Appendix N

# HYDRAULIC MODEL UPDATE AND CALIBRATION

City of Tumwater

# Technical Memorandum 3
# HYDRAULIC MODEL UPDATE AND CALIBRATION

FINAL | June 2021

City of Tumwater

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# INTRODUCTION

This technical memorandum (TM) summarizes the process of updating and calibrating the hydraulic model of the City of Tumwater's (City) water distribution system from the latest available GIS data.

## 1.1 Hydraulic Model Updates

The following general updates to the model were made:

- Added pipes from developments identified by the City.
- Simplified the pipe network:
  - Trimmed pipes less than 100 feet long with diameters less than 11 inches.
  - Combined adjacent pipes that are the same material and diameter.
- Allocated water demands based on the land use of the adjacent parcel.
- Updated demands for large customers.
- Updated the wells:
  - Removed Well 2 and Well 5.
  - Deactivated Well 3.
  - Added Well 16 and Well 17.
- Added a check valve to the Bush Mountain Pump Station for fire flows.
- Checked and updated junction elevations.
- Updated fire flow requirements for the 549 Pressure Zone.

A table showing the detailed model changes during calibration and initial model scenario set-up is shown at the end of this TM (Table 3).

It should be noted that the hydraulic model does not include all the pipes within the City's water distribution system. To stay within the City's H20NET license (2,000 pipe limit), the City designated which pipes from new developments should be added to the existing model. Any additional pipes added to the hydraulic model (that were necessary to maintain model connectivity) are summarized in Table 3.

## 1.2 Hydraulic Model Calibration

Calibration is the process of comparing model simulation results to actual field data, and making corrections and adjustments to the model to achieve a loose agreement between model predictions and field measured data. This section describes the different steps of the hydraulic model calibration.

### 1.2.1 Model Calibration Overview

The purpose of the water system hydraulic model is to estimate, or predict, how the water system will respond under a given set of conditions. One way to test the accuracy of the hydraulic model is to create a set of known conditions in the water system and then compare the results observed in the field against the results of the hydraulic model simulation using the same conditions. Field flow tests can verify data used in the hydraulic model and yield a greater understanding of how the water system operates.

Field-testing can help identify errors in the data used to develop the hydraulic model, or show that a condition might exist in the field not otherwise known. Valves reported as being open might actually be partially closed or closed (or vice versa). An obstruction could exist in a pipeline, or pressure settings for PRV may be different from noted. Field-testing can also correct erroneous model data such as incorrect pipe diameters or connections. Data obtained from the field tests can be used to determine appropriate roughness coefficients for each pipeline, as roughness coefficients can vary with age, pipe material, and construction quality. Other parameters can also be adjusted to generate a calibrated model.

The calibration process for the City's hydraulic model consisted of two parts: a macro calibration and a hydrant test calibration, or micro calibration. The following sections describe both calibration steps.

#### 1.2.1.1 Macro-Calibration Process

The initial calibration process consists of a macro calibration. The model was run for existing demand conditions, and adjustments were made to produce reasonable system pressures. Such adjustments included modifications of pipeline connectivity, ground elevations, and facility characteristics. The macro calibration process involved several steps to ensure that the model produces reasonable results:

- Transmission Main Connectivity: The connectivity tool in InfoWater was used to verify the transmission mains were connected. Problems found using the connectivity locator were reviewed to determine whether adjustments were needed to the pipe network. Output reports of pipe flow characteristics such as head loss per thousand feet and velocity were also used to locate potential network problems.
- System Pressures: the model results were compared to typical pressures expected within a distribution system. This located issues such as problems with elevation, or connectivity, as well as some operational controls.

Minor issues were identified in the macro calibration process and corrected. The resulting model was then calibrated using the more detailed hydrant tests.

#### 1.2.1.2 Micro-Calibration Process

During average day demand conditions, roughness coefficients have a relatively small effect on operation of the distribution system due to low velocities. As flows increase in the system on higher demand days, velocity within pipelines increase leading to higher system head losses. Hydrant flow tests are used to stress the distribution system and create additional losses to generate a local HGL differential between the static and flowing conditions, highlighting local loss coefficients.

The model is calibrated by simulating the hydrant test and adjusting setting and parameters to match the field measured pressures under similar demand and system boundary conditions. Computer modeling of Water Distribution Systems (AWWA-M32 2012) recommends that the calculated pressures match the field-measured pressures within 10 feet (4.3 psi) for long range planning models, such as the updated City model.

The primary parameters adjusted during calibration were the pipeline roughness coefficients. Other parameters, such as booster pump station controls and well controls, were evaluated and can be adjusted if needed.

The Hazen-Williams roughness coefficient, or C-factor, is a function of pipeline material, diameter, and age. In addition, for simplicity in the model, minor losses were not applied at fittings, and instead losses at fittings were incorporated into (slightly higher) C-factors. Hydrant test calibration refines the initial estimation of the value of roughness coefficients that best represent current conditions within the City's distribution system. The roughness coefficients should be adjusted only within the accepted roughness coefficient range of $80 < C < 130$, but values have been reported as low as 60 for very old pipes and up to 150 for some new materials (InfoWater 2011).

