Bluffdale Water Distribution Model

Ben Felix

Jacob Linford

Adam Rose

Executive Summary

The task of creating a water distribution network model for the city of Bluffdale was given to FLR Engineering by capstone sponsor Aquaveo LLC. A geodatabase of each pipe and node connected to the city was provided by Aquaveo as an ArcMap file. Together with the sponsor, FLR originally decided to use Quantum GIS (QGIS) to format the input data provided into a format that EPA NET would be able to use. QGIS uses a plug-in called GHydraulics that allows attribute tables from GIS software to be transferred into EPA NET. EPA NET is a program that can analyze flow and pressure throughout a water distribution system. As the project progressed, QGIS was deemed too unfamiliar for our engineers to use. The decision was made for the data transfer to be performed through Microsoft Excel. This resulted in greater confidence in the results and better progress on the project.

Aquaveo eventually hopes to develop a module to perform similar functions as GHydraulics, but with better functionality for end users. The original scope of the project included FLR Engineering performing the hydraulic analysis not only through EPA NET, but then also on a beta version of a module in Watershed Modeling Software (WMS), a software program created by Aquaveo. However, Aquaveo and FLR Engineering agreed to focus only on the analysis through EPA NET and simply provide guidance for ways to improve on GHydraulics within WMS.

The largest task for the project was manipulating the data into a format that EPA NET could understand and analyze. Since ArcMap's format is not compatible with EPA NET, the data was taken from ArcMap into Excel and subsequently into EPA NET. The pre-processing involved formatting features in separate attribute tables to be read for EPA NET. The data transfer was successful and the model in EPA NET is functioning but not yet completely calibrated to match the actual system. The report below outlines the process and complications with performing an EPA NET hydraulic analysis using GIS data.

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Introduction

Situated between major population densities on the Wasatch Front, Bluffdale is set to increase its population at a much faster rate than ever before. Already Bluffdale has increased to a population of 8,000, up 69.7% from the year 2000 (1). Along with this growth, Bluffdale supplies water to the new National Security Administration's (NSA) $1.5 billion data center at Camp Williams on the South end of town. The new City Engineer has determined that a water distribution network model is needed in order to keep track of the current and future water supply needs to various parts of the city. To do this Aquaveo was asked to create a model to match these needs. Bluffdale hopes to make the model public so that it is accessible to everyone. Specifically, it will be used to aid the fire department and city engineering office in doing their jobs.

Aquaveo is a water modeling software provider and water resources engineering consulting firm. The company specializes in ground water, watershed, and surface water modeling. Their software is being used by over 12,000 consulting firms, universities, and government agencies in over 120 countries. Aquaveo has asked that FLR Engineering perform the analysis of Bluffdale's current water distribution network using an open source hydraulic modeling software called EPA NET, which was created by the Environmental Protection Agency (EPA). Along with this Aquaveo hopes to further develop their own program, WMS, to be compatible with EPA NET for future use.

Report

Scope

The City of Bluffdale has contracted with Aquaveo to create a digital inventory of their water distribution network. This work also involves the development of an EPA NET model of the existing water distribution network. FLR Engineering has contracted with Aquaveo to develop the numerical models of the water distribution system. Data collection and system mapping for the project commenced on 18 Aug 2014 by Cody Alberts of Aquaveo. Although the numerical modeling was set to begin on 25 Nov 2014 and end on 23 Dec 2014, this was adjusted to fit the constraints of the capstone course. Data provided to FLR for this project included a geodatabase of system pipes and nodes. A new EPA NET module, created by Aquaveo, is currently being implemented into the Watershed Modeling System (WMS) software to allow for easy importing of the pipe network and attributes and exporting to the EPA NET program.

Aquaveo has asked that FLR Engineering provided deliverables in two forms. First, a geodatabase of the city of Bluffdale containing a system of pipes and nodes, pressure gradient, maximum flow rate for the pipes and nodes, and maximum pressure at each node. Second, FLR Engineering is to provide a detailed analysis of the process using Quantum GIS (QGIS) and its module to compute hydraulic modeling values using EPA NET. This will include a final report, a presentation to Aquaveo and the City of Bluffdale, a list of suggestions for Aquaveo to create their own WMS module for EPA NET, and a poster summarizing the results of the analysis. All documents and deliverables will be provided “as is” without engineering stamps and given to Aquaveo to use in their future improvements.

Procedure

To accomplish all deliverables within the scope of this project a plan was created to keep FLR Engineering on track. Figure 1 describes FLR Engineering's plan to finish the project. Steps are outlined in more detail below to describe how each one was accomplished.

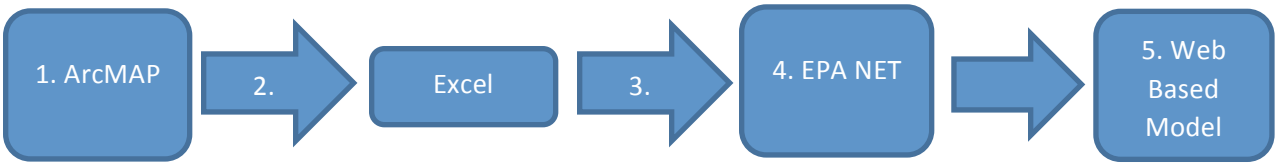


Figure 1 Project Management Plan

ArcMap

All information given to FLR Engineering by Aquaveo was created using ArcMAP. To save time formatting the data, ArcMAP was used to modify attribute tables and to perform spatial joins to connect pipes to nodes. A spatial join left the "pipes" attribute table a step away from what EPA NET required for categories "NODE1" and "NODE2". To complete this step Microsoft Excel combined the data into proper columns and transferred it back into ArcMAP. Separate shape files were created for the six different object types in EPA NET. A list of those attributes and their required features are listed in Figure 2 below. Categories in blue were required numerical values.

pipes	junctions	valves	tanks	pumps	reservoir
dc_id	dc_id	dc_id	dc_id	dc_id	dc_id
length	demand	elevation	elevation	elevation	elevation
node1	elevation	diameter	initiallev	properties	head
node2	pattern	setting	minimumlev	power_low	pattern
diameter		minorloss	maximumlev		
roughness		type	diameter		
status			minimumvol		
minorloss			volumecurv		

Figure 2 Attributes and features required for EPA NET

Excel

Excel was used to manipulate the data beyond the spatial join from ArcMap. For example, when the spatial join was used some of the pipes only had one node. These missing pipes were found in Excel and given to Aquaveo to correct. These missing nodes were given an elevation from an elevation raster in ArcMap. Excel's main purpose however, was to assign the appropriate information and formatting for EPA NET. In the "Assumption" section, listed below, this information is outlined.

