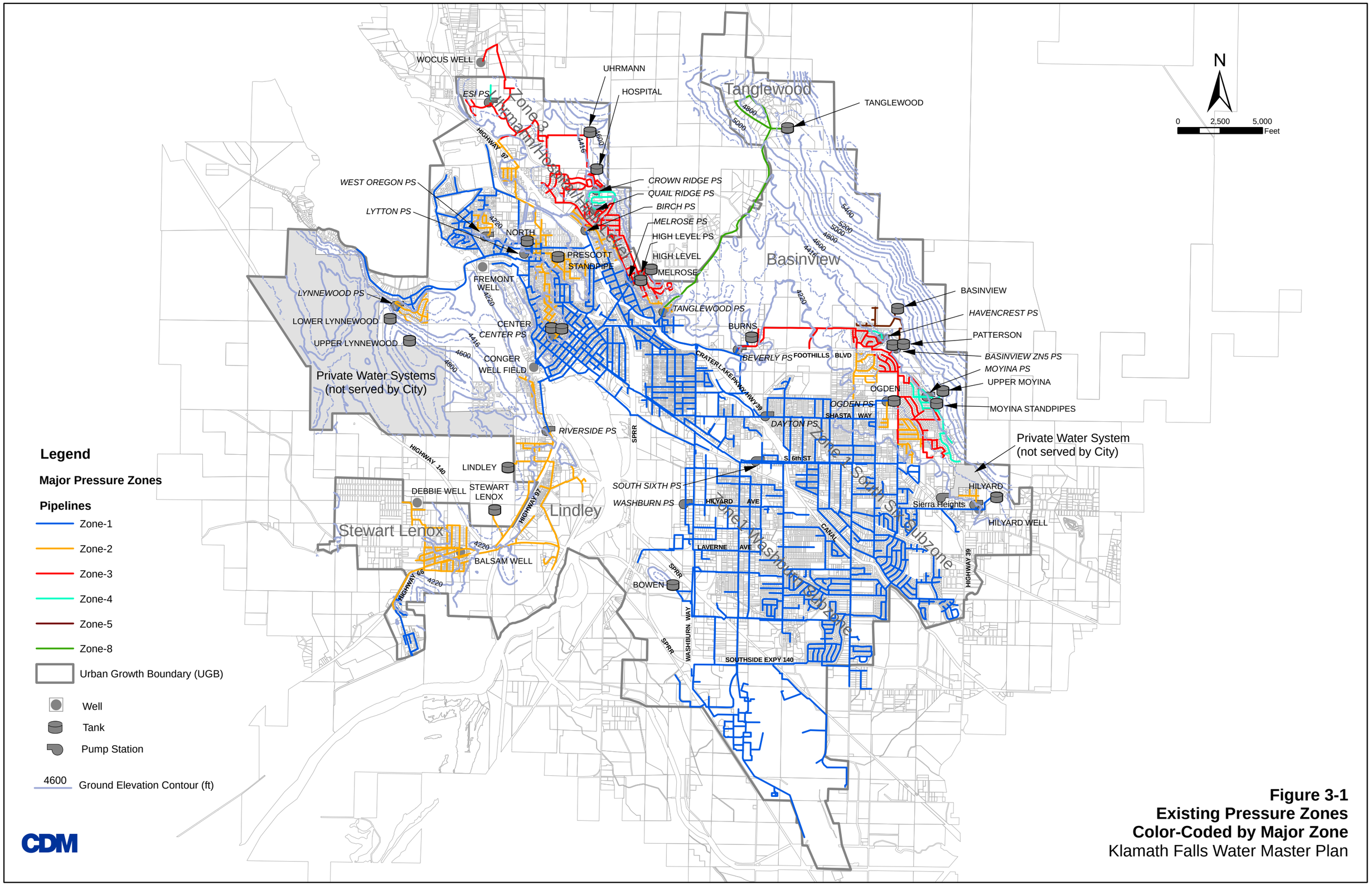


Figure 3-1
Existing Pressure Zones
Color-Coded by Major Zone
Klamath Falls Water Master Plan

Table 3-1
Existing Groundwater Wells

Well Name	Well ID	Location	Year Drilled	Depth Drilled (ft)	Casing Size [1] (in)	Control Points and Operational Notes	Water Rights (mgd)			Pump Capacity	
							Certified	Permitted	Total [2] [3]	(gpm)	(mgd)
Conger #7	12923	530 Conger Avenue Well Field	1926	370	16	Center Reservoirs	2.33	--	2.33	1,100	1.6
Conger #8	37866		1930	830	12	North Reservoir; Center Reservoirs optional	3.75	2.71	6.46	1,125	1.6
Conger #9	37867		1958	435	16	Center Reservoirs	2.59	2.00	4.59	3,500	5.0
Conger #10	46115		1968	559	20	Center Reservoirs	1.81	3.94	5.75	4,200	6.0
Conger #25	30205		1992	625	20	Center Reservoirs	--	7.11	7.11	4,700	6.8
Subtotal Capacity in Conger Avenue Well Field							***10.48***	***15.76***	***26.24***	***14,625***	***21.0***
Balsam #20	30204	4047 Balsam Dr.	1989	438	10	Stewart Lenox Reservoir	--	0.97	0.97	325	0.5
Debbie#22 [4]	13322	2623 Debbie Dr.	1987	380	16		--	2.13	2.13	525	0.7
Subtotal Capacity in Stewart-Lenox Area							***--***	***3.10***	***3.10***	***850***	***1.2***
Wocus#1 [5]	38275	790 Longacre Ln.	1991	530	8	Uhrmann Reservoir; Hospital Reservoir optional. Arsenic at levels below regulatory limit.	--	2.16	2.16	750	1.1
Moyina #4	12872	1401 Kimberly Dr.	1961	1100	16	NA – not used	0.16	--	0.16	0	0.0
Fremont #11	30203	510 Nevada Dr.	1961	701	16	Lower Lynnewood Reservoir; North Reservoir optional. Only used in summer due to high manganese.	--	1.58	1.58	1,100	1.6
Henley #12	30202	4623 Alt Way	1993	155	10	No control; emergency use only due to high manganese.	--	1.01	1.01	320	0.5
Homedale #13	11636	1430 Homedale	1981	427	16	No control; operated 24/7 during peak demands; sand issues.	--	1.08	1.08	400	0.6
Unity #18	11637	2000 Chinchilla	1977	1000	12	No control; emergency use only due to high levels of entrained air	--	0.54	0.54	325	0.5
Hilyard #19	37981	7850 Margraf Ln	1993	732	16	Hilyard Reservoir	--	1.08	1.08	550	0.8
Subtotal Capacity of Remaining Wells							***0.16***	***7.45***	***7.61***	***3,445***	***5.1***
						Total Capacity	**10.64**	**26.31**	**36.95**	**18,920**	**27.3**

(1) The wells in Table 3-1 are typically cased to a depth where the geology is stable (e.g., the Conger wells are cased to a depth of approximately 160 feet).
(2) Total water rights include both certified and permitted rights.
(3) City is investigating a future well permit for 0.87 mgd at an undetermined location. Potential locations may be south of Stewart Lenox area.
(4) City conducted an evaluation of the Debbie Well to determine if it could be upsized in the future. The report indicates that the long-term (safe yield) pumping rate for the Debbie Well is 1,500 gpm if the existing well is improved to its maximum capacity. An alternate option would be keep the existing well and install another deep well in the same aquifer, which would provide some redundancy. A new well should be located at least 2,000 feet away from the existing deep wells in the area (including larger capacity irrigation wells).
(5) City had considered adding another well at the Wocus site. However, this is no longer being considered due to the potential regulatory hurdles associated with water rights, land use permitting, and the potential cost of treatment if arsenic removal is required. .

Figure 3-2 shows a schematic profile of the system showing service zones and elevations of key facilities. Table 3-2 summarizes key features of the existing service zones. There are currently six major zones based on service elevation ranges.

As indicated on Table 3-2, there are a number of small separate service zones that serve similar elevation ranges throughout the service area. Zone 1, the Main Subzone, is the lowest and largest zone in the system. Twenty other subzones are much smaller and serve outlying and/or higher elevation areas. The configuration of the existing system limits the amount of water that can effectively be conveyed to some areas.

Table 3-2
Existing Service Zones

Major Zone	*Subzone Name*	*Subzone Type*	*Active Wells Directly Pumping into Subzone*	*Reservoirs in Subzone*	*Booster Stations Serving Subzone*	*Pressure Reducing Valve Stations (PRVs) Serving Subzone*
1	Main (includes South 6th, Washburn, and North/Central subzones)	Reservoir	Conger Well Field Fremont Well Henley Well Hilyard Well	Lower Lynnewood North Center #1 Center #2 Melrose Bowen Ogden Hilyard Burns	South 6th Washburn Dayton (backup) Melrose In-Line Booster Burns In-Line Booster	
	West Klamath Reduced	PRV (Stewart Lenox-PRV)				West Klamath
2	Stewart Lenox / Lindley	Reservoir	Debbie Well Balsam Well	Stewart Lenox Lindley	Riverside (backup)	
	Upper Lynnewood	Reservoir		Upper Lynnewood	Lynnewood	
	West Oregon	Booster Only			West Oregon	
	Mollie's Area Reduced	PRV (PRV-2-HWY)				Dan O'Brien Way
	Prescott	Reservoir		Prescott Standpipe	Center Tanks Lytton	
	Sierra Heights	Booster Only			Sierra Heights	
	Eldorado Reduced	PRV (PRV-2)				Eldorado Area
	Old Fort Road Reduced	PRV (PRV-6)				South Hillside
	North Hills Reduced	PRV (PRV-1)				North Hills Area
	Moyina Reduced	PRV (PRV-13)				Moyina Area
	Ogden Reduced	PRV (PRV-OGDEN)				Ogden
	Katie Lane Reduced	PRV (Katie Lane)				Katie Lane
3	Hospital/Uhrmann	Reservoir	Wocus Well	Uhrmann Hospital High Level	Birch High Level	
	Patterson	Reservoir		Patterson #1 Patterson #2	Beverly Ogden	
	Upper Moyina Reduced	PRV (PRV-3)				Upper Moyina Area
4	ESI	Booster Only			ESI	
	Crown Ridge Boosted	Booster Only			Crown Ridge Quail Ridge	
	Havencrest	Booster Only			Havencrest	
	Upper Moyina	Reservoir		Upper Moyina Moyina Standpipes	Moyina	
5	Basinview 5	Reservoir		Basinview	Basinview	
8	Tanglewood	Reservoir		Tanglewood	Tanglewood (Laguna)	

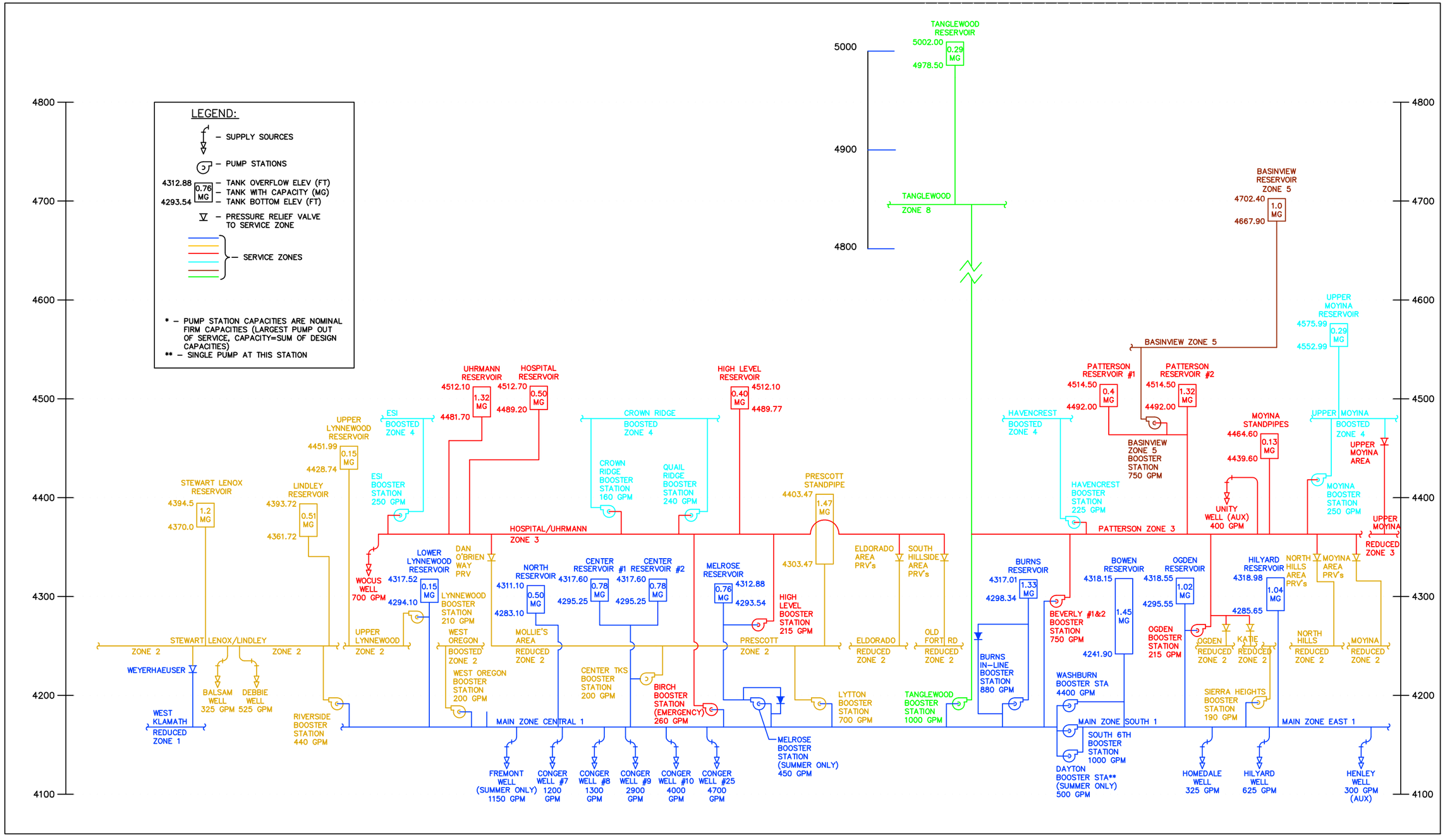


Figure 3-2
Existing System Schematic Profile
Klamath Falls Water Master Plan

CDM

3.3 Reservoir Storage

There are 22 existing reservoirs with a total storage capacity of 16.7 million gallons. Table 3-3 summarizes key features of the reservoirs, which range in size from 0.15 to 1.5 million gallons. Reservoir locations are shown on Figure 3-1 and elevations are represented graphically on Figure 3-2. Some reservoirs are standpipes, so a portion of the storage volume is not usable where the normal hydraulic gradeline in the distribution system is higher than the bottom portion of the standpipe.

Table 3-3
Existing Storage Reservoirs

Reservoir Name	Pressure Zone	Capacity (MG)	Bottom Elevation (feet)	Overflow Elevation (feet)	Diameter (feet)	Height (feet)	Supply to Reservoir / Controlling Pump Station(s)
Basin View	5	0.53	4677.9	4702.7	60	26	Basinview Booster
Bowen	1	1.45	4241.9	4318.2	57	80	Washburn Booster
Burns	1	1.33	4298.3	4317.0	110	20	Beverly Booster Pump #3
Center Reservoirs No. 1 and No. 2	1	1.56 (each 0.78)	4295.3	4317.6	77	24	Conger Well Field
High Level	3	0.40	4489.8	4512.1	55	24	High Level Booster
Hilyard	1	1.04	4285.7	4319.0	73	35	Hilyard Well #19
Hospital	3	0.50	4489.2	4512.7	60	24	Wocus Well #1 Birch Booster
Lindley	2	0.51	4361.7	4393.7	52	33	Riverside Booster
Lynnewood Lower	1	0.15	4294.1	4317.5	33	24	Fremont Well #11
Lynnewood Upper	2	0.15	4428.7	4452.0	33	24	Lynnewood Booster
Melrose Reservoir	1	0.76	4293.5	4312.9	82	20	Melrose Booster
Moyina Lower (6 standpipes)	3	0.13	4439.6	4464.6	12	26	Gravity fill from Patterson Reservoir via altitude valve Lower Moyina Reservoir
Moyina Upper	4	0.29	4553.0	4576.0	46	24	Moyina Booster
North Tank	1	0.50	4283.1	4311.1	55	30	Conger Well #8 Fremont Well #11 optional
Ogden	1	1.02	4295.6	4318.6	87	24	So 6th Street Booster
Patterson #1	3	0.41	4492.0	4511.5	60	20	Beverly Booster #1 & #2 Ogden Booster #3 & #4
Patterson #2	3	1.31	4492.0	4514.5	100	24	Beverly Booster #1 & #2 Ogden Booster #3 & #4
Prescott	2	1.47	4303.5	4403.5	50	100	Lytton Booster
Stewart Lenox	2	1.24	4370.0	4394.5	93	25.5	Balsam Well #20 Debbie Well #22
Tanglewood	8	0.29	4978.5	5002.0	46	24	Laguna Booster
Uhrmann	3	1.32	4481.7	4512.1	86	33	Wocus Well #1 Birch Booster
Total Storage Capacity		**16.4**					

3.4 Pump Stations

Booster pump stations are located throughout the City at key locations to pump water into reservoirs, provide adequate pressures in higher elevation areas or small isolated areas, and offset pressure losses when conveying water to some outlying areas.

Table 3-4 summarizes key features of the existing booster stations. Figure 3-1 shows booster station locations. Figure 3-2 indicates their relationship to pressure zones and other facilities.

Table 3-4
Existing Booster Pump Stations

Pump Station Name	Service Zone (Zone Pumping to)	Source Zone (Zone Pumping From)	Location	Ground Elevation (feet)	Number and Capacities of Pumps (gpm)	Controlled By / Operational Notes
Basinview	5	3	Patterson Reservoir Site	4492	#1 - 750 #2 - 750	Basin View Reservoir Level
Beverly Pumps #1 & #2	3	1	Beverly Dr / Foothills Blvd	4193	#1 - 750 #2 - 750	Patterson #1 Reservoir Level; Patterson #2 Reservoir optional; Works with Ogden Booster Station; during summer, Beverly is lead station.
Beverly Pump #3 (Burns inline)	3	1	Beverly Dr / Foothills Blvd	4193	#3 - 1000	Burns Reservoir Level; inline to Burns Reservoir
Birch	3	1	Birch St / Delores St	4212	#1 - 260 #2 - 260	Uhrmann Reservoir Level; Hospital Reservoir optional
Center	2	1	Center Reservoir Site	4297	#1 - 200 #2 - 200	No control; manually operated 24/7 during peak demand periods
Crown Ridge	4	3	1807 Harmony Lane	4131	#1 - 160 #2 - 600	Discharge pressure; operated 24/7; pumps to zone with no storage. Works with Quail Ridge booster serving same area.
Dayton	1	1	Dayton St/Shasta Way	4424	#1 - 500	No control; manually operated 24/7 during peak demand periods (works with South 6th Booster Station in summer only)
ESI	4	3	ESI Way/Harbor View St	4291	#1 - 10-60 #2 - 60-250 #3 - 1500	Discharge pressure; operated 24/7; VFD Pumps #1 & #2
Harriman	2	1	Harriman St / Oregon Ave	4294	#1 - 60 #2 - 200	No control; emergency use only

Table 3-4
Existing Booster Pump Stations

Pump Station Name	Service Zone (Zone Pumping to)	Source Zone (Zone Pumping From)	Location	Ground Elevation (feet)	Number and Capacities of Pumps (gpm)	Controlled By / Operational Notes
Havencrest	4	3	5871 Havencrest Dr	4254	#1 - 150 #2 - 225 #3 – 375	Discharge pressure; operated 24/7
High Level	3	1	Melrose Reservoir Site	4440	#1 - 225 #2 - 435	High Level Reservoir Level
Lynnewood	2	1	Lower Lynnewood Reservoir Site	4388	#1 - 210 #2 - 210	Upper Lynnewood Reservoir Level
Lytton	2	1	Lytton St / Van Camp St	4215	#1 - 700 #2 - 700	Prescott Reservoir Level
Melrose	1	1	2030 Melrose Street	4167	425	Melrose Reservoir Level; Summer only, inline to fill reservoir
Moyina	4	3	Lower Moyina Reservoir Site	4113	#1 - 500 #2 - 250	Upper Moyina Reservoir Level
Ogden	3	1	1435 Ogden St	4173	#3 - 215 #4 - 430	Patterson Reservoir Level. Works with Beverly Booster; during winter, Ogden is lead station.
Quail Ridge	4	3	Wade Circle / Eulalona Ct.	4388	#1 - 80 #2 - 240 #3 - 430	Discharge pressure; operated 24/7; pumps to zone with no storage. Works with Crown Ridge booster serving same area.
Riverside	2	1	800 block Riverside Dr	4091	#1 - 440 #2 - 440	Lindley Reservoir Level
Sierra Heights	2	1	Sierra Heights Blvd / Hilyard Ave		#1 - 10-50 #2 - 40-190 #3 - 1000	Discharge pressure; operated 24/7; VFD Pumps #1 & #2
South 6th Street	1	1	3700 block South 6th St	4113	#1 - 1000 #2 - 1000	Ogden Reservoir Level
Tanglewood (at Laguna)	8	1	Laguna St/Old Fort Rd	4286	#1 - 1000 #2 - 1000 #3 - 1000	Tanglewood Reservoir Level
Washburn [(1)]	1	1	2515 Hilyard Ave	4091	#1 – 1500 - 3100 #2 – 1500 - 3100 #3 – 1500 - 3100 # 4 Future (same)	Bowen Reservoir Level; All VFD 100 HP pumps – up to 4400 gpm total with 2 pumps running.
West Oregon	2	1	W Oregon Av / Harvard St		#1 - 50 #2 - 200 #3 - 600	Discharge pressure; operated 24/7; zone has no storage.

(1) Washburn Booster Station information shows the upgraded improvements implemented in 2009. The expanded pump station building is designed to accommodate a total of 4 pumps. Initially, there are 2 active duty pumps and 1 standby pump. Another pump of the same size can be added later as needed to meet future growth in demands.

3.5 Pressure Regulating Stations

Pressure regulating stations are located where water is supplied to a lower elevation area from a zone with higher pressures. At these locations, pressure reducing valves are used to reduce pressures in the service zone to avoid over-pressurizing lower elevation customers.

Table 3-5 summarizes key features of existing pressure regulating stations.

Table 3-5
Existing Pressure Reducing Stations

PRV Zone	Zone Supplied From	Locations of PRV Station Serving Zone	Number of Valves	Sizes of Valves (inches)	PRV Settings (psi)	
					Inlet	Outlet
Zone 1 West Klamath Reduced	2	Weyerhauser Rd / Highway 66	2	6, 2	78	42
		Douglas / Granite (serves only a few homes)	1	2	98	54
Zone 1 Harbor Isles Area	2	Lakeport Blvd / Quarry St (purpose is solely for fire backup to area)	1	6	73	42
Zone 2 Mollie's Area Reduced/ Dan O'Brien Way	3	Highway 97 / Dan O'Brien Rd.	1	8	145	76
Zone 2 Eldorado Reduced	3	Eldorado / Sloan	1	6	110	46
		N. Pacific Terrace / Van Ness	1	4	88	44
		Lowell / Pacific Terrace	1	2	110	50
Zone 2 Old Fort Road Reduced/ South Hillside Area	3	Dixon / Damont	1	4	120	62
		Hillside / Auburn	1	4	115	48
Zone 2 North Hills Reduced	3	Homedale / Foothills Blvd.	1	4	92	60
		Spring Crest / Madison	1	6	96	60
		Shasta View Blvd.	2	8,3	120	70
Zone 2 Moyina Reduced	3	Katie Lane	1	2	120	84
		Carlson / Valhala	1	4	104	78
Zone 2 Ogden Reduced	3	Ogden Booster Station	1	2	106	72
Zone 2 Katie Lane Reduced	3	Katie Lane/Patterson Street	2	6,2	120	84
Zone 3 Upper Moyina Reduced	4	Climax / Kimberly Dr.	1	4	84	64
		Climax / Kimberly Ct.	1	2	93	65
		Beckton / Tamera (serves only a few homes)	1	2	90	52

Section 4
Water Demands

This section summarizes historic water production and consumption data, describes unit demand factors and peaking factors developed for the master plan, and presents demand projections for the master plan analysis.

4.1 Historic Water Demand

4.1.1 Production Data

The City provided well production data for 1998 through 2007. Appendix A contains detailed information on the historic production data.

Table 4-1 summarizes historic production data on a system-wide basis for total annual production, average daily production, maximum day production, and minimum day production. Table 4-1 also shows the relationship (peaking factor) between maximum and minimum day production and average daily production over the year.

Table 4-1
Summary of Historic Well Production

Year	Total Annual Production	Average Daily Production	Maximum Day Production	Minimum Day Production	Peaking Factor to Average Daily Production	
					Maximum Day	Minimum Day
1998	2,665 MG	7.3 mgd 5069 gpm	16.3 mgd 11,319 gpm (August)	4 mgd 2,778 gpm (December)	2.24	0.56
1999	2,845 MG	7.8 mgd 5417 gpm	16.5 mgd 11,458 gpm (July)	4 mgd 2,778 gpm (December)	2.12	0.51
2000	2,920 MG	8 mgd 5,555 gpm	16.9 mgd 11,736 gpm (June)	4.3 mgd 2,986 gpm (January)	2.12	0.54
2001	2,995 MG	8.2 mgd 5,694 gpm	16.4 mgd 11,389 gpm (June)	3.7 mgd 2,569 gpm (December)	1.99	0.45
2002	2,845 MG	7.8 mgd 5,417 gpm	15.6 mgd 10,833 gpm (July)	3.6 mgd 2,500 gpm (December)	2.01	0.46
2003	2,647 MG	7.2 mgd 5,022 gpm	17.3 mgd 11,987 gpm (July)	3.7 mgd 2,593 gpm (March)	2.39	0.52
2004	2,809 MG	7.7 mgd 5,322 gpm	15.6 mgd 10,857 gpm (July)	3.9 mgd 2,730 gpm (December)	2.04	0.51
2005	2,674 MG	7.3 mgd 5,074 gpm	16.5 mgd 11,454 gpm (July)	3.9 mgd 2,694 gpm (May)	2.26	0.53
2006	2,892 MG	7.9 mgd 5,489 gpm	16.5 mgd 11,454 gpm (June)	3.9 mgd 2,694 gpm (January)	2.09	0.49

Table 4-1
Summary of Historic Well Production

Year	Total Annual Production	Average Daily Production	Maximum Day Production	Minimum Day Production	Peaking Factor to Average Daily Production	
					Maximum Day	Minimum Day
2007	3,028 MG	8.3 mgd 5,752 gpm	16.1 mgd 11,213 gpm (July)	4.0 mgd 2,787 gpm (December)	1.95	0.48
10-Year Average (1998-2007)	2,832 MG	7.7 mgd 5,381 gpm	16.4 mgd 11,370 gpm	3.9 mgd 2,711 gpm	2.11	0.50
5-Year Average (2003-2007)	2,810 MG	7.7 mgd 5,332 gpm	16.4 mgd 11,393 gpm	3.9 mgd 2,700 gpm	2.14	0.51

Average daily production for each year over the 10-year period ranged from 7.2 to 8.3 mgd. The average production over the full 10-year period was 7.7 mgd, and was also 7.7 mgd on average over the most recent 5-year period.

For an existing study area population of about 46,000 residents, the average day per capita production over the last 10 years has averaged 167 gallons per capita per day for the total system (residential and non-residential uses). Based on 16,300 existing services (meters), the average day production over the last 10 years has averaged about 472 gallons per meter per day for the total system (residential and non-residential uses).

Figure 4-1 shows the average day, average summer day, maximum day and minimum day production for each of the 10-years.

Figure 4-2 shows the monthly peaking factors, which were averaged over the 10-year period (1998-2007). The monthly peaking factors relate the average monthly production to the average daily production over the year. As indicated on these figures, a wide range in demands occurs over the course of a year.

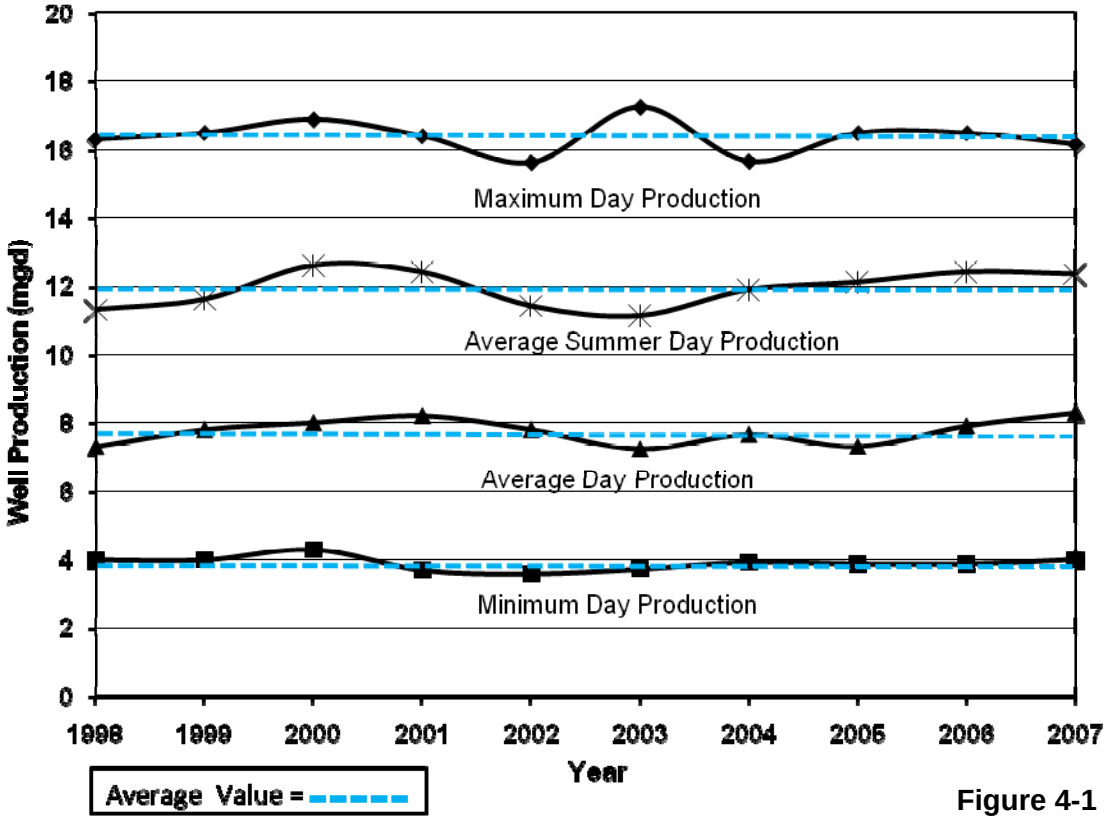


Figure 4-1
Historic Well Production

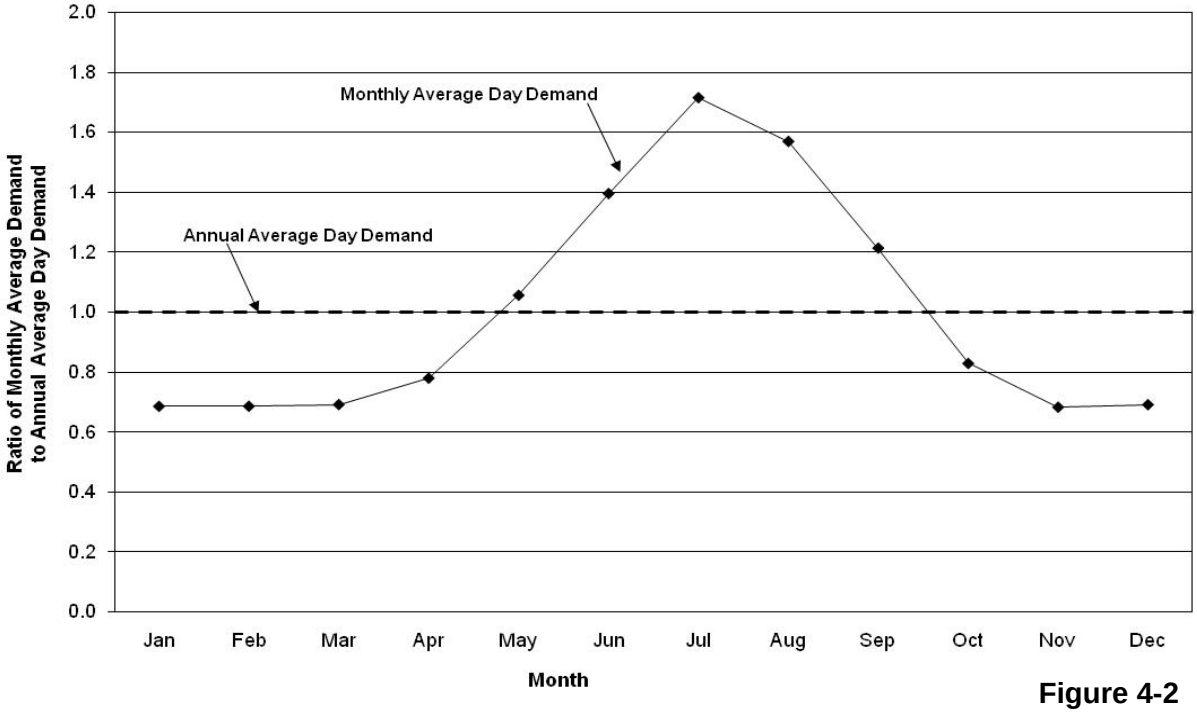


Figure 4-2
Average Monthly Peaking Factors

4.1.2 Consumption Data

The City provided water consumption data for 2007 from customer billing records by customer type and by meter size and cycle (meter reading route). Table 4-2 summarizes the 2007 consumption data on a system-wide basis by customer type.

As indicated in Table 4-2, residential usage accounts for 75 percent of the total metered demand, with non-residential uses comprising about 25 percent. Table 4-3 summarizes the 2007 consumption data by meter size as well as customer type, and shows both the total usage and the average day use per meter. As of 2007, the City had a total of 16,295 meters (customers). About 92 percent of the services were for residential customers and the remaining 8 percent for commercial and industrial (non-residential) customers.

Table 4-2 shows actual usage according to water meter records; and does not include unaccounted-for water (system losses), as discussed further below in Section 4.1.3. The total production in 2007 was 8.3 mgd as shown on Table 4-1, which indicates relatively high system losses of 21 percent between production and consumption.

In the previous master plan, similar detailed consumption data was provided for 2002. The City provided the detailed consumption data by meter-reading cycle for users within the City and outside the City. This information allowed consumption data to be analyzed with regard to the spatial distribution of existing demands within the service area.

The historic consumption data was used to determine appropriate unit demand and maximum day peaking factors for the master plan demand projections, as discussed later in this section. Review of the 2007 usage data indicated that overall usage patterns were similar to the 2002 usage data analyzed in the previous master plan. Therefore, it remains appropriate to utilize system-wide unit demand and maximum day peaking factors for the master plan. Storage and pumping capacities were based on the system-wide maximum day peaking factor. For pipeline sizing and extended period simulations, zone-specific peak hour factors were developed based on operations data, as discussed in Section 4.2.

Between 2002 and 2007, there was an increase in the total number of services of about 5 percent. The total metered usage (customer consumption from billing records) decreased slightly between 2002 and 2007, while total demand, including system losses, increased only slightly. This data indicates that the average demand per customer is holding steady or slightly declining, which is likely due to the City's water conservation efforts.

Appendix B contains tables providing detailed information on the actual 2007 consumption data by meter size and by meter reading cycle. These tables include: Appendix B-1 Total Annual Usage for 2007, Appendix B-2 Average Day Usage per Service in 2007, and Appendix B-3 Number of Meters in 2007.

Table 4-2 Summary of 2007 Water Consumption by Customer Type			
Customer Type	**Total Annual Consumption (MG)**	**Average Day Consumption (mgd)**	**Percent of Total Metered Demand**
SF – Single Family Residential, Duplexes	1,553	4.3	65%
MF – Multiple Family Residential, Mobile Home Parks, Four-Plexes, Apartments	243	0.7	10%
CM – Commercial, Industrial, Other Non-Residential	584	1.6	25%
Total Usage from Metered Billing (1)	**2,380**	**6.5**	**100%**

(1) Total Usage is consumption from metered billing records, and does not include system losses (unaccounted-for water) between production and consumption.

Table 4-3 Summary of 2007 Water Consumption by Meter Size						
Customer Type	**Meter Size (in)**	**Total Usage (gallon)**	**Total Number of Services**	**Average Day Use per Service (gpd)**	**% of Total Annual Usage**	**% of Total Services**
SF – Single Family Residential, Duplexes	5/8	1,449,534,577	14133	281	61%	87%
	1	84,956,254	468	498	4%	3%
	1.5	14,195,033	63	613	1%	0%
	2	4,191,335	16	725	0%	0%
	3	172051.937	1	404	0%	0%
SF Total		**1,553,049,251**	**14,681**	**290**	**65%**	**90%**
MF – Multiple Family Residential, Mobile Home Parks, Four-Plexes, Apartment	5/8	32,601,598	144	620	1%	1%
	1	46,510,127	113	1,124	2%	1%
	1.5	42,762,387	29	3,994	2%	0%
	2	65,661,752	15	12,336	3%	0%
	3	25,636,487	7	9,801	1%	0%
	4	3,598,130	1	9,858	0%	0%
	6	25,947,676	4	17,410	1%	0%
MF Total		**242,718,156**	**314**	**2,119**	**10%**	**2%**
CM – Commercial, Industrial, Other Non-Residential	5/8	99,324,895	781	348	4%	5%
	1	82,567,725	216	1,048	3%	1%
	1.5	112,132,980	126	2,433	5%	1%
	2	136,215,015	127	2,950	6%	1%
	3	44,442,511	28	4,323	2%	0%
	4	89,277,750	15	16,490	4%	0%
	6	17,613,630	5	9,651	1%	0%
	8	2,280,810	2	3,124	0%	0%
CM Total		**583,855,316**	**1,300**	**1,231**	**25%**	**8%**
Grand Total		**2,379,622,723**	**16,294**	**400**	**100%**	**100%**

4.1.3 Unaccounted-for Water

Unaccounted-for water refers to system losses between production and consumption. These losses may occur from fire flows, construction use, hydrant flushing, leaks, main breaks, metering inaccuracies, illegal connections or usage, and other types of unmetered water use.

In the previous 2004 master plan, the City's historical unaccounted-for water typically had ranged from 10 to 15 percent; and a 12.5 percent allowance was used for estimating future unaccounted-for water. In 2007, unaccounted-for water was as high as 21 percent based on the metered consumption data in Table 4-2 and the production data in Table 4-1. Since 2007, the City has instituted a program to replace old and outdated meters with more accurate meters, and has re-initiated a systematic leak detection program, e.g., 65 leaks repaired in 2007/2008. By the end of 2008, the City's efforts had reduced the unaccounted-for water percentage by 3 percent to 18 percent.

For this master plan, a 15 percent allowance has been selected for estimating future unaccounted-for water. Due to the City's continuing efforts in reducing unaccounted-for water through meter replacements and leak detection, the 2008 rate of 18 percent is expected to drop by another 3 percent to achieve 15 percent in the future. Further reductions in unaccounted-for water may occur and should be re-evaluated in future master plan updates.

4.1.4 Large Users

Table 4-4 shows the top 9 largest water users served by the City based on 2007 consumption data, with respect to their annual consumption amount. These largest water users are typically the larger meters, although the amount of usage does not correspond exactly to the size of the meter, i.e., the largest user may not have the largest meter. Seven of the top 9 largest users are industrial, business or institutional users. The remaining two of the top 9 are mobile home parks/multiple family residential users. These large meters have higher consumption than the typical customer, and account for about 7 percent of total existing consumption.

Table 4-4 Large Users		
Large User (Nearest Model Node)	**Total Annual Consumption (MG)**	**Average Daily Consumption**
Thomas Lumber Co (J-707)	29.5	0.081 mgd 56 gpm
Klamath Cogeneration (SL-J-58)	24.0	0.066 mgd 46 gpm
Kingsley Field (J-295)	22.2	0.061 mgd 42 gpm
Jeld-Wen Fiber (3034)	17.9	0.049 mgd 34 gpm
Merle West Medical Center (3038)	17.4	0.048 mgd 33 gpm
Villa West Mobile Home Park (J-614)	13.5	0.037 mgd 26 gpm
Emerald Estates (to be determined)	13.3	0.036 mgd 25 gpm
City Wastewater (3030)	11.8	0.032 mgd 22 gpm
Klamath Co Jail (J-1127)	11.2	0.031 mgd 21 gpm
Total for Large Users	**160.8**	**0.441 mgd** **306 gpm**

4.2 Peaking Factors and Diurnal Curve

Water system facilities are generally sized for peak demand periods, as discussed in the Section 5 Performance Objectives. The peaking conditions of most concern for water facility sizing are maximum day demand with fire flow and the peak hour demand on the maximum day.

Average day demand refers to the average daily usage of water over a year. Maximum day demand is the maximum water usage for a 24-hour period during a year, which generally occurs during the maximum month of usage in summer. Peak hour demand is the peak flow during a one-hour period on the day of maximum demand.

Monthly peaking factors are also of interest in water system planning, since the level of water use varies significantly over the course of a year. Typically, water demands during the hotter and drier summer months are higher than in the cooler and wetter winter months. Figure 4-2 shows the monthly peaking factors for the system as a whole. These monthly peaking factors relate the monthly average daily flow to the annual average daily flow. The monthly peaking factors are based on the average of the well production data over the 10-year period from 1998 through 2007.

The maximum day peaking factor relates the maximum day average daily demand to the annual average day system demand. Based on the well production data from 1998 through 2007, as shown on Table 4-1, the maximum day peaking factor ranged from about 2.0 to 2.4. The maximum day peaking factor averaged 2.11 over the entire 10-year period, and 2.14 over the recent 5-year period. The maximum day peaking factor is affected by weather/hydrologic conditions that influence water use.

For this master plan update, a maximum day peaking factor of 2.3 has been selected for planning purposes based on the 10 years of historic data. For the previous master plan, a maximum day peaking factor of 2.2 was used as a conservative value, which was the highest that occurred in the 5-year period of the available historical data from 1998 through 2002. For the 10-year period of historical data available for this master plan update, the highest peaking factors occurred in 1998 (2.24), 2003 (2.39), and 2005 (2.26); which is an average of 2.3 for these three highest years. Rather than using the single highest factor of 2.4, the average high of 2.3 is considered reasonably conservative to reflect a variety of weather/hydrologic conditions affecting seasonal and annual water use. The highest factor of 2.4 in 2003 is overly conservative, as the average daily demand was lowest that year, which resulted in the high peaking factor.

For this master plan update, the City provided water system operations data to use in developing a diurnal curve. A diurnal curve shows the hourly variation in customer demand (hourly peaking factors) over a 24-hour period. The diurnal curve is a dimensionless profile that shows the ratio of the flow during each time interval to the average daily flow rate over the 24-hour period, starting with 0 hours at midnight.

Figure 4-3 shows a system-wide diurnal curve calculated from the City's water system operations data for Zone 1, which is the largest zone in the system. The curve, based on 10-minute interval data, was calculated from actual Supervisory Control and Data Acquisition (SCADA) data. The hourly curve shows the smoothed hourly flow ratios from the calculated curve, and is the overall planning-level curve used for the master plan. While the representative system-wide curve may vary for individual users or small areas such as industries or industrial parks; such locations are spread out and individual demands are not large compared to total system demand, when considered on a system-wide basis.

The peak hour factor is the highest hourly flow ratio from the diurnal curve. As indicated in Figure 4-3, the peak hour factor is 1.6 times the average hourly demand. This calculated factor agrees with the factor provided by the City for the previous master plan.

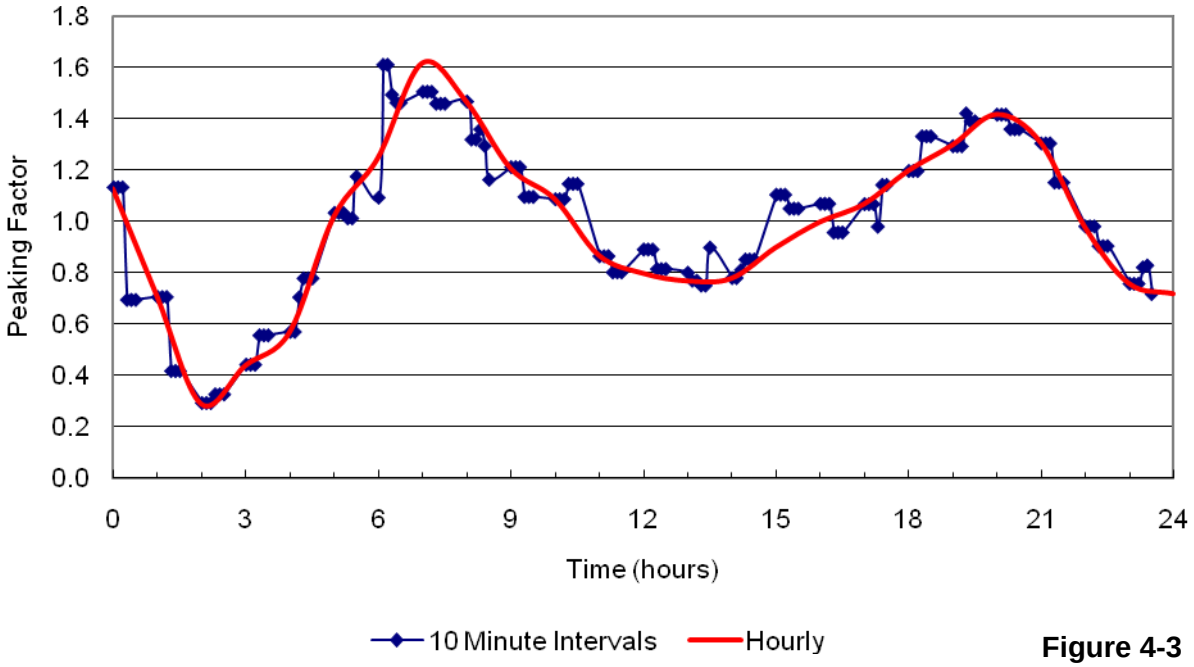


Figure 4-3
Diurnal Curve

For development of the diurnal curve, the City provided SCADA data from January through July 2008 for reservoir levels and for operation of the wells and booster stations, i.e., ON and OFF status and number of hours operated. The well and booster station data was provided in 10 minute intervals and the tank data was provided in 30 minute intervals. This data was analyzed and used to develop the diurnal curve by taking into account flows supplied by wells into the system and flows going into storage or passed through to other zones, e.g., during parts of the day, some flows in the system may be going to re-fill storage rather than to meet customer demands.

Zone 1 was selected for development of a system-wide diurnal curve, since it is the largest zone in the City's system and represents the majority of the demands. SCADA data for a typical summer weekday (Wednesday July 16, 2008) was selected to develop the diurnal curve for Zone 1. The diurnal curve for Zone 1 is generally representative of the overall pattern of the entire system. The other zones in the system are anticipated to have usage patterns similar to Zone 1. There may be more variations in daily usage for the very small zones, which are entirely residential, and may have higher peak hour factors; however, the critical condition for pipeline sizing in the small zones is maximum day plus fire flow conditions rather than peak hour. For small zones without storage, the peak hour demand is important for sizing booster pumps and pressure reducing valve capacity to meet normal demands. As discussed in the next paragraph, a more detailed analysis of peak hour factors by zone was also done.

As part of the model verification for existing maximum day demand conditions, discussed in Appendix C, detailed SCADA data for the 2008 maximum day demand provided by the City for zones other than Zone 1, was analyzed and some modifications were made to the peak hour factor of the system-wide diurnal curve to better reflect specific demand conditions in the smaller zones. Section 6.1 provides a more detailed discussion of the zone-specific peak hour factors (see Table 6-2 footnotes for the zone-specific peak hour factors).

4.3 Unit Demand Factors

A land-used based methodology has been used to develop the demand projections for the master plan. This methodology uses the land use information from Section 2, in conjunction with unit demand factors by land use type, in order to estimate demand. This section describes the basis of the unit demand factors. Section 4.5 describes how the unit demand factors have been used in conjunction with the land use information to develop the demand projections. The appropriate unit demand factors by land use types are multiplied by the acreages of the various land uses to estimate the demands.

4.3.1 Recommended Unit Demand Factors

To estimate demands, unit demand factors have been developed for average day demand per acre (gallons per day per acre) based on master plan land use types in Section 2. Table 4-5 shows the unit demand factors recommended for this master plan update. The unit demand factors in Table 4-5 include unaccounted-for water. The recommended unit demand factors have been used to develop the demand projections for all the master plan scenarios: existing, intermediate and buildout. A sensitivity analysis of the recommended unit demand factors is discussed in Section 4.3.2.

Unit demand factors were derived by relating historical water consumption data to the master plan land uses and existing acreages served. Representative existing unit demand factors for the existing service area were determined on a system-wide basis for residential and non-residential land uses based on existing demand and land use information. The unit demand factors assume the City is not providing irrigation water for large landscape areas, such as parks, schools, and medians. Irrigation water for large landscape areas is assumed to be provided from private (non-municipal) irrigation wells or irrigation canals.

Table 4-5 Unit Demand Factors for Average Day Demand [1]		
Land Use Type	**Recommended Unit Demand Factors Used for All Scenarios in Master Plan Update (Same as Existing Factors from 2004 Plan) (gpd/ac)**	**Sensitivity Analysis using Higher Buildout Unit Demand Factors from 2004 Plan (Used only for Sensitivity Analysis in This Update) (gpd/ac)**
Residential		
Very Low Density Residential (10,000 SF minimum lot size, 4.4 units/ac)	700	1450 [3]
Low Density Residential (7,000 SF minimum lot size, 6.2 units/ac)	1100	2050 [3]
Medium Density Residential (5,000 SF minimum lot size, 8.7 units/ac)	1600	2450 [3]
High Density Residential (10 to 24 units/acre, used average value of 17 units/acre)	2000	4250 [3]
Non-Residential		
Commercial	650	1300 [4]
Light Industrial	650	1300 [4]
Heavy Industrial	650	1300 [4]
Public Facility - School	850	850 [2]
Public Facility	100	200 [2]
Others		
Lake, Ponds	0	0
Open Space, Special Reserve, No City Water Service, Private Water System, Right of Way	0	0

(1) The unit demand factors include an allowance for unaccounted-for water.

(2) The unit demand factors for public facilities and schools assume that the large landscape areas associated with these facilities are not irrigated with City water. Irrigation water is assumed to be provided from private irrigation wells or irrigation canals.

(3) For the sensitivity analysis, the higher buildout unit demand factors per acre for future residential development were estimated based on the number of allowable units at the minimum lot size and estimated usage per unit, which typically decreases per unit as the density increases due to less outdoor water use. Future unit demand factors for very low and low density residential development areas were estimated at 330 gallons per day per residential unit, which is the same as for the previous master plan, since the demand per unit including unaccounted-for water was similar for the 2007 data as for the previous 2002 data. The buildout unit demand factors for medium density and high density residential were adjusted slightly from the 2004 Master Plan. Future medium density residential unit demand was estimated at 280 gallons per day per unit (85 percent of low density); and high density residential at 250 gallons per day per unit (75 percent of low density).

(4) For the sensitivity analysis, the higher buildout unit demand factors for non-residential uses were based on analysis conducted as part of the 2004 master plan, and CDM's experience with other master plans.

4.3.2 Sensitivity Analysis of Unit Demand Factors

The unit demand factors developed for the previous master plan were reviewed based on the more recent available historical data to determine if adjustments were needed. The recommended unit demand factors for all scenarios in this master plan update are the same as the unit demand factors for the existing scenario in the 2004 Plan. The 2004 Plan used different sets of unit demand factors for projecting demands for existing and future development. For the 2004 Plan, it was anticipated that unit demands for future development areas may be higher than for existing development, e.g., due to more intensive development/landscaping; and the higher buildout unit demand factors in Table 4-5 were applied to future development areas.

However, for this master plan update, review of recent production and consumption data indicates this assumption is no longer applicable. Based on analysis of the more recent data, as discussed in Section 4.1.2, there is no longer a basis for assuming that unit demands will be higher in the future. Instead, based on recent production data and evidence of declining unaccounted-for water losses, it appears that unit demand is holding steady or even decreasing slightly, which is likely due to the City's water conservation efforts and the fact that new developments are constructed with more efficient low water use fixtures. For this update, the higher buildout unit demand factors have been used only for a sensitivity analysis of the future demand projections, i.e., to provide a high end estimate, in the event that long-term unit demands may potentially increase in the future, which should be re-evaluated in future updates.

As part of the analysis, existing demands were estimated using the unit demand factors with the current information on existing acreages to assess how closely the estimate approximated the existing demand. The current 2007 water demand is about 85 to 90 percent of the estimated demand using the unit demand factors. This is reasonable considering that information on current existing acreages may include small vacant/infill parcels in predominantly developed areas, as well as undeveloped lots that the City has already agreed to serve but are not yet tied into the City system.

In particular, many existing parcels in the southern County suburbs in the study area are not developed to their maximum allowable density. Therefore, the existing unit demand for these under-utilized parcels is lower than indicated by the recommended system-wide unit demand factor in Table 4-5. The existing model verification analysis discussed in Appendix C explored this issue in more detail, and made adjustments to the existing demands in the southern area to better reflect the underutilized parcels. As discussed in Section 4.5, future demand projections assume that the larger under-utilized parcels in this area, greater than 1 acre in size, will be redeveloped in the future at their maximum allowable density.

4.4 Future Demands Outside UGB

City staff also identified some future customers outside the Urban Growth Boundary that may potentially be served by the City's water system in the future. For this update, the Henley Schools have been identified for inclusion in the master plan. Table 4-6 shows the estimated demand for the Henley Schools. This demand is included at the appropriate location (model node) where water would be delivered from the City's system to the schools.

Table 4-6
Future Demands for Henley Schools Outside the Urban Growth Boundary

Future Area (Model Node)	Estimated Demands				
	Existing	Intermediate (Within 10 Years)		Ultimate Buildout	
	Average or Maximum Day	Average Day (gpm)	Maximum Day (gpm)	Average Day (gpm)	Maximum Day (gpm)
Henley Schools [(1) (2)] (Model Node J-3003)	0	28	64	42	97

(1) Henley Schools (elementary, middle, high school) – 1600 current students/faculty, 2000 students/faculty within 10 years; 3000 students/faculty at buildout. Assumes average day consumption of 20 gallons per day per person.
(2) Maximum day peaking factor of 2.3 was used; the same factor as the rest of the City's system.

4.5 Demand Projections

Table 4-7 summarizes average day demands by land use type within the entire City system for existing, intermediate, and ultimate scenarios. Land use types are those described in Section 2, which were derived from City and County planning information. The existing scenario includes some undeveloped lots for anticipated developments for which the City already has plans and/or tentative approval, as shown in Table 2-2. The actual current demand from historic well production records is less than the Existing demand in Table 4-7.

4.5.1 Planning Level Demands for Master Plan

A land-used based methodology has been used for projecting demands. Average day demand for each land use type was calculated by multiplying the estimated number of acres served of that land use by the unit demand factor per acre, as shown in Table 4-5, for that land use. The planning-level demand projections for all scenarios (existing, intermediate, buildout) have been based on the same unit demand factors, which are the recommended factors in Table 4-5. These unit demand factors were derived based on current demand and land use information, as discussed in Section 4.3.

For existing and future demands, Table 4-8 shows the estimated average day, maximum day, and peak hour demands, as well as the average daily demand on a seasonal basis for winter, spring, summer, and fall. Table 4-8 demands are based on peaking factors discussed in Section 4.2. Peaking factors are calculated as the ratio of each demand condition to the annual average day demand.

Table 4-7
Average Day Demands by Land Use Type [1]

Land Use Type	Existing [2] (mgd)	Intermediate [3] (mgd)	Buildout [4] (mgd)
Residential			
Very Low Density Residential	1.65	2.77	3.04
Low Density Residential	2.17	2.92	4.85
Medium Density Residential	2.62	3.10	3.74
High Density Residential	0.91	1.22	1.67
Subtotal - Residential	*7.36*	*10.01*	*13.30*
Non-Residential			
Commercial	0.82	1.04	1.07
Light Industrial	0.23	0.44	0.46
Heavy Industrial	0.63	1.55	1.64
Public Facility - School	0.21	0.27	0.27
Public Facility	0.17	0.19	0.22
Subtotal - Non Residential	*2.06*	*3.49*	*3.66*
Large Users	0.30	0.30	0.30
Others			
Lake, Ponds	0.0	0.0	0.0
Open Space, Special Reserve, No City Water Service, Private Water System, Right of Way	0.0	0.0	0.0
Total	***9.7***	***13.8***	***17.3***

(1) Demand projections are based on the recommended unit demand factors from Table 4-5, and the corresponding acreages of each land use.
(2) Existing Scenario includes water use for some currently undeveloped lots for anticipated developments that the City already has plans and/or tentative approval, as shown on Table 2-2.
(3) Intermediate Scenario includes some currently undeveloped lots for anticipated developments that the City already has plans and/or tentative approval, as shown on Table 2-2.
(4) Buildout Scenario assumes that all under-utilized very low density residential parcels in the County south suburbs have been re-developed at their maximum allowable density of approximately 4 units per acre.
(5) Large users – additional demand from Table 4-4 adjusted to avoid double-counting of demand by land use type.

Table 4-8
Total Projected Demands for Entire System

Demand Condition	Peaking Factor [1]	Demand (mgd)		
		Existing Scenario	Intermediate Scenario	Ultimate Scenario
Annual Average Day	1.0	9.7	13.8	17.3
Minimum Day	0.5	4.9	6.9	8.6
Maximum Day	2.3	22.3	31.7	39.8
Peak Hour on Maximum Day (varies from 1.6 to 3.3 x maximum day depending on zone) [2]	3.7 – 7.6	39.8	56.7	79.8
Seasonal Demands				
Average Winter Day (November through March)	0.7	6.8	9.7	12.1
Average Spring Day (April, May)	1.0	9.7	13.8	17.3
Average Summer Day (June, July, August)	1.6	15.5	22.1	27.7
Average Fall Day (September, October)	1.0	9.7	13.8	17.3

(1) Peaking factors are the ratio to the annual average day demand.
(2) Section 6.1 provides a more detailed discussion of the zone-specific peak hour factors.

The master plan demand projections represent existing demand patterns, and do not include irrigation water for open space or large irrigated areas. The demand projections indicate the importance of conservation to manage ultimate demands. The City's Water Conservation and Management Plan addresses water conservation efforts as mandated by State regulatory requirements. As discussed earlier in this section, there has been an increase in recent years in the total number of services. However, total demand has held steady or slightly declined. This data indicates that the average demand per customer is holding steady or slightly declining, which is likely due to the City's water conservation efforts.

In terms of equivalent residential units (ERUs), an ERU is a unit used to describe the water demand of a "typical" single family dwelling. For the City's existing system, the average day demand is about 350 gallons per day per ERU, including unaccounted-for water; and the maximum day demand is 805 gallons per day per ERU based on the maximum day peaking factor of 2.3. For the projected maximum day demands shown in Table 4-8, the existing projected maximum day demand of 22.3 mgd is equivalent to about 27,700 ERUs (22.3 mgd divided by 805 gpd/ERU). The intermediate projected maximum day demand of 31.7 mgd is equivalent to about 39,400 ERUs (31.7 mgd divided by 805 gpd/ERU); which is an increase of about 11,700 ERUs over existing. The buildout projected average day demand of 39.8 mgd is equivalent to about 49,400 ERUs (39.8 mgd divided by 805 gpd/ERU), which is an increase of about 10,000 ERUs over the intermediate timeframe.

4.5.1.1 Future Redevelopment of Very Low Density Residential Parcels

The planning-level demands shown in Table 4-7 account for some redevelopment occurring in the very low density residential parcels in the southern portion of the service area (County south suburbs). Many of these larger very low density residential parcels are currently not developed to their maximum allowable density. In the future, it is assumed that these larger parcels will be re-developed at their higher allowable density. The key demand assumptions for these parcels are summarized below:

- 5 acres and larger parcels:
  - Intermediate scenario: The potential for growth of these parcels in the intermediate time frame has been identified in the Table 2-2 listing of anticipated developments with plans and/or tentative approval. The demands for these proposed developments are included in the intermediate scenario. So no need to do any more with this – it is already factored into our intermediate scenario demands based on the land use info provided in Table 2-2 of the Interim Submittal on Anticipated Developments with Plans and/or Tentative Approval.
  - Buildout scenario: It is assumed that all 5-acre and greater parcels will be fully developed at their maximum allowable density of 10,000 SF per unit (about 4 units per acre).

- 1 to 5 acres parcels:
  - Intermediate scenario: Based on historic conversion data from the County and City, it is estimated that about 346 new equivalent dwelling units (ERUs) will occur over the next 10 years within the study area due to re-development of these parcels. About 85 percent of these dwelling units are expected to be within the County and the remainder in the City. The intermediate scenario includes the future demands for these 295 ERUs (85% x 346 total) in the County south suburbs.
  - Buildout scenario: It is assumed that all parcels between 1 to 5 acres in size will be fully developed at their maximum allowable density of 10,000 SF per unit (about 4 units per acre).
- Less than 1 acre parcels:
  - It is assumed that these smaller parcels will not be redeveloped in the future. Potential future conversion of lots smaller than 1 acre is low, and would not make a significant difference in the future demand projections.

4.5.2 Sensitivity Analysis of Buildout Demand Projections

Uncertainties exist regarding the actual level of future demands, since future land uses and water use patterns are not known with certainty and the ultimate buildout timeframe is very long. As a sensitivity check on the potential variation in future demands, a range of average day demand projections for the ultimate buildout scenario was calculated. Table 4-9 shows a planning-level demand, as well as a high end of the anticipated ultimate demand range, based on the assumptions listed at the bottom of the table.

As indicated in Table 4-9, there is a wide variation in buildout demand projections depending on the assumptions regarding unit demand factors. In future master plan updates, unit demand factors and demand projections should be re-confirmed with additional historic data and updated planning information.

Table 4-9 Sensitivity Analysis for Ultimate Buildout Average Day Demands		
Land Use Type	***Planning Level*** [(1) (2)] ***(mgd)***	***High End*** [(3)] ***(mgd)***
Residential		
Very Low Density Residential	3.0	3.1
Low Density Residential	4.9	6.8
Medium Density Residential	3.7	4.1
High Density Residential	1.7	2.2
Subtotal - Residential	*13.3*	*16.1*
Non-Residential		
Commercial	1.1	1.1
Light Industrial	0.5	0.5
Heavy Industrial	1.6	1.7
Public Facility - School	0.3	0.3
Public Facility	0.2	0.3
Subtotal - Non Residential	*3.7*	*3.8*
Large Users	0.3	0.3
Others		
Lake, Ponds	0	0
Open Space, Special Reserve, No City Water Service, Private Water System, Right of Way	0	0
Total	***17.3***	***20.2***

(1) Planning-level demand at buildout uses the same unit demand factors as for the existing and intermediate scenarios to calculate all demands for both existing and future service areas. This assumes that future water use patterns continue the same as existing. As noted in footnote 2 below, recent information indicates that unit demands may be trending downward. However, using the unit demands based on the existing information is considered appropriate for master planning, since it allows for some uncertainty for future land uses and water use, but is not overly conservative.

(2) On the low end, there may be a potential future lower demand at buildout if current trends toward lower unit water usage continue into the future. At this point, there is too little historic information on which to assume a future lower demand trend. Therefore, a low end estimate is not included in Table 4-9. This potential trend should be re-assessed in future updates, as the City continues implementation of its water conservation program.

(3) High end of the demand range at buildout assumes that higher buildout unit demand factors may apply to the incremental growth areas that are anticipated to occur between intermediate and buildout timeframe. For example, if unit demands were to increase in the future rather than holding steady or decreasing, and tend to return to higher historic levels that have been seen in the past. The purpose of this high end estimate is to provide information for the City's use in evaluating long-term water supply needs and long-term improvements, e.g., a factor of safety for meeting those future needs which are subject to considerable uncertainties due to the very long buildout timeframe. For most water system improvement needs, the critical sizing condition is to be able to meet fire flow requirements which are much larger than normal demands; so recommended sizes are not significantly impacted by the average day unit demand factors.

Section 5
Performance Objectives

This section discusses the performance objectives used for evaluating the water system in Section 6 and determining recommended improvements in Section 7.

5.1 Overview of Performance Objectives

The State of Oregon Administrative Rules (OAR), Chapter 333, Division 061 contains requirements for public water systems. The requirements relevant to the master plan analysis are included in the performance objectives.

The City Public Works Department's Engineering Standards (2007) describe the current performance objectives and design criteria for the City's water system. These criteria have been reviewed with respect to current American Water Works Association guidelines, current practices of similar water utilities, and CDM's engineering experience on similar projects. Based on this evaluation, appropriate performance objectives for the master plan study have been determined.

Table 5-1 summarizes the key performance objectives established for the master plan components. The remainder of this section provides a more detailed discussion of each component, including relevant standards, typical industry practices, and the recommendations.

Table 5-1
Summary of Performance Objectives for Water Master Plan

Component	*Description*
Groundwater Well Supply	o Firm well capacity = maximum day demand o System-wide reserve capacity = well capacity of a minimum of 15% of total maximum day demand for reserve o Backup power required for well pumps
Distribution System Pressures	o Minimum under peak hour demand on the maximum day = 40 psi o Minimum with fire flow plus maximum day demand = 20 psi residual at hydrants o Target maximum pressure of 105 psi; will be evaluated as part of pressure zone boundary analysis.
Water Mains	o Sized to meet minimum pressure requirements o Maximum velocities: 5 fps desirable; maximum to 7 fps during peak hour demand. o Minimum pipe diameter: 8-inches in residential areas 12-inches in commercial/industrial areas o Standard allowable diameters of 8-, 12-, 16-, 20-, and 24-inch.
Fire Flows	o Required fire flows on system-wide basis: 1500 gpm for residential 2500 gpm for non-residential o Zone must have either gravity storage or pump station with backup power.
Reservoir Storage	o Sum of following 3 components = 100% of maximum day demands plus fire reserve – Operational (balancing or equalizing) storage (about 30-50% of maximum day demand) – Emergency storage (50-70% of maximum day demand) – Fire reserve for most critical (highest) required flow in zone The evaluation considers whether an emergency storage credit is applicable if there is standby power at wells and booster stations, whereby the pumping capacity with standby power can be considered equivalent to providing emergency storage in tanks.

Table 5-1 Summary of Performance Objectives for Water Master Plan	
Component	**Description**
Pumping Facilities	o Firm pumping capacity requirements: Zones with reservoir storage = maximum day demand Small booster zones without storage = peak hour on maximum day plus fire pump. o All zones must have capacity to lift water through to higher zones. o Firm capacity defined with the largest pump out of service (which may be a fire pump). o Minimum of 2 pumps to meet non-fire conditions. o Backup power required at booster stations.
Pressure Reducing Stations	o Required total valve capacity = peak hour demand plus fire flow. o PRV stations typically have 1 or more small valves for normal operation, plus a large valve to provide fire flow and backup to small valve(s).

5.2 Supply – Groundwater Wells

The City's current standards require that all new production wells must provide a minimum of 115 percent of the maximum day demand at ultimate buildout of the area to be served by the well. All new production wells dedicated to the City must have a minimum capacity of 420 gpm or greater. The City requires generator backup power at all wells fully sized to power the well pump and associated facilities. Generators must be diesel powered and capable of operating at least 24 hours without re-fueling.

Many water agencies, particularly those with surface water supply, provide supply capacity equal to the maximum day demand, and then meet peak hour needs from storage. Water agencies with primarily groundwater supply sometimes provide supply capacity to meet some or all of the peak hour demand to reduce reservoir storage requirements.

For the master plan, is the recommended system-wide criterion is that firm well capacity be equal to the maximum day demand, with peak hour needs met from storage. The City's main transmission system conveys supply for long distances from the centralized well field to other parts of the system, and reliability is enhanced by having storage at various locations throughout the system in the event of hydraulic bottlenecks or outages.

In addition, total well pumping capacity must also include reserve capacity for reliability, i.e., to account for well outages. For the master plan, a minimum total well capacity of 115 percent of the maximum day demand is recommended, which would be a 15 percent system-wide reserve. As part of the evaluation, an assessment will also be made of specific supply service areas to determine if a higher reserve may be appropriate in the event that the largest well serving the area may be out of service.

5.3 Distribution System Pressures

The State requires that public drinking water systems deliver 20 pounds per square inch (psi) to the customer at all times, including periods of foreseeable power outages and supply disruptions. Each water agency determines how to meet this requirement.

The City's current standards for distribution system pressures are to maintain a minimum of 40 psi and a maximum of 105 psi during normal usage periods. Under fire flow conditions, a minimum pressure of 20 psi must be maintained.

For other water agencies, typical minimum service pressures under non-fire conditions are: 30 to 40 psi during peak hour demand; and/or 40 to 50 psi during maximum day demand. Under fire flow conditions, 20 psi minimum pressure is the typical criterion for all agencies. The typical maximum pressure is about 100 to 110 psi to avoid over-pressurizing the system.

For the master plan evaluation, the following criteria are recommended:

- Minimum of 40 psi under peak hour conditions.
- Minimum 20 psi residual pressure with fire flows of 1500 gpm for residential and 2500 gpm for non-residential areas.
- Target maximum pressure of 105 psi; however, the master plan will evaluate pressure zone service elevations and operating ranges which may result in higher pressures in some areas. An appropriate range for maximum pressures will be determined as part of the evaluation. The Uniform Plumbing Code requires individual pressure reducing valves on new customer services if system pressures exceed 80 psi.

5.4 Water Mains

The City's current standards contain the requirements for water mains. Except as noted below, these criteria are used for the system-wide master plan analysis:

- Sizing to maintain a minimum residual pressure of 20 psi within the existing system during fire flow conditions and 40 psi during normal demand conditions.
- Maximum velocities of 5 feet per second (fps) desirable; maximum to 7 fps during peak hour demand. The 5 fps desirable maximum velocity is used for designing new improvements; while the 7 fps maximum is used in evaluating the need for improvements to existing facilities.
- Minimum pipe diameter requirement of 8-inch in residential areas and 12-inch in commercial/industrial areas.
- Standard allowable diameters of 8-, 12-, 16-, 20-, and 24-inch.

Other agencies typically have main sizing criteria including system pressures and pipe velocities similar to the City's current standards. Typical system pressure criteria were discussed in Section 5.3. Other agencies commonly use a criterion for maximum desirable velocity of 5 fps under peak hour conditions. Typically, a maximum velocity criterion is not used for fire flows, a temporary emergency condition. Instead, the key criterion for fire flows is the ability to maintain the required minimum pressure of 20 psi at all locations. For the master plan analysis, which is system-wide, it is recommended that a maximum velocity criterion apply only to peak hour demand conditions, not to fire flow conditions.

In addition, many water agencies also specify maximum head losses in pipelines. The typical range for headlosses is from 5 feet per 1000 feet under maximum day demand up to a maximum of 10 feet per 1000 feet for peak hour demand. A maximum of 10 feet per 1000 feet under any non-fire demand condition is the most typically used head loss criterion, and is equivalent to 4.3 psi pressure loss per 1000 feet. For this master plan, a maximum headloss criterion of 10 feet per 1000 feet for non-fire flow conditions is recommended.

For this master plan evaluation, existing pipelines are not identified for replacement solely due to not meeting velocity and headloss criteria. Existing pipelines would only be replaced in order to meet system pressure criteria. However, if existing pipelines must be improved to provide adequate pressures, then improvements would be designed to meet the velocity and headloss criteria.

Typically, high velocities and/or high head losses may manifest as a reduction in pressure. However, high velocities and corresponding high headlosses are also a concern for water hammer. According to the American Water Works Association's Manual M32 – "Distribution Network Analysis for Water Utilities" (AWWA, 1989), velocities are acceptable up to a maximum of about 10 fps to minimize such problems, while velocities of about 5 fps are desirable. Under fire flow conditions, the most likely cause of water hammer would be from rapid closure of a hydrant following use. This infrequent scenario would not warrant applying the same velocity and headloss criteria for fire flow conditions.

5.5 Fire Flows

The City's current engineering standards call for water availability at 20 psi minimum residual pressure of 1,500 gpm for 2 hours in residential areas, and 2,500 gpm for 3 hours in commercial/industrial areas. So that fire flows will be available at all times, even in event of a power outage, the City requires either gravity storage in a zone, or a pump station with backup power that supplies the zone. Backup power at pump stations also helps fulfill the vulnerability provisions of a good security plan, so that there are no service interruptions.

Klamath County Fire District No. 1 provides fire service in the City. The Fire District follows the requirements set by the Oregon State Fire Marshall (OSFM) in the 2004 Oregon Fire Code. These requirements are based on the 2003 International Fire Code with Oregon amendments as authorized by Oregon Revised Statute (ORS) 476.030 and in accordance with OAR Chapter 837, Division 40.

According to the Fire District requirements, the minimum available fire flow for 1 and 2 family dwellings must be 1,000 gpm for structures of 3600 square feet or less. If structures exceed 3600 square feet in total building area, then higher fire flows of 1500 gpm or more are required, based on the size of the structure. These flows must be provided for minimum 2-hour duration. The required fire flows are determined on a case-by-case basis depending on size of the building and type of construction. If buildings have approved fire sprinklers, the required flow may be reduced by up to 50 percent at the discretion of the Fire District.

For the master evaluation, it is recommended that the City's criteria be used for the overall system analysis, which focuses on the backbone system. For new development and/or redevelopment projects, the specific fire flow would be determined on a case by case basis in accordance with City and Fire District requirements. For facilities that will become part of the City's system, it is recommended that the City consider the more stringent of the two requirements (City or Fire District) as a condition of accepting the facilities.

There are varying ideas of the amount of fire flow that should be provided by the City's system. The City has selected goals for its water system that are reasonable for the City's infrastructure planning. The City goals are for 1500 gpm in residential areas for 2 hours, and up to 2500 gpm for non-residential development for 3 hours. The Fire Department may require higher flows depending on the type/size of building. Other industry standards, such as the Insurance Services Office recommend much higher flows for various land uses, such as 3500 gpm for commercial for 3-4 hours and 4000-5000 gpm in industrial areas for 4-5 hours. At this point, the City's target fire flows are not available everywhere in the system. Each development proposal will be evaluated on a case-by-case basis, with the developer responsible for constructing required improvements or modifying the development plan as needed to meet Fire Department requirements.

5.6 Reservoir Storage

Water system storage is typically sized based on the following three components: operational storage (also called equalizing or balancing storage); fire reserve storage; and, emergency storage. Water systems with surface water supply must rely on reservoir storage for all three components. Water systems with groundwater supply, such as the City's, sometimes use wells with backup power to provide some or all of these components, as discussed below.

Operational (equalizing or balancing storage) is the volume of water required to meet daily fluctuations in demand in excess of the water supply production capacity on the maximum day. This storage volume is determined by the variation in the hourly demand during the day of maximum demand. When supply capacity is provided to meet the maximum day demand, operational storage requirements typically range from 25 to 50 percent of the maximum day demand. Firm well capacity in excess of the maximum day demand can also be used to meet these operational peaking needs, and will be considered in the master plan evaluation.

Fire reserve storage is the amount of storage volume necessary to supply fire flow for the most critical land use within a pressure zone. The fire reserve storage is typically computed for each pressure zone or service area, based on the most restrictive (highest) fire flow requirement times the duration for which it must be supplied. The fire reserve storage should always be available for fire protection to every part of the distribution system. For example, under normal operations, water levels in reservoirs are typically maintained within the top third to top half of the storage volume to reserve the remainder for fire flows or other emergencies Reservoirs are continually re-filled when water levels drop to the pre-determined level.

Emergency storage is the volume of water required to supply the service area during planned or unplanned equipment outages, power outages, or well shutdowns for unexpected mechanical difficulties or quality issues. This storage needs to be sufficient to provide a reasonable level of uninterrupted service under such circumstances. The minimum recommended emergency storage generally represents a 6-hour power outage on the maximum demand day (25 percent of maximum day demand). A typical assumption for emergency storage is that there may be a supply outage and/or power outage for up to 12 hours on the maximum demand day (50 percent of the maximum day demand).

If standby power is provided at wells and/or booster stations, the pumping capacity with standby power may be considered as providing equivalent customer service reliability as emergency storage if appropriate for overall system operations. The amount of emergency storage is considered equivalent to the pumping capacity with standby power over a 24-hour period. For well capacity to be considered as equivalent to an emergency water source, the standby power should be available for outage duration of at least 12 hours, and preferably 24 hours. The master plan evaluation considers the ability of the City's wells and booster stations with standby power to offset some of the required emergency storage in tanks, depending on the number of wells serving the area (whether multiple wells or a single well) and the amount of standby power capacity.

In some cases, it may be possible to utilize well capacity to meet peak hour needs in lieu of reservoir operational storage, if there is well capacity in excess of the maximum day demand. Interim use of excess well capacity as operational storage may be considered as part of phasing of reservoir improvements, e.g., if operational

peaking could be used in the near-term to delay reservoir construction. The operational storage amount would be equivalent to the amount of well capacity in excess of the maximum day demand over a 24-hour period.

For small isolated zones with a single supply source, storage requirements may also be met by providing pumping capacity with standby power into the zone, thereby meeting some peaking and emergency needs from pumping instead of storage.

The City's current standards specify a storage requirement of 100 percent of the maximum day demand plus the applicable fire flow for any proposed development larger than 450 equivalent residential units (ERUs) or a development that will impose capacity requirements greater than the existing system will support. In areas with multiple storage or pumping facilities, storage requirements may be reduced upon concurrence by the City and Fire Department.

For this master plan analysis, a system-wide criterion of 100 percent of maximum day demand plus fire reserve is recommended to determine system-wide storage needs, as summarized below:

Storage Component	***Master Plan Criteria***
Operational Storage (also called equalizing or balancing storage)	About 30 to 50 percent of maximum day demand based on diurnal curve in Section 4.
Emergency Storage	About 50 to 70 percent of maximum day demand (which is about one average summer day).
Fire Reserve	Based on most critical land use within zone and required fire flow amount and duration. See Section 5.5 for discussion of fire flows.
Total Storage Volume	100 percent of maximum day demand plus fire reserve.

With increased storage in the system, the City will need to design and operate the reservoirs to minimize water quality impacts from low turnover during low demand periods.

5.7 Pumping Facilities

The City's current engineering standards indicate that specific service areas or pressure zones may require installation of a pumping plant to provide flow capacity or adequate water pressure. The developer is required to design and install the booster station according to the requirements specified in the City's Water Booster Station Design Standards.

Booster station design is specific to the distribution service area and the hydraulic conditions of the system supplying the station. The developer must provide a detailed hydraulic study with modeling to verify the booster station operation and the system operation both before and after installation of the booster station. The City accepts only booster stations that serve more than 25 ERUs. Private booster stations serve smaller areas.

As part of the City requirements for new facilities to maintain water supply during emergencies, the City requires generator backup power at each booster station location. Generators must be sized to fully power all pumps and associated facilities. Generators must be diesel powered and capable of operating at least 48 consecutive hours without re-fueling.

The State also requires that, wherever possible, booster pumps take suction from tanks and reservoirs to avoid the potential for negative pressures on the suction line which may occur when the pump suction is connected directly to a distribution main. For pumps taking suction from distribution mains to serve higher elevation areas, a low pressure cutoff switch is required on the suction side set at no less than 20 psi.

The following criteria are recommended for the master plan evaluation:

- Firm pumping capacity is defined as the capacity with the largest pumping unit at the pump station out of service.
- Zones with reservoir storage must provide firm pumping capacity sufficient to meet maximum day demand. For zones with storage, fire reserves are provided from storage.
- Small zones served solely through boosters without storage in the zone must have firm pumping capacity to meet the peak hour demand on the maximum day, plus a fire pump. The minimum number of pumps to meet non-fire conditions is two. Fire flows can be provided with all small pumps running, one large fire pump running, and a second (identical) fire pump out of service.
- For all zones, the pump station must also have the ability to pump any flow that would be lifted through to supply subsequent higher zones.

From CDM's experience in other areas, some other agencies size pumps to allow time-of-use pumping to reduce energy costs. In such cases, pump stations may be sized for 150 percent of the maximum day demand. This sizing allows for operating the pump station during a 16-hour period, and keeping the pumps off for 8 hours during the day (6-hour peak energy cost period plus an hour on either end as an operational cushion). With time-of-use pumping, more reservoir storage is needed to store the water for use during the "pumps off" period, and more pumping capacity is needed to move the water during the shorter "pumps on" period.

Based on experience with other agencies, CDM has found it generally not cost effective to construct capital improvements solely to allow time-of-use pumping during higher demand periods, since the payback period from the annual energy savings is very long. If there is available pumping and storage capacity, such as during lower demand periods, this type of operation can provide energy cost savings.

