GeoHydroCycle, Inc.

Hazardous Waste
Water Supply

Assessment
Remediation
Analyses
Permitting
Modeling
Software

March 4, 2016

Mr. Daniel Ruiz
Permitting Manager
Capital Group Properties
259 Turnpike Road, Suite 100
Southborough, MA 01772

re: Groundwater Modeling Evaluation
Proposed Development
133 West Union Street
Ashland, MA
GHC #15036

Dear Mr. Ruiz:

GeoHydroCycle, Inc. (GHC) is pleased to provide Capital Group Properties this letter report summarizing the results of our review and evaluation of hydrogeologic information related to the proposed development at 133 West Union Street in Ashland, MA 01721 (the Site). GHC focused the review on information about the drainage and subsequent recharge of groundwater from two retaining walls at the Site. Based on plan sets[1] obtained from Guerriere & Halnon, Inc., GHC understands that perforated pipes (drains) upgradient of two retaining walls will drain groundwater from behind the walls and discharge the water to trenches and basins located at other portions of the Site.

GHC's work included: 1) a review of test pit information performed by Guerriere & Halnon, Inc.; 2) a review of the plans for the wall drains, trenches and basins; 3) a review of soil boring and test pit information performed by Paul B. Aldinger Associates, Inc. including test pits, grain size analyses, and general soil descriptions; and 4) preparing a groundwater flow model to evaluate the hydrologic effects of draining groundwater from behind the retaining wells and discharging that water to other site locations. For GHC’s work, the hydrologic effects are related to changes in groundwater elevations that result in changes in flow in the intermittent stream.

[1] Plan set prepared by Guerriere & Halnon, Inc. entitled *"Proposed Site Plan for 133 West Union Street in Ashland, Massachusetts"* dated November 4, 2015 and revised November 21, 2015.

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1.0 Review of Geohydrologic Information

The objectives of GHC's work included: 1) develop an understanding of site conditions and Guerriere & Halnon's and Aldinger's work; 2) evaluation of the data relative to the characterization of Site geohydrology for groundwater modeling; 3) based on a groundwater model, determining the changes to flows in the intermittent stream during a typical spring; and 4) based on the modeling results developing conclusions.

To achieve these objectives, GHC’s review included the relevant portions of the following documents provided by either the Capital Properties Group or Guerriere & Halnon, Inc.

- Guerriere & Halnon, Inc. Proposed Site Plan for 133 West Union Street in Ashland, MA. Dated 11/4/15, revised 11/20/15.
- Guerriere & Halnon, Inc. AutoCAD files showing retaining wall drains, infiltration trenches, infiltration basins and retaining wall drain elevations.
- Guerriere & Halnon, Inc. Test pit Logs dated 9/23/13 and 1/29/14.
- Paul B. Aldinger & Associates, Inc. Preliminary Geotechnical Engineering Letter, 133 West Union Street, Ashland, MA PBA No. 14030, dated 8/6/14
- Paul B. Aldinger & Associates, Inc. Boring Logs (9/25 and 9/26/14), Test Pit Logs (9/24/14) and Subsurface Location Plan (2/21/14), 133 West Union Street, Ashland, MA PBA No. 14021.

GHC’s review was focused on geohydrologic information in the areas of the retaining walls and the infiltration trenches and basins within the Site property. Some of the information provided to GHC by Guerriere & Halnon related to the geotechnical properties of Site soils and design details of the retaining walls, retaining wall drains, infiltration trenches, and infiltration basins. Review of geotechnical information was not considered part of GHC’s work. GHC’s review of the design details for the retaining walls, retaining wall drains, infiltration trenches/basins was limited to the drain locations, drain elevations, where the drains discharged, and the size and location of the infiltration trenches/basins. The design of the drains, trenches and basins were done by Guerriere & Halnon, and GHC’s work did not include a review or evaluation of the analyses or calculations performed by Guerriere & Halnon.

GHC did not conduct a Site visit, perform any subsurface exploration, or do any independent testing as part of our work. GHC’s work is based on work performed and reported by others for different objectives rather than the collection of detailed data to characterize the Site geohydrology.

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2.0 Retaining Wall Drains, Infiltration Trenches/Basins and Geohydrology

Retaining Wall Drains, Infiltration Trenches/Basins

As illustrated in Figure 1, the Site is located in south central Ashland at 133 West Union Street (Route 135). The approximate 7.7 acre Site is on the west side of West Union Street and a portion runs parallel to West Union Street. As Figure 2 shows, most of the Site lies within a 40.1 acre watershed boundary established from a point on the intermittent stream where it exits the northern Site boundary.

Based on AutoCAD files obtained from Guerriere and Halnon, GHC prepared Figure 3 showing Site features, including locations of the intermittent stream, the wetland setbacks, retaining walls, the retaining wall drains, the infiltration trenches, and the infiltration basins. It is GHC's understanding that the retaining wall drains are designed to remove groundwater from behind the retaining walls and to discharge that water into infiltration trenches and/or basins elsewhere on the Site.

Based on our understanding, because the water being removed by the drains is being returned to groundwater by the trenches and basins at different locations, no water is lost from the aquifer and the resulting flow in the stream is unchanged where it leaves the Site.

As GHC understands the design of the drains and infiltration trenches/basins related to our work, their properties include:

Table 1. Drain, Trench and Basin Properties.

