Naval Facilities Engineering Systems Command
Norfolk, Virginia

Public Water Supply Contingency Plan Update For OU2 Volatile Organic Compounds and 1,4-Dioxane

Naval Weapons Industrial Reserve Plant
Bethpage, New York

October 2023

Final

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PUBLIC WATER SUPPLY CONTINGENCY PLAN UPDATE FOR OU2 VOLATILE ORGANIC COMPOUNDS AND 1,4-DIOXANE

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Department of the Navy
Naval Facilities Engineering Systems Command
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Norfolk, VA 23511-3095

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CONTRACT NUMBER N62470D9008
CONTRACT TASK ORDER WE16

OCTOBER 2023

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Acronyms and Abbreviations

AOP	Advanced oxidation process
AS	Air stripping
Bgs	Below ground surface
GAC	Granular activated carbon
CACF	Contribution area correction factor
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chemical of concern
ESD	Explanation of Significant Differences
FI	Filtration
Freon 113	1,1,2-trichlorotrifluoroethane
LUWD-SNR	Liberty Utilities Water District – Seamans Neck Road
LWD	Levittown Water District
MCL	Maximum Contaminant Level
µg/L	Microgram per liter
MWD	Massapequa Water District
NAVFAC	Naval Facilities Engineering Systems Command
NWIRP	Naval Weapons Industrial Reserve Plant
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OU	Operable Unit
PCE	Tetrachloroethene
PWS	Public water supply
PWSCP	Public Water Supply Contingency Plan
ROD	Record of Decision
SFWD	South Farmingdale Water District
TCE	Trichloroethene
TVOC	Total volatile organic compound
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile organic compound

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Executive Summary

Tetra Tech has prepared this update to the 2003 Public Water Supply Contingency Plan (2003 PWSCP) for the Naval Facilities Engineering Systems Command (NAVFAC) Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N6247016D9008 Task Order WE16, which is part of the Navy's ongoing Environmental Restoration Program for the Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage Operable Unit (OU) 2 Plume. This PWSCP replaces the previous version of the 2003 PWSCP and associated addenda.

The 2003 PSWCP incorporated five main elements, as follows:

- Groundwater Modeling
- Trigger Values
- Outpost (Early Warning) Monitoring Wells
- Groundwater Monitoring of Outpost Monitoring Wells
- Well Treatment/Comparable Alternative Measures

Originally four clusters of outpost monitoring wells (nine wells) were identified in the 2003 PWSCP. These wells were installed in 2003. The purpose of these wells were to provide a 5-year notice of potential impact to the associated public water supply well. Calculated action levels for specific, site-related VOC concentrations(referred to as trigger values, see below) ranged from 0.6 to 1.5 micrograms per liter (μg/L).

Exceedance of a trigger value would indicate that well head treatment, or comparable alternative measures, is required and it is time to begin planning wellhead treatment or comparable alternative measures to address the potential for a specific public supply well or well field to be impacted. This process would not preclude the water district(s) from taking any action they deem appropriate.

The modeling used for the 2003 PWSCP[1] predicted impacts to:

- South Farmingdale Water District (SFWD) Plant 1 in 11 years (2014)
- SFWD Plant 3 in 4 years (2007)
- Liberty Utilities Water District – Seamans Neck Road[2] (LUWD-SNR) Wells 3S/4S in 18 years (2021)
- Levittown Water District (LWD) Well 13 (no impact).

[1] At the time of the 2003 PWSCP, none of the refenced PWS wells had treatment for VOCs in the extracted groundwater prior to distribution. Since that time, treatment is used as needed to remove contaminants from the water to comply with the New York State Department of Health (NYSDOH) maximum contaminant levels (MCLs) prior to distribution.
[2] Liberty Utilities Water District (also known as Liberty Utilities New York) was formerly known at Aqua New York and New York American Water.

Based on investigations between 2003 and 2023, it was determined that the OU2 Plume was further south and deeper than originally anticipated. In addition, groundwater flow was determined to be more southernly. As a result, the following outpost monitoring wells were added to the program:

- SFWD Plant 1 - one shallow and five deep wells (BPOW 1-4 through 1-6 that were installed in 2011 and BPOW 1-7 and 1-8 that were installed in 2020)
- SFWD Plant 3 – one deep well (BPOW 2-3 that was installed in 2011)
- LUWD-SNR – two deep wells (BPOW 3-3 and 3-4 that were installed in 2011)
- SFWD 6 – seven deep wells (BPOW 5-1 through 5-3 that were installed in 2012 and BPOW 5-4 through 5-7 that were installed in 2015)
- Massapequa Water District (MWD) Public Water Supply (PWS) Wells 4 and 5 - six deep wells (BPOW 6-1 through 6-6 that were installed in 2014 and 2015)

The current understanding of the properties of the OU2 Plume are as follows:

- The OU2 Plume is estimated to extend south to approximately the Southern State Parkway (14,000 feet from the former Northrop Grumman facility).
- An eastern finger of the OU2 Plume (GM38 Area Hotspot) has been contained and remediated via the GM38 Groundwater Treatment System.
- Regional groundwater flow that controls the movement of the OU2 Plume is more southernly and moves faster than previously modeled.

The current nature and extent of the OU2 Plume, remains mostly defined by trichloroethene (TCE). While the development of the OU2 Plume boundary is based primarily on TCE data and groundwater flow, as indicated in the Navy's 2021 Explanation of Significant Differences to the OU2 ROD, the OU2 Plume has been updated to include 1,4-dioxane, resulting it its boundary being extended to the south. 1,4-Dioxane can move with groundwater and migrate slightly faster than TCE, whose migration is also attenuated by degradation and adsorption factors.

Other VOC and 1,4-dioxane plumes are located in close proximity to, and in some locations commingled with, the OU2 Plume, including the OU3 Plume, one or more PCE plumes characteristic of dry cleaner releases, a benzene plume characteristic of a gasoline release, as well as similar VOC releases by other industries in the area. These other plumes can be located above, below, or adjacent to the OU2 Plume.

Between 2016 and 2023, the computer model was updated to reflect data collected since 2003. The objectives of the current modeling effort to support PWSCP development are as follows:

- Model the travel pathway and time required for PWS wells to intercept groundwater from each of the outpost monitoring wells.

- Model the width and direction of the capture zone for SFWD Plants 3 and 6, and MWD Wells 4 and 5 to estimate the contribution area correction factor (CACF)[3].

This PWSCP updates and replaces the 2003 PWSCP and addenda issued for the 2003 OU2 ROD. Factors that led to this update are follows:

- Over the past 20 years, there have been extensive hydrogeological and groundwater investigations conducted in the area downgradient of the former NWIRP Bethpage.
- These investigations have substantially improved the Navy's understanding of the horizontal and vertical extent of the OU2 Plume, as well as its migration.
- In 2021, the Navy issued an ESD for the OU2 ROD that modified the remedy, including:
  - Addition of 1,4-dioxane as an OU2 Plume COC.
  - Extended the use of groundwater extraction, treatment, and discharge remedies to groundwater than contain more than 150 µg/L of VOCs (this concentration was formerly 1,000 µg/L). This action will reduce and eventually eliminate potential impacts for PWS wells within or in close proximity to the OU2 Plume.
  - Implementation of groundwater extraction system near the Southern State Parkway (Phase III Treatment System) to intercept the OU2 Plume in this area, as practicable. This action will reduce or eliminate, to the extent practicable, potential impacts for PWS wells located to the south of the OU2 Plume.
- While the OU2 Plume remains defined primarily by TCE, the addition of 1,4 dioxane as COC does not affect the northern or side boundaries of the OU2 Plume previously presented, it does result in the downgradient boundary of the plume being extended to the south.
- Since 2003, VOC treatment has been installed and is operating to comply with NYSDOH MCLs for each of the PWS wells that were identified as being potentially impacted by the OU2 Plume, including SFWD Plant 1 and SFWD Plant 3, and LUWD. In addition, 1,4-dioxane treatment has been installed or is being installed to comply with NYSDOH MCLs for each of the PWS wells that are currently projected to be impacted by the OU2 Plume. The United States government has provided funding for each of these treatment systems.

[3] The CACF represents a conservative estimate of the fraction of water entering the public water supply well associated from the area of specific outpost monitoring well relative to the total amount of water entering that public water supply well.

- With the installation of treatment at each of the PWS facilities that may be affected by the OU2 Plume, the need for outpost monitoring wells has decreased or been eliminated. Note that these wells will continue to be sampled as part of the overall monitoring well network for the OU2 Plume that currently includes over 150 wells.
- Starting in 2024, the status of the current outpost wells will be changed as follows:
  - BPOW 1-1 through BPOW 1-8 (SFWD Plant 1): Because these wells do not monitor OU2 Plume groundwater that may impact SFWD Plant 1, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 2-1 through BPOW 2-3 (SFWD Plant 3): Because wellhead treatment is in place and is operating to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 3-1 and BPOW 3-2 (LUWD-SNR): Because these wells monitoring groundwater than may contain much higher levels of Freon 113 (from an adjacent plume) and the existing and currently planned wellhead treatment provides limited protection from this chemical, these wells will remain as outpost monitoring wells and continue to be sampled on a quarterly basis.
  - BPOW 3-3 and BPOW 3-4 (LUWD-SNR): Because wellhead treatment is in place and is operating to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 4-1R and 4-2R (LWD Well 13). Because these wells are not within the flow pathway for the OU2 Plume, wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 5-1 through BPOW 5-7 (SFWD Plant 6): Because wellhead treatment that is expected to be installed and operating in the near future to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered

outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.

- BPOW 6-1 through BPOW 6-6 (MWD Well 5). Under current conditions (without the Phase III treatment system operating) these wells are anticipated to provide 11 years to greater than 30 years advance notice of potential migration from the outpost wells to MWD Well 5. With the planned construction and operation of the Phase III treatment system within the next three years, the calculated travel times are estimated to increase to 22 to greater than 30 years, which is too long to effectively evaluate potential impacts to this MWD well field (MWD Wells 4 and 5). As such, four new outpost wells (BPOW 6-7 through 6-10) will be installed to the north and northwest of this MWD field and south of the current outpost monitoring wells. These locations are expected to provide a minimum of 5 years notice under current conditions, and 5 to 10 years under the planned operation of the Phase III treatment system.

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1.0 Introduction

Tetra Tech has prepared this update to the 2003 Public Water Supply Contingency Plan (2003 PWSCP) for the Naval Facilities Engineering Systems Command (NAVFAC) Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N6247016D9008 Task Order WE16, which is part of the Navy's ongoing Environmental Restoration Program for the Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage Operable Unit (OU) 2 Plume. This PWSCP replaces the previous version of the 2003 PWSCP and associated addenda. As shown in Figure 1, NWIRP Bethpage is located in east-central Nassau County, Long Island, New York, approximately 30 miles east of New York City.

The 2003 PSWCP incorporated five main elements, as follows:

- Groundwater Modeling
- Trigger Values
- Outpost (Early Warning) Monitoring Wells
- Groundwater Monitoring of Outpost Monitoring Wells
- Well Treatment/Comparable Alternative Measures

This current PWSCP incorporates these same elements. As discussed below, groundwater modeling of the area has improved significantly since the early 2000s, when the original PWSCP was finalized. Trigger values are chemical specific concentrations that are present in monitoring well(s) located upgradient from a public water supply well without treatment for that chemical. The distance from the outpost monitoring well to the public water supply should be sufficient to allow enough time for the water supplier to take action to meet applicable drinking water standards. The 2003 PWSCP determined that a five-year time period from notice to action was sufficient. Quarterly to semi-annual monitoring of the outpost wells has been conducted since 2003. In response to outpost well or public water supply impacts from site-related chemicals of concern (COCs), the United States Government has funded wellhead treatment on seven public water supply wells in the area. This treatment has reduced or eliminated the need for monitoring.

Volatile organic compounds (VOCs) have been identified in groundwater at and downgradient of the former NWIRP Bethpage and Northrop Grumman properties that were related to the historic use of chlorinated and non-chlorinated solvents at the facilities. Seventeen VOCs are identified under the OU2 Record of Decision (ROD) (Navy, 2003) or the 2003 PWSCP COCs for the OU2 Plume (Arcadis, 2003). They consist of the following compounds: 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene[4], 1,2-dichloroethane, carbon tetrachloride, carbon disulfide, chlorobenzene, chloroform, cis-1,2-dichloroethene, tetrachloroethene (PCE), trichloroethene (TCE), trichloro-trifluoroethane (Freon 113), trans-1,2-dichloroethene, and vinyl chloride.

Additionally, 1,4-dioxane has been detected in groundwater downgradient of the former NWIRP Bethpage and Northrop Grumman facilities, including the VOC-impacted groundwater associated with these facilities. Based on analysis of the operations at these facilities, historic VOC releases, and groundwater flow, 1,4-dioxane was subsequently added as a chemical of concern for OU2 groundwater in the Explanation of Significant Differences (ESD) for the OU2 ROD (Navy, 2021c). 1,4-Dioxane is most notably known for its industrial use as a stabilizer in 1,1,1-trichloroethane. It may have also been used in other site-related solvents (TCE), although a direct link between 1,4-dioxane and TCE has not been established for the site. However, it is also widely used in a variety of other residential and commercial products (including dish soaps, cosmetics, shampoos, and deodorants), and discharged to the groundwater via residential drain fields prior to the late 1970s or early 1980s. As a result, some of the 1,4- dioxane in the OU2 Plume is not likely associated with industrial activities at the former facilities.

1.1 Outpost Monitoring Well History

Originally four clusters of outpost monitoring wells (nine wells) were identified in the 2003 PWSCP (Table 1). These wells were installed in 2003. The purpose of these wells was to provide a 5-year notice of potential impact to the associated public water supply well (Arcadis, 2003). Calculated action levels (referred to as trigger values, see below) ranged from 0.6 to 1.5 micrograms per liter (µg/L) (Table 1).

The placement of the outpost monitoring wells and determination of the trigger values was based on groundwater flow and contaminant transport modeling developed in the late 1990s and early 2000s. This modeling used local and regional geological and hydrogeological information available at the time, pumping rates for the local public water supply (PWS) wells, and the estimated concentration and distribution of VOCs in the OU2 Plume.

Contaminant transport modeling was then used to estimate plume travel times and impacts to PWS wells that would first result in a concentration of 0.5 µg/L in the corresponding PWS wells. This approach factored in the length, width, thickness, depth, and concentration of the VOCs in the OU2 Plume, as well as relative contribution of the OU2 Plume to the overall extraction of groundwater of the PWS well, including

[4] Note that 1,2-dichloroethene is the sum of cis-1,2-dichloroethene and trans-1,2-dichloroethene.

water from non-OU2 Plume portions of the aquifer. Outpost well locations and depths were then selected and installed using the modeling to correspond to potential primary and secondary flow paths from the OU2 Plume to each of the PWS wells. The model-generated estimated concentrations of COCs in each of the outpost wells were identified as trigger values. The trigger values were developed to provide for approximately five years early warning prior to the COC being detected at 0.5 µg/L in the downgradient PWS well.

In accordance with the 2003 ROD, exceedance of a trigger value would indicate that well head treatment, or comparable alternative measures, is required and it is time to begin planning wellhead treatment or comparable alternative measures to address the potential for a specific public supply well or well field to be impacted. This process would not preclude the water district(s) from taking any action they deem appropriate.

The modeling used for the 2003 PWSCP[5] predicted impacts from the OU2 Plume to:

- South Farmingdale Water District (SFWD) Plant 1 in 11 years (2014)
- SFWD Plant 3 in 4 years (2007)
- Liberty Utilities Water District – Seamans Neck Road[6] (LUWD-SNR) Wells 3S/4S in 18 years (2021)
- Levittown Water District (LWD) Well 13 (no impact).

Based on additional investigation, it was determined that the OU2 Plume was further south and deeper than originally anticipated. In addition, groundwater flow was determined to be more southernly. As a result, the following outpost monitoring wells were added to the program:

- SFWD Plant 1 - one shallow and five deep wells (BPOW 1-4 through 1-6 that were installed in 2011 and BPOW 1-7 and 1-8 that were installed in 2020)
- SFWD Plant 3 – one deep well (BPOW 2-3 that was installed in 2011)
- LUWD-SNR – two deep wells (BPOW 3-3 and 3-4 that were installed in 2011)
- SFWD 6 – seven deep wells (BPOW 5-1 through 5-3 that were installed in 2012 and BPOW 5-4 through 5-7 that were installed in 2015)

[5] At the time of the 2003 PWSCP, none of the refenced PWS wells had treatment for VOCs in the extracted groundwater prior to distribution. Since that time, treatment is used as needed to remove contaminants from the water to comply with the New York State Department of Health (NYSDOH) maximum contaminant levels (MCLs) prior to distribution.
[6] Liberty Utilities Water District (also known as Liberty Utilities New York) was formerly known at Aqua New York and New York American Water.

- Massapequa Water District (MWD) Public Water Supply (PWS) Wells 4 and 5 - six deep wells (BPOW 6-1 through 6-6 that were installed in 2014 and 2015)

Trigger values were established for most of these new wells in two addenda prepared in 2015 and 2016 (Resolution, 2015 and Resolution, 2016). Trigger values were not established for two sets of the outpost monitoring wells. For BPOW 2-1 and 2-2, these values were not established because of the proximity of these wells to the PWS was less than 5 years. For BPOW 1-7 and 1-8, these wells were only recently installed (2020), and potential trigger values for these two wells are considered in this report.

1.2 Conceptual Site Model Update

Since the issuance of the 2003 PWSCP, there has been significant progress in the delineation of the OU2 Plume, mapping of the local geology, and understanding of groundwater and plume migration pathways. Approximately 80 vertical profile borings to depths up to 1,000 feet and 170 monitoring wells have been installed, and approximately 10,000 groundwater samples have been collected and analyzed. In addition, groundwater remedial systems have been installed and are operating. These systems have mitigated much of this plume. These systems include the OU1 Site 1 air sparging and soil vapor extraction system, the OU2 Onsite Containment System, the GM38 Area Hotspot Treatment System, the Phase I (recovery well RW4) RE108 Area Hotspot Treatment System, and the RE137 Interim Treatment System. Additional actions are expected to be in operation within the next few years that would further control the migration of the OU2 Plume.

Also, well head protection treatment systems have been implemented or are in the planning stage for those public water supplies that have actual or prospective VOC and/or 1,4-dioxane impacts. These actions are detailed in the various documents including the following:

- 2021 CERCLA Five-Year Review Report (Navy, 2021a)
- 2021 Annual Report for Groundwater Impacts (Navy, 2021b)
- 2021 Explanation of Significant Differences to the OU2 Record of Decision (Navy, 2021c)

As detailed below, each of these factors has reduced or eliminated the need for trigger values in the outpost monitoring wells.

Based on the recent field investigations, the horizontal and vertical extents of the OU2 Plume and the associated RE108 Area Hotspot sub plume were found to be more extensive than estimated in the 2003 ROD. At the time of the 2003 PWCP, the downgradient boundary of the OU2 Plume was estimated to be north of the Hempstead

Turnpike (5,000 feet from the Northrop Grumman facility) (Arcadis, 2000). Major changes to the understanding of the OU2 Plume are as follows:

- The OU2 Plume is estimated to extend south to approximately the Southern State Parkway (14,000 feet from the former Northrop Grumman facility) (Figure 2).
- An eastern finger of the OU2 Plume (GM38 Area Hotspot) has been contained and remediated via the GM38 Groundwater Treatment System.
- Regional groundwater flow that controls the movement of the OU2 Plume is more southernly and moves faster than previously modeled.

The current nature and extent of the OU2 Plume remains mostly defined by TCE (Figures 2 and 3). These figures are based on water quality data collected through 2021 as detailed in the *2021 Annual Groundwater Sampling Data Report, OU2 VOC and 1,4-Dioxane Investigation* (Tetra Tech, 2022b). While the development of the OU2 Plume boundary is based primarily on TCE data and groundwater flow, as indicated in the OU2 ESD (Navy, 2021), the OU2 Plume has been updated to include 1,4-dioxane, resulting it its boundary being extended to the south. 1,4-Dioxane can move with groundwater and migrate slightly faster than TCE, whose migration is attenuated by degradation and adsorption factors.

Other VOC and 1,4-dioxane plumes are located in close proximity to, and in some locations commingled with, the OU2 Plume, including the OU3 Plume, one or more PCE plumes characteristic of dry cleaner releases, a benzene plume characteristic of a gasoline release, as well as similar VOC releases by other industries in the area. These other plumes can be located above, below, or adjacent to the OU2 Plume.

1.3 Groundwater Remedial Activities

Groundwater remedial activities that are currently underway to intercept and cleanup the OU2 Plume are as follows (Figure 3):

- Northrop Grumman Onsite Containment System (Wells 1, 3R, 17. 18, and 19) that uses air stripping to remove VOCs (started operation in 1998)
- Navy GM38 Groundwater Treatment Plant (RW1 and RW4) that uses air stripping, advanced oxidation process (AOP), and granular activated carbon (GAC) treatment technologies to remove VOCs and 1,4-dioxane (started operation in 2009 and 2021, respectively)
- Navy RE108 Area Hotspot Phase I Interim Treatment System (RE137) that uses AOP and GAC treatment technologies to remove VOCs and 1,4-dioxane (started operation in 2022)

- Navy RE108 Area Hotspot Phase II Treatment System (RW5, RW6, and RW7) that uses air stripping, AOP, and GAC treatment technologies to remove VOCs and 1,4-dioxane (under construction, anticipated startup in late-2023
- Navy Phase III Southern Plume Intercept System (RW8, RW9, RW10, and potentially RW11) that will likely use AOP and GAC treatment technologies to remove VOCs and 1,4-dioxane (predesign testing underway, anticipated startup in 2025).

These remedial activities will remove mass and intercept the leading edge of the OU2 Plume as practicable.

In addition, Northrop Grumman is installing remedial systems to remove VOCs from soil and groundwater under its OU3 Program. This program includes extraction and VOC treatment of groundwater at the Bethpage Community Park (Wells RW1 through RW4), installation and operation of the OU3 Hotspot Treatment System (RW20, RW21, and RW22) (currently undergoing startup), and investigation of VOC-impacted groundwater downgradient of the OU3 Plume.

1.4 VOC and 1,4-Dioxane Evaluation of Existing Outpost Monitoring Wells

This section presents an overview of the VOC and 1,4-dioxane concentrations in each of the outpost monitoring wells and potential impacts to the associated PWS well. The potential impact to PWS wells from a groundwater plume is dependent on the location of the plume, natural migration of the plume with groundwater, contaminant concentration, the location of the PWS, the pumping rate of the PWS, and local geology. Particle track – computer modeling (Appendix A) is used estimate groundwater flow pathways and timing. Since the regional groundwater flow is from north to south, the majority of the groundwater entering a PWS in the area is from the north; and based on the horizontal layering of the local geology, the majority of the groundwater is typically from a depth similar to the PWS well screen[7].

<u>SFWD Plant 1 Outpost Monitoring Wells</u>

Based on additional delineation of the OU2 Plume as well as a better understanding of groundwater flow, SFWD Plant 1 has been determined to be too far east of the OU2 Plume for the SFWD Plant 1 PWS wells to intercept it. While VOCs and/or 1,4-dioxane have been detected in several of the shallow outpost wells associated with SFWD Plant 1 (BPOW 1-1 to 1-4), the origin of these VOCs and 1,4-dioxane is east of the OU2 Plume. Also, even though recently added outpost wells BPOW 1-7 and 1-8 contain

[7] Water supply wells are normally screened within a conductive zone of the aquifer.

detectable concentrations of VOCs and are deep, modeling indicates that these wells are too far west to be representative of groundwater that would be intercepted by the deep SFWD Plant 1 PWS wells.

Previously, based on groundwater data and modeling from 2000 to 2003, the OU2 Plume was projected to impact the shallow PWS wells at SFWD Plant 1. In response to this concern, an air stripping treatment system was installed and has been operating. Approximately 20 years later, VOCs have not yet been detected in these PWS wells, suggesting that the previous modeling was overly conservative in estimating the magnitude of the VOC plumes in this area and the potential impact to SFWD Plant 1.

While 1,4-dioxane is present in two of the Plant 1 outpost wells, the detected concentrations are relatively low (0.11 to 0.24 µg/L). Based on the location of SFWD Plant 1 to the east of the OU2 Plume, the 1,4-dioxane in these outpost wells is not associated with OU2 Plume.