5.8 Pressure Reducing Stations

The City's current standards state that if a pressure reducing valve (PRV) is required within a development to provide appropriate pressure, the developer must design and install an approved PRV station. PRV station design and hydraulic capabilities are determined specific to the distribution area served. The developer must provide a detailed hydraulic study with modeling to verify the PRV station operation and the system operation both before and after installation of the PRV station.

PRV stations are typically used in the following cases: when an area is geographically or topographically isolated from the zone to which it logically belongs, to compensate for elevation variations within a zone, when the zone/area does not have storage, or the zone experiences high pressures. There is no storage in PRV-supplied zones. From an energy standpoint, the cost of pumping to high elevations and delivering water to lower elevations via PRVs needs to be balanced against the cost of building additional reservoirs and booster stations to eliminate the need for PRVs.

For the master plan evaluation, the following criteria are recommended:

- PRV stations will typically consist of one or more small 2- to 4-inch valves for normal operation, and a large valve to meet fire flow.
- The small valve(s) would operate continuously under normal operations. The large fire flow valve would operate infrequently as a backup to the small valve under peak conditions and during fire flows. The valve vendor recommends that the large valve serve as the standby to the small valve(s) so that it gets exercised periodically.
- The small valves must provide at least the average flow on the maximum day for normal operations. The large valve would operate if needed to meet peak hourly flows on maximum (high demand) days and during fire flows.
- The PRV-supplied zones are primarily residential with a 1500 gpm fire flow requirement. For PRV-supplied zones with non-residential uses, i.e., Mollie's Area, the fire flow requirement is 2500 gpm.
- The total valve capacity must equal a minimum of the maximum day demand plus fire flow. During demand conditions that are at or lower than the average on the maximum day, the small valve(s) would be adequate to meet demands. During peak hour demands on maximum (high demand) days and during fire flows, the large valve would also operate. Due to the relatively small size of the PRV zones and the large fire flow amount relative to maximum day or peak hour demands, this operational criterion will not significantly affect the valve sizing.
- To provide some redundancy, the small valve(s) are sized at or close to the average hourly on the maximum demand day at buildout.

Section 6
Water System Analysis

This section summarizes the results of the water system analysis. The water demands and performance objectives established in Sections 4 and 5, respectively, were applied to the City's water system using spreadsheets and hydraulic model as analysis tools. The sub-sections summarize the system analysis and recommendations for improvements as follows:

- Section 6-1: Overview of Recommended System Configuration
- Section 6-2: Major Features of Overall Configuration
- Section 6-3: Well Pumping Capacity Evaluation
- Section 6-4: Storage Evaluation
- Section 6-5: Pumping Evaluation
- Section 6-6: Pressure Reducing Station Evaluation
- Section 6-7: Distribution System Evaluation

Section 7 contains the Capital Improvement Program recommendations and costs based on the water system analysis presented in this section.

6.1 Overview of Recommended System Configuration

Figure 6-1 shows existing and future distribution system facilities color-coded by major zone. Figures 6-2A and 6-2B show the elevation profile schematic for existing and future major zones and subzones. Table 6-1 lists the existing and future service zones. This overall configuration serves as the basis for the water system analysis. The highlighted facilities in Table 6-1 indicate those locations where new facilities or significant upgrades will be needed, based on the system analysis presented in this section.

Significant future growth is anticipated within the City's Urban Growth Boundary (UGB), and much will occur in new areas with no existing facilities. Therefore, an overall system configuration lays out future waterline extensions to new areas and potential locations for other major facilities, such as storage reservoirs and pump stations. These future facility locations are conceptual and identify a general location or vicinity for master planning purposes.

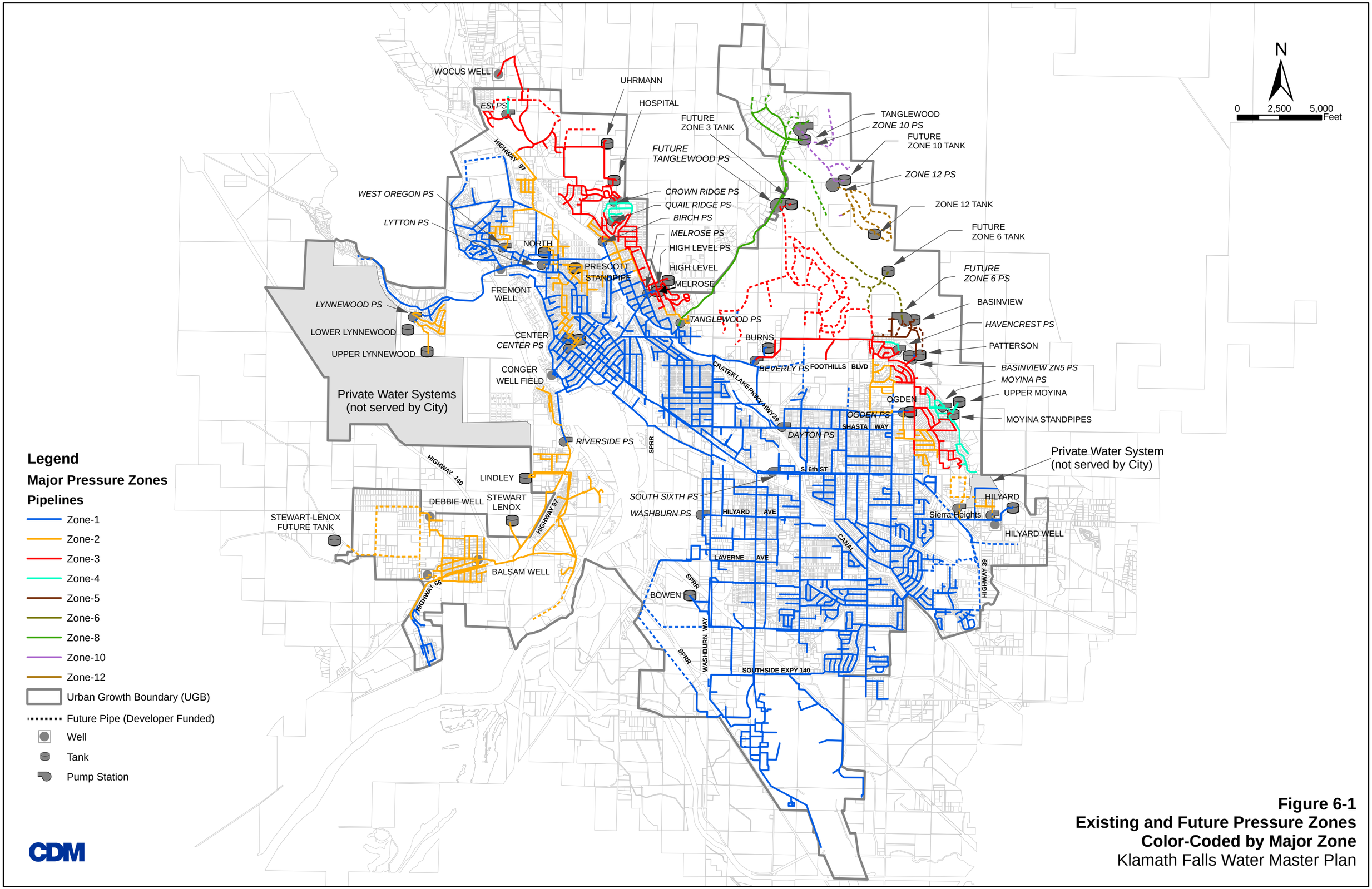
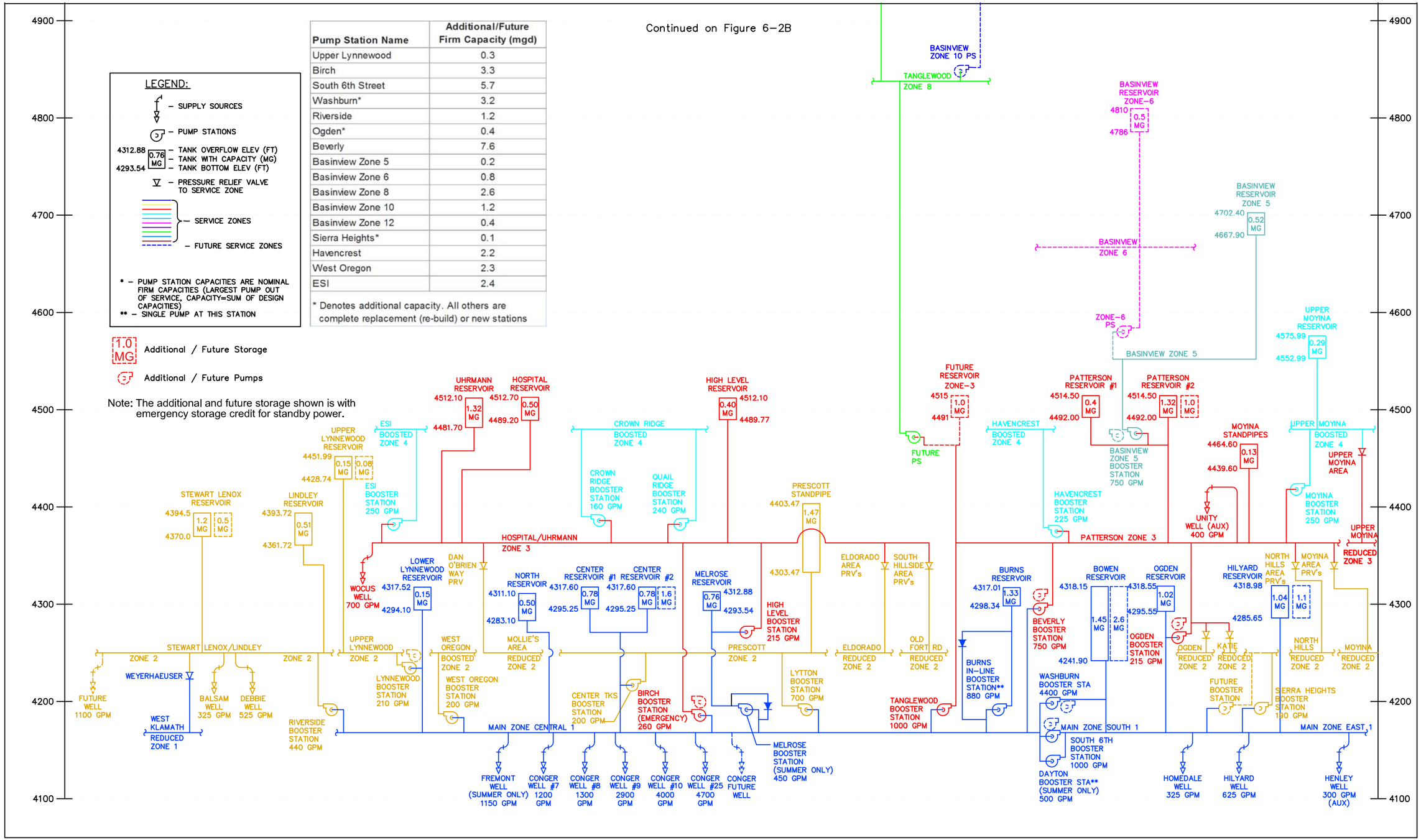


Figure 6-1
Existing and Future Pressure Zones
Color-Coded by Major Zone
Klamath Falls Water Master Plan

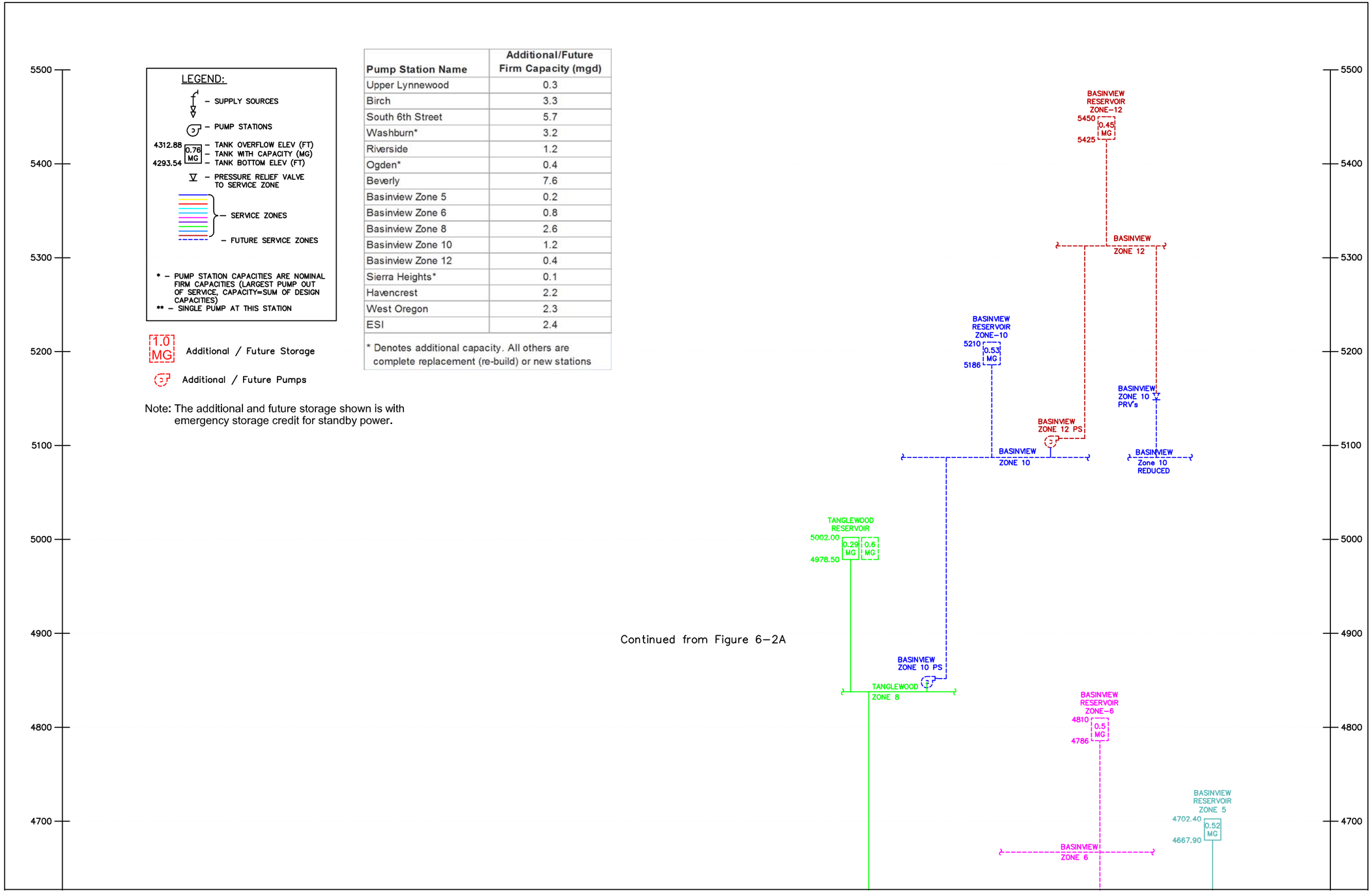


Pump Station Name	Additional/Future Firm Capacity (mgd)
Upper Lynnewood	0.3
Birch	3.3
South 6th Street	5.7
Washburn*	3.2
Riverside	1.2
Ogden*	0.4
Beverly	7.6
Basinview Zone 5	0.2
Basinview Zone 6	0.8
Basinview Zone 8	2.6
Basinview Zone 10	1.2
Basinview Zone 12	0.4
Sierra Heights*	0.1
Havencrest	2.2
West Oregon	2.3
ESI	2.4

* Denotes additional capacity. All others are complete replacement (re-build) or new stations

Figure 6-2A
Future System Schematic Profile
Klamath Falls Water Master Plan

CDM



Pump Station Name	Additional/Future Firm Capacity (mgd)
Upper Lynnewood	0.3
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South 6th Street	5.7
Washburn*	3.2
Riverside	1.2
Ogden*	0.4
Beverly	7.6
Basinview Zone 5	0.2
Basinview Zone 6	0.8
Basinview Zone 8	2.6
Basinview Zone 10	1.2
Basinview Zone 12	0.4
Sierra Heights*	0.1
Havencrest	2.2
West Oregon	2.3
ESI	2.4

* Denotes additional capacity. All others are complete replacement (re-build) or new stations

Figure 6-2B
Future System Schematic Profile
Klamath Falls Water Master Plan

CDM

Table 6-1
Existing and Future Service Zones

Major Zone	*Subzone Name*	*Existing or Future*	*Subzone Type*	*Active Wells Directly Pumping into Subzone*	*Reservoirs in Subzone*	*Booster Stations Serving Subzone*	*Pressure Reducing Valve Stations (PRVs) Serving Subzone*
1	Main (includes South 6th, Washburn, and North/Central subzones)	Existing	Reservoir	Conger Well Field Fremont Well Henley Well Hilyard Well	Lower Lynnewood North Center #1 Center #2 Melrose Bowen Ogden Hilyard Burns	South 6th Washburn Dayton (backup) Melrose In-Line Booster Burns In-Line Booster	
	West Klamath Reduced	Existing	PRV (Stewart Lenox-PRV)				West Klamath
2	Stewart Lenox / Lindley	Existing	Reservoir	Debbie Well Balsam Well Future Well	Stewart Lenox Lindley	Riverside (backup)	
	Upper Lynnewood	Existing	Reservoir		Upper Lynnewood	Lynnewood	
	West Oregon	Existing	Booster Only			West Oregon	
	Mollie's Area Reduced	Existing	PRV (PRV-2-HWY)				Dan O'Brien Way
	Prescott	Existing	Reservoir		Prescott Standpipe	Center Tanks Lytton	
	Sierra Heights	Existing	Booster Only			Sierra Heights	
	Eldorado Reduced	Existing	PRV (PRV-2)				Eldorado Area
	Old Fort Road Reduced	Existing	PRV (PRV-6)				South Hillside
	North Hills Reduced	Existing	PRV (PRV-1)				North Hills Area
	Moyina Reduced	Existing	PRV (PRV-13)				Moyina Area
	Ogden Reduced	Existing	PRV (PRV-OGDEN)				Ogden
	Katie Lane Reduced	Existing	PRV (Katie Lane)				Katie Lane
3	Hospital/Uhrmann	Existing	Reservoir	Wocus Well	Uhrmann Hospital High Level	Birch High Level	
	Patterson Upper Moyina Reduced	Existing Existing	Reservoir PRV (PRV-3)		Patterson #1 Patterson #2	Beverly Ogden	Upper Moyina Area

Table 6-1
Existing and Future Service Zones

Major Zone	Subzone Name	Existing or Future	Subzone Type	Active Wells Directly Pumping into Subzone	Reservoirs in Subzone	Booster Stations Serving Subzone	Pressure Reducing Valve Stations (PRVs) Serving Subzone
4	ESI	Existing	Booster Only			ESI	
	Crown Ridge Boosted	Existing	Booster Only			Crown Ridge Quail Ridge	
	Havencrest	Existing	Booster Only			Havencrest	
	Upper Moyina	Existing	Reservoir		Upper Moyina Moyina Standpipes	Moyina	
5	Basinview 5	Existing	Reservoir		Basinview	Basinview Z5	
6	Basinview 6	Future	Reservoir		Future	Future	
8	Tanglewood	Existing	Reservoir		Tanglewood	Laguna Tanglewood – Future at New Location	
10	Basinview 10	Future	Reservoir		Future	Future	
12	Basinview 12	Future	Reservoir		Future	Future	

Note: Shaded facilities note locations where new facilities or significant upgrades will be needed, based on the system analysis presented in Section 6.

The overall ultimate system configuration follows a standard approach used by other cities and water agencies with pressure zones at approximately 100-foot elevation intervals. As indicated on Figures 6-1 and 6-2, there will be 9 major zones at buildout. These zones are numbered sequentially from 1 through 12 based on service elevation. The lowest service elevation is Zone 1 and the highest is Zone 12. There are no Zones 7, 9 or 11; since no development is anticipated at the service elevations served by these zones.

This typical approach includes: supply provided from a lower zone, pumping up into the next zone including pass-through to higher zones, and storage within each zone. Some options are also discussed in this section for alternate approaches in the Basinview future growth area, and some smaller areas within the City.

Table 6-2 provides the demands by zone/subzone for average day, maximum day and peak hour demand conditions. The demands are shown for the Existing, Intermediate, and Buildout Scenarios. These demands were used for the analyses described in this section. As discussed in Section 2, the Existing Scenario includes demands for anticipated developments at the time of the master plan with plans and/or tentative approval (Table 2-2). The actual current demand from historic well production records is less than the Existing demands in Table 6-2.

As described in Section 4 Water Demands, the master plan uses a system-wide factor of 2.3 based on historical analysis of well production data and system demands over a 10-year period as described in Section 4. The maximum day peaking factor of 2.3 relates the maximum day average daily demand to the annual average day system demand for the entire system as a whole. Based on the 10 years of well production data, the system-wide maximum day peaking factor ranged from a low of about 2.0 to a high of about 2.4. The maximum day peaking factor is affected by weather/hydrologic conditions that affect water use, i.e., some years have hotter weather and higher water use than other years. Using a long period of historic record, a reasonable maximum day peaking factor for long-term master planning is selected to reflect a variety of weather/hydrologic conditions affecting seasonal and annual water use.

Also as described in Section 4, as a refinement for this master plan update, the City provided SCADA data for one recent maximum demand day in 2008 that was used to develop peak hour factors by zone for the model verification analysis presented in Appendix C. SCADA data is only recently available for City facilities, so there is limited historic data; which is typical for many water systems. Basing the maximum day peaking factor on a long period of system-wide historical data and the peak hour factor on a limited amount of SCADA data is typical. The system analysis in this section uses the peak hour factors by zone for the pipeline distribution system analysis.

Table 6-2
Demands by Zone/Subzone

Major Zone	Subzones Included	Existing			Intermediate			Buildout		
		Average Day (mgd)	Maximum Day (mgd)(1)	Peak Hour (mgd)(2)	Average Day (mgd)	Maximum Day (mgd)(1)	Peak Hour (mgd)(2)	Average Day (mgd)	Maximum Day (mgd)(1)	Peak Hour (mgd)(2)
Zone 1	Zone 1 (Central/North)	4.23	9.73	15.57	4.56	10.50	16.79	4.66	10.72	17.16
	West Oregon	0.01	0.03	0.05	0.03	0.07	0.11	0.03	0.07	0.11
	Subtotal	4.24	9.76	15.62	4.59	10.56	16.90	4.69	10.79	17.27
	South 6th Street	1.18	2.72	4.35	2.22	5.11	8.18	2.31	5.32	8.51
	Sierra Heights	0.01	0.03	0.05	0.02	0.04	0.07	0.02	0.04	0.07
	Subtotal	1.20	2.75	4.40	2.24	5.15	8.25	2.33	5.36	8.58
	Washburn	2.00	4.61	7.38	3.06	7.04	11.26	3.11	7.16	11.46
	Subtotal	2.00	4.61	7.38	3.06	7.04	11.26	3.11	7.16	11.46
Zone 2	*Prescott*	0.18	0.42	0.72	0.31	0.71	1.21	0.31	0.71	1.21
	Upper Lynnewood	0.04	0.10	0.32	0.04	0.10	0.32	0.04	0.10	0.32
	Stewart-Lenox/Lindley	0.45	1.04	2.07	1.18	2.72	5.45	1.45	3.33	6.66
	West Klamath Reduced (Stewart-Lenox PRV)	0.05	0.12	0.24	0.10	0.23	0.47	0.10	0.23	0.47
	Subtotal	0.50	1.16	2.32	1.29	2.96	5.91	1.55	3.56	7.12
Zone 3	Hospital/Uhrmann	0.44	1.02	1.83	0.77	1.78	3.20	1.20	2.76	4.96
	Eldorado Reduced (PRV-2)	0.07	0.16	0.29	0.07	0.16	0.29	0.07	0.16	0.29
	Mollie's Area Reduced (PRV-2-HWY)	0.06	0.14	0.26	0.09	0.21	0.38	0.09	0.21	0.38
	Old Fort Road Reduced (PRV-6)	0.03	0.06	0.11	0.03	0.06	0.11	0.03	0.07	0.13
	ESI	0.01	0.02	0.03	0.07	0.17	0.30	0.07	0.17	0.30
	Quail/Crown Ridge	0.02	0.05	0.10	0.03	0.07	0.13	0.05	0.11	0.20
	Subtotal	0.63	1.45	2.62	1.07	2.45	4.41	1.51	3.48	6.26
	Patterson	0.35	0.81	2.42	0.46	1.06	3.17	0.58	1.33	4.00
	Ogden Reduced (PRV-Ogden)	0.03	0.07	0.22	0.04	0.10	0.31	0.04	0.10	0.31
	North Hills Reduced (PRV-1)	0.11	0.25	0.74	0.12	0.28	0.84	0.14	0.33	0.98
	Moyina Reduced (PRV-13)	0.04	0.09	0.28	0.04	0.09	0.28	0.04	0.09	0.28
	Havencrest	0.01	0.03	0.08	0.0003	0.0006	0.0019	0.0003	0.0006	0.0019
	Katie Lane Reduced	0.03	0.07	0.21	0.03	0.08	0.23	0.03	0.08	0.23
	Basinview Z3	--	--	--	--	--	--	1.16	2.66	7.98
	Subtotal	0.57	1.32	3.95	0.70	1.61	4.83	2.00	4.59	13.77
Zone 4	Upper Moyina	0.08	0.18	0.55	0.08	0.19	0.58	0.10	0.24	0.71
	Upper Moyina Reduced (PRV-3)	0.02	0.05	0.15	0.04	0.10	0.30	0.04	0.10	0.30
	Subtotal	0.10	0.23	0.70	0.13	0.29	0.88	0.15	0.34	1.02
Zone 5	*Basinview Z5*	0.07	0.15	0.45	0.17	0.40	1.19	0.26	0.60	1.81
Zone 6	*Basinview Z6*	--	--	--	0.03	0.08	0.23	0.28	0.64	1.93
Zone 8	*Tanglewood*	0.14	0.32	1.31	0.14	0.32	1.31	0.62	1.42	5.81
Zone 10	*Basinview Z10*	--	--	--	--	--	--	0.31	0.71	2.12
Zone 12	*Basinview Z12*	--	--	--	--	--	--	0.12	0.28	0.85
	Basinview Z10 PRV	--	--	--	--	--	--	0.03	0.08	0.24
	Subtotal	--	--	--	--	--	--	0.16	0.36	1.09
Total Demand		**9.68**	**22.27**	**39.78**	**13.77**	**31.67**	**56.71**	**17.32**	**39.82**	**79.77**

Notes:
(1) Maximum Day Demand = 2.3 * Average Day Demand for all zones. See discussion in Section 6.1 about the maximum day peaking factor.
(2) Peak hour factors by zone were developed based on detailed SCADA data provided by the City for the 2008 maximum day demands: See discussion in Section 6.1 about peak hour factors by zone.

Zone		
Zone 1 – Main Zone	1.6	From SCADA Data
Zone 2 - Prescott	1.7	From SCADA Data
Zone 2 - Stewart Lenox	2.0	From SCADA Data
Zone 2 - Upper Lynnewood	3.3	From SCADA Data
Zone 3 - Patterson	3.0	From SCADA Data
Zone 4 - Upper Moyina	3.0	From SCADA Data
Zone 5 - Basinview	3.0	Assumed peaking factor, similar land use and demand as Upper Moyina Zone
Zone 6 - Basinview	3.0	Assumed peaking factor, similar land use and demand as Upper Moyina Zone
Zone 8 - Tanglewood	4.1	For Existing and Intermediate the peaking factor is 4.1 based on SCADA Data. For Buildout a peaking factor of 3.0 is assumed due to increase in zone demand based on other zones with similar size and land use.
Zone 10 – Basinview	3.0	Assumed peaking factor, similar land use and demand as Upper Moyina Zone
Zone 12 – Basinview	3.0	Assumed peaking factor, similar land use and demand as Upper Moyina Zone

Note: For small residential booster areas, in general, a peak hour factor of 3.0 to 3.5 times the maximum day demand is a representative peaking factor.

As a general check, maximum day peaking factors by zone were calculated based on the verification maximum day demand and the computed current average day demand. Current average day demands which include planned approved development were computed based on unit demand factors using system-wide production data. The range of the zone-specific maximum day peaking factors varied from 1.8 to 2.6. The zone-specific maximum day peaking factors are not accurate enough to be used for the long-term master planning analysis due to the following:

- There was no SCADA data available by zone to determine the average day demands that would be needed to determine the maximum day peaking factor for each zone. Data is needed for a long period of time to establish a normalized average day demand.
- Maximum day demand by zone was based only on one maximum day demand which is not sufficient, to establish a normalized maximum day.
- The zone-specific maximum day peaking factors based on limited historic SCADA data and assumed average day demands by zone do not provide any cushion to handle fluctuations in long-term weather/hydrologic conditions and future demand fluctuations. Using the 2.3 system-wide maximum day peaking factor provides some cushion for the City to meet long-term future demand fluctuations for well, storage and pumping capacities that affect large areas in the overall system. For example, as discussed in Section 6.4, the storage requirement is already reduced in some zones by up to 50 percent of maximum day demand based on an emergency storage credit for standby power at wells. Due to future growth, in some zones such as the Hospital Zone where the residential density might be higher in the future, it might be more appropriate to use a higher peaking factor of 2.3.
- The geo-coding of demand was useful as a general check on the demand distribution for the larger zones and was not accurate enough in the smaller zones.

6.2 Major Features of Overall Configuration

The following subsections summarize the major features of the overall system configuration for Zone 1; small upper zones; and major future growth areas.

The master plan study addresses the major transmission system facilities only, and does not include analysis of smaller pipelines serving local areas. Therefore, it does not identify all localized improvements that would be needed to provide required fire flows throughout the existing system. In conjunction with new connection requests and main replacement upgrade projects, the City conducts detailed analyses of local areas to refine the master plan work and identify such localized improvements.

6.2.1 Zone 1

The Conger well field and some smaller wells located throughout the zone primarily supply Zone 1 in the main system. There are currently nine storage reservoirs located throughout Zone 1. Several booster stations within the zone replenish storage during high demand periods.

As shown on Figure 6-1, Zone 1 operates as several major subzones:

- Washburn subzone in the southwest is currently served by Bowen reservoir and supplied from Washburn Booster Station. A new booster station built in summer 2008 replaced the existing one. This new booster station has three variable speed pumps, each at design flow of 3,100 gpm. Based on field tests, when two pumps are operating the total flow is 4,400 gpm. The new booster station is also equipped with a standby power generator for emergency conditions

- South 6th subzone in the east is currently served by Ogden and Hilyard reservoirs and supplied by South 6th Booster Station; the Dayton booster station (a seasonally operated standby unit to help keep Ogden reservoir full); and the Hilyard well and Homedale well (summer only).

- North/Central subzone, comprising the remainder of Zone 1, is currently served by the North and Center reservoirs and supplied directly from wells without booster pumps. Under maximum demand conditions, Conger Well #8 is valved off to supply the northern part of Zone 1.

- Based on the analysis, it is recommended that the future configuration continue to utilize the existing major Zone 1 subzones shown on Figure 6-1, with implementation of some recommendations to improve operations and reliability. As described later in Section 6.7, pipe improvements are recommended to strengthen the transmission grid and provide capacity for future growth. In addition, some localized areas with high service elevations were identified for re-zoning to Zone 2 to improve pressures.

- As shown on Figure 6-1, service areas for the Washburn and South 6th subzones are defined by the irrigation canal across the southern part of Zone 1 that acts as a natural divider and splits that part of the zone into two systems. The Washburn and South 6th subzones are not completely separate; there are a few connections underneath the canal at the southeast subzone boundary to provide additional system reliability.

6.2.2 Small Upper Zones

There are several existing outlying smaller zones at higher elevations across the distribution system. These smaller zones and subzones are located around the peripheries and are typically isolated from each other. Some of the small subzones

have reservoir storage. Some very small isolated areas are served only from booster pumps or PRVs and have no storage within the zone.

The hydraulic analysis described in Section 6.7 identifies the following existing locations as possible consideration to improve pressures:

- If possible, re-zone high elevation services in Zone 1 near Ogden Reservoir to be served from Zone 2 North Hills PRV zone to improve pressures.
- If possible, consider re-zoning high elevation services near Center Reservoirs and near North Reservoir to be served from Zone 2 Prescott zone.
- The pressure setting of PRV station at Highway 66 and Weyerhauser Road could be raised to 52 psi to improve the pressure near the PRV station, exceeding the maximum pressure at the low elevations in the zone.
- If possible, consider re-zoning high elevation services in Zone 3 along Kimberly Drive near Moyina Standpipe to be served from Zone 4 Moyina zone.

In the future, development may also occur in small isolated areas where the typical zone configuration with storage will not be feasible. Such small isolated areas typically occur at the extreme edge of the Urban Growth Boundary (UGB) and/or where restricted by topography, such as in canyons, that prevent the area from being easily served from the existing system.

These small areas will be addressed on an individual basis to determine the most appropriate approach that is consistent with the overall system configuration. Options for service include, but are not limited to:

- Conveying flow through pressure reducing valve (PRV) from a higher zone;
- Constructing a small booster pump station to supply water from the zone below (if only a few services);
- Specifying a maximum service elevation for development in the area to allow service from the existing system.

6.2.3 Stewart Lenox/Lindley Area

The Stewart Lenox/Lindley area is in Zone 2 and located on the west side of the City. This area was initially two separate zones and was recently combined into one zone by a 16-inch pipeline to connect the Stewart Lenox zone to the Lindley zone. This area is supplied from two wells located within its service area, and has its own storage reservoir. The existing Riverside Pump Station provides backup supply from Conger well field to the combined Stewart Lenox/Lindley area.

6.2.4 Future Major Growth Areas

The largest future growth location is in the Basinview area located on the northeast side of the City. This area will be supplied from Zone 1 and the Conger well field. There will be several future zones in the Basinview area with service elevations ranging from 4,500 to 5,400 feet. Other future growth areas include the northwest area near the hospital and Oregon Institute of Technology, the Stewart-Lenox area to the southwest, and the vicinity of the airport.

Future growth areas will be served by extending the existing distribution system. Future growth within the existing pressure zones will be served through new waterline extensions. Additional well supply, pumping and storage capacity will be required for these new areas.

As discussed later in this section, improvements to existing distribution pipelines will also be needed to provide adequate hydraulic capacity to convey supply from the Conger well field across Zone 1 to the Basinview area.

6.3 Well Pumping Capacity Evaluation

Groundwater is the City's sole source of water supply. Section 3 describes the City's existing wells. Currently, Conger well field supplies about 80 percent of the existing well pumping capacity. Other wells located throughout the system provide the remaining 20 percent.

For future water supply, the City provided the following key assumptions for the evaluation:

- Additional supply will be added at the following locations: 1) Conger well field in Zone 1; and 2) Stewart-Lenox area in Zone 2.
- The following existing wells will remain in service in the future, but will not be expanded beyond their existing capacities: Fremont, Hilyard and Homedale wells in Zone 1; and Wocus Well in Zone 3.
- The following existing wells were assumed not to be used in the future due to small size or water quality issues: Moyina well (small size), Henley well (manganese), and Unity well (entrained air). However, the City could study the Henley and Unity wells to determine the cost-effectiveness of treating the water as an alternative to producing water elsewhere.

Table 6-3 evaluates well pumping capacity by comparing system demand and supply for existing, intermediate, and buildout timeframes. The additional capacity requirements shown on the table are the total cumulative additional capacity required (not the incremental capacity from one timeframe to the next).

The evaluation of well pumping capacity requirements assumes that wells will provide the maximum day demand, with peak hour needs met from storage. In addition, well pumping capacity must also include reserve capacity for reliability, i.e., to account for well outages. For this evaluation, a 15 percent reserve pumping capacity was assumed.

Table 6-3
Well Pumping Capacity Evaluation

Well Locations	Existing Wells	Well Pumping Capacity Evaluation (4)								
		Maximum Day Demand (mgd)			Maximum Day Demand Plus 15% Reserve Pumping Capacity (mgd)			Surplus or (Deficit) of Well Pumping Capacity Needed to Meet Maximum Day Demand (including 15% reserve) (mgd)		
	Existing Pumping Capacity (mgd)(3)	Existing	Intermediate	Buildout	Existing	Intermediate	Buildout	Existing	Intermediate	Buildout
Conger Well Field (1)	21.1	(see subtotal row below)								
Other Wells except Wocus and Stewart-Lenox (2)	3.0									
Subtotal	24.0	19.7	26.4	33.1	22.6	30.3	38.0	1.4	(6.3)	(14.0)
Wocus Area (5)	1.1	1.5	2.4	3.5	1.7	2.8	4.0	(0.6)	(1.7)	(2.9)
Stewart Lenox/Lindley Area	1.2	1.2	3.0	3.6	1.3	3.4	4.1	(0.1)	(2.2)	(2.9)
Overall Total for System	*26.3*	*22.3*	*31.8*	*40.1*	*25.6*	*36.5*	*46.1*	*0.7*	*(10.2)*	*(19.8)*

(1) The majority of additional supply needed for future demands is assumed to be provided at Conger Well Field.
(2) Other wells not in Conger Field and outside the Wocus and Stewart Lenox areas are assumed to continue in service as needed and remain at existing pump capacities include: Fremont, Wocus, Hilyard, and Homedale. City staff indicated that these wells are not suitable for expansion. Existing wells that are assumed not to be used at all due to small size or poor water quality include: Moyina (small size), Henley (manganese), and Unity (entrained air).
(3) Existing pumping capacity includes only the active wells (non-emergency) wells, excludes Moyina, Henley, and Unity.
(4) Evaluation of additional well pumping capacity requirements assumes that wells will provide the maximum day demand, with peak hour needs met from storage. The required capacity also includes a 15 percent reserve pumping capacity for reliability, to account for well outages. The water system evaluation will also consider whether one or multiple wells serve an area.
(5) The deficit in the Wocus area will be met from Conger Well Field through Birch Pump Station and High Level Pump Station. At this time, the City is not considering adding another well at Wocus.

Key findings from Table 6-3 for well pumping capacity are summarized below:

- The City has adequate well pumping capacity to meet existing demands.
- Additional well pumping capacity will be needed at the following locations to meet intermediate and buildout demands:
  - Conger Well Field: Additional 9.0 mgd capacity by intermediate (6.3 mgd for Conger plus 1.4 for Wocus area) and 16.9 mgd at buildout (14.0 mgd for Conger area plus 2.9 for Wocus area). This is a 7.9 mgd incremental additional increase between intermediate and buildout for both the Conger and Wocus areas combined. Additional capacity would be provided by installing larger pumps at existing wells, if feasible, or constructing new well(s).

- Wocus Well: At this time, the City is not planning to expand the Wocus Well due to the potential regulatory hurdles associated with water rights, land use permitting, and the potential cost of treatment if arsenic removal is required. The additional supply required will be provided from Conger Well Field through Birch Pump Station. The existing small deficit can be met by available excess capacity at the existing Conger Well Field. The additional capacity for both the Conger and Wocus areas to meet intermediate and buildout needs are shown in the bullet above.
- Stewart Lenox: Additional 2.2 mgd by intermediate and 2.9 mgd by buildout (0.7 mgd incremental additional between intermediate and buildout). With upsizing the capacity of Debbie Well to 2.16 mgd (1,500 gpm) the deficit for intermediate would be 0.80 mgd and that for Buildout would be 1.5 mgd. The remaining deficit could be met either by adding a new well in Steward Lenox or from Conger Well Field.

For well supply, there is only 0.7 mgd available surplus well pumping capacity, as shown on Table 6-3, to meet existing maximum day demands in the water system from the Conger well field. This surplus well pumping capacity is equivalent to 870 equivalent residential units (ERUs) at 805 gal/day/ERU for maximum day demand (which is a 350 gal/day/ERU average day rate times 2.3 maximum day peaking factor). However, as discussed in Section 2, the Existing Scenario includes demands for anticipated developments with plans and/or tentative approval at the time of the master plan (see Table 2-2). The actual current maximum day demand from historic well production records is about 18 mgd, rather than the 22 mgd shown in Table 6-3.

The City should consider increasing conservation measures as development occurs to decrease maximum day demands and peak hour demands. Decreasing these demands will reduce infrastructure cost because these high demand conditions drive the sizing of wells, pumps, reservoirs, and pipes.

6.4 Storage Evaluation

The storage evaluation compares existing storage available in each zone with required storage calculated using the established performance objectives. Two options were considered:

1. Storage volume in tanks equal to 100 percent of the maximum day demand for operational (balancing) and emergency storage, plus a fire reserve, for each zone.
2. Emergency storage credit for standby power of up to 50 percent of maximum day demand for those zones supplied by wells with standby power, instead of having the emergency storage in tanks. This assumes that the zone/subzone is either supplied directly from the wells, or there is standby power at booster pump stations that convey the water from the wells. In order to use the emergency storage credit, requires an unbroken chain of reliable conveyance and pumping between the well supply and the zone being evaluated.

Tables 6-4, 6-5, and 6-6 compare existing storage capacities in each zone with the needed storage under existing, intermediate, and buildout conditions for a criterion of 100 percent of the maximum day demand. The tables show the total storage needed, the available storage, and whether there is a deficit or surplus of storage capacity in the zone. Future zones all appear as a storage deficit, since there is no existing storage. The last three columns show the storage requirements with a credit for installing backup power for the emergency storage component.

Table 6-7 summarizes overall findings regarding required additional storage capacity in both existing and future service zones. The table summarizes the increment of additional storage needed for each timeframe, and shows the cumulative total at buildout. The cumulative total at buildout sums the increments shown for existing, intermediate and buildout timeframes.

As indicated in Table 6-7, some additional storage could be provided with an emergency storage credit for subzones with standby power at wells and booster pumps. As noted in the Table 6-7 comments, formulation of recommended improvements will be based on use of standby power to provide the emergency storage credit. Section 6.5 Pumping Evaluation discusses the booster stations that will require installation of standby power for the emergency storage credit.

Key findings as summarized in Table 6-7 include:

- Existing – Zone 1 requires additional storage under existing conditions. The amount of tank storage can be reduced by providing an emergency storage credit utilizing standby power at wells/booster stations. There are other small storage deficits in some upper zones under existing conditions that are not significant.
- Intermediate – By the intermediate timeframe, Zone 1 will require more storage. Stewart Lenox/Lindley will also require additional storage, as well as Zone 3 Hospital. There are other small storage deficits in some upper zones under intermediate conditions that will require standby power at key pump stations to provide an emergency storage credit in some zones, as shown in Table 6-7.
- Buildout – By buildout, Zone 1 would require total additional tank storage of 17 MG; which can be reduced to 5.2 MG with the emergency storage credit for standby power at Conger Well Field and the Washburn and South 6th Pump Stations. In the Stewart Lenox/Lindley area, the total additional 2.3 MG at buildout can be reduced to 0.5 MG with the emergency storage credit for standby power at Debbie Well. In Zone 3 Patterson, the total additional 3.3 MG at buildout can be reduced to 1 MG additional with standby power at Ogden and Beverly Pump Stations. In Zone 8 Tanglewood, the total additional 1.3 MG can be reduced to 0.6 MG with standby power at the new Tanglewood pump station.
- Future tanks in future zones – Future tanks will also be required to serve future zones in the Basinview development area.

Table 6-4
Storage Evaluation for Existing Scenario

Major Zone	***Subzones Included***	***Demands***			***Storage Requirements (MG)***			***Existing Storage***		***Evaluation with All Storage in Tanks***		Evaluation of Emergency Storage Credit With Standby Power		
		Average Day Demand (mgd)	***Maximum Day Demand (mgd)(1)***	***Maximum Fire Flow Requirement (gpm)(2)***	***Operational and Emergency (100% Max Day)***	***Fire Reserve***	***Total Storage Needed***	***Existing Tanks***	***Existing Storage (MG)***	***Storage Deficit (MG)***	***Storage Surplus (MG)***	***Potential Storage Credit (MG)(3)***	***Storage Deficit after Credit (MG)***	***Storage Surplus after Credit (MG)***
Zone 1	Zone 1(Central/North)	4.23	9.73		9.73			Lower Lynnewood	0.15					
	West Oregon	0.01	0.03		0.03			North	0.50					
								Center 1	0.78					
								Center 2	0.78					
								Melrose	0.76					
								Burns	1.33					
	Subtotal	***4.24***	***9.76***	***2500***	***9.76***	***0.45***	***10.21***	***--***	***4.30***	***5.91***	***-***	**4.88**	**1.03**	**-**
	South 6th Street	1.18	2.72		2.72			Ogden	1.02					
	Sierra Heights	0.01	0.03		0.03			Hilyard	1.04					
	Subtotal	***1.20***	***2.75***	***2500***	***2.75***	***0.45***	***3.20***	***--***	***2.06***	***1.14***	***-***	**1.38**	**-**	**0.23**
	Washburn	2.00	4.61		4.61			Bowen	1.45					
	Subtotal	***2.00***	***4.61***	***2500***	***4.61***	***0.45***	***5.06***	***--***	***1.45***	***3.61***	***-***	**2.31**	**1.31**	**-**
Zone 2	*Prescott(5)*	***0.18***	***0.42***	***2500***	***0.42***	***0.45***	***0.87***	Prescott	***0.79***	***0.08***	***-***	**0.21**	**-**	**0.13**
	Upper Lynnewood(6)	**0.04**	**0.10**	**1500**	**0.10**	**0.18**	**0.28**	Upper Lynnewood	**0.15**	**0.13**	**-**	**0.05**	**0.08**	**-**
	Stewart-Lenox/Lindley	0.45	1.04		1.04			Lindley	0.51					
	West Klamath Reduced (Stewart-Lenox PRV)	0.05	0.12		0.12			Stewart-Lenox	1.24					
	Subtotal	***0.50***	***1.16***	***2500***	***1.16***	***0.45***	***1.61***	***--***	***1.75***	***-***	***0.14***	**0.58**	**-**	**0.72**
Zone 3	Hospital/Uhrmann	0.44	1.02		1.02			Uhrmann	1.32					
	Eldorado Reduced (PRV-2)	0.07	0.16		0.16			Hospital	0.50					
	Mollie's Area Reduced (PRV-2-HWY)	0.06	0.14		0.14			High Level	0.40					
	Old Fort Road Reduced (PRV-6)	0.03	0.06		0.06									
	ESI	0.01	0.02		0.02									
	Quail/Crown Ridge	0.02	0.05		0.05									
	Subtotal	***0.63***	***1.45***	***2500***	***1.45***	***0.45***	***1.90***	***--***	***2.22***	***-***	***0.32***	**0.73**	**-**	**1.04**
	Patterson	0.35	0.81		0.81			Patterson 1	0.41					
	Ogden Reduced (PRV_Ogden)	0.03	0.07		0.07			Patterson 2	1.31					
	North Hills Reduced (PRV-1)	0.11	0.25		0.25									
	Moyina Reduced (PRV-13)	0.04	0.09		0.09									
	Havencrest	0.01	0.03		0.03									
	Katie Lane Reduced	0.03	0.07		0.07									
	Subtotal	***0.57***	***1.32***	***2500***	***1.32***	***0.45***	***1.77***	***--***	***1.72***	***0.05***	***-***	**0.66**	**-**	**0.61**
Zone 4 (7)	Upper Moyina	0.08	0.18		0.18			Upper Moyina	0.29					
	Upper Moyina Reduced (PRV-3)	0.02	0.05		0.05			Lower Moyina	0.13					
	Subtotal	***0.10***	***0.23***	***1500***	***0.23***	***0.18***	***0.41***	***--***	***0.42***	***-***	***0.01***	**0.12**	**-**	**0.12**
Zone 5	*Basinview Z5*	***0.07***	***0.15***	***1500***	***0.15***	***0.18***	***0.33***	Basinview	***0.52***	***-***	***0.19***	**0.08**	**-**	**0.26**
Zone 8	*Tanglewood*	***0.14***	***0.32***	***1500***	***0.32***	***0.18***	***0.50***	Tanglewood	***0.29***	***0.21***	***-***	**0.16**	**0.05**	**-**

(1) Maximum Day Demand = 2.3 * Average Day Demand.
(2) Fire flows are assumed to be 1500 gpm with 2-hour duration for residential and 2500 gpm with 3-hour duration for non-residential.
(3) The potential Emergency Storage Credit assumed equal to 50% of the maximum day demand based on the emergency criteria, if there is adequate capacity and booster station capacity to provide emergency water from the wells in case of a power outage.
(4) The total well capacity with standby power at Conger Well Field equals 13.4 mgd. This would be the maximum available total emergency storage credit for all areas served solely by Conger wells.
The Conger wells with standby power are Conger #8 at 1.6 mgd; Conger #9 at 5.0 mgd; and Conger #25 at 6.8 mgd. All pump into Zone 1
(5) The bottom 46 feet of Prescott Tank is considered to be unusable storage. The 0.79 MG existing storage includes only the useable storage (excludes the bottom 46 feet).
(6) The storage deficit could be met from the available surplus pumping capacity and backup power at Upper Lynnewood Pump Station. There is 0.21 mgd surplus pumping capacity at buildout. A total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(7) A residential fire flow of 1500 gpm is used for Zone 4 Upper Moyina. There is a church at the boundary of the zone that can be served from several adjacent hydrants located in Zone 3. There is no other non-residential near Upper Moyina zone.

Table 6-5
Storage Evaluation for Intermediate Scenario

Major Zone	Subzones Included	Demands			Storage Requirements (MG)			Existing Storage		Evaluation with All Storage in Tanks		Evaluation of Emergency Storage Credit With Standby Power		
		Average Day Demand (mgd)	Maximum Day Demand (mgd)[1]	Maximum Fire Flow Requirement (gpm)[2]	Operational and Emergency (100% Max Day)	Fire Reserve	Total Storage Needed	Existing Tanks	Existing Storage (MG)	Storage Deficit (MG)	Storage Surplus (MG)	Potential Storage Credit (MG)[3]	Storage Deficit after Credit (MG)	Storage Surplus after Credit (MG)
Zone 1	Zone 1(Central/North)	4.56	10.50		10.50			Lower Lynnewood	0.15					
	West Oregon	0.03	0.07		0.07			North	0.50					
								Center 1	0.78					
								Center 2	0.78					
								Melrose	0.76					
								Burns	1.33					
	Subtotal	***4.59***	***10.56***	***2500***	***10.56***	***0.45***	***11.01***	***--***	***4.30***	***6.71***	***-***	**5.28**	**1.43**	**-**
	South 6th Street	2.22	5.11		5.11			Ogden	1.02					
	Sierra Heights	0.02	0.04		0.04			Hilyard	1.04					
	Subtotal	***2.24***	***5.15***	***2500***	***5.15***	***0.45***	***5.60***	***--***	***2.06***	***3.54***	***-***	**2.58**	**0.97**	**-**
	Washburn	3.06	7.04		7.04			Bowen	1.45					
	Subtotal	***3.06***	***7.04***	***2500***	***7.04***	***0.45***	***7.49***	***--***	***1.45***	***6.04***	***-***	**3.52**	**2.52**	**-**
Zone 2	*Prescott*[5]	***0.31***	***0.71***	***2500***	***0.71***	***0.45***	***1.16***	Prescott	***0.79***	***0.37***	***-***	**0.36**	**0.01**	**-**
	Upper Lynnewood[6]	**0.04**	**0.10**	**1500**	**0.10**	**0.18**	**0.28**	Upper Lynnewood	**0.15**	**0.13**	**-**	**0.05**	**0.08**	**-**
	Stewart-Lenox/Lindley	1.18	2.72		2.72			Lindley	0.51					
	West Klamath Reduced (Stewart-Lenox PRV)	0.10	0.23		0.23			Stewart-Lenox	1.24					
	Subtotal	***1.29***	***2.96***	***2500***	***2.96***	***0.45***	***3.41***	***--***	***1.75***	***1.66***	***-***	**1.48**	**0.18**	**-**
Zone 3	Hospital/Uhrmann	0.77	1.78		1.78			Uhrmann	1.32					
	Eldorado Reduced (PRV-2)	0.07	0.16		0.16			Hospital	0.50					
	Mollie's Area Reduced (PRV-2-HWY)	0.09	0.21		0.21			High Level	0.40					
	Old Fort Road Reduced (PRV-6)	0.03	0.06		0.06									
	ESI	0.07	0.17		0.17									
	Quail/Crown Ridge	0.03	0.07		0.07									
	Subtotal	***1.07***	***2.45***	***2500***	***2.45***	***0.45***	***2.90***	***--***	***2.22***	***0.68***	***-***	**1.22**	**-**	**0.55**
	Patterson	0.46	1.06		1.06			Patterson 1	0.41					
	Ogden Reduced (PRV_Ogden)	0.04	0.10		0.10			Patterson 2	1.31					
	North Hills Reduced (PRV-1)	0.12	0.28		0.28									
	Moyina Reduced (PRV-13)	0.04	0.09		0.09									
	Havencrest	0.0003	0.0006		0.0006									
	Katie Lane	0.03	0.08		0.08									
	Subtotal	***0.70***	***1.61***	***2500***	***1.61***	***0.45***	***2.06***	***--***	***1.72***	***0.34***	***-***	**0.80**	**-**	**0.47**
Zone 4 [7]	Upper Moyina	0.08	0.19		0.19			Upper Moyina	0.29					
	Upper Moyina Reduced (PRV-3)	0.04	0.10		0.10			Lower Moyina	0.13					
	Subtotal	***0.13***	***0.29***	***1500***	***0.29***	***0.18***	***0.47***	***--***	***0.42***	***0.05***	***-***	**0.15**	**-**	**0.09**
Zone 5	*Basinview Z5*	***0.17***	***0.40***	***1500***	***0.40***	***0.18***	***0.58***	Basinview	***0.52***	***0.06***	***-***	**0.20**	**-**	**0.14**
Zone 6	*Basinview Z6*	***0.03***	***0.08***	***1500***	***0.08***	***0.18***	***0.26***		***0.00***	***0.26***	***-***	**0.04**	**0.22**	**-**
Zone 8	*Tanglewood*	***0.14***	***0.32***	***1500***	***0.32***	***0.18***	***0.50***	Tanglewood	***0.29***	***0.21***	***-***	**0.16**	**0.05**	**-**

(1) Maximum Day Demand = 2.3 * Average Day Demand.
(2) Fire flows are assumed to be 1500 gpm with 2-hour duration for residential and 2500 gpm with 3-hour duration for non-residential.
(3) The potential Emergency Storage Credit assumed equal to 50% of the maximum day demand based on the emergency criteria, if there is adequate capacity and booster station capacity to provide emergency water from the wells in case of a power outage.
(4) The total well capacity with standby power at Conger Well Field equals 13.4 mgd. This would be the maximum available total emergency storage credit for all areas served solely by Conger wells. The Conger wells with standby power are Conger #8 at 1.6 mgd; Conger #9 at 5.0 mgd; and Conger #25 at 6.8 mgd. All pump into Zone 1
(5) The bottom 46 feet of Prescott Tank is considered to be unusable storage. The 0.79 MG existing storage includes only the useable storage (excludes the bottom 46 feet).
(6) The storage deficit could be met from the available surplus pumping capacity and backup power at Upper Lynnewood Pump Station. There is 0.21 mgd surplus pumping capacity at buildout. A total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(7) A residential fire flow of 1500 gpm is used for Zone 4 Upper Moyina. There is a church at the boundary of the zone that can be served from several adjacent hydrants located in Zone 3. There is no other non-residential near Upper Moyina zone.

Table 6-6
Storage Evaluation for Buildout Scenario

Major Zone	Subzones Included	Demands			Storage Requirements (MG)			Existing Storage		Evaluation with All Storage in Tanks		Evaluation of Emergency Storage Credit with Standby Power		
		Average Day Demand (mgd)	Maximum Day Demand (mgd)[1]	Maximum Fire Flow Requirement (gpm)[2]	Operational and Emergency (100% Max Day)	Fire Reserve	Total Storage Needed	Existing Tanks	Existing Storage (MG)	Storage Deficit (MG)	Storage Surplus (MG)	Potential Storage Credit (MG)[3]	Storage Deficit after Credit (MG)	Storage Surplus after Credit (MG)
Zone 1	Zone 1(Central/North)	4.66	10.72		10.72			Lower Lynnewood	0.15					
	West Oregon	0.03	0.07		0.07			North	0.50					
								Center 1	0.78					
								Center 2	0.78					
								Melrose	0.76					
								Burns	1.33					
	Subtotal	***4.69***	***10.79***	***2500***	***10.79***	***0.45***	***11.24***	***--***	***4.30***	***6.94***	***-***	**5.40**	**1.55**	**-**
	South 6th Street	2.31	5.32		5.32			Ogden	1.02					
	Sierra Heights	0.02	0.04		0.04			Hilyard	1.04					
	Subtotal	***2.33***	***5.36***	***2500***	***5.36***	***0.45***	***5.81***	***--***	***2.06***	***3.75***	***-***	**2.68**	**1.07**	**-**
	Washburn	3.11	7.16		7.16			Bowen	1.45					
	Subtotal	***3.11***	***7.16***	***2500***	***7.16***	***0.45***	***7.61***	***--***	***1.45***	***6.16***	***-***	**3.58**	**2.58**	**-**
Zone 2	*Prescott*[5]	***0.31***	***0.71***	***2500***	***0.71***	***0.45***	***1.16***	Prescott	***0.79***	***0.37***	***-***	**0.36**	**0.01**	**-**
	Upper Lynnewood[6]	**0.04**	**0.10**	**1500**	**0.10**	**0.18**	**0.28**	Upper Lynnewood	**0.15**	**0.13**	**-**	**0.05**	**0.08**	**-**
	Stewart-Lenox/Lindley	1.45	3.33		3.33			Lindley	0.51					
	West Klamath Reduced (Stewart-Lenox PRV)	0.10	0.23		0.23			Stewart-Lenox	1.24					
	Subtotal	***1.55***	***3.56***	***2500***	***3.56***	***0.45***	***4.01***	***--***	***1.75***	***2.26***	***-***	**1.78**	**0.48**	**-**
Zone 3	Hospital/Uhrmann	1.20	2.76		2.76			Uhrmann	1.32					
	Eldorado Reduced (PRV-2)	0.07	0.16		0.16			Hospital	0.50					
	Mollie's Area Reduced (PRV-2-HWY)	0.09	0.21		0.21			High Level	0.40					
	Old Fort Road Reduced (PRV-6)	0.03	0.07		0.07									
	ESI	0.07	0.17		0.17									
	Quail/Crown Ridge	0.05	0.11		0.11									
	Subtotal	***1.51***	***3.48***	***2500***	***3.48***	***0.45***	***3.93***	***--***	***2.22***	***1.71***	***-***	**1.74**	**-**	**0.03**
	Patterson	0.58	1.33		1.33			Patterson 1	0.41					
	Ogden Reduced (PRV_Ogden)	0.04	0.10		0.10			Patterson 2	1.31					
	North Hills Reduced (PRV-1)	0.14	0.33		0.33									
	Moyina Reduced (PRV-13)	0.00	0.00		0.00									
	Havencrest	0.00	0.00		0.00									
	Katie Lane	0.03	0.08		0.08									
	Basinview Z3	1.16	2.66		2.66									
	Subtotal	***1.96***	***4.50***	***2500***	***4.50***	***0.45***	***4.95***	***--***	***1.72***	***3.23***	***-***	**2.25**	**0.98**	**-**
Zone 4 [7]	Upper Moyina	0.10	0.24		0.24			Upper Moyina	0.29					
	Upper Moyina Reduced (PRV-3)	0.04	0.10		0.10			Lower Moyina	0.13					
	Subtotal	***0.15***	***0.34***	***1500***	***0.34***	***0.18***	***0.52***	***--***	***0.42***	***0.10***	***-***	**0.17**	**-**	**0.07**
Zone 5	*Basinview Z5*	***0.26***	***0.60***	***1500***	***0.60***	***0.18***	***0.78***	Basinview	***0.52***	***0.26***	***-***	**0.30**	**-**	**0.04**
Zone 6	*Basinview Z6*	***0.28***	***0.64***	***1500***	***0.64***	***0.18***	***0.82***		***0.00***	***0.82***	***-***	**0.32**	**0.50**	**-**
Zone 8	*Tanglewood*	***0.62***	***1.42***	***1500***	***1.42***	***0.18***	***1.60***	Tanglewood	***0.29***	***1.31***	***-***	**0.71**	**0.60**	**-**
Zone 10	*Basinview Z10*	***0.31***	***0.71***	***1500***	***0.71***	***0.18***	***0.89***		***0.00***	***0.89***	***-***	**0.35**	**0.53**	**-**
Zone 12	Basinview Z12	0.12	0.28		0.28									
	Basinview Z10 PRV	0.03	0.08		0.08									
	Subtotal	***0.16***	***0.36***	***1500***	***0.36***	***0.27***	***0.63***	***--***	***0.00***	***0.63***	***-***	**0.18**	**0.45**	**-**

(1) Maximum Day Demand = 2.3 * Average Day Demand. (2) Fire flows are assumed to be 1500 gpm with 2-hour duration for residential and 2500 gpm with 3-hour duration for non-residential.
(3) The potential Emergency Storage Credit assumed equal to 50% of the maximum day demand based on the emergency criteria, if there is adequate capacity and booster station capacity to provide emergency water from the wells in case of a power outage.
(4) The total well capacity with standby power at Conger Well Field equals 13.4 mgd. This would be the maximum available total emergency storage credit for all areas served solely by Conger wells.
The Conger wells with standby power are Conger #8 at 1.6 mgd; Conger #9 at 5.0 mgd; and Conger #25 at 6.8 mgd. All pump into Zone 1
(5) The bottom 46 feet of Prescott Tank is considered to be unusable storage. The 0.79 MG existing storage includes only the useable storage (excludes the bottom 46 feet).
(6) The storage deficit could be met from the available surplus pumping capacity and backup power at Upper Lynnewood Pump Station. There is 0.21 mgd surplus pumping capacity at buildout. A total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(7) A residential fire flow of 1500 gpm is used for Zone 4 Upper Moyina. There is a church at the boundary of the zone that can be served from several adjacent hydrants located in Zone 3. There is no other non-residential near Upper Moyina zone.

Table 6-7
Summary of Required Additional Storage Capacity

Major Zone	Subzones Included	All Storage in Tanks				With Emergency Storage Credit for Standby Power				Comments Regarding Potential Emergency Storage Credit
		Incremental Additional Capacity Required[1]			Total Additional by Buildout (MG)	Incremental Additional Capacity Required[1]			Total Additional by Buildout (MG)	
		Existing (MG)	Intermediate (MG)	Buildout		Existing (MG)	Intermediate (MG)	Buildout (MG)		
Existing Service Zones										
Zone 1	Zone 1(Central/North)	5.91	0.80	0.23	6.94	1.03	0.40	0.11	1.55	Storage credit is applied to Zone 1 Central and North with standby power available at Conger Well field at Well #8, 9 and #25. Wells pump directly into this subzone. There is sufficient well capacity with standby power at Conger for all the Zone 1 subzones.
	South 6th Street	1.14	2.40	0.21	3.75	-	0.97	0.10	1.07	Area served by South 6th PS could receive storage credit and benefit from the standby power available at Conger Well Field if the South 6th pump station is equipped with standby power. South 6th PS has adequate existing capacity but will require expansion to meet Intermediate and Buildout needs. Existing storage needs can be met with a 1 MG tank at the Hilyard location. After the South 6th PS expansion with standby power for Intermediate, the additional 1 MG storage installed at Hilyard for existing will be sufficient to meet Buildout needs.
	Washburn	3.61	2.43	0.12	6.16	1.31	1.21	0.06	2.58	Storage credit is applied with standby power available at Washburn Pump Station.
Zone 2	Prescott	0.08	0.29	-	0.37	-	0.01	-	0.01	The bottom 46 feet of Prescott Tank is considered unusable storage under normal conditions. However, some of this storage could be used in emergency conditions to mitigate the marginal storage deficit. To meet the 0.08 MG existing deficit the water level in the tank will be dropped by 6 feet and the pressure will be reduced only by 2.5 psi. Prescott Zone could receive storage credit and benefit from the standby power available at Conger Well Field if the Lytton PS is equipped with standby power by Intermediate timeframe. With backup power at Lytton PS, no additional tank storage is needed.
	Upper Lynnewood	0.13	-	-	0.13	0.08	-	-	0.08	Upper Lynnewood PS has standby power that currently does not function. The City plans on addressing the storage deficit by means of pumping capacity and adding functional backup power in conjunction with pump upgrade, which is needed in the Existing timeframe.
	Stewart-Lenox/Lindley	-	1.66	0.61	2.26	-	0.18	0.30	0.48	No storage deficit under existing conditions. For Intermediate and Buildout, Debbie Well's capacity could potentially be increased to 2.16 mgd. If this well is equipped with standby power, a storage credit up to 1.78 mgd could be applied toward the storage deficit, reducing the additional tank storage volume to 0.5 MG. Riverside Booster Station can be expanded to provide supply redundancy.
Zone 3	Hospital/Uhrmann	-	0.68	1.03	1.71	-	-	-	-	The existing Wocus well has a capacity of 1.08 mgd and is equipped with standby power. As a first phase, Birch PS will be upgraded for redundancy in the event of a Wocus Well outage, and the second phase will be to meet future growth. Birch PS should be equipped with standby power to receive the emergency storage credit.
	Patterson	0.05	0.29	2.89	3.23	-	-	0.98	0.98	The Existing deficit is very small and does not need to be addressed. The Intermediate storage deficit could be met by providing standby power at Ogden PS, in conjunction with some additional pumping capacity for intermediate growth. For Buildout, Beverly PS will be expanded to serve the Basinview area, and standby power should be provided at Beverly PS for the emergency storage credit. At Buildout, a 1 MG tank will also be needed.
Zone 4	Upper Moyina	-	0.05	0.05	0.10	-	-	-	-	With standby power at Moyina Booster Station, there is no storage deficit.
Zone 5	Basinview Z5	-	0.06	0.20	0.26	-	-	-	-	Intermediate deficit is very small and does not need to be addressed. For buildout either storage or standby power at the Basinview Z5 PS could be considered. Standby power will be assumed.
Zone 8	Tanglewood	0.16	-	1.10	1.31	0.05	-	0.55	0.60	The Tanglewood area could receive storage credit and benefit from the standby power available at Conger Well Field if its pump station is equipped with standby power. Laguna PS has adequate pumping capacity for existing and intermediate needs, but requires standby power for the emergency storage credit. A new pump station will be needed to meet buildout needs, and should be equipped with standby power.
Future Service Zones										
Zone 6	Basinview Z6	-	0.26	0.57	0.82	-	0.22	0.28	0.50	These are new zones. It is assumed that future storage requirements will be based on the emergency storage credit assuming that all pump stations up the cascade have backup power. If not, the full amount of tank storage would be needed.
Zone 10	Basinview Z10	-	-	0.89	0.89	-	-	0.53	0.53	
Zone 12	Basinview Z12	-	-	0.63	0.63	-	-	0.45	0.45	

[1] Incremental capacity is the increment of additional pumping capacity needed for each timeframe. It is not the cumulative required amount, that is, the cumulative total at buildout is the sum of the increments shown for existing, intermediate, and buildout.

Potential locations for additional storage in existing zones include existing storage sites if space is available or can be acquired; or new locations at the proper elevation for additional storage; including:

- In the South 6th subzone of Zone 1, in the vicinity of the Hilyard reservoir site or in the vicinity of Ogden reservoir site.
- In the Washburn subzone of Zone 1, at the current site of Bowen Tank by replacing the existing small tank.
- In Washburn subzone of Zone 1, ground level storage at Kingsley Field near the Airport that will not be gravity flow and will require pumping out of the tank into the system. This option is less attractive than gravity storage because it adds complexity to operate the system where a booster station is needed to match the hydraulic grade line in the zone and a valve station to maintain system pressure while tank is filling.
- In the middle of Zone 1 on the hill to the north of the intersection of Crater Lake Parkway and Washburn Way.
- In the Central subzone of Zone 1, at the current site of Center tanks by replacing existing tanks with larger tanks.
- On the western side of the Stewart-Lenox subzone of Zone 2 at a site with appropriate ground elevation for gravity storage.
- Zone 3, to the north of College Way, in the general vicinity of Uhrmann Reservoir.

In future zones, conceptual locations for future storage are based on the overall system configuration and recent contour elevations provided by the City. The actual locations for future storage for new development will be determined in conjunction with City staff as part of the development planning process.

6.5 Pumping Evaluation

The pumping evaluation compares existing pumping capacity available in each zone with required capacity calculated using the established performance objectives. The pumping criterion used for zones with reservoir storage is to provide firm pumping capacity sufficient to meet maximum day demand. For zones with storage, fire reserves are provided from storage. Small zones served solely through boosters without storage in the zone must have firm pumping capacity to meet the peak hour demand on the maximum day, plus a fire pump. Firm capacity is defined as the capacity with the largest pumping unit at the pump station out of service.

Tables 6-8, 6-9, and 6-10 compare existing pump station capacities with the required pumping capacity in each zone for existing, intermediate, and buildout timeframes. The tables show the firm pumping capacity in each subzone to meet both maximum demands for the zone that the pump station is pumping into, and also the pass through capacity needed to supply the maximum day demands for higher zones.

Table 6-8
Pump Station Capacity Evaluation for Existing Scenario

Service Location	Subzones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Existing Pump Stations/Wells	No. of Units	Firm Capacity (mgd)	Total Capacity (mgd)	Deficit (mgd)	Surplus (mgd)	Comments/August 15, 2008 Runtime
Zones with Storage										
Zone 1	Zone 1 met from wells only	4.23	9.73		--	--	--	--	--	
	Washburn	2.00	4.61	Washburn	3	6.34	9.50	-	1.73	No runtime information provided for Washburn, assumed operated all day
	South 6th Street[1]	1.33	3.06	South 6th	2	1.44	2.88			South 6th pump 1 operates for 24 hours and pump 2 operates for 17.3 hours
	Sierra Heights	0.01	0.05	Dayton	1	0.72	0.72			No runtime information provided for Dayton, assumed operated all day
				Hilyard Well[1]	1	0.79	0.79			Hilyard Well was off all day
				Homedale Well[1]	1	0.58	0.58			No runtime information was provided for Homedale Well
	Subtotal	1.35	3.11		--	3.53	4.97	-	0.41	
Zone 2	Prescott	0.18	0.42	Lytton	2	1.01	2.02			Lytton pump 1 operated for 5.3 hours and pump 2 was off all day
				Center[2]	2	0.58	0.58			Center pumps 1 and 2 operated for 24 hours
	Subtotal	0.18	0.42		--	1.58	2.59	-	1.16	
	Upper Lynnewood	0.04	0.10	Lynnewood	2	0.30	0.60	-	0.21 [3]	Lynnewood pump 1 operated for 5.5 hours and pump 2 was off all day
	Stewart-Lenox/Lindley[4]	0.45	1.04	Riverside (backup only)	2	0.00	0.00			Assumes Riverside as backup only. Riverside pump 1 operated for .67 hours and pump 2 was off all day
	West Klamath Reduced (Stewart-Lenox PRV)	0.05	0.12	Balsam Well[4]	1	0.47	0.47			Balsam Well operated for 23.3 hours
				Debbie Well[4]	1	0.76	0.76			Debbie Well operated for 17.3 hours. For reliability, Debbie Well (largest well) should get backup power.
	Subtotal	0.50	1.16		--	1.22	2.22	-	0.07	
Zone 3	Patterson	0.35	0.81	Beverly	2	1.08	2.16			Beverly pumps 1 and 2 operated for 24 hours
	North Hills Area	0.11	0.25	Ogden[2]	2	0.93	0.93			Ogden pumps 1 and 2 were off all day
	Ogden Reduced (PRV-Ogden)	0.03	0.07							
	Moyina Reduced (PRV-13)	0.04	0.09							
	Havencrest	0.01	0.04							
	Upper Moyina	0.08	0.18							
	Upper Moyina Reduced (PRV-3)	0.02	0.05							
	Katie Lane Reduced	0.03	0.07							
	Basinview Z5	0.07	0.15							
	Subtotal	0.74	1.72		--	2.01	3.09	-	0.29	
	Hospital/Uhrmann[5]	0.44	1.02	High Level	2	0.32	0.95			No runtime information provided for High Level Pump Station. Runtime was inferred from High Level Tank; Pump 1 operated for 16 hours and pump 2 operated for 3 hours
	Eldorado Reduced (PRV-2)	0.07	0.16	Birch[2]	2	0.75	0.75			Birch pumps 1 and 2 were off all day
	Mollie's Area Reduced(PRV-2-HWY)	0.06	0.14	Wocus Well Capacity[5]		0.00	0.00			Wocus Well (1.08 mgd capacity) operated for 17.2 hours on maximum day. For reliability, analysis assumes Wocus Well may be out of service in determining booster pumping requirement.
	Old Fort Road Reduced (PRV-6)	0.03	0.06							
	Quail/Crown Ridge	0.02	0.09							
	ESI	0.01	0.03							
	Subtotal	0.63	1.50		--	1.07	1.70	0.42	-	
Zone 4	Upper Moyina	0.08	0.18	Moyina	2	0.36	1.08			Moyina pump 1 operated for 9.7 hours and pump 2 was off all day
	Upper Moyina Reduced (PRV-3)	0.02	0.05							
	Subtotal	0.10	0.23		--	0.36	1.08	-	0.13	
Zone 5	Basinview Z5	0.07	0.15	Basinview	2	1.08	2.16	-	0.93	Basinview pumps 1 and 2 were off all day
Zone 8	Tanglewood	0.14	0.32	Tanglewood	2	2.88	4.32	-	2.56	Tanglewood pumps 1 and 2 were off all day, pump 3 operated for 5.7 hours
Small Booster Only Zones Without Storage [6]										
Service Location	***Subzones Included***	***Average Day Demand (mgd)***	***Peak Hour Demand (mgd)***	***Existing Pump Stations***	***No. of Units***	***Firm Capacity for Peak Hour (mgd)***	***Total Capacity (mgd)***	***Deficit for Peak Hour (mgd)***	***Surplus for Peak Hour (mgd)[7]***	***Comments/August 15, 2008 Runtime***
Zone 2	West Oregon	0.01	0.05	West Oregon	3	0.07	1.22	-	0.02	No runtime information provided for West Oregon Pump Station, assumed operated all day
	Sierra Heights	0.01	0.05	Sierra Heights	3	0.07	1.79	-	0.02	Sierra Heights pump 1 operated for 24 hours, pump 2 for 5.3 hours, and pump 3 was off all day. This indicates the peak hour factor in this zone is higher than typical for larger zones.
Zone 4	ESI	0.01	0.03	ESI	3	0.09	2.61	-	0.06	ESI pump 1 operated for 24 hours, pump 2 for 0.3 hours, and no runtime information was provided for pump 3 (pump 3 is a fire pump and is normally off all day)
	Quail/Crown Ridge	0.02	0.09	Quail Ridge[2]	3	0.12	1.08			No runtime information provided for Quail Ridge Pump Station
				Crown Ridge	2	0.23	1.09			No runtime information provided for Crown Ridge Pump Station, assumed operated all day
	Subtotal	0.02	0.09		--	0.35	2.17	-	0.26	
	Havencrest	0.01	0.04	Havencrest	3	0.22	1.08	-	0.18	No runtime information provided for Havencrest Pump Station

(1) Pumping capacity for South 6th Subzone assumes that Hilyard Well and Homedale Well will operate at their current capacities of 0.79 mgd and 0.58 mgd, respectively. Pass through for firm capacity of Ogden Pump Station included in demand.
(2) For pressure zones that are served by multiple pump stations, only the largest pump of all the pump stations is considered as a standby pump.
(3) The existing capacity of Lynnewood Pump Station is adequate to meet the storage deficit at Buildout. However, the City plans to upgrade the pump station and provide backup power in order to meet storage needs in the zone by means of the emergency storage credit for backup power. The storage deficit could be met from the available surplus pumping capacity and backup power at Upper Lynnewood Pump Station. There is 0.21 mgd surplus pumping capacity at buildout; a total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(4) Existing pumping capacity for Lindley/Stewart-Lenox assumes that Balsam Well and Debbie Well will operate at their current capacities of 0.47 mgd and 0.76 mgd, respectively. Backup power is needed at Debbie Well for reliability.
(5) Pumping capacity for Uhrmann-Hospital area assumes that Wocus Well, which is currently the main supply to the zone, remains at its current 1.08 mgd capacity. The pumping capacity analysis assumes that Wocus Well may be out of service. Birch Pump Station will be upgraded to provide redundancy in the event of a Wocus Well outage, and to meet future growth.
(6) Small hydropneumatic booster zones without storage require normal pumping capacity for peak hour flows on the maximum day, plus a large pump for fire flows.
(7) Surplus shown for small booster only zones is for peak hour. The Sierra Heights station will require that the smallest pump be replaced with a larger one to provide firm capacity for peak hour demands, as the existing SCADA data indicates that both small pumps are running during the existing maximum demand day, indicating it has a higher peak hour factor than typical for other larger zones. The following zones need a fire pump: West Oregon, ESI, and Havencrest.

Table 6-9
Pump Station Capacity Evaluation for Intermediate Scenario

Service Location	Subzones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Existing Pump Stations/Wells	No. of Units	Firm Capacity (mgd)	Total Capacity (mgd)	Deficit (mgd)	Surplus (mgd)
Zones with Storage									
Zone 1	Zone 1 met from wells only	4.56	10.50		--	--	--	--	--
	Washburn	3.06	7.04	Washburn	3	6.34	9.05	0.70	-
	South 6th Street(1)	2.36	5.42	South 6th	2	1.44	2.88		
	Sierra Heights	0.02	0.07	Dayton	1	0.72	0.72		
				Hilyard Well(1)	1	0.79	0.79		
				Homedale Well(1)	1	0.58	0.58		
	Subtotal	2.38	5.49		--	3.53	4.97	1.96	-
Zone 2	Prescott	0.31	0.71	Lytton	2	1.01	2.02		
				Center(2)	2	0.58	0.58		
	Subtotal	0.31	0.71		--	1.58	2.59	-	0.87
	Upper Lynnewood	0.04	0.10	Lynnewood(3)	2	0.30	0.60	-	0.21(3)
	Stewart-Lenox/Lindley(4)	1.18	2.72	Riverside (backup only)	2	0.00	0.00		
	West Klamath Reduced (Stewart-Lenox PRV)	0.10	0.23	Balsam Well(4)	1	0.47	0.47		
				Debbie Well(4) (assumed out of service for reliability)	1	0.00	0.00		
				Future Well(4)	1	1.50	1.50		
	Subtotal	1.29	2.96		--	1.97	1.97	0.99	--- -
Zone 3	Patterson	0.46	1.06	Beverly	2	1.08	2.16		
	North Hills Area	0.12	0.28	Ogden(2)	2	0.93	0.93		
	Ogden Reduced (PRV-Ogden)	0.04	0.10						
	Moyina Reduced (PRV-13)	0.04	0.09						
	Havencrest	0.01	0.04						
	Upper Moyina	0.08	0.19						
	Upper Moyina Reduced (PRV-3)	0.04	0.10						
	Katie Lane	0.03	0.08						
	Basinview Z5	0.17	0.40						
	Basinview Z6	0.03	0.08						
	Subtotal	1.05	2.42		--	2.01	3.09	0.41	-
	Hospital/Uhrmann(5)	0.77	1.78	High Level	2	0.32	0.95		
	Eldorado Reduced (PRV-2)	0.07	0.16	Birch(2)	2	0.75	0.75		
	Mollie's Area Reduced (PRV-2-HWY)	0.09	0.21	Wocus Well Capacity(5)		0.00	0.00		
	Old Fort Road Reduced (PRV-6)	0.03	0.06						
	Quail/Crown Ridge	0.03	0.12						
	ESI	0.07	0.26						
	Subtotal	1.07	2.59		--	1.07	1.70	1.52	-
Zone 4	Upper Moyina	0.08	0.19	Moyina	2	0.36	1.08		
	Upper Moyina Reduced (PRV-3)	0.04	0.10						
	Subtotal	0.13	0.29		--	0.36	1.08	-	0.07
Zone 5	Basinview Z5	0.17	0.40	Basinview	2	1.08	2.16		
	Basinview Z6	0.03	0.08						
	Subtotal	0.21	0.48		--	1.08	2.16	-	0.60
Zone 6	Basinview Z6	0.03	0.08		--	0.00	0.00	0.08	-
Zone 8	Tanglewood	0.14	0.32	Tanglewood	2	2.88	4.32	-	2.56

Table 6-9
Pump Station Capacity Evaluation for Intermediate Scenario

Small Booster Only Zones Without Storage [6]

Service Location	Subzones Included	Average Day Demand (mgd)	Peak Hour Demand (mgd)	Existing Pump Stations	No. of Units	Firm Capacity for Peak Hour (mgd)	Total Capacity (mgd)	Deficit for Peak Hour (mgd)	Surplus for Peak Hour (mgd)[7]
Zone 2	West Oregon	0.03	0.11	West Oregon	3	0.07	1.22	0.04	-
	Sierra Heights	0.02	0.07	Sierra Heights	3	0.07	1.79	-	-
Zone 4	ESI	0.07	0.26	ESI	3	0.09	2.61	0.17	-
	Quail/Crown Ridge	0.03	0.12	Quail Ridge[2]	3	0.12	1.08		
				Crown Ridge	2	0.23	1.09		
	Subtotal	0.03	0.12		--	0.35	2.17	-	0.23
	Havencrest	0.01	0.04	Havencrest	3	0.22	1.08	-	0.18

(1) Pumping capacity for South 6th Subzone assumes that Hilyard Well and Homedale Well will operate at their current capacities of 0.79 mgd and 0.58 mgd, respectively. Pass through for firm capacity of Ogden Pump Station included in demand.
(2) For pressure zones that are served by multiple pump stations, only the largest pump of all the pump stations is considered as a standby pump.
(3) The existing capacity of Lynnewood Pump Station is adequate to meet the storage deficit at Buildout. However, the City plans to upgrade the pump station and provide backup power in order to meet storage needs in the zone by means of the emergency storage credit for backup power. There is 0.21 mgd surplus pumping capacity at buildout; a total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(4) Pumping capacity for Lindley/Stewart-Lenox assumes that Balsam Well remains at its current capacity of 0.47 mgd; that Debbie Well is upgraded to 2.16 mgd capacity; and that a new 1.5 mgd well is installed to meet intermediate needs.. The expanded Debbie Well and the new well should have backup power for reliability.
(5) Pumping capacity for Uhrmann-Hospital area assumes that Wocus Well, which is currently the main supply to the zone, remains at its current 1.08 mgd capacity. The pumping capacity analysis assumes that Wocus Well may be out of service. Birch Pump Station will be upgraded to provide redundancy in the event of a Wocus Well outage, and to meet future growth.
(6) Small hydropneumatic booster zones without storage require normal pumping capacity for peak hour flows on the maximum day, plus a large pump for fire flows.
(7) Surplus shown for small booster only zones is for peak hour. The Sierra Heights station will require that the smallest pump be replaced with a larger one to provide firm capacity for peak hour demands, as the existing SCADA data indicates that both small pumps are running during the existing maximum demand day, indicating it has a higher peak hour factor than typical for other larger zones. The following zones need a fire pump: West Oregon, ESI, and Havencrest.