EPA NET

EPA NET was the primary software used to obtain pressure data at each node and flow data in each pipe. The program allows for the user to determine which loss coefficients and modeling equations to use. Values for loss coefficients, lengths of pipes, elevations of nodes and base demand at junctions were used by EPA NET to determine these flows and pressures. EPA NET reads a text (input) file with specific formatting in order to place nodes at their coordinate locations. Once all errors were made taken out of the data, the model was able to run successfully and yield data for the Bluffdale distribution model.

Assumptions

There were several assumptions that had to be made for the model and the calculations to be functional, conservative, and realistic. The assumptions are outlined below in the following list.

- All underground elements are determined to be four feet below the given elevation. This was done for simplicity and convenience. Pipes, valves, and nodes were included in this. Fire hydrants were not given this assumed elevation.
- Fire hydrants not part of the system were ignored. Those that were part of the system were treated as junctions with no demand on them.

- Manholes are considered closed valves. The reason being, for EPA NET to run every element in the model must be labeled as one of six things: junction, tank, reservoir, valve, pipe, or pump. Water is not flowing out of manholes, therefore they act like closed valves.
- Pump PS-0003 was the only pump attached to the system. All other pumps were ignored. The power for the pump was set at 150 hp. An efficiency curve was not used in EPA NET.
- JVWCD source connections are used as reservoirs. EPA NET requires any "infinite" input to be classified as a reservoir.
- Water meters are not part of the system. These don't have any contribution to the model. They were used however in determining the demand at junctions. In Excel a distance function was performed for the closest junction to each water meter. A demand for each water meter was assigned based on water meter "class". The classes used were residential, commercial, apartments, and townhomes.
- For major and minor losses within the system, we used the Hazen-Williams equation. The roughness values for the pipes are as follows: 140 for both the PVC pipes and the ductile iron.

$$H_P + Z_1 - Z_2 + \frac{P_1 - P_2}{S} + \frac{V_1^2 - V_2^2}{2g} = h_f + h_m \quad \text{where:}$$

$$h_f = L\left[\frac{V}{kC}\left(\frac{4}{D}\right)^{0.63}\right]^{1/0.54} \qquad h_m = K_m \frac{V^2}{2g} \qquad Q = VA \qquad A = \frac{\pi}{4}D^2$$

- Elevations and roughness values to pipes were inputted using an Excel "if" statement.
- Figures from the article "Embedded Energy in Water Studies Study 3: End-use Water Demand Profiles" were used to create demand patterns (Funk, DeOreo 2011). Google maps helped determine which areas should use associated patterns. Figure 3 shows the demand pattern used.

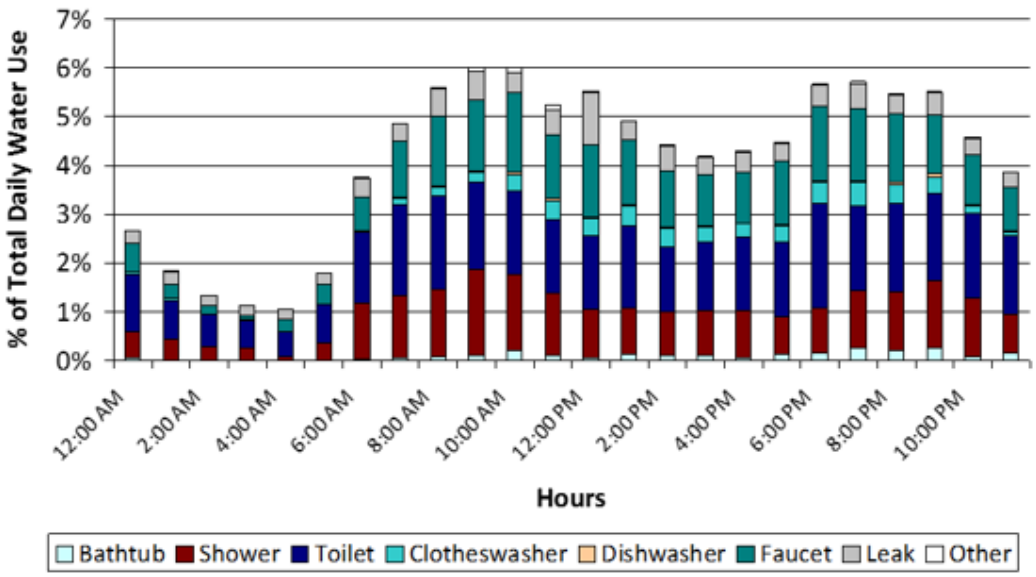


Figure 3 Demand Pattern for 24-hour period

- Pipes without diameter values were assumed to be the average of the diameters in the near proximity. Pipes with unrealistic diameters, such as 99 feet, were given diameters in a similar manner. All non-whole number diameters represent pipes where assumptions were made by FLR Engineering on size.
- EPA NET uses valves in a similar way it uses pipes. Valves are links between two nodes. The valves supplied by Aquaveo were given as nodes. Thus, to circumvent this problem, FLR Engineering assigned a new node just next to each valve node. If a valve was titled VV-0001 then a new node was created called VV-0001a. Those two points had a link between them in EPA NET that represented the actual valve. This method was used when EPA NET needed to model a Pressure Reducing Valve (PRV). Another method is discussed below for other valve types.
- A minor loss of 0.2 was assumed for all other valves in the system. Due to EPA NET functionality, the minor loss coefficient for the valves was assigned to the upstream pipe corresponding to any valve not included in the assumption above.