Unit	Length (ft)	Width (ft)	Elevation (MSL)
Retaining Wall Drain 1	211.0	0.5	261.0
Retaining Wall Drain 2	170.0	0.5	276.0
Retaining Wall Drain 3	163.0	0.5	269.8
Retaining Wall Drain 4	102.0	0.5	269.8
Infiltration Trench 1	42.4	3.0	-
Infiltration Trench 2	125.2	3.0	-
Infiltration Trench 3	170.0	3.0	-
Infiltration Basin 1	37.6	58.5	-
Infiltration Basin 2	37.6	58.5	-

Notes:
1. See Figure 3 for locations.
2. Information provided by Guerriere & Halnon, Inc.

Geohydrology

Based on soil borings and test pits performed by Aldinger, soils beneath the Site that have an effect on groundwater flow consist of dense, coarse sands and gravels with varying amounts of silt, cobbles and boulders. This type of soil is generally classified as a sandy glacial till.

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GHC reviewed five laboratory grain size analysis of glacial till samples collected by Aldinger during 7/21/14 test pit excavations. We analyzed four of the grain size data sets (TP-1, TP-4, TP-5 and TP-6) for saturated hydraulic conductivity using a method developed by Kasenow[2]. The results of GHC's calculations show a hydraulic conductivity range of between 9.6 and 26.4 feet per day. This range of values is within the published range of hydraulic conductivity for glacial tills in Southern New England[3].

GHC reviewed the 7/23/14 and 7/24/14 soil borings advanced by Aldinger. Soil borings B-4, B-6 and B-7 revealed a thickness of the saturated soils beneath the Site ranged between 8.5 and 15.2 feet.

3.0 Groundwater Model Development and Simulation

GHC accomplished the groundwater flow modeling for the Site with the widely used and accepted numeric groundwater model, MODFLOW. Input parameters to the model were based on CAD files obtained from Guerriere & Halnon, and our review of the Site geohydrologic data.

3.1 Conceptual Model

In developing the groundwater model to simulate groundwater flow beneath the Site, GHC prepared a conceptual model of the aquifer. Features of the conceptual model include:

1. The aquifer is unconfined with the water table as the upper surface;
2. The first stage of modeling will be the calibration of a base model without drains, trenches or basins. Using the calibrated model, the drains, trenches and basins can be included in a second stage to simulate groundwater changes that could have an effect on the intermittent stream;
3. Stream effects in MODFLOW can be determined using the Zone Budget feature to determine relative amounts water into or out of the stream before and after the drain, trench and basin system.
4. Steady-state calibration of the model can be accomplished using estimated seasonal high groundwater levels from Site test pits;
5. Modeling of the drain, trenches and basins can be done under steady-state, spring seasonal high groundwater to represent worst-case conditions.
6. The intermittent stream can be modeled as a river boundary in MODFLOW, because during the spring it carries runoff. Stream elevations can be based on the intersection of Site topographic contours with the stream course;

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[2] *Kasenow, M. and H. Feng, Determination of Hydraulic Conductivity from Grain Size Analysis, Water Resources Publications LLC, 2002.*

[3] *R.L. Melvin, deLama, V., and Stone, B.D. The Stratigraphy and Hydraulic Properties of Tills in Southern New England. USGS OFR 91-481.*

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7. Aquifer hydraulic conductivity can be estimated using the analyses of grain size curves;
8. The aquifer can be simulated as homogeneous and isotropic with a single value for hydraulic conductivity;
9. No flow boundaries can be used to form the outline of the 40.1 acre watershed boundary;
10. Retaining wall drains can be simulated as drain modules in MODFLOW;
11. Infiltration trenches and basins can be modeled as recharge in MODFLOW; and
12. The recharge module in MODFLOW can also be used to provide water for the model.

The data GHC reviewed for this work is generally sufficient to develop an understanding of aquifer conditions for the groundwater modeling. However, additional data obtained from groundwater monitoring wells, including groundwater levels, hydraulic conductivity testing, and soils descriptions would normally be done to develop a groundwater flow model.

<u>Groundwater Model and Results</u>

GHC has prepared Figures 4 through 7 showing the layout of the Calibration Model and the Prediction Model. Figure 4 shows the general layout of the model at a watershed scale. Figure 5 shows details of the drain, trench and basin system in relation to the intermittent stream. Figure 6 shows the results of the model calibration process.

Using the Calibrated Model, GHC activated the drains, trenches and basins in order to predict effects of the drain system. The results, presented in Figure 7, show the changes in groundwater levels beneath the drains, trenches and basins. As the figure demonstrates, groundwater around the wall drains is lowered, and groundwater beneath the trenches and drains is raised.

To determine effects of the drains, trenches and basins on flow to or from the intermittent stream, GHC used the budgeting feature in MODFLOW. This feature shows the rate of water either entering or leaving the stream, and was used by GHC to show the changes with and without the proposed drain system. Figure 8 shows the location of the eleven budgeted stream sections, and a table showing the flow to or from the stream and the percent change.

Based on the results, and as the table in Figure 8 shows, it is my professional opinion that the overall change in groundwater flow to or from the intermittent stream during the spring is minimal and will not adversely effect the wetland stream. Because groundwater flow to or from the stream is balanced through discharging all the water removed by the drains into the infiltration trenches and basins, the change of 1.7 percent in Table 2 is mostly due to errors in model budgeting. Other factors that indicate changes to the stream will be minimal include: 1) the stream is intermittent and these

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conditions will not exist year-round; and 2) the model is set up to be conservative and the drain, trench and basin system will likely transfer less water.

If you have any questions, please call me.

Sincerely,
GeoHydroCycle, Inc.

Stephen W. Smith, P.E., P.HGW.

