SANBORN | HEAD
Building Trust. Engineering Success.

MEMORANDUM

To: David Roache, P.E. ~Mark Development, LLC

From: Matthew Heil, P.E., LSP and Kevin Stetson, P.E. ~ Sanborn, Head & Associates, Inc.

File: 4575.00

Date: 3/24/2020

Re: Groundwater Mounding Analysis – Proposed Stormwater Infiltration System
Riverside Station Redevelopment
325-333 and 399 Grove Street
Newton, Massachusetts

Sanborn, Head & Associates, Inc. (Sanborn Head) has prepared this memorandum to summarize the groundwater mounding analysis performed for three proposed infiltration systems (101, 102 and 103) at the proposed Riverside Station Redevelopment project in Newton, Massachusetts (the Site). Our mounding analysis was completed based on stormwater design volumes provided by the project civil engineer, Vanasse Hangen Bruslin, Inc. (VHB), on February 11, 2020.

SUBSURFACE CONDITIONS

Based on subsurface investigations performed by others and Sanborn Head in September 2019, subsurface conditions at the Site generally consist of topsoil and a 2 to 11-foot thick layer of granular urban fill soil. The fill layer is generally underlain by a sand layer with varying amounts of silt and gravel. For the purposes of this mounding analysis, we have broken the sand unit up into two units: silty sand and sand and gravel. Where observed, the sand and gravel layers range in thickness from at least 10 feet to over 40 feet thick and are underlain by glacial till and eventually bedrock. Intermittent organic silt and peat layers have been observed at several borings at the site. However, for the purposes of this mounding analysis, the organic silt and peat layer has been excluded based on its relatively limited intermittent extent on the northernmost portion of the Site. In addition, the proposed plan for the Site includes over-excavation of excessively silty soils within the proposed infiltration systems. This will allow stormwater to recharge directly to the more permeable and transmissive underlying sands and gravels. Based on observations made by Sanborn Head, bedrock at the site is variable in depth and has been observed as shallow as 3 feet below ground surface in the western portion of the Site and has not been encountered at depths greater than 49 feet below grade. Groundwater at the Site is generally anticipated to flow to the north/northwest toward the Charles River based on existing grades and groundwater gauging data and is generally deep (greater than 15 below ground surface).

The fill soil at each proposed infiltration system will be removed and replaced with permeable imported soils as noted below. For infiltration system 101, the proposed bottom of the system is at approximate elevation (El.) 51.0 feet. Based on the nearest borings (SH-106 and SH-107), we anticipate that the area of the proposed system will be over-excavated to remove the less favorable silty sand layer to approximately El. 47 feet. Following over-excavation, we anticipate that the system 101 will infiltrate directly into the underlying natural sand and gravel deposit. For infiltration systems 102 and 103, the bottoms of the proposed systems are at approximate El. 54.1 and 54.8 feet, respectively. Based on the nearest borings (SH-111, SH-103, and HA09-4), the systems are anticipated to infiltrate into existing granular fill or sand deposits after removal of the overlying fill soils. Additional borings will be required in the western end of system 103 to confirm soil conditions based on the shallow bedrock at SH-103.

Hydraulic conductivity represents the soils relative ability to transport water and is a key parameter required for the groundwater mounding analysis. Grain size data were used to estimate the assumed hydraulic conductivities at the Site based on typical values published by the United State Department of Agriculture (USDA) Natural Resources Conservation service. Based on the soil descriptions and grain size analyses, the assumed hydraulic conductivities for each unit are described in the table below. These values were used in the groundwater mounding analysis described below.

Geologic Unit	Estimated Hydraulic Conductivity (feet per day)	Notes
Bed Area	200	Assumed imported permeable soil below proposed system footprint
Granular Fill	10	Above receiving layer and above groundwater table
Silty Sand	5	Receiving layer (To be removed below System 101)
Sand and Gravel	20	Receiving layer (Systems 102 and 103)
Glacial Till	0.01	Bottom Layer

As a conservative modeling step, bedrock was excluded from the numerical groundwater model. Further, based on the available information, significant areas of shallow bedrock are not located near the largest proposed stormwater system (101) and are not anticipated to materially impact groundwater flow at the Site as it relates to the proposed stormwater systems.

CONCEPUTAL SITE MODEL AND GROUNDWATER MOUNDING RESULTS

A mounding analysis was performed using Visual MODFLOW software (Version 4.6.0.167) developed by the Waterloo Hydrogeologic, Inc. of Ontario, Canada and the information obtained during the subsurface exploration programs. The Site conceptual model is based on infiltrated stormwater applied to the proposed bed area and receiving layer soils downward to the groundwater table, then to the north/northeast based on ambient groundwater elevation data. The assumed fill, silty sand and sand and gravel receiving layers and underlying glacial till layer, considered a restrictive, lower-permeability layer, were input into the model based on the boring data. Constant head boundaries were assumed on the upgradient side (southeast) and downgradient side (northwest) to model groundwater flowing onto and across the Site from southeast to northwest. The hydraulic conductivities assumed for the different layers and soil types in the models are described in the table above. A specific yield (drainable porosity) of 0.2 and an overall porosity of 0.3 were also assumed. The model structure is shown on Figure 1. Modeled ambient groundwater conditions prior to loading of the proposed stormwater systems are shown on Figure 3, and a cross-section through system 101 is shown as Figure 4.

