TO: Dave Stoneback, City of Evanston
FROM: Paul Moyano, Catherine Hurley
SUBJECT: Hydraulic Model Services
          Task Order No. 01 – Model Update
          Model Update and Verification

Objective

The objective of Task Order No. 01 was to update the City of Evanston’s existing water distribution system hydraulic model using the City’s latest water geodatabase. The purpose of this memorandum is to summarize and document the model update and validation.

Approach

The focus of the 2009 model update was to incorporate water main improvements constructed by the City since the previous model update. In addition, the model update was intended to incorporate the changes the City has made to their water geodatabase based on as-built conditions. The existing water distribution model for the City of Evanston was used by MWH in the spring of 2009 to perform simulations for Evanston’s Unidirectional Flushing (UDF) Pilot Program. The 2009 model update was accomplished by starting with the model used for the UDF Pilot Program (UDF Model) and replacing the pipe network with the City’s latest water geodatabase. The model update was validated by comparing results from the 2009 Model with the UDF Model using the same boundary conditions. The UDF Model represents the latest calibrated system model and is an appropriate model to use for validating the 2009 model update. Details of the model update and validation are presented in the next sections.

Model Update

The 2009 model update consisted of two subtasks: Data Review and Preparation, and Hydraulic Model Update. During the Data Review and Preparation subtask, MWH reviewed the City’s latest water geodatabase for consistency and hydraulic connectivity and provided feedback to the City on changes required for importing the database into the hydraulic model. Two primary types of modifications were required. The first modification was to confirm that pipe segments in the geodatabase are properly connected to fittings which are intended to be included in the model. The second modification was to confirm that all connected pipe segments are properly linked together at their endpoints. MWH provided a shapefile for the locations that required review and modification by the City. The modifications were completed by the City and a revised geodatabase submitted to MWH.
The next subtask was to update the hydraulic model. Based on the goal of the 2009 model update, changes were only made to the water distribution pipe network, which includes pipes and nodes. The demands, elevations, and facility data from the UDF Model were carried over to the updated model. The modeled pipes and nodes were created by importing pipes and fittings from the City’s updated geodatabase. Pipes from the City’s geodatabase which were identified as active pressurized water main owned by the City were imported into the model along with private mains providing distribution capacity to the system. Hydraulic pipe data for length, diameter and roughness (C-factor) were included in the City’s geodatabase and mapped to the proper fields in the model. Fittings were imported into the model and model nodes were created at each. Elevations and demands assigned to nodes were transferred from the UDF Model. Each pipe and node was given an identification number (ID) based on the City’s FacilityID in the geodatabase. In cases where there was not a unique Facility ID in the geodatabase (for example private water mains and fittings), the nodes and pipes were given a unique ID starting with “J” for junction (node) and “P” for pipe followed by a three digit number.

Figure 1 presents the modeled nodes and pipes which were modified since the last model update. The complete updated hydraulic pipe network is shown in Figure 2. Water main improvements from the last two years which are included in the model are highlighted in Figure 2.

During the model update process, MWH made additional modifications to the City’s data for modeling purposes. These additional items are described in detail in Attachment 1. The City may use this information to refine their geodatabase to reflect the final model requirements.

**Model Validation**

The hydraulic model update was validated by comparing model results between the 2009 Model and the UDF Model from average day and maximum day demand analyses. The model simulations compared for the validation were based on the same demand, pump operation, and tank elevation data for each model. Demand data was determined based on average day and maximum day pumpage provided by the City for 2009. Pump operation and standpipe levels were determined based on the operator logs provided by the City for August 10 – 16, 2009. A summary of model input parameters is provided in Table 1.