Enclosures: 1 - Figures

cc: Mr. Scott Goddard, Goddard Consulting

Ashland Report.lwp

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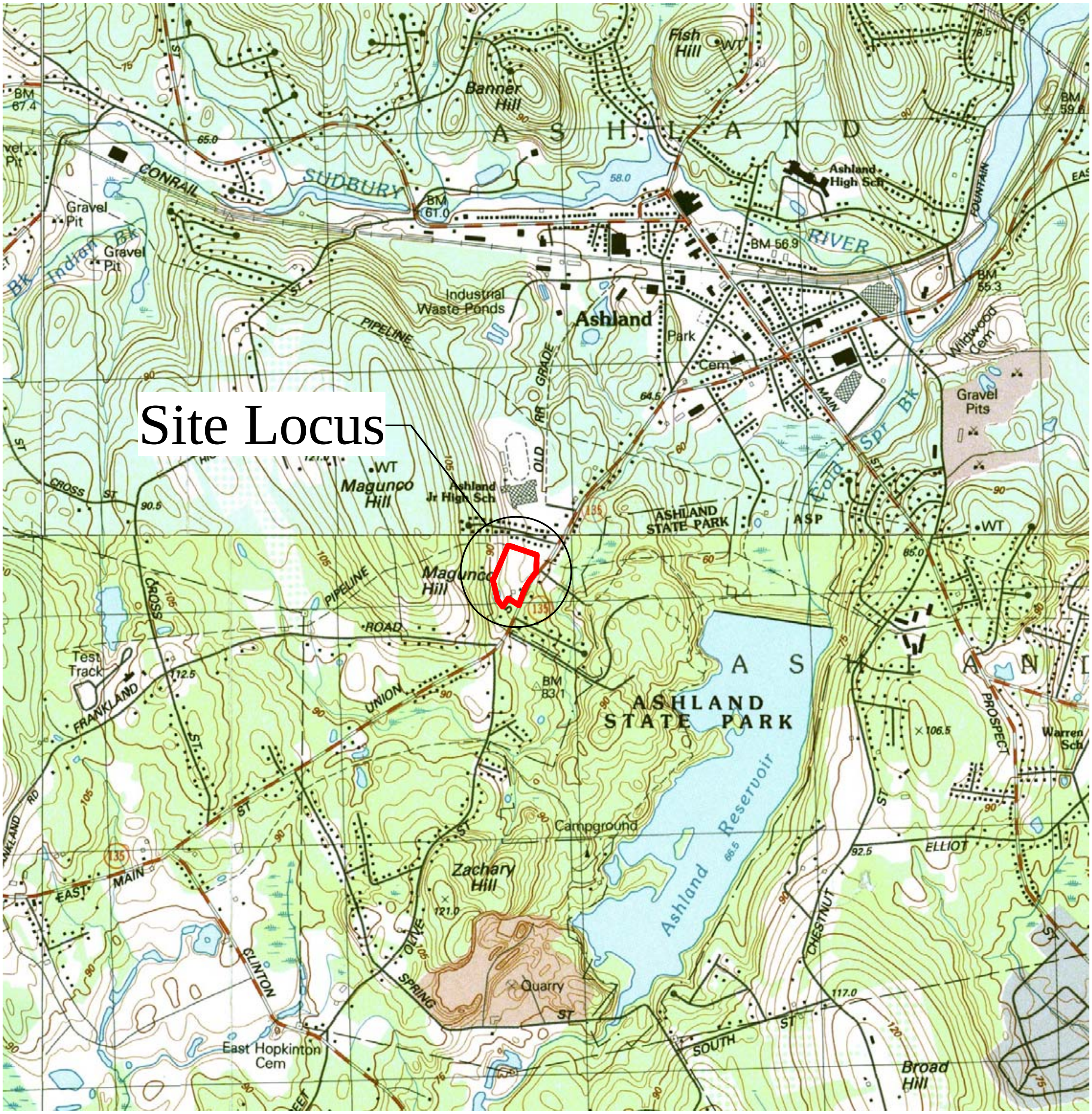
Enclosure 1 - Figures