Based on stormwater design information provided by the project's civil engineer, VHB, the design storm and loading for each proposed stormwater system is shown in the table below. According to VHB, the infiltration capacities for systems 101 and 102 were designed to recharge at least the 1-inch storm to provide water quality treatment through infiltration. System 102 provides capacity for the 2-year design storm based on VHB's calculations; therefore, the 2-year frequency rainfall event was used for design. Because system 103 is unable to be connected to an overflow drain line due to elevation conflicts, the system has been designed to infiltrate the design storm listed below.

Infiltration Feature	Design Storm	Numerical Model Recharge Loading Rate (ft/day) over 72 hours
System 101	1-inch (water quality)	1.7
System 102	2-year	0.6
System 103	100-year	0.4

The results of our mounding analysis, including the groundwater conditions 72 hours after the design storms described above are shown on the attached Figure 4, and cross-sections of each proposed system are included as Figures 5 through 7. Our findings based on the mounding analysis following the design storm event are described below.

System 101

The maximum mound height at system 101 is estimated to be as high as approximately 5 feet in the bed area 72 hours after the design storm (after the system has been emptied in accordance with the stormwater design requirements). Although the maximum change in groundwater elevation may be up to 5 feet in the bed area, groundwater in this area of the Site is anticipated to be at approximately El. 43 feet (i.e. a maximum mounded groundwater elevation of El. 48 feet using superposition). Based on information reviewed, groundwater on this portion of the Site is anticipated to be located approximately 20 feet below ground surface or greater based on actual monitoring data. Fill on this portion of the Site has been observed at depths up to 8 feet below ground surface. Therefore, although groundwater will likely mound above the existing groundwater table, the increased groundwater surface will not impact overlying fill material as up to 10 feet of vertical separation will still remain between the mounded groundwater height and the fill unit. Further, groundwater at monitoring wells located at the immediately downgradient property indicate groundwater is consistently located approximately 20 feet below ground surface or greater, and fill soil are generally less than 15 feet thick.

Based on the results of the groundwater model, the maximum mound height decreases to approximately less than 6 inches approximately 100 feet downgradient of system 101 And becomes negligible approximately 140 feet downgradient of system 101. The mounded groundwater surface cross-section for system 1 is included as Figure 5. Based on the relatively limited extent of elevated groundwater surface caused by the proposed system 101, downgradient fill soil contamination is not anticipated to be impacted by the proposed system.

System 102 and 103

Similar to system 101, maximum groundwater mounds below systems 102 and 103 are observed directly below the systems and are estimated to have a maximum change in water table elevation up to 2 feet. Using superposition of the maximum mound to on top of observed groundwater elevations, mounded groundwater elevations at system 102 and 103 are anticipated to rise to approximate El. 50 feet and 54 feet, respectively. The mounds become negligible approximately 60 feet downgradient of each proposed system. Following similar logic presented above, since groundwater at each proposed system is anticipated to diminish relatively close to each system, impacts to downgradient fill soil are not anticipated given the lateral proximity as well as the elevation.

DMD/MPH/KPS: dmd

Encl. Figure 1 – Exploration Location Plan
Figure 2 – Model Boundary Conditions
Figure 3 – Modeled Ambient Groundwater Conditions
Figure 4 – Modeled Ambient Groundwater Conditions – Cross Section A-A’ through System 101
Figure 5 – Modeled Loaded Groundwater Contours
Figure 6 – Modeled Loaded Groundwater Conditions – Cross Section A-A’ through System 101
Figure 7 – Modeled Loaded Groundwater Conditions – Cross Section B-B’ through System 102
Figure 8 – Modeled Loaded Groundwater Conditions – Cross Section C-C’ through System 103

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NOTES:

1. THE BASE MAP WAS DRAWN FROM A PLAN ENTITLED, "EXHIBIT PLAN - SUPPLEMENTAL TOPO", PREPARED BY FELDMAN LAND SURVEYORS (FELDMAN) OF BOSTON, MA, DATED MAY 14, 2009 WITH AN ORIGINAL SCALE OF 1" = 20'.
2. THE PROPOSED SITE FEATURES WERE DRAWN FROM A PLAN ENTITLED, "GRADING, DRAINAGE AND EROSION CONTROL PLAN", PREPARED BY VANASSE HANGEN BRUSTLIN, INC. (VHB) OF WATERTOWN, MA, DATED DECEMBER 9, 2019 WITH AN ORIGINAL SCALE OF 1" = 40'.
3. EXPLORATIONS BY HALEY & ALDRICH AND TEST PITS EXCAVATED BY J.MARCHESE AND SONS WERE TAKEN FROM AN ELECTRONIC PLAN ENTITLED, "SITE AND SUBSURFACE EXPLORATION LOCATION PLAN", PREPARED BY HALEY & ALDRICH (H&A) OF BOSTON, MA, DATED OCTOBER 29, 2009 AND SHOULD BE CONSIDERED APPROXIMATE.
4. EXPLORATIONS BY RIZZO WERE TAKEN FROM AN ELECTRONIC PLAN ENTITLED, "SITE PLAN AND SAMPLING LOCATIONS", PREPARED BY RIZZO ASSOCIATES, INC. (RIZZO) OF PITTSBURGH, PA, DATED DECEMBER 30, 1998 AND SHOULD BE CONSIDERED APPROXIMATE.
5. EXPLORATIONS DESIGNATED SH-101 THROUGH SH-112 WERE ADVANCED BY NORTHERN DRILLING SERVICES, INC. OF NORTHBOROUGH, MASSACHUSETTS AND OBSERVED BY SANBORN HEAD BETWEEN SEPTEMBER 23 AND OCTOBER 1, 2019.
6. APPROXIMATE LOCATIONS OF EXPLORATIONS ARE BASED ON TAPED MEASUREMENTS MADE IN THE FIELD RELATIVE TO PROMINENT SITE FEATURES. THIS DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

