MEMO

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Date:

August 5, 2016

Arcadis Project No.:

NY001496.2515

Subject:

Evaluation of Remedial Well RW-20 Options

RW-21 Project Area, Operable Unit 3, Bethpage, New York

This memorandum has been prepared by Arcadis of New York, Inc. (Arcadis) on behalf of Northrop Grumman Systems Corporation (Northrop Grumman) in support of efforts to obtain Town of Oyster Bay (TOB) approval (the well location has been approved by the New York State Department of Environmental Conservation [NYSDEC]) of the location of Remedial Well RW-20, at the intersection of William Street and Broadway (intersection), in Bethpage New York. The RW-20 location was included in the conceptual remedial designs provided in the NYSDEC-approved RW-21 Pre-Design Report and RW-21 Remedial Design Work Plan.

The work zone necessary to install RW-20 requires closure of the intersection for approximately two months. In response to community objections as to the intersection closure and the time of year for the work, the TOB suspended the permit application for Well RW-20 pending resolution of stakeholder concerns. As a result, Northrop Grumman has directed Arcadis to prepare a comprehensive evaluation of possible options to the planned RW-20 installation. This memo provides a summary of the options evaluated and a determination of their viability relative to the current plan, including the following:

- Eliminate RW-20 as part of the RW-21 remedy
- Install RW-20 using Directional Drilling
- Re-Locate RW-20
- Reconfigure RW-20 Work Zone

BACKGROUND

On February 7, 2011 and April 7, 2011 respectively, Northrop Grumman submitted to the NYSDEC the Study Area Remedial Investigation (RI) and Study Area Feasibility Study (FS) reports. The RI report identified an area of elevated total Volatile Organic Compounds (TVOCs) in groundwater (initially referred to as the groundwater "hot spot" and currently referred to as the "RW-21 Project Area") downgradient of the Bethpage Community Park. The FS recommended the installation and operation of Remedial Well RW-21 to address this area. On March 29, 2013, the NYSDEC issued a Record of Decision (ROD) for the Northrop Grumman Bethpage Facility Operable Unit 3 (OU3). The ROD presented the NYSDEC selected remedy to address off-site groundwater identified in the Study Area RI report as follows:

> *"One or more groundwater extraction well(s) along with the necessary treatment will be installed in the groundwater plume emanating from OU3 (the exact number to be determined during the design phase). The wells will be located downgradient of the area(s) of elevated contaminant levels identified upgradient of Bethpage Water District Plant 4. This system will be designed to capture and treat the "hot spot" area of the plume to the maximum extent practicable, at a minimum capturing and treating 90 percent of the mass of groundwater migrating from the elevated "hot spot area" (the recommendation by the Technical Team for Optimization of the Bethpage Plume Remedy in their June 15, 2011 report prepared for the U.S. Navy). Considerations may be given to the use of Bethpage Water District facilities for all or part of treatment system. Additional monitoring wells will also be installed and monitored to allow completion of a 3 dimensional delineation of the leading edge of the OU3 plume and an assessment as to whether the remedy for the contaminated groundwater in this area needs to be further evaluated."*

In 2014/2015, Arcadis conducted a groundwater investigation in accordance with the NYSDEC-approved Work Plan. The results of this investigation, and associated modeling, indicated that two remedial wells (RW-20 and RW-21) each pumping at 500 gallons per minute (gpm) would meet the ROD requirement for capturing and treating 90 percent of the TVOC mass discharge moving through the aquifer. Northrop Grumman subsequently decided to add a third remedial well (RW-22) pumping at 500 gpm to remove additional TVOC mass, significantly expedite cleanup, and enhance public water supply protection. The NYSDEC has required implementation of the RW-21 Project Area Remedy on an expedited basis and Northrop Grumman has committed to this.

The investigation conducted near RW-20 was performed to identify the portion of the aquifer through which the greatest mass of TVOCs is moving. Defining this area of the aquifer is a critical aspect of the design; it is where the remedy will have the greatest likelihood of success to restore groundwater quality in the least amount of time. That area of the aquifer is less than 300 feet wide and centered beneath the intersection of William Street and Broadway, which is approximately midway between wells RW-21 and RW-22 and the optimal location to install RW-20 to comply with the ROD. Subsequent field reconnaissance of the RW-20 area was conducted to verify the accessibility of the proposed drill site, including avoiding obstructing access to residences and driveways, avoiding both overhead and underground utilities, and minimizing the size of the work zone to the extent practical.

Subsequent to the presentation to the public on June 21, 2016 which depicted the planned drilling locations and the need to close the Broadway/William Street intersection for approximately 2 months, several residents attended a TOB board meeting objecting to the closing of the intersection and the timing of the planned RW-20 work. The RW-20 options provided in this memo focus on alternatives to the closure of the intersection.

EVALUATION OF OPTIONS

Well RW-20 represents a critical element of the ROD groundwater remedy, as this well provides control and treatment of elevated concentrations in the OU3 groundwater plume as called for in the ROD. To address stakeholder objections, Arcadis evaluated four options, as summarized below.