- Six pressure reducing valves (PRVs) were used in the system.
- The tank near the NSA building is considered to be 30 feet in height and 30 feet in diameter. For demand purposes the tank is assumed to reach half full after five days of draining. The pump that fills this tank is assumed to then turn on and fill the tank. The water from the tank goes to the NSA building. In the model supplied to Aquaveo this pump was closed and not used to fill the tank. A single moment analysis of the distribution model was used so the pump did not have time to turn on.
- Given the volume and discharge rate the demand for the NSA building is assumed to be 200 gpm.
- Reservoir head values were supplied by Jordan Valley Water Conservancy District (JVWCD). These values were used as the total head values for each reservoir.
- Gallons per minute, gpm, were the units used throughout the project for flow and demand; including the Hazen-Williams equations. Units of feet were used for dimensions and elevations.
- Butterfly valves are treated as intermediate connections. The initial ArcMap data showed them as being offset from the main pipe by a few feet in order to accurately show their location.
- The demand per person per day was recommended to be 250 gallons. The recommendation came from Dr. Wood Miller from Brigham Young University (BYU).
- Number of persons per water meter class are as follows: Residential 4.7, Commercial 15, Apartment 2, and Townhomes 3 people per water meter.
- Other assumptions are listed in the Appendix.

Findings

Once the data was inputted into EPA NET and the errors corrected, the model ran successfully. The model appears to be fairly reasonable. There are a few issues with unrealistically high pressures at certain junctions, and high flows out of reservoirs. Specifically, reservoir HS-SC-0003 has a much higher

outflow than is shown on the hourly flow data supplied by JVWCD as seen in Figure 3. Final calibration of the model to fit the true system was not completed and it was determined that there could potentially be missing valves pipes that cause inaccurate pressure distribution. This next step will be performed by Aquaveo.

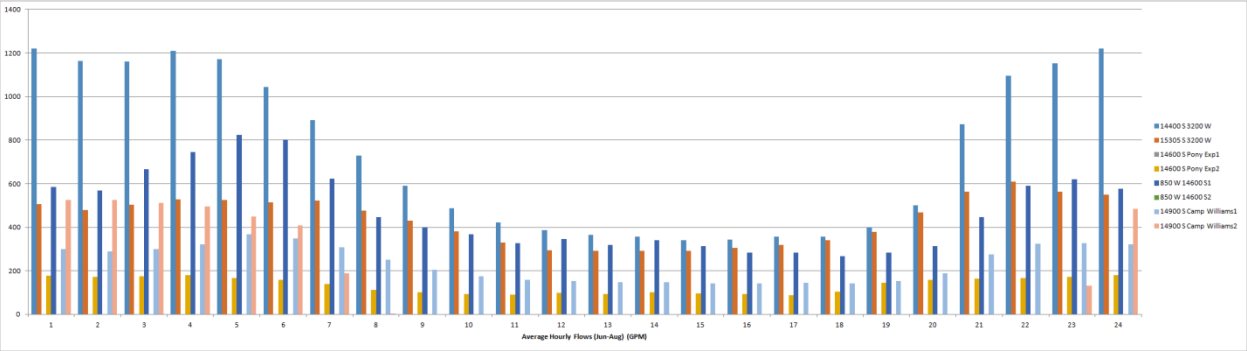


Figure 3 Average hourly flow for the months of June to August

There were some pressure patterns associated with certain areas within the model, as seen in Figure 4. The top right section of the model displays high pressures because of the lower elevation in this region compared to the other areas. This creates a situation where the total pressure head is higher due to the change in elevation. The bottom portion of the figure shows the highest pressure. This is due to a tank that helps supply the NSA Data Center at the very south end of the system. This tank is up on a hill and creates a large amount of head in this part of the system.