LEGEND:

APPROXIMATE PROPERTY BOUNDARY

APPROXIMATE INTERIM WELLHEAD PROTECTION AREA (IWPA) BOUNDARY

APPROXIMATE RTN DISPOSAL SITE BOUNDARY

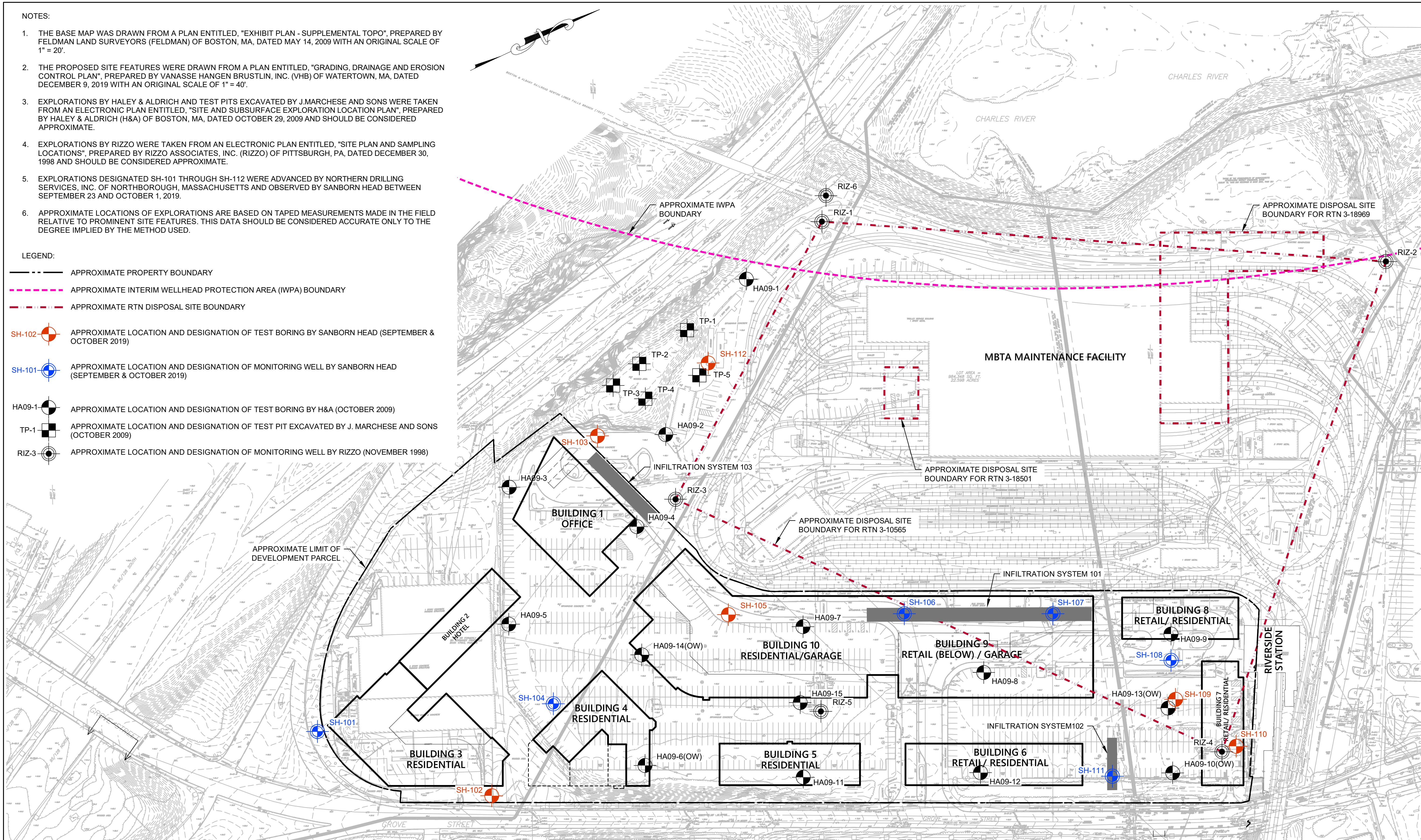
SH-102 APPROXIMATE LOCATION AND DESIGNATION OF TEST BORING BY SANBORN HEAD (SEPTEMBER & OCTOBER 2019)

SH-101 APPROXIMATE LOCATION AND DESIGNATION OF MONITORING WELL BY SANBORN HEAD (SEPTEMBER & OCTOBER 2019)

HA09-1 APPROXIMATE LOCATION AND DESIGNATION OF TEST BORING BY H&A (OCTOBER 2009)

TP-1 APPROXIMATE LOCATION AND DESIGNATION OF TEST PIT EXCAVATED BY J. MARCHESE AND SONS (OCTOBER 2009)

RIZ-3 APPROXIMATE LOCATION AND DESIGNATION OF MONITORING WELL BY RIZZO (NOVEMBER 1998)



SANBORN HEAD

GRAPHICAL SCALE

70' 35' 0' 70' 140'