Option 1: Eliminate RW-20

Arcadis performed groundwater flow and transport modeling to evaluate the effects of eliminating RW-20 from the RW-21 Project Area remedy. Elimination of RW-20 results in less TVOC mass removed by the remedy, when compared to the three-well scenario (RW-20, RW-21, and RW-22). These results demonstrate the value of pumping RW-20 in the planned location.

The intent of the ROD is to remediate the highest concentrations of VOCs in groundwater upgradient of BWD Plant 4. Eliminating RW-20 from the design would result in the remedy not meeting the ROD criteria of capturing 90 percent of VOC mass upgradient of BWD Plant 4. Based on this determination, NYSDEC has stated that eliminating RW-20 is not acceptable and would not be approved.

Arcadis also evaluated the effect of increasing the pumping rates of RW-21 and RW-22 (i.e., without RW-20) on the time to meet the 90 percent mass reduction. The results indicated that the remedial timeframe would be decreased by approximately two years.

Based on 1) NYSDECs requirement to install RW-20, 2) the evaluation that showed without RW-20, the remedy would be deficient in meeting the ROD objective of 90 percent mass removal, and 3) the evaluation that showed increasing the pumping rates of RW-21 and RW-22 did not substantially change the remedial timeframe, this option is not viable.

Option 2: Use Directional Drilling

Arcadis evaluated the viability of installing a directionally (angled) drilled remedial well as an alternative to the conventional method of installing a vertical remedial well. The goal of the evaluation was to answer the basic question: Is it possible to drill an angled well to reach the desired well depth at the RW-20 location without having the drilling rig positioned in, and therefore closing down, the intersection?

In theory, directional drilling could be used to install RW-20 without closing the road intersection and would remove drilling operations from the residential community and avoid utility issues typically associated with traditional vertical wells. The angled well in this scenario would be drilled starting at a location east of Route 135 and terminate beneath the intersection at the targeted well screen interval (600 to 650 ft bls). Using this technique, the total drilled length (approximately 1,300 ft) would be greater than a traditional vertical well.

Angled wells of this length and complexity are likely beyond the capabilities of environmental well drillers; therefore, a specialty driller (e.g., contractor from the oil and gas industry) would need to be utilized. Directional drilling presents significant technical challenges to successful well construction, compared to a traditional vertical well. Specifically, the well screen and gravel pack design would have to be estimated prior to drilling, in contrast to industry-standard methods used to design traditional vertical wells. If an incorrect well screen slot size and gravel pack are selected, the well would be unsuitable for its intended use and the entire process would need to be restarted.

Given the limitations expressed above, this option is not viable.

Option 3: Re-Locate RW-20

Although it may be possible to re-locate RW-20 to another area within the plume, there would be significant drawbacks to this approach, as follows:

- Any re-location of RW-20 would still require the well to be installed in the residential community, which would not eliminate the potential for inconveniences to residents, including street closures.
- Re-location North or South – The location of RW-20 was proposed in the NYSDEC-approved conceptual design to maximize VOC mass removal, minimize cleanup time, and enhance protection of public water suppliers. Re-location of RW-20 in either direction would extend the cleanup time and result in less than optimal mass removal.
- Re-location East or West – RW-20 would no longer be located within the center of the aquifer zone of highest concentrations of VOCs. Re-location in either direction would result in lateral spreading of the plume to an area with lower VOC concentrations, resulting in extending the cleanup time and less than optimal mass removal.

Based on the modeling performed, RW-20 is optimally located at the intersection of William Street and Broadway and as re-location would result in either extending the cleanup time or spreading of the plume, this option is not viable.

Option 4: Reconfigure Existing RW-20 Work Zone

Arcadis, in consultation with the drilling subcontractor, investigated other positions/configurations of the drilling work zone to permit RW-20 to be installed near the intersection without closure of Broadway. It was determined that a smaller work zone slightly east of the intersection could be achieved. This proposed work zone would require closure of William Street east of Broadway and ending mid-block west of North Windhorst Avenue. This smaller work zone would reduce the available space for equipment and material storage and would slow productivity, resulting in an additional 4 weeks to complete the work. This option would require additional up-front planning, coordination, and logistics, as follows:

- Temporary re-location of overhead utilities to two residences for the duration of the well installation project. This will require:
    - Either re-locating utilities to another existing pole or installation of a temporary pole at the northeast corner of the intersection.
    - Reconnection of utilities to the original pole at the conclusion of the project (and removal of the temporary pole, if installed).

  This utility relocation will require coordination with the affected service providers.
- Removal of two small trees on William Street within the proposed footprint of the drill rig. The two trees will be replaced at the completion of RW-20.
- Pruning of a larger tree located on the north side of William Street to accommodate raising and lowering of the drill rig mast. This pruning will be conducted by a licensed arborist.
- Installation of a new sewer manhole on William Street east of Broadway to maintain the reduced work zone. This will require coordination with Nassau County Department of Public Works.

This option is viable, however it will require additional time and cost to complete.

CONCLUSION

Based on the requirements for installing Well RW-20 and in consideration of the above evaluation, Option 4 is the only viable option. Northrop Grumman is committed to implementing this option to reduce inconvenience to the residents, while implementing the most technically sound solution that meets the requirements of the ROD.