0 — 2,000 Scale in feet	Figure 1. Site Locus.
Base Map: MassGIS Quads q201890, q201886, q205890 & q205886.	Project No. GHC #15036 Drafted SWS Checked Date 1/12/15 Rev
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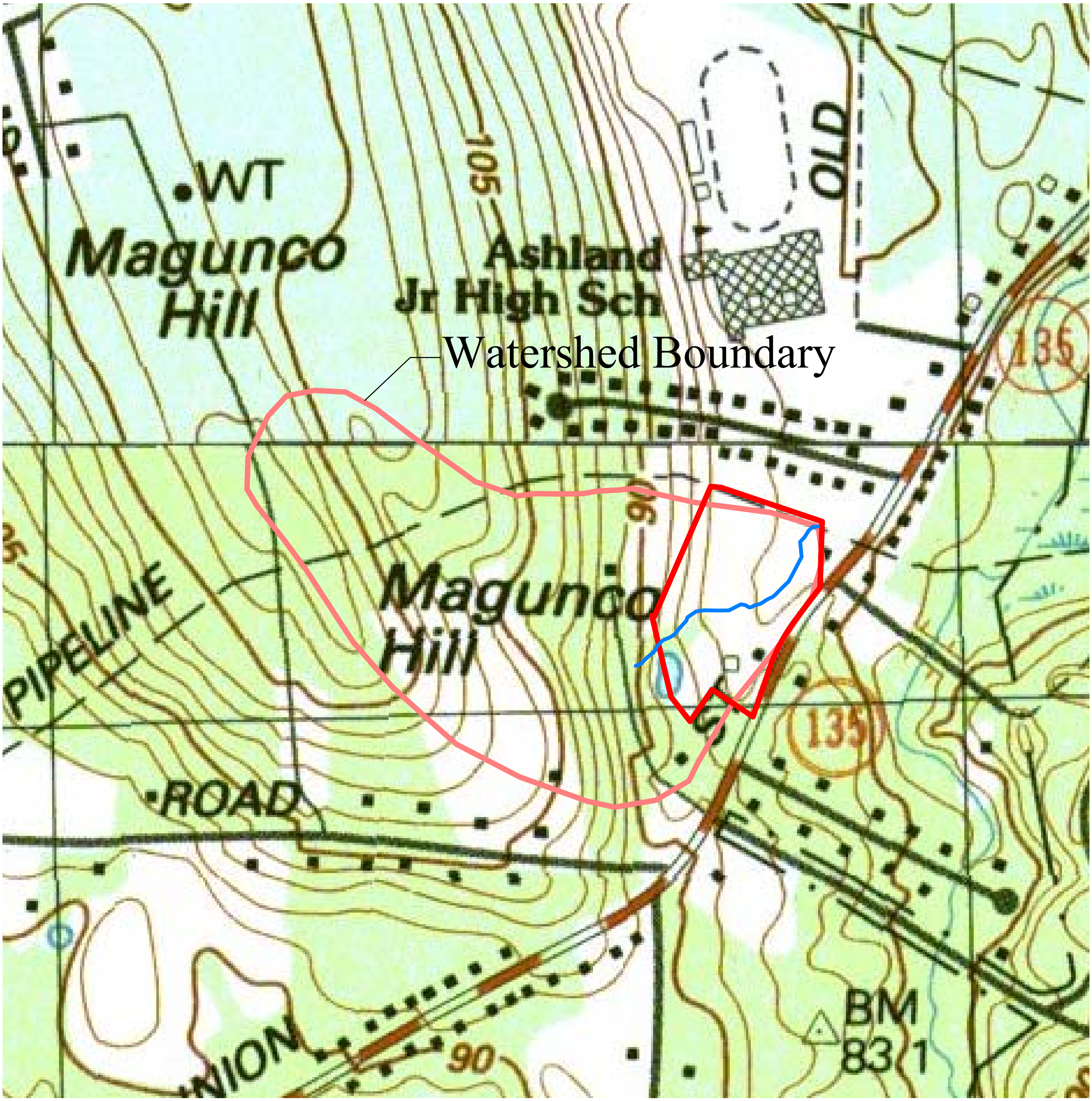

Figure 2. Intermittent Stream Watershed.

Base Map: MassGIS Quads q201890, q201886, q205890 & q205886.

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Project No. GHC #15036

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Proposed Development
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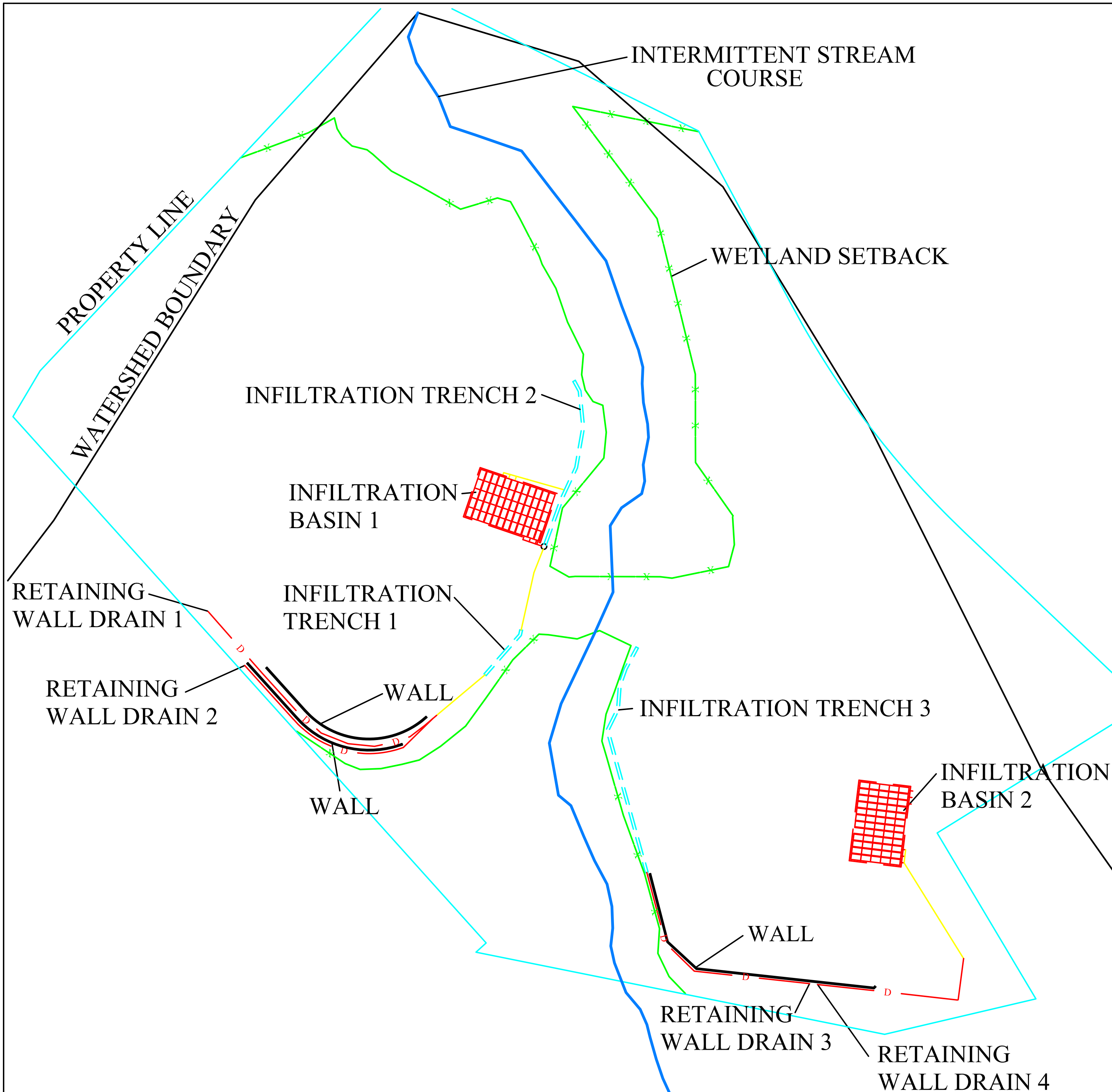

