Using Sanitary Sewer I/I Field Data to Calibrate a Storm Sewer Model

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Since 1992, the City of Columbus Division of Sewerage and Drainage (DOSD) has conducted detailed investigations of its infrastructure to identify, mitigate and eliminate sanitary sewer infiltration and inflow (I/I). In 2009, DOSD selected Camp Dresser McKee to perform a detailed evaluation of the wastewater and stormwater infrastructure for the approximately 6 mi² (16 km²) capital improvement project (CIP) No. 650405.7, Northwest Alum Creek area sanitary sewer system inflow and infiltration remediation project (NWAC) as shown in Figure 15.1.

Figure 15.1 Project location map.
The goals of the project are to:
1. Conduct detailed studies of the sanitary sewer collection system in order to identify the locations and causes of sewage overflows from manholes, sanitary reliefs, sewage system surcharging and sewage backup into basements; and
2. Develop plans for specific sanitary and storm sewer system improvements and I/I remediation that successfully address the identified problems. The remediation plans will define cost-effective improvements to the storm and sanitary collection systems to mitigate or eliminate sanitary sewer surcharges and consequent overflows at manholes, structures and water in basements for a selected performance target.

Although the focus of NWAC is the sanitary collection system, a new model of the stormwater collection system was developed to evaluate the hydraulic connections between the sanitary and storm sewer systems and the stormwater impacts of inflow and infiltration remediation. For consistency with the NWAC sanitary sewer system model, the new stormwater model was constructed in the PCSWMM environment with the USEPA SWMM 5.21 engine.

The existing storm sewer system was analysed to determine a baseline condition that could be used in the development of different I/I removal alternatives. As part of the storm sewer analysis, fifteen flow meters were installed in the storm sewer system to allow for calibration of the SWMM5 model. Input parameters for the SWMM5 model were calculated from existing geographic information system (GIS) data of the study area, as well as leveraging detailed drainage reconnaissance (DDR) information that was originally gathered to identify potential sources of I/I to the sanitary sewer system.

The field data gathered to identify I/I sources was also used to refine the SWMM5 parameter that represents the percentage of impervious surfaces that are tributary to pervious surfaces, called disconnected impervious surfaces (DIS). The initial DIS values input to the storm sewer model, calculated from the DDR data, were sufficient to support adequate calibration of the model.

15.1 Model Representation of the Study Area

Building upon the City of Columbus GIS storm sewer infrastructure database and an existing stormwater model of the Linden Ditch watershed (developed as part of CIPs 704, 974 and 990), the new model represents the hydraulics of the modeled storm sewer network and stream channels and the hydrology of the watersheds tributary to the conveyance system. The city’s storm sewer database contains pipe diameter data for most of the sewers within the study area; however, database enhancement was necessary to complete the pipe and node data
needed for the SWMM5 model (e.g. invert elevations) and to add the open channel sections of the stormwater conveyance network. Areas tributary to Linden Ditch were previously modeled as noted above; the existing model was provided by the city and incorporated directly into the NWAC stormwater model.

15.1.1 Database Extraction of the Pipe Network

Using the city’s sewer network GIS shape files, the project team developed an inventory of pipes within the NWAC project boundary to be modeled. Pipes ≥24 in. (61.0 cm) diameter within Columbus were extracted to a database that housed the modeling data. Figure 15.2 shows a map of the modeled stormwater collection system (overleaf).

15.1.2 Downstream Boundary Conditions

The downstream outlets of the model were set at each of the outfalls where the storm sewer intersected an open channel. An exception to this was created for the portions of the study area that are tributary to Linden Ditch (approximately the southernmost third of the study area) due to the large area that could be interrelated due to backwater conditions in Linden Ditch. The parts of the study area north of Linden Ditch discharge into multiple smaller unnamed tributaries to Alum Creek.

The areas not tributary to Linden Ditch are assumed to have a free outfall to their streams based on the slope of the streams at the discharge point. Linden Ditch is modeled almost to its confluence with Alum Creek near interstate highway I-670 and is also modeled with a free outfall. The free outfall to Alum Creek is considered a reasonable assumption, given the differences in timing between the Alum Creek watershed and the Linden Ditch watershed and the fact that the purpose of the storm sewer model would not be affected by backwater from Alum Creek.

