Appendix C Vol. 1

Groundwater Model Update Report

U.S. Army Corps of Engineers – New York District

Groundwater Model Update Report

ERCIP Well Field Expansion Project
Wheeler-Sack Army Airfield Bedrock Potable Water Wellfield – Area 4
United States Army Garrison, Fort Drum, New York

Contract: W912DS20D0002

December 2025

Groundwater Model Update Report

ERCIP Well Field Expansion Project
Wheeler-Sack Army Airfield Bedrock Potable Water Wellfield – Area 4
United States Army Garrison, Fort Drum, New York

Contract: W912DS20D0002

December 2025

Prepared By:
Arcadis U.S., Inc.
One Lincoln Center, 110 West Fayette Street, Suite 300
Syracuse, NY 13202
United States
Phone: 315 446 9120
Fax: 315 449 0017

Prepared For:
U.S. Army Corps of Engineers – New York District

Our Ref:
30244799

Andrew R. Vitolins, PG
Vice President

Jennifer Wahlberg
Senior Environmental Specialist

This document is intended only for the use of the individual or entity for which it was prepared and may contain information that is privileged, confidential and exempt from disclosure under applicable law. Any dissemination, distribution or copying of this document is strictly prohibited.

Version Control

Issue	Revision No.	Date Issued	Description
1	0	9/19/2025	Draft Report
2	1	10/22/2025	Final Report

Contents

Acronyms and Abbreviations v
1 Introduction 1
2 History of Groundwater Model Development 2
2.1 2011 Groundwater Flow Model 2
2.2 2020 Groundwater Flow Model Update 2
2.3 2024 Groundwater Flow Model Update 2
3 Conceptual Site Model 4
3.1 Geology 4
3.2 Hydrogeology 5
3.2.1 Assessment of Hydraulic Conductivity in Area 4 5
3.3 Groundwater Recharge 6
3.4 Conceptual Site Model Summary 6
4 Groundwater Flow Model Update 7
4.1 Boundary Conditions 7
4.1.1 Constant Head Cells 7
4.1.2 No Flow Boundaries 7
4.1.3 Recharge 8
4.1.4 Production Wells 8
4.2 Hydraulic Conductivity 8
5 Groundwater Flow Model Calibration 9
5.1 Steady-State Calibration 9
5.2 Sensitivity Analysis 10
5.3 Transient Calibration 11
5.3.1 Transient Model Set-Up 11
5.3.2 Transient Model Results 11
6 Production Scenarios 12
6.1 Scenario 1 – Area 4 Estimated Sustainable Rates 13
6.1.1 Steady-State – Drought Conditions 13
6.1.2 Transient 14
6.2 Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates 14
6.2.1 Steady State 15
6.2.1.1 Steady State – Drought Conditions 15

6.2.2 Transient 16
6.3 Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates 16
6.3.1 Steady State 17
6.3.1.1 Steady State – Drought Conditions 17
6.3.2 Transient 18
7 Summary and Conclusions 19
8 Uncertainties and Limitations 20
9 References 21

Tables

Table 4-1 Model Layer Description (in text)
Table 4.2-1 Overall Model Hydraulic Conductivity Summary
Table 4.2-2 Area 4 Hydraulic Conductivity Summary
Table 5.1-1 Steady-State Water Level Targets and Calibration Results
Table 5.2-1 Summary of Groundwater Flow Model Sensitivity Analysis Results
Table 5.3-1 Transient Model Set-Up
Table 6-1 Production Scenario Well Rates (in text)
Table 6.1-1 Simulated Drawdown at Area 4 Wells and Potential Off-Site Potable Well Locations

Figures

Figure 1-1 Site Location
Figure 2-1 Extents of Previous and Current Groundwater Models
Figure 4-1 Cross-Section A-A’
Figure 4-2 Cross-Section B-B’
Figure 4-3 Cross-Section C-C’
Figure 4.1-1 Boundary Conditions
Figure 4.2-1 Hydraulic Conductivity Distribution Model Layers 1 and 2
Figure 4.2-2 Hydraulic Conductivity Distribution Model Layers 3 and 4
Figure 4.2-3 Hydraulic Conductivity Distribution Model Layers 5 and 6
Figure 4.2-4 Hydraulic Conductivity Distribution Model Layers 7 and 8
Figure 4.2-5 Hydraulic Conductivity Distribution Model Layers 9 and 10
Figure 4.2-6 Hydraulic Conductivity Distribution Model Layers 11 and 12

Figure 5.1-1 **Steady-State Calibration Scatter Plot – Overall Model**

Figure 5.1-2 **Steady-State Calibration Scatter Plot – Bedrock Only**

Figure 5.1-3 **Steady-State Calibration Scatter Plot – Area 4 Only**

Figure 5.1-4 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 1 and 2**

Figure 5.1-5 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 3 and 4**

Figure 5.1-6 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 5 and 6**

Figure 5.1-7 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 7 and 8**

Figure 5.1-8 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 9 and 10**

Figure 5.1-9 **Steady-State Simulated Groundwater Elevation and Weighted Residuals Model Layers 11 and 12**

Figure 5.3-1 **Storage Distribution**

Figure 5.3-2 **Transient Calibration Simulated Drawdown over Time – Set 1**

Figure 5.3-3 **Transient Calibration Simulated Drawdown over Time – Set 2**

Figure 5.3-4 **Transient Calibration Simulated Drawdown over Time – Set 3**

Figure 5.3-5 **Transient Calibration Simulated Drawdown over Time – Set 4**

Figure 6.1-1 **Scenario 1 – Area 4 Estimated Sustainable Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10)**

Figure 6.1-2 **Scenario 1 – Area 4 Estimated Sustainable Rates: Simulated Water Table Drawdown (Model Layer 1)**

Figure 6.1-3 **Scenario 1 – Area 4 Estimated Sustainable Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10) Under Drought Conditions**

Figure 6.1-4 **Scenario 1 – Area 4 Estimated Sustainable Rates: Simulated Water Table Drawdown (Model Layer 1) Under Drought Conditions**

Figure 6.1-5 **Scenario 1 – Area 4 Estimated Sustainable Rates: Forward Particle Tracking at Top of Bedrock (Model Layer 9) Under Transient Conditions**

Figure 6.2-1 **Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10)**

Figure 6.2-2 **Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates: Simulated Water Table Drawdown (Model Layer 1)**

Figure 6.2-3 **Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10) Under Drought Conditions**

Figure 6.2-4 **Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates: Simulated Water Table Drawdown (Model Layer 1) Under Drought Conditions**

Figure 6.2-5 **Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates: Forward Particle Tracking at Top of Bedrock (Model Layer 9) Under Transient Conditions**

Figure 6.3-1 **Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10)**

Figure 6.3-2 **Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates: Simulated Water Table Drawdown (Model Layer 1)**

Figure 6.3-3 **Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates: Simulated Drawdown and Steady-State Area of Flow Contribution in Limestone/Sandstone (Model Layer 10) Under Drought Conditions**

Figure 6.3-4 **Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates: Simulated Water Table Drawdown (Model Layer 1) Under Drought Conditions**

Figure 6.3-5 **Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates: Forward Particle Tracking at Top of Bedrock (Model Layer 9) Under Transient Conditions**

Appendices

Appendix A **Sensitivity Analysis**

Acronyms and Abbreviations

%	percent
Arcadis	Arcadis U.S., Inc.
ASTM	American Standard Test Method
CSM	conceptual site model
Fort Drum	United States Army Garrison in Fort Drum, New York
ft^2	square feet
gpm	gallons per minute
in/yr	inches per year
MODALL	MODular flow ALLocation
MGD	million gallons per day
NOAA	National Oceanic and Atmospheric Administration
RSS	residual sum-of-squares
2011 groundwater model	groundwater flow model developed by the USACE Philadelphia District in 2011
2020 groundwater model	groundwater flow model developed by the USACE Philadelphia District in 2020
2024 groundwater model	groundwater flow model developed by Arcadis in 2024
USACE	United States Army Corps of Engineers, New York District
WSAAF	Wheeler-Sack Army Airfield

1 Introduction

Arcadis U.S., Inc. (Arcadis) has prepared this Groundwater Model Update Report to support the design of a new potable water supply source at the United States Army Garrison in Fort Drum, New York (Fort Drum). This work is being conducted on behalf of the United States Army Corps of Engineers, New York District (USACE) under Contract W912DS20D0002 and the associated USACE Statement of Work dated July 23, 2024. The Statement of Work and associated draft wellfield design state that a new well field within the area, designated as Area 4, would include five new bedrock groundwater supply wells located northwest of the Wheeler-Sack Army Airfield (WSAAF) and the equipment and infrastructure to connect the wells to the Fort Drum potable water supply (Figure 1-1). The location of the test wells and the observation wells in Area 4 are shown on Figure 1-1.

This report summarizes the updates made to the groundwater flow model over time, the conceptual site model (CSM), and updates made to the existing groundwater flow model developed in 2024 (Arcadis 2024). This model report also summarizes pumping scenarios developed for five proposed new groundwater supply wells to further evaluate if these wells will be sufficient to address potable water supply needs while not affecting existing water supply wells or receiving impacts from known sources of contamination at Fort Drum. The objective of the modeling study was to evaluate if five new water supply wells installed within Area 4 can produce the minimum desired production rate of 500 gallons per minute (gpm), or 0.72 million gallons per day (MGD).

2 History of Groundwater Model Development

Three groundwater models, identified below, have been developed to assess groundwater conditions at Fort Drum. The extents of these models are presented on Figure 2-1.

2.1 2011 Groundwater Flow Model

The groundwater flow model for Fort Drum was first developed in 2011 by the USACE (USACE 2011), referred to hereafter as the 2011 groundwater model. The 2011 groundwater model was a watershed level model and WASH123D was used for the analyses. The objective of the 2011 groundwater model was to evaluate groundwater flow paths based on proposed pumping operations of the well field consisting of Wells 13, 14, 15, 16, 17, and 18, located proximate to the WSAAF, as well as the potential impacts to the Philadelphia Reservoir.

2.2 2020 Groundwater Flow Model Update

The 2011 groundwater model was updated in 2020 by the USACE (USACE 2020), referred to hereafter as the 2020 groundwater model. Between 2011 and 2020, the groundwater model was used to evaluate several production scenarios that were more reflective of anticipated well field operations (USACE 2018). The objective of the 2020 groundwater model was to assess the potential of Areas 3 and 4 to supply clean drinking water for Fort Drum. Figure 2-1 shows the locations of Areas 3 and 4. Between 2017 and 2018, these areas were identified as areas for further exploration for water supply and field work, including well installation and pumping tests, was conducted. Similar to the 2011 groundwater model, WASH123D was used for the analyses. The 2020 groundwater model expanded the model domain to the north to minimize the possibility of boundary effects when simulating pumping in Area 4. The 3D mesh was adjusted to refine the model in Areas 3 and 4. The geologic framework was updated to account for additional boring data. Various pumping scenarios were evaluated under both steady-state and transient conditions. Based on the results of these analyses, personnel at Fort Drum decided to pursue the installation of production wells in Area 4.

2.3 2024 Groundwater Flow Model Update

The 2020 groundwater model was updated in 2024 by Arcadis (Arcadis 2024), referred to hereafter as the 2024 groundwater model, to further evaluate groundwater production potential in Area 4, based on the results of the 2020 assessment. The 2020 groundwater model was transformed to a MODFOW-USG (Panday et al. 2013) model and further updated using recently collected data. MODFLOW-USG was selected because it uses unstructured grids that can use similar properties as the original 2020 groundwater model, and the MODFLOW family of codes are the standard software in the industry used to simulate groundwater flow.

The objective of the 2024 groundwater modeling study was to evaluate if five new water supply wells installed within Area 4 can produce the minimum desired production rate of 500 gpm, or 0.72 MGD. The 2024 groundwater model was updated and calibrated based on initial well testing data from 2024 production tests in Area 4 (a 72-hour wellfield pumping test), using both quantitative (e.g., calibration statistics) and qualitative (e.g., groundwater flow directions) methods for both steady-state and transient conditions. The transient model was further validated using drawdown data collected during the 72-hour pumping test for Area 4, the pumping test for Well 17, and the pumping test for Area 3. The resultant calibrated model was used to evaluate four different production scenarios:

- Scenario 1 – Area 4 Estimated Sustainable Rates;
- Scenario 2 – Area 4 Simulated Pumping (Wells 3 and 4 moved);
- Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Field at Current Rates; and
- Scenario 4 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates.

All scenarios were evaluated under steady-state conditions with the same parameters (e.g., recharge and hydraulic conductivity) as the calibrated model. Scenarios 2, 3, and 4 were also evaluated under drought conditions (25 percent [%] reduced recharge) to assess the increased drawdown and the increased area of flow contribution for the pumping wells. Scenarios 3 and 4 were also evaluated under transient conditions to evaluate the potential for contaminant migration from the WSAAF.

3 Conceptual Site Model

The CSM presented herein is a written and/or illustrative representation of the physical processes in operation at Fort Drum. The goal of a CSM is to provide a description of relevant site features and characteristics that represent the site processes that result in the observed site conditions. The CSM provides a framework of conditions to construct a mathematical model (i.e., a computer-generated representation of the actual flow system). The CSM is an iterative tool that may be further developed and refined as information is obtained throughout the site investigation.

3.1 Geology

Unconsolidated deposits from the Pleistocene era within the model domain represent glacial kame, lacustrine delta, lacustrine shoreline, and ice contact deposition (Reynolds 1986). Unconsolidated deposits within Area 4 are predominantly recent silty clays with scattered clay dominated lenses while, in some areas, a sandy layer between one and ten feet in thickness was observed. These deposits vary between 16 and 60 feet in thickness throughout Area 4 and increase in thickness toward the south and east as the deposits transition to the deltaic deposits of the Pine Plains aquifer underlying the WSAAF. The WSAAF is situated atop the Pleistocene Pine Plains deltaic deposit (Reynolds 1986), which is generally comprised of silty fine sand, with silt and clay content increasing with depth throughout the area. Geologic cross-sections (Reynolds 1986) indicate bedrock underlying the WSAAF was truncated by a glacial ice lobe, producing a buried valley that increased the thickness of Pleistocene deposits in the ice lobe's former channel. Based on geologic cross-sections provided in Hydrogeology of the Fort Drum Area (Reynolds 1986), the thickness of the unconsolidated deposits ranges from approximately 100 to 220 feet. Generally, the thickest of these deposits occur in the vicinity of the WSAAF. The Pine Plains unconsolidated deposits underlying the WSAAF consist of deltaic silty sands, lacustrine bottom clays and silts, and clayey gravel, with a thin layer of basal till at the bedrock contact. These deposits thin considerably towards the north and west of the WSAAF and toward Area 4 as the deltaic complex ends and are replaced by thinner lacustrine and more recent floodplain deposits consisting of sandy silts and clays overlying bedrock.

Bedrock in the region consists of a complex of dolomitic limestones and sandstone overlying a basement metamorphic unit consisting of mylonitic gneiss. Cambrian-aged dolomitic and calcitic sandstones (e.g., Potsdam and Theresa Sandstones and Theresa Dolostones) and Ordovician-aged limestones of the Black River Group (e.g., Pamelia, Lowville, and Chaumont Limestones) are underlain by the Potsdam Sandstone (Reynolds 1986). Dolomite concentrations are higher in the lower Black River Group than the upper units, such that the Pamelia is defined as a dolomitic limestone (Johnsen 1971). The Chaumont, however, is a pure limestone within which most of the karstic features in the region are expressed. However, published geologic information for this area shows that the Chaumont is not present within Area 4. The bedrock surface varies in elevation within the study area, between 480 and 570 feet above mean sea level, and increases in elevation toward the east of Area 4 while maintaining a somewhat level trend north to south. The contacts between the three limestones appear relatively flat under the airfield; however, as presented in Hydrogeology of the Fort Drum Area (Reynolds 1986), these contacts dip westerly towards the airfield, in the vicinity of the Black River. Boring data from the test and observation wells in Area 4 similarly indicate that the upper formations generally dip toward the west to the west-northwest, as does the contact between the sedimentary units and the underlying basement rock.

Based on regional and local geologic cross-sections and bedrock mapping (Reynolds 1986; Johnsen 1971), the approximate thickness of Cambrian sandstones and Ordovician limestones near the airfield is 200 and 150 feet,

respectively. However, the limestone units thin north and northwest of the WSAAF toward Area 4 and ultimately pinch out in this direction to the north and west of Fort Drum (Reynolds 1986; Johnsen 1971). The dolomitic limestone units thin northwesterly toward Area 4 to thicknesses of less than 50 feet, and the Potsdam Sandstone unit similarly thins northwesterly, varying in thicknesses of up to 40 feet within Area 4. Based on geologic cross-sections in Hydrogeology of the Fort Drum Area (Reynolds 1986), the Potsdam Sandstone also pinches out locally towards the east of Fort Drum and is not present south and east of the Black River. Basement rock in the study area consists of a generally massive mylonitic gneiss of undefined thickness, with no significant water bearing fractures within the study area.

3.2 Hydrogeology

A drainage divide extends from west to east through the Pine Plains aquifer within the model domain. Surface drainage within Area 4 and northern portions of the Pine Plains aquifer is toward the north into the Indian River watershed and north to the St. Lawerence River drainage. Southern portions of the Pine Plains aquifer along the Black River discharge to the Black River and into the Lake Ontario watershed.

Groundwater flow occurs within both overburden materials (sand, silty sand, and clay/silt) and bedrock. Although complex flow patterns are known to exist within the overburden, particularly around the OASIS site, the model includes a simplified representation of the overburden geology that simulates average flow conditions and flux to the bedrock. The bedrock aquifer is the principal water-bearing unit at Fort Drum, with the primary water-bearing units being fracture-dominant portions of the upper dolomitic limestones/sandstones of the Pamelia and Theresa formations and the underlying Potsdam Sandstones. The mylonitic gneiss basement rock underlying the region is not a source of water within the model domain. Generally, the bedrock aquifer is thinnest near the northwestern end of Fort Drum and thickens closer to the Black River. The carbonate and sandstone units also thin and pinch out to the northeast toward the Black Creek drainage (Reynolds 1986).

The groundwater system is fracture-flow dominant, with differences in pumping rates in wells within the bedrock aquifer suggesting that the availability of groundwater from bedrock is dependent on the size and number of fractures intersected by wells. Water-bearing fracture zones were present within the uppermost limestone units and the sandstone unit at the top 10 to 20 feet of the bedrock. Within some areas, especially in the vicinity of Test Wells 3 and 4, these fracture zones were heavily weathered, resulting in some calving and deterioration of the borehole walls during drilling. Other areas of Fort Drum with thicker limestone units and more extensive fracture zones can produce significant water from the dolomitic limestone/sandstone units (such as the existing well field shown on Figure 1-1). Groundwater within the bedrock generally flows from southeast to northwest; however, there are some local differences, particularly in the area where the bedrock is thickest close to the Black River.

3.2.1 Assessment of Hydraulic Conductivity in Area 4

The drawdown data obtained from the 72-hour pumping test conducted at Area 4, described in the Updated Field Investigation Summary Report (Arcadis 2025), was analyzed using AQTESOLV (Duffield 2007) to determine the transmissivity of the bedrock materials within Area 4. The results of the pumping test analysis and resultant AQTESOLV estimates for aquifer parameters are summarized in the Updated Field Investigation Summary Report. AQTESOLV has numerous options for solutions that can be used to estimate transmissivity results from the data. In this case, the Hantush Leaky Confined Solution (Hantush 1960, 1961a/b, 1964) was used. The results of the analysis for the bedrock wells are presented in the Updated Field Investigation Summary Report, along with a discussion of the rationale for the applicability of the selected analytical solution. The pumping test

analyses showed that hydraulic conductivity within the bedrock in Area 4 varied from approximately 20 to 200 feet per day. It should be noted that those hydraulic conductivities represent the bulk hydraulic conductivity for the entire bedrock and do not reflect localized higher hydraulic conductivity areas within the bedrock that may have a more extensive fracture network.

3.3 Groundwater Recharge

The primary recharge mechanism within Fort Drum is precipitation (natural recharge). Natural recharge is variable from year to year, changing with annual precipitation. Over the last 20 years (2005 to 2024), annual precipitation has ranged from 32.80 inches per year (in/yr) to 63.08 in/yr, with an average of 46.64 in/yr (National Oceanic and Atmospheric Administration [NOAA] 2025). The annual precipitation for the past 2 years (2023 and 2024) was 48.13 and 54.39 in/yr, respectively, indicating recent annual precipitation was similar to the 20-year average. Recharge from precipitation typically ranges from 5 to 25% of annual precipitation. The spatial distribution of recharge is variable, and several factors influence the rate and spatial distribution of recharge, including:

- Recharge may be significantly reduced in winters, after the ground has frozen and precipitation occurs as snow. Snowmelt and early spring rains may restrict the ability to infiltrate and preferentially drain as surface runoff.
- The developed areas of Fort Drum are drained by a storm sewer designed to intercept and remove runoff that might otherwise infiltrate to groundwater.
- The airfield sanitary landfill has an installed cap designed to reduce recharge to the underlying groundwater system.

3.4 Conceptual Site Model Summary

Based on a review of published and subsurface geologic and hydrogeologic data, the aquifer system underlying the WSAAF and vicinity consists of an upper unconfined aquifer overlying a bedrock aquifer that is partially confined within the study area. The upper unconfined aquifer is comprised of glacially derived soils and extends throughout the WSAAF and southern portions of the Cantonment. Within the soils of the upper water-bearing unit are units of silty fine sand, silty clay, and a basal boulder till. The silty clay units are assumed to be laterally discontinuous and leaky confining units for the underlying bedrock aquifer. The boulder till is also laterally discontinuous but is highly conductive to groundwater flow where present. The Pine Plains aquifer is discontinuous to the north and west of the WSAAF, where the aquifer rapidly pinches out into lowlands of thin silty sands and clays overlying bedrock.

The bedrock aquifer is comprised of both carbonate and siliceous sedimentary bedrock that thicken toward the Black River and thin northwesterly toward Area 4 within the model domain. The bedrock aquifer is the principal water-bearing unit at Fort Drum, with the primary water-bearing units being fracture-dominant portions of the upper dolomitic limestones/sandstones of the Pamelia and Theresa formations and the underlying Potsdam Sandstones. The system is fracture-flow dominant with differences in pumping rates in wells within the bedrock aquifer suggesting that the availability of groundwater from bedrock is dependent on the size and number of fractures intersected by the wells.

4 Groundwater Flow Model Update

The boundary conditions and hydraulic properties were updated or revised to reflect data collected since the model was last updated in 2024. The model extents and resolution are the same as the 2024 groundwater model (12 layers and 425,520 nodes covering an area of approximately 40 square miles). In general, the 12 model layers represent the units as summarized in Table 4-1 below.

Table 4-1. Model Layer Description

Model Layer	Overall Description	Area 4 Description
1,2	Medium and Deltaic Sand	Medium and Deltaic Sand
3,4	Silty Deltaic Sand	Silty Deltaic Sand
5,6	Clay/Silt	Clay/Silt or Limestone/Sandstone
7,8	Boulder Till	Clay/Silt or Limestone/Sandstone
9,10	Limestone	Limestone/Sandstone
11,12	Sandstone or Gneiss	Gneiss (no flow layers in Area 4)

There are local exceptions to these units that are reflected in the hydraulic conductivity distribution presented in Section 4.2. Changes were made to the model structure in Area 4 to reflect the bedrock conditions in that area. All other areas are the same as the 2024 groundwater model.

Cross-sections showing the model structure within Area 4 are provided on Figures 4-1 to 4-3. The cross-sections are similar to those presented in the Updated Field Investigation Summary Report (Arcadis 2025). However, since cross-sections within the groundwater flow model are along a straight line and geology cannot be projected from locations that are not on the cross-section line, there are some differences between the model cross-sections and the Updated Field Investigation Summary Report cross-sections.

4.1 Boundary Conditions

Boundary conditions used in the model are summarized on Figure 4.1-1 and described in more detail below.

4.1.1 Constant Head Cells

The constant head cell locations are the same as the 2020 and 2024 groundwater models. The elevations of the constant head cells were adjusted as part of this model update. The constant head cell elevations within the northern portion of the model proximate to Area 4 were slightly adjusted from the 2024 groundwater model to account for the new groundwater elevations within Area 4 wells as the general increase in groundwater elevations by approximately 2.5 feet in Area 4 compared with the 2024 groundwater model. All other areas of the model have the same constant head elevations as the 2024 groundwater model.

4.1.2 No Flow Boundaries

The no flow boundaries are the same as the 2024 groundwater model. To be conservative, no flow boundaries were assigned to model layers 11 and 12 in Area 4, which represent the gneiss in that portion of the model. As

discussed in Sections 3.1 and 3.2, based on field observations, the gneiss is not a source of groundwater within Area 4.

4.1.3 Recharge

Recharge rates and distribution were the same as the 2024 groundwater model. Recharge rates representing infiltration by precipitation to the subsurface were distributed spatially within the model domain according to land use. Values ranged from approximately 17 in/yr, approximately 40% of annual precipitation [NOAA 2025], to approximately 1 in/yr over the airfield sanitary landfill, where a cap has been installed (approximately 2% of annual precipitation).

Similar to the 2024 groundwater model, drainage features, such as small or typically ephemeral creeks, were not explicitly simulated. Rather, the land surface elevation (top of model layer 1) was used such that if the simulated water table elevation increases above the top elevation of model layer 1 during the simulations, groundwater is removed from the model along drainage areas. This option is activated within the recharge package in MODFLOW-USG.

4.1.4 Production Wells

The existing well field production wells were simulated in model Scenario 2 (Section 6.2) at the current average pumping rates, representing January 2025 to July 2025. Note that times when Well 16 was down for maintenance (January through March 2025) were not included in the averages:

- Well 14 – 59.3 gpm;
- Well 15 – 282 gpm;
- Well 16 – 127.7 gpm;
- Well 17 – 120 gpm; and
- Well 18 – 39.3 gpm.

The steady-state and transient model calibration does not include production well pumping as there is significant uncertainty regarding pumping rates on any given day. The production wellfield area monitoring well groundwater elevations are very sensitive to production well pumping (see Section 5.2 for more information regarding overall model sensitivity); however, groundwater elevations in Area 4 are relatively insensitive to pumping at the existing well field production wells.

4.2 Hydraulic Conductivity

The hydraulic conductivity distribution in the model is largely the same as the 2024 groundwater model. The hydraulic conductivity in model layers 9 and 10 were updated in Area 4 to reflect the results of the pumping test for the groundwater monitoring locations and test wells installed in 2025. All other areas are the same as the 2024 groundwater model. The hydraulic conductivity is presented in Figures 4.2-1 to 4.2-6. Consistent with regional geologic data and the Airfield area of the groundwater model, the bedrock was assumed to have a 3:1 (K_y : K_x) anisotropy ratio within Area 4. Tables 4.2-1 and 4.2-2 present ranges of hydraulic conductivities within each model layer for the overall model and Area 4, respectively.

5 Groundwater Flow Model Calibration

Calibration of a groundwater flow model refers to the iterative process of systematically adjusting the model boundary conditions and input parameters within a justifiable or published range of values to obtain as close a match as possible between observed and simulated water levels. The generally accepted process for the comparison of simulated and observed water levels is summarized in American Standard Test Method (ASTM) D-5490-93 (ASTM 1994) and utilizes the concept of residuals, which is the difference between the simulated and observed water level.

The residuals are evaluated using standard statistical measures, residual mean, residual sum-of-squares (RSS), variance, and normalized root mean squared error. The standard deviation (the square root of the variance) is the median error and needs to be small compared to the range in observed data. In Applied Groundwater Modeling, Simulation of Flow and Advective Transport (Anderson et al. 2015), it is indicated that there are no established industry guidelines regarding the acceptable magnitude of residual statistics, including the residual mean, the standard deviation, or the normalized root mean squared error, other than it is desirable to minimize these values. Moreover, the acceptability of the calibration is somewhat dependent on the complexity of the model, quantity and quality of available data, and modeling objectives. The model's ability to represent the observed characteristics of the system being simulated (e.g., observed flow patterns, distribution of heads, flow volumes and water balance, adherence to the CSM, and other subjective criteria) provide another measure of calibration.

5.1 Steady-State Calibration

The groundwater model was calibrated under steady-state conditions using 286 water level targets from the following:

- 27 water levels collected from Area 4 monitoring/test wells during April/May 2025;
- 93 water levels from monitoring locations collected as part of the per- and polyfluoroalkyl substances remedial investigation in November 2022; and
- Water levels from an additional 166 locations (August or September 2023), representing heads from the OASIS site and throughout Fort Drum, collected as part of the per- and polyfluoroalkyl substances remedial investigation.

The 259 water level targets outside of Area 4 were included in the steady-state calibration presented in the Groundwater Model Update Report (Arcadis 2024). The 286 water level targets are compiled in Table 5.1-1. The 93 water levels collected in November 2022 were given a weight of 0.5 to account for the much earlier time period from the other water levels. The term residual within this section refers to weighted residuals and all calibration statistics were calculated using weighted residuals.

The steady-state calibration was evaluated for the overall model, bedrock only, and Area 4 only. Results of the overall model steady-state calibration are presented graphically on Figure 5.1-1 in a scatter plot of simulated versus observed head values. As shown by the RSS, the majority of the data points generally fall near a 1:1 ratio line, which indicates that simulated values approximate the field-measured water levels, with outliers on both ends of the available data. Groundwater elevations are generally both over-predicted in the mid-range of observed heads and under-predicted where under-predicted values tend to fall more within higher observed head ranges. The residual mean, residual standard deviation, RSS, and absolute residual mean (the average of the absolute value of all the residuals) were calculated to be -0.78 feet, 1.56 feet, 1,240.6 square feet (ft^2), and 1.56 feet,

respectively. The scaled residual standard deviation, which is the residual standard deviation divided by the range of observed heads and assesses overall model fit adjusted for scaling effects, is 1.15%. The residual mean is close to zero, relative to the large range in water levels, and the absolute residual mean and the standard deviation have similar values, also indicating a well-calibrated model.

Results of the bedrock portion of the model steady-state calibration are presented graphically on Figure 5.1-2 in a scatter plot of simulated versus observed head values. As shown by the RSS, the majority of the data points generally fall near a 1:1 ratio line, which indicates that simulated values approximate the field-measured water levels, with outliers on both ends of the available data. Groundwater elevations are generally both over-predicted in the mid-range of observed heads and under-predicted where under-predicted values tend to fall more within higher observed head ranges. The residual mean, residual standard deviation, RSS, and absolute residual mean were calculated to be 0.32 feet, 2.16 feet, 314.5 ft^2, and 2.16 feet, respectively. The scaled residual standard deviation is 1.80%. The residual mean is close to zero, relative to the large range in water levels, and the absolute residual mean and the standard deviation have similar values, also indicating a well-calibrated model within the bedrock.

Results of the Area 4 portion of the model steady-state calibration are presented graphically on Figure 5.1-3 in a scatter plot of simulated versus observed head values. As shown by the RSS, the majority of the data points generally fall near a 1:1 ratio line, which indicates that simulated values approximate the field-measured water levels, with outliers on both ends of the available data. Groundwater elevations are generally both over-predicted in the mid-range of observed heads and under-predicted where under-predicted values tend to fall more within higher observed head ranges. The residual mean, residual standard deviation, RSS, and absolute residual mean were calculated to be -0.74 feet, 2.03 feet, 153.9 ft^2, and 2.03 feet, respectively. The scaled residual standard deviation is 2.60%. The residual mean is close to zero, relative to the large range in water levels, and the absolute residual mean and the standard deviation have similar values, also indicating a well calibrated model within Area 4.

The simulated groundwater elevations and residuals for each model layer are presented on Figures 5.1-4 through 5.1-9. The flow patterns are similar to previous versions of the groundwater model, including the 2024 groundwater model.

5.2 Sensitivity Analysis

Sensitivity analyses were performed on all the parameters adjusted during the calibration process: horizontal and vertical hydraulic conductivity, groundwater recharge, and existing wellfield pumping. The sensitivity analyses focused on quantitative calibration metrics, RSS, and residual mean. These metrics were assessed to determine if the model calibration could be improved (if the RSS can be lowered or residual mean can be closer to zero) and whether the changes in a model parameter have a large or small effect on the model calibration. These metrics were evaluated for the overall model, bedrock only, and Area 4 only. The results of the sensitivity analyses are discussed in detail in Appendix A of this report. All the parameters used in the calibrated model were sensitive either in the overall model, bedrock only, or Area 4 only. Some parameters were more sensitive than others; for example, the overall model was most sensitive to recharge in the airfield area. Area 4 was also sensitive to recharge variation within the area and to changes in hydraulic conductivity within bedrock, but not within the overburden (which is mostly clay/silt in Area 4). The results of the sensitivity analysis for these parameters suggest that they are likely the best fit for model calibration and provide greater confidence in the predicted well yield from Area 4. When parameters are generally insensitive or unconstrained by the calibration, they do not seem to have significant impact on the overall scenario results presented in Section 6. The results of the sensitivity analyses are summarized in Table 5.2-1.

5.3 Transient Calibration

5.3.1 Transient Model Set-Up

Validation of the calibrated groundwater model was accomplished by incorporating aquifer storage into the model and simulating the groundwater drawdown at 21 monitoring locations collected during the 72-hour pumping test conducted in May 2025 for the five test wells installed in Area 4. Drawdown was calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the transient groundwater elevation. Starting heads for the simulation used the steady-state model described in Section 5.1. Table 5.3-1 presents the transient model set-up. The pumping rate for each of the five test wells were varied over time. Stress periods 1 through 12 represent the active pumping period during the 72-hour pumping test. All other parameters and boundary conditions remained the same as the steady-state calibrated model.

Storage was assigned in the model based on aquifer conditions. Aquifer storage and specific yield were varied for each model layer (Figure 5.3-1).

5.3.2 Transient Model Results

The groundwater flow model was transiently calibrated using a set of 288,504 drawdown measurements collected from 21 monitoring locations during the 72-hour pumping test (Table 5.3-1). The simulated drawdown over time for each location is presented on Figures 5.3-2 through 5.3-5. Fifteen monitoring locations (61% of the monitoring locations) very closely matched both the peak observed groundwater drawdown and the observed recovery (A4-OBS-10D, A4-OBS-03D, A4-OBS-7D, A4-OBS-05D, A4-OBS-04D, A4-OBS-09D, A4-OBS-14, A4-OBS-15, A4-OBS-13, A4-OBS-08D, A4-OBS-12, A4-OBS-11, A4-OBS-16, Well-3R, and Well-4R). One monitoring location had simulated the peak drawdown higher than the observed drawdown (Well-1). Five monitoring locations did not simulate as much drawdown as was observed in field measurements (A4-OBS-06D, A4-OBS-02D, A4-MW-1, Well-2, and Well-5). This could be due to preferential flow pathways or fracture-dominant flow that is not simulated in the equivalent porous media-based groundwater flow model. Additionally, groundwater recovery (i.e., drawdown decreasing back to zero and return of the aquifer to near pre-pumping conditions) was simulated at a similar rate as observed in the field data. The residual mean, residual standard deviation, RSS, and absolute residual mean for the transient drawdown targets were calculated to be 0.19 feet, 2.20 feet, 1,412,460 ft^2, and 1.17 feet, respectively. Of the 288,504 drawdown targets, 86% are within the 10% range of observed drawdown (2.58 feet).

To ensure the updated model adequately represents the observed drawdown within the existing production wellfield and Area 3, the 2024 groundwater model was previously validated to those pumping tests previously completed by the USACE for Well 17 (USACE 2011) and within Area 3 (USACE 2018). As there were no changes made to those areas of the groundwater model during the update process, these validations were not replicated for this effort.

6 Production Scenarios

The calibrated model was used to assess conceptual multi-well fields in Area 4. Steady-state pumping scenarios were used to evaluate drawdown and the flow area for each production well. Transient pumping scenarios were run to assess variations in travel times from the WSAAF (an area of known groundwater contamination).

The production scenarios assumed the same boundary conditions as the steady-state calibrated model (described in Section 4). Drawdown from pumping is shown for each scenario. Drawdown was calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the groundwater elevation for each scenario. Consistent with known site conditions, 10% porosity was assumed for bedrock material and 30% porosity was assumed for overburden materials. These scenarios are representative of average flow conditions based on an equivalent porous media approach and do not account for preferential flow pathways.

The percentage (and area) of contributing flow for each production well was evaluated under steady-state conditions using the MODular flow ALLocation (MODALL) program (Potter et al. 2008). This program uses the same MODFLOW-calculated cell-by-cell flow output as MODPATH (Pollock 1989), but rather than tracking individual particle paths, it directly computes the percentage (and area) of contributing flow for each production well.

Forward particle tracking from the WSAAF (an area of known groundwater contamination) was simulated under transient conditions for all scenarios using mod-PATH3DU (Muffels et al. 2020), a MODFLOW-USG specific pathline analysis program developed by S.S. Papadopulos & Associates, Inc., and the University of Waterloo. This particle tracking is not intended to quantify concentrations that may be observed in the production wells in the future but is only intended to be a qualitative assessment of potential risk posed by the presence of known areas of contamination to the Area 4 wells. While the production scenario simulations below suggest there may be flow contribution from areas of known contamination in groundwater, including the WSAAF, the model cannot evaluate the timing, fate, or transport of compounds present in the model domain, or how dilution from other areas of flow contribution nearer the well may result in dilution of any contaminants. Therefore, any assessment of contaminant flow or potential impacts to the Area 4 wells beyond an assessment of contributing flow areas is beyond the scope of this assessment.

The pumping wells for each Scenario are shown in Table 6-1 below. Each scenario and the results are described in more detail in Sections 6.1 to 6.3.

Table 6-1. Production Scenario Well Rates

Production Scenario	Extraction Rate (gpm)										
	Well 1	Well 2	Well 3R	Well 4R	Well 5	Well 14	Well 15	Well 16	Well 17	Well 18	Total Rate
Scenario 1 – Area 4 Estimated Sustainable Rates	100	115	50	100	135	0	0	0	0	0	**500**
Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current (2025) Rates	100	115	50	100	135	59.3	282	127.7	120	39.3	**1,128.4**
Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Design Rates	100	115	50	100	135	95	300	400	600	95	**1,990**

6.1 Scenario 1 – Area 4 Estimated Sustainable Rates

As discussed in the Updated Field Investigation Summary Report (Arcadis 2025), the estimated sustainable rates for the Area 4 production wells yield a combined total of 500 gpm (approximately 0.72 MDG) over the 3-day pumping test:

- Well 1 – 100 gpm;
- Well 2 – 115 gpm;
- Well 3R – 50 gpm;
- Well 4R – 100 gpm;
- Well 5 – 135 gpm; and
- Total – 500 gpm.

The area of contributing flow for each well, drawdown, and impact to nearby water supplies was evaluated. The results of the steady-state analysis in model layer 10 (limestone/sandstone) are shown on Figure 6.1-1. Greater than 1 foot of drawdown was observed within the limestone/sandstone when the five wells were pumping; this drawdown extended to the north and south of Area 4. The primary area contributing to the yield for Wells 1 and 2 originates from beneath the WSAAF. The flow for Wells 3R, 4R, and 5 primarily originates to the east. A small portion of the flow for Wells 3R, 4R, and 5 also originates near the existing production well field when it is not operating. Potential off-site potable wells located to the northeast could have up to 2.2 feet of drawdown in the limestone/sandstone. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

The water table drawdown (model layer 1) from the Area 4 test wells is shown on Figure 6.1-2. There is one isolated area where greater than 1 foot of drawdown is shown within Area 4. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations, compared to the safe drawdown limits as established by Fort Drum as their presumed limit for the purposes of permitting the new wells. Drawdown was calculated using both feet below top of casing and feet below ambient (non-pumping) groundwater conditions. The five test wells in Area 4 do not exceed the safe drawdown limits. The safe drawdown limit of zero (e.g., no impact) was not exceeded for the Philadelphia Reservoir. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations.

6.1.1 Steady-State – Drought Conditions

Drought conditions (reduction in recharge from precipitation) could impact the available drawdown and the area of flow contribution for the pumping wells. To simulate drought conditions, the recharge applied to the model was reduced by 25% below the calibration conditions (see Figure 4.1-1). Drawdown was then calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 1 groundwater elevation under drought conditions. Therefore, drawdown represents the cumulative impact of the reduced recharge and pumping. This reduction in recharge caused water levels within the bedrock to drop by 3 to 5 feet in the area of Wells 14 to 18 and Area 3 (Figure 6.1-3). In areas of groundwater discharge (Area 4), water levels within the bedrock dropped by less than 1 foot. Due to the drop in water levels, the area of flow contribution for the Area 4 wells expanded slightly to the northeast and south (Figure 6.1-3).

Potential off-site potable wells located to the northeast could have up to 2.5 feet of drawdown in the limestone/sandstone.

The water table drawdown (model layer 1) from the Area 4 test wells under drought conditions is shown on Figure 6.1-4. There are additional areas of drawdown due to drought conditions, particularly in the airfield area, where there are areas with greater than 10 feet of water table drawdown. There are areas within Area 4 where more than 1 foot of drawdown is shown in the wetlands and intermittent/ephemeral streams due to drought conditions. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4. Less than 1 foot of drawdown is expected in the area of the Philadelphia Reservoir due to drought conditions.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations compared to the safe drawdown limits for adjacent potable sources. The five test wells in Area 4 do not exceed the safe drawdown limits. The safe drawdown limit of zero (e.g., no impact) was exceeded for the Philadelphia Reservoir; however, some level of drawdown is likely during drought conditions. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations.

6.1.2 Transient

This scenario was run under transient conditions to evaluate the potential for contaminant migration from the WSAAF. Pumping rates for the well fields were constant for 30 years. A 5-day timestep was used for the evaluation. Figure 6.1-5 shows the results of the forward particle tracking under transient conditions. The starting locations for the particles were the top of the bedrock (model layer 9) at the WSAAF. These locations are not intended to illustrate all locations that may be contaminated at Fort Drum but are meant to show the potential for long-term well field contamination. As mentioned previously, this analysis is not intended to quantify concentrations that may be observed in production wells in the future but is only intended to be a qualitative assessment of potential risk posed by the presence of known areas of contamination to the Area 4 wells. The results under this pumping regime show that Wells 1, 2, and 5 capture initialized particles beneath the WSAAF within 30 years. While the groundwater model results show that many of the wells do not capture the initialized particles, it is recommended that sentinel well monitoring be implemented to ensure the well fields are unimpacted. Additionally, the travel time is dependent on the porosity used for each model layer (30% for overburden and 10% for bedrock). If the porosity is smaller, the travel times will be faster.

6.2 Scenario 2 – Area 4 Simulated Pumping Rates with Existing Well Fields at Current Rates

The Area 4 simulated pumping rates and locations (assessed in Scenario 1) were evaluated with existing well fields at current pumping rates:

- Well 1 – 100 gpm;
- Well 2 – 115 gpm;
- Well 3R – 50 gpm;
- Well 4R – 100 gpm;
- Well 5 – 135 gpm;

- Well 14 – 59.3 gpm;
- Well 15 – 282 gpm;
- Well 16 – 127.7 gpm;
- Well 17 – 120 gpm;
- Well 18 – 39.3 gpm; and
- Total – 1,128.4 gpm.

This scenario was run under both steady-state and transient conditions. The steady-state conditions evaluated the area of flow for each production well. The transient conditions evaluated the potential for migration from the WSAAF (an area of known contamination) under variable pumping conditions.

6.2.1 Steady State

The primary groundwater area contributing to the yield for each well, drawdown, and impact to nearby water supplies was evaluated. The results of the steady-state analysis in model layer 10 (limestone/sandstone) are shown on Figure 6.2-1. Greater than 1 foot of drawdown was observed within the limestone/sandstone when the five wells were pumping; this drawdown extended to the north and south of Area 4. Like Scenario 1, the primary area contributing to the yield for Wells 1 and 2 originates from beneath the WSAAF. The flow for Wells 3R, 4R, and 5 primarily originates to the east. A small portion of the flow for Wells 3R, 4R, and 5 also originates near the existing production well field. Potential off-site potable wells located to the northeast could have up to 2.3 feet of drawdown in the limestone/sandstone.

The water table drawdown (model layer 1) from the Area 4 test wells and the operation of the existing wellfield at average rates is shown on Figure 6.2-2. There are five isolated areas where greater than 1 foot of drawdown is shown in the wetlands and intermittent/ephemeral streams within Area 4. The operation of the existing wellfield has 1 to 4 feet of drawdown within model layer 1, in the airfield area. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4 and has limited impacts from pumping at the existing wellfield at current average rates.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations, compared to the safe drawdown limits for adjacent potable sources. The five test wells in Area 4 do not exceed the safe drawdown limits. The safe drawdown limit of zero (e.g., no impact) was exceeded for the Philadelphia Reservoir with the addition of the operation of the existing wellfield. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

6.2.1.1 Steady State – Drought Conditions

Drought conditions (reduction in recharge from precipitation) could impact the available drawdown and the area of flow contribution for the pumping wells. To simulate drought conditions, the recharge applied to the model was reduced by 25% below the calibration conditions (see Figure 4.1-1). Drawdown was calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 2 groundwater elevation under drought conditions. Therefore, drawdown represents the cumulative impact of the reduced recharge and pumping. This reduction in recharge caused water levels within the bedrock to drop by 3 to 5 feet in the area of Wells 14 to 18 and Area 3 (Figure 6.2-3). In areas of groundwater discharge (Area 4), water levels within the

bedrock dropped by less than 1 foot. Due to the drop in water levels, the area of flow contribution for the Area 4 wells expanded slightly to the northeast and south (Figure 6.2-3). Potential off-site potable wells located to the northeast could have up to 2.8 feet of drawdown in the limestone/sandstone.

The water table drawdown (model layer 1) from the operation of the five Area 4 test wells and the existing wellfield at average rates is shown on Figure 6.2-4. There are additional areas of drawdown due to drought conditions, particularly in the airfield area, where there is greater than 10 feet of water table drawdown. There are areas within Area 4 where more than 1 foot of drawdown is shown in the wetlands and intermittent/ephemeral streams due to drought conditions. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4. Less than 1 foot of drawdown is expected in the Philadelphia Reservoir under drought conditions.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations, compared to the safe drawdown limits for adjacent potable sources. The five test wells in Area 4 do not exceed the safe drawdown limits. The safe drawdown limit of zero (e.g., no impact) was exceeded for the Philadelphia Reservoir; however, some level of drawdown is likely during drought conditions. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

6.2.2 Transient

This scenario was run under transient conditions to evaluate the potential for contaminant migration from the WSAAF. Pumping rates for the well fields were constant for 30 years. A 5-day timestep was used for the evaluation. Figure 6.2-5 shows the results of the forward particle tracking under transient conditions. The starting locations for the particles were the top of the bedrock (model layer 9) at the WSAAF. These locations are not intended to illustrate all locations that may be contaminated at Fort Drum but are meant to show the potential for long-term well field contamination. As mentioned previously, this analysis is not intended to quantify concentrations that may be observed in production wells in the future but is only intended to be a qualitative assessment of potential risk posed by the presence of known areas of contamination to the Area 4 wells. The results under this pumping regime show that Wells 1, 2, and 16 capture initialized particles beneath the WSAAF within 30 years. While the groundwater model results show that many of the wells do not capture the initialized particles, it is recommended that sentinel well monitoring be implemented to ensure the well fields are unimpacted. Additionally, the travel time is dependent on the porosity used for each model layer (30% for overburden and 10% for bedrock). If the porosity is smaller, the travel times will be faster.

6.3 Scenario 3 – Area 4 Simulated Pumping Rates with Existing Well Fields at Permitted Rates

The Area 4 simulated pumping rates and locations (assessed in Scenario 1) were evaluated with existing well fields at maximum pumping rates:

- Well 1 – 100 gpm;
- Well 2 – 115 gpm;
- Well 3R – 50 gpm;
- Well 4R – 100 gpm;

- Well 5 – 135 gpm;
- Well 14 – 95 gpm;
- Well 15 – 300 gpm;
- Well 16 – 400 gpm;
- Well 17 – 600 gpm;
- Well 18 – 95 gpm; and
- Total – 2,040 gpm.

This scenario was run under both steady-state and transient conditions. The steady-state conditions evaluated the area of flow for each production well. The transient conditions evaluated the potential for migration from the WSAAF (an area of known contamination).

6.3.1 Steady State

The primary groundwater area contributing to the yield for each well, drawdown, and impact to nearby water supplies was evaluated. The results of the steady-state analysis in model layer 10 (limestone/sandstone) are shown on Figure 6.3-1. Greater than 1 foot of drawdown extended throughout the model domain within the limestone/sandstone when the 10 wells were pumping. The primary area of groundwater yield contribution for Wells 1 and 2 and the existing production wells primarily originates from beneath the WSAAF and areas to the south, where there are areas of known contamination. With the existing production wells operating, the yield contribution for Wells 3R, 4R, and 5 is farther to the north and east, primarily away from the WSAAF. Potential off-site potable wells located to the northeast could have nearly 3 feet of drawdown in the limestone/sandstone. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

The water table drawdown (model layer 1) from the Area 4 test wells and the operation of the existing wellfield at permitted rates is shown on Figure 6.3-2. There are five isolated areas where greater than 1 foot of drawdown is shown in the wetlands and intermittent/ephemeral streams within Area 4. The operation of the existing wellfield has 1 to 10 feet of drawdown within model layer 1 in the airfield area. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4. Approximately 1 foot of drawdown is expected in the Philadelphia Reservoir with the existing wellfield operating at permitted rates.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations, compared to the safe drawdown limits for adjacent potable sources. The five test wells in Area 4 do not exceed the safe drawdown limits. The safe drawdown limit of zero (e.g., no impact) was exceeded for the Philadelphia Reservoir with the addition of the operation of the existing wellfield. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

6.3.1.1 Steady State – Drought Conditions

Drought conditions (reduction in recharge from precipitation) could impact the available drawdown and the area of flow contribution for the pumping wells. To simulate drought conditions, the recharge applied to the model was reduced by 25% below the calibration conditions (see Figure 4.1-1). Drawdown was calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 3 groundwater elevation

under drought conditions. Therefore, drawdown represents the cumulative impact of the reduced recharge and pumping. This reduction in recharge caused water levels within the bedrock to drop by 3 to 5 feet around Wells 14 to 18 and Area 3 (Figure 6.3-3). In areas of groundwater discharge (Area 4), water levels within the bedrock dropped by less than 1 foot. Due to the drop in water levels, the area of flow contribution for the Area 4 wells expanded slightly to the northeast and south (Figure 6.3-3). Potential off-site potable wells located to the northeast could have nearly 3 feet of drawdown in the limestone/sandstone.

The water table drawdown (model layer 1) from the operation of the five Area 4 test wells and the existing wellfield at permitted rates is shown on Figure 6.3-4. There are additional areas of drawdown due to drought conditions, particularly in the airfield area, where there are extensive areas with greater than 10 feet of water table drawdown. There are areas within Area 4 where more than 1 foot of drawdown is shown in the wetlands and intermittent/ephemeral streams due to drought conditions. The simulation results also suggest that the Philadelphia Reservoir is unaffected by pumping from the five test wells in Area 4. Approximately 3 feet of drawdown is expected in the Philadelphia Reservoir under drought conditions.

Table 6.1-1 provides a summary of the simulated drawdown in the Area 4 test wells, the Philadelphia Reservoir, and the potential off-site potable well locations, compared to the safe drawdown limits for adjacent potable sources. The safe drawdown limit of zero (e.g., no impact) was exceeded for the Philadelphia Reservoir; however, some level of drawdown is likely during drought conditions. As noted above, the safe drawdown of zero (e.g., no impact) was exceeded for the potential off-site potable well locations. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically collected to assess this risk.

6.3.2 Transient

This scenario was run under transient conditions to evaluate the potential for migration from the WSAAF. Pumping rates for the well fields were constant for 30 years. A 5-day timestep was used for the evaluation. Figure 6.3.5 shows the results of the forward particle tracking under transient conditions. The starting locations for the particles were the top of the bedrock (model layer 9) at the WSAAF. These locations are not intended to illustrate all locations that may be contaminated at Fort Drum but are meant to show the potential for long-term well field contamination. The results under this pumping regime show that Wells 1, 2, 16, and 17 capture initialized particles beneath the WSAAF within 30 years. While the groundwater model results show that many of the wells do not capture the initialized particles, it is recommended that sentinel well monitoring be implemented to ensure the well fields are unimpacted. Additionally, the travel time is dependent on the porosity used for each model layer (30% for overburden and 10% for bedrock). If the porosity is smaller, the travel times will be faster.