Table 6-10
Pump Station Capacity Evaluation for Buildout Scenario

Service Location	Subzones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Existing Pump Stations/Wells	No. of Units	Firm Capacity (mgd)	Total Capacity (mgd)	Deficit (mgd)	Surplus (mgd)
Zones with Storage									
Zone 1	Zone 1 met from wells only	4.66	10.72		--	--	--	--	--
	Washburn	3.11	7.16	Washburn	3	6.34	9.50	0.83	-
	South 6th Street(1)	2.45	5.63	South 6th	2	1.44	2.88		
	Sierra Heights	0.02	0.07	Dayton	1	0.72	0.72		
				Hilyard Well(1)	1	0.79	0.79		
				Homedale Well(1)	1	0.58	0.58		
	Subtotal	2.46	5.69		--	3.53	4.97	2.17	-
Zone 2	Prescott	0.31	0.71	Lytton	2	1.01	2.02		
				Center(2)	2	0.58	0.58		
	Subtotal	0.31	0.71		--	1.58	2.59	-	0.87
	Upper Lynnewood	0.04	0.10	Lynnewood(3)	2	0.30	0.60	-	0.21(3)
	Stewart-Lenox/Lindley(4)	1.45	3.33	Riverside (backup only)	2	0.00	0.00		
	West Klamath Reduced (Stewart-Lenox PRV)	0.10	0.23	Balsam Well(4)	1	0.47	0.47		
				Debbie Well(4) (assumed out of service for reliability)	1	0.00	0.00		
				Future Well(4)	1	1.50	1.50		
	Subtotal	1.55	3.56		--	1.97	1.97	-1.59	-
Zone 3	Patterson	0.58	1.33	Beverly	2	1.08	2.16		
	North Hills Area	0.14	0.33	Ogden(2)	2	0.93	0.93		
	Ogden Reduced (PRV-Ogden)	0.04	0.10	Tanglewood (Laguna) (5)	--				
	Moyina Reduced (PRV-13)	0.04	0.09						
	Havencrest	0.01	0.04						
	Upper Moyina	0.10	0.24						
	Upper Moyina Reduced (PRV-3)	0.04	0.10						
	Katie Lane	0.03	0.08						
	Basinview Z3	1.16	2.66						
	Basinview Z5	0.26	0.60						
	Basinview Z6	0.28	0.64						
	Tanglewood	0.62	1.42						
	Basinview Z10	0.31	0.71						
	Basinview Z12	0.12	0.28						
	Basinview Z10 PRV	0.03	0.08						
	Subtotal	3.78	8.71		--	2.01	3.09	6.70	-
	Hospital/Uhrmann(6)	1.20	2.76	High Level	2	0.32	0.95		
	Eldorado Reduced (PRV-2)	0.07	0.16	Birch(2)	2	0.75	0.75		
	Mollie's Area Reduced (PRV-2-HWY)	0.09	0.21	Wocus Well Capacity(6)		0.00	0.00		
	Old Fort Road Reduced (PRV-6)	0.03	0.07						
	Quail/Crown Ridge	0.05	0.18						
	ESI	0.07	0.26						
	Subtotal	1.51	3.64		--	1.07	1.70	2.57	-
Zone 4	Upper Moyina	0.10	0.24	Moyina	2	0.36	1.08		
	Upper Moyina Reduced (PRV-3)	0.04	0.10						
	Subtotal	0.15	0.34		--	0.36	1.08	-	0.02
Zone 5	Basinview Z5	0.26	0.60	Basinview	2	1.08	2.16		
	Basinview Z6	0.28	0.64						
	Subtotal	0.54	1.25		--	1.08	2.16	0.17	-
Zone 6	Basinview Z6	0.28	0.64		--	0.00	0.00	0.64	-
Zone 8	Tanglewood	0.62	1.42	New Tanglewood(5)	--				
	Basinview Z10	0.31	0.71						
	Basinview Z12	0.12	0.28						
	Basinview Z10 PRV	0.03	0.08						
	Subtotal	1.08	2.49		--	0.00	0.00	2.49	-

Table 6-10
Pump Station Capacity Evaluation for Buildout Scenario

Service Location	Subzones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Existing Pump Stations/Wells	No. of Units	Firm Capacity (mgd)	Total Capacity (mgd)	Deficit (mgd)	Surplus (mgd)
Zone 10	Basinview Z10	0.31	0.71						
	Basinview Z12	0.12	0.28						
	Basinview Z10 PRV	0.03	0.08						
	Subtotal	0.46	1.07		--	0.00	0.00	1.07	-
Zone 12	Basinview Z12	0.12	0.28						
	Basinview Z10 PRV	0.03	0.08						
	Subtotal	0.16	0.36		--	0.00	0.00	0.36	-
Small Booster Only Zones Without Storage [7]									
Service Location	**Subzones Included**	**Average Day Demand (mgd)**	**Peak Hour Demand (mgd)**	**Existing Pump Stations**	**No. of Units**	**Firm Capacity for Peak Hour (mgd)**	**Total Capacity (mgd)**	**Deficit for Peak Hour (mgd)**	**Surplus for Peak Hour (mgd)[8]**
Zone 2	West Oregon	0.03	0.11	West Oregon	3	0.07	1.22	0.04	-
	Sierra Heights	0.02	0.07	Sierra Heights	3	0.07	1.79	-	-
Zone 4	ESI	0.07	0.26	ESI	3	0.09	2.61	0.17	-
	Quail/Crown Ridge	0.05	0.18	Quail Ridge[2]	3	0.12	1.08		
				Crown Ridge	2	0.23	1.09		
	Subtotal	0.05	0.18		--	0.35	2.17	-	0.17
	Havencrest	0.01	0.04	Havencrest	3	0.22	1.08	-	0.18

(1) Pumping capacity for South 6th Subzone assumes that Hilyard Well and Homedale Well will operate at their current capacities of 0.79 mgd and 0.58 mgd, respectively. Pass through for firm capacity of Ogden Pump Station included in demand.
(2) For pressure zones that are served by multiple pump stations, only the largest pump of all the pump stations is considered as a standby pump.
(3) The existing capacity of Lynnewood Pump Station is adequate to meet the storage deficit at Buildout. However, the City plans to upgrade the pump station and provide backup power in order to meet storage needs in the zone by means of the emergency storage credit for backup power. There is 0.21 mgd surplus pumping capacity at buildout; a total of 0.13 mgd pumping capacity with backup power is required to fully meet the storage deficit, which would include the emergency storage credit plus a small increment for operational storage.
(4) Pumping capacity for Lindley/Stewart-Lenox assumes that Balsam Well remains at its current capacity of 0.47 mgd; that Debbie Well is upgraded to 2.16 mgd capacity; and that a new 1.5 mgd well is installed to meet intermediate needs. The expanded Debbie Well and the new well should have backup power for reliability.
(5) The pumping capacity evaluation is based on Option 1A with future service to the Basinview and Tanglewood areas primarily through Beverly Pump Station. With Option 1A, the existing Tanglewood (Laguna) Pump Station would not be needed. A new Tanglewood Zone 8 Pump Station will be built at the future Zone 3 tank site. If the alternate Option 1B pipeline alignment should be implemented, the existing Tanglewood (Laguna) Pump station would need to be refitted with new pumps to pump to the future Zone 3 Reservoir; and suction pipeline improvements would be needed in Old Fort Road between Main Street and the existing station (800 LF of 24-inch pipe).
(6) Pumping capacity for Uhrmann-Hospital area assumes that Wocus Well, which is currently the main supply to the zone, remains at its current 1.08 mgd capacity. The pumping capacity analysis assumes that Wocus Well may be out of service. Birch Pump Station will be upgraded to provide redundancy in the event of a Wocus Well outage, and to meet future growth.
(7) Small hydropneumatic booster zones without storage require normal pumping capacity for peak hour flows on the maximum day, plus a large pump for fire flows.
(8) Surplus shown for small booster only zones is for peak hour. The Sierra Heights station will require that the smallest pump be replaced with a larger one to provide firm capacity for peak hour demands, as the existing SCADA data indicates that both small pumps are running during the existing maximum demand day, indicating it has a higher peak hour factor than typical for other larger zones. The following zones need a fire pump: West Oregon, ESI, and Havencrest.

Table 6-11 summarizes the additional firm capacity requirements at pump stations for existing and future conditions. In addition, some pump stations will require backup power for the emergency storage credit discussed in Section 6.4 (summarized in Table 6-7); although do not need additional pumping capacity.

Table 6-11
Summary Required Additional Firm Pumping Capacity

Zone	Facilities Needed	Incremental Additional Firm Capacity Required (mgd) (1)			
		Existing	Intermediate	Buildout	Total Additional Firm Capacity by Buildout (mgd)
Existing Pump Station Expansion Locations					
Zone 1	Washburn	-	0.7	0.1	0.8
	South 6th Street	-	2.0	0.2	2.2
Zone 2	Stewart Lenox/Lindley: Riverside PS for Backup	-	1.0	0.6	1.6
Zone 3	Beverly/Ogden	-	0.4	6.3	6.7
	High Level/Birch	0.4	1.1	1.0	2.6
Zone 5	Basinview-Z5	-	-	0.2	0.2
Zone 8	Tanglewood (New)	-	-	2.5	2.5
Future Service Zones - Future Pump Stations					
Zone 6	Basinview-Z6	-	0.1	0.5	0.6
Zone 10	Basinview-Z10	-	-	1.1	1.1
Zone 12	Basinview-Z12	-	-	0.4	0.4
Small Booster Only Zones Without Storage - Upgrades (2)					
Zone 2	West Oregon Station Replacement	2.3	-	-	2.3
	Sierra Heights - Replace Pump	0.3	-	-	0.3
Zone 4	ESI Station Replacement	2.4	-	-	2.4
	Havencrest Station Replacement	2.2	-	-	2.2

(1) Incremental capacity is the increment of additional pumping capacity needed for each timeframe. It is not the cumulative required amount, that is, the cumulative total at buildout is the sum of the increments shown for existing, intermediate, and buildout.

(2) For the small booster only zones, the station replacements include firm capacity for peak hour demands plus a 1500 gpm fire pump. These are small package stations that will require complete replacement. The Sierra Heights station requires replacement of the smallest pump with a larger one to provide firm capacity for peak hour demands.

Key findings from the pump station evaluation include:

- Existing –
  - Birch Pump Station will require replacement to provide additional capacity for reliability in the event of a Wocus Well outage. In addition, backup power is required at the station for the emergency storage credit, in lieu of additional tank storage.

- Upper Lynnewood Pump Station will need upgrades and backup power to meet the storage deficit in lieu of providing additional tank storage. The existing pumping capacity is adequate for buildout needs.

- Moyina Booster Station will require backup power to meet the storage deficit in lieu of additional tank storage.

- The existing Tanglewood (Laguna) Station will require backup power to meet the existing and intermediate storage deficit in lieu of additional tank storage.

- For the small booster only zones without storage, station replacements are required at the West Oregon, ESI and Havencrest stations to provide firm capacity for peak hour demands plus a 1500 gpm fire pump and backup power. These are small package stations that will require complete replacement. The Sierra Heights station requires replacement of the smallest pump with a larger pump to provide firm capacity for peak hour demands. Quail Ridge/Crown Ridge stations require backup power for reliability.

- Intermediate –

  - Washburn Station will require 0.7 mgd additional capacity for the intermediate timeframe, and an incremental additional 0.13 mgd at buildout. The total additional capacity needed for buildout is 0.83 mgd. The existing station has been planned to accommodate adding one more pump similar to the existing pumps to meet future needs.

  - The South 6th Street Station will require 2.0 mgd additional capacity for the intermediate timeframe, and an incremental additional 0.2 mgd at buildout. At buildout, South 6th Street Station will require a total of 2.2 mgd additional capacity. It is anticipated that the existing station would be replaced with a new station at the required size, as it is an older and outdated station.

  - Ogden Pump Station will require additional capacity of 0.4 mgd to meet intermediate needs, in conjunction with installation of standby power at its firm capacity to provide an emergency storage credit in lieu of tank storage.

  - Riverside Pump Station will require additional capacity of 1.0 mgd for reliability backup to the Stewart-Lenox subzone in Zone 2.

  - Lytton Pump Station will require backup power to provide the emergency storage credit in lieu of tank storage.

  - Birch Pump Station in Zone 3 will require additional capacity of 1.1 mgd (with backup power) to meet buildout needs.

- Future Zone 6 in Basinview is anticipated to begin to develop in the Intermediate timeframe, which will require a new pump station (0.1 mgd capacity at intermediate), with provision for adding another pump to meet buildout demands.

- Buildout –

  - Riverside Pump Station will require additional capacity of 0.6 mgd for reliability backup to the Stewart-Lenox subzone in Zone 2. This will require replacement of the station.

  - Birch Pump Station in Zone 3 will require additional capacity of 1.0 mgd (with backup power) to meet buildout needs.

  - Beverly Pump Station in Zone 3 will require additional capacity of 6.3 mgd to serve future growth in the Basinview area and pass through to the Tanglewood area (per the Option 1A pipeline alignment). Standby power will be needed at the new station to provide the emergency storage credit in lieu of tank storage.

  - Additional capacity will be required at Basinview Zone 5 (0.2 mgd additional), with backup power for the emergency storage credit. This will require replacement of the existing station.

  - For Zone 8 Tanglewood, the improvements are based on the Option 1A pipeline alignment with future capacity put at the Beverly Pump Station to pump to a future Zone 3 tank on the west side of Basinview. A new Zone 8 pump station will be needed at the future Zone 3 tank site, with 2.5 mgd firm capacity, that will pump from the tank into the zone. Backup power would be installed with the pump station improvements to provide the emergency storage credit. [Note: If Option 1A is implemented, the existing Tanglewood (Laguna) Pump Station would not be needed. An alternate Option 1B pipeline alignment was identified in Old Fort Road. If Option 1B were to be implemented, then the existing Laguna PS would be refitted with new pumps to pump to the future Zone 3 tank; and suction pipeline improvements would be needed between Main Street and the existing station. The recommended improvements in Section 7 are based on the Option 1A alignment.]

  - Future pump stations will be required to serve the future Basinview zones 10 and 12. Backup power will be needed at the new pump stations for the emergency storage credit in lieu of tank storage.

In future zones, conceptual locations were identified for future pump stations based on the overall system configuration and hydraulic considerations. Actual locations for future pump stations for new development will be determined as part of the

development planning process in conjunction with City staff review of proposed developer plans.

The small booster only zones without storage were adequate when built, although some do not meet the City's current criteria. Most of these facilities are buried package stations and not expandable (except for Sierra Heights). When improvements are implemented, feasibility studies and more detailed analyses will be needed to determine the appropriate locations and configurations for the new stations based on site constraints and zone-specific conditions. These small booster only zones have varying fire flow pumping capability, depending on the Fire Department requirements in effect when the facilities were constructed. The recommended replacement improvements include fire pumps, as well as standby power at the stations. Most of the existing stations include a bypass that allows water to be provided from the lower zone if the pump is not operating, although it will be at lower pressure.

6.6 Pressure Reducing Station Evaluation

For the pressure reducing station evaluation, existing capacity available in each zone was compared with required capacity based on the established performance objectives.

PRV stations typically consist of one or more small 2- to 4-inch valves for normal operation sized at or close to peak hour demand, and a large valve to meet fire flow. The total valve capacity must equal a minimum of the peak hour demand plus fire flow. The small valve will operate continuously under normal operations. The large fire flow valve will operate infrequently as a backup to the small valve under peak conditions and during fire flows.

The PRV-supplied zones are primarily residential with a fire flow requirement of 1,500 gpm; except Mollie's Area Reduced which has some non-residential uses requiring 2,500 gpm. For 1,500 gpm fire flow, a minimum of 6-inch valve (e.g., *Cla-Val Co., 100-01 valve body)* is needed, since it can provide a maximum continuous flowrate of 1,800 gpm that meets the fire flow criteria of 1,500 gpm provided adequate head is available. An 8-inch valve is needed for 2,500 gpm fire flow, since it can provide a maximum continuous flow rate of 3,100 gpm. A 4-inch valve can only provide 800 gpm.

Table 6-12 compares existing valve station capacity with peak hour demands in existing PRV-supplied zones. The table identifies additional valves that are required, and the timing for these improvements. As indicated on Table 6-12, several zones require PRV improvements under existing conditions. Only the West Klamath subzone will require additional capacity for future conditions.

Table 6-12
Evaluation of Pressure Reducing Station Capacity

PRV Zone	Location of PRV Station Serving Zone	Existing Peak Hour Demand (gpm)	Intermediate Peak Hour Demand (gpm)	Buildout Peak Hour Demand (gpm)	Existing No. of Valves	Size of Existing Valves (in)	Maximum Valve Capacity (gpm) [1]	Required Improvements
West Klamath Reduced (Zone 1)	Highway 66/ Weyerhauser Rd.	168	324	325	1	6	1800	Intermediate: one 2-inch valve for normal operation (this will also meet buildout needs) or replace the 2-inch with a 3-inch valve.
					1	2	210	
Mollie's Area Reduced/ Dan O'Brien Way (Zone 2)	Highway 97/ Dan O'Brien Rd.	178	266	266	1	8	3100	No improvements required
					1	4	800	
Eldorado Reduced (Zone 2)	Sloan/ Eldorado	202	202	202	1	6	1800	No improvements required.
	Pacific Terrace/ Van Ness				1	4	800	
	Pacific Terrace/ Lowell				1	2	210	
Old Fort Road Reduced/ South Hillside Area (Zone 2)	Dixon/ Damont	77	77	87	1	4	800	No improvements required.
	Hillside/ Auburn				1	4	800	
North Hills Reduced (Zone 2)	Homedale/ Foothills Blvd.	511	580	679	1	4	800	No improvements required.
	Springcrest/ Madison				1	6	1800	
Moyina Reduced (Zone 2)	Carlson/ Valhala	194	194	194	1	4	800	Existing: one 4-inch valve needed for fire flows to the combined area. The two 4-inch valves would be the fire flow valves.
Ogden Reduced (Zone 2)	Ogden Booster Station	155	193	193	1	6	1800	No improvements required.
					1	1.25	90	
Upper Moyina Reduced (Zone 3)	Climax/ Kimberly Dr.	102	211	211	1	4	800	Existing: one 4-inch valve. Two 4-inch valves would be fire flow valves or replace the 4-inch with a 6-inch valve.
	Climax/ Kimberly Ct.				1	2	210	
Katie Lane (Zone 2)	Katie Lane/Patterson Street	144	159	159	1	6	1800	No improvements required.
					1	2	210	
Basinview (Zone 10)	--	--	--	164	1	6	1800	Future Zone
					1	2	210	

[1] Valve capacity is based on "Cla-Val" globe style pressure reducing valve operating at its maximum continuous flow rate.

There is one future PRV Zone 10 in the future Basinview development area that would be installed by the developer. There may also be special cases in the future where the City may consider PRVs for service to isolated small areas or a few homes. These special cases would be evaluated individually by the City.

6.7 Distribution System Evaluation

6.7.1 Hydraulic Analysis

A hydraulic analysis was performed to assess performance of the distribution system under existing, intermediate, and buildout demands. The analysis used static (snapshot in time) runs to identify system deficiencies and evaluate improvements for peak hour demand on the maximum day – to evaluate the system performance for normal operation on a maximum demand day. Extended period simulation (EPS) runs were also done to confirm the findings and verify that the reservoirs would be re-filled on the maximum demand day. Appendix D shows the EPS results for the system reservoirs.

Key criteria established for distribution system analysis are summarized below:

- Minimum of 40 psi under peak hour conditions.
- Minimum 20 psi residual pressure with fire flows. Fire flows of 1,500 gpm for residential and 2,500 gpm for non-residential areas.
- Maximum pressure of 105 psi.
- Maximum head loss criterion of 10 feet/1000 feet and maximum velocity criterion of 5 feet/second under peak non-fire conditions.
- The hydraulic model was used to identify improvements needed to both correct existing deficiencies and to provide capacity for future growth, as follows:
- Existing pipelines were identified for improvement only if pressures did not meet the minimum criterion. The headloss and velocity analysis helped to identify hydraulic bottlenecks that could be improved to help meet pressure requirements.
- Future facilities were sized to serve new development areas. Future pipelines are sized to meet all performance criteria for minimum pressures, maximum headloss, and maximum velocity.

6.7.1.1 Peak Hour Scenario

Model runs were performed for peak hour demand conditions on the maximum day with: 1) reservoirs set at 75 percent full (or 75 percent of usable storage as in the case of Prescott Reservoir), which is at bottom of a normal operating range that leaves emergency and fire reserves; and 2) with pumps operating at a capacity equal to maximum day demands. This reservoir setting is a conservative representation of the system that assumes reservoirs are not completely full, i.e., at less than maximum hydraulic head to the system.

The peak hour analysis evaluated both system pressures and headlosses. Figure 6-3, 6-4, and 6-5 show the model results for peak hour demand conditions for Existing, Intermediate, and Buildout scenarios respectively. These figures are color coded by junction to show the range of pressure during peak hour conditions, and are color coded by pipe to show the range of the system head loss.

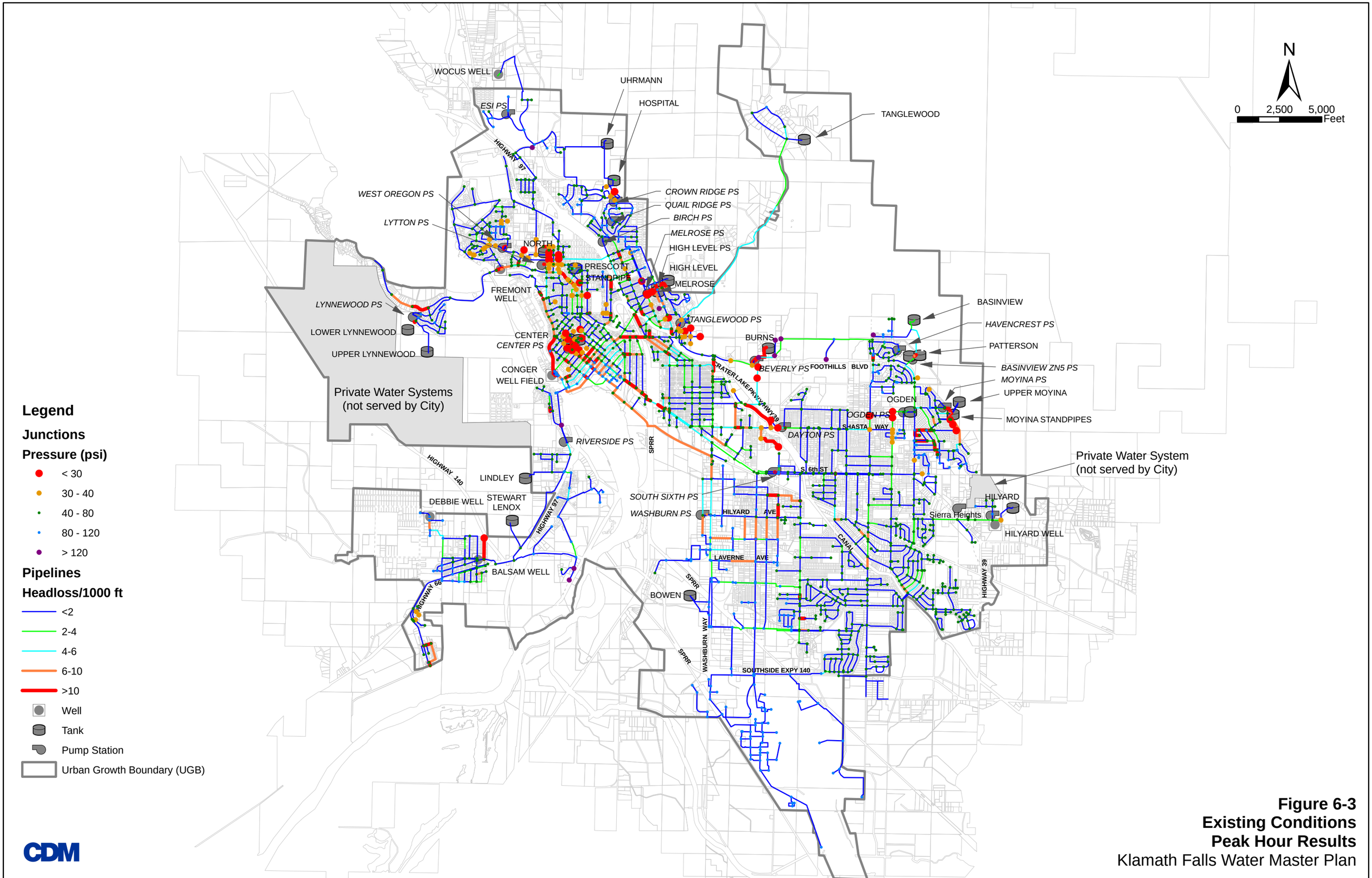


Figure 6-3
Existing Conditions
Peak Hour Results
Klamath Falls Water Master Plan

CDM

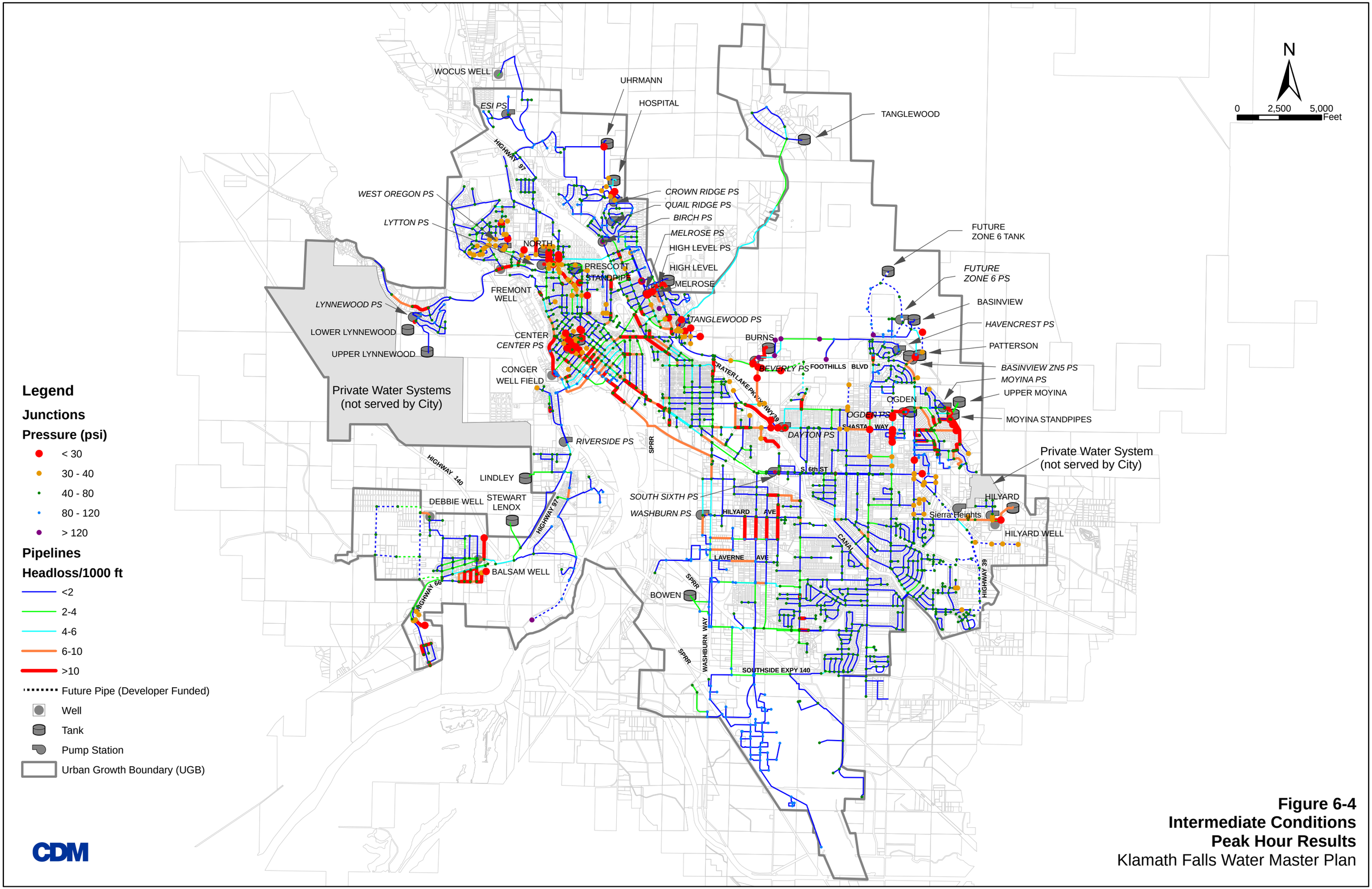


Figure 6-4
Intermediate Conditions
Peak Hour Results
Klamath Falls Water Master Plan

CDM

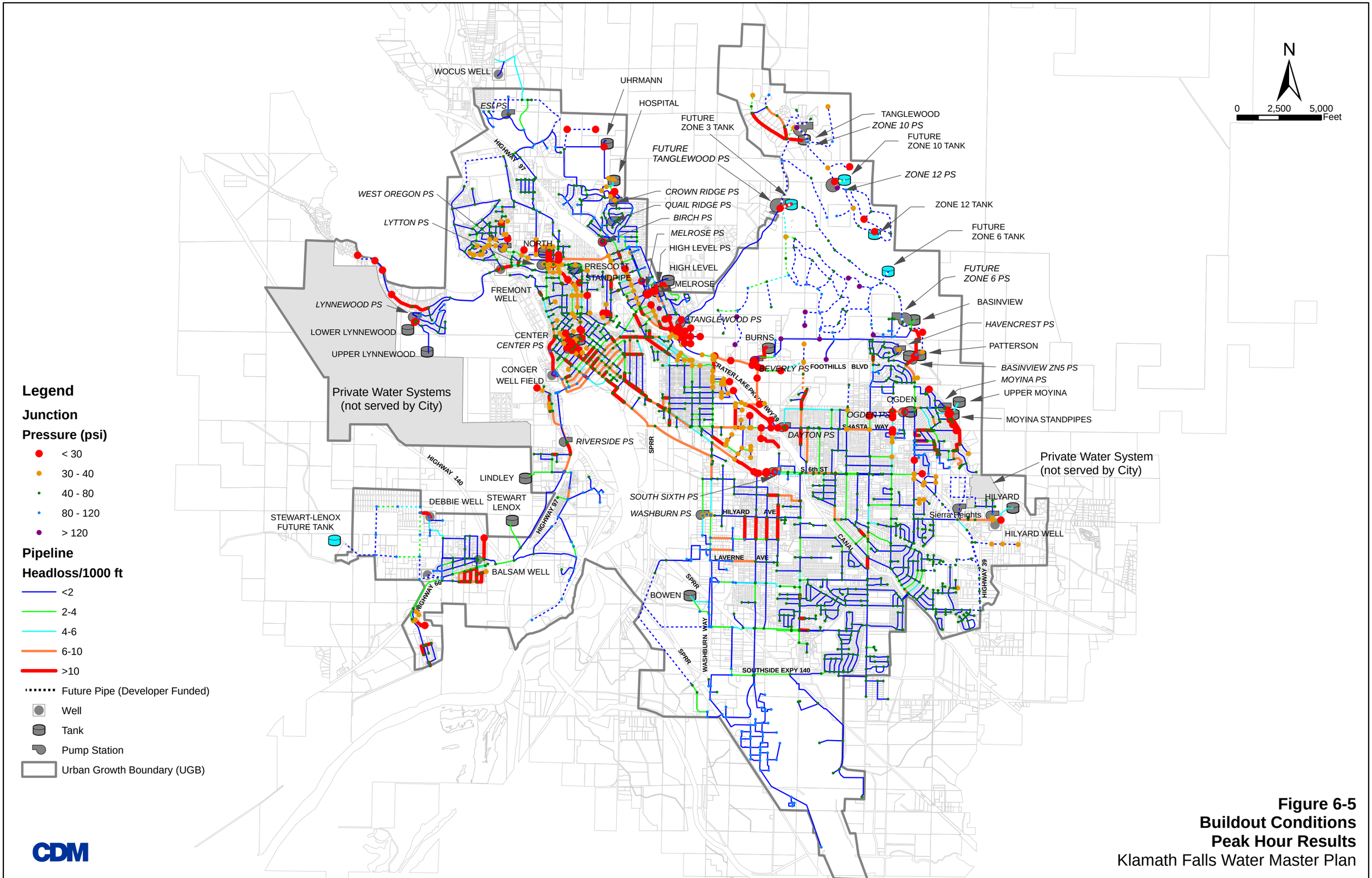


Figure 6-5
Buildout Conditions
Peak Hour Results
Klamath Falls Water Master Plan

Overall, system pressures were above the required 40 psi minimum except for locations noted where pressures did not meet the minimum criterion. In many of these locations, affected nodes are at the highest ground elevations in the zone and therefore have low static pressures. Some nodes are actually above the top of zone, i.e., above the ground elevation that would provide the required minimum pressure under static conditions with no headlosses in the pipes. These locations generally experience marginal pressures of between 30 to 40 psi under peak hour conditions. At these locations, pipe improvements would not improve pressures, and re-zoning to a higher subzone should be considered if feasible.

Key findings from the peak hour scenario are summarized below:

Zone 1

- Near Ogden Reservoir in the general area of Madison Street at Shasta Way. Nodes with elevations at the top of the zone are deficient (20 psi) under existing conditions and more deficient under intermediate timeframe (16 psi). Most elevations in this area are above the top of the zone. This area should be re-zoned to the North Hills pressure regulated zone (Foothill/Homedale).
- Near Beverly Pump Station on Beverly Drive. Nodes with elevations at the top of the zone are deficient (6-25 psi) under existing conditions and are somewhat worse under intermediate timeframe (4-24 psi). Most elevations in this area are above the normal top of the zone service elevation. There are no opportunities for re-zoning at this location, but the City or developers could consider a small booster zone for this area as a localized improvement.
- In the vicinity of Center Reservoirs. Nodes with elevations at the top of the zone are deficient (11-25 psi) under both existing and intermediate conditions. This area should be re-zoned to the Zone 2 Prescott subzone.
- In the vicinity of North Reservoir. Nodes with elevations at the top of the zone are deficient (13 psi) under existing conditions and more deficient under intermediate timeframe (12 psi). Most elevations in this area are above the top of the zone. This area should be re-zoned to Zone 2 Prescott subzone.

Zone 2

- Stewart Lenox on Butte Street. This area is served by a 2-inch line, which is constricting flow and causing low pressures. Pipeline improvements are needed to improve pressure as well as fire flow. Replace the 2-inch line with an 8-inch line plus looping to adjacent main with an 8-inch line to the north end of Cortez Street.
- Near the PRV station at Highway 66 and Weyerhauser Road. Nodes with elevations at the top of the zone are deficient (33 psi) under existing conditions and are somewhat worse under intermediate timeframe (27 psi). The current PRV setting is 42 psi. The hydraulic analysis indicates that the PRV setting should be raised to 52 psi to improve the pressure, without over-pressurizing lower parts of the zone.

Zone 3

- Near High Level, Hospital, and Uhrmann reservoirs. Nodes with elevations at the top of the zone are deficient (23 psi) under existing conditions and are somewhat worse under intermediate timeframe (21 psi). Most nodes in this area are above the top service elevation of the zone.

6.7.1.2 Fire Flow

The existing system has significant weaknesses due to lack of transmission capacity. Of modeled existing pipelines (about 230 miles total), about 17 percent are 4-inch or smaller diameter, and about 70 percent are 8-inch or smaller diameter. There are also significant gaps in the existing transmission lines and incomplete transmission loops.

In the 2004 Master Plan, improvements were identified to strengthen the transmission grid to improve overall fire flow transmission. These transmission grid improvements are still recommended.

For this master plan update, the InfoWater fire flow utility was used to develop a report showing the available flow while maintaining 20 psi residual pressure at all system nodes within the zone. Appendix E contains the fire flow report, including a color-coded map showing the range of the available fire flow. The InfoWater fire flow utility analysis results are based on the hydraulic model and are suitable for planning purposes only. The model results are not intended to substitute for actual hydrant flow tests under representative conditions.

This master plan study addresses the major transmission system facilities only, and does not include analysis of smaller pipelines serving local areas. Therefore, it does not identify all localized improvements that would be needed to provide required fire flows throughout the existing system. Subsequent to this master plan, it is recommended that the City conduct detailed analyses of local areas to refine the master plan work and identify such localized improvements. The detailed analyses are performed on a case-by-case basis during development reviews and as main replacements are planned. In general, locations served by 2-inch and 4-inch pipes will not meet the current fire flow criteria.

6.7.2 Key Findings from Hydraulic Analysis

The master plan evaluation focused on major transmission improvements to improve system performance, and did not include analysis of smaller pipelines. Major pipeline improvements have been identified for the following reasons:

- To correct hydraulic bottlenecks that cause low pressures under normal peak hour conditions.
- To increase the transmission capability of the system to meet fire flows and peak demands by completing transmission loops and filling gaps.
- To combine small subzones and improve reliability.

- To provide additional transmission capacity for future growth.
- To extend waterlines to future development areas (to be built by developers when development occurs).

Figure 6-6 shows the location of recommended improvements to existing pipelines to correct identified deficiencies. Figure 6-6 also shows the conceptual locations for future waterline extensions to serve new development areas.

All pipe improvements are sized to meet buildout demand conditions. Improvements required to meet existing deficiencies were sized for buildout and therefore can accommodate future growth. Pipe improvements conform to standard diameters: 8, 12, 16, 20, 24, 30, and 36 inches. No pipe improvements were sized less than 8-inch diameter.

Existing pipelines were identified for improvement only if pressures did not meet minimum criterion. The headloss and velocity analysis helped to identify hydraulic bottlenecks that could be improved to help meet the pressure requirements. Future pipelines are sized to meet all the performance criteria for minimum pressures, maximum headloss, and maximum velocity.

Key recommendations for pipeline improvements include:

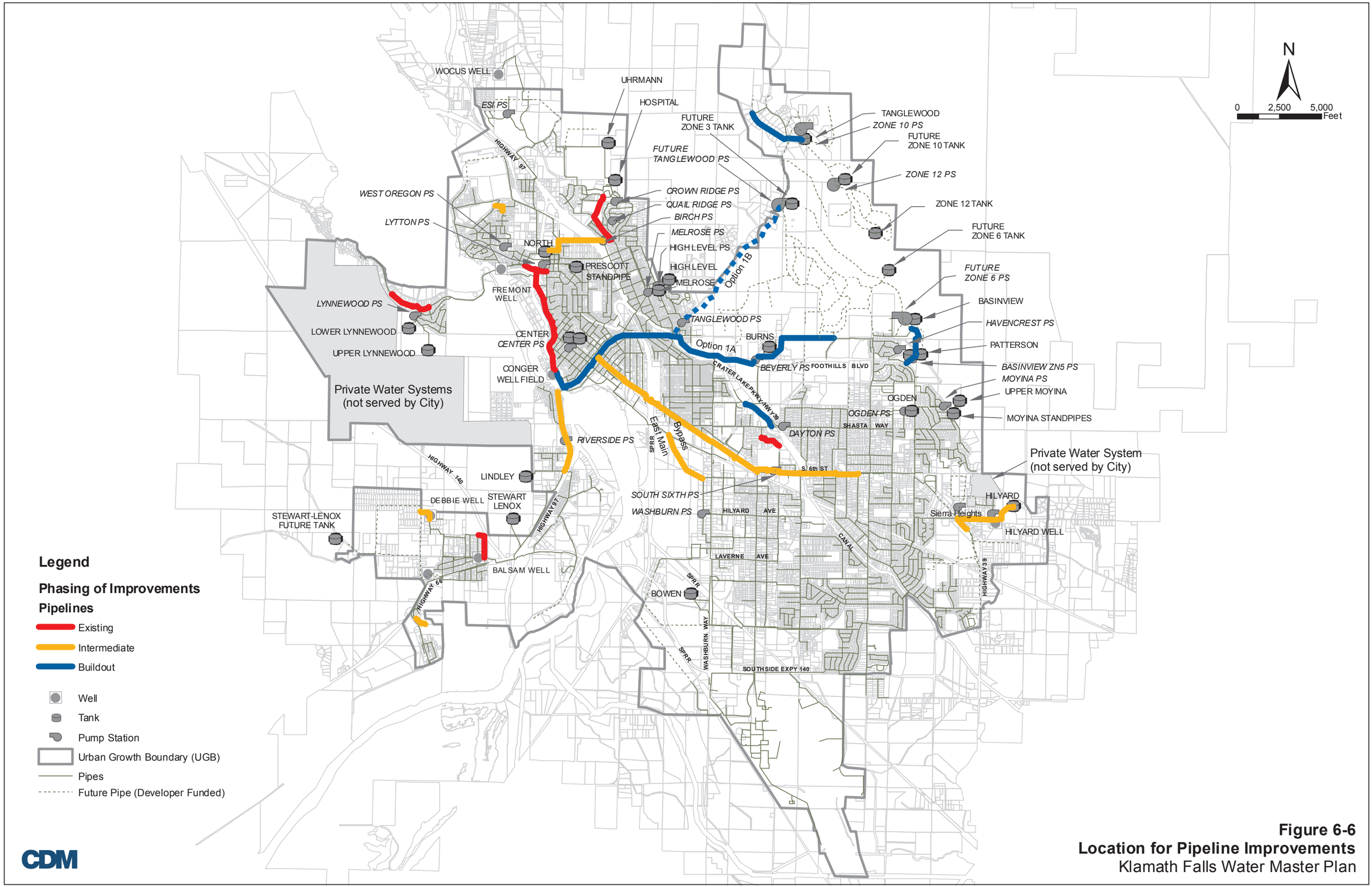
- **<u>Existing</u>**

Zone 1:

- Pipe improvements are needed in the North subzone in California Avenue and Nevada Avenue to improve system pressure, strengthen the transmission grid, and improve fire flow capabilities in those areas. The analysis indicated that pipe improvements are needed from Conger Well Field to force water north to fill North Reservoir and Lynnewood Reservoir, and to convey water to the Wocus area in the future.

- Pipe improvements are needed in the west side of the North subzone in Lakeshore Drive to eliminate a 4-inch "bottleneck" to improve system pressure and fire flow capabilities.

- The 2-inch pipeline segment (1,290 feet) in Alva Avenue that is connected to a 6-inch line in Burns Street should be replaced. The model is predicting negative pressure due to high head loss in the pipeline which could be attributed to the high demand allocated at the end of the 2-inch line using the Thiessen polygon approach. In actuality, the demands would be distributed along the length of the pipeline; however, the small line is still a bottleneck and should be replaced.



CDM

Figure 6-6
Location for Pipeline Improvements
Klamath Falls Water Master Plan

Zone 2

- Stewart/Lenox area on Butte Street, the 2-inch line is too small to provide adequate pressure. Adding a new 8-inch at the end of Butte Street to Cortez Street will establish a loop and improve pressures as well as fire flow.

Zone 3:

- Pipe improvements are needed for Zone 3 (Hospital Zone) from Birch Booster Station to North Eldorado Boulevard and then to Mountain View Boulevard to provide transmission capacity, improve pressures and fire flow capabilities.

- **<u>Intermediate</u>**

Zone 1:

- Pipe improvements are needed for Zone 1 in South 6th Street from Main Street to South 6th Booster Station and from South 6th Booster Station to Kane Street to provide transmission capacity, improve system pressure, and improve fire flow capabilities.

- A bypass is proposed by the City on East Main Street between SPPR and Maywood Drive.

- Pipe improvements are needed in the South 6th subzone from Hilyard Reservoir to South 6th Street and in 6th Street between Hilyard Avenue and Highway 140 E to improve system pressure, strengthen the transmission grid, and improve fire flow capabilities.

- Pipe improvements, 12-inch in diameter, are needed in the North subzone from the North Reservoir to the Birch Pump Station to provide redundancy for the Hospital Zone for supply from Conger well field. Currently, Wocus Well is the only supply to the Hospital zone area.

- Pipe improvements are needed in the northwest part of the North subzone in Corvallis Street and Mclean Street to improve system pressures and fire flow capabilities.

Zone 2:

- Pipe improvements, 12-inch in diameter, are needed to replace the existing 6-inch lines in Riverside Drive on the suction and discharge side of the Riverside Pump Station to provide redundancy for the Stewart Lenox Area from Zone 1 and Conger well field. Currently, Stewart Lenox Area is supplied by two local wells (Balsam and Debbie Wells).

- Pipe improvements are needed to provide transmission capacity at the discharge side of Debbie Well when the well is upgraded.

- Pipe improvements are needed in Stebbins Avenue in Stewart Lenox Area to improve system pressure and fire flow capabilities.

- **Buildout**

Zone 1:

- Pipe improvements are needed in Zone 1 in South Alameda Avenue between Shasta Way and Eberlein Avenue to improve transmission capacity, system pressure and fire flow capabilities.

- Pipe improvements are needed in Zone 1 in Old Fort Road to provide adequate capacity for the suction pipeline between Main Street and the Tanglewood (Laguna) Pump Station.

- Pipe improvements are needed in Zone 1 to convey Conger well supply to the Basinview area. Conger well field is the only source of supply to serve the projected future growth in the Basinview area. For buildout, new transmission lines will need to be extended from Conger well field to the Basinview area. The new lines will extend through the downtown along Main Street and then have two possible alternative branches:

    1) Option 1A - Branch to Beverly Pump Station and continuing along Beverly Road to the southern part of Basinview area. This option appears more consistent with the anticipated direction of future growth in the Basinview Area, as an expansion to the existing system. It is anticipated that development may be more likely to occur first in the Basinview area that is part of Zone 3 and served by Beverly Pump Station. For the future growth area, this will affect the locations of the new storage, pumping, and pipeline improvements required to serve those areas. The actual alignment will be determined based on future growth patterns, when known. The recommended improvements in Section 7 are based on the Option 1A alignment. With Option 1A, future service to the Basinview and Tanglewood areas is primarily through Beverly Pump Station to a future Zone 3 tank on the west side of the Basinview area. A future new Zone 8 Tanglewood Pump Station would be located at the future Zone 3 tank site. With Option 1A, the existing Tanglewood (Laguna) Pump Station would no longer be needed.

    2) Option 1B - Branch to Tanglewood Pump Station and continuing along Old Fort Road to serve Zone 3 Basinview area from the north, and convey flows through to higher zones in Basinview and Tanglewood. New pipe would replace the existing poor condition line. The City would construct the new

line within the roadway, although has indicated that the easement for the existing line does not coincide with the road in some places. With Option 1B, the existing Tanglewood (Laguna) Pump Station would require refitting to pump to the future Zone 3 tank. The future new Zone 8 Tanglewood Pump Station at the Zone 3 tank site would still be needed to lift water from the tank to Zone 8.

Depending on how development actually occurs, the expansion pattern should be re-evaluated in future master plan updates.

Zones 3 and 5:

- Pipe improvements are needed on suction and discharge side of Basinview Zone 5 Pump Station to improve transmission capacity.

Zone 8:

- Pipe improvements are needed in the Tanglewood Zone in Northridge Drive to provide transmission capacity to serve future growth areas.

Section 7
Recommended Water System Improvements

This section presents recommended water system improvements, capital cost estimates, project phasing, and implementation considerations. As part of implementation, the City should update its water rates and developer charges to reflect the updated master plan improvements.

7.1 Overview of Recommended Improvements

Figure 7-1 shows recommended water system improvements. Improvements include: wells, pipelines, reservoirs, pump stations, and pressure reducing valves. The recommended improvements are based on water system analyses described in Section 6 and the performance criteria in Section 5. Sections 6.1 and 6.2 provide an overview and major features of the ultimate system configuration. Sections 6.3 to 6.7 present the basis for the facility recommendations.

Improvements are summarized in a Capital Improvement Program (CIP). The CIP includes the costs of improvements required for all major facilities, including improvements to existing pipelines.

The CIP does not include the cost of new pipeline extensions to areas that are currently undeveloped and not served by an existing pipeline. It is assumed that these facilities would be constructed by developers as part of the new developments. However, major pipeline extensions are described in this section for planning purposes. Developers may also be required to contribute to the cost for new water production, storage, and pumping facilities as required by City standards.

Projects included in the CIP are:

- New well capacity (new wells or larger pumps in existing wells);
- Improvements to existing pipelines;
- New reservoir storage;
- New pump stations (to replace or expand existing stations or serve new areas); and
- Pressure reducing valve (PRV) station improvements.

CIP projects are staged by timeframe needed:

- Existing - to correct existing deficiencies and provide some capacity for future growth;

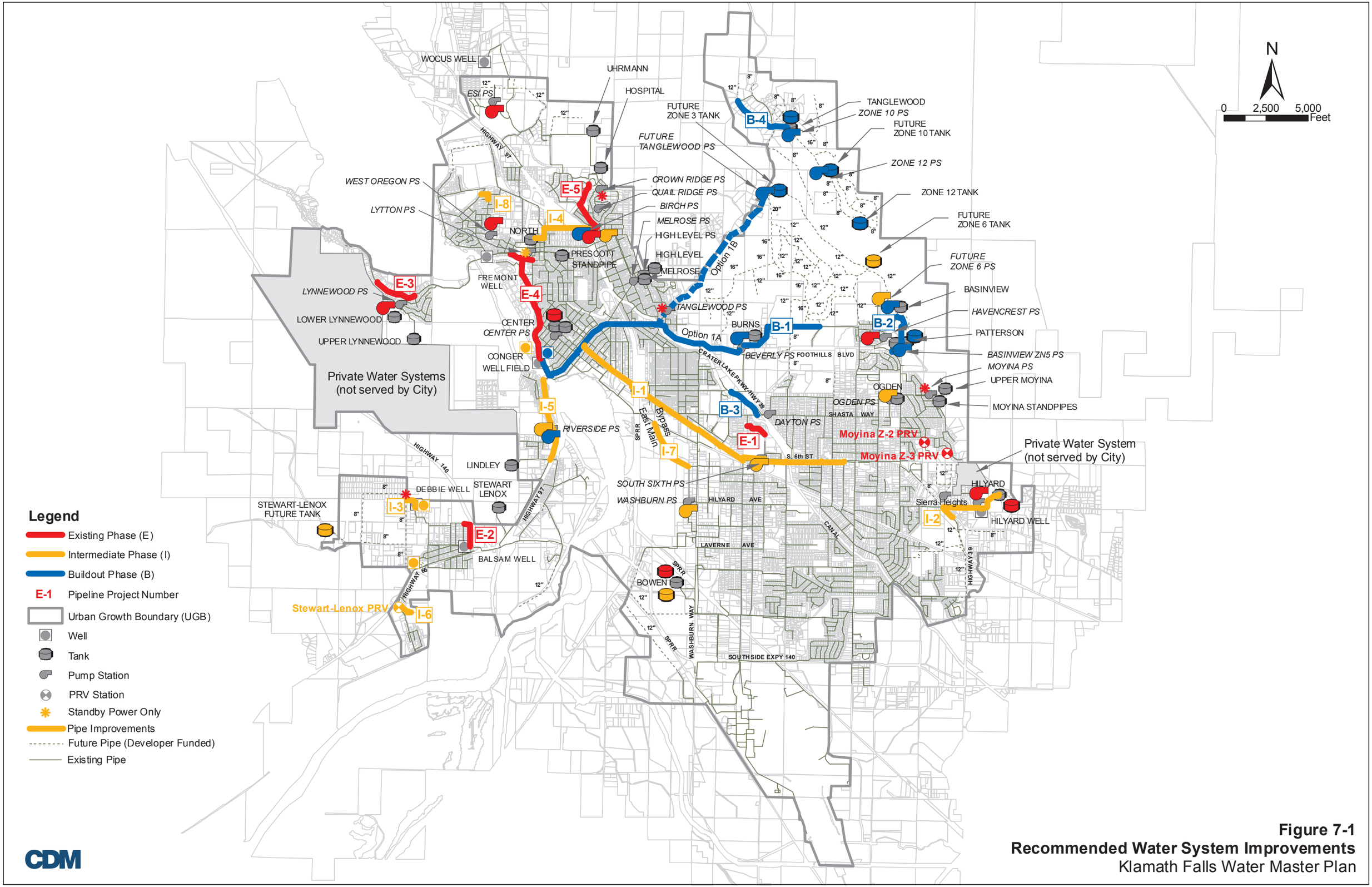


Figure 7-1
Recommended Water System Improvements
Klamath Falls Water Master Plan

- Intermediate timeframe to provide capacity for future growth within the next 10 years to year 2020 ; and
- Buildout of the remaining area within the Urban Growth Boundary which will occur after 2020 and will exceed the planning horizon of this study. The City will re-evaluate buildout demands and corresponding facilities needs in future master plan updates.

Project staging information is intended as a guideline for City staff. Specific implementation priorities and timing for projects will be determined by City staff considering future development requests and overall City needs, such as coordination with other projects.

7.2 Basis of Capital Cost Estimates

Planning-level capital cost estimates were developed for improvements. Estimated capital costs include construction costs, construction contingencies, and project implementation costs. All costs are in current dollars and are indexed to the Engineering New Records Construction Cost Index "20-City Average" of 8660 (January 2010). The accuracy of the estimate is within the +15% to -35% standard for a planning-level estimate.

Table 7-1 summarizes unit capital costs for water system improvements that were used to determine cost estimates. These unit capital costs include construction costs plus a 60 percent total markup for contingencies and project implementation.

Construction contingencies were estimated as 30 percent of construction costs to account for: additional work identified during design, uncertainties in the bidding climate, and change orders during construction. Project implementation costs were estimated as 30 percent of construction costs, and include project management and design (20 percent) and construction management and inspection (10 percent). The project management and design component includes administration, environmental, legal, surveying, preliminary and final design.

Construction costs are based on cost data from other CDM projects and input from City staff. The unit costs assume a normal (average) construction environment, and do not include such things as significant rock excavation or dewatering, unusual working hours, or exotic construction methods. Pipeline unit costs include valves and appurtenances, as well as pavement removal and replacement, traffic control, and a general allowance for correction of utility interferences where applicable. Pump station costs are based on an expandable aboveground enclosed building with standby pump, backup power and telemetry. Reservoir costs include average site work, valve vault, telemetry, piping and appurtenances. PRV station costs assume a simple vault with no telemetry. Well costs include standby power and disinfection (no other treatment).

Table 7-1
Unit Capital Costs for Water System Improvements [(1)]

Pipelines

Diameter	*Unit Capital Cost Within Existing Paved Rights of Way ($/foot)*	*Unit Capital Cost Outside of Existing Paved Right of Way ($/foot)*
6	175	160
8	215	190
12	250	225
16	330	295
20	450	400
24	510	465
30	560	505
36	640	575

Pump Stations

HP	*Unit Costs ($/HP)*	*Total Capital Cost ($ per Station)*
20	14,000	280,000
40	10,300	412,000
60	8,900	534,000
80	7,300	584,000
100	6,300	630,000
150	4,900	735,000
200	4,400	880,000
300	4,000	1,200,000
400	3,900	1,560,000
500	3,900	1,950,000
600	3,800	2,280,000
700	3,700	2,590,000
800	3,400	2,720,000

Storage

Capacity (MG)	*Total Unit Capital Cost for Buried Concrete Reservoir (Million $/MG)*	*Total Capital Cost for Buried Concrete Reservoir ($ per Tank)*	*Total Unit Capital Cost for Above-Ground Steel Tanks (Million $/MG)*	*Total Capital Cost for Above-Ground Steel Tanks ($ per Tank)*
0.25	2.00	500,000	1.55	390,000
0.5	1.90	950,000	1.50	750,000
0.75	1.90	1,430,000	1.50	1,130,000
1	1.85	1,850,000	1.45	1,450,000
1.5	1.80	2,700,000	1.40	2,100,000
2	1.70	3,400,000	1.40	2,800,000
2.5	1.70	4,250,000	1.40	3,500,000
3	1.65	4,950,000	1.30	3,900,000
3.5	1.60	5,600,000	1.25	4,380,000
4	1.60	6,400,000	1.25	5,000,000
5	1.50	7,500,000	1.20	6,000,000

Valve Stations

Size (in)	*Total Unit Capital Cost ($ per Station)*
2	25,000
4	65,000
6	105,000

Wells

Capacity (mgd)	*Total Unit Capital Cost ($ per mgd)*
1	900,000

(1) Capital costs include construction costs plus a 60 percent markup for contingencies and project implementation. All costs are in current $ and indexed to the Engineering News Record Construction Cost Index "20-City Average" of 8660 (January 2010).

Land acquisition costs are not included in capital costs. Pipelines are assumed to be constructed within public right-of-way or easements dedicated to the City. Unless otherwise noted in the cost tables, other facilities (wells, reservoirs, pump stations, PRV stations) are assumed to be constructed on existing City-owned properties or lands dedicated to the City.

7.3 Recommended Improvements and Phasing

7.3.1 Wells

Table 7-2 summarizes recommended well improvements and estimated capital costs. The City has adequate well pumping capacity under existing conditions. However, additional well capacity will be needed for intermediate and buildout conditions. All costs for well improvements are attributable to future users.

Table 7-2
Recommended Well Improvements

Location and Timeframe	Facilities	Capacity (mgd) [1]	Capital Cost ($ Million)	Allocation of Costs ($ Million)	
				Existing	Future[4]
EXISTING					
Stewart-Lenox/Lindley Area	Install backup power at existing Debbie Well for reliability. Backup power to be sized large enough to accommodate an expanded Debbie Well during Intermediate timeframe (see below). Capital cost in existing scenario is for backup power only, not additional well capacity.	NA	0.14	0.05	0.00
INTERMEDIATE					
Conger Well Field[2]	Expand existing well capacity (larger pumps) or construct new wells to provide capacity for Conger area and Wocus Area.	8.0	7.20	0.00	7.20
Stewart-Lenox/Lindley Area [3]	Upgrade Debbie Well (larger pump) from 0.76 to 2.16 mgd (200 HP) by installing larger pump to provide 1.4 mgd additional capacity for intermediate timeframe. [5]	2.2	0.22	0.00	0.22
	New well(s) for remaining additional capacity needed for intermediate and to include the small additional amount for buildout. [3]	1.5	1.35	0.00	1.35
	Intermediate Subtotal	***11.7***	***8.77***	***0.00***	***8.75***
BUILDOUT					
Conger Well Field[2]	Expand existing wells or construct new wells to serve Conger area and Wocus area	7.7	6.93	0.00	6.93
	Buildout Subtotal	***7.7***	***6.93***	***0.00***	***6.93***
GRAND TOTAL		**19.4**	**15.84**	**0.05**	**15.79**

(1) Additional capacity includes a 15 percent reserve for reliability, i.e., wells out of service.
(2) Conger Well Field improvements also provide the additional capacity needed for the Wocus Well area. Costs for Conger Well Field improvements are based on new wells.
(3) New well for Stewart Lenox/Lindley subzone is sized for buildout, since the incremental increase between intermediate and buildout is only 0.7 mgd. Depending on timeframe when the buildout capacity would be needed, a variable frequency drive pump could be installed to handle the lower initial flows, or a smaller pump could be initially installed and then replaced later with a larger pump.
(4) Developers may be required to fund all, or a portion of, the facilities required for their development.
(5) Planning-level cost for Debbie Well pump replacement obtained from July 2009 evaluation report prepared by Applied Geotechnical Engineering for Harrison Engineering.

7.3.2 Pipelines

Table 7-3 summarizes recommended pipeline CIP projects, costs, and project phasing. Pipeline improvement locations are shown on Figure 7-1. These projects are for improvements to existing pipelines to correct existing deficiencies, and also provide capacity for future growth since all pipe improvements are sized for buildout demands. The pipe improvements in Table 7-3 and Figure 7-1 are identified by project numbers.

For improvements to existing pipes, it is assumed that a replacement pipe will be constructed within existing right-of-way. During predesign of pipeline projects, the City will evaluate specific alignments and determine whether to replace or parallel the existing pipe based on its age and condition, available space, number of services on the pipe, and other factors.

Pipeline projects in Table 7-3 are grouped according to the timeframe needed – existing (E), intermediate (I) and buildout (B). Within each timeframe, the projects are prioritized based on the severity of the deficiency, from most severe to least severe. The priorities are based on: 1) correcting low pressure problems under normal peak hour conditions; 2) replacing "bottlenecks" to improve fire flow conditions; and 3) improving transmission capacity to pump stations and reservoirs.

It is assumed that implementation of existing projects would be spread over an extended period, depending on the available funding. For example, if implementation were over a 10-year period: projects to improve system pressure would be constructed during 2010-2015 timeframe; and projects to improve transmission capacity would be constructed during 2015-2020. The City will need to determine available funding to set a specific timeframe for implementation. A shorter time period for implementation of existing projects would be beneficial to accelerate system improvements and upgrades.

Projects needed for the intermediate and buildout timeframes are solely to provide capacity for future growth, and would be implemented based on development needs. It is assumed that intermediate projects would be needed within the next 10 years by 2020 (in place by 2020), and buildout projects after 2020.

The righthand column of Table 7-3 shows the allocation of project costs to existing and future users. Costs for existing projects were allocated based on the ratio of existing and future demands in the zone, since the pipe improvements to strengthen the existing system and provide additional reliability will benefit both existing and future users. All costs for pipe improvements needed to provide additional capacity for intermediate and buildout conditions are attributable to future users.

Table 7-3
Recommended Pipeline Improvement Projects

Project	Zone	General Area	Location 1 - In Street	Location 2 - between Streets	Diameter (in)	Length (ft)	Total Cost ($ Million) (1)	Allocation of Costs ($ Million)	
								Existing	Future (2)
Existing									
Existing Pipeline Improvements									
E-1	Zone 1	North/Central	Alva Avenue	Burns Street to Crest Street	8	1,300	0.28	0.25	0.03
E-2	Zone 2	Stewart Lenox/Lindley	Butte Street	Balsam Drive to the end of Butte Street	8	1,300	0.28	0.28	0.00
	Zone 2	Stewart Lenox/Lindley	Field between Butte Street and Cortex Street	Butte Street to Cortez Street	8	500	0.11	0.11	0.00
	Subtotal for E-2					*1,800*	*0.39*	*0.39*	*0.00*
E-3	Zone 1	North/Central	West on Lakeshore Blvd.	From Lynnewood Blvd.	8	2,600	0.56	0.51	0.05
E-4	Zone 1	North/Central	Conger Avenue	From Conger Well Field to California Avenue	16	1,300	0.43	0.39	0.04
	Zone 1	North/Central	California Avenue	From Conger Avenue to Oregon St.	16	5,400	1.78	1.61	0.17
	Zone 1	North/Central	West on Oregon Avenue which becomes Nevada Street	From Siskiyou Street to Thrall Street	12	2,300	0.58	0.52	0.05
	Subtotal for E-4					*9,000*	*2.79*	*2.52*	*0.27*
E-5	Zone 3	Urhman/Hospital/High Level	Dolores Avenue	Discharge of Birch Pump Station and Dahlia Street	12	700	0.18	0.00	0.18
	Zone 3	Urhman/Hospital/High Level	Dahlia Street	Dolores Avenue and Eldorado Avenue	12	600	0.15	0.00	0.15
	Zone 3	Urhman/Hospital/High Level	Eldorado Avenue	Dahlia Street and Lexington Avenue	12	800	0.20	0.00	0.20
	Zone 3	Urhman/Hospital/High Level	Lexington Avenue	Eldorado Avenue and Mountain View Avenue	12	1,400	0.35	0.00	0.35
	Subtotal for E-5					*3,500*	*0.70*	*0.00*	*0.70*
Existing Total						**18,200**	**4.71**	**3.67**	**1.05**
Intermediate									
I-1	Zone 1	North/Central	6th Street	Main Street to suction side of South 6th Pump Station just before Crest Street.	16	13,500	4.46	0.00	4.46
	Zone 1	South Sixth	6th Street	Discharge of South 6th Pump Station just before Crest Street to Kane Street	16	5,200	1.72	0.00	1.72
	Subtotal for I-1					*18,700*	*6.17*	*0.00*	*6.17*
I-2	Zone 1	South Sixth	Hilyard Avenue	From Hilyard Reservoir to 6th Street	12	1,400	0.35	0.00	0.35
	Zone 1	South Sixth	6th Street	Hilyard Avenue to Hwy 140	12	1,800	0.45	0.00	0.45
	Subtotal for I-2					*3,200*	*0.80*	*0.00*	*0.80*
I-3	Zone 2	Stewart Lenox/Lindley	Debbie Drive	Orindale Road to Sue Drive	12	900	0.23	0.00	0.23
I-4	Zone 1	North/Central	Siskiyou Street	North Reservoir to Hawthorne Street	12	100	0.03	0.00	0.03
	Zone 1	North/Central	Hawthorne Street	Siskiyou Street to Biehn Street	12	600	0.15	0.00	0.15
	Zone 1	North/Central	Biehn Street	Hawthorne Street to Lakeport Street	12	700	0.18	0.00	0.18
	Zone 1	North/Central	Field parallel to Van Ness Avenue across the canal and HWY 97	Biehn Street to suction of Birch Pump Station	12	2,700	0.68	0.00	0.68
	Subtotal for I-4					*4,100*	*1.03*	*0.00*	*1.03*
I-5	Zone 1	North/Central	Riverside Drive	Main Street to suction of Riverside Pump Station	12	3,100	0.78	0.00	0.78
	Zone 2	Stewart Lenox/Lindley	Riverside Drive with becomes Frontage Road	Discharge of Riverside Pump Station to Autumn Avenue	12	1,900	0.48	0.00	0.48
	Subtotal for I-5					*5,000*	*1.25*	*0.00*	*1.25*
I-6	Zone 1	Stewart Lenox PRV	Stebbins Avenue	Anderson Ave. and Kelly Dr.	12	1,200	0.30	0.00	0.30
I-7	Zone 1	North/Central	East Main Bypass	6th Street to Maywood Drive	16	3,500	1.16	0.00	1.16
I-8	Zone 1	North/Central	Corvallis Street	Torrey Street to Mclean Street	8	300	0.06	0.00	0.06
	Zone 1	North/Central	Field West of Mclean Street	Corvallis Street to Hanks Street	8	500	0.11	0.00	0.11
	Subtotal for I-8					*800*	*0.17*	*0.00*	*0.17*
Intermediate Total						**37,400**	**11.10**	**0.00**	**11.10**

Table 7-3
Recommended Pipeline Improvement Projects

Project	Zone	General Area	Location 1 - In Street	Location 2 - between Streets	Diameter (in)	Length (ft)	Total Cost ($ Million) [1]	Allocation of Costs ($ Million)	
								Existing	Future [2]
Buildout									
B-1 [3]	Zone 1	North/Central	Conger Drive	From Conger Well Field to Main Street	24	1,200	0.61	0.00	0.61
	Zone 1	North/Central	Main Street	Conger Drive to 6th Street	30	2,900	1.62	0.00	1.62
	Zone 1	North/Central	Main Street	6th Street to Seldon Street	24	5,600	2.86	0.00	2.86
	Zone 1	North/Central	Sheldon Street	Main Street to Alameda Avenue	24	2,600	1.33	0.00	1.33
	Zone 1	North/Central	Parallel to Alameda Avenue	Sheldon Street to Foothills Blvd.	16	2,500	0.83	0.00	0.83
	Zone 1	North/Central	Foothills Blvd to the suction of Beverly Pump Station	Alameda Avenue to Beverly Drive	16	400	0.13	0.00	0.13
	Zone 3	Patterson	Beverly Drive parallel to an existing pipe alignment	Beverly Pump station discharge to a future street located in a field east of Beverly Drive and North of Foothills Blvd.	16	4,500	1.49	0.00	1.49
	Subtotal for B-1					*19,700*	*8.86*	*0.00*	*8.86*
B-2	Zone 3	Patterson	Access road to Patterson Tanks	Foothills Blvd. to Suction of Basinview Z5 Pump Station	16	700	0.23	0.00	0.23
	Zone 5	Basinview	Field north of Patterson Reservoir	Discharge of Basinview Z5 Pump Station to Basinview Reservoir	16	2,000	0.66	0.00	0.66
	Subtotal for B-2					*2,700*	*0.89*	*0.00*	*0.89*
B-3	Zone 1	North/Central	Alameda Avenue	Eberlein Avenue to Shasta Way	12	2,200	0.55	0.00	0.55
B-4	Zone 7	Tanglewood	Field west of Tanglewood Reservoir	From Tanglewood Reservoir to California Blvd.	16	1,000	0.33	0.00	0.33
	Zone 8	Tanglewood	California Blvd.	Old Fort Road to Hunters Ridge Road	12	2,800	0.70	0.00	0.70
	Subtotal for B-4					*3,800*	*1.03*	*0.00*	*1.03*
Buildout Total						**28,400**	**11.33**	**0.00**	**11.33**
Grand Total for All Pipeline Improvement Projects						**84,000**	**27.14**	**3.67**	**23.48**

(1) All pipeline costs are based on construction within existing paved right of way.
(2) Developers may be required to fund all, or a portion of, the facilities required for their development.
(3) The recommended pipeline projects are based on implementing the Option 1A pipeline alignment, which is Project B-1, and the corresponding Beverly and Tanglewood Pump Station improvements in Table 7-5. With B-1 (Option 1A), future service to the Basinview and Tanglewood areas is primarily through Beverly Pump Station to a future Zone 3 tank on the west side of the Basinview area. A future new Zone 8 Tanglewood Pump Station would be located at the future Zone 3 tank site. With Option 1A, the existing Tanglewood (Laguna) Pump Station would no longer be needed. If the alternate Option 1B alignment were implemented, the existing Tanglewood (Laguna) Pump Station would require refitting to pump to the future Zone 3 tank; and suction pipeline improvements would be needed between Main Street and the existing pump station, in addition to another new pipeline in Old Fort Road between the existing Laguna Station and the new Zone 3 tank.

Figure 7-1 also shows conceptual alignments and sizes for future pipeline extensions to serve new development areas. These extensions, shown for planning purposes, are not in the CIP. Pipeline extensions will be constructed by developers as part of new development projects. All costs for pipeline extensions are attributable to future users.

The sizes and alignments shown on Figure 7-1 are intended to serve as a guideline for the City to use in evaluating projects proposed by developers. The conceptual pipeline extensions have been routed along existing roads, planned future roads, or assumed extensions of existing roads. Actual alignments and sizes of future pipeline extensions will depend on future development plans.

The master plan pipeline improvements in Table 7-3 are to provide additional capacity. An annual budget item should be included in the CIP for pipeline replacement upgrades over time. Such replacement upgrades could include replacing old cast iron and steel pipes, replacing leaky pipes, replacing small 4-inch or less diameter pipes, and other similar projects. Subsequent to the master plan, the City would conduct localized studies to determine upgrade projects for specific areas. The City can utilize its GIS database and historic information to create an inventory and prioritized list of replacement improvements in order to determine appropriate future annual replacement budgets. Replacement costs are not included in Table 7-3.

Currently, the City budgets $500,000 per year for pipeline replacement projects based on historic data, which addresses critical system needs. With $0.5 million annually, it would take about 90 years to replace the 39 miles of modeled 4-inch or smaller diameter pipes. To replace these pipes more quickly will require larger annual budgets. For example, to replace 39 miles of small diameter pipes within 20 years would require about $2.2 million budgeted each year. Replacement improvements, which do not provide capacity for future growth, are funded from water rates.

7.3.3 Reservoirs

Table 7-4 summarizes recommended reservoir projects, costs, and phasing. Projects are grouped according to the timeframe needed – existing, intermediate, and buildout. The reservoir costs in Table 7-4 are for above ground steel tanks.

The recommended sizes of reservoir projects in Table 7-4 are based on using backup power at wells and booster pump stations to provide an emergency storage credit, in lieu of tank storage. This assumes that the zone/subzone is either supplied directly from wells having backup power, or there is also backup power at booster pump stations that convey the water from the wells. The emergency storage credit is discussed in detail in Section 6.4 (Table 6-7). The well pumping improvements in Section 7.3.1 and the pump station improvement recommendations in Section 7.3.4 include backup power improvements needed for the emergency storage credits.

For the existing scenario, the Zone 1 storage projects are the highest priority. The remainder of the storage is needed for intermediate and buildout.

Table 7-4 and Figure 7-1 indicate conceptual locations for future reservoirs. Conceptual locations are based on the ultimate system configuration, ground elevations from the 2-foot contour map provided by the City and hydraulic considerations. The locations are a guideline for the City to use in siting studies for future reservoirs, and sites proposed by developers. The actual locations and sizes of future reservoirs will depend on site availability and future development plans.

The righthand column of the table shows the allocation of project costs to existing and future users. Costs were allocated between existing and future users based on the storage capacity required for existing needs and that provided for future needs.

Table 7-4
Recommended Reservoir Improvement Projects

Zone	*Projects*	*Capacity (MG)*	*Capital Cost ($ Million)* [1]	*Allocation of Costs ($ Million)*	
				Existing	*Future* [3]
EXISTING					
Zone 1 (Central)	New reservoir in Central Zone 1. Existing deficiency requires 1.03 MG; total buildout deficiency requires 1.55 MG. Recommend a 1.6 MG reservoir at the existing site.	1.6	2.24	2.03	0.21
Zone 1 (Washburn)	New reservoir in Washburn area of Zone 1. Recommend building a 1.3 MG reservoir at Bowen site to meet existing deficiency by replacing the adjacent lower height tank which currently not in use. The new tank overflow should match the existing higher height tank. [4]	1.3	1.85	1.85	0.00
Zone 1 (South 6th)	New 1 MG reservoir in the east side of zone near existing Hilyard reservoir or Ogden reservoir.	1.1	1.58	0.48	1.10
	Existing Subtotal	**4.0**	**5.67**	**4.35**	**1.32**
INTERMEDIATE					
Zone 1 (Washburn)	New reservoir in Washburn area of Zone 1. Recommend building a 1.3 MG reservoir at Bowen site to meet both intermediate and buildout deficiency. The incremental additional capacity needed between intermediate and buildout is very small. [4]	1.3	1.85	0.00	1.85
Zone 2	New 0.5 MG reservoir in Stewart-Lenox. Intermediate requirement is 0.18 MG and total requirement is 0.48 MG. Reservoir may be located near the existing Stewart-Lenox Reservoir or in the area of future growth in the west side of the Zone.	0.5	0.75	0.00	0.75
Zone 6	Future Zone 6 - Build new 0.5 MG reservoir to meet future demand.	0.5	0.75	0.00	0.75
	Intermediate Subtotal	**2.3**	**3.35**	**0.00**	**3.35**
BUILDOUT					
Zone 3	Patterson - A new 1.0 MG reservoir in the future areas to meet future demand.	1.0	1.45	0.00	1.45
Zone 8	Tanglewood - Future 0.6 MG reservoir	0.6	0.89	0.00	0.89
Zone 10	Future Zone 10 - Build new 0.5 MG Reservoir to meet future demand.	0.5	0.75	0.00	0.75
Zone 12	Future Zone 12 - Build new 0.5 MG Reservoir to meet future demand.	0.5	0.75	0.00	0.75
	Buildout Subtotal	**2.6**	**3.84**	**0.00**	**3.84**
Grand Total for All Improvements		**8.9**	**12.86**	**4.35**	**8.51**

(1) Capacities are based on emergency storage credits for standby power. Tables 7-2 and 7-5 include backup power improvements at pump stations that are required for the emergency storage credit.
(2) All reservoir costs are based on aboveground steel reservoirs.
(3) Developers may be required to fund all, or a portion of, the facilities required for their development.
(4) Based on the hydraulic analysis, all the existing storage at the Bowen site is usable storage, i.e., there is no dead storage. Even at the minimum level (bottom), a static pressure of 40 psi can be maintained at the highest service elevations in the zone.

With increased storage in the system, the City will need to operate the reservoirs to minimize water quality impacts from low turnover during low demand periods. Design of future reservoirs should consider dual (multiple) tanks at a site to allow one or more to be taken out of service during low demand periods. In addition, design features to address water quality should be incorporated into the reservoir design to achieve good mixing, avoid baffling that can inhibit mixing, avoiding stratification of water in the tank, and include sampling ports to identify mixing problems and low disinfectant residuals.

7.3.4 Pump Stations

Table 7-5 summarizes recommended pump station projects, costs, and phasing. Conceptual locations are shown on Figure 7-1. The projects include adding pumping capacity, and providing backup power for an emergency storage credit in lieu of tank storage as discussed in Section 7.3.3. Most projects in Table 7-5 include both capacity and backup power upgrades. In some cases, only backup power is needed.

As indicated on Table 7-5, some pump station projects are replacements that will involve demolishing the existing structure and replacing it with a new facility that meets the City's current standards, since the existing stations are old and outdated. Other pump station expansion projects assume that additional pump(s) will be added at existing stations. New pump stations will be required to serve future service zones.

Pump stations provide the required firm capacity with a standby pump. Pumps were sized assuming an overall station efficiency of 70 percent of the total rated capacity. Total horsepower in Table 7-5 for replacement and new pump stations is the total station horsepower including the standby pump. For expansion projects that add pumps at an existing facility, the total HP is for the additional pump HP to be installed assuming that the existing facility provides the standby pump. The costs for expansion projects assume that structural, mechanical, and electrical/instrumentation improvements may be needed at the existing sites (as if constructing a complete station for the new pump). During predesign/design of expansion projects, field assessments and evaluations will be needed of the existing structures/equipment to determine the most feasible method of adding the new pump.

Conceptual pump station locations have been identified based on the ultimate system configuration and hydraulic considerations. The locations are intended to serve as a guideline for the City to use in evaluating proposed projects. The actual locations and sizes of future stations will depend on site availability and future development plans.

The righthand column of Table 7-5 shows allocation of project costs to existing and future users. For expansions of existing pump stations, costs are allocated to existing users for the portion of the capacity needed for existing demands, and to future users for the capacity provided for future demands. All new pump stations to serve new development areas are solely for future demands and all costs are attributable to future users.