SFWD Plant 3 Outpost Monitoring Wells

There are three outpost monitoring wells associated with SFWD Plant 3. Despite the presence of the OU2 Plume to the north, east, and west of Plant 3, VOCs have not been detected consistently in these outpost monitoring wells or the associated PWS well (SFWD Well 3-1). However, in response to the proximity of the OU2 VOC plume to this plant and potential for rapid and significant impact, an air stripping treatment system was installed in 2013 and is operating at this plant.

1,4-Dioxane has been consistently detected in associated outpost monitoring wells and in the SFWD Well 3-1, with most of the recent results exceeding 1.0 µg/L, the current NYSDOH MCL. As a result, SFWD installed an AOP and GAC treatment system in 2021 to reduce the concentrations of 1,4-dioxane in the PWS well to less than the NYSDOH MCLs prior to distribution.

LUWD-SNR Outpost Monitoring Wells

There are four outpost monitoring wells associated with LUWD-SNR. Two of the outpost monitoring wells (BPOW 3-1 and 3-2) are located north of the LUWD-SNR Plant, which is the primary source of groundwater entering this plant. These outpost wells remain free of VOCs.

The other two outpost monitoring wells are located north and east of the LUWD-SNR Plant (BPOW 3-4 and 3-4). The shallower of these other two wells has been relatively free of VOCs (BPOW 3-3) (less than 0.5 µg/L). The deeper well (BPOW 3-4) contains relatively high concentrations of VOCs (i.e., TCE at 181 µg/L). This well is screened below the LUWD-SNR PWS well intake and appears to be associated with a relatively deep finger of the OU2 Plume in this area. Subsequent analysis of the groundwater in this area has concluded that this OU2 Plume finger is moving south past LUWD-SNR, but is located east and deeper than the LUWD-SNR PWS wells.

However, the LUWD-SNR PWS wells are pumping at high enough rates to cause a portion of the OU2 Plume to migrate upward and westward into the LUWD-SNR PWS wells. In response to TCE being detected in these PWS wells, GAC treatment was installed and has been operating. This treatment reduces the VOCs in the PWS wells to less than the NYSDOH MCLs prior to distribution. Over the next few years, the concentration of VOCs at the LUWD-SNR Plant are anticipated to increase and start decreasing as a result of the planned Phase II and Phase II Extension remediation wells improving the groundwater quality in the area.

Each of the outpost monitoring wells associated with LUWD-SNR contains 1,4-dioxane at concentrations ranging from 0.71 to 9.7 µg/L. In addition, LUWD-SNR PWS wells contain 1,4-dioxane at concentrations greater than 1.0 µg/L. As a result, LUWD is installing the AOP treatment technology to reduce 1,4-dioxane concentrations in the PWS wells to less than the NYSDOH MCL prior to distribution.

LWD Well 13 Outpost Monitoring Wells

There are two outpost monitoring wells associated with LWD Well 13 (BPOW 4-1R and 4-2R).[8] Groundwater flow in this area is primarily from north to south. These outpost wells are located north and east of LWD Well 13. Both wells contain relatively high concentrations of Freon 113 (27 to 46 µg/L) and much lower concentrations of several other VOCs. While the initial 2003 PWSCP modeling did not predict an impact to the LWD Well 13 from the OU2 Plume, these wells were installed as a contingency in the event that the OU2 Plume migrated to the west. Subsequent analysis of the groundwater in the area has concluded that the OU2 Plume is generally moving south and remains east of the LWD PWS Well 13. In addition, the relatively high rate of pumping from the LUWD-SNR PWS wells adds a local southeast component to groundwater flow. In response to Freon 113 being detected in the LWD PWS well, air stripping treatment was installed and has been operating at the LWD Well 13 Plant since 2018/2019.

The outpost monitoring wells associated with LWD contain 1,4-dioxane at concentrations ranging from 2.4 to 4.1 µg/L. The 1,4-dioxane in these outpost wells is

[8] In, 2013, outpost monitoring wells BPOW 4-1 and 4-2 were found to be damaged. As a result, these wells were replaced with two new wells BPOW 4-1R and 4-2R in 2014 at the same screen depths and approximate location.

not associated with the OU2 Plume. The status of AOP treatment technology for control of 1,4-dioxane at this plant is uncertain.

SFWD Plant 6 Outpost Monitoring Wells

There are seven outpost monitoring wells associated with SFWD Plant 6. Despite the presence of the OU2 Plume to the north, east, and west of Plant 6, VOCs have not been detected in these outpost monitoring wells or the associated PWS wells. Treatment for VOCs is not anticipated to be required at this plant at this time, but may be needed in the future.

1,4-Dioxane has been consistently detected in 6 of the 7 outpost monitoring wells associated with SFWD Plant 6 PWS wells, with a maximum concentration of 2.1 µg/L. 1,4-Dioxane has also been detected in one of the two PWS wells (SFWD Well 6-2) at a concentration greater than 0.5 µg/L and the 1,4-dioxane concentrations have been trending upward in each of these wells. As a result, SFWD is installing an AOP and GAC treatment system to reduce the concentrations of 1,4-dioxane in the PWS well to less than the NYSDOH MCL prior to distribution. The combination of an AOP and GAC treatment system has the added benefit of removing VOCs from the extracted water should they migrate to this well.

MWD Wells 4 and 5 Outpost Monitoring Wells

There are six outpost monitoring wells associated with MWD Wells 4 and 5. Each of these wells are located between the OU2 Plume and the MWD Plant. Site-related VOCs have not been detected in these outpost monitoring wells or the MWD PWS wells.

1,4-Dioxane has been consistently detected in 2 of the 6 outpost monitoring wells. These two wells are screened at a depth of approximately 550 to 570 feet bgs. The maximum concentration detected was 0.6 µg/L and there is trend of increasing concentrations. 1,4-Dioxane has not been detected (or detected infrequently) in the other four outpost wells in this area. The Navy does not have evidence of 1,4-dioxane being detected in these MWD PWS well, but will continue to monitor available data.

1.5 PWS Treatment Systems

In response to actual or prospective impacts to PWS wells within or downgradient of the OU2 Plume, the Navy or the water supplier has or is planning to install and operate treatment for OU2 VOCs and/or 1,4-dioxane. The anticipated treatment efficiency (design) for each of the PWS wells associated with outpost monitoring wells is summarized in Table 2. The current status of treatment for each PWS well field is discussed below.

- SFWD Plant 1. Filtration and air stripping treatment technologies have been installed to treat iron and VOCs in water from the shallow PWS wells. No treatment is in place for water from the deep PWS wells at this plant.
- SFWD Plant 3. Filtration, air stripping, AOP, and GAC treatment technologies have been installed to treat iron, VOCs, and 1,4-dioxane in water from the supply well. The addition of AOP and GAC treatment technologies was in response to the presence of 1,4-dioxane in the PWS well at a sustained concentration greater than 1.0 µg/L, the current NYSDOH MCL and the presence of 1,4-dioxane at a maximum concentration of 4.5 µg/L in one of the associated outpost monitoring wells in 2022.
- LUWD-SNR. Filtration and GAC treatment technologies have been installed to treat iron and VOCs in water from the PWS wells. Based on the presence of 1,4-dioxane in the PWS wells at a concentration greater than 1.0 µg/L, an AOP treatment system is being installed that would also remove higher concentrations of VOCs and 1,4-dioxane.
- SFWD Plant 6. Filtration, AOP, and GAC treatment technologies are being installed to treat iron, VOCs, and 1,4-dioxane in water from one of the two supply wells (Well 6-2). The second well (Well 6-1) is not frequently used and is not expected to be impacted from the OU2 Plume in the near future. In response to 1,4-dioxane being detected in SFWD Well 6-2 at concentrations exceeding one half the NYSDOH MCL of 1.0 µg/L, SFWD is installing filtration, AOP, and GAC treatment at Plant 6 to remove iron, 1,4-dioxane, and VOCs from the PWS well prior to distribution.
- LWD Well 13. Town of Hempstead has installed an air stripping system to treat for VOCs in water from the supply well. The plans for additional treatment at this location is uncertain at this time.

2.0 Groundwater Modeling

Groundwater modeling is used to evaluate the current nature and extent of contamination, how this contamination migrates with groundwater to the south, and potential impacts to downgradient public water supplies.

To support evaluation of the migration and potential impacts associated with the OU2 Plume, the Navy developed a three-dimensional groundwater flow model - *Documentation of the Construction and Calibration of 3-D Groundwater Flow and Solute Transport Model for Former NWIRP Bethpage* (Tetra Tech, 2022a). While this model was primarily developed based on data through 2021 including pumping tests conducted in the northern and central portion of the OU2 Plume, initially data was lacking in the area near and south of the Southern State Parkway.

As a result, pumping tests were conducted using the newly installed recovery wells RW8 and RW9 (see Figure 2) and associated monitoring wells in late 2022. The existing groundwater model was updated with this information. The evaluation concluded that the model effectively predicts groundwater movement in that area (Appendix A). The modeling was conducted using two scenarios, one scenario was with the continued use of the remedial systems that are currently in operation (identified as current operation) and the second scenario was with the addition of the planned Phase II and Phase III treatment systems in operation (future operation). Appendix A provides additional detail on the pumping rates of various wells, including the PWS wells.

The objectives of the current modeling effort to support PWSCP development are as follows:

1. Model the travel pathway and time required for PWS wells to intercept groundwater from each of the outpost monitoring wells.
2. Model the width and direction of the capture zone for SFWD Plants 3 and 6, and MWD Wells 4 and 5 to estimate the contribution area correction factor (CACF).

The results of this evaluation for Objective 1 are summarized in Tables 3 and 4, under the column “Travel Time to Public Water Supply (Current/Future) (Years)” and discussed below. The results of Objective 2 are used to support the development of CACF also presented in Tables 3 and 4. The purpose and development of the CACFs are discussed below.

The primary purpose of the CACF is to incorporate the effects of the volumetric flow of groundwater plume relative to the extraction rate of an extraction (PWS) well. Contaminant fate and transport models incorporate this concept in calculating impacts. However, the modeling requires well-established and accurate plume definition, a detailed understanding of the extraction well pumping rates, and groundwater flow. Since it is not feasible to fully characterize all of the water entering a PWS well, strategic wells are placed and monitored. Each outpost monitoring well is selected to represent a single flow pathway for groundwater entering the PWS well, generally the primary and secondary flow pathways. The CACF is used to conservatively represent the impact of COCs in groundwater from a single outpost monitoring well on the concentration of that COC in the associated PWS extraction well. These factors are developed as follows.

CACF of 1 – This factor is assigned to those outpost monitoring wells that are on the primary flow path, both horizontally and vertically, for the capture zone of a PWS well. Impacts to these outpost monitoring wells and PWS wells would indicate that the center line of a groundwater plume is flowing directly, through the outpost monitoring well, and into a PWS well. Attenuation effects from other groundwater that is horizontally or vertically outside of this primary flow path would only occur after long-term high-rate extraction of the groundwater.

CACF of 2 – This factor is assigned to those outpost monitoring wells that are not on the primary flow path, either horizontally or vertically, for the capture zone of a PWS well. The use of this factor indicates that at least 50 percent of the groundwater entering PWS well is not intercepting the groundwater plume, as monitored by these outpost wells. An impact to one of these secondary outpost monitoring wells and PWS well would indicate that the center line of a groundwater plume is flowing above, below, or to the side of the PWS well, but is being pulled into the extraction well by the pumping.

CACF of 4 – This factor is assigned to those wells that are only marginally within the capture zone of a PWS well. The use of this factor indicates that at least 75 percent of the groundwater entering PWS well is not intercepting the groundwater plume as monitored by these outpost wells. Impacts from groundwater monitored by these wells would only result during extended high-rate pumping of the PWS wells.

SFWD Plant 1 Outpost Monitoring Wells

As indicated in Tables 3 and 4, the computer modeling supports the location of BPOW 1-1 through 1-6 as being within the capture zone for the appropriate shallow and deep PWS wells at SFWD Plant 1. In addition, the predicted travel times from the outpost well to the PWS wells (current) are in the 5- to 12-year range. These estimates are generally consistent with the 2003 PWSCP objective of providing a 5-year notice of potential impact.

The modeling confirmed that the primary source of groundwater entering SFWD Plant 1 is from the north, with lessor amounts of groundwater entering from the northeast and northwest. As a result, the CACF for BPOW 1-4 through 1-6 (being directly in line with groundwater flow is “1”, whereas as the CACF for BPOW 1-1 through 1-3 is “2”.

The current modeling also indicates that groundwater associated with BPOW 1-7 and 1-8 would not be captured by SFWD Plant 1 or other PWS wells. As a result, these wells should not be considered outpost monitoring wells.

SFWD Plant 3 Outpost Monitoring Wells

As indicated in Tables 3 and 4, the computer modeling supports the location of BPOW 2-1 through 2-3 as being within the capture zone for the PWS well at SFWD Plant 3. In addition, the predicted travel time from the outpost wells to the PWS wells (current) is less than 5 years, consistent with the previous estimates.

The primary source of groundwater entering SFWD Plant 3 is from the north at the depth interval consistent with BPOW 2-3, with lessor amounts of groundwater entering from the shallower depth. As a result, the CACF for BPOW 2-3 is “1”, whereas as the CACF for BPOW 2-1 and 2-2 is “2”.

LUWD-SNR Outpost Monitoring Wells

As indicated in Tables 3 and 4, the computer modeling supports the location of BPOW 3-1 through 3-4 as being within the capture zone for the PWS well at LUWD-SNR. However, the travel times predicted for groundwater from Wells 3-1 and 3-2 are less than 5 years, contrary to the 5 years targeted in the 2003 ROD.

The estimated travel time for groundwater from BPOW 3-3 and 3-4 to the LUWD-SNR Plant under current conditions is 5 years and 13 years, respectively. BPOW 3-3 is screened at the same depth at the LUWD-SNR PWS wells, whereas BPOW 3-4 is located deeper. Under the future scenario, recovery wells RW7A and RW7B will be extracting groundwater in close proximity to BPOW 3-3 and 3-4, and would reduce or eliminate the projected capture of groundwater from these PWS wells. This action is expected to help control the OU2 Plume in this area and reduce impacts on the LUWD-SNR Plant in the future.

The primary source of groundwater entering LUWD-SNR is from the north. Under current conditions, groundwater capture from the east is limited by the operation of SFWD PWS wells and groundwater capture from the west is limited by the operation of Town of Hempstead (LWD) PWS wells. As a result, the CACF for BPOW 3-1 and 3-2 is “1”, whereas as the CACF for BPOW 3-3 and 3-4 is “2”.

LWD Well 13

As indicated in Tables 3 and 4, the computer modeling supports the location of BPOW 4-1R and 4-2R as being within the capture zone of LWD Well 13. However, the travel times predicted for groundwater from BPOW 4-1 and 4-2 are less than 5 years, contrary to the 5 years targeted in the 2003 ROD.

The primary source of groundwater entering LWD Well 13 is from the north, whereas BPOW 4-1R and 4-2R are located to the northeast. Under current conditions, groundwater capture from the east is limited by the operation of LUWD-SNR and groundwater capture from the west is limited by the operation of other Town of Hempstead (LWD) PWS wells. As a result, the CACF for BPOW 4-1R and 4-2R is “2”. As previously indicated, groundwater in the PWS well and BPOW 4-1R and 4-2R are not consistent with the characteristics of the OU2 Plume.

SFWD Plant 6

As indicated in Tables 3 and 4, the computer modeling indicates that groundwater associated with outpost monitoring wells BPOW 5-1 through 5-6 do not flow to SFWD Plant 6. Rather, groundwater from these six outpost monitoring wells flows to LUWD-SNR. Only groundwater from the eastern most outpost monitoring well (BPOW 5-7) is intercepted by SFWD Plant 6. Evaluation of the capture zone analysis for this PWS well indicates that the capture zone for SFWD Plant 6 is from the northeast, likely as a result of the relatively high pumping rate at LUWD-SNR and to a lesser extent, SFWD Plant 3 to the north.

The estimated travel time from BPOW 5-7 to SFWD Plant 6 is 11 to 14 years, which is longer than the 5-year travel time identified in the 2003 ROD.

Because BPOW 5-7 is directly in line with the capture zone for SFWD Plant 6, the CACF is “1”. Regarding BPOW 5-1 through BPOW 5-6, because these wells are located to the east of LUWD SNR, a CACF is “4” for potential impacts to LUWD-SNR.

MWD Wells 4 and 5

As indicated in Tables 3 and 4, the computer modeling supports the location of BPOW 6-1 through 6-6 as being within the capture zone for MWD Well 5. However, the travel time predicted for groundwater from BPOW 6-1 through BPOW 6-6 range from 11 to greater than 30 years, which is much higher than the 5 years targeted in the 2003 ROD.

The primary source of groundwater entering MWD Wells 4 and 5 is from the north. However, the operation of Navy recovery wells RW8 through RW10A are expected to be online within three years. The operation of these wells will expand the capture zone MWD Wells 4 and 5 to the east and west. As a result of the expansion of the MWD Wells 4 and 5 capture zone, the CACF for each of the BPOW 6-1 through 6-6 outpost monitoring wells is “2”.

In order to better evaluate potential impacts to the MWD Wells 4 and 5 from the OU2 Plume, new outpost wells in closer proximity to the MWD plant would be required. These outpost wells would address both of the PWS wells at this location. The Navy is working on identifying the number, location, depths of these wells. Preliminary locations are presented in Figure 4.

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3.0 Trigger Value Development and PWSCP Monitoring Requirements

The revised trigger values for the outpost monitoring wells are developed and discussed in this section. Tables 3 and 4 present the new trigger values for VOCs and 1,4-dioxane, respectively. Also presented in this section are recommendations for classification and ongoing sampling and analysis of the outpost monitoring wells.

SFWD Plant 1

The outpost monitoring wells associated with SFWD Plant 1 do not provide early warning for potential impacts from OU2 site-related VOCs or 1,4-dioxane. As a result, BPOW 1-1 through BPOW 1-8 should no longer be identified as outpost monitoring wells. These wells should continue to be monitored on a semi-annual basis until the Phase II and Phase III treatment systems are brought online (two to three years), and then annually for five years.

SFWD Plant 3

The outpost monitoring wells associated with SFWD Plant 3 provide early warning for potential impacts from site-related VOCs and 1,4-dioxane. However, SFWD Plant 3 has existing wellhead treatment in place that is designed to remove VOCs by greater than 99.99 percent and 1,4-dioxane by 99.5 percent. As a result, BPOW 2-1 through BPOW 2-3 no longer provide value as outpost monitoring wells. These wells should continue to be monitored on a semi-annual basis until the Phase II and Phase III treatment systems are brought online (two to three years), and then annually for five years.

LUWD-SNR

The outpost monitoring wells associated with LUWD-SNR provide early warning for potential impacts from site-related VOCs or 1,4-dioxane. However, LUWD-SNR is installing wellhead treatment that is designed to remove most VOCs by 99.99 percent and 1,4-dioxane by 99.5 percent. Freon 113, a minor component of the OU2 Plume, is not effectively removed by the AOP technology and is not efficiently removed by GAC. In the event that Freon 113 concentrations continue to increase in the PWS wells, an air stripping treatment system would be required in the future. As a result, BPOW 3-1 and BPOW 3-2 should continue to be monitored on a quarterly basis to provide early warning for potential Freon 113 impacts. BPOW 3-3 and 3-4 no longer provide value as outpost monitoring wells, but should continue to be monitored on a semi-annual basis until the Phase II and Phase III treatment systems are brought online (two to three years), and then annually for five years.

SFWD Plant 6

BPOW 5-7 provides early warning for potential impacts from site-related VOCs or 1,4-dioxane to SFWD Plant 6. However, SFWD Plant 6 is installing wellhead treatment that is designed to remove VOCs by greater than 99.99 percent and 1,4-dioxane by 99.5 percent. As a result, BPOW 5-1 through BPOW 5-7 no longer provide value as outpost monitoring wells. These wells should continue to be monitored on a semi-annual basis until the Phase II and Phase III treatment systems are brought online (two to three years), and then annually for five years.

MWD Wells 4 and 5

The outpost monitoring wells associated with MWD Wells 4 and 5 provide early warning for potential impacts from site-related VOCs or 1,4-dioxane for MWD Well 5. However, these wells are too far north to be consistent with the goal of the 2003 PWSCP to provide 5 years of advance notice of potential impacts. In addition, with the planned operation of the Phase III treatment system, OU2 Plume-impacted groundwater may not reach these PWS wells. Also, the current outpost monitoring wells do not track the shallow groundwater that may impact MWD Well 4.

The existing outpost monitoring wells should continue to be tested on a quarterly basis until new outpost wells are installed to the south. Approximately two shallow and two deep outpost wells should be installed at a location to provide an approximate 5-year notice of OU2 Plume impact to MWD Wells 4 and 5, respectively. Planning documents for these wells are in progress. These wells would also be used to evaluate whether the Phase III treatment system is effective at controlling the migration of the OU2 Plume.

Note that during the May 2023 NYSDEC review of the draft March 2023 PWSCP, NYSDEC tasked the United States Geological Survey (USGS) to conduct an evaluation of groundwater flow in the area south of Southern State Parkway. As discussed in Appendix B, the USGS modeling indicated faster groundwater travel times than that provided by the Navy modeling. Based on a review of the modeling efforts, current analytical data, and discussions with USGS, the Navy has concluded that the Navy's modeling provides a more reasonable representation of groundwater flow in this area, but additional data in the area would help resolve some uncertainty with the local geology. This data will be collected during the installation of the new outpost wells.

4.0 Conclusions and Recommendation

This PWSCP updates and replaces the 2003 PWSCP and addenda issued for the 2003 OU2 ROD. Factors that led to this update are as follows.

- Over the past 20 years, there have been extensive hydrogeological and groundwater investigations conducted in the area downgradient of the former NWIRP Bethpage.
- These investigations have substantially increased the Navy's understanding of the horizontal and vertical extent of the OU2 Plume, as well as its migration.
- In 2021, the Navy issued an ESD for the OU2 ROD that modified the remedy, including:
  - Addition of 1,4-dioxane as an OU2 Plume COC.
  - Extended the use of groundwater extraction, treatment, and discharge remedies to groundwater than contain more than 150 µg/L of VOCs (this concentration was formerly 1,000 µg/L). This action will reduce and eventually eliminate potential impacts for PWS wells within or in close proximity to the OU2 Plume.
  - Implementation of groundwater extraction system near the Southern State Parkway (Phase III treatment system) to incept the OU2 Plume in this area, as practicable. This action will reduce or eliminate to the extent practicable potential impacts for PWS wells located to the south of the OU2 Plume.
- While the OU2 Plume remains defined primarily by TCE and the addition of 1,4 dioxane as COC does not affect the northern or side boundaries of the OU2 Plume previously presented, it does result in the downgradient boundary of the plume being extended to the south.
- Since 2003, VOC treatment have been installed and are operating to comply with NYSDOH MCLs for each of the PWS wells that were identified as being potentially impacted the OU2 Plume, including SFWD Plant 1 and SFWD Plant 3, and LUWD. In addition, 1,4-dioxane treatment has been installed or is being installed to comply with NYSDOH MCLs for each of the PWS wells that are currently projected to be impacted by the OU2 Plume. The United States government has provided funding for each of these treatment systems.
- With the installation of treatment at each of the PWS facilities that may be affected by the OU2 Plume, the need for outpost monitoring wells has decreased or been eliminated. Note that these wells may continue to be sampled as part of

the overall monitoring well network for the OU2 Plume that currently includes over 150 wells.

- Starting in 2024, the status of the current outpost wells will be changed as follows:
  - BPOW 1-1 through BPOW 1-8 (SFWD Plant 1): Because these wells do not monitor OU2 Plume groundwater that may impact SFWD Plant 1, they will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 2-1 through BPOW 2-3 (SFWD Plant 3): Because wellhead treatment is in place and is operating to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 3-1 and BPOW 3-2 (LUWD-SNR): Because these wells monitoring groundwater than may contain much higher levels of Freon 113 (from an adjacent plume) and the existing and currently planned wellhead treatment provides limited protection from this chemical, these wells will remain as outpost monitoring wells and continue to be sampled on a quarterly basis.
  - BPOW 3-3 and BPOW 3-4 (LUWD-SNR): Because wellhead treatment is in place and is operating to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 4-1R and 4-2R (LWD Well 13). Because these wells are not within the flow pathway for the OU2 Plume, wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.
  - BPOW 5-1 through BPOW 5-7 (SFWD Plant 6): Because wellhead treatment that is expected to be installed and operating in the near future to effectively reduce current and potential future OU2 Plume COCs to less than the NYSDOH MCLs prior to distribution, these wells will no longer be considered outpost monitoring wells. These wells will continue to be sampled and analyzed on a semi-annual basis for 2 to 3 years, and then annually for five years.