7 Summary and Conclusions

The 2024 groundwater model was updated using recently collected data. Based on both quantitative (e.g., calibration statistics) and qualitative (e.g., groundwater flow directions) analyses, the groundwater flow model was adequately calibrated for both steady-state and transient conditions. The transient model was further validated using drawdown data collected during the 72-hour pumping test for Area 4. The calibrated model was used to evaluate three different production scenarios:

- Scenario 1 – Area 4 Estimated Sustainable Rates;
- Scenario 2 – Area 4 Estimated Sustainable Rates with Existing Well Field at Current Rates; and
- Scenario 3 – Area 4 Estimated Sustainable Rates with Existing Well Fields at Permitted Rates.

All scenarios were evaluated under steady-state conditions with the same parameters (e.g., recharge and hydraulic conductivity) as the calibrated model. The scenarios were also evaluated under drought conditions (25% reduced recharge) to assess the increased drawdown and the increased area of flow contribution for the pumping wells. Each scenario was also evaluated under transient conditions to evaluate the potential for contaminant migration from the WSAAF, based on a limited assessment of particle flow, without considering other contaminant transport processes (e.g., retardation, diffusion).

Based on the results of the steady-state and transient simulations, the following conclusions can be drawn:

1. The current well field in Area 4 is able to provide groundwater pumping at the minimum desired production rate of 500 gpm (0.72 MGD), based on the results of the pumping test and the long-term steady-state analyses.
2. All wells were within the safe drawdown limit for the long-term steady-state analyses based on the parameters of the simulations, and assuming existing site conditions. However, changes to existing conditions, such as future land development or modification of infiltration and drainage patterns within the vicinity, could result in reduced infiltration and aquifer recharge. Such modifications could reduce actual production rates and long-term sustainable yields and would need to be considered carefully and fully assessed.
3. **Impacts to Existing Wellfield**: The model suggests that groundwater production in Area 4 would not impact current production from the existing well field (Wells 14, 15, 16, 17, and 18).
4. **Area 4 Wells Vulnerable to Contamination**: As the groundwater model results suggest that Wells 1, 2, and 5 could receive groundwater flow contribution from beneath the airfield within 30 years of pumping, it is recommended that sentinel wells be installed between the airfield and Area 4 to support monitoring of flow from the WSAAF.
5. **Potential Off-Site Potable Well Impacts**: Simulations suggest that areas of the aquifer where off-site potable wells may be located to the northeast of Area 4 could have between 2 and 3 feet of drawdown in the limestone/sandstone during continuous long-term operation of the Area 4 wells. Water levels at monitoring wells A4-MW-10D and A4-MW-11 should be periodically monitored to assess this risk. If such impacts are observed in the monitoring wells, the data could be used to validate, or further refine the model predictions.
6. **Impacts to Surface Water/Wetlands**: The modeling results suggest, under the conditions present at the pumping test, groundwater production in Area 4 does not significantly impact surface water/wetlands.
7. **Impacts to the Philadelphia Reservoir**: The Philadelphia Reservoir is not impacted by the operation of the Area 4 wells. However, limited drawdown was simulated at the Philadelphia Reservoir (ranging from 0.3 to 2.8 feet) during operation of the existing wellfield under drought conditions.

8 Uncertainties and Limitations

The groundwater flow model described in this report relied on the CSM developed for the vicinity and data collected at Fort Drum to simulate groundwater flow. Where site-specific data was not available or monitored, specific hydraulic and other physical parameters were approximated for Fort Drum based on literature values and/or the experience of the project team. Because models are representations of natural systems, there is a level of uncertainty in the abstraction of a complex natural system into a multilayer numerical flow model. According to Applied Groundwater Modeling, Simulation of Flow and Advective Transport (Anderson et al. 2015), two broad sources of uncertainty can be considered: (1) uncertainty associated with the model itself; and (2) uncertainty associated with accurate specifications of future conditions.

The first source of uncertainty arises from assumptions in the underlying CSM, the accuracy of the assumed boundary conditions, measurement errors in observations used for calibrating the model, the quality of the calibration, and simplifications in model scale, temporalization, and parameterization. The second source of uncertainty arises from our inability to anticipate future conditions (for example: long-term changes to precipitation and recharge and the location of future sources and sinks).

In this report, it is assumed that the calibrated flow model is capable of simulating future groundwater flow conditions to within a reasonable margin of error. The predicted results and interpretation should be considered in the context of these uncertainties and limitations. To improve the accuracy of the model predictions, the model may be revised or updated periodically (if required) as additional data becomes available.

As the groundwater model is simulating the bedrock as equivalent porous media, it does not account for preferential flow pathways or changes in aquifer storage and other potential limitations or potential sources of water availability that may exist within the bedrock.

9 References

Anderson, Mary P., W. W. Woessner, and R. J. Hunt. 2015. Applied Groundwater Modeling, Simulation of Flow and Advective Transport, second edition. Elsevier Publishing.

Arcadis. 2024. Groundwater Model Update Report. ERCIP Well Field Expansion Project – United States Army Garrison, Fort Drum, New York. May.

Arcadis. 2025. Updated Field Investigation Summary Report. ERCIP Well Field Expansion Project – United States Army Garrison, Fort Drum, New York.

ASTM. 1994. ASTM D 5490-93. Standard Guide for Comparing Ground-Water Flow Model Simulations to Site-Specific Information. Approved November 15, 1993. Published January 1994.

Duffield, G.M. 2007. *AQTESOLV for Windows Version 4.5 User's Guide*, HydroSOLVE, Inc., Reston, VA

Hantush, M.S. 1960. Modification of the theory of leaky aquifers, Jour. of Geophys. Res., vol. 65, no. 11, pp. 3713-3725.

Hantush, M.S. 1961a. Drawdown around a partially penetrating well, Jour. of the Hyd. Div., Proc. of the Am. Soc. of Civil Eng., vol. 87, no. HY4, pp. 83-98.

Hantush, M.S. 1961b. Aquifer tests on partially penetrating wells, Jour. of the Hyd. Div., Proc. of the Am. Soc. of Civil Eng., vol. 87, no. HY5, pp. 171-194.

Hantush, M.S. 1964. Hydraulics of wells, in: Advances in Hydroscience, V.T. Chow (editor), Academic Press, New York, pp. 281-442.

Muffels, C., L. Scantlebury, X. Wang, M. Tonkin, C. Neville, M. Ramadhan, and J.R. Craig. 2020. User's Guide for mod-PATH3DU. Bethesda, Maryland. Waterloo, Ontario. April 2020. http://mp3du.sspa.com/man/#Introduction

NOAA. 2025. NOAA Station USC0030900. Watertown, NY. https://www.ncei.noaa.gov/access/search/data-search/global-summary-of-the-month?dataTypes=PRCP&pageNum=1&bbox=44.129,-76.072,43.709,-75.310&startDate=2015-01-04T00:00:00&endDate=2024-01-04T23:59:59

Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D. 2013. MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p. http://pubs.usgs.gov/tm/06/a45

Pollock, D. 1989. Documentation of Computer Programs to Compute and Display Pathlines Using Results for the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. U.S. Geological Survey Open File Report 89-381. Reston, Virginia.

Potter, S.T., E. Moreno-Barbero, and C.E. Divine. 2008. MODALL: A Practical Tool for Designing and Optimizing Plume Capture Systems. Groundwater. 46(2): 335-340.

Reynolds, Richard J. 1986. Hydrogeology of the Fort Drum Area, Jefferson, Lewis, and St. Lawrence Counties, New York: United States Geological Survey. Albany, New York.

USACE. 2011. Final Groundwater Model Report. Fort Drum Watershed, Fort Drum, New York.

USACE. 2018. Evaluation of Potential Water Supply Areas, Fort Drum, New York. November.

USACE. 2020. DRAFT – Update to 2011 Groundwater Model. Fort Drum Watershed, Fort Drum, New York. Prepared by U.S. Army Corps of Engineers, Philadelphia District. April 2020.

USACE. 2024. Statement of Work, Design Services for ERCIP Well Field Expansion Project, United States Army Garrison – Fort Drum, NY, Contract W912DS20D0002 (Arcadis), July 23.

Tables

Table 4.2-1
Overall Model Hydraulic Conductivity Summary
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Model Layer	Horizontal K Range (ft/day)	Vertical K Range (ft/day)	Ky:Kx Range
1	0.01264 - 300	0.00017484 - 300	1 - 1
2	0.009398 - 200	0.00001661 - 200	1 - 1
3	0.01231 - 270.2	0.00002324 - 200	1 - 3
4	0.01231 - 270.2	0.0002324 - 200	1 - 3
5	0.0007276 - 176	0.00006564 - 17.6	1 - 3
6	0.0007276 - 176	0.00001145 - 17.6	1 - 3
7	0.008599 - 473.8	0.0008599 - 28.5	1 - 3.1
8	0.009217 - 473.8	0.0009217 - 31.4	1 - 3.1
9	0.475 - 317.3	0.0075 - 31.73	1.5 - 3.1
10	0.475 - 317.3	0.0475 - 31.73	1.5 - 3.1
11	0.25 - 90.09	0.0075 - 9.009	1.5 - 3.4
12	0.05 - 166.58	0.0005 - 1.6658	1.5 - 3.4

Notes and Abbreviations:
ft/day = feet per day

Table 4.2-2
Area 4 Hydraulic Conductivity Summary
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Model Layer	Horizontal K Range (ft/day)	Vertical K Range (ft/day)	Ky:Kx Range
1	0.01264 - 200	0.00017484 - 200	1 - 1
2	0.01248 - 200	0.00001661 - 200	1 - 1
3	0.012448 - 200	0.00002324 - 200	1 - 1
4	0.012448 - 200	0.0002324 - 200	1 - 1
5	0.006145 - 23.37	0.0001145 - 1.614	1 - 3
6	0.006145 - 25.24	0.00001145 - 0.9375	1 - 3
7	0.009217 - 295.7	0.0009217 - 24.14	1 - 3
8	0.009217 - 155.6	0.0009217 - 8.966	1 - 3
9	0.75 - 225	0.0075 - 5	1.5 - 3
10	0.75 - 250	0.075 - 25	1.5 - 3
11	Area 4 is no flow in model layers 11 and 12.		
12			

Notes and Abbreviations:
ft/day = feet per day

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
A12-N	1	650.91	651.03	1.00	-0.12
A15-N	1	649.78	650.62	1.00	-0.84
B16-N	1	651.02	650.47	1.00	0.55
B14-X	1	650.84	650.76	1.00	0.08
B10-X	1	651.45	651.25	1.00	0.20
B7-X	1	650.56	651.55	1.00	-0.99
B6-X	1	650.77	651.63	1.00	-0.86
SPMP-01	1	651.40	651.62	1.00	-0.22
C3-N	1	651.00	651.89	1.00	-0.89
PZ-07	1	649.35	651.72	1.00	-2.37
C5-N	1	651.37	651.71	1.00	-0.35
C7-N	1	651.27	651.55	1.00	-0.27
C16-N	1	650.57	650.47	1.00	0.09
C17-N	1	650.36	650.33	1.00	0.03
GMP-03S	1	650.76	650.81	1.00	-0.05
D12-N	1	649.62	651.00	1.00	-1.38
E7-N	1	650.91	651.53	1.00	-0.62
E9-N	1	650.77	651.32	1.00	-0.55
MP-04	1	647.41	651.16	1.00	-3.76
E16-N	1	650.28	650.44	1.00	-0.16
F6-X	1	650.88	651.60	1.00	-0.72
MP-03	1	650.84	651.61	1.00	-0.77
F2-X	1	651.18	651.91	1.00	-0.73
SPMP-02	1	650.91	651.79	1.00	-0.88
G4-N	1	649.18	651.74	1.00	-2.56
G5-N	1	648.75	651.66	1.00	-2.91
G7-N	1	650.58	651.50	1.00	-0.91
G8-N	1	648.91	651.40	1.00	-2.49
MP-01	1	650.46	651.37	1.00	-0.91
G9-N	1	650.36	651.30	1.00	-0.95
PZ-01	1	647.92	651.25	1.00	-3.32
G10-N	1	649.57	651.17	1.00	-1.60
G11-N	1	649.25	651.06	1.00	-1.81
G12-N	1	652.41	650.90	1.00	1.51
RW-13	1	650.43	650.75	1.00	-0.32
G14-N	1	649.16	650.65	1.00	-1.49
G17-X	1	650.68	650.26	1.00	0.42
RW-05	1	649.25	650.46	1.00	-1.21
SPMP-05	1	650.74	651.86	1.00	-1.11
I5-N	1	648.61	651.61	1.00	-3.01
I6-N	1	650.47	651.53	1.00	-1.05
SPMP-06	1	650.39	651.52	1.00	-1.13
SPMP-07	1	649.88	650.61	1.00	-0.73

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
K5-N	1	650.26	651.54	1.00	-1.29
K8-N	1	649.98	651.27	1.00	-1.29
K16-N	1	649.65	650.31	1.00	-0.65
MP-06	1	651.51	650.19	1.00	1.32
O18	1	649.27	650.09	1.00	-0.82
SPMP-10	1	650.67	650.30	1.00	0.37
L11-X	1	649.72	650.92	1.00	-1.20
RW-10	1	647.14	651.57	1.00	-4.43
MP-12	1	649.66	651.57	1.00	-1.90
N8-X	1	649.59	651.15	1.00	-1.56
SPMP-12	1	649.43	651.01	1.00	-1.58
RW-08	1	649.42	650.80	1.00	-1.38
SPMP-11	1	649.25	650.70	1.00	-1.45
RW-09	1	648.38	650.44	1.00	-2.06
Q5-X	1	648.25	651.28	1.00	-3.02
R5-X	1	647.26	651.24	1.00	-3.98
R7	1	649.08	651.05	1.00	-1.97
R9-X	1	649.06	650.88	1.00	-1.82
PZ-09	1	649.06	650.66	1.00	-1.60
R13-X	1	648.97	650.54	1.00	-1.57
Q15-N	1	649.14	650.36	1.00	-1.22
MP-08	1	648.82	650.16	1.00	-1.34
T14-X	1	648.38	650.42	1.00	-2.04
T11-X	1	648.78	650.66	1.00	-1.88
T8	1	648.73	650.90	1.00	-2.16
T7	1	648.81	650.98	1.00	-2.18
T5	1	648.77	651.12	1.00	-2.35
S4	1	649.02	651.31	1.00	-2.29
MP-11	1	652.11	650.77	1.00	1.34
V15-X	1	647.54	650.33	1.00	-2.80
V17	1	648.54	650.18	1.00	-1.64
W16	1	648.52	650.24	1.00	-1.72
X15	1	648.50	650.31	1.00	-1.81
Y13-X	1	648.32	650.43	1.00	-2.11
MW-01S	1	648.53	650.56	1.00	-2.02
Z14	1	648.13	650.37	1.00	-2.24
Z17	1	649.13	650.20	1.00	-1.07
TW-23	1	647.60	650.42	1.00	-2.82
TW-24	1	647.42	650.38	1.00	-2.96
TW-27	1	647.53	650.27	1.00	-2.74
MP-10	1	648.24	650.52	1.00	-2.28
TW-17	1	648.02	650.48	1.00	-2.46
MP-09	1	647.72	650.20	1.00	-2.48

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
TW-18	1	647.55	650.42	1.00	-2.88
TW-25	1	647.46	650.31	1.00	-2.85
TW-20	1	647.11	650.33	1.00	-3.22
MW-03	1	650.76	650.83	1.00	-0.07
MW-10S	1	648.39	649.46	1.00	-1.07
PZ-06	1	649.10	649.82	1.00	-0.72
SPMP-04	1	649.98	650.15	1.00	-0.17
FTD-1995-MWS2	1	610.47	616.05	0.50	-2.79
FTD-1995-MWS9	1	646.14	646.82	0.50	-0.34
FTD-3805-15	1	635.93	638.05	0.50	-1.06
FTD-3805-MW41	1	648.45	647.87	0.50	0.29
FTD-3805-MWS2	1	638.65	638.53	0.50	0.06
FTD-3805-MWS3	1	629.92	629.56	0.50	0.18
FTD-3805-MWS8	1	621.71	625.27	0.50	-1.78
FTD-3805-PZ12S	1	628.14	626.67	0.50	0.74
FTD-3805-PZ13S	1	627.08	626.65	0.50	0.22
FTD-MW-10S	1	647.21	649.46	0.50	-1.13
FTD-OSL-MW07	1	650.21	656.13	0.50	-2.96
FTD-PCERI-MW-06S	1	644.50	645.10	0.50	-0.30
FTD-PCERI-MW16S	1	646.35	646.57	0.50	-0.11
FTD-PCERI-MW21S	1	647.53	648.45	0.50	-0.46
FTD-PCERI-MW22S	1	645.21	648.26	0.50	-1.52
FTD-PCERI-MW24S	1	650.44	652.66	0.50	-1.11
A4-OBS-01S	2	583.30	581.31	1.00	1.99
MW-02I	2	648.97	649.82	1.00	-0.85
MW-02D	2	649.05	649.82	1.00	-0.77
MW-08I	2	644.77	646.22	1.00	-1.45
MW-08D	2	645.03	646.22	1.00	-1.19
MW-09I1	2	649.84	649.72	1.00	0.12
MW-09I2	2	649.62	649.72	1.00	-0.10
MW-09D1	2	649.93	649.71	1.00	0.22
MW-10I	2	648.37	648.21	1.00	0.16
MW-10D	2	648.42	648.21	1.00	0.21
MW-11I	2	647.20	647.77	1.00	-0.57
MW-11D	2	649.47	647.77	1.00	1.70
MW-12I1	2	648.39	648.90	1.00	-0.51
MW-12I2	2	648.42	648.89	1.00	-0.47
MW-12D1	2	648.14	648.90	1.00	-0.76
MW-12D2	2	648.00	648.89	1.00	-0.89
MW-13S	2	645.00	646.56	1.00	-1.56
MW-13I1	2	645.00	646.57	1.00	-1.57
MW-13I2	2	645.49	646.57	1.00	-1.08
MW-13D1	2	645.50	646.58	1.00	-1.08

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
MW-14I	2	646.29	647.46	1.00	-1.17
MW-15I	2	642.47	642.70	1.00	-0.23
MW-16I	2	639.71	638.18	1.00	1.53
MW-16D1	2	639.42	638.18	1.00	1.24
MW-19	2	650.05	650.13	1.00	-0.08
MW-21	2	649.02	649.43	1.00	-0.41
MW-22	2	649.07	649.14	1.00	-0.07
MW-24I1	2	646.77	648.22	1.00	-1.45
MW-24I2	2	649.44	648.22	1.00	1.22
MW-26I1	2	645.38	646.94	1.00	-1.56
MW-26I2	2	645.37	646.94	1.00	-1.57
MW-27I1	2	640.67	640.43	1.00	0.24
MW-27I2	2	639.75	640.43	1.00	-0.68
MW-29I1	2	639.08	640.26	1.00	-1.18
MW-32I1	2	625.29	629.13	1.00	-3.84
MW-33I1	2	639.84	640.07	1.00	-0.23
MW-34I1	2	638.96	640.62	1.00	-1.66
GMP-01D	2	650.51	649.56	1.00	0.95
GMP-03D	2	650.23	649.58	1.00	0.65
GMP-04D	2	650.34	649.80	1.00	0.54
SGMP-01	2	651.22	650.36	1.00	0.86
SGMP-01A	2	650.61	650.20	1.00	0.41
FTD-1995-MW44	2	642.46	648.30	0.50	-2.92
FTD-1995-MWS3	2	630.86	627.12	0.50	1.87
FTD-3805-MWI12	2	623.95	615.07	0.50	4.44
FTD-3805-MWS14	2	594.15	604.87	0.50	-5.36
FTD-3805-MWS19	2	593.69	605.40	0.50	-5.86
FTD-3805-MWS4	2	588.29	598.47	0.50	-5.09
FTD-3805-PZ13I	2	625.56	621.01	0.50	2.27
FTD-ASL-MW12A	2	628.79	627.72	0.50	0.54
FTD-ASL-MW13	2	640.96	644.35	0.50	-1.69
FTD-ASL-MW14	2	631.97	644.02	0.50	-6.03
FTD-ASL-MW942	2	645.28	656.24	0.50	-5.48
FTD-ASL-MW943	2	639.46	643.26	0.50	-1.90
FTD-ASL-MW944	2	643.04	639.91	0.50	1.56
FTD-MW-09D1	2	648.90	649.71	0.50	-0.41
FTD-MW-09D2	2	648.80	649.71	0.50	-0.46
FTD-MW-09I1	2	648.96	649.72	0.50	-0.38
FTD-MW-09I2	2	648.94	649.72	0.50	-0.39
FTD-MW-10D	2	647.63	648.21	0.50	-0.29
FTD-MW-10I	2	647.46	648.21	0.50	-0.37
FTD-MW-12D1	2	647.36	648.90	0.50	-0.77
FTD-MW-12D2	2	645.26	648.89	0.50	-1.82

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
FTD-MW-12I	2	647.31	648.90	0.50	-0.79
FTD-MW-12I2	2	647.35	648.89	0.50	-0.77
FTD-MW-13D1	2	643.84	646.58	0.50	-1.37
FTD-MW-13D2	2	643.67	646.58	0.50	-1.46
FTD-MW-13I1	2	643.86	646.57	0.50	-1.36
FTD-MW-13I2	2	644.04	646.57	0.50	-1.27
FTD-MW-13S	2	643.69	646.56	0.50	-1.43
FTD-MW-14I	2	645.72	647.46	0.50	-0.87
FTD-MW-14S	2	645.70	647.45	0.50	-0.88
FTD-MW-15I	2	642.14	642.70	0.50	-0.28
FTD-MW-15S	2	642.07	642.64	0.50	-0.28
FTD-MW-16D1	2	639.23	638.18	0.50	0.53
FTD-MW-16I	2	640.33	638.18	0.50	1.08
FTD-MW-28RI1	2	642.47	643.36	0.50	-0.44
FTD-MW-28RI2	2	642.35	643.25	0.50	-0.45
FTD-MW-29I	2	640.13	640.26	0.50	-0.06
FTD-MW-36I	2	641.41	641.15	0.50	0.13
FTD-OSL-MW02	2	596.53	591.24	0.50	2.64
FTD-OSL-MW08	2	647.05	642.50	0.50	2.27
FTD-PCERI-MW-16I	2	646.46	643.89	0.50	1.28
FTD-PCERI-MW17S	2	650.45	648.28	0.50	1.09
MW-09D2	3	649.62	649.22	1.00	0.40
MW-13D2	3	645.38	646.17	1.00	-0.79
MW-14D	3	646.21	646.99	1.00	-0.78
MW-15D	3	642.34	642.10	1.00	0.24
MW-16D2	3	632.05	636.41	1.00	-4.36
MW-24D	3	649.46	647.60	1.00	1.86
MW-26D	3	644.68	646.42	1.00	-1.74
MW-29I2	3	638.68	638.71	1.00	-0.03
MW-33I2	3	639.56	638.82	1.00	0.74
MW-34I2	3	638.49	640.25	1.00	-1.76
FTD-3805-MWI15	3	593.41	604.95	0.50	-5.77
FTD-3805-PZ13D	3	626.40	619.87	0.50	3.26
FTD-FTA-MW06	3	664.60	663.18	0.50	0.71
FTD-FTA-MW11	3	656.62	660.11	0.50	-1.75
FTD-MW-13D3	3	644.58	646.17	0.50	-0.80
FTD-MW-14D	3	645.75	646.99	0.50	-0.62
FTD-MW-15D	3	642.04	642.10	0.50	-0.03
FTD-MW-16D2	3	631.98	636.40	0.50	-2.21
FTD-MW-18I	3	626.54	624.90	0.50	0.82
FTD-MW-28RD1	3	642.14	642.91	0.50	-0.39
FTD-OSL-MW10	3	587.24	595.14	0.50	-3.95
FTD-PCERI-MW21D	3	647.09	646.22	0.50	0.44

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
MW-09D3	4	649.35	648.71	1.00	0.64
MW-13D3	4	645.03	645.29	1.00	-0.26
MW-13D4	4	643.54	645.29	1.00	-1.75
MW-16D3	4	631.06	632.10	1.00	-1.04
MW-29D	4	633.43	634.36	1.00	-0.93
MW-32I2	4	626.28	624.29	1.00	1.99
MW-33D	4	627.00	634.72	1.00	-7.72
MW-34D	4	637.58	637.35	1.00	0.23
FTD-3805-MWS21	4	583.66	596.28	0.50	-6.31
FTD-ASL-MW941	4	625.25	625.17	0.50	0.04
FTD-ASL-MW961	4	624.07	621.86	0.50	1.11
FTD-FTA-MW08	4	649.01	651.09	0.50	-1.04
FTD-MW-09D3	4	648.40	648.71	0.50	-0.15
FTD-MW-13D4	4	642.47	645.29	0.50	-1.41
FTD-MW16D3	4	630.52	632.09	0.50	-0.79
FTD-MW-28RD2	4	635.72	640.19	0.50	-2.24
FTD-MW-28RD3	4	624.92	640.34	0.50	-7.71
FTD-OSL-MW11	4	593.98	594.71	0.50	-0.36
FTD-PCERI-MW10D	4	648.58	646.18	0.50	1.20
FTD-3805-MWD16	5	593.10	600.49	0.50	-3.70
FTD-FTA-MW10	5	635.15	637.15	0.50	-1.00
FTD-MW-16D4	5	624.87	624.98	0.50	-0.05
MW-16D4	6	625.10	622.97	1.00	2.13
W9-MW-05	6	616.42	621.63	0.50	-2.60
MW-32D	7	626.33	623.26	1.00	3.07
FTD-3805-MWI22	7	586.22	587.99	0.50	-0.88
FTD-MW-16D5-Bedrock	7	623.26	622.74	0.50	0.26
FTD-MW-18D	7	628.94	623.41	0.50	2.76
W9-MW-02	7	627.88	622.17	0.50	2.85
A4-OBS-04S	8	525.59	527.26	1.00	-1.67
A4-OBS-06S	8	511.10	515.24	1.00	-4.14
MW-16D5	8	622.00	622.59	1.00	-0.59
FTD-MW-28RD4	8	624.74	622.23	0.50	1.26
A4-MW-2	8	527.26	527.82	1.00	-0.56
A4-OBS-10I	9	496.57	498.41	1.00	-1.84
MW-18Bedrock	9	624.50	622.77	1.00	1.73
FTD-FTA-MW06D	9	617.73	604.69	0.50	6.52
FTD-FTA-MW11D	9	610.59	606.45	0.50	2.07
Area3-MW-3	9	637.39	638.97	0.50	-0.79
Area3-TW	9	635.71	637.99	0.50	-1.14
OBS-05	9	629.11	623.75	0.50	2.68
A4-OBS-01D	10	583.86	583.66	1.00	0.20
A4-OBS-02D	10	523.98	524.81	1.00	-0.83

Table 5.1-1
Steady-State Water Level Targets and Calibration Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Name	Layer	Observed Groundwater Elevation (ft NAVD 88)	Computed Groundwater Elevation (ft NAVD 88)	Target Weight	Weighted Residual (ft)
A4-OBS-03D	10	523.70	528.46	1.00	-4.76
A4-OBS-04D	10	528.13	527.14	1.00	0.99
A4-OBS-05D	10	525.24	523.81	1.00	1.43
A4-OBS-06D	10	512.77	508.73	1.00	4.04
A4-OBS-08D	10	522.27	524.94	1.00	-2.67
A4-OBS-09D	10	538.10	538.05	1.00	0.05
A4-OBS-10D	10	496.96	498.51	1.00	-1.55
Well-1	10	523.68	520.58	1.00	3.10
Well-2	10	526.45	527.93	1.00	-1.48
Well-5	10	517.00	520.29	1.00	-3.29
A4-OBS-07D	10	528.70	530.48	1.00	-1.78
A4-MW-1	10	524.35	527.84	1.00	-3.49
A4-MW-3	10	527.79	528.65	1.00	-0.86
Area3-MW-1	10	633.32	637.93	0.50	-2.31
OBS-04	10	632.16	629.05	0.50	1.56
A4-OBS-11	10	525.85	523.98	1.00	1.87
A4-OBS-12	10	527.57	530.22	1.00	-2.65
A4-OBS-13	10	527.47	528.17	1.00	-0.71
A4-OBS-14	10	542.34	539.86	1.00	2.48
A4-OBS-15	10	540.93	539.64	1.00	1.29
A4-OBS-16	10	521.12	524.98	1.00	-3.86
Well-3R	10	524.42	525.72	1.00	-1.31
FTD-ASL-3D	11	627.15	617.96	0.50	4.59
OBS-02	11	628.85	624.43	0.50	2.21
W9-MW-03	11	630.43	621.51	0.50	4.46
WW009	11	607.73	609.96	0.50	-1.12
FTD-ASL-1D	12	630.12	624.00	0.50	3.06
FTD-ASL-2D	12	628.73	622.72	0.50	3.01

Residual Statistics	
Residual Mean (ft)	-0.78
Residual Std. Deviation (ft)	1.93
Sum of Squares (ft^2)	1,241
Number of Observations	286
Range in Observations (ft)	168.03
Scaled Residual Standard Deviation	1.15%

Notes and Abbreviations:
ft = feet
ft^2 = square feet
NAVD 88 = North American Vertical Datum of 1988

Table 5.2-1
Summary of Groundwater Flow Model Sensitivity Analysis Results
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Parameter	Zone Number (Recharge) or Model Layer (Hydraulic Conductivity)	Calibration Value	Range of Values Tested	Relative Sensitivity - Overall	Relative Sensitivity - Bedrock	Relative Sensitivity - Area 4 Only
Recharge (in/yr)	1	9.0	4.5 - 13.4	Insensitive	**Sensitive**	**Sensitive**
	2	15.6	7.8 - 23.4	**Sensitive**	**Sensitive**	**Sensitive**
	4	8.2	4.1 - 12.3	**Sensitive**	Insensitive	Insensitive
	5	17.0	8.5 - 25.5	Insensitive	**Sensitive**	Insensitive
	9	15.6	7.8 - 23.4	**Sensitive**	Insensitive	Insensitive
Horizontal Hydraulic Conductivity Multiplier	1	1	0.5 - 1.5	**Sensitive**	**Sensitive**	Insensitive
	2	1	0.5 - 1.5	**Sensitive**	Insensitive	**Sensitive**
	3	1	0.5 - 1.5	**Sensitive**	Insensitive	Insensitive
	4	1	0.5 - 1.5	**Sensitive**	Insensitive	Insensitive
	5	1	0.5 - 1.5	**Sensitive**	**Sensitive**	Insensitive
	6	1	0.5 - 1.5	**Sensitive**	**Sensitive**	Insensitive
	7	1	0.5 - 1.5	Insensitive	**Sensitive**	**Sensitive**
	8	1	0.5 - 1.5	**Sensitive**	**Sensitive**	Insensitive
	9	1	0.5 - 1.5	**Sensitive**	**Sensitive**	**Sensitive**
	10	1	0.5 - 1.5	**Sensitive**	**Sensitive**	**Sensitive**
	11	1	0.5 - 1.5	**Sensitive**	**Sensitive**	**Sensitive**
	12	1	0.5 - 1.5	Insensitive	**Sensitive**	Insensitive
Existing Wellfield Pumping	NA	NA	off - on	**Sensitive**	**Sensitive**	Insensitive

Notes and Abbreviations:
in/yr = inches per year
NA = not applicable

Table 5.3-1
Transient Model Set-Up
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Stress Period	Period Length (day)	Number of Time Steps	Time Step Length (hours)	Elapsed Time (days)	Well 1 Rate (gpm)	Well 2 Rate (gpm)	Well 3R Rate (gpm)	Well 4R Rate (gpm)	Well 5 Rate (gpm)
1	0.25	60	0.10	0.25	100	115	50	100	140
2	0.25	60	0.10	0.50	100	115	50	100	140
3	0.25	60	0.10	0.75	100	115	50	100	140
4	0.25	60	0.10	1.00	100	115	50	100	140
5	0.25	60	0.10	1.25	100	115	50	100	140
6	0.25	60	0.10	1.50	100	115	50	100	140
7	0.25	60	0.10	1.75	100	115	50	100	140
8	0.25	60	0.10	2.00	100	115	50	100	140
9	0.25	60	0.10	2.25	100	115	50	100	140
10	0.25	60	0.10	2.50	100	115	50	100	140
11	0.25	60	0.10	2.75	100	115	50	100	140
12	0.25	60	0.10	3.00	100	115	50	100	140
13	0.25	60	0.10	3.25	0	0	0	0	0
14	0.25	60	0.10	3.50	0	0	0	0	0
15	0.25	60	0.10	3.75	0	0	0	0	0
16	0.25	60	0.10	4.00	0	0	0	0	0
17	0.25	60	0.10	4.25	0	0	0	0	0
18	0.25	60	0.10	4.50	0	0	0	0	0
19	0.25	60	0.10	4.75	0	0	0	0	0
20	0.25	60	0.10	5.00	0	0	0	0	0
21	0.25	20	0.30	5.25	0	0	0	0	0
22	0.25	20	0.30	5.50	0	0	0	0	0
23	0.25	20	0.30	5.75	0	0	0	0	0
24	0.25	20	0.30	6.00	0	0	0	0	0
25	0.25	20	0.30	6.25	0	0	0	0	0
26	0.25	20	0.30	6.50	0	0	0	0	0
27	0.25	20	0.30	6.75	0	0	0	0	0
28	0.25	20	0.30	7.00	0	0	0	0	0
29	0.25	20	0.30	7.25	0	0	0	0	0

Table 5.3-1
Transient Model Set-Up
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

Stress Period	Period Length (day)	Number of Time Steps	Time Step Length (hours)	Elapsed Time (days)	Well 1 Rate (gpm)	Well 2 Rate (gpm)	Well 3R Rate (gpm)	Well 4R Rate (gpm)	Well 5 Rate (gpm)
30	0.25	20	0.30	7.50	0	0	0	0	0
31	0.25	20	0.30	7.75	0	0	0	0	0
32	0.25	20	0.30	8.00	0	0	0	0	0
33	0.25	20	0.30	8.25	0	0	0	0	0
34	0.25	20	0.30	8.50	0	0	0	0	0
35	0.25	20	0.30	8.75	0	0	0	0	0
36	0.25	20	0.30	9.00	0	0	0	0	0
37	0.25	20	0.30	9.25	0	0	0	0	0
38	0.25	20	0.30	9.50	0	0	0	0	0
39	0.25	20	0.30	9.75	0	0	0	0	0
40	0.25	20	0.30	10.00	0	0	0	0	0

Notes and Abbreviations:
gpm = gallons per minute

Table 6.1-1
Simulated Drawdown at Test Area 4 Wells and Potential Off-Site Potable Well Locations
Groundwater Model Update Report
ERCIP Well Field Expansion Project
United States Army Garrison, Fort Drum, New York

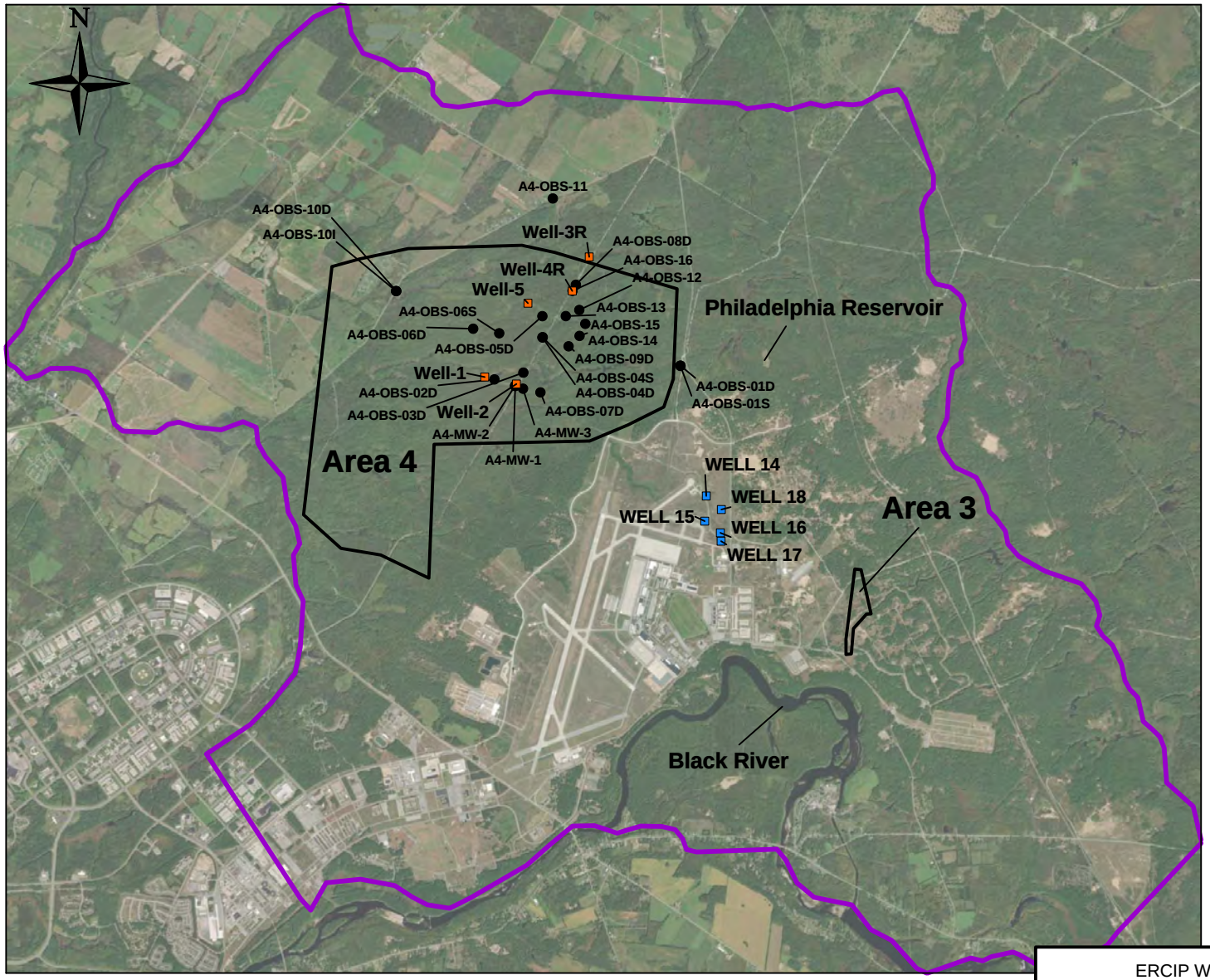
Location	Top of Limestone or Sandstone (ft btoc)	Top of Gneiss (ft btoc)	Pump Intake Depth (ft btoc)	Safe Drawdown Limit (ft btoc)	Safe Drawdown Limit (ft)	Scenario 1 - Area 4 Estimated Sustainable Rates					Scenario 2 - Area 4 Estimated Sustainable Rates with Existing Well Fields at Current Rates					Scenario 3 - Area 4 Estimated Sustainable Rates with Existing Well Fields at Design Rates				
						Pumping Rate (gpm)	Maximum Simulated Drawdown (ft btoc)	Maximum Simulated Drawdown (ft)	Maximum Simulated Drawdown (ft btoc) - Drought Conditions	Maximum Simulated Drawdown (ft) - Drought Conditions	Pumping Rate (gpm)	Maximum Simulated Drawdown (ft btoc)	Maximum Simulated Drawdown (ft)	Maximum Simulated Drawdown (ft btoc) - Drought Conditions	Maximum Simulated Drawdown (ft) - Drought Conditions	Pumping Rate (gpm)	Maximum Simulated Drawdown (ft btoc)	Maximum Simulated Drawdown (ft)	Maximum Simulated Drawdown (ft btoc) - Drought Conditions	Maximum Simulated Drawdown (ft) - Drought Conditions
Well 1	54	63	58	48	37.3	100	42.9	30.8	43.6	31.5	100	43.2	31.1	44.1	32.0	100	44.0	32.0	45.7	33.6
Well 2	33	62	64	54	39.7	115	22.9	14.1	23.7	14.9	115	23.3	14.6	24.4	15.6	115	24.4	15.6	26.3	17.5
Well 3R	16	43	57	47	28.0	50	34.1	16.2	34.4	16.5	50	34.2	16.3	34.5	16.7	50	34.5	16.6	35.2	17.3
Well 4R	21	58.2	62	52	20.4	100	34.3	7.6	34.7	8.0	100	34.4	7.8	34.9	8.2	100	34.8	8.1	35.8	9.1
Well 5	42	55	77	67	40.9	135	30.2	13.7	30.5	14.0	135	30.3	13.8	30.7	14.2	135	30.7	14.2	31.5	15.0
Philadelphia Reservoir*	26	72	NA	0	0	NA	0.0	0.0	**0.3**	**0.3**	NA	**0.8**	**0.8**	**1.0**	**1.0**	NA	**1.3**	**1.3**	**2.8**	**2.8**
Bedrock Beneath Philadelphia Reservoir*	26	72	NA	0	0	NA	0.0	0.0	**0.7**	**0.7**	NA	**1.5**	**1.5**	**2.6**	**2.6**	NA	**5.7**	**5.7**	**8.8**	**8.8**
Potential Off-Site Potable Well Locations*	40	60	NA	10	0	NA	**12.2**	**2.2**	**12.5**	**2.5**	NA	**12.3**	**2.3**	**12.8**	**2.8**	NA	**12.5**	**2.5**	**12.9**	**2.9**

Notes and Abbreviations:

1. Depth to water at the potential off-site potable well locations was estimated to be 10 feet below ground surface
2. Drought conditions are a 25 percent reduction in groundwater recharge.
3. Bolded cells indicate an exceedance of the safe drawdown limit.
4. Drawdown was calculated using both ft btoc and ft below ambient (non-pumping) groundwater conditions.

* = bedrock contacts are estimated from the model
btoc = below top of casing
ft = feet
gpm = gallons per minute
NA = not applicable

Figures



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Area 4 Monitoring Well
- Model Boundary

Scale in feet

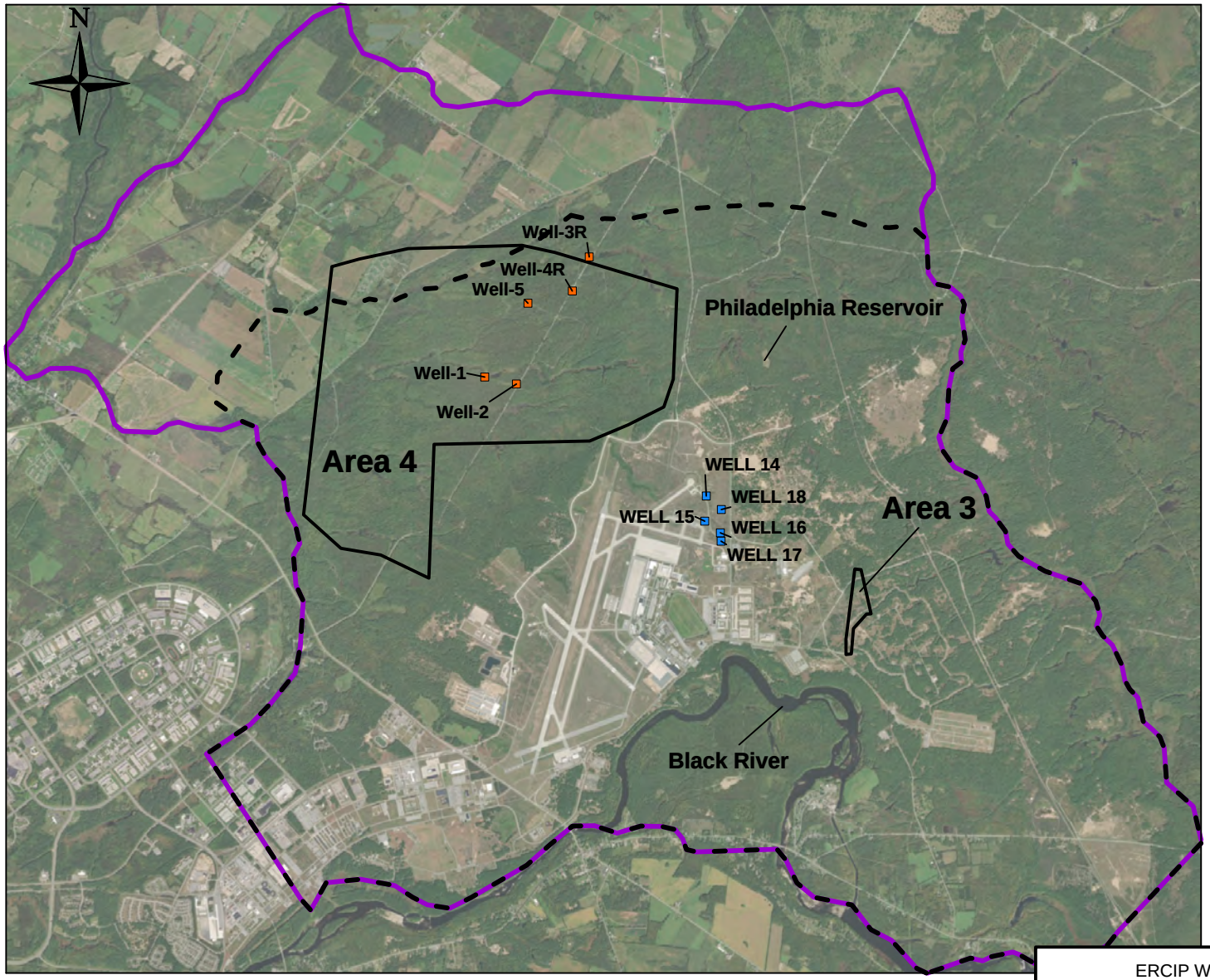
0 6,500 13,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SITE LOCATION

ARCADIS

FIGURE
1-1



Legend

- Current Water Supply Well
- Area 4 Test Wells
- 2020, 2024, and 2025 Model Extents
- 2011 Model Extents

Scale in feet

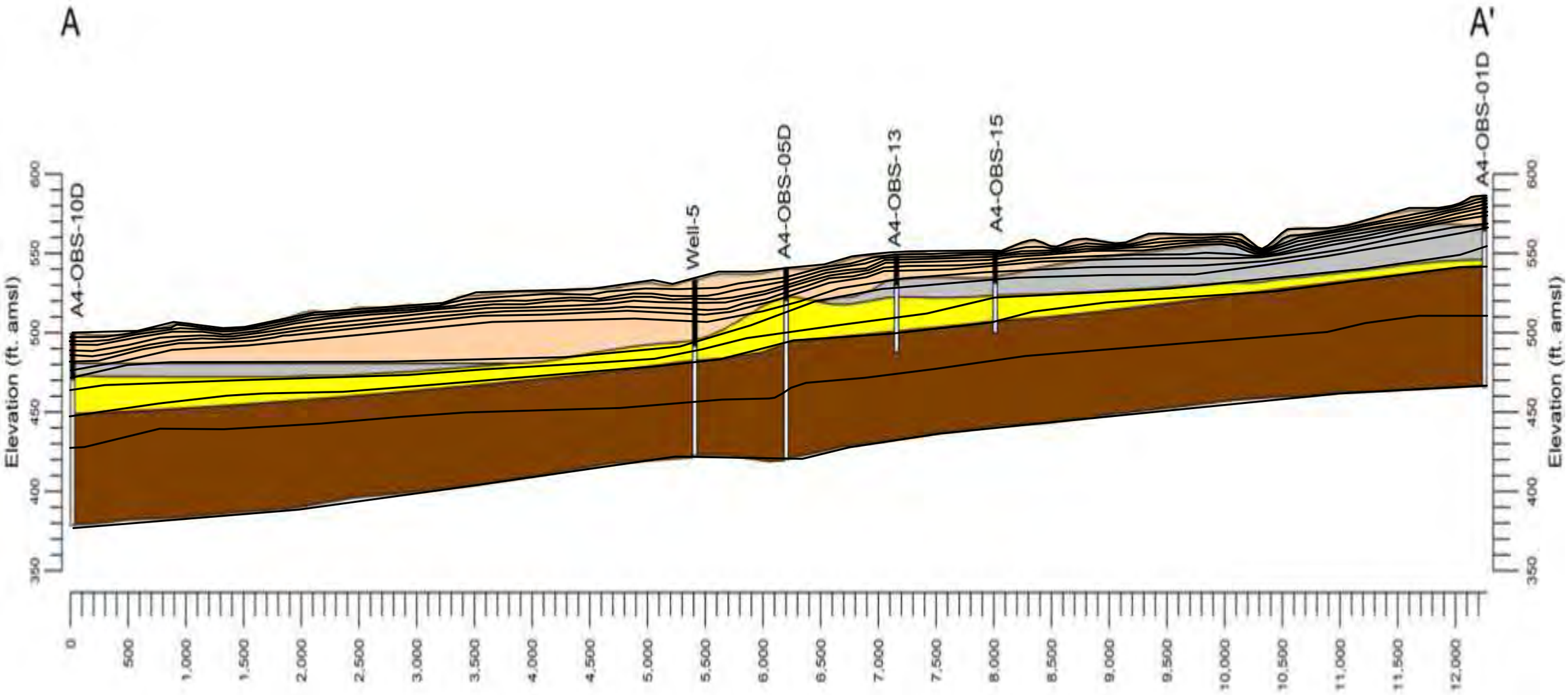
0 6,500 13,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

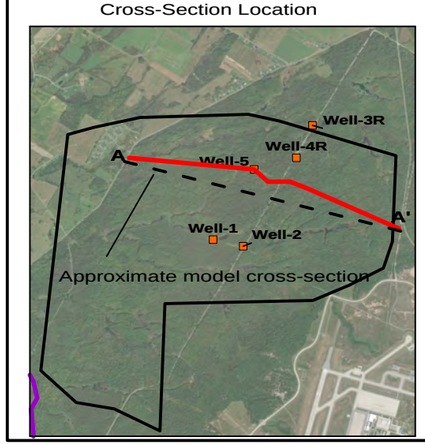
EXTENTS OF PREVIOUS AND CURRENT GROUNDWATER MODELS

ARCADIS

FIGURE
2-1



Cross-Section Location



Geology

- Overburden – silts & clays, sandy clays.
- Limestone – [description, e.g., Black River group, Theresa Limestone]
- Sandstone – [description, e.g., Potsdam Sandstone]
- Gneiss – [e.g., Mylonitic Gneiss]

Scale in feet

0 6,500 13,000

Well Construction

Surface Casing

Open Hole

Legend

Model Layer

Notes:

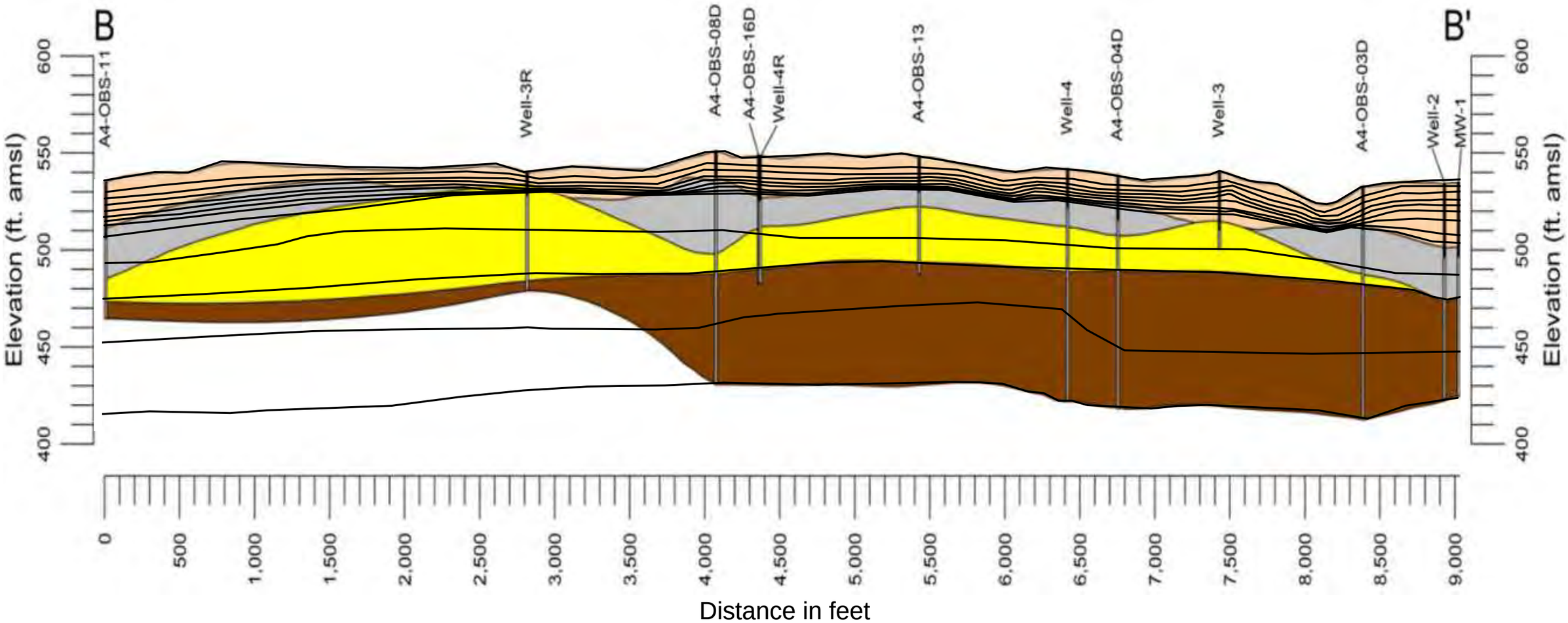
1. The groundwater model cross-section represents a slice along the plane and as such geology is not projected.
2. Groundwater model cross-sections must be in a single straight line and the cross-section location was chosen to be as close as possible to the cross-section in the Field Investigation Summary Report.