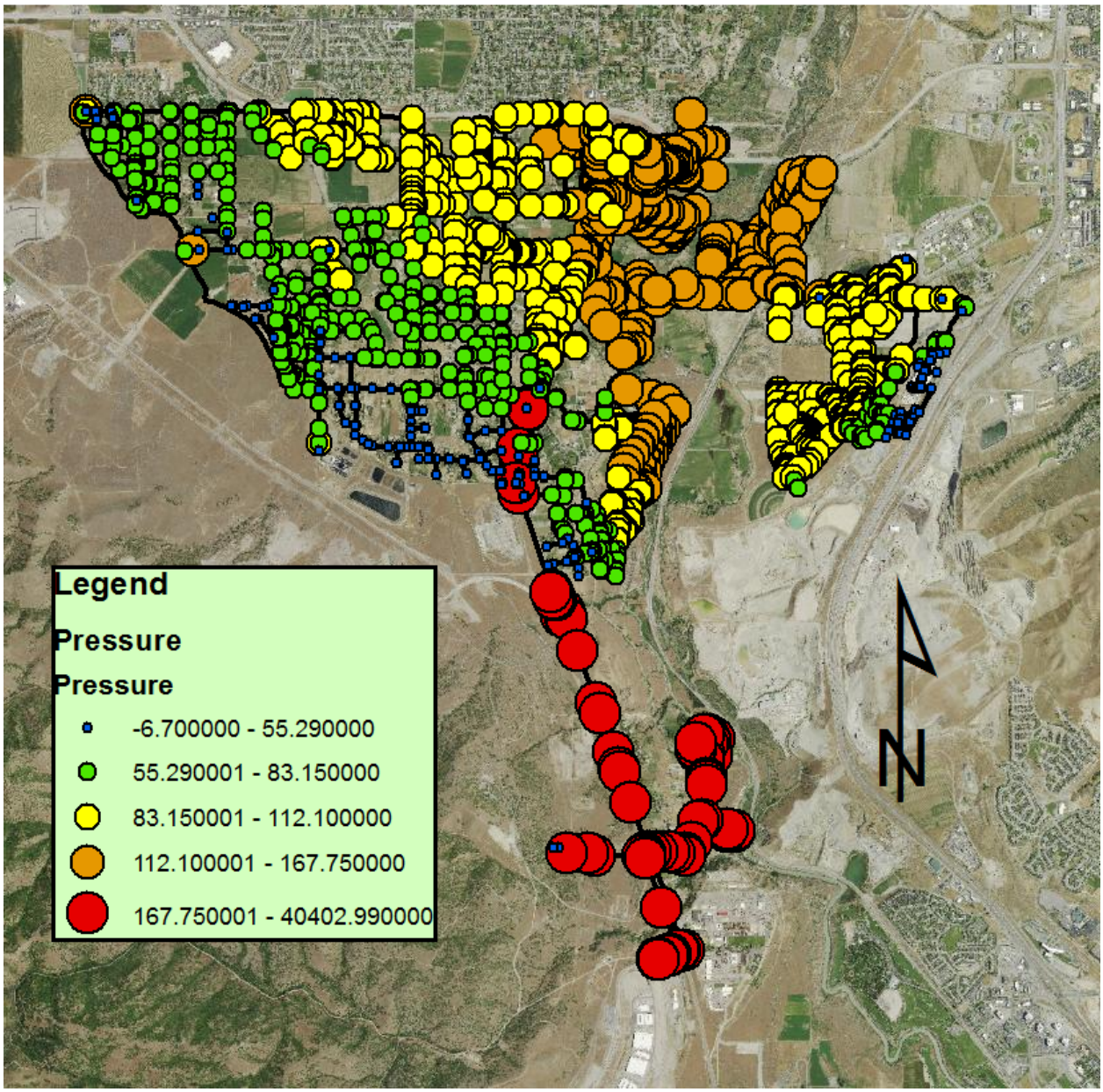


Figure 4 Pressure map from EPA NET model

Limitations

The original plan was to use both QGIS and WMS in order to run the model, but Aquaveo decided that running the model within EPA NET alone was the most reasonable option. WMS is still being developed to handle GIS data and use it in EPA NET.

Major Client, Stakeholder, General Information

Major Sponsor

Cody Alberts

calberts@aquaveo.com

Graduate Mentor

Justin Relitz

justin.relitz@gmail.com

(559) 681-9365

Faculty Advisor

Wood Miller

wood_miller@byu.edu

(801) 422-6331

Organizational Structure

Justin Relitz

- Give direction to team
- Update sponsor on progress of project
- Evaluate team and project progress

Jacob Linford

- Project manager
- Responsible for EPA NET interface and necessary requirements to transfer geodatabase

Adam Rose

- WMS QA Supervisor
- Learn Aquaveo's WMS to suggest module options for EPA NET
- Estimated Demand for junctions

Ben Felix

- ArcMap Specialist
- Lead in pre-programming data in ArcMap to transfer to EPA NET
- Estimated Demand patterns for 24-hr analysis

Project Budget

Research on QGIS, WMS, and EPA NET- 100 hours

Modeling Bluffdale's Water System in QGIS and potentially working with WMS- 100 hours

Project Management and Report Preparation- 100 hours

Lunch Meetings- $100

Presentation Supplies- $100

Communication Plan

Water Distribution Network Modeling		**Start Date:**	**January 5, 2015**		
FLR					
Task	**Start Date**	**End Date**	**Duration (days)**	**Percent Complete**	**Person Responsible**
					Date:
1.0 Planning	2015-01-05	2015-02-03	30	75.00%	Team
1.1 PMP	2015-01-05	2015-02-03	30	75.00%	Jacob
2.0 Research	2015-01-05	2015-02-03	30	75.00%	
2.1 QGIS Program	2015-01-05	2015-02-03	30	75.00%	Ben
2.2 EPANet Program	2015-01-05	2015-02-03	30	75.00%	Jacob
2.3 WMS Program	2015-01-05	2015-02-03	30	75.00%	Adam
3.0 Analysis	2015-02-03	2015-03-02	30	50.00%	
3.1 QGIS Model	2015-02-03	2015-03-02	30	50.00%	Ben
3.2 WMS Model	2015-02-03	2015-03-02	30	50.00%	Adam
4.0 Report	2015-03-03	2015-03-14	14	#DIV/0!	
4.1 Presentation	2015-03-03	2015-03-02	14	90.00%	Ben
4.2 Technical Report	2015-03-03	2015-03-02	14	90.00%	Jacob
4.3 Beta Report	2015-03-03	2015-03-02	14	90.00%	Adam