- BPOW 6-1 through BPOW 6-6 (MWD Well 5). Under current conditions (without the Phase III treatment system operating) these wells are anticipated to provide 11 years to greater than 30 years advance notice of potential migration from the outpost wells to MWD Well 5. With the planned construction and operation of the Phase III treatment system within the next three years, the calculated travel times are estimated to increase to 22 to greater than 30 years, which is too long to effectively evaluate potential impacts to this MWD well field (MWD Wells 4 and 5). As such, four new outpost wells (BPOW 6-7 through 6-10) will be installed to the north and northwest of this MWD field and south of the current outpost monitoring wells. These locations are expected to provide a minimum of 5 years notice under current conditions, and 5 to 10 years under the planned operation of the Phase III treatment system.

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TABLES

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Table 1
Outpost Monitoring Well Groundwater Quality (2022) and Current TVOC Trigger Values
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Outpost Well ID	Associated Public Water Supply	Outpost Well Screen Interval (feet bgs)	Current TVOC Trigger Value (µg/L)	Maximum Concentration TVOC (µg/L)	Maximum Concentration VOC (µg/L)	VOC Associated with Maximum Concentration	Maximum 1,4-Dioxane Concentration (µg/L)
BPOW 1-1[(1)]	SFWD Plant 1	196 - 241	0.6	0.46	0.46	TCE	ND
BPOW 1-2[(1)]	SFWD Plant 1	310 - 335	0.6	0.78	0.78	TCE	ND
BPOW 1-3[(1)]	SFWD Plant 1	374 - 419	0.6	ND	ND	NA	0.11
BPOW 1-4	SFWD Plant 1	340 - 400	0.67	ND	ND	NA	0.24
BPOW 1-5	SFWD Plant 1	600 - 650	0.67	ND	ND	NA	ND
BPOW 1-6	SFWD Plant 1	700 - 750	0.67	ND	ND	NA	ND
BPOW 1-7	SFWD Plant 1	600 - 640	NA	3.2	3.2	TCE	ND
BPOW 1-8	SFWD Plant 1	725 - 755	NA	0.96	0.96	TCE	ND
BPOW 2-1[(1)]	SFWD Plant 3	356 - 396	NE	ND	ND	NA	0.59
BPOW 2-2[(1)]	SFWD Plant 3	455 - 495	NE	ND	ND	NA	0.74
BPOW 2-3	SFWD Plant 3	564 - 594	0.54	ND	ND	NA	4.5
BPOW 3-1[(1)]	LUWD-SNR	426 - 516	1.5	ND	ND	NA	0.71
BPOW 3-2[(1)]	LUWD-SNR	612 - 647	1.5	ND	ND	NA	2.4
BPOW 3-3	LUWD-SNR	580 - 620	1.13	0.48	0.48	Freon 113	9.1
BPOW 3-4	LUWD-SNR	640 - 690	1.13	197	181	TCE	9.7
BPOW 4-1R[(1,2)]	LWD Well 13	652 - 692	0.54	50	46	Freon 113[(3)]	4.1
BPOW 4-2R[(1,2)]	LWD Well 13	725 - 765	0.57	33	27	Freon 113[(3)]	2.4
BPOW 5-1	SFWD Plant 6	480 - 510	1.2	ND	ND	NA	0.98
BPOW 5-2	SFWD Plant 6	540 - 580	1.2	ND	ND	NA	1.8
BPOW 5-3	SFWD Plant 6	620 - 660	1.2	ND	ND	NA	2.1
BPOW 5-4	SFWD Plant 6	545 - 570	1.4	ND	ND	NA	1.6
BPOW 5-5	SFWD Plant 6	515 - 540	0.7	ND	ND	NA	2.1
BPOW 5-6	SFWD Plant 6	585 - 610	0.7	ND	ND	NA	1.3
BPOW 5-7	SFWD Plant 6	525 - 550	0.8	ND	ND	NA	ND
BPOW 6-1	MWD Wells 4/5	550 - 575	1.8	ND	ND	NA	0.23
BPOW 6-2[4]	MWD Wells 4/5	755 - 780	1.8	ND	ND	NA	ND
BPOW 6-3[4]	MWD Wells 4/5	750 - 775	2.8	ND	ND	NA	0.143
BPOW 6-4	MWD Wells 4/5	545 - 570	2.8	ND	ND	NA	0.6

Table 1
Outpost Monitoring Well Groundwater Quality (2022) and Current TVOC Trigger Values
(Page 2 of 2)

Outpost Well ID	Associated Public Water Supply	Outpost Well Screen Interval (feet bgs)	Current TVOC Trigger Value (µg/L)	Maximum Concentration TVOC (µg/L)	Maximum Concentration VOC (µg/L)	VOC Associated with Maximum Concentration	Maximum 1,4-Dioxane Concentration (µg/L)
BPOW 6-5	MWD Wells 4/5	525 - 550	1.6	ND	ND	NA	ND
BPOW 6-6	MWD Wells 4/5	770 - 795	1.6	ND	ND	NA	ND

bgs – Below ground surface.
BPOW – Bethpage Outpost Well.
BWD – Bethpage Water District.
MWD – Massapequa Water District.
µg/L – Microgram per liter.
VOC – Volatile organic compound.
NA – Not applicable.
TCE – Trichloroethene.
PWS – Public Water Supply.
SFWD – South Farmingdale Water District.
LWD – Levittown Water District (Town of Hempstead).
LUWD-SNR – Liberty Utilities Water District Seamans Neck Road.
TVOC – Total volatile organic compound.
ND – Not detected.
NE – Not established.

1. Original nine outpost wells installed in 2003.
2. BPOW 4-1 and 4-2 were replaced in 2013 as BPOW 4-1R and 4-2R, respectively.
3. Based on the VOCs in these outpost wells being primarily Freon 113 as opposed to TCE, which is a characteristic of the OU2 Plume, and consistent with the 2000 Feasibility Study modeling results used in the 2003 Public Water Supply Contingency Plant, the current impacts to these outpost wells are not associated with the OU2 Plume.
4. For outpost monitoring wells, BPOW 6-2 and 6-3, the laboratory reported results for these wells in November 2022 were 0.51 µg/L and 0.31 µg/L, respectively. 1,4-Dioxane concentrations in samples collected from these wells prior and after November 2022 were generally not detected. As such, it is believed the BPOW 6-1 and BPOW 6-4 samples were switched with the BPOW 6-2 and 6-3 samples and the maximum results presented in Table 1 above are accurate.

Table 2
Outpost Monitoring Well Construction, Associated Public Water Supplies, and Treatment on Public Water Supplies
(Page 1 of 2)

Outpost Well ID	Outpost Well Screen Interval (feet bgs)	Associated Public Water Supply	Distance to Public Water Supply (Mile)	Public Water Supply Treatment/ Design[(1)]	VOC (TCE) Treatment Efficiency (Log Removal)	1,4-Dioxane Treatment Efficiency (Log Removal)
BPOW 1-1	196 - 241	SFWD Plant 1	0.17	FI, AS	1.9	0
BPOW 1-2	310 - 335	SFWD Plant 1	0.17	FI, AS	1.9	0
BPOW 1-3	374 - 419	SFWD Plant 1	0.17	FI, AS	1.9	0
BPOW 1-4	340 - 400	SFWD Plant 1	0.28	FI, AS	1.9	0
BPOW 1-5	600 - 650	SFWD Plant 1	0.28	None	0	0
BPOW 1-6	700 - 750	SFWD Plant 1	0.28	None	0	0
BPOW 1-7	600 - 640	SFWD Plant 1	0.45	None	0	0
BPOW 1-8	725 - 755	SFWD Plant 1	0.45	None	0	0
BPOW 2-1	356 - 396	SFWD Plant 3	0.06	FI, AS, AOP, GAC	6.6	2.7
BPOW 2-2	455 - 495	SFWD Plant 3	0.06	FI, AS, AOP, GAC	6.6	2.7
BPOW 2-3	564 - 594	SFWD Plant 3	0.06	FI, AS, AOP, GAC	6.6	2.7
BPOW 3-1	426 - 516	LUWD-SNR	0.19	FI, AOP[(2)], GAC	4.0	2.7
BPOW 3-2	612 - 647	LUWD-SNR	0.19	FI, AOP[(2)], GAC	4.0	2.7
BPOW 3-3	580 - 620	LUWD-SNR	0.38	FI, AOP[(2)], GAC	4.0	2.7
BPOW 3-4	640 - 690	LUWD-SNR	0.38	FI, AOP[(2)], GAC	4.0	2.7
BPOW 4-1R	652 - 692	LWD Well 13	0.21	AS[(3)]	1.6	0
BPOW 4-2R	725 - 765	LWD Well 13	0.21	AS[(3)]	1.6	0
BPOW 5-1	480 - 510	SFWD Plant 6	0.44	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-2	540 - 580	SFWD Plant 6	0.44	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-3	620 - 660	SFWD Plant 6	0.44	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-4	545 - 570	SFWD Plant 6	0.24	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-5	515 - 540	SFWD Plant 6	0.17	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-6	585 - 610	SFWD Plant 6	0.17	FI, AOP[(4)], GAC	4.0	2.7
BPOW 5-7	525 - 550	SFWD Plant 6	0.29	FI[(4)], AOP[(4)], GAC[(4)]	4.0	2.7
BPOW 6-1	550 - 575	MWD Wells 4/5	0.43	None	0	0

Table 2
Outpost Monitoring Well Construction, Associated Public Water Supplies, and Treatment on Public Water Supplies
(Page 2 of 2)

Outpost Well ID	Outpost Well Screen Interval (feet bgs)	Associated Public Water Supply	Distance to Public Water Supply (Mile)	Public Water Supply Treatment/ Design(1)	VOC (TCE) Treatment Efficiency (Log Removal)	1,4-Dioxane Treatment Efficiency (Log Removal)
BPOW 6-2	755 - 780	MWD Wells 4/5	0.43	None	0	0
BPOW 6-3	750 - 775	MWD Wells 4/5	0.53	None	0	0
BPOW 6-4	545 - 570	MWD Wells 4/5	0.53	None	0	0
BPOW 6-5	525 - 550	MWD Wells 4/5	0.50	None	0	0
BPOW 6-6	770 - 795	MWD Wells 4/5	0.50	None	0	0

bgs – Below ground surface.
BPOW – Bethpage Outpost Well.
BWD – Bethpage Water District.
MWD – Massapequa Water District.
GAC – Granular activated carbon.
FI – Iron filtration.
PWS – Public Water Supply.
SFWD – South Farmingdale Water District.
LWD – Levittown Water District (Town of Hempstead).
LUWD-SNR – Liberty Utilities Water District Seamans Neck Road.
AS – Air stripping.
AOP – Advanced oxidation process technology.

Log Removal – Treatment efficiency is presented on a log removal basis. A log removal of “0” indicates that no removal would occur (10^0). A log removal of “1”, “2”, and “3” correspond to removal efficiencies of 90 percent (10^1), 99 percent (10^2), and 99.9 percent (10^3) respectively.

1. Except as otherwise noted, referenced treatment units are in place and in operation for the PWS well.
2. LUWD-SNR is currently designing and preparing to construct and operate an AOP unit. Iron filtration and GAC units are currently in place and operating.
3. The status of the design and construction of an AOP and GAC system is uncertain at this time.
4. SFWD is in the process of designing and constructing an iron filtration, AOP, and GAC treatment system.

Table 3
Outpost Monitoring Well Trigger Value
Development for Volatile Organic Compounds
(Page 1 of 2)

Outpost Well ID	Associated Public Water Supply	Current TVOC Trigger Value (µg/L)	Travel Time to Public Water Supply (Current/ Future)(Years)	Contribution Area Correction Factor	Treatment Correction Factor	Revised Trigger Value VOC (µg/L)(1)
BPOW 1-1	SFWD Plant 1	0.6	10/10	2	80	NA(2)
BPOW 1-2	SFWD Plant 1	0.6	<5/<5	2	80	NA(2)
BPOW 1-3	SFWD Plant 1	0.6	6/7	2	80	NA(2)
BPOW 1-4	SFWD Plant 1	0.67	7/8	1	80	NA(2)
BPOW 1-5	SFWD Plant 1	0.67	7/7	1	80	NA(2)
BPOW 1-6	SFWD Plant 1	0.67	12/>30	1	80	NA(2)
BPOW 1-7	None(3)	NA(3)	NA(3)	NA(3)	NA(3)	NA(3)
BPOW 1-8	None(3)	NA(3)	NA(3)	NA(3)	NA(3)	NA(3)
BPOW 2-1	SFWD Plant 3	NE	<5/<5	2	4,000,000	>500
BPOW 2-2	SFWD Plant 3	NE	<5/<5	2	4,000,000	>500
BPOW 2-3	SFWD Plant 3	0.54	<5/<5	1	4,000,000	>500
BPOW 3-1	LUWD-SNR	1.5	<5/<5	1	10,000	500
BPOW 3-2	LUWD-SNR	1.5	<5/<5	1	10,000	500
BPOW 3-3	LUWD-SNR	1.13	5/7	2	10,000	>500
BPOW 3-4	LUWD-SNR	1.13	13/NA	2	10,000	>500
BPOW 4-1	LWD Well 13	0.54	<5/<5	2	40(4)	40(4)
BPOW 4-2	LWD Well 13	0.57	<5/<5	2	40(4)	40(4)
BPOW 5-1	LUWD-SNR	1.2	17/13	4	10,000	>500
BPOW 5-2	LUWD-SNR	1.2	15/13	4	10,000	>500
BPOW 5-3	LUWD-SNR	1.2	18/11	4	10,000	>500
BPOW 5-4	LUWD-SNR	1.4	<5/<5	4	10,000	>500
BPOW 5-5	LUWD-SNR	0.7	7/6	4	10,000	>500
BPOW 5-6	LUWD-SNR	0.7	<5/11	4	10,000	>500
BPOW 5-7	SFWD Plant 6	0.8	14/11	1	10,000	>500
BPOW 6-1	MWD Wells 4/5	1.8	26/>30	2	1	1.0 + 20 yrs(5)
BPOW 6-2	MWD Wells 4/5	1.8	11/22	2	1	1.0 + 15 yrs(5)
BPOW 6-3	MWD Wells 4/5	2.8	12/>30	2	1	1.0 + 20 yrs(5)
BPOW 6-4	MWD Wells 4/5	2.8	28/>30	2	1	1.0 + 20 yrs(5)
BPOW 6-5	MWD Wells 4/5	1.6	>30/>30	2	1	1.0 + 20 yrs(5)

Table 3
Outpost Monitoring Well Trigger Value
Development for Volatile Organic Compounds
(Page 2 of 2)

Outpost Well ID	Associated Public Water Supply	Current TVOC Trigger Value (µg/L)	Travel Time to Public Water Supply (Current/ Future)(Years)	Contribution Area Correction Factor	Treatment Correction Factor	Revised Trigger Value VOC (µg/L)[1]
BPOW 6-6	MWD Wells 4/5	1.6	>30/>30	2	1	1.0 + 20 yrs[5]

bgs – Below ground surface.
PWS – Public Water Supply.
BPOW – Bethpage Outpost Well.
SFWD – South Farmingdale Water District.
BWD – Bethpage Water District.
MWD – Massapequa Water District.
LWD – Levittown Water District (Town of Hempstead).
µg/L – Microgram per liter.
LUWD-SNR – Liberty Utilities Water District Seamans Neck Road.
TBD – To be determined.
TVOC – Total volatile organic compound.
VOC – Volatile organic compound.
ND – Not detected.
NA – No applicable.
> – Greater than.

Current/Future – Travel times estimates are affected by the operation of various pumping wells in the area and in particular the operation of Navy Recovery Wells RW5 to RW11. Under current conditions, these wells are not operating, whereas under the future conditions, these wells would be in operation.

Revised Trigger Values (RTVs) are calculated as follows: RTV = 0.5 ug/L x Contribution Area Correction Factor x Treatment Correction Factor.

Current groundwater modeling has determined that groundwater flow in this area is different than had been previously estimated.

1. Trigger values are to be based on individual site-related VOCs, not TVOCs. The goal for the public water supply wells remains at 0.5 ug/L for individual site-related VOCs. Individual well trigger values are based on an assumption that other non-OU2 Plume groundwater entering the PWS wells are free of VOCs.
2. VOCs found in these Outpost Monitoring Wells have been determined to not be associated with the OU2 Plume. Field investigations conducted since the 2003 ROD and PWSCP have determined that SFWD Plant 1 is too far east to be affected by the OU2 Plume.
3. Modeling results under current and future pumping rates indicate that groundwater from this area will not be captured by SFWD Plant 1.
4. Based on the primary VOC in these outpost wells being Freon 113, as opposed to TCE, which is a characteristic of the OU2 Plume, and consistent with the 2000 Feasibility Study modeling results used to support the 2003 Public Water Supply Contingency Plan, the current impacts to these outpost wells are not associated with the OU2 Plume.
5. As an interim approach, when or if the concentration of a site-related VOC is sustained in a current Outpost Monitoring Well at an average concentration of 1.0 ug/L or greater for period of at least one year, then treatment may be required at 20 to 30 years in the future. Once triggered, the Navy will begin discussions with the appropriate water district regarding ongoing monitoring, various treatment alternatives, and the timing and need for wellhead treatment. Earlier, sustained, and increasing concentrations of site-related VOCs in the PWS well would also trigger additional analysis and potentially the need for action. This interim approach would be eliminated once the new MWD Wells 4 and 5 outpost wells are installed and trigger values assigned for them.

Table 4
Outpost Monitoring Well Groundwater
Quality and Trigger Value Development For 1,4-Dioxane
(Page 1 of 2)

Well ID	Associated Public Water Supply	Current Trigger Value (µg/L)	Travel Time to Public Water Supply (Current/ Future)(Years)	Contribution Area Correction Factor	Treatment Correction Factor	1,4-Dioxane Trigger Value (µg/L)(1)
BPOW 1-1	SFWD Plant 1	NA	10/10	2	0	NA(2)
BPOW 1-2	SFWD Plant 1	NA	<5/<5	2	0	NA(2)
BPOW 1-3	SFWD Plant 1	NA	6/7	2	0	NA(2)
BPOW 1-4	SFWD Plant 1	NA	7/8	1	0	NA(2)
BPOW 1-5	SFWD Plant 1	NA	7/7	1	0	NA(2)
BPOW 1-6	SFWD Plant 1	NA	12/>30	1	0	NA(2)
BPOW 1-7	None(3)	NA	NA(3)	NA(3)	NA(3)	NA(3)
BPOW 1-8	None(3)	NA	NA(3)	NA(3)	NA(3)	NA(3)
BPOW 2-1	SFWD Plant 3	NA	<5/<5	2	500	>50
BPOW 2-2	SFWD Plant 3	NA	<5/<5	2	500	>50
BPOW 2-3	SFWD Plant 3	NA	<5/<5	1	500	>50
BPOW 3-1	LUWD-SNR	NA	<5/<5	1	500	>50
BPOW 3-2	LUWD-SNR	NA	<5/<5	1	500	>50
BPOW 3-3	LUWD-SNR	NA	5/7	2	500	>50
BPOW 3-4	LUWD-SNR	NA	13/NA	2	500	>50
BPOW 4-1	LWD Well 13	NA	<5/<5	2	1	NA(4)
BPOW 4-2	LWD Well 13	NA	<5/<5	2	1	NA(4)
BPOW 5-1	LUWD-SNR	NA	17/13	4	500	>50
BPOW 5-2	LUWD-SNR	NA	15/13	4	500	>50
BPOW 5-3	LUWD-SNR	NA	18/11	4	500	>50
BPOW 5-4	LUWD-SNR	NA	<5/<5	4	500	>50
BPOW 5-5	LUWD-SNR	NA	7/6	4	500	>50
BPOW 5-6	LUWD-SNR	NA	<5/11	4	500	>50
BPOW 5-7	SFWD Plant 6	NA	14/11	1	500	>50
BPOW 6-1	MWD Wells 4/5	NA	26/>30	2	1	1.0 + 20 yrs(5)
BPOW 6-2	MWD Wells 4/5	NA	11/22	2	1	1.0 + 15 yrs(5)
BPOW 6-3	MWD Wells 4/5	NA	>30/>30	2	1	1.0 + 20 yrs(5)
BPO W6-4	MWD Wells 4/5	NA	28/>30	2	1	1.0 + 20 yrs(5)

Table 4
Outpost Monitoring Well Groundwater
Quality and Trigger Value Development For 1,4-Dioxane

Well ID	Associated Public Water Supply	Current Trigger Value (µg/L)	Travel Time to Public Water Supply (Current/ Future)(Years)	Contribution Area Correction Factor	Treatment Correction Factor	1,4-Dioxane Trigger Value (µg/L)[1]
BPOW 6-5	MWD Wells 4/5	NA	>30/>30	2	1	1.0 + 20 yrs[5]
BPOW 6-6	MWD Wells 4/5	NA	>30/>30	2	1	1.0 + 20 yrs[5]

bgs – Below ground surface.
SFWD – South Farmingdale Water District.
MWD – Massapequa Water District.
µg/L – Microgram per liter.
NA – No applicable.
PWS – Public Water Supply.
BWD – Bethpage Water District.
LUWD-SNR – Liberty Utilities Water District Seamans Neck Road.
TBD – To be determined.
> – Greater than.
BPOW – Bethpage Outpost Well.
LWD – Levittown Water District (Town of Hempstead).
ND – Not detected.
Yrs – Years.

Current/Future – Travel times estimates are affected by the operation of various pumping wells in the area and in particular the operation of Navy Recovery Wells RW5 to RW11. Under current conditions, these wells are not operating, whereas under the future conditions, these wells would be in operation.

Revised Trigger Values (RTVs) are calculated as follows: RTV = 0.5 ug/L x Contribution Area Correction Factor x Treatment Correction Factor.

Current groundwater modeling has determined that groundwater migration in this area is different than had been previously

1. The goal for the public water supply wells is 0.5 ug/L for 1,4-dioxane. Individual well trigger values are based on an assumption that other non-OU2 Plume groundwater entering the PWS wells are free of 1,4-dioxane.
2. 1,4-Dioxane found in these Outpost Monitoring Wells have been determined to not be associated with the OU2 Plume. Field investigations conducted since the 2003 ROD and PWSCP have determined that SFWD Plant 1 is too far east to be affected by the OU2 Plume.
3. Modeling results under current and future pumping rates indicate that groundwater from this area will not be captured by SFWD Plant 1.
4. Based on the primary VOC in these outpost wells being Freon 113, as opposed to TCE, which is a characteristic of the OU2 Plume, and consistent with the 2000 Feasibility Study modeling results used in the 2003 Public Water Supply Contingency Plant, the current impacts to these outpost wells are not associated with the OU2 Plume.
5. As in interim approach, when or if 1,4-dioxane is sustained in the Outpost Monitoring Wells at an average concentration of at least 1.0 ug/L for period of at least one year, then treatment may be required at 20 to 30 years in the future. Once triggered, the Navy will begin discussions with the appropriate water district regarding ongoing monitoring, various treatment alternatives, and timing and need for wellhead treatment. Earlier, sustained, and increasing concentrations of site-related 1,4-dioxanes in the PWS well would also trigger additional analysis and potentially the need for action. This interim approach would be eliminated once the new MWD Wells 4 and 5 outpost wells are installed and trigger values assigned for them.