15.1.3 Catchment Delineation

Stormwater catchments were delineated using the Franklin County auditor’s 2 ft (61 cm) contour interval topographic mapping in conjunction with the City’s storm sewer GIS. Boundaries were drawn utilizing the contour information first and then checked against the storm sewer routing to ensure an accurate delineation had been made. Catchments were delineated to strategic flow loading points within the model, including junctions between multiple storm sewers, outfalls to open channels and pipe size changes.
Figure 15.2 NWAC modeled storm sewer system.
15.1.4 Delineation Results

The five major drainage basins within the NWAC study area were divided into fifteen subbasins based on the flow monitor locations shown on Figure 15.2 above. As seen in Figure 15.3 overleaf, the subsewersheds were further divided into 483 catchments, which range from 0.31 acres (0.13 ha) to 63.6 acres (25.7 ha) area. The average catchment area is 8.99 acres (3.64 ha).

15.2 Hydrologic Data

Each catchment area is characterized by area, hydraulic length and slope, soils, imperviousness, and other parameters that determine the volume and rate of stormwater runoff. Each of these parameters is calculated utilizing a combination of information from the city and the Franklin County auditor’s GIS database, as well as information from the DDR.

15.2.1 Hydraulic Length and Slope

To calculate the hydraulic length and catchment slope, overland flow paths were delineated in GIS. The Franklin County Digital Elevation Model was used to determine the elevation difference along each flow path and calculate the catchment slope.

15.2.2 Soils

The hydrologic soil group allocations were determined for each catchment from the United States Department of Agriculture Soil Conservation Service Soil Survey (USDASCS, 1980) for Franklin County. There are four hydrologic soil groups, denoted by A, B, C and D.

The soil types vary in their parameters such as initial and final infiltration rate, decay rate and total soil storage, which are important in calculating the total runoff from pervious areas. Typical soil parameters were developed for the various soils types and verified through model calibrations. Table 15.1 shows the typical values that were used to simulate soil conditions for each soil type.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Initial Infiltration Rate (in./h) (cm/h)</th>
<th>Final Infiltration Rate (in./h) (cm/h)</th>
<th>Decay Rate (1/sec)</th>
<th>Total Soil Storage (in.) (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12.00 (30.48)</td>
<td>1.00 (2.54)</td>
<td>0.000 556</td>
<td>6.75 (17.15)</td>
</tr>
<tr>
<td>B</td>
<td>9.00 (22.86)</td>
<td>0.50 (1.27)</td>
<td>0.000 556</td>
<td>5.00 (12.70)</td>
</tr>
<tr>
<td>C</td>
<td>6.00 (15.24)</td>
<td>0.25 (0.64)</td>
<td>0.000 556</td>
<td>3.80 (9.65)</td>
</tr>
<tr>
<td>D</td>
<td>4.00 (10.16)</td>
<td>0.10 (0.25)</td>
<td>0.000 556</td>
<td>1.40 (3.56)</td>
</tr>
</tbody>
</table>
Figure 15.3 NWAC modeled storm sewer system (showing catchments).
15.2.3 Impervious Area

To delineate existing impervious cover, two GIS data sources were utilized:

1. The City of Columbus impervious cover GIS shapefile was used to determine the amount of impervious area in commercial areas within the study area; and
2. For residential areas, the Franklin County auditor’s shapefiles for rights of way and buildings was used to delineate impervious cover. Although wider than the roadway, the right of way provides an approximation of the roadway, sidewalks, and driveways that otherwise are not available as GIS polygons.

Figure 15.4 overleaf shows the existing impervious cover in the NWAC study area. Overall, the study area is approximately 44% impervious area.

Estimates of the percentage of impervious area that is routed to pervious surfaces prior to leaving the catchment were derived from the detailed drainage reconnaissance (DDR). The DDR dataset contained the number and type of downspouts for each residential structure in the study area, including disconnected downspouts. The project’s automated decision tree was applied to the DDR dataset to estimate the amount of DIS in each catchment. More information regarding the calculation of DIS is presented in subsequent sections.