If the model is unable to match the calibration results within the acceptable range of roughness coefficient values for a given pipeline material and age, there may be cause for further investigation of a previously unknown field condition. Examples of conditions that can arise during hydraulic model calibration include closed valves, partially closed or malfunctioning valves, extreme corrosion within pipelines or connectivity, and diameter errors in GIS layers, or record drawings.

### 1.2.2 Hydrant Calibration

The City conducted six hydrant tests in November 2017. The hydrant flow tests consisted of one flowing hydrant (two when necessary to achieve adequate pressure drop), and two pressure hydrants. These field tests were simulated in the model to calibrate the model under stead state conditions.

#### 1.2.2.1 Hydrant Flow Test Locations

The location of the City's six hydrant flow tests are shown on Figure 1. The testing sites were distributed across the City and were selected based on location, accessibility, and representation of the various portions of the City's distribution system.

#### 1.2.2.2 Hydrant Flow Test Data

The key data collected during the hydrant flow test included the following:

- Test Location (Fire Hydrant ID, Static Pressure Reading Address/ID): it is very important to locate the exact nodes in the model where the fire hydrant test is performed and results read.
- Test Date, Time, and Duration: the date and time were used to determine the system demands based on SCADA data.
- Hydrant Flow: The hydrant flow directly affects head losses through the system, and therefore the residual pressure
- Static and Residual Pressures: These are the values that the model needs to match within the criteria.
- SCADA data for pumps and tanks: Tank levels and pump operations at the time of the hydrant test are set in the model for each test case.

An example Hydrant Flow Test data sheet is shown in Figure 2.