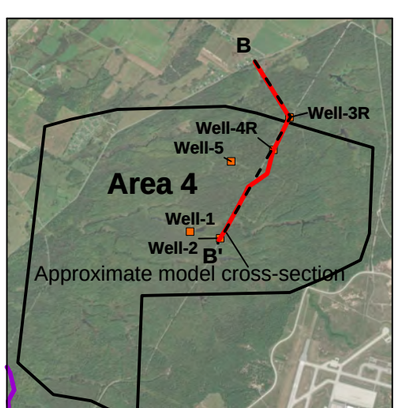
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

CROSS-SECTION A-A'

ARCADIS

FIGURE
4-1





Geology

- Overburden – silts & clays, sandy clays.
- Limestone – [description, e.g., Black River group, Theresa Limestone]
- Sandstone – [description, e.g., Potsdam Sandstone]
- Gneiss – [e.g., Mylonitic Gneiss]

Well Construction

- Surface Casing
- Open Hole

Legend

— Model Layer

Scale in feet

0 6,500 13,000

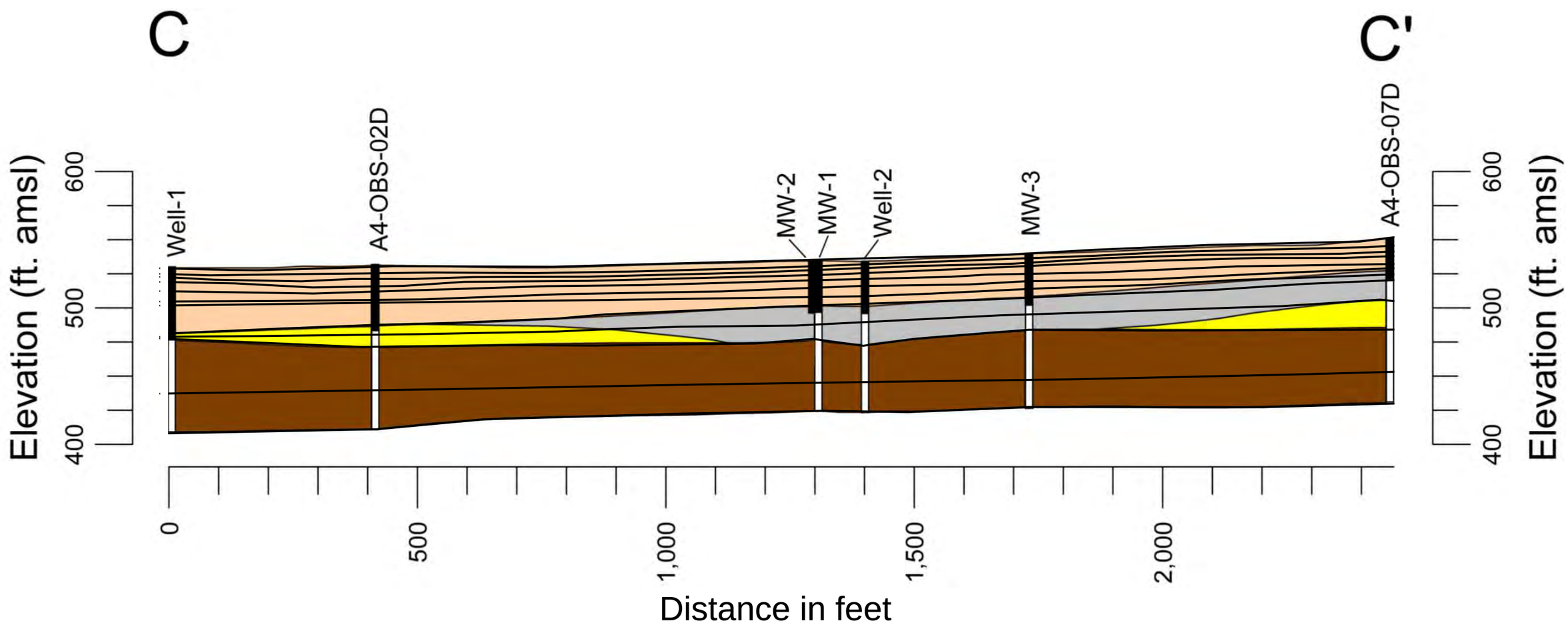
Notes:
1. The groundwater model cross-section represents a slice along the plane and as such geology is not projected.
2. Groundwater model cross-sections must be in a single straight line and the cross-section location was chosen to be as close as possible to the cross-section in the Field Investigation Summary Report.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

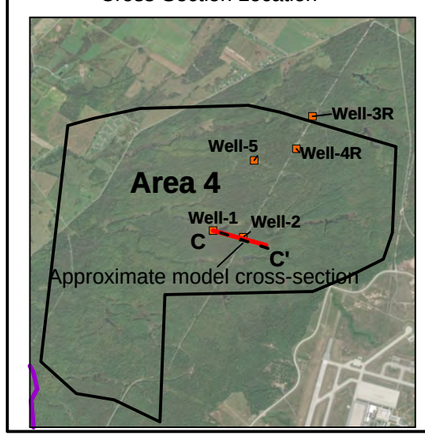
CROSS-SECTION B-B'

ARCADIS

FIGURE
4-2



Cross-Section Location



Geology

- Overburden – silts & clays, sandy clays.
- Limestone – [description, e.g., Black River group, Theresa Limestone]
- Sandstone – [description, e.g., Potsdam Sandstone]
- Gneiss – [e.g., Mylonitic Gneiss]

Well Construction

- Surface Casing
- Open Hole

Legend

— Model Layer

Scale in feet

0 6,500 13,000

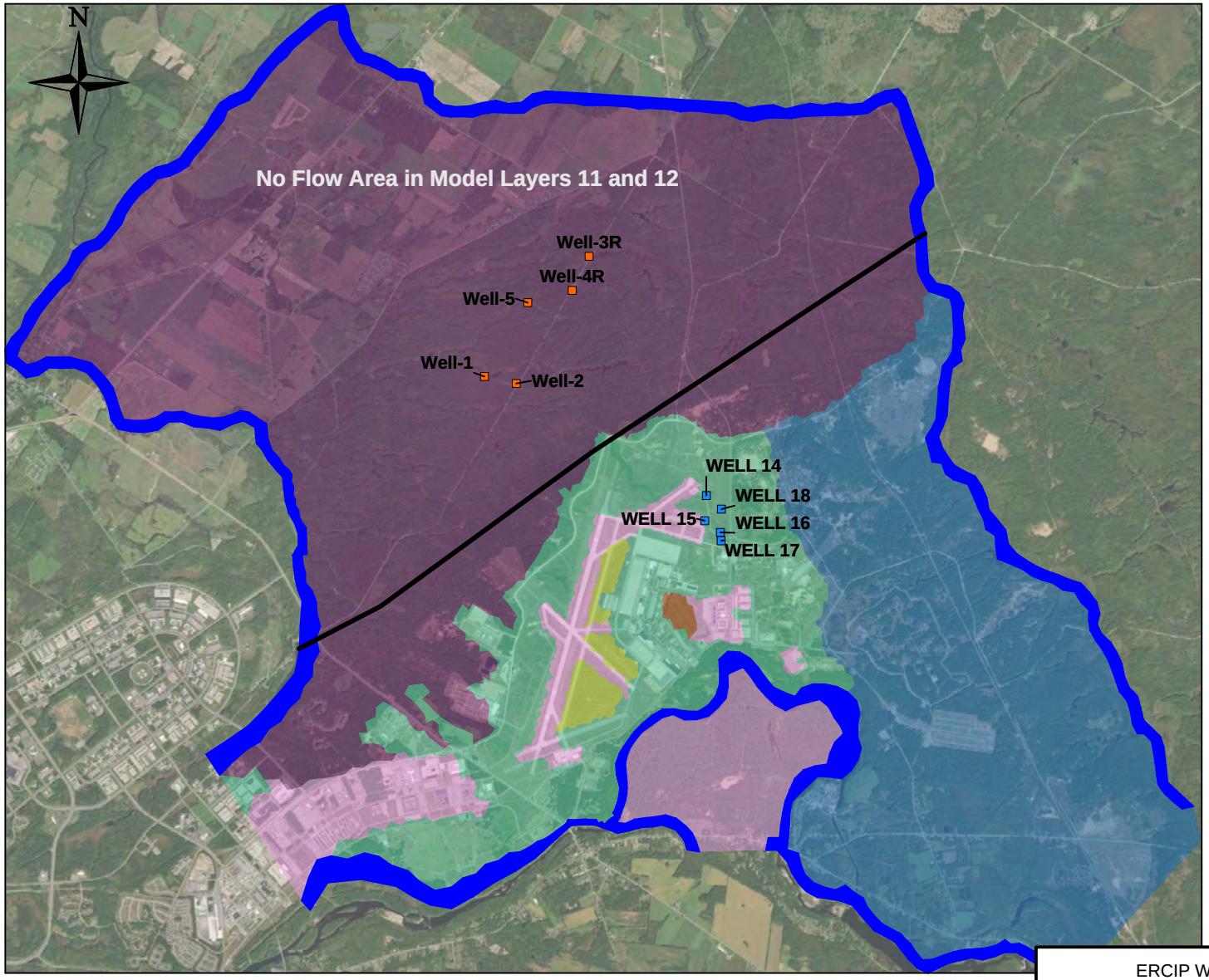
Notes:
1. The groundwater model cross-section represents a slice along the plane and as such geology is not projected.
2. Groundwater model cross-sections must be in a single straight line and the cross-section location was chosen to be as close as possible to the cross-section in the Field Investigation Summary Report.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

CROSS-SECTION C-C'

ARCADIS

FIGURE
4-3



Recharge

- Zone 1 = 9.0 in/yr
- Zone 2 = 15.6 in/yr
- Zone 4 = 8.2 in/yr
- Zone 5 = 17 in/yr
- Zone 6 = 1.4 in/yr
- Zone 9 = 15.6 in/yr
- Constant Head Boundary
- Current Water Supply Well
- Area 4 Test Well
- No Flow Boundary (Model Layers 11 and 12)

Notes
1. in/yr = inches per year

Scale in feet

0 6,500 13,000

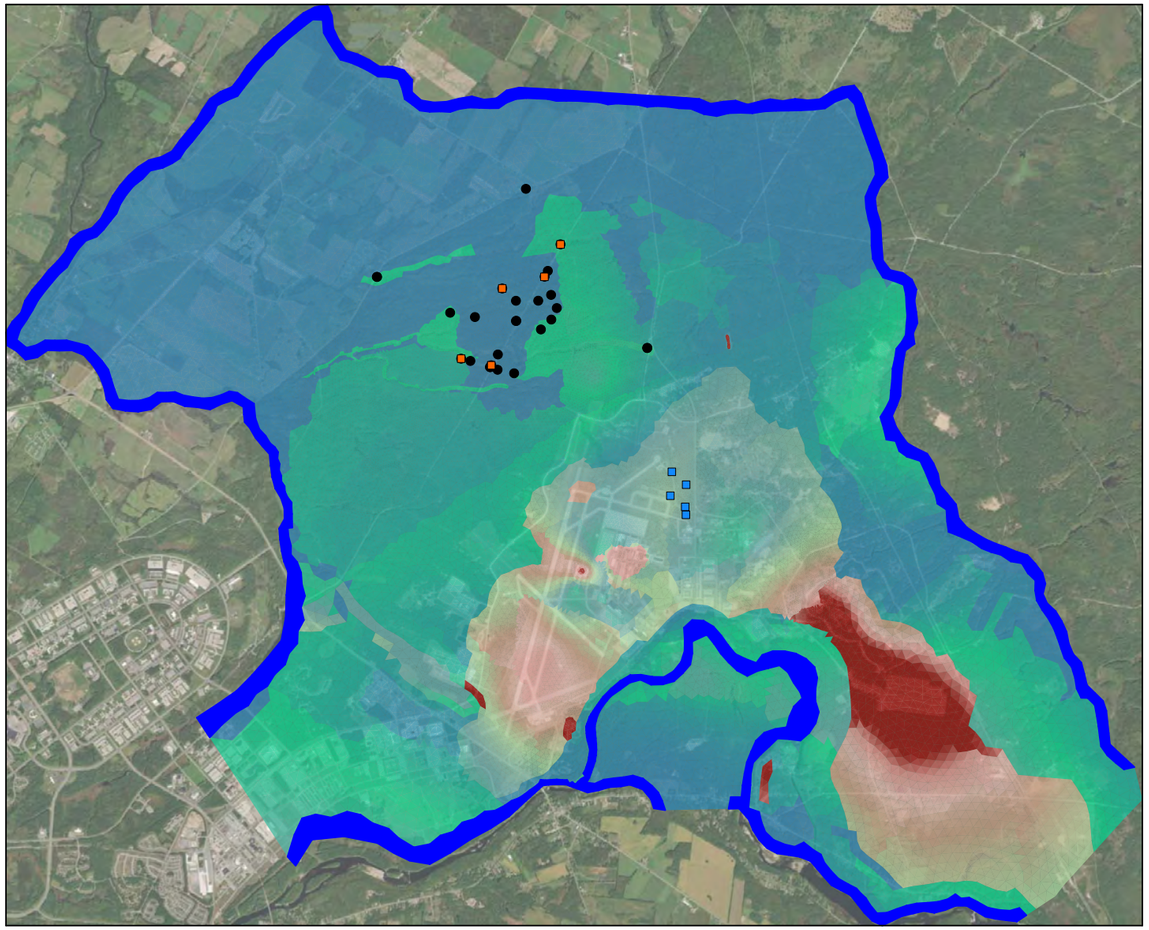
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

BOUNDARY CONDITIONS

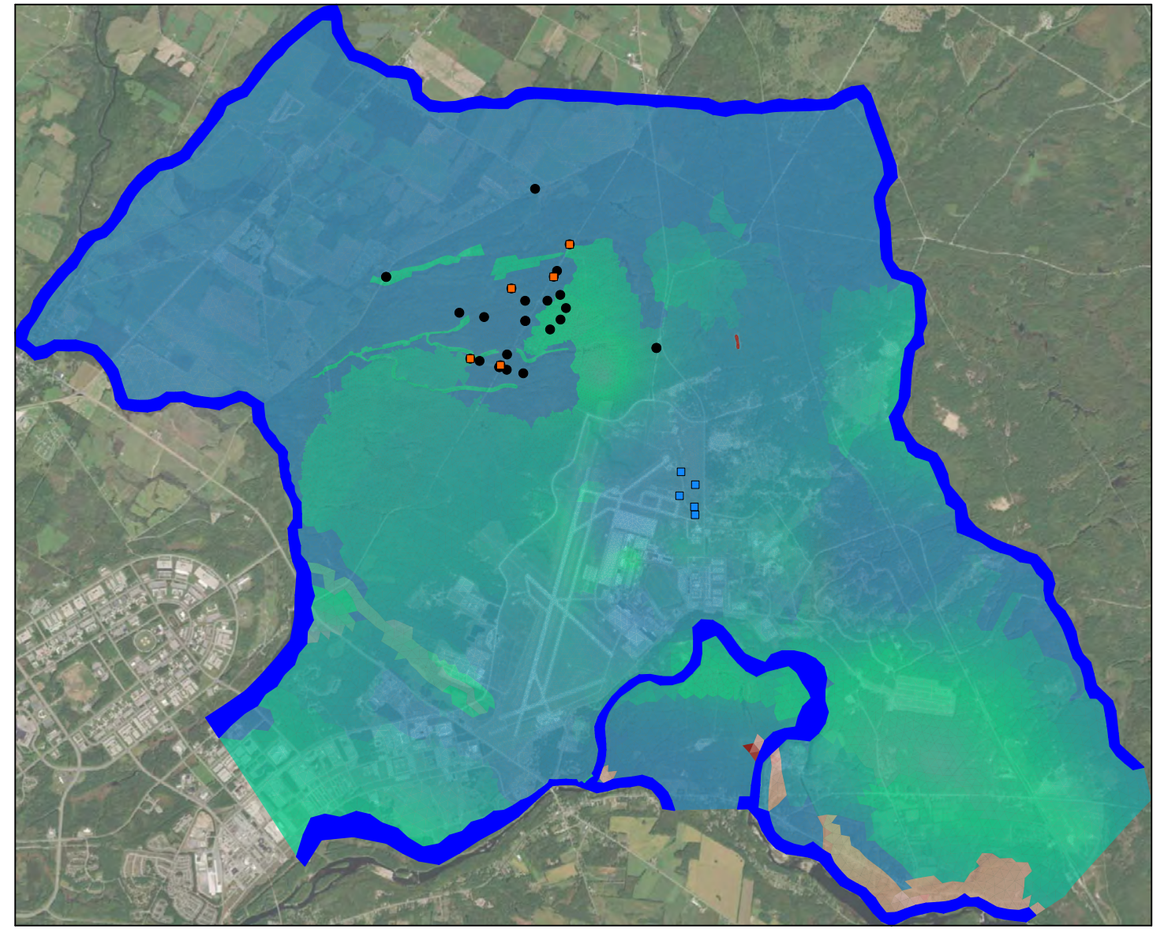
ARCADIS

FIGURE
4.1-1

Model Layer 1



Model Layer 2



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well

Horizontal Hydraulic Conductivity (ft/day)

<0.1 10 20 30 40 50 > 75 ft/day

N

Scale in feet

0 6,500 13,000

Notes:

1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

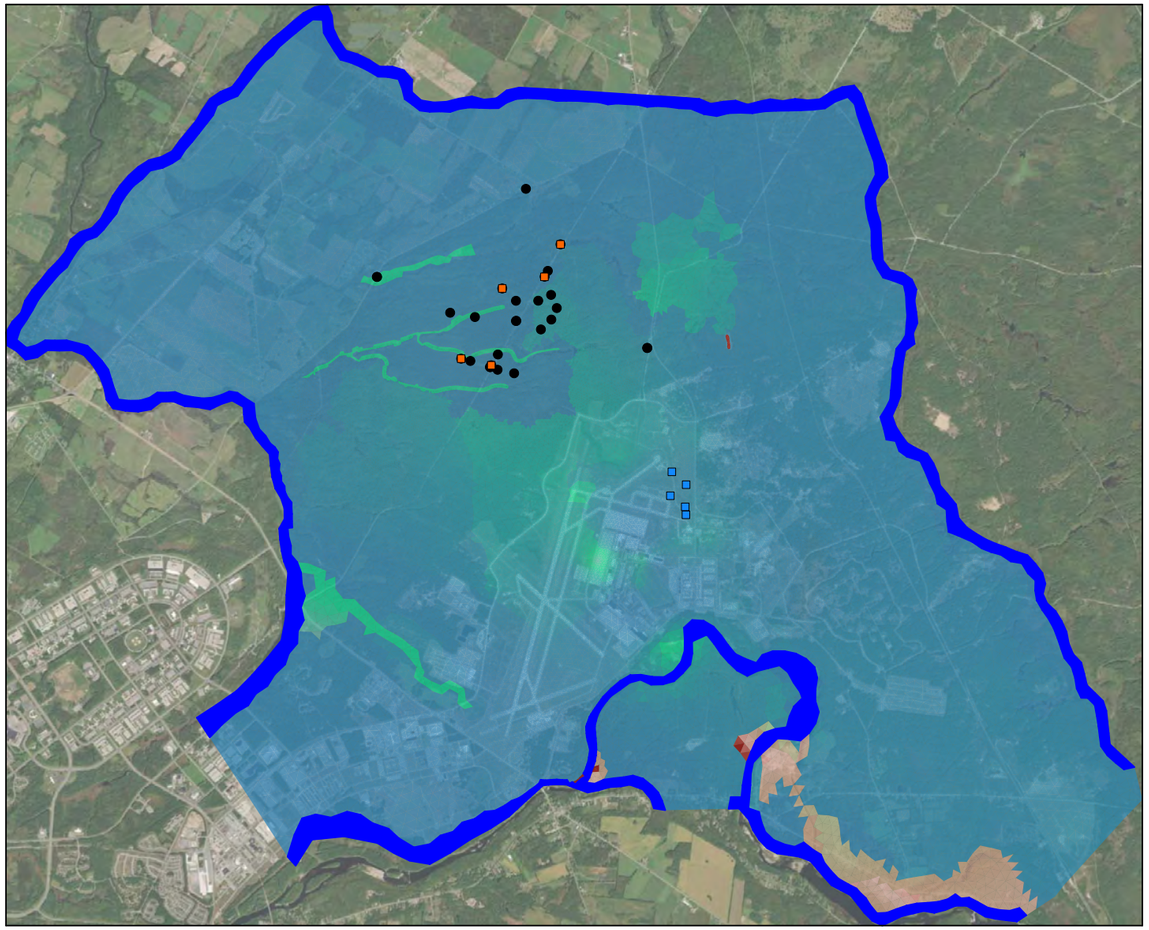
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 1 AND 2

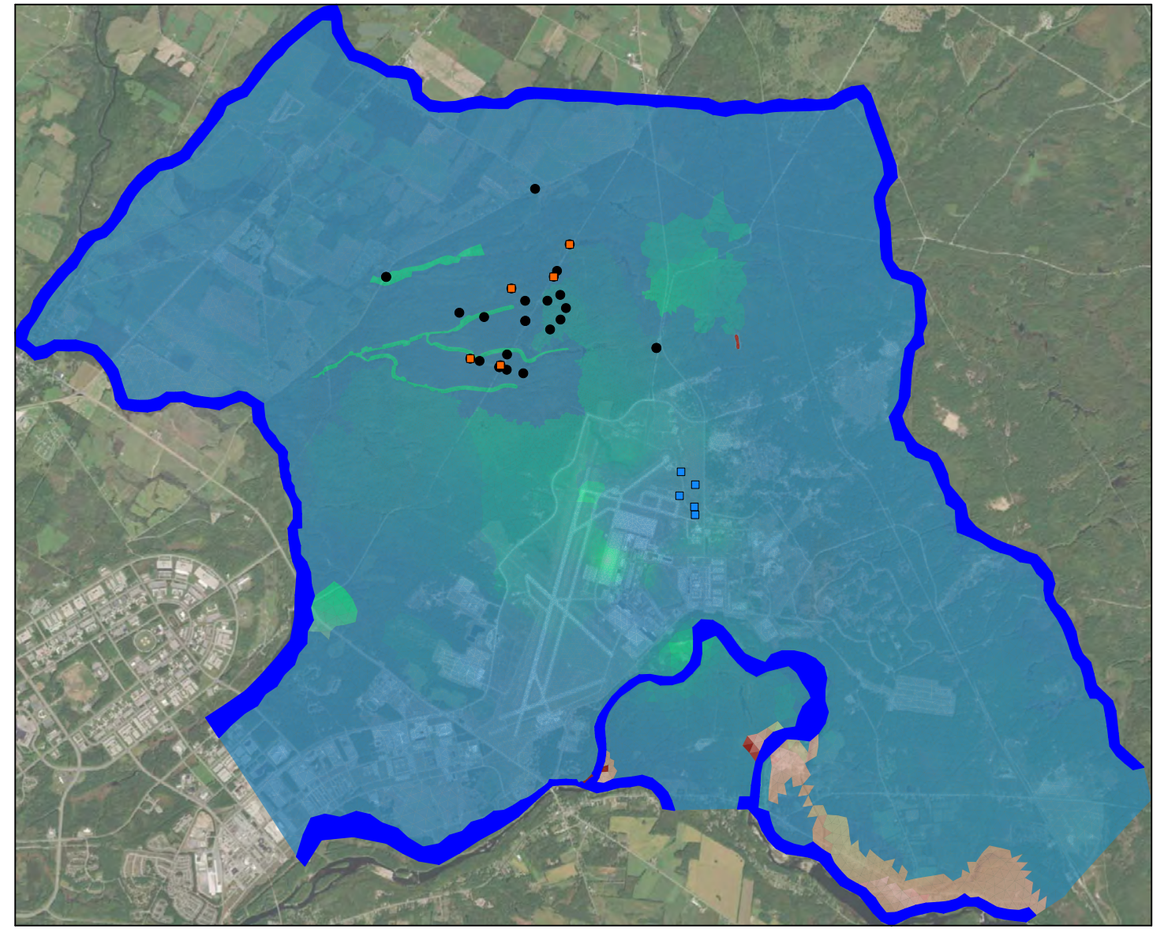
ARCADIS

FIGURE
4.2-1

Model Layer 3



Model Layer 4



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well

Horizontal Hydraulic Conductivity (ft/day)

<0.1 10 20 30 40 50 > 75 ft/day

N

Scale in feet

0 6,500 13,000

Notes:

1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

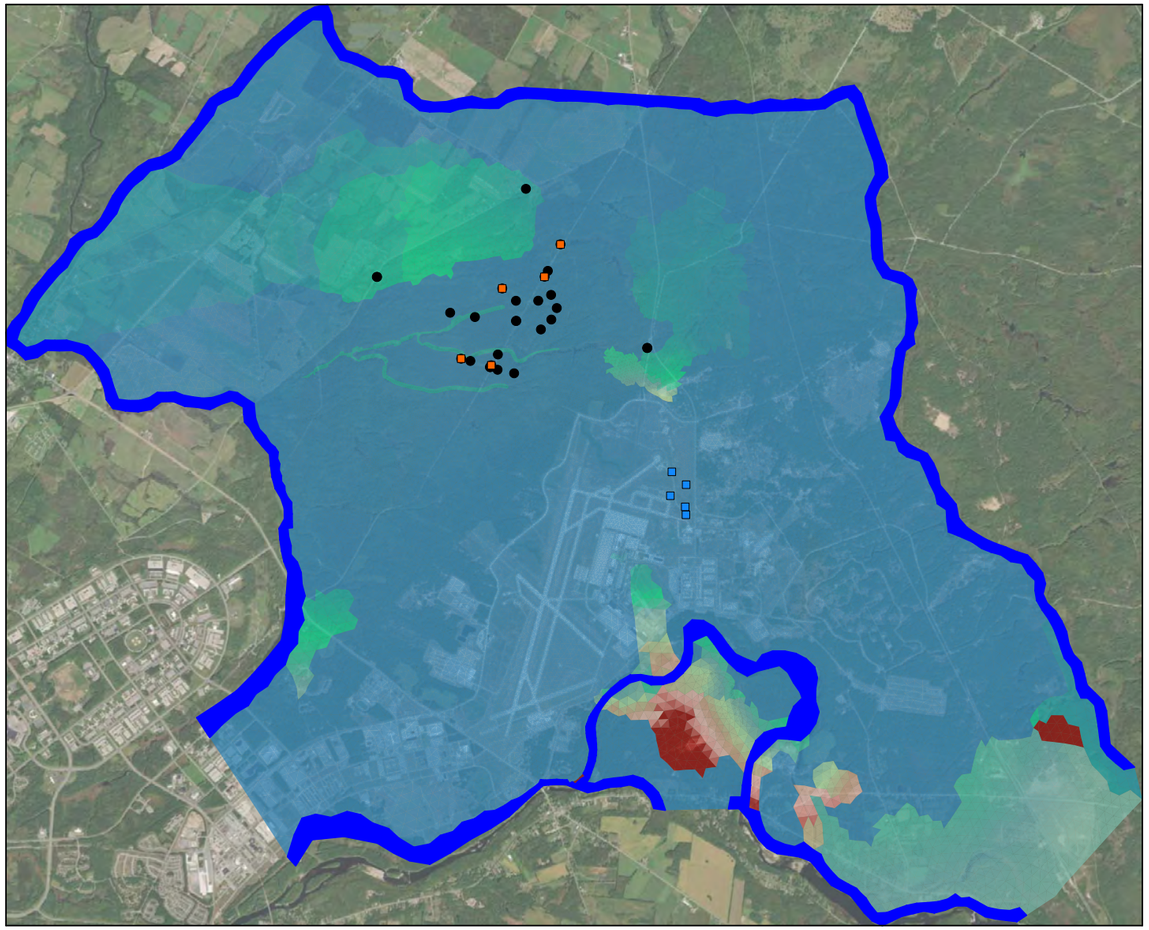
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 3 AND 4

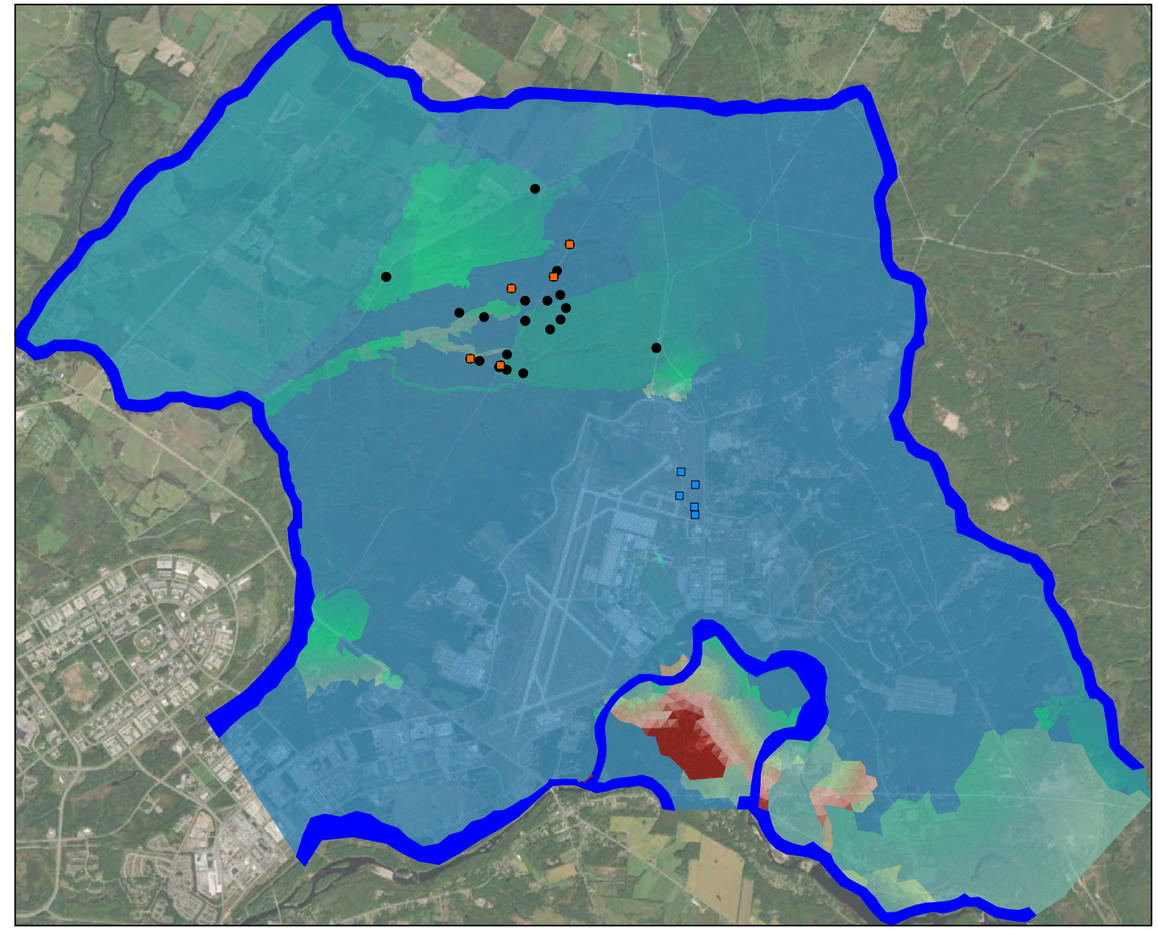
ARCADIS

FIGURE
4.2-2

Model Layer 5



Model Layer 6



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well

Horizontal Hydraulic Conductivity (ft/day)

<0.1 10 20 30 40 50 > 75 ft/day

N

Scale in feet

0 6,500 13,000

Notes:

1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

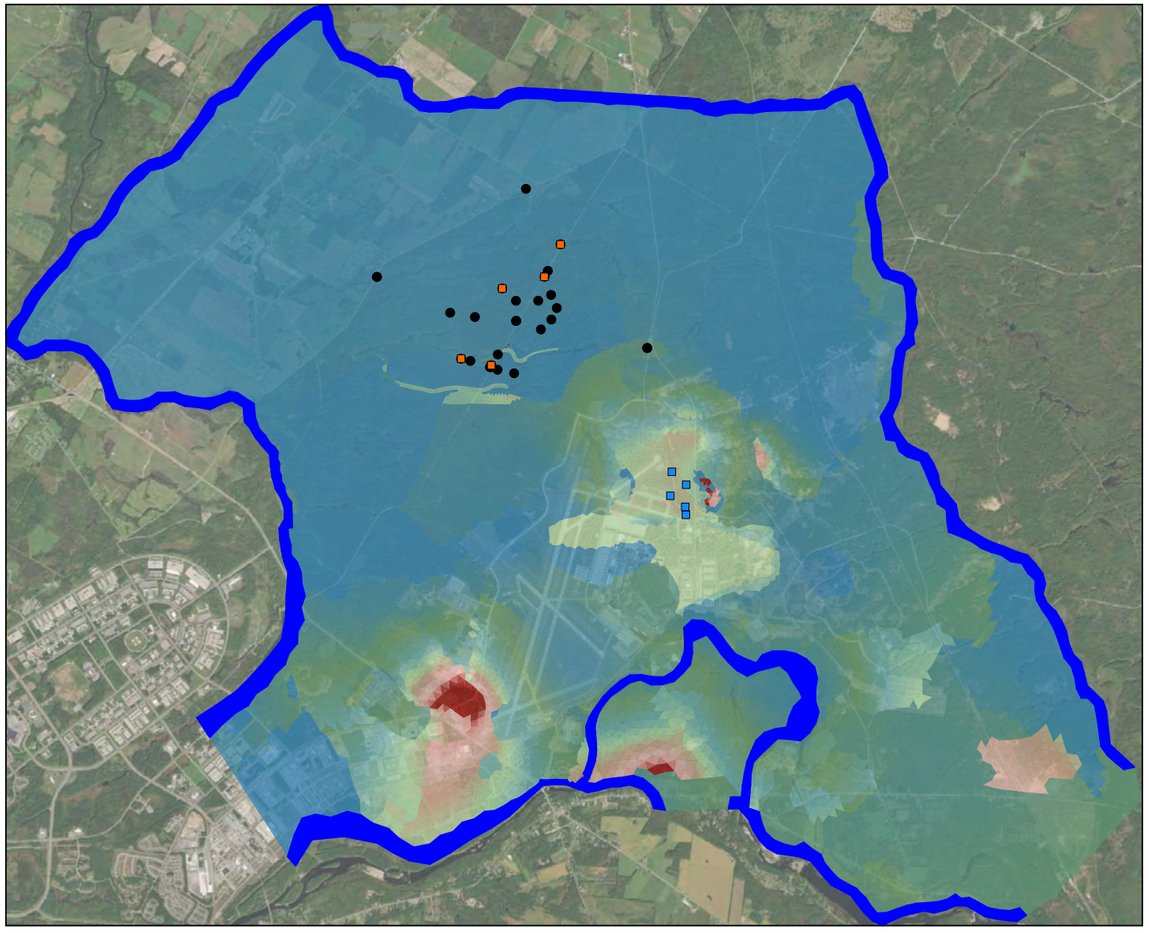
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 5 AND 6

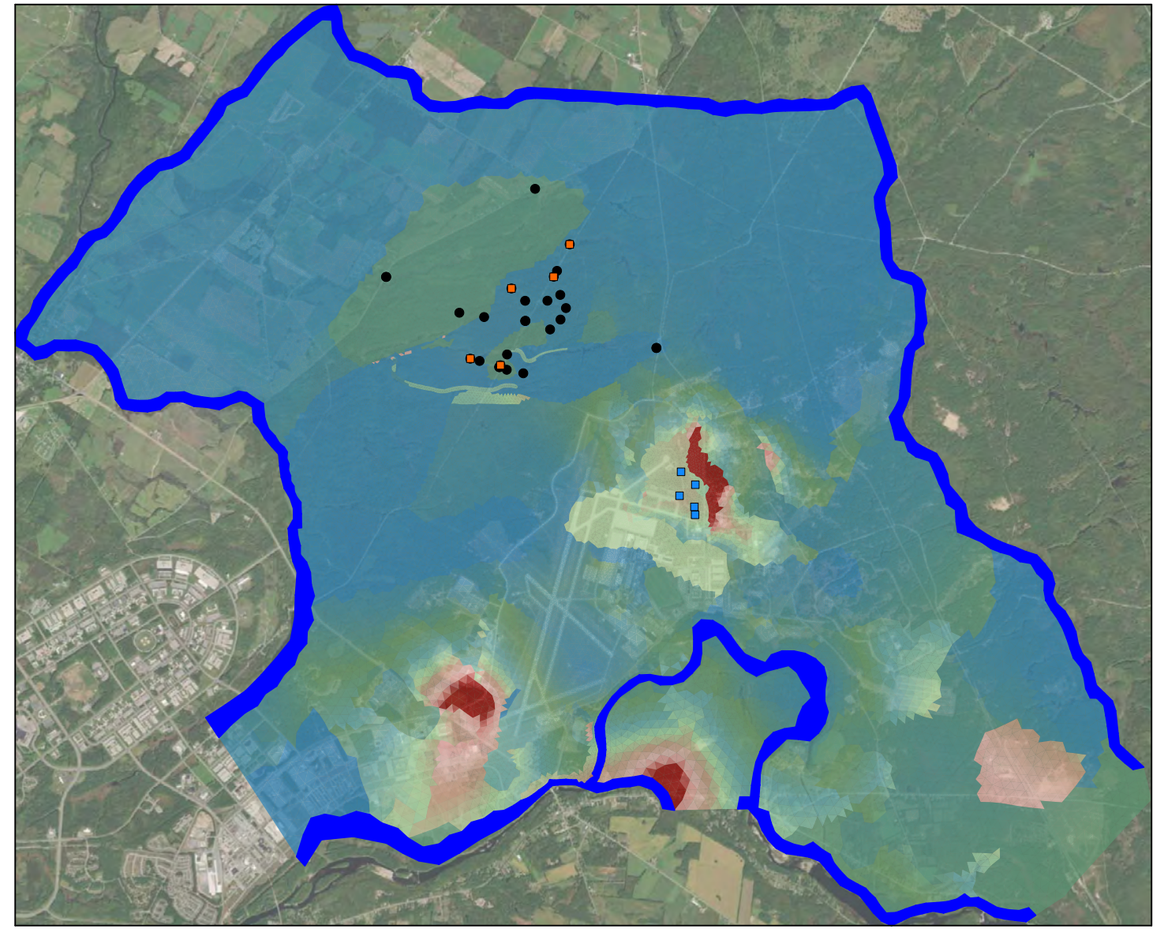
ARCADIS

FIGURE
4.2-3

Model Layer 7



Model Layer 8



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well

Horizontal Hydraulic Conductivity (ft/day)

<1 | 30 | 60 | 90 | 110 | 140 | 160 | > 200 ft/day

N

Scale in feet

0 | 6,500 | 13,000

Notes:

1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

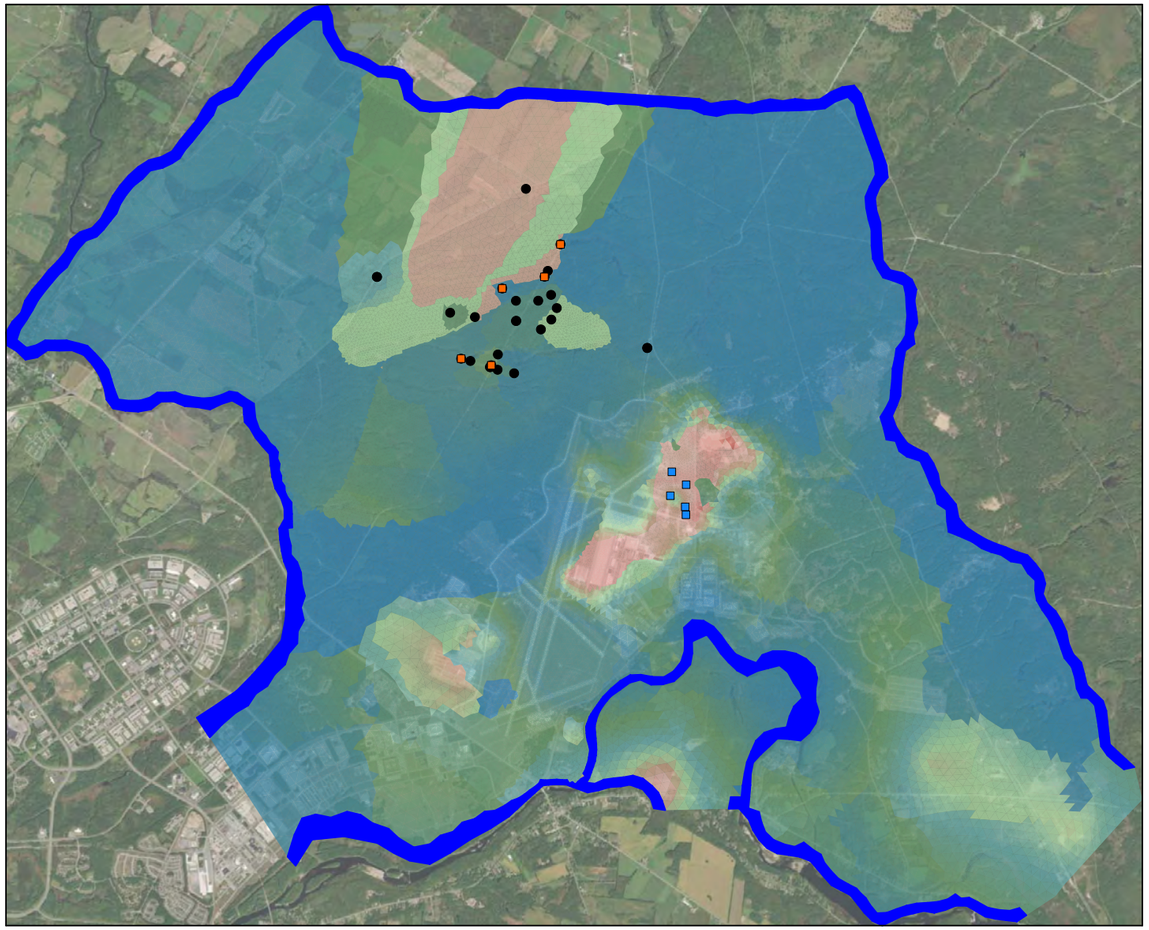
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 7 AND 8

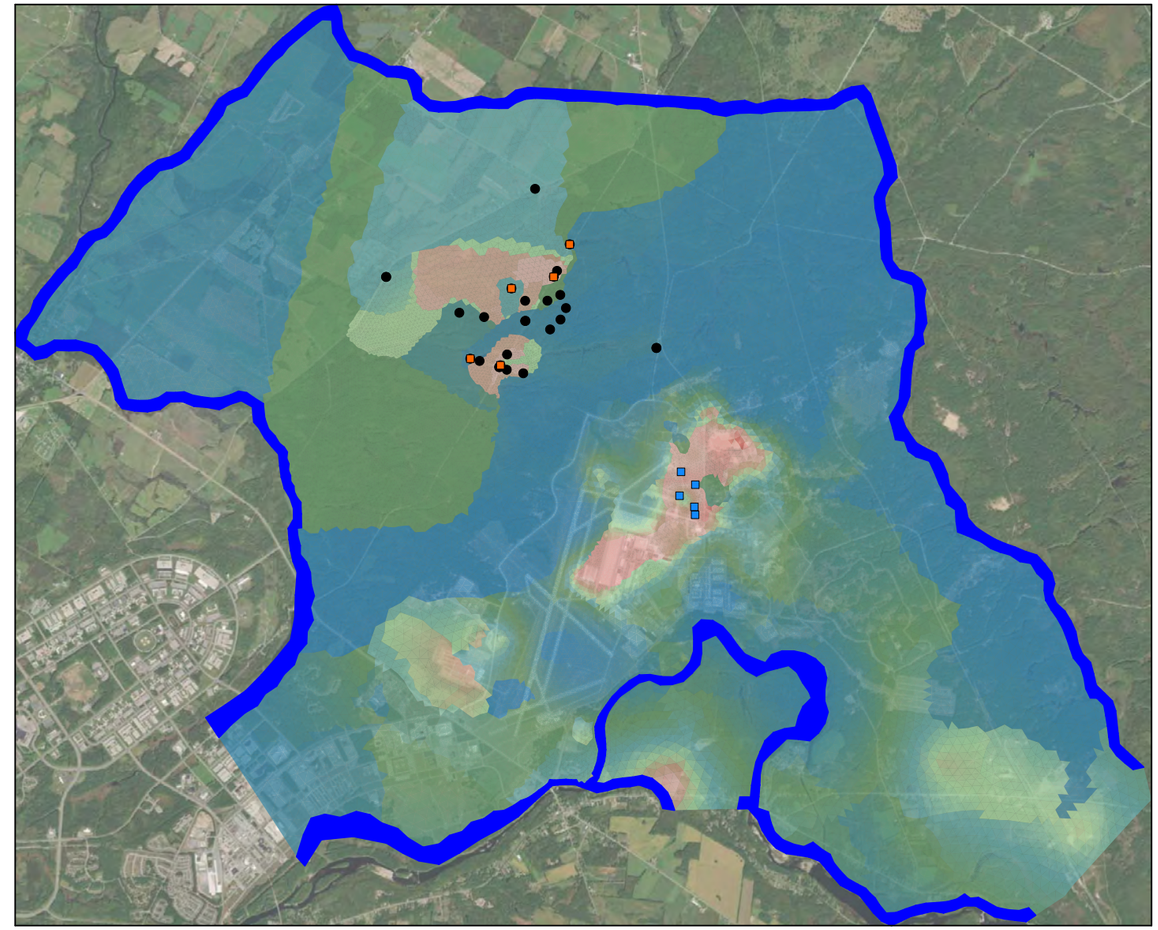
ARCADIS

FIGURE
4.2-4

Model Layer 9



Model Layer 10



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well

Horizontal Hydraulic Conductivity (ft/day)

<1 | 50 | 100 | 150 | 200 | 250 | 300 | > 350 ft/day

N

Scale in feet

0 | 6,500 | 13,000

Notes:

1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

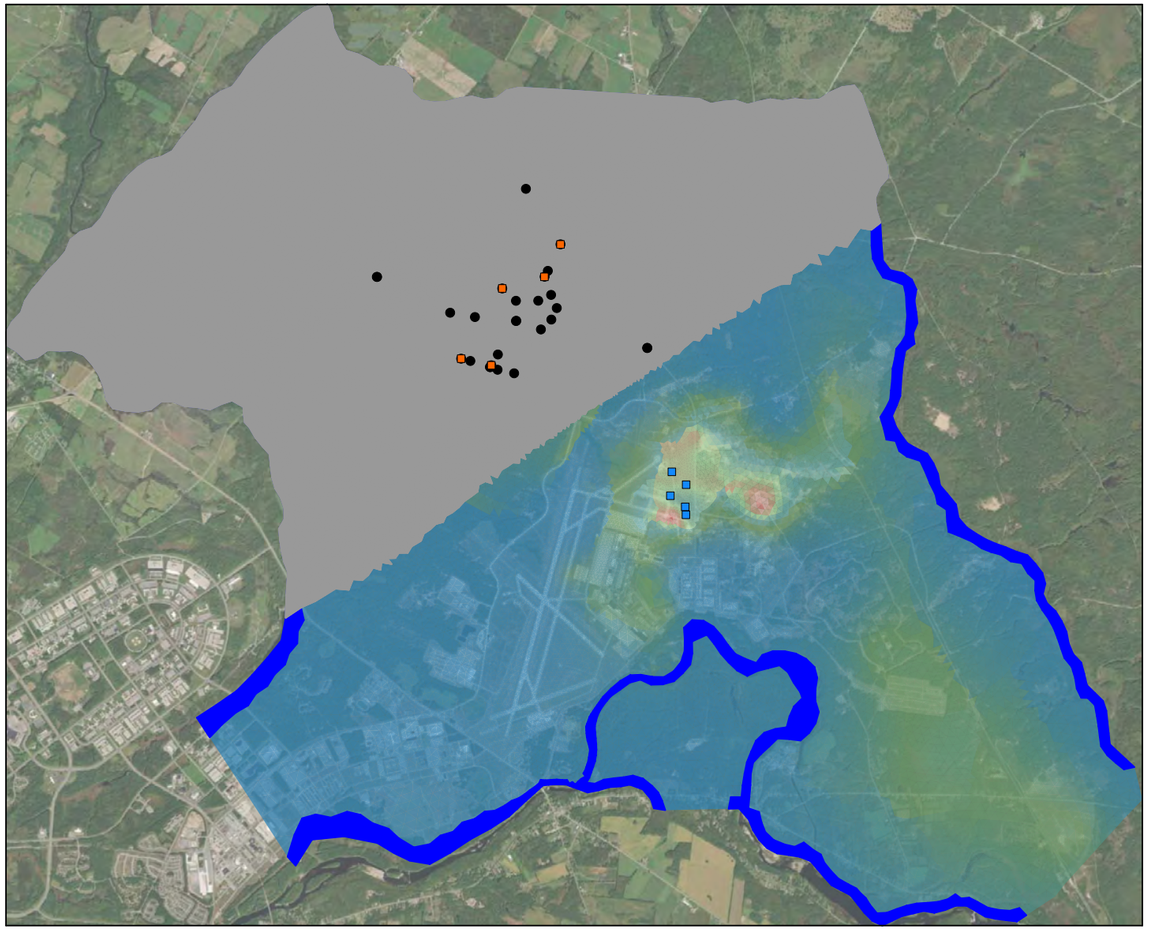
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 9 AND 10

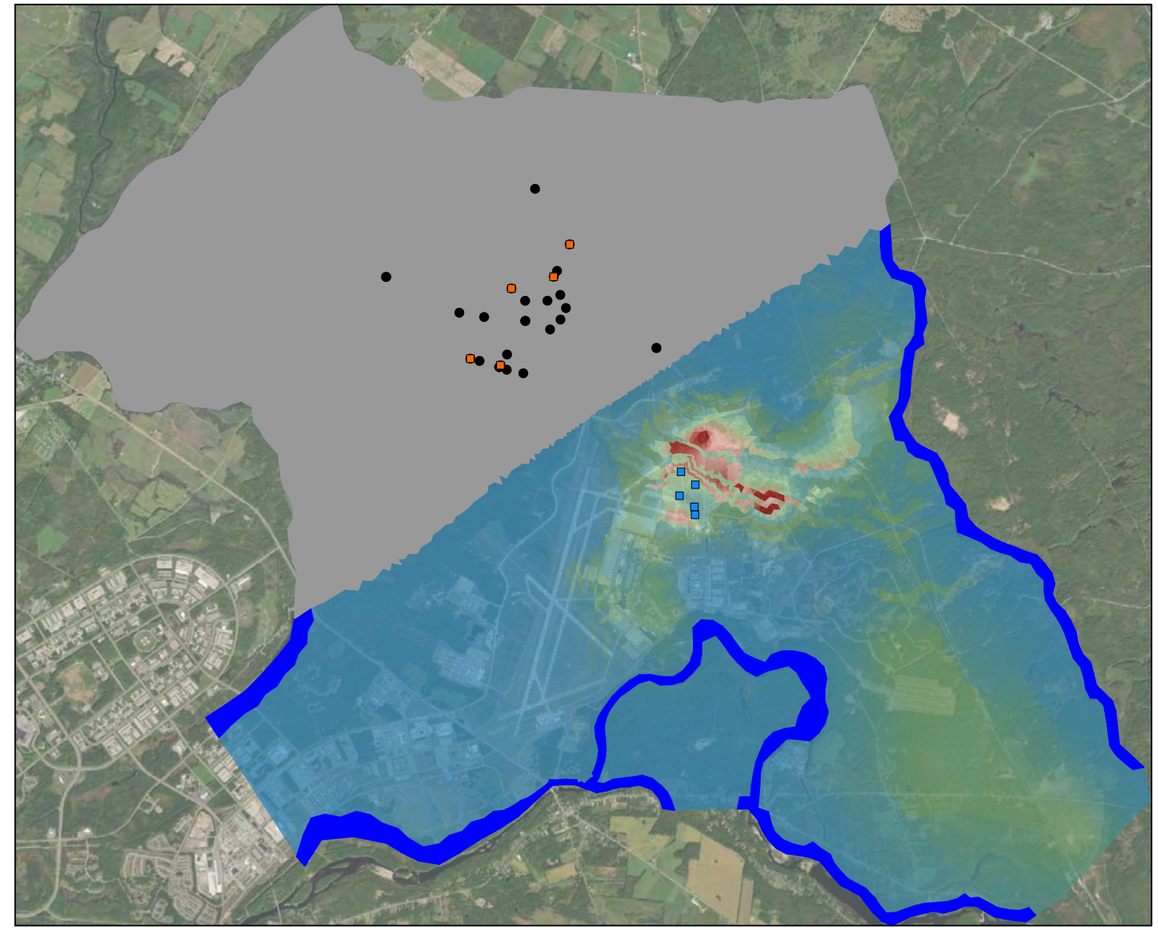
ARCADIS

FIGURE
4.2-5

Model Layer 11



Model Layer 12



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well
- No Flow Boundary

Horizontal Hydraulic Conductivity (ft/day)

<1 15 30 45 60 70 85 > 100 ft/day

N

Scale in feet

0 6,500 13,000

Notes:

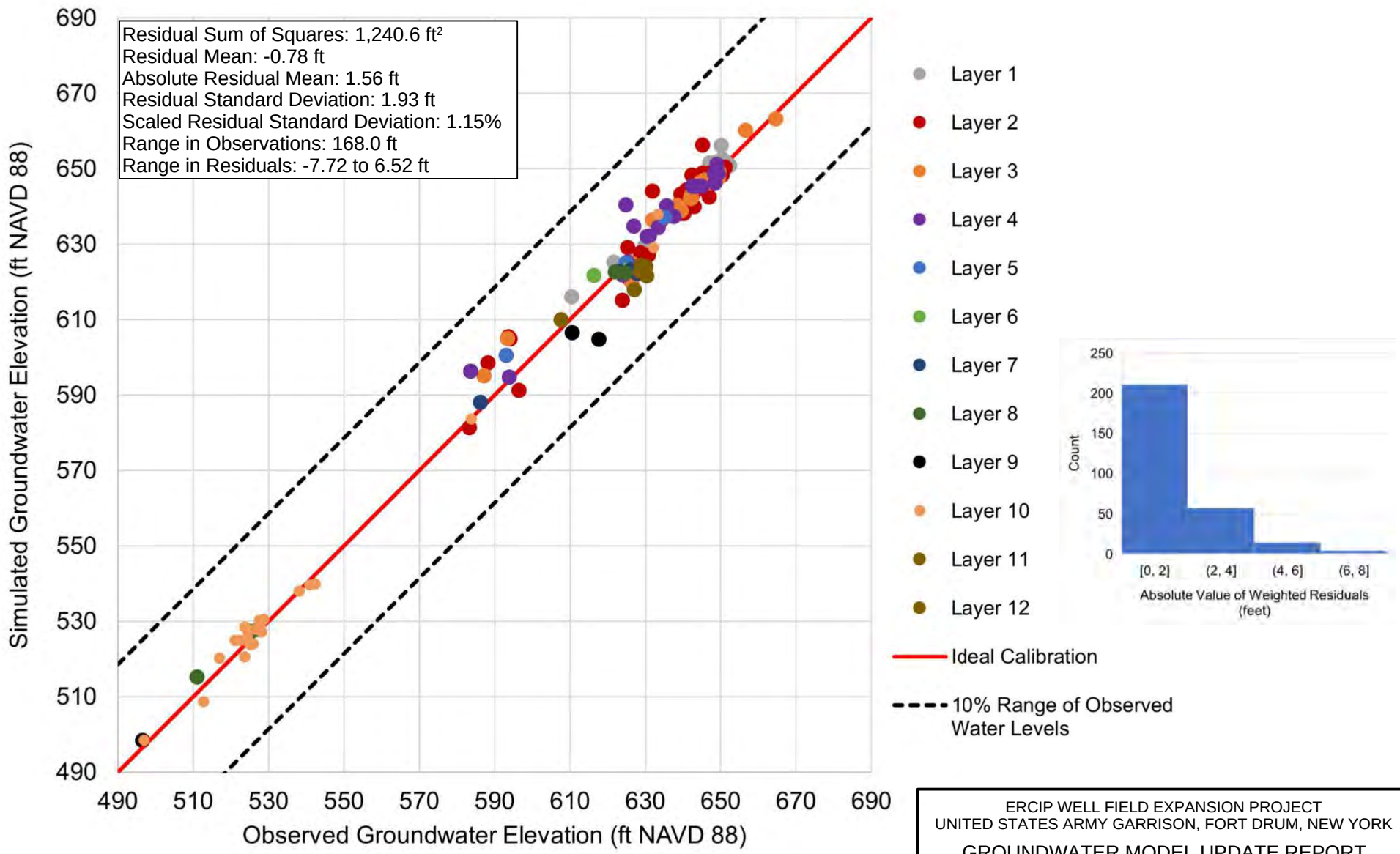
1. ft/day = feet per day
2. Test wells and monitoring wells are shown for reference.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY DISTRIBUTION
MODEL LAYERS 11 AND 12

ARCADIS

FIGURE
4.2-6



Note: All residuals are weighted residuals.