15.3 Flow Monitoring and Rainfall Data Analysis

To characterize the flow within the storm sewer system and calibrate the model, flow monitoring and rainfall data was collected from April 2010 to June 2011.

15.3.1 Rain Gauge and Flow Monitor Locations

Four temporary rain gauges were installed within the project area to collect rainfall data in 5 min intervals. Another two city rain gauges close to the study area were also used based on the distance from the study area and the data availability. The rainfall gauges provided higher resolution data for radar rainfall calibration. Table 15.2 lists the meter name and type and Figure 15.4 displays their locations.

<table>
<thead>
<tr>
<th>Meter Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>RG1</td>
<td>Temporary</td>
</tr>
<tr>
<td>RG2</td>
<td>Temporary</td>
</tr>
<tr>
<td>RG3</td>
<td>Temporary</td>
</tr>
<tr>
<td>RG4</td>
<td>Temporary</td>
</tr>
<tr>
<td>RG4350</td>
<td>DIAD</td>
</tr>
<tr>
<td>RG11</td>
<td>City gauge</td>
</tr>
</tbody>
</table>
Figure 15.4 NWAC modeled storm sewer system (showing impervious area).
Fifteen temporary flow meters were installed in the storm sewer system specifically for this project at locations selected to provide a better understanding of the dynamic conditions that exist between the designed sewer reliefs (DSRs) and the storm sewer system, and to provide model calibration data. Figure 15.4 above shows the locations of the rain gauges and flow monitors within and adjacent to the project area. The locations of the temporary flow monitors were selected using the following criteria:

- locations and manholes are easy to access;
- monitors are located at the downstream end of each of the larger watersheds within the study area to calibrate the hydrologic parameters;
- monitors are located at critical locations such as flow diversions/splits or where large trunk sewers confluence to assist in calibrating the hydraulics at these locations; and
- monitors are located near known DSRs to better understand the interactions of DSR and storm sewer.

The drainage areas that are tributary to the meter locations range in size from 38.4 acres (15.5 ha) (meter 66) to 789.9 acres (319.7 ha) (meter 53). Table 15.3 summarizes the flow meter locations and drainage area and Figure 15.3 above displays the drainage areas to each of the meters.

**Table 15.3 Summary of flow meter information.**

<table>
<thead>
<tr>
<th>Meter</th>
<th>Drainage area (acre) (ha)</th>
<th>Total Area to Meter (acre) (ha)</th>
<th>Structure ID</th>
<th>Pipe Size (in.) (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>202.6 (82.0)</td>
<td>202.6 (82.0)</td>
<td>0056T0385</td>
<td>54 (137.2)</td>
</tr>
<tr>
<td>51</td>
<td>91 (36.8)</td>
<td>193.6 (78.3)</td>
<td>0089T0201</td>
<td>48 (121.9)</td>
</tr>
<tr>
<td>52</td>
<td>102.6 (41.5)</td>
<td>102.6 (41.5)</td>
<td>0089T0065</td>
<td>42 (106.7)</td>
</tr>
<tr>
<td>53</td>
<td>248.6 (100.6)</td>
<td>789.9 (319.7)</td>
<td>0130T0999</td>
<td>78 (198.1)</td>
</tr>
<tr>
<td>54</td>
<td>139.8 (56.6)</td>
<td>541.3 (219.1)</td>
<td>0130T0062</td>
<td>78 (198.1)</td>
</tr>
<tr>
<td>55</td>
<td>94.6 (38.3)</td>
<td>401.6 (162.5)</td>
<td>0130T0070</td>
<td>78 (198.1)</td>
</tr>
<tr>
<td>56</td>
<td>152.7 (61.8)</td>
<td>306.9 (124.2)</td>
<td>0129T0243</td>
<td>78 (198.1)</td>
</tr>
<tr>
<td>59</td>
<td>154.2 (62.4)</td>
<td>154.2 (62.4)</td>
<td>0129T0322</td>
<td>54 (137.2)</td>
</tr>
<tr>
<td>60</td>
<td>233 (94.3)</td>
<td>489.3 (198.0)</td>
<td>0179T0133</td>
<td>60 (152.4)</td>
</tr>
<tr>
<td>61</td>
<td>256.3 (103.7)</td>
<td>256.3 (103.7)</td>
<td>0179T0650</td>
<td>54 (137.2)</td>
</tr>
<tr>
<td>62</td>
<td>74.9 (30.3)</td>
<td>74.9 (30.3)</td>
<td>0236T0101</td>
<td>26 (66.0)</td>
</tr>
<tr>
<td>63</td>
<td>67.7 (27.4)</td>
<td>67.7 (27.4)</td>
<td>0236T0026</td>
<td>30 (76.2)</td>
</tr>
<tr>
<td>64</td>
<td>382.1 (154.6)</td>
<td>382.1 (154.6)</td>
<td>0301T0004</td>
<td>66 (167.7)</td>
</tr>
<tr>
<td>65</td>
<td>25.9 (10.5)</td>
<td>408 (165.1)</td>
<td>0301T0958</td>
<td>60 (152.4)</td>
</tr>
<tr>
<td>66</td>
<td>38.4 (15.5)</td>
<td>38.4 (15.5)</td>
<td>0301T0959</td>
<td>30 (76.2)</td>
</tr>
</tbody>
</table>