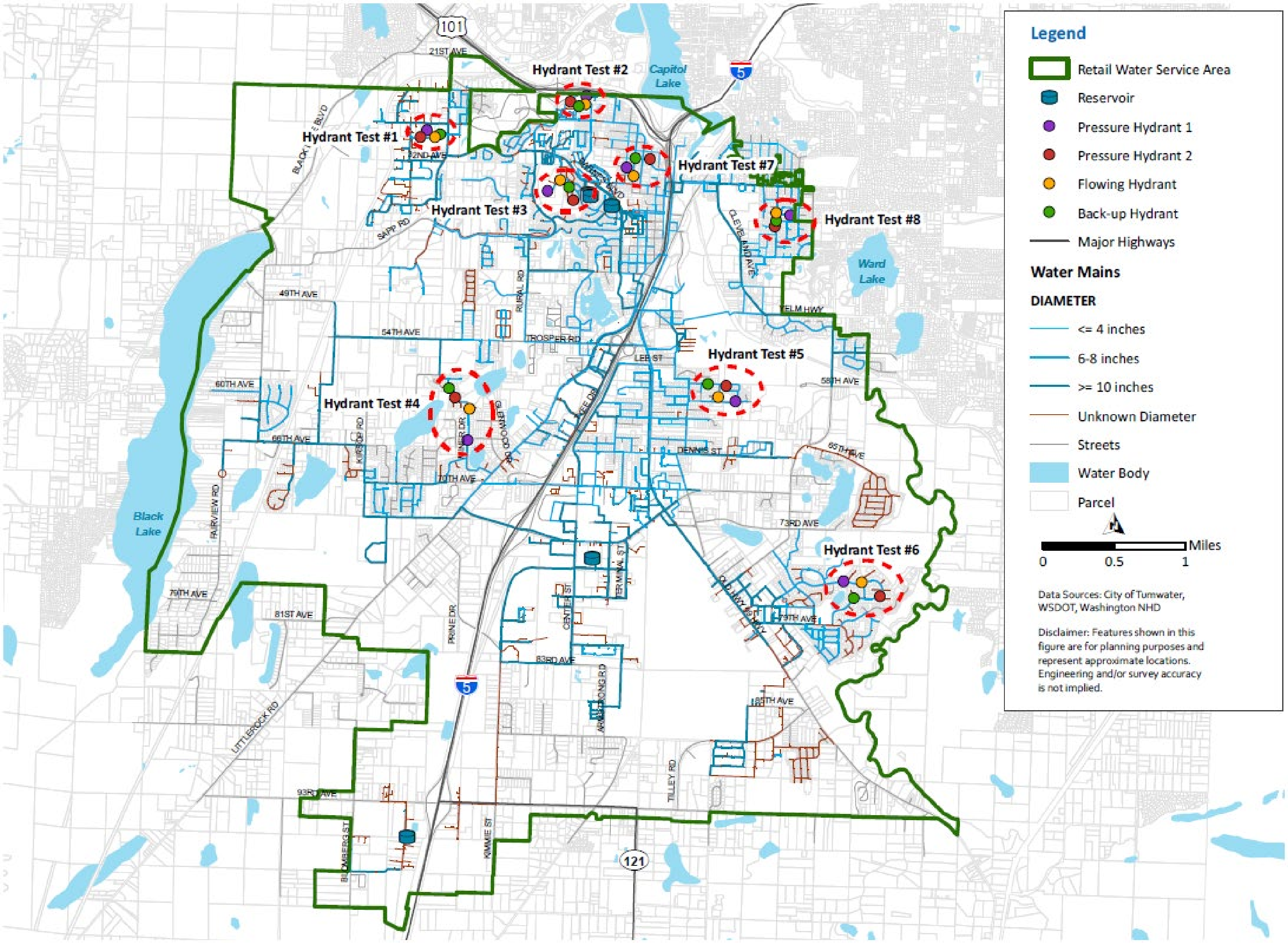


Figure 1 Hydrant Flow Testing Overview


Hydrant Test 1
Pressure Zone: 350
Date: ____________
Time Flushing Started: ____________
Time Flushing Ended: ____________
Notes/Observations: ____________

**Flowing Hydrant 1**
Hydrant #: ____________
Make: ____________
Main Size: ____________
Static PSI: ____________
Residual PSI: ____________
Pitot PSI: ____________
Flow GPM: ____________
Duration: ____________

**Pressure Hydrant 1**
Hydrant #: ____________
Make: ____________
Main Size: ____________
Static PSI: ____________
Residual PSI: ____________

**Pressure Hydrant 2**
Hydrant #: ____________
Make: ____________
Main Size: ____________
Static PSI: ____________
Residual PSI: ____________

**Back-up Hydrant 2**
Hydrant #: ____________
Make: ____________
Main Size: ____________
Static PSI: ____________
Residual PSI: ____________
Pitot PSI: ____________
Flow GPM: ____________
Duration:

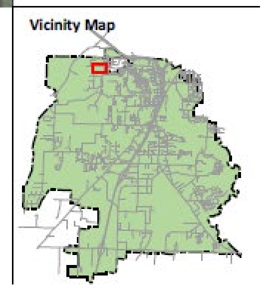


Figure 2 Hydrant Flow Test 1 Detail

#### 1.2.2.3 Model Hydrant Test Calibration Process

Scenarios were created in the hydraulic model for each fire hydrant test. Each scenario comprises different dataset (demands, controls, reservoir levels, etc.) in order to reproduce the model conditions similar to the field conditions during each fire hydrant test. Both pipe and valve datasets are the same for all the scenarios. This set-up makes it easy to check all the calibration points at the end of the calibration process in order to make sure that any adjustments made to one zone did not affect the calibration points in the adjacent pressure zones.

#### 1.2.2.4 Hydrant Test Calibration Results

Calibration to hydrant tests is conducted individually in order to specifically represent the conditions of the system at the time of the test. Therefore, numerous simulations are performed during the calibration phase. Adjustments are made to the model between runs to minimize the differences between the model and the field measured results.

The results of the calibration are summarized in Table 1. The goal of model calibration was to calibrate the hydraulic model pressures to within 4.3 psi of the field-measured pressures for each hydrant test site. Test 5 and 6 required hydrant elevation confirmation from the City to get closer to the model calibration goal.

Figure 3 summarizes all calibration point results on a 1 to 1 plot. The x-axis is the field measured pressure, and the y-axis is the modeled pressure. Each point on Figure 3 represents a calibration point, which is the field measured pressure and modeled pressure for each hydrant. The calibration points include all static and residual pressure data for a total of 31 calibration points (19 static pressure calibration points and 12 residual pressure calibration points).

A linear regression analysis was performed on the data comparison. The linear regression curve obtained from this comparison intercepts at zero with a slope near 1 and a percentage of determination ($R^2$) of 97.88%. The red lines of Figure 3 show the +/- 4.3 psi recommended by AWWA-M32 2012.