Table 7-5
Recommended Pump Station Improvement Projects [1]

Zone	Projects	Description	Firm Capacity (mgd)[2]	Total HP	Capital Cost ($ Million)	Allocation of Costs ($ Million)	
						Existing	Future[3]
Existing							
Zone 2	Upper Lynnewood PS Replacement	Replace existing pumps with two 700 gpm pumps (1 duty and 1 standby) with backup power for firm capacity to provide emergency storage credit.	0.3	20	0.28	0.28	0.00
	West Oregon PS Replacement [7]	Replace existing package station with new station, two 75 gpm pumps (1 duty and 1 standby) plus a 1500 gpm fire pump, and standby power.	2.3	60	0.53	0.24	0.29
	Sierra Heights Expansion [7]	Replace existing smallest pump with a larger VFD pump similar in size to the other existing small pump that can provide up to 190 gpm for peak hour demands.	0.3	20	0.28	0.20	0.08
Zone 3	Birch PS Replacement	Replace existing pumps with two 800 gpm pumps (1 duty and 1 standby) to provide reliability backup in case of Wocus Well outage; design building to accommodate adding two future pumps to serve future growth (one in intermediate and one for buildout). Provide backup power for emergency storage credit.	1.1	200	0.88	0.88	0.00
Zone 4	Moyina PS Backup Power	Install backup power at Moyina PS equal to firm capacity (1 pump) to provide emergency storage credit. [4]	NA	20	0.03	0.01	0.02
	Quail /Crown Ridge Backup Power	Install backup power at Quail Ridge/ Crown Ridge PS for reliability.	NA	80	0.08	0.04	0.04
	ESI PS Replacement [7]	Replace existing package station with new station, three 90 gpm pumps (2 duty and 1 standby) plus a 1500 gpm fire pump, and standby power.	2.4	40	0.41	0.05	0.36
	Havencrest PS Replacement [7]	Replace existing package station with a new station, two 30 gpm pumps (1 duty and 1 standby) plus a 1500 gpm fire pump, and standby power.	2.2	40	0.41	0.41	0.00
Zone 8	Tanglewood (Laguna) PS Backup Power	Install backup power at the existing Tanglewood (Laguna) PS equal to firm capacity of 1 pump to provide emergency storage credit for existing and intermediate timeframes. For buildout, Beverly PS will be expanded with backup power to pump to a future Zone 3 tank that will serve future growth in the Tanglewood area. [6]	NA	250	0.20	0.20	0.00
		Existing Subtotal	**8.6**		**3.11**	**2.31**	**0.79**

Table 7-5
Recommended Pump Station Improvement Projects (1)

Zone	Projects	Description	Firm Capacity (mgd)(2)	Total HP	Capital Cost ($ Million)	Allocation of Costs ($ Million)	
						Existing	Future(3)
Intermediate							
Zone 1	South 6th Street PS Replacement	Replace existing South 6th Booster Station to provide all required capacity for South Sixth subzone. Dayton Booster Station will be abandoned. Station is sized for Buildout since only a very small incremental increase between intermediate and buildout. Cost assumes 2 duty pumps and a standby unit (2000 gpm each). Standby power is required for the emergency storage credit.	5.7	300	1.20	0.30	0.90
	Washburn PS Expansion	Expand pump station by adding one pump similar to the existing pumps, which will meet buildout demands. (5)	3.2	100	0.32	0.00	0.32
Zone 2	Riverside Pump Station Replacement	Replace existing station with three 440 gpm pumps for reliability backup from Conger well field in the event Debbie Well outage in Stewart-Lenox area. This will provide 2 duty and 1 standby pumps. Design station to accommodate adding a fourth pump to meet reliability needs at buildout, if needed.	1.9	80	0.58	0.19	0.39
	Lytton PS Backup Power	Install backup power at Lytton PS equal to firm capacity (1 pump) to provide emergency storage credit.	NA	40	0.04	0.02	0.02
Zone 3	Birch PS Expansion	Expand pump station with an additional 800 gpm pump to meet intermediate needs.	1.1	100	0.63	0.43	0.20
Zone 3	Ogden PS Expansion	Expand Pump Station with one additional 250 gpm pump. Provide backup power for emergency storage credit.	0.4	40	0.41	0.00	0.41
Zone 6	Basinview Z6 Future Pump Station	Build new pump station with two 250 gpm pumps (1 duty and 1 standby) and provision for adding one more pump to meet buildout needs. Provide backup power at pump station for emergency storage credit.	0.4	20	0.28	0.00	0.28
		Intermediate Subtotal	**12.7**		**3.46**	**0.94**	**2.52**
Buildout							
Zone 2	Riverside Pump Station Expansion	Add another 440 gpm pump for reliability backup from Conger well field in the event of a Debbie Well outage in Stewart-Lenox area. (8)	0.6	20	0.14	0.00	0.14
Zone 3	Beverly PS Replacement (6)	Replace existing three 750 gpm pumps with four 1750 gpm pumps (three duty and one standby). Provide backup power at pump station for emergency storage credit.	7.6	800	2.72	0.39	2.33
	Birch PS Expansion	Expand pump station with an additional 800 gpm pump to meet buildout needs.	1.1	100	0.63	0.00	0.63
Zone 5	Basinview Z5 Pump Station	Replace existing station with new station, three 450 gpm pumps (2 duty and 1 standby) to meet buildout needs, and backup power.	1.3	100	0.63	0.08	0.55

Table 7-5
Recommended Pump Station Improvement Projects [1]

Zone	Projects	Description	Firm Capacity (mgd)[2]	Total HP	Capital Cost ($ Million)	Allocation of Costs ($ Million)	
						Existing	Future[3]
Zone 6	Basinview Z6 Future Pump Station Expansion	Expand Pump Station with one additional 250 gpm pump.	0.4	20	0.28	0.00	0.28
Zone 8	Tanglewood Future Pump Station (at future Zone 3 tank site) [6]	Build new pump station with three 900 gpm pumps and backup power.	2.6	500	1.95	0.00	1.95
Zone 10	Basinview Z10 Future Pump Station	Build new pump station with three 400 gpm pumps and backup power.	1.2	100	0.63	0.00	0.63
Zone 12	Basinview Z12 Future Pump Station	Build new pump station with three 150 gpm pumps and backup power.	0.4	40	0.41	0.00	0.41
		Buildout Subtotal	**15.2**		**7.39**	**0.47**	**6.93**
		Grand Total for All Pump Station Projects	**36.5**		**13.96**	**3.72**	**10.24**

(1) All pump station improvement projects should be constructed with backup power for reliability and to provide the emergency storage credit. Project costs include backup power.
(2) Firm capacity is dependent upon the type of project. For pump station replacements, firm capacity is the capacity required to meet demands and does not include a standby pump. For pump station expansions, firm capacity is the additional capacity required to meet future demands and assumes that there is a standby pump at the existing facility.
(3) Developers may be required to fund all, or a portion of, the facilities required for their development.
(4) Moyina Booster standby power improvements for emergency storage credit are based on 1500 gpm fire flow reserve and assume the church at the zone boundary can be provided fire flow from both the Moyina and Patterson subzones. The church is located at the boundary of both zones with adjacent pipes from both zones.
(5) Washburn Pump Station has been planned to add another pump similar to the existing pumps. The CIP project assumes addition of a pump of the same size as the existing pumps, consistent with the station design, which will meet the increase in future demand, provide operational flexibility for refilling reservoir storage, and reliability backup for Zone 1. When the project is implemented, the City could consider adding a smaller pump solely to meet the future increase in demand. Expansion cost is estimated as 50% of the cost of a complete expansion since the newly built station was designed with space to accommodate adding a future pump; the expansion cost covers pump & motor, electrical & instrumentation, and ancillary piping and appurtenances.
(6) The Beverly and Tanglewood Pump Station improvements in this table are based on the Option 1A pipeline alignment (Pipeline Project B-1) shown on Figure 7-1. With Option 1A, future service to the Basinview and Tanglewood areas is primarily through Beverly Pump Station to a future Zone 3 tank on the west side of the Basinview area. A future new Zone 8 Tanglewood Pump Station would be located at the future Zone 3 tank site. With Option 1A, the existing Tanglewood (Laguna) Pump Station would no longer be needed. If the Option 1B alignment were implemented, the existing Tanglewood (Laguna) Pump Station would require refitting to pump to the future Zone 3 tank; and suction pipeline improvements would be needed between Main Street and the existing pump station.
(7) For the small booster only zones without storage, the station replacements include firm capacity for peak hour demands plus a 1500 gpm fire pump. These are small package stations that will require complete replacement. The Sierra Heights station requires replacement of the smallest pump with a larger pump to provide firm capacity for peak hour demands. These small booster only zones were adequate at the time designed, but do not meet the City's current criteria.
(8) For Riverside Pump Station expansion at buildout, the cost of adding a fourth pump is estimated at 50% of the cost of a complete expansion. It is assumed that the PS replacement for intermediate will be designed to accommodate the fourth pump, which is reflected in the intermediate cost for the replacement project.

7.3.5 Pressure Reducing Valve Stations

Table 7-6 summarizes recommended PRV projects, costs, and phasing. The locations are shown on Figure 7-1. The righthand column of the table shows the allocation of project costs to existing and future users. Costs were allocated between existing and future users based on the capacity required for existing needs and that for future needs.

Table 7-6
Recommended Pressure Reducing Valve Projects

PRV Zone	Location of PRV Station Serving Zone	New Valve Sizes (in)	Capital Cost ($ Million)	Allocation of Costs ($ Million)		Basis for Cost Allocation
				Existing	Future[1]	
EXISTING						
Moyina Reduced (Zone 2)	Carlson/ Valhala	4	0.065	0.065	0	Valve needed for existing timeframe to provide fire flow capacity.
Upper Moyina Reduced (Zone 3)	Climax/ Kimberly Dr., Climax/Kimberly Ct.	4	0.065	0.047	0.018	Valve needed for existing timeframe to provide fire flow capacity and will also meet future needs.
Existing Subtotal			**0.130**	**0.112**	**0.018**	
INTERMEDIATE AND BUILDOUT						
West Klamath Reduced (Zone 1)	Highway 66/ Weyerhauser Rd.	2	0.025	0	0.025	Valve needed at intermediate timeframe to provide peak hour capacity for future growth and will also meet buildout needs. All costs allocated to future users.
Total for All Pressure Reducing Valve Projects			**0.155**	**0.112**	**0.043**	

[1] Developers may be required to fund all, or a portion of, the facilities required for their development.

7.4 Summary of Recommended Improvements

Table 7-7 summarizes recommended water system improvements, phasing, and costs. These costs include new well supply, reservoirs, pump stations, pipelines, and pressure reducing valve stations.

The total cost for all improvements is about $70 million. The costs would be phased as about $14 million for existing conditions, $27 million for the intermediate timeframe which is the next 10 years (by 2020), and $29 million for buildout (after 2020).

Table 7-7
Summary of Recommended Improvements and Capital Costs

Timeframe Needed	Wells		Pipelines		Reservoirs		Pump Stations		PRVs		Total Capital Cost ($ Million)
	Capacity (mgd)	Capital Cost ($ Million)	Length (LF)	Capital Cost ($ Million)	Capacity (MG)	Capital Cost ($ Million)	Capacity (mgd)	Capital Cost ($ Million)	Number of Valves	Capital Cost ($ Million)	
Existing	0	$0.14	18,200	$4.71	4.0	$5.67	8.6	$3.11	2	$0.13	$13.76
Intermediate (by 2020)	11.7	$8.77	37,400	$11.10	2.3	$3.35	12.7	$3.46	1	$0.03	$26.70
Buildout (after 2020)	7.7	$6.93	28,400	$11.33	2.6	$3.84	15.2	$7.39	-	-	$29.50
GRAND TOTAL	**19.4**	**$15.84**	**84,000**	**$27.14**	**8.9**	**$12.86**	**36.5**	**$13.96**	**3**	**$0.16**	**$69.96**

7.5 Implementation Considerations

The master plan provides a tool for the City to continue upgrading and expanding its water system. It should be updated periodically, at approximately 5-year intervals, or more frequently if major land use or other changes occur. Other key implementation considerations include:

- Developer fees and water rates should be updated, as further discussed below, to incorporate the recommended improvements in the master plan, in order to allocate costs appropriately to existing and future users.
- The City should investigate its existing and future groundwater supply availability to confirm its ability to meet future supply needs. This investigation should include groundwater yield, water quality, and water rights conditions of use.
- The hydraulic model should be kept up-to-date and used on an ongoing basis as a tool to analyze localized improvements and evaluate developer proposals.
- Sizing, location, and estimated costs of master plan projects are at a conceptual level. Project implementation will require predesign studies, including specific routing and siting studies, environmental review, and detailed design of specific projects.
- The master plan phasing for project implementation is intended as a guideline. Timing for specific projects will be determined based on development needs, coordination with other construction projects, such as those for other utilities and street improvements, or for other City needs.
- The City should update its Water Conservation and Management Plan to investigate potential reductions in future maximum day and peak hour demands that could be achieved through water conservation measures. Facility sizing is based on the ability of the system to meet maximum day and peak hour demands. If future maximum day and/or peak hour demands are reduced, future facilities requirements and costs may also be reduced. Potential demand reductions and corresponding reductions in facility costs need further study to determine impacts.
- The City could consider conducting an operational study of the water system. Key features would include evaluating methodologies for assessing the need for upgrade, repair, and replacement of utility assets; understanding processes for updating and modifying asset inventories; identifying most critical assets and risks associated with those assets failing; and developing utility asset management goals and measures.

In conjunction with this master plan update, the City prepared a separate Water Utility Geographic Information System (GIS) Strategic Plan, and developed a water system facility GIS database and mapping. The GIS database and mapping is integrated with the water system hydraulic model. The City should keep the database and mapping up-to-date as changes occur in the water system over time. Depending

on future needs, the City could also consider expanding the GIS database to incorporate other functions, such as maintenance management, integration with water demand (billing) data and/or production data, or other useful features.

Current developer fees and water rates should be updated to incorporate the information developed on recommended improvements and the allocation of costs to existing and future users. The City's last System Development Charge (SDC) study was done in 2002. Typically, water agencies update rates/charges upon completion of a master plan update or other major change in water system requirements. It is appropriate that developer fees include all costs allocated to future users for projects that will be constructed and funded by the City.

The City may also consider issuing municipal bonds to facilitate faster implementation of recommended projects to improve the existing system. Debt service on the bonds would be recovered through rates and developer fees. In some cases, the City may reach agreements with developers to construct recommended improvement projects as a condition of development approval.

The City should also investigate potential funding sources through the State of Oregon. Such programs include:

- Safe Drinking Water Revolving Loan Fund for collection, treatment, distribution and related infrastructure. Loans are made at very favorable interest rates to water systems serving at least 25 service connections. The primary purpose is to fund projects that resolve an existing or potential health hazard or noncompliance under federal/state standards related to the public provision and conveyance of water for human consumption. Applications are prioritized and project funded based on severity of the system's need. Eligible costs include project planning, engineering, surveying, design, construction, upgrades, land acquisition, environmental review, and investments to enhance the physical security of the drinking water system.

- Special Public Works Fund to help municipalities finance public infrastructure that helps attract and retain good jobs in Oregon communities. Drinking water systems are one of the types of infrastructure eligible for funding. Eligible costs include planning, designing, purchasing, improving, and constructing municipally-owned facilities. The program provides both grant and loan funding, primarily loans. Grants are available for projects that will create or retain certain traded-sector jobs or for planning work required for industrial lands development. Loans are made at favorable interest rates, and the department absorbs the costs of debt issuance such as bond counsel and insurance.

- Water/Wastewater Financing Program only offers loans if a system has received or is likely to soon receive a Notice of Non-Compliance with the Safe Drinking Water Act or Clean Water Act, or other state or federal water quality statutes and standards.

Appendix A
Historic Well Production Data
(1998-2007)

Appendix A: Well Production for Entire System

Klamath Falls Well Production for Entire System - Summary of Annual and Monthly Production from 1998 - 2007

Note: Units are in gallons unless otherwise indicated.

Month	FOR ENTIRE SYSTEM																	
	1998			1999			2000			2001			2002			2003		
	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual
Jan.	159,705,200	5,151,781	0.71	168,346,400	5,430,529	0.70	167,914,100	5,416,584	0.68	170,492,500	5,499,758	0.67	160,471,300	5,176,494	0.67	157,321,832	5,074,898	0.70
Feb.	141,395,200	5,049,829	0.69	148,854,500	5,316,232	0.68	157,095,300	5,417,079	0.68	152,935,300	5,461,975	0.66	147,083,760	5,252,991	0.68	144,994,676	5,178,381	0.71
Mar.	157,063,700	5,066,571	0.70	166,286,600	5,364,084	0.69	168,837,500	5,446,371	0.68	171,302,600	5,525,890	0.67	160,389,300	5,173,848	0.67	156,144,085	5,036,906	0.69
Apr.	168,000,100	5,600,003	0.77	175,294,300	5,843,143	0.75	197,656,100	6,588,537	0.83	179,057,600	5,968,587	0.73	193,662,400	6,455,413	0.83	153,419,364	5,113,979	0.71
May	171,443,000	5,530,419	0.76	279,535,600	9,017,277	1.16	259,796,500	8,380,532	1.05	315,607,900	10,180,900	1.24	252,960,714	8,160,023	1.05	220,513,767	7,113,347	0.98
Jun.	244,557,300	8,151,910	1.12	364,263,500	12,142,117	1.56	385,701,900	12,856,730	1.62	353,139,300	11,771,310	1.43	334,356,006	11,145,200	1.43	227,425,464	7,580,849	1.05
Jul.	415,455,000	13,401,774	1.84	427,352,300	13,785,558	1.77	395,806,200	12,767,942	1.61	388,813,300	12,542,365	1.53	416,597,880	13,438,641	1.73	433,625,817	13,987,930	1.93
Aug.	402,573,700	12,986,248	1.78	297,201,400	9,587,142	1.23	396,113,500	12,777,855	1.61	418,401,600	13,496,826	1.64	358,348,395	11,559,626	1.49	365,234,732	11,781,766	1.62
Sep.	280,222,500	9,340,750	1.28	287,192,400	9,573,080	1.23	254,703,700	8,490,123	1.07	300,210,000	10,007,000	1.22	283,922,166	9,464,072	1.22	281,028,158	9,367,605	1.29
Oct.	185,090,200	5,970,652	0.82	204,768,400	6,605,432	0.85	194,836,000	6,285,032	0.79	221,498,400	7,145,110	0.87	217,547,851	7,017,673	0.90	203,778,146	6,573,489	0.91
Nov.	154,424,900	5,147,497	0.71	154,902,500	5,163,417	0.66	162,994,800	5,433,160	0.68	162,059,900	5,401,997	0.66	157,430,566	5,247,686	0.67	151,450,599	5,048,353	0.70
Dec.	175,949,500	5,675,790	0.78	164,371,000	5,302,290	0.68	169,493,500	5,467,532	0.69	164,531,600	5,307,471	0.65	156,032,568	5,033,309	0.65	152,516,218	4,919,878	0.68
TOTAL	2,655,880,300			2,838,368,900			2,910,949,100			2,998,050,000			2,838,802,906			2,647,452,858		
Average annual daily production (gpd)		7,276,384			7,776,353			7,953,413			8,213,836			7,777,542			7,253,296	
Average annual daily production (mgd)		7.28			7.78			7.95			8.21			7.78			7.25	
Average annual daily production (gpm)		5,053			5,400			5,523			5,704			5,401			5,037	
Maximum day (mgd)		16.31	2.24		16.51	2.12		16.88	2.12		16.36	1.99		15.62	2.01		17.26	2.38
Month when maximum day occurred		August			July			June			June			July			July	
Minimum day (mgd)		4.05	0.56		3.97	0.51		4.34	0.55		3.73	0.45		3.61	0.46		3.73	0.51
Month when minimum day occurred		December			December			January			December			December			March	

Appendix A: Well Production for Entire System - Continued

Klamath Falls Well Production for Entire System - Summary of Annual and Monthly Production from 1998 - 2007

Note: Units are in gallons unless otherwise indicated.

Month	FOR ENTIRE SYSTEM															
	2004			2005			2006			2007			Over 10 Year Period		Over Last 5 Year Period	
	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Total Production (Gallons)	Average Daily Production (gpd)	Ratio to Average Annual	Average Daily Production (gpd)	Ratio to Average Annual	Average Daily Production (gpd)	Ratio to Average Annual
Jan.	155,025,235	5,000,814	0.65	160,873,800	5,189,477	0.71	152,187,600	4,909,277	0.62	190,872,500	6,157,177	0.74	5,300,679	0.69	5,266,329	0.69
Feb.	143,664,415	4,953,945	0.65	139,697,500	4,989,196	0.68	142,130,900	5,076,104	0.64	177,792,600	6,349,736	0.77	5,304,547	0.69	5,309,472	0.69
Mar.	163,227,583	5,265,406	0.69	159,267,700	5,137,668	0.70	156,430,700	5,046,152	0.64	198,847,200	6,414,426	0.77	5,347,732	0.69	5,380,111	0.70
Apr.	203,827,800	6,794,260	0.89	159,506,700	5,316,890	0.73	155,718,900	5,190,630	0.66	222,375,600	7,412,520	0.89	6,028,396	0.78	5,965,656	0.78
May	264,642,900	8,536,868	1.11	185,934,800	5,997,897	0.82	268,513,600	8,661,729	1.09	312,906,900	10,093,771	1.22	8,167,276	1.06	8,080,722	1.05
Jun.	333,506,400	11,116,880	1.45	291,933,300	9,731,110	1.33	349,697,300	11,656,577	1.47	353,166,000	11,772,200	1.42	10,792,488	1.40	10,371,523	1.35
Jul.	387,760,000	12,508,387	1.63	422,091,200	13,615,845	1.86	424,546,900	13,695,061	1.73	400,307,000	12,913,129	1.56	13,265,663	1.72	13,344,071	1.74
Aug.	372,430,900	12,013,900	1.57	401,554,400	12,953,368	1.77	367,986,300	11,870,526	1.50	382,949,300	12,353,203	1.49	12,138,046	1.57	12,194,553	1.59
Sep.	273,607,700	9,120,257	1.19	266,099,100	8,869,970	1.21	304,935,800	10,164,527	1.28	283,233,900	9,441,130	1.14	9,383,851	1.21	9,392,698	1.22
Oct.	201,088,300	6,486,719	0.85	182,515,100	5,887,584	0.80	198,457,600	6,401,858	0.81	177,032,900	5,710,739	0.69	6,408,429	0.83	6,212,078	0.81
Nov.	152,376,400	5,079,213	0.66	145,576,600	4,852,553	0.66	178,382,400	5,946,080	0.75	164,677,000	5,489,233	0.66	5,280,919	0.68	5,283,087	0.69
Dec.	157,638,500	5,085,113	0.66	159,106,800	5,132,477	0.70	193,150,200	6,230,652	0.79	163,856,900	5,285,706	0.64	5,344,022	0.69	5,330,765	0.69
TOTAL	2,808,796,133			2,674,157,000			2,892,138,200			3,028,017,800			7,730,171		7,677,589	
Average annual daily production (gpd)		7,674,306			7,326,458			7,923,666			8,295,939		**7,730,171**		**7,677,589**	
Average annual daily production (mgd)		7.67			7.33			7.92			8.30		**7.73**		**7.68**	
Average annual daily production (gpm)		5,329			5,088			5,503			5,761		**5,368**		**5,332**	
Maximum day (mgd)		15.63	2.04		16.49	2.25		16.39	2.07		16.15	1.95	**16.36**	**2.12**	**16.39**	**2.13**
Month when maximum day occurred		July			July			June			July					
Minimum day (mgd)		3.93	0.51		3.88	0.53		3.64	0.46		4.01	0.48	3.89	**0.50**	3.84	**0.50**
Month when minimum day occurred		December			May			January			December					

Appendix B
Historic (2007) Consumption Data

Appendix B-1: 2007 Consumption Data for Total Annual Usage
Summary of 2007 Consumption Data - Klamath Falls Water System

Total Annual Gallons for the 11 Meter Reading Cycles by Service Size																	
Sum of Total Usage (Gallon)			**Cycle**												**Total Number**	**% of Total**	**% of Total**
Class	**I or O**	**Size**	1	2	3	4	5	6	7	8	9	10	11	Grand Total	**of Services**	**Usage**	**Services**
CM	I	0625	18,723,188	5,182,144	5,574,096	5,856,152		11,549,868	8,406,024	101,728	1,036,728	1,464,584	2,992	57,897,504	545	2%	3%
		1000	14,856,776	11,309,012	9,053,044	2,079,440		9,667,152	7,648,300	915,552	156,332	721,820		56,407,428	150	2%	1%
		1500	14,131,964	33,954,712	7,167,336	1,662,056		9,857,144	8,950,568	1,116,016		5,173,916		82,013,712	95	3%	1%
		2000	14,010,788	30,074,836	20,101,004	7,288,512	1,496	18,334,228	4,122,976	1,751,816		6,383,432		102,069,088	95	4%	1%
		3000	2,613,512	0	15,287,624	3,810,312		8,470,352	4,210,492			988,856		35,381,148	23	1%	0%
		4000	12,430,264		30,779,452	471,240						4,157,384		47,838,340	11	2%	0%
		6000	0			5,013,096		11,226,732				160,820		16,400,648	4	1%	0%
		8000				467,500								467,500	1	0%	0%
	I Total		**76,766,492**	**80,520,704**	**87,962,556**	**26,648,308**	**1,496**	**69,105,476**	**33,338,360**	**3,885,112**	**1,193,060**	**19,050,812**	**2,992**	**398,475,368**	**922**	**17%**	**6%**
	O	0625	160,072	77,792	363,528	14,212	1,871,496	1,525,172	21,311,268	7,257,096	276,760	5,679,564	2,883,540	41,420,500	236	2%	1%
		1000	605,880				175,780	4,469,300	12,790,052	3,496,900		2,863,344	1,753,312	26,154,568	66	1%	0%
		1500	819,060				3,061,564	1,964,996	8,872,028	6,826,996		8,566,844		30,111,488	32	1%	0%
		2000	1,750,320				2,288,880	908,072	9,646,956	10,003,004	3,631,540	130,152	5,777,552	34,136,476	32	1%	0%
		3000							2,647,920	5,707,988			702,372	9,058,280	6	0%	0%
		4000							15,798,508	1,676,268	23,958,440			41,433,216	4	2%	0%
		6000								1,211,760				1,211,760	1	0%	0%
		8000							1,813,152					1,813,152	1	0%	0%
	O Total		**3,335,332**	**77,792**	**363,528**	**14,212**	**7,397,720**	**8,867,540**	**72,879,884**	**36,180,012**	**27,866,740**	**17,239,904**	**11,116,776**	**185,339,440**	**377**	**8%**	**2%**
CM Total			**80,101,824**	**80,598,496**	**88,326,084**	**26,662,520**	**7,399,216**	**77,973,016**	**106,218,244**	**40,065,124**	**29,059,800**	**36,290,716**	**11,119,768**	**583,814,808**	**1,299**	**25%**	**8%**
MF	I	0625	7,318,432	3,466,980	1,528,912	7,205,484		5,998,212	67,320		145,112			25,730,452	131	1%	1%
		1000	4,085,576	3,104,200	2,829,684	6,247,296		8,002,104	2,572,372					26,841,232	89	1%	1%
		1500	6,215,880	8,505,508	699,380	2,025,584		1,564,068	2,986,764					21,997,184	21	1%	0%
		2000	1,784,728			1,914,880								3,699,608	3	0%	0%
		3000	1,496,000					8,565,348					5,069,944	15,131,292	4	1%	0%
		4000	3,597,880											3,597,880	1	0%	0%
		6000										1,777,248		1,777,248	1	0%	0%
	I Total		**24,498,496**	**15,076,688**	**5,057,976**	**17,393,244**		**24,129,732**	**5,626,456**		**145,112**	**1,777,248**	**5,069,944**	**98,774,896**	**250**	**4%**	**2%**
	O	0625					31,416	700,128	885,632	3,151,324		1,766,028	334,356	6,868,884	13	0%	0%
		1000					1,567,808	5,508,272	2,163,964	3,452,768	494,428	3,021,920	3,456,508	19,665,668	25	1%	0%
		1500	1,374,824				884,136	9,614,792		8,888,484				20,762,236	8	1%	0%
		2000	13,511,124				9,180,952		2,490,840	25,231,536	664,972	8,967,024	1,911,140	61,957,588	11	3%	0%
		3000					1,033,736	203,456		5,146,988	4,119,236			10,503,416	3	0%	0%
		6000								10,912,572			13,256,056	24,168,628	3	1%	0%
	O Total		**14,885,948**				**12,698,048**	**16,026,648**	**5,540,436**	**56,783,672**	**5,278,636**	**13,754,972**	**18,958,060**	**143,926,420**	**63**	**6%**	**0%**
MF Total			**39,384,444**	**15,076,688**	**5,057,976**	**17,393,244**	**12,698,048**	**40,156,380**	**11,166,892**	**56,783,672**	**5,423,748**	**15,532,220**	**24,028,004**	**242,701,316**	**314**	**10%**	**2%**
SF	I	0625	57,610,960	150,635,232	114,141,060	106,833,100	160,072	105,549,532	39,015,680	293,216	24,418,460	1,324,708	10,871,432	610,853,452	6,868	26%	42%
		1000	3,654,728	9,182,448	34,872,508	15,645,168		1,216,248	105,468	131,648		207,196		65,015,412	382	3%	2%
		1500	1,286,560	235,620	8,661,840	2,015,112			480,216					12,679,348	58	1%	0%
		2000		41,140	992,596	0		664,972				1,127,984		2,826,692	10	0%	0%
		3000			172,040									172,040	1	0%	0%
	I Total		62,552,248	160,094,440	158,840,044	124,493,380	160,072	107,430,752	39,601,364	424,864	24,418,460	2,659,888	10,871,432	691,546,944	7,320	29%	45%
	O	0625	24,045,956	2,018,852		6,688,616	137,931,200	52,247,800	64,904,708	171,671,984	54,001,112	137,665,660	187,404,668	838,580,556	7,264	35%	45%
		1000	801,108			425,612	7,776,956	507,144	1,904,408	3,264,272	5,236	2,512,532	2,737,680	19,934,948	86	1%	1%
		1500		302,192					264,044	917,048			31,416	1,514,700	6	0%	0%
		2000				705,364	93,500				481,712		83,776	1,364,352	6	0%	0%
	O Total		**24,847,064**	**2,321,044**		**7,819,592**	**145,801,656**	**52,754,944**	**67,073,160**	**175,853,304**	**54,488,060**	**140,178,192**	**190,257,540**	**861,394,556**	**7,361**	**36%**	**45%**
SF Total			87,399,312	162,415,484	158,840,044	132,312,972	145,961,728	160,185,696	106,674,524	176,278,168	78,906,520	142,838,080	201,128,972	1,552,941,500	14,681	65%	90%
Grand Total			206,885,580	258,090,668	252,224,104	176,368,736	166,058,992	278,315,092	224,059,660	273,126,964	113,390,068	194,661,016	236,276,744	2,379,457,624	16,294	100%	100%

Appendix B-1: 2007 Consumption Data for Total Annual Usage -- Continued
Summary of 2007 Consumption Data - Klamath Falls Water System

Total Annual Gallons for the 11 Meter Reading Cycles by Service Size																	
Sum of Total Usage (Gallon)			**Cycle**												**Total Number**	**% of Total**	**% of Total**
Class	**I or O**	**Size**	1	2	3	4	5	6	7	8	9	10	11	Grand Total	**of Services**	**Usage**	**Services**
CM	I + O	0625	18,883,260	5,259,936	5,937,624	5,870,364	1,871,496	13,075,040	29,717,292	7,358,824	1,313,488	7,144,148	2,886,532	99,318,004	781	4%	5%
		1000	15,462,656	11,309,012	9,053,044	2,079,440	175,780	14,136,452	20,438,352	4,412,452	156,332	3,585,164	1,753,312	82,561,996	216	3%	1%
		1500	14,951,024	33,954,712	7,167,336	1,662,056	3,061,564	11,822,140	17,822,596	7,943,012		13,740,760		112,125,200	126	5%	1%
		2000	15,761,108	30,074,836	20,101,004	7,288,512	2,290,376	19,242,300	13,769,932	11,754,820	3,631,540	6,513,584	5,777,552	136,205,564	127	6%	1%
		3000	2,613,512		15,287,624	3,810,312		8,470,352	6,858,412	5,707,988		988,856	702,372	44,439,428	28	2%	0%
		4000	12,430,264		30,779,452	471,240			15,798,508	1,676,268	23,958,440	4,157,384		89,271,556	15	4%	0%
		6000				5,013,096		11,226,732		1,211,760		160,820		17,612,408	5	1%	0%
		8000				467,500			1,813,152					2,280,652	2	0%	0%
CM Total I + O			80,101,824	80,598,496	88,326,084	26,662,520	7,399,216	77,973,016	106,218,244	40,065,124	29,059,800	36,290,716	11,119,768	583,814,808	1,299	25%	8%
MF	I + O	0625	7,318,432	3,466,980	1,528,912	7,205,484	31,416	6,698,340	952,952	3,151,324	145,112	1,766,028	334,356	32,599,336	144	1%	1%
		1000	4,085,576	3,104,200	2,829,684	6,247,296	1,567,808	13,510,376	4,736,336	3,452,768	494,428	3,021,920	3,456,508	46,506,900	113	2%	1%
		1500	7,590,704	8,505,508	699,380	2,025,584	884,136	11,178,860	2,986,764	8,888,484				42,759,420	29	2%	0%
		2000	15,295,852			1,914,880	9,180,952		2,490,840	25,231,536	664,972	8,967,024	1,911,140	65,657,196	15	3%	0%
		3000	1,496,000				1,033,736	8,768,804		5,146,988	4,119,236		5,069,944	25,634,708	7	1%	0%
		4000	3,597,880											3,597,880	1	0%	0%
		6000								10,912,572		1,777,248	13,256,056	25,945,876	4	1%	0%
MF Total I + O			**39,384,444**	**15,076,688**	**5,057,976**	**17,393,244**	**12,698,048**	**40,156,380**	**11,166,892**	**56,783,672**	**5,423,748**	**15,532,220**	**24,028,004**	**242,701,316**	**314**	**10%**	**2%**
SF	I + O	0625	81,656,916	152,654,084	114,141,060	113,521,716	138,091,272	157,797,332	103,920,388	171,965,200	78,419,572	138,990,368	198,276,100	1,449,434,008	14,133	61%	87%
		1000	4,455,836	9,182,448	34,872,508	16,070,780	7,776,956	1,723,392	2,009,876	3,395,920	5,236	2,719,728	2,737,680	84,950,360	468	4%	3%
		1500	1,286,560	537,812	8,661,840	2,015,112			744,260	917,048			31,416	14,194,048	63	1%	0%
		2000		41,140	992,596	705,364	93,500	664,972			481,712	1,127,984	83,776	4,191,044	16	0%	0%
		3000			172,040									172,040	1	0%	0%
SF Total I + O			**87,399,312**	**162,415,484**	**158,840,044**	**132,312,972**	**145,961,728**	**160,185,696**	**106,674,524**	**176,278,168**	**78,906,520**	**142,838,080**	**201,128,972**	**1,552,941,500**	**14,681**	**65%**	**90%**
Total CM + MF + SF (I + O)			**206,885,580**	**258,090,668**	**252,224,104**	**176,368,736**	**166,058,992**	**278,315,092**	**224,059,660**	**273,126,964**	**113,390,068**	**194,661,016**	**236,276,744**	**2,379,457,624**	**16,294**	**100%**	**100%**

NOTES: Classes: CM = Non-Residential (Commercial, Industrial, MF = Multiple Family Residential, SF = Single Family Residential.
I or O: I = Inside City; O= Outside City
Size: 0625 = 5/8-inch meter, 1000 = 1-inch meter, 1500 = 1.5 inch meter, 2000 = 2-inch meter, 3000 = 3-inch meter, 4000 = 4-inch meter, 6000 = 6-inch meter, 8000= 8-inch meter.

Appendix B-2: 2007 Consumption Data for Average Day Usage Per Service
Summary of 2007 Usage Per Service (gpd per service) - Klamath Falls Water System

Average Day Usage (gpd) per service for the 11 Meter Reading Cycles by Service Size																		
			Cycle											Total Annual Usage (gal)	Total Number of Services	Average Day Use Per Service (gpd)	% of Total Usage	% of Total Services
Class	I or O	Size	1	2	3	4	5	6	7	8	9	10	11					
CM	I	625	186	26	46	18	0	38	69	4	32	37	1	57,897,504	545	291	2%	3%
		1000	664	131	92	61	0	114	142	70	17	82	0	56,407,428	150	1,030	2%	1%
		1500	1,153	853	111	93	0	196	136	170	0	236	0	82,013,712	95	2,378	3%	1%
		2000	1,500	664	244	171	1	285	314	229	0	138	0	102,069,088	95	2,951	4%	1%
		3000	1,432	0	455	435	0	645	320	0	0	226	0	35,381,148	23	4,277	1%	0%
		4000	11,352	0	1,259	108	0	0	0	0	0	876	0	47,838,340	11	12,287	2%	0%
		6000	0	0	0	1,145	0	2,563	0	0	0	37	0	16,400,648	4	11,233	1%	0%
		8000	0	0	0	107	0	0	0	0	0	0	0	467,500	1	1,281	0%	0%
	I Total		**519**	**2,563**	**2,484**	**719**	**16**	**1,585**	**1,497**	**926**	**347**	**1,754**	**7**	**398,475,368**	**922**	**1,184**	**17%**	**6%**
	O	625	239	85	1,707	78	228	196	690	352	569	589	433	41,420,500	236	480	2%	1%
		1000	797	0	0	0	241	2,041	1,054	974	0	1,121	873	26,154,568	66	1,091	1%	0%
		1500	2,244	0	0	0	4,194	2,692	1,801	2,059	0	5,633	0	30,111,488	32	2,598	1%	0%
		2000	4,110	0	0	0	3,135	2,488	2,298	3,256	4,975	357	3,392	34,136,476	32	2,946	1%	0%
		3000	0	0	0	0	0	0	3,627	6,255	0	0	1,924	9,058,280	6	4,512	0%	0%
		4000	0	0	0	0	0	0	21,642	3,936	65,640	0	0	41,433,216	4	27,244	2%	0%
		6000	0	0	0	0	0	0	0	3,320	0	0	0	1,211,760	1	3,320	0%	0%
		8000	0	0	0	0	0	0	4,968	0	0	0	0	1,813,152	1	4,968	0%	0%
	O Total		**1,502**	**85**	**1,707**	**78**	**711**	**801**	**1,350**	**1,120**	**17,619**	**1,224**	**1,035**	**185,339,440**	**377**	**1,346**	**8%**	**2%**
CM Total			**534**	**2,493**	**2,480**	**716**	**705**	**1,427**	**1,393**	**1,098**	**5,790**	**1,455**	**996**	**583,814,808**	**1,300**	**1,231**	**25%**	**8%**
MF	I	625	459	348	644	649	0	913	42	0	398	0	0	25,730,452	131	537	1%	1%
		1000	746	646	694	1,223	0	835	783	0	0	0	0	26,841,232	89	830	1%	1%
		1500	2,838	11,651	1,916	2,775	0	3,955	909	0	0	0	0	21,997,184	21	2,858	1%	0%
		2000	2,173	0	0	5,246	0	0	0	0	0	0	0	3,699,608	3	3,119	0%	0%
		3000	3,513	0	0	0	0	12,243	0	0	0	0	13,890	15,131,292	4	10,152	1%	0%
		4000	9,857	0	0	0	0	0	0	0	0	0	0	3,597,880	1	9,857	0%	0%
		6000	0	0	0	0	0	0	0	0	0	4,869	0	1,777,248	1	4,869	0%	0%
	I Total		**972**	**972**	**742**	**1,005**	**0**	**1,399**	**688**	**0**	**398**	**4,869**	**13,890**	**98,774,896**	**250**	**1,081**	**4%**	**2%**
	O	625	0	0	0	0	1,033	1,918	1,213	1,233	0	4,838	523	6,868,884	13	1,466	0%	0%
		1000	0	0	0	0	2,148	4,894	5,473	3,784	1,355	1,380	1,033	19,665,668	25	2,170	1%	0%
		1500	3,767	0	0	0	2,076	6,585	0	11,689	0	0	0	20,762,236	8	6,895	1%	0%
		2000	37,017	0	0	0	25,153	0	6,824	13,380	1,562	24,567	5,236	61,957,588	11	14,978	3%	0%
		3000	0	0	0	0	2,832	6,689	0	14,101	11,286	0	0	10,503,416	3	9,333	0%	0%
		6000	0	0	0	0	0	0	0	14,949	0	0	33,524	24,168,628	3	21,475	1%	0%
	O Total		**20,392**	**0**	**0**	**0**	**6,627**	**5,377**	**3,717**	**7,877**	**4,567**	**4,711**	**3,995**	**143,926,420**	**63**	**6,218**	**6%**	**0%**
MF Total			**1,518**	**972**	**742**	**1,005**	**6,627**	**1,985**	**1,154**	**7,877**	**3,566**	**4,728**	**4,702**	**242,701,316**	**314**	**2,119**	**10%**	**2%**
SF	I	625	197	242	256	206	292	314	266	402	212	199	496	610,853,452	6,868	244	26%	42%
		1000	306	469	444	649	0	320	289	361	0	284	0	65,015,412	382	466	3%	2%
		1500	445	323	585	895	0	0	1,316	0	0	0	0	12,679,348	58	602	1%	0%
		2000	0	85	725	0	0	911	0	0	0	1,030	0	2,826,692	10	762	0%	0%
		3000	0	0	404	0	0	0	0	0	0	0	0	172,040	1	404	0%	0%
	I Total		**203**	**248**	**294**	**229**	**292**	**316**	**269**	**388**	**212**	**312**	**496**	**691,546,944**	**7,320**	**259**	**29%**	**45%**
	O	625	280	309	0	376	362	269	277	294	326	335	328	838,580,556	7,264	316	35%	45%
		1000	439	0	0	583	545	463	870	813	14	626	978	19,934,948	86	637	1%	1%
		1500	0	828	0	0	0	0	723	914	0	0	86	1,514,700	6	722	0%	0%
		2000	0	0	0	828	220	0	0	0	1,320	0	197	1,364,352	6	660	0%	0%
	O Total		**283**	**336**	**0**	**404**	**369**	**270**	**283**	**299**	**328**	**338**	**331**	**861,394,556**	**7,361**	**321**	**36%**	**45%**
SF Total			**221**	**249**	**294**	**235**	**369**	**299**	**278**	**299**	**280**	**337**	**337**	**1,552,941,500**	**14,681**	**290**	**65%**	**90%**
Grand Total			362	369	433	285	407	456	476	431	394	431	385	**2,379,457,624**	**16,294**	**400**	**100%**	**100%**

Appendix B-2: 2007 Consumption Data for Average Day Usage Per Service -- Continued
Summary of 2007 Usage Per Service (gpd per service) - Klamath Falls Water System

Average Day Usage (gpd) per service for the 11 Meter Reading Cycles by Service Size																		
			Cycle											Total for All Cycles	Total Number of Services	Average Use Per Service (gpd)	% of Total Usage	% of Total Services
Class	**I or O**	**Size**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**					
CM	I + O	625	186	297	576	213	228	393	725	326	415	551	407	99,318,004	781	348	4%	5%
		1,000	668	1,575	1,102	727	241	1,529	1,228	942	206	1,091	873	82,561,996	216	1,048	3%	1%
		1,500	1,184	10,241	1,331	1,115	4,194	2,399	1,713	2,056	0	4,107	0	112,125,200	126	2,433	5%	1%
		2,000	1,614	7,974	2,924	2,048	3,138	3,365	2,602	3,168	4,975	1,541	3,392	136,205,564	127	2,950	6%	1%
		3,000	1,432	0	5,463	5,220	0	7,735	3,758	6,255	0	2,709	1,924	44,439,428	28	4,323	2%	0%
		4,000	11,352	0	15,103	1,291	0	0	21,642	3,936	65,640	10,514	0	89,271,556	15	16,489	4%	0%
		6,000	0	0	0	13,735	0	30,758	0	3,320	0	441	0	17,612,408	5	9,651	1%	0%
		8,000	0	0	0	1,281	0	0	4,968	0	0	0	0	2,280,652	2	3,124	0%	0%
CM Total I + O			**534**	**2,493**	**2,480**	**716**	**711**	**1,427**	**1,393**	**1,098**	**5,790**	**1,455**	**996**	**583,814,808**	**1,300**	**1,231**	**25%**	**8%**
MF	I + O	625	459	348	644	649	0	966	407	1,233	398	4,838	523	32,599,336	144	620	1%	1%
		1,000	746	646	694	1,223	2,148	1,262	1,287	3,784	1,355	1,380	1,033	46,506,900	113	1,123	2%	1%
		1,500	2,971	11,651	1,916	2,775	2,076	6,025	909	11,689	0	0	0	42,759,420	29	3,994	2%	0%
		2,000	12,894	0	0	5,246	25,153	0	6,824	13,380	1,562	24,567	5,236	65,657,196	15	12,335	3%	0%
		3,000	3,513	0	0	0	2,832	12,534	0	14,101	11,286	0	13,890	25,634,708	7	9,800	1%	0%
		4,000	9,857	0	0	0	0	0	0	0	0	0	0	3,597,880	1	9,857	0%	0%
		6,000	0	0	0	0	0	0	0	14,949	0	4,869	33,524	25,945,876	4	17,408	1%	0%
MF Total I + O			**1,518**	**972**	**742**	**1,005**	**6,733**	**1,988**	**1,154**	**7,877**	**3,566**	**4,728**	**4,702**	**242,701,316**	**314**	**2,119**	**10%**	**2%**
SF	I + O	625	215	242	256	212	362	298	273	294	279	333	334	1,449,434,008	14,133	281	61%	87%
		1,000	323	469	444	647	545	352	787	775	14	573	978	84,950,360	468	497	4%	3%
		1,500	445	491	585	895	0	0	1,020	914	0	0	86	14,194,048	63	613	1%	0%
		2,000	0	85	725	828	220	911	0	0	1,320	1,030	197	4,191,044	16	725	0%	0%
		3,000	0	0	404	0	0	0	0	0	0	0	0	172,040	1	404	0%	0%
SF Total I + O			**221**	**249**	**294**	**235**	**369**	**299**	**278**	**299**	**280**	**337**	**337**	**1,552,941,500**	**14,681**	**290**	**65%**	**90%**
Total CM + MF + SF (I + O)			**362**	**369**	**433**	**285**	**407**	**456**	**476**	**431**	**394**	**431**	**385**	**2,379,457,624**	**16,294**	**400**	**100%**	**100%**

NOTES:

Classes: CM = Non-Residential (Commercial, Industrial, MF = Multiple Family Residential, SF = Single Family Residential.

I or O: I = Inside City; O= Outside City

Size: 0625 = 5/8-inch meter, 1000 = 1-inch meter, 1500 = 1.5 inch meter, 2000 = 2-inch meter, 3000 = 3-inch meter, 4000 = 4-inch meter, 6000 = 6-inch meter, 8000= 8-inch meter.

Appendix B-3: 2007 Data for Number of Meters
Summary of 2007 Number of Meters - Klamath Falls Water System

Number of Meters for the 11 Meter Reading Cycles by Service Size														
			Cycle											
Class	**I or O**	**Size**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Grand Total**
CM	I	625	276	46	28	75		70	28	5	7	9	1	545
		1000	61	20	23	8		19	12	3	2	2		150
		1500	34	9	15	4		12	15	2		5		95
		2000	26	10	19	10		15	3	2		11		95
		3000	5	1	8	2		3	3			1		23
		4000	3		6	1						1		11
		6000	1			1		1				1		4
		8000				1								1
	I Total		**405**	**86**	**97**	**102**		**119**	**61**	**12**	**9**	**30**	**1**	**922**
	O	625	2	3	1	1	23	21	85	57	1	26	18	236
		1000	2				2	6	33	10		7	6	66
		1500	1				2	2	14	9		4		32
		2000	1				2	1	12	8	2	1	5	32
		3000							2	3			1	6
		4000							2	1	1			4
		6000								1				1
		8000							1					1
	O Total		**6**	**3**	**1**	**1**	**29**	**30**	**148**	**89**	**4**	**39**	**29**	**377**
CM Total			**411**	**89**	**98**	**102**	**29**	**150**	**209**	**100**	**14**	**68**	**31**	**1299**
MF	I	625	44	27	7	30		18	4		1			131
		1000	15	13	11	14		26	9					89
		1500	6	2	1	2		1	9					21
		2000	2			1								3
		3000	1					2					1	4
		4000	1											1
		6000										1		1
	I Total		**69**	**43**	**19**	**47**		**47**	**22**		**1**	**1**	**1**	**250**
	O	625						1	2	7		1	2	13
		1000					2	3	1	3	1	6	9	25
		1500	1				1	4		2				8
		2000	1				1		1	5	1	1	1	11
		3000					1			1	1			3
		4000												
		6000								2			1	3
	O Total		**2**				**5**	**8**	**4**	**20**	**3**	**8**	**13**	**63**
MF Total			**71**	**43**	**19**	**47**	**5**	**55**	**27**	**20**	**4**	**9**	**14**	**314**
SF	I	625	803	1708	1219	1419	2	920	402	2	315	18	60	6868
		1000	33	54	215	66		10	1	1		2		382
		1500	8	2	41	6			1					58
		2000		1	4			2				3		10
		3000			1									1
	I Total		**844**	**1765**	**1480**	**1492**	**2**	**932**	**404**	**3**	**315**	**23**	**60**	**7319**
	O	625	235	18		49	1043	533	642	1599	453	1126	1567	7264
		1000	5			2	39	3	6	11	1	11	8	86
		1500		1					1	3			1	6
		2000				2	1				1		1	6
		3000												
	O Total		**240**	**19**		**53**	**1083**	**536**	**649**	**1612**	**455**	**1137**	**1576**	**7361**
SF Total			**1084**	**1784**	**1480**	**1545**	**1085**	**1468**	**1053**	**1615**	**771**	**1160**	**1636**	**14681**
Grand Total			**1566**	**1915**	**1596**	**1694**	**1119**	**1673**	**1288**	**1735**	**789**	**1237**	**1681**	**16294**
			Cycle											
Class	**I or O**	**Size**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total for All Cycles**
CM	I + O	625	278	49	28	75	23	91	112	62	9	36	19	781
		1,000	63	20	23	8	2	25	46	13	2	9	6	216
		1,500	35	9	15	4	2	14	29	11		9		126
		2,000	27	10	19	10	2	16	15	10	2	12	5	126
		3,000	5	1	8	2		3	5	3		1	1	28
		4,000	3		6	1			2	1	1	1		15
		6,000	1			1		1		1		1		5
		8,000				1			1					2
CM Total	**I + O**		**411**	**89**	**98**	**102**	**29**	**150**	**209**	**100**	**14**	**68**	**31**	**1299**
MF	I + O	625	44	27	7	30	0	19	6	7	1	1	2	144
		1,000	15	13	11	14	2	29	10	3	1	6	9	113
		1,500	7	2	1	2	1	5	9	2	0	0	0	29
		2,000	3	0	0	1	1	0	1	5	1	1	1	15
		3,000	1	0	0	0	1	2	0	1	1	0	1	7
		4,000	1	0	0	0	0	0	0	0	0	0	0	1
		6,000	0	0	0	0	0	0	0	2	0	1	1	4
MF Total	**I + O**		**71**	**43**	**19**	**47**	**5**	**55**	**27**	**20**	**4**	**9**	**14**	**314**
SF	I + O	625	1038	1726	1219	1468	1045	1452	1044	1601	769	1144	1627	14133
		1000	38	54	215	68	39	13	7	12	1	13	8	468
		1500	8	3	41	6	0	0	2	3	0	0	1	63
		2000	0	1	4	2	1	2	0	0	1	3	1	16
		3000	0	0	1	0	0	0	0	0	0	0	0	1
SF Total	**I + O**		**1084**	**1784**	**1480**	**1545**	**1085**	**1468**	**1053**	**1615**	**771**	**1160**	**1636**	**14681**
Total CM+MF+SF (I+O)			**1566**	**1915**	**1596**	**1694**	**1119**	**1673**	**1288**	**1735**	**789**	**1237**	**1681**	**16294**

NOTES: Classes: CM = Non-Residential (Commercial, Industrial), MF = Multiple Family Residential, SF = Single Family Residential.

I or O: I = Inside City; O= Outside City

Size: 625 = 5/8-inch meter, 1000 = 1-inch meter, 1500 = 1.5 inch meter, 2000 = 2-inch meter, 3000 = 3-inch meter, 4000 = 4-inch meter, 6000 = 6-inch meter, 8000= 8-inch meter.

Appendix C
Hydraulic Model
Calibration and Verification

Appendix C
Hydraulic Model
Calibration and Verification

Appendix C provides an overview of the hydraulic model used for this master plan update, and describes the model calibration and model verification conducted as part of this update.

Overview of Hydraulic Model

For this master plan update, the City's H_2ONET model of the water distribution system from the 2004 Plan was converted to InfoWater software that works within an ESRI ARC-GIS environment. The hydraulic model is a tool to represent the City's water distribution system and simulate its performance under various demand conditions. Model simulations are done to identify deficiencies and determine recommended improvements for both the existing system and future expansion.

The converted InfoWater model was checked to assure that all model elements were successfully converted into the proper formats. The converted model was then updated to reflect recent or planned improvements not already included, and facility settings and pump curves were reviewed and updated as needed. Locations for future facilities were also reviewed and updated. CDM worked closely with City staff to obtain the information to update the model.

The updated model includes the following facilities:

- **Pipes –** All existing pipes that are 6 inches and greater in diameter are included in the model. Many, although not all, existing pipes less than 6 inches are also included. For this update, the modeled pipes in the 2004 hydraulic model were checked against the City's legacy maps and recent improvement plans, and about 900 additional pipes were added to the model. The modeled pipes were geo-referenced to the City's GIS base mapping; and pipe diameters and materials were checked against the legacy maps. The model automatically calculates pipe length based on the digitized length of the pipe. CDM reviewed the pipe roughness factors (C-factors) used in the previous model for reasonableness. Some adjustments were made to the C-factors as discussed later in this appendix under the Model Calibration section.
- **Nodes (Junctions) –** Ground elevations at nodes were obtained from the City's 2-foot contour maps.
- **Pumps –** The model includes all existing City-owned pump stations, except for some very small in-line booster pumps serving very small, localized areas. Privately owned boosters are not included in the model. Some pumps are modeled as 3-point curves and some as design point curves based on information provided by City staff.

- **Reservoirs –** The model includes all existing reservoirs serving the City's system. The reservoirs are modeled as cylindrical tanks with diameter, floor elevation, initial level and maximum level. The City provided the reservoir elevation information.
- **Pressure Reducing Valves –** The model includes all existing pressure reducing valves serving the City's system. The City provided information on the PRV settings and the number and size of valves.
- **Wells –** The model includes all existing City-owned groundwater wells. The well pumps are modeled using design point curves. The City provided information on the well pump flows, discharge pressure, groundwater level with pumps operating, and the elevation of centerline of the pump. The total dynamic head (TDH) was computed by adding the depth to ground water measured from the centerline of the pump to the measured discharge head. The well pumps were modeled as design point (one-point) curves using this information. With the design point curve, the pump flow rate varies in response to system operating conditions. If modeled as an injected flow, the pump produces a single flow rate that might over-pressurize the system under certain operating conditions**.** Homedale Well was the only well modeled as an injected flow, as no information was available**.**

Section 3 of the Master Plan Report contains detailed information on the existing water system facilities.

In addition to the existing facilities, the model includes future pipeline alignments and conceptual locations for future wells, pump stations and reservoirs identified during the water system analysis. Future facilities are separately flagged to allow easy identification of future facilities and set-up of future scenarios.

Model demands were updated based on the revised demand projections developed for the master plan update. Allocation of demands to hydraulic model nodes used a Geographic Information System (GIS) approach with the ArcInfo software program to distribute demands spatially throughout the system based on land uses. Existing, intermediate and buildout demands were allocated to the model nodes. The demand allocation procedure included the following steps:

- Excluded nodes from the demand allocation process at locations where there are no customer service connections. Such locations include nodes at high elevations near the reservoirs, nodes at the suction and discharge side of pump stations, and nodes at the upstream and downstream sides of valve stations.
- Delineated the boundary for each pressure zone.
- Used the Thiessen polygon method to allocate demands within each pressure zone. The Thiessen polygon method draws a polygon around each node so that the polygon boundaries are equidistant from adjacent nodes.
- Used GIS tools to intersect the Thiessen polygons with the land uses within each polygon to determine the area of each land use type served by node.

- Calculated the demands by node, by multiplying the unit demand factors with the area of each land use type allocated to that node, and then summing all the demands.
- Added large user demands to nodes after subtracting the initial demand computed from land use to avoid double counting demands.
- Added future demands for customers outside the Urban Growth Boundary at the appropriate nodes for the intermediate and ultimate scenarios.

As described below, the model was calibrated to adjust the model to more closely simulate actual pressures observed during hydrant testing and to evaluate whether the model reasonably simulates the actual system operation. In addition, model verification was conducted for a recent maximum demand day, where model results are compared with the actual (observed) system data. If the model is reasonably accurate, modeled reservoir levels should track actual (observed) levels, and modeled pump station flows and suction and discharge pressures should match actual (observed) flows and pressures. These evaluations were key elements of the master plan study since the model is used to determine the size and location of water system improvement projects. As described below, the overall calibration and verification results indicate that the model is a reasonable representation of the City's system, and can be used to predict system performance.

Model Calibration

This section of the appendix describes the model calibration conducted as part of the master plan update. As described below, the overall calibration results indicate that the model is a reasonable representation of the system, and can be used to predict system performance.

Hydrant Test Locations

In the 2004 Water Master Plan (2004 Plan), thirty-three hydrant tests were performed across the system to calibrate the hydraulic model. The purpose of the model calibration was to adjust the model to more closely simulate actual pressures observed during hydrant testing. The results of the calibration conducted for the 2004 Plan are described in Appendix C of the 2004 report. For this 2009 master plan update, the City provided hydrant test data that was collected since the 2004 Plan for CDM to select additional locations to cover areas that were not evaluated in the previous plan.

Five additional hydrant tests were selected and used to calibrate the hydraulic model in this 2009 Update. These tests were conducted between June 2006 and July 2008. The City re-tested one location in May 2009 to provide additional information for the calibration.

This appendix discusses the model calibration using these additional five hydrant tests. Figure 1 shows the five additional test locations for this update, and the previous locations of the hydrant tests that were used for the 2004 Plan.

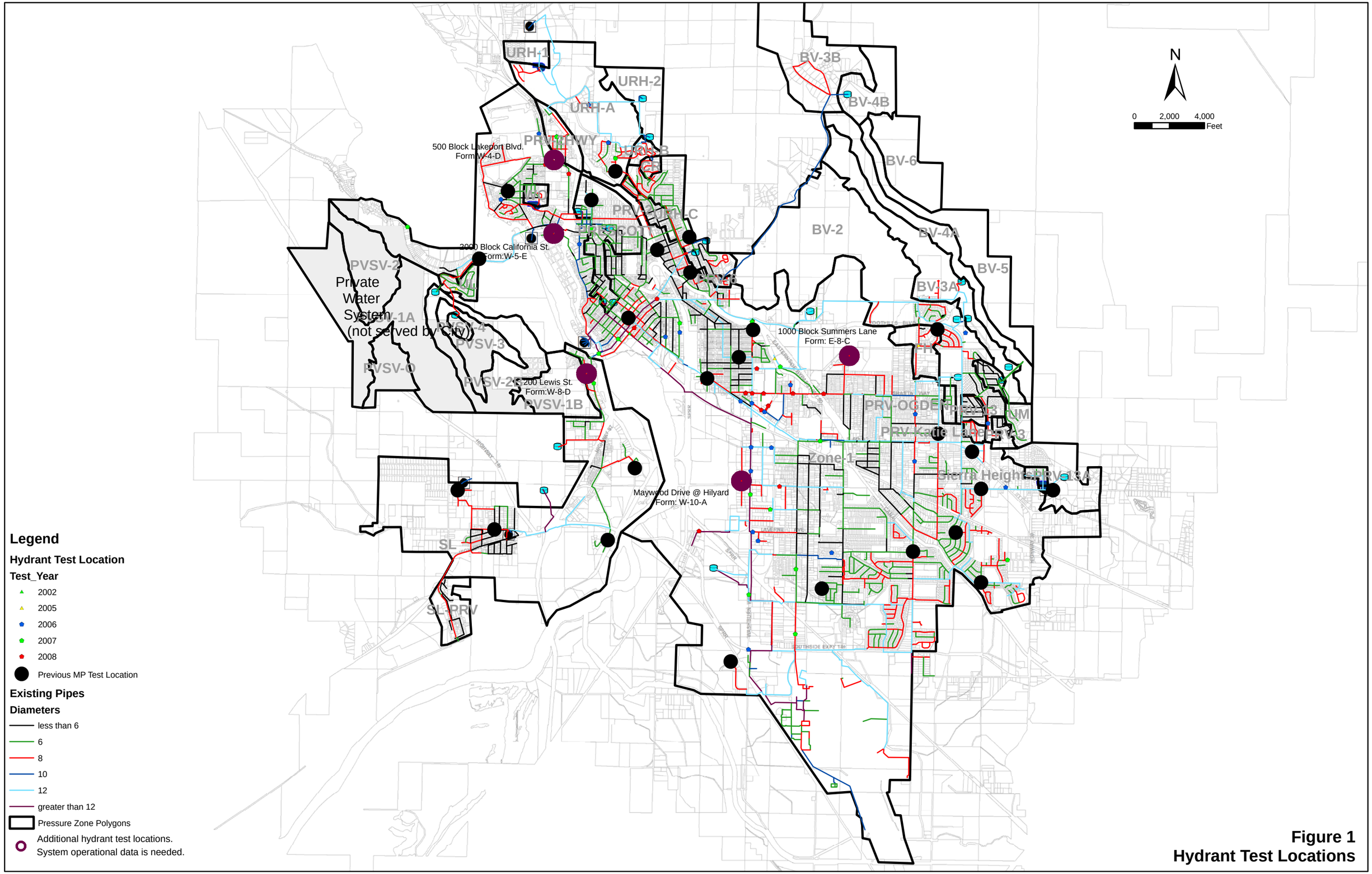


Figure 1
Hydrant Test Locations

Hydrant Test Procedure

At each of the test locations for this update, one hydrant was selected as the flow hydrant, and one nearby hydrant was selected to measure residual pressures. The static pressure was first recorded at both hydrants, then the flow hydrant was opened and the flowrate out of the hydrant was measured. While the flow hydrant was open, the pressure at the observation hydrant was also recorded. City staff typically used a pitot pressure gage with an instrument-specific chart that relates flowrate to pitot pressure.

Typically, the observation hydrant is several hundred feet away from the flow hydrant. The observed pressure drop at the observation hydrant during the test is related to the diameter and roughness of the pipes in the vicinity of the tested hydrant. This relationship is the basis for the adjustments in roughness values made during model calibration.

Model Input for Calibration

The City provided CDM with the hydrant test data, as well as system data at the time of the tests. The data indicated the nearby reservoir levels, pump and well on/off status, and the pressure regulating station settings. This information was used to setup the hydraulic model for calibration. Table 1 presents the demand calculated for each hydrant test.

Table 1
Summary of Calibration Demand Data

Run No.	Pressure Zone	*Test Location*	Time	Date	Total Daily Production	Daily Demand Factor	Diurnal Factor	Total Demand Factor	Total Demand at Time of Test
1	Zone 1	Maywood Dr. at Hilyard Ave.	1:10 PM	7/10/2008	15.05	1.66	0.70	1.16	10.54
2	Zone 1	1000 Block of Summers Ln.	10:15 AM	1/9/2008	5.20	0.57	1.00	0.57	5.20
3	Lindley	200 Block of Lewis St.	7:00 AM	5/28/2009 (2nd test)	5.13	0.57	0.90	0.51	4.61
4	Prescott	500 Block of Lakeport Blvd.	1:30 PM	6/2/2006	7.15	0.79	0.70	0.55	5.01
5	Zone 1	2000 Block of California St.	2:39 PM	5/20/2008	8.50	0.94	0.80	0.75	6.80

Calibration Method

One model calibration scenario was set up with 10 steps to simulate the 5 hydrant tests (each hydrant test comprised two time steps of the model run). The first time step of each hydrant test represented static conditions before the hydrant was turned on. The second time step represented residual conditions when the hydrant was flowing. The model average daily demands were adjusted to match daily production for each test day.

For each hydrant test (or every two time steps), system demands, relevant pump operations and relevant tank levels were set to represent conditions at the time of the hydrant test. The appropriate multiplier from the diurnal curve was used to simulate the demands at the time of each hydrant test.

For static conditions, model results were compared with operating data to make sure results were consistent with observations. For example, model results were reviewed to make sure pump discharge pressures were consistent with system data.

Modeled static pressures were also compared with actual (observed) static (pre-test) pressures. These comparisons, however, were not used for calibration purposes because, under low flow conditions, modifying roughness values does not produce a large change in static pressure. An error in static pressure is most likely due to another source, such as errors in ground elevation. In the 2004 Water Master Plan, modeled ground elevations were assigned using a Digital Elevation Model (DEM) derived from USGS topographic maps. For this Water Master Plan Update, node elevations were derived from the 2-foot contour maps that the City provided.

Once model results were checked, the difference in pressure between the two runs (non-flowing hydrant and flowing hydrant) was compared with the pressure drop observed during hydrant testing at the observation hydrant. By comparing the pressure drop rather than modeled and measured pressures, potential errors due to incorrect model elevations were eliminated. The analysis focused on the pressure drops at the observation hydrants due to the potential error in measurements that might have been introduced as a result of the high velocities at the fire flow hydrants.

The calibration process consisted of adjusting pipe roughness values until the difference between observed and modeled pressure drops at the observation hydrants reached a minimum or acceptably low value. The model was considered to be calibrated when the modeled pressure drop was within +/- 5 psi of observed pressure drops at the observation hydrants. This is the criterion recommended by the AWWA Engineering Computer Applications Committee for calibration of models used for

planning applications.[1] Generally, roughness factor adjustments were made to groups of pipes based on pipe material and diameter.

For locations with significant differences between modeled and observed pressures, the following steps were taken to investigate the source of differences:

1) Elevation verification - checked node elevations in the model.
2) Geometric verification – checked for missing pipes or incorrect diameters in the model. An efficient checking method was to create a hydraulic grade line (HGL) profile across the system from the source of supply to the hydrant test location, and then visually inspect the HGL profile for sharp drops that usually indicate hydraulic constraints.
3) If the pressure difference was still significant after conducting the above two steps, then investigated the distribution of supply from tanks and/or well pumps and whether the results may have been affected by the way these sources are modeled. For example, modeled 1-point design curves for well pumps may not have accurately simulated the range of flow conditions, and may have either over or under estimated the relative contribution of flows from wells and tanks. The relative contribution of supply from the various sources significantly may affect headlosses in the system.

If the pressure difference was still significant after conducting the above step, the distribution of supply from pumps was then investigated, to see whether the results may have been affected by the way these sources are modeled. The relative contribution of supply from the various sources may significantly affect headloss in the system.

Calibration Results

During the calibration process, revisions were made to the model as needed in order to correct geometric anomalies in the modeled system, and adjust the pipe roughness factors to reasonable values. City staff assisted in the checking and verification of revisions needed to the modeled facilities. In the downtown area, adding smaller diameter pipes to the model made a significant difference in modeled pressures at some locations. The pipes were added to the model using the detailed "Legacy" map provided by the City. With the added pipes, the modeled pressures more closely matched the observed pressures.

Table 2 summarizes results from the calibration analysis after all adjustments were made to the model. It shows the observed flows and pressures, the modeled pressures, and the observed and modeled drops in pressure between static conditions and hydrant flow conditions. Differences between observed and modeled pressures

[1] AWWA Engineering Computer Applications Committee, 1999."Calibration Guidelines for Water Distribution System Modeling." 1999 AWWA Information Management Technology Conference Proceedings.

Table 2
Summary of Calibration Results

Run No.	Pressure Zone	Test Location	Time	Date	Opened Hydrants				Residual Hydrants								Comments
					Field Data		Model Data	Difference Between Observed and Modeled Pressures (psi)	Field Data			Modeled Results			Difference Between Observed and Modeled Pressure Drops (psi)	Difference Between Observed and Modeled Residual Pressures (psi)	
					Static Pressure (psi)	Observed Flows (gpm)	Modeled Static Pressure (psi)		Observed Static Pressure (psi)	Observed Residual Pressure (psi)	Observed Pressure Drop (psi)	Modeled Static Pressure (psi)	Modeled Residual Pressure (psi)	Modeled Pressure Drop (psi)			
1	Zone 1	Maywood Dr. at Hilyard Ave.	1:10 PM	7/10/2008	75	1814	75	0	75	56	19	75	61	14	5	-5	C-values adjustments did not significantly change results
2	Zone 1	1000 Block of Summers Ln.	10:15 AM	1/9/2008	68	1553	71	-3	67	32	35	67	31	36	-1	1	
3	Lindley	200 Block of Lewis St.	7:00 AM	5/28/2009 (second test)	81	1147	80	1	73	16	57	69	10	59	-2	6	
4	Prescott	500 Block of Lakeport Blvd.	1:30 PM	6/2/2006	87	2094	97	-10	90	71	19	98	76	22	-3	-5	Adjusted AC pipes C-values lower
5	Zone 1	2000 Block of California St.	2:39 PM	5/20/2008	70	1047	67	3	68	57	11	64	50	13	-2	7	Adjusted Cast Iron pipes C-values lower

drops and observed and modeled residual pressures are shown in the right columns. At all five locations, differences between observed and modeled pressure drops were 5 psi or less.

Recommended Roughness Factors

For each calibration location, adjustments to pipe roughness were compiled taking into account the material and estimated age. Overall pipe roughness factors were formulated after evaluating all results.

Table 3 summarizes the overall resulting roughness values for use in the master plan study. These values are based on the calibration analysis, and are also within the reasonable ranges typically specified in standard references. For planning purposes, relatively conservative values in the mid part of the standard ranges were selected to provide a factor of safety for aging of pipes over time.

The cast iron pipes in the City's system seem to be in good condition, so a C-value of up to 120 is reasonable. Although there was not enough data to adjust the C-values for the steel pipes, standard references typically show lower C-values for smaller diameter steel pipes than cast iron pipes. Therefore, steel pipes were assigned somewhat lower C-values than cast iron.

Table 3
Recommended Pipeline Roughness Factors
Formulated by Model Calibration

C	Material	Size	Age
115-120	DIP	< 16"	1920-1950
120-130	DIP	16" and up	1920-1950
110	CIP	<12"	1940-1950
120	CIP	12" and up	1920-1950
100	STEEL	<6"	1940-1970
110	STEEL	6 – 12"	1920-1950
120-125	ACP	All	1930-1985
130	PVC	All	1950's on

Overall Calibration Findings

Overall, the model is predicting reasonable results and can be used to predict system performance under future demand conditions. The overall calibration results based on the available data indicate that the model is a reasonable representation of the system. The modeled results for both pressure drop and residual pressure were within 5 psi or less of the observed pressures for five out of five test locations.

Model Verification

This section of the appendix describes the model verification conducted as part of the master plan update. The calibrated hydraulic model was used for the verification analysis. To verify the validity of the calibrated model, CDM simulated historic operating conditions on the following day using system data provided by the City of Klamath Falls (City): Maximum demand day of August 15, 2008.

The results of the maximum day verification are described below. The maximum demand day is the most important period for verification, since it is typically the period for which hydraulic stresses are highest under normal operating conditions. The maximum demand day is the basis for determining required facility capacities.

As described below, the maximum day verification evaluation indicates that the calibrated model provides a reasonable representation of the system performance under high demand conditions, which is the most stressful for the system and the basis for facilities sizing.

Purpose of Model Verification

The model verification process refines the model and its ability to mimic system behavior over a longer period of time. Model verification is required for the extended period simulation (EPS) that is part of the master plan scope. The EPS indicates how the system performs over a 24-hour period, how reservoirs are filling and draining, and how pumps are operating.

For the model verification, model results are compared with the actual (observed) system data. If the model is reasonably accurate, modeled reservoir levels should track actual (observed) levels, and modeled pump station flows and suction and discharge pressures should match actual (observed) flows and pressures.

To perform the model verification, the City provided detailed information on the runtime status for the booster pumps and well pumps, as well as reservoir levels. The runtime status along with pump design flow was used to calculate the hourly inflow and outflow of the pressure zone. The zone demand was calculated on hourly basis for each zone using a water balance approach (inflow – outflow – change in storage = demand). The demand data was used to create a diurnal curve for each zone, and to develop maximum day/ average day demand multipliers. The model was set up to reproduce both observed demands and operating conditions (pump starts/stops).

Model results were reviewed to determine how well the model predicts zone operations (pump station flows, suction and discharge pressures, and reservoir levels). Similarly, if pump station flow, suction and discharge pressure information is available, the pump total dynamic head and flow, based on measurements, can be compared with pump performance in the model, and model results adjusted to get the best fit of actual pump performance conditions.

Input Data for Verification Run

City of Klamath Falls provided system data for the selected verification day for CDM's use in the verification. This field data was used as follows:

- Electronic files of SCADA data indicating reservoir levels at thirty minute intervals.
- Electronic files of SCADA data indicating booster pump operation (On/Off) at ten minute intervals.
- Electronic files of SCADA data indicating well pump operation (On/Off) at ten minute intervals.
- Design information of pumps stations including number of pumps and pump design points. The City does not have pressure and flow data on SCADA for many pumps; therefore the model relies on design curves or design points in many cases.
- Design information of reservoirs including height, diameter, elevation, and total volume.

The daily demand was calculated as 16.3 mgd using the SCADA data provided by the City. The calculations were based on well runtime and well pump design point as well as the contribution from the storage tanks in the system, in order to determine the daily system demand for the selected August 15, 2008 verification day.

Verification Methods

A 24-hour simulation was set up to represent the actual maximum day conditions using the system data provided by the City. Available reservoir level trends were used as the basis of comparison. The verification analysis evaluated whether the modeled results generally tracked the observed system performance trends in the field data.

Reservoir level data was provided for all the tanks. The SCADA data points were used for comparison to determine how well the modeled reservoir levels matched those measured in the field. The general trend of a reservoir was considered to match field data if the data matched in the following three ways:

- Reservoir levels throughout the 24-hour period in the model correspond to levels in measured in the field;
- Filling and drafting trends in the model are consistent with measured trends; and
- Upper and lower water levels in the model correspond to measured upper and lower levels.

The recorded pump operation and reservoir levels were used to develop diurnal curves for this day. Attachment 1 provides diurnal curves for maximum day demand (August 15, 2008) of Zone 1, Prescott, Patterson, Uhrmann/Hospital, Lindley/Stewart-Lenox, Upper Lynnewood, and Tanglewood Zones/Subzones. The average demand for this day was 16.3 mgd.

Verification Results

The maximum day verification run with the available system data indicate that the calibrated model provides a reasonable representation of the system performance under high demand conditions, which is the most stressful for the system and the basis for facilities sizing. The evaluations consisted of comparing reservoir levels and cycling trends for consistency with operating data. Attachment 2 provides plots for the maximum day verification results showing hourly modeled and measured water level at each reservoir.

Zone 1 Results

Zone 1 is the largest zone in the system and mainly served by Conger Well Field. It extends as far south as the Airport and as far north as west of the Merle West Medical Center. Its demand represents 78% of the total system demands. Due to its large size, Zone 1 under maximum day demand conditions is hydraulically divided into four subzones: 1) Washburn which is served by Washburn Booster Station and includes Bowen Tank; 2) South 6th which is served by South 6th and Dayton booster stations, and includes Ogden and Hilyard tanks; 3) Central which is directly served by Conger Well Field and includes Center and Melrose tanks; and 4) North which is supplied by Conger 8 and Fremont wells and includes North and Lower Lynnewood tanks. Under low demand conditions, Zone 1 could be supplied by Conger Well Field without pumping.

Key findings for Zone 1 of the maximum day verification are summarized below:

- The demands in the Zone 1 areas directly served by Central tanks were adjusted based on the geocoded results of the water billing records as a percentage of the total demands. This demand adjustment was made to better reflect actual demand conditions on the verification day, which better matched the field (measured) data. This adjustment is further explained below.

- The modeled reservoir levels in Zone 1 reasonably match the observed field trends and are within two feet.

Based on the initial setup and distribution of demands which were allocated based on land use, Center Reservoirs remained full all the time and did not cycle during the simulation. In the initial model simulation, the tanks in the southern part of the zone were drafting and could not recover at the end of the day. This indicated that the allocated demands by land use in the southern part of the zone appeared somewhat high and in the central area appeared low relative to the apparent actual demand

pattern. This allocation difference may be due to the fact that not all the small vacant parcels were excluded from the existing land use based demands, and such parcels are more prevalent in the southern area.

In order to adjust the demand, the 2008 water billing records were geocoded (geographically locating the billing address on the map). This geocoding approach was used as a guide to apply the percentages by area to proportion the model demands. Once the demands were redistributed, Center Reservoirs operation matched the field trends and model results were within two feet of the recorded data. Tanks in the southern part of the system were no longer drafting and were reasonably matching field trends.

The initial model verification results showed that North Tank was drafting over time and did not recover at the end of the day. Based on the model configuration, there was difficulty moving water toward North Tank. Adjusting the demand did not result in significant improvements in the model results; therefore, it was suspected that there may be isolation valves along the way. After consultation with the City, locations of isolation valves were identified as normally closed valves, which improved the verification results.

The initial model verification results showed that Ogden Tank was drafting over time and Hilyard Tank filling. After performing sensitivity runs, it was determined the issue was not related to demand allocation between the two tanks. It was suspected that the model configuration is not in agreement with field configuration. After consulting with the City, the City provided a map showing the locations of check valves and other valves that could potentially be closed to balance the filling cycle of the two tanks. Once those changes were made, the model results were in agreement with the measured data.

Zone 2 Results

There are three main subzones in Zone 2: Lindley/Stewart-Lenox, Upper Lynnewood, and Prescott. Lindley/Stewart-Lenox is supplied by Debbie and Balsam Wells and Riverside Booster Pump Station as a backup. Two reservoirs, Lindley and Steward Lenox are now connected with a 16-inch pipeline and provide storage for the zone. Upper Lynnewood is supplied by Lower Lynnewood Booster Pump Station and includes Upper Lynnewood Reservoir. Prescott is supplied from Center Booster Pump Station and Lytton Booster Pump Station and includes Prescott Standpipe. There are five PRV subzones in Zone 2: El Dorado, Old Fort, Ogden, North Hills, and Moyina (PRV-3). There are two hydropnuematic subzones in Zone 2: West Oregon and Sierra Heights.

The following are key Zone 2 findings for the maximum day verification:

- Lindley/Stewart-Lenox demands were adjusted using the same approach as was used in Zone 1.

- The two pumps at Center Pump Station pumping into Prescott Zone are operating under capacity due to low lifting head of the pumps.
- All Zone 2 modeled reservoir levels show a reasonable match to field levels.

The same methodology to reallocate demands in Zone 1 was used to reallocate demands in Lindley/Stewart-Lenox. After the demand was adjusted, the reservoir trends in the zone were similar to observed field trends.

Center Booster Pump Station lifts water from Zone 1 into Prescott Zone. The provided pump curves show that the each of the two pumps has a point of design point of 200 gpm and a total dynamic head (TDH) of 70 feet. The modeled pumps are operating at half capacity or less due to the high HGL in Prescott which forces the pumps to operate back on the curve, consequently reducing the capacity of the pumps.

Zone 3 Results

There are two main subzones in Zone 3: Hospital/Uhrmann and Patterson. Hospital/Uhrmann, on the northern side of the City, is supplied by High Level Booster Pump Station and Wocus Well. The subzone includes three reservoirs: High Level, Hospital, and Uhrmann. Patterson, on the eastern side of the City, is supplied by Beverly Booster Pump Station and Ogden Booster Pump Station and includes Patterson Reservoirs 1 and 2.

The following are key Zone 3 findings for the maximum day verification:

- The two pumps at Beverly Booster Pump Station that lift water into Patterson Zone are operating under capacity.
- All Zone 3 modeled reservoir levels show a reasonable match to field levels.

Beverly Booster Pump Station lifts water from Zone 1 into Patterson Zone. The design information for the pumps indicates a design point of 750 gpm at 215 feet of TDH. The modeled pumps are operating at half capacity. This is due to the high HGL in Patterson which forces the pumps to operate high on the pump curves and reduces the capacity of the pumps.

In addition to this, the reservoir levels at Patterson show high and low spikes, even though the overall trend generally matches the field trend. The two Patterson tanks have the same ground elevation and are interconnected but do not have the same dimensions. SCADA data shows Patterson tank 1 has an initial level of 13.9 feet and Patterson Tank 2 has an initial level of 15.8 feet. This indicates there are control valves in the field that are not in the model to control filling the tanks. Since in the model the two tanks are connected with no valves in between, water is being transferred at a high rates and causing these spikes in the model results. However, these spikes are too small to have an effect on the model results and the use of the model for the

system analysis. Subsequent to the calibration analysis, the City indicated that one of the tanks has inlet/outlet check valves to promote turnover, and the other does not; these valves are not modeled at the master planning level.

Zone 4 Results

There is one main subzone in Zone 4: Upper Moyina. Upper Moyina is supplied by Moyina Booster Pump Station and includes Upper Moyina Tank. Lower Moyina Tanks is hydraulically disconnected from Patterson subzone and serves as a suction supply for Moyina Booster Pump Station. Therefore, the storage at Lower Moyina Tank is used for Upper Moyina Zone. There are three hydropnuematic subzones in Zone 4: Havencrest, Crown Ridge, and ESI.

The following are key Zone 4 findings for the maximum day verification:

- Modeled Upper Moyina Reservoir levels show a reasonable match to field levels.

Zone 5 Results

There is one main subzone in Zone 5: Basinview. Basinview is supplied by Basinview Booster Pump Station and includes Basinview Reservoir.

The following are key Zone 4 findings for the maximum day verification:

- Modeled Basinview Reservoir levels show a reasonable match to field levels.

Zone 8 Results

There is one main subzone in Zone 8: Tanglewood. Tanglewood is supplied by Tanglewood Booster Pump Station and includes Tanglewood Reservoir.

