RANSOM
Consulting, Inc.

Consulting
Engineers
and Scientists

May 31, 2013 Project 111.01095.008

Mr. Chris Moretti
Gershman Brown Crowley, Inc.
14 Breakneck Hill Road, Suite 101
Lincoln, Rhode Island 02865

RE: Analysis of Potential Hydraulic Mounding Effects
Proposed Subsurface Stormwater Infiltration System
Proposed CVS Pharmacy/Store No. 10129
Washington and Swanton Streets
Winchester, Massachusetts

Dear Chris:

Ransom Consulting, Inc. (Ransom) has completed an analysis of potential hydraulic mounding that would occur beneath the proposed subsurface stormwater infiltration system for the proposed CVS Pharmacy, Store No. 10129, in Winchester, Massachusetts (the Site) during a 1-percent-probability (i.e., 100-year storm) rainfall event. As described below, our analysis included the use of a three-dimensional numerical groundwater flow model to simulate transient groundwater table conditions and determine peak mounding levels.

This report has been prepared to describe our analytical approach and present a summary of our findings. Based on our analysis, mounding conditions that may occur as a result of subsurface stormwater disposal at the Site will **not** impact neighboring properties. Furthermore, mounding will not result in significant changes to groundwater flow patterns in that portion of the Site where elevated concentrations of petroleum have been documented in the subsurface soils and groundwater.

CONCEPTUAL MODEL CONSIDERATIONS

Proposed Subsurface Disposal System

The proposed subsurface disposal system (also referred to herein as the "basin"), designed by R. J. O'Connell & Associates, Inc. (R. J. O'Connell) of Stoneham, Massachusetts, will be approximately 79.5 feet wide by 87 feet long and will be positioned in the western portion of the Site (see attached Figure 1). The basin will consist of ten rows of 60-inch-diameter pipes approximately 75 feet in length, with two rows of 60-inch-diameter connecting pipes, each approximately 77.5 feet long. The system has been designed to hold the 100-year, 24-hour storm as represented in a design stormwater inflow hydrograph developed for the proposed system. The base of the proposed system will be at approximate elevation 40.0 feet (NAVD88), which is a minimum of 4 feet above the interpreted seasonal high groundwater table at the Site. During the 100-year storm, when the system is filled to capacity, water will rise in the pipes to approximately elevation 44.16 feet (as per design calculations performed by R. J.

O'Connell). Once the infiltration basin has reached its peak volume capacity (elevation 44.16 feet), water will infiltrate into the subsurface soils over a period of approximately 25.5 hours following the peak of the storm, at which point the basin will be empty.

In our numerical simulations of the proposed disposal system, we assumed that the system would be filled with water according to the design inflow hydrograph and that, once the peak water level (44.16 feet NAVD88) was reached, water would infiltrate steadily, causing the head in the pipes to decrease to the invert (empty) elevation of 40.0 feet over the following 25.5 hours.

Site and Regional Geologic Setting

Based on recent site investigations by Ransom (see January 25, 2013, letter report "Test Pits and Infiltration Testing"), soil beneath the location of the proposed infiltration system consists of 4 to 5.3 feet of fill material overlying native glacial till, generally described as brown to gray, fine to coarse sand with varying amounts of silt, gravel, cobbles, and boulders. Based on Site soil borings, the till ranges in thickness from about 7.5 to 17 feet. Till overlies bedrock mapped as Dedham granite in the vicinity of the Site and is bounded by metamorphosed mafic rocks forming the hills to the east and diorite/gabbro metavolcanics in the valley of the Aberjona River to the west of the Site (Wones & Goldsmith, 1991, *Intrusive Rocks of Eastern Massachusetts*; Zen et al., 1983, *Bedrock Geologic Map of Massachusetts*).

We represented Site and regional geology by constructing a three-dimensional finite-difference model with two layers, the top layer representing till and the bottom layer representing the bedrock. Our model extended out from the Site to include the hills to the east and the Aberjona river valley to the west (see Figure 2, attached). The top and bottom of Layer 1 and the top of Layer 2 were sloped according to our site information and regional topography to match the approximate slope of each geologic unit. The model grid was aligned to run approximately parallel to the regional slope (ESE to WNW) to facilitate this (Figure 2). Layer properties such as recharge, storage, and hydraulic conductivity were chosen based on our site data, field and laboratory hydraulic conductivity and grain-size analyses, and the general characteristics of the geologic units from regional mapping.