FIGURES

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NAVFAC

GENERAL LOCATION MAP
NWIRP BETHPAGE, NEW YORK

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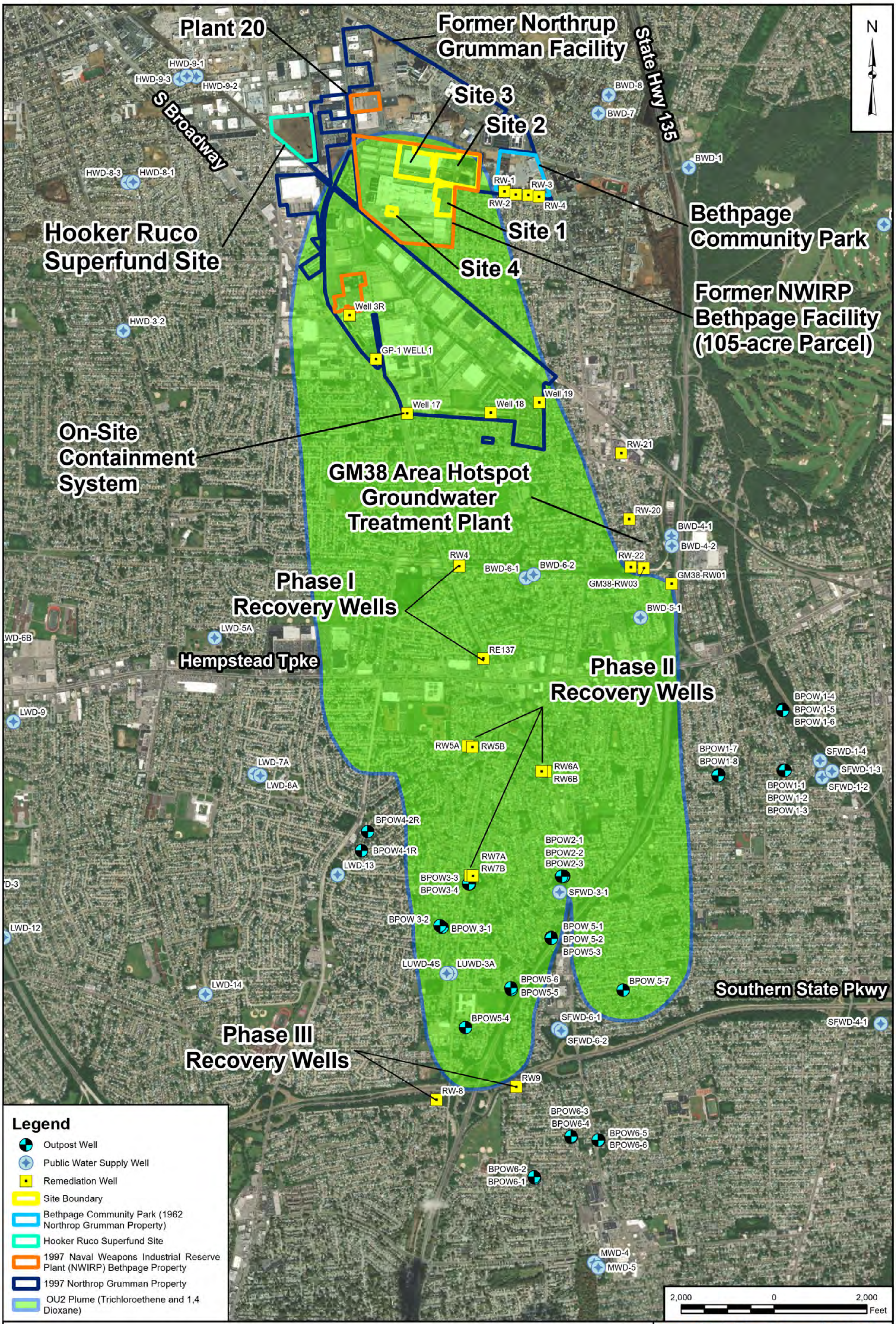
CHECKED BY EW	DATE 03/31/20
FIGURE NUMBER 1	



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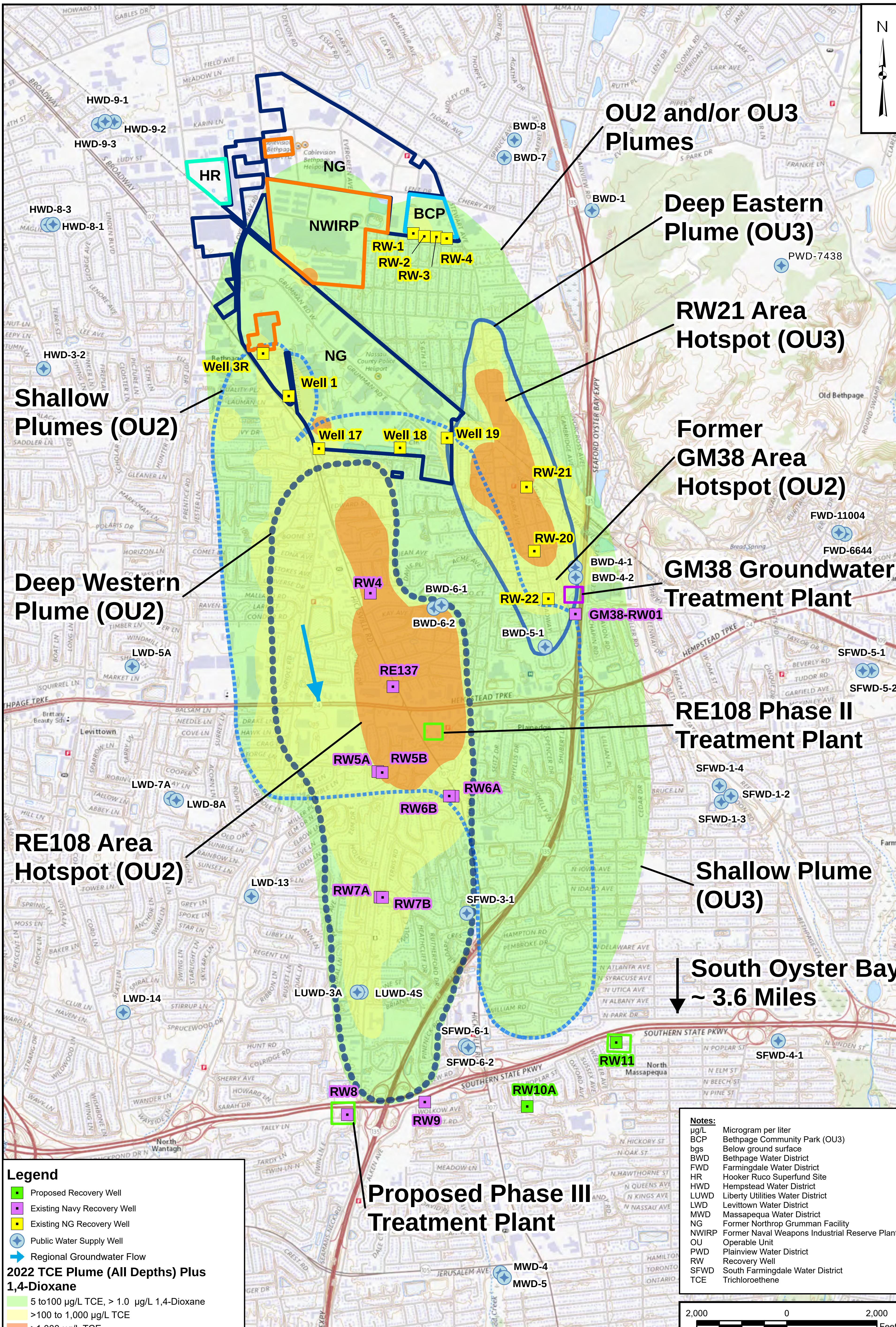
OU2 PLUME AREA AND OUTPOST MONITORING WELL LAYOUT
NWIRP BETHPAGE, NEW YORK

NAVFAC
Naval Facilities Engineering Systems Command

DRAWN BY	DATE	CTO
I. CHAPMAN	7/21/2023	N62470-16-D-9008-WE16
CHECKED BY	DATE	FIGURE NUMBER
D. BRAYACK	7/21/202	2



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PLANNED AND POTENTIAL OU2 & OU3 GROUNDWATER INFRASTRUCTURE
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

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M. SOLANO	9/6/2023	WE13
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R. MOORE	9/6/2023	3

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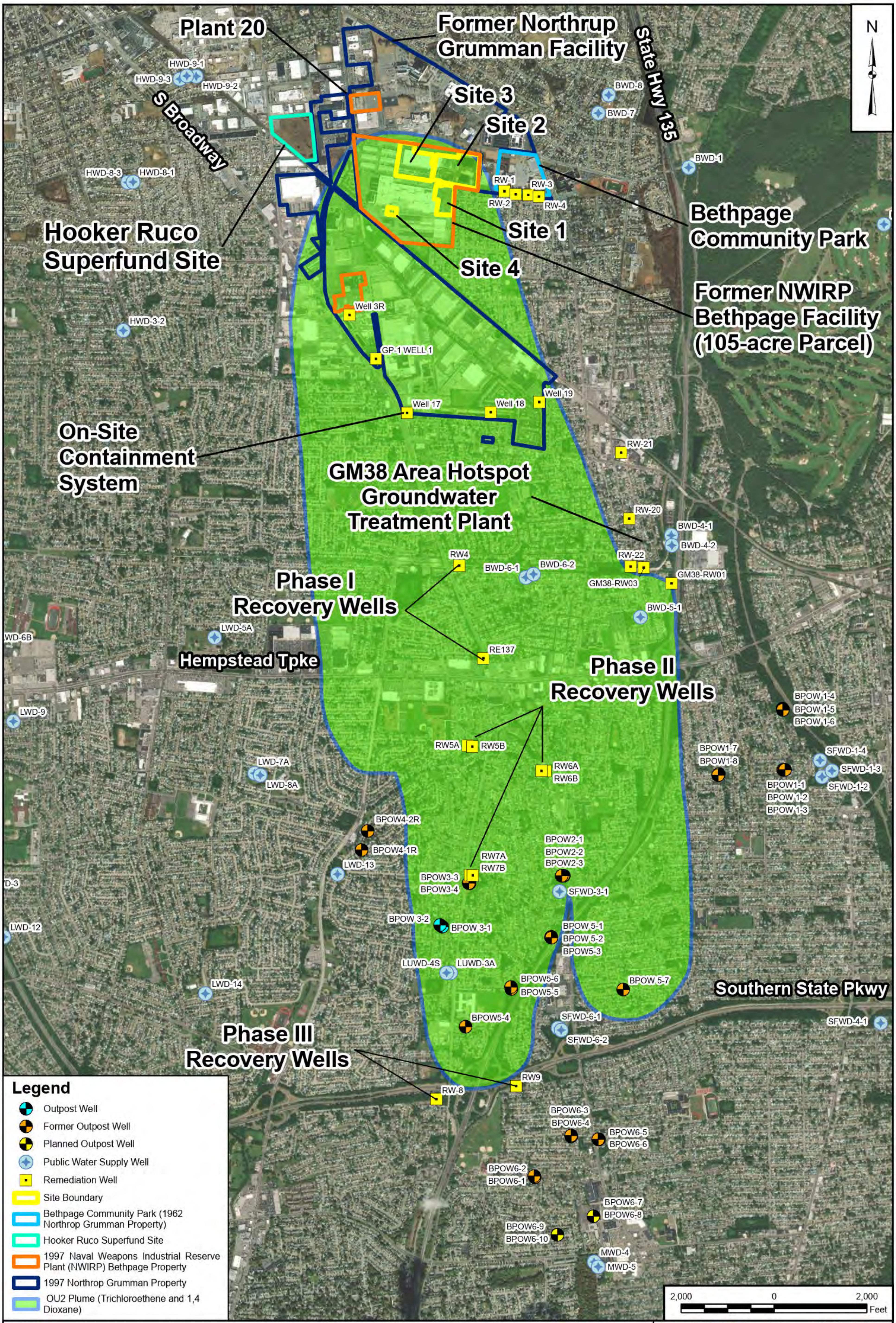

OU2 PLUME AREA AND PLANNED OUTPOST MONITORING WELL LAYOUT
NWIRP BETHPAGE, NEW YORK

NAVFAC
Naval Facilities Engineering Systems Command

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I. CHAPMAN	8/14/2023	N62470-16-D-9008-WE16
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D. BRAYACK	8/14/202	4

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APPENDICES

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APPENDIX A
COMPUTER MODELING DOCUMENTATION

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Appendix A
Outpost Monitoring Well and Local Public Water Supply Well Evaluation – Groundwater Modeling Support, NWIRP Bethpage, New York

Purpose and Approach - The calibrated steady-state finite-difference groundwater model for the former NWIRP Bethpage was used to evaluate groundwater migration pathways (1) from the Bethpage outpost monitoring wells (BPOW) (BPOW 1-1 through BPOW6-6) using forward particle tracking to identify local public water supply (PWS) wells that could intercept groundwater associated with them and their approximate travel times and (2) capture zones from five PWS wells using reverse particle tracking. The forward and reverse particle tracking was conducted under two scenarios, as follows:

- Scenario A Current Condition – All PWS wells operating under average pumping rates plus Navy recovery wells RW-4 and RE137 operating.
- Scenario B Future Condition – All PWS wells operating under average pumping rates plus Navy recovery wells RW-4 through RW-10 and RE137 are operating at the currently-planned minimum pumping rates.

In addition, as a sensitivity analysis, a variation of Scenario B (Scenario B1) was conducted in which the pumping rates for each of the five of the PWS (South Farmingdale Water District [SFWD] Wells 3-1, 6-1, and 6-2 and Massapequa Water District [MWD] 4 and 5) in the area of the Phase III recovery wells (Southern State Parkway) were increased by up to 100 percent (but limited to a maximum rate of 2 million gallon per day [MGD]).

The results of these evaluations are presented below.

Groundwater Modeling Background – The calibrated steady-state finite-difference groundwater model for the former NWIRP Bethpage OU2 Plume was documented in the March 2022 Final Documentation of the Construction and Calibration of 3-D Groundwater Flow and Solute Transport Model. Modifications to the model since this report consist of (1) splitting Model Layer 18 into two layers to better represent laterally continuous fine-grained materials present in the upper portion of the previous layer and (2) to incorporate screen section details in six recently installed Navy recovery wells (RW-5A/5B, RW-7A/B, RW-8 and RW-9) based on actual construction.

Figure A1 presents the locations of the actual and potential Navy and New York State recovery wells in the area of Southern State Parkway. Also presented are public water supply wells in the area.

Figure A2 presents the summary of an optimization process used to establish the reasonable minimum pumping rates (Version 6) to fully capture the OU2 Plume. Minimum pumping rates for RW-8, -9, and -10 would be approximately 450 gallons per minute (GPM) each. Version 6 pumping rates represents the Future Condition (Scenario B) used in this evaluation.

Figures A3 and A4 present the actual well screens and blanks used in the construction of most of the Navy recovery wells. The final location and screen depth for RW-10 has not been finalized. Based on current modeling results, pumping at recovery well RW-11 (not yet installed) may not be required.

Forward Particle Tracking Results from Bethpage Outpost Monitoring Wells – Forward particle tracking was performed from the BPOWs with Navy Recovery Wells RW-5 through RW-7 pumping at the Current Condition (Scenario A) and Future Condition (Scenario B) in order to evaluate where groundwater from the area of these wells are simulated to flow and then be captured by PWS wells or recovery wells.

Figure A5 presents a summary of the construction data for the BPOWs, location and the depths and elevation of the screens. As observed in Figure A5, screen lengths of these wells vary from 20 to 90 feet in length, with most being 25 to 40 feet long. To ensure accurate forward particle tracking, especially where longer well screens occur, a particle was initiated at the top of the screen, mid-point of the screen, and bottom of the screen. For many BPOWs, this action resulted in particles originating in at least two or three model layers.

Figure A6 presents the results of the forward particle tracking from the BPOWs with Navy recovery wells RW-5 through RW-10 offline (Current Condition – Scenario A). Table A-1 presents the depth-specific and BPOW-average travel times (in days and years) for particles released within the BPOW screen and the wells that captures these particles.

Figure A7 presents the results of the forward particle tracking from the BPOWs under the Future Condition (Scenario B) with all Navy recovery wells operating). Table A-2 presents the depth-specific and BPOW-average travel times (in days and years) for particles released within the BPOW screen and the wells that captures these particles.

Comparing these results (Figure A6 versus Figure A7), the primary difference observed is that the capture zone of MWD Well 5 is expanded to the east and west, due to the impacts of pumping at Navy recovery wells RW-8, -9 and -10. This would be expected because the operation of these recovery wells would limit the flow of water from the north. These effects are further illustrated in later figures.

Reverse Particle Tracking from Five PWS Wells – Reverse particle tracking was performed to simulate the capture zone of five PWS wells under current and anticipated future conditions. Figure A8 presents the locations of the five PWS wells evaluated (SFWD Wells 3-1, 6-1 and 6-2; and MWS Wells 4 and 5). Three pumping scenarios were evaluated (Current Condition [Scenario A], Future Condition [Scenario B], and

Future Conditions with increased pumping rates at the PWS wells [Scenario B1]). These scenarios were evaluated with a circle of 25 particles placed within a radius of 50 feet, within the layer(s) where the well screen occurs. The extraction rate presented on the table in Figure A8 represents the 2017 to 2019 long-term average monthly rate, which was used with the Current and Future Conditions.

To provide a more conservative analysis, under Scenario B1, these PWS rates were doubled (and/or rounded to either 1 or 2 MGD, as applicable) to represent an increased demand in the future. The rates of other PWS wells across in the area were not increased for this evaluation, just these five wells in order to maximize the extent of the simulated capture zone.

Figures A9 to A11 present the simulated capture zone for the three SFWD wells and Figures A12 and A13 present the simulated capture zone for the two MWD wells under the Current Condition (Scenario A). Additional particles were placed immediately north of the two MWD wells (Wells 4 and 5) in order to better represent the simulated capture zone due to the orientation of the two wells that resulted in a perceived gap along the central axis of the capture area. These additional particle locations were not added to the two other pumping scenarios but would result in similar in-filling if they were added (i.e., there is no gap in reverse particle tracking).

Figures A14 to A16 present the simulated capture zone for the three SFWD wells and Figures A17 and A18 present the simulated capture zone for the two MWD wells, both under the Future Condition (Scenario B). For SFWD, a comparison of the particle tracks in Figures A9 to A11 (current) with Figures A14 to A16 (future) indicates that the additional pumping from recovery wells RW-5 through RW-10 will cause the capture zones for these SFWD wells to extend further north and east. For MWD, a comparison of the particle tracks in Figures A12 and A13 (current) with Figures A17 and A18 (future) indicates that the additional pumping from recovery wells RW-5 through RW-10 will cause the capture zone for MWD Well 5 to be expanded to the east and west. However, the recovery wells would have only a limited effect on the capture zone of MWD Well 4, likely due the screen interval on MWD Well 4 being relatively shallow.

Figures A19 to A21 present the simulated capture zone for the three SFWD wells and Figures A22 and A23 present the simulated capture zone for the two MWD wells under increased pumping rates under the potential Future Condition (Scenario B1). Under Scenario B1, due to the increased pumping, the capture zones are similar to those under Scenario B but are expanded outward slightly.

TABLE A-1
CAPTURE TIME SUMMARY
WITH PHASE III RECOVERY WELLS
(RW8 TRHOUGH RW10) PUMPING

Capture Well	Alias		Tavel Time (Days)	Source Well	Tavel Time (Years)
			5,145	BPOW 1-1 A	
N-5148	SF Well 1-3		3,575	BPOW 1-1 B	
			2,770	BPOW 1-1 C	
		AVERAGE	3,830		10.5
			1,477	BPOW 1-2 A	
N-5148	SF Well 1-3		1,377	BPOW 1-2 B	
			1,319	BPOW 1-2 C	
		AVERAGE	1,391		3.8
			2,433	BPOW 1-3 A	
N-5148	SF Well 1-3		2,628	BPOW 1-3 B	
			2,732	BPOW 1-3 C	
		AVERAGE	2,598		7.1
			2,824	BPOW 1-4 A	
N-7377	SF Well 1-4		2,637	BPOW 1-4 B	
			2,858	BPOW 1-4 C	
		AVERAGE	2,773		7.6
			1,128	BPOW 1-5 A	
N-13822	SF Well 1-5		3,269	BPOW 1-5 B	
			3,539	BPOW 1-5 C	
		AVERAGE	2,645		7.2
			3,547	BPOW 1-6 A	
N-13822	SF Well 1-5		2,642	BPOW 1-6 B	
N/A			29,102	BPOW 1-6 C	
		AVERAGE	11,764		32.2
			21,781	BPOW 1-7 A	
N-6443	Mass Well 5		22,992	BPOW 1-7 B	
			23,747	BPOW 1-7 C	
		AVERAGE	22,840		62.6
			15,173	BPOW 1-8 A	
RW-9-C			14,994	BPOW 1-8 B	
N-6443	Mass Well 5		51,908	BPOW 1-8 C	
		AVERAGE	27,359		75.0
			535	BPOW 2-1 A	
N-6150	SF Well 3-1		475	BPOW 2-1 B	
			417	BPOW 2-1 C	
		AVERAGE	476		1.3
			215	BPOW 2-2 A	
N-6150	SF Well 3-1		143	BPOW 2-2 B	
			75	BPOW 2-2 C	

Capture Well	Alias		Tavel Time (Days)	Source Well	Tavel Time (Years)
		AVERAGE	144		0.4
			80	BPOW 2-3 A	
N-6150	SF Well 3-1		80	BPOW 2-3 B	
			80	BPOW 2-3 C	
		AVERAGE	80		0.2
			1,191	BPOW 3-1 A	
N-9338	NYAW 9338		622	BPOW 3-1 B	
			321	BPOW 3-1 C	
		AVERAGE	711		1.9
			623	BPOW 3-2 A	
N-9338	NYAW 9338		623	BPOW 3-2 B	
			623	BPOW 3-2 C	
		AVERAGE	623		1.7
N-14347	NYAW 14347		4,543	BPOW 3-3 A	
RW-7-C			1,549	BPOW 3-3 B	
			1,141	BPOW 3-3 C	
		AVERAGE	2,411		6.6
			915	BPOW 3-4 A	
RW-7-C			484	BPOW 3-4 B	
			290	BPOW 3-4 C	
		AVERAGE	563		1.5
			624	BPOW 3-5 A	
N-14347	NYAW 14347		583	BPOW 3-5 B	
			583	BPOW 3-5 C	
		AVERAGE	597		1.6
			1,478	BPOW 4-1R A	
N-5303	LWD 5303		1,035	BPOW 4-1R B	
			586	BPOW 4-1R C	
		AVERAGE	1,033		2.8
			653	BPOW 4-2R A	
N-5303	LWD 5303		653	BPOW 4-2R B	
			1,232	BPOW 4-2R C	
		AVERAGE	846		2.3
			4,674	BPOW 5-1 A	
N-14347	NYAW 14347		4,645	BPOW 5-1 B	
			4,683	BPOW 5-1 C	
		AVERAGE	4,667		12.8
			4,603	BPOW 5-2 A	
N-14347	NYAW 14347		4,488	BPOW 5-2 B	
			4,115	BPOW 5-2 C	
		AVERAGE	4,402		12.1
			3,431	BPOW 5-3 A	
N-14347	NYAW 14347		3,804	BPOW 5-3 B	
			5,263	BPOW 5-3 C	

Capture Well	Alias		Tavel Time (Days)	Source Well	Tavel Time (Years)
		AVERAGE	4,166		11.4
			1,456	BPOW 5-4 A	
N-9338	NYAW 9338		1,077	BPOW 5-4 B	
			683	BPOW 5-4 C	
		AVERAGE	1,072		2.9
			2,378	BPOW 5-5 A	
N-14347	NYAW 14347		2,250	BPOW 5-5 B	
			2,118	BPOW 5-5 C	
		AVERAGE	2,249		6.2
			1,431	BPOW 5-6 A	
N-14347	NYAW 14347		1,248	BPOW 5-6 B	
			1,056	BPOW 5-6 C	
		AVERAGE	1,245		3.4
			5,801	BPOW 5-7 A	
N-8665	SF Well 6-2		3,963	BPOW 5-7 B	
			2,185	BPOW 5-7 C	
		AVERAGE	3,983		10.9
			13,091	BPOW 6-1 A	
N-6443	Mass Well 5		11,977	BPOW 6-1 B	
			10,128	BPOW 6-1 C	
		AVERAGE	11,732		32.1
			4,883	BPOW 6-2 A	
N-6443	Mass Well 5		5,595	BPOW 6-2 B	
			13,367	BPOW 6-2 C	
		AVERAGE	7,948		21.8
			25,973	BPOW 6-3 A	
N-6443	Mass Well 5		26,122	BPOW 6-3 B	
			17,264	BPOW 6-3 C	
		AVERAGE	23,120		63.3
			13,293	BPOW 6-4 A	
N-6443	Mass Well 5		12,213	BPOW 6-4 B	
			11,062	BPOW 6-4 C	
		AVERAGE	12,189		33.4
			12,590	BPOW 6-5 A	
N-6443	Mass Well 5		12,008	BPOW 6-5 B	
			11,449	BPOW 6-5 C	
		AVERAGE	12,016		32.9
			17,497	BPOW 6-6 A	
N-6443	Mass Well 5		13,474	BPOW 6-6 B	
			12,376	BPOW 6-6 C	
		AVERAGE	14,449		39.6