The following are key Zone 4 findings for the maximum day verification:

- Modeled Tanglewood Reservoir levels show a reasonable match to field levels.

Recommendations for Future Model Refinements

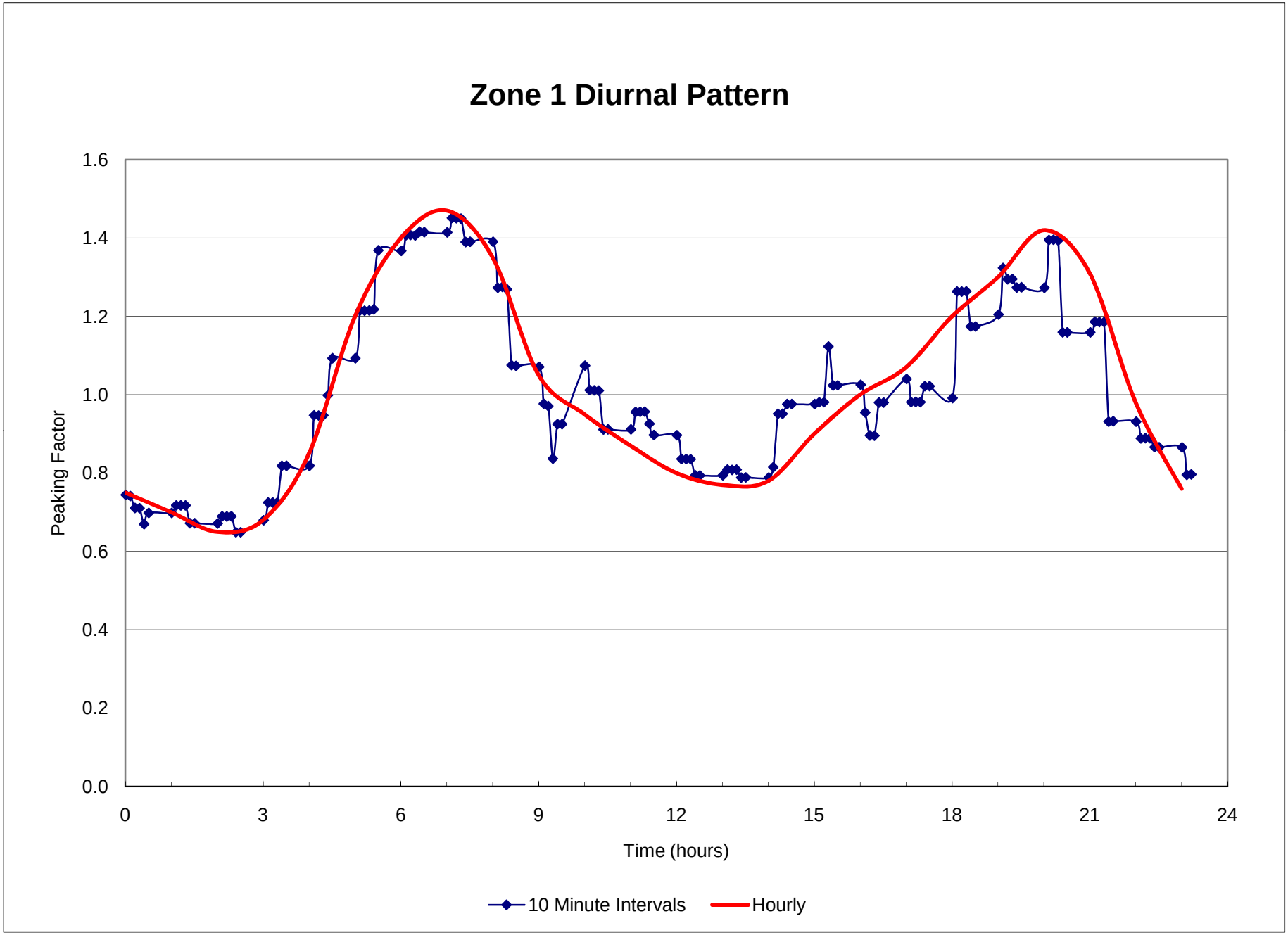
The updated calibrated and verified model reasonably represents the system for the master plan analysis. However, there are additional refinements that the City may want to consider implementing after completion of the master plan:

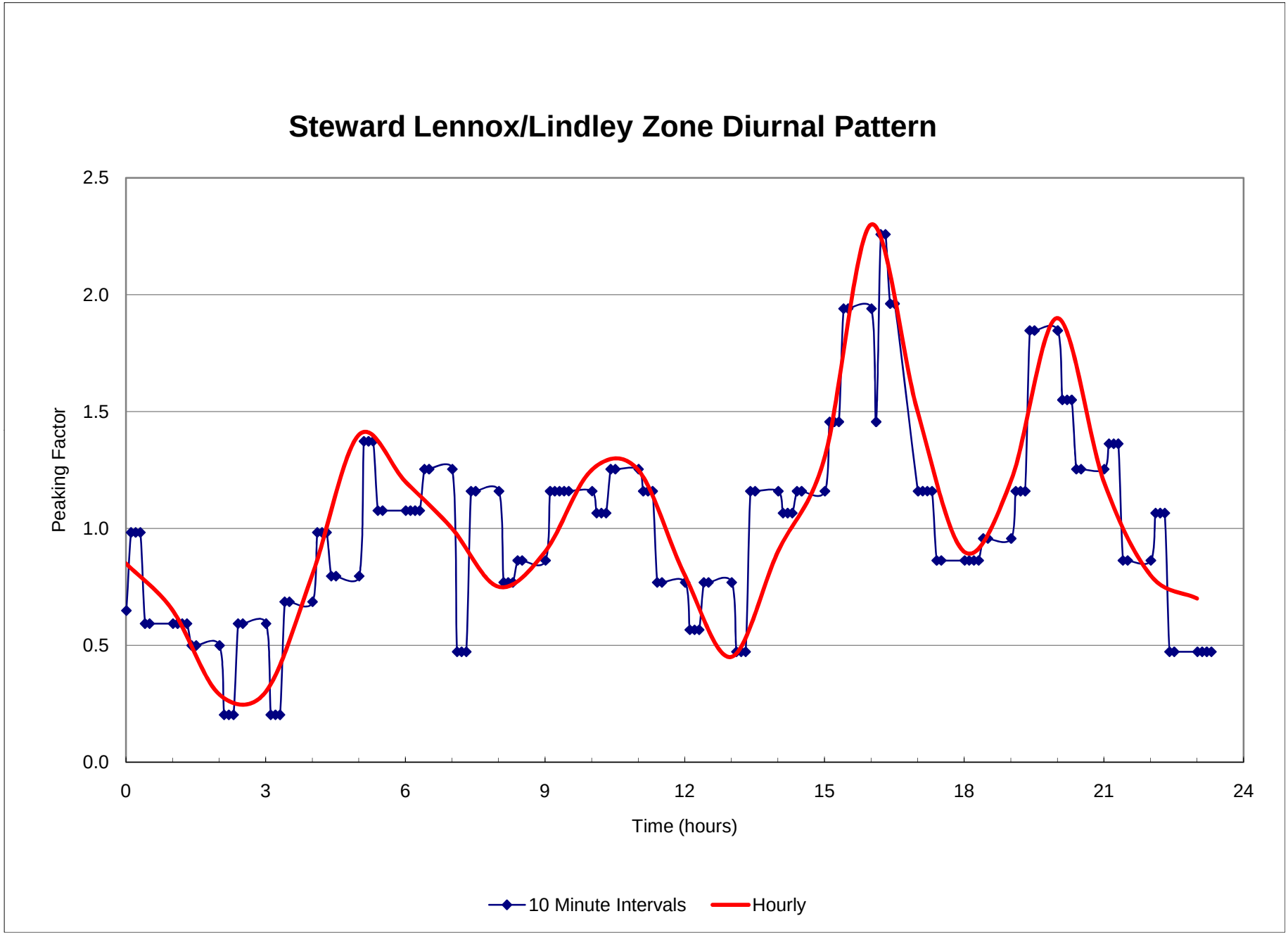
- Equip all pumps/wells with equipment for inlet and outlet pressure readings and flow meters, ideally on SCADA, but at least able to be read manually. Use this data to update and keep pump curves current.

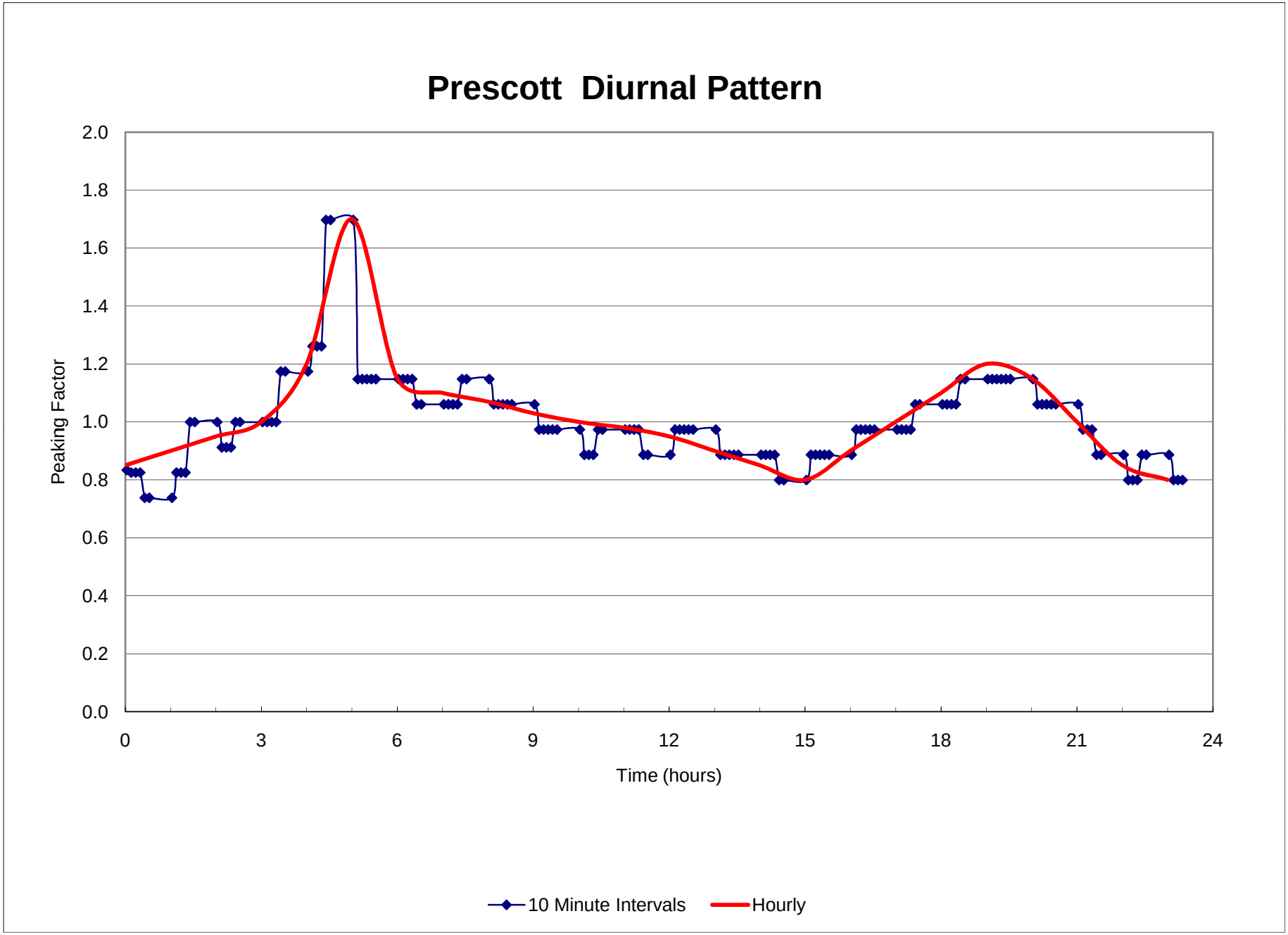
- Calibrate hydrant test measuring equipment regularly, suggested at least once a year, to improve level of confidence in field measurements used for model calibration.

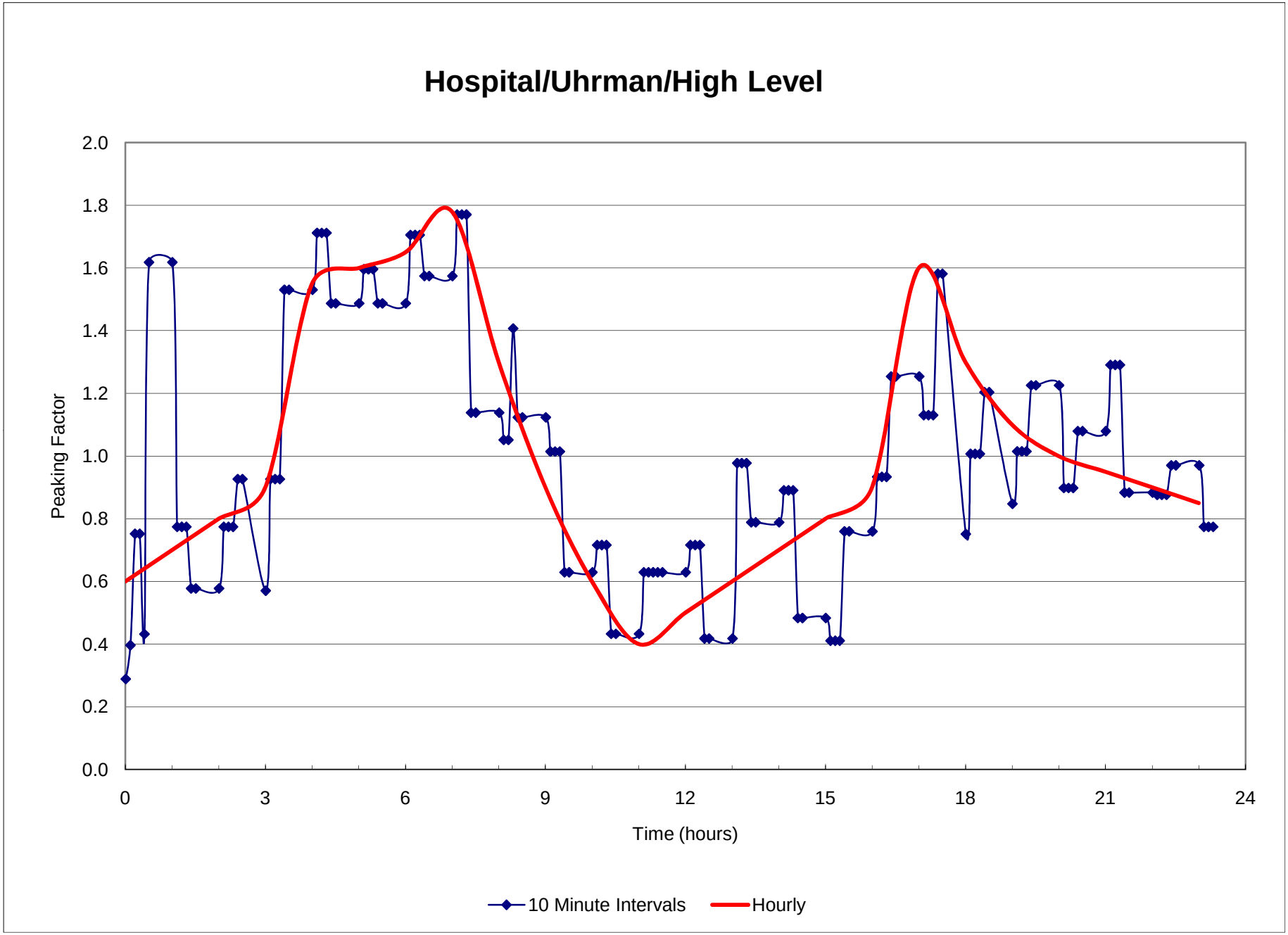
- Keep model software upgraded on an ongoing basis to take advantage of new enhancements.
- Utilize water billing records as appropriate to refine existing demand allocations.

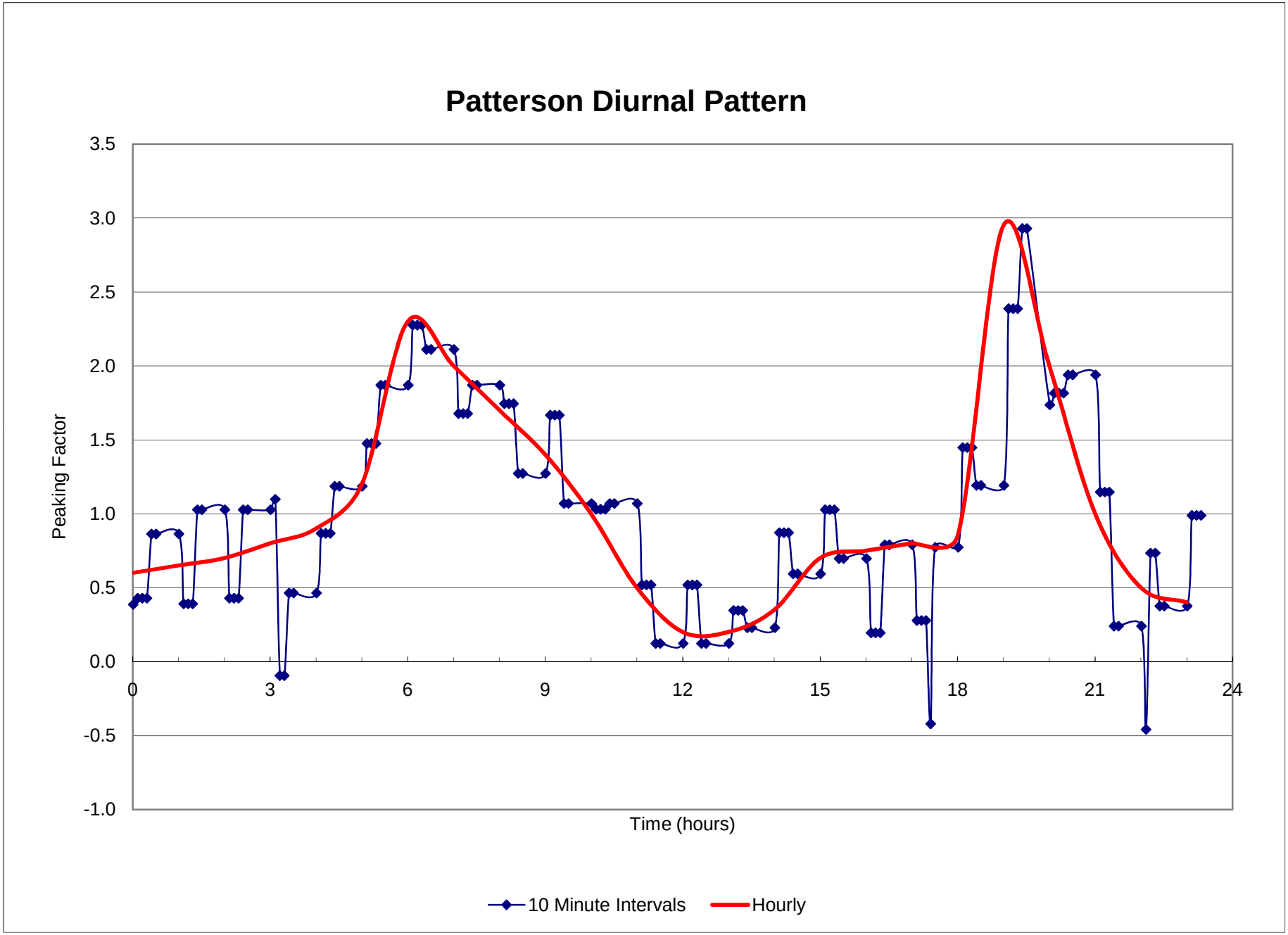
Attachment 1 to Appendix C
Diurnal Curves by Zone

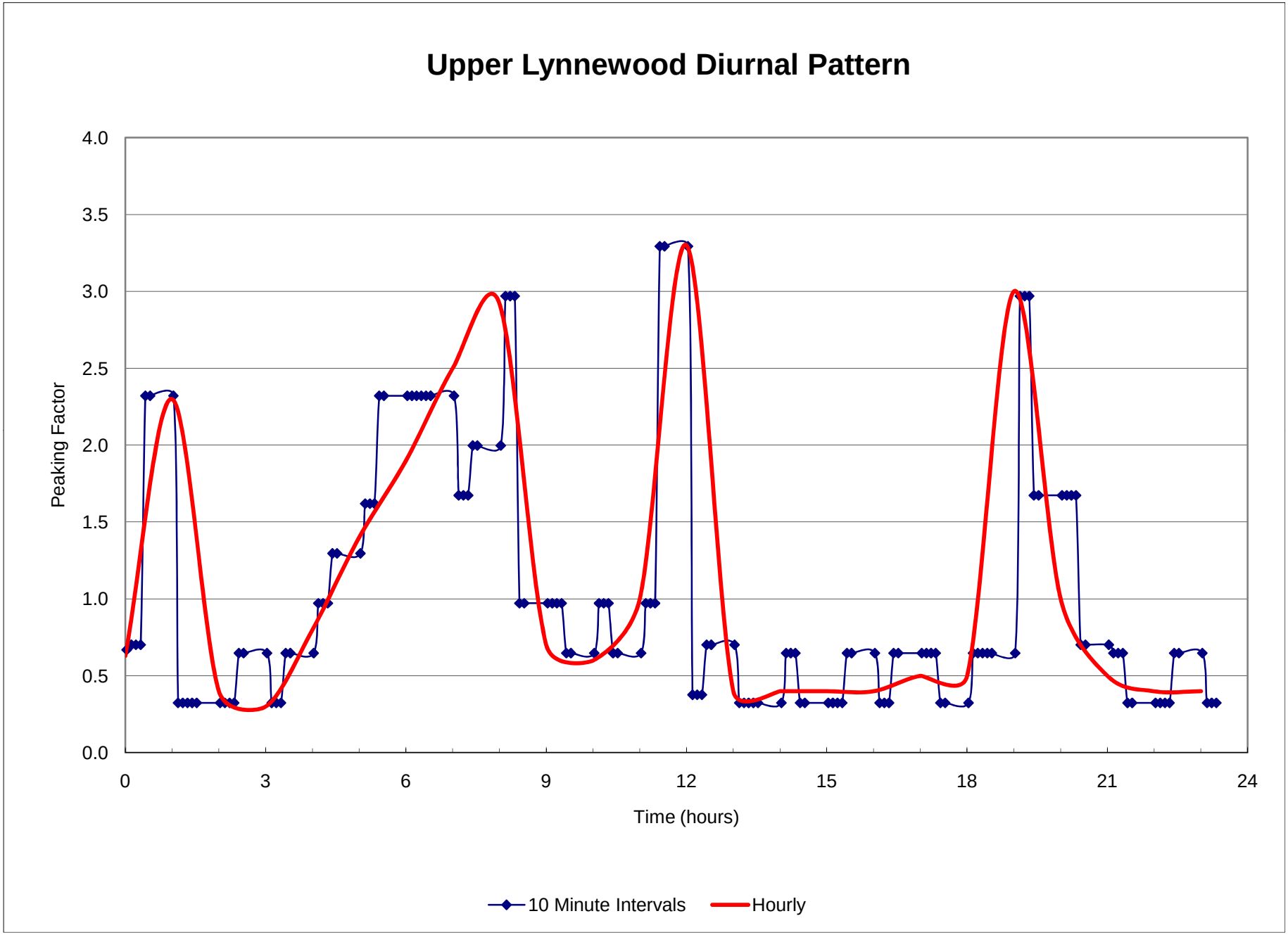

Zone 1 Diurnal Pattern
Peaking Factor
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly

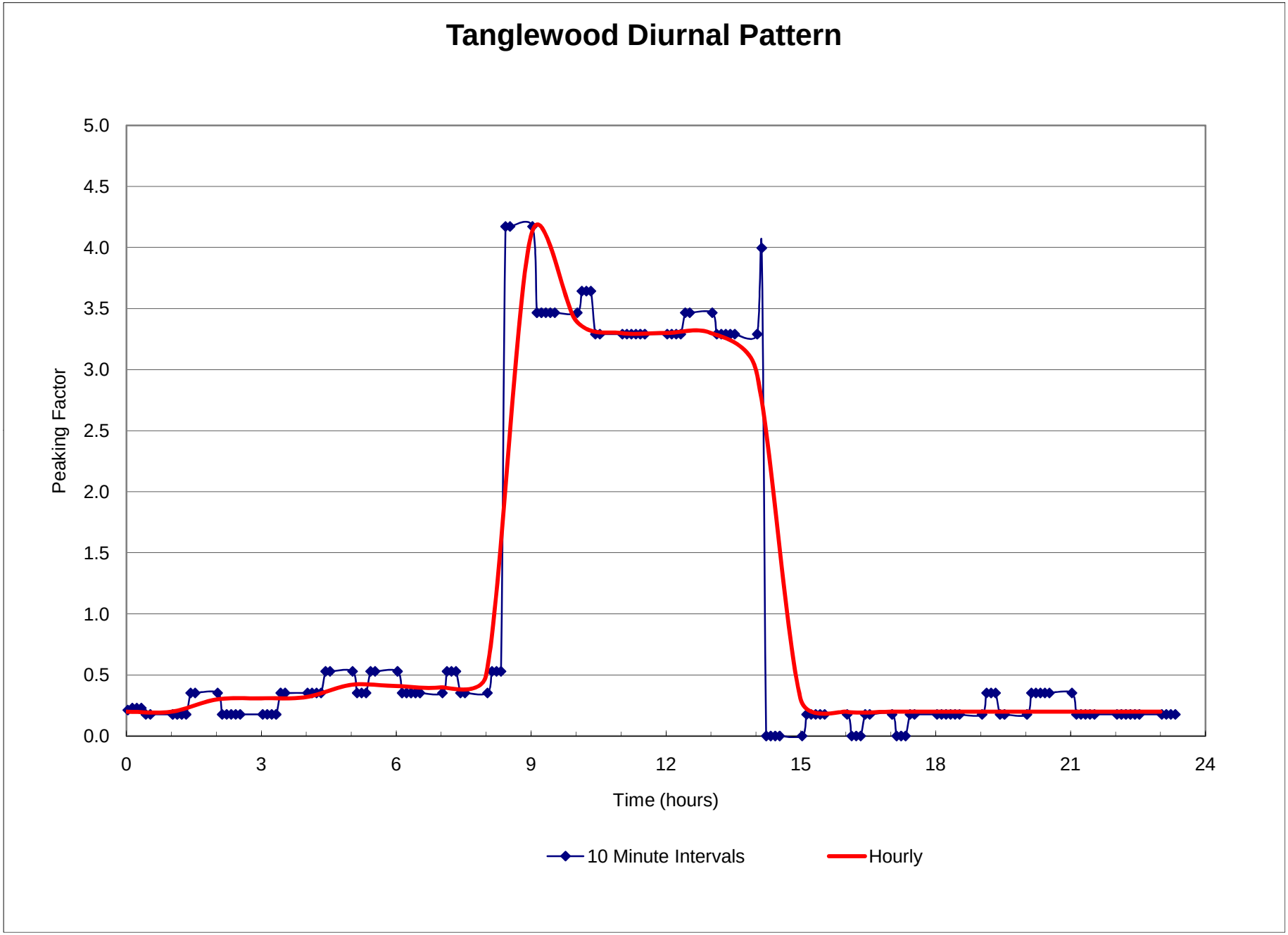

Steward Lennox/Lindley Zone Diurnal Pattern
Peaking Factor
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly


Prescott Diurnal Pattern
Peaking Factor
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly


Hospital/Uhrman/High Level
Peaking Factor
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly


Patterson Diurnal Pattern
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Peaking Factor
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly

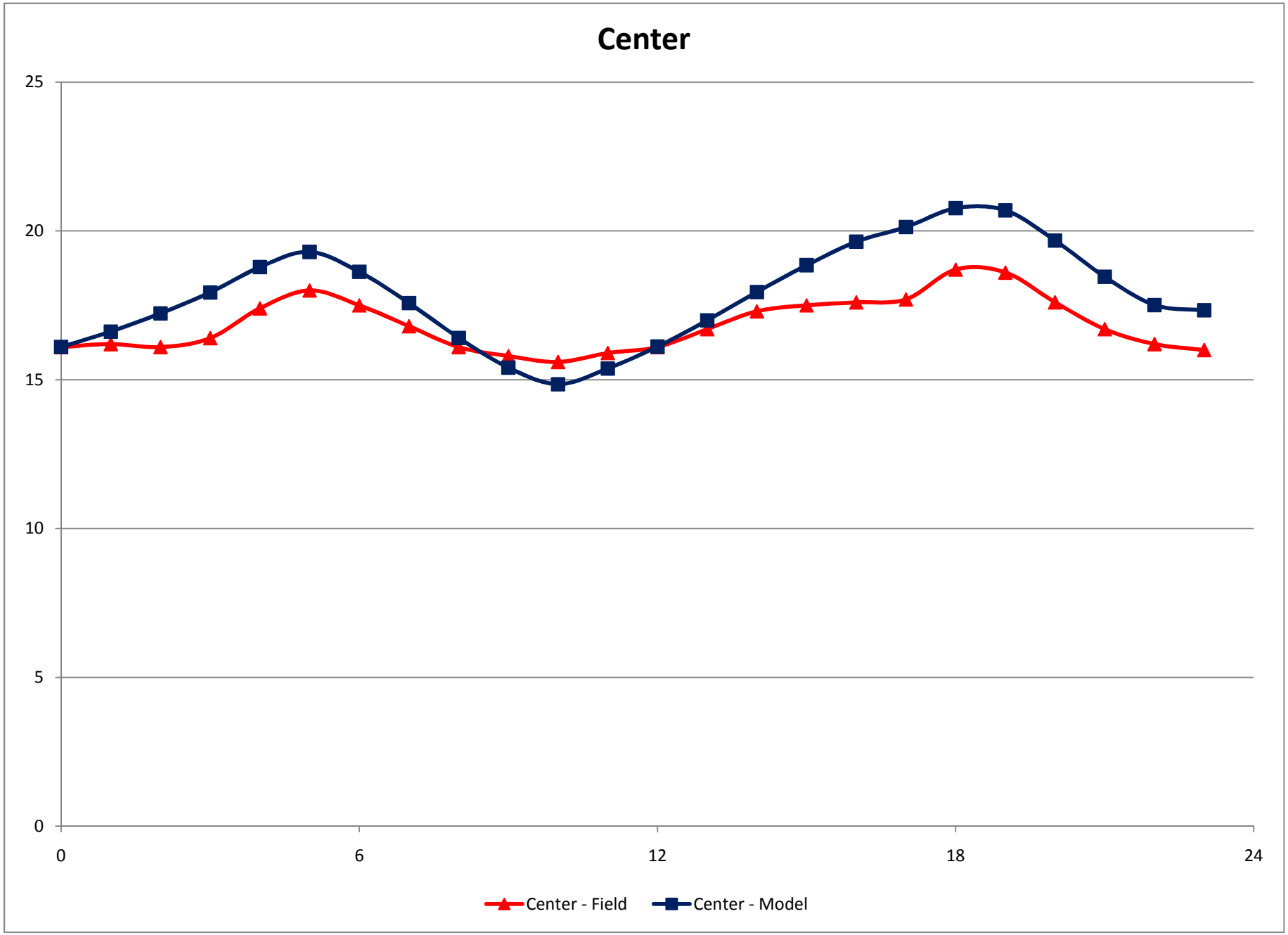

Upper Lynnewood Diurnal Pattern
Peaking Factor
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly

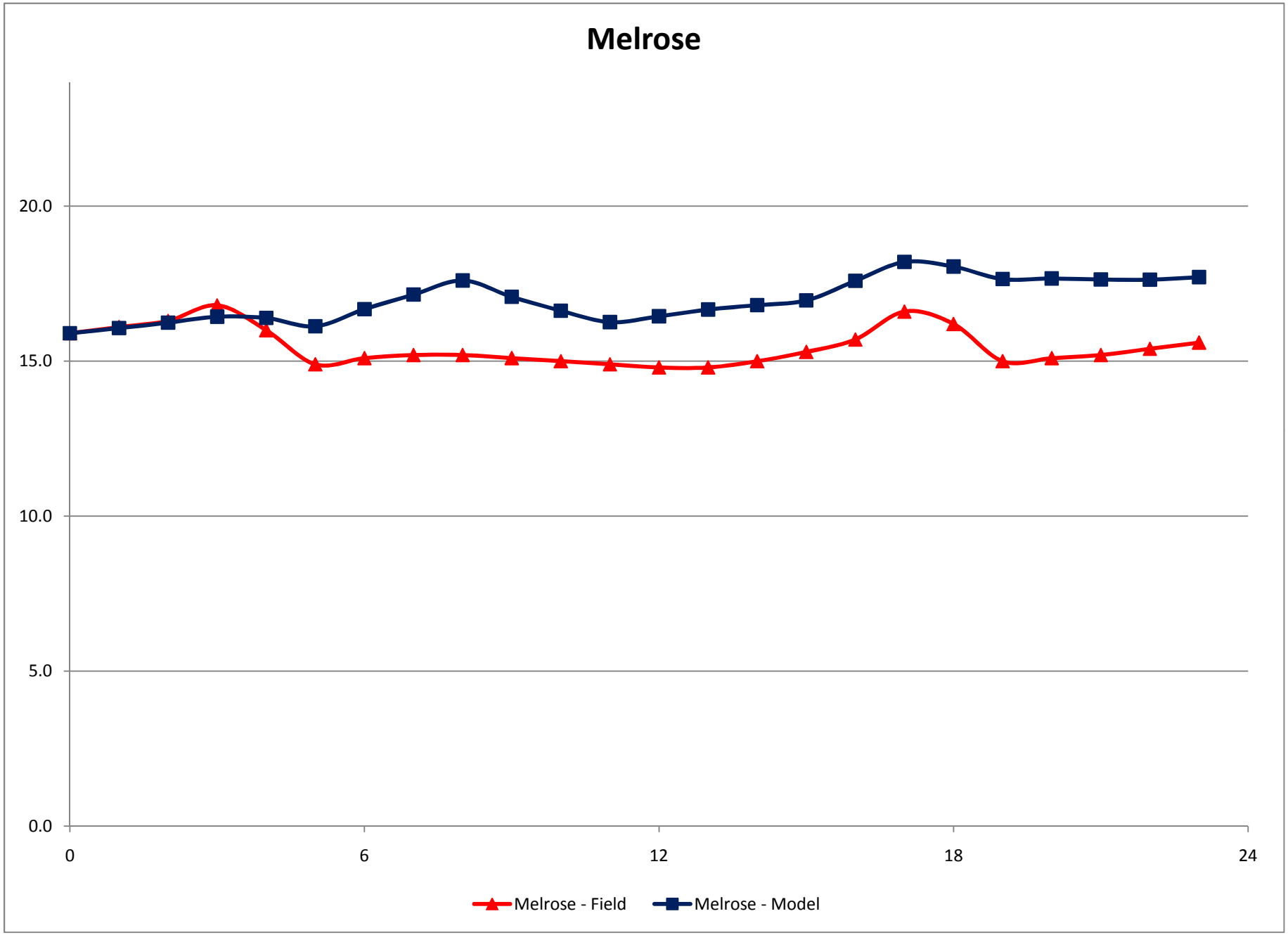

Tanglewood Diurnal Pattern
Peaking Factor
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24
Time (hours)
10 Minute Intervals
Hourly

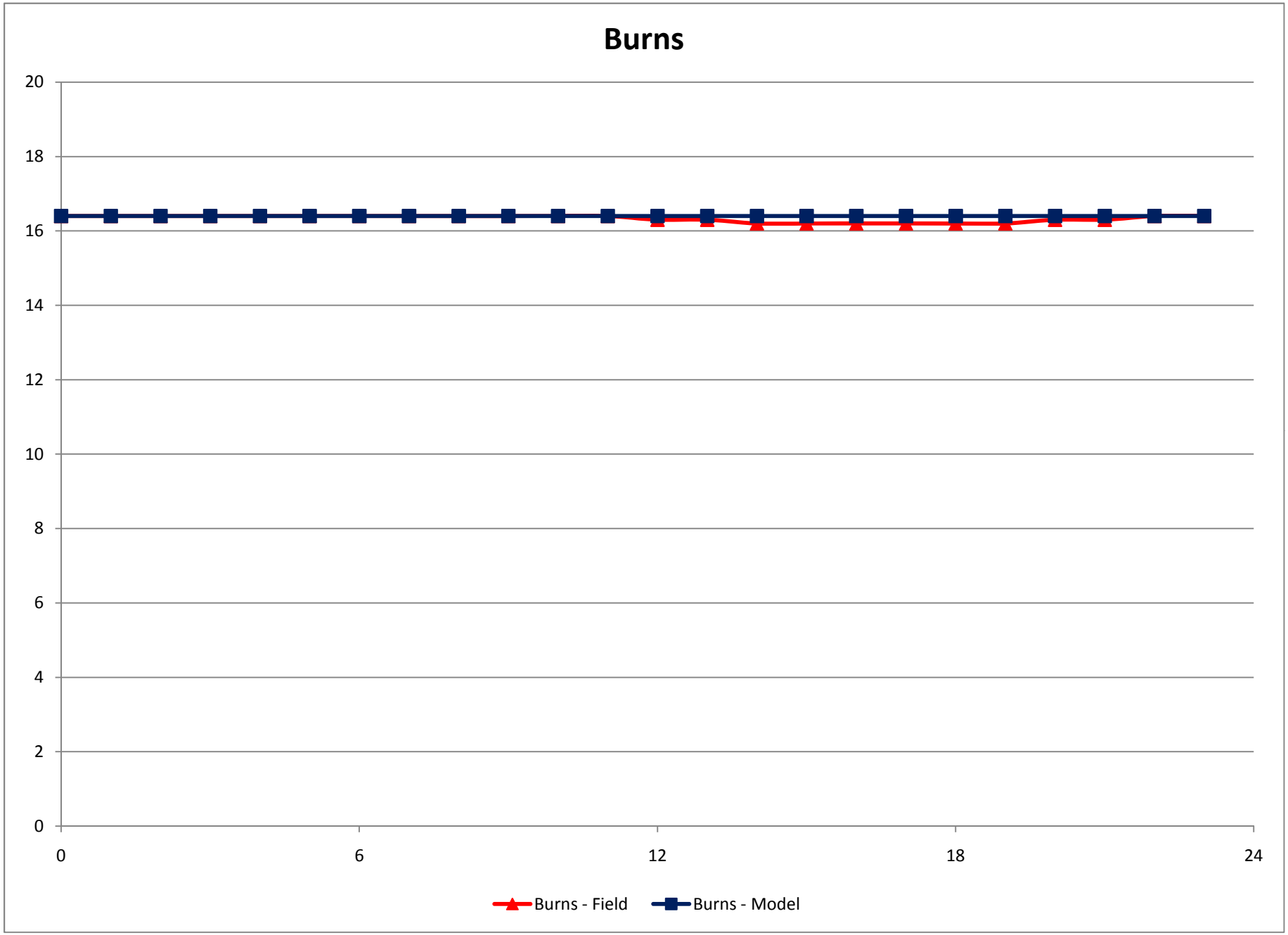
Attachment 2 to Appendix C
Verification Plots
for Maximum Demand Day

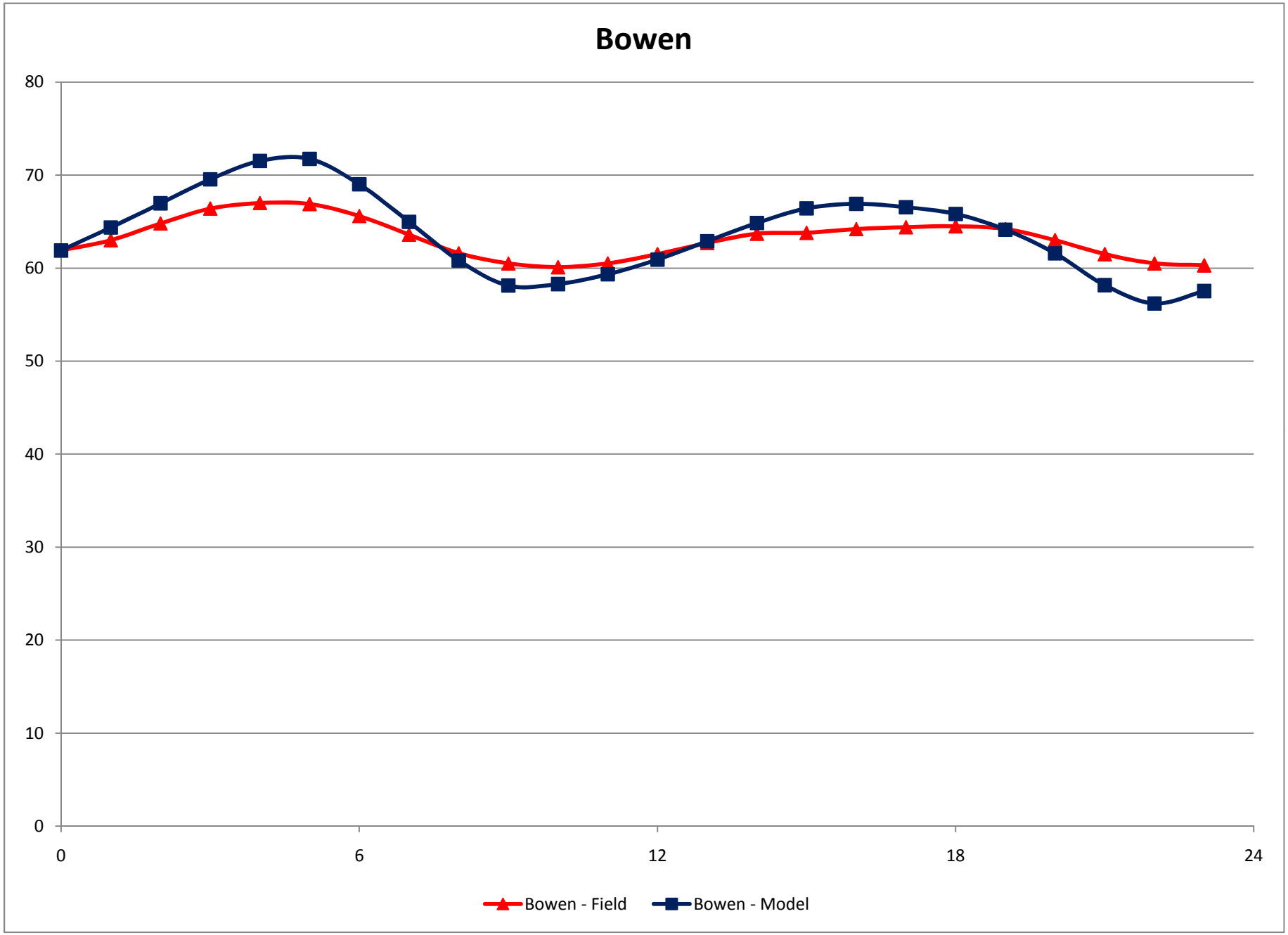
Verification Plots
for Maximum Demand Day:

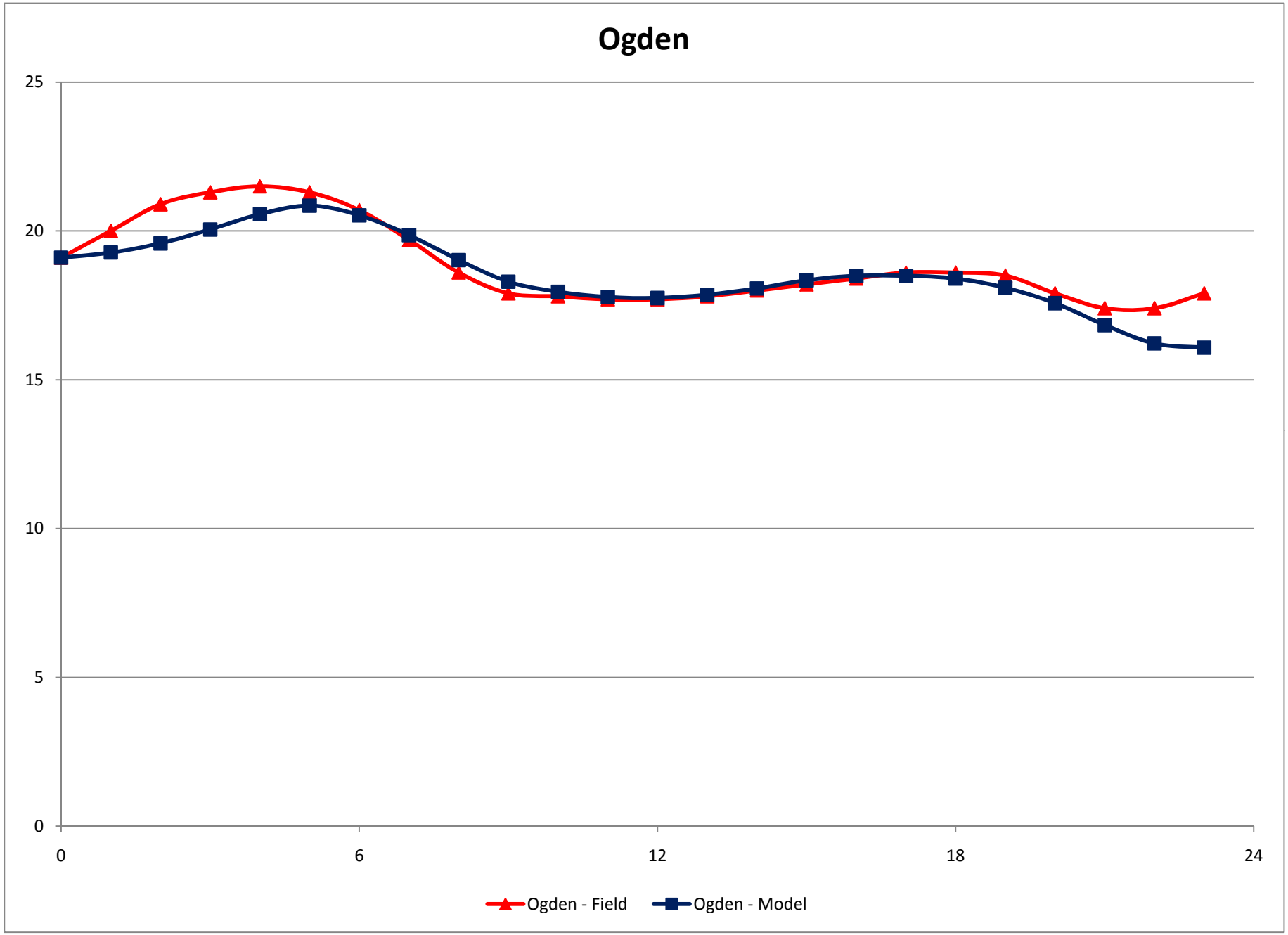
Reservoir Levels

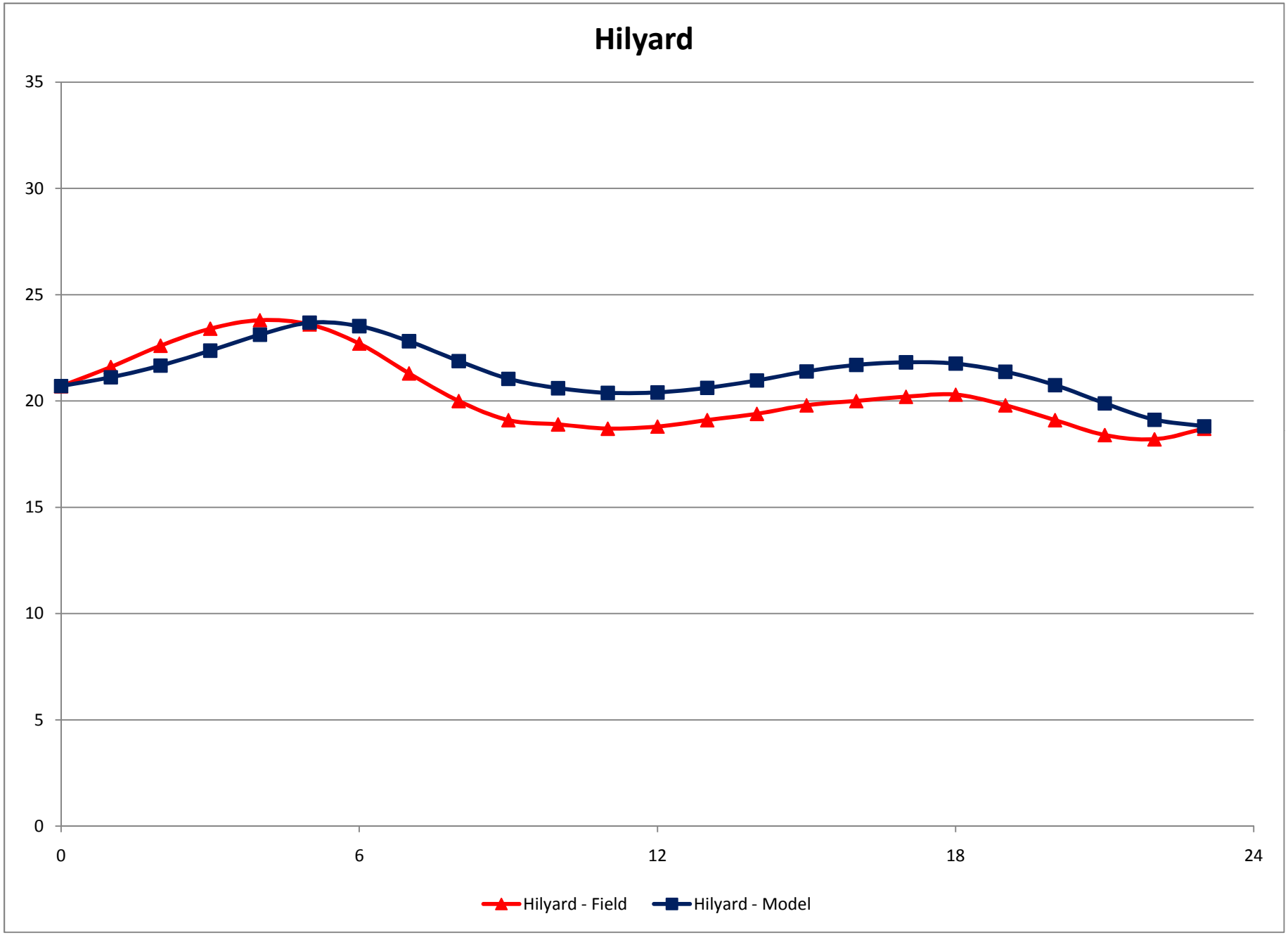

Center
25
20
15
10
5
0
0
6
12
18
24
Center - Field
Center - Model

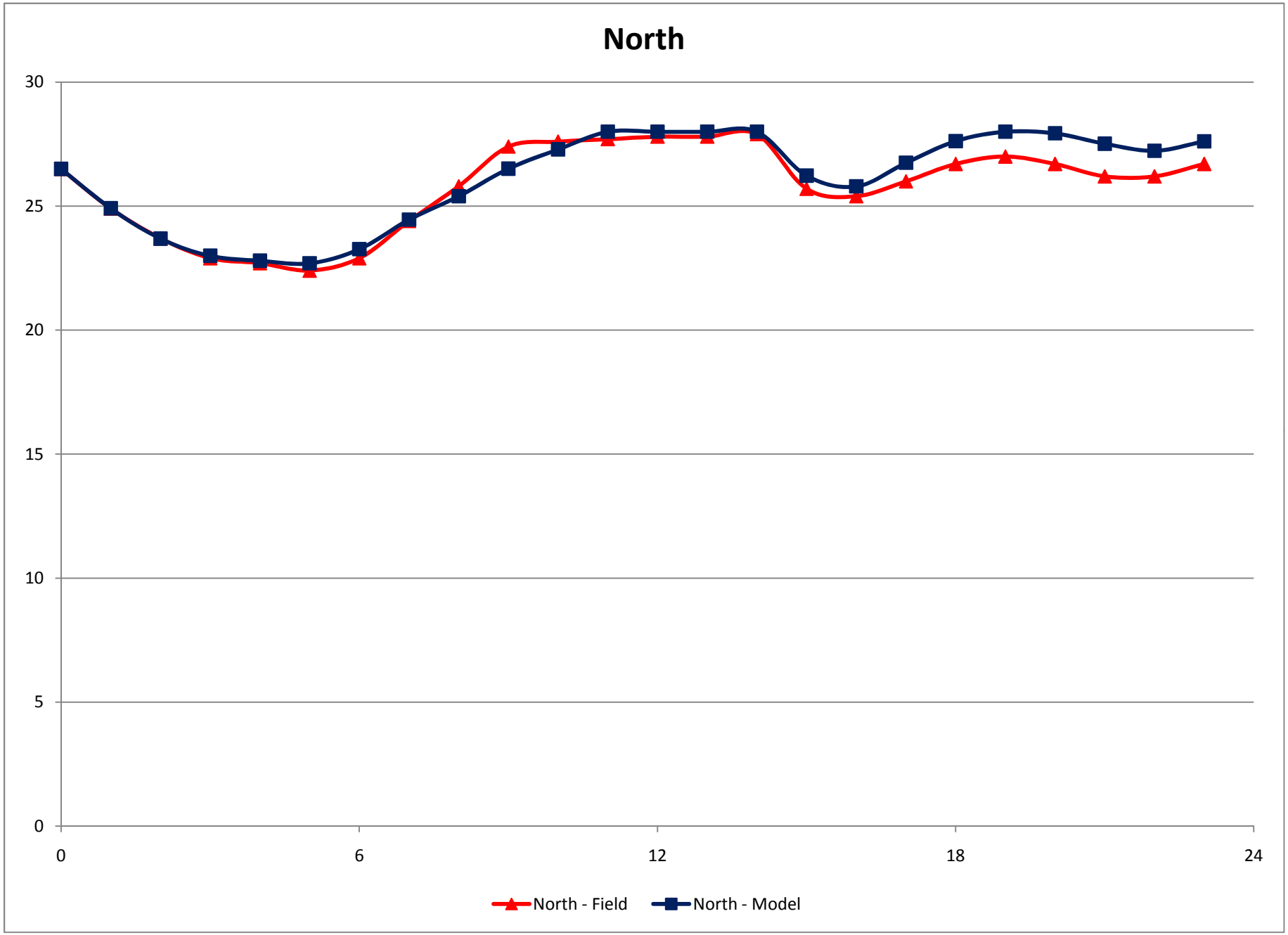

Melrose
20.0
15.0
10.0
5.0
0.0
0
6
12
18
24
Melrose - Field
Melrose - Model

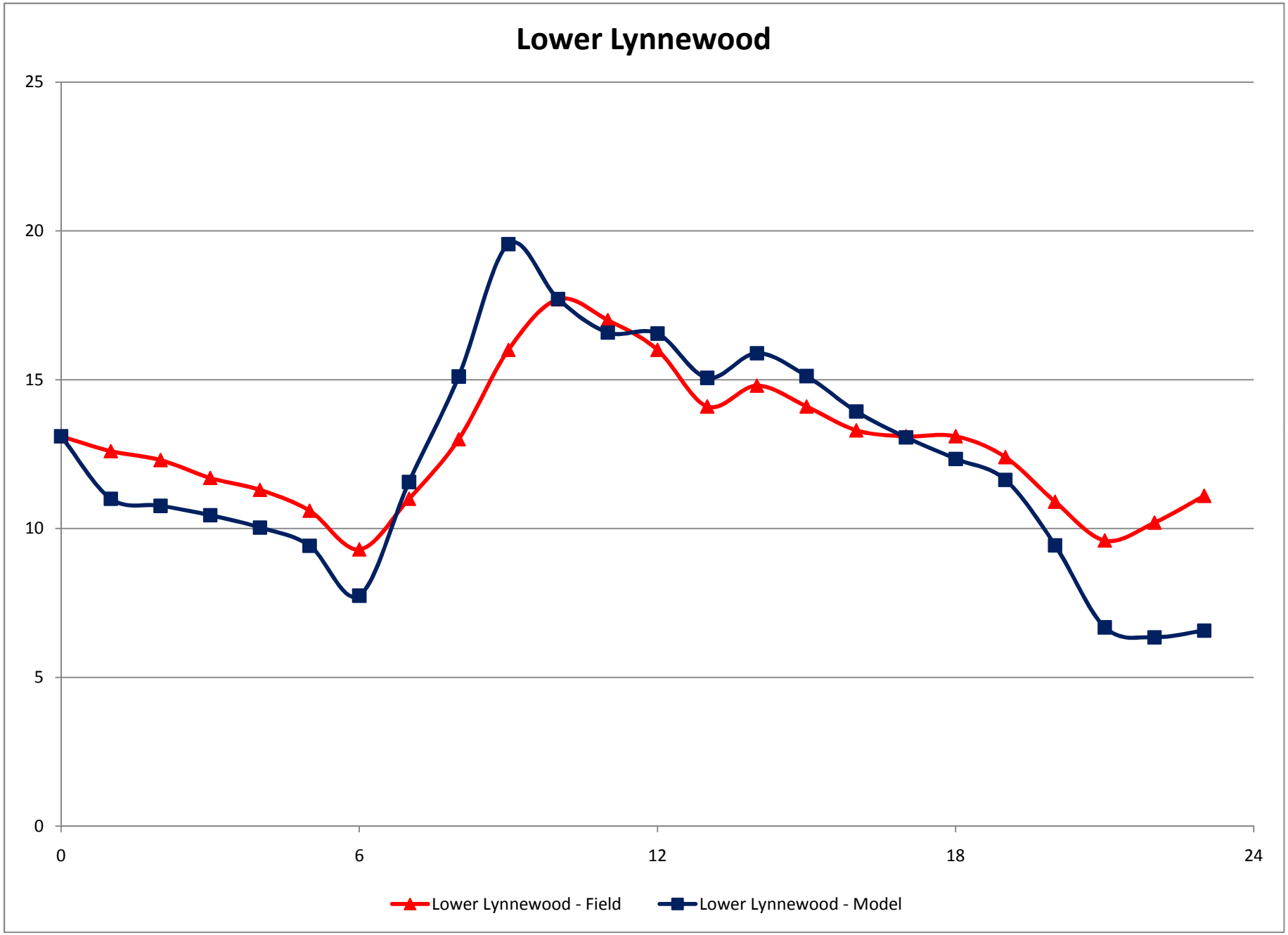

Burns
20
18
16
14
12
10
8
6
4
2
0
0
6
12
18
24
Burns - Field
Burns - Model

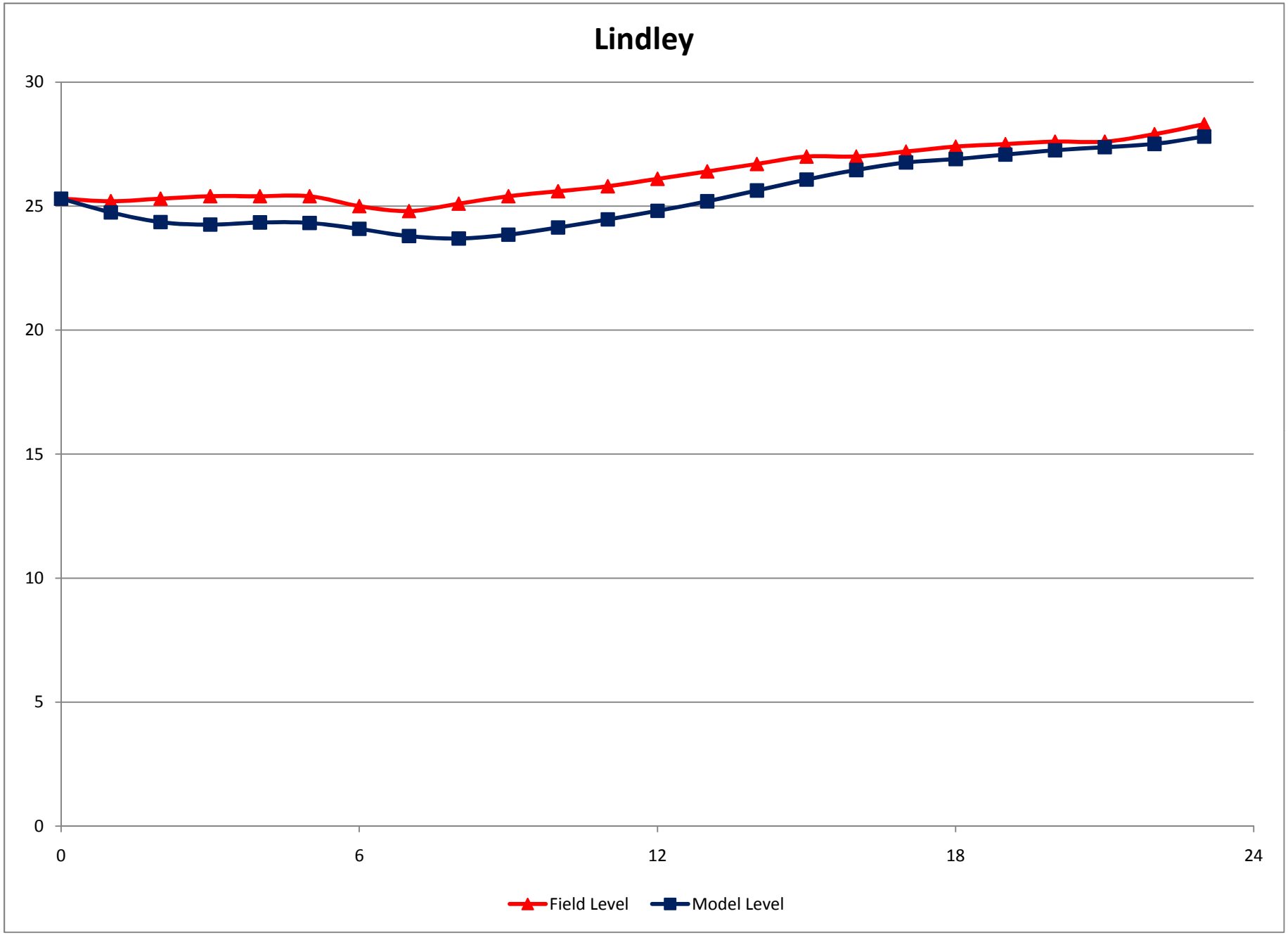

Bowen
80
70
60
50
40
30
20
10
0
0
6
12
18
24
Bowen - Field
Bowen - Model

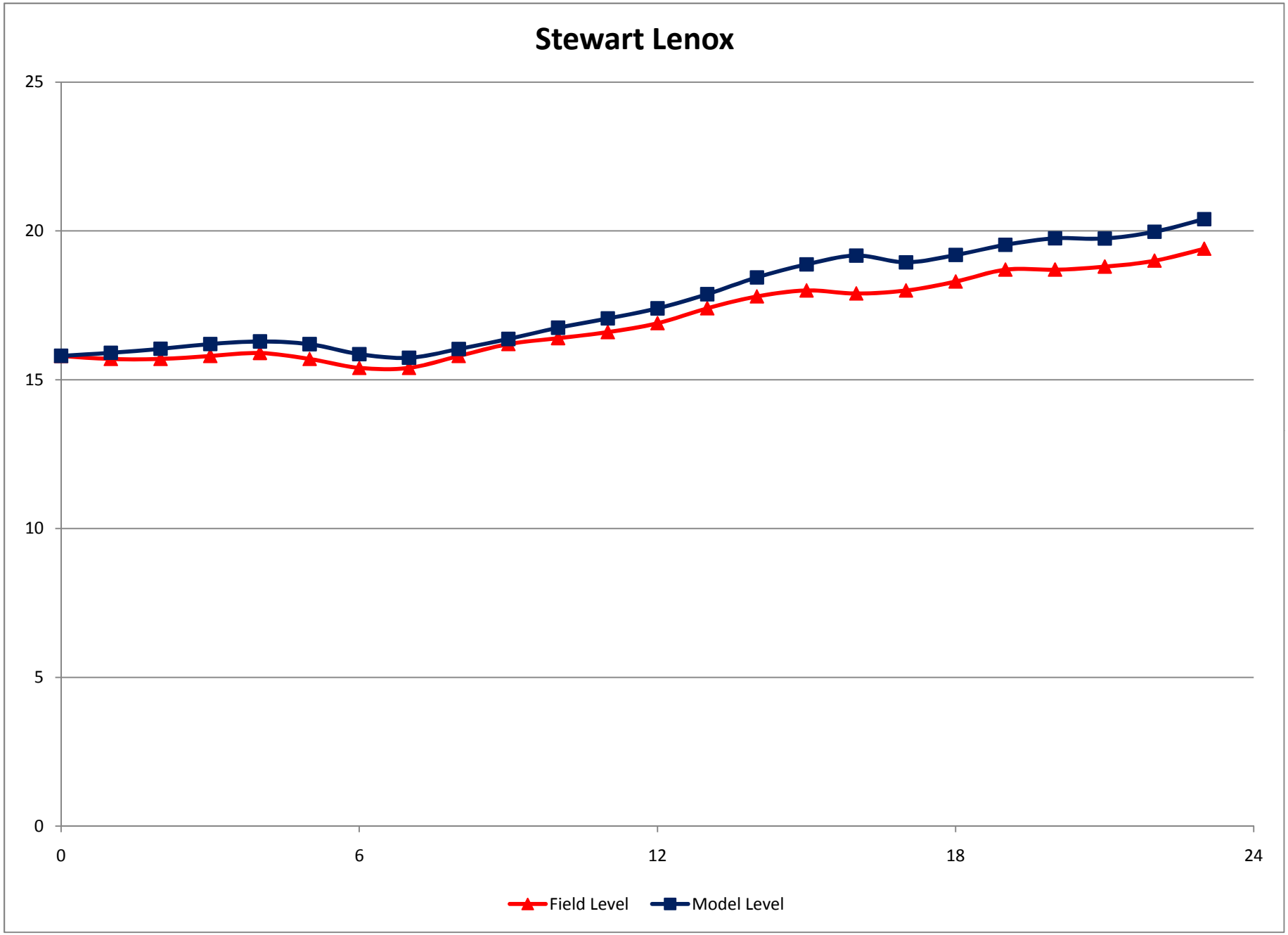

Ogden
25
20
15
10
5
0
0
6
12
18
24
Ogden - Field
Ogden - Model

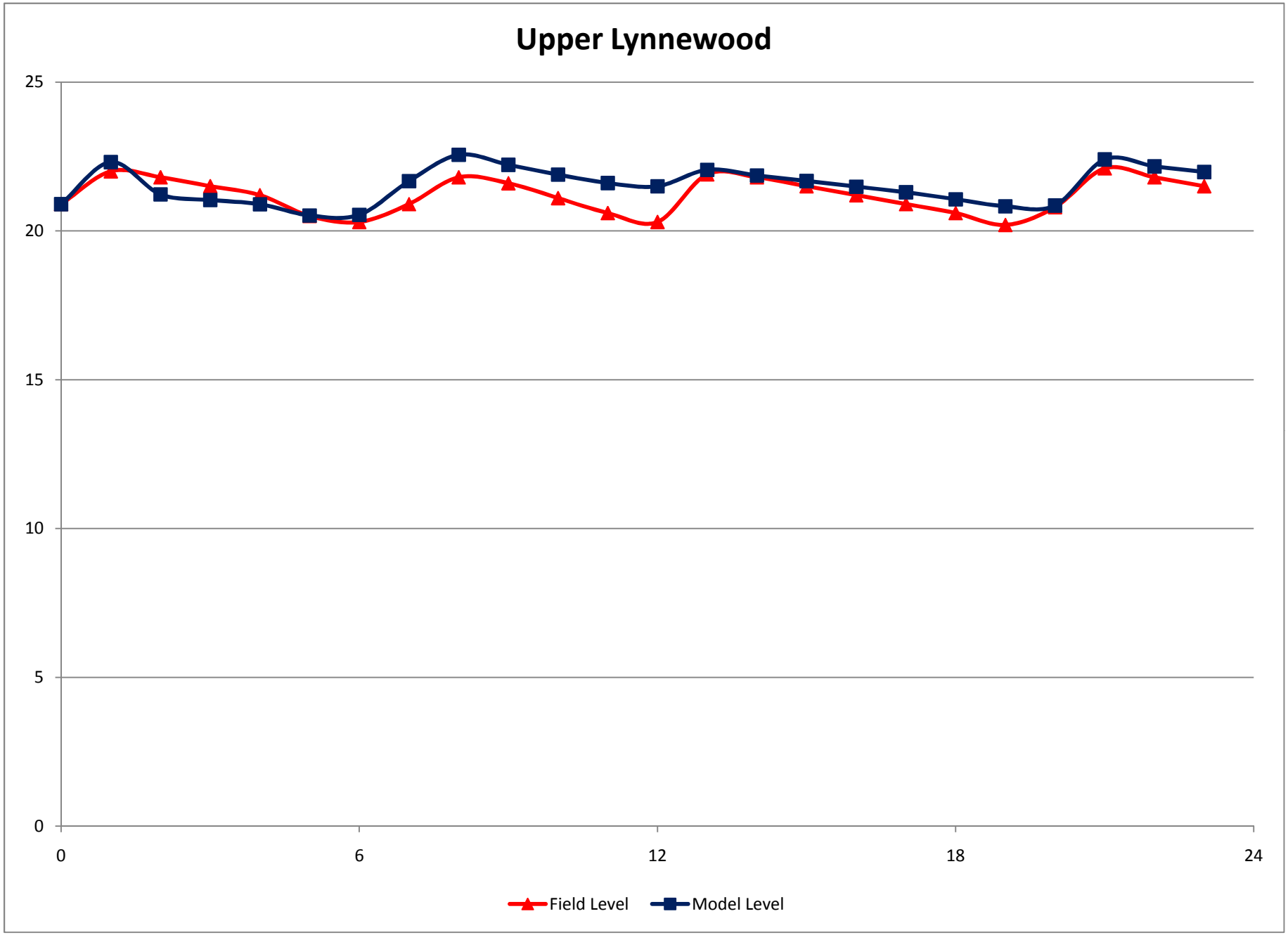

Hilyard
35
30
25
20
15
10
5
0
0
6
12
18
24
Hilyard - Field
Hilyard - Model

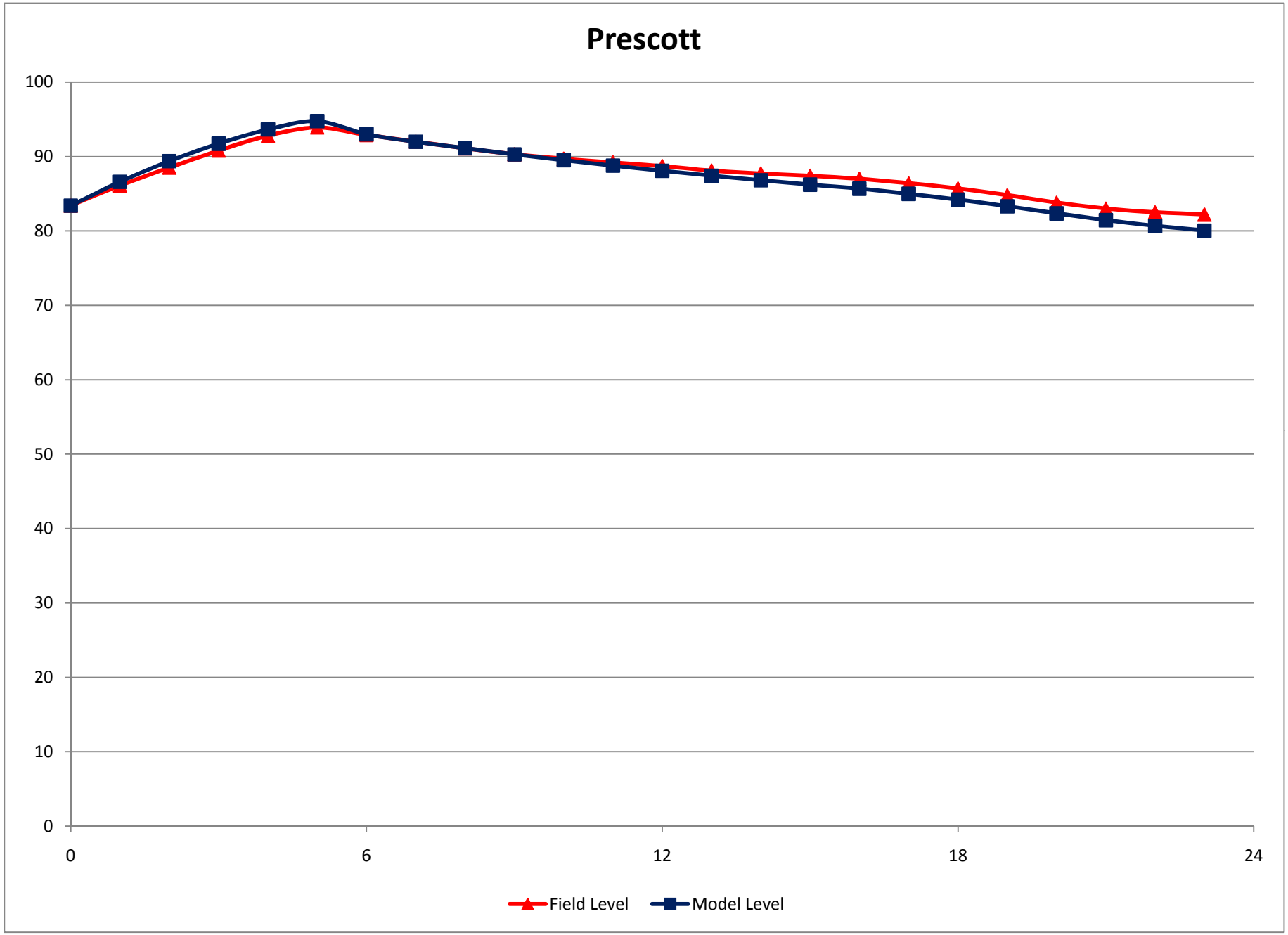

North
30
25
20
15
10
5
0
0
6
12
18
24
North - Field
North - Model

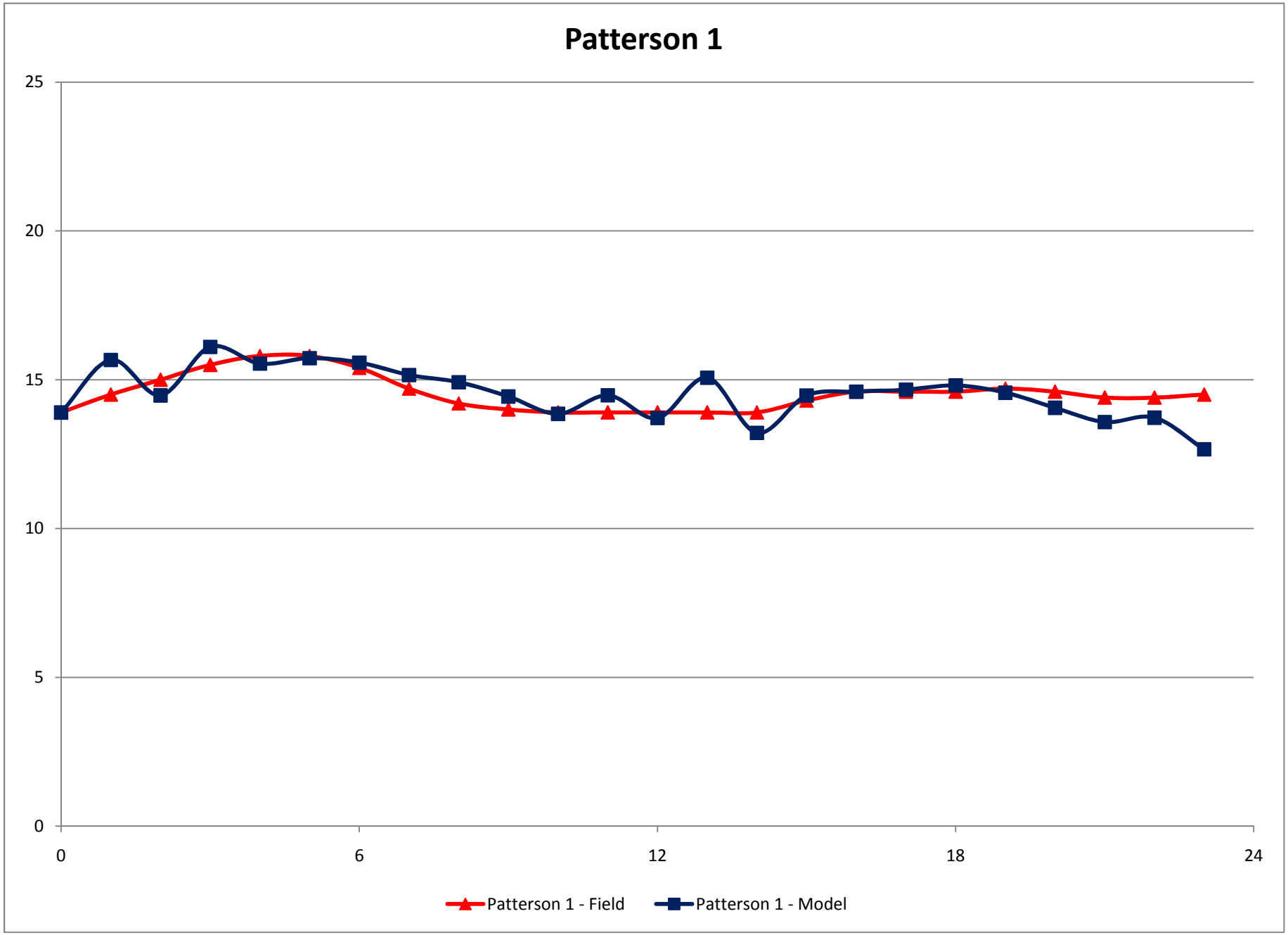

Lower Lynnewood
25
20
15
10
5
0
0
6
12
18
24
Lower Lynnewood - Field
Lower Lynnewood - Model