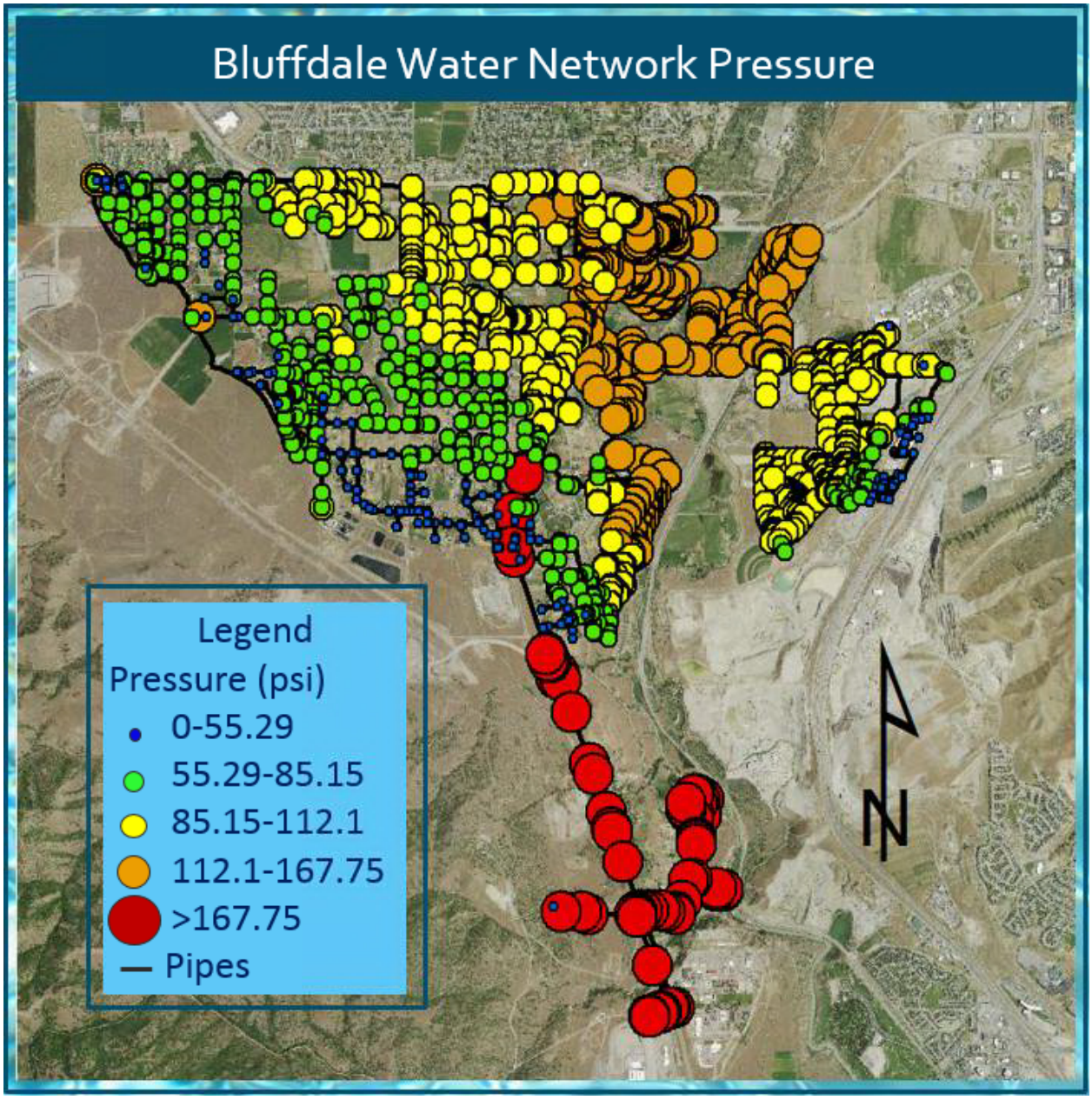
We decided to use a Google document in order to document our hours and collaborate with our graduate mentor. In addition to reporting our time on a living document we met every Friday at 8:00 a.m. in order to discuss our progress with our mentor. Much of our work involved learning the software required to run the EPA NET models. Since our graduate mentor has extensive knowledge in most of the programs that we will be using, we collaborated with him during those meetings about how to complete the assignment.

Conclusion

Currently, software has not been developed extensively to evaluate a GIS geodatabase in EPA NET. Aquaveo seeks to create a module for their own program, WMS, in order to make the process more user-friendly. FLR Engineering has determined that QGIS currently has the capability to use EPA NET's hydraulic analysis through a plug-in called GHydraulics which requires very specific formatting in order to transfer information over to EPA NET. While this is manageable, a sufficient amount of time can be saved to justify a new WMS/ EPA NET module. FLR Engineering chose to manipulate the data given in ArcMap within Excel. The data could be easily formatted and imported to EPA NET for analysis. Current trends show high pressure in the low elevation, Northeast portion of Bluffdale and in the South portion near NSA's data center. The model is not calibrated completely to fit the actual system, so Aquaveo will determine the final modifications.

Appendix

Map displayed at open house for presentation.



List of Pipe and Node changes and modifications.

Pipe/Node Type	Question	Notes
PS-0003	What is the head curve?	Never received curve
AV-0005	Not connected	Remove
AV-0007	Not connected	Remove
AV-0008	Not connected	Remove
AV-0009	Not connected	Remove
AV-0010	Not connected	Remove
AV-0011	Not connected	Remove
AV-0012	Not connected	Remove
AV-0013	Not connected	Remove
AV-0014	Not connected	Remove
CV-0001	Not connected	Don't include
FH-0136	Add and connect 3770 from GV-FH0466 to FH-0136	Added pipe 3770
FH-0237	Not connected	Split pipe 0894 (into 0894 and 3778), added pipes 3771 & 3772, added JT-1281
FH-0245	Not connected	Remove (water lines not drawn due to unknown water line locations)
FH-0246	Not connected	Remove (water lines not drawn due to unknown water line locations)
FH-0259	Not connected	Remove, duplicate (I also removed this from master Feature class)
FH-0318	Not connected	Remove, duplicate (I also removed this from master Feature class)
FH-0361	Not connected	Remove (on separate well water system)
FH-0390	Not connected	Remove (on Riverton's system, included as info for the Fire dept.)
FH-0391	Not connected	Remove (on Riverton's system, included as info for the Fire dept.)
FH-0439	Not connected	Remove (on separate well water system)
FH-0468	Not connected	Split pipe 0077 (into 0077 and 3777), added pipes 3773 & 3774, added JT-1282
FH-0469	Not connected	Remove, duplicate (I also removed this from master Feature class)
FH-0483	Not connected	Remove (on separate well water system)
FH-0484	Not connected	Remove (on separate well water system)
FH-0485	Not connected	Remove (on separate well water system)
FH-0486	Not connected	Remove (on separate well water system)
FH-0519	Not connected	Remove (on separate well water system)
FH-0520	Not connected	Remove (on separate well water system)
GV-FDC-0024	Not connected	Remove (nonessential)
GV-FH-0223	Not connected	See note for FH-0237 above
GV-FH-0231	Not connected	Remove (water lines not drawn due to unknown water line locations)
GV-FH-0232	Not connected	Remove (water lines not drawn due to unknown water line locations)
GV-FH-0236	Not connected	Connected to Pipes 1075 and 1074, deleted node MN-60
GV-FH-0345	Not connected	Remove (on separate well water system)
GV-FH-0374	Not connected	Remove (on Riverton's system, included as info for the Fire dept.)