All but one of the meters (meter 50) are located in the northern two-thirds of the study area because the southern third of the study area contains many smaller disjointed storm sewers and more open channel conveyance. Where possible the meters were located upstream and downstream of DSR locations to gather information on the response of the storm sewer and what effect it might
have on the sanitary sewer system or vice versa. Meter 64 is located just up-
stream of a storm sewer to storm sewer relief point to assist the calibration of
the storm sewer system model at that point.

The flow monitoring data that was being gathered was used to calibrate the
storm sewer system model of the study area for some of the same rainfall
events that are being modeled as part of the sanitary sewer system modeling
effort.

15.3.2 Quality Control of Flow Monitoring Data

Not all of the flow meters gathered valid information for the entire period that
the meters were in the storm sewer. On the dates selected for calibration model-
ing, there was no one event where all fifteen meters gathered accurate velocity
and depth information, nor was there one meter that gathered accurate velocity
and depth information for all of the selected storm events.

15.4 Detailed Drainage Reconnaissance

Field conditions are such that some of the impervious surfaces are disconnected
from one another and routed across pervious surfaces (e.g. grass) prior to
leaving the catchment. This has the effect of reducing the volume and peak of
the runoff. Typically, estimations of the amount of the impervious surfaces that
are directly connected are based on past experience with different land use
types. For example, in typical commercial development all of the impervious
surfaces are connected, while in a residential area it is more likely to be closer
to 50% of the surfaces that are connected.

The current version of SWMM5 allows for a percentage of the runoff gener-
ated from impervious surfaces to be routed across the pervious surfaces prior to
being discharged into the storm sewer system which more closely replicates
what occurs in the field. During the development stages of the stormwater
model, it became apparent that a dataset that details individual parcel drainage
characteristics could be used to identify impervious surfaces that are routed
across pervious surfaces prior to discharge. The DDR collected property
maintenance as well as drainage characteristics on a parcel to parcel basis. This
dataset was used to quantify the percentage of impervious surfaces routed to
pervious surfaces.

The DDR data was gathered utilizing two three-person field crews. Each
crew used a handheld GPS unit with pre-loaded mapping information and pull-
down menus to characterize multiple data parameters for each individual resi-
dential parcel. The primary purpose of the data gathering was to indentify
potential pathways for I/I to enter the sanitary sewer system. Since I/I is storm-
water that is entering the sanitary sewer, much of the data collected could be described as identifying stormwater runoff pathways.

15.4.1 Downspout and Outlet Definitions

The DDR dataset collected the number and type of downspouts for each major structure in residential neighborhoods within the project area. By definition, a downspout is the vertical element of a home’s stormwater collection system. Rainwater generally falls on the roof of a home, is collected in a gutter (horizontal element) and directed to a downspout.

