Assessment of Massapequa Water District