TABLE A-2
CAPTURE TIME SUMMARY
WITHOUT PHASE III RECOVERY WELLS
(RW8 TRHOUGH RW10) PUMPING

Capture Well	Alias		Travel Time (Days)	Source Well	Travel Time (Years)
			4,679	BPOW 1-1 A	
N-5148	SF Well 1-3		3,374	BPOW 1-1 B	
			2,658	BPOW 1-1 C	
		AVERAGE	3,570		9.8
			1,385	BPOW 1-2 A	
N-5148	SF Well 1-3		1,282	BPOW 1-2 B	
			1,223	BPOW 1-2 C	
		AVERAGE	1,297		3.6
			2,153	BPOW 1-3 A	
N-5148	SF Well 1-3		2,350	BPOW 1-3 B	
			2,451	BPOW 1-3 C	
		AVERAGE	2,318		6.4
			2,581	BPOW 1-4 A	
N-7377	SF Well 1-4		2,365	BPOW 1-4 B	
			2,523	BPOW 1-4 C	
		AVERAGE	2,490		6.8
			1,052	BPOW 1-5 A	
N-13822	SF Well 1-5		3,058	BPOW 1-5 B	
			3,272	BPOW 1-5 C	
		AVERAGE	2,461		6.7
			7,127	BPOW 1-6 A	
N-13822	SF Well 1-5		1,796	BPOW 1-6 B	
			4,182	BPOW 1-6 C	
		AVERAGE	4,368		12.0
			24,086	BPOW 1-7 A	
N/A			24,074	BPOW 1-7 B	
			25,577	BPOW 1-7 C	
		AVERAGE	24,579		67.3
			20,360	BPOW 1-8 A	
N/A			23,112	BPOW 1-8 B	
			24,869	BPOW 1-8 C	
		AVERAGE	22,780		62.4
			559	BPOW 2-1 A	
N-6150	SF Well 3-1		498	BPOW 2-1 B	
			434	BPOW 2-1 C	
		AVERAGE	497		1.4
			224	BPOW 2-2 A	
N-6150	SF Well 3-1		148	BPOW 2-2 B	
			76	BPOW 2-2 C	

Capture Well	Alias		Travel Time (Days)	Source Well	Travel Time (Years)
		AVERAGE	149		0.4
			80	BPOW 2-3 A	
N-6150	SF Well 3-1		80	BPOW 2-3 B	
			80	BPOW 2-3 C	
		AVERAGE	80		0.2
			1,180	BPOW 3-1 A	
N-9338	NYAW 9338		628	BPOW 3-1 B	
			319	BPOW 3-1 C	
		AVERAGE	709		1.9
			611	BPOW 3-2 A	
N-9338	NYAW 9338		611	BPOW 3-2 B	
			611	BPOW 3-2 C	
		AVERAGE	611		1.7
			1,132	BPOW 3-3 A	
N-14347	NYAW 14347		2,404	BPOW 3-3 B	
			2,446	BPOW 3-3 C	
		AVERAGE	1,994		5.5
			2,453	BPOW 3-4 A	
N-14347	NYAW 14347		7,002	BPOW 3-4 B	
			4,845	BPOW 3-4 C	
		AVERAGE	4,767		13.1
			482	BPOW 3-5 A	
N-9338	NYAW 9338		455	BPOW 3-5 B	
			458	BPOW 3-5 C	
		AVERAGE	465		1.3
			1,598	BPOW 4-1R A	
N-5303	LWD 5303		1,093	BPOW 4-1R B	
			593	BPOW 4-1R C	
		AVERAGE	1,095		3.0
			472	BPOW 4-2R A	
N-5303	LWD 5303		472	BPOW 4-2R B	
			897	BPOW 4-2R C	
		AVERAGE	614		1.7
			6,483	BPOW 5-1 A	
N-14347	NYAW 14347		6,361	BPOW 5-1 B	
			5,999	BPOW 5-1 C	
		AVERAGE	6,281		17.2
			5,791	BPOW 5-2 A	
N-14347	NYAW 14347		5,670	BPOW 5-2 B	
			5,139	BPOW 5-2 C	
		AVERAGE	5,533		15.2
			4,243	BPOW 5-3 A	
N-14347	NYAW 14347		4,612	BPOW 5-3 B	
			11,329	BPOW 5-3 C	

Capture Well	Alias		Travel Time (Days)	Source Well	Travel Time (Years)
		AVERAGE	6,728		18.4
			1,572	BPOW 5-4 A	
N-9338	NYAW 9338		1,126	BPOW 5-4 B	
			673	BPOW 5-4 C	
		AVERAGE	1,124		3.1
			2,874	BPOW 5-5 A	
N-14347	NYAW 14347		2,780	BPOW 5-5 B	
			2,514	BPOW 5-5 C	
		AVERAGE	2,723		7.5
			1,583	BPOW 5-6 A	
N-14347	NYAW 14347		1,327	BPOW 5-6 B	
			1,068	BPOW 5-6 C	
		AVERAGE	1,326		3.6
			7,723	BPOW 5-7 A	
N-8665	SF Well 6-2		5,184	BPOW 5-7 B	
			2,842	BPOW 5-7 C	
		AVERAGE	5,250		14.4
			9,777	BPOW 6-1 A	
N-6443	Mass Well 5		9,381	BPOW 6-1 B	
			9,806	BPOW 6-1 C	
		AVERAGE	9,655		26.5
			2,915	BPOW 6-2 A	
N-6443	Mass Well 5		3,441	BPOW 6-2 B	
			5,298	BPOW 6-2 C	
		AVERAGE	3,885		10.6
			4,427	BPOW 6-3 A	
N-6443	Mass Well 5		44,799	BPOW 6-3 B	
			38,959	BPOW 6-3 C	
		AVERAGE	29,395		80.5
			12,242	BPOW 6-4 A	
N-6443	Mass Well 5		9,720	BPOW 6-4 B	
			8,630	BPOW 6-4 C	
		AVERAGE	10,197		27.9
			13,739	BPOW 6-5 A	
N-6443	Mass Well 5		12,897	BPOW 6-5 B	
			9,422	BPOW 6-5 C	
		AVERAGE	12,019		32.9
			7,148	BPOW 6-6 A	
N-6443	Mass Well 5		22,886	BPOW 6-6 B	
			8,656	BPOW 6-6 C	
		AVERAGE	12,897		35.3

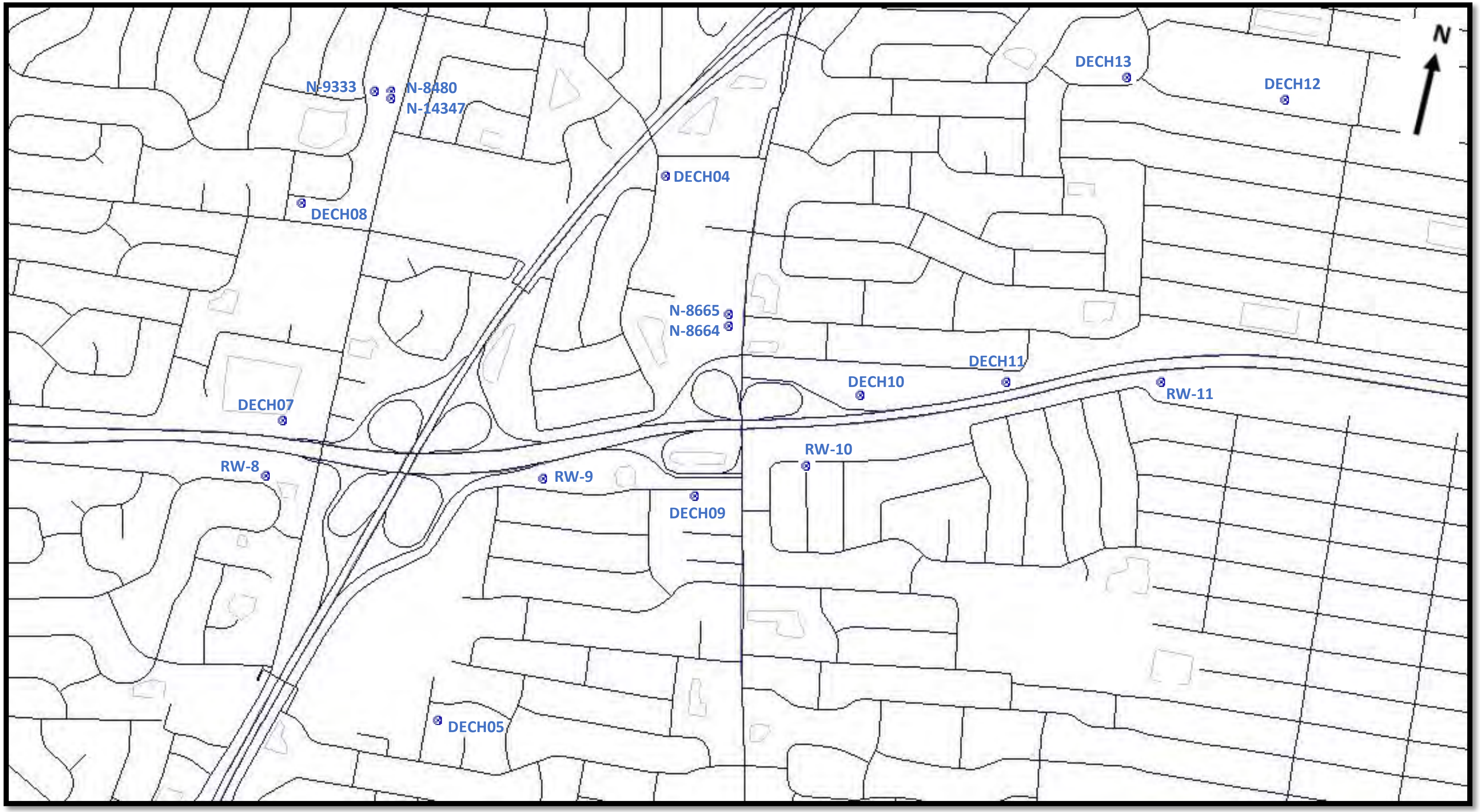


Figure A1 – Public Water Supply and New York State and Navy Recovery Well Locations

	GPM													
Version	RW-4	RW-6U	RW-6L	RW-11	RE137	RW-5U	RW-5L	RW-7U	RW-7L	RW-8	RW-9	RW-10	**Total**	**Complete Capture**
Baseline	400	200	400	0	360	200	400	200	400	750	750	750	4810	Yes
1	400	200	400	0	360	200	400	200	400	650	650	650	4510	Yes
2	400	200	400	0	200	200	400	200	400	650	650	650	4350	Yes
3	400	200	400	0	200	200	400	200	400	600	600	600	4200	Yes
4	400	200	400	0	200	200	400	200	400	550	550	550	4050	Yes
5	400	200	400	0	200	200	400	200	400	500	500	500	3900	Yes
6	400	200	400	0	200	200	400	200	400	450	450	450	3750	Yes
7	400	200	400	0	200	200	400	200	400	400	400	400	3600	No - 1 particle at RW10
8	400	200	400	0	200	200	400	200	400	400	400	425	3625	Yes

Version 6 (in blue) represents the reasonable minimum pumping rate evaluated that captures the OU2 Plume.

Figure A2 – Recovery Well RW-8, -9, and -10 - Currently Planned Minimum Pumping Rates

Top Depth	Bottom Depth		Screen Length		Top Elevation	Bottom Elevation	Mid-Point	Partition %	Q Total	Q Partitioned
538	548	A	10		-471	-481	-476	0.16		-6311.475815
554	580	B	26		-487	-513	-500	0.43		-16409.83712
584	592	C	8		-517	-525	-521	0.13		-5049.180652
615	622	D	7		-548	-555	-551.5	0.11		-4418.033071
636	641	E	5		-569	-574	-571.5	0.08		-3155.737908
646	651	F	5		-579	-584	-581.5	0.08		-3155.737908
			61							
								200.00	-38500	
	RW-5A		Ground	67				750.00	-144375	
								900.00	-173250	

Top Depth	Bottom Depth		Screen Length		Top Elevation	Bottom Elevation	Mid-Point	Partition %	Q Total	Q Partitioned
663	670	A	7		-596	-603	-599.5	0.15		-5858.696029
690	694	B	4		-623	-627	-625	0.09		-3347.826302
711	718	C	7		-644	-651	-647.5	0.15		-5858.696029
725	730	D	5		-658	-663	-660.5	0.11		-4184.782878
734	746	E	12		-667	-679	-673	0.26		-10043.47891
763	767	F	4		-696	-700	-698	0.09		-3347.826302
777	784	G	7		-710	-717	-713.5	0.15		-5858.696029
			46							
								400.00	-77000	
	RW-5B		Ground	67				600.00	-115500	
								900.00	-173250	

Figure A3 – RW-5A and RW-5B Construction and Operation Details (Located north of Southern Parkway RWs) (Scenario B)

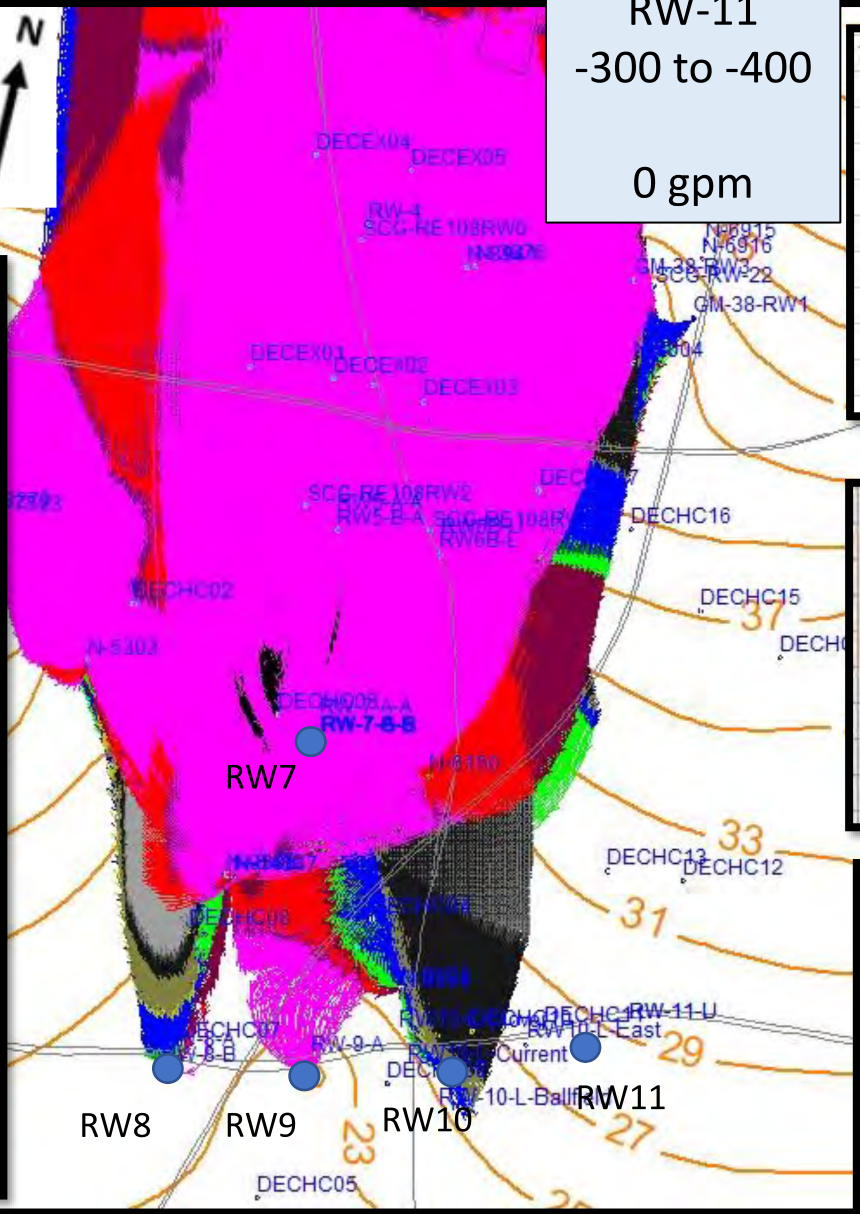
RW-10
-400 to -500

450 gpm

RW-11
-300 to -400

0 gpm

Layer	Color	Elevation
1		7
2		-120
3		-200
4		-225
5		-265
6		-325
7		-360
8		-410
9		-455
10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865



Potentiometric contours from Layer 18 (-730 feet msl)

Top Depth	Bottom Depth		Screen Length		Top Elevation	Bottom Elevation	Mid-Point
615	625	A	10	61.2	-553.81	-563.81	-558.81
655	688	B	33	61.2	-593.81	-626.81	-610.31
692	708	C	16	61.2	-630.81	-646.81	-638.81
			59				
721	733	D	12	61.2	-659.81	-671.81	-665.81
737	766	E	29	61.2	-675.81	-704.81	-690.31
			41				
	RW-7						

200 gpm in ABC (Upper), 400 gpm in DC (Lower)

Top Depth	Bottom Depth		Screen Length		Top Elevation	Bottom Elevation	Mid-Point
595	644	A	49		-544.5	-593.5	-569
698	718	B	20		-647.5	-667.5	-657.5
737	755	C	18		-686.5	-704.5	-695.5
780	790	D	10		-729.5	-739.5	-734.5
			97				
	RW-8						

450 gpm

Top Depth	Bottom Depth		Screen Length		Top Elevation	Bottom Elevation	Mid-Point
650	670	A	20		-600.1	-620.1	-610.1
715	725	B	10		-665.1	-675.1	-670.1
740	750	C	10	49.9	-690.1	-700.1	-695.1
755	778	D	23		-705.1	-728.1	-716.6
855	865	E	10		-805.1	-815.1	-810.1
			73				
	RW-9						

450 gpm

Figure A4 – Construction and Operation Data for RW-8, RW-9 and RW-10 – Future Condition (Scenario B)

location_id	location_alias	easting	northing	ground_surface	Top of Casing	Depth	Screen	Top of Screen	Bottom of Screen	Screen Length	Screen Midpoint	Top of Screen (elevation)	Screen Midpoint (elevation)	Bottom of Screen (elevation)
BPOW 1-1	BPOW 1-1	1132151.643	202008.734	72.47	72	241	196-241	196	241	45	218.5	-123.53	-146.03	-168.53
BPOW 1-2	BPOW 1-2	1132173.169	202009.697	72.36	71.82	335	310-335	310	335	25	322.5	-237.64	-250.14	-262.64
BPOW 1-3	BPOW 1-3	1132189.152	202010.024	72.39	71.92	419	374-419	374	419	45	396.5	-301.61	-324.11	-346.61
BPOW 1-4	BPOW 1-4	1132135.673	203327.989	57.37	56.68	410	340-400	340	400	60	370	-282.63	-312.63	-342.63
BPOW 1-5	BPOW 1-5	1132141.261	203315.538	57.49	56.75	665	600-650	600	650	50	625	-542.51	-567.51	-592.51
BPOW 1-6	BPOW 1-6	1132142.003	203299.025	57.57	57.06	770	700-750	700	750	50	725	-642.43	-667.43	-692.43
BPOW 1-7	BPOW 1-7	1130763.623	201917.5439	73.2	72.83	658	600-640	600	640	40	620	-526.8	-546.8	-566.8
BPOW 1-8	BPOW 1-8	1130748.579	201893.5203	73.4	72.91	773	725-755	725	755	30	740	-651.6	-666.6	-681.6
BPOW 2-1	BPOW 2-1	1127424.086	199726.122	58.99	58.64	400	356-396	356	396	40	376	-297.01	-317.01	-337.01
BPOW 2-2	BPOW 2-2	1127412.832	199726.254	58.84	58.5	510	455-495	455	495	40	475	-396.16	-416.16	-436.16
BPOW 2-3	BPOW 2-3	1127377.781	199725.231	58.3	57.98	610	564-594	564	594	30	579	-505.7	-520.7	-535.7
BPOW 3-1	BPOW 3-1	1124804.492	198628.43	61.94	61.43	516	426-516	426	516	90	471	-364.06	-409.06	-454.06
BPOW 3-2	BPOW 3-2	1124757.479	198664.297	62.43	61.82	647	612-647	612	647	35	629.5	-549.57	-567.07	-584.57
BPOW 3-3	BPOW 3-3	1125394.146	199565.166	61.57	60.64	635	580-620	580	620	40	600	-518.43	-538.43	-558.43
BPOW 3-4	BPOW 3-4	1125377.086	199566.193	62.89	62.44	840	640-690	640	690	50	665	-577.11	-602.11	-627.11
BPOW 3-5	RE139D2	1124864.9	198600.08	61.9	61.65	765	740-760	740	760	20	750	-678.1	-688.1	-698.1
BPOW 4-1R	BPOW 4-1R	1123067.51	200281.26	64.08	63.67	697	652-692	652	692	40	672	-587.92	-607.92	-627.92
BPOW 4-2R	BPOW 4-2R	1123199.9	200691.4	66.6	66.11	770	725-765	725	765	40	745	-658.4	-678.4	-698.4
BPOW 5-1	BPOW 5-1	1127145.842	198399.79	56.76	56.12	515	480-510	480	510	30	495	-423.24	-438.24	-453.24
BPOW 5-2	BPOW 5-2	1127152.768	198410.857	56.81	56.32	585	540-580	540	580	40	560	-483.19	-503.19	-523.19
BPOW 5-3	BPOW 5-3	1127156.801	198389.891	56.45	56.04	665	620-660	620	660	40	640	-563.55	-583.55	-603.55
BPOW 5-4	BPOW 5-4	1125307.44	196471.55	54.49	53.88	575	545-570	545	570	25	557.5	-490.51	-503.01	-515.51
BPOW 5-5	BPOW 5-5	1126291.269	197285.189	57.97	57.58	545	515-540	515	540	25	527.5	-457.03	-469.53	-482.03
BPOW 5-6	BPOW 5-6	1126285.56	197327.15	58.21	57.72	615	585-610	585	610	25	597.5	-526.79	-539.29	-551.79
BPOW 5-7	BPOW 5-7	1128702.39	197274.15	56.2	55.92	555	525-550	525	550	25	537.5	-468.8	-481.3	-493.8
BPOW 6-1	BPOW 6-1	1126796.92	193228.16	43.61	42.93	580	550-575	550	575	25	562.5	-506.39	-518.89	-531.39
BPOW 6-2	BPOW 6-2	1126785.34	193253.75	43.58	43.08	785	755-780	755	780	25	767.5	-711.42	-723.92	-736.42
BPOW 6-3	BPOW 6-3	1127582.36	194106.07	40.34	39.96	780	750-775	750	775	25	762.5	-709.66	-722.16	-734.66
BPOW 6-4	BPOW 6-4	1127580.66	194127	40.4	40.02	575	545-570	545	570	25	557.5	-504.6	-517.1	-529.6
BPOW 6-5	BPOW 6-5	1128178.28	194045.49	43.27	43.3	555	525-550	525	550	25	537.5	-481.73	-494.23	-506.73
BPOW 6-6	BPOW 6-6	1128163.72	194044.59	43.17	43.16	800	770-795	770	795	25	782.5	-726.83	-739.33	-751.83