Downspouts can be grouped into five categories according to a combination of their condition and discharge point:

1. Connected: The downspout is physically connected to a pipe that enters the ground. This pipe is then connected to a storm sewer, curb cut, or, in older neighborhoods, the sanitary sewer;
2. Disconnected: The downspout does not connect to a pipe that enters the ground. This condition includes downspouts that discharge drainage to splash blocks, and other means of downspout extensions;
3. Missing: The vertical element is obviously missing from the home. Generally, this leads to a condition that is similar to disconnected;
4. Defective: The vertical element is in a compromised state. It can be dented, severely misaligned or otherwise fail to provide the conveyance properties that were intended when it was installed. This could be similar to either the connected or disconnected conditions; and
5. Unable to determine: The relationship between the downspout and the ground was not able to be seen by field crews.

These conditions can be counted and compared to the total number of downspouts for each major residential structure as a percentage. These percentages can be used in the automated decision tree to determine the potential for impervious area being routed to pervious area on a parcel by parcel level.

15.4.2 Calculating Disconnected Impervious Surfaces

To use the DDR data, the stormwater tributary areas were overlaid with the DDR data. Stormwater tributary areas follow the topography of the project area and are relatively independent of parcel lines. To account for this discrepancy, any parcel that touched a stormwater flow meter boundary was included with that flow meter. This gives a many to one relationship (i.e. parcels on the edges of storm flow meter basins are included in multiple basins), and the user should
never add or subtract the parcel data from one flow meter basin to another. Only relative percentages of one basin to another should be compared. The potential for disconnected impervious surfaces (DIS) was calculated according to the following equation:

\[
\text{DIS} = [\text{Disconnected}] \times 1 + [\text{Missing}] \times 0.5 + [\text{Defective}] \times 0.5 + [\text{Unable to determine}] \times 0.5 \quad (15.1)
\]

where:

\[
[\text{state}] = \text{a percentage of the total number of downspouts.}
\]

It was assumed that 50% of Missing, Defective or Unable to determine are tributary to a pervious surface. The sum of the DIS score per flow meter basin divided by the number of surveyed properties is the DIS for the entire flow meter basin.

For example, for a home with four downspouts, all of which are disconnected would have a DIS potential = 1:

\[
\text{DIS} = \left[\frac{4}{4}\right] \times 1 + [0] \times 0.5 + [0] \times 0.5 + [0] \times 0.5 = 1
\]

Further, a home that has two disconnected downspouts and one connected downspout and one unable to be determined downspout has a DIS Potential = 0.63:

\[
\text{DIS} = \left[\frac{2}{4}\right] \times 1 + [0] \times 0.5 + [0] \times 0.5 + [1/4] \times 0.5 = 0.63
\]

If the flow meter basin contained only these two properties, DIS should be \((1 + 0.63) / 2 = 0.82\); or 82% of the impervious surfaces are tributary to a pervious surface.

**15.4.3 DDR Data Analysis Summary**

The data is summarized in Table 15.4 below. The proportion of disconnected impervious surfaces varies even in heavily residential basins, from a maximum of 68% of properties in NW51 to a relatively low 36% in NW63.

There are large areas in basins NW50, NW56, NW59 and NW64 that were not evaluated during the DDR as they are outside of the study area. They are denoted by an asterisk (*) in Table 15.4. The portions of the tributary area that are outside the NWAC study area were visually reviewed and then given the same percentage value as the rest of the tributary area since the land uses of the areas outside the study area were similar to those inside the study area.

Each of the subcatchments that contained significant commercial development areas was identified visually and the percentage of impervious surfaces routed to pervious surfaces was decreased to 0 in order to more accurately represent the field conditions. In areas that did not have observed flow meter data, 50% of the impervious surfaces were routed to pervious surfaces.
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Table 15.4 Disconnected impervious surfaces.