Proposed Development
133 West Union Street
Ashland, MA 01721

Figure 3. Site Features.

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Date 1/12/15 Rev
Base Map: CAD file from G&H.

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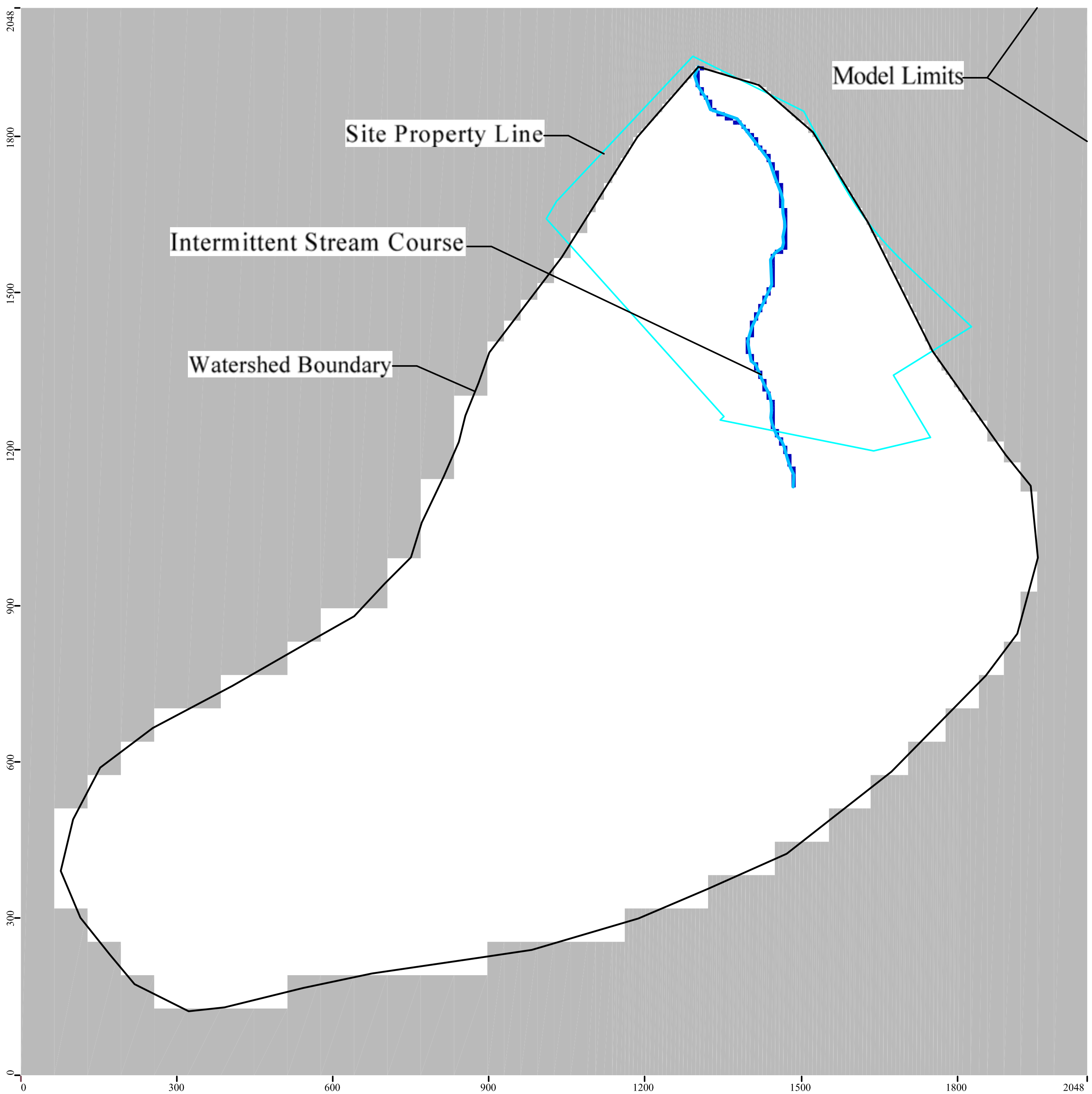

Grey Denotes Inactive Portions of the Model
Open or Color Shaded are Active Portions of the Model

Proposed Development
133 West Union Street
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Figure 4. Calibration Model Layout.