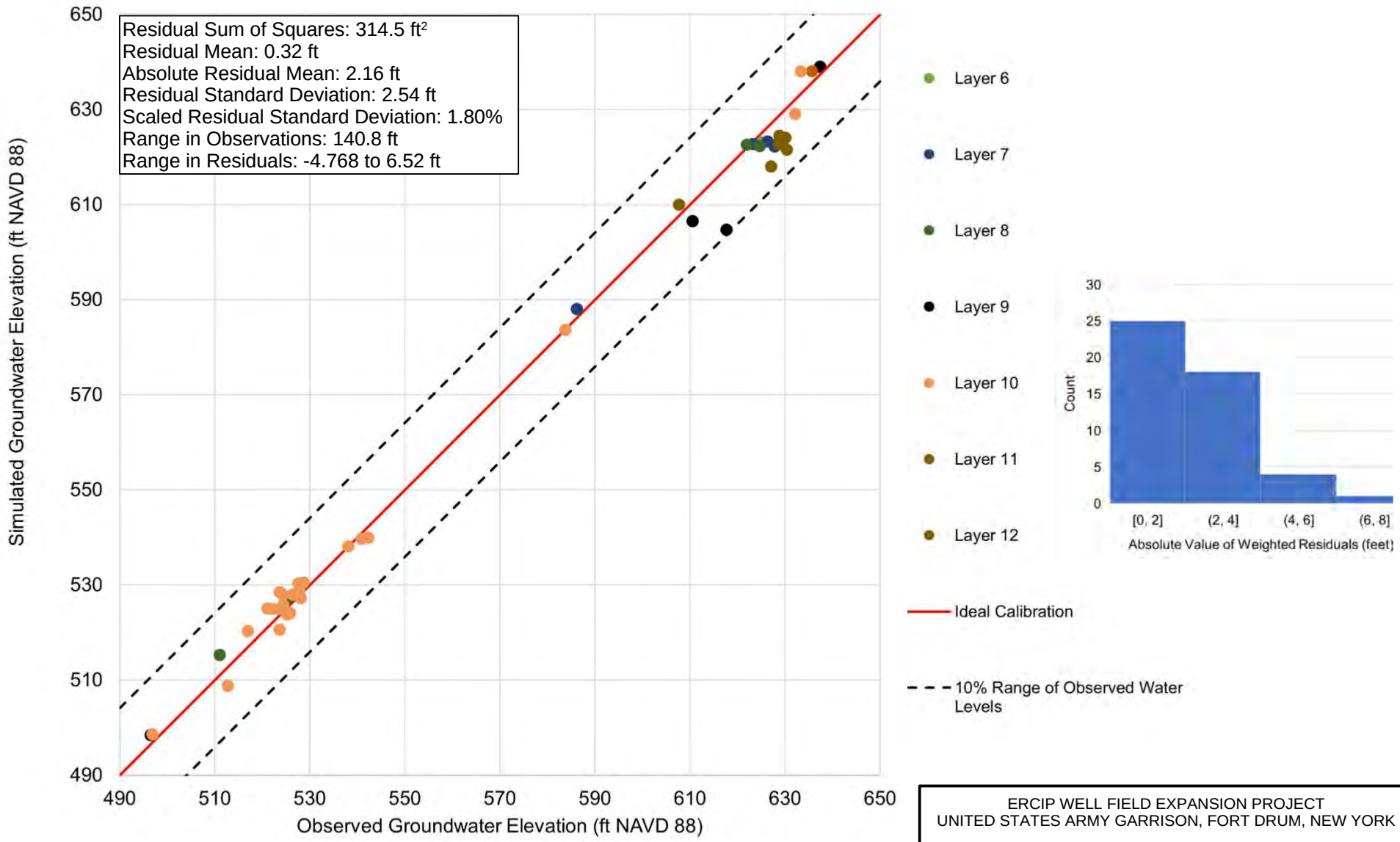
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE
CALIBRATION SCATTER PLOT
OVERALL MODEL

ARCADIS

FIGURE
5.1-1



Note: All residuals are weighted residuals.

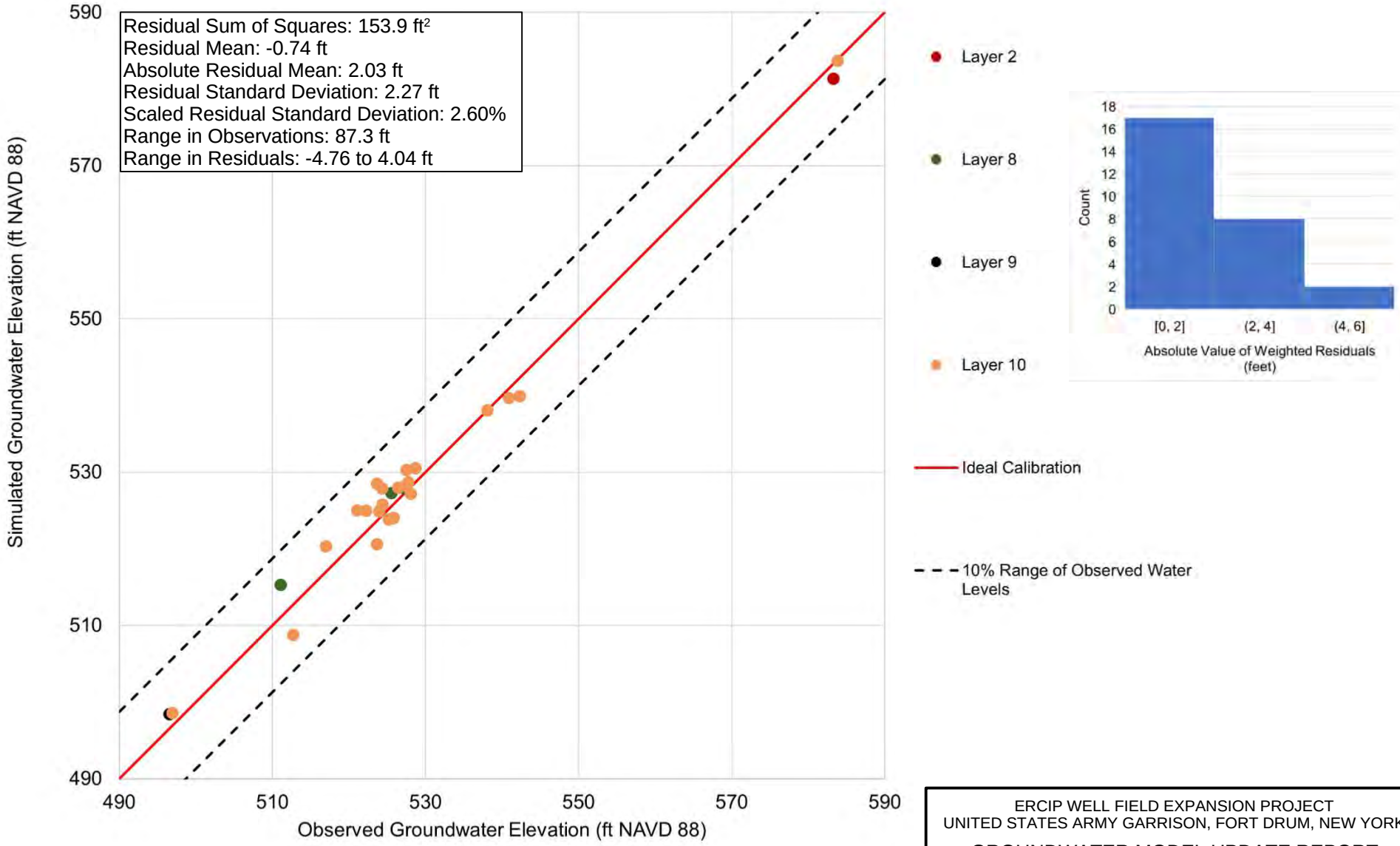
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE
CALIBRATION SCATTER PLOT
BEDROCK ONLY

ARCADIS

FIGURE
5.1-2



Note: All residuals are weighted residuals.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

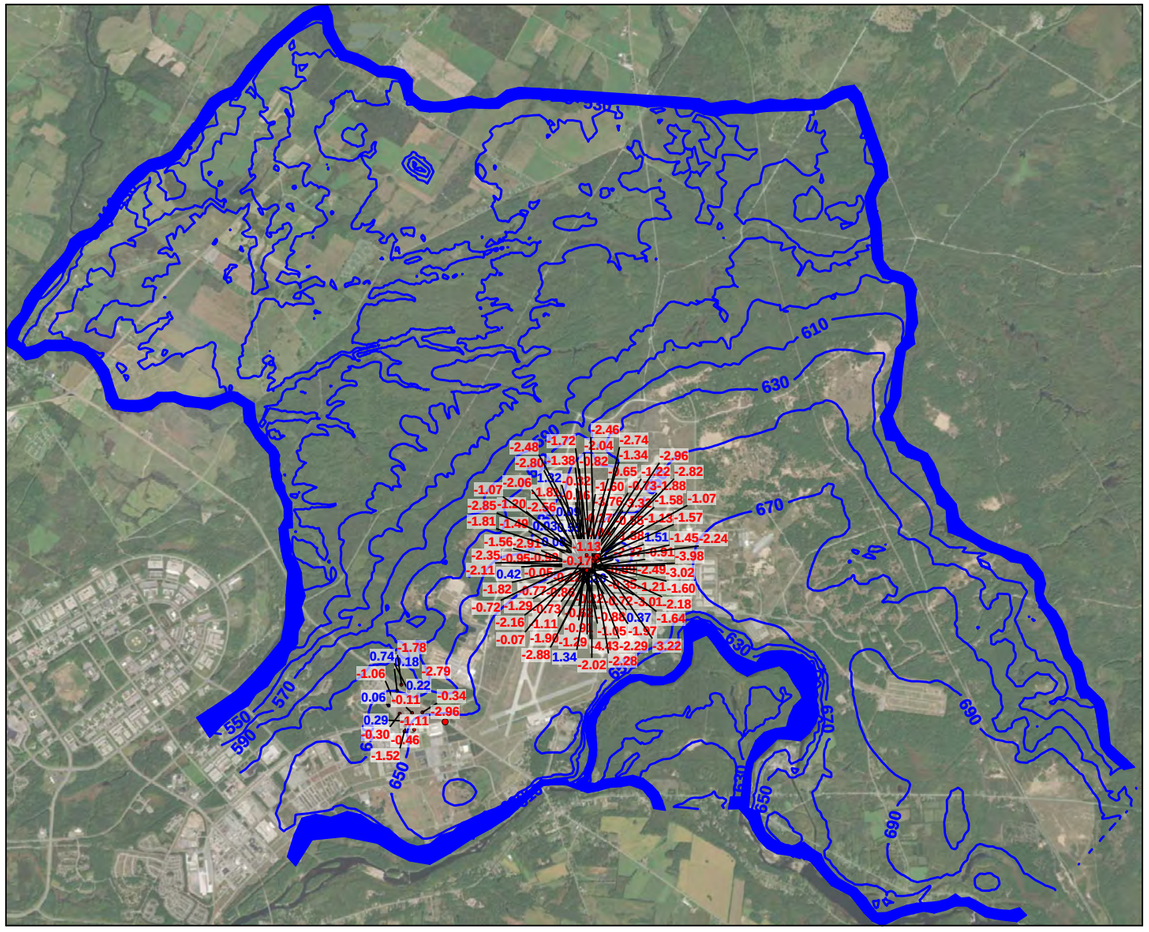
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE
CALIBRATION SCATTER PLOT
AREA 4 ONLY

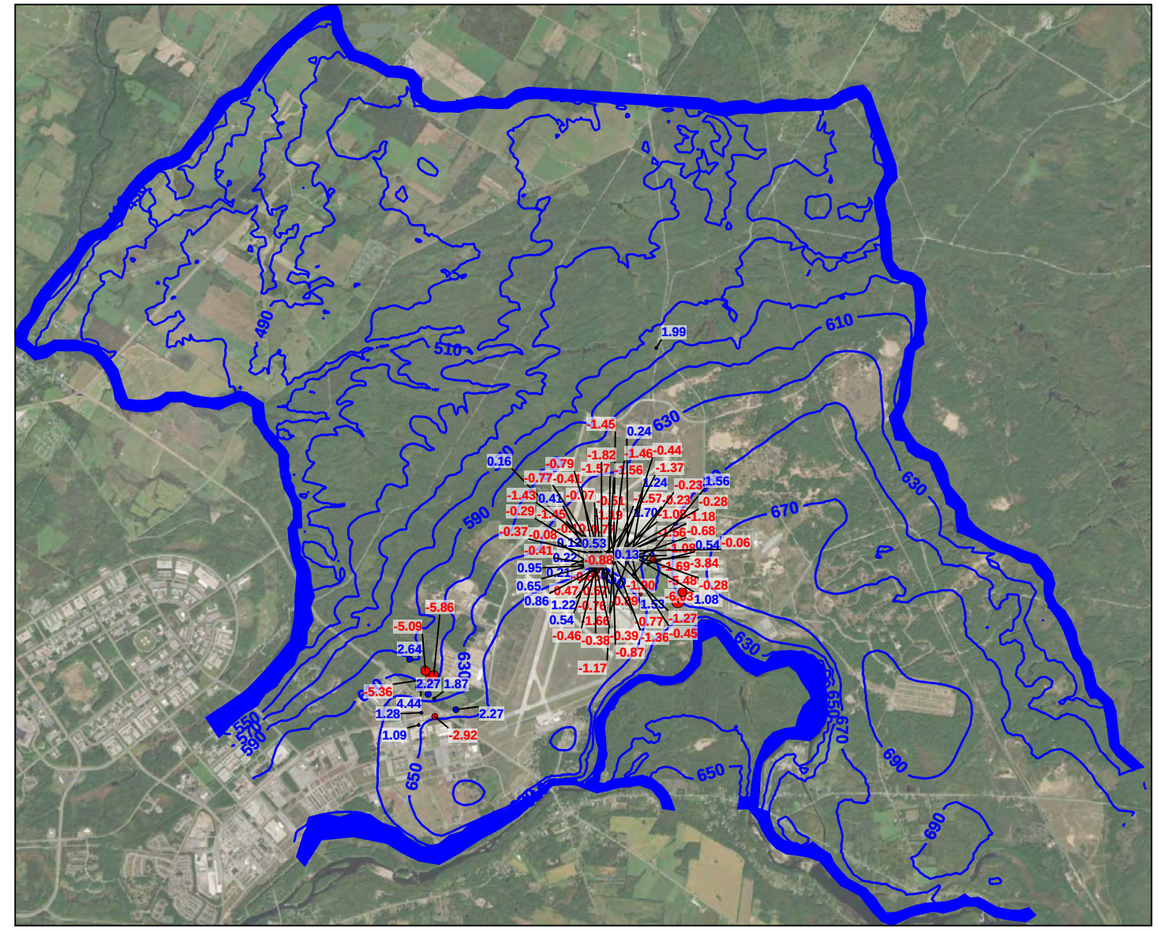
ARCADIS

FIGURE
5.1-3

Model Layer 1



Model Layer 2



Legend

Constant Head Boundary

580 Simulated Groundwater Elevation (ft NAVD 88)

0.1 -0.1 Weighted Residual (ft)
(Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet

0 6,500 13,000

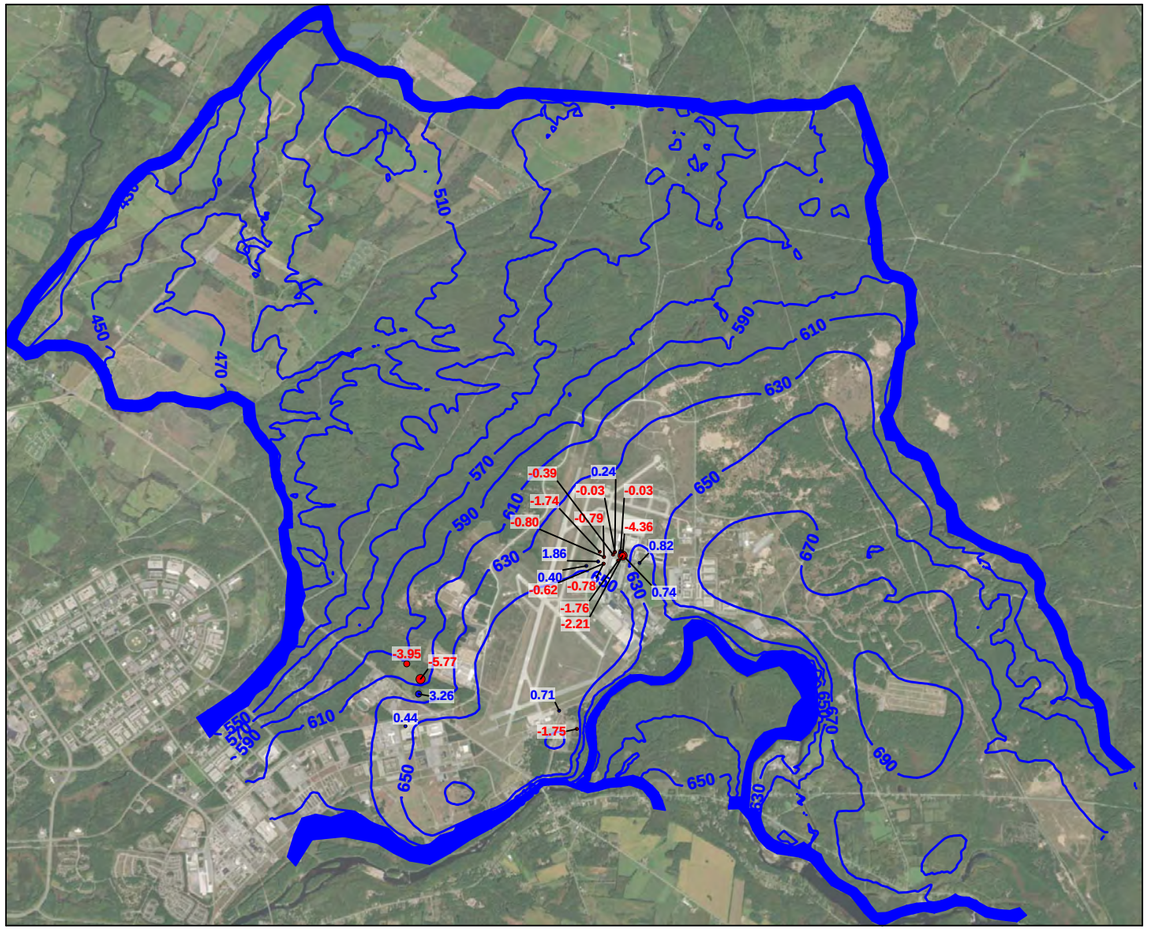
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 1 AND 2

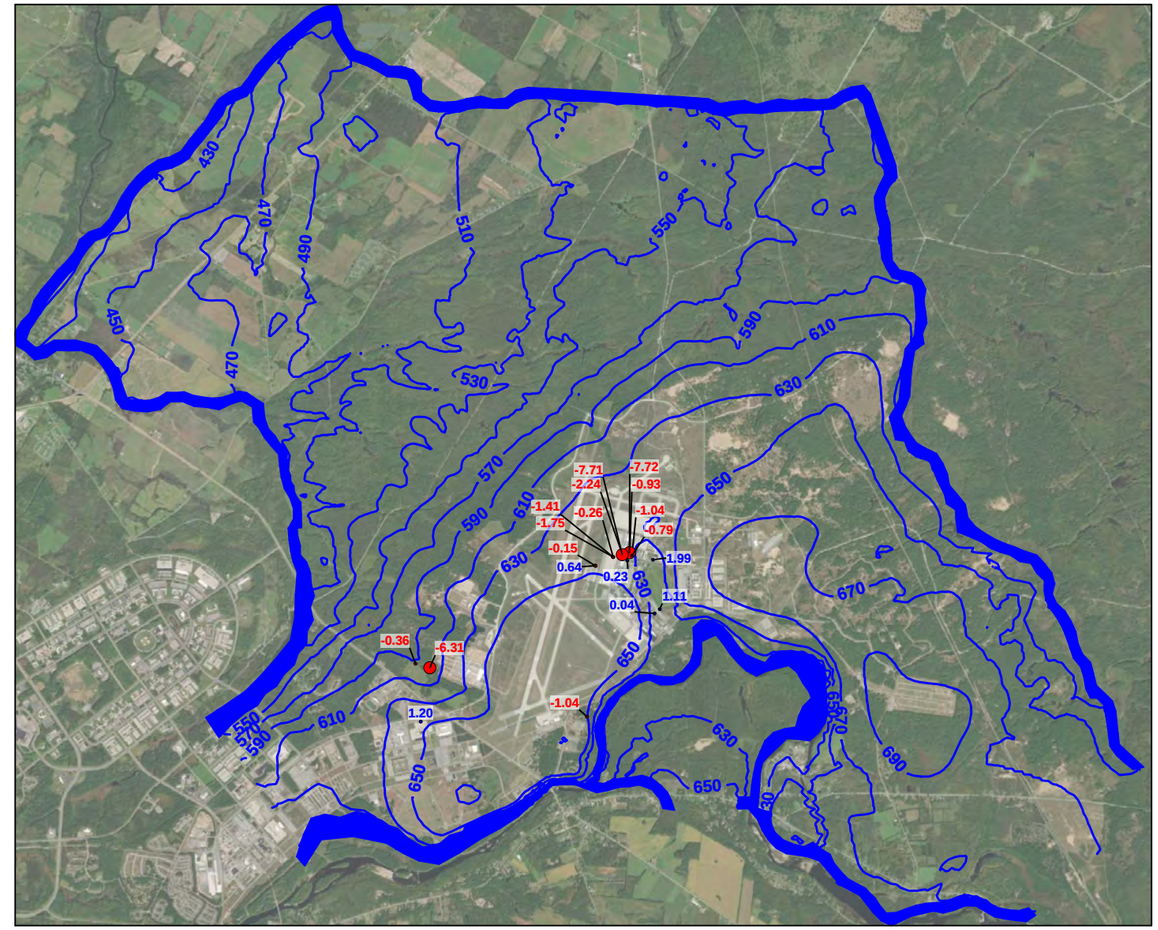
ARCADIS

FIGURE 5.1-4

Model Layer 3



Model Layer 4



Legend

Constant Head Boundary

580 Simulated Groundwater Elevation (ft NAVD 88)

0.1 -0.1 Weighted Residual (ft)
(Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet

0 6,500 13,000

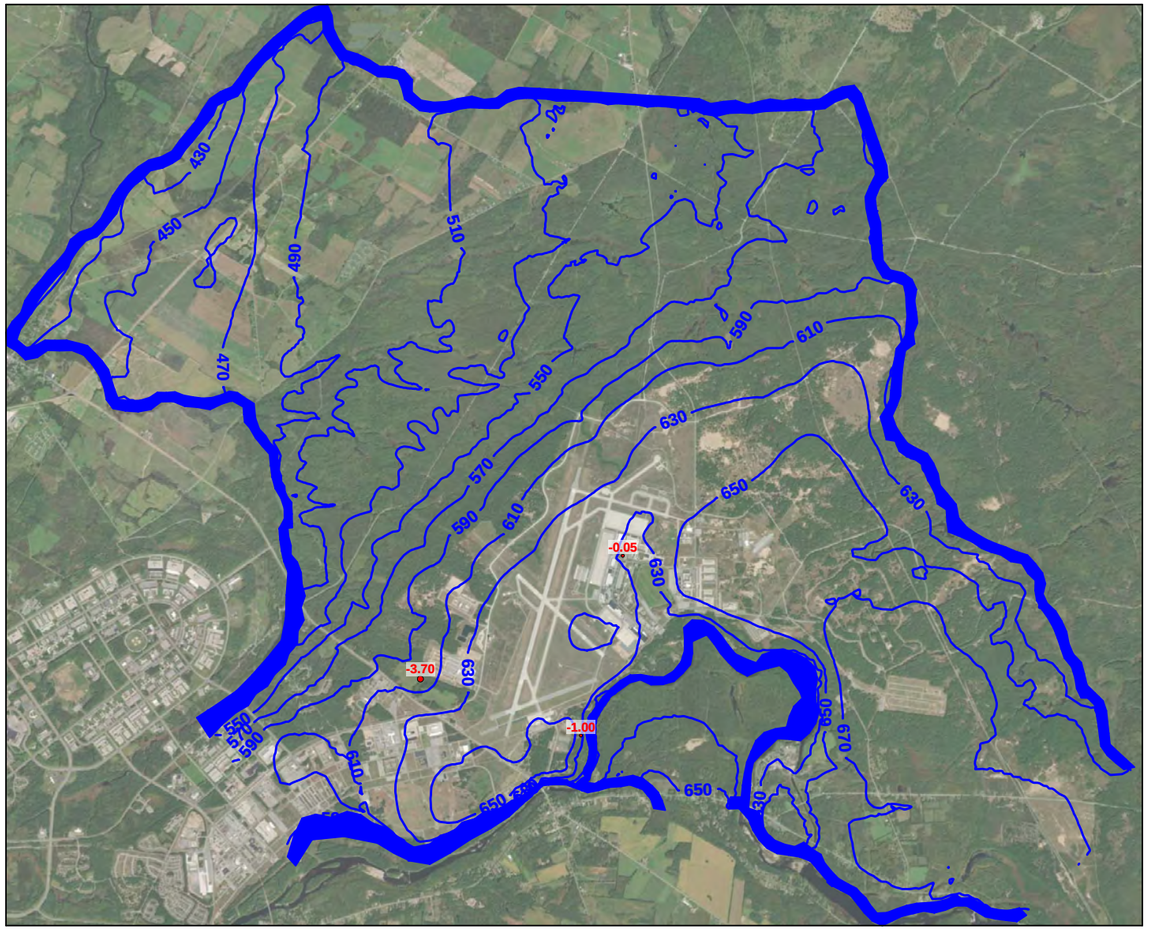
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 3 AND 4

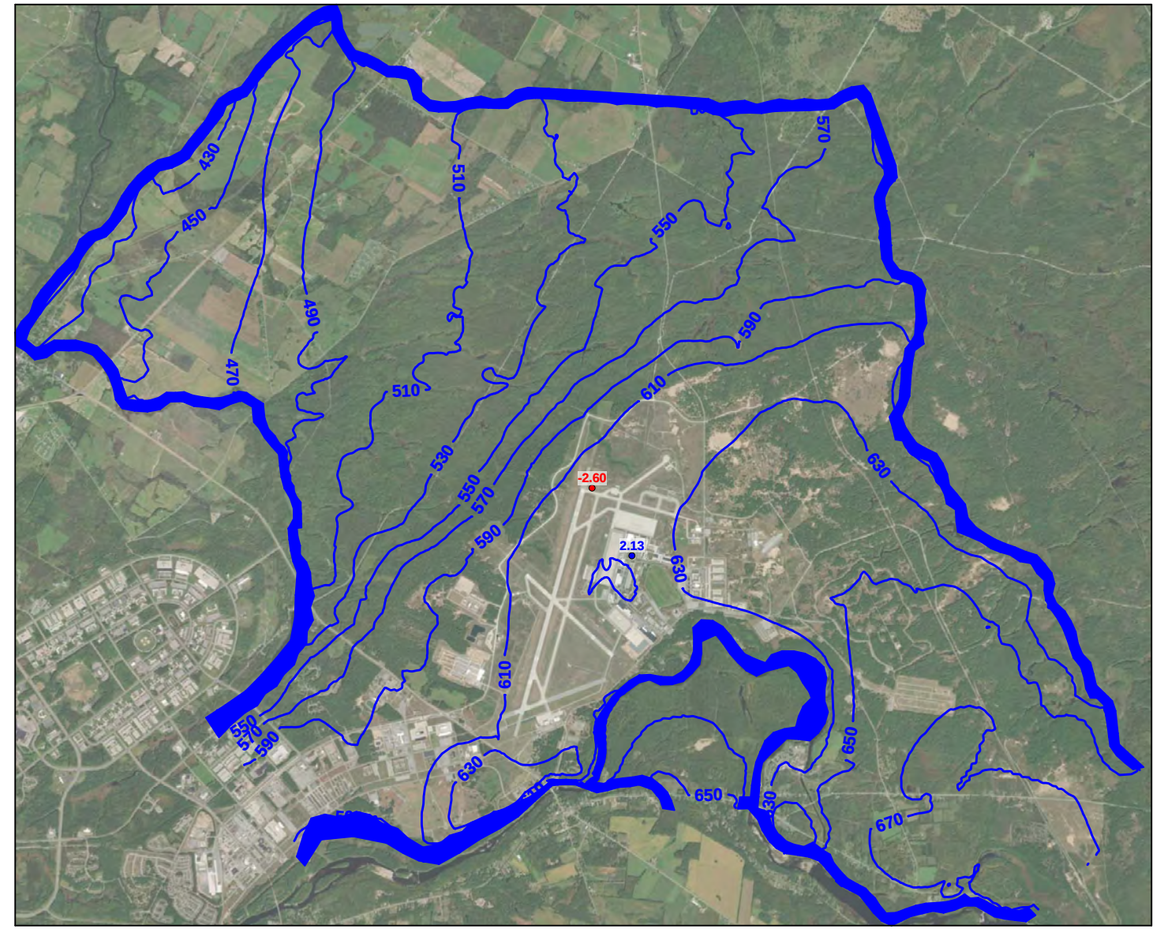
ARCADIS

FIGURE 5.1-5

Model Layer 5



Model Layer 6



Legend

Constant Head Boundary

580 Simulated Groundwater Elevation (ft NAVD 88)

0.1 -0.1 Weighted Residual (ft)
(Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet
0 6,500 13,000

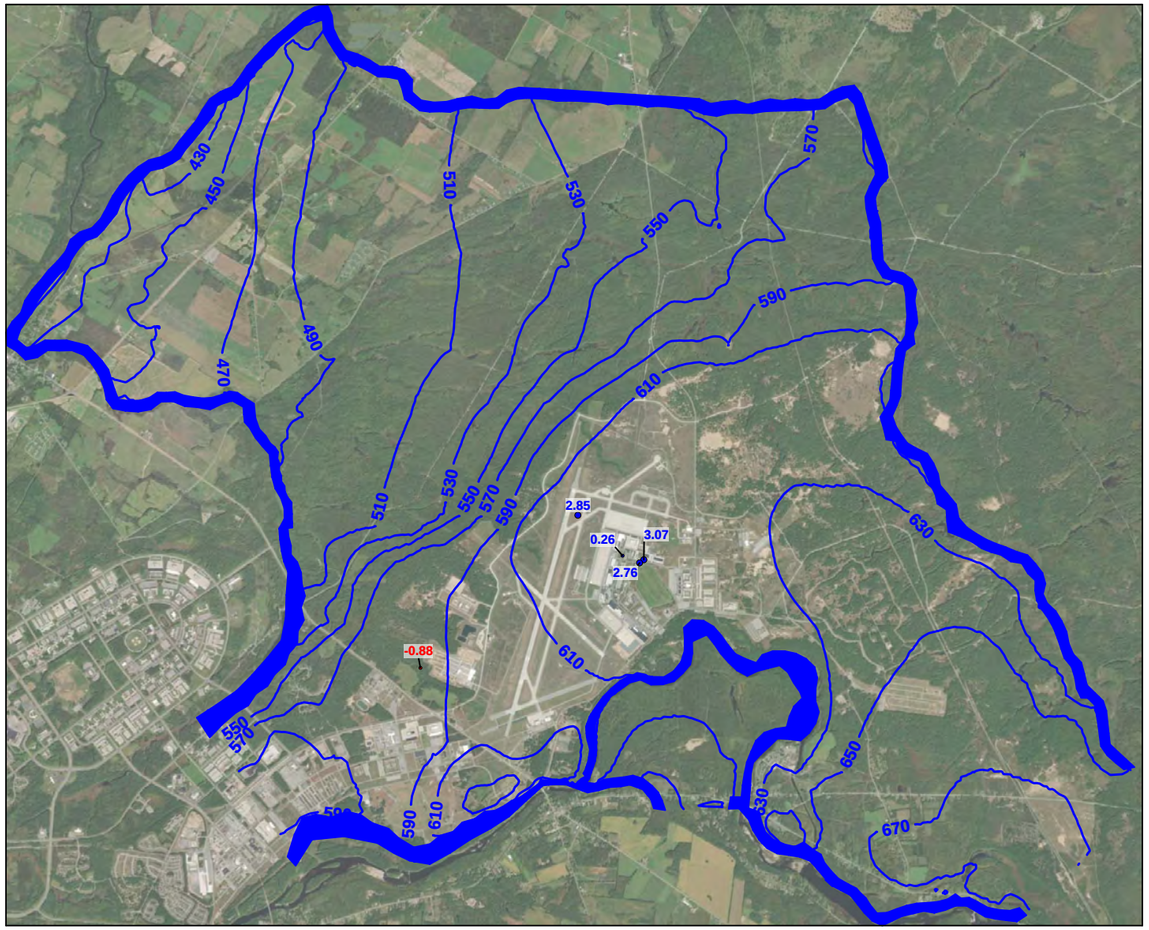
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 5 AND 6

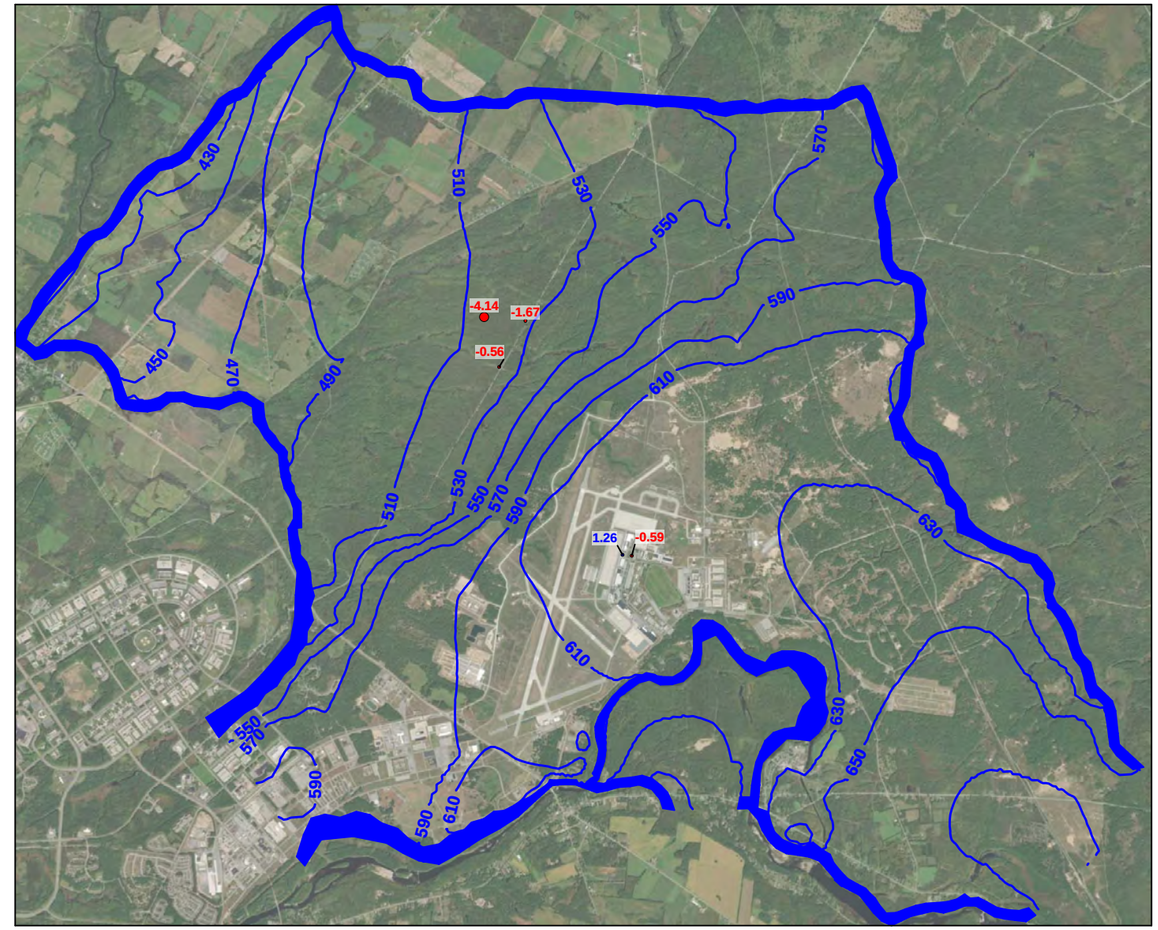
ARCADIS

FIGURE
5.1-6

Model Layer 7



Model Layer 8



Legend

Constant Head Boundary

580 Simulated Groundwater Elevation (ft NAVD 88)

0.1 -0.1 Weighted Residual (ft)
(Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet

0 6,500 13,000

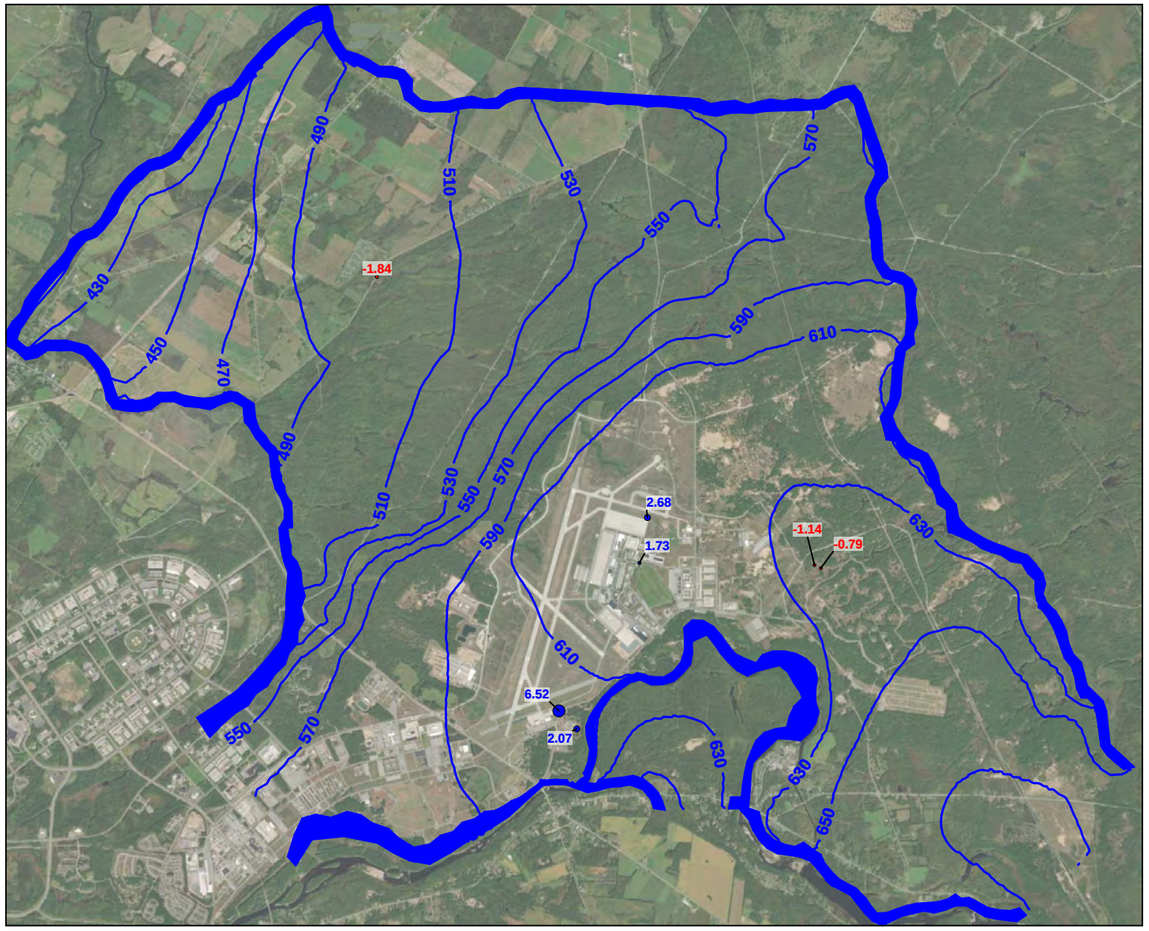
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 7 AND 8

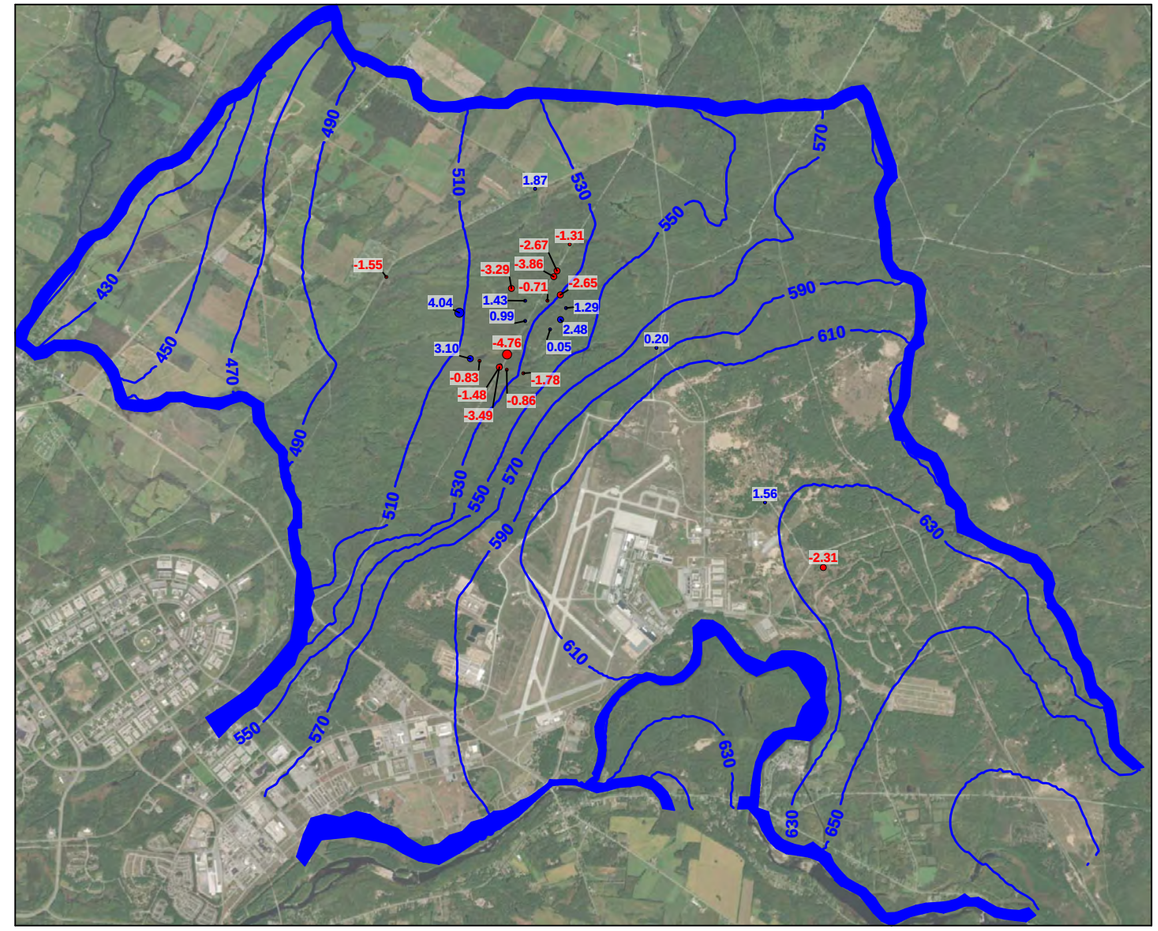
ARCADIS

FIGURE 5.1-7

Model Layer 9



Model Layer 10



Legend

Constant Head Boundary

580 Simulated Groundwater Elevation (ft NAVD 88)

0.1 -0.1 Weighted Residual (ft)
(Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet

0 6,500 13,000

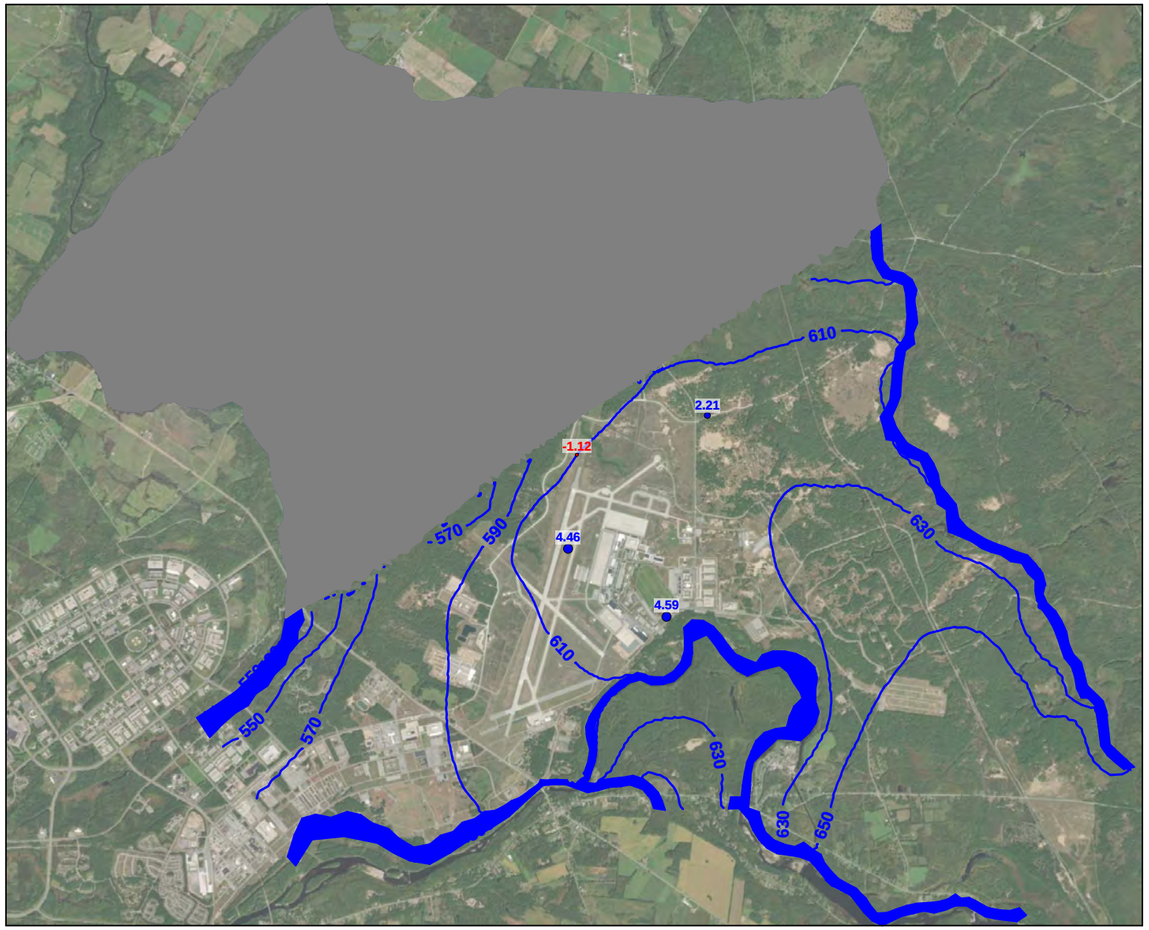
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 9 AND 10

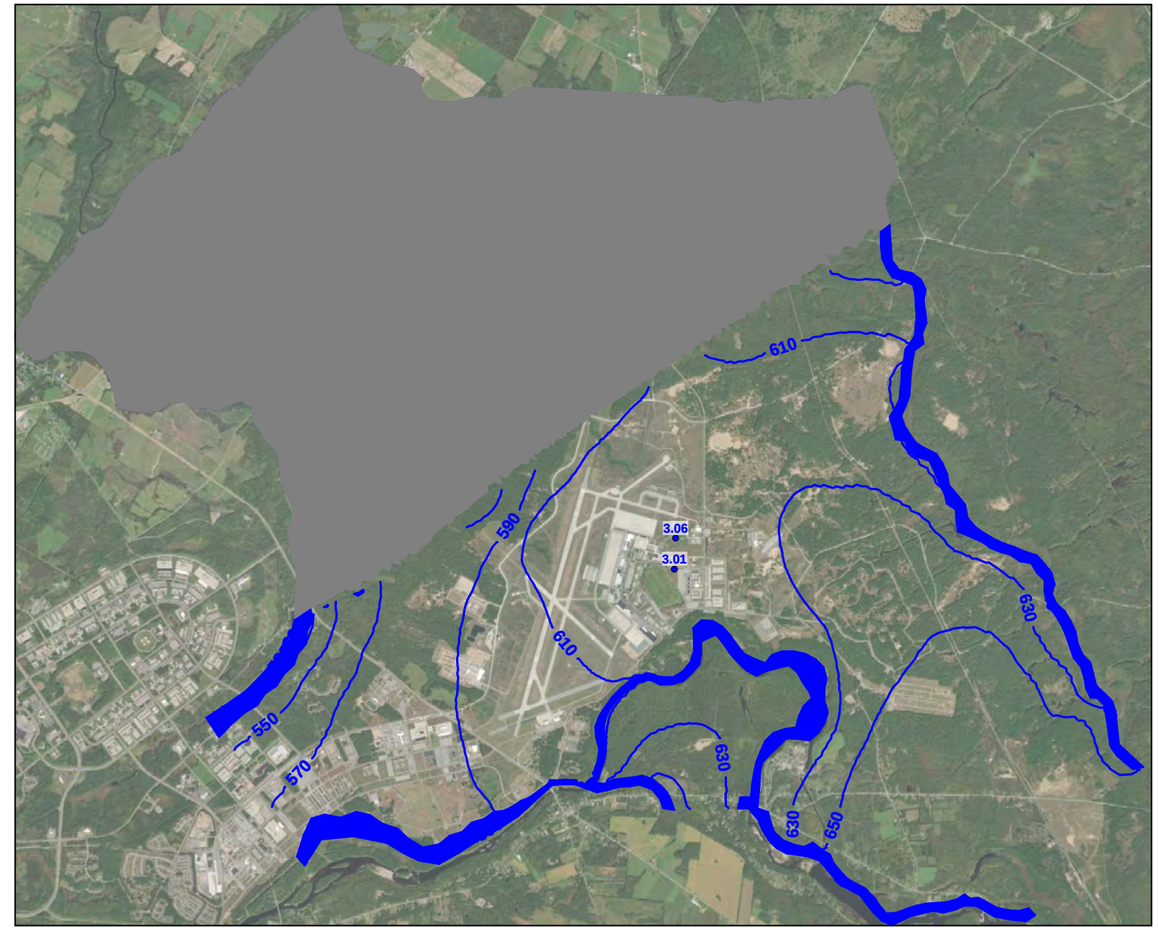
ARCADIS

FIGURE 5.1-8

Model Layer 11



Model Layer 12



Legend

- Constant Head Boundary
- 580 Simulated Groundwater Elevation (ft NAVD 88)
- 0.1 -0.1 Weighted Residual (ft)
  (Weighted Residual = [Observed Water Level - Simulated Water Level] x Residual Weight)
- No flow boundary

Notes:

1. ft = feet
2. NAVD 88 = North American Vertical Datum of 1988
3. Blue circles represent simulated water levels that are less than observed water levels.
4. Red circles represent simulated water levels that are greater than observed water levels.