Site and Regional Hydrology

The seasonal high groundwater table is estimated to reach an elevation of about 35.8 feet NAVD88 at the location of TP-104 within the footprint of the proposed subsurface infiltration system (Figure 1). Under normal conditions, the groundwater table is several feet lower. Based on water level measurement in Site monitoring wells, the groundwater table is typically at or near the bedrock surface at the base of the till in many locations, indicating that much of the till unit is unsaturated. Based on regional geologic mapping and topography, we assume that the regional groundwater table more or less mimics the topography. However, it is likely that the surficial deposits are thinner and less saturated in the upland areas (hills to the east) and become thicker with a shallower water table nearer the Aberjona River, which likely acts as a regional hydraulic discharge feature. In the model, we included the Aberjona as a discharge boundary condition along the west side of the model. To the east, we input a drain (head-dependent boundary) feature to maintain a realistic hydraulic head near the base of the steeper topography along Highland Avenue.

These hydraulic boundaries control the shape and slope of the simulated regional phreatic surface (unconfined groundwater table) in the model but are at a sufficient distance from the Site to prevent undue influence on simulated groundwater flow and mounding effects at or near the Site.

SELECTION OF MODELING CODE AND MODEL CONSTRUCTION

We elected to use the MODFLOW flow modeling code for our numerical simulations. MODFLOW, (McDonald and Harbaugh, USGS, 1988) is a three-dimensional, finite-difference, saturated flow model. The MODFLOW code is widely used and accepted for representative modeling purposes. The software that we used to build and run the MODFLOW model was Groundwater Vistas (Version 6.11 Build 8) developed by J. and D. Rumbaugh (c. 1996–2011). Groundwater Vistas allows import of Site and regional features from an ArcGIS database developed for this Site and export of modeling results back to ArcGIS for presentation as included in this report.

The model for the Site was constructed in two layers, as mentioned above, the top layer representing till and the lower layer representing the bedrock. The areal extent of the model measures 5,400 feet by 4,000 feet, encompassing about 496 acres. The geometry of the finite-difference grid includes 221 rows and 297 columns. Grid spacing varies from 20 feet by 20 feet away from the Site to a finer discretization of 10 feet by 10 feet on and near the Site. Precipitation recharge enters the model in the top layer. Water discharges from the model at the hydraulic boundaries, particularly the Aberjona River, which represents the downgradient discharge feature in the model. Till and bedrock properties are input in individual cells of the model and are summarized as ranges of values used below (Table 1).

Table 1: Flow Model Hydrogeologic Properties

	Hydraulic Conductivity (ft./day)[1]	Effective Porosity	Specific Storage (1/ft.)	Recharge (inches/year)
Layer 1 (Till)	0.1 to 8	0.15 to 0.28	0.0005 to 0.001	4 to 7.7
Layer 2 (Bedrock)	0.001 to 0.15	0.05 to 0.1	0.00001	--

[1]Till values based on analysis of Site soil samples and infiltration testing; other values based on estimated values in literature for similar geologic materials.

As described below, property values were varied within the ranges shown in Table 1 in order to bring the model to a "calibrated" state where simulated groundwater flow conditions are representative of actual conditions based on Site water level data and regional interpretation.

MODEL CALIBRATION

Parameter values within the model framework, particularly hydraulic conductivity within the till layer, were varied in order to match the simulated groundwater phreatic surface with the interpreted location of the seasonal high groundwater table based on groundwater level measurements taken from Site monitoring wells. Figure 3 contains a graphical depiction of observed (field values) versus simulated phreatic surface elevations for the calibrated flow model. This figure shows that a reasonable match was obtained with a mean residual error of less than 0.1 foot and a root mean squared (RMS) error of 0.7 feet.

For predictive mounding simulations (see below), additional recharge was added to achieve a simulated phreatic surface that reflects the worst case or highest possible seasonal high groundwater table based on the interpreted maximum groundwater elevation of 35.8 at TP-104. We believe this represents a very conservative scenario, where the groundwater has reached an unusually high condition during or prior to a significant (100-year) rainfall event). The shape of the simulated phreatic surface (Figure 4, attached) is consistent with our interpretation of the groundwater flow directions based on Site data.