Table 1 Hydraulic Model Calibration Results

| Test No. | Pressure Zone | Date | Time | Duration (mins) | Hydrant | Hydrant Number | Model Junction ID | El. (ft) | Flow (gpm) | Field Results | | | | Model Results | | | | Comparison | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Static Pressure (psi) | Static HGL (FT) | Res. Pressure (psi) | Res. HGL (FT) | Static Pressure (psi) | Static HGL (FT) | Residual Pressure (psi) | Res. HGL (FT) | Static Pressure Diff (psi) | Res. Pressure Diff (psi) | Static Pressure Error (%) | Residual Pressure Error (%) | Pressure Drop (psi) Measured | Pressure Drop (psi) Modeled | Pressure Drop (psi) Difference |
| 1 | 350 Zone | 9-Nov | 10:18 | 5 | F1 | FH175 | J28-036 | 160 | 820 | 84 | 354 | 60 | 299 | 80 | 345 | | | 3.7 | | 4.4% | | 24 | | |
| | | | | | P1 | FH1252 | J820 | 163.8 | | 80 | 349 | 70 | 326 | 79 | 345 | 73 | 332 | 1.4 | -3.0 | 1.7% | -4.2% | 10 | 5.7 | 4.3 |
| | | | | | P2 | FH173 | J822 | 160 | | 84 | 354 | 76 | 336 | 80 | 345 | 75 | 332 | 3.7 | 1.5 | 4.4% | 1.9% | 8 | 5.7 | 2.3 |
| 2 | 454 Zone | 9-Nov | 10:40 | 3 | F1 | FH8 | J27-045 | 198 | 1240 | 112 | 457 | 100 | 429 | 110 | 452 | | | 2.1 | | 1.9% | | 12 | | |
| | | | | | P1 | FH6 | J27-046 | 163 | | 122 | 445 | 116 | 431 | 125 | 452 | 118 | 435 | -3.1 | -1.9 | -2.5% | -1.6% | 6 | 7.1 | -1.1 |
| | | | | | P2 | FH1295 | J27-055 | 193 | | 110 | 447 | 104 | 433 | 112 | 452 | 107 | 439 | -2.1 | -2.5 | -1.9% | -2.4% | 6 | 5.6 | 0.5 |
| 3 | 549 Zone | 9-Nov | 10:58 | 16 | F1 | FH1173 | J27-117 | 406 | 790 | 57 | 538 | 51 | 524 | 59 | 543 | | | -2.3 | | -4.1% | | 6 | | |
| | | | | | F2 (Backup) | FH1363 | J838 | 417.66 | 820 | 57 | 549 | 52 | 538 | 54 | 543 | | | 2.7 | | 4.8% | | 5 | 54.3 | |
| | | | | | P1 | FH1176 | J840 | 414.81 | | 55 | 542 | 48 | 526 | 56 | 543 | 50 | 530 | -0.5 | -1.7 | -0.9% | -3.5% | 7 | 5.8 | 1.2 |
| | | | | | P2 | FH1361 | J834 | 408.85 | | 58 | 543 | 52 | 529 | 58 | 543 | 55 | 535 | -0.1 | -2.6 | -0.1% | -5.0% | 6 | 3.5 | 2.5 |
| 4 | 350 Zone | 14-Nov | 10:06 | 4 | F1 | FH319 | J832 | 180 | 950 | 78 | 360 | 68 | 337 | 75 | 353 | | | 3.3 | | 4.2% | | 10 | | |
| | | | | | P1 | FH317 | J830 | 184.57 | | 70 | 346 | 64 | 332 | 73 | 353 | 69 | 343 | -2.8 | -4.6 | -4.0% | -7.1% | 6 | 4.3 | 1.8 |
| | | | | | P2 | FH321 | J04-015 | 162 | | 85 | 358 | 78 | 342 | 82 | 352 | 77 | 340 | 2.6 | 1.1 | 3.0% | 1.4% | 7 | 5.6 | 1.5 |
| 5 | 350 Zone | 14-Nov | 10:26 | 4 | F1 | FH544 | J02-053 | 160 | 820 | 82 | 349 | 56 | 289 | 86 | 359 | | | -4.2 | | -5.1% | | 26 | | |
| | | | | | P1 | FH1404 | J02-080 | 140 | | 96 | 362 | 74 | 311 | 95 | 359 | 78 | 319 | 1.2 | -3.7 | 1.2% | -5.0% | 22 | 17.2 | 4.8 |
| | | | | | P2 | FH1407 | J02-078 | 169 | | 83 | 361 | 65 | 319 | 83 | 361 | 65 | 320 | -0.3 | -0.4 | -0.3% | -0.6% | 18 | 17.9 | 0.1 |
| 6 | 350 Zone | 14-Nov | 10:47 | 7 | F1 | FH1043 | J12-042 | 159.5 | 980 | 90 | 367 | 68 | 317 | 85 | 356 | | | 4.8 | | 5.3% | | 22 | | |
| | | | | | P1 | FH1041 | J826 | 159.3 | | 88 | 363 | 72 | 326 | 85 | 356 | 75 | 333 | 2.7 | -3.3 | 3.1% | -4.6% | 16 | 10.0 | 6.0 |
| | | | | | P2 | FH1047 | J828 | 172.71 | | 84 | 367 | 68 | 330 | 79 | 356 | 69 | 333 | 4.5 | -1.2 | 5.4% | -1.8% | 16 | 10.3 | 5.8 |