Figure A5 – Bethpage Outpost Monitoring Well Construction Data

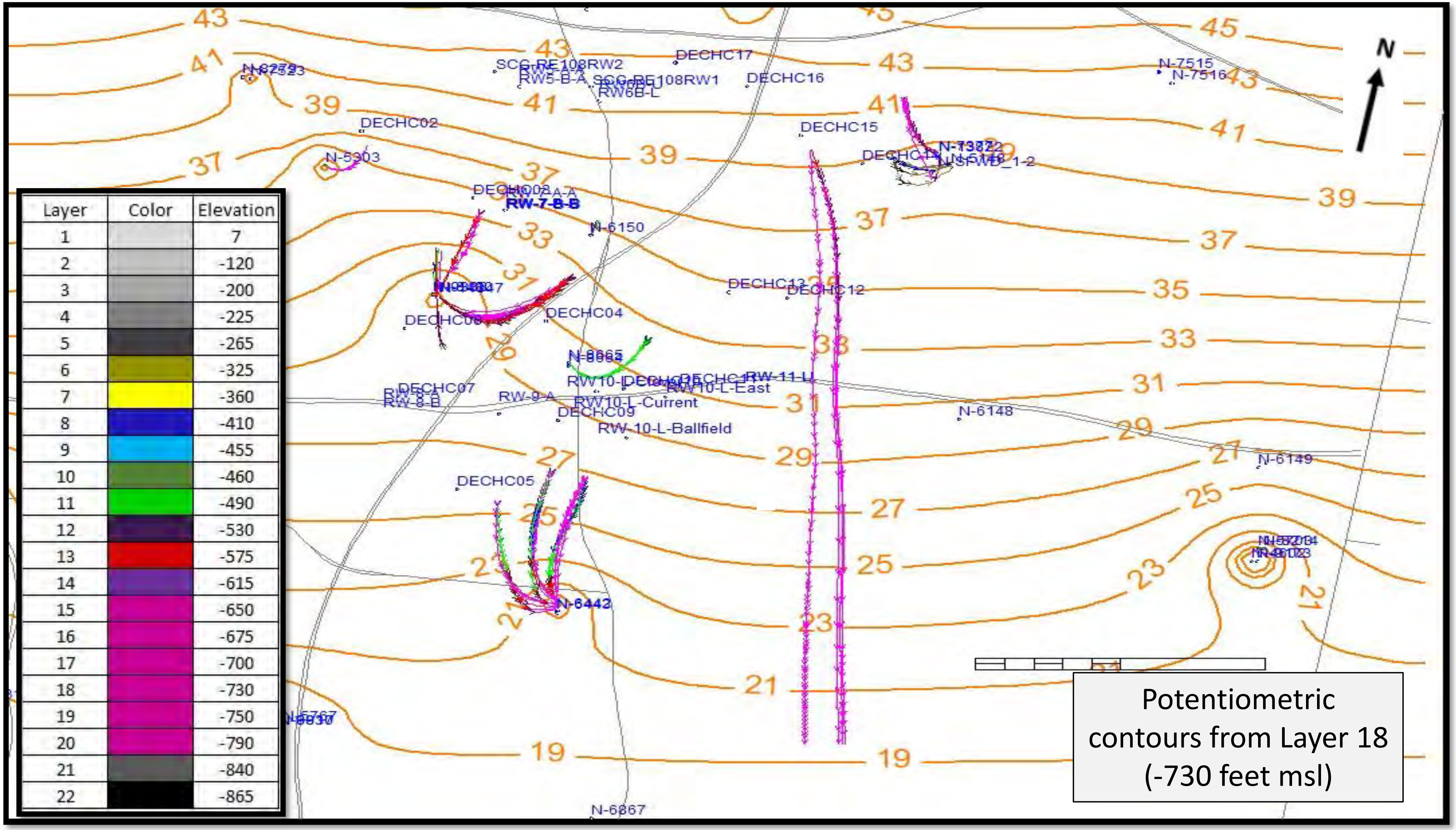


Figure A6 – Forward Particle Tracking from BPOWs – Current Condition (Scenario A)

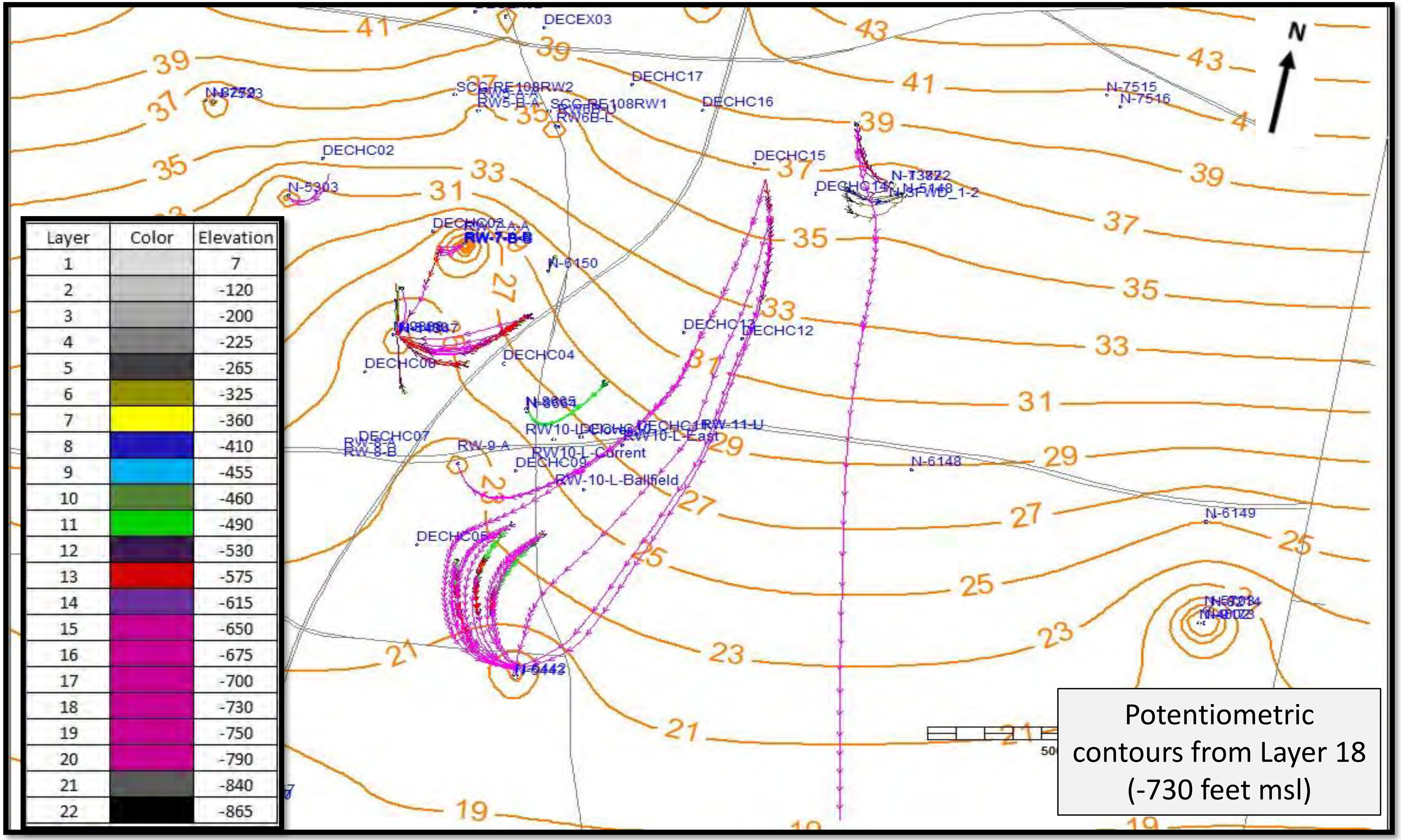


Figure A7 – Forward Particle Tracking From BPOWs – Future Condition (Scenario B)

									Scenarios A and B		Scenario B1		
Name	Alias	X	Y	row	column	Top Layer	Bottom Layer		Q (ft3/day)	Q (gpm)	Q (gpm) - Increased Future	Q (ft3/day) - Increased Future	
N-6150	SF Well 3-1			246	130	11	13		-223998.45	-1163.63	-1388.88	-267359.42	
N-8664	SF Well 6-1			296	123	8	11		-6828.895	-35.47	-70.95	-13657.79	
N-8665	ST Well 6-2			295	123	10	12		-54032.794	-280.69	-694.44	-133679.71	
N-6442	Mass Well 4			383	119	8	11		-24527.879	-127.42	-347.22	-66839.85	
N-6443	Mass Well 5			383	119	15	19		-120826.77	-627.67	-1255.34	-241653.54	
									1 MGD =	694.44 GPM			
									2 MGD =	1388.88 GPM			

- For the 5 PWS wells, a circle of 25 particles with a radius of 50 feet was placed around the well within each of the model layers at the center of the layer where the well occurs (i.e., 3 sets of particles, one in the middle of layer 11, 12 and 13 for SF Well 3-1)

- Reverse Particle Tracking was performed individually for each well under 3 different scenarios –

  - Current Conditions (Scenario A, RW-5 through RW-10 not pumping)
  - Future Conditions (Scenario B, RW-5 through RW-10 pumping)
  - Future Conditions (Scenario B1, increased pumping rates at the five PWS wells (see above – rates doubled or to 2 MGD maximum)

Figure A8 – Model Details for Reverse Particle Tracking from SFWD and MWD Wells

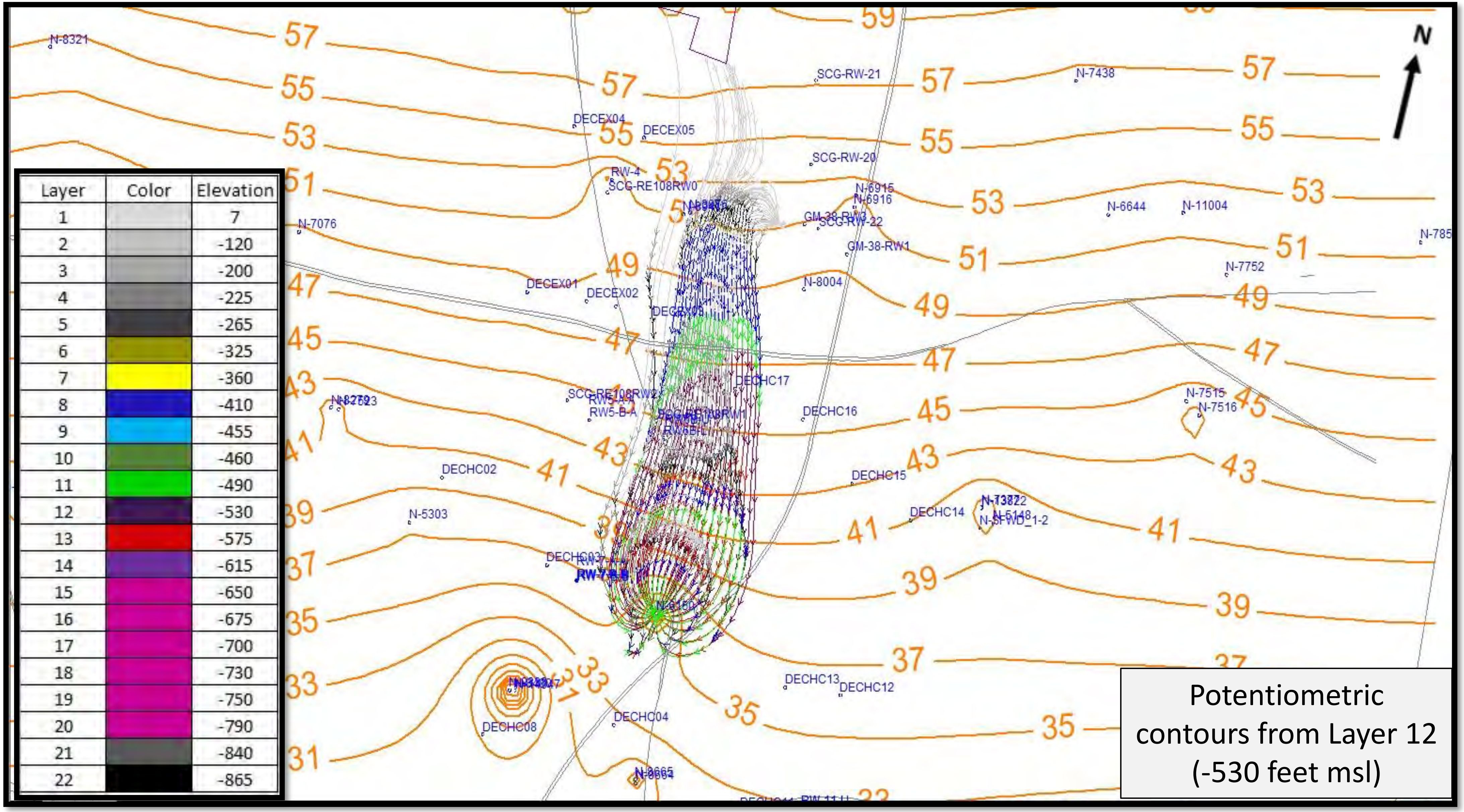


Figure A9 - Reverse Particle Tracking from SFWD Well 3-1 (N-6150) – Current Condition (Scenario A)

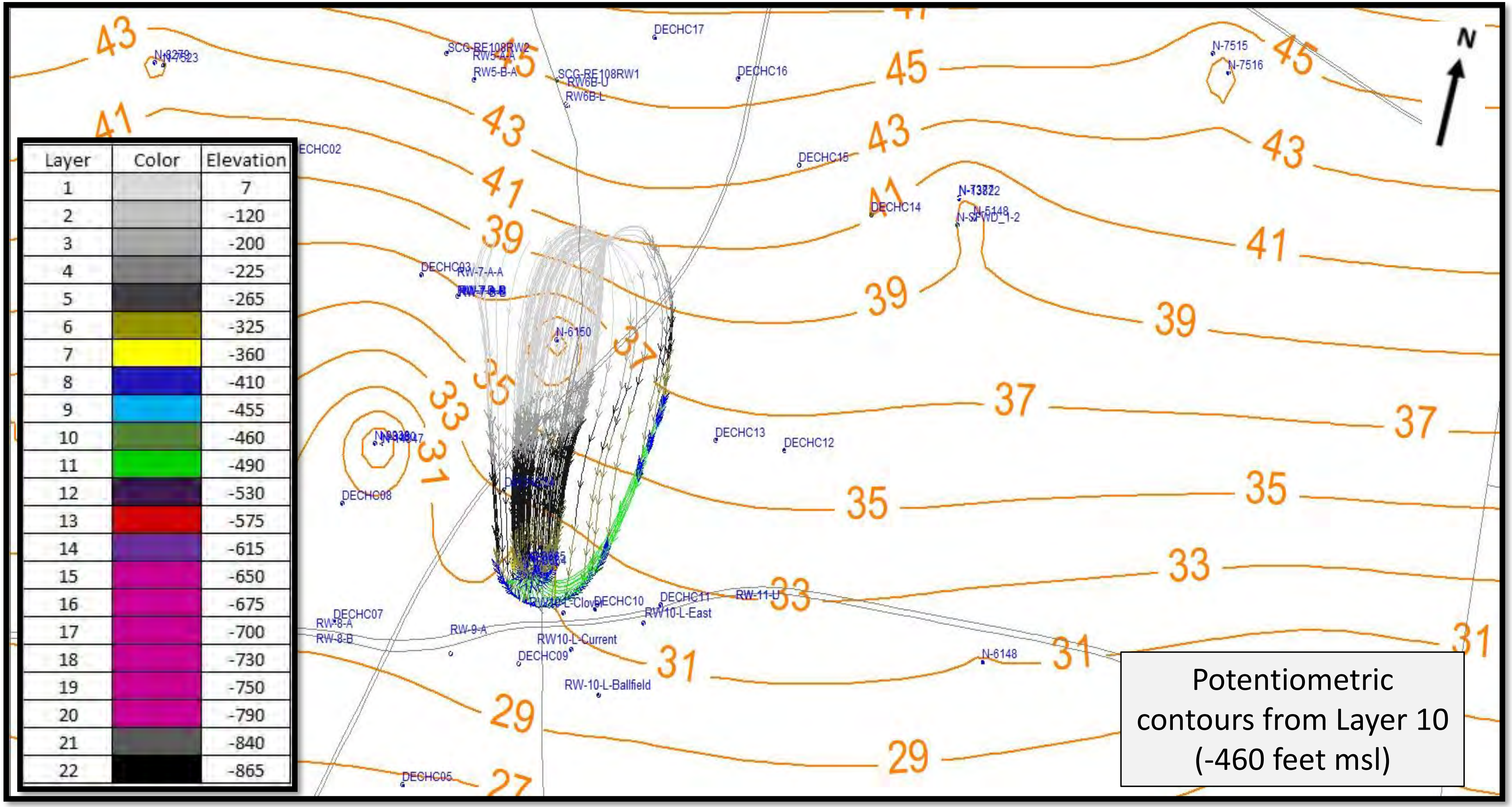
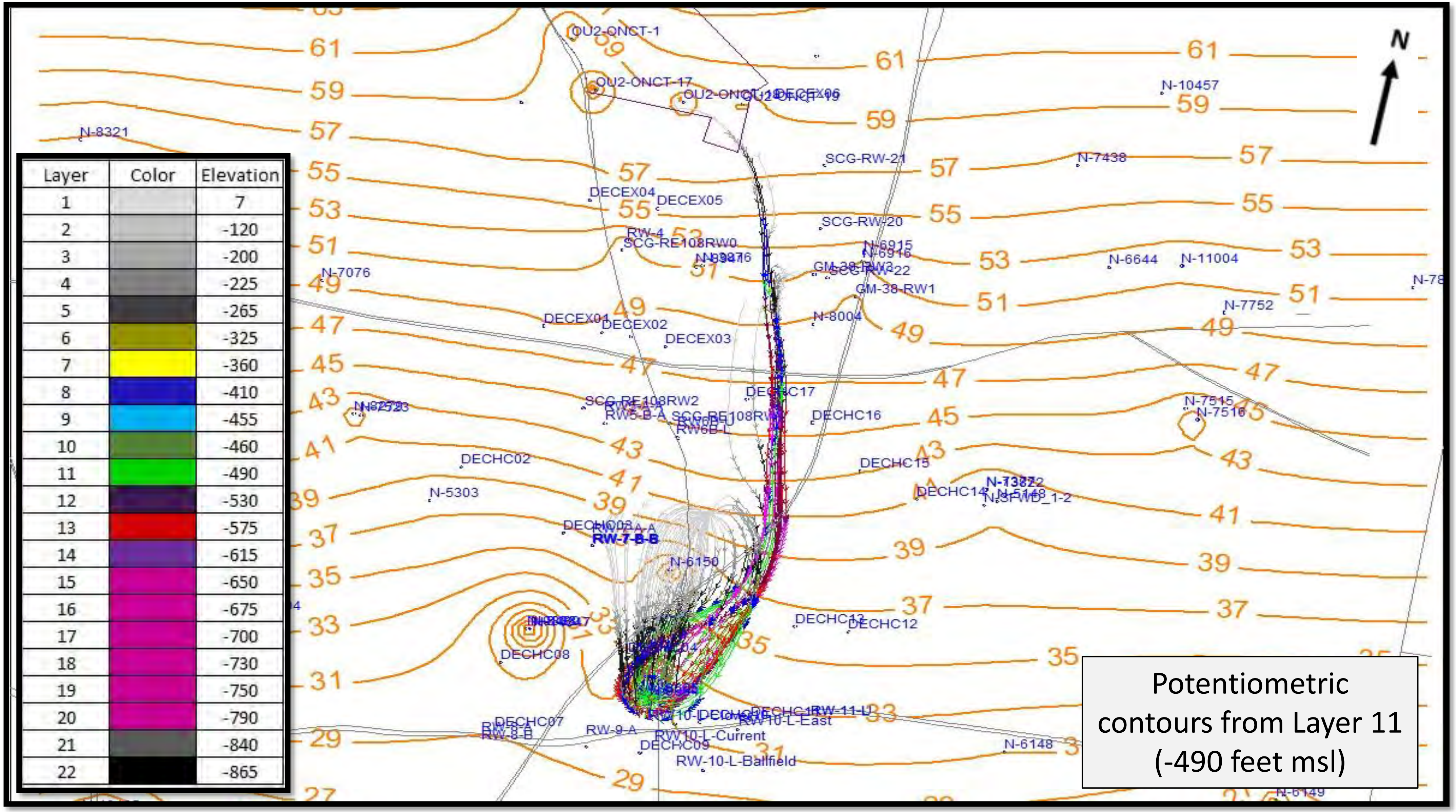


Figure A10 - Reverse Particle Tracking from SFWD Well 6-1 (N-8664) – Current Condition (Scenario A)



Layer	Color	Elevation
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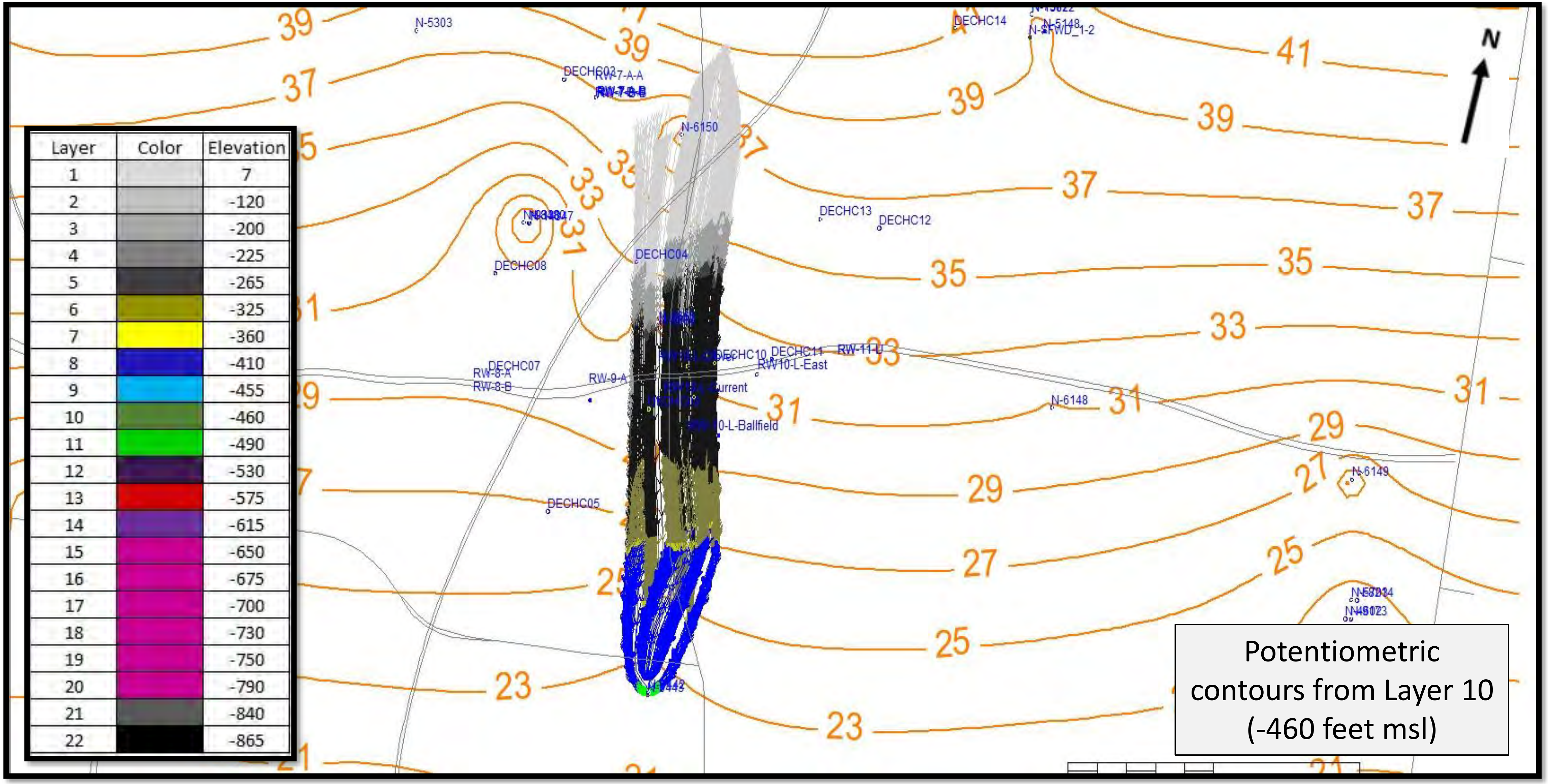
2		-120
3		-200
4		-225
5		-265
6		-325
7		-360
8		-410
9		-455
10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865

Figure A11 - Reverse Particle Tracking from SFWD Well 6-2 (N-8665) – Current Condition (Scenario A)



Layer	Color	Elevation
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3		-200
4		-225
5		-265
6		-325
7		-360
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9		-455
10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865

Figure A12 - Reverse Particle Tracking from MWD Well 4 (N-6442) – Current Condition (Scenario A)