N

Scale in feet

0 6,500 13,000

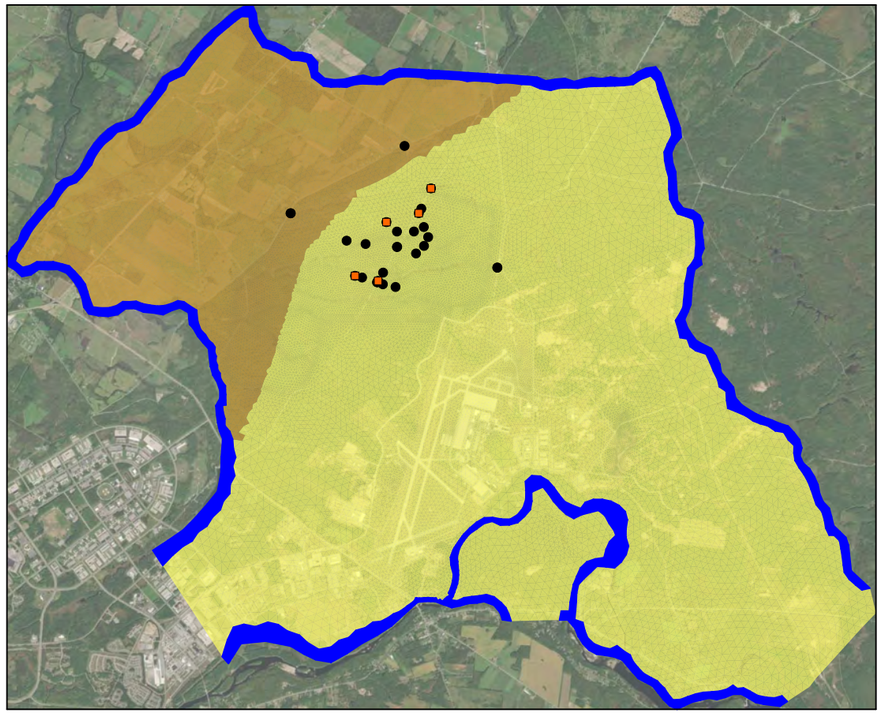
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

STEADY-STATE SIMULATED GROUNDWATER ELEVATION AND WEIGHTED RESIDUALS MODEL LAYERS 11 AND 12

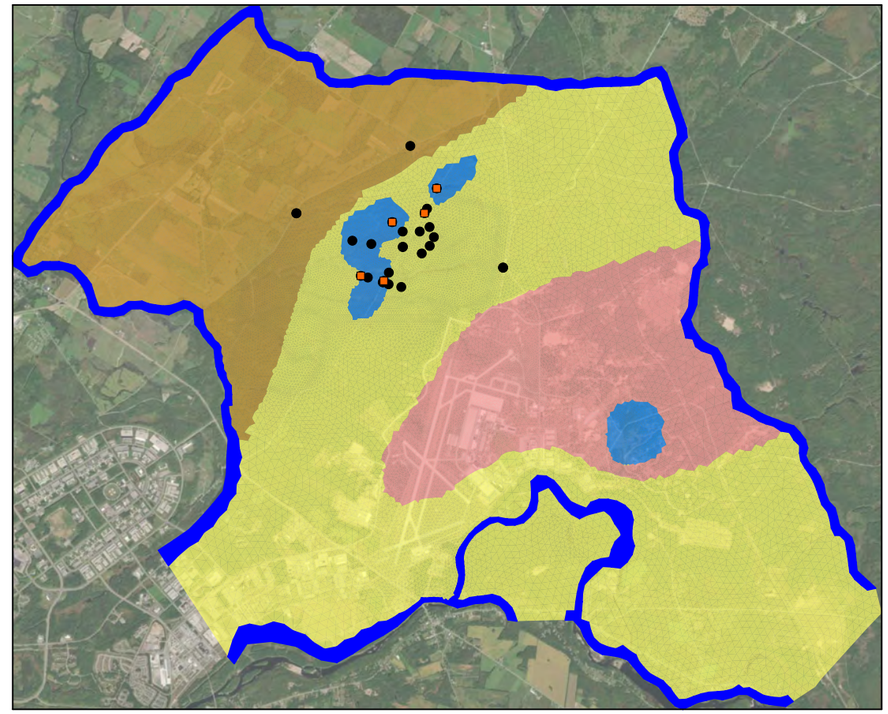
ARCADIS

FIGURE 5.1-9

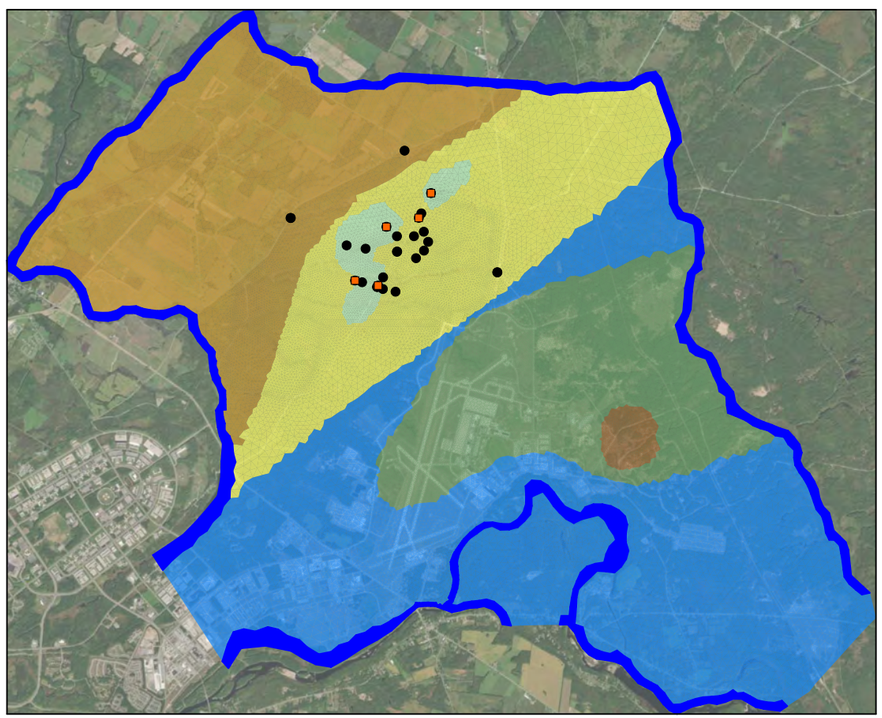
Model Layer 5



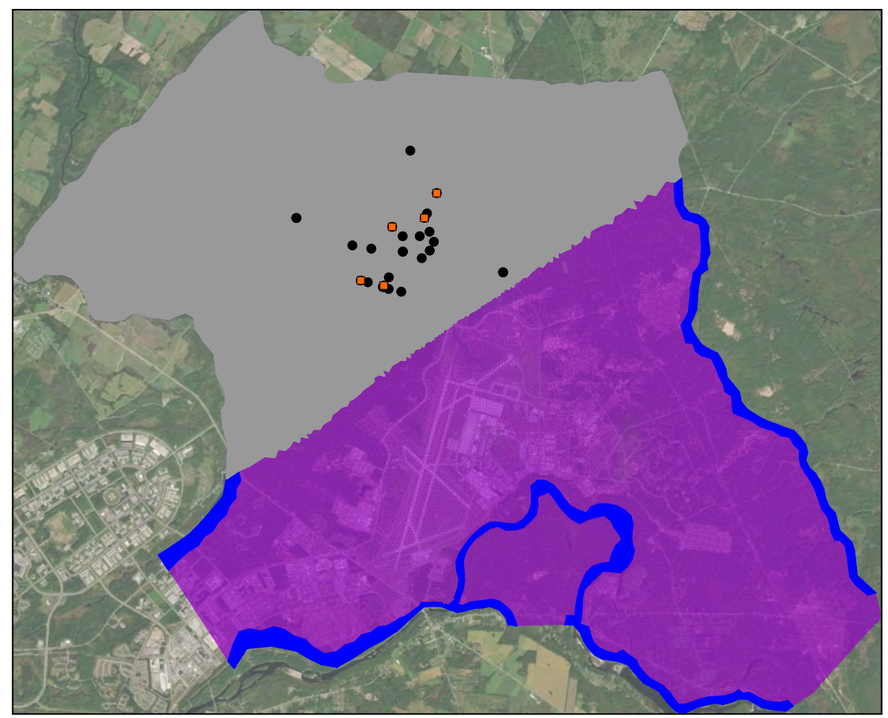
Model Layer 6



Model Layer 7-10



Model Layer 11-12



Legend

- Area 4 Test Wells
- Constant Head Boundary
- Area 4 Monitoring Well
- No Flow Boundary

Specific Storage/Specific Yield

Model Layer 1 and 2 = 1.00E-02

Model Layer 3 and 4 = 1.00E-03

- 1.00E-03
- 1.00E-04
- 1.00E-05
- 5.00E-06
- 5.00E-07
- 1.00E-08
- 5.00E-09
- 1.00E-10

N

Scale in feet

0 8,500 17,000

Notes:

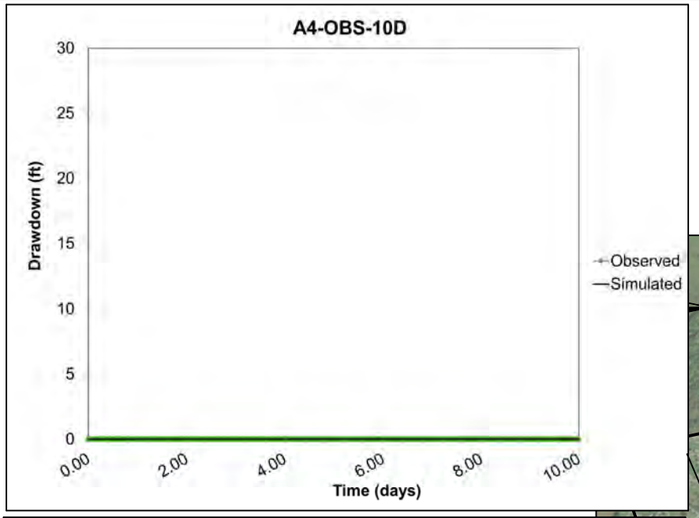
1. Test wells and monitoring wells are shown for reference.

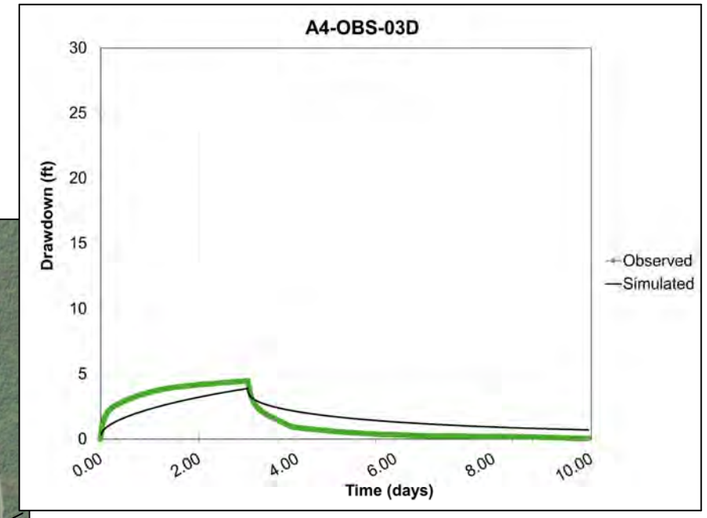
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

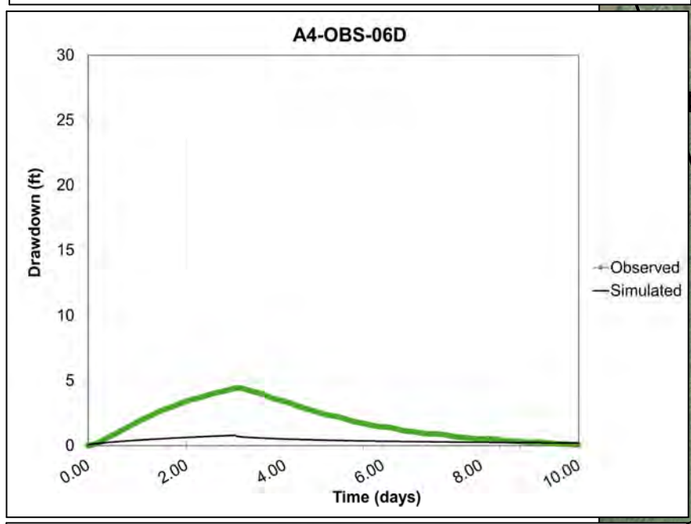
STORAGE DISTRIBUTION

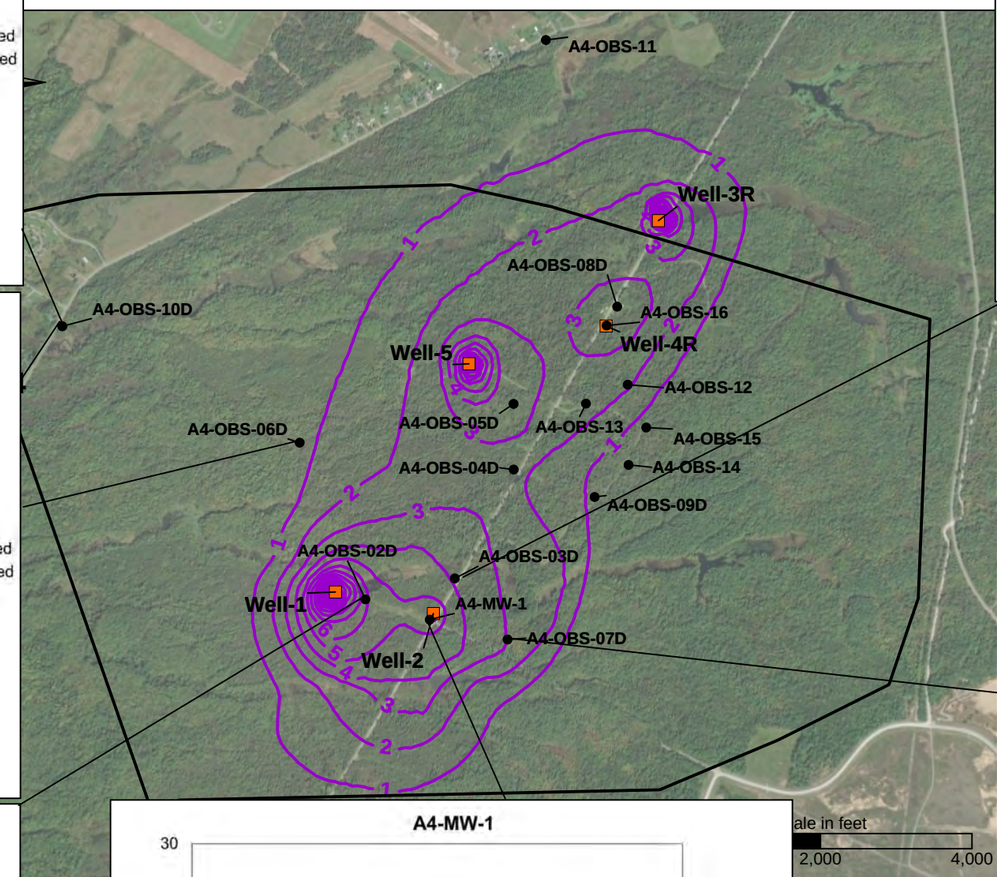
ARCADIS

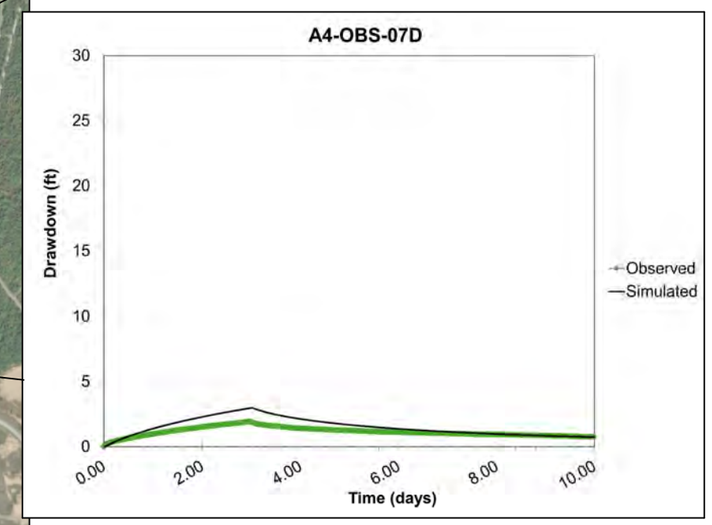
FIGURE
5.3-1

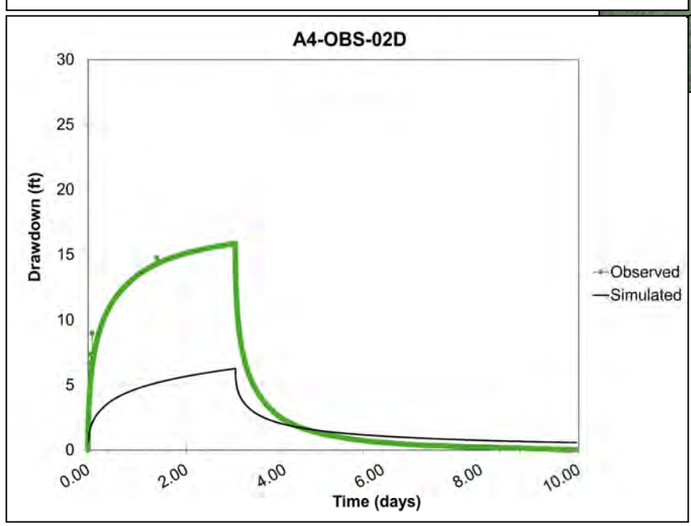


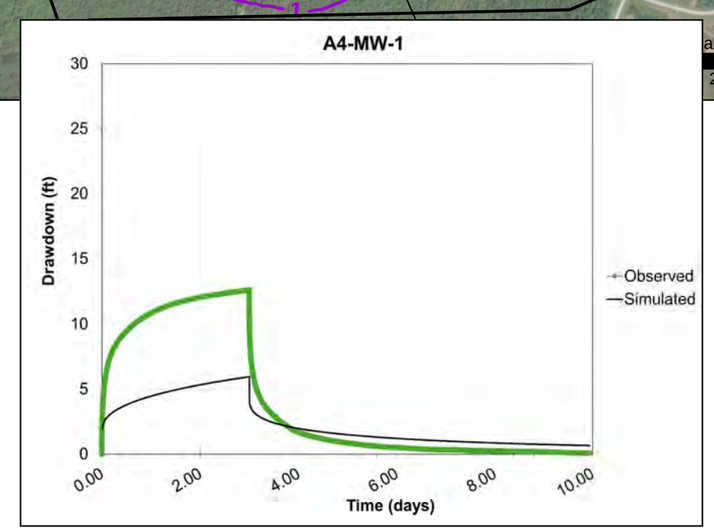












Legend

- Area 4 Test Wells
- Simulated Drawdown at Day 4 (ft)
- Area 4 Monitoring Well

Notes:

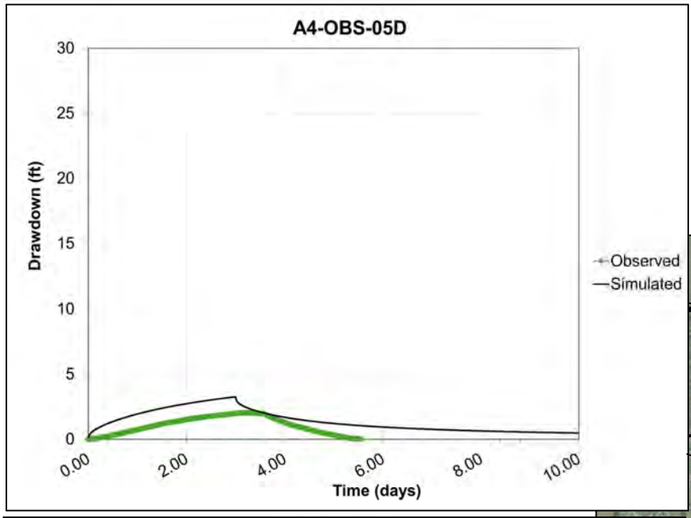
1. ft = feet
2. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the transient groundwater elevation.

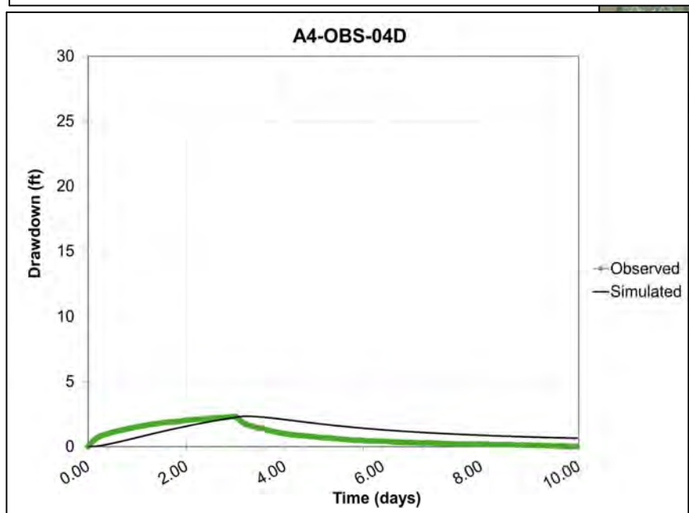
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

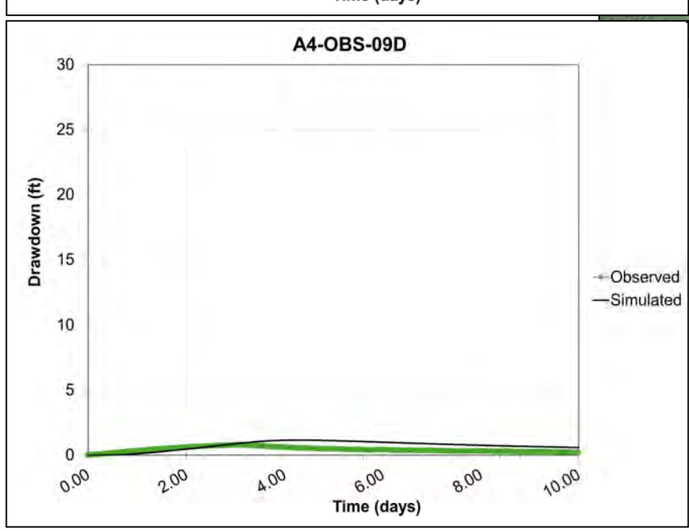
TRANSIENT CALIBRATION SIMULATED DRAWDOWN OVER TIME - SET 1

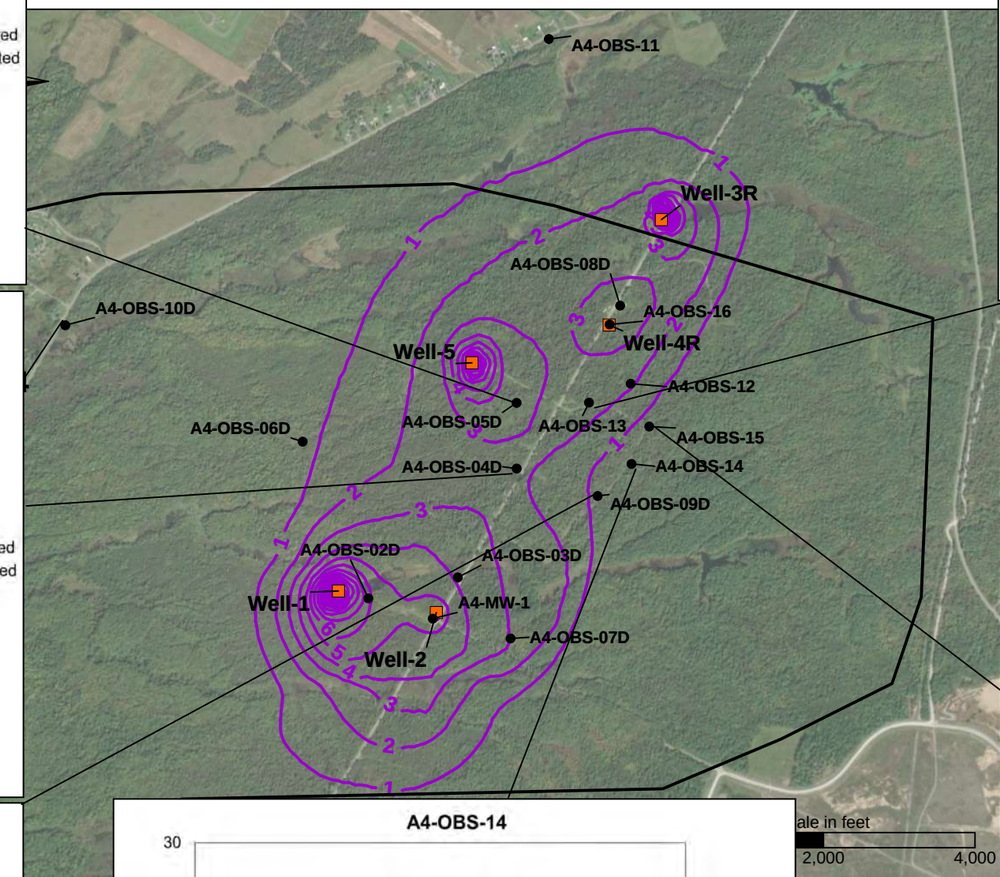
ARCADIS

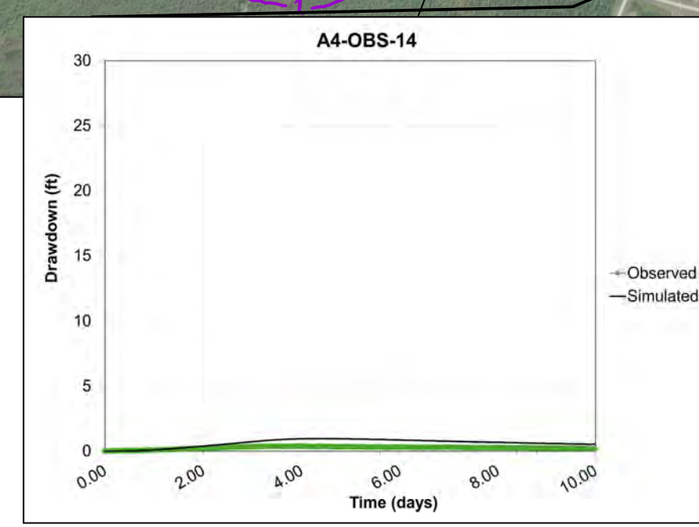
FIGURE
5.3-2

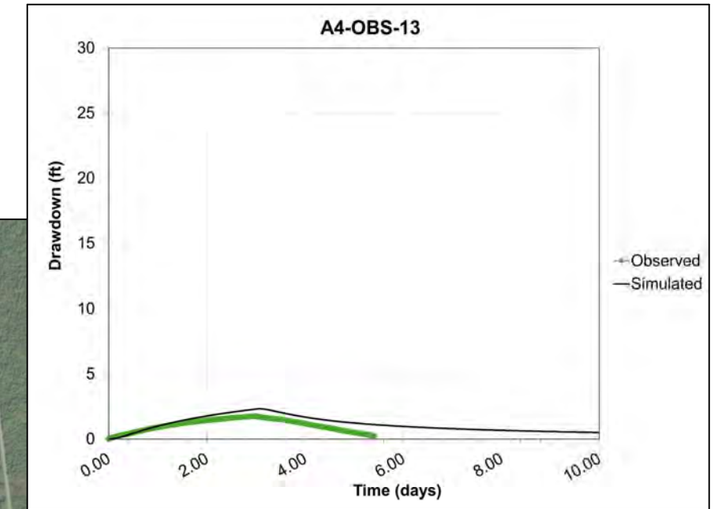


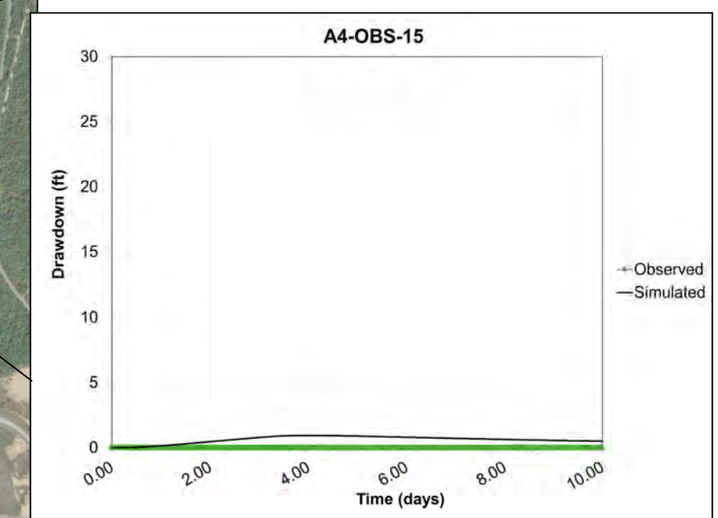












Legend

- Area 4 Test Wells
- Simulated Drawdown at Day 4 (ft)
- Area 4 Monitoring Well

Notes:

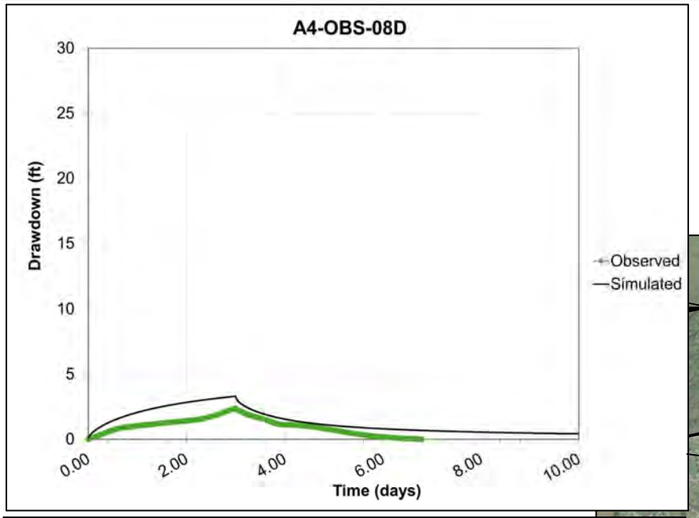
1. ft = feet
2. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the transient groundwater elevation.

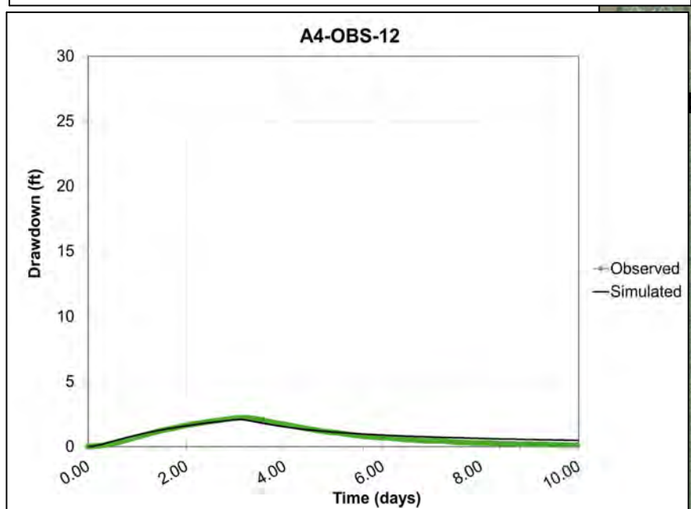
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

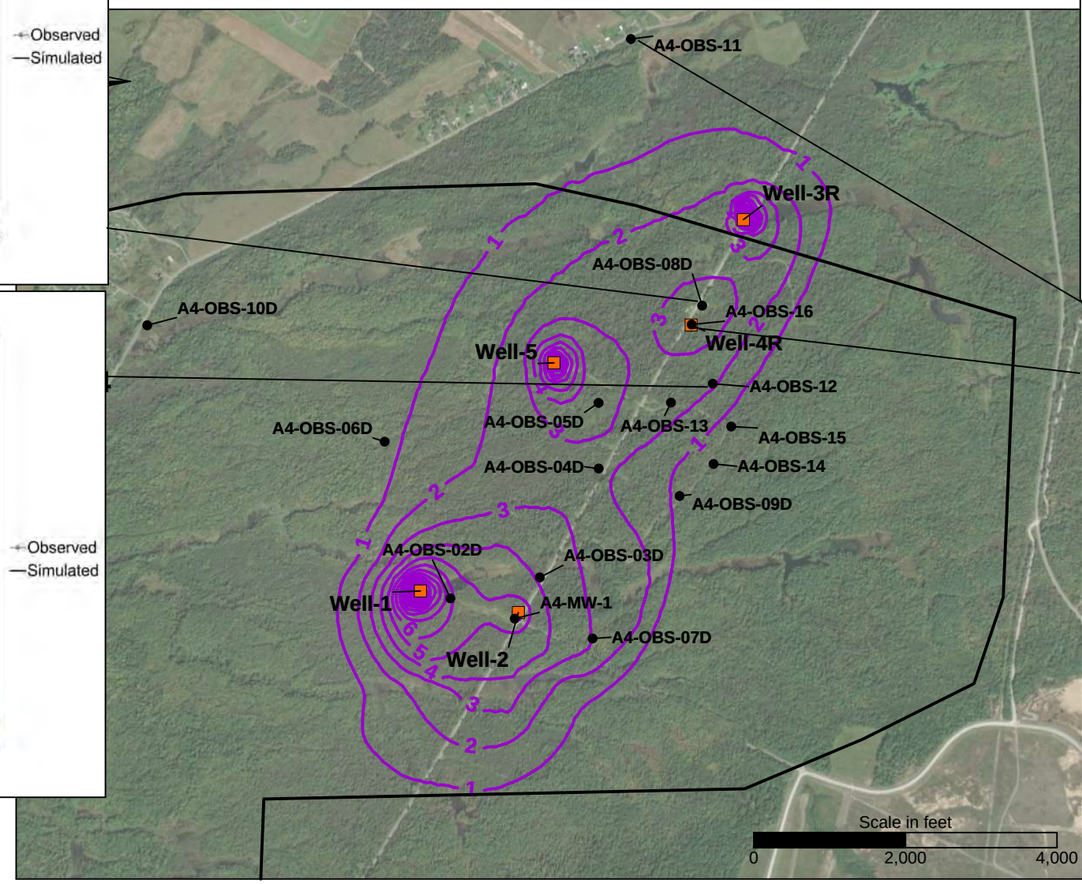
TRANSIENT CALIBRATION SIMULATED DRAWDOWN OVER TIME - SET 2

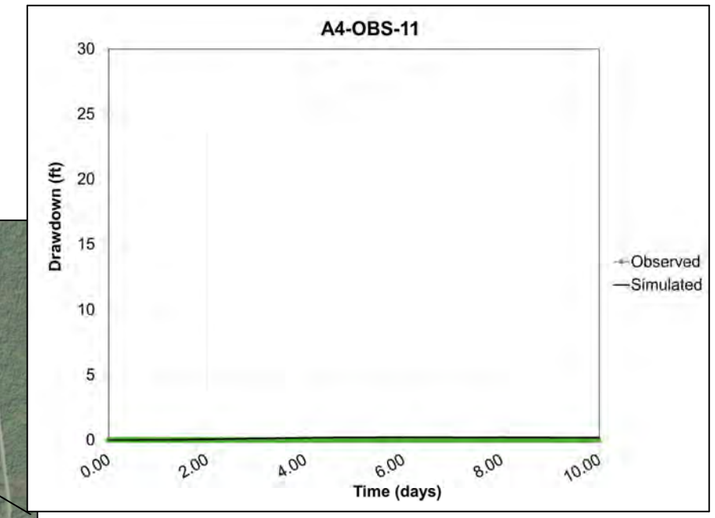
ARCADIS

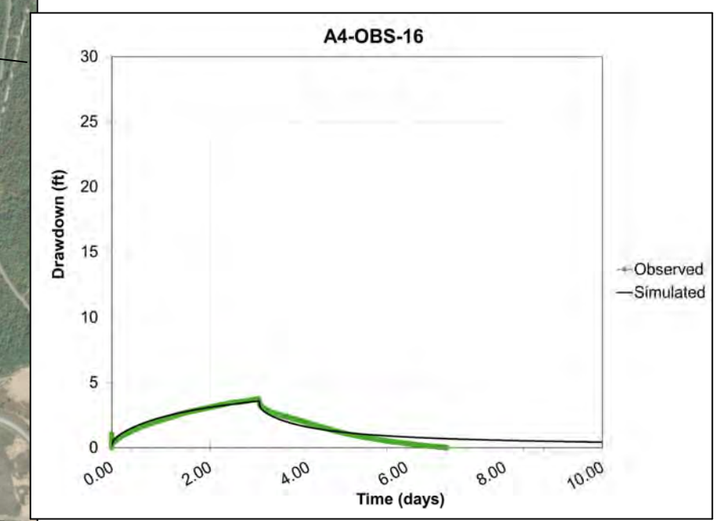
FIGURE
5.3-3











Legend

- Area 4 Test Wells
- Simulated Drawdown at Day 4 (ft)
- Area 4 Monitoring Well

Notes:

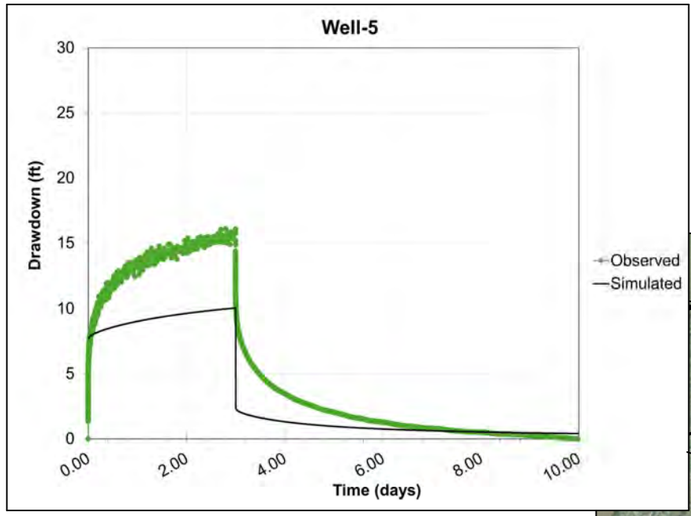
1. ft = feet
2. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the transient groundwater elevation.

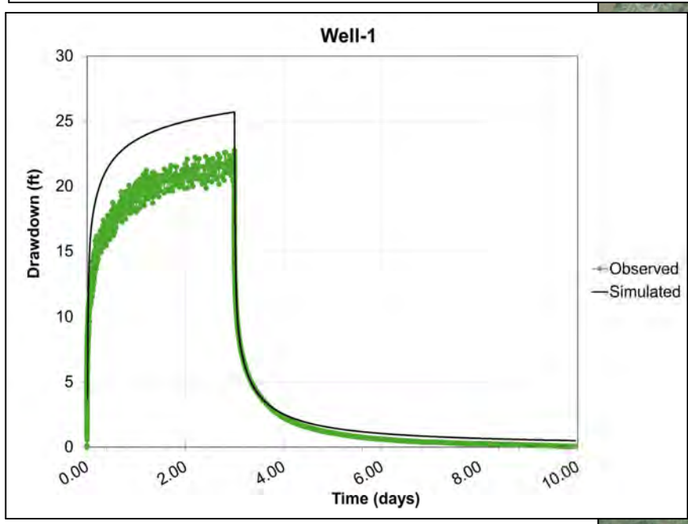
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

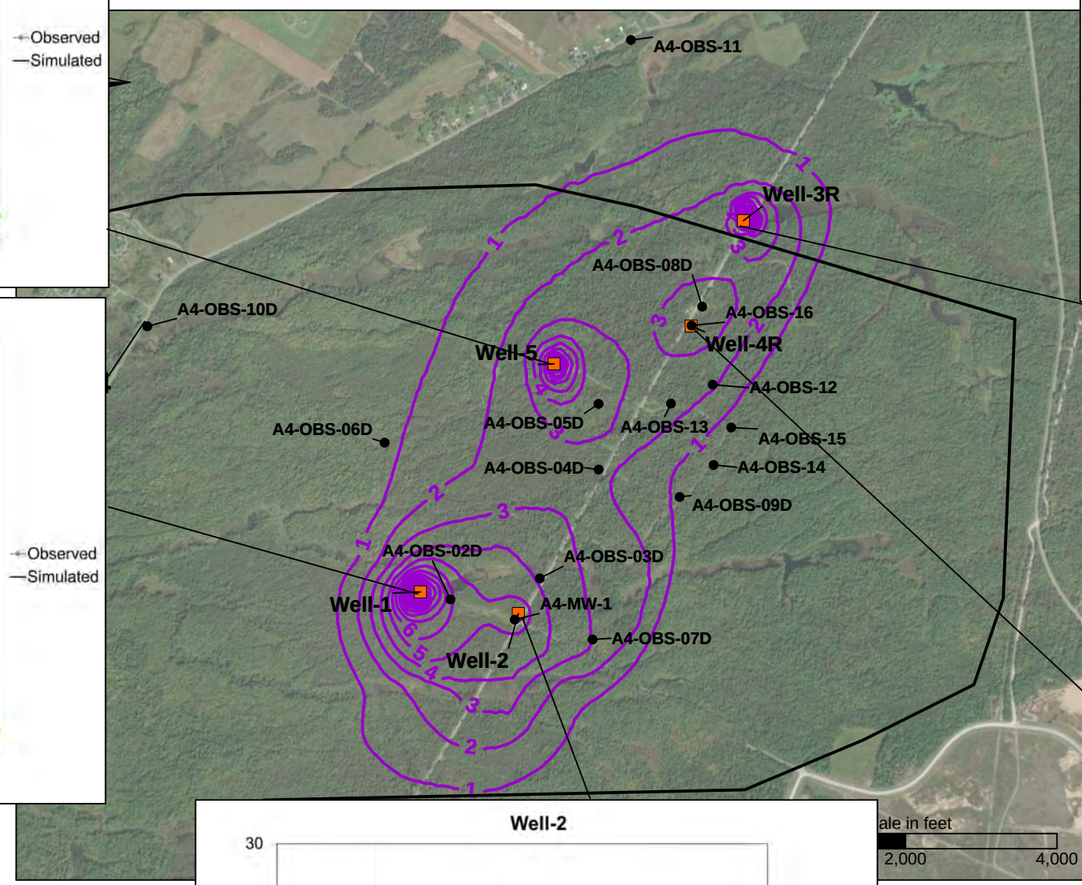
TRANSIENT CALIBRATION SIMULATED DRAWDOWN OVER TIME - SET 3

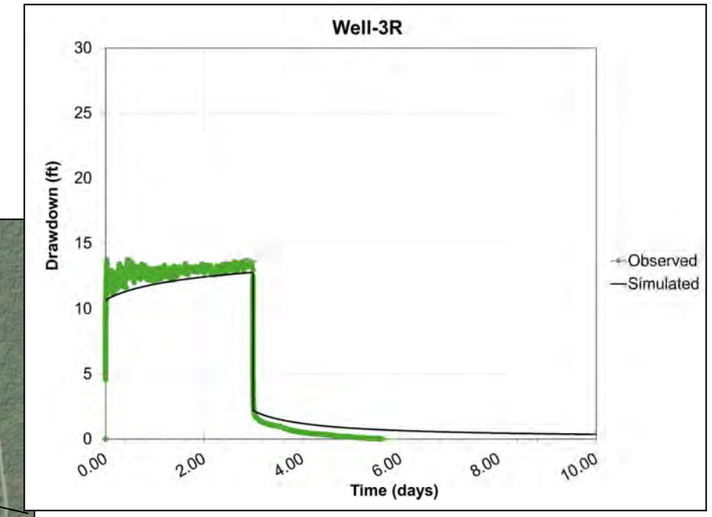
ARCADIS

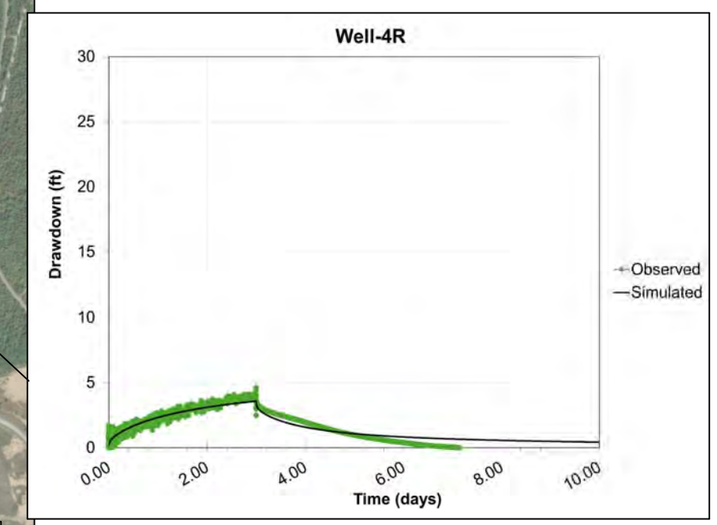
FIGURE
5.3-4

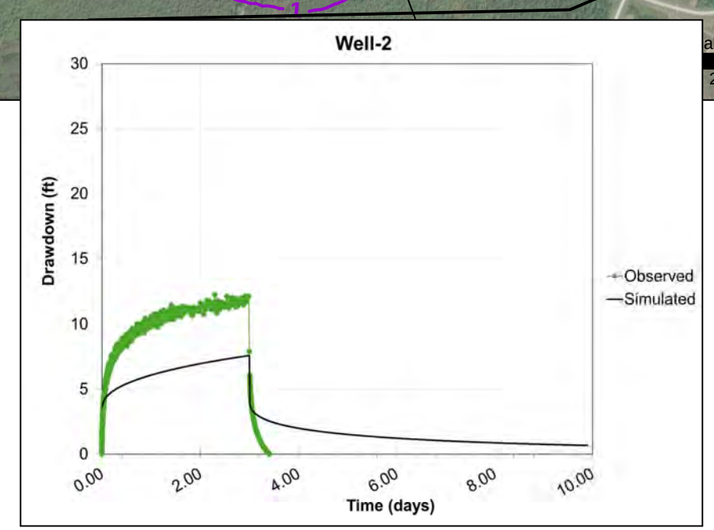












Legend

- Area 4 Test Wells
- Simulated Drawdown at Day 4 (ft)
- Area 4 Monitoring Well

Notes:

1. ft = feet
2. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the transient groundwater elevation.