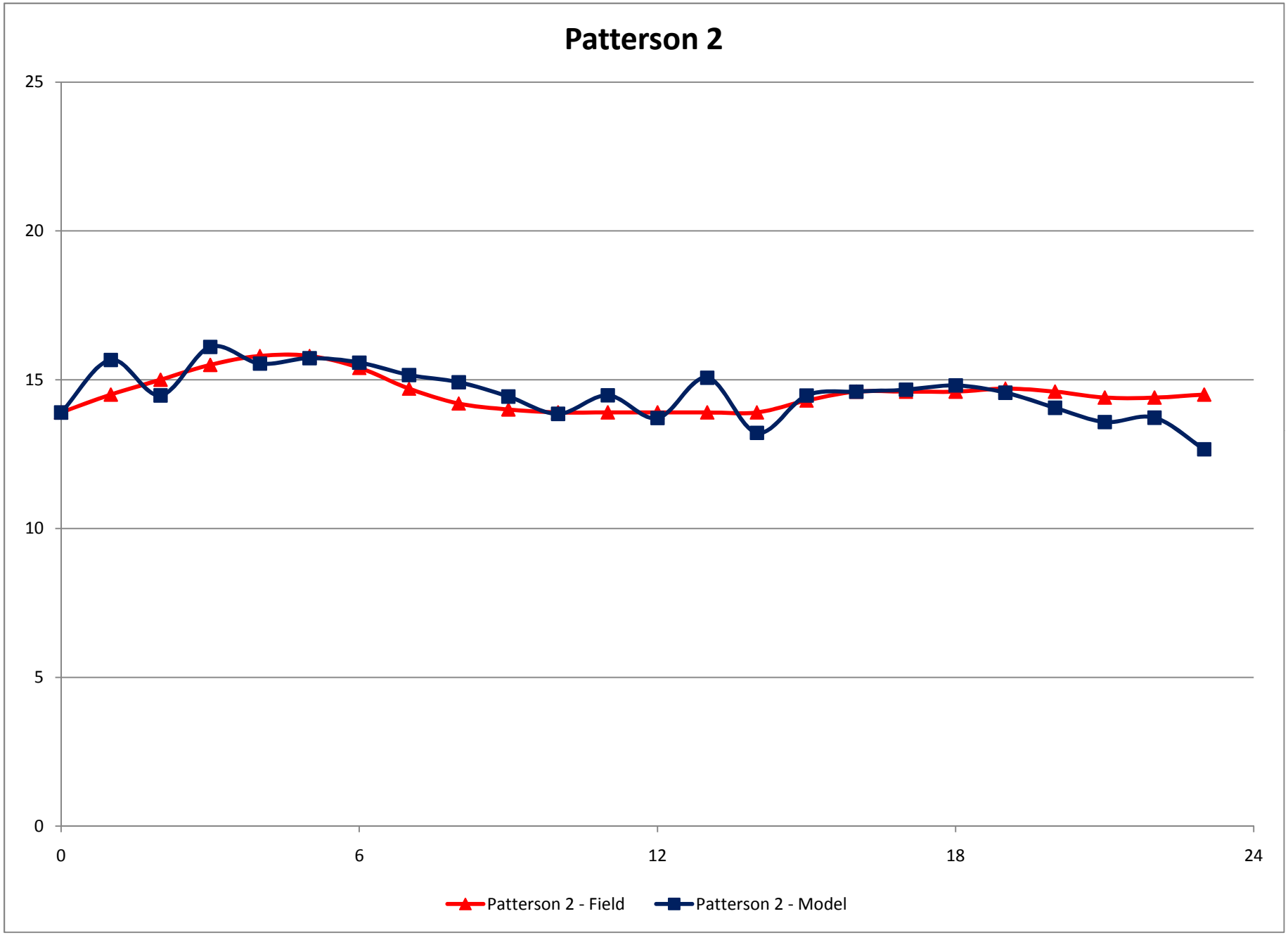

Lindley
30
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

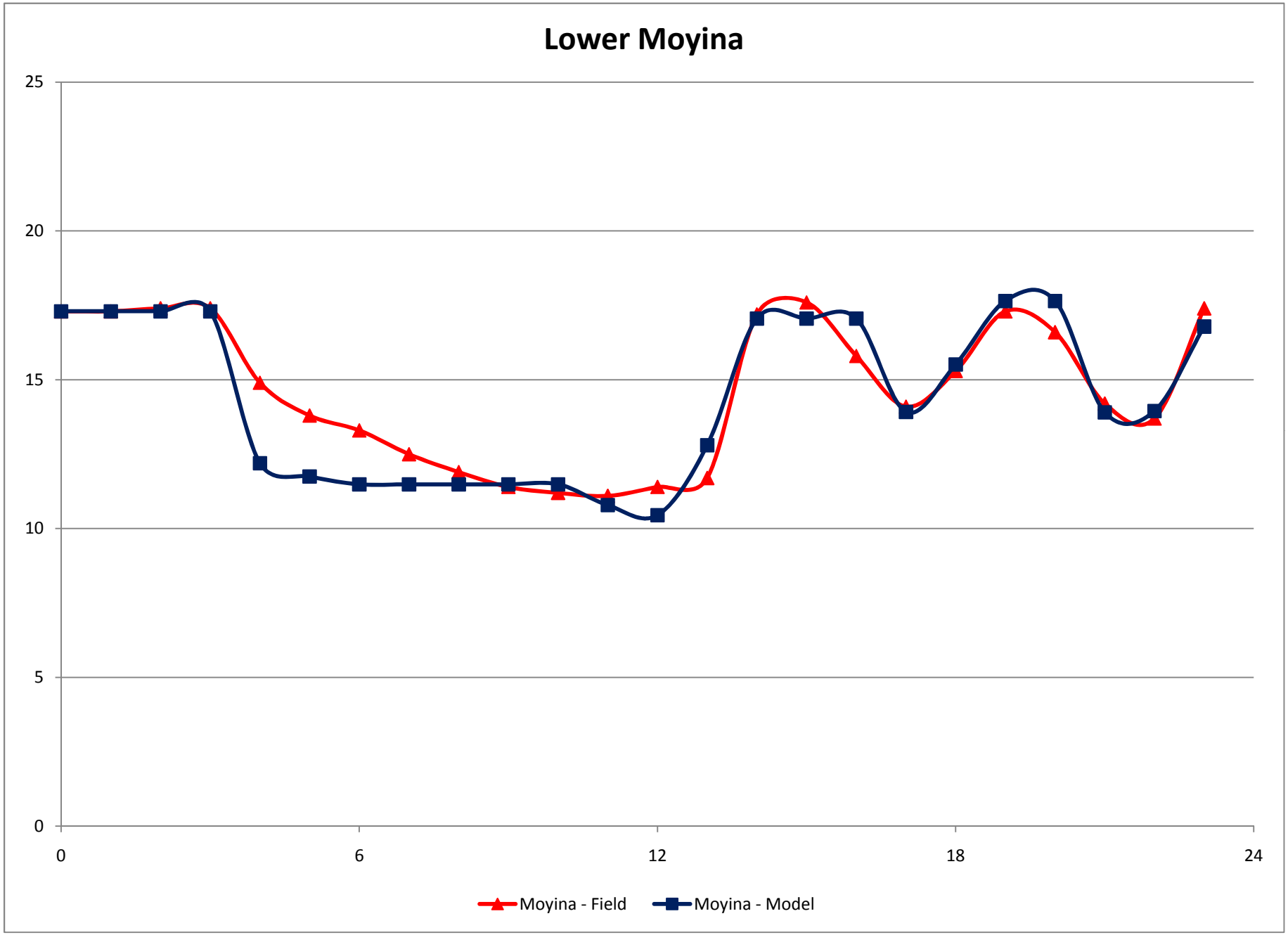

Stewart Lenox
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

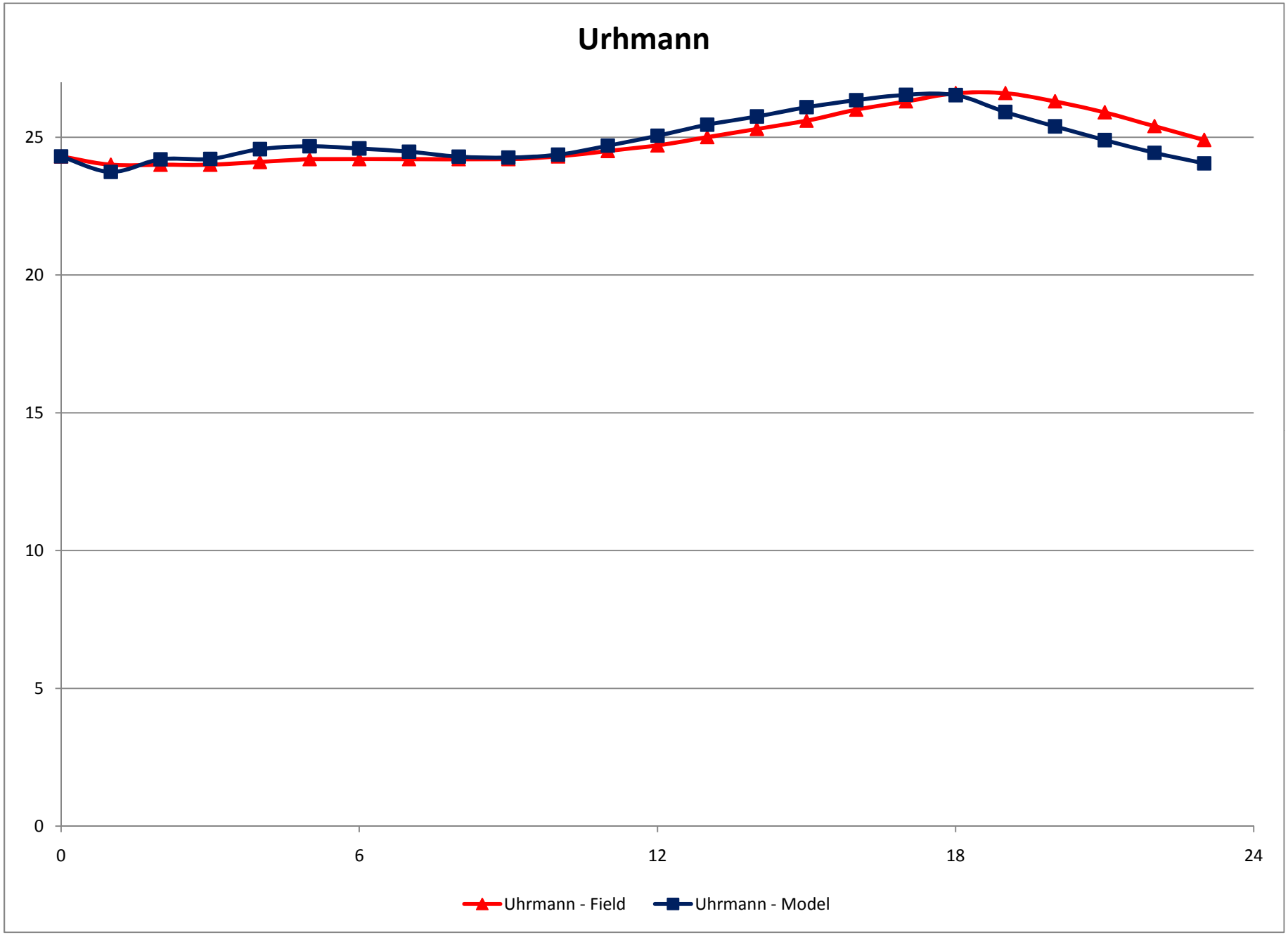

Upper Lynnewood
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

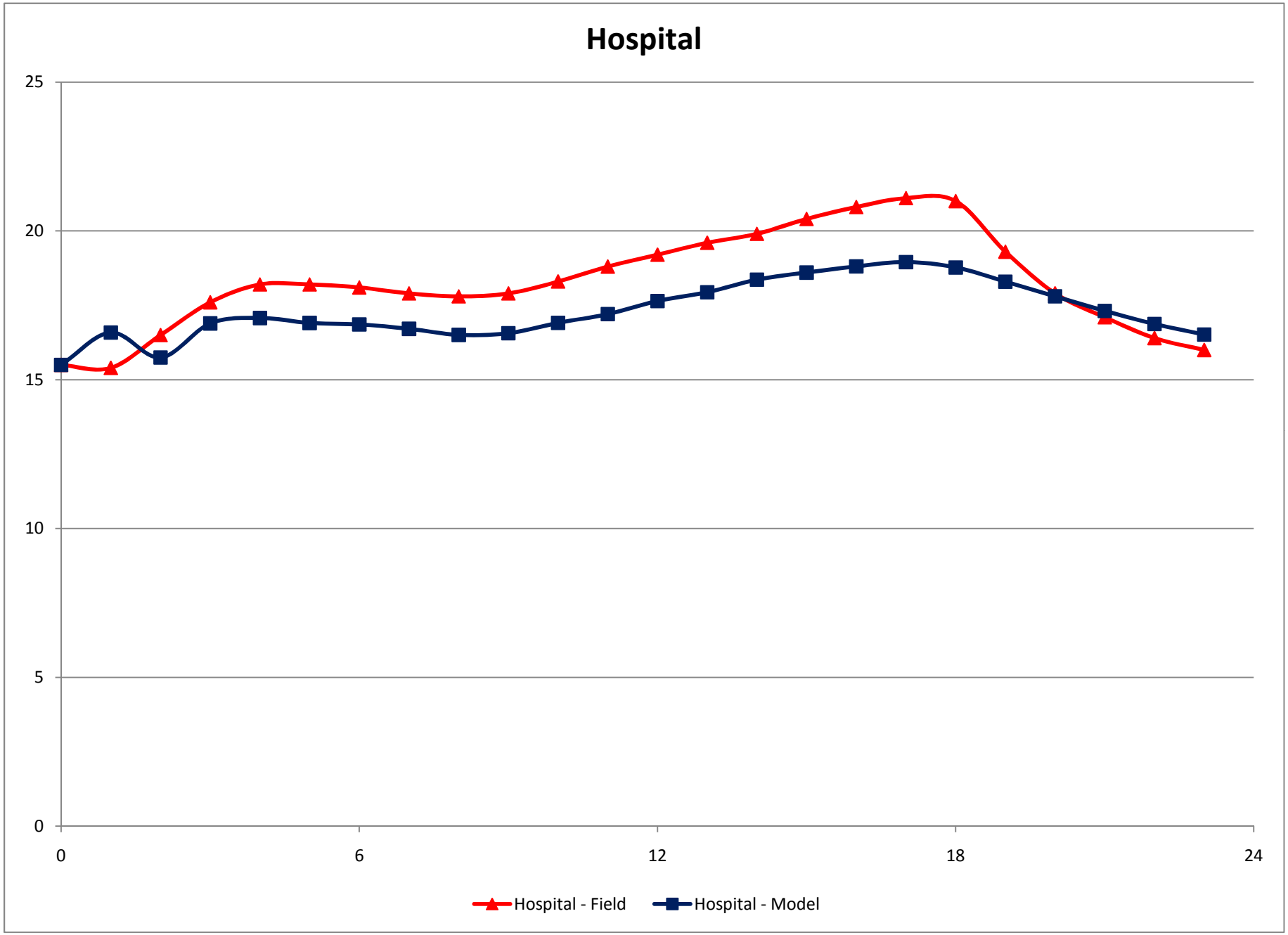

Prescott
100
90
80
70
60
50
40
30
20
10
0
0
6
12
18
24
Field Level
Model Level

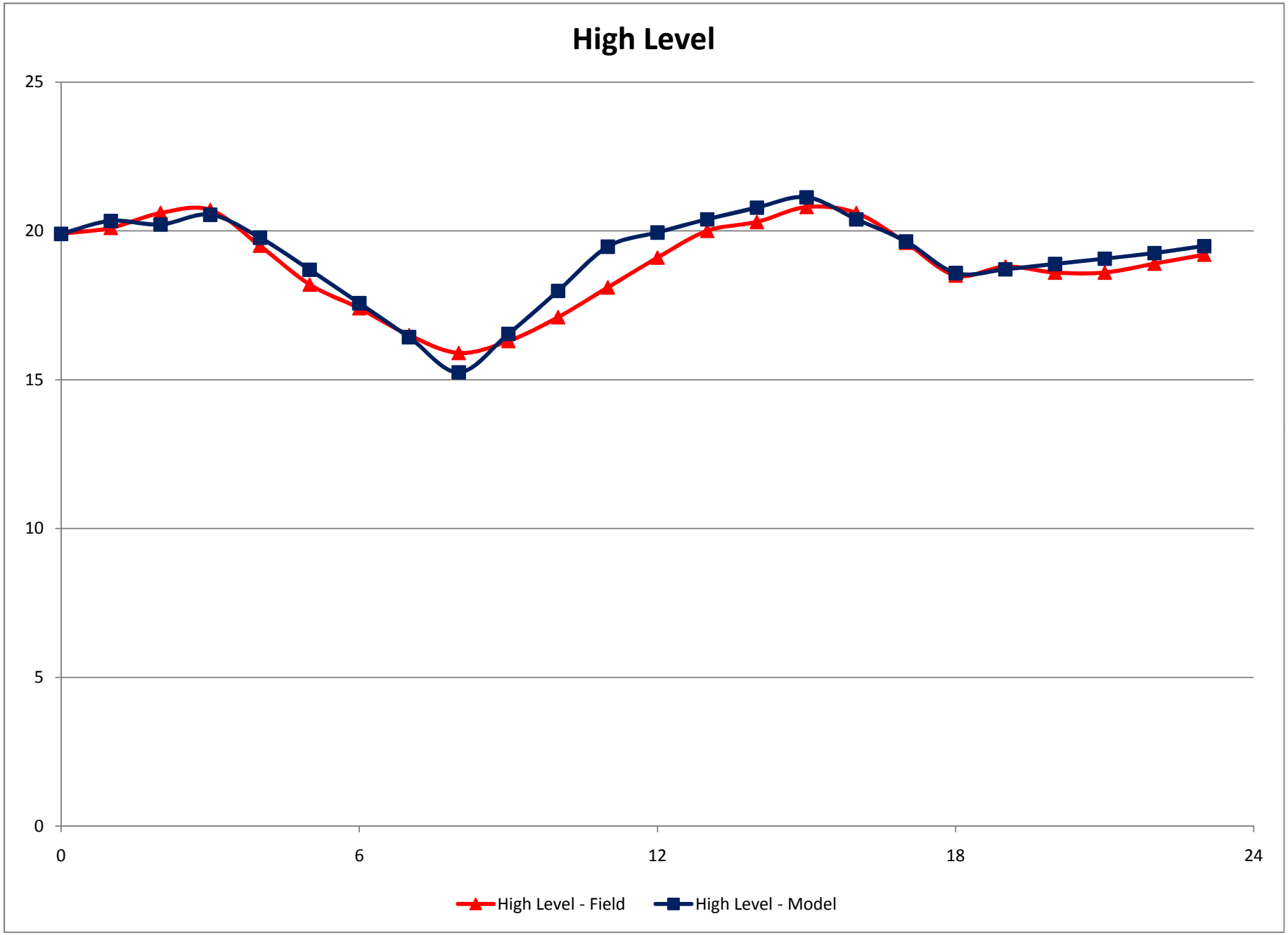

Patterson 1
25
20
15
10
5
0
0
6
12
18
24
Patterson 1 - Field
Patterson 1 - Model

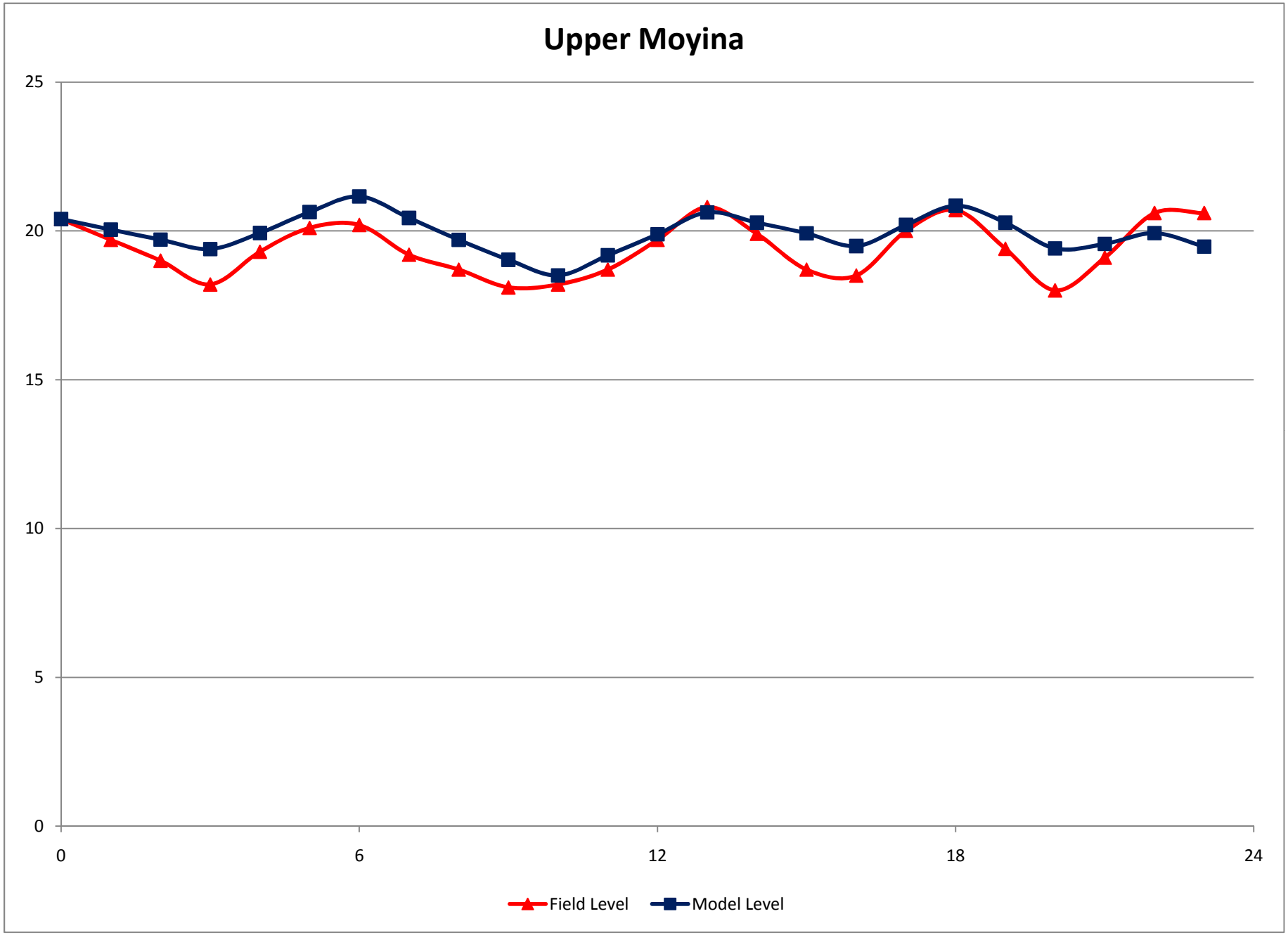

Patterson 2
25
20
15
10
5
0
0
6
12
18
24
Patterson 2 - Field
Patterson 2 - Model

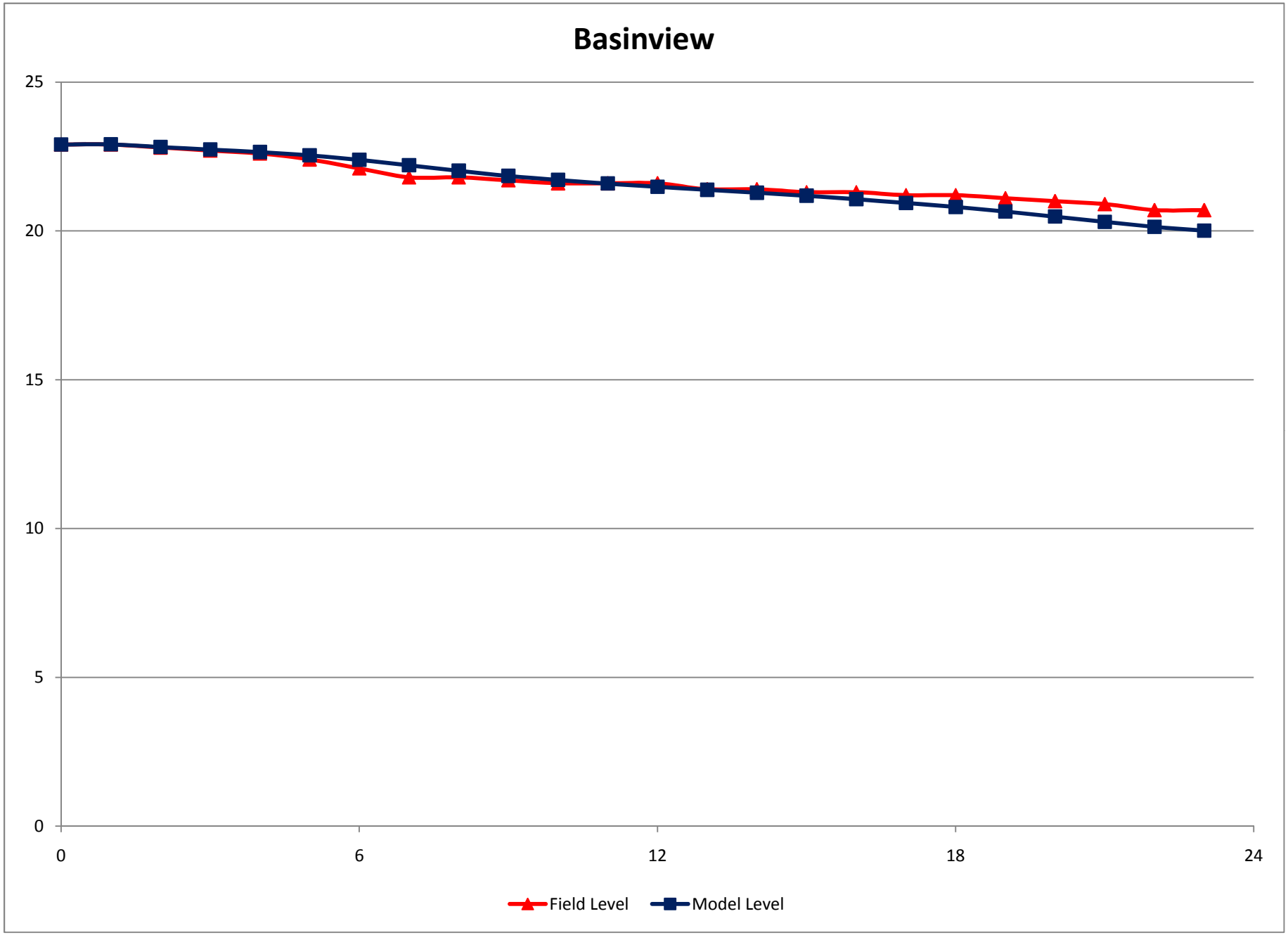

Lower Moyina
25
20
15
10
5
0
0
6
12
18
24
Moyina - Field
Moyina - Model

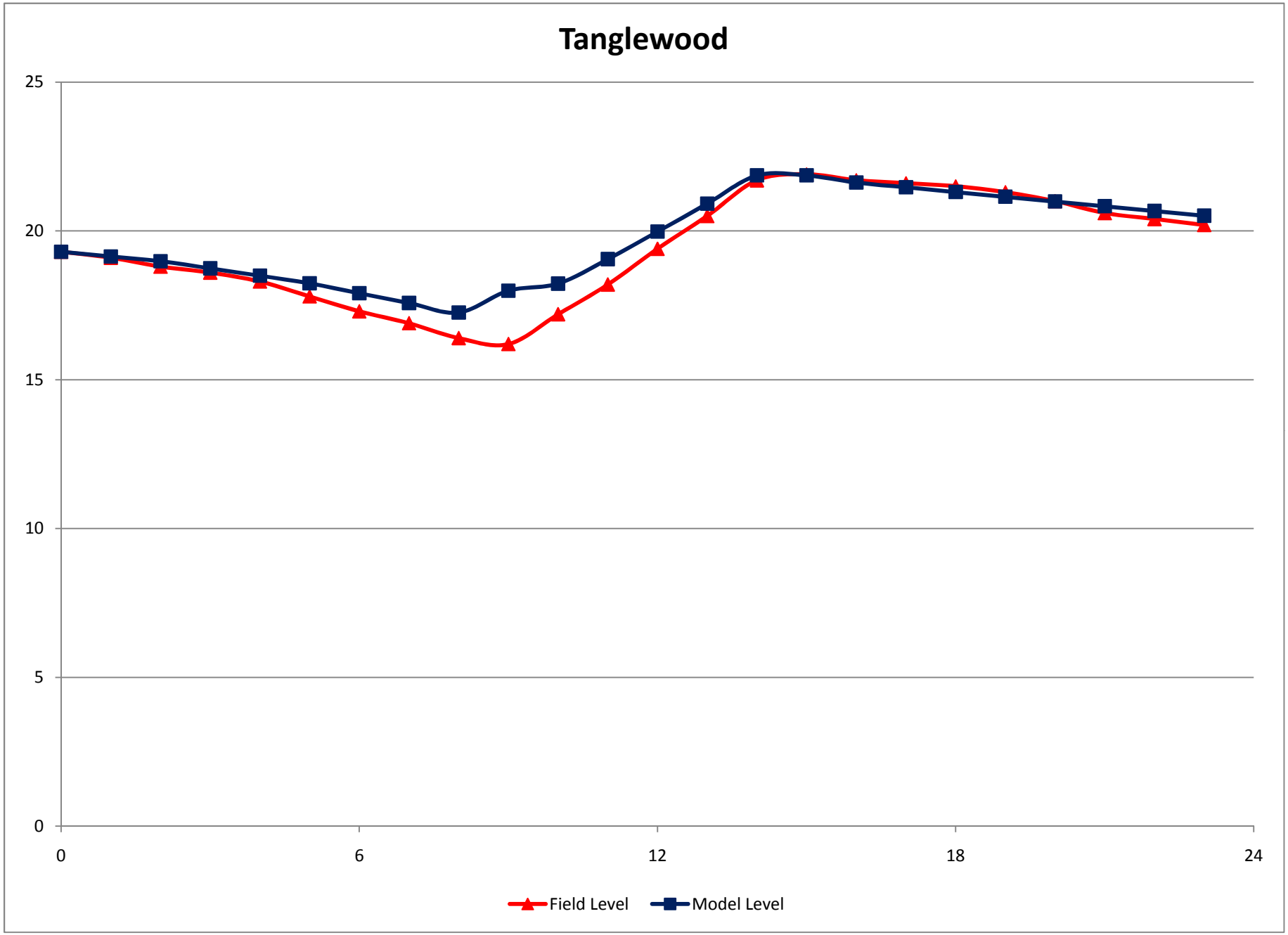

Urhmann
25
20
15
10
5
0
0
6
12
18
24
Uhrmann - Field
Uhrmann - Model


Hospital
25
20
15
10
5
0
0
6
12
18
24
Hospital - Field
Hospital - Model


High Level
25
20
15
10
5
0
0
6
12
18
24
High Level - Field
High Level - Model

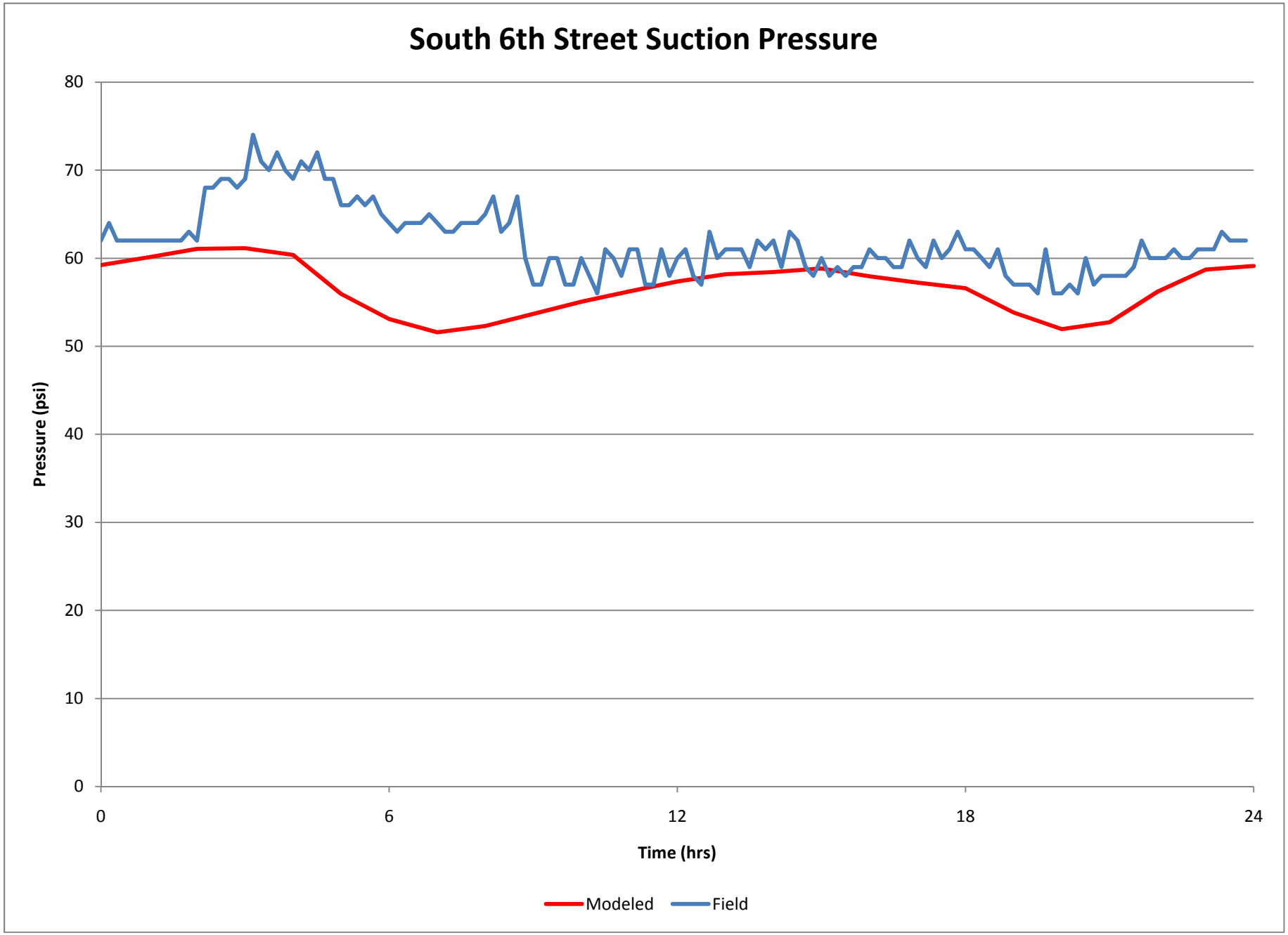

Upper Moyina
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

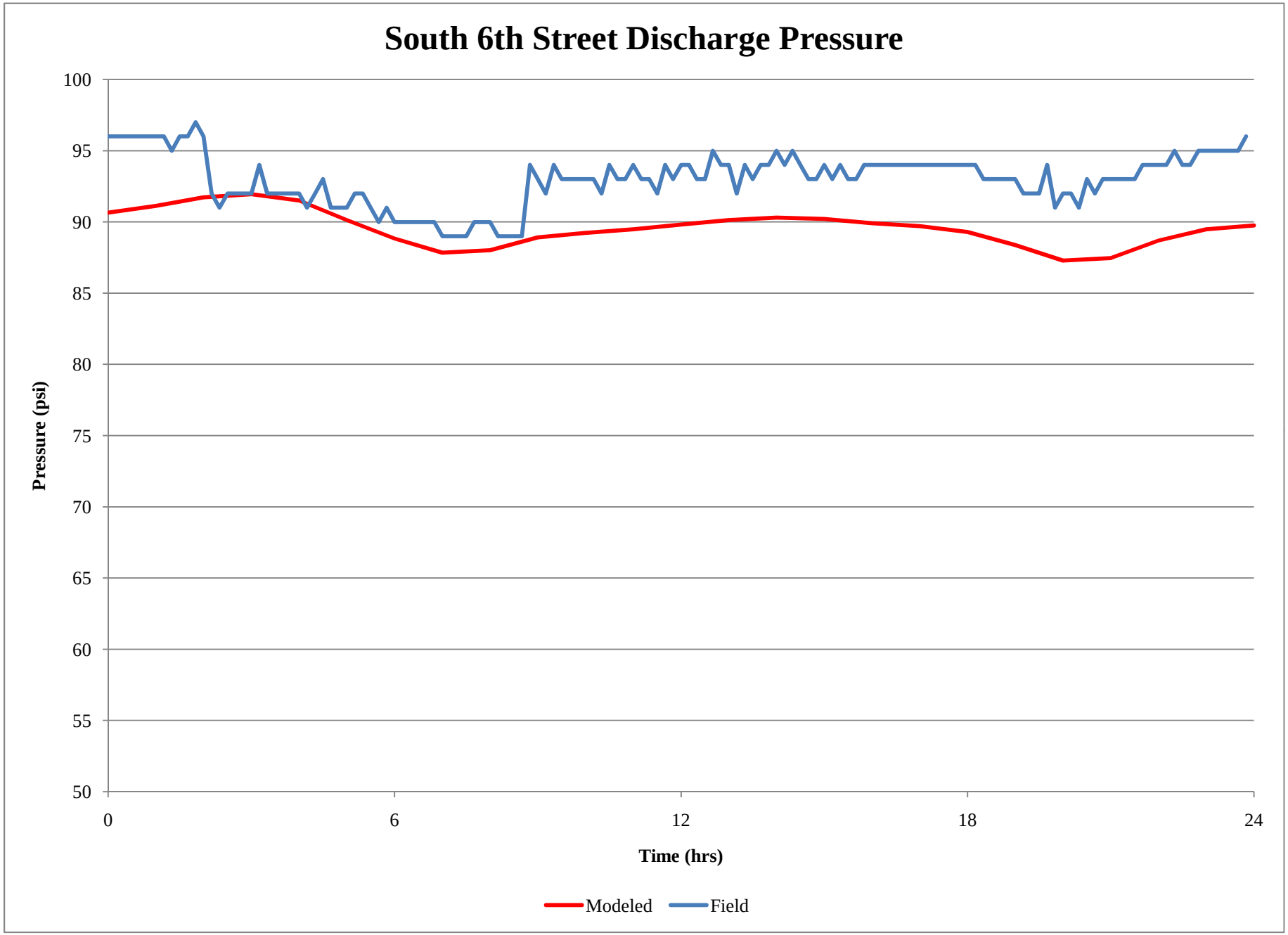

Basinview
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

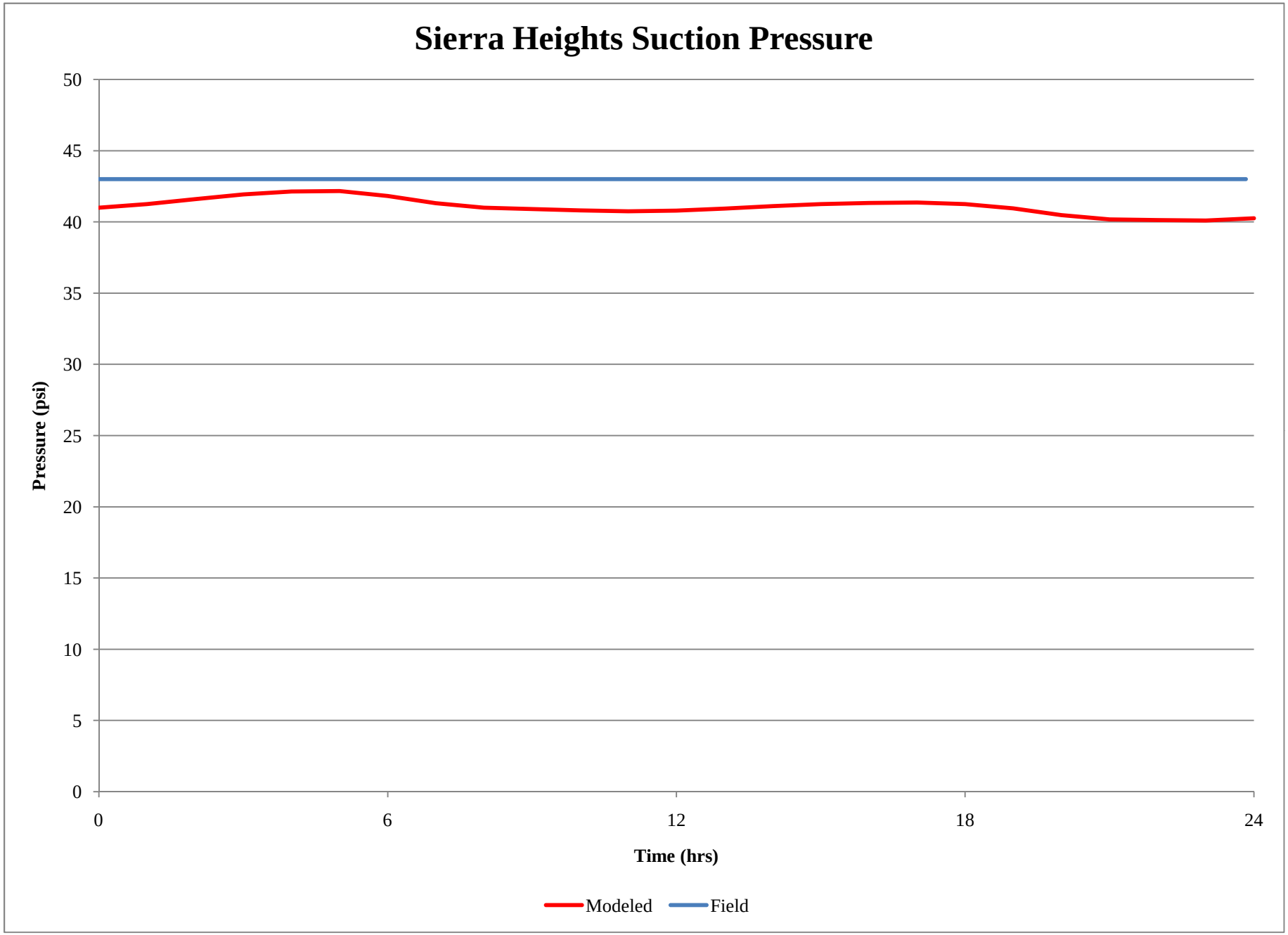

Tanglewood
25
20
15
10
5
0
0
6
12
18
24
Field Level
Model Level

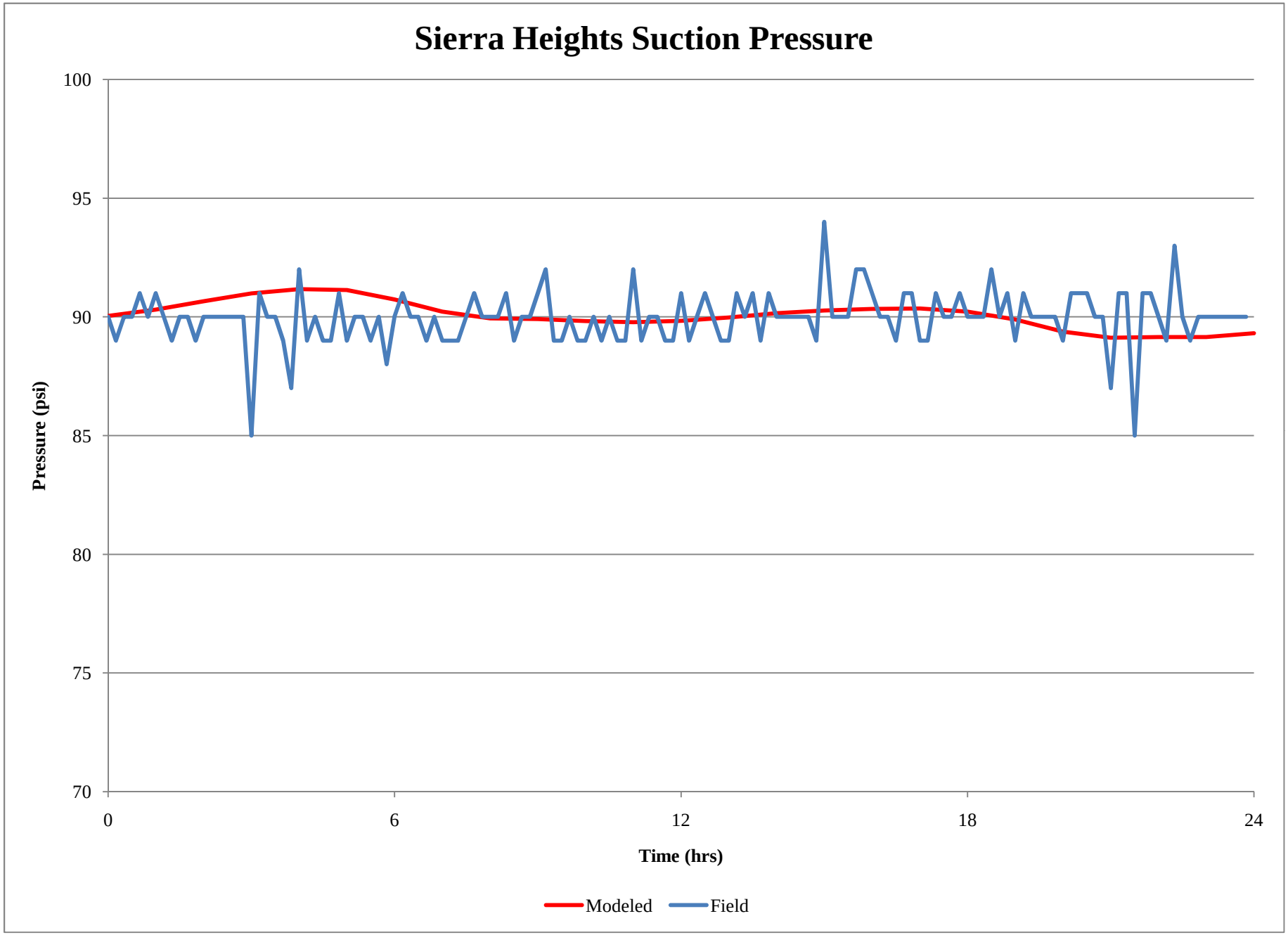
Verification Plots
for Maximum Demand Day:

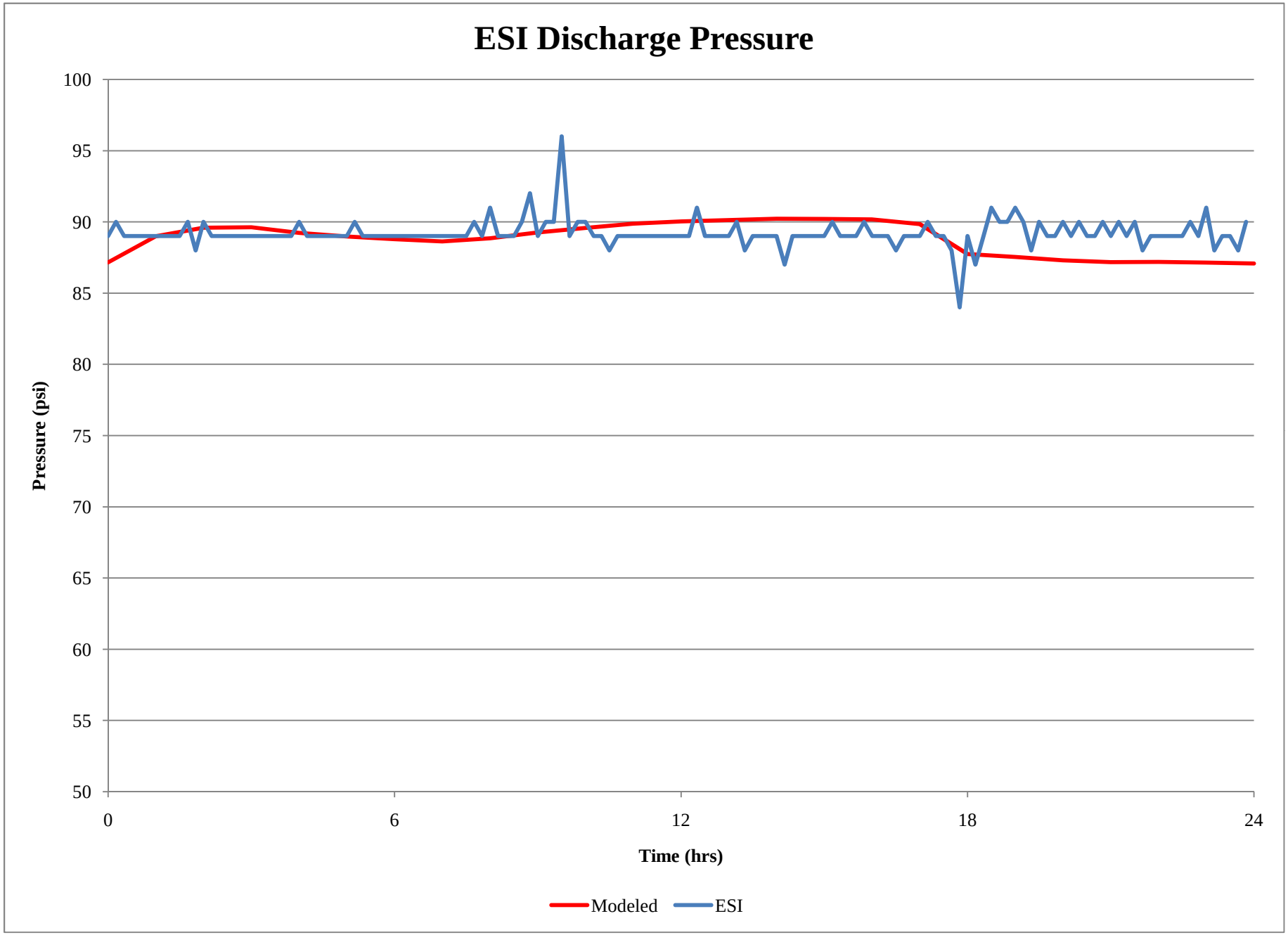
Pump Station Pressures


South 6th Street Suction Pressure
80
70
60
50
40
30
20
10
0
Pressure (psi)
0
6
12
18
24
Time (hrs)
Modeled
Field

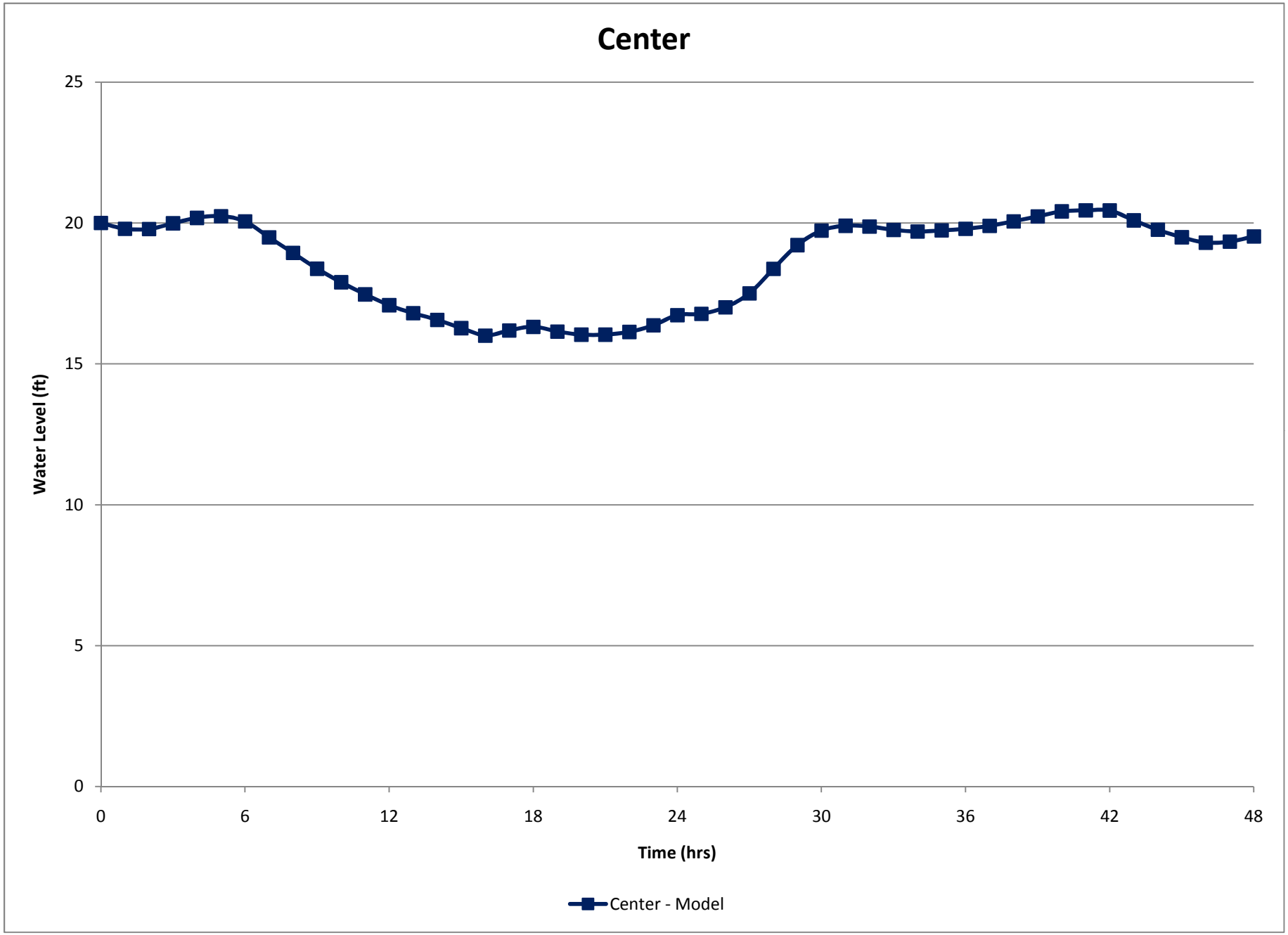

South 6th Street Discharge Pressure
100
95
90
85
80
75
70
65
60
55
50
Pressure (psi)
0
6
12
18
24
Time (hrs)
Modeled
Field

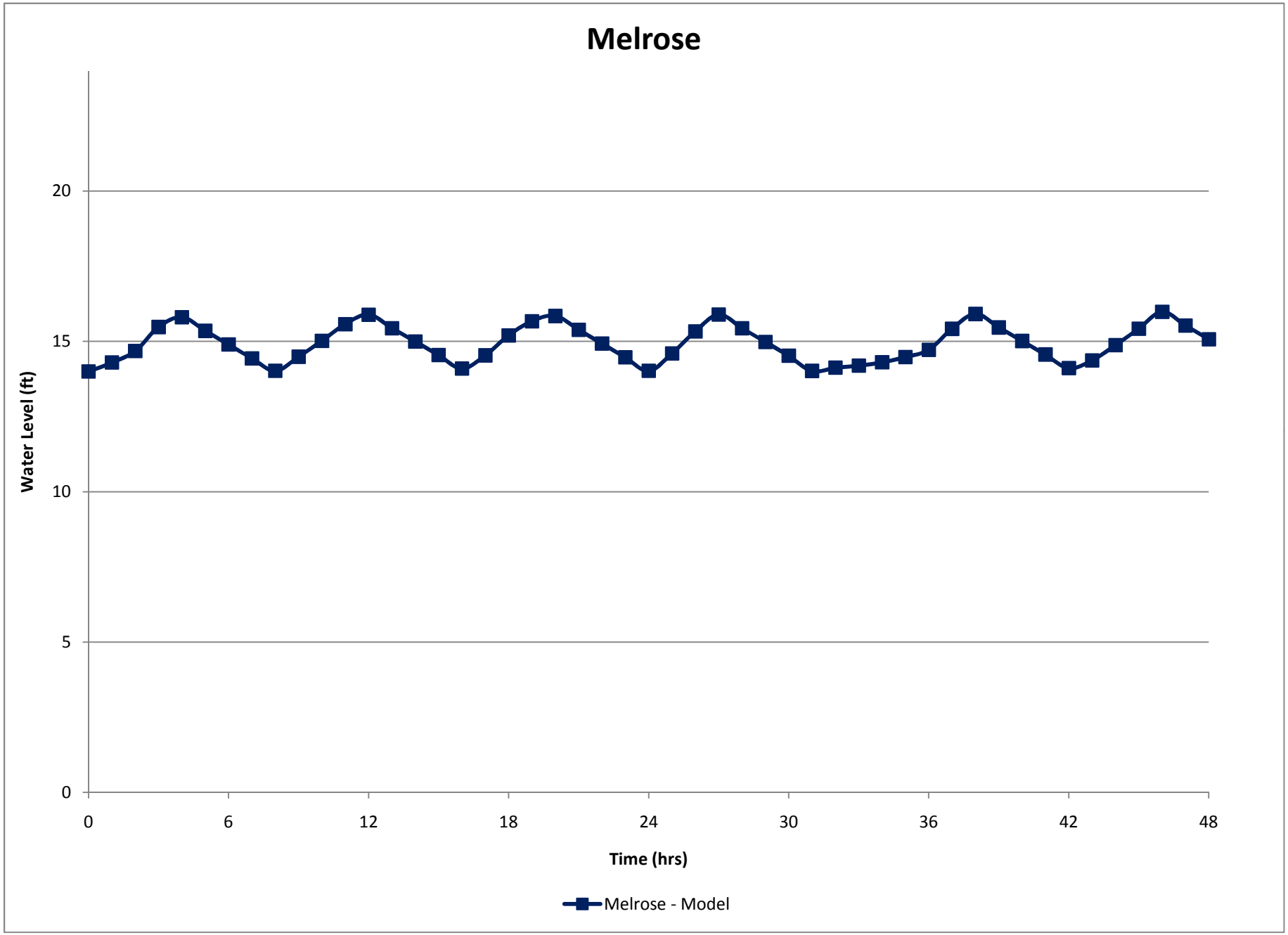

Sierra Heights Suction Pressure
50
45
40
35
30
25
20
15
10
5
0
Pressure (psi)
0
6
12
18
24
Time (hrs)
Modeled
Field

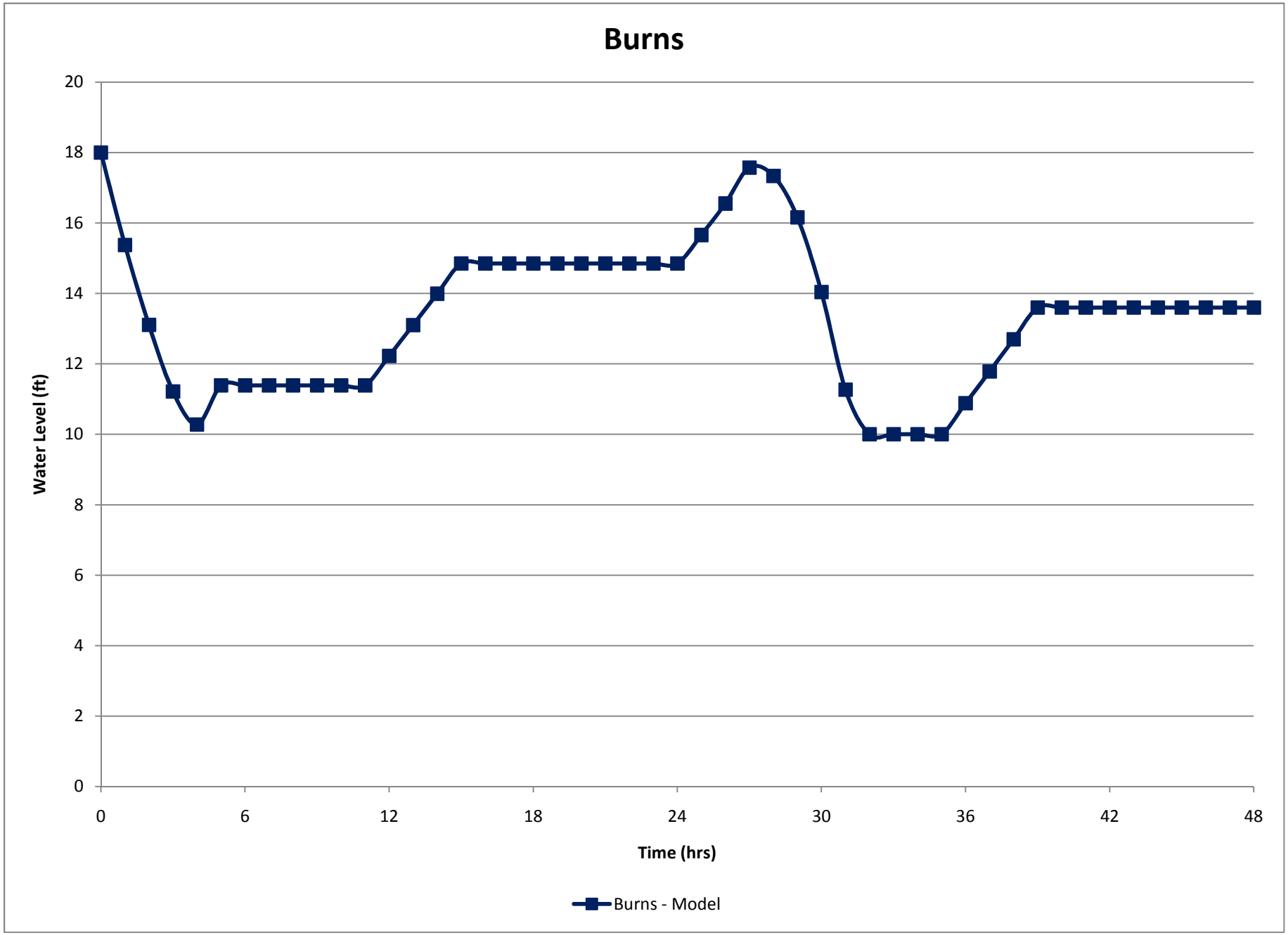

Sierra Heights Suction Pressure
100
95
90
85
80
75
70
Pressure (psi)
0
6
12
18
24
Time (hrs)
Modeled
Field

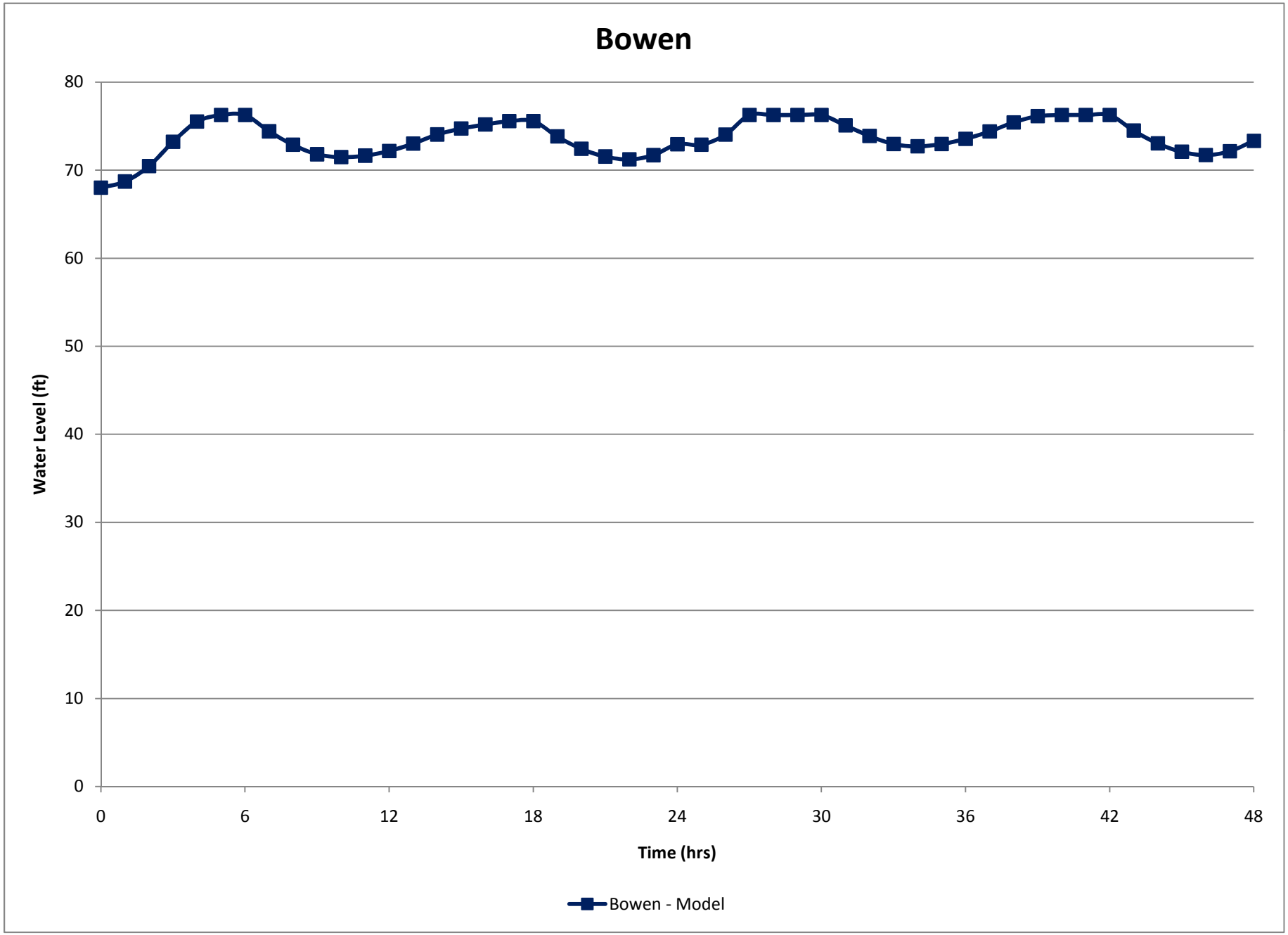

ESI Discharge Pressure
100
95
90
85
80
75
70
65
60
55
50
Pressure (psi)
0
6
12
18
24
Time (hrs)
Modeled
ESI

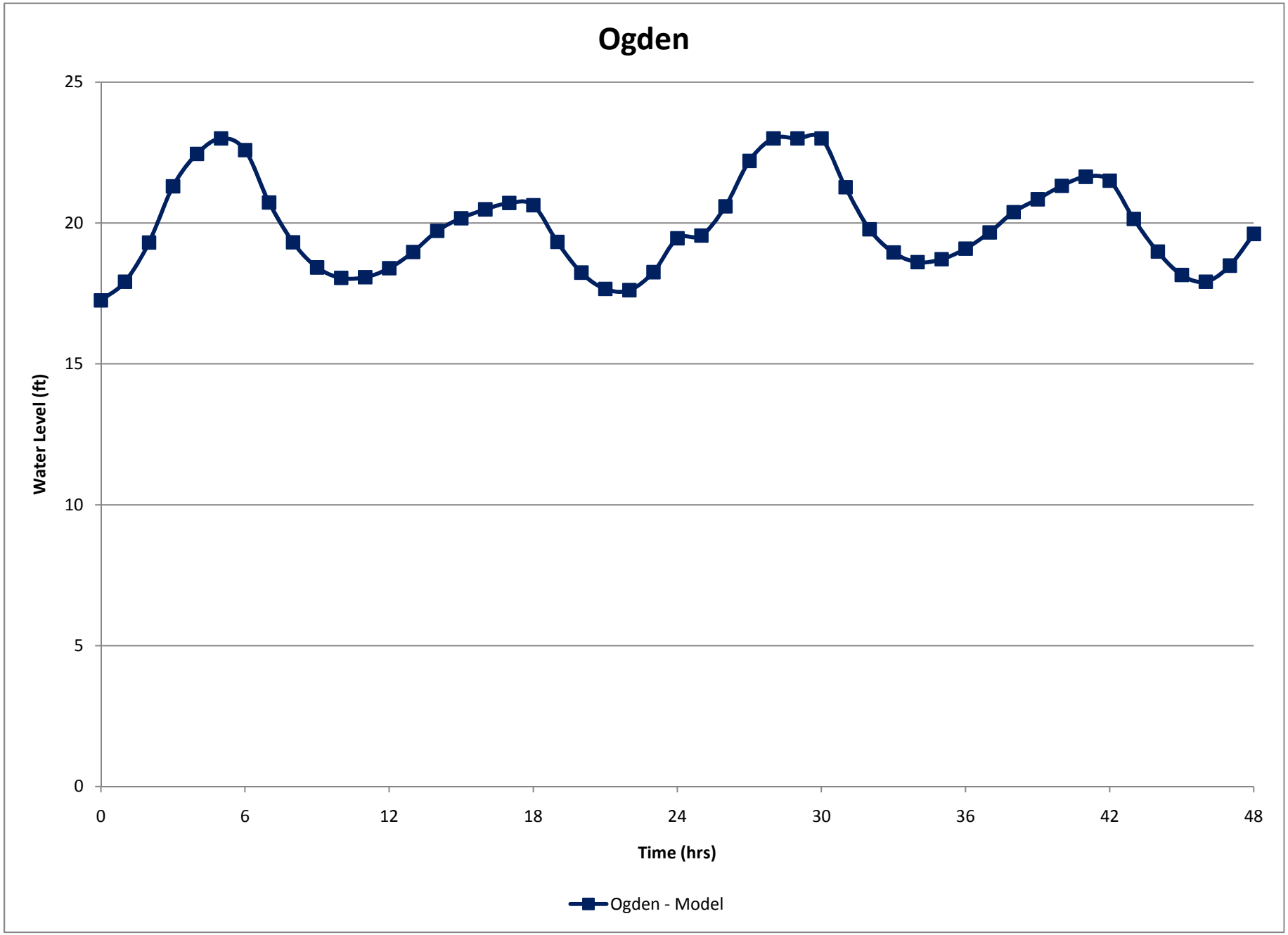
Appendix D
Extended Period Simulation (EPS)Results

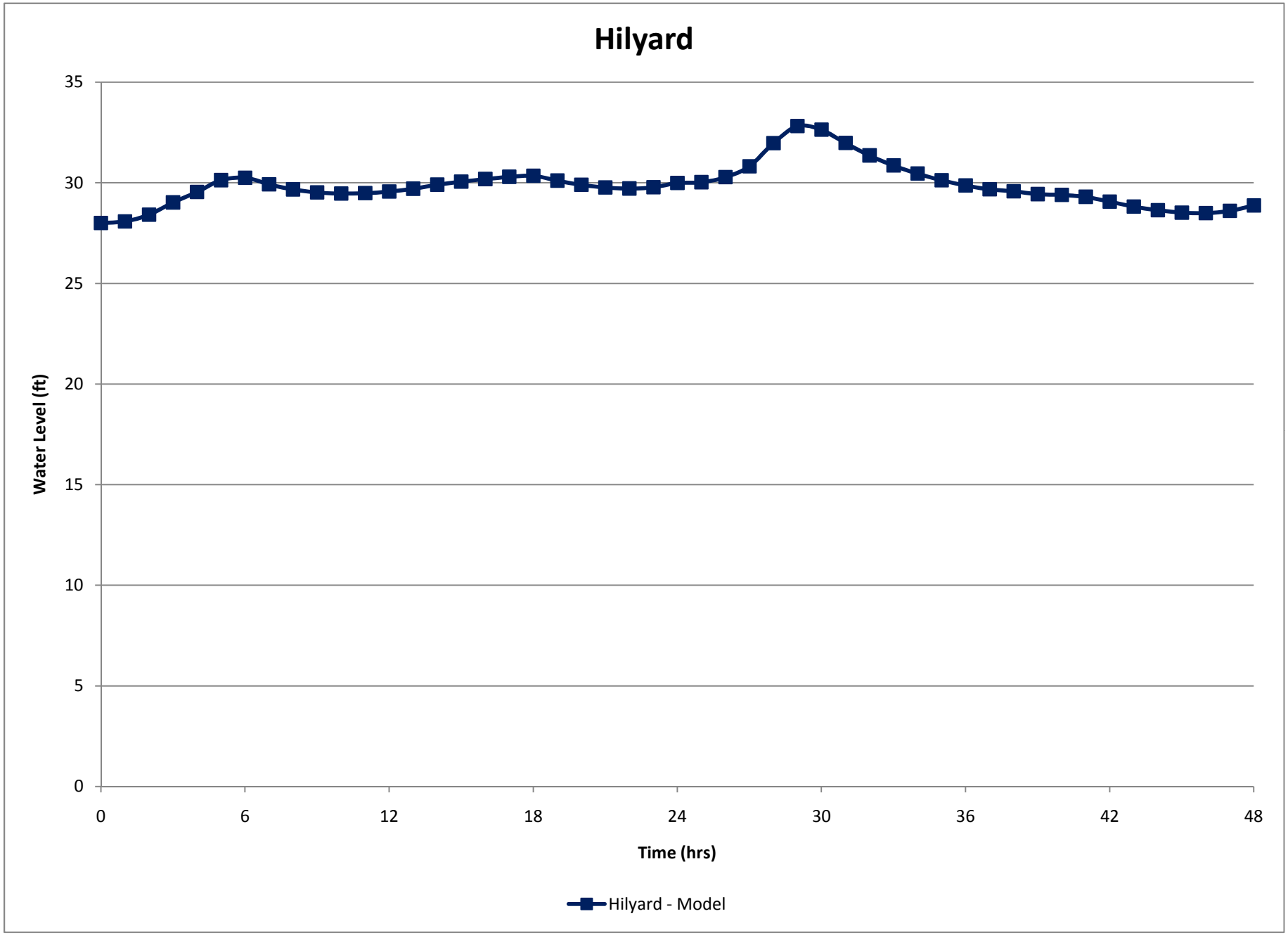

Center
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Center - Model

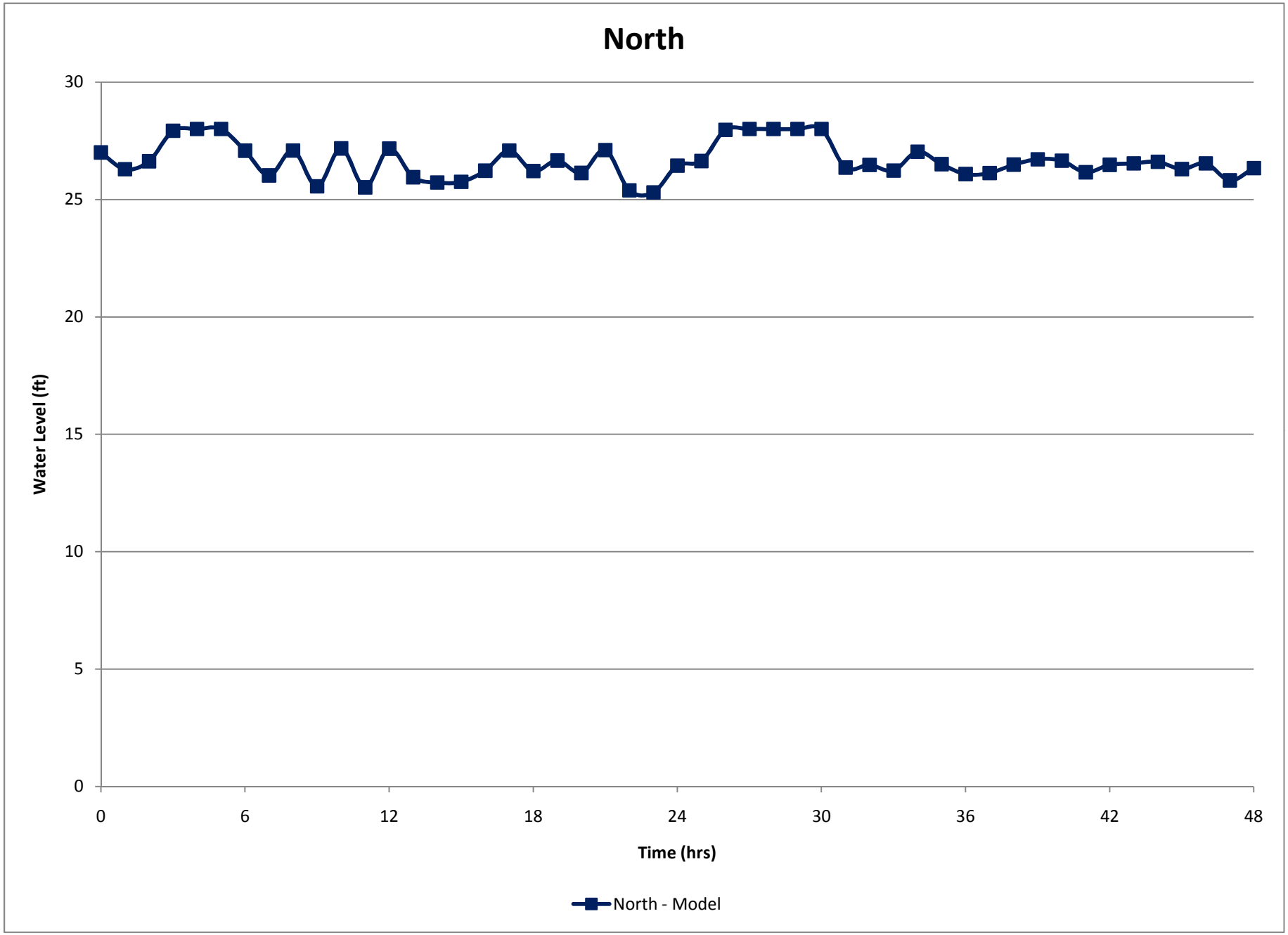

Melrose
Water Level (ft)
20
15
10
5
0
0
6
12
18
24
30
36
42
48
Time (hrs)
Melrose - Model

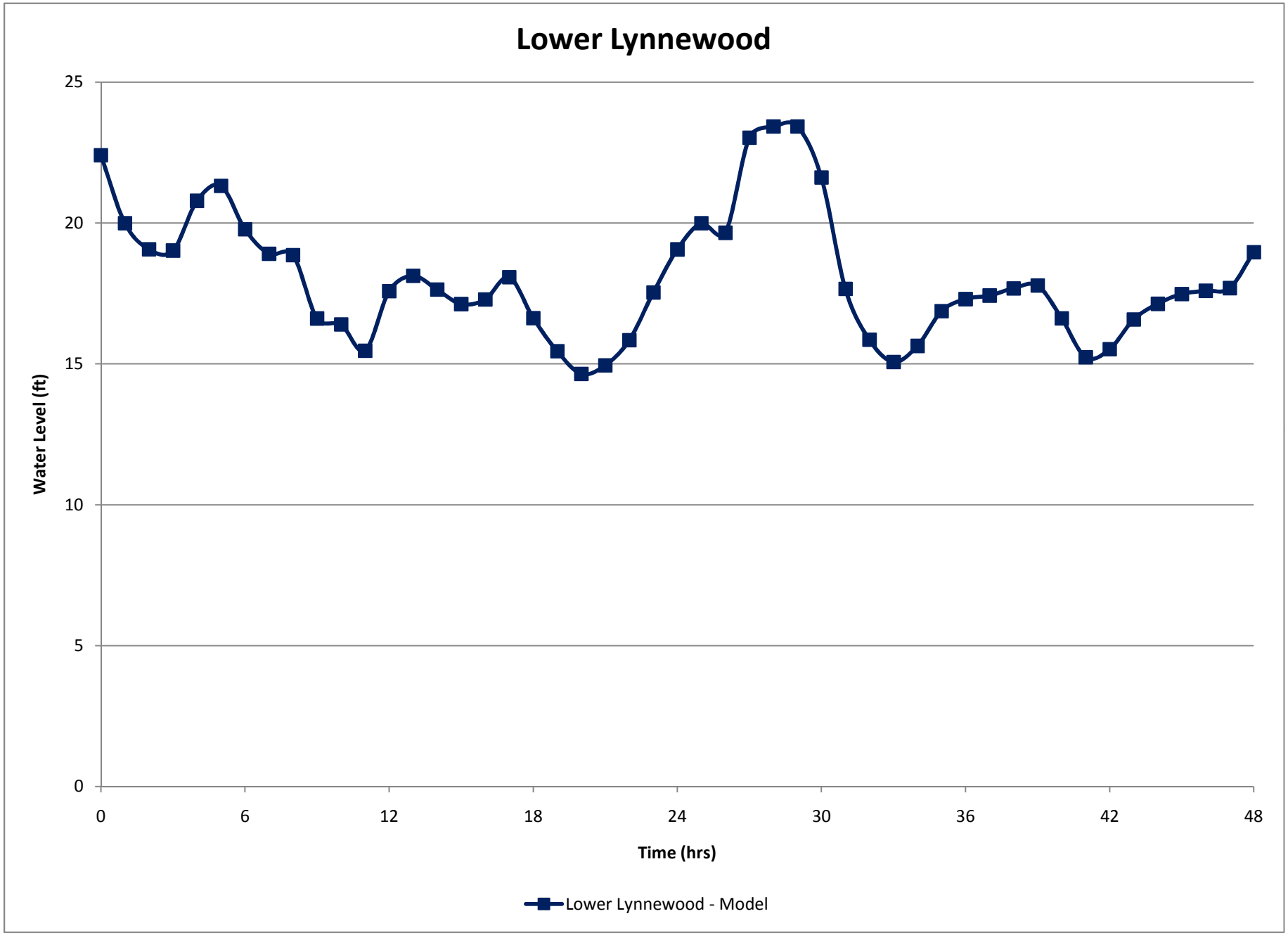

Burns
Water Level (ft)
20
18
16
14
12
10
8
6
4
2
0
0
6
12
18
24
30
36
42
48
Time (hrs)
Burns - Model

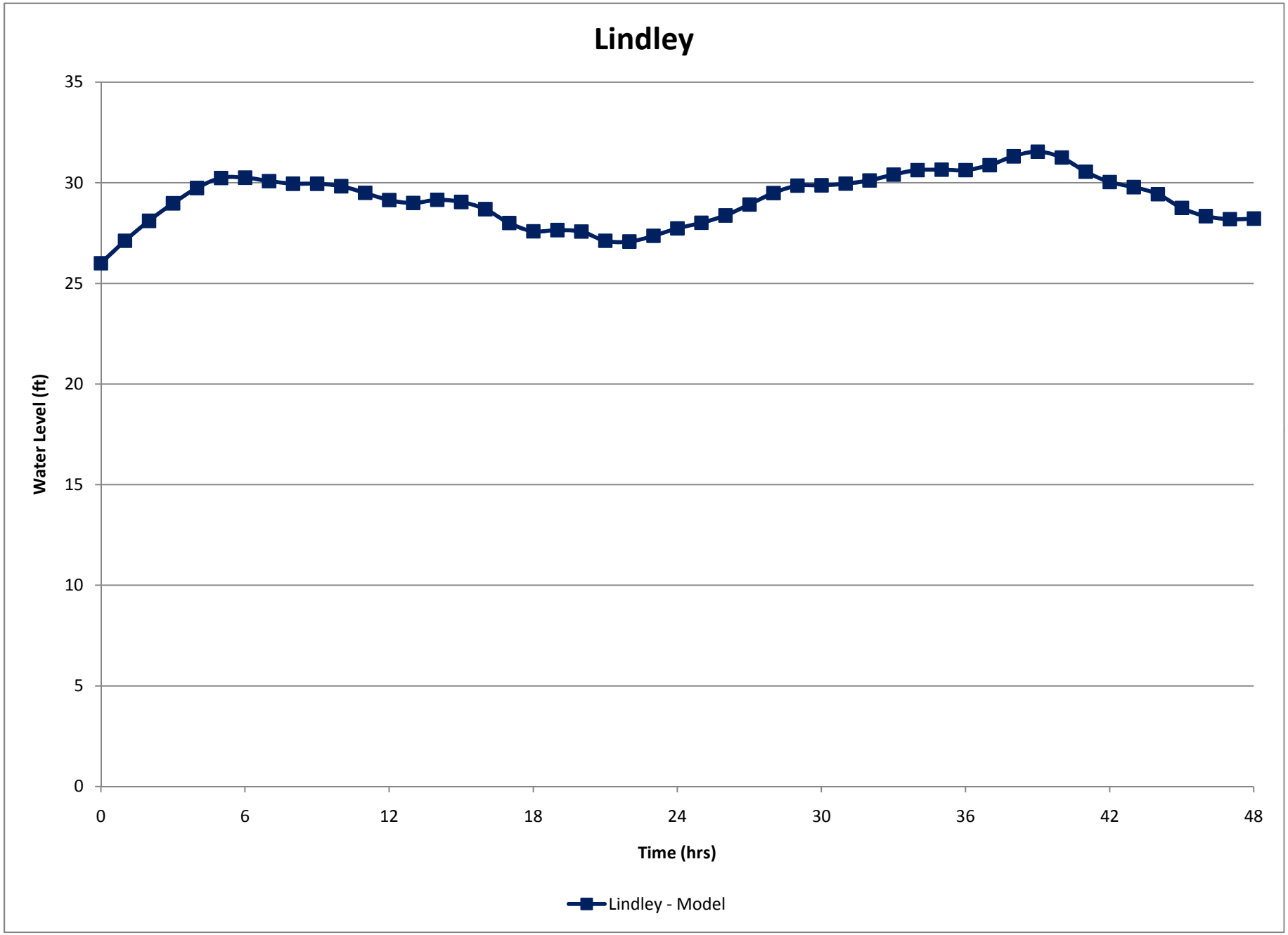

Bowen
80
70
60
50
40
30
20
10
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Bowen - Model