NO.	DATE	DESCRIPTION	BY

DRAWN BY: D.DOMBROWSKY
DESIGNED BY: M.RUBERTI
REVIEWED BY: M.HEIL
PROJECT MGR: M.RUBERTI
PIC: K.STETSON
DATE: MARCH 2020

ENVIRONMENTAL ENGINEERING SERVICES

RIVERSIDE STATION

NEWTON, MASSACHUSETTS

EXPLORATION LOCATION PLAN

PROJECT NUMBER: 4575.00

SHEET NUMBER: 1

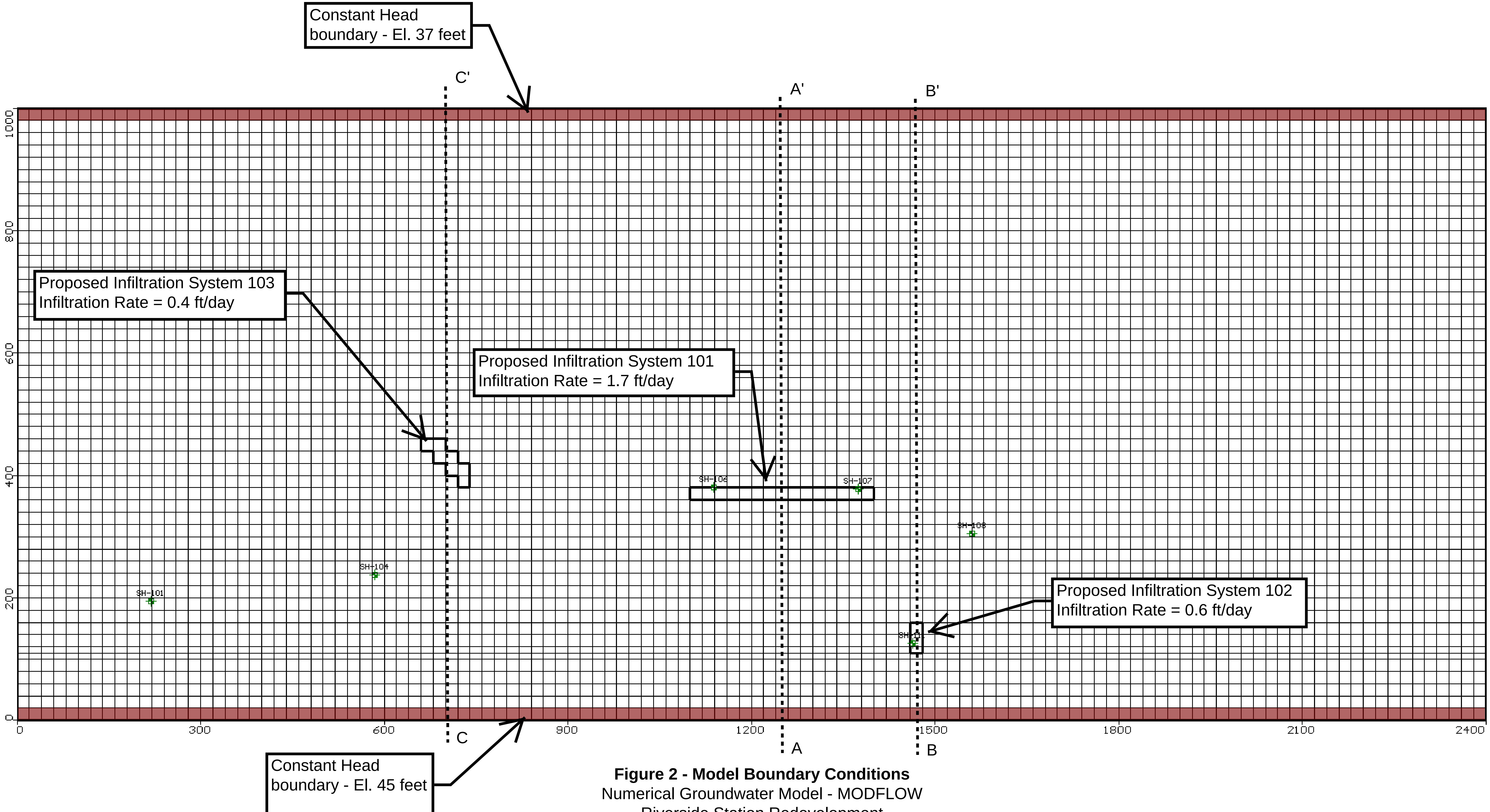


Figure 2 - Model Boundary Conditions
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