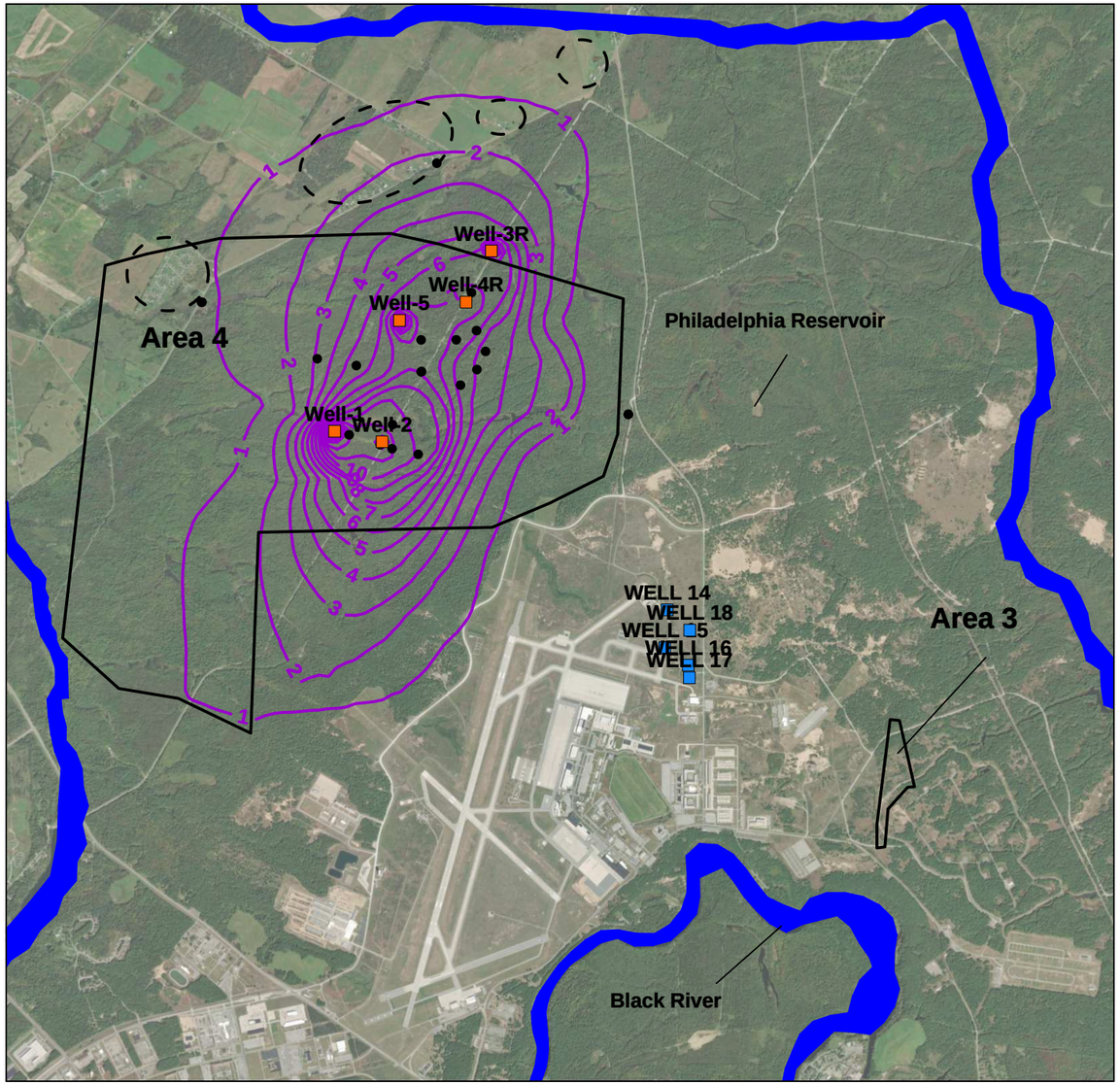
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

TRANSIENT CALIBRATION SIMULATED DRAWDOWN OVER TIME - SET 4

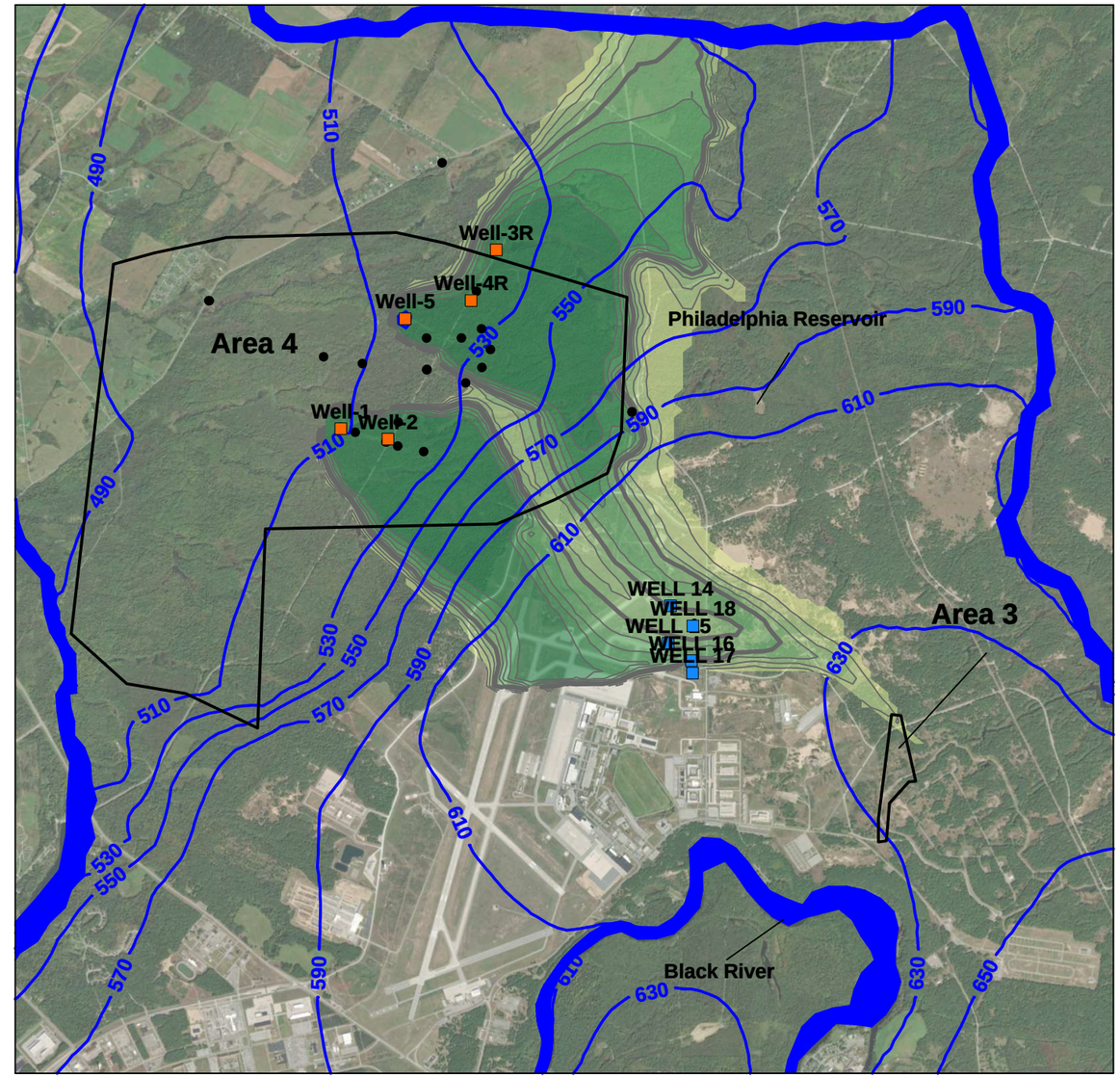
ARCADIS

FIGURE
5.3-5

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 1 groundwater elevation.

Flow Rates in Extraction Wells

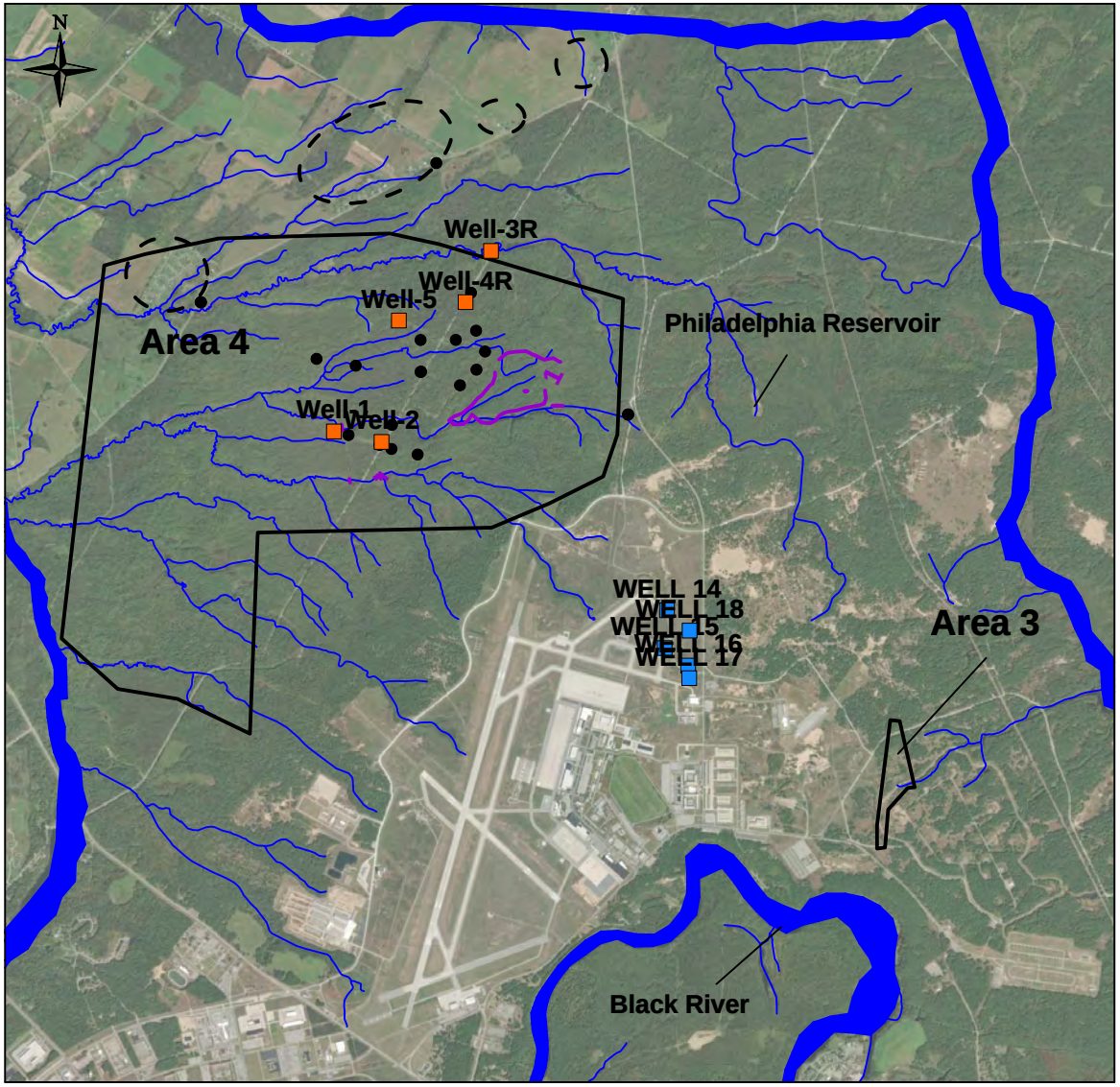
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 0 gpm
- Well 15 – 0 gpm
- Well 16 – 0 gpm
- Well 17 – 0 gpm
- Well 18 – 0 gpm
- Total – 500 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 1 - AREA 4 ESTIMATED SUSTAINABLE RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10)

ARCADIS

FIGURE 6.1-1



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 0 gpm
- Well 15 – 0 gpm
- Well 16 – 0 gpm
- Well 17 – 0 gpm
- Well 18 – 0 gpm
- Total – 500 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 1 groundwater elevation.

Scale in feet

0 5,000 10,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

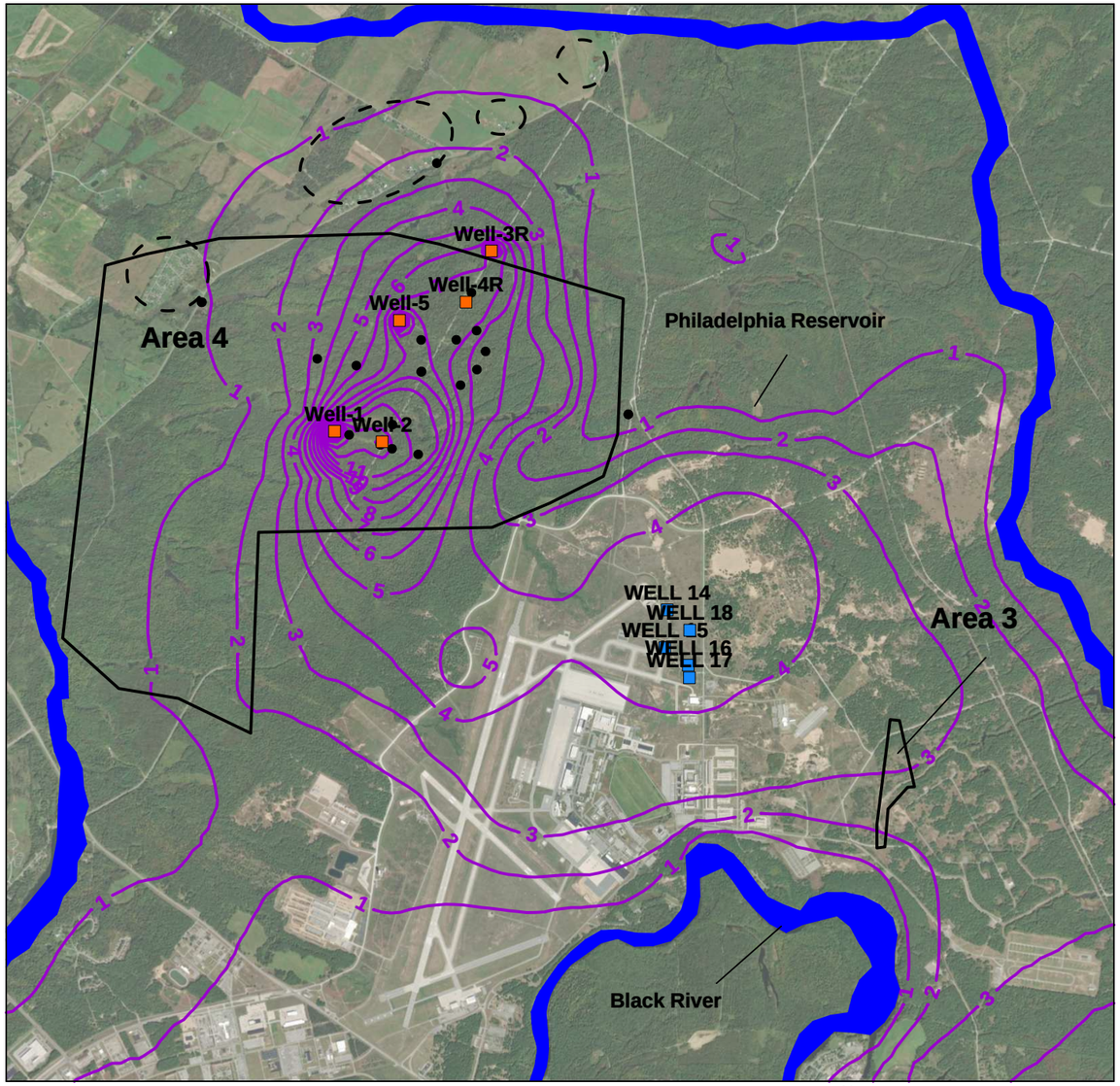
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 1 - AREA 4 ESTIMATED SUSTAINABLE RATES
SIMULATED WATER TABLE DRAWDOWN
(MODEL LAYER 1)

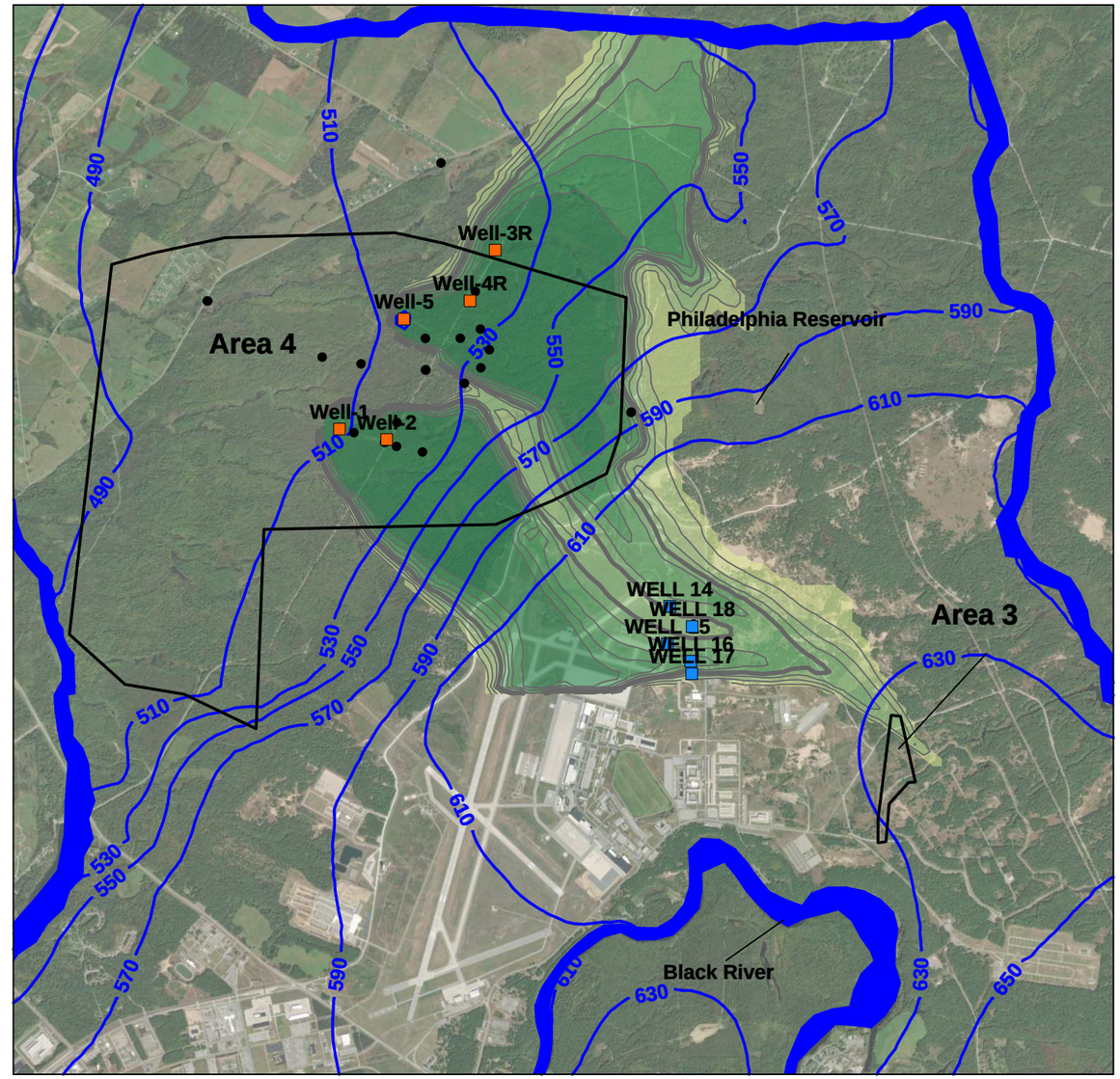
ARCADIS

FIGURE
6.1-2

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 1 groundwater elevation under drought conditions.
5. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Flow Rates in Extraction Wells

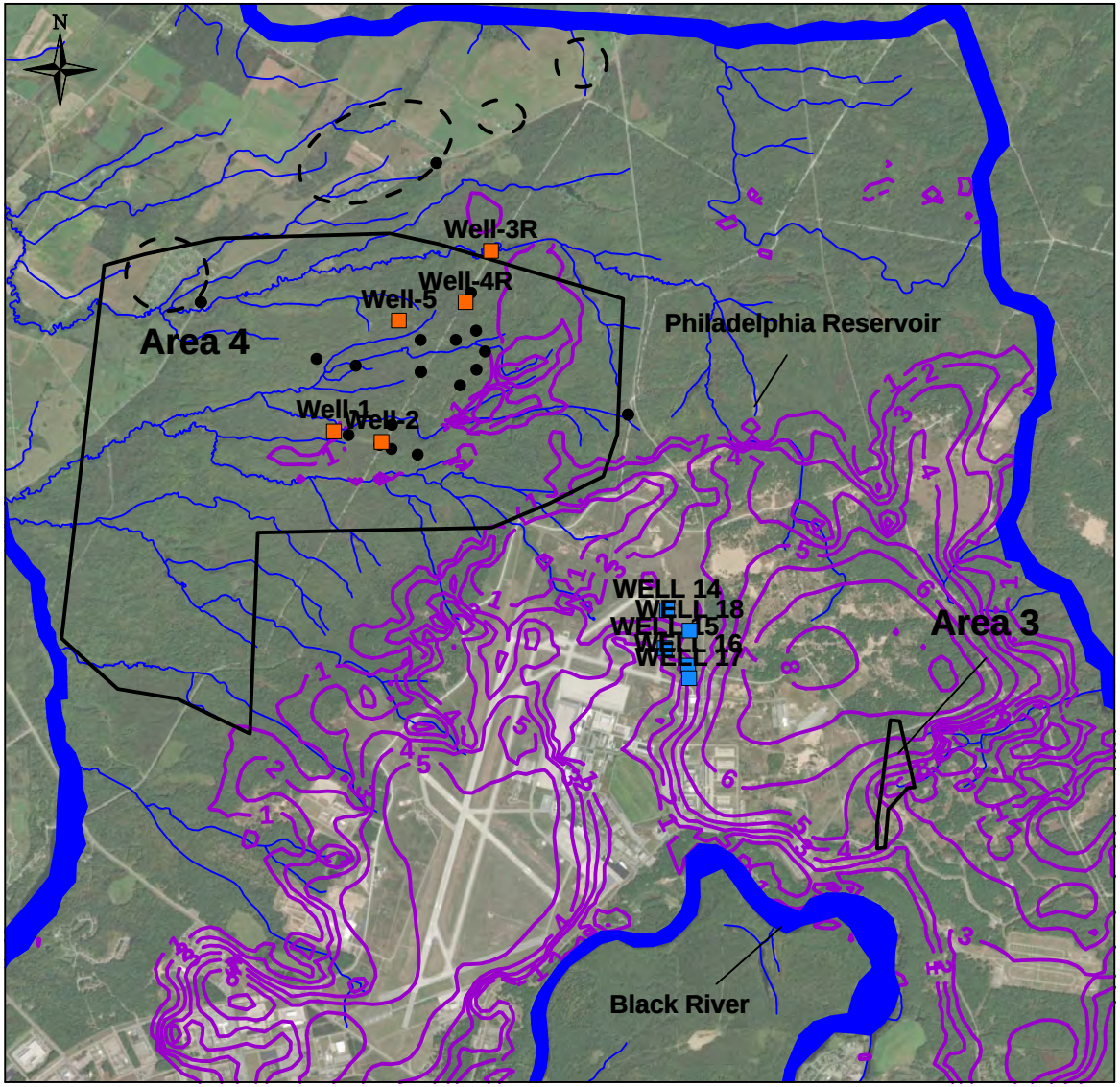
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 0 gpm
- Well 15 – 0 gpm
- Well 16 – 0 gpm
- Well 17 – 0 gpm
- Well 18 – 0 gpm
- Total – 500 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 1 - AREA 4 ESTIMATED SUSTAINABLE RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10) UNDER DROUGHT CONDITIONS

ARCADIS

FIGURE 6.1-3



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 0 gpm
- Well 15 – 0 gpm
- Well 16 – 0 gpm
- Well 17 – 0 gpm
- Well 18 – 0 gpm
- Total – 500 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 1 groundwater elevation under drought conditions.
6. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Scale in feet

0 5,000 10,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

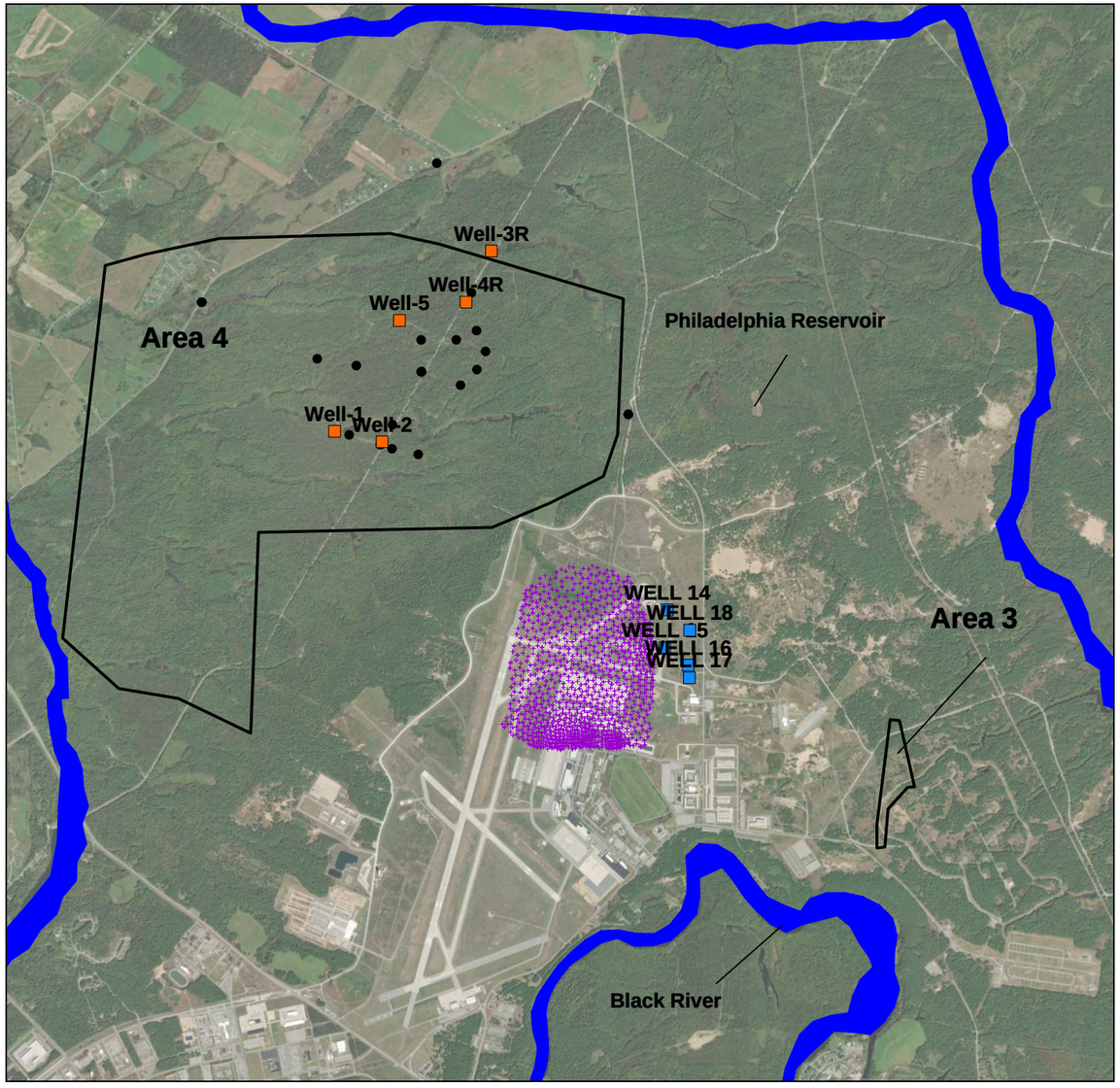
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 1 - AREA 4 ESTIMATED SUSTAINABLE RATES
SIMULATED WATER TABLE DRAWDOWN
(MODEL LAYER 1) UNDER DROUGHT CONDITIONS

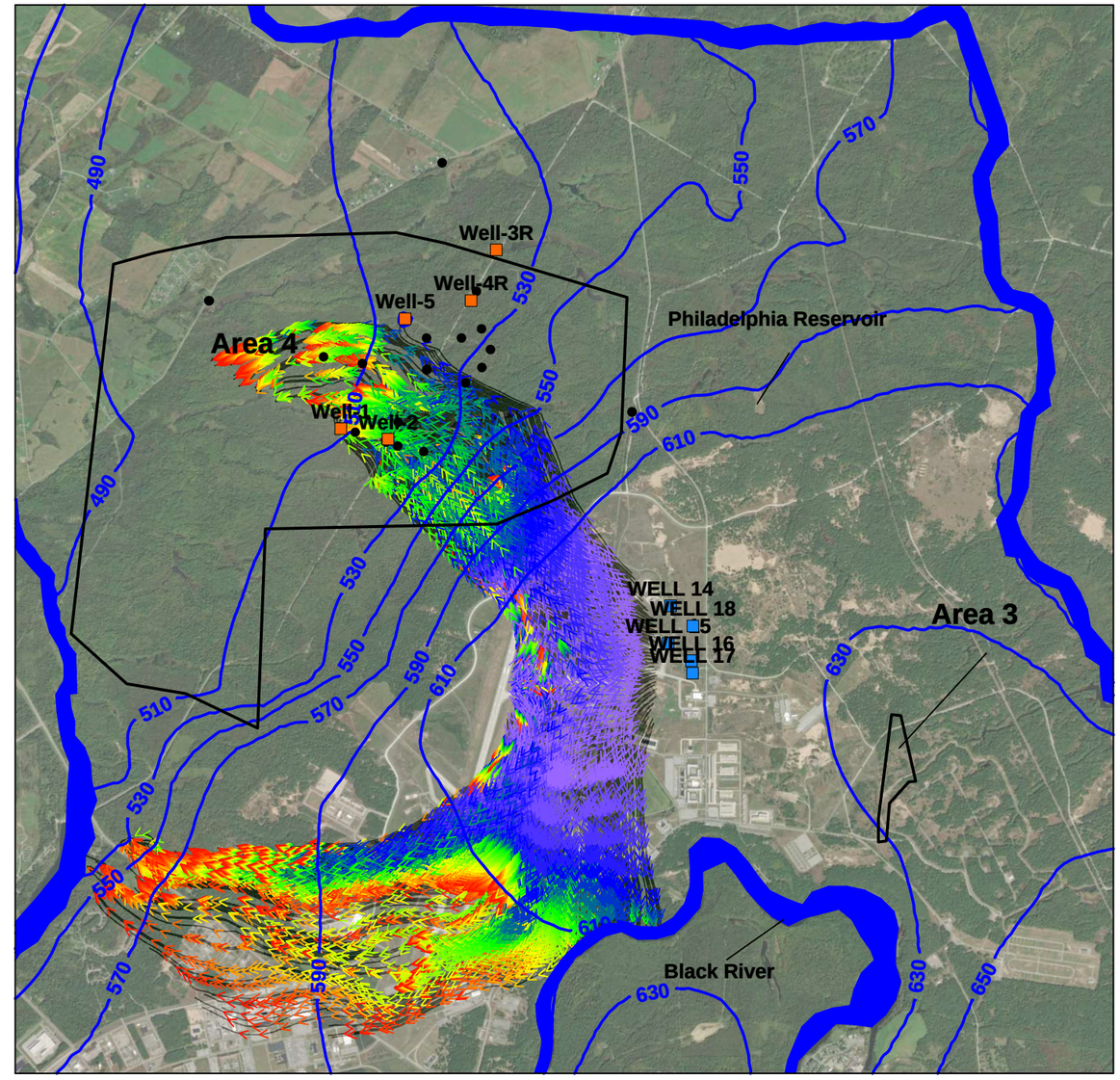
ARCADIS

FIGURE
6.1-4

Particle Starting Location



Forward Particle Tracking



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Particle Starting Location
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well

N

Scale in feet

0 4,000 8,000

Travel Time (years)

1 10 15 20 30

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute

Flow Rates in Extraction Wells

- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 0 gpm
- Well 15 – 0 gpm
- Well 16 – 0 gpm
- Well 17 – 0 gpm
- Well 18 – 0 gpm
- Total – 500 gpm

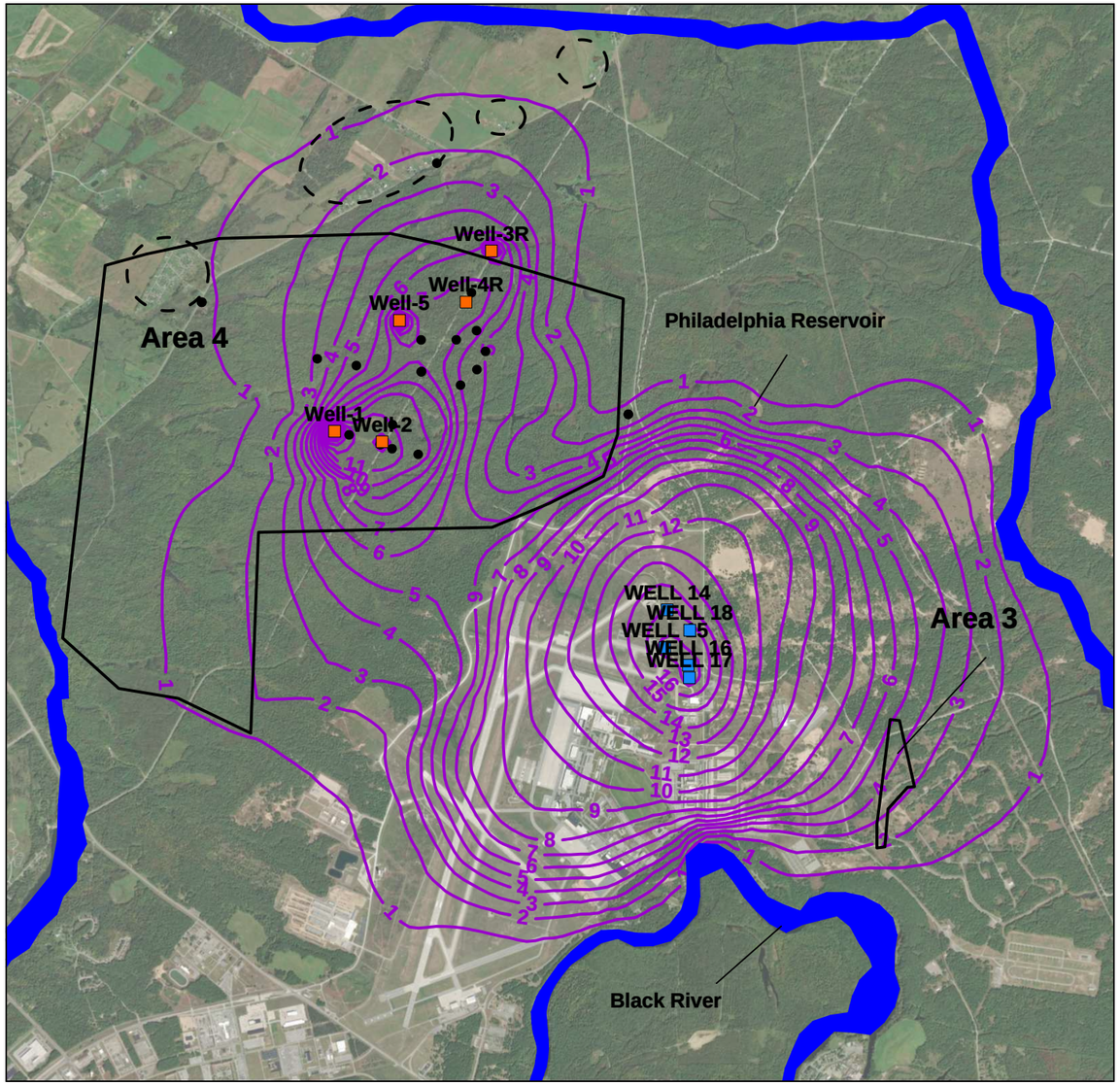
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 1 - AREA 4 SIMULATED PUMPING RATES
SIMULATED FORWARD PARTICLE TRACKING
AT TOP OF BEDROCK (MODEL LAYER 9)
UNDER TRANSIENT CONDITIONS

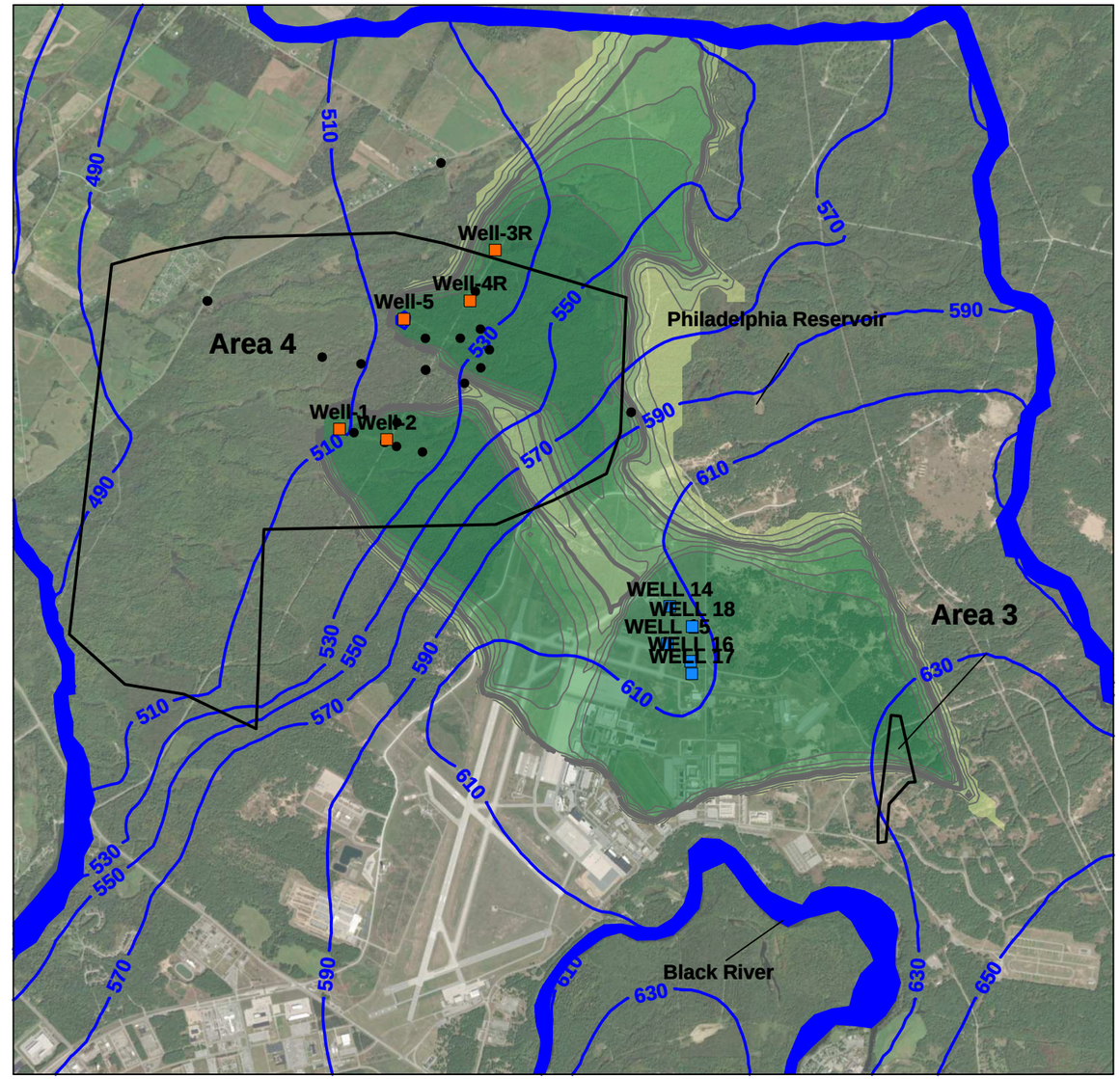
ARCADIS

FIGURE 6.1-5

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 2 groundwater elevation.

Flow Rates in Extraction Wells

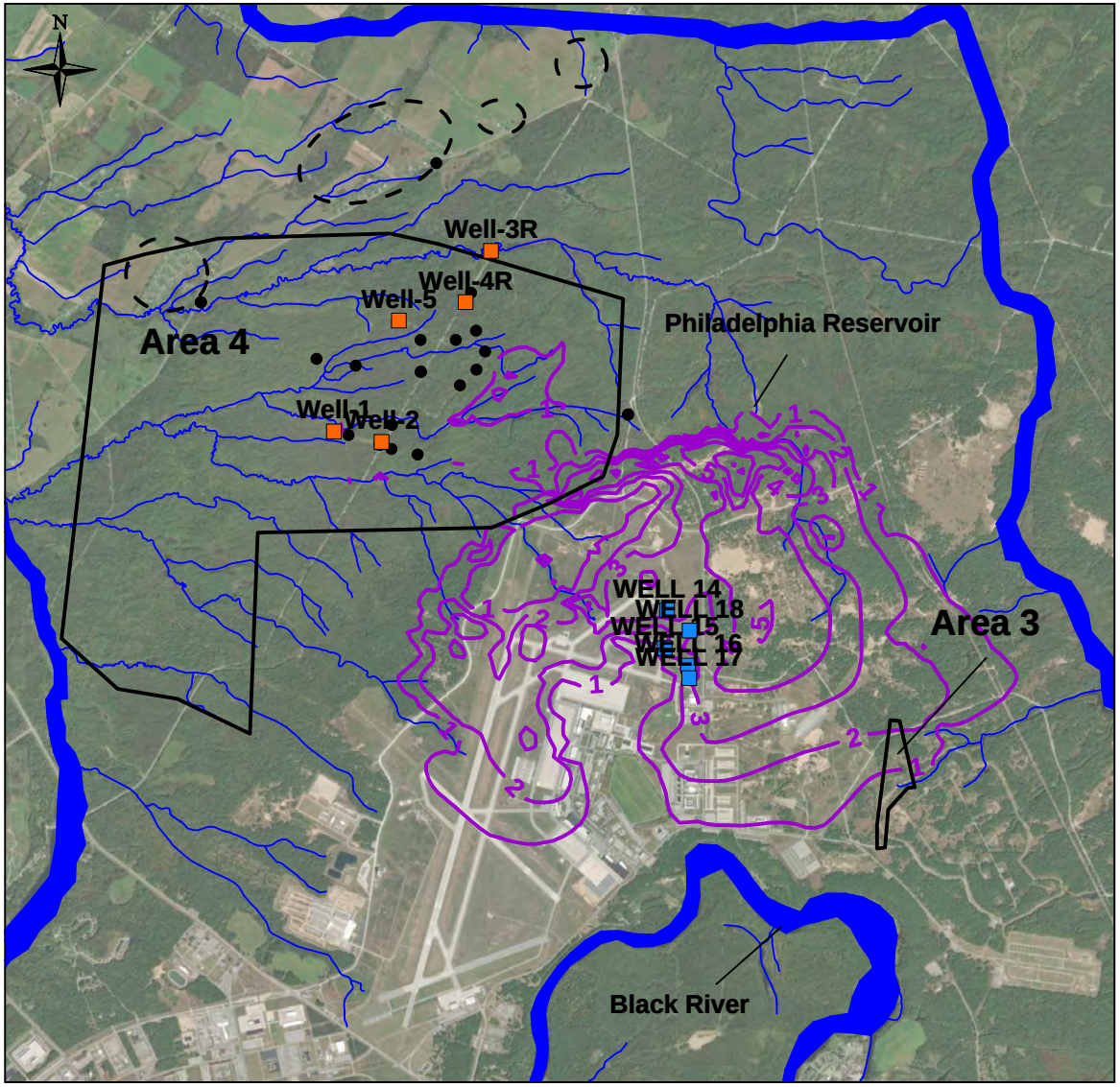
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 59.3 gpm
- Well 15 – 282 gpm
- Well 16 – 127.7 gpm
- Well 17 – 120 gpm
- Well 18 – 39.3 gpm
- Total – 1,128.4 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 2 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT CURRENT RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10)

ARCADIS

FIGURE 6.2-1



Scale in feet

0 5,000 10,000

Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 59.3 gpm
- Well 15 – 282 gpm
- Well 16 – 127.7 gpm
- Well 17 – 120 gpm
- Well 18 – 39.3 gpm
- Total – 1,128.4 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 2 groundwater elevation.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

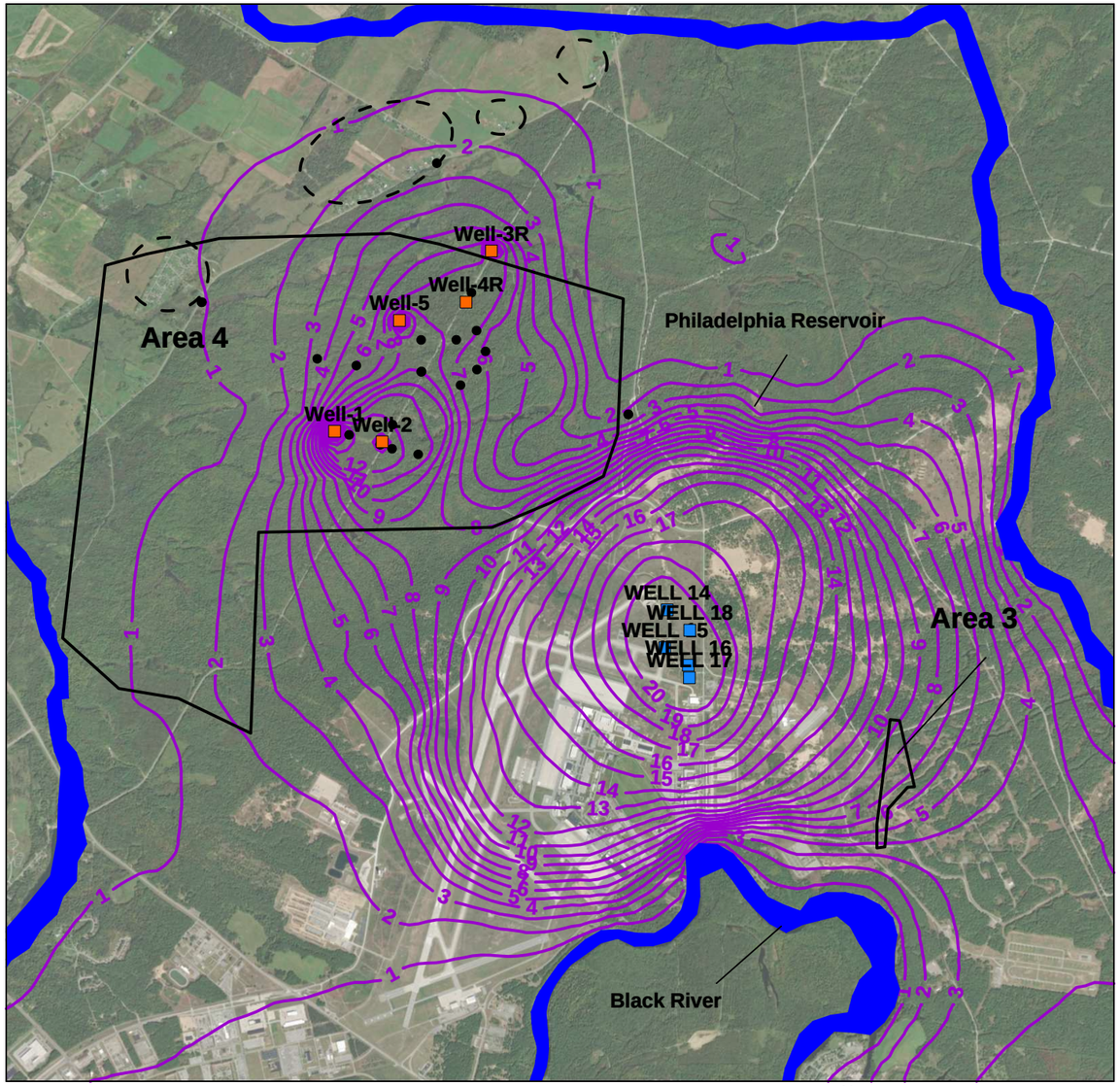
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 2 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT CURRENT RATES SIMULATED WATER TABLE DRAWDOWN (MODEL LAYER 1)

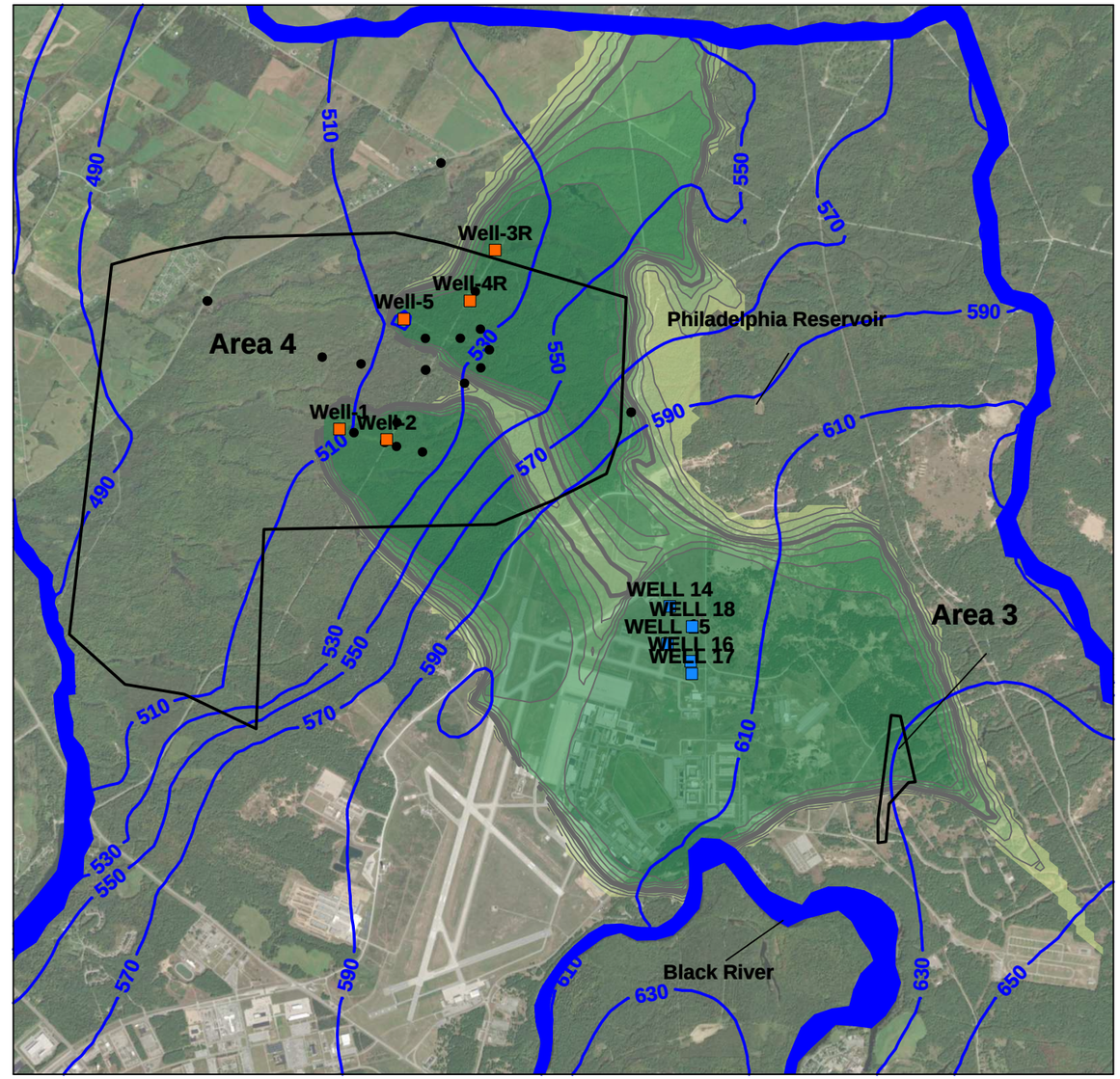
ARCADIS

FIGURE 6.2-2

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 2 groundwater elevation under drought conditions.
5. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Flow Rates in Extraction Wells