<table>
<thead>
<tr>
<th>Table 1 – Summary of Model Input Parameters for Model Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Day Condition</strong></td>
</tr>
<tr>
<td><strong>Total Plant Pumpage</strong></td>
</tr>
<tr>
<td><strong>Pump Operation</strong></td>
</tr>
<tr>
<td><strong>Evanston Demand</strong></td>
</tr>
<tr>
<td><strong>Northwest Water Commission Demand</strong></td>
</tr>
<tr>
<td><strong>Skokie Demand</strong></td>
</tr>
<tr>
<td><strong>North Standpipe Water Level</strong></td>
</tr>
<tr>
<td><strong>South Standpipe Water Level</strong></td>
</tr>
</tbody>
</table>
Model results for average day and maximum day conditions simulated with the 2009 Model and the UDF Model were compared and found to be in close agreement. Results were compared for the discharge pressure and flow from the facilities as well as system pressure. A summary of the model comparison for facility pressure and flow is provided in Tables 2 and 3.

### Table 2 – Summary of Model Comparison – Average Day Condition

<table>
<thead>
<tr>
<th></th>
<th>2009 Updated Model</th>
<th>UDF Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Treatment Plant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Pumpage</td>
<td>43.28 MGD</td>
<td>43.24 MGD</td>
</tr>
<tr>
<td>Pump 5 Flow</td>
<td>16.49 MGD</td>
<td>16.47 MGD</td>
</tr>
<tr>
<td>Pump 9 Flow</td>
<td>26.79 MGD</td>
<td>26.77 MGD</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>56.66 psi</td>
<td>56.69 psi</td>
</tr>
<tr>
<td><strong>Standpipes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Flow to Storage</td>
<td>3.63 MGD</td>
<td>3.61 MGD</td>
</tr>
<tr>
<td>North Standpipe Inflow</td>
<td>1.16 MGD</td>
<td>1.15 MGD</td>
</tr>
<tr>
<td>South Standpipe Inflow</td>
<td>2.47 MGD</td>
<td>2.46 MGD</td>
</tr>
</tbody>
</table>

### Table 3 – Summary of Model Comparison – Maximum Day Condition

<table>
<thead>
<tr>
<th></th>
<th>2009 Updated Model</th>
<th>UDF Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Treatment Plant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Pumpage</td>
<td>61.60 MGD</td>
<td>61.57 MGD</td>
</tr>
<tr>
<td>Pump 5 Flow</td>
<td>16.10 MGD</td>
<td>16.08 MGD</td>
</tr>
<tr>
<td>Pump 5 Flow</td>
<td>20.25 MGD</td>
<td>20.25 MGD</td>
</tr>
<tr>
<td>Pump 9 Flow</td>
<td>25.25 MGD</td>
<td>25.24 MGD</td>
</tr>
<tr>
<td>Discharge Pressure</td>
<td>57.33 psi</td>
<td>57.34 psi</td>
</tr>
<tr>
<td><strong>Standpipes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Flow to Storage</td>
<td>1.07 MGD</td>
<td>1.03 MGD</td>
</tr>
<tr>
<td>North Standpipe Inflow</td>
<td>0.24 MGD</td>
<td>0.21 MGD</td>
</tr>
<tr>
<td>South Standpipe Inflow</td>
<td>0.83 MGD</td>
<td>0.82 MGD</td>
</tr>
</tbody>
</table>

System pressures and hydraulic grade line (HGL) elevations were also compared for the 2009 Model and the UDF Model. Pressure and HGL contours were developed from analysis results of the average day and maximum day conditions and are presented in Figures 3 thru 6. As shown in the figures, both models generated very similar pressure and HGL contours under each demand condition. A detailed comparison of the pressure at individual model nodes resulted in a pressure difference greater than 1 psi at only 9 of the 2887 nodes. In other words, calculated pressure at 99.7% of the nodes in the updated 2009 Model was within 1 psi of the pressure calculated in the UDF model using the same boundary conditions. The difference in pressure for these 9 model nodes was due to changes in the node elevation that resulted from adjustments to node locations that occurred during the model update. This high level of agreement validates the 2009 update of the Evanston water system hydraulic model.

It should also be noted that the pressure and HGL contours generated using the Updated 2009 Model for the average day and maximum day conditions are very similar and show a small
amount of head loss thru the distribution system. These results confirm previous analyses that the distribution system is robust and capable of meeting existing average day and maximum day conditions without significant head loss or stress on the system.