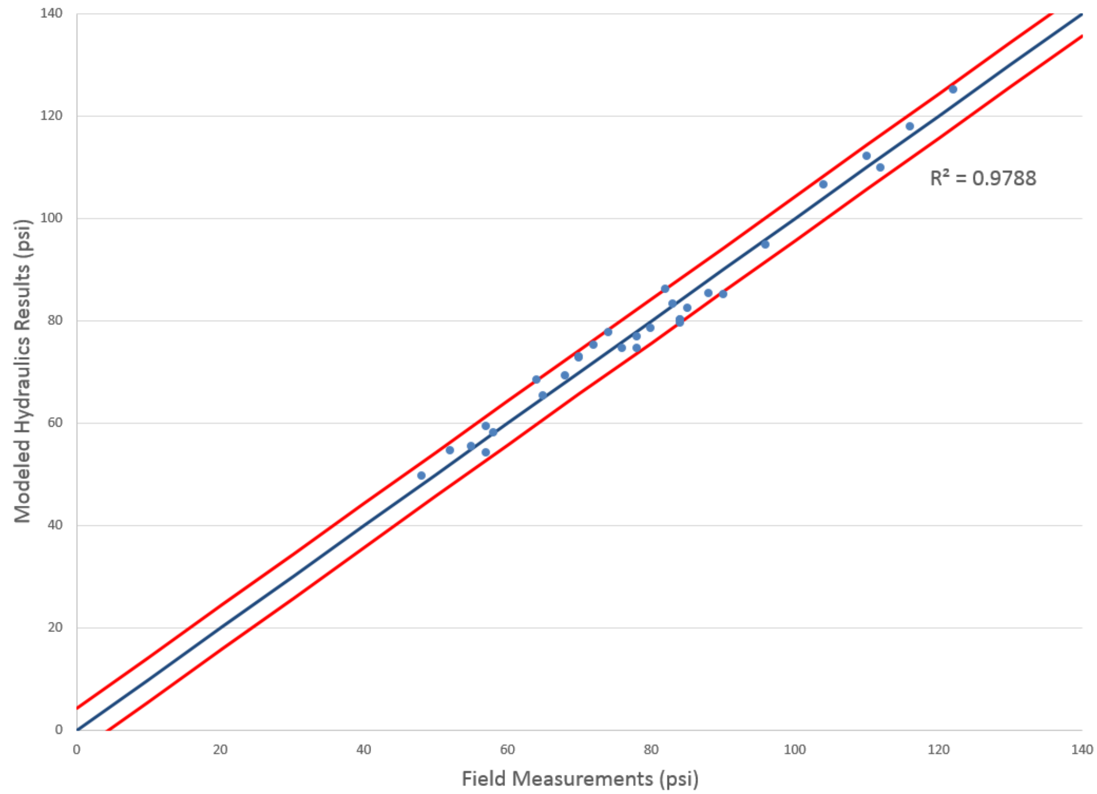


Figure 3 Hydraulic Model Calibration Point Results

### 1.2.2.5 Challenging Calibration Tests

Test 6 was particularly difficult to calibrate the field measured data to the model results. After further investigation and communication with the City, it was determined that the elevations of the nodes in the model needed to be changed to match the field measured elevations. Table 2 summarizes the changes in elevations for the Test 6 model junctions.

Table 2 Hydrant Test 6 Elevations

| Junction ID | J12-042 | J286 | J828 |
|---|---|---|---|
| Hydrant ID | FH1041 | FH1043 | FH1047 |
| Original Model Elevation | 171 | 173 | 185 |
| City GIS Elevation | 170 | 170 | 184 |
| Field Measured Elevation(1) | 159.5 | 159.3 | 172.7 |

Notes:
(1) The field measured elevations were used in the model after discussion with the City.