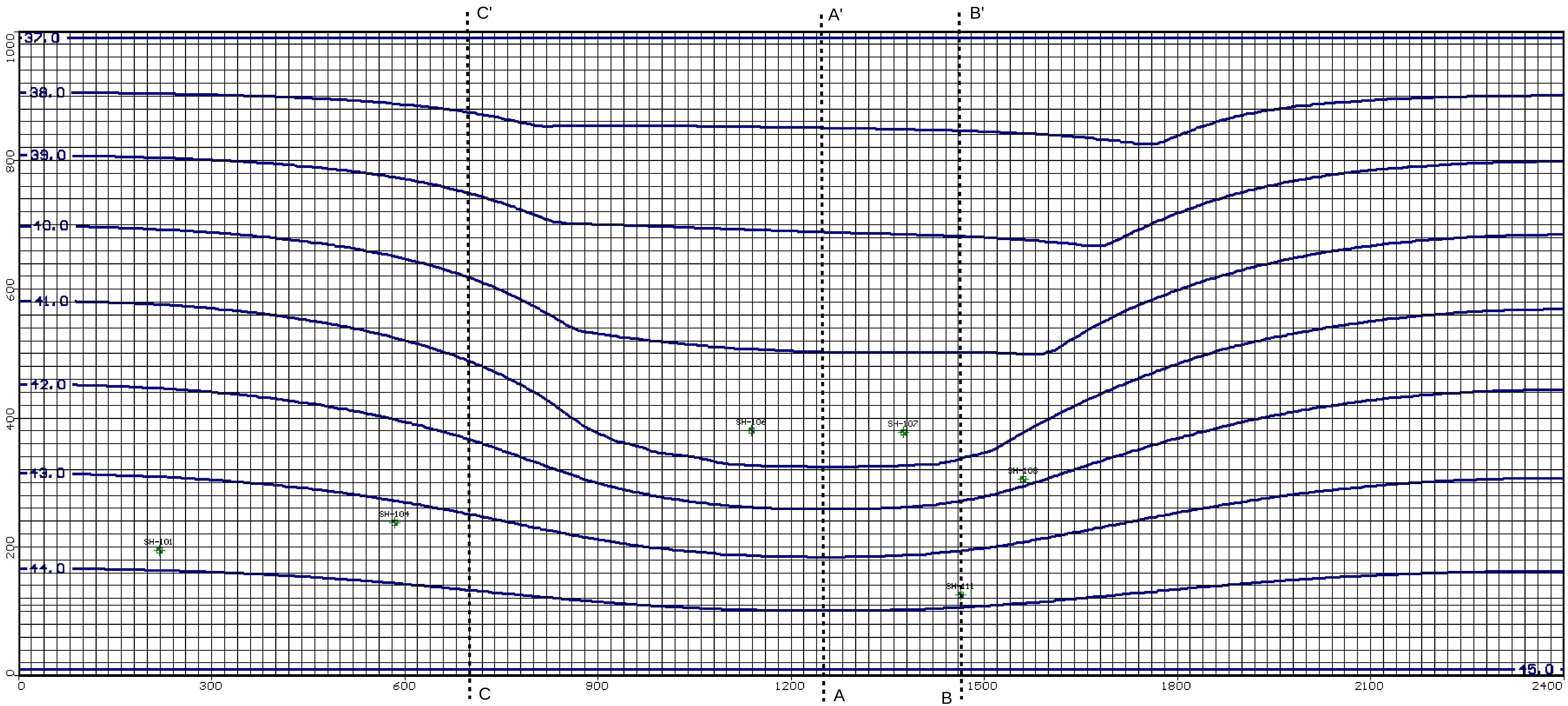


Figure 3 - Modeled Ambient Groundwater Contours
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

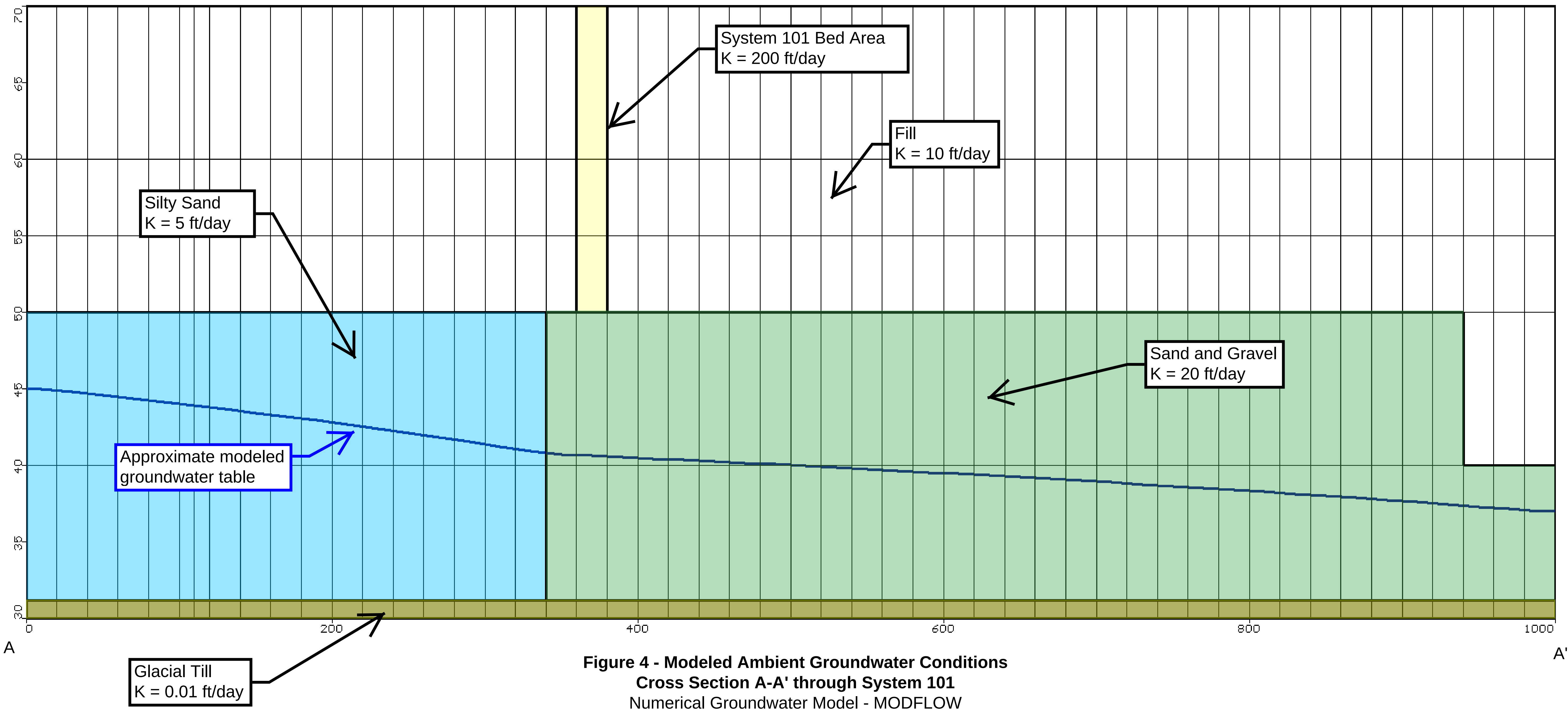


Figure 4 - Modeled Ambient Groundwater Conditions
Cross Section A-A' through System 101
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