<table>
<thead>
<tr>
<th>Stormwater Basin</th>
<th>Number of Surveyed Residential Properties</th>
<th>Number of Potential Properties DIS</th>
<th>Percentage D = C / B</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW51</td>
<td>402</td>
<td>272.60</td>
<td>68%</td>
</tr>
<tr>
<td>NW52</td>
<td>515</td>
<td>292.34</td>
<td>57%</td>
</tr>
<tr>
<td>NW65</td>
<td>74</td>
<td>39.06</td>
<td>53%</td>
</tr>
<tr>
<td>NW53</td>
<td>1,136</td>
<td>599.12</td>
<td>53%</td>
</tr>
<tr>
<td>NW54</td>
<td>438</td>
<td>226.81</td>
<td>52%</td>
</tr>
<tr>
<td>NW62</td>
<td>266</td>
<td>137.48</td>
<td>52%</td>
</tr>
<tr>
<td>NW60</td>
<td>796</td>
<td>399.88</td>
<td>50%</td>
</tr>
<tr>
<td>*NW50</td>
<td>259</td>
<td>128.97</td>
<td>50%</td>
</tr>
<tr>
<td>*NW56</td>
<td>667</td>
<td>326.25</td>
<td>49%</td>
</tr>
<tr>
<td>NW61</td>
<td>495</td>
<td>242.84</td>
<td>49%</td>
</tr>
<tr>
<td>*NW59</td>
<td>532</td>
<td>258.58</td>
<td>49%</td>
</tr>
<tr>
<td>NW55</td>
<td>422</td>
<td>192.62</td>
<td>46%</td>
</tr>
<tr>
<td>NW66</td>
<td>213</td>
<td>94.93</td>
<td>45%</td>
</tr>
<tr>
<td>*NW64</td>
<td>586</td>
<td>255.92</td>
<td>44%</td>
</tr>
<tr>
<td>NW63</td>
<td>287</td>
<td>103.77</td>
<td>36%</td>
</tr>
</tbody>
</table>

15.5 Wet Weather Flow Model and Calibration

15.5.1 Wet Weather Flow Calibration Events Selection

Calibration events for the storm sewer modeling were selected to coincide with events chosen for validation of the sanitary sewer model. A review of the velocity and depth data was also undertaken to ensure that the events chosen generated a system response within the storm sewer. Each of the possible events had a return interval of less than a 1 year event and three of the six possible events were less than a 6 month event. A summary of the possible calibration events is shown in Table 15.5.

Table 15.5 Summary of possible calibration events.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date (M/D/Y)</th>
<th>Total Storm Volume (in.)</th>
<th>Peak 5 min Storm Intensity (in.)</th>
<th>Storm Duration (h)</th>
<th>Antecedent Dry Day (d)</th>
<th>Recurrence Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/11/10</td>
<td>1.02 (2.59)</td>
<td>0.07 (0.18)</td>
<td>7.72</td>
<td>3.04</td>
<td>&lt; 3 month</td>
</tr>
<tr>
<td></td>
<td>5/12/10</td>
<td>0.42 (1.07)</td>
<td>0.05 (0.13)</td>
<td>9.33</td>
<td>0.56</td>
<td>&lt; 2 month</td>
</tr>
<tr>
<td>2</td>
<td>5/21/10</td>
<td>0.71 (1.80)</td>
<td>0.06 (0.15)</td>
<td>24.89</td>
<td>1.47</td>
<td>&lt; 2 month</td>
</tr>
<tr>
<td>3</td>
<td>6/2/10</td>
<td>0.93 (2.36)</td>
<td>0.27 (0.69)</td>
<td>2.40</td>
<td>2.05</td>
<td>&lt; 6 month</td>
</tr>
<tr>
<td>4</td>
<td>6/26/10</td>
<td>1.16 (2.95)</td>
<td>0.40 (1.01)</td>
<td>3.92</td>
<td>10.78</td>
<td>&lt; 6 month</td>
</tr>
<tr>
<td></td>
<td>6/27/10</td>
<td>1.22 (3.10)</td>
<td>0.24 (0.61)</td>
<td>10.83</td>
<td>0.45</td>
<td>&lt; 4 month</td>
</tr>
<tr>
<td>5</td>
<td>7/9/10</td>
<td>1.01 (2.57)</td>
<td>0.18 (0.46)</td>
<td>8.08</td>
<td>9.85</td>
<td>&lt; 3 month</td>
</tr>
<tr>
<td>6</td>
<td>7/12/10</td>
<td>1.80 (4.57)</td>
<td>0.27 (0.69)</td>
<td>10.05</td>
<td>2.15</td>
<td>&lt; 1 y</td>
</tr>
<tr>
<td></td>
<td>7/13/10</td>
<td>0.93 (2.36)</td>
<td>0.16 (0.41)</td>
<td>4.87</td>
<td>0.54</td>
<td>&lt; 3 month</td>
</tr>
</tbody>
</table>
15.5.2 Radar Rainfall Totals for Calibration Events