PREDICTIVE SIMULATIONS FOR 1% CHANCE RAINFALL EVENT (100-YEAR STORM)

The proposed subsurface infiltration system was incorporated into the model as a group of head-dependent cells in Layer 1. In each cell, the hydraulic head could be specified above a "bed" elevation of 40.0 feet NAVD88, which represents the bottom of the proposed system. For the simulated 100-year storm, we specified that water would rise in each of these cells to an elevation of 44.16 feet to represent the full condition. After the peak head was reached in the disposal system, the head was allowed to decrease steadily for 25.5 hours until the system was empty, thereby representing complete infiltration of all the collected stormwater into the underlying till. During this transient simulation, the phreatic surface was monitored at frequent time-intervals to determine when the peak in hydraulic mounding occurred beneath the disposal system. The simulated peak in mounding occurred at about 15 hours after the beginning of the storm. This is about 2 hours after the peak in the stormwater inflow hydrograph.

Figure 5 shows the magnitude of simulated peak mounding in the phreatic surface. This represents the worst-case scenario where a large storm event occurs when groundwater levels are at the seasonal high. During a typical rainfall event (e.g., 2-year, 24-hour storm), mounding effects would be substantially less than shown in Figure 5. At the peak of hydraulic mounding for the 100-year storm, a portion of the water table directly beneath the infiltration system reaches a mounding height at or near the bottom of the system (about 4 feet above the seasonal high groundwater table). The magnitude of hydraulic mounding decreases in an approximately radial direction from the center of the system. Due to the flow direction of the groundwater system and the slope of the bedrock surface, the effects of mounding are slightly greater toward the west and southwest (i.e., in the approximate direction of the regional groundwater flow gradient). Mounding effects are minimized to the east and northeast toward the center of the Site and the location of the interpreted petroleum-impacted groundwater plume. This degree of mounding will not affect the plume configuration and/or contaminant concentrations.

As shown in Figure 5, mounding effects beyond Site boundaries are minimal and are not sufficient to cause surface breakout, as the resultant groundwater table will remain at several feet below the ground surface at the property boundary, even under peak mounding conditions. Therefore, hydraulic mounding related to the proposed infiltration system will not cause adverse impacts to offsite properties.

SUMMARY OF RESULTS

As described in the preceding sections of this letter report, a three-dimensional numerical model was conducted to simulate the potential effects of hydraulic mounding that would occur beneath a proposed subsurface stormwater infiltration basin during a 100-year storm event. The results of our mounding analysis indicated the following:

1. The peak of hydraulic mounding beneath the system occurs about 2 hours after the peak of the stormwater inflow hydrograph;
2. Mounding rises to at or near the bottom of the infiltration system, then begins to decrease;
3. Mounding effects are minimal in the vicinity of the interpreted petroleum-impacted groundwater plume and will not impact the plume; and
4. Mounding effects are minimal at Site boundaries and will not impact off-site properties.

The groundwater flow model presented herein is a mathematical representation of the groundwater system and geologic setting. Due to the natural complexity of these entities, a model can only achieve a simplified representation of the actual system and therefore must be considered as a generalized screening tool for use in studying this Site. Furthermore, the calibration and validation of any model is limited by the availability and accuracy of field data and historical records of site activities.

This letter report and attached documents have been prepared for the exclusive use of Gershman Brown Crowley, Inc. in reference to the Site. All other uses are not authorized unless written permission is obtained from Ransom.

Please feel free to contact us anytime with questions or comments regarding this project.