Table 3 Hydraulic Model Updates

| Date | Element | Model Label | Change | Reason | Applicable Scenarios |
|---|---|---|---|---|---|
| March 2018 | Junctions | Multiple | Updated junction connectivity. | "Trace Connected Nodes" function showed junctions that were not connected. | BASE |
| March 2018 | Pipe | Multiple | Added pipes from ARC development area. | This development linked two parts of the distribution system so it was necessary to add the loop. | BASE |
| March 2018 | Pipe | Multiple | Skeletonized pipes - trimmed pipes 100' and shorter, 11" diameter and smaller (131 pipes trimmed) | The model had many dead end pipes that were not necessary for hydraulic modeling purposes. | BASE |
| March 2018 | Pipe | Multiple | Skeletonized pipes - reduced pipes that had same zone, material, and diameter (323 pipes reduced) | The model had many pipes that could be combined. | BASE |
| March 2018 | Pipe | Multiple | Diameters were updated based on as-builts from city of Tumwater. | Some pipes in the hydraulic model did not have diameters. | BASE |
| March 2018 | Pipe | 6796, 6794 | Pipe diameters were updated to 8". | Pipes did not have diameters assigned. 8" was chosen based on pipe directly north. | BASE |
| March 2018 | Junctions | Multiple | Updated junction elevation based on raster elevation file from GIS. | New junctions did not have elevations assigned. | BASE |
| March 2018 | Junctions | Multiple | Added junctions to allocate demand from large developments. | Some useful junctions were removed during the skeletonization, and demands for larger developments needed junctions to allocate demand. | BASE |
| March 2018 | Scenarios | Multiple | Created "STATICCALIBRATION" scenario and the following scenarios for each individual hydrant test:<br>• ADD_CALIBRATION_TEST1<br>• ADD_CALIBRATION_TEST2<br>• ADD_CALIBRATION_TEST3<br>• ADD_CALIBRATION_TEST4<br>• ADD_CALIBRATION_TEST5<br>• ADD_CALIBRATION_TEST6 | The "STATICCALIBRATION" scenario will be used to create scenarios for calibrating the model based on the six hydrant tests. | STATICCALIBRATION |
| March 2018 | Data Sets | Multiple | Created the following Data Sets:<br>• Tank Set: ADD_CALIBRATION<br>• Reservoir Set: STATIC_CALIB<br>• Pump Set: ADD_CAL_454&549_OFF and ADD_CAL_549_OFF<br>• Valve Set: ADD_CALIBRATION<br>• Control Set: STATIC_CALIB | To calibrate the hydraulic model based on the results of the hydrant tests, the data sets are needed to reflect the actual settings of the water system during the hydrant tests. | STATICCALIBRATION<br>ADD_CALIBRATION_TEST1<br>ADD_CALIBRATION_TEST2<br>ADD_CALIBRATION_TEST3<br>ADD_CALIBRATION_TEST4<br>ADD_CALIBRATION_TEST5<br>ADD_CALIBRATION_TEST6 |
| March 2018 | Junctions | Multiple | Allocated demands to the junctions based on Demand Allocation workbook. | Demands needed for calibration. | ALL |
| March 2018 | Junctions | Multiple | Updated junction demand for the large customers. | We have specific values for large customers so the closest junctions to the customers were updated. | ALL |
| March 2018 | Junctions | J834 | Added junction J834. | Need junction to reach pressure hydrant. | ALL |
| March 2018 | Pipe | P3694 | Added pipe P3694. | Connected J834 to system. Made diameter and roughness same as connecting pipe. | ALL |
| April 2018 | Junctions | J02-053 | Changed elevation of J02-053 to 160' from 156'. | USGS topo map shows the junction is above the 160' topo line. | ALL |
| April 2018 | Junctions | J02-080 | Changed elevation of J02-080 to 140' from 134. | USGS topo map shows the junction is above the 140' topo line. | ALL |
| April 2018 | Junctions | J832 | Changed elevation of J832 to 180' from 171.39'. | USGS topo map shows the junction is above the 180 ft topo line. | ALL |
| April 2018 | Junctions | J04-015 | Changed elevation of J04-015 to 180' from 162'. | USGS topo map shows the junction is above the 180 ft topo line. | ALL |
| April 2018 | Junctions | J838 | Added junction J838. | Need closer junction for hydrant test. | ALL |
| April 2018 | Junctions | J840 | Added junction J840. | Need closer junction for hydrant test. | ALL |
| April 2018 | Junctions | J834 | Changed elevation of J834 to 420' from 408'. | USGS topo map shows the junction is above the 420 ft topo line. | ALL |
| April 2018 | Junctions | J822 | Changed elevation of J822 to 160' from 150.59'. | USGS topo map shows the junction is above the 160 ft topo line. | ALL |
| April 2018 | Junctions | J28-036 | Changed elevation of J28-036 to 160' from 149'. | USGS topo map shows the node is above the 160 ft topo line | ALL |
| April 2018 | Valves | V5 & V2 | Wells 2 & 5 were deactivated. | Wells 2 and 5 are decommissioned. | ALL |
| April 2018 | Junctions | Multiple | Updated demand ratios for the calibration test demand sets. | The demands needed to be scaled based on actual demands during the hydrant tests. One ratio was used for each day of the hydrant testing. | ADD_CALIBRATION_TEST1<br>ADD_CALIBRATION_TEST2<br>ADD_CALIBRATION_TEST3<br>ADD_CALIBRATION_TEST4<br>ADD_CALIBRATION_TEST5<br>ADD_CALIBRATION_TEST6 |

Table 3 Hydraulic Model Updates (Continued)