GV-FH-0375	Not connected	Remove (on Riverton's system, included as info for the Fire dept.)
GV-FH-0454	Not connected	Remove, duplicate (I also removed this from master Feature class)
GV-FH-0459	Not connected	See note for FH-0468 above
GV-FH-0460	Not connected	Remove, duplicate (I also removed this from master Feature class)
GV-FH-0475	Not connected	Remove (on separate well water system)
GV-FH-0476	Not connected	Remove (on separate well water system)
GV-FH-0477	Not connected	Remove (on separate well water system)
GV-FH-0478	Not connected	Remove (on separate well water system)
GV-FH-0511	Not connected	Remove (on separate well water system)
GV-FH-0512	Not connected	Remove (on separate well water system)
GV-M-0266	Not connected	Remove (abandoned valve)
GV-M-0296	Not connected	Remove (abandoned/Irrigation valve)
GV-M-0307	Not connected	Remove (abandoned valve)
GV-M-0313	Not connected	Remove (abandoned valve)
GV-M-0326	Not connected	Remove (Irrigation system valve)
GV-M-0327	Not connected	Remove (Irrigation system valve)
GV-M-0350	Not connected	Remove (Irrigation system valve)
GV-M-0359	Not connected	Remove (abandoned/Irrigation valve)
GV-M-0381	Not connected	Remove (Irrigation system valve)
GV-M-0384	Not connected	Remove (Irrigation system valve)
GV-M-0393	Not connected	Remove (abandoned/Irrigation valve)
GV-M-0430	Not connected	Remove (abandoned/Irrigation valve)
GV-M-0458	Not connected	Remove (future use)
GV-M-0459	Not connected	Remove (future use)
GV-M-0467	Not connected	Remove
GV-M-0468	Not connected	Remove, duplicate (I also removed this from master Feature class)
GV-M-0469	Not connected	Remove (abandoned/Irrigation valve)
GV-M-0537	Not connected	Connected to Pipes 1863 and 2920, deleted node MN-64
GV-M-0538	Not connected	Remove (Irrigation system valve)
GV-M-0562	Not connected	Remove
GV-M-0572	Not connected	Remove
GV-M-0573	Not connected	Remove (future use)
GV-M-0596	Not connected	Remove

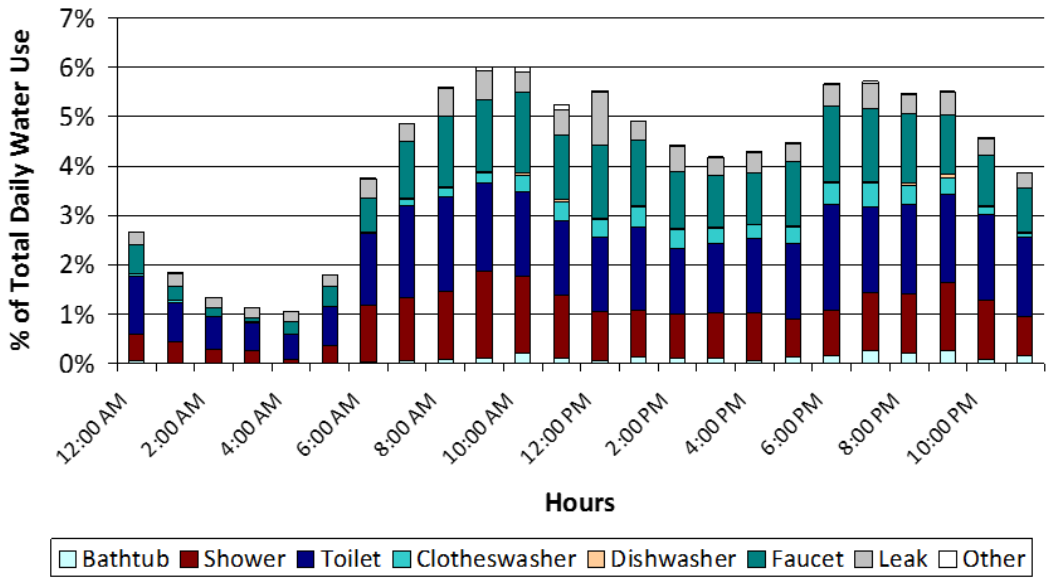
GV-M-0637	Not connected	Remove (nonessential)
GV-M-0638	Not connected	Remove (nonessential)
GV-M-0679	Not connected	Remove, duplicate (I also removed this from master Feature class)
GV-M-0689	Not connected	Remove (nonessential)
GV-M-0711	Not connected	Remove (abandoned valve)
GV-M-0846	Not connected	Remove (abandoned valve)
HS-AV-0001	Not connected	Remove
HS-AV-0002	Not connected	Remove
HS-OTHER-0002	Not connected	Can be ignored see email chain for "Meeting Agenda 2/24/2015"
HS-OTHER-0003	Not connected	Can be ignored see email chain for "Meeting Agenda 2/24/2015"
HS-OTHER-0004	Not connected	Can be ignored see email chain for "Meeting Agenda 2/24/2015"
HS-WM-0001	Not connected	Remove
JT-0029	Not connected	Remove (I also removed this from master feature class)
JT-0322	Not connected	Split arc 1130 into 1130, 3780, 3781, 3782 and connect them to respective junctions
JT-0323	Not connected	Split arc 1130 into 1130, 3780, 3781, 3782 and connect them to respective junctions
JT-0324	Not connected	Split arc 1130 into 1130, 3780, 3781, 3782 and connect them to respective junctions
MH-0001	Not connected	Remove
MH-0002	Not connected	Remove
MH-0003	Not connected	Remove
MH-0004	Not connected	Remove
MH-0008	Not connected	Remove
MH-0009	Not connected	Remove
MH-0010	Not connected	Remove
MH-0011	Not connected	Remove
MH-0012	Not connected	Remove (Belongs to JVWCD, probably should be deleted entirely)
MH-0013	Not connected	Remove
MH-0014	Not connected	Remove
MH-0016	Not connected	Remove
MH-0020	Not connected	Remove
MH-0021	Not connected	Remove
MH-0022	Not connected	Remove
OTHER-0003	Not connected.	Remove
OTHER-0004	Not connected	Can be ignored see email chain for "Meeting Agenda 2/24/2015"
PRV-0002	Not connected	Remove (Also removed from master feature class)
PRV-0003	Not connected	Remove (Also removed from master feature class)
PRV-0005	Not connected	Remove (Irrigation system valve)