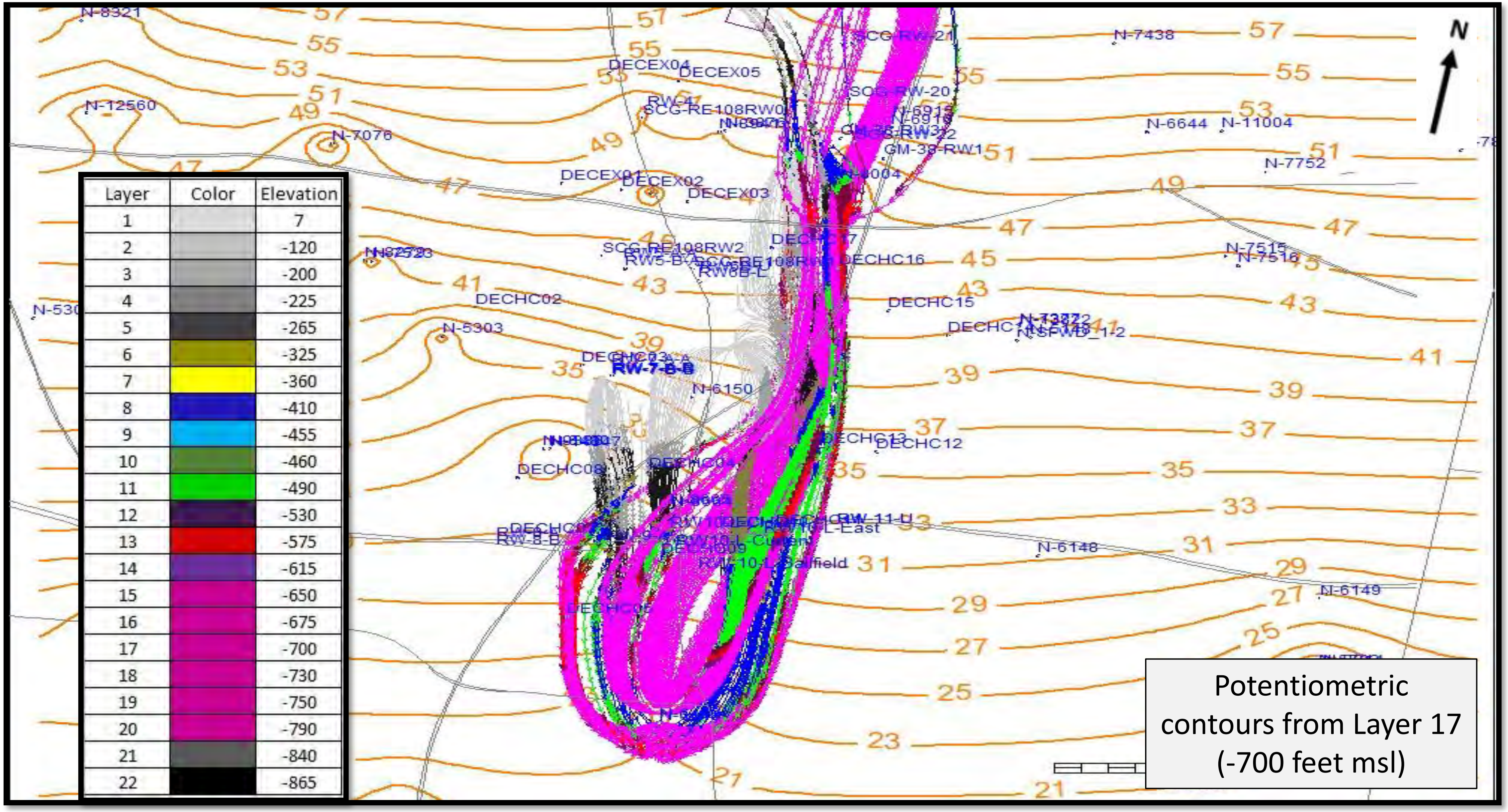


Figure A13 - Reverse Particle Tracking from MWD Well 5 (N-6443) – Current Condition (Scenario A)

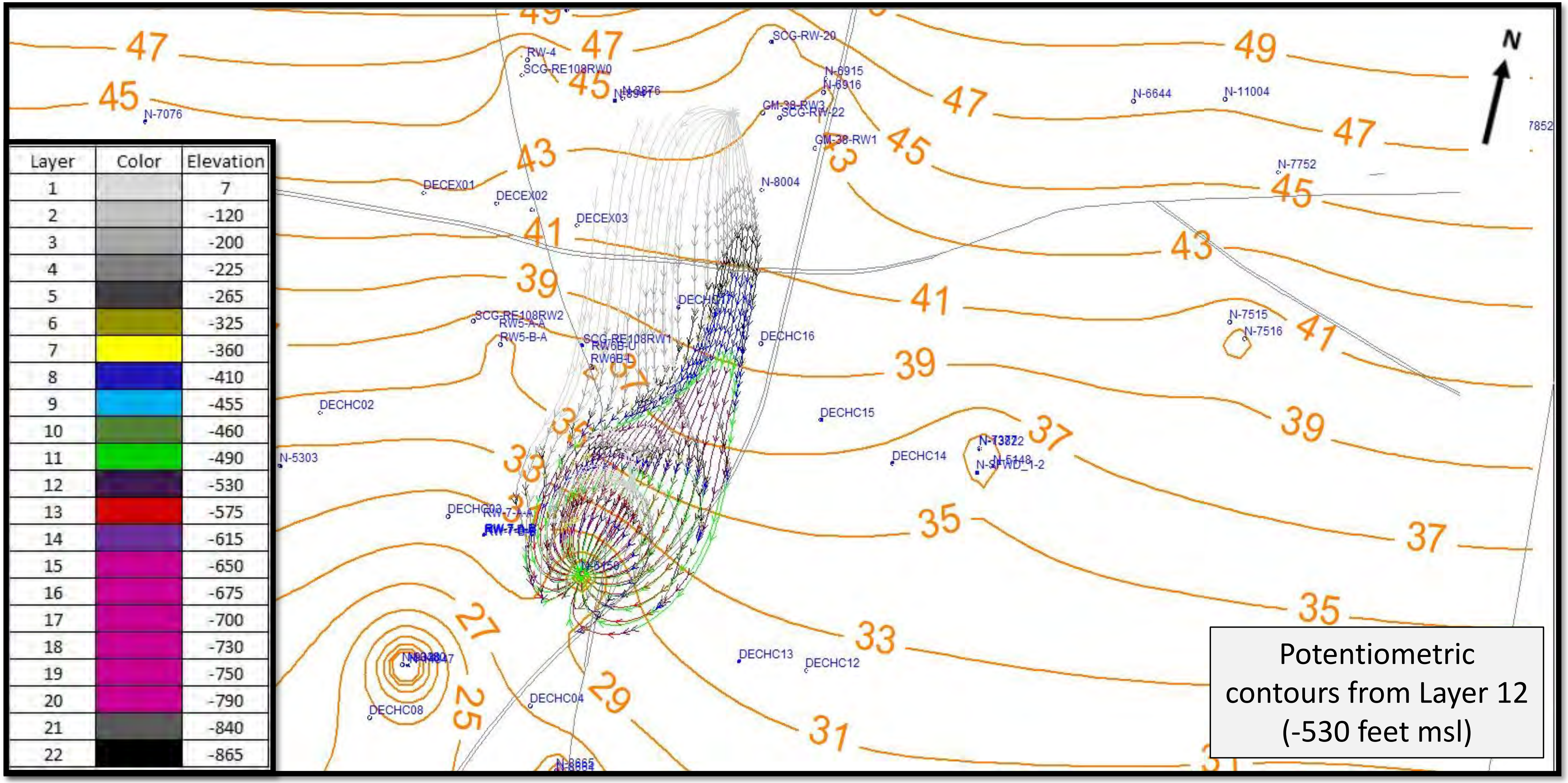
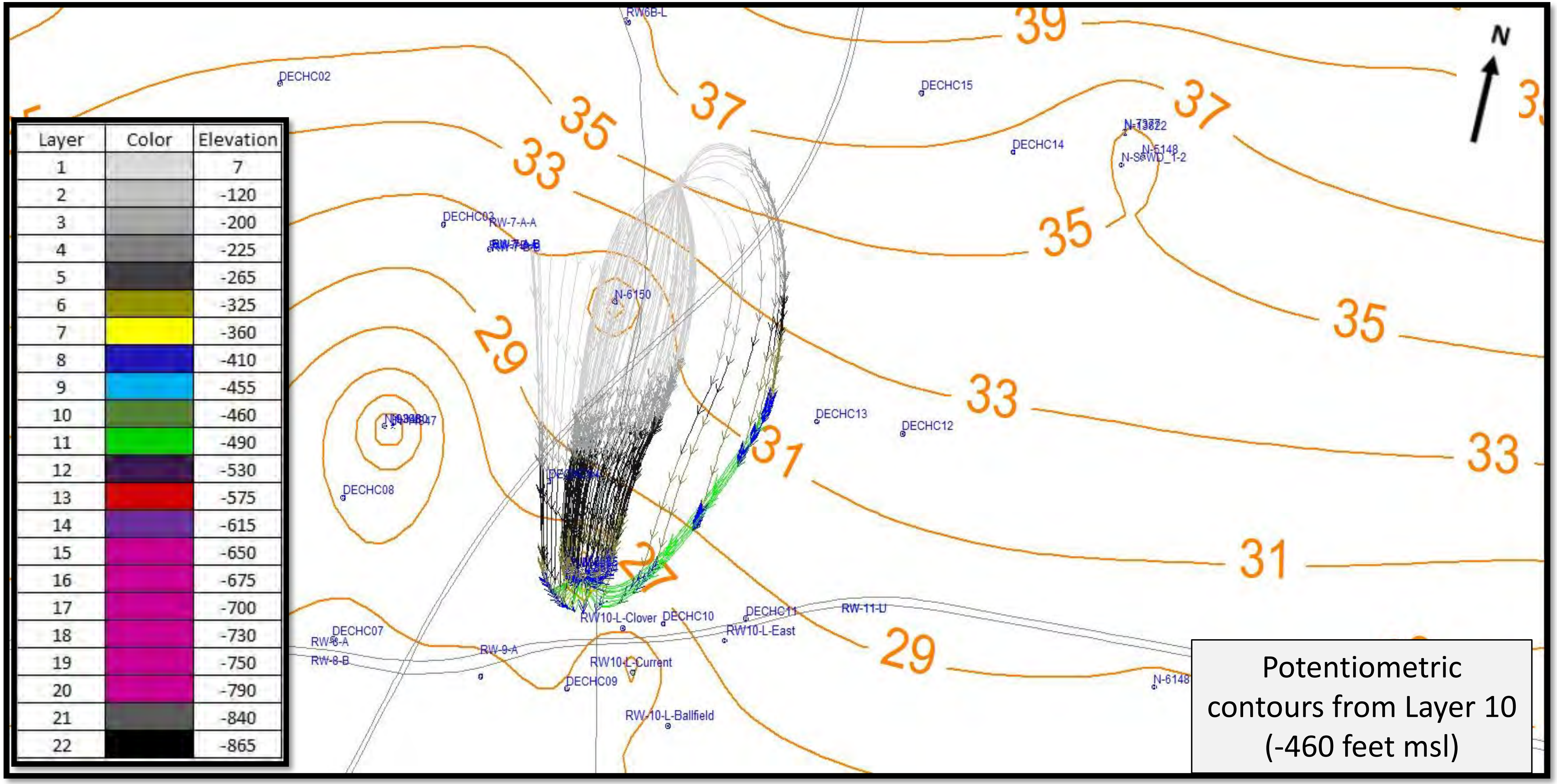


Figure A14 - Reverse Particle Tracking from SFWD Well 3-1 (N-6150) – Future Condition (Scenario B)



Layer	Color	Elevation
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2		-120
3		-200
4		-225
5		-265
6		-325
7		-360
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9		-455
10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865

Figure A15 - Reverse Particle Tracking from SFWD Well 6-1 (N-8664) – Future Condition (Scenario B)

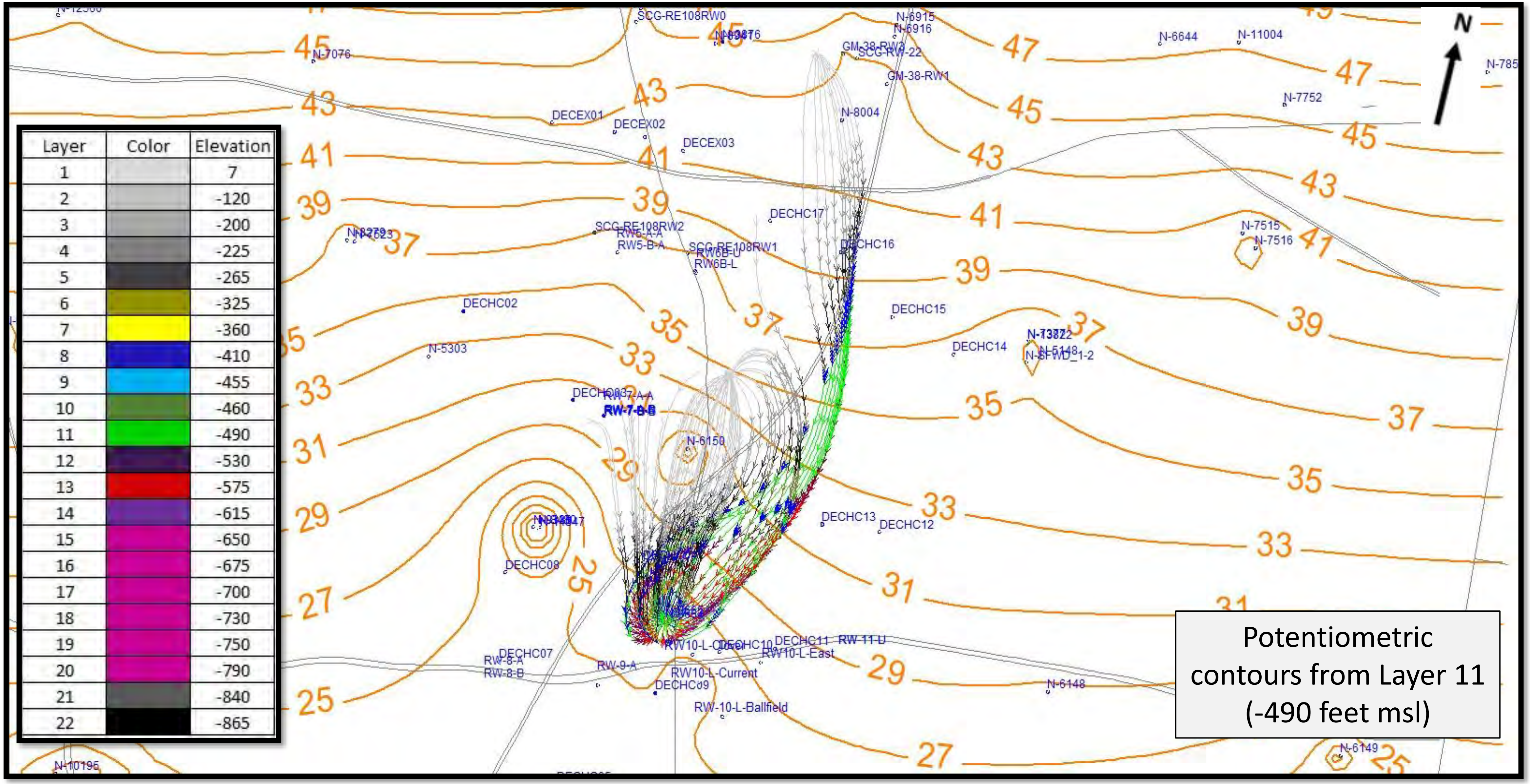


Figure A16 - Reverse Particle Tracking from SFWD Well 6-2 (N-8665) – Future Condition (Scenario B)

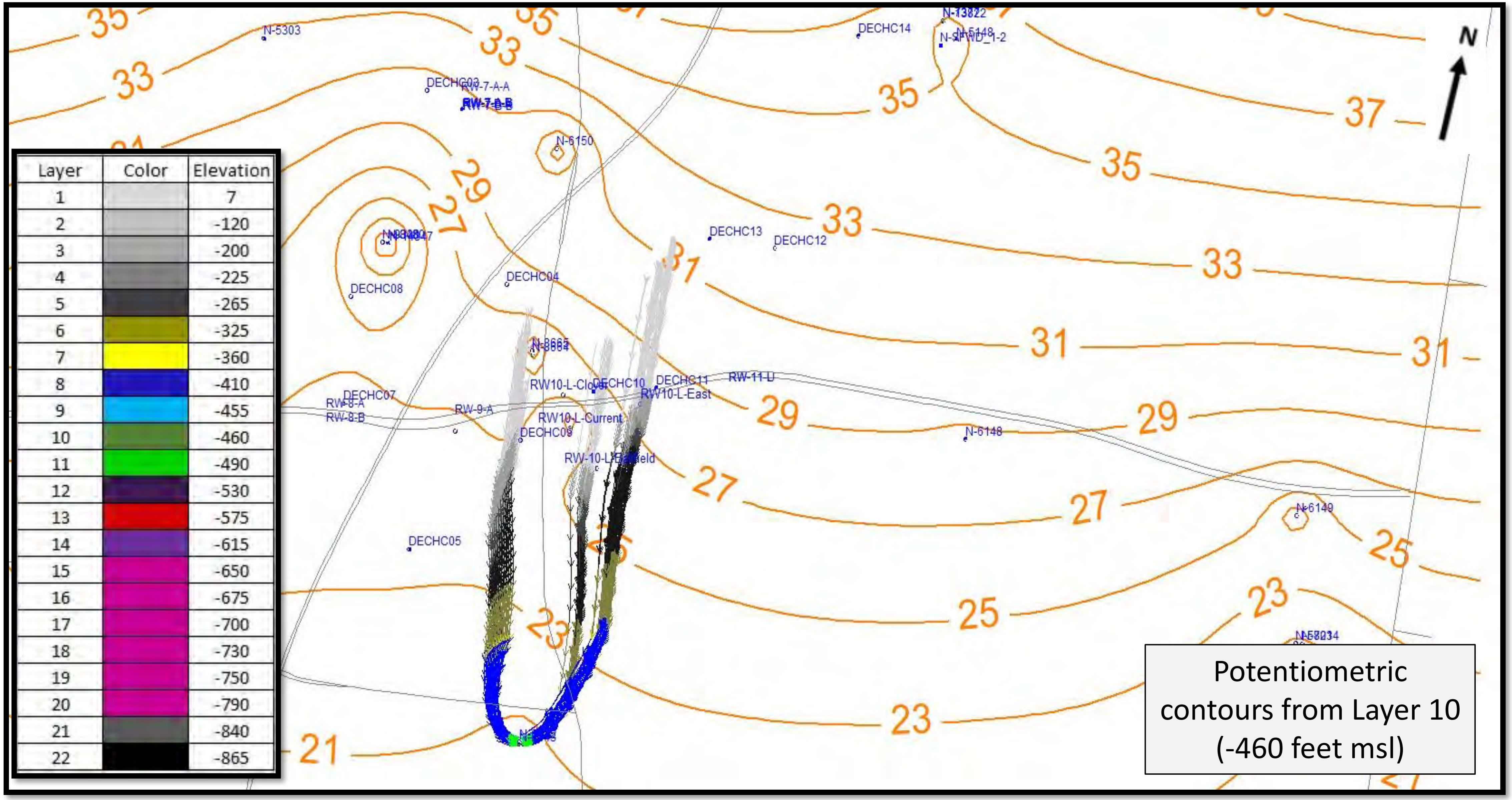


Figure A17 - Reverse Particle Tracking from MWD Well 4 (N-6442) – Future Condition (Scenario B)

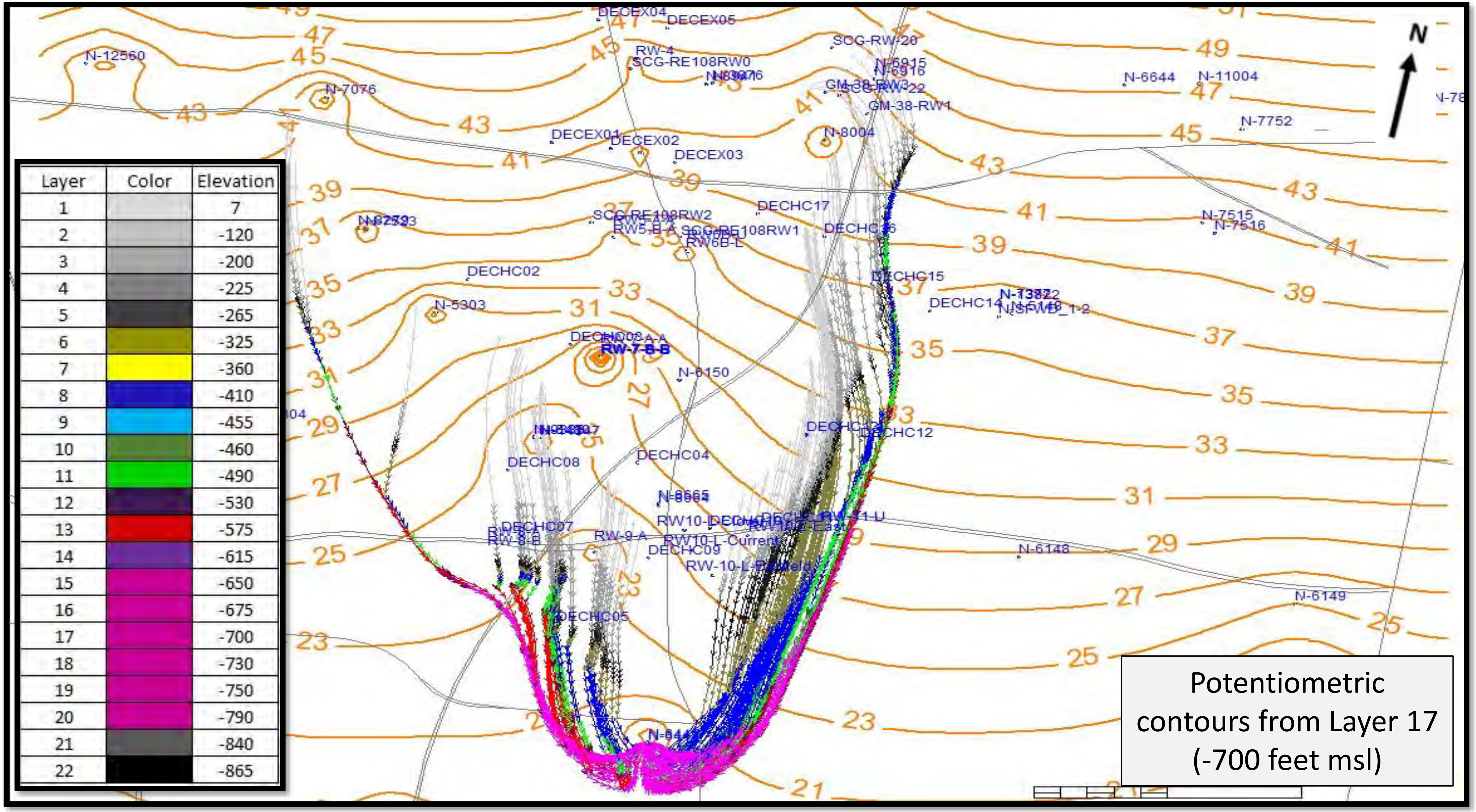
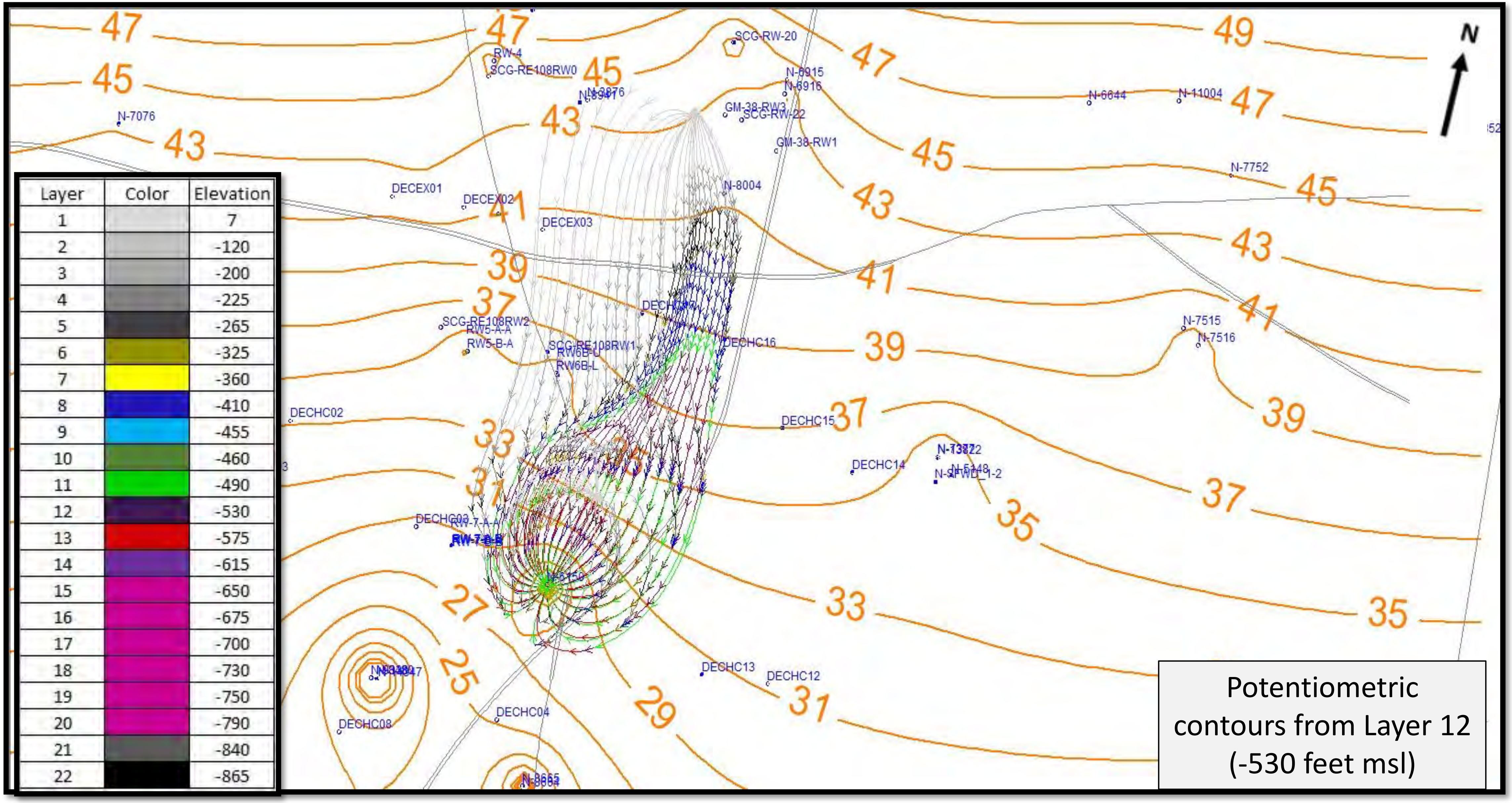