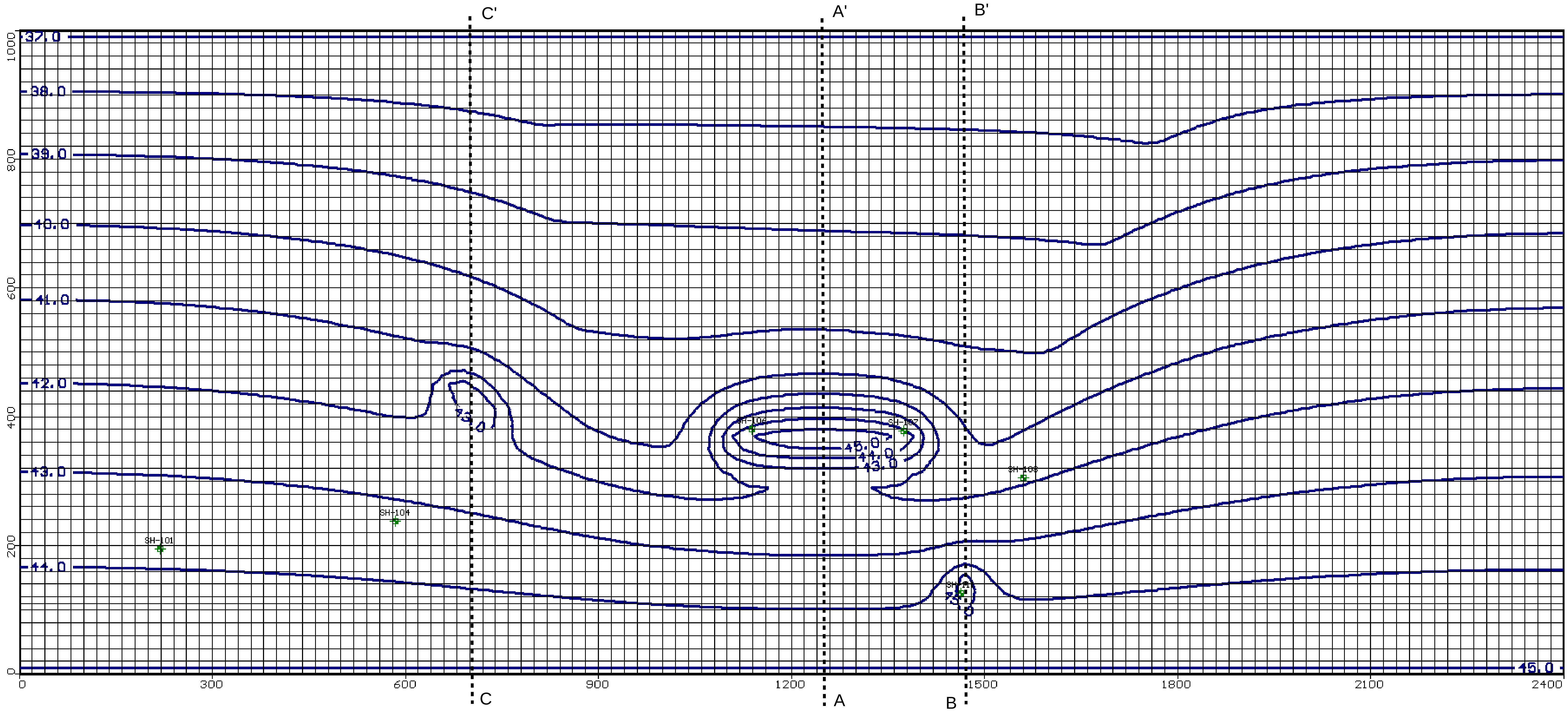


Figure 5 - Modeled Loaded Groundwater Contours
72 Hours of Design Storm Loading
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