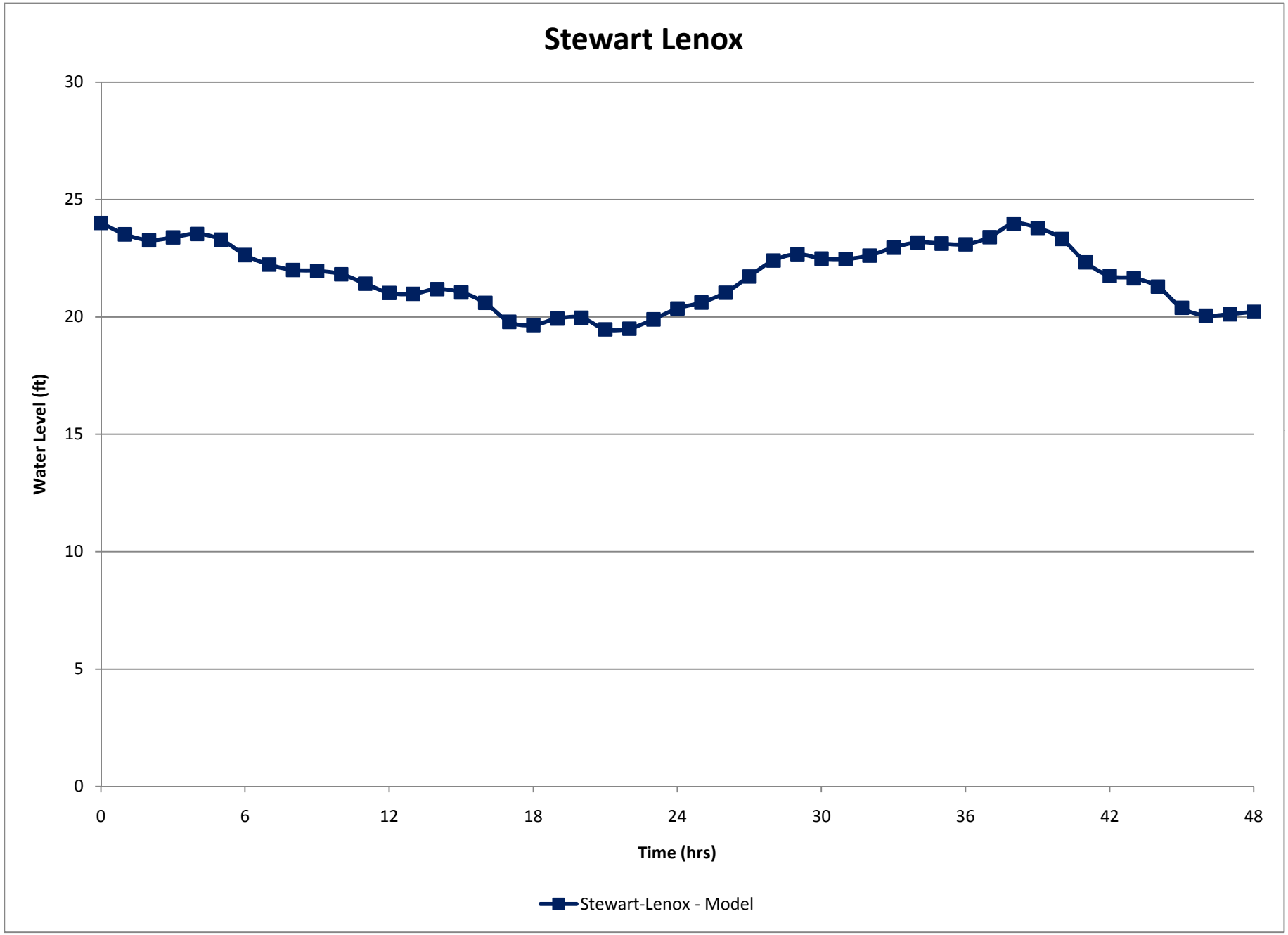

Ogden
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Ogden - Model

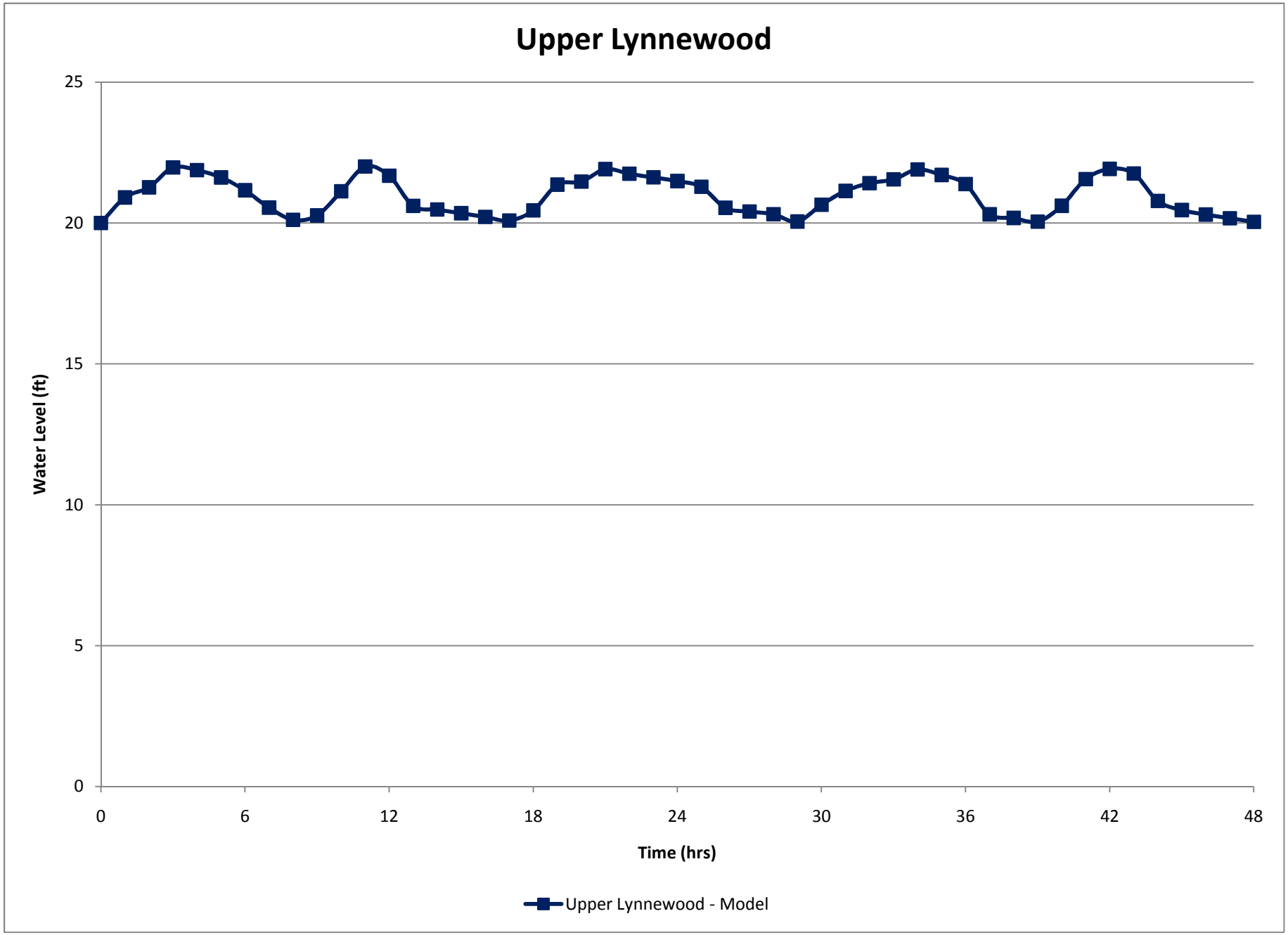

Hilyard
35
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Hilyard - Model

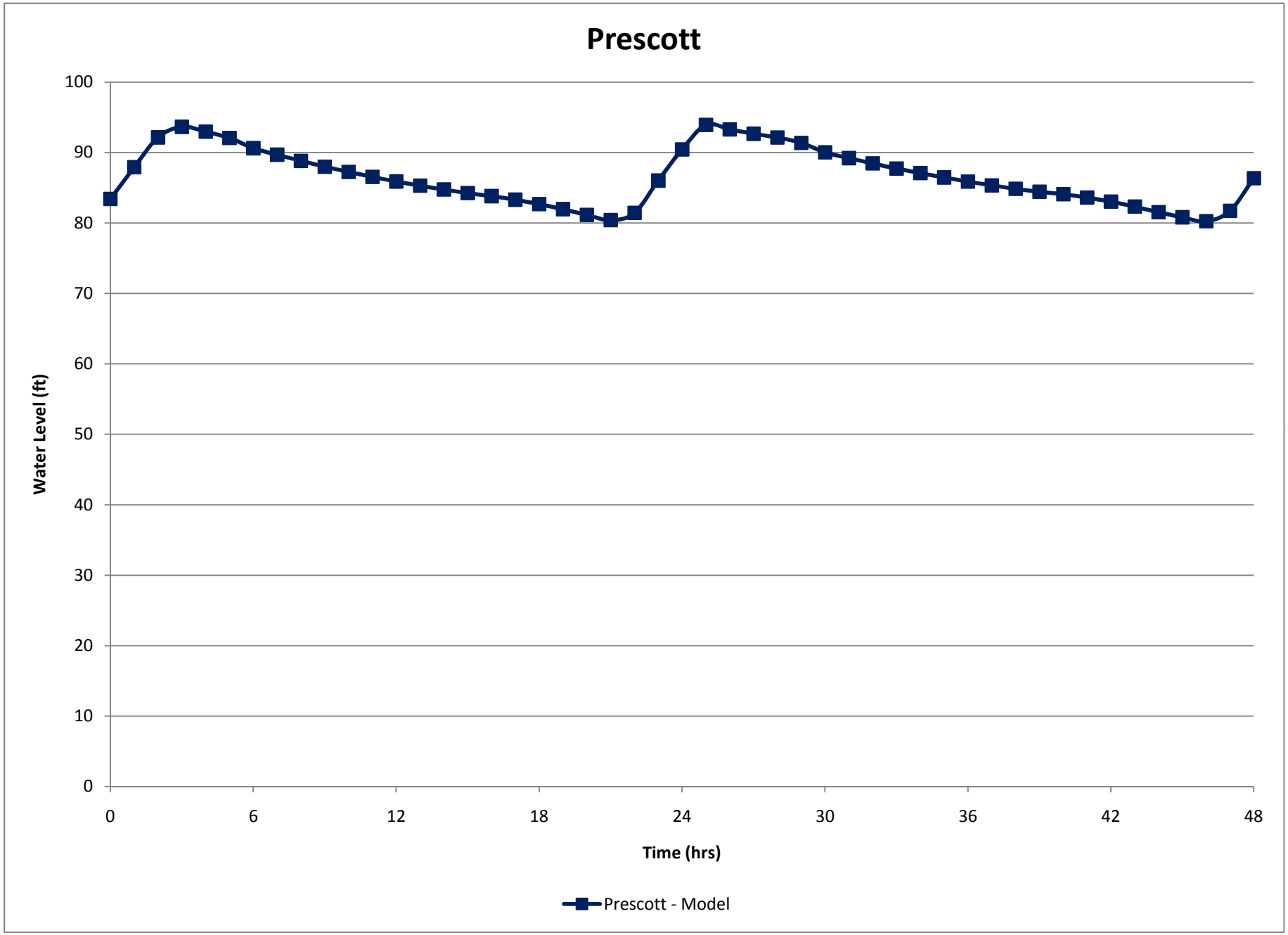

North
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
North - Model

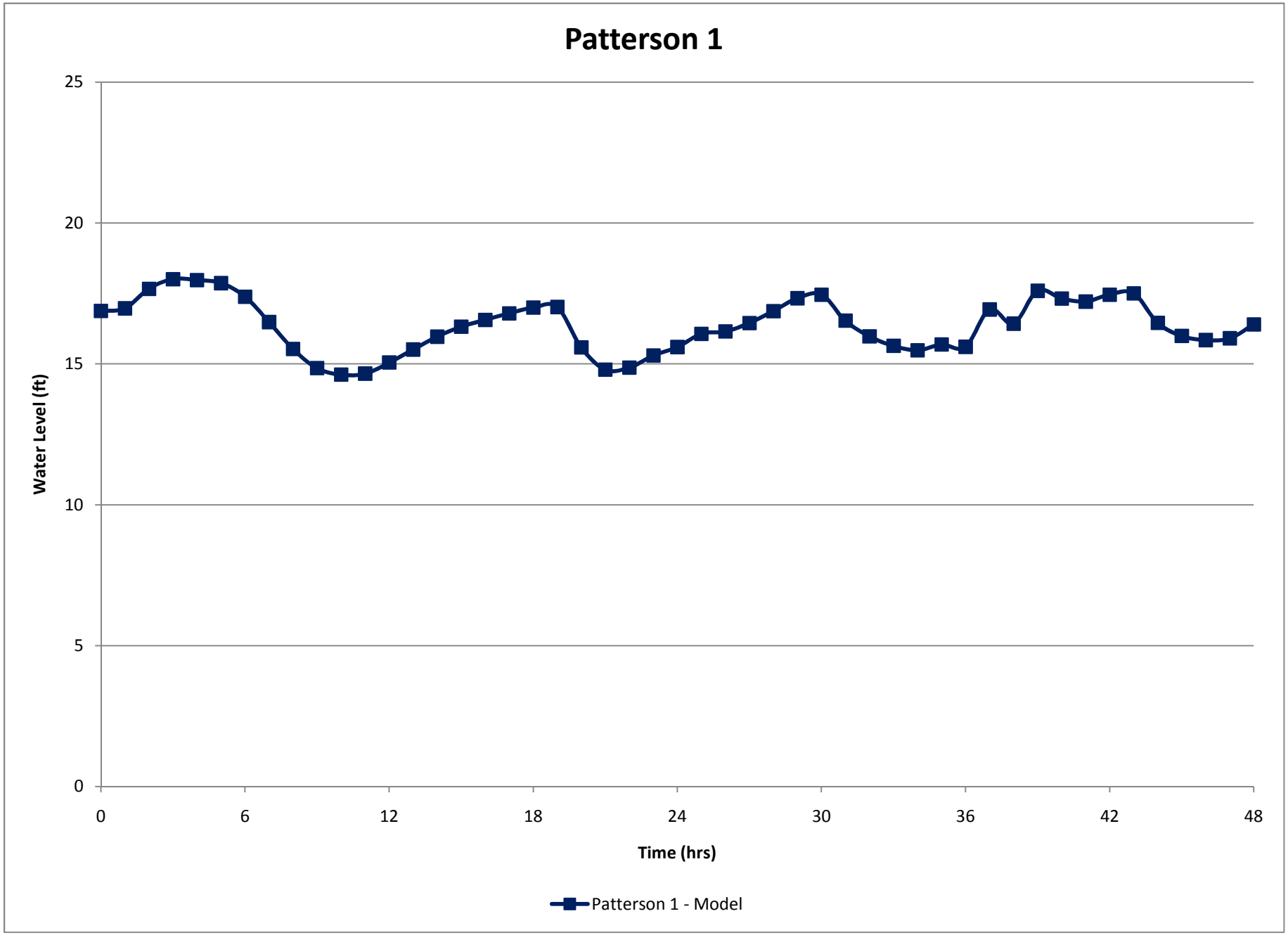

Lower Lynnewood
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Lower Lynnewood - Model

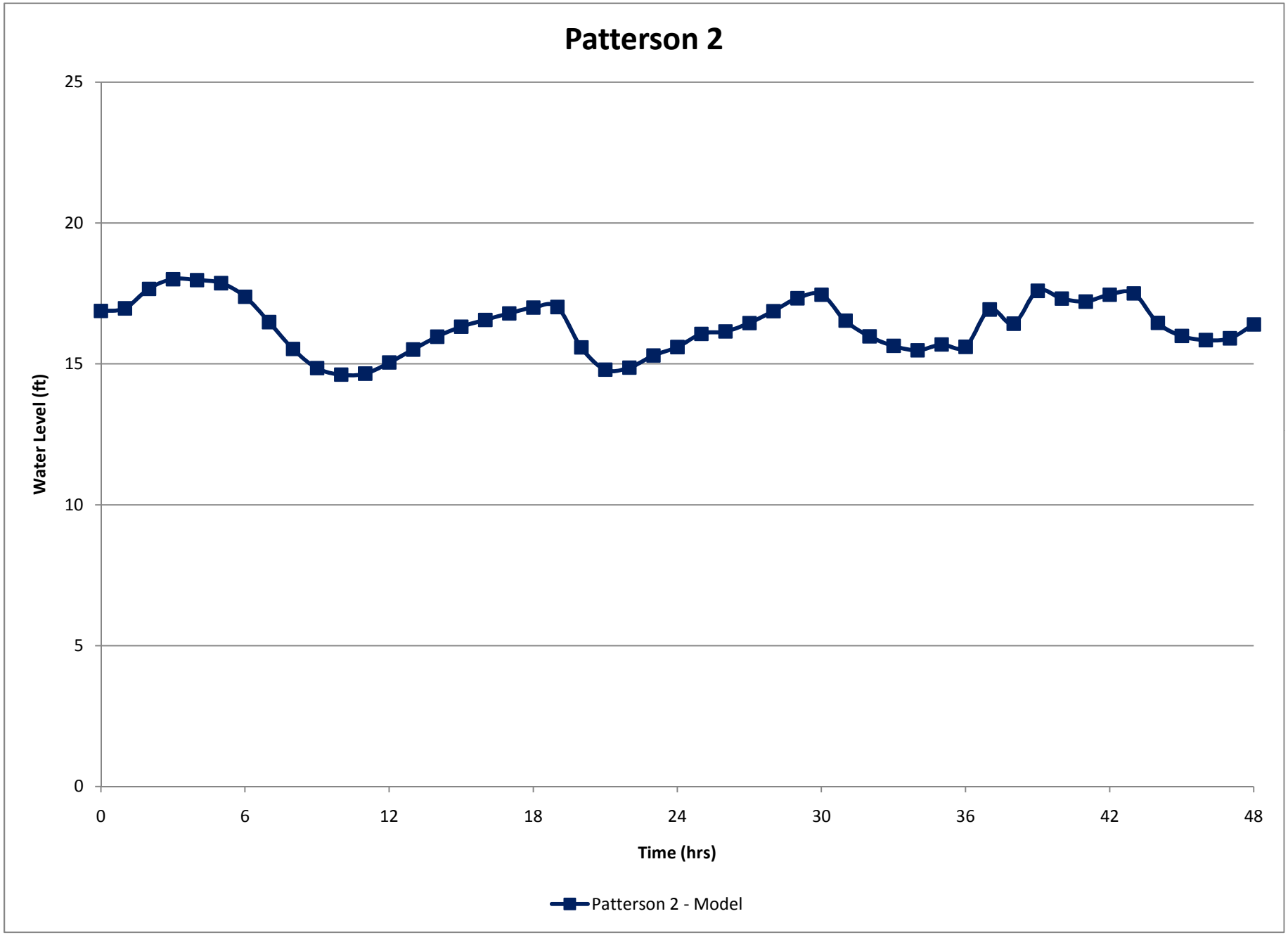

Lindley
35
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Lindley - Model

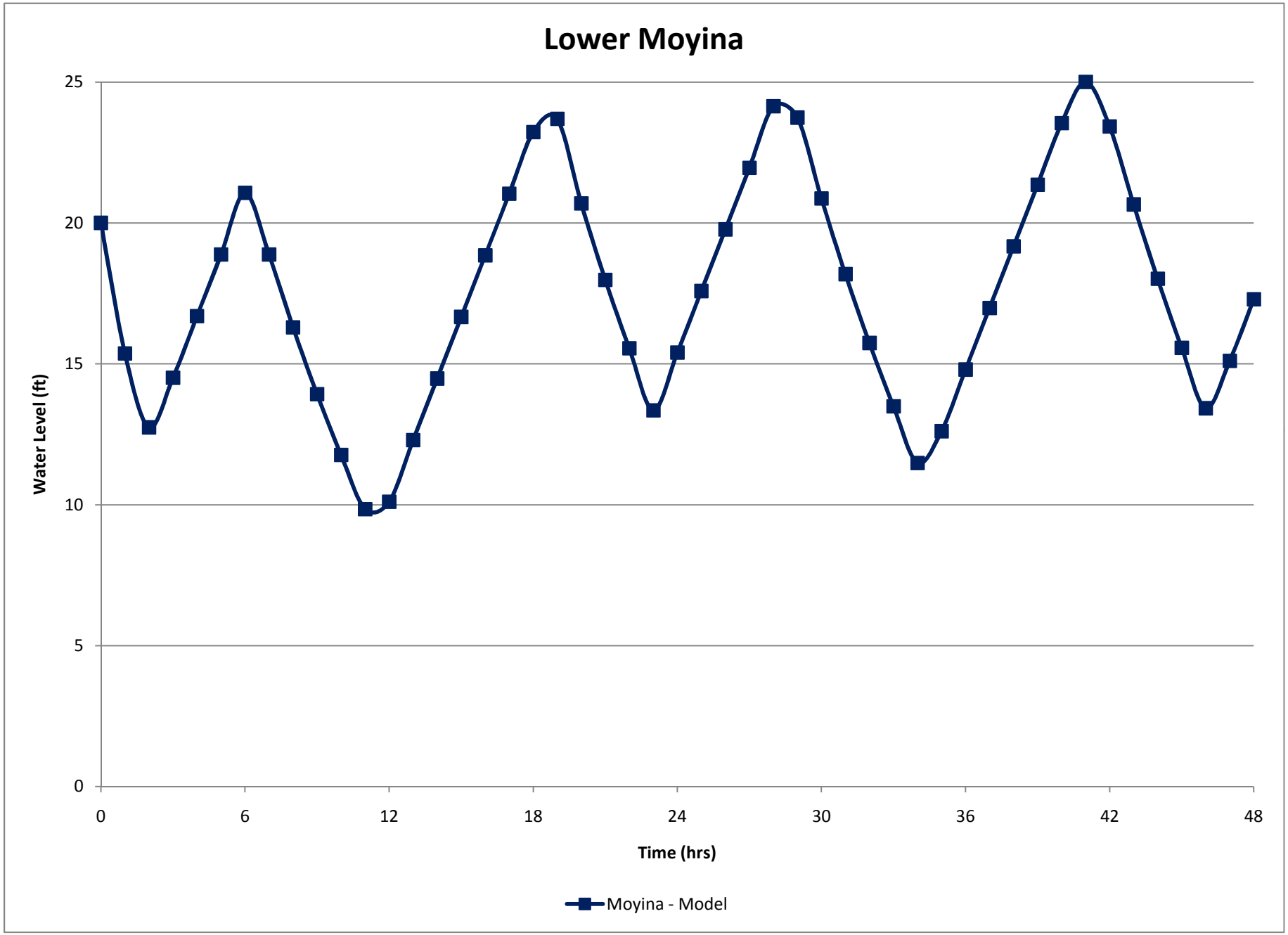

Stewart Lenox
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Stewart-Lenox - Model

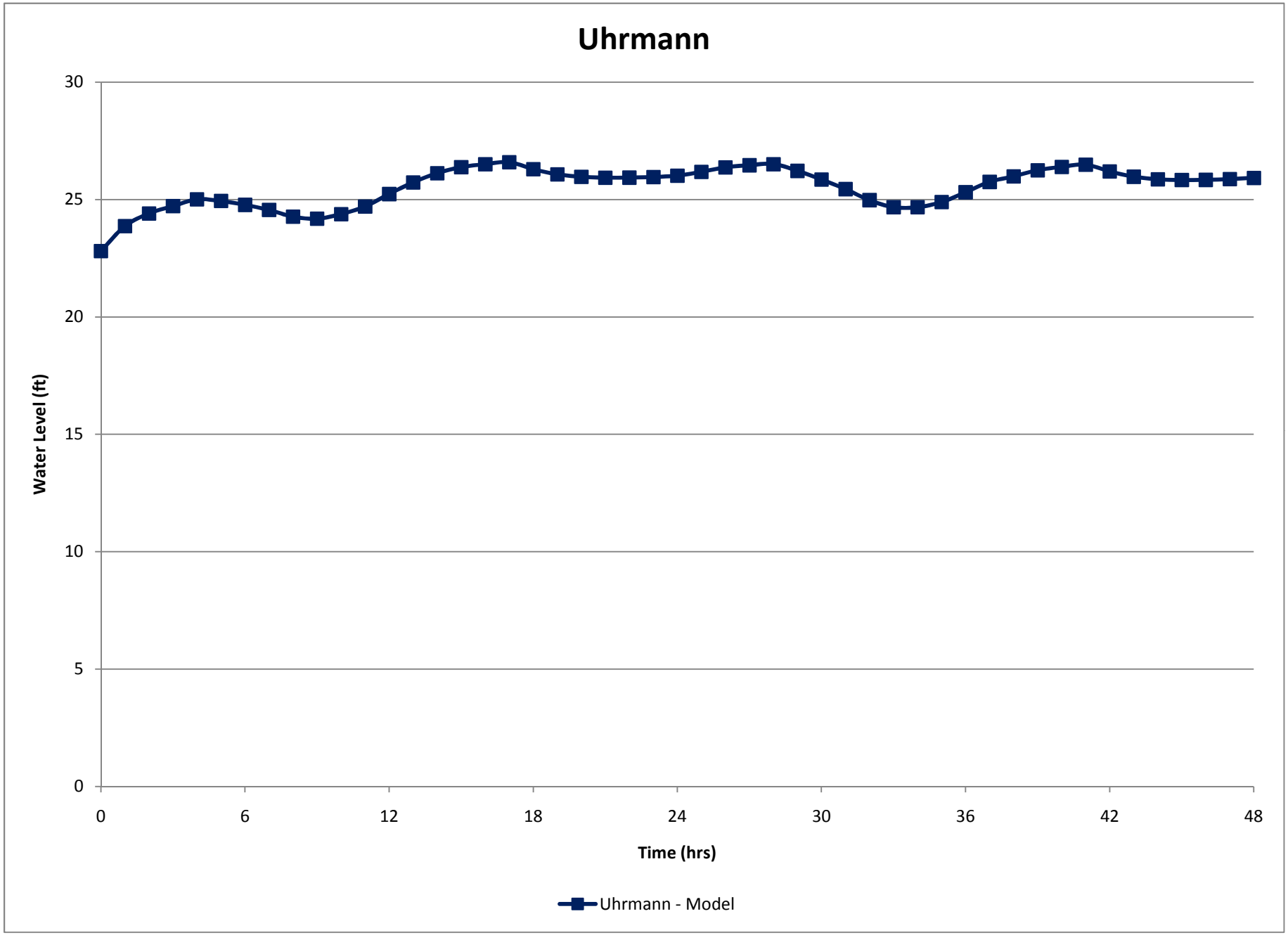

Upper Lynnewood
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Upper Lynnewood - Model

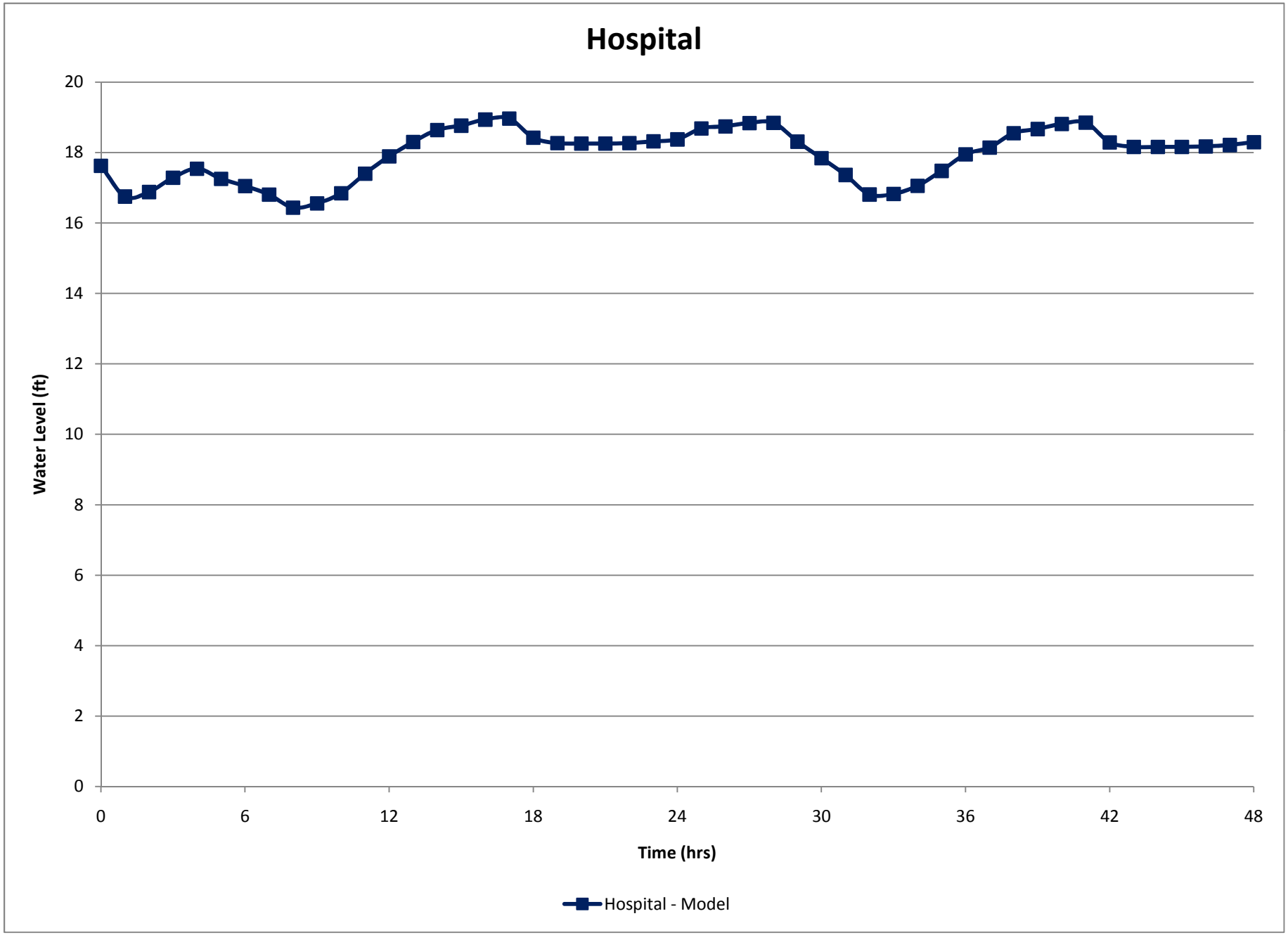

Prescott
100
90
80
70
60
50
40
30
20
10
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Prescott - Model

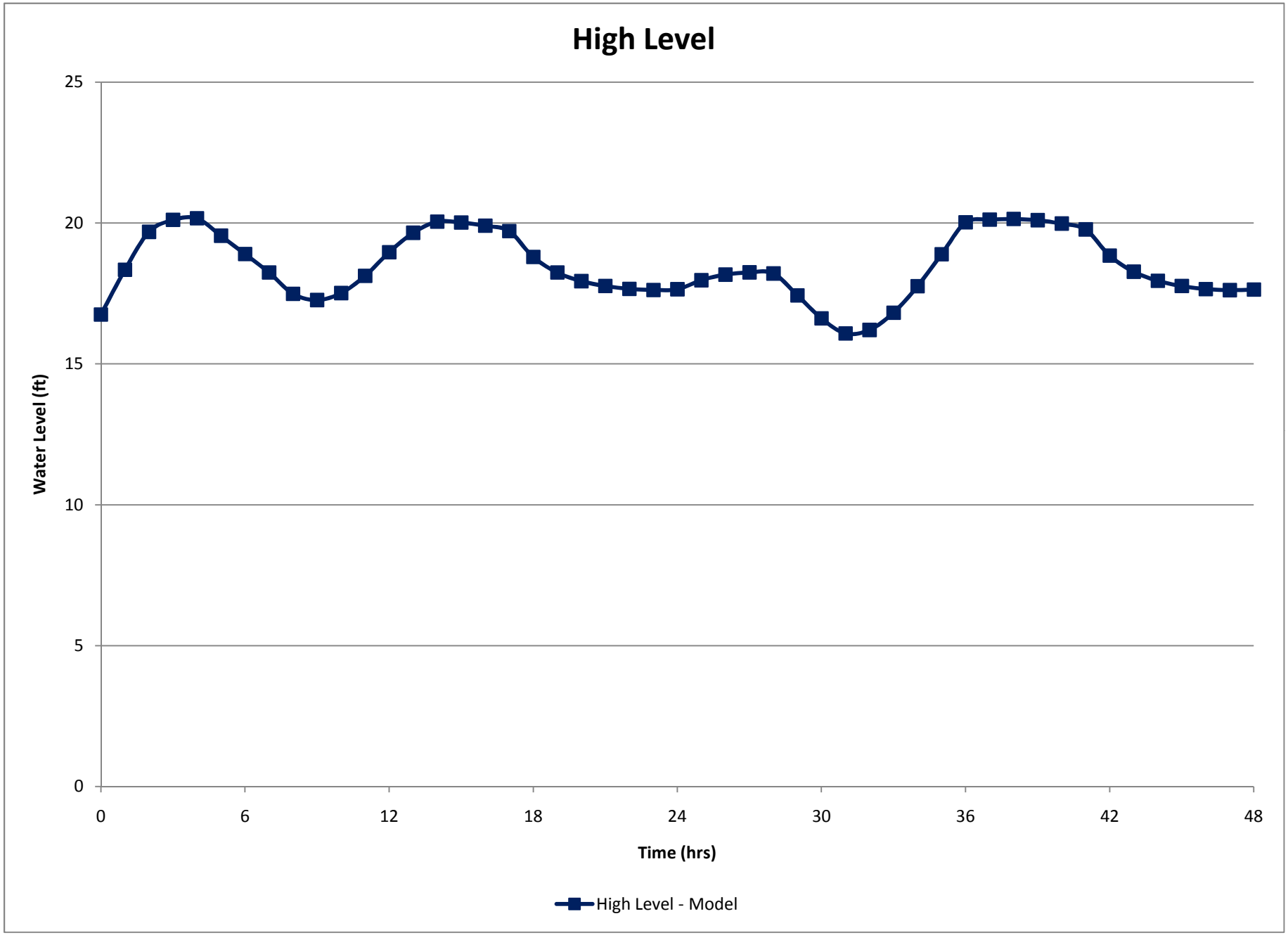

Patterson 1
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Patterson 1 - Model

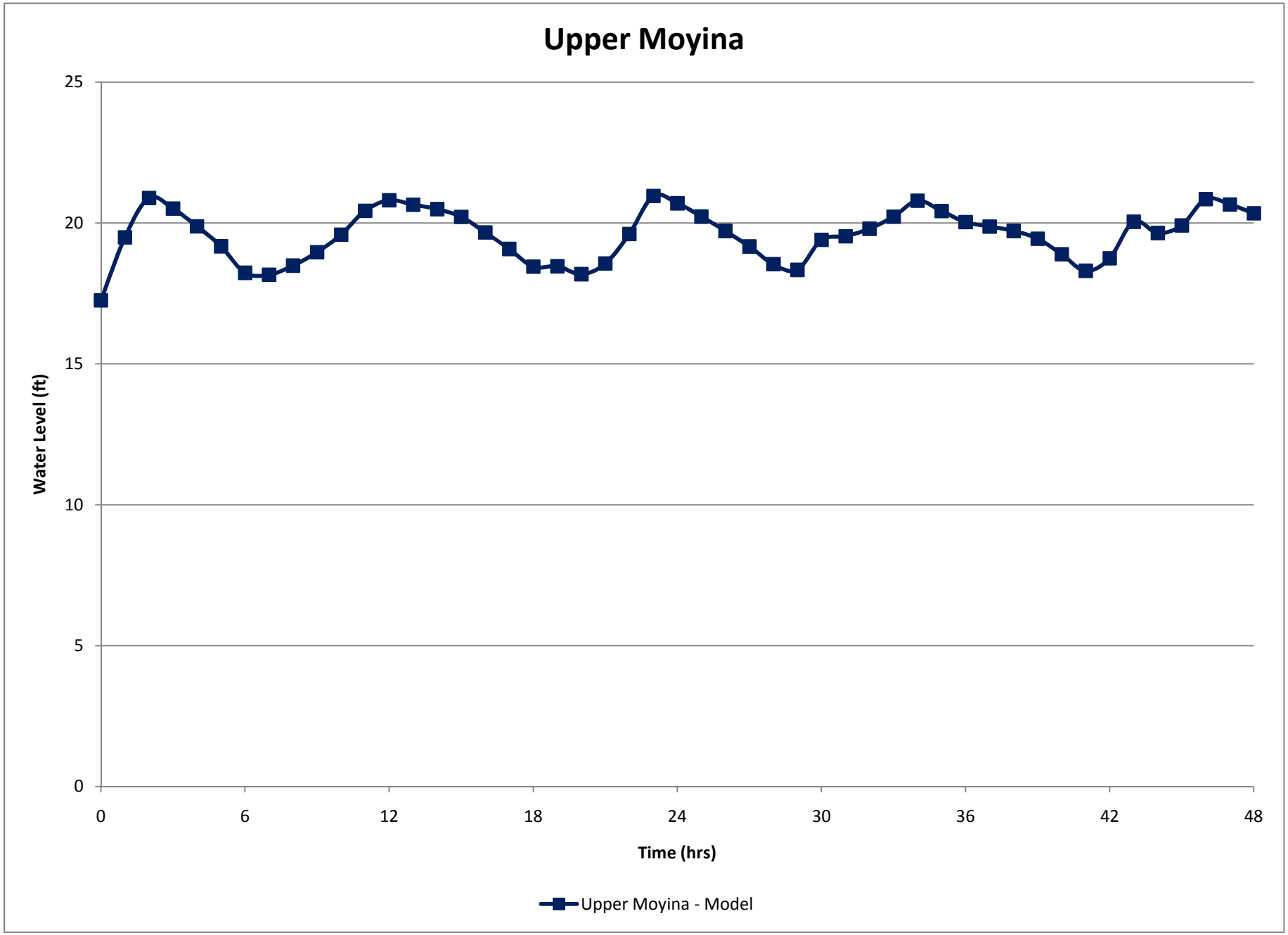

Patterson 2
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Patterson 2 - Model

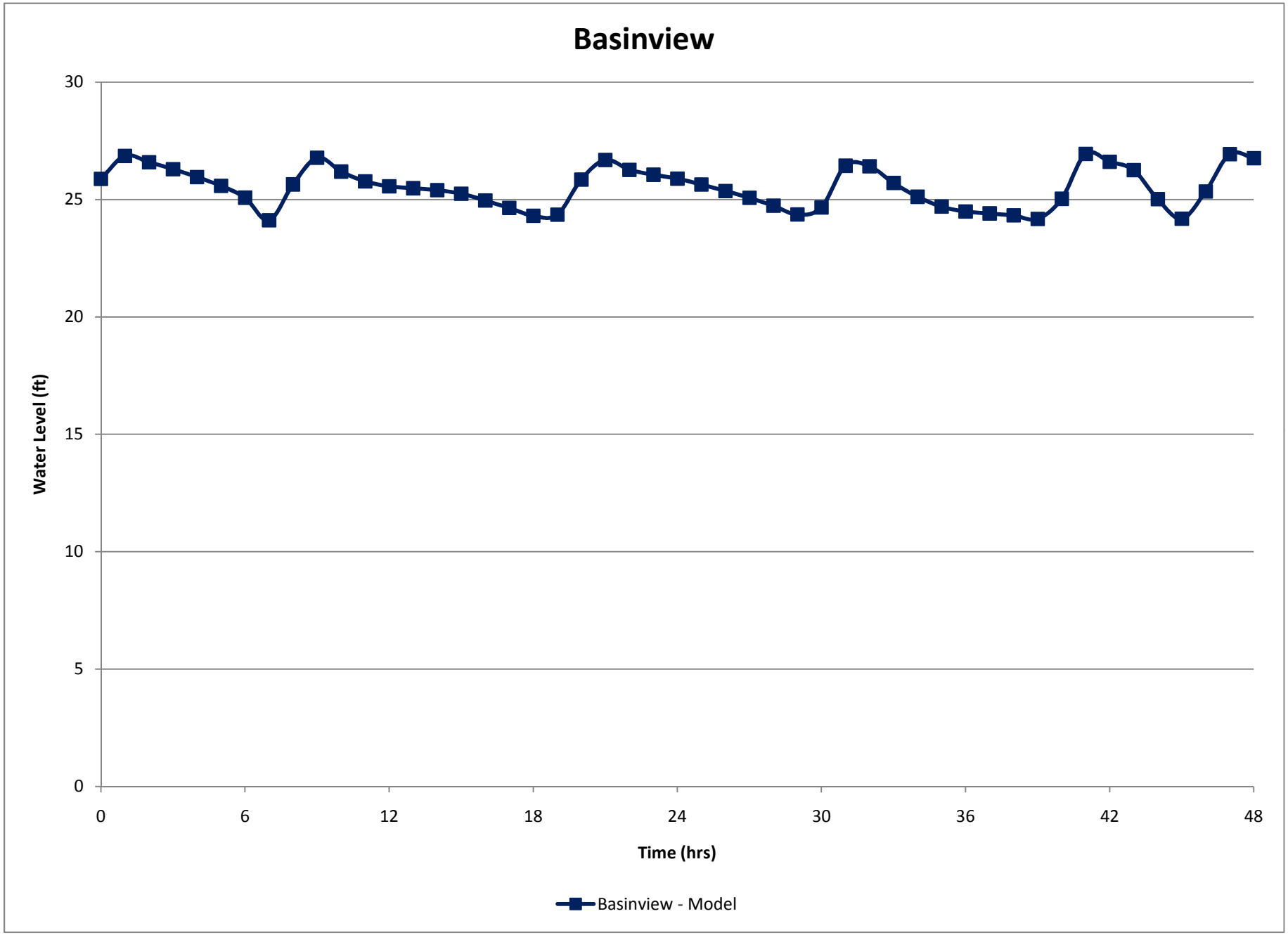

Lower Moyina
Water Level (ft)
25
20
15
10
5
0
0
6
12
18
24
30
36
42
48
Time (hrs)
Moyina - Model

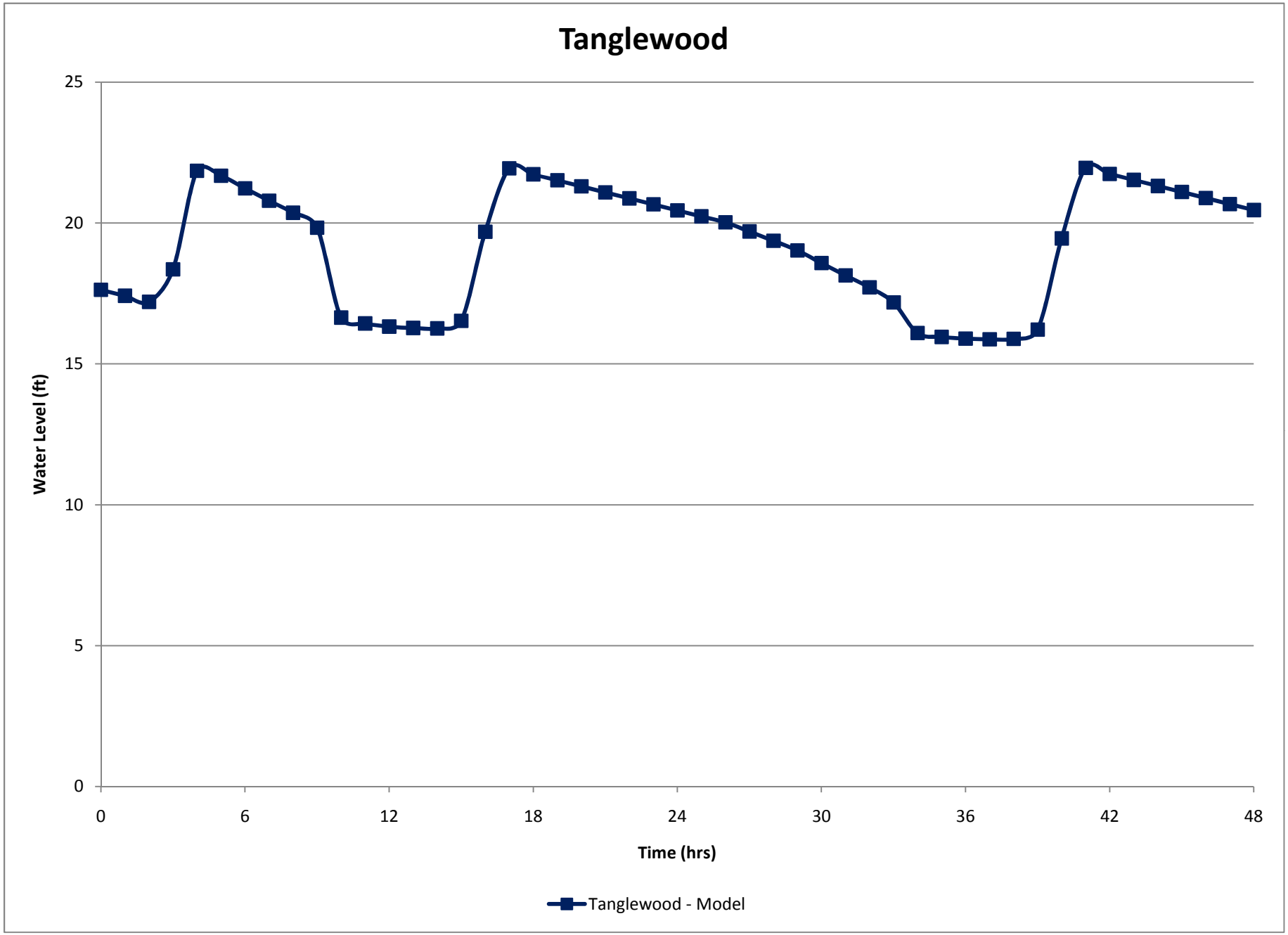

Uhrmann
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Uhrmann - Model


Hospital
20
18
16
14
12
10
8
6
4
2
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Hospital - Model


High Level
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
High Level - Model


Upper Moyina
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Upper Moyina - Model


Basinview
30
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Basinview - Model


Tanglewood
25
20
15
10
5
0
Water Level (ft)
0
6
12
18
24
30
36
42
48
Time (hrs)
Tanglewood - Model

Appendix E
Fire Flow Analysis Results

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0003	Zone-1	4092	2,063	2,063
J-ZN1-0004	Zone-1	4092	1,525	1,525
J-ZN1-0005	Zone-1	4146	1,366	1,357
J-ZN1-0006	Zone-1	4145	793	793
J-ZN1-0007	Zone-1	4144	1,236	1,236
J-ZN1-0008	Zone-1	4239	3,455	3,490
J-ZN1-0009	Zone-1	4153	1,637	1,638
J-ZN1-0010	Zone-1	4148	1,714	1,715
J-ZN1-0011	Zone-1	4251	2,026	2,040
J-ZN1-0012	Zone-1	4179	2,702	2,541
J-ZN1-0013	Zone-1	4194	1,557	1,396
J-ZN1-0014	Zone-1	4150	1,572	849
J-ZN1-0015	Zone-1	4183	1,316	918
J-ZN1-0016	Zone-1	4175	4,688	4,001
J-ZN1-0017	Zone-1	4186	3,062	2,978
J-ZN1-0018	Zone-1	4111	5,729	4,267
J-ZN1-0019	Zone-1	4114	4,725	4,082
J-ZN1-0020	Zone-1	4122	3,951	3,942
J-ZN1-0021	Zone-1	4187	4,726	3,977
J-ZN1-0022	Zone-1	4122	3,629	3,636
J-ZN1-0023	Zone-1	4125	3,617	3,595
J-ZN1-0024	Zone-1	4146	4,373	2,867
J-ZN1-0025	Zone-1	4147	4,886	2,903
J-ZN1-0026	Zone-1	4096	6,351	5,678
J-ZN1-0027	Zone-1	4123	1,318	1,173
J-ZN1-0028	Zone-1	4138	453	453
J-ZN1-0029	Zone-1	4208	3,751	2,481
J-ZN1-0030	Zone-1	4144	3,093	1,405
J-ZN1-0031	Zone-1	4145	2,606	1,281
J-ZN1-0032	Zone-1	4136	2,223	1,589
J-ZN1-0033	Zone-1	4157	3,163	1,912
J-ZN1-0035	Zone-1	4108	22,693	3,701
J-ZN1-0036	Zone-1	4092	10,975	3,550
J-ZN1-0037	Zone-1	4104	904	904
J-ZN1-0038	Zone-1	4104	5,048	5,061
J-ZN1-0039	Zone-1	4226	3,875	1,871
J-ZN1-0040	Zone-1	4100	774	774
J-ZN1-0041	Zone-1	4100	520	518
J-ZN1-0042	Zone-1	4104	1,646	1,646
J-ZN1-0044	Zone-1	4098	6,809	6,839
J-ZN1-0045	Zone-1	4110	3,611	3,616
J-ZN1-0046	Zone-1	4144	3,654	3,660
J-ZN1-0047	Zone-1	4168	6,629	3,156
J-ZN1-0048	Zone-1	4140	4,381	4,392
J-ZN1-0049	Zone-1	4138	5,371	5,370

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0050	Zone-1	4138	3,733	3,739
J-ZN1-0051	Zone-1	4142	2,205	2,206
J-ZN1-0052	Zone-1	4142	3,161	3,165
J-ZN1-0053	Zone-1	4140	751	751
J-ZN1-0054	Zone-1	4145	7,274	5,663
J-ZN1-0055	Zone-1	4180	5,674	5,266
J-ZN1-0056	Zone-1	4143	5,981	3,105
J-ZN1-0057	Zone-1	4178	6,431	4,824
J-ZN1-0058	Zone-1	4143	1,618	1,618
J-ZN1-0059	Zone-1	4156	6,940	3,062
J-ZN1-0061	Zone-1	4205	1,231	1,231
J-ZN1-0062	Zone-1	4174	3,364	2,607
J-ZN1-0063	Zone-1	4114	5,948	3,209
J-ZN1-0064	Zone-1	4114	2,566	2,568
J-ZN1-0065	Zone-1	4182	6,762	4,309
J-ZN1-0066	Zone-1	4096	9,527	9,603
J-ZN1-0067	Zone-1	4116	4,420	4,430
J-ZN1-0068	Zone-1	4185	5,718	4,656
J-ZN1-0069	Zone-1	4154	1,297	1,297
J-ZN1-0070	Zone-1	4140	987	987
J-ZN1-0071	Zone-1	4134	831	831
J-ZN1-0072	Zone-1	4148	1,895	1,896
J-ZN1-0073	Zone-1	4140	530	530
J-ZN1-0074	Zone-1	4152	7,057	3,019
J-ZN1-0075	Zone-1	4152	1,666	1,657
J-ZN1-0076	Zone-1	4142	1,159	1,159
J-ZN1-0077	Zone-1	4150	6,528	3,052
J-ZN1-0078	Zone-1	4151	1,087	1,088
J-ZN1-0079	Zone-1	4137	413	413
J-ZN1-0080	Zone-1	4138	236	236
J-ZN1-0081	Zone-1	4135	423	420
J-ZN1-0082	Zone-1	4141	769	769
J-ZN1-0083	Zone-1	4169	5,674	2,809
J-ZN1-0084	Zone-1	4137	918	918
J-ZN1-0085	Zone-1	4092	7,597	6,727
J-ZN1-0086	Zone-1	4124	5,505	5,522
J-ZN1-0087	Zone-1	4112	6,236	5,938
J-ZN1-0088	Zone-1	4134	1,711	1,711
J-ZN1-0089	Zone-1	4096	16,422	14,525
J-ZN1-0090	Zone-1	4186	1,804	1,805
J-ZN1-0091	Zone-1	4142	4,109	3,758
J-ZN1-0092	Zone-1	4114	544	544
J-ZN1-0093	Zone-1	4176	5,360	2,738
J-ZN1-0094	Zone-1	4148	1,109	1,109
J-ZN1-0095	Zone-1	4148	1,269	1,269

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0096	Zone-1	4175	1,616	1,631
J-ZN1-0097	Zone-1	4173	1,939	1,633
J-ZN1-0099	Zone-1	4139	5,800	3,141
J-ZN1-0100	Zone-1	4254	1,581	1,589
J-ZN1-0102	Zone-1	4174	3,234	3,240
J-ZN1-0103	Zone-1	4155	2,854	2,858
J-ZN1-0104	Zone-1	4144	964	964
J-ZN1-0105	Zone-1	4121	889	889
J-ZN1-0106	Zone-1	4152	5,321	3,636
J-ZN1-0107	Zone-1	4159	2,084	2,085
J-ZN1-0108	Zone-1	4122	2,027	2,028
J-ZN1-0109	Zone-1	4217	876	876
J-ZN1-0110	Zone-1	4192	1,279	1,279
J-ZN1-0111	Zone-1	4184	1,011	1,011
J-ZN1-0112	Zone-1	4182	5,412	4,053
J-ZN1-0113	Zone-1	4180	998	998
J-ZN1-0114	Zone-1	4193	1,615	1,616
J-ZN1-0115	Zone-1	4192	1,194	1,194
J-ZN1-0116	Zone-1	4166	4,150	4,163
J-ZN1-0117	Zone-1	4168	3,625	3,633
J-ZN1-0118	Zone-1	4164	3,919	3,920
J-ZN1-0119	Zone-1	4166	3,046	3,051
J-ZN1-0120	Zone-1	4167	2,342	2,344
J-ZN1-0121	Zone-1	4170	3,404	3,411
J-ZN1-0122	Zone-1	4164	1,193	1,194
J-ZN1-0123	Zone-1	4162	1,304	1,305
J-ZN1-0124	Zone-1	4144	4,928	3,822
J-ZN1-0125	Zone-1	4151	4,771	4,584
J-ZN1-0126	Zone-1	4141	5,138	3,723
J-ZN1-0127	Zone-1	4149	6,464	5,688
J-ZN1-0128	Zone-1	4138	3,571	3,577
J-ZN1-0129	Zone-1	4140	3,984	3,992
J-ZN1-0130	Zone-1	4134	4,141	4,149
J-ZN1-0131	Zone-1	4144	3,790	3,797
J-ZN1-0132	Zone-1	4142	3,881	3,889
J-ZN1-0133	Zone-1	4150	6,630	6,075
J-ZN1-0134	Zone-1	4136	3,846	3,853
J-ZN1-0135	Zone-1	4133	4,678	4,691
J-ZN1-0136	Zone-1	4145	4,988	4,765
J-ZN1-0137	Zone-1	4151	6,217	5,697
J-ZN1-0138	Zone-1	4148	5,031	5,048
J-ZN1-0139	Zone-1	4142	5,074	5,092
J-ZN1-0140	Zone-1	4134	5,285	4,633
J-ZN1-0141	Zone-1	4140	3,751	3,758
J-ZN1-0142	Zone-1	4136	3,996	4,004

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0143	Zone-1	4144	4,541	4,554
J-ZN1-0144	Zone-1	4139	3,872	3,517
J-ZN1-0145	Zone-1	4134	4,957	3,513
J-ZN1-0146	Zone-1	4150	5,618	5,066
J-ZN1-0147	Zone-1	4144	4,223	4,191
J-ZN1-0148	Zone-1	4146	4,079	4,089
J-ZN1-0149	Zone-1	4134	5,718	4,058
J-ZN1-0150	Zone-1	4155	2,683	2,494
J-ZN1-0151	Zone-1	4168	2,225	2,152
J-ZN1-0152	Zone-1	4160	2,713	2,334
J-ZN1-0153	Zone-1	4150	3,061	2,446
J-ZN1-0154	Zone-1	4139	3,589	2,638
J-ZN1-0155	Zone-1	4134	4,569	3,239
J-ZN1-0156	Zone-1	4136	2,862	2,762
J-ZN1-0157	Zone-1	4138	2,256	2,231
J-ZN1-0158	Zone-1	4140	1,346	1,347
J-ZN1-0159	Zone-1	4140	2,812	2,550
J-ZN1-0160	Zone-1	4143	2,467	2,284
J-ZN1-0161	Zone-1	4144	2,142	1,875
J-ZN1-0162	Zone-1	4146	1,943	1,872
J-ZN1-0163	Zone-1	4154	2,030	1,764
J-ZN1-0164	Zone-1	4194	5,332	4,739
J-ZN1-0165	Zone-1	4177	5,749	5,563
J-ZN1-0166	Zone-1	4169	6,230	5,498
J-ZN1-0167	Zone-1	4159	2,013	1,700
J-ZN1-0168	Zone-1	4090	6,713	6,739
J-ZN1-0169	Zone-1	4173	1,031	1,032
J-ZN1-0170	Zone-1	4158	1,556	1,557
J-ZN1-0171	Zone-1	4120	6,213	4,126
J-ZN1-0172	Zone-1	4120	4,129	4,137
J-ZN1-0173	Zone-1	4122	3,436	3,440
J-ZN1-0174	Zone-1	4118	6,239	4,477
J-ZN1-0175	Zone-1	4118	6,265	4,369
J-ZN1-0176	Zone-1	4118	6,306	4,280
J-ZN1-0177	Zone-1	4114	6,368	5,067
J-ZN1-0178	Zone-1	4265	-1,621	90,176
J-ZN1-0179	Zone-1	4112	6,317	6,345
J-ZN1-0180	Zone-1	4107	5,751	5,771
J-ZN1-0181	Zone-1	4112	3,620	3,625
J-ZN1-0182	Zone-1	4112	3,097	3,101
J-ZN1-0183	Zone-1	4116	3,632	3,637
J-ZN1-0184	Zone-1	4112	3,210	3,213
J-ZN1-0185	Zone-1	4166	2,186	2,077
J-ZN1-0186	Zone-1	4164	2,168	2,076
J-ZN1-0187	Zone-1	4160	2,193	2,077

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0188	Zone-1	4152	2,286	2,105
J-ZN1-0189	Zone-1	4236	3,314	2,283
J-ZN1-0190	Zone-1	4160	1,406	1,407
J-ZN1-0191	Zone-1	4167	1,497	1,498
J-ZN1-0192	Zone-1	4198	2,590	2,550
J-ZN1-0193	Zone-1	4108	5,771	5,792
J-ZN1-0194	Zone-1	4206	3,830	2,476
J-ZN1-0195	Zone-1	4189	4,625	3,937
J-ZN1-0196	Zone-1	4175	4,317	2,545
J-ZN1-0197	Zone-1	4172	2,022	2,023
J-ZN1-0198	Zone-1	4120	3,857	3,863
J-ZN1-0199	Zone-1	4155	4,530	2,590
J-ZN1-0200	Zone-1	4116	1,631	1,411
J-ZN1-0201	Zone-1	4098	6,931	4,850
J-ZN1-0202	Zone-1	4134	4,958	4,026
J-ZN1-0203	Zone-1	4110	2,335	1,668
J-ZN1-0204	Zone-1	4118	4,226	4,171
J-ZN1-0205	Zone-1	4095	6,106	4,471
J-ZN1-0206	Zone-1	4098	6,905	5,008
J-ZN1-0207	Zone-1	4095	8,895	5,410
J-ZN1-0208	Zone-1	4100	2,127	2,112
J-ZN1-0209	Zone-1	4117	5,036	5,051
J-ZN1-0210	Zone-1	4181	6,347	4,524
J-ZN1-0211	Zone-1	4095	875	875
J-ZN1-0212	Zone-1	4091	15,378	13,687
J-ZN1-0213	Zone-1	4116	5,045	5,059
J-ZN1-0214	Zone-1	4092	16,031	15,056
J-ZN1-0215	Zone-1	4094	5,887	5,806
J-ZN1-0216	Zone-1	4096	1,080	1,081
J-ZN1-0217	Zone-1	4158	2,283	2,169
J-ZN1-0218	Zone-1	4164	1,794	1,778
J-ZN1-0219	Zone-1	4114	5,364	5,321
J-ZN1-0220	Zone-1	4141	3,446	2,567
J-ZN1-0221	Zone-1	4094	15,371	49,738
J-ZN1-0222	Zone-1	4096	20,886	18,536
J-ZN1-0223	Zone-1	4090	3,642	3,647
J-ZN1-0224	Zone-1	4121	2,593	2,587
J-ZN1-0225	Zone-1	4088	1,832	1,820
J-ZN1-0226	Zone-1	4090	1,660	1,660
J-ZN1-0227	Zone-1	4088	6,847	6,876
J-ZN1-0228	Zone-1	4175	1,129	791
J-ZN1-0229	Zone-1	4122	1,545	1,546
J-ZN1-0230	Zone-1	4214	3,782	2,157
J-ZN1-0231	Zone-1	4232	3,533	2,354
J-ZN1-0232	Zone-1	4136	3,870	2,790

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0233	Zone-1	4218	1,596	1,009
J-ZN1-0234	Zone-1	4231	1,697	1,036
J-ZN1-0235	Zone-1	4224	1,885	739
J-ZN1-0236	Zone-1	4246	495	430
J-ZN1-0237	Zone-1	4224	4,365	1,656
J-ZN1-0238	Zone-1	4139	3,070	2,563
J-ZN1-0239	Zone-1	4164	1,696	1,697
J-ZN1-0240	Zone-1	4108	427	427
J-ZN1-0241	Zone-1	4112	1,151	1,152
J-ZN1-0242	Zone-1	4219	358	358
J-ZN1-0243	Zone-1	4138	2,754	2,564
J-ZN1-0244	Zone-1	4140	3,091	3,095
J-ZN1-0245	Zone-1	4162	3,809	2,173
J-ZN1-0246	Zone-1	4150	3,989	1,380
J-ZN1-0247	Zone-1	4140	1,290	1,290
J-ZN1-0248	Zone-1	4162	1,981	1,122
J-ZN1-0249	Zone-1	4184	1,049	679
J-ZN1-0250	Zone-1	4196	641	641
J-ZN1-0251	Zone-1	4097	24,153	4,037
J-ZN1-0252	Zone-1	4134	2,645	2,647
J-ZN1-0253	Zone-1	4189	1,608	532
J-ZN1-0254	Zone-1	4149	4,475	1,039
J-ZN1-0255	Zone-1	4102	4,185	2,651
J-ZN1-0256	Zone-1	4118	1,569	1,570
J-ZN1-0257	Zone-1	4112	2,929	2,931
J-ZN1-0258	Zone-1	4122	1,231	1,232
J-ZN1-0259	Zone-1	4110	4,185	4,192
J-ZN1-0260	Zone-1	4110	3,881	3,887
J-ZN1-0261	Zone-1	4109	4,306	4,314
J-ZN1-0262	Zone-1	4224	3,921	2,563
J-ZN1-0263	Zone-1	4108	3,617	3,622
J-ZN1-0264	Zone-1	4108	3,195	3,198
J-ZN1-0265	Zone-1	4108	3,539	3,544
J-ZN1-0266	Zone-1	4110	4,401	4,410
J-ZN1-0267	Zone-1	4110	4,957	4,970
J-ZN1-0268	Zone-1	4110	4,561	4,571
J-ZN1-0269	Zone-1	4112	4,291	4,300
J-ZN1-0270	Zone-1	4112	2,739	2,741
J-ZN1-0271	Zone-1	4108	4,416	4,425
J-ZN1-0272	Zone-1	4108	4,515	4,525
J-ZN1-0273	Zone-1	4207	4,923	2,860
J-ZN1-0274	Zone-1	4108	4,493	4,503
J-ZN1-0275	Zone-1	4109	3,844	3,829
J-ZN1-0276	Zone-1	4109	3,178	3,181
J-ZN1-0277	Zone-1	4110	2,307	2,309

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0278	Zone-1	4110	1,632	1,633
J-ZN1-0279	Zone-1	4110	4,136	4,144
J-ZN1-0280	Zone-1	4112	3,757	3,762
J-ZN1-0281	Zone-1	4114	4,346	4,355
J-ZN1-0282	Zone-1	4113	1,867	1,868
J-ZN1-0283	Zone-1	4114	4,137	4,145
J-ZN1-0284	Zone-1	4108	4,155	4,124
J-ZN1-0285	Zone-1	4108	4,739	4,750
J-ZN1-0286	Zone-1	4110	1,807	1,807
J-ZN1-0287	Zone-1	4110	4,828	4,840
J-ZN1-0288	Zone-1	4104	4,955	4,968
J-ZN1-0289	Zone-1	4107	5,199	5,213
J-ZN1-0290	Zone-1	4104	4,453	4,462
J-ZN1-0291	Zone-1	4102	3,498	3,502
J-ZN1-0292	Zone-1	4104	4,411	4,420
J-ZN1-0293	Zone-1	4106	3,527	3,532
J-ZN1-0294	Zone-1	4098	1,664	1,664
J-ZN1-0295	Zone-1	4096	2,508	2,488
J-ZN1-0296	Zone-1	4101	3,360	3,363
J-ZN1-0297	Zone-1	4099	3,129	3,132
J-ZN1-0298	Zone-1	4100	3,238	3,241
J-ZN1-0299	Zone-1	4098	2,908	2,910
J-ZN1-0300	Zone-1	4099	4,127	4,134
J-ZN1-0301	Zone-1	4098	8,661	8,723
J-ZN1-0302	Zone-1	4104	7,367	6,116
J-ZN1-0303	Zone-1	4108	464	461
J-ZN1-0304	Zone-1	4109	413	413
J-ZN1-0305	Zone-1	4104	5,240	5,099
J-ZN1-0306	Zone-1	4116	1,370	1,205
J-ZN1-0307	Zone-1	4098	5,252	5,266
J-ZN1-0308	Zone-1	4097	6,913	6,943
J-ZN1-0309	Zone-1	4100	1,694	1,695
J-ZN1-0310	Zone-1	4100	1,291	1,291
J-ZN1-0311	Zone-1	4096	5,556	5,572
J-ZN1-0312	Zone-1	4094	18,047	17,393
J-ZN1-0314	Zone-1	4096	16,515	14,490
J-ZN1-0315	Zone-1	4096	17,533	17,522
J-ZN1-0316	Zone-1	4090	11,210	11,132
J-ZN1-0317	Zone-1	4090	11,687	11,664
J-ZN1-0318	Zone-1	4092	4,709	4,719
J-ZN1-0319	Zone-1	4102	5,849	5,869
J-ZN1-0320	Zone-1	4100	6,196	6,206
J-ZN1-0321	Zone-1	4104	6,325	6,352
J-ZN1-0322	Zone-1	4102	6,588	6,604
J-ZN1-0323	Zone-1	4159	3,476	3,482

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0325	Zone-1	4090	2,640	2,641
J-ZN1-0326	Zone-1	4088	2,271	2,272
J-ZN1-0327	Zone-1	4089	1,384	1,384
J-ZN1-0328	Zone-1	4198	2,968	2,975
J-ZN1-0333	Zone-1	4103	6,543	6,572
J-ZN1-0334	Zone-1	4104	6,618	6,649
J-ZN1-0335	Zone-1	4102	5,758	5,778
J-ZN1-0336	Zone-1	4102	5,616	5,634
J-ZN1-0337	Zone-1	4102	5,847	5,868
J-ZN1-0338	Zone-1	4102	4,451	4,459
J-ZN1-0339	Zone-1	4198	3,329	3,332
J-ZN1-0340	Zone-1	4179	3,555	3,321
J-ZN1-0341	Zone-1	4198	3,283	3,292
J-ZN1-0342	Zone-1	4197	3,138	3,146
J-ZN1-0343	Zone-1	4104	4,081	4,088
J-ZN1-0344	Zone-1	4104	4,213	4,220
J-ZN1-0345	Zone-1	4102	5,278	5,293
J-ZN1-0346	Zone-1	4104	4,687	4,698
J-ZN1-0347	Zone-1	4107	4,187	4,195
J-ZN1-0348	Zone-1	4109	4,753	4,764
J-ZN1-0349	Zone-1	4106	4,887	4,899
J-ZN1-0350	Zone-1	4104	5,163	5,178
J-ZN1-0351	Zone-1	4102	4,012	4,018
J-ZN1-0352	Zone-1	4110	5,824	5,845
J-ZN1-0353	Zone-1	4110	6,690	6,723
J-ZN1-0354	Zone-1	4110	6,238	6,264
J-ZN1-0355	Zone-1	4110	3,126	3,129
J-ZN1-0356	Zone-1	4108	4,897	4,909
J-ZN1-0357	Zone-1	4114	1,032	1,032
J-ZN1-0358	Zone-1	4124	1,955	1,956
J-ZN1-0359	Zone-1	4120	1,262	1,262
J-ZN1-0360	Zone-1	4102	1,559	1,475
J-ZN1-0361	Zone-1	4116	1,497	1,497
J-ZN1-0362	Zone-1	4104	925	875
J-ZN1-0363	Zone-1	4104	865	865
J-ZN1-0364	Zone-1	4108	771	745
J-ZN1-0365	Zone-1	4115	604	605
J-ZN1-0366	Zone-1	4107	1,754	1,572
J-ZN1-0367	Zone-1	4115	1,077	1,047
J-ZN1-0368	Zone-1	4110	856	856
J-ZN1-0369	Zone-1	4100	795	795
J-ZN1-0370	Zone-1	4115	1,125	1,050
J-ZN1-0371	Zone-1	4119	988	944
J-ZN1-0372	Zone-1	4128	752	752
J-ZN1-0374	Zone-1	4100	3,391	3,286

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0375	Zone-1	4096	1,374	1,374
J-ZN1-0376	Zone-1	4096	1,481	1,481
J-ZN1-0377	Zone-1	4098	4,340	3,668
J-ZN1-0378	Zone-1	4098	4,639	4,651
J-ZN1-0379	Zone-1	4108	2,903	2,614
J-ZN1-0380	Zone-1	4092	4,042	4,009
J-ZN1-0381	Zone-1	4092	3,733	3,742
J-ZN1-0382	Zone-1	4122	5,159	3,194
J-ZN1-0383	Zone-1	4120	4,114	3,200
J-ZN1-0384	Zone-1	4116	2,667	2,604
J-ZN1-0385	Zone-1	4098	2,725	2,726
J-ZN1-0386	Zone-1	4098	10,753	10,870
J-ZN1-0388	Zone-1	4099	21,855	21,002
J-ZN1-0389	Zone-1	4100	14,709	72,294
J-ZN1-0390	Zone-1	4100	1,085	1,085
J-ZN1-0391	Zone-1	4092	15,923	14,860
J-ZN1-0392	Zone-1	4092	4,536	4,516
J-ZN1-0393	Zone-1	4094	2,484	2,485
J-ZN1-0394	Zone-1	4091	15,394	13,665
J-ZN1-0395	Zone-1	4091	7,699	6,791
J-ZN1-0396	Zone-1	4094	5,908	5,930
J-ZN1-0397	Zone-1	4093	6,282	6,309
J-ZN1-0398	Zone-1	4093	5,186	5,202
J-ZN1-0399	Zone-1	4092	14,619	13,135
J-ZN1-0400	Zone-1	4092	6,218	6,338
J-ZN1-0401	Zone-1	4090	5,017	5,050
J-ZN1-0402	Zone-1	4090	5,056	5,109
J-ZN1-0403	Zone-1	4092	7,348	7,518
J-ZN1-0404	Zone-1	4096	8,599	7,090
J-ZN1-0405	Zone-1	4094	9,101	5,423
J-ZN1-0406	Zone-1	4094	1,122	1,122
J-ZN1-0407	Zone-1	4092	16,313	3,082
J-ZN1-0408	Zone-1	4091	2,540	2,542
J-ZN1-0409	Zone-1	4091	17,549	3,038
J-ZN1-0410	Zone-1	4092	18,859	2,997
J-ZN1-0411	Zone-1	4093	19,577	2,976
J-ZN1-0412	Zone-1	4099	20,519	3,026
J-ZN1-0413	Zone-1	4094	11,483	3,083
J-ZN1-0414	Zone-1	4104	11,739	3,598
J-ZN1-0415	Zone-1	4094	6,934	5,867
J-ZN1-0416	Zone-1	4096	2,269	2,270
J-ZN1-0417	Zone-1	4092	1,599	1,582
J-ZN1-0418	Zone-1	4094	7,926	5,891
J-ZN1-0419	Zone-1	4092	7,244	4,181
J-ZN1-0420	Zone-1	4092	7,630	4,088

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0422	Zone-1	4093	4,877	4,088
J-ZN1-0423	Zone-1	4092	2,951	2,954
J-ZN1-0424	Zone-1	4092	2,035	2,036
J-ZN1-0425	Zone-1	4094	13,498	3,020
J-ZN1-0426	Zone-1	4093	8,681	3,425
J-ZN1-0427	Zone-1	4092	8,507	3,485
J-ZN1-0428	Zone-1	4182	6,143	4,932
J-ZN1-0429	Zone-1	4093	7,760	3,843
J-ZN1-0430	Zone-1	4104	16,098	2,562
J-ZN1-0431	Zone-1	4106	10,750	2,458
J-ZN1-0432	Zone-1	4112	5,806	2,433
J-ZN1-0433	Zone-1	4106	7,663	2,421
J-ZN1-0434	Zone-1	4106	869	869
J-ZN1-0435	Zone-1	4099	14,963	2,676
J-ZN1-0436	Zone-1	4099	15,231	2,663
J-ZN1-0437	Zone-1	4093	12,034	2,913
J-ZN1-0438	Zone-1	4102	4,489	2,617
J-ZN1-0439	Zone-1	4106	2,925	2,868
J-ZN1-0440	Zone-1	4094	6,386	2,823
J-ZN1-0441	Zone-1	4236	548	548
J-ZN1-0442	Zone-1	4206	1,427	796
J-ZN1-0443	Zone-1	4159	4,756	1,813
J-ZN1-0444	Zone-1	4121	11,293	2,584
J-ZN1-0445	Zone-1	4107	19,854	2,773
J-ZN1-0446	Zone-1	4108	18,691	2,491
J-ZN1-0447	Zone-1	4237	735	735
J-ZN1-0448	Zone-1	4125	6,938	1,366
J-ZN1-0449	Zone-1	4117	7,693	1,983
J-ZN1-0450	Zone-1	4114	9,799	1,753
J-ZN1-0451	Zone-1	4109	17,376	2,316
J-ZN1-0452	Zone-1	4185	13,616	3,852
J-ZN1-0453	Zone-1	4251	3,572	3,648
J-ZN1-0454	Zone-1	4225	7,770	3,875
J-ZN1-0455	Zone-1	4182	13,250	3,813
J-ZN1-0456	Zone-1	4145	17,050	3,466
J-ZN1-0457	Zone-1	4106	21,886	3,096
J-ZN1-0458	Zone-1	4267	-3,364	13,928
J-ZN1-0459	Zone-1	4282	-7,201	14,524
J-ZN1-0461	Zone-1	4103	3,731	2,160
J-ZN1-0462	Zone-1	4099	25,665	4,331
J-ZN1-0463	Zone-1	4198	3,349	3,356
J-ZN1-0464	Zone-1	4185	3,495	2,325
J-ZN1-0465	Zone-1	4166	4,536	4,238
J-ZN1-0466	Zone-1	4178	4,285	2,889
J-ZN1-0467	Zone-1	4139	9,978	3,444

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0468	Zone-1	4172	2,638	1,140
J-ZN1-0469	Zone-1	4150	2,660	903
J-ZN1-0470	Zone-1	4223	932	932
J-ZN1-0471	Zone-1	4190	1,523	1,524
J-ZN1-0472	Zone-1	4117	20,119	3,250
J-ZN1-0473	Zone-1	4098	22,784	3,295
J-ZN1-0474	Zone-1	4120	5,733	1,703
J-ZN1-0475	Zone-1	4130	5,839	1,663
J-ZN1-0476	Zone-1	4111	14,319	3,045
J-ZN1-0478	Zone-1	4102	3,759	2,707
J-ZN1-0479	Zone-1	4098	3,327	2,714
J-ZN1-0480	Zone-1	4102	1,687	1,687
J-ZN1-0481	Zone-1	4159	1,934	839
J-ZN1-0482	Zone-1	4262	-452	1,392
J-ZN1-0483	Zone-1	4194	2,436	2,446
J-ZN1-0484	Zone-1	4190	1,425	512
J-ZN1-0485	Zone-1	4187	1,565	510
J-ZN1-0486	Zone-1	4176	1,468	575
J-ZN1-0487	Zone-1	4217	861	383
J-ZN1-0488	Zone-1	4202	2,650	1,745
J-ZN1-0489	Zone-1	4205	2,667	1,694
J-ZN1-0490	Zone-1	4178	3,695	1,635
J-ZN1-0491	Zone-1	4182	3,671	1,628
J-ZN1-0492	Zone-1	4181	4,972	1,597
J-ZN1-0493	Zone-1	4146	4,331	3,660
J-ZN1-0494	Zone-1	4202	5,024	1,585
J-ZN1-0495	Zone-1	4208	4,839	1,624
J-ZN1-0496	Zone-1	4215	4,543	1,638
J-ZN1-0497	Zone-1	4244	2,354	1,830
J-ZN1-0499	Zone-1	4219	2,839	2,291
J-ZN1-0500	Zone-1	4214	4,021	2,275
J-ZN1-0501	Zone-1	4219	2,269	1,347
J-ZN1-0502	Zone-1	4134	4,930	3,900
J-ZN1-0503	Zone-1	4213	1,386	1,168
J-ZN1-0504	Zone-1	4215	1,313	1,193
J-ZN1-0505	Zone-1	4114	12,925	2,694
J-ZN1-0506	Zone-1	4111	10,219	3,777
J-ZN1-0507	Zone-1	4104	3,447	2,745
J-ZN1-0508	Zone-1	4109	3,051	2,904
J-ZN1-0509	Zone-1	4126	4,812	1,544
J-ZN1-0510	Zone-1	4138	3,429	1,467
J-ZN1-0511	Zone-1	4130	2,947	1,490
J-ZN1-0512	Zone-1	4132	5,401	1,495
J-ZN1-0513	Zone-1	4153	2,894	2,901
J-ZN1-0514	Zone-1	4114	8,113	1,699

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0515	Zone-1	4121	6,554	1,383
J-ZN1-0516	Zone-1	4150	3,478	1,144
J-ZN1-0517	Zone-1	4122	5,672	1,413
J-ZN1-0518	Zone-1	4136	3,533	1,165
J-ZN1-0519	Zone-1	4141	2,460	1,156
J-ZN1-0520	Zone-1	4172	2,902	1,039
J-ZN1-0521	Zone-1	4140	3,116	1,289
J-ZN1-0522	Zone-1	4148	2,984	1,342
J-ZN1-0523	Zone-1	4211	1,308	883
J-ZN1-0524	Zone-1	4164	4,106	4,117
J-ZN1-0525	Zone-1	4104	7,451	5,296
J-ZN1-0526	Zone-1	4227	773	774
J-ZN1-0527	Zone-1	4162	1,517	939
J-ZN1-0528	Zone-1	4146	2,568	1,125
J-ZN1-0529	Zone-1	4160	2,095	1,102
J-ZN1-0530	Zone-1	4160	1,915	1,093
J-ZN1-0531	Zone-1	4162	2,015	1,146
J-ZN1-0532	Zone-1	4152	1,569	1,127
J-ZN1-0533	Zone-1	4164	1,120	1,120
J-ZN1-0535	Zone-1	4196	1,803	1,246
J-ZN1-0536	Zone-1	4137	5,125	2,945
J-ZN1-0537	Zone-1	4207	879	679
J-ZN1-0538	Zone-1	4225	545	545
J-ZN1-0539	Zone-1	4192	3,107	1,662
J-ZN1-0540	Zone-1	4206	1,154	953
J-ZN1-0541	Zone-1	4220	607	607
J-ZN1-0542	Zone-1	4162	812	812
J-ZN1-0544	Zone-1	4164	5,915	2,422
J-ZN1-0545	Zone-1	4194	1,114	1,115
J-ZN1-0546	Zone-1	4150	5,024	2,857
J-ZN1-0547	Zone-1	4179	1,436	1,356
J-ZN1-0548	Zone-1	4207	2,140	1,548
J-ZN1-0550	Zone-1	4150	2,185	1,273
J-ZN1-0551	Zone-1	4156	2,179	1,211
J-ZN1-0552	Zone-1	4153	2,231	1,148
J-ZN1-0553	Zone-1	4149	2,091	1,073
J-ZN1-0554	Zone-1	4148	1,662	879
J-ZN1-0555	Zone-1	4148	1,210	879
J-ZN1-0556	Zone-1	4152	1,560	771
J-ZN1-0557	Zone-1	4161	4,537	3,284
J-ZN1-0558	Zone-1	4148	1,694	694
J-ZN1-0559	Zone-1	4149	1,169	851
J-ZN1-0560	Zone-1	4192	1,180	1,136
J-ZN1-0561	Zone-1	4167	1,292	1,013
J-ZN1-0562	Zone-1	4185	1,230	946