Sincerely,

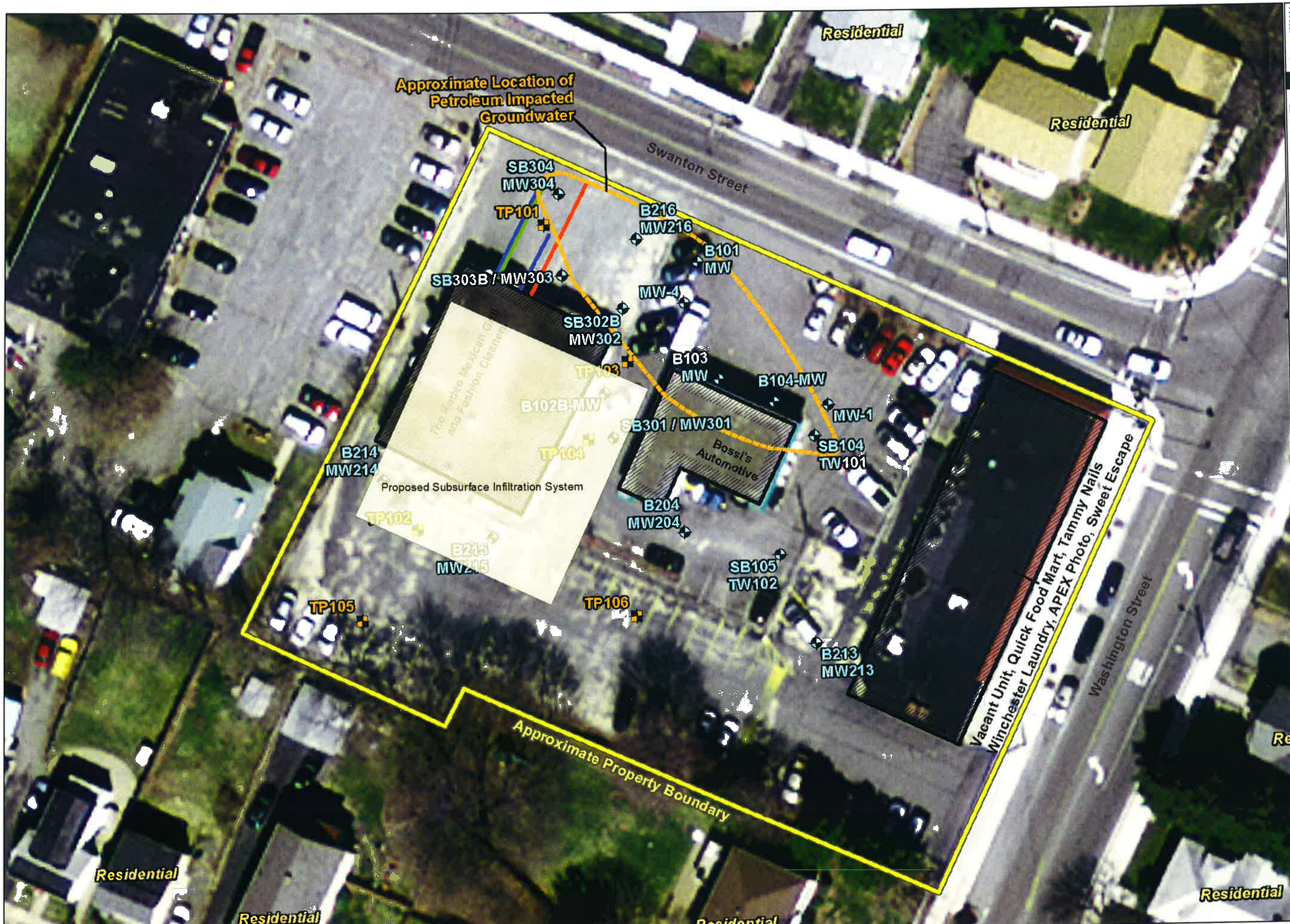
RANSOM CONSULTING, INC.

Michael D. Abbott, P.E., C.G.
Senior Engineer & Geologist

Brian Pettingill
2013.05.31 12:37:47
-04'00'

Brian R. Pettingill, P.G.
Senior Project Manager/CVS Program Manager

MDA/HED/BRP:jsh
Attachments



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Legend

Proposed Infiltration System

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Notes

1. Site Plan based on 2008 Orthoimagery and Ransom site data
2. Some features are approximate in location and scale
3. This plan has been prepared for Gershman Brown Crowley, Inc.. All other uses are not authorized unless written permission is obtained from Ransom Environmental Consultants, Inc.