PRV-0006	Not connected	Remove (Nonessential)
PRV-0007	Not connected	Remove
PS-0001	Not connected	Remove (This pump station belongs to JVWCD)
PS-0002	Not connected	Remove (This pump station is not in use yet)
VV-0001	Not connected	Remove
VV-0002	Not connected	Remove
VV-0003	Not connected	Remove
VV-0004	Not connected	Remove
VV-0005	Not connected	Remove
WS-0001	Not connected	Remove
WS-0002	Not connected	Remove
GV-FH-0024	No pipe connecting	Added pipe 3776
GV-FH-0243	No pipe connecting same point as GV-FH-0094	Remove, duplicate (I also removed this from master Feature class)
JT-0298	All three of these connected to each other but not system	Split Pipe 1036 into 1036 and 3779
GV-FH-0208	All three of these connected to each other but not system	see solution at JT-0298 above
FH-0222	All three of these connected to each other but not system	see solution at JT-0298 above
1036	Pipe has JT-0298 running through it. Do we split it up	see solution at JT-0298 above
1818	Pipe skips over GV-M-0546	see solution at GV-M-0546 below
GV-M-0546	Doesn't connect to pipe 1818	Split pipe 1818 (into 1818 and 3783), added pipes 3775, added JT-1283
OTHER-0009	Doesn't connect to pipe 1819	Remove
GV-M-0886	Same as GV-M-0887	Keep, duplicate was removed
GV-M-0887	Same as GV-M-0886	Remove, duplicate (I also removed this from master Feature class)
3528	Connects points at same node and not to the other one	One of the duplicates that I removed
3417	Really long. Does it need to be split up	Does not need to be split.
JT-1167	Will be fixed with 3417 solution above.	Maybe we need to split arc 3528? Let me know what you think would solve this.
PS-0002		I renamed the one with a DEVICE_NO of 0003 to have a DEVICE_ID of "PS-0003"

Demand Patterns for different area classes.

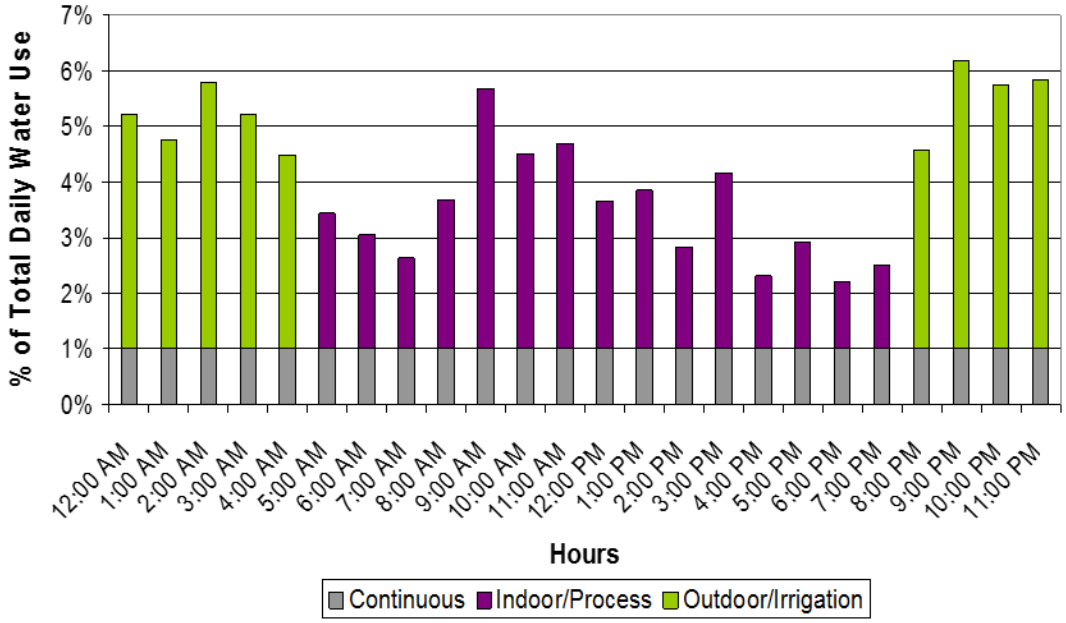
Residential Pattern

Figure 25: Disaggregated Hourly Water Demand Profiles - Low-income Multi-family Indoor