**Conclusion**

The Evanston water system hydraulic model has been updated to reflect the City’s most recent water geodatabase. Validation of the model shows a high level of agreement between analysis from the updated model and the UDF Model under average and maximum day demand conditions.

The City may update its water main and fitting database to reflect the final updates described in Attachment 1. Specific updates may include adding a unique Facility ID to all pipes and fittings, including pipes and fittings for private water main. The City should also designate pipes and fittings in the database that are to be included in the model with a unique data field that can track which elements were included in the last model update.

The 2009 model update focused on incorporating changes to the City’s water distribution pipe network and drew on data from the previous model for representing facilities (Water Treatment Plant, North Standpipe, South Standpipe), demands, elevations, and roughness factors. This model update did not include an updated demand allocation. Future task orders could include an evaluation of the City’s billing data and a fresh allocation of demands to the model. This task could also include an evaluation of the distribution of demand for the three Skokie connections. In addition, once significant changes have been made to the physical distribution system, the City should consider re-calibration of the hydraulic model.
Legend
- Nodes
- Facilities
- Active City Pipes
- Pipe Improvements 2007-08
- Pipe Improvements 2009
Figure 3 - 2009 Updated Model
Pressure Contours for Average Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL

Legend
- Nodes
- Facilities
- Active City Pipes
- Pressure Contours (psi)

1-15-2010
Legend

M Facilities
Nodes
Active City Pipes
Pressure Contours (psi)

Figure 3a - UDF Model
Pressure Contours for Average Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL
Figure 4a - UDF Model
HGL Contours for Average Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL

Legend
M Facilities
Nodes
Active City Pipes
HGL Contours (feet)
Figure 5 - 2009 Updated Model
Pressure Contours for Maximum Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL
Figure 5a - UDF Model
Pressure Contours for Maximum Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL

Legend
- Facilities
- Nodes
- Active City Pipes
- Pressure Contours (psi)
Figure 6 - 2009 Updated Model
HGL Contours for Maximum Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL

Legend
- Nodes
- Facilities
- Active City Pipes
- HGL Contours (feet)

1-15-2010
Figure 6a - UDF Model
HGL Contours for Maximum Day Demand
Evanston Water Model Update 2009
Hydraulic Modeling Services
City of Evanston, IL
The City of Evanston’s Geodatabase dated 12/29/2009 was used to update the hydraulic model. A shapefile was created to document the pipes and nodes that are in the updated model. They are titled “Nodes.09” and “Pipes.09”.

**Modeled Pipes**

Pipes to be modeled were selected from the City’s wpressurizedmain file that met the following criteria:

- **SUBTYPE** = wdistributionmain
- **RESPONSIBILITY** = City
- **LIFECYCLE** = Active

In addition, several private water mains where Responsibility = Private were included in the model update. These mains are interconnected to the water distribution and provide distribution capacity to the system. The “Pipes.09” shapefile has a column titled “Private” which is populated with “Yes” for any private water main that was included in the model.

There were a few pipe segments which were split in order to include a particular fitting that was selected based on the fitting criteria. The following pipes were split in the model to include a break at a modeled fitting:

- **FACILITYID:**
  - 22-188
  - 25-134
  - 22-178
  - 22-182
  - 30-034
  - 30-042
  - 30-038

The City may update its water main database to reflect the modeled pipes. Specifically, the City should designate pipes in the database that are to be included in the model with a unique data field. The City may also consider splitting the pipes identified above at the fittings in its database.
**Modeled Nodes**

Nodes to be modeled were created from the City’s wfitting file that met the following criteria:

MODELED = YES, plus MODELED = NULL for fittings added in December

After a review of the fittings which met the criteria above, eleven fittings were found to be duplicates of other fittings in the City’s Geodatabase. These fittings were not included in the model. The fittings did not have a Facility ID but are provided in the shapefile “DupNodes.09”. The final set of modeled nodes is shown in “Nodes.09”.

The City should update its fitting database to reflect the modeled nodes. Specifically, the City should designate fittings in the database that are to be included in the model with a unique data field. The City should also consider deleting the duplicate fittings from the database.