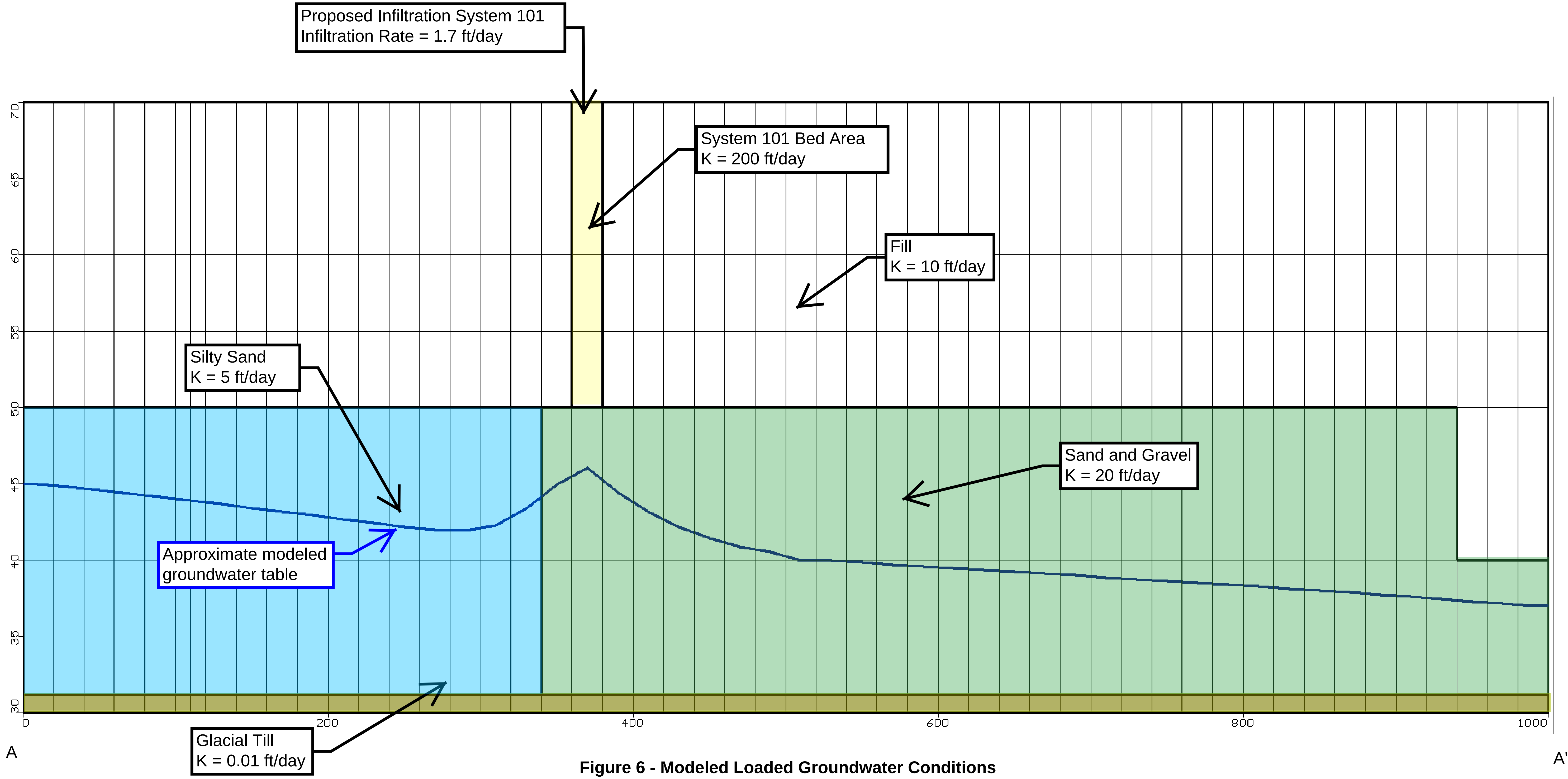


Figure 6 - Modeled Loaded Groundwater Conditions
72 Hours of Design Storm Loading
Cross Section A-A' through System 101
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