Scale and Orientation

0 5 10 20 30 40
Feet

Prepared For

Gershman Brown Crowley, Inc.
14 Breakneck Road, Suite 101
Lincoln, Rhode Island

Site Address

10 -12 Swanton Street
Winchester, Massachusetts

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Figure 1
Site Plan

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Legend

- Site
- Boundary Feature
- Model Grid

N

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Scale and Orientation

0 200 400 600 800
Feet

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Figure 2
Model Grid Layout

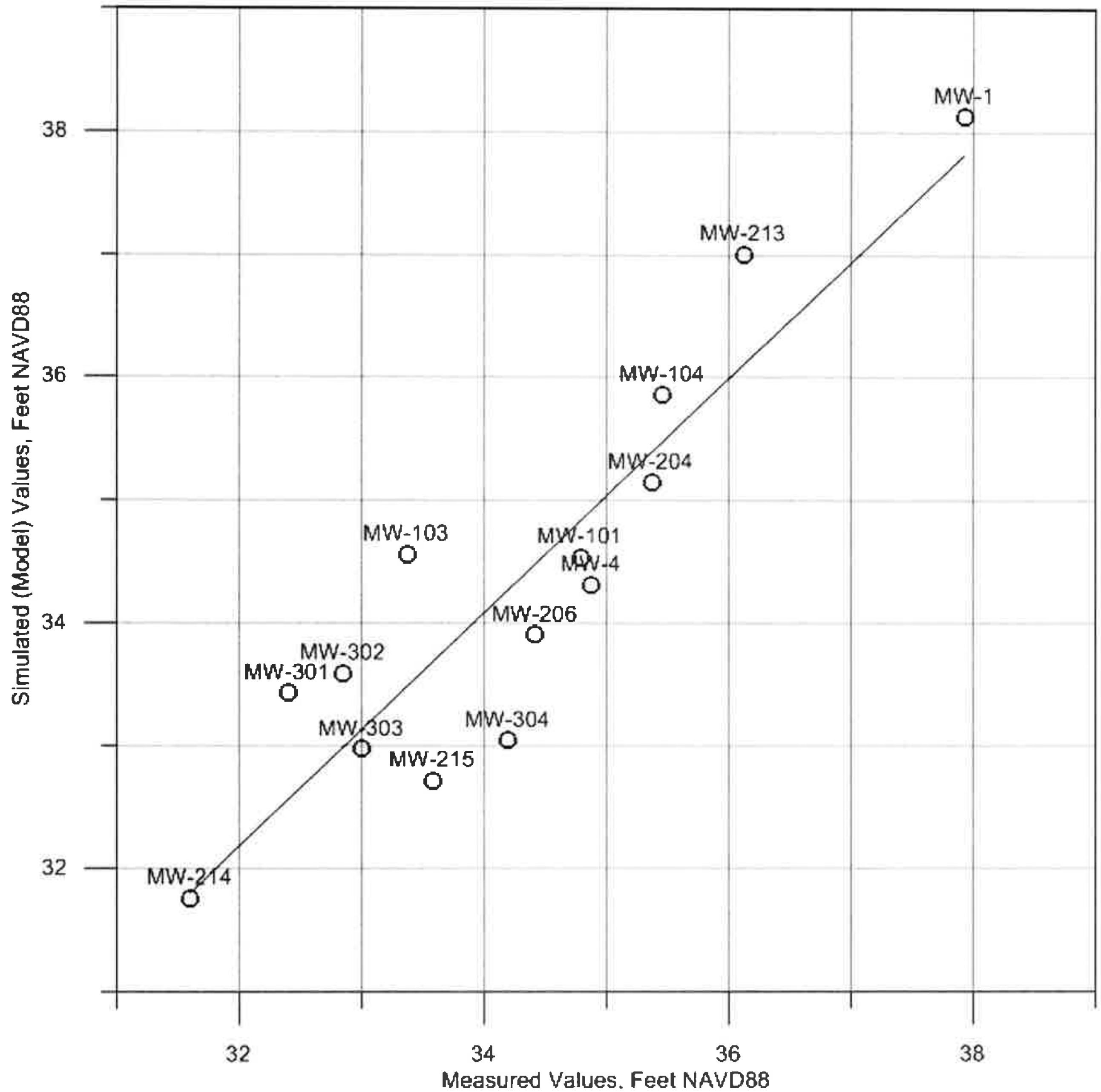

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Figure 3
Observed vs. Simulated Head Values
Calibrated Phreatic Surface
10-12 Swanton Street
Winchester Massachusetts

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Legend

- Simulated High GW Table
- Calibration Wells
- Model Grid
- Proposed Infiltration System