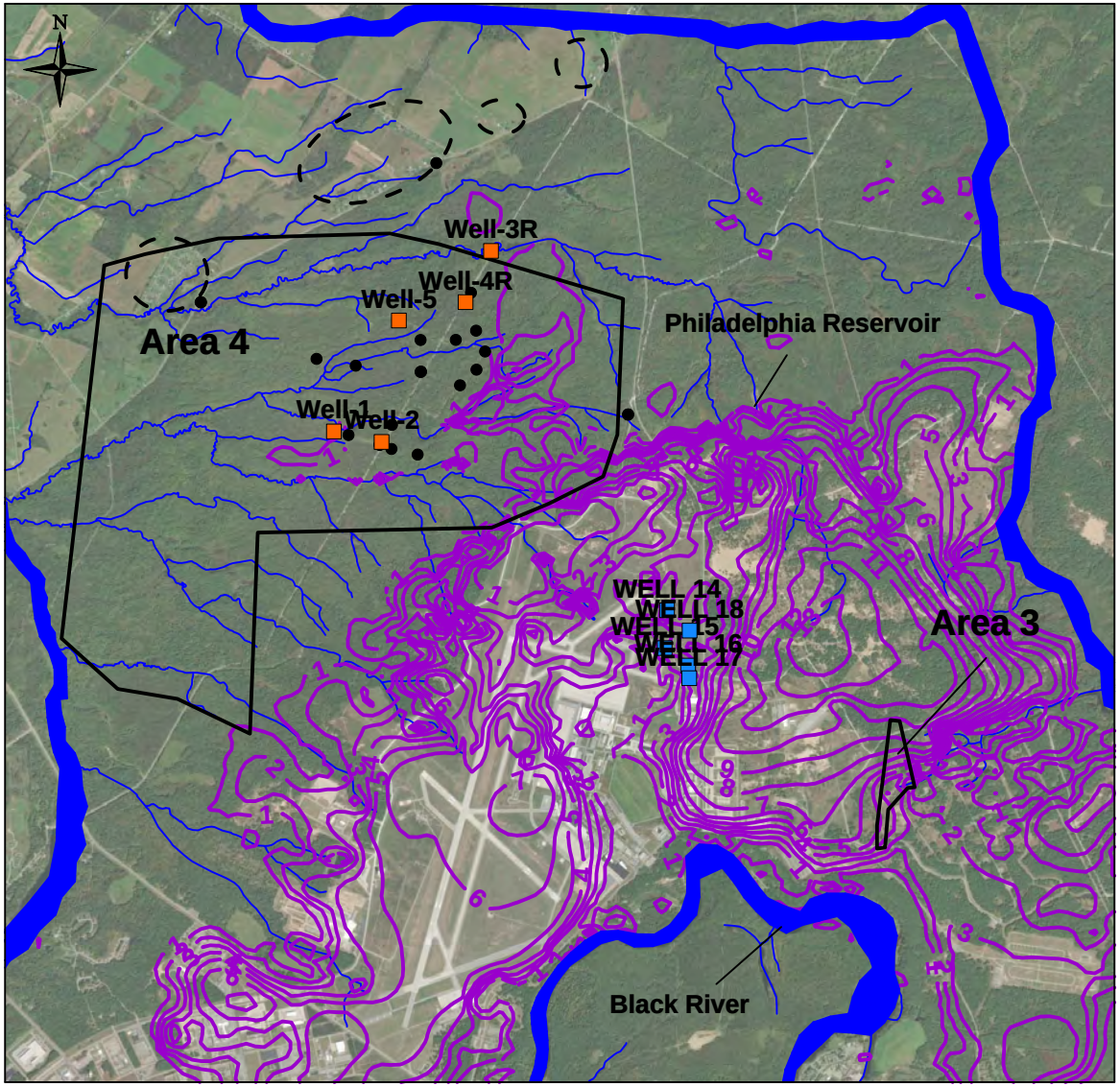
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 59.3 gpm
- Well 15 – 282 gpm
- Well 16 – 127.7 gpm
- Well 17 – 120 gpm
- Well 18 – 39.3 gpm
- Total – 1,128.4 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 2 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT CURRENT RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10) UNDER DROUGHT CONDITIONS

ARCADIS

FIGURE 6.2-3



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 59.3 gpm
- Well 15 – 282 gpm
- Well 16 – 127.7 gpm
- Well 17 – 120 gpm
- Well 18 – 39.3 gpm
- Total – 1,128.4 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 2 groundwater elevation under drought conditions.
6. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Scale in feet

0 5,000 10,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

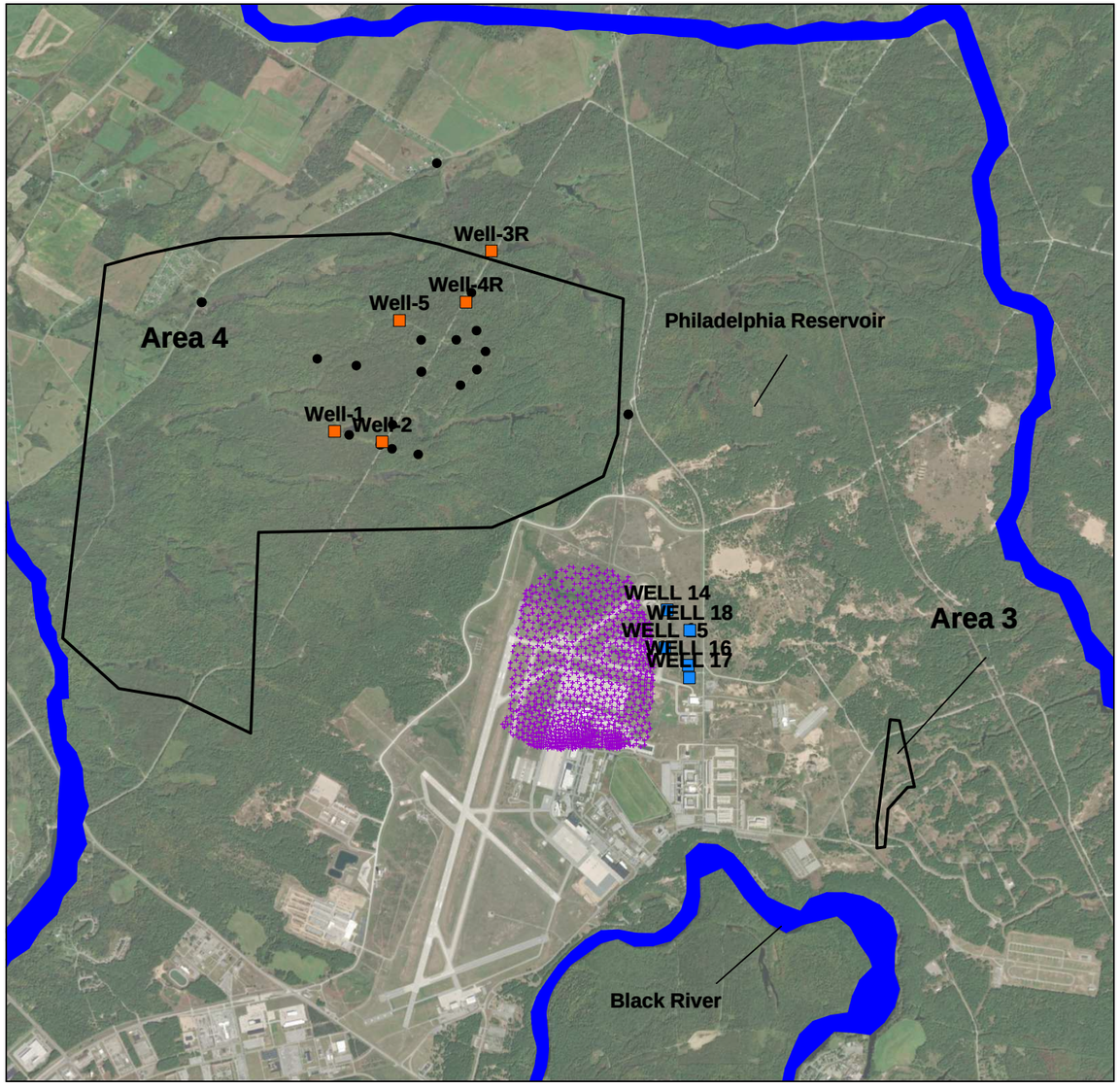
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 2 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT CURRENT RATES SIMULATED WATER TABLE DRAWDOWN (MODEL LAYER 1) UNDER DROUGHT CONDITIONS

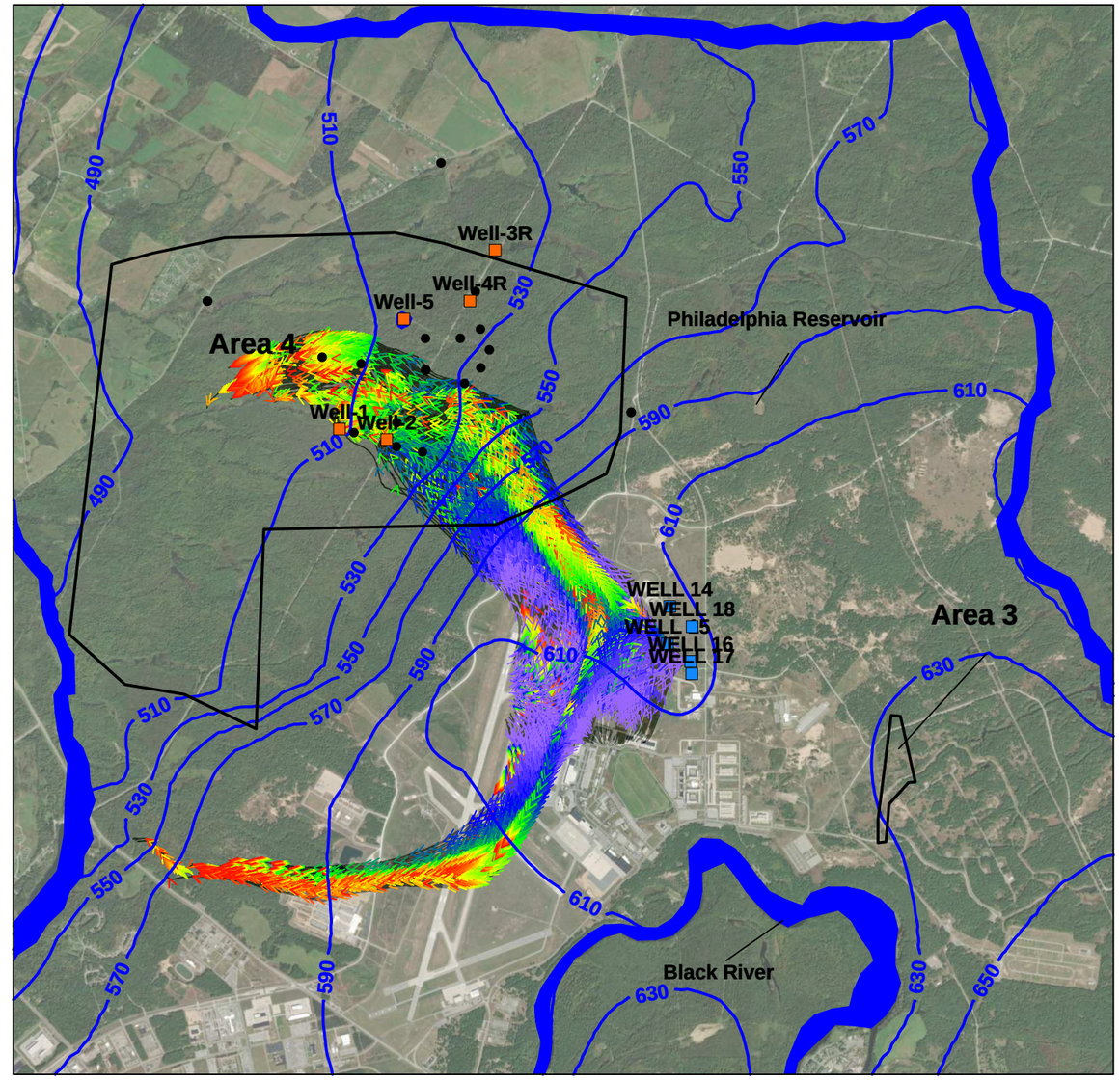
ARCADIS

FIGURE 6.2-4

Particle Starting Location



Forward Particle Tracking



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Particle Starting Location
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well

N

Scale in feet

0 4,000 8,000

Travel Time (years)

1 10 15 20 30

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute

Flow Rates in Extraction Wells

- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 59.3 gpm
- Well 15 – 282 gpm
- Well 16 – 127.7 gpm
- Well 17 – 120 gpm
- Well 18 – 39.3 gpm
- Total – 1,128.4 gpm

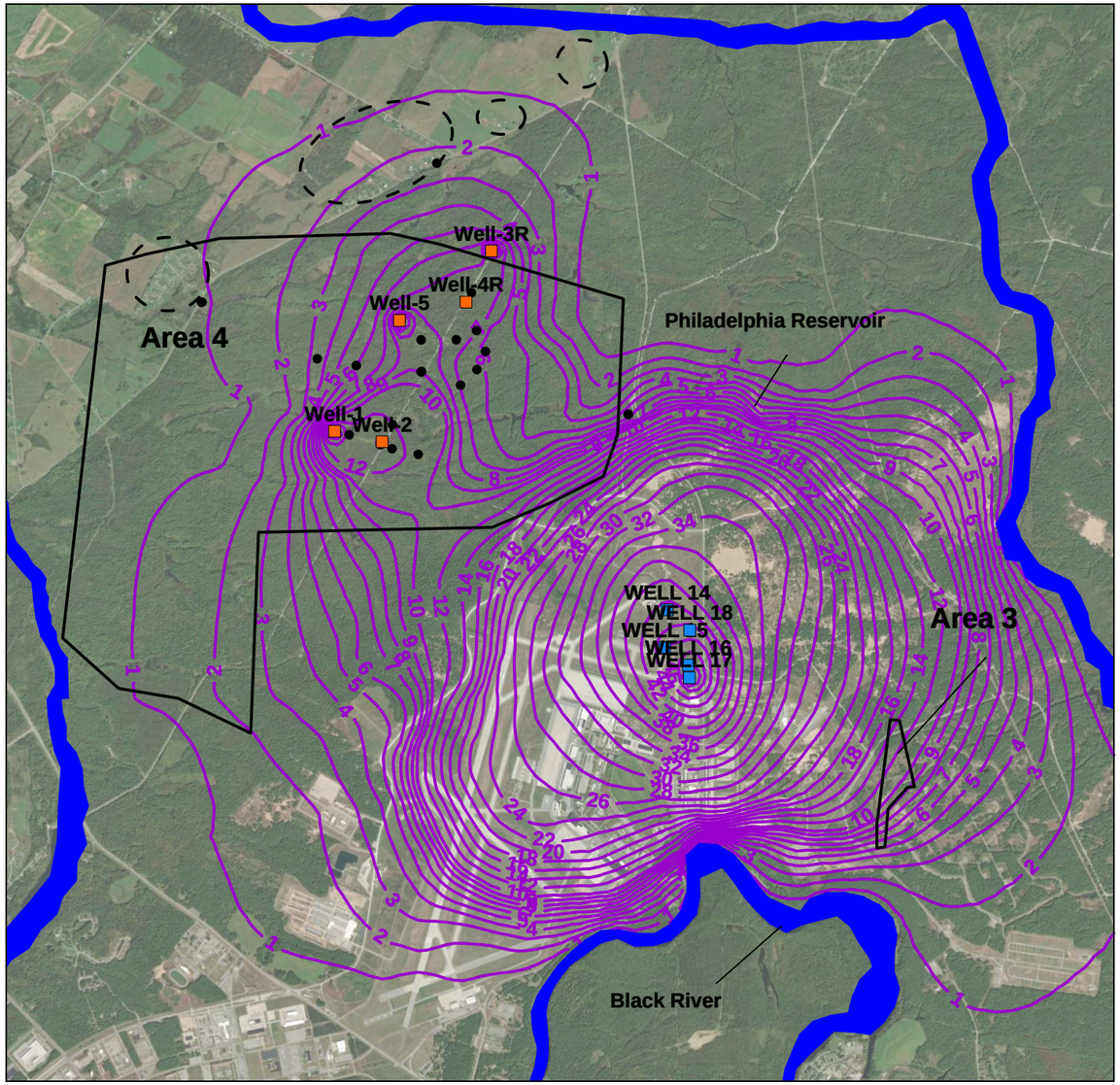
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 2 - AREA 4 SIMULATED PUMPING RATES WITH EXISTING WELL FIELDS AT CURRENT RATES SIMULATED FORWARD PARTICLE TRACKING AT TOP OF BEDROCK (MODEL LAYER 9) UNDER TRANSIENT CONDITIONS

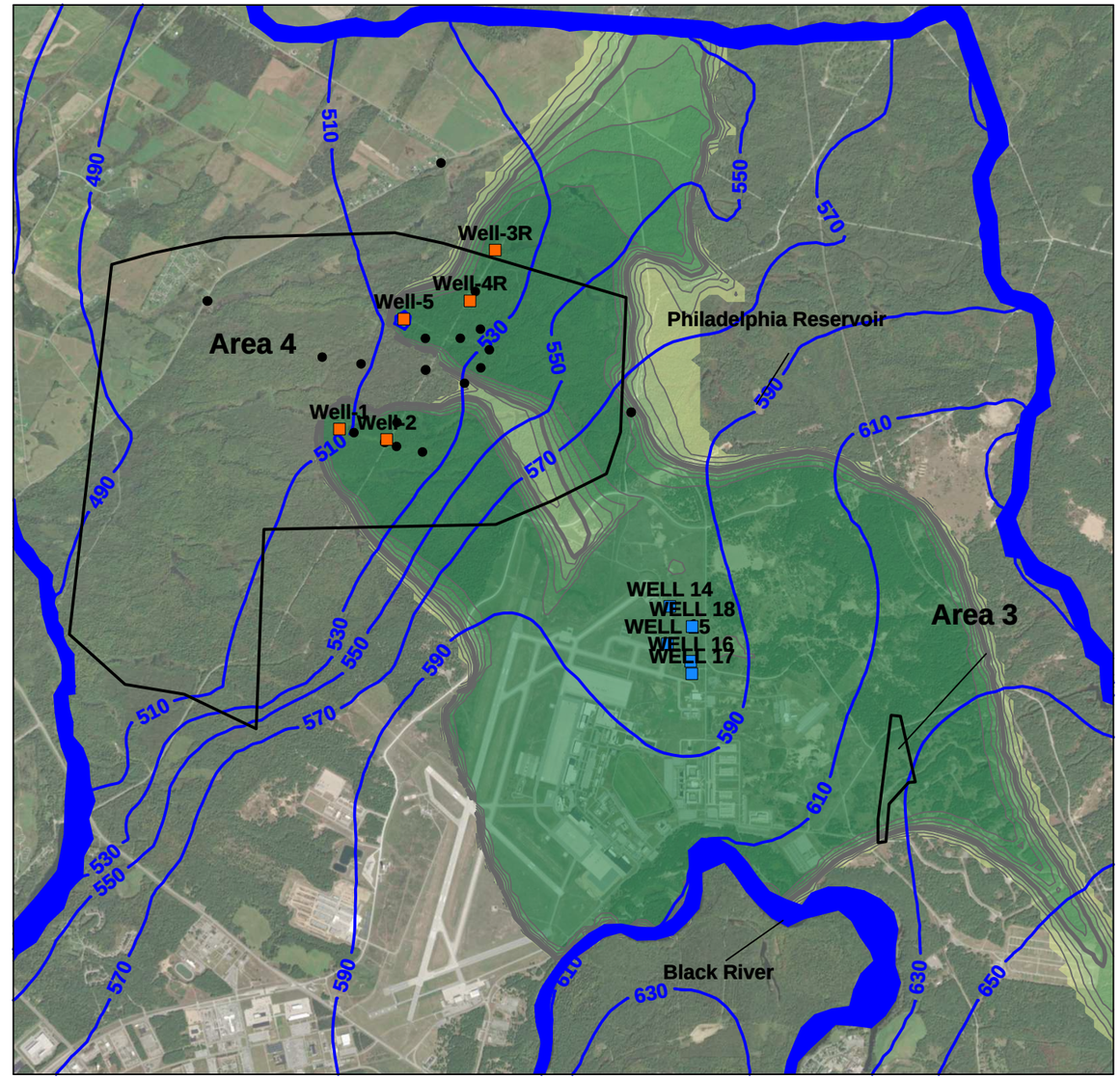
ARCADIS

FIGURE 6.2-5

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 3 groundwater elevation.

Flow Rates in Extraction Wells

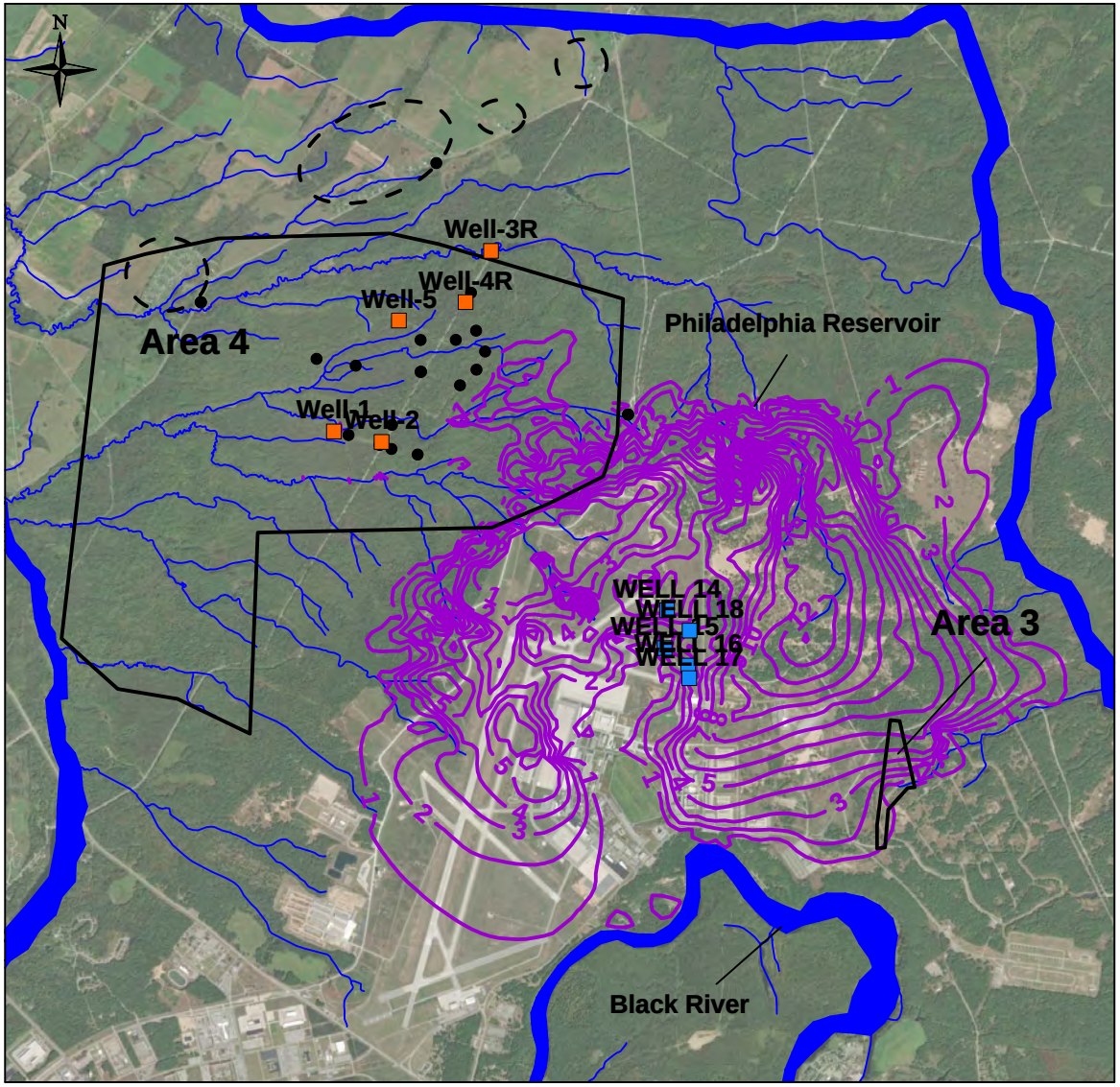
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 95 gpm
- Well 15 – 300 gpm
- Well 16 – 400 gpm
- Well 17 – 600 gpm
- Well 18 – 95 gpm
- Total – 1,990 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 3 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT DESIGN RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10)

ARCADIS

FIGURE 6.3-1



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 95 gpm
- Well 15 – 300 gpm
- Well 16 – 400 gpm
- Well 17 – 600 gpm
- Well 18 – 95 gpm
- Total – 1,990 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 3 groundwater elevation.

Scale in feet

0 5,000 10,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

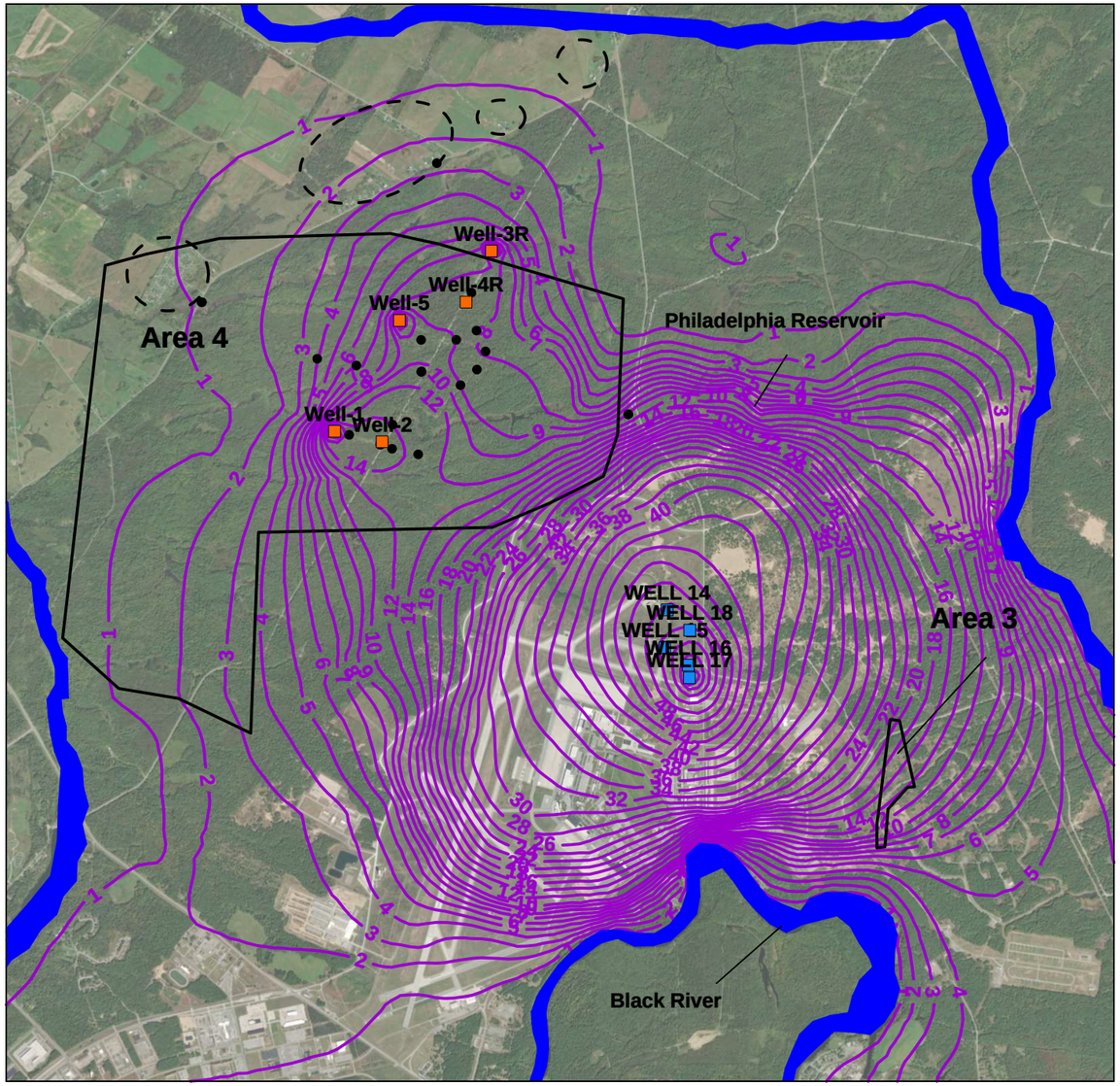
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 3 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT DESIGN RATES SIMULATED WATER TABLE DRAWDOWN (MODEL LAYER 1)

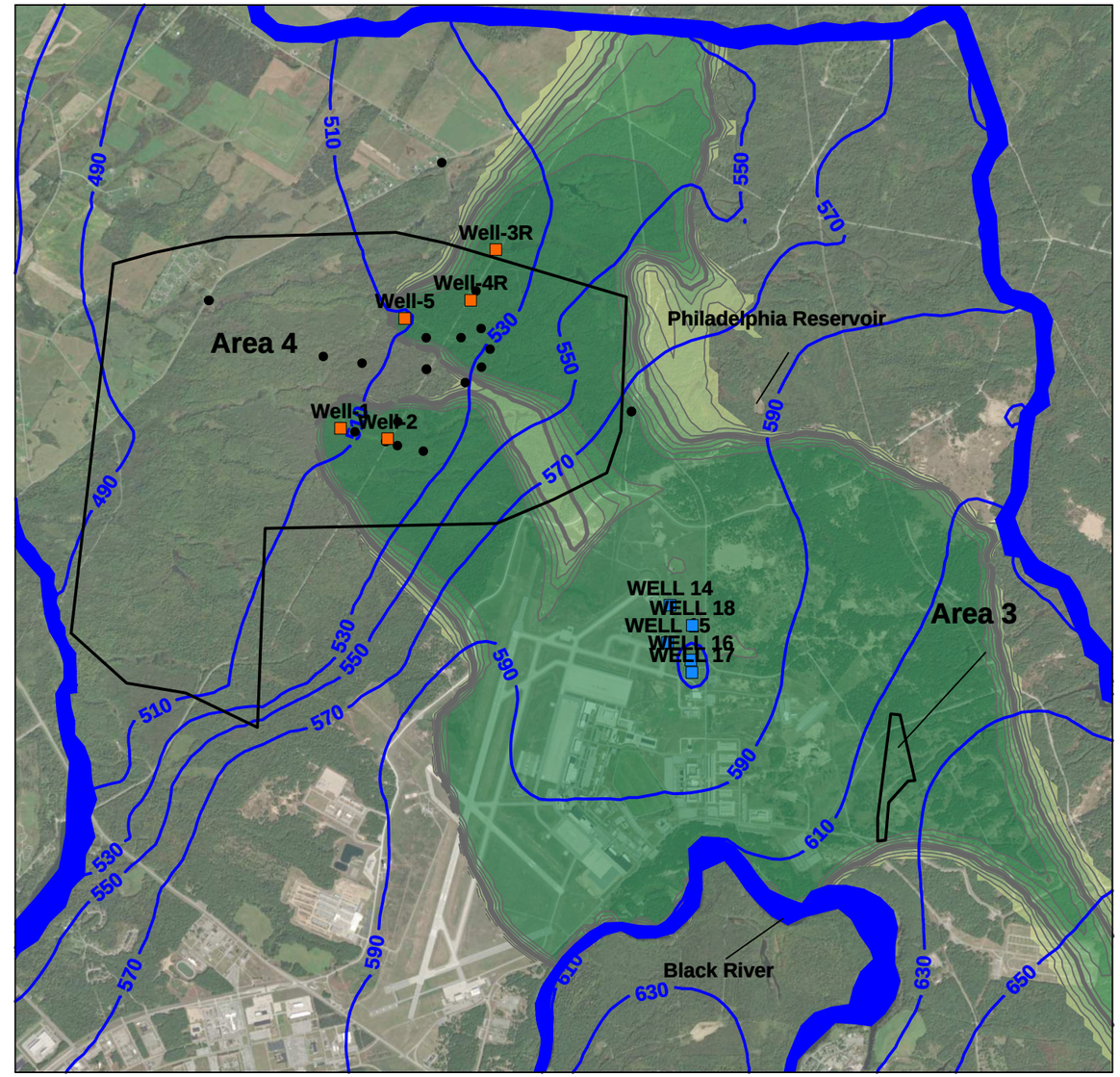
ARCADIS

FIGURE 6.3-2

Drawdown (ft)



Area of Flow Contribution



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

N

Scale in feet

0 4,000 8,000

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 3 groundwater elevation under drought conditions.
5. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Percentage of Flow Contribution

0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Flow Rates in Extraction Wells

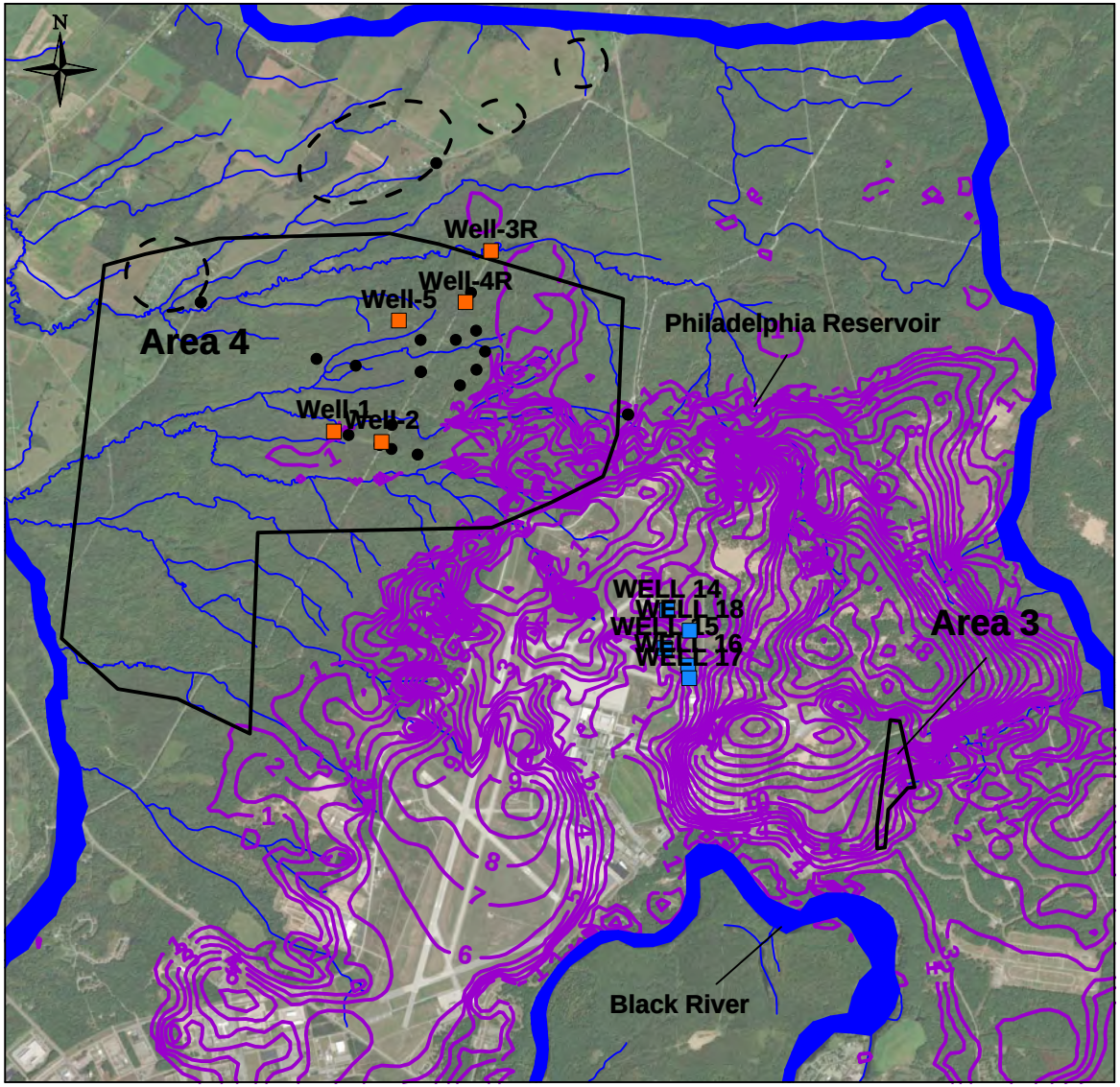
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 95 gpm
- Well 15 – 300 gpm
- Well 16 – 400 gpm
- Well 17 – 600 gpm
- Well 18 – 95 gpm
- Total – 1,990 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 3 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT DESIGN RATES SIMULATED DRAWDOWN AND STEADY-STATE AREA OF FLOW CONTRIBUTION IN LIMESTONE/SANDSTONE (MODEL LAYER 10) UNDER DROUGHT CONDITIONS

ARCADIS

FIGURE 6.3-3



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Simulated Steady-State Drawdown (ft)
- Stream Location
- Area 4 Monitoring Well
- Potential Off-Site Potable Well Location

Flow Rates in Extraction Wells
- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 95 gpm
- Well 15 – 300 gpm
- Well 16 – 400 gpm
- Well 17 – 600 gpm
- Well 18 – 95 gpm
- Total – 1,990 gpm

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute
4. Drawdown contours are 1 foot.
5. Drawdown is calculated as the steady-state calibration groundwater elevation (non-pumping conditions) minus the Scenario 3 groundwater elevation under drought conditions.
6. Drawdown represents the cumulative impact of the reduced recharge and pumping.

Scale in feet

0 5,000 10,000

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK

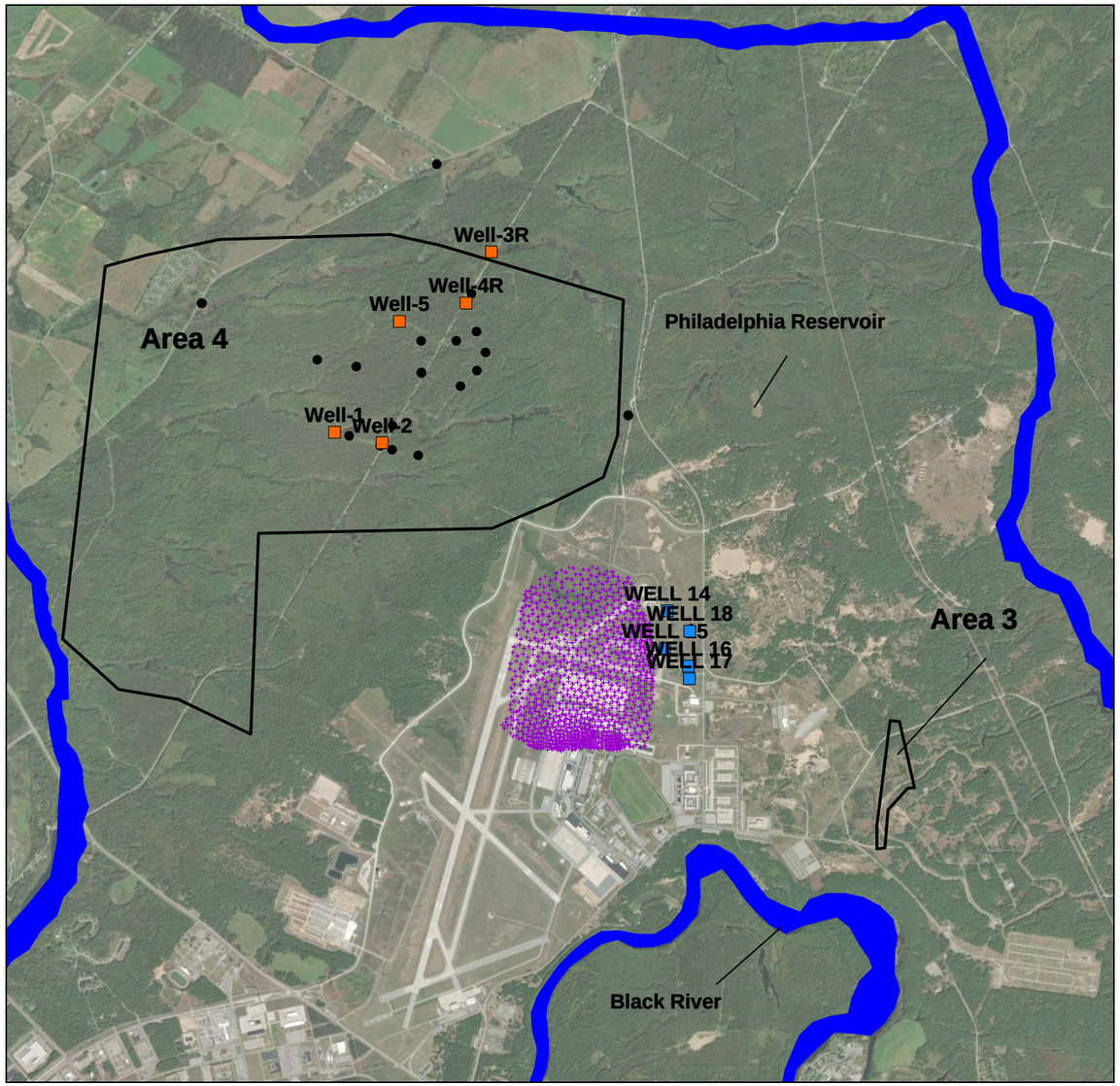
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 3 - AREA 4 ESTIMATED SUSTAINABLE RATES WITH EXISTING WELL FIELDS AT DESIGN RATES SIMULATED WATER TABLE DRAWDOWN (MODEL LAYER 1) UNDER DROUGHT CONDITIONS

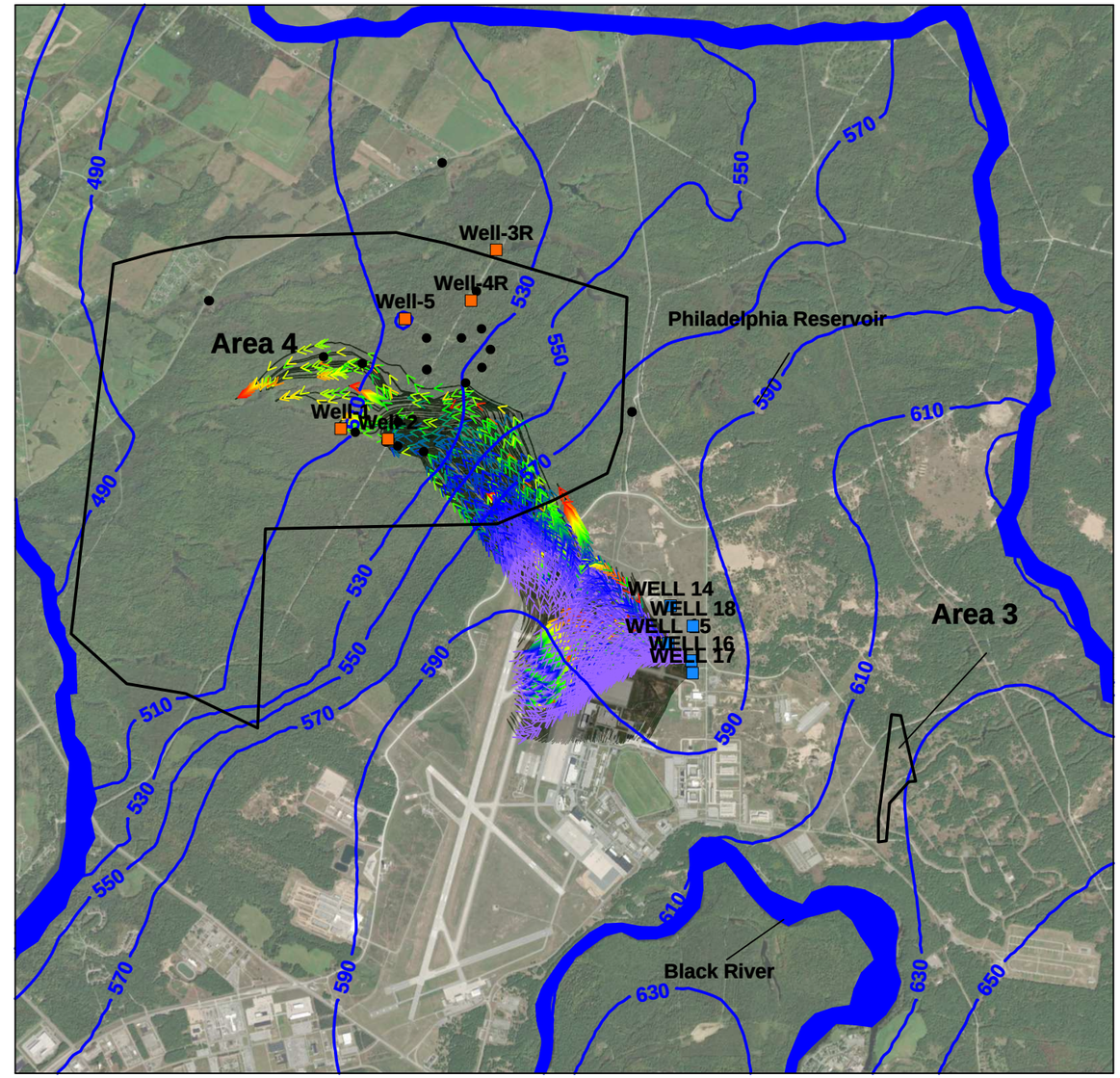
ARCADIS

FIGURE 6.3-4

Particle Starting Location



Forward Particle Tracking



Legend

- Current Water Supply Well
- Area 4 Test Wells
- Constant Head Boundary
- Particle Starting Location
- Simulated Groundwater Contour (ft NAVD88)
- Area 4 Monitoring Well

N

Scale in feet

0 4,000 8,000

Travel Time (years)

1 10 15 20 30

Notes:

1. ft = feet
2. NAVD88 = North American Vertical Datum of 1988
3. gpm = gallons per minute

Flow Rates in Extraction Wells

- Well 1 – 100 gpm
- Well 2 – 115 gpm
- Well 3R – 50 gpm
- Well 4R – 100 gpm
- Well 5 – 135 gpm
- Well 14 – 95 gpm
- Well 15 – 300 gpm
- Well 16 – 400 gpm
- Well 17 – 600 gpm
- Well 18 – 95 gpm
- Total – 1,990 gpm

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

SCENARIO 3 - AREA 4 SIMULATED PUMPING RATES WITH EXISTING WELL FIELDS AT DESIGN RATES SIMULATED FORWARD PARTICLE TRACKING AT TOP OF BEDROCK (MODEL LAYER 9) UNDER TRANSIENT CONDITIONS

ARCADIS

FIGURE 6.3-5

Appendix A

Sensitivity Analyses

Appendix A: Groundwater Flow Model Sensitivity

Sensitivity analyses were performed on all the parameters adjusted during the calibration process: horizontal and vertical hydraulic conductivity, groundwater recharge, and current wellfield pumping. The sensitivity analyses focused on quantitative calibration metrics, residual sum-of-squares (RSS), and residual mean. These metrics were assessed to determine if the model calibration could be improved (if the RSS can be lowered or residual mean can be closer to zero) and whether the changes in a model parameter have a large or small effect on the model calibration. These metrics were evaluated for the overall model, bedrock only, and Area 4 only. All the parameters used in the calibrated model were sensitive either in the overall model, bedrock only, or Area 4 only. Some parameters were more sensitive than others; for example, the overall model was most sensitive to recharge in the airfield area. Area 4 was also sensitive to recharge variation within Area 4 and to changes in hydraulic conductivity within bedrock but not within the overburden (which is mostly clay/silt in Area 4). The results of the sensitivity analysis for these parameters suggest that they are likely the best fit for the model calibration and provide greater confidence in the predicted well yield from Area 4.

A.1 Recharge

The recharge zonation and the values within each zone are summarized on Figure 4.1-1 in the main report. The use of a multiplier allows for the assessment of proportional changes in a parameter on the model calibration. For example, a multiplier of 1.5 is 1.5 times the calibrated value, and a value of 0.5 is one-half the calibrated value. Figure A-1 presents the sensitivity analysis for the overall model for each of the recharge zones with respect to the RSS and residual mean. The RSS and residual mean are highly sensitive to changes in the values of recharge zones 2, 4, and 9 and insensitive to changes in the values of zones 1 and 5, likely because the majority of the monitoring well targets in the overall model are within the areal footprint of recharge zones 2, 4, and 9.

Figure A-2 presents the sensitivity analysis for the bedrock portion of the model for each of the recharge zones with respect to the RSS and residual mean. The RSS and residual mean are highly sensitive to changes in the values of recharge zones 1, 2, and 5 and insensitive to changes in the values of zones 3 and 4. The majority of the bedrock monitoring well targets are within the areal footprint of recharge zones 1 and 2.

Figure A-3 presents the sensitivity analysis for the Area 4 portion of the model for each of the recharge zones with respect to the RSS and residual mean. The RSS and residual mean are sensitive to changes in the values of recharge zones 1 and 2 and insensitive to changes in the values of zones 3, 4, and 9. All the Area 4 monitoring wells are within the areal footprint of recharge zone 1; however, flow from the airfield (zone 2) impacts the water levels within Area 4.

The values used in the calibrated model resulted in the overall lowest RSS and residual mean closest to zero in the model, while trying to balance that, for some zones, the smallest RSS was obtained using a smaller multiplier for the overall model and a larger multiplier for bedrock portions of the model (as was the case for zone 2). Therefore, no adjustments were made to the recharge zones in the calibrated model based on the sensitivity analyses.

A.2 Hydraulic Conductivity

The hydraulic conductivity distribution is summarized on Figures 4.2-1 to 4.2-6 of the main report. Figure A-4 presents the results of the sensitivity analysis of hydraulic conductivity for the overall model with respect to RSS and residual mean. The use of a multiplier allows for the assessment of proportional changes in a parameter on the model calibration. For example, a multiplier of 1.5 is 1.5 times the calibrated value and a value of 0.5 is one-

half the calibrated value. The multiplier was applied to both horizontal and vertical hydraulic conductivity. The anisotropy ratio is the same as the calibrated model. All model layers, except layers 7 and 12, were sensitive to changes in the values of hydraulic conductivity.

Figure A-5 presents the results of the sensitivity analysis of hydraulic conductivity for the bedrock portion of the model with respect to RSS and residual mean. All model layers, except layers 2, 3, and 4, were sensitive to changes in the values of hydraulic conductivity.

Figure A-6 presents the results of the sensitivity analysis of hydraulic conductivity for the Area 4 portion of the model with respect to RSS and residual mean. Model layers 2, 7, 9, 10, and 11 were sensitive to changes in the values of hydraulic conductivity. While model layer 11 is no-flow in the Area 4 portion of the model, the hydraulic conductivity of model layer 11 within the southern portion of the model helps control the amount of groundwater that Area 4 bedrock receives from the airfield.