Project No. GHC #15036
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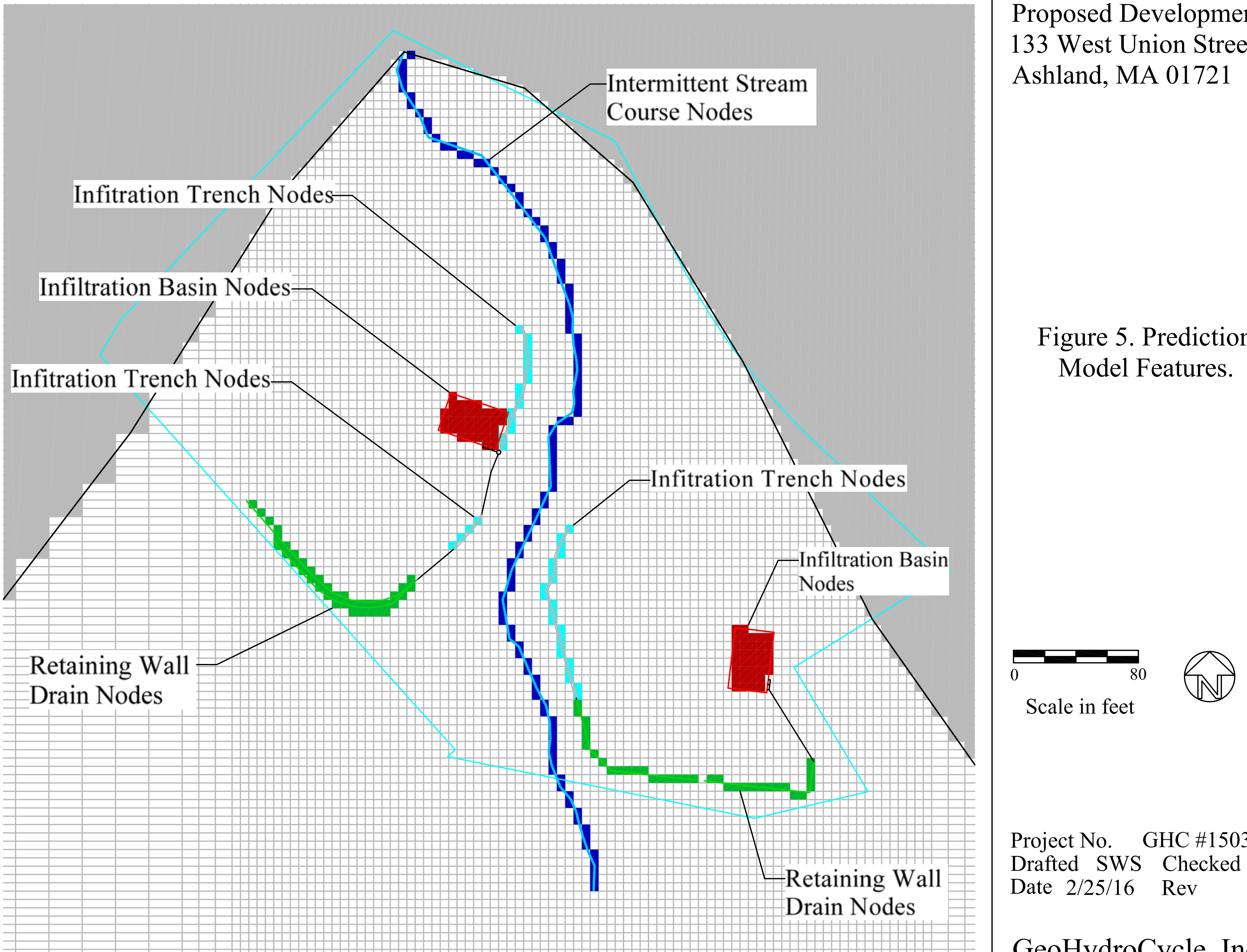

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133 West Union Street
Ashland, MA 01721

Figure 5. Prediction Model Features.

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133 West Union Street
Ashland, MA 01721