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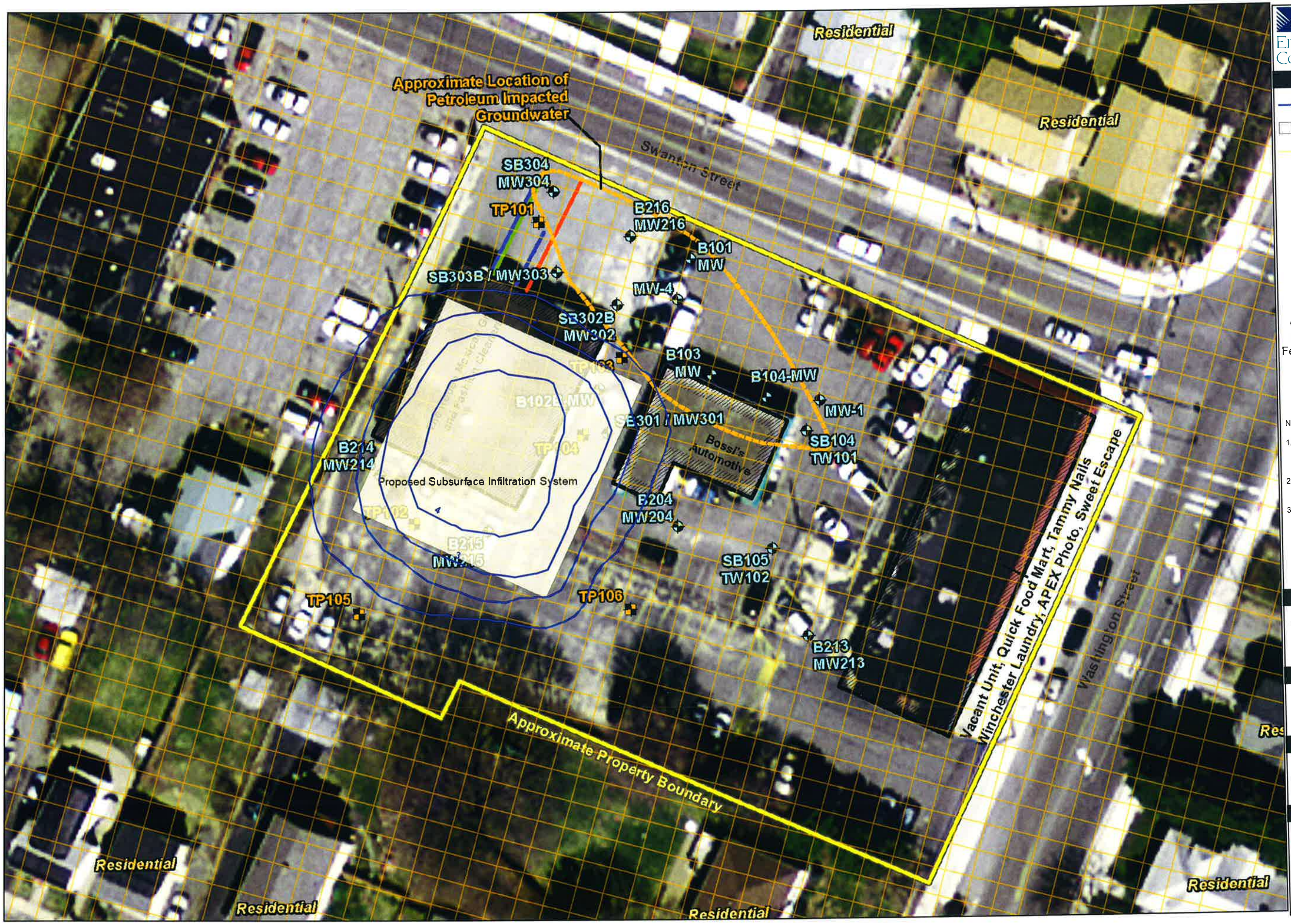
Figure 4
Simulated Seasonal High Groundwater Table



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Legend

- Simulated Mounding
- Proposed Infiltration System
- Model Grid

N

Contours Indicate Peak Hydraulic Mounding in Feet Above Seasonal High Groundwater Table for 100 Year Storm

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Scale and Orientation

0 5 10 20 30 40
Feet

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Figure 5

Simulated Mounding for 100 Year Storm