Rainfall data from each of the rain gauges was studied for each of the calibration events. As expected, given the size of the study area, each of the events showed both spatial and temporal variations in rainfall for the events. In order to generate more accurate rainfall data over the study area, radar rainfall data was used.

15.5.3 Wet Weather Flow Calibration Process and Results

The initial creation of the storm sewer model routed all the runoff generated during a rain event to the outlet of the subcatchment. This represents a condition where all of the impervious surfaces are connected one to one another, which results in short travel times for runoff and higher peak flow rates; it is also not representative of the conditions in the subcatchment.

Once the percentage of impervious surface routed to pervious surface parameters was incorporated into the storm sewer model the model was largely calibrated. When looking at the results of the calibration events, no one event showed that all fifteen meters were fully calibrated and no one meter was fully calibrated for all four events. What was apparent was that the velocity data obtained from the meters was too inconsistent to be used as a primary calibration tool. There are many reasons for the inconsistent quality of data, including the fouling of the velocity meter by debris in the storm sewer, but the more likely reason is that the water in the pipe was too clean to accurately register a velocity. Velocity meters depend on radar signals bouncing off of particles in the flow stream to record the velocity; however, if there are few particles in the flow, it is harder for the meter to accurately register flow.

Figures 15.5 and 15.7 are examples of the results of the modeling before the implementation of the DIS parameters and Figures 15.6 and 15.8 are examples of the results with DIS implemented in the model. Results from other meters within the study area did not show consistent results. No one meter location showed consistent calibration results for all four rain events, and no one rain event showed consistent calibration results for all fifteen meter locations. Since the primary purpose of the overall study is to indentify sources of I/I to the sanitary sewer, and is not to study the storm sewer in great detail, the results of the calibration were deemed sufficient for the project goals. In order to more fully calibrate the model, additional data would have to be gathered including, but not limited to, the physical condition of the storm sewer network and the location of debris within the system for each event. This level of detail was not collected as part of this project.
Figure 15.5  Meter NW53 100% routed to the outlet.

Figure 15.6  Meter NW53 DIS implemented.
15.6 Discussion

The detailed information gathered as part of this study corroborated this general assumption, but did find that some areas can vary greatly from that assumption. In this particular study, the availability of the data to calculate a DIS percentage rather than making assumptions provided a greater level of accuracy in the modeling results as well as generating greater confidence in the model. Even though there is greater confidence in the modeling results, if less information
had been available for the study area a model could still have been created using standard modeling practices that would generate the same results. In this particular case the high level of detailed information was available and used to benefit the overall project. For other study areas that have observed data from the storm sewer but cannot reach calibration without changes to the DIS percentages the methodology outlined here could be used to gather field data to calculate a more representative DIS.

15.7 Conclusions

As of the time of this writing, the project is still ongoing. Future uses of the storm sewer model will involve the analysis of the potential for impacts on the storm sewer from the removal of I/I from the sanitary sewer. Findings to date indicate that the storm sewer has little to no direct impact on the sanitary sewer. However, it is possible that removing I/I from the sanitary sewer could have an adverse impact on the capacity of the storm sewer.

15.8 References

CIP 650405.7 Report. City of Columbus, Ohio, Northwest Alum Creek Area Sanitary Sewer System Inflow and Remediation Project