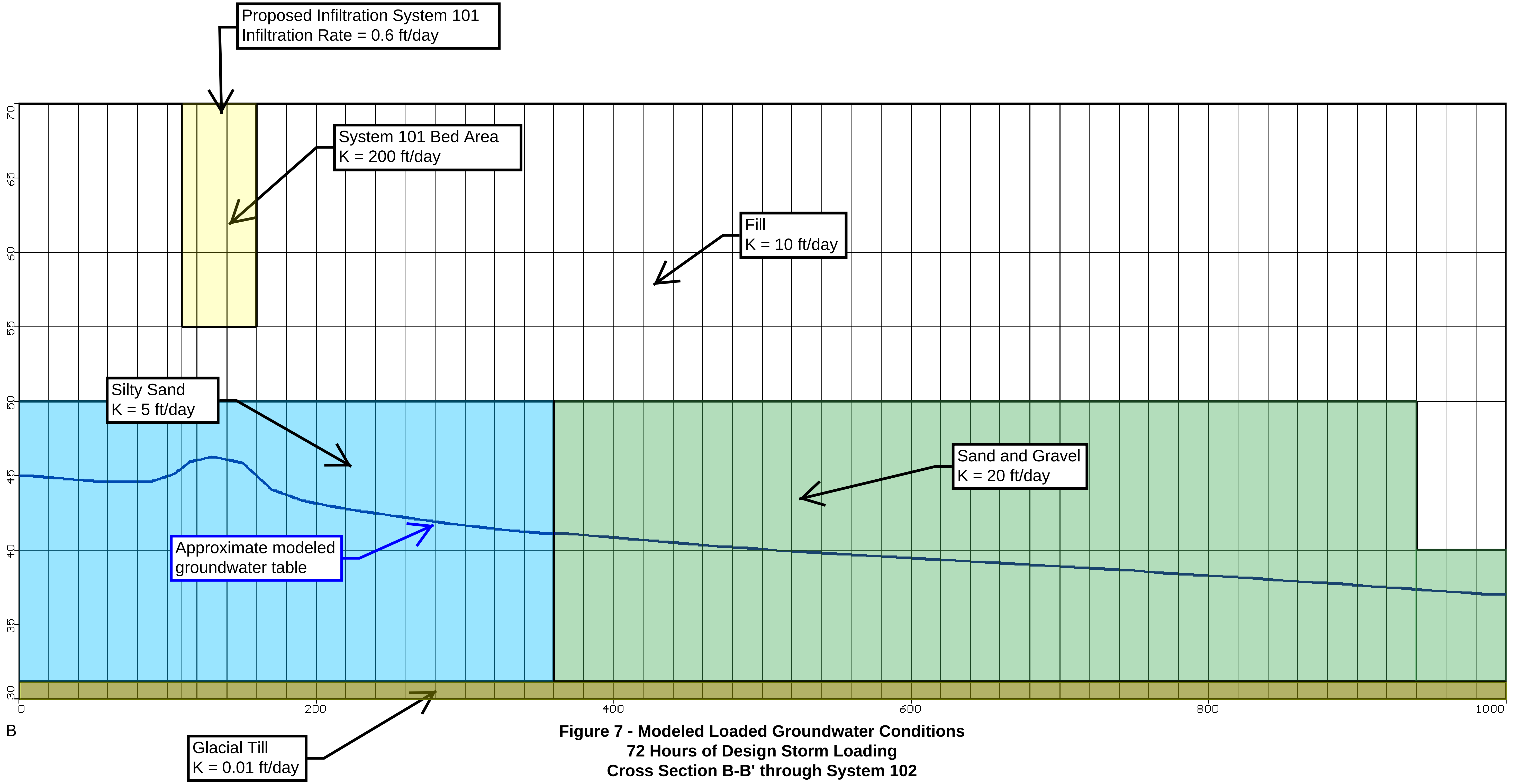


Figure 7 - Modeled Loaded Groundwater Conditions
72 Hours of Design Storm Loading
Cross Section B-B' through System 102
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts

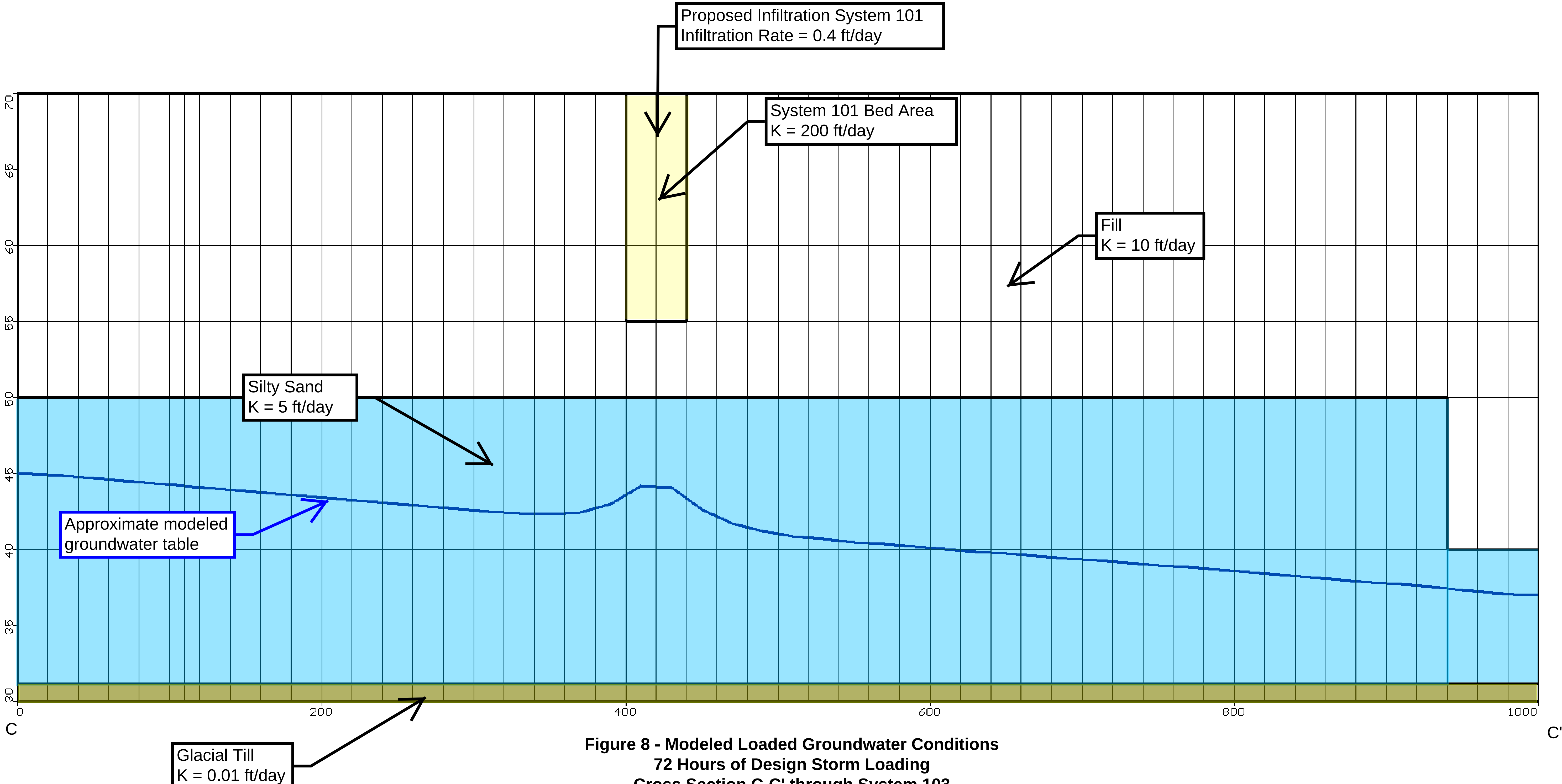


Figure 8 - Modeled Loaded Groundwater Conditions
72 Hours of Design Storm Loading
Cross Section C-C' through System 103
Numerical Groundwater Model - MODFLOW
Riverside Station Redevelopment
Newton, Massachusetts