| Date | Element | Model Label | Change | Reason | Applicable Scenarios |
|---|---|---|---|---|---|
| April 2018 | Data Sets | Multiple | Created the following Demand Sets:<br>• ADD_CALIB_TEST1<br>• ADD_CALIB_TEST2<br>• ADD_CALIB_TEST3<br>• ADD_CALIB_TEST4<br>• ADD_CALIB_TEST5<br>• ADD_CALIB_TEST6 | The demand sets for each hydrant test include the flow from the fire hydrant that was recorded during the hydrant test. The flow was added as a demand to the appropriate junction. | ADD_CALIBRATION_TEST1<br>ADD_CALIBRATION_TEST2<br>ADD_CALIBRATION_TEST3<br>ADD_CALIBRATION_TEST4<br>ADD_CALIBRATION_TEST5<br>ADD_CALIBRATION_TEST6 |
| April 2018 | Pipes | Multiple | Decreased roughness by 20 for pipes near calibration test, created pipe set specifically for this change. | Static pressures for test 2 seemed incorrect so one idea was to lower the c-factors of the pipes. | ADD_CALIBRATION_TEST2 |
| April 2018 | Junctions | J12-042, J826, J828 | Updated elevations | Received updated elevations for FH1043, FH1041, and FH1047 from the City. | ALL |
| April 2018 | Scenarios | Multiple | Created "SHORT_TERM" scenario. | The "SHORT_TERM" scenario will be used to check short-term pressures, velocities, and fire flow requirements. | SHORT_TERM |
| April 2018 | Junctions, Pipes, Valves, Tanks, Reservoirs, Pumps | Multiple | Added "SHORT_TERM" and "BASE" column to modeling components. | Need to identify components in the "BASE" vs. SHORT_TERM scenario. | ALL |
| April 2018 | Data Sets | Multiple | Created 2020_ADD demand set based on ratio of projected ADD in 2020 to 2017 demand. | Need a demand set for short term analysis. | 2020_ADD |
| April 2018 | Data Sets | Multiple | Created 2020_MDD demand set: multiplied 2020_ADD by peaking factor (2.04). | Need an MDD demand set for short term analysis. | 2020_MDD&FIRE |
| April 2018 | Tanks | Multiple | Created ADD tank level set based on bottom of equalizing elevation in reservoir. | Need tank set for short term analysis. | 2020_ADD |
| April 2018 | Tanks | Multiple | Created MDD tank level set based on bottom of fire suppression elevation in reservoir. | Need tank set for short term analysis. | 2020_MDD&FIRE |
| April 2018 | Tanks | Multiple | Created PHD tank level set based on bottom of equalizing elevation in reservoir. | Need tank set for short term analysis. | 2020_PHD |
| April 2018 | Data Sets | Multiple | Set controls for pumps based on existing data set points | Need control set for short term analysis. | 2020_ADD<br>2020_MDD&FIRE<br>2020_PHD |
| April 2018 | Junctions | Multiple | Assigned fire flow demands based on future land use type and fire flow requirements (used shapefile from GIS) | Need for fire flow analysis. | 2020_MDD&FIRE |
| April 2018 | Junctions | Multiple | Created 2020_PHD demand set: multiplied 2020_MDD by peaking factor (1.34) | Need PHD demand set for short term analysis. | 2020_PHD |
| April 2018 | Reservoirs and valves | Multiple | Closed original well pumps and PRVs, set tank levels to 0 ft, inactivated components in base and short term facility sets.<br>Adjusted how the wells are set up. The wells now run with flow control valves instead of pumps as follows:<br>• Well 14 (Bush MS): SR-14A, FCV-14A (Setting = 2273 gpm).<br>• Well 12 (Bush MS): SR-12A, FCV-12A (Setting = 665 gpm).<br>• Well 9 (Airport): SR-9A, FCV-9A (Setting = 371 gpm).<br>• Well 10 (Airport): SR-10A, FCV-10A (Setting = 118 gpm).<br>• Well 15 (Airport): SR-15A, FCV-15A (Setting = 811 gpm).<br>• Well 11 (Airport): SR-11A, FCV-11A (Setting = 240 gpm).<br>• Well 6 (Palermo): SR-6A, FCV-6A (Setting = 364 gpm).<br>• Well 3 (Palermo): SR-3A, FCV-3A (Setting = 284 gpm but closed).<br>• Well 4 (Palermo): SR-4A, FCV-4A (Setting = 373 gpm). | Need to adjust how the wells were set up. | ALL |
| May 2018 | Tanks | T-1 T-2 & T-4 | Adjusted initial tank levels to match updated levels in Storage and Pumping analysis spreadsheet. | Storage heights were updated. | 2020_ADD<br>2020_MDD&FIRE<br>2020_PHD |

Table 3 Hydraulic Model Updates (Continued)