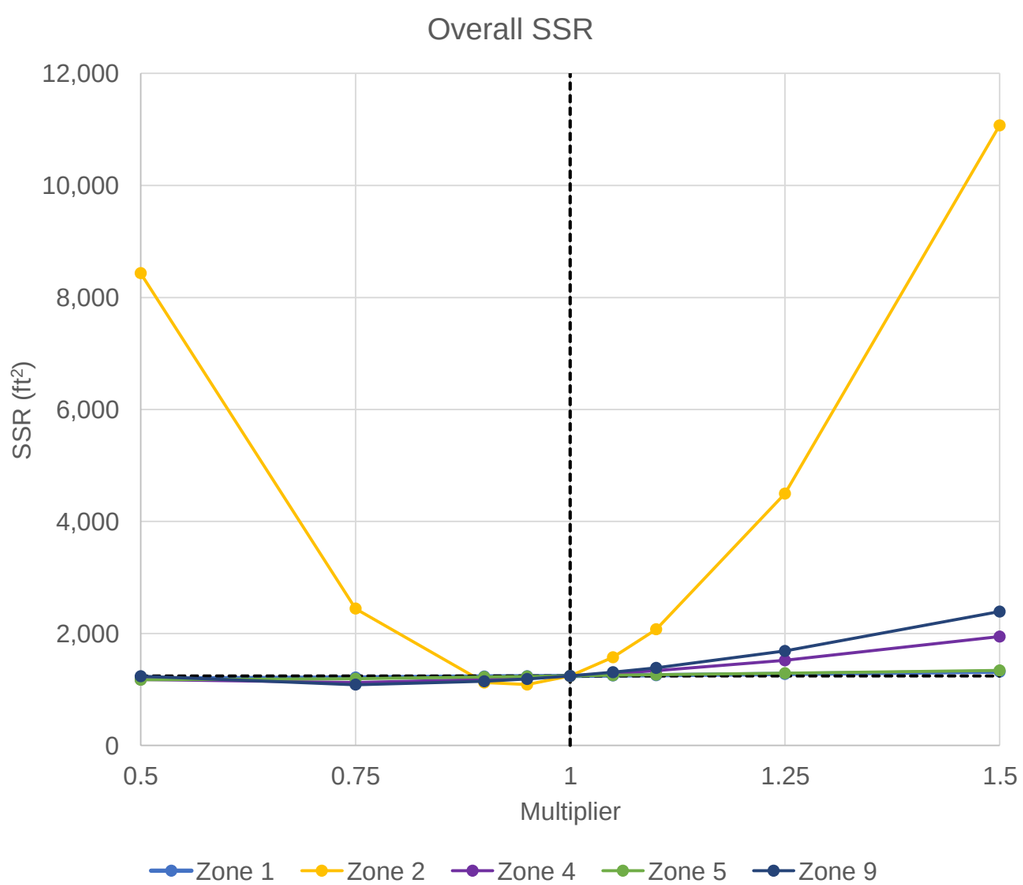
The values used in the calibrated model resulted in the overall lowest RSS and residual mean closest to zero in the model, while trying to balance that, for some layers, the smallest RSS was obtained using a smaller multiplier for the overall model and a larger multiplier for bedrock portions of the model. Therefore, no adjustments were made to the hydraulic conductivity in the calibrated model based on the sensitivity analyses.

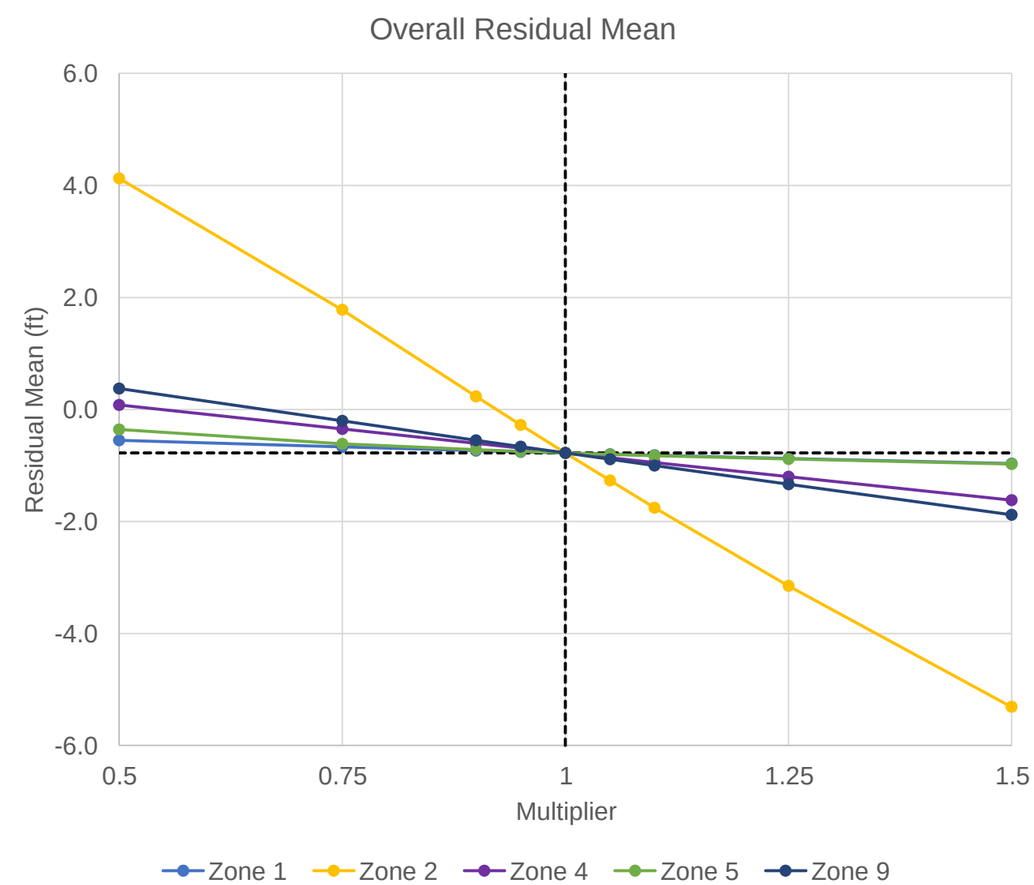
A.3 Existing Wellfield Pumping

The sensitivity of the model calibration to existing wellfield pumping was assessed for the overall model (Figure A-7) and bedrock portions of the model (Figure A-8). The model calibration described in the main report does not have the existing wellfield pumping. The existing wellfield pumping sensitivity was assessed by pumping the wells at the current average rate (described in Sections 4.4.1 and 6.3 of the main report). The model calibration for both the overall model and the bedrock portion of the model is highly sensitive to whether the existing wellfield is pumping or not. Bedrock water levels within the airfield drop by greater than 10 feet when the existing wellfield is pumping. Area 4 is largely unimpacted by the existing wellfield pumping at the current average rates.

Figures:

Figure A-1 – Recharge Sensitivity – Overall Model
Figure A-2 – Recharge Sensitivity – Bedrock Only
Figure A-3 – Recharge Sensitivity – Area 4 Only
Figure A-4 – Hydraulic Conductivity Sensitivity – Overall Model
Figure A-5 – Hydraulic Conductivity Sensitivity – Bedrock Only
Figure A-6 – Hydraulic Conductivity Sensitivity – Area 4 Only
Figure A-7 – Wellfield Pumping Sensitivity – Overall Model
Figure A-8 – Wellfield Pumping Sensitivity – Bedrock Only





SSR = sum of squared residual
ft = foot
In/yr = inches per year
Zone 1 = Area 4 Recharge (9 in/yr)
Zone 2 = Airfield Recharge (15.6 in/yr)
Zone 4 = Runway and other less permeable areas of the airfield (8.2 in/yr)
Zone 5 = Area 3 and locations east of the airfield (17 in/yr)
Zone 9 = Airfield Recharge close to runway (15.6 in/yr)

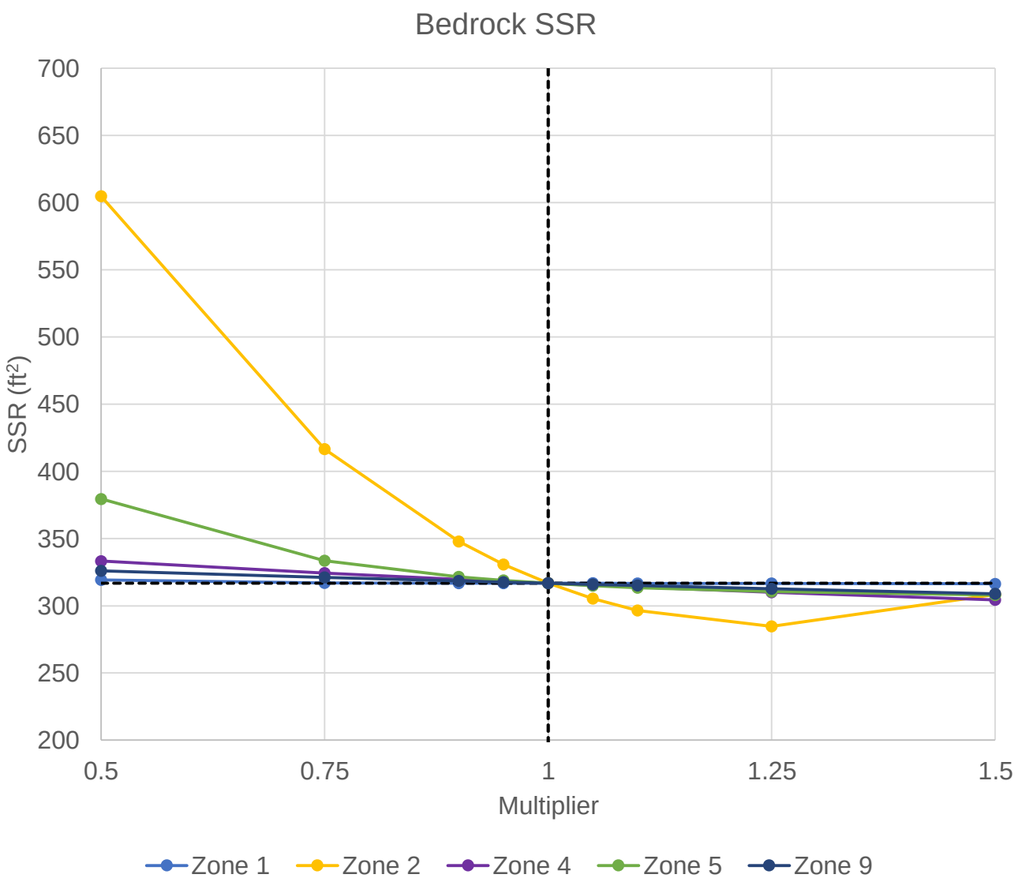
Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

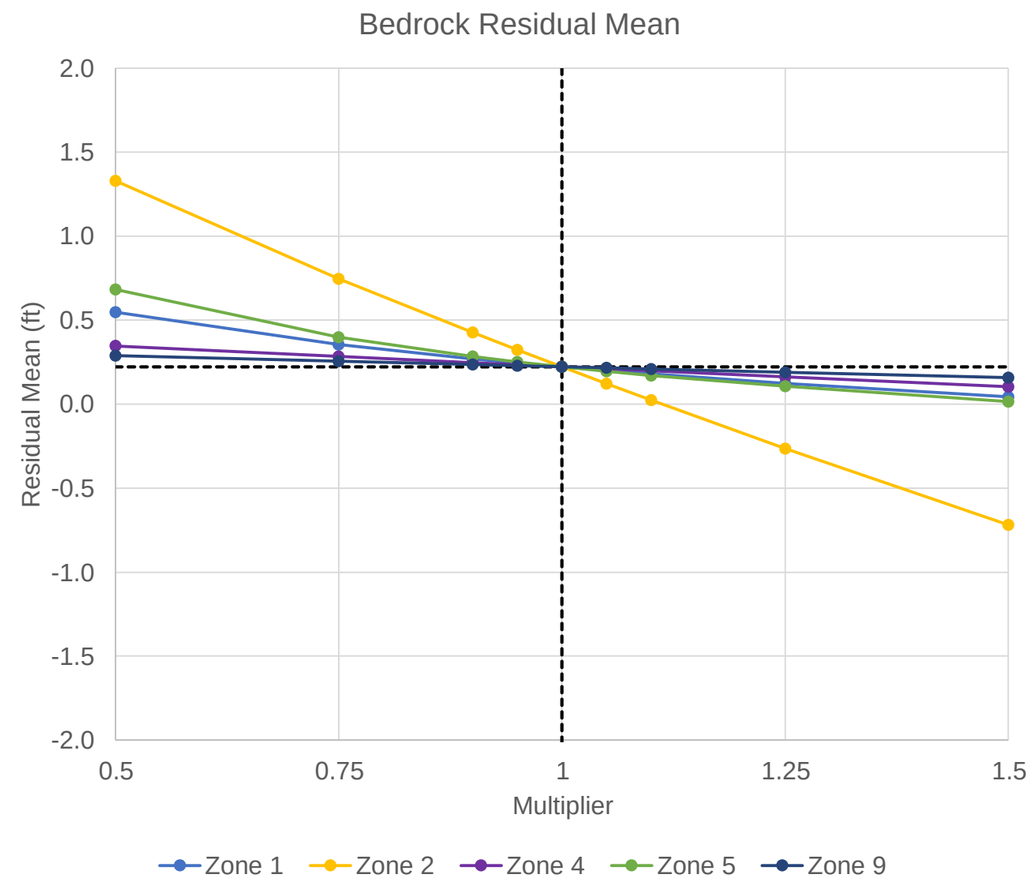
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

RECHARGE SENSITIVITY – OVERALL MODEL

ARCADIS

FIGURE
A-1





SSR = sum of squared residual
ft = foot
In/yr = inches per year
Zone 1 = Area 4 Recharge (9 in/yr)
Zone 2 = Airfield Recharge (15.6 in/yr)
Zone 4 = Runway and other less permeable areas of the airfield (8.2 in/yr)
Zone 5 = Area 3 and locations east of the airfield (17 in/yr)
Zone 9 = Airfield Recharge close to runway (15.6 in/yr)

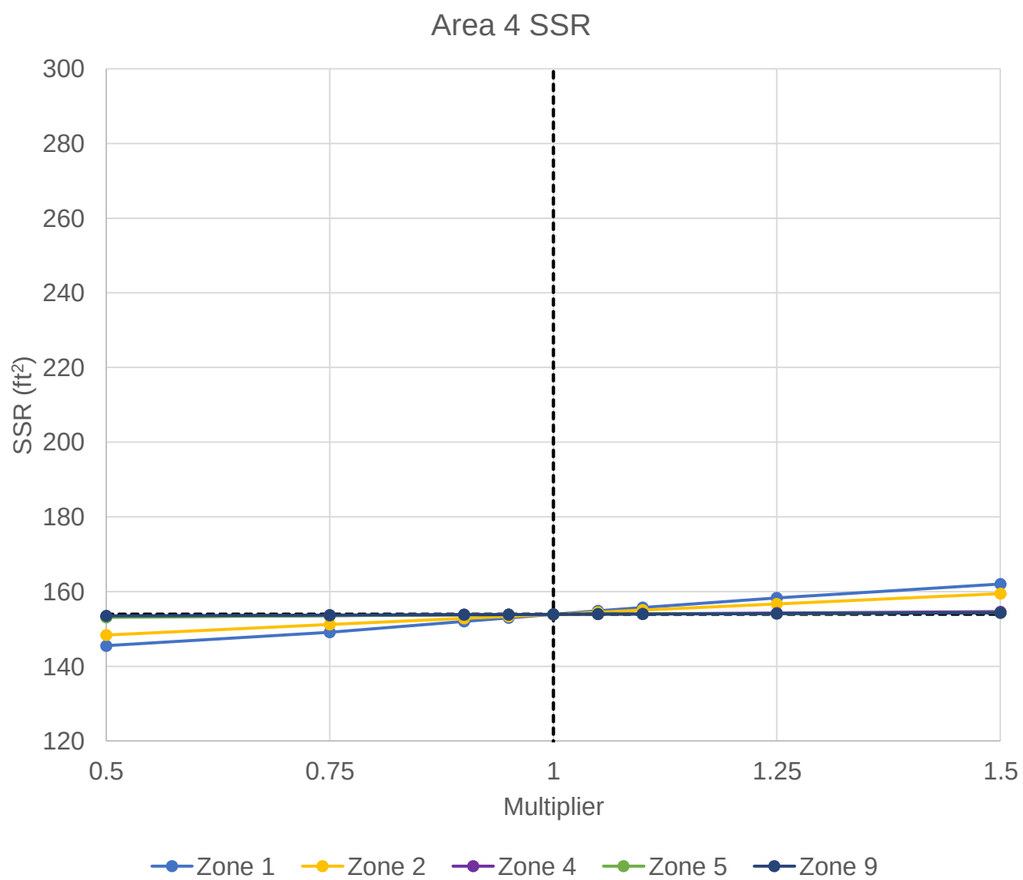
Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

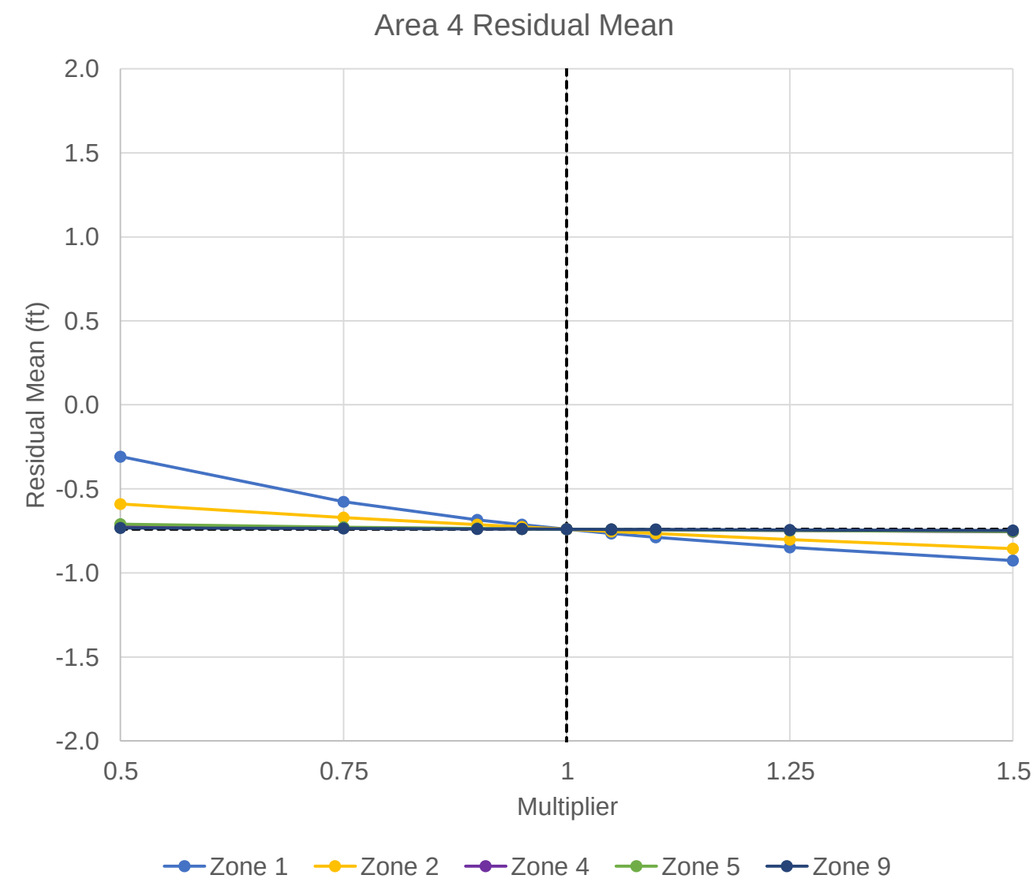
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

RECHARGE SENSITIVITY – BEDROCK ONLY

ARCADIS

FIGURE
A-2





SSR = sum of squared residual
ft = foot
In/yr = inches per year
Zone 1 = Area 4 Recharge (9 in/yr)
Zone 2 = Airfield Recharge (15.6 in/yr)
Zone 4 = Runway and other less permeable areas of the airfield (8.2 in/yr)
Zone 5 = Area 3 and locations east of the airfield (17 in/yr)
Zone 9 = Airfield Recharge close to runway (15.6 in/yr)

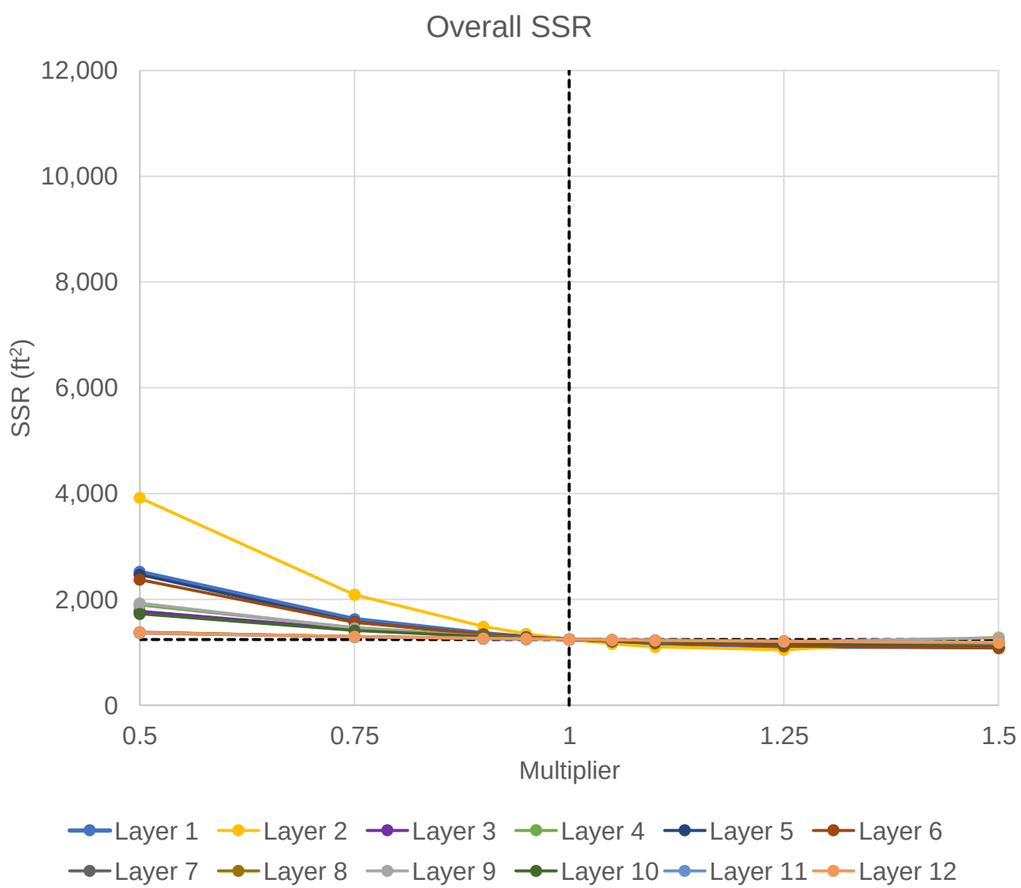
Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

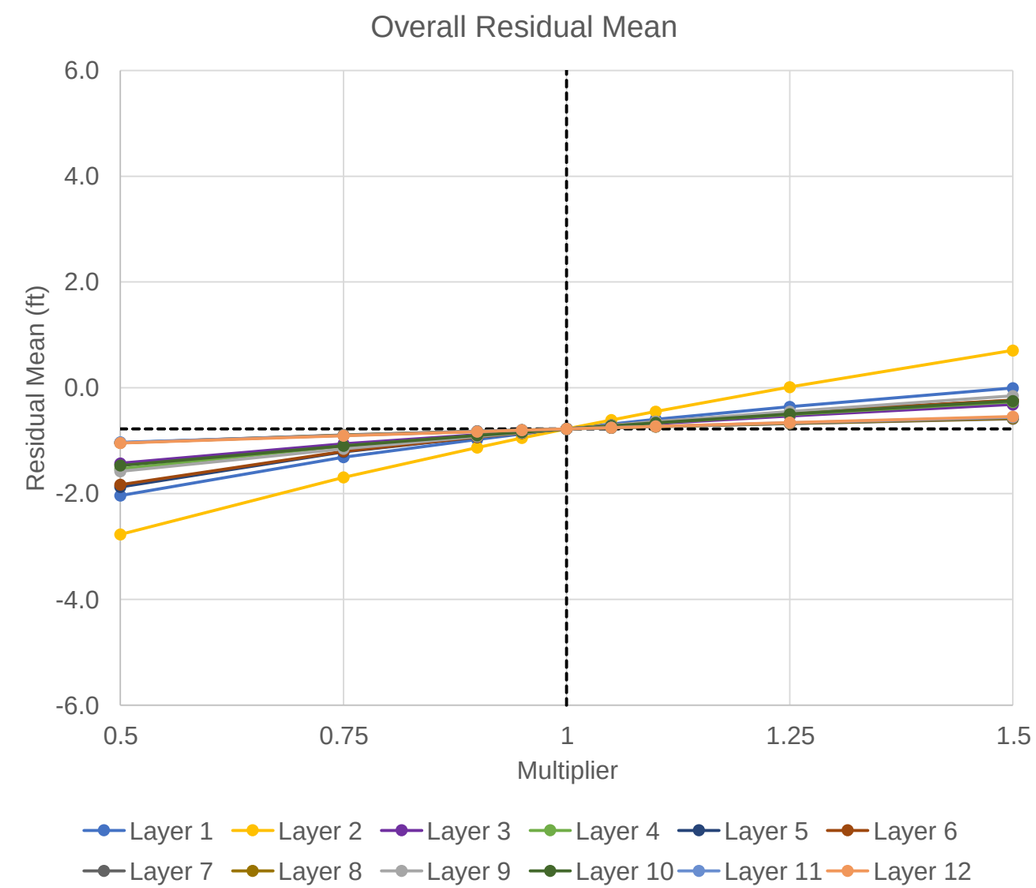
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

RECHARGE SENSITIVITY – AREA 4 ONLY

ARCADIS

FIGURE
A-3





SSR = sum of squared residual

ft = foot

In/yr = inches per year

Multiplier applied to both horizontal and vertical hydraulic conductivity,

Anisotropy ratio is the same as the calibrated model.

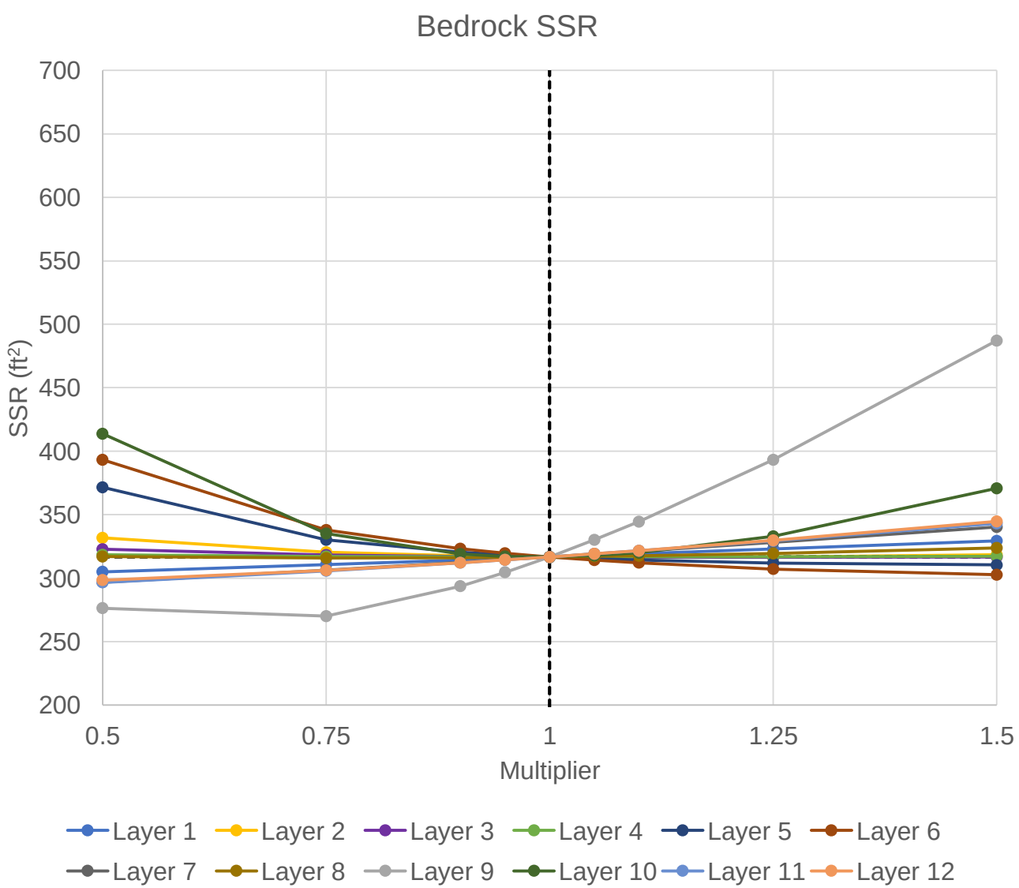
Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

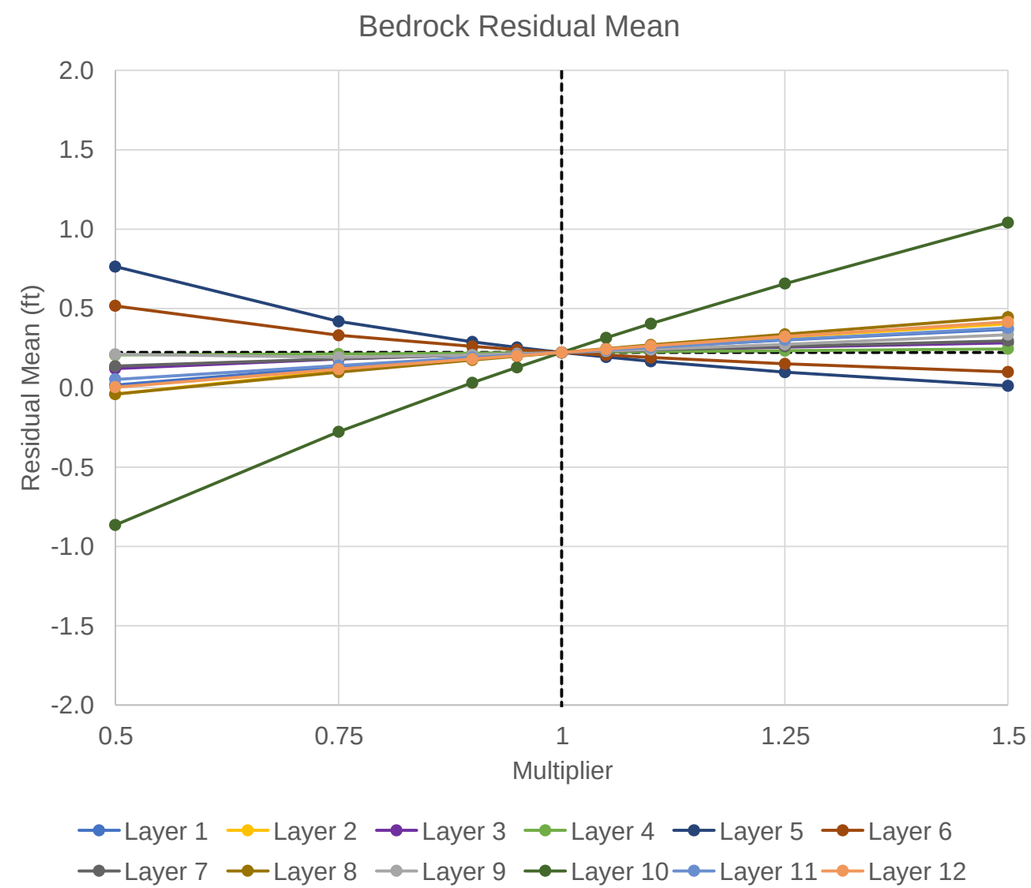
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY SENSITIVITY – OVERALL MODEL

ARCADIS

FIGURE
A-4





SSR = sum of squared residual
ft = foot
In/yr = inches per year
Multiplier applied to both horizontal and vertical hydraulic conductivity,
Anisotropy ratio is the same as the calibrated model.

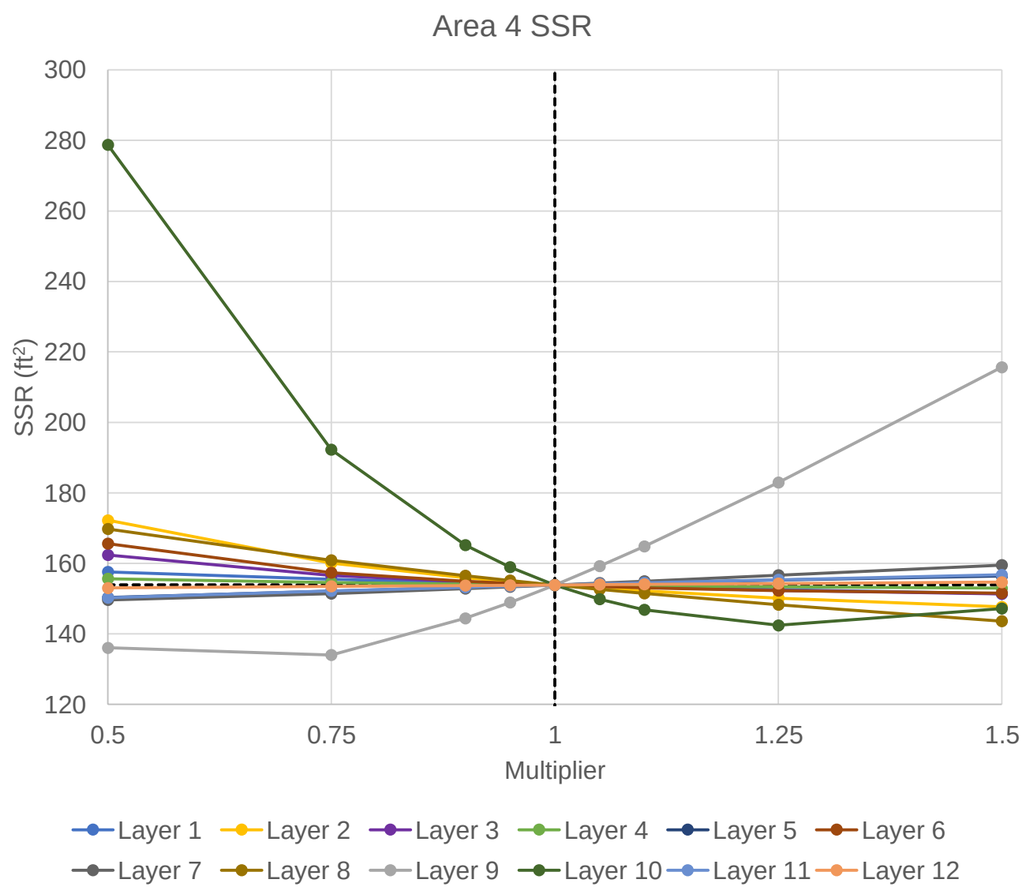
Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

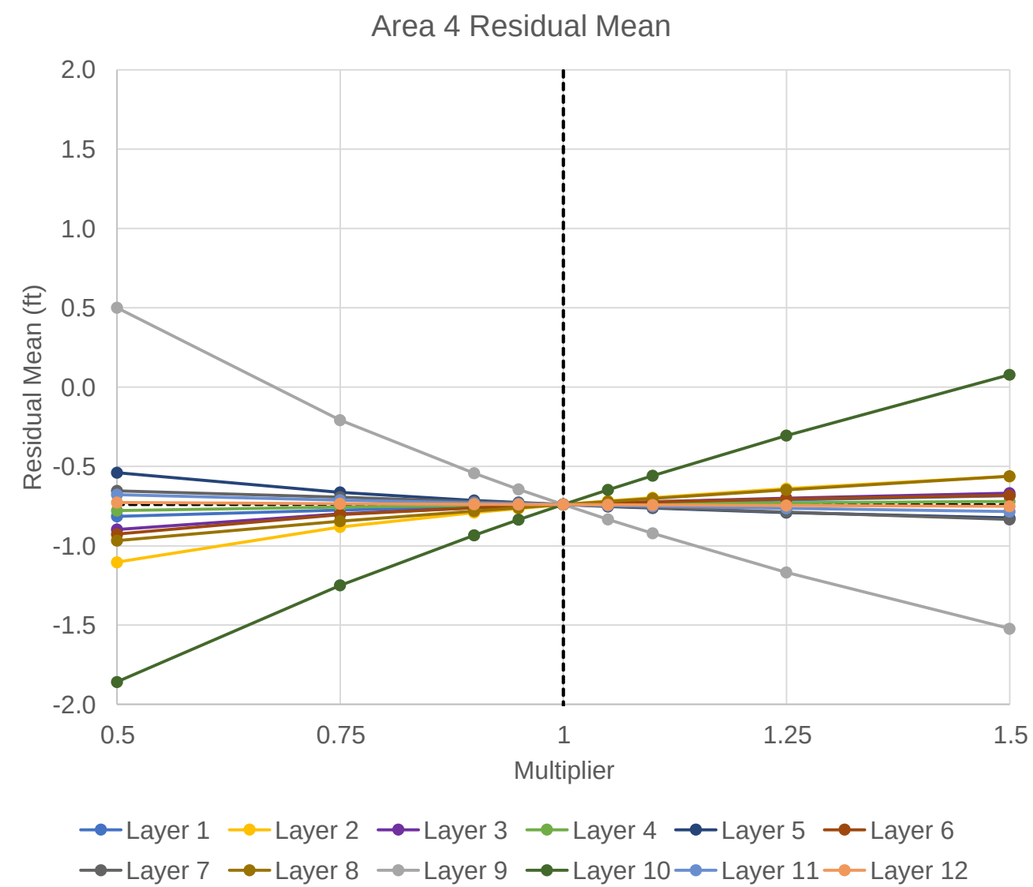
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY SENSITIVITY – BEDROCK ONLY

ARCADIS

FIGURE
A-5





SSR = sum of squared residual
ft = foot
In/yr = inches per year
Multiplier applied to both horizontal and vertical hydraulic conductivity,
Anisotropy ratio is the same as the calibrated model.

Statistics were calculated using weighted residuals.
Dashed line represents model calibration values.

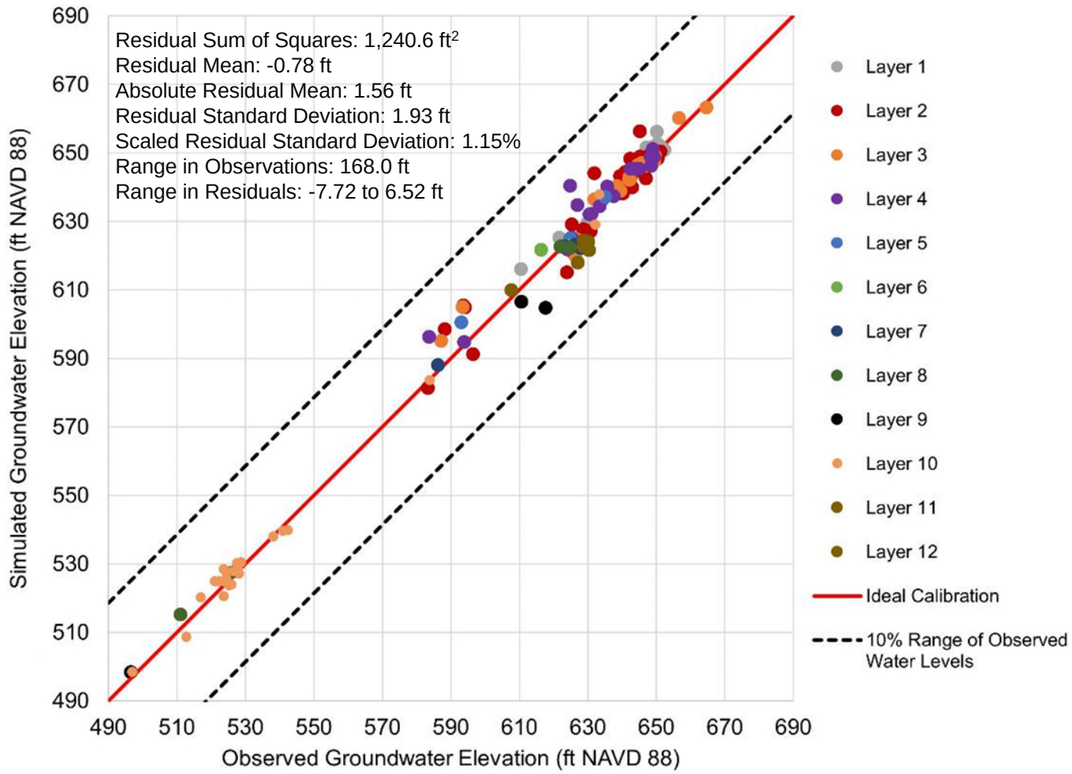
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

HYDRAULIC CONDUCTIVITY SENSITIVITY – AREA 4 ONLY

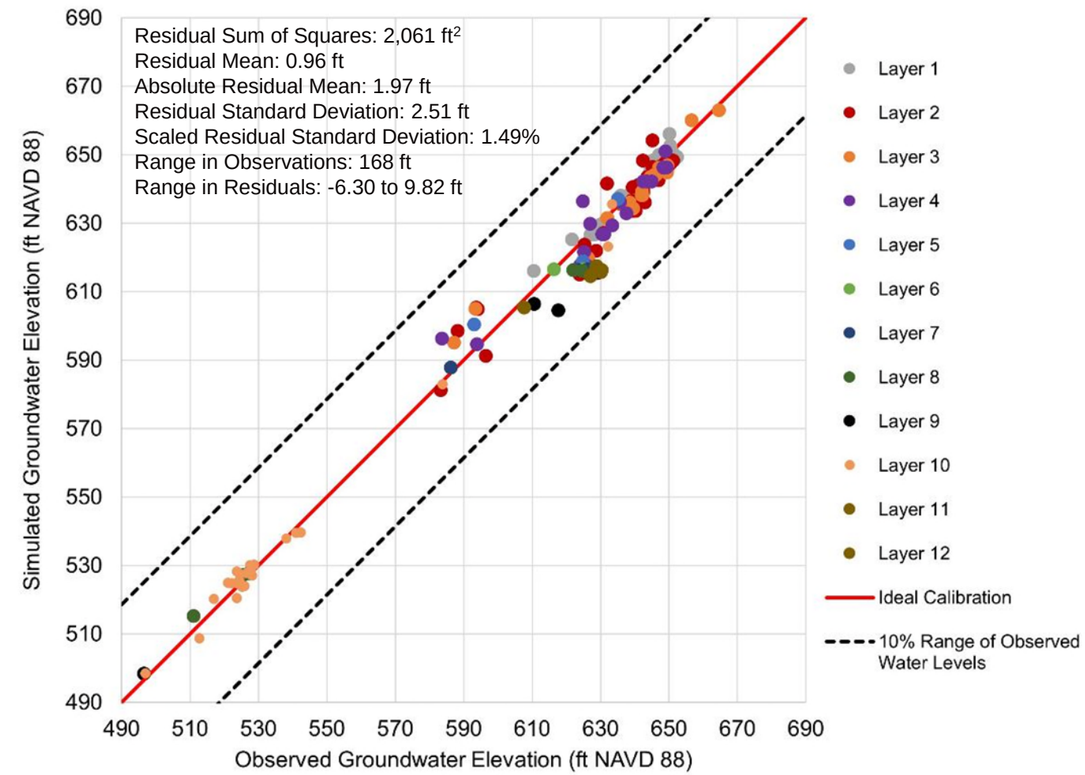
ARCADIS

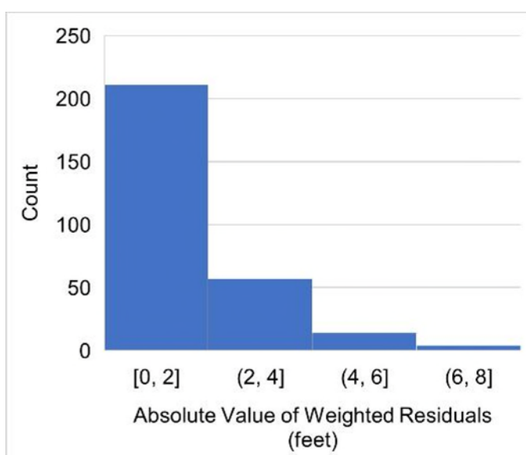
FIGURE
A-6

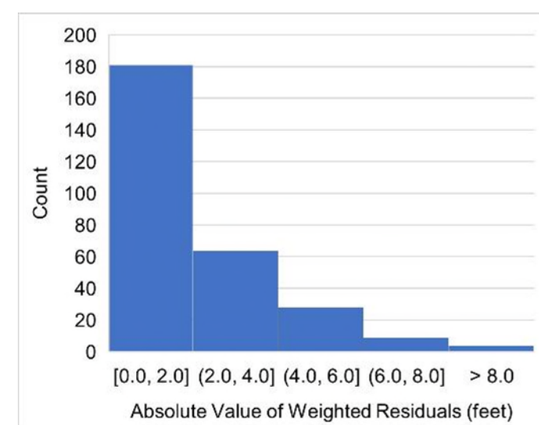
Without Existing Wellfield Pumping



With Existing Wellfield Pumping







SSR = sum of squared residual

ft = foot

Statistics were calculated using weighted residuals.

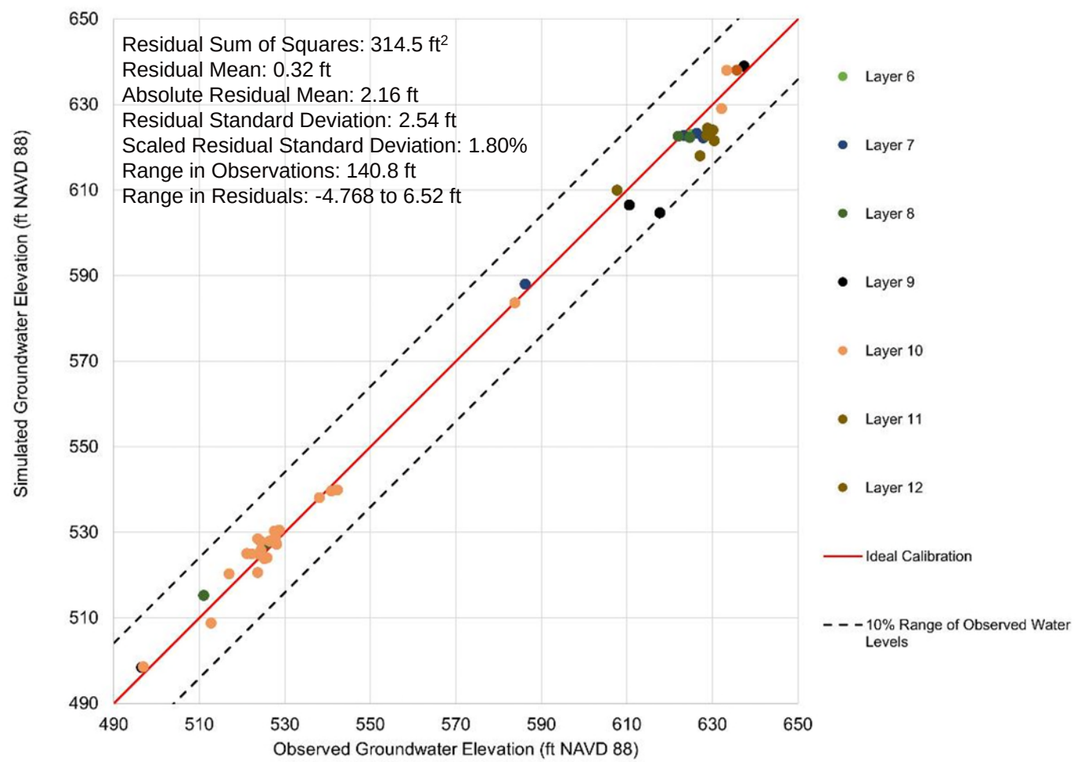
ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

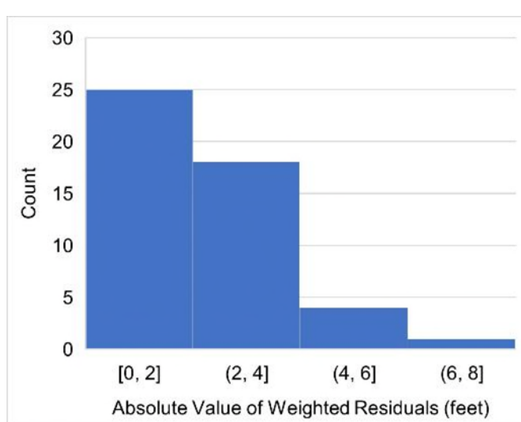
WELLFIELD PUMPING SENSITIVITY – OVERALL MODEL

ARCADIS

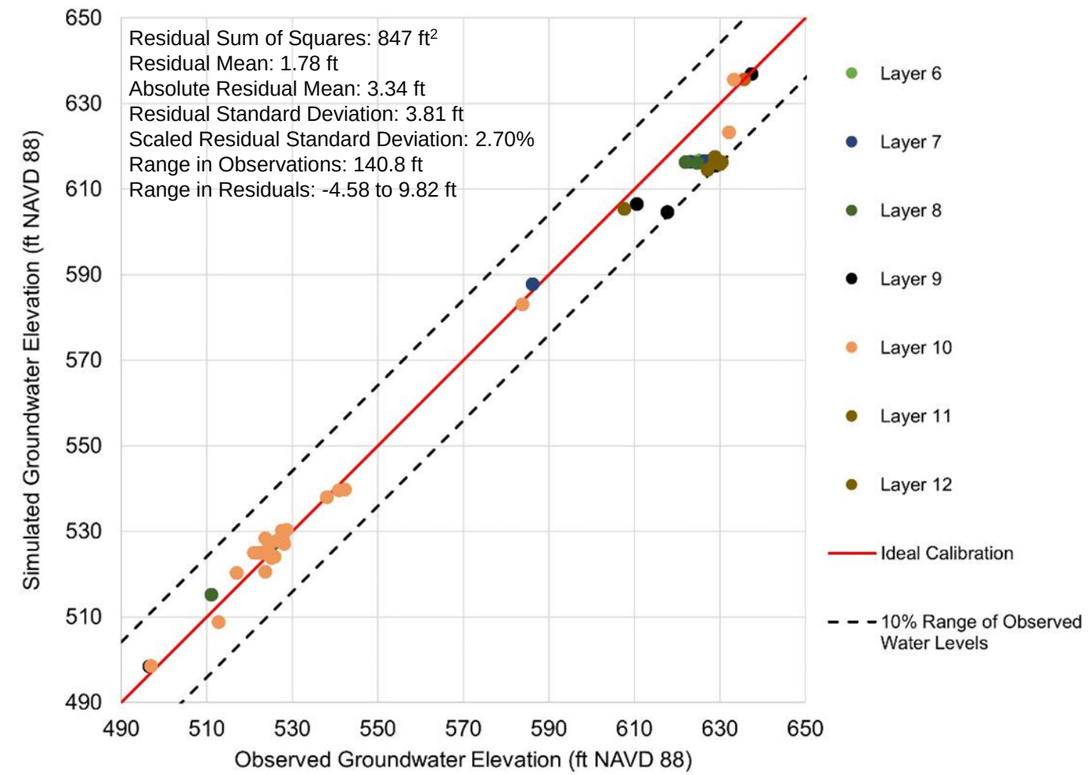
FIGURE
A-7

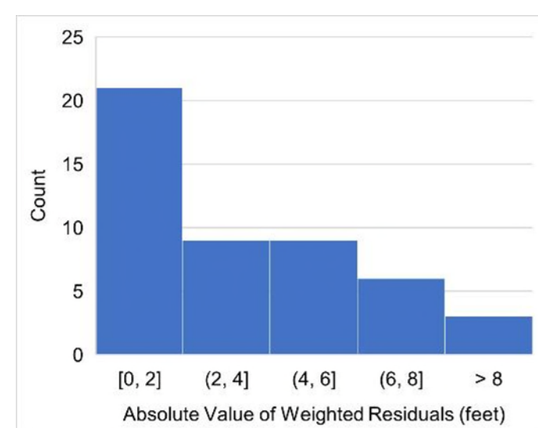
Without Existing Wellfield Pumping





With Existing Wellfield Pumping





SSR = sum of squared residual

ft = foot

Statistics were calculated using weighted residuals.

ERCIP WELL FIELD EXPANSION PROJECT
UNITED STATES ARMY GARRISON, FORT DRUM, NEW YORK
GROUNDWATER MODEL UPDATE REPORT

WELLFIELD PUMPING SENSITIVITY–BEDROCK ONLY

ARCADIS

FIGURE
A-8

Arcadis U.S., Inc.
One Lincoln Center, 110 West Fayette Street, Suite 300
Syracuse, NY 13202
United States
Phone: 315 446 9120
Fax: 315 449 0017
www.arcadis.com