Figure A18 - Reverse Particle Tracking from MWD Well 5 (N-6443) – Future Condition (Scenario B)



Layer	Color	Elevation
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3		-200
4		-225
5		-265
6		-325
7		-360
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9		-455
10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865

Figure A19 - Reverse Particle Tracking from SFWD Well 3-1 (N-6150) – Future Condition (Scenario B1)

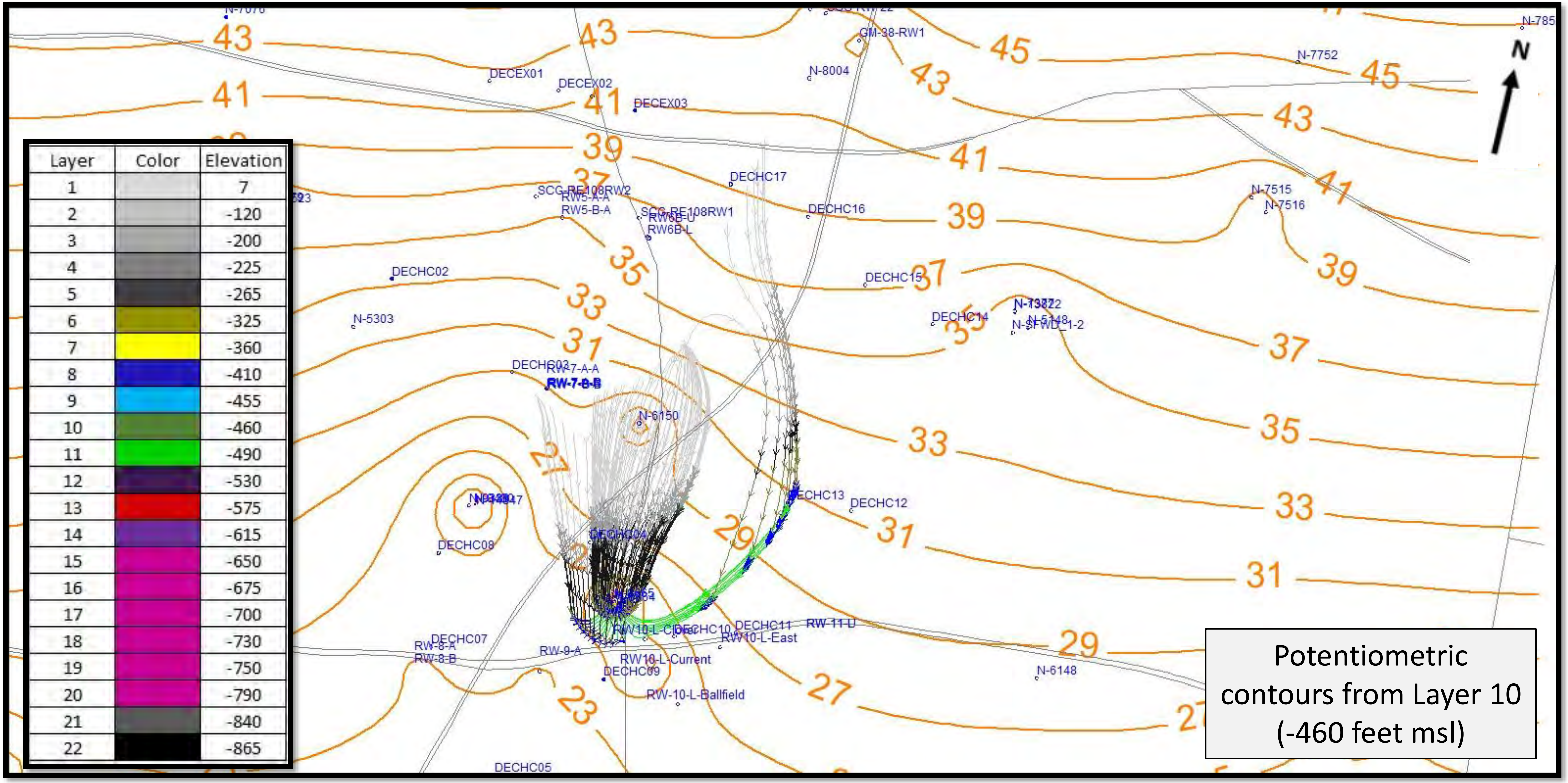


Figure A20 - Reverse Particle Tracking from SFWD Well 6-1 (N-8664) – Future Condition (Scenario B1)

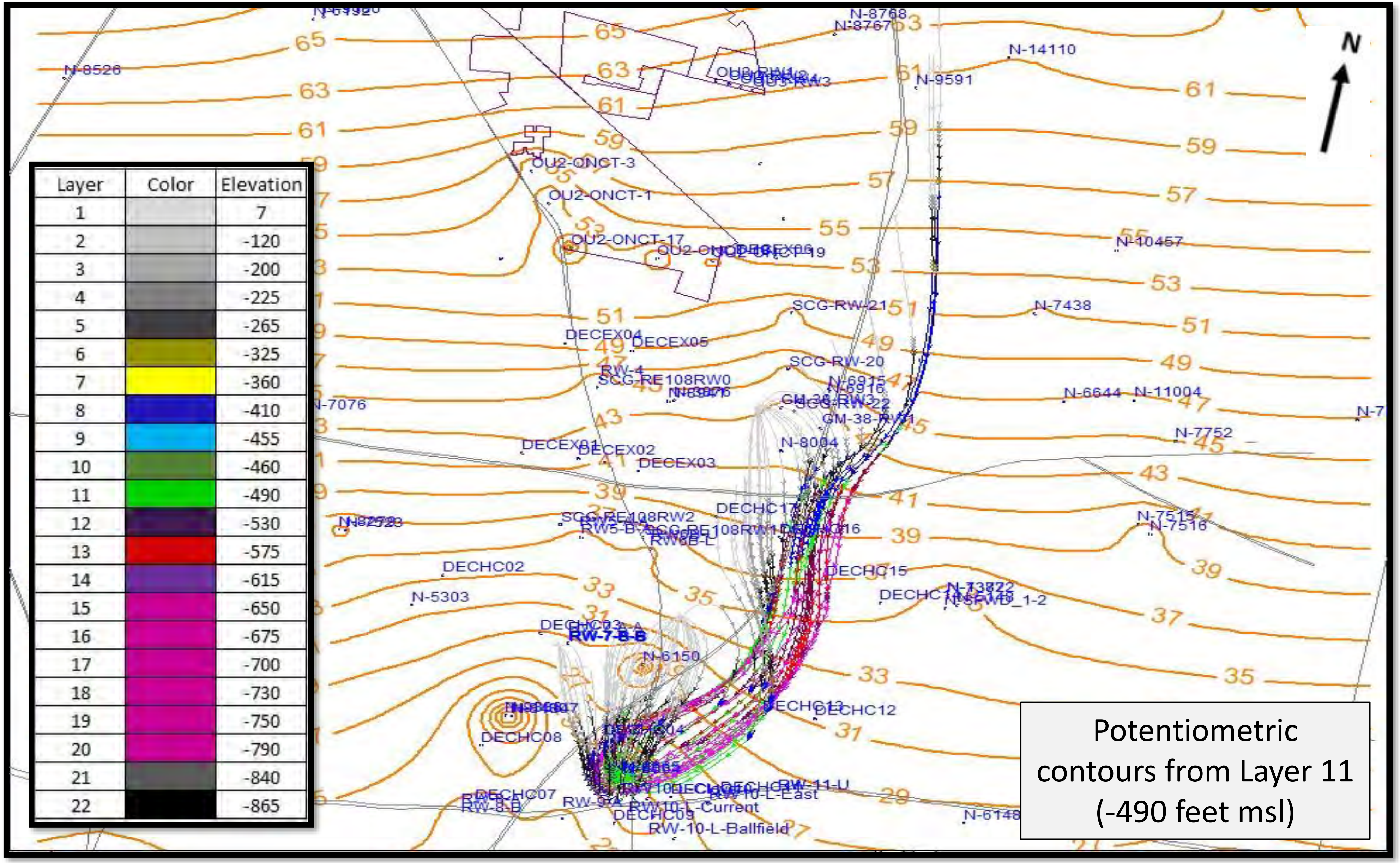
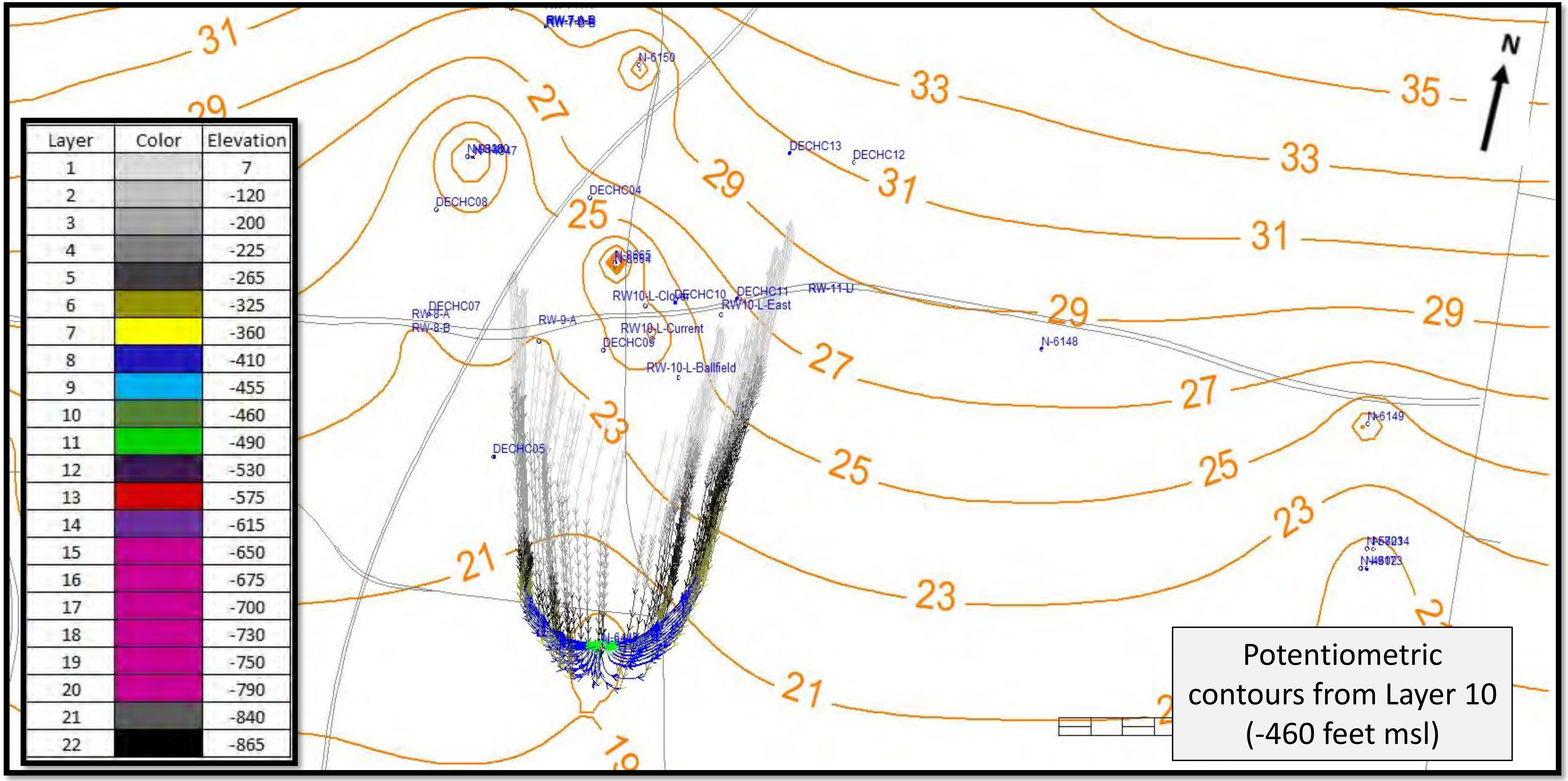


Figure A21 - Reverse Particle Tracking from SFWD Well 6-2 (N-8665) – Future Condition (Scenario B1)



Layer	Color	Elevation
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2		-120
3		-200
4		-225
5		-265
6		-325
7		-360
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10		-460
11		-490
12		-530
13		-575
14		-615
15		-650
16		-675
17		-700
18		-730
19		-750
20		-790
21		-840
22		-865

Figure A22 - Reverse Particle Tracking from MWD Well 4 (N-6442) – Future Condition (Scenario B1)

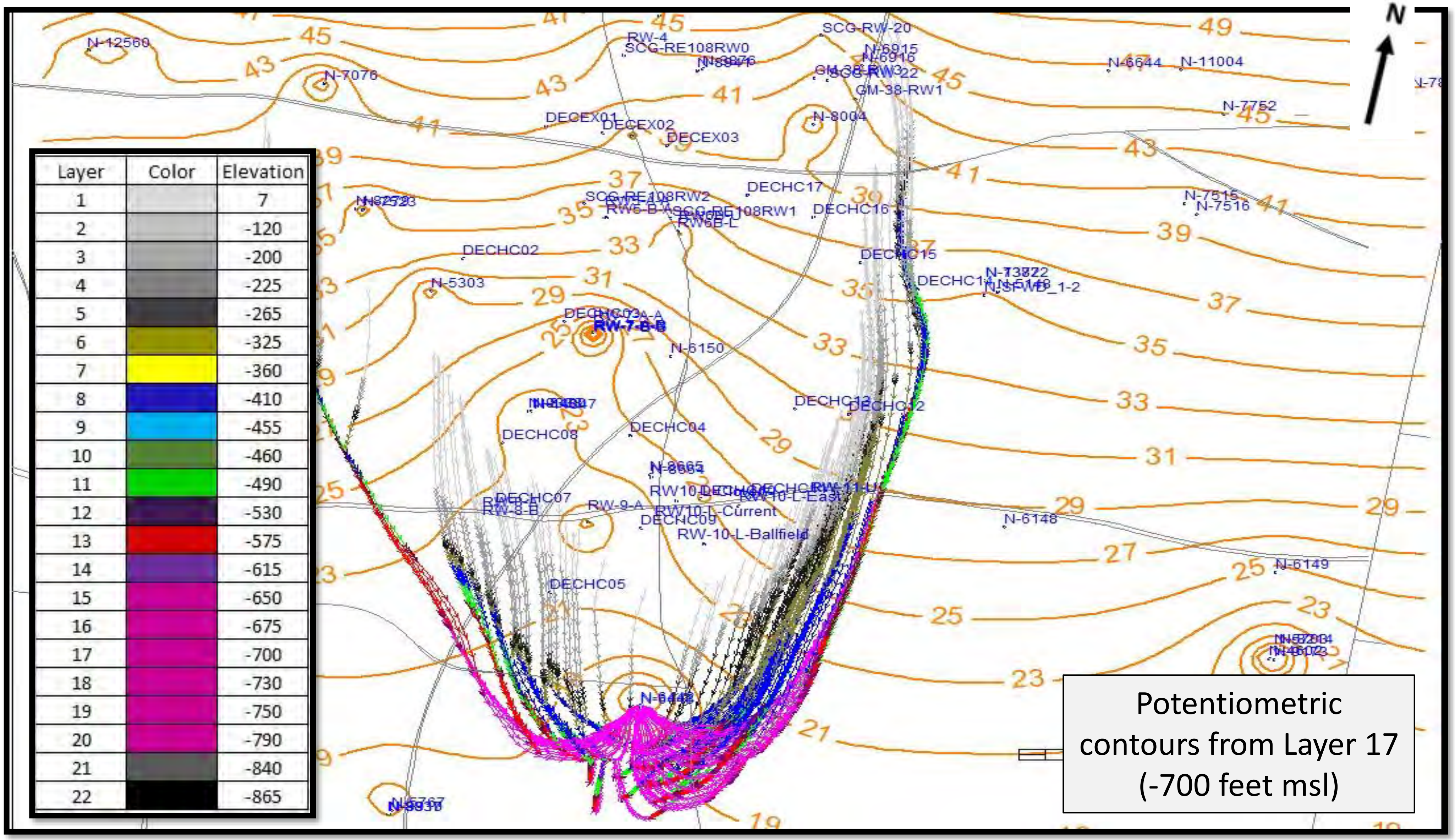

Figure A23 - Reverse Particle Tracking from MWD Well 5 (N-6443) – Future Condition (Scenario B1)

APPENDIX B
COMPARISON OF UGGS AND NAVY MODELING

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Appendix B
Comparison of USGS and Navy Modeling

During the May 2023 New York State Department of Environmental Conservation (NYSDEC) review of the draft March 2023 Public Water Supply Contingency Plan (PWSCP), NYSDEC tasked United States Geological Survey (USGS) to conduct an evaluation of groundwater flow in the area south of Southern State Parkway. In particular, this analysis considered groundwater flow from three moderately deep outpost monitoring wells (BPOW 6-1, 6-4, and 6-5) with screen depths between 525 and 575 feet below ground surface (bgs) that were installed to monitor groundwater upgradient of Massapequa Water District (MWD) Well 4 (screened at a depth of 524 to 612 feet bgs) and three deeper outpost monitoring wells (BPOW 6-2, 6-3, and 6-6) with screen depths of 740 to 820 feet bgs that were installed to monitor groundwater upgradient of MWD Well 5 (screened at a depth of 770 to 850 feet bgs).

To evaluate groundwater flow, both the Navy and USGS models use particle track analysis to provide an indication of groundwater flow direction and migration rates. The discussion below is based on pumping assumptions and information by the USGS in the 2020 *Analysis of Remedial Scenarios Affecting Plume Movement Through a Sole-Source Aquifer System, Southeastern Nassau County, New York* (USGS, 2020), and using updated planned pumping rates presented in the Navy's March 2022 modeling report *Final Documentation of the Construction and Calibration of 3-D Groundwater Flow and Solute Transport Model* (Tetra Tech, 2022a). In addition, the current Navy model includes pumping assumptions and hydrogeological information collected and evaluated through early 2023, and in particular, aquifer pumping tests conducted in newly constructed recovery wells (RW8 and RW9) south of the Southern State Parkway. These new recovery wells are screened in a gravel zone that is believed to be directly connected to the deeper outpost monitoring wells BPOW 6-2, 6-3, and 6-6 and MWD Well 5. This gravel unit has been observed in most of the soil borings in the area and during pumping tests conducted with MWD Well 5, these outpost monitoring wells showed a good response.

The depths of the outpost monitoring wells and MWD water supply wells are important because groundwater in the area has a tendency to flow horizontally along naturally formed high permeability geological units (e.g. gravel zones). Additionally, pumping from extraction wells such as the MWD water supply wells can also cause groundwater from a wider area and other depths to be intercepted, including zones not directly screened by the outpost monitoring wells and MWD water supply wells.

Groundwater monitoring in the area of the Southern State Parkway has determined that 1,4-dioxane is more commonly found in the shallow and moderately deep groundwater (e.g., less than 600 feet bgs) than in the deeper groundwater (greater than 700 feet bgs). For example, 1,4-dioxane has been detected at a maximum concentration of 0.23 µg/L and 0.6 µg/L, in the moderately deep wells BPOW 6-1 and 6-4, respectively.

Whereas, it has not been detected, or when detected, the detections are infrequent and at a low concentration (maximum concentration of 0.14 µg/L) in the three deeper outpost wells (BPOW 6-2, 6-3, and 6-6), as well as the third moderately deep well that is located further to the east (BPOW 6-5).

These results are also consistent with monitoring wells that are located further north of the BPOW #6 cluster. For example, TT102D1 (screened 560 to 600 feet bgs) has a 1,4-dioxane concentration of 0.45 µg/L, whereas TT102D2 (screened 740 to 770 feet bgs) does not have detectable levels of 1,4-dioxane. The monitoring wells associated with RW9 (RW09-MW01D1, D2, and D3) show similar results. In addition, the concentration of 1,4-dioxane in BPOW 6-1 and 6-4 increased very slowly, with detections increasing from approximately the detection limit to approximately ¼ to ½ the drinking water standard over a four-year period. For reference, the New York State Department of Health (NYSDOH) drinking water standard for 1,4-dioxane is 1.0 µg/L.

Under the future scenario (i.e., pumping the Navy Phase III wells), general findings of the USGS model results as compared to the Navy model results are summarized as follows:

- For MWD Well 4 and the three moderately deep outpost wells, the USGS model did not predict that the particles would be intercepted by MWD Wells 4 or 5. The Navy model predicted that these particles would be intercepted by MWD Well 5 (due to the relatively high pumping rates in this well), but with a travel time of greater than 30 years. The long travel time results from the need for groundwater to flow vertically through less permeable geological units as well as a generally flattened gradient in the area of the outpost wells due to the Navy Phase III well pumping. While the model results differ, in either case, the 1,4-dioxane currently detected in these outpost wells would not be expected to impact MWD Wells 4 or 5, within the next 30 years.
- Grid resolution between the USGS and Navy model differed with USGS using 150 feet and Navy using 50 feet. Grid resolution can affect the results in relatively small areas of the model such as around MWD wells as it allows for more rapid transport due to simplifications of the increased grid size (directions and rates of movements are calculated with respect to grid centers).
- As described above, the Navy's model is based on more extensive regional and local lithologies, and provide a very good correlation between modeling and actual results. The USGS data in this area is more limited.

The Navy modeling results indicated that travel times between the deeper outpost monitoring wells and MWD Well 5 would exceed 20 years, and that there were no outpost monitoring wells for MWD Well 4. Based on these results, the Navy plans to proceed with the installation of new monitoring wells approximately halfway between the existing outpost monitoring wells and MWD Wells 4 and 5 (depicted in Figure 4). Two moderately deep wells will be installed to evaluate groundwater that may be captured by

MWD Well 4 and two deeper wells will be installed to evaluate groundwater that may be captured by MWD Well 5. The drilling of these monitoring wells will produce new hydrogeological data, which is generally deficient in this area, and when coupled with new pumping tests, can be used to improve the confidence of the Navy's modeling results for groundwater flow and contaminant transport in this area.

The USGS model and associated report have not been released for review by the Navy as of the date of this document. Currently no date for release has been set by the USGS. The Navy will conduct more in-depth reviews of the USGS model when it is released.

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