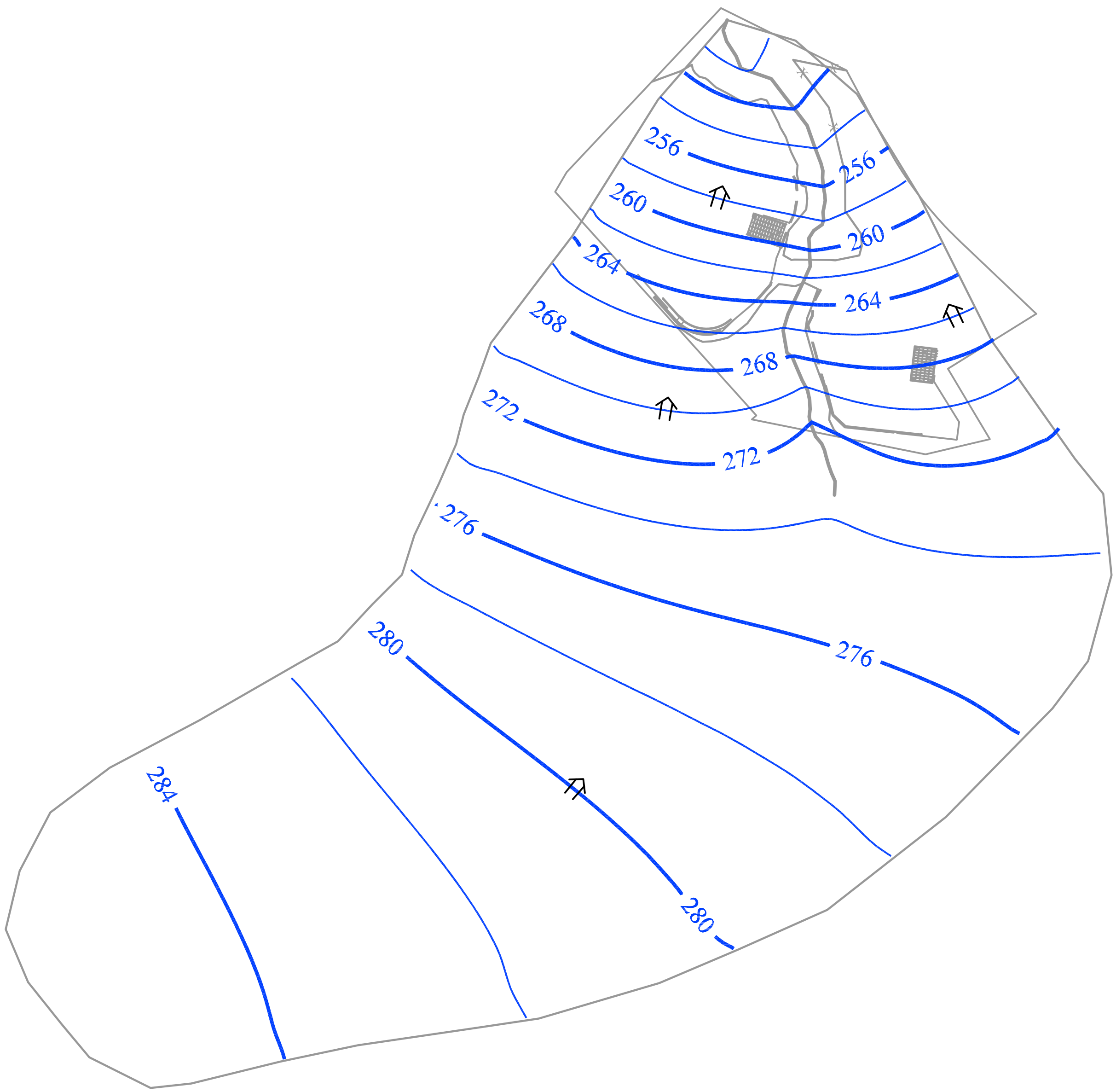

Figure 6. Simulated Calibration Model Groundwater Elevation Contours - Drains and Infiltration Basins Not Active.

LEGEND:

264 — Simulated Groundwater Elevation Contours. Interval = 2 foot.

Inferred Groundwater Flow Direction.

NOTES:

1. Simulated groundwater contour data are calculated and interpreted as described in the text.
2. See text for MODFLOW model descriptions.

0 300

Scale in feet

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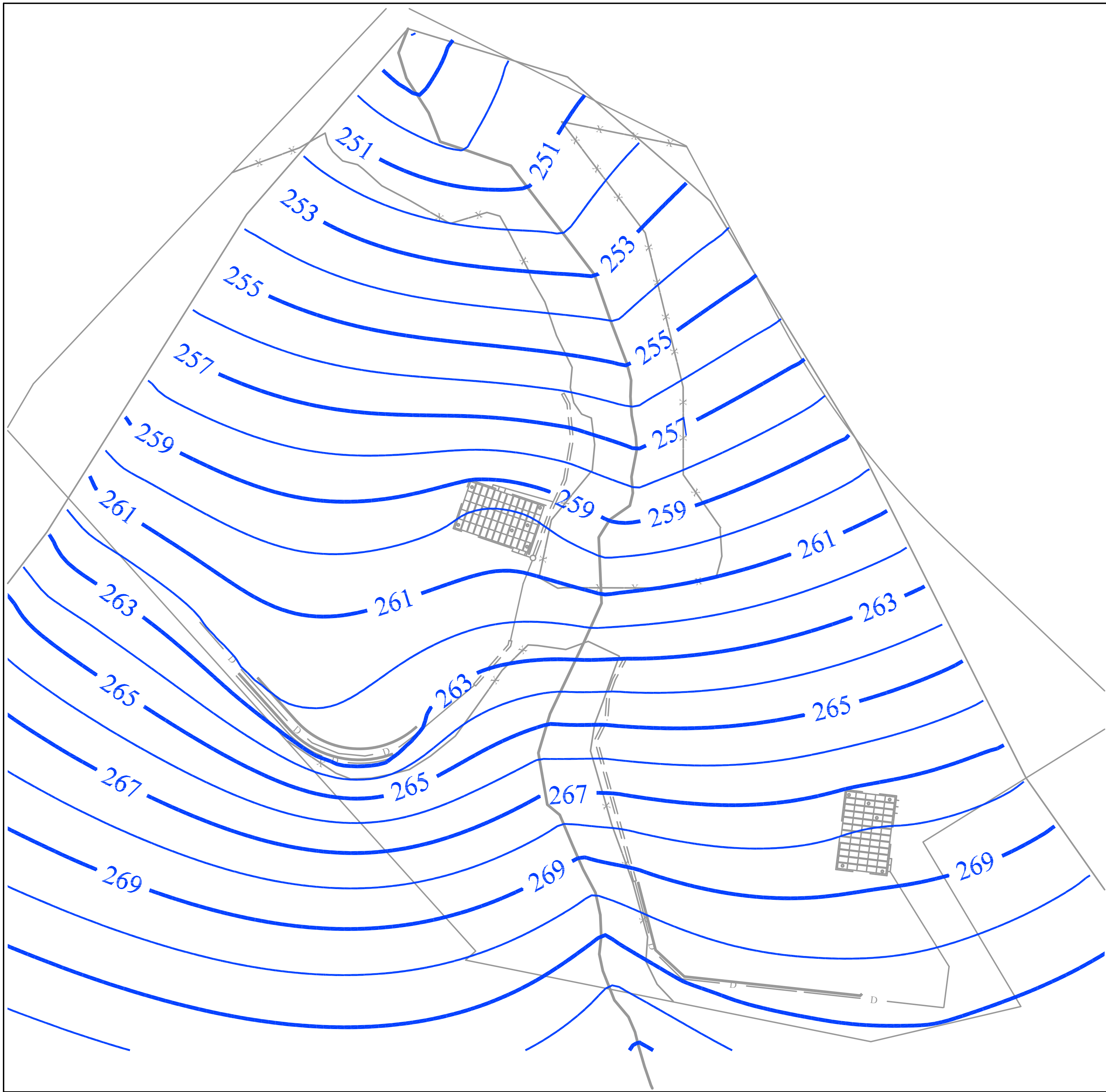

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133 West Union Street
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Figure 7. Simulated Groundwater Elevation Contours - Drains and Infiltration Basins Active.