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0563	Zone-1	4204	1,088	1,018
J-ZN1-0564	Zone-1	4216	961	962
J-ZN1-0565	Zone-1	4191	1,155	962
J-ZN1-0566	Zone-1	4142	5,176	2,609
J-ZN1-0567	Zone-1	4167	1,519	1,066
J-ZN1-0568	Zone-1	4181	1,401	1,030
J-ZN1-0569	Zone-1	4166	1,204	712
J-ZN1-0570	Zone-1	4178	1,162	559
J-ZN1-0571	Zone-1	4216	467	468
J-ZN1-0572	Zone-1	4176	1,123	800
J-ZN1-0573	Zone-1	4209	2,352	1,101
J-ZN1-0574	Zone-1	4233	1,657	1,039
J-ZN1-0575	Zone-1	4143	5,180	2,261
J-ZN1-0576	Zone-1	4217	1,671	1,001
J-ZN1-0577	Zone-1	4163	3,494	1,992
J-ZN1-0578	Zone-1	4218	1,612	957
J-ZN1-0579	Zone-1	4224	1,729	764
J-ZN1-0581	Zone-1	4193	1,200	832
J-ZN1-0582	Zone-1	4167	4,139	2,172
J-ZN1-0583	Zone-1	4154	1,553	1,328
J-ZN1-0584	Zone-1	4221	1,277	1,244
J-ZN1-0585	Zone-1	4172	2,416	1,312
J-ZN1-0586	Zone-1	4180	962	962
J-ZN1-0587	Zone-1	4218	1,578	1,243
J-ZN1-0588	Zone-1	4133	5,778	1,488
J-ZN1-0589	Zone-1	4118	8,398	2,003
J-ZN1-0590	Zone-1	4153	5,101	1,997
J-ZN1-0591	Zone-1	4165	2,986	1,673
J-ZN1-0592	Zone-1	4114	8,359	2,607
J-ZN1-0593	Zone-1	4187	1,591	1,137
J-ZN1-0594	Zone-1	4209	955	955
J-ZN1-0595	Zone-1	4141	4,614	2,240
J-ZN1-0596	Zone-1	4204	884	668
J-ZN1-0597	Zone-1	4205	2,619	1,710
J-ZN1-0598	Zone-1	4207	514	441
J-ZN1-0599	Zone-1	4116	6,227	3,224
J-ZN1-0600	Zone-1	4184	1,068	693
J-ZN1-0602	Zone-1	4160	2,456	1,584
J-ZN1-0603	Zone-1	4156	1,071	1,060
J-ZN1-0604	Zone-1	4150	1,132	1,132
J-ZN1-0605	Zone-1	4166	984	984
J-ZN1-0606	Zone-1	4158	1,394	1,028
J-ZN1-0607	Zone-1	4165	822	823
J-ZN1-0608	Zone-1	4122	5,529	3,432
J-ZN1-0609	Zone-1	4157	850	850

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0610	Zone-1	4160	986	986
J-ZN1-0611	Zone-1	4179	495	473
J-ZN1-0612	Zone-1	4187	432	432
J-ZN1-0613	Zone-1	4156	1,312	1,106
J-ZN1-0614	Zone-1	4170	2,007	1,351
J-ZN1-0615	Zone-1	4142	533	533
J-ZN1-0616	Zone-1	4092	4,432	4,129
J-ZN1-0617	Zone-1	4145	7,255	5,672
J-ZN1-0618	Zone-1	4118	5,572	3,540
J-ZN1-0619	Zone-1	4163	1,852	1,317
J-ZN1-0620	Zone-1	4140	1,166	1,166
J-ZN1-0621	Zone-1	4140	15,326	3,763
J-ZN1-0622	Zone-1	4109	22,661	3,721
J-ZN1-0623	Zone-1	4104	22,348	3,517
J-ZN1-0624	Zone-1	4096	25,149	4,046
J-ZN1-0625	Zone-1	4100	5,808	3,600
J-ZN1-0626	Zone-1	4100	6,187	3,997
J-ZN1-0627	Zone-1	4101	6,439	4,088
J-ZN1-0628	Zone-1	4148	4,270	3,233
J-ZN1-0629	Zone-1	4110	6,667	5,190
J-ZN1-0630	Zone-1	4151	253	243
J-ZN1-0631	Zone-1	4148	3,761	3,102
J-ZN1-0632	Zone-1	4152	5,514	2,758
J-ZN1-0633	Zone-1	4112	2,362	2,364
J-ZN1-0634	Zone-1	4113	1,316	1,316
J-ZN1-0635	Zone-1	4090	8,963	9,028
J-ZN1-0636	Zone-1	4090	8,601	8,591
J-ZN1-0637	Zone-1	4092	6,030	6,050
J-ZN1-0638	Zone-1	4092	5,586	5,601
J-ZN1-0639	Zone-1	4091	6,642	6,668
J-ZN1-0640	Zone-1	4089	1,847	1,848
J-ZN1-0641	Zone-1	4112	1,554	1,555
J-ZN1-0642	Zone-1	4095	2,051	2,052
J-ZN1-0644	Zone-1	4116	5,634	3,635
J-ZN1-0645	Zone-1	4118	2,126	2,127
J-ZN1-0646	Zone-1	4104	1,645	1,646
J-ZN1-0647	Zone-1	4194	4,729	3,386
J-ZN1-0648	Zone-1	4116	1,552	1,394
J-ZN1-0650	Zone-1	4184	5,422	4,272
J-ZN1-0651	Zone-1	4121	1,420	1,258
J-ZN1-0652	Zone-1	4173	3,174	3,179
J-ZN1-0653	Zone-1	4147	4,952	3,793
J-ZN1-0654	Zone-1	4148	1,364	1,365
J-ZN1-0655	Zone-1	4160	2,120	2,121
J-ZN1-0656	Zone-1	4137	534	535

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0657	Zone-1	4134	187	187
J-ZN1-0658	Zone-1	4138	1,396	1,396
J-ZN1-0659	Zone-1	4094	3,521	2,932
J-ZN1-0660	Zone-1	4169	1,050	984
J-ZN1-0661	Zone-1	4123	1,345	1,294
J-ZN1-0662	Zone-1	4198	2,889	1,676
J-ZN1-0663	Zone-1	4094	2,157	2,158
J-ZN1-0664	Zone-1	4096	2,396	2,398
J-ZN1-0665	Zone-1	4094	4,627	2,875
J-ZN1-0666	Zone-1	4104	2,969	2,816
J-ZN1-0667	Zone-1	4094	3,133	3,046
J-ZN1-0668	Zone-1	4110	8,835	2,891
J-ZN1-0669	Zone-1	4118	1,440	1,396
J-ZN1-0671	Zone-1	4098	5,792	5,810
J-ZN1-0672	Zone-1	4098	1,176	1,176
J-ZN1-0673	Zone-1	4096	1,865	1,866
J-ZN1-0674	Zone-1	4100	3,853	3,294
J-ZN1-0675	Zone-1	4098	624	624
J-ZN1-0676	Zone-1	4098	1,214	1,215
J-ZN1-0677	Zone-1	4106	1,705	1,705
J-ZN1-0678	Zone-1	4099	1,241	1,242
J-ZN1-0679	Zone-1	4100	1,324	1,324
J-ZN1-0680	Zone-1	4102	1,449	1,450
J-ZN1-0681	Zone-1	4100	3,519	3,001
J-ZN1-0682	Zone-1	4102	163	163
J-ZN1-0683	Zone-1	4098	128	128
J-ZN1-0684	Zone-1	4146	6,186	3,083
J-ZN1-0685	Zone-1	4161	4,566	4,051
J-ZN1-0686	Zone-1	4115	4,545	4,090
J-ZN1-0687	Zone-1	4150	4,486	2,593
J-ZN1-0688	Zone-1	4190	6,104	4,577
J-ZN1-0689	Zone-1	4182	3,526	3,162
J-ZN1-0690	Zone-1	4171	2,526	2,529
J-ZN1-0691	Zone-1	4228	3,719	2,456
J-ZN1-0692	Zone-1	4179	1,816	1,817
J-ZN1-0693	Zone-1	4194	1,907	1,909
J-ZN1-0694	Zone-1	4185	552	552
J-ZN1-0695	Zone-1	4119	2,698	2,701
J-ZN1-0696	Zone-1	4199	616	616
J-ZN1-0697	Zone-1	4197	852	628
J-ZN1-0698	Zone-1	4096	2,746	2,749
J-ZN1-0699	Zone-1	4129	500	467
J-ZN1-0700	Zone-1	4097	1,575	1,576
J-ZN1-0701	Zone-1	4100	6,955	5,145
J-ZN1-0702	Zone-1	4098	873	873

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0703	Zone-1	4100	1,306	1,306
J-ZN1-0704	Zone-1	4101	1,733	1,733
J-ZN1-0705	Zone-1	4103	6,441	4,199
J-ZN1-0706	Zone-1	4108	6,923	5,624
J-ZN1-0707	Zone-1	4099	3,169	3,173
J-ZN1-0708	Zone-1	4101	7,158	5,594
J-ZN1-0709	Zone-1	4098	2,890	2,894
J-ZN1-0710	Zone-1	4096	8,474	6,766
J-ZN1-0711	Zone-1	4096	1,198	1,198
J-ZN1-0712	Zone-1	4092	1,370	1,371
J-ZN1-0713	Zone-1	4122	1,035	1,035
J-ZN1-0714	Zone-1	4125	1,268	1,269
J-ZN1-0715	Zone-1	4158	2,758	1,505
J-ZN1-0716	Zone-1	4111	679	673
J-ZN1-0717	Zone-1	4111	8,577	2,714
J-ZN1-0718	Zone-1	4138	5,387	1,410
J-ZN1-0719	Zone-1	4117	1,586	1,586
J-ZN1-0720	Zone-1	4115	2,112	2,114
J-ZN1-0721	Zone-1	4097	8,121	5,726
J-ZN1-0723	Zone-1	4200	351	351
J-ZN1-0724	Zone-1	4201	330	330
J-ZN1-0725	Zone-1	4172	12,533	3,858
J-ZN1-0726	Zone-1	4090	9,334	9,210
J-ZN1-0727	Zone-1	4090	9,148	9,074
J-ZN1-0728	Zone-1	4090	11,860	3,426
J-ZN1-0730	Zone-1	4225	4,259	1,662
J-ZN1-0732	Zone-1	4196	3,518	3,381
J-ZN1-0733	Zone-1	4097	6,924	4,814
J-ZN1-0736	Zone-1	4222	425	425
J-ZN1-0737	Zone-1	4246	668	668
J-ZN1-0738	Zone-1	4212	839	755
J-ZN1-0739	Zone-1	4221	762	762
J-ZN1-0740	Zone-1	4104	3,577	2,904
J-ZN1-0741	Zone-1	4220	505	505
J-ZN1-0743	Zone-1	4120	349	349
J-ZN1-0744	Zone-1	4092	2,797	2,800
J-ZN1-0745	Zone-1	4092	4,982	4,680
J-ZN1-0746	Zone-1	4109	2,847	2,584
J-ZN1-0748	Zone-1	4220	2,419	2,425
J-ZN1-0749	Zone-1	4124	5,501	4,168
J-ZN1-0750	Zone-1	4098	5,527	4,273
J-ZN1-0751	Zone-1	4220	513	513
J-ZN1-0752	Zone-1	4162	1,270	1,156
J-ZN1-0753	Zone-1	4139	1,221	1,174
J-ZN1-0754	Zone-1	4098	3,595	3,439

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0755	Zone-1	4098	4,445	3,260
J-ZN1-0756	Zone-1	4213	189	155
J-ZN1-0758	Zone-1	4217	1,343	1,256
J-ZN1-0759	Zone-1	4223	153	153
J-ZN1-0760	Zone-1	4190	253	157
J-ZN1-0761	Zone-1	4106	3,603	2,482
J-ZN1-0762	Zone-1	4186	375	214
J-ZN1-0763	Zone-1	4163	1,721	1,233
J-ZN1-0764	Zone-1	4146	1,792	929
J-ZN1-0765	Zone-1	4151	813	813
J-ZN1-0767	Zone-1	4110	2,454	1,753
J-ZN1-0768	Zone-1	4120	1,757	1,336
J-ZN1-0770	Zone-1	4178	6,195	5,096
J-ZN1-0771	Zone-1	4165	3,922	3,931
J-ZN1-0772	Zone-1	4180	6,302	4,588
J-ZN1-0773	Zone-1	4100	3,970	3,976
J-ZN1-0774	Zone-1	4092	9,435	9,511
J-ZN1-0775	Zone-1	4116	865	865
J-ZN1-0776	Zone-1	4102	16,527	75,851
J-ZN1-0777	Zone-1	4097	1,877	1,878
J-ZN1-0778	Zone-1	4096	1,044	1,044
J-ZN1-0779	Zone-1	4109	4,213	4,220
J-ZN1-0780	Zone-1	4140	2,026	2,027
J-ZN1-0781	Zone-1	4141	2,171	2,172
J-ZN1-0782	Zone-1	4143	5,356	3,717
J-ZN1-0783	Zone-1	4176	6,476	3,274
J-ZN1-0784	Zone-1	4162	5,498	3,531
J-ZN1-0785	Zone-1	4178	5,278	3,247
J-ZN1-0786	Zone-1	4204	4,227	3,235
J-ZN1-0787	Zone-1	4122	1,427	1,427
J-ZN1-0788	Zone-1	4175	6,429	3,293
J-ZN1-0789	Zone-1	4168	4,481	3,184
J-ZN1-0790	Zone-1	4115	2,640	2,642
J-ZN1-0791	Zone-1	4105	2,977	2,981
J-ZN1-0792	Zone-1	4104	2,390	2,394
J-ZN1-0795	Zone-1	4128	5,189	3,190
J-ZN1-0796	Zone-1	4132	5,829	3,160
J-ZN1-0798	Zone-1	4100	3,604	3,611
J-ZN1-0799	Zone-1	4106	582	582
J-ZN1-0801	Zone-1	4092	13,775	11,538
J-ZN1-0803	Zone-1	4096	6,127	4,793
J-ZN1-0804	Zone-1	4096	4,547	4,503
J-ZN1-0805	Zone-1	4137	4,447	2,931
J-ZN1-0806	Zone-1	4149	5,050	2,829
J-ZN1-0807	Zone-1	4128	886	886

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0808	Zone-1	4098	1,336	1,337
J-ZN1-0810	Zone-1	4098	7,963	2,746
J-ZN1-0811	Zone-1	4094	5,380	3,200
J-ZN1-0812	Zone-1	4094	9,276	3,291
J-ZN1-0813	Zone-1	4092	6,092	4,109
J-ZN1-0814	Zone-1	4094	1,426	1,427
J-ZN1-0818	Zone-1	4098	5,451	3,937
J-ZN1-0822	Zone-1	4149	5,923	2,697
J-ZN1-0823	Zone-1	4098	3,987	3,937
J-ZN1-0824	Zone-1	4164	6,057	2,343
J-ZN1-0825	Zone-1	4199	1,887	1,889
J-ZN1-0828	Zone-1	4195	248	158
J-ZN1-0829	Zone-1	4194	249	161
J-ZN1-0830	Zone-1	4186	3,273	1,763
J-ZN1-0831	Zone-1	4179	3,208	1,833
J-ZN1-0832	Zone-1	4211	1,132	1,133
J-ZN1-0833	Zone-1	4099	2,529	2,532
J-ZN1-0835	Zone-1	4197	949	739
J-ZN1-0837	Zone-1	4136	2,940	2,906
J-ZN1-0838	Zone-1	4215	1,741	750
J-ZN1-0839	Zone-1	4192	689	511
J-ZN1-0841	Zone-1	4134	2,985	1,154
J-ZN1-0842	Zone-1	4111	16,010	3,574
J-ZN1-0843	Zone-1	4106	21,842	3,093
J-ZN1-0844	Zone-1	4100	12,404	2,905
J-ZN1-0845	Zone-1	4150	4,331	2,631
J-ZN1-0846	Zone-1	4094	4,975	2,823
J-ZN1-0847	Zone-1	4092	3,381	2,810
J-ZN1-0848	Zone-1	4090	3,416	2,807
J-ZN1-0849	Zone-1	4110	9,615	3,387
J-ZN1-0850	Zone-1	4108	2,858	2,733
J-ZN1-0851	Zone-1	4103	7,649	2,553
J-ZN1-0852	Zone-1	4104	5,256	2,486
J-ZN1-0853	Zone-1	4093	12,715	2,955
J-ZN1-0854	Zone-1	4093	6,163	2,855
J-ZN1-0855	Zone-1	4110	619	619
J-ZN1-0856	Zone-1	4144	3,081	2,795
J-ZN1-0857	Zone-1	4140	2,287	1,747
J-ZN1-0858	Zone-1	4154	4,571	1,322
J-ZN1-0859	Zone-1	4152	3,956	1,803
J-ZN1-0860	Zone-1	4175	1,923	1,182
J-ZN1-0861	Zone-1	4200	573	573
J-ZN1-0862	Zone-1	4163	968	589
J-ZN1-0863	Zone-1	4158	1,303	809
J-ZN1-0864	Zone-1	4151	5,022	2,141

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0865	Zone-1	4137	5,951	2,272
J-ZN1-0866	Zone-1	4118	2,295	2,018
J-ZN1-0867	Zone-1	4146	2,139	1,958
J-ZN1-0868	Zone-1	4137	2,430	1,700
J-ZN1-0869	Zone-1	4183	667	667
J-ZN1-0870	Zone-1	4088	6,790	6,817
J-ZN1-0871	Zone-1	4088	6,141	6,161
J-ZN1-0872	Zone-1	4088	3,688	3,693
J-ZN1-0873	Zone-1	4088	4,575	4,583
J-ZN1-0874	Zone-1	4214	988	965
J-ZN1-0875	Zone-1	4238	489	489
J-ZN1-0876	Zone-1	4231	1,715	540
J-ZN1-0877	Zone-1	4245	1,831	1,594
J-ZN1-0878	Zone-1	4226	3,305	1,525
J-ZN1-0880	Zone-1	4092	11,482	3,196
J-ZN1-0881	Zone-1	4094	3,047	3,050
J-ZN1-0884	Zone-1	4114	4,543	4,088
J-ZN1-0885	Zone-1	4144	2,969	2,689
J-ZN1-0886	Zone-1	4096	1,504	1,505
J-ZN1-0887	Zone-1	4092	11,530	3,198
J-ZN1-0888	Zone-1	4090	18,598	3,021
J-ZN1-0889	Zone-1	4094	11,597	3,075
J-ZN1-0890	Zone-1	4169	3,855	3,192
J-ZN1-0891	Zone-1	4178	6,417	4,844
J-ZN1-0892	Zone-1	4194	1,958	1,959
J-ZN1-0893	Zone-1	4182	6,757	4,307
J-ZN1-0894	Zone-1	4203	4,148	3,154
J-ZN1-0895	Zone-1	4182	6,171	4,973
J-ZN1-0896	Zone-1	4182	6,178	4,963
J-ZN1-0897	Zone-1	4098	627	627
J-ZN1-0898	Zone-1	4096	1,361	1,361
J-ZN1-0899	Zone-1	4100	3,338	3,235
J-ZN1-0900	Zone-1	4104	3,014	2,998
J-ZN1-0901	Zone-1	4092	13,789	11,578
J-ZN1-0902	Zone-1	4090	7,750	6,827
J-ZN1-0903	Zone-1	4098	4,994	5,009
J-ZN1-0904	Zone-1	4104	931	881
J-ZN1-0905	Zone-1	4167	4,166	4,178
J-ZN1-0906	Zone-1	4149	4,961	4,659
J-ZN1-0907	Zone-1	4163	4,577	4,593
J-ZN1-0908	Zone-1	4144	5,383	5,280
J-ZN1-0909	Zone-1	4121	3,395	3,399
J-ZN1-0910	Zone-1	4110	4,072	4,079
J-ZN1-0911	Zone-1	4093	21,564	18,866
J-ZN1-0912	Zone-1	4092	21,389	18,898

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0913	Zone-1	4092	9,527	9,607
J-ZN1-0915	Zone-1	4093	9,224	9,296
J-ZN1-0916	Zone-1	4100	7,799	6,545
J-ZN1-0917	Zone-1	4102	7,097	6,666
J-ZN1-0918	Zone-1	4098	8,585	8,440
J-ZN1-0919	Zone-1	4097	1,989	1,989
J-ZN1-0920	Zone-1	4104	5,069	5,083
J-ZN1-0921	Zone-1	4114	5,788	3,205
J-ZN1-0922	Zone-1	4122	1,783	1,784
J-ZN1-0923	Zone-1	4179	2,619	2,162
J-ZN1-0924	Zone-1	4164	5,921	2,440
J-ZN1-0926	Zone-1	4223	1,216	1,219
J-ZN1-0927	Zone-1	4180	4,104	4,043
J-ZN1-0928	Zone-1	4179	3,415	3,328
J-ZN1-0929	Zone-1	4182	2,680	2,683
J-ZN1-0930	Zone-1	4090	5,389	5,403
J-ZN1-0931	Zone-1	4090	6,989	7,014
J-ZN1-0932	Zone-1	4088	899	899
J-ZN1-0933	Zone-1	4153	171	171
J-ZN1-0934	Zone-1	4088	1,298	1,298
J-ZN1-0936	Zone-1	4098	8,212	5,791
J-ZN1-0937	Zone-1	4247	426	426
J-ZN1-0938	Zone-1	4234	1,361	444
J-ZN1-0939	Zone-1	4137	954	954
J-ZN1-0940	Zone-1	4151	186	185
J-ZN1-0941	Zone-1	4181	4,161	1,612
J-ZN1-0942	Zone-1	4170	3,989	1,631
J-ZN1-0943	Zone-1	4161	3,642	1,617
J-ZN1-0946	Zone-1	4095	7,838	5,743
J-ZN1-0947	Zone-1	4250	-970	1,219
J-ZN1-0948	Zone-1	4250	2,260	2,283
J-ZN1-0949	Zone-1	4210	197	157
J-ZN1-0950	Zone-1	4215	1,145	1,035
J-ZN1-0951	Zone-1	4158	4,285	2,221
J-ZN1-0952	Zone-1	4142	5,590	2,194
J-ZN1-0953	Zone-1	4102	2,439	2,441
J-ZN1-0954	Zone-1	4104	5,964	3,948
J-ZN1-0955	Zone-1	4090	1,594	1,594
J-ZN1-0956	Zone-1	4094	17,936	17,332
J-ZN1-0957	Zone-1	4098	9,606	9,289
J-ZN1-0958	Zone-1	4097	9,839	9,449
J-ZN1-0959	Zone-1	4098	25,861	4,328
J-ZN1-0960	Zone-1	4095	25,758	4,390
J-ZN1-0961	Zone-1	4098	25,479	4,240
J-ZN1-0962	Zone-1	4100	25,183	4,355

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-0963	Zone-1	4103	24,345	4,323
J-ZN1-0982	Zone-1	4159	512	512
J-ZN1-1000	Zone-1	4184	985	910
J-ZN1-1001	Zone-1	4168	1,544	892
J-ZN1-1002	Zone-1	4201	729	729
J-ZN1-1003	Zone-1	4118	8,425	2,005
J-ZN1-1004	Zone-1	4112	1,408	1,408
J-ZN1-1005	Zone-1	4112	944	927
J-ZN1-1006	Zone-1	4118	917	917
J-ZN1-1007	Zone-1	4155	4,532	1,322
J-ZN1-1008	Zone-1	4150	3,916	1,386
J-ZN1-1009	Zone-1	4150	4,102	1,379
J-ZN1-1010	Zone-1	4188	2,731	1,503
J-ZN1-1011	Zone-1	4152	3,603	2,005
J-ZN1-1012	Zone-1	4154	3,473	2,007
J-ZN1-1013	Zone-1	4184	936	865
J-ZN1-1014	Zone-1	4166	1,101	985
J-ZN1-1015	Zone-1	4225	927	927
J-ZN1-1016	Zone-1	4219	820	382
J-ZN1-1017	Zone-1	4250	325	325
J-ZN1-1018	Zone-1	4169	2,638	1,111
J-ZN1-1019	Zone-1	4148	2,606	1,139
J-ZN1-1020	Zone-1	4130	4,270	1,140
J-ZN1-1021	Zone-1	4195	1,297	1,049
J-ZN1-1022	Zone-1	4092	1,909	1,910
J-ZN1-1023	Zone-1	4090	3,360	2,807
J-ZN1-1024	Zone-1	4090	2,107	2,108
J-ZN1-1025	Zone-1	4119	7,406	2,463
J-ZN1-1026	Zone-1	4120	1,377	1,372
J-ZN1-1027	Zone-1	4119	1,399	1,377
J-ZN1-1028	Zone-1	4122	1,318	1,319
J-ZN1-1029	Zone-1	4108	419	419
J-ZN1-1030	Zone-1	4106	421	421
J-ZN1-1031	Zone-1	4110	527	527
J-ZN1-1032	Zone-1	4106	507	507
J-ZN1-1033	Zone-1	4149	1,104	1,104
J-ZN1-1034	Zone-1	4164	964	893
J-ZN1-1035	Zone-1	4120	3,796	3,557
J-ZN1-1036	Zone-1	4129	1,094	1,094
J-ZN1-1037	Zone-1	4175	4,284	2,552
J-ZN1-1038	Zone-1	4162	1,676	1,677
J-ZN1-1039	Zone-1	4158	1,156	1,156
J-ZN1-1040	Zone-1	4160	4,538	4,049
J-ZN1-1041	Zone-1	4159	4,211	2,584
J-ZN1-1042	Zone-1	4150	4,514	2,589

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-1043	Zone-1	4151	4,187	2,597
J-ZN1-1044	Zone-1	4138	1,040	979
J-ZN1-1045	Zone-1	4140	967	967
J-ZN1-1046	Zone-1	4112	1,435	1,421
J-ZN1-1047	Zone-1	4104	3,550	2,578
J-ZN1-1048	Zone-1	4109	1,353	1,353
J-ZN1-1049	Zone-1	4120	2,480	2,444
J-ZN1-1050	Zone-1	4122	1,184	1,184
J-ZN1-1051	Zone-1	4092	1,337	1,316
J-ZN1-1052	Zone-1	4095	1,136	1,136
J-ZN1-1053	Zone-1	4094	6,972	4,315
J-ZN1-1054	Zone-1	4092	5,499	4,299
J-ZN1-1055	Zone-1	4092	1,501	1,485
J-ZN1-1056	Zone-1	4094	1,297	1,297
J-ZN1-1057	Zone-1	4108	3,638	3,615
J-ZN1-1058	Zone-1	4094	8,218	6,227
J-ZN1-1059	Zone-1	4094	3,236	3,242
J-ZN1-1060	Zone-1	4098	3,384	3,342
J-ZN1-1061	Zone-1	4100	1,992	1,993
J-ZN1-1063	Zone-1	4101	1,885	1,886
J-ZN1-1064	Zone-1	4099	1,695	1,696
J-ZN1-1065	Zone-1	4148	1,586	814
J-ZN1-1066	Zone-1	4146	1,319	809
J-ZN1-1067	Zone-1	4209	5,355	3,938
J-ZN1-1068	Zone-1	4186	5,495	5,321
J-ZN1-1069	Zone-1	4191	2,105	2,107
J-ZN1-1070	Zone-1	4168	1,177	1,125
J-ZN1-1071	Zone-1	4176	651	651
J-ZN1-1072	Zone-1	4176	554	554
J-ZN1-1073	Zone-1	4166	3,476	3,336
J-ZN1-1074	Zone-1	4172	2,449	2,451
J-ZN1-1075	Zone-1	4173	3,102	3,107
J-ZN1-1076	Zone-1	4161	934	934
J-ZN1-1077	Zone-1	4172	3,059	3,063
J-ZN1-1078	Zone-1	4172	3,177	3,183
J-ZN1-1079	Zone-1	4174	870	870
J-ZN1-1080	Zone-1	4178	2,313	2,315
J-ZN1-1081	Zone-1	4092	4,547	4,516
J-ZN1-1082	Zone-1	4092	6,164	6,073
J-ZN1-1083	Zone-1	4094	1,162	1,162
J-ZN1-1084	Zone-1	4173	1,330	1,077
J-ZN1-1085	Zone-1	4090	9,288	8,207
J-ZN1-1086	Zone-1	4090	11,863	10,546
J-ZN1-1087	Zone-1	4091	4,757	4,766
J-ZN1-1088	Zone-1	4090	15,109	13,892

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-1089	Zone-1	4090	2,812	2,814
J-ZN1-1090	Zone-1	4171	1,260	959
J-ZN1-1091	Zone-1	4092	7,661	6,773
J-ZN1-1092	Zone-1	4088	7,058	6,780
J-ZN1-1093	Zone-1	4093	6,312	6,331
J-ZN1-1094	Zone-1	4094	4,940	4,083
J-ZN1-1095	Zone-1	4092	4,673	4,674
J-ZN1-1096	Zone-1	4092	2,476	2,478
J-ZN1-1097	Zone-1	4100	2,744	2,747
J-ZN1-1098	Zone-1	4100	2,428	2,430
J-ZN1-1099	Zone-1	4189	1,482	1,164
J-ZN1-1100	Zone-1	4098	3,357	2,836
J-ZN1-1101	Zone-1	4100	2,829	2,828
J-ZN1-1102	Zone-1	4100	2,779	2,782
J-ZN1-1103	Zone-1	4099	2,747	2,750
J-ZN1-1104	Zone-1	4126	2,743	2,746
J-ZN1-1105	Zone-1	4125	2,828	2,823
J-ZN1-1106	Zone-1	4122	2,750	2,753
J-ZN1-1107	Zone-1	4130	2,809	2,811
J-ZN1-1108	Zone-1	4119	2,657	2,660
J-ZN1-1109	Zone-1	4120	2,638	2,640
J-ZN1-1110	Zone-1	4204	1,289	1,155
J-ZN1-1111	Zone-1	4138	4,327	4,330
J-ZN1-1112	Zone-1	4138	3,887	3,894
J-ZN1-1113	Zone-1	4138	1,636	1,636
J-ZN1-1114	Zone-1	4157	3,351	3,357
J-ZN1-1115	Zone-1	4177	6,069	5,215
J-ZN1-1116	Zone-1	4156	4,308	4,288
J-ZN1-1117	Zone-1	4156	3,646	3,653
J-ZN1-1118	Zone-1	4154	3,133	3,138
J-ZN1-1119	Zone-1	4204	1,171	1,144
J-ZN1-1120	Zone-1	4162	3,886	3,863
J-ZN1-1121	Zone-1	4163	3,083	3,088
J-ZN1-1122	Zone-1	4166	4,031	3,918
J-ZN1-1123	Zone-1	4170	2,102	2,103
J-ZN1-1124	Zone-1	4164	3,548	3,519
J-ZN1-1125	Zone-1	4166	1,889	1,890
J-ZN1-1126	Zone-1	4168	3,533	3,494
J-ZN1-1127	Zone-1	4170	1,897	1,898
J-ZN1-1128	Zone-1	4165	1,661	1,662
J-ZN1-1129	Zone-1	4216	1,214	1,141
J-ZN1-1130	Zone-1	4153	3,060	2,815
J-ZN1-1131	Zone-1	4154	1,727	1,728
J-ZN1-1132	Zone-1	4158	2,124	2,125
J-ZN1-1133	Zone-1	4162	1,961	1,962

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-1134	Zone-1	4162	1,643	1,421
J-ZN1-1135	Zone-1	4172	1,094	1,095
J-ZN1-1136	Zone-1	4171	1,165	1,086
J-ZN1-1137	Zone-1	4205	1,254	1,155
J-ZN1-1138	Zone-1	4178	1,040	1,040
J-ZN1-1139	Zone-1	4175	1,082	1,055
J-ZN1-1140	Zone-1	4168	1,070	1,068
J-ZN1-1141	Zone-1	4156	1,686	1,652
J-ZN1-1142	Zone-1	4159	1,360	1,360
J-ZN1-1143	Zone-1	4149	2,072	1,816
J-ZN1-1144	Zone-1	4151	1,570	1,570
J-ZN1-1145	Zone-1	4107	3,095	3,098
J-ZN1-1146	Zone-1	4208	1,240	1,154
J-ZN1-1147	Zone-1	4108	3,236	3,240
J-ZN1-1148	Zone-1	4108	1,501	1,502
J-ZN1-1149	Zone-1	4100	702	702
J-ZN1-1150	Zone-1	4101	499	499
J-ZN1-1151	Zone-1	4110	2,996	2,999
J-ZN1-1152	Zone-1	4110	111	111
J-ZN1-1153	Zone-1	4211	1,240	1,069
J-ZN1-1154	Zone-1	4110	114	114
J-ZN1-1155	Zone-1	4104	979	931
J-ZN1-1156	Zone-1	4110	103	103
J-ZN1-1157	Zone-1	4109	402	402
J-ZN1-1158	Zone-1	4117	997	892
J-ZN1-1159	Zone-1	4117	1,001	884
J-ZN1-1160	Zone-1	4139	762	762
J-ZN1-1161	Zone-1	4108	6,205	6,231
J-ZN1-1162	Zone-1	4109	6,493	6,522
J-ZN1-1163	Zone-1	4104	4,308	4,316
J-ZN1-1164	Zone-1	4105	6,549	6,534
J-ZN1-1165	Zone-1	4106	1,971	1,972
J-ZN1-1166	Zone-1	4108	6,493	6,523
J-ZN1-1167	Zone-1	4108	6,453	6,482
J-ZN1-1168	Zone-1	4110	6,559	6,590
J-ZN1-1169	Zone-1	4108	5,929	5,952
J-ZN1-1170	Zone-1	4110	6,452	6,482
J-ZN1-1171	Zone-1	4108	5,744	5,764
J-ZN1-1172	Zone-1	4220	760	761
J-ZN1-1173	Zone-1	4106	3,308	3,312
J-ZN1-1174	Zone-1	4106	3,304	3,308
J-ZN1-1175	Zone-1	4106	2,861	2,863
J-ZN1-1176	Zone-1	4137	1,969	1,960
J-ZN1-1177	Zone-1	4138	1,945	1,946
J-ZN1-1178	Zone-1	4136	2,179	2,156

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-1179	Zone-1	4168	1,890	1,891
J-ZN1-1180	Zone-1	4165	1,859	1,861
J-ZN1-1181	Zone-1	4220	1,133	1,134
J-ZN1-1182	Zone-1	4164	2,163	2,077
J-ZN1-1183	Zone-1	4158	2,212	2,078
J-ZN1-1184	Zone-1	4176	2,173	2,175
J-ZN1-1185	Zone-1	4159	1,219	1,219
J-ZN1-1186	Zone-1	4166	2,177	2,077
J-ZN1-1187	Zone-1	4168	1,920	1,922
J-ZN1-1188	Zone-1	4149	2,410	2,360
J-ZN1-1189	Zone-1	4152	1,404	1,405
J-ZN1-1190	Zone-1	4148	2,237	2,239
J-ZN1-1191	Zone-1	4109	3,239	3,242
J-ZN1-1192	Zone-1	4207	1,226	1,147
J-ZN1-1193	Zone-1	4109	3,546	3,551
J-ZN1-1194	Zone-1	4107	3,726	3,732
J-ZN1-1195	Zone-1	4104	3,889	3,895
J-ZN1-1196	Zone-1	4105	3,829	3,835
J-ZN1-1197	Zone-1	4105	4,468	4,477
J-ZN1-1198	Zone-1	4104	2,515	2,517
J-ZN1-1199	Zone-1	4102	5,990	5,922
J-ZN1-1200	Zone-1	4088	3,967	3,941
J-ZN1-1201	Zone-1	4090	1,839	1,840
J-ZN1-1202	Zone-1	4208	1,299	1,147
J-ZN1-1203	Zone-1	4090	1,847	1,844
J-ZN1-1204	Zone-1	4090	1,671	1,672
J-ZN1-1205	Zone-1	4086	3,007	2,964
J-ZN1-1206	Zone-1	4089	1,077	1,077
J-ZN1-1207	Zone-1	4094	5,819	5,837
J-ZN1-1209	Zone-1	4089	7,362	7,397
J-ZN1-1212	Zone-1	4205	1,428	1,140
J-ZN1-1213	Zone-1	4089	7,322	7,332
J-ZN1-1214	Zone-1	4088	7,138	7,170
J-ZN1-1215	Zone-1	4089	7,138	7,144
J-ZN1-1217	Zone-1	4090	4,028	4,034
J-ZN1-1218	Zone-1	4090	2,475	2,476
J-ZN1-1219	Zone-1	4090	2,462	2,463
J-ZN1-1220	Zone-1	4090	2,880	2,883
J-ZN1-1221	Zone-1	4090	2,782	2,783
J-ZN1-1222	Zone-1	4090	3,904	3,909
J-ZN1-1223	Zone-1	4090	5,199	5,212
J-ZN1-1224	Zone-1	4090	3,130	3,133
J-ZN1-1225	Zone-1	4090	2,823	2,825
J-ZN1-1226	Zone-1	4090	2,282	2,283
J-ZN1-1227	Zone-1	4090	2,662	2,664

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ZN1-1228	Zone-1	4089	2,606	2,608
J-ZN1-1229	Zone-1	4090	2,636	2,638
J-ZN1-1230	Zone-1	4089	1,956	1,957
J-ZN1-1231	Zone-1	4089	1,926	1,927
J-ZN1-1232	Zone-1	4088	2,154	2,154
J-ZN1-1233	Zone-1	4084	1,508	1,508
J-ZN1-1234	Zone-1	4090	1,753	1,752
J-ZN1-1235	Zone-1	4089	1,652	1,652
J-ZN1-1236	Zone-1	4090	6,778	6,806
J-ZN1-1237	Zone-1	4088	1,207	1,207
J-ZN1-1238	Zone-1	4088	7,106	7,138
J-ZN1-1239	Zone-1	4088	7,279	7,313
J-ZN1-1240	Zone-1	4088	1,833	1,834
J-ZN1-1241	Zone-1	4174	713	713
J-WO-0001	West Oregon	4226	1,139	1,060
J-WO-0002	West Oregon	4209	1,149	1,063
J-WO-0003	West Oregon	4224	1,048	1,010
J-WO-0004	West Oregon	4238	965	965
J-WO-0005	West Oregon	4223	1,152	1,111
J-WO-0006	West Oregon	4230	1,123	1,108
J-WO-0007	West Oregon	4268	1,107	1,107
J-WO-0008	West Oregon	4219	630	630
J-WO-0009	West Oregon	4213	1,013	1,008
J-WO-0010	West Oregon	4194	1,108	1,063
J-WO-0011	West Oregon	4242	1,128	1,109
J-WO-0012	West Oregon	4244	1,158	1,107
J-HOS-0001	URH-HOSP-HLVL	4292	4,571	497
J-HOS-0004	URH-HOSP-HLVL	4373	1,315	444
J-HOS-0005	URH-HOSP-HLVL	4409	4,281	354
J-HOS-0006	URH-HOSP-HLVL	4281	4,033	325
J-HOS-0007	URH-HOSP-HLVL	4380	3,579	235
J-HOS-0008	URH-HOSP-HLVL	4279	2,829	1,443
J-HOS-0009	URH-HOSP-HLVL	4319	1,466	397
J-HOS-0010	URH-HOSP-HLVL	4410	182	182
J-HOS-0011	URH-HOSP-HLVL	4224	5,239	1,009
J-HOS-0012	URH-HOSP-HLVL	4338	3,058	1,092
J-HOS-0013	URH-HOSP-HLVL	4307	3,286	1,063
J-HOS-0014	URH-HOSP-HLVL	4356	4,912	341
J-HOS-0015	URH-HOSP-HLVL	4451	321	191
J-HOS-0016	URH-HOSP-HLVL	4322	4,920	268
J-HOS-0017	URH-HOSP-HLVL	4324	2,123	502
J-HOS-0018	URH-HOSP-HLVL	4269	3,286	622
J-HOS-0019	URH-HOSP-HLVL	4320	5,706	1,512
J-HOS-0020	URH-HOSP-HLVL	4228	2,804	406
J-HOS-0021	URH-HOSP-HLVL	4261	3,573	365

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-HOS-0022	URH-HOSP-HLVL	4253	2,880	416
J-HOS-0023	URH-HOSP-HLVL	4267	2,938	459
J-HOS-0024	URH-HOSP-HLVL	4300	2,649	507
J-HOS-0025	URH-HOSP-HLVL	4322	6,515	1,807
J-HOS-0026	URH-HOSP-HLVL	4271	3,383	632
J-HOS-0027	URH-HOSP-HLVL	4313	2,654	609
J-HOS-0028	URH-HOSP-HLVL	4317	2,079	461
J-HOS-0029	URH-HOSP-HLVL	4344	1,715	1,112
J-HOS-0030	URH-HOSP-HLVL	4357	1,205	980
J-HOS-0031	URH-HOSP-HLVL	4273	4,813	328
J-HOS-0032	URH-HOSP-HLVL	4269	4,148	316
J-HOS-0033	URH-HOSP-HLVL	4320	4,978	268
J-HOS-0034	URH-HOSP-HLVL	4378	3,719	236
J-HOS-0035	URH-HOSP-HLVL	4367	4,562	264
J-HOS-0036	URH-HOSP-HLVL	4383	5,566	364
J-HOS-0037	URH-HOSP-HLVL	4420	3,849	334
J-HOS-0038	URH-HOSP-HLVL	4345	6,933	351
J-HOS-0039	URH-HOSP-HLVL	4330	7,986	469
J-HOS-0043	URH-HOSP-HLVL	4415	2,438	226
J-HOS-0044	URH-HOSP-HLVL	4431	1,790	215
J-HOS-0045	URH-HOSP-HLVL	4414	1,717	222
J-HOS-0046	URH-HOSP-HLVL	4287	4,369	327
J-HOS-0047	URH-HOSP-HLVL	4311	7,037	478
J-HOS-0048	URH-HOSP-HLVL	4268	5,728	476
J-HOS-0049	URH-HOSP-HLVL	4238	5,805	4,365
J-HOS-0050	URH-HOSP-HLVL	4333	3,437	484
J-HOS-0051	URH-HOSP-HLVL	4252	3,805	473
J-HOS-0052	URH-HOSP-HLVL	4322	2,644	1,558
J-HOS-0053	URH-HOSP-HLVL	4369	1,356	954
J-HOS-0054	URH-HOSP-HLVL	4388	216	188
J-HOS-0055	URH-HOSP-HLVL	4337	386	386
J-HOS-0057	URH-HOSP-HLVL	4386	934	403
J-HOS-0058	URH-HOSP-HLVL	4369	1,373	1,036
J-HOS-0059	URH-HOSP-HLVL	4312	2,368	1,364
J-HOS-0060	URH-HOSP-HLVL	4251	3,300	395
J-HOS-0061	URH-HOSP-HLVL	4253	2,999	410
J-HOS-0062	URH-HOSP-HLVL	4274	2,416	331
J-HOS-0063	URH-HOSP-HLVL	4314	4,528	284
J-HOS-0064	URH-HOSP-HLVL	4302	3,699	287
J-HOS-0065	URH-HOSP-HLVL	4344	1,131	1,039
J-HOS-0066	URH-HOSP-HLVL	4401	972	421
J-HOS-0067	URH-HOSP-HLVL	4385	442	218
J-HOS-0068	URH-HOSP-HLVL	4253	1,927	458
J-HOS-0069	URH-HOSP-HLVL	4361	1,975	503
J-HOS-0070	URH-HOSP-HLVL	4346	2,263	541

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-HOS-0071	URH-HOSP-HLVL	4286	2,866	540
J-HOS-0072	URH-HOSP-HLVL	4338	288	183
J-HOS-0073	URH-HOSP-HLVL	4334	3,480	486
J-HOS-0074	URH-HOSP-HLVL	4334	3,396	483
J-HOS-0075	URH-HOSP-HLVL	4249	2,773	1,632
J-HOS-0076	URH-HOSP-HLVL	4263	5,248	1,206
J-HOS-0077	URH-HOSP-HLVL	4303	4,087	330
J-HOS-0078	URH-HOSP-HLVL	4324	2,802	329
J-HOS-0079	URH-HOSP-HLVL	4381	1,610	479
J-HOS-0080	URH-HOSP-HLVL	4283	2,641	467
J-HOS-0081	URH-HOSP-HLVL	4236	4,197	819
J-HOS-0082	URH-HOSP-HLVL	4296	1,954	822
J-HOS-0083	URH-HOSP-HLVL	4274	2,491	667
J-HOS-0084	URH-HOSP-HLVL	4309	1,542	665
J-HOS-0085	URH-HOSP-HLVL	4257	3,556	666
J-HOS-0086	URH-HOSP-HLVL	4276	383	221
J-HOS-0087	URH-HOSP-HLVL	4301	332	176
J-HOS-0089	URH-HOSP-HLVL	4292	2,148	485
J-HOS-0090	URH-HOSP-HLVL	4316	2,107	482
J-HOS-0091	URH-HOSP-HLVL	4331	1,776	483
J-HOS-0092	URH-HOSP-HLVL	4284	1,971	482
J-HOS-0093	URH-HOSP-HLVL	4315	1,735	491
J-HOS-0094	URH-HOSP-HLVL	4328	3,223	472
J-HOS-0095	URH-HOSP-HLVL	4454	-193	191
J-HOS-0096	URH-HOSP-HLVL	4452	192	192
J-HOS-0097	URH-HOSP-HLVL	4365	4,507	265
J-HOS-0098	URH-HOSP-HLVL	4352	1,016	262
J-HOS-0099	URH-HOSP-HLVL	4318	2,872	273
J-HOS-0102	URH-HOSP-HLVL	4266	2,920	621
J-HOS-0103	URH-HOSP-HLVL	4274	327	327
J-HOS-0104	URH-HOSP-HLVL	4227	5,796	508
J-HOS-0105	URH-HOSP-HLVL	4260	3,463	362
J-HOS-0106	URH-HOSP-HLVL	4314	1,214	1,214
J-HOS-0107	URH-HOSP-HLVL	4268	760	760
J-HOS-0108	URH-HOSP-HLVL	4259	1,225	623
J-UM-0001	Upper Moyina	4417	351	323
J-UM-0002	Upper Moyina	4353	452	308
J-UM-0003	Upper Moyina	4364	668	668
J-UM-0004	Upper Moyina	4429	192	192
J-UM-0005	Upper Moyina	4417	239	221
J-UM-0006	Upper Moyina	4369	421	305
J-UM-0007	Upper Moyina	4434	1,364	1,236
J-UM-0008	Upper Moyina	4362	769	545
J-UM-0009	Upper Moyina	4360	670	554
J-UM-0010	Upper Moyina	4384	541	541

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-UM-0012	Upper Moyina	4375	417	308
J-UM-0013	Upper Moyina	4401	313	313
J-UM-0014	Upper Moyina	4400	736	547
J-UM-0015	Upper Moyina	4446	475	475
J-UM-0016	Upper Moyina	4353	454	310
J-UM-0017	Upper Moyina	4419	343	320
J-UM-0018	Upper Moyina	4377	416	311
J-UM-0021	Upper Moyina	4336	586	543
J-UM-0022	Upper Moyina	4356	727	539
J-TW-0003	Tanglewood	4820	5,182	5,141
J-TW-0004	Tanglewood	4814	2,965	2,967
J-TW-0005	Tanglewood	4772	2,970	2,742
J-TW-0007	Tanglewood	4822	2,488	2,490
J-PRV-SL-0001	Stewart_Lennox_PRV	4118	285	285
J-PRV-SL-0002	Stewart_Lennox_PRV	4215	926	884
J-PRV-SL-0005	Stewart_Lennox_PRV	4225	647	647
J-PRV-SL-0006	Stewart_Lennox_PRV	4216	268	268
J-PRV-SL-0009	Stewart_Lennox_PRV	4141	1,079	887
J-PRV-SL-0011	Stewart_Lennox_PRV	4145	169	169
J-PRV-SL-0012	Stewart_Lennox_PRV	4157	113	113
J-PRV-SL-0014	Stewart_Lennox_PRV	4117	1,079	887
J-PRV-SL-0016	Stewart_Lennox_PRV	4213	936	886
J-PRV-SL-0017	Stewart_Lennox_PRV	4214	938	890
J-SL-0001	Stewart_Lennox	4225	616	616
J-SL-0002	Stewart_Lennox	4186	1,910	1,911
J-SL-0004	Stewart_Lennox	4190	3,622	3,595
J-SL-0006	Stewart_Lennox	4227	4,168	4,027
J-SL-0007	Stewart_Lennox	4220	471	471
J-SL-0008	Stewart_Lennox	4212	222	222
J-SL-0009	Stewart_Lennox	4247	3,862	3,869
J-SL-0010	Stewart_Lennox	4199	2,602	2,256
J-SL-0011	Stewart_Lennox	4200	4,612	4,360
J-SL-0012	Stewart_Lennox	4227	3,814	3,820
J-SL-0013	Stewart_Lennox	4220	3,998	3,941
J-SL-0014	Stewart_Lennox	4178	3,819	3,823
J-SL-0015	Stewart_Lennox	4188	2,702	2,668
J-SL-0016	Stewart_Lennox	4178	3,326	3,329
J-SL-0018	Stewart_Lennox	4228	4,451	4,443
J-SL-0019	Stewart_Lennox	4242	4,576	4,431
J-SL-0020	Stewart_Lennox	4248	4,925	4,940
J-SL-0021	Stewart_Lennox	4236	210	210
J-SL-0022	Stewart_Lennox	4189	2,207	2,148
J-SL-0023	Stewart_Lennox	4198	1,838	1,838
J-SL-0024	Stewart_Lennox	4192	1,834	1,835
J-SL-0025	Stewart_Lennox	4187	2,343	2,310

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-SL-0026	Stewart_Lennox	4188	2,157	2,158
J-SL-0027	Stewart_Lennox	4226	1,746	1,661
J-SL-0028	Stewart_Lennox	4238	1,281	1,281
J-SL-0029	Stewart_Lennox	4232	3,649	3,654
J-SL-0030	Stewart_Lennox	4234	3,494	3,499
J-SL-0032	Stewart_Lennox	4198	263	263
J-SL-0033	Stewart_Lennox	4247	4,093	4,101
J-SL-0034	Stewart_Lennox	4187	4,021	3,662
J-SL-0035	Stewart_Lennox	4182	4,510	4,048
J-SL-0036	Stewart_Lennox	4210	244	244
J-SL-0037	Stewart_Lennox	4181	4,494	4,049
J-SL-0038	Stewart_Lennox	4185	2,420	2,421
J-SL-0039	Stewart_Lennox	4224	559	559
J-SL-0040	Stewart_Lennox	4189	237	237
J-SL-0041	Stewart_Lennox	4249	4,138	4,147
J-SL-0042	Stewart_Lennox	4242	4,586	4,430
J-SL-0043	Stewart_Lennox	4247	3,949	3,943
J-SL-0044	Stewart_Lennox	4226	564	564
J-SL-0045	Stewart_Lennox	4228	4,530	4,382
J-SL-0047	Stewart_Lennox	4210	1,463	1,454
J-SL-0048	Stewart_Lennox	4209	1,313	1,300
J-SL-0049	Stewart_Lennox	4235	144	144
J-SL-0050	Stewart_Lennox	4219	825	761
J-SL-0052	Stewart_Lennox	4188	2,176	2,156
J-SL-0053	Stewart_Lennox	4211	1,296	1,297
J-SL-0063	Lindley	4138	2,464	2,465
J-SL-0064	Lindley	4147	1,494	1,494
J-SL-0065	Lindley	4124	5,635	4,366
J-SL-0066	Lindley	4184	2,014	2,014
J-SL-0067	Lindley	4216	1,966	1,588
J-SL-0068	Lindley	4235	1,539	1,437
J-SL-0069	Lindley	4232	1,649	1,650
J-SL-0070	Lindley	4221	6,770	5,982
J-SL-0071	Lindley	4214	11,884	9,697
J-SL-0072	Lindley	4260	923	923
J-SL-0073	Lindley	4239	1,387	1,210
J-SL-0074	Lindley	4213	5,229	4,385
J-SL-0075	Lindley	4233	2,544	1,660
J-SL-0076	Lindley	4188	7,468	4,045
J-SL-0077	Lindley	4185	4,286	3,749
J-SL-0078	Lindley	4154	4,415	3,462
J-SL-0079	Lindley	4148	4,075	3,371
J-SL-0080	Lindley	4105	5,339	3,950
J-SL-0081	Lindley	4108	4,856	3,964
J-SL-0082	Lindley	4204	1,169	1,169

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-SL-0083	Lindley	4151	2,153	1,667
J-SL-0084	Lindley	4146	1,926	1,655
J-SL-0085	Lindley	4134	1,834	1,685
J-SL-0086	Lindley	4217	1,057	1,057
J-SL-0088	Lindley	4098	1,582	614
J-SL-0089	Lindley	4284	387	387
J-SL-0090	Lindley	4236	629	412
J-SL-0091	Lindley	4180	1,011	500
J-SL-0092	Lindley	4210	964	545
J-SL-0094	Lindley	4149	4,249	3,278
J-SL-0095	Lindley	4188	8,819	4,813
J-SL-0096	Lindley	4272	10,705	9,749
J-SL-0102	Lindley	4224	711	504
J-SL-0103	Lindley	4231	715	566
J-SL-0104	Lindley	4218	649	413
J-SL-0105	Lindley	4209	1,288	1,288
J-SL-0106	Lindley	4203	6,699	6,727
J-SL-0107	Lindley	4188	4,333	4,340
J-SH-0001	Sierra Heights	4232	397	1,559
J-SH-0003	Sierra Heights	4225	406	1,615
J-SH-0004	Sierra Heights	4250	368	1,557
J-SH-0005	Sierra Heights	4252	362	1,555
J-SH-0006	Sierra Heights	4242	381	1,558
J-SH-0007	Sierra Heights	4262	342	1,068
J-SH-0008	Sierra Heights	4274	320	923
J-PRV-2-OGD-0001	PRV_Ogden	4266	1,270	1,270
J-PRV-2-OGD-0002	PRV_Ogden	4281	2,885	2,887
J-PRV-2-OGD-0003	PRV_Ogden	4255	1,068	1,069
J-PRV-2-OGD-0004	PRV_Ogden	4266	1,117	1,117
J-PRV-2-OGD-0005	PRV_Ogden	4242	1,054	1,054
J-PRV-2-OGD-0006	PRV_Ogden	4236	976	976
J-PRV-2-OGD-0007	PRV_Ogden	4250	1,207	1,207
J-PRV-OFR-0001	PRV-6	4264	749	749
J-PRV-OFR-0002	PRV-6	4248	667	657
J-PRV-OFR-0003	PRV-6	4225	752	697
J-PRV-OFR-0004	PRV-6	4185	766	656
J-PRV-OFR-0005	PRV-6	4210	715	656
J-PRV-OFR-0006	PRV-6	4198	742	657
J-PRV-OFR-0007	PRV-6	4231	682	659
J-PRV-OFR-0008	PRV-6	4254	595	595
J-PRV-3-UMO-0001	PRV-3	4285	1,534	1,535
J-PRV-3-UMO-0002	PRV-3	4317	662	662
J-PRV-3-UMO-0003	PRV-3	4300	672	672
J-PRV-3-UMO-0004	PRV-3	4324	660	660
J-PRV-3-UMO-0006	PRV-3	4337	682	682

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-PRV-3-UMO-0007	PRV-3	4321	546	541
J-PRV-3-UMO-0008	PRV-3	4325	541	540
J-PRV-3-UMO-0009	PRV-3	4343	692	692
J-PRV-HWY-0001	PRV-2-HWY	4234	1,673	1,569
J-PRV-HWY-0002	PRV-2-HWY	4218	1,700	1,505
J-PRV-HWY-0003	PRV-2-HWY	4216	1,704	1,479
J-PRV-HWY-0004	PRV-2-HWY	4243	1,446	1,446
J-PRV-HWY-0005	PRV-2-HWY	4238	1,538	1,487
J-PRV-HWY-0006	PRV-2-HWY	4222	1,663	1,492
J-PRV-HWY-0007	PRV-2-HWY	4191	4,843	4,309
J-PRV-HWY-0008	PRV-2-HWY	4233	1,649	1,545
J-PRV-HWY-0009	PRV-2-HWY	4206	1,648	1,513
J-PRV-HWY-0010	PRV-2-HWY	4195	444	444
J-PRV-HWY-0011	PRV-2-HWY	4184	1,762	1,762
J-PRV-HWY-0013	PRV-2-HWY	4217	1,568	1,455
J-PRV-HWY-0014	PRV-2-HWY	4221	1,635	1,508
J-PRV-HWY-0015	PRV-2-HWY	4216	1,673	1,470
J-PRV-HWY-0016	PRV-2-HWY	4238	1,464	1,456
J-PRV-HWY-0017	PRV-2-HWY	4241	1,413	1,413
J-PRV-HWY-0018	PRV-2-HWY	4216	1,684	1,479
J-PRV-HWY-0019	PRV-2-HWY	4222	1,658	1,491
J-PRV-HWY-0021	PRV-2-HWY	4238	1,531	1,483
J-PRV-HWY-0022	PRV-2-HWY	4189	5,044	4,468
J-PRV-2-ELD-0001	PRV-2	4229	2,116	1,652
J-PRV-2-ELD-0002	PRV-2	4248	859	859
J-PRV-2-ELD-0003	PRV-2	4226	1,153	876
J-PRV-2-ELD-0004	PRV-2	4252	800	761
J-PRV-2-ELD-0005	PRV-2	4218	1,941	1,407
J-PRV-2-ELD-0006	PRV-2	4232	172	142
J-PRV-2-ELD-0007	PRV-2	4228	1,024	813
J-PRV-2-ELD-0008	PRV-2	4218	1,360	982
J-PRV-2-ELD-0009	PRV-2	4231	613	484
J-PRV-2-ELD-0010	PRV-2	4219	352	255
J-PRV-2-ELD-0011	PRV-2	4202	214	146
J-PRV-2-ELD-0012	PRV-2	4219	182	138
J-PRV-2-ELD-0013	PRV-2	4208	439	439
J-PRV-2-ELD-0014	PRV-2	4192	309	253
J-PRV-2-ELD-0016	PRV-2	4224	1,228	921
J-PRV-2-ELD-0017	PRV-2	4203	299	196
J-PRV-2-ELD-0018	PRV-2	4240	165	144
J-PRV-2-ELD-0020	PRV-2	4253	139	139
J-PRV-2-ELD-0021	PRV-2	4238	2,149	1,797
J-PRV-2-ELD-0022	PRV-2	4250	330	330
J-PRV-MOY-0001	PRV-13	4276	964	881
J-PRV-MOY-0002	PRV-13	4298	227	227

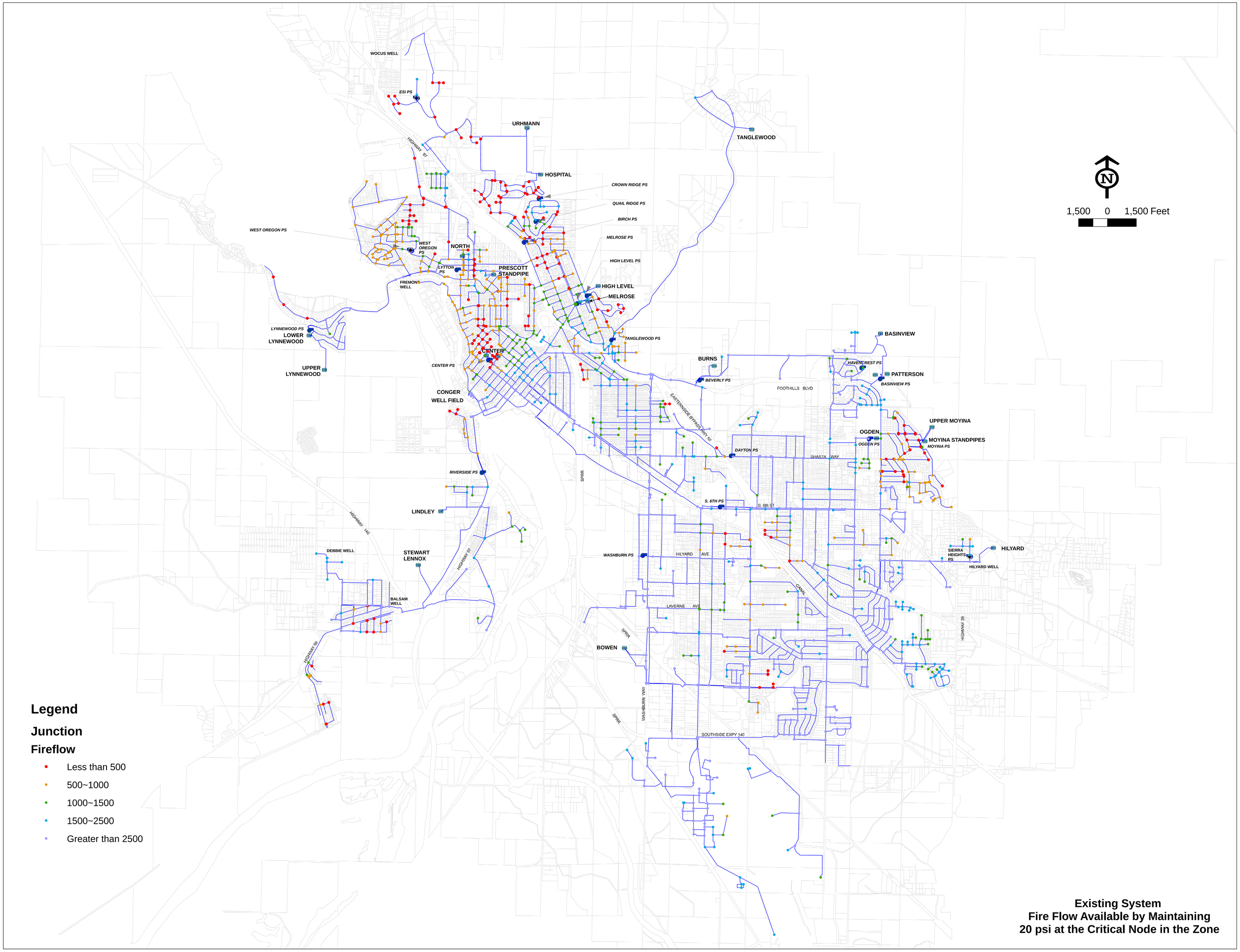
Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-PRV-MOY-0004	PRV-13	4281	108	108
J-PRV-MOY-0005	PRV-13	4268	318	309
J-PRV-MOY-0006	PRV-13	4295	305	300
J-PRV-MOY-0007	PRV-13	4255	111	111
J-PRV-MOY-0010	PRV-13	4274	579	527
J-PRV-MOY-0011	PRV-13	4292	372	360
J-PRV-MOY-0012	PRV-13	4293	344	334
J-PRV-MOY-0013	PRV-13	4275	491	442
J-PRV-MOY-0015	PRV-13	4278	1,097	1,009
J-PRE-0001	Prescott	4269	585	407
J-PRE-0002	Prescott	4252	670	402
J-PRE-0003	Prescott	4250	635	406
J-PRE-0004	Prescott	4243	698	403
J-PRE-0005	Prescott	4277	560	400
J-PRE-0006	Prescott	4306	373	373
J-PRE-0007	Prescott	4303	429	412
J-PRE-0009	Prescott	4282	557	421
J-PRE-0010	Prescott	4291	484	418
J-PRE-0011	Prescott	4213	1,345	1,345
J-PRE-0012	Prescott	4206	770	477
J-PRE-0013	Prescott	4218	4,955	3,193
J-PRE-0014	Prescott	4224	6,431	3,119
J-PRE-0015	Prescott	4247	1,256	1,257
J-PRE-0016	Prescott	4258	1,103	832
J-PRE-0017	Prescott	4284	534	419
J-PRE-0018	Prescott	4290	449	449
J-PRE-0019	Prescott	4254	1,081	832
J-PRE-0020	Prescott	4300	450	416
J-PRE-0021	Prescott	4265	628	421
J-PRE-0022	Prescott	4241	661	497
J-PRE-0023	Prescott	4255	1,988	1,989
J-PRE-0024	Prescott	4230	471	471
J-PRE-0025	Prescott	4248	4,987	2,831
J-PRE-0026	Prescott	4234	1,058	761
J-PRE-0027	Prescott	4261	804	729
J-PRE-0028	Prescott	4240	676	449
J-PRE-0029	Prescott	4237	644	470
J-PRE-0030	Prescott	4244	1,560	1,561
J-PRE-0031	Prescott	4223	1,144	768
J-PRE-0032	Prescott	4263	844	823
J-PRE-0033	Prescott	4202	728	464
J-PRE-0034	Prescott	4243	652	442
J-PRE-0035	Prescott	4236	652	504
J-PRE-0036	Prescott	4306	950	951
J-PRE-0037	Prescott	4242	771	771

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-PRE-0038	Prescott	4184	669	530
J-PRE-0039	Prescott	4224	3,799	3,014
J-PRE-0040	Prescott	4232	4,107	3,028
J-PRE-0041	Prescott	4250	4,097	3,017
J-PRE-0042	Prescott	4258	4,159	3,012
J-PRE-0043	Prescott	4263	4,168	3,011
J-PRE-0045	Prescott	4272	917	917
J-PRE-0046	Prescott	4256	1,201	1,202
J-PRE-0047	Prescott	4246	5,106	3,010
J-PRE-0049	Prescott	4271	1,632	876
J-PRE-0050	Prescott	4232	1,328	1,328
J-PRE-0051	Prescott	4249	7,004	4,075
J-PRE-0052	Prescott	4259	1,039	825
J-PRE-0054	Prescott	4265	1,085	830
J-PRE-0056	Prescott	4233	2,167	2,169
J-PRE-0057	Prescott	4311	581	555
J-PRE-0058	Prescott	4313	487	487
J-PRE-0059	Prescott	4257	3,239	2,912
J-PRE-0060	Prescott	4248	722	722
J-PRE-0061	Prescott	4268	533	533
J-PRE-0062	Prescott	4218	739	487
J-PRE-0063	Prescott	4230	625	426
J-PRE-0064	Prescott	4256	643	412
J-PRE-0065	Prescott	4246	2,013	2,014
J-PRE-0066	Prescott	4232	5,933	2,934
J-PRE-0067	Prescott	4298	2,587	2,353
J-PRE-0068	Prescott	4299	1,153	1,154
J-PRE-0069	Prescott	4257	374	363
J-PRE-0070	Prescott	4261	343	343
J-PRE-0071	Prescott	4186	682	535
J-PRE-0072	Prescott	4201	612	533
J-PRE-0073	Prescott	4196	601	536
J-PRE-0074	Prescott	4280	8,897	7,011
J-PRE-0075	Prescott	4269	3,965	2,352
J-PRE-0076	Prescott	4212	762	488
J-PRE-0077	Prescott	4269	986	987
J-PRE-0078	Prescott	4253	1,073	989
J-PRE-0079	Prescott	4254	1,555	1,352
J-PRE-0085	Prescott	4242	656	497
J-PRE-0086	Prescott	4210	565	565
J-PRE-0087	Prescott	4300	451	416
J-PRE-0088	Prescott	4256	632	420
J-PAT-0001	Patterson	4232	3,948	994
J-PAT-0002	Patterson	4281	1,496	532
J-PAT-0003	Patterson	4321	3,972	1,168

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-PAT-0004	Patterson	4332	2,135	867
J-PAT-0005	Patterson	4311	2,004	595
J-PAT-0006	Patterson	4349	1,249	681
J-PAT-0007	Patterson	4332	1,152	408
J-PAT-0008	Patterson	4372	3,283	3,258
J-PAT-0009	Patterson	4368	4,980	4,060
J-PAT-0010	Patterson	4326	6,396	3,999
J-PAT-0011	Patterson	4376	3,040	3,044
J-PAT-0012	Patterson	4274	4,002	993
J-PAT-0013	Patterson	4315	1,793	530
J-PAT-0014	Patterson	4435	209	199
J-PAT-0015	Patterson	4431	232	200
J-PAT-0016	Patterson	4313	1,523	536
J-PAT-0017	Patterson	4357	272	272
J-PAT-0018	Patterson	4396	2,822	2,826
J-PAT-0019	Patterson	4393	2,347	2,349
J-PAT-0020	Patterson	4255	1,514	529
J-PAT-0021	Patterson	4437	195	195
J-PAT-0022	Patterson	4298	2,731	726
J-PAT-0023	Patterson	4187	3,305	3,306
J-PAT-0027	Patterson	4314	3,955	1,145
J-PAT-0028	Patterson	4367	5,881	3,947
J-PAT-0029	Patterson	4344	6,805	3,930
J-PAT-0030	Patterson	4350	7,093	3,903
J-PAT-0032	Patterson	4394	3,603	1,733
J-PAT-0035	Patterson	4346	6,187	3,974
J-PAT-0036	Patterson	4321	6,341	4,010
J-PAT-0037	Patterson	4378	4,675	4,070
J-PAT-0038	Patterson	4211	6,109	4,586
J-PAT-0040	Patterson	4244	6,348	4,263
J-PAT-0041	Patterson	4227	5,736	4,829
J-PAT-0042	Patterson	4306	2,226	601
J-PAT-0043	Patterson	4310	2,744	1,733
J-PAT-0045	Patterson	4356	911	369
J-PAT-0046	Patterson	4394	3,151	3,157
J-PAT-0049	Patterson	4223	5,840	4,706
J-PAT-0050	Patterson	4236	1,818	1,818
J-PAT-0051	Patterson	4342	5,710	4,035
J-PAT-0052	Patterson	4334	2,978	2,634
J-PAT-0053	Patterson	4361	1,490	1,491
J-PAT-0054	Patterson	4322	2,041	2,042
J-PAT-0055	Patterson	4373	1,343	1,343
J-PAT-0056	Patterson	4326	2,945	1,735
J-PAT-0057	Patterson	4318	2,365	1,737
J-PAT-0058	Patterson	4348	3,245	1,736

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-PAT-0059	Patterson	4377	3,198	1,734
J-PAT-0060	Patterson	4357	2,224	1,740
J-PAT-0061	Patterson	4349	2,907	1,739
J-PAT-0062	Patterson	4373	2,524	1,743
J-PAT-0063	Patterson	4396	3,852	1,914
J-PAT-0064	Patterson	4413	1,510	1,511
J-PAT-0065	Patterson	4383	1,702	1,140
J-PAT-0066	Patterson	4420	675	675
J-PAT-0067	Patterson	4389	292	292
J-PAT-0068	Patterson	4386	1,522	1,044
J-PAT-0069	Patterson	4322	1,605	514
J-PAT-0070	Patterson	4381	3,725	1,596
J-PAT-0071	Patterson	4247	3,906	992
J-PAT-0072	Patterson	4256	3,334	994
J-PAT-0073	Patterson	4238	2,517	995
J-PAT-0074	Patterson	4333	1,178	559
J-PAT-0075	Patterson	4243	1,404	529
J-PAT-0079	Patterson	4314	5,422	3,918
J-PAT-0081	Patterson	4306	2,688	1,732
J-PAT-0082	Patterson	4280	1,188	529
J-KL-0001	Katie Lane	4232	3,330	3,315
J-KL-0002	Katie Lane	4232	2,713	2,714
J-KL-0003	Katie Lane	4233	3,009	3,003
J-KL-0004	Katie Lane	4234	2,929	2,930
J-KL-0005	Katie Lane	4212	2,931	2,933
J-KL-0006	Katie Lane	4202	2,621	2,621
J-HC-0001	Havencrest	4417	1,228	1,229
J-HC-0002	Havencrest	4396	1,193	1,193
J-FHH-0001	Foothill_Homedale	4289	3,423	3,426
J-FHH-0002	Foothill_Homedale	4270	4,095	3,953
J-FHH-0003	Foothill_Homedale	4285	3,518	3,521
J-FHH-0004	Foothill_Homedale	4232	4,488	3,932
J-FHH-0005	Foothill_Homedale	4252	2,180	2,181
J-FHH-0006	Foothill_Homedale	4296	3,989	3,994
J-FHH-0007	Foothill_Homedale	4266	3,969	3,954
J-FHH-0008	Foothill_Homedale	4257	4,400	4,168
J-FHH-0010	Foothill_Homedale	4307	3,436	3,440
J-FHH-0011	Foothill_Homedale	4279	3,657	3,497
J-FHH-0012	Foothill_Homedale	4256	3,692	3,379
J-FHH-0013	Foothill_Homedale	4306	3,149	3,151
J-FHH-0014	Foothill_Homedale	4236	4,168	3,774
J-FHH-0015	Foothill_Homedale	4249	4,113	3,926
J-FHH-0016	Foothill_Homedale	4248	3,803	3,807
J-FHH-0017	Foothill_Homedale	4300	4,069	4,074
J-FHH-0018	Foothill_Homedale	4301	3,917	3,871

Appendix E Existing Fireflow Analysis Results				
ID	Zone	Ground Elevation at Fireflow Node (ft)	Available Flow with 20 psi Residual Pressure at Fireflow Node (gpm)	Available Flow Maintaining Minimum 20 psi Residual Pressure at Highest Elevation Service Node in Zone (gpm)
J-ESI-0002	ESI	4388	735	2,334
J-ESI-0003	ESI	4354	802	2,334
J-CR-0001	Crown Ridge	4436	2,283	2,226
J-CR-0002	Crown Ridge	4417	2,098	2,098
J-CR-0003	Crown Ridge	4422	2,558	2,446
J-CR-0004	Crown Ridge	4444	1,850	1,850
J-CR-0005	Crown Ridge	4435	2,422	2,398
J-CR-0006	Crown Ridge	4439	2,331	2,332
J-CR-0007	Crown Ridge	4415	2,405	2,385
J-CR-0008	Crown Ridge	4396	2,310	2,311
J-BV-0001	Zone-5	4546	2,194	2,172
J-BV-0002	Zone-5	4401	6,373	5,109
J-BV-0003	Zone-5	4442	6,549	5,103
J-BV-0004	Zone-5	4460	5,267	5,104
J-BV-0005	Zone-5	4547	2,080	2,081
J-BV-0006	Zone-5	4543	2,084	2,085
J-BV-0007	Zone-5	4486	6,550	5,140
J-BV-0008	Zone-5	4548	2,144	2,145
J-BV-0009	Zone-5	4503	3,984	3,287
J-BV-0010	Zone-5	4494	3,567	3,285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ESI PS
URHMANN
TANGLEWOOD
HIGHWAY 97
HOSPITAL
CROWN RIDGE PS
QUAIL RIDGE PS
BIRCH PS
MELROSE PS
HIGH LEVEL PS
WEST OREGON PS
WEST OREGON PS
NORTH
LYTTON PS
PRESCOTT STANDPIPE
FREMONT WELL
HIGH LEVEL
MELROSE
LYNNEWOOD PS
LOWER LYNNEWOOD
UPPER LYNNEWOOD
TANGLEWOOD PS
CENTER
CENTER PS
BASINVIEW
BURNS
HAVENCREST PS
PATTERSON
BEVERLY PS
BASINVIEW PS
FOOTHILLS BLVD
CONGER WELL FIELD
EASTERNSIDE BYPASS HWY 50
UPPER MOYINA
OGDEN
MOYINA STANDPIPES
OGDEN PS
MOYINA PS
DAYTON PS
SHASTA WAY
RIVERSIDE PS
SPRR
S. 6TH PS
S. 6th ST
LINDLEY
HIGHWAY 140
DEBBIE WELL
STEWART LENNOX
HIGHWAY 97
WASHBURN PS
HILYARD AVE
SIERRA HEIGHTS PS
HILYARD
HILYARD WELL
BALSAM WELL
CANAL
LAVERNE AVE
HIGHWAY 99
BOWEN
SPRR
HIGHWAY 39
WASHBURN WAY
SPRR
SOUTHSIDE EXPY 140
N
1,500 0 1,500 Feet
Legend
Junction
Fireflow
Less than 500
500~1000
1000~1500
1500~2500
Greater than 2500
Existing System
Fire Flow Available by Maintaining
20 psi at the Critical Node in the Zone

Appendix F
Glossary of Terms

Appendix F
Glossary of Key Terms

Average Day Demand (ADD) – The average daily usage of water over a given one year period.

Average Summer Day Demand – The average daily usage of water during the four summer months. In Klamath Falls the average summer day demand is 1.6 times greater than the yearly average day demand (ADD), primarily due to outside irrigation use.

Conservation – Measures used to reduce the consumption of potable (drinking) water. Examples of conservation measures are: installing low-flow fixtures, using non-potable water to irrigate open spaces, and landscaping with low water use drought-tolerant plants. Water conservation will be a key element in planning for future growth in Klamath Falls. If the City continues to consume water at the current rate, the cost of infrastructure required to meet those demands will be very high and a burden on the community. In addition, there is a limited supply of groundwater and groundwater rights (issued by the Oregon Water Resources Department), and surface water rights are currently over-allocated.

Equivalent Residential Unit (ERU) – A unit used to describe the water demand of a "typical" single family dwelling. In Klamath Falls, a typical family requires 805 gallons of water during the maximum demand day (MDD) of the year. The same family requires 350 gallons of water during the average demand day (ADD) each year.

Fire Flow – The criteria (Performance Objective) used to evaluate the ability of the water system to provide adequate water for fighting fires. For City Water, the objective is to provide a flow of 1500 gallons per minute (gpm) for two hours in residential areas or a flow of 2500 gpm for three hours in non-residential areas. These flow criteria are to be met while maintaining a system pressure of 20 pounds per square inch (psi) at all "points of service."

Groundwater Wells – Pumps, casings and appurtenances that extract water from water-bearing underground aquifers. The City Water system relies exclusively on water pumped from underground sources. Groundwater is a valuable resource that must be conserved and protected from contamination. City Water has carefully constructed all of our production wells to protect the aquifers from infiltration of surface water or surface contamination.

Head Loss – The amount of "drag" that occurs in water mains, due to friction between the water and the pipe, in relation to the flow. This "drag" causes a reduction in pressure and limits the rate at which water can be distributed throughout the system. The maximum head loss allowed for the Master Plan evaluation is 10 feet (which is equivalent to a pressure loss of 4.3 psi) per 1000 feet of water main.

Irrigation Water – The amount of water required to maintain grass ground cover suitable for parks and athletic fields. In Klamath Falls, one acre of grass (43,560 square feet) consumes as much water per year as seven ERUs.

Master Plan - A planning document that evaluates the existing water system demands and forecasts future demands. The plan identifies the infrastructure improvements necessary to provide service under existing and anticipated future conditions. A master plan also includes estimates of the capital costs associated with the infrastructure improvements, and recommends a construction sequence/priority.

Maximum Day Demand (MDD) – The maximum water usage within a single twenty-four hour period during the course of a year. In Klamath Falls, the MDD typically occurs on a hot summer day in June or July. The MDD is an important number because it is a primary factor in determining the required size of wells, reservoirs, and booster pump stations. The ratio of the MDD to the ADD is 2.3, which means that the amount of water consumed on the maximum day of the year is 2.3 times as great as on the average day of the year. This difference is primarily due to usage of potable (drinking) water for irrigation during the summer.

Oregon Water Resources Department (WRD) – The State agency that issues and administers the water rights for all users in the state. In Oregon, the State controls all water rights. Ground and surface water usage and allocations are strictly regulated by the WRD.

Peak Hour Demand (PHD) – The water flow required during the maximum usage hour of the maximum demand day (MDD). On a system-wide basis, the ratio of PHD to average day demand (ADD) is 3.7. The peaking factor may vary for individual zones based on zone-specific characteristics.

Performance Objective – A measure of production or capacity that represents the ideal level of service supplied to City Water customers.

Pressure Reducing Valve (PRV) – A control device that maintains system pressures at the boundary of adjacent pressure zones.

Pressure Zone – A portion of the distribution system in which all customers receive water within a defined pressure range. Due to the extreme elevation changes within the City system, pressure zone boundaries exist at approximately 100-foot elevation intervals.

Unit Demand Factors – The amount of water used per acre or per unit by various land uses (or zoning designations), which is usually determined as gallons per day per acre of the specified land use or gallons per day per residential unit. Existing unit demands are based on the existing consumption and land use. Build-out unit demand factors are based on the projected number of developed units per acre at complete usage of all available land within the UGB.

Urban Growth Boundary (UGB) – An area within the Klamath Basin formally recognized by the City of Klamath Falls and Klamath County as appropriate for urbanization and the extension of key urban services and facilities, such as the water system, that are essential for the support of more intensive, "urban" development.

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