| Date | Element | Model Label | Change | Reason | Applicable Scenarios |
|---|---|---|---|---|---|
| May 2018 | Valves | FCV for wells | Adjusted the flow control valve control set so all controls are disabled except the "if level at node: T-1 below *minimum control level*" setting. | Control sets are not needed for steady state models. | 2020_ADD<br>2020_MDD&FIRE<br>2020_PHD |
| May 2018 | Well 16 & 17 | Multiple | Added Palermo wells 16 & 17 to model based on GIS location. The controls are set up like the other Palermo wells (1000' head, flow is controlled by flow control valves that are set to current capacity of well):<br>• Well 16 (Palermo): R-16A, FCV-16A (Setting = 355 gpm).<br>• Well 17 (Palermo): R-17A, FCV-17A (Setting = 284 gpm). | Wells 16 & 17 were not in model. | ALL |
| May 2018 | Valve | Multiple | Added check valve to Pump 28. | Per hydraulic profile, there is a check valve for pump 28 in the Bush Mt area. | ALL |
| May 2018 | Junctions | Multiple | Removed fire flow demands from junctions adjacent to facilities. | These junctions do not need fire flow demands. | 2020_MDD&FIRE |
| June 2018 | Junctions | Multiple | Added SRVCE_NODE column to identify junctions that have customers (New junctions with FF demands but have no demand are considered service nodes). | Need to identify which junctions have service demands. | ALL |
| June 2018 | Junctions | Multiple | Added FF_JUNCT column to identify junctions that have fire flow demands. | Need to identify which junctions have service demands. | ALL |
| June 2018 | Junction and Pipe | J05-034, P2608 | Deactivated Lakeland Manor Water system Pipe and junctions. | Lakeland Manor is not part of Tumwater service area. | ALL |
| June 2018 | Scenarios | Multiple | Added the following scenarios to evaluate the future water system based on the hydraulic model:<br>• 2028<br>– 2028_ADD<br>– 2028_MDD&FIRE<br>– 2028_PHD<br>• 2038<br>– 2038_ADD<br>– 2038_MDD&FIRE<br>– 2038_PHD | These scenarios are necessary to evaluate the water system based on future demands and identify any deficiencies | 2028<br>2038 |
| June 2018 | Scenarios | Multiple | Created the following demand sets for 2028 and 2038 scenarios:<br>• 2028_ADD<br>• 2028_MDD<br>• 2028_PHD<br>• 2038_ADD<br>• 2038_MDD<br>• 2038_PHD | The future demands developed for the Water System Master Plan were allocated to junctions in the model based on the future planning year and type of demand. | 2028_ADD<br>2028_MDD&FIRE<br>2028_PHD<br>2038_ADD<br>2038_MDD&FIRE<br>2038_PHD |
| June 2018 | Reservoirs, Valves | Multiple | The following wells were added to the 2028 scenarios in the model:<br>• Brewery Wellfield: SR-23, V23 (Setting = 2171 gpm)<br>• Golf Course Well: SR-20, V20 (Setting = 2000 gpm)<br>• SW Wellfield: SR-22, V26 (Setting = 2226 gpm)<br>The following well was added to the 2038 scenarios in the model:<br>• NE Wellfield: SR-24, V24 (Setting = 2000 gpm) | Wells will be activated within the planning period. | 2028_ADD<br>2028_MDD&FIRE<br>2028_PHD<br>2038_ADD<br>2038_MDD&FIRE<br>2038_PHD |
| June 2018 | Tank | T-5 | A new reservoir (T-5) was added to the 350 PZ in the SE area. | Reservoir will be built within the planning period. | 2028_ADD<br>2028_MDD&FIRE<br>2028_PHD<br>2038_ADD<br>2038_MDD&FIRE<br>2038_PHD |
| June 2018 | Junctions, Pipes, Valves, Tanks, Reservoirs, Pumps | Multiple | Added the following columns to all model component information: 2028, 2038, 2028_IMP, 2038_IMP. | Needed different facility sets for each planning year (2028 and 2038) and needed additional facility sets for scenarios with recommended improvements (2028_IMP and 2038_IMP). | All 2028 and 2038 scenarios |

Table 3 Hydraulic Model Updates (Continued)

| Date | Element | Model Label | Change | Reason | Applicable Scenarios |
|---|---|---|---|---|---|
| June 2018 | Scenarios | Multiple | Created the following scenarios to develop distribution system improvements based on deficiencies found in 2028 and 2038 scenarios:<br>• 2028_IMPROVEMENTS<br>– 2028_IMP_ADD<br>– 2028_IMP_MDD&FIRE<br>– 2028_IMP_PHD<br>• 2038_IMPROVEMENTS<br>– 2038_IMP_ADD<br>– 2038_IMP_MDD&FIRE<br>– 2038_IMP_PHD | These new scenarios will be used to develop distribution system improvements. | Scenarios Notes |
| June 2018 | Pipes | Multiple | Added pipes to model to address deficiencies in system. | Pipes were added to address deficiencies in the system. | Improvements Scenarios |
| June 2018 | Pipes | Multiple | Added the following columns to the pipe data:<br>• CIP_ID<br>• IMP_PROJ | Columns were added so that distribution system projects could be labeled in the model and figures. | ALL |
| November 2018 | 549 Zone Tank | T-4 | Changed fire flow level in tank. | City adjusted fire flow requirements for 549 Zone so the FSS changed. Updated the tank level for FF scenarios to reflect the change in required FSS. | 2020_MDD&FF<br>2028_MDD&FIRE<br>2038_MDD&FIRE |
| November 2018 | Junctions | Multiple | Updated fire flow requirements for junctions in 549 zone to 1,500 gpm, except Tumwater Hill Elementary school, which has fire flow requirement of 1,625 gpm. | Based on conversations with the City, the fire flow requirements were updated for junctions in the 549 Zone. | ALL |
| November 2018 | Pipes | Multiple | Updated CIP IDs for pipe distribution recommended projects. Added new columns in the pipe data:<br>• PROJ_CAT_1<br>• PROJ_CAT_2<br>• PROJ_TYP_1<br>• PROJ_TYP_2<br>• NEW_CIP_ID | Some CIP projects were combined so updated CIP IDs were established. The project category and project type label the trigger for the improvement project and the category of the improvement project. | ALL |