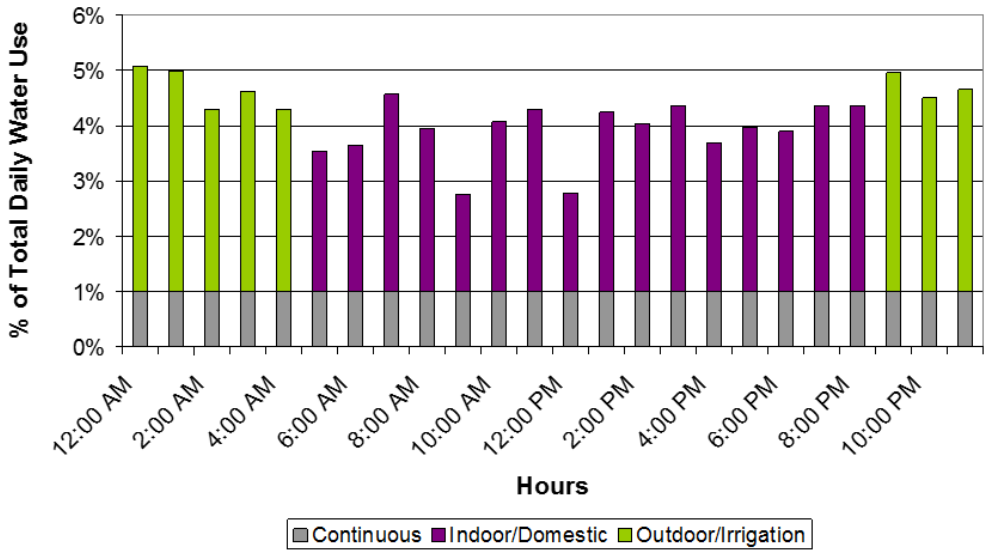
Commercial Pattern

Figure 34: Disaggregated Hourly Water Demand Profiles - Offices



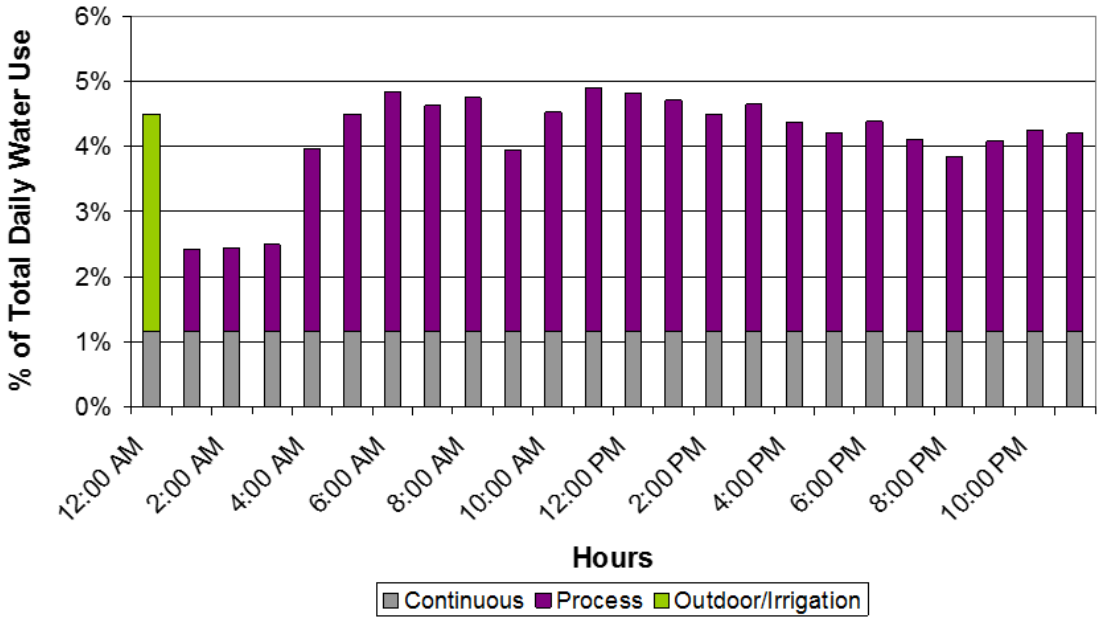
School Pattern

Figure 53: Disaggregated Hourly Water Demand Profiles - Schools



Industrial pattern

Figure 58: Disaggregated Hourly Water Demand Profiles - Industrial



Other Pipes and Nodes changed per Aquaveo's request

OTHER-0001 - Fire Sprinkler Post Indicator Valve - Modeled as an EPA-Net node.

OTHER-0002 - Many types of valves here controlling flow into the elementary school - Modeled as a single EPA-NET node so we can simply compute the pressure.

OTHER-0003 - Fire Sprinkler Post Indicator Valve - Modeled as an EPA-Net node.

OTHER-0004 - Not connected to water mains - Can be ignored.

OTHER-0005 - Point marking exact coordinate location of pipe crossing under a channel - Modeled as an EPA-NET node junction with zero demand.

OTHER-0006 - Point marking exact coordinate location of pipe crossing under a channel - Modeled as an EPA-NET node junction with zero demand.

OTHER-0007 - Point marking exact coordinate location of pipe crossing under a channel - Modeled as an EPA-NET node junction with zero demand.

OTHER-0008 - Point marking exact coordinate location of pipe crossing under a channel - Modeled as an EPA-NET node junction with zero demand.

OTHER-0009 - Check Valve.

OTHER-0010 - End of line cap/valve - Modeled as an EPA-NET node.

OTHER-0011 - End of line cap/valve - Modeled as an EPA-NET node.

OTHER-0012 - End of line cap/valve for future development - Modeled as an EPA-NET node.

OTHER-0013 - End of line cap/valve - Modeled as an EPA-NET node.

HS-OTHER-0001 - Check Valve.

HS-OTHER-0002 - Re-Use water meter - Not directly connected to pipe mains, can be ignored.

HS-OTHER-0003 - Re-Use water sample vault - Not directly connected to pipe mains, can be ignored.

HS-OTHER-0004 - Re-Use manhole. - Not directly connected to pipe mains, can be ignored.

HS-OTHER-0005 - Storage tank (filled by pump on 150th S and Camp Williams Rd) - Modeled as an EPA-NET tank. I will get dimensions and storage capacity specs from Bluffdale.