LEGEND:

264 Simulated Groundwater Elevation Contours. Interval = 0.2 foot.

NOTES:

1. Simulated groundwater contour data are calculated and interpreted as described in the text.
2. See text for MODFLOW model descriptions.
3. Drains withdrawing, and trenches/basins infiltrating equal amounts (11,023 gallons per day).

0 100

Scale in feet

N

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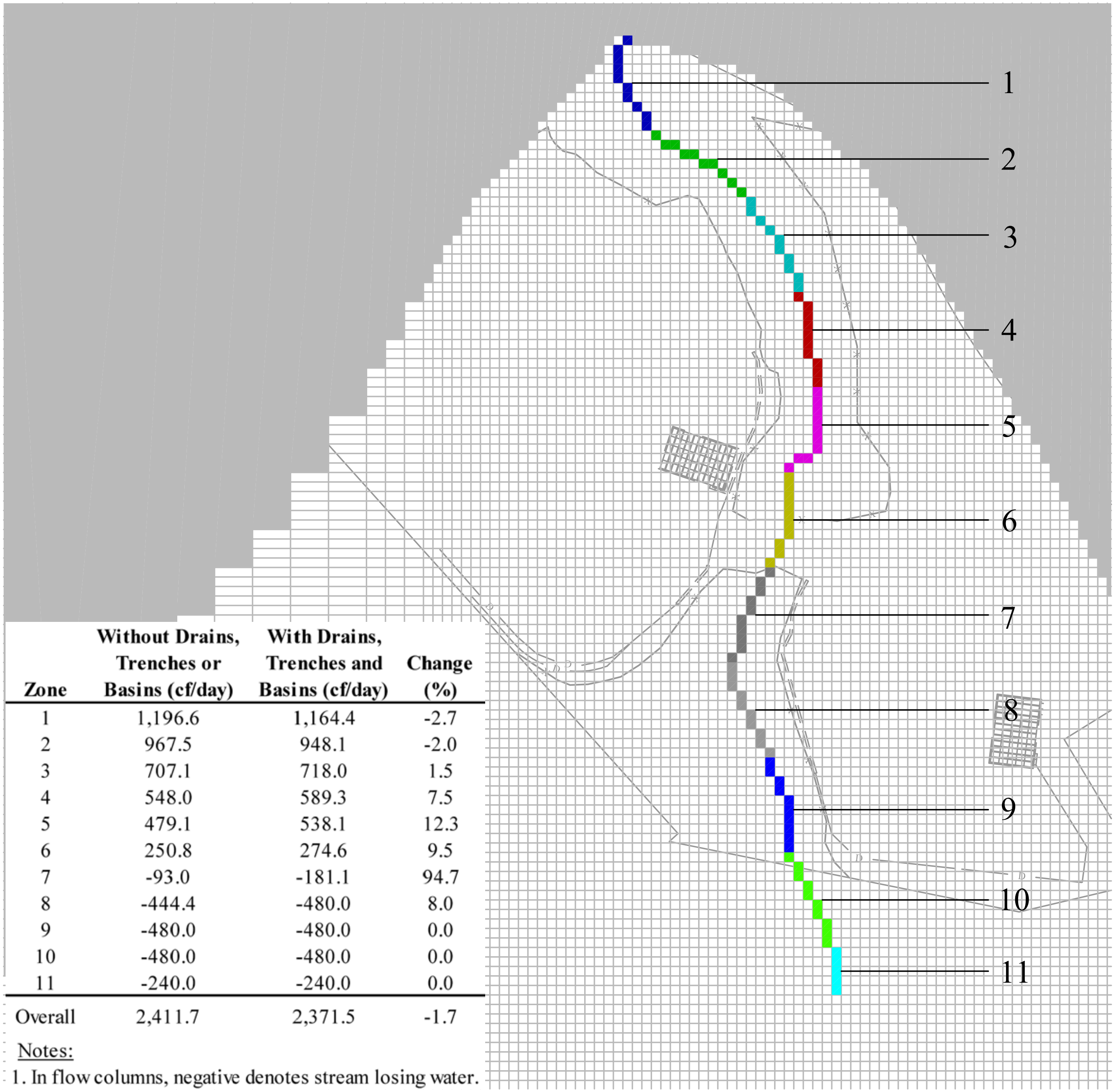
Proposed Development
133 West Union Street
Ashland, MA 01721



Zone	Without Drains, Trenches or Basins (cf/day)	With Drains, Trenches and Basins (cf/day)	Change (%)
1	1,196.6	1,164.4	-2.7
2	967.5	948.1	-2.0
3	707.1	718.0	1.5
4	548.0	589.3	7.5
5	479.1	538.1	12.3
6	250.8	274.6	9.5
7	-93.0	-181.1	94.7
8	-444.4	-480.0	8.0
9	-480.0	-480.0	0.0
10	-480.0	-480.0	0.0
11	-240.0	-240.0	0.0
Overall	2,411.7	2,371.5	-1.7

Notes:
1. In flow columns, negative denotes stream losing water.

Figure 8. Stream Budget Reaches and Results.

0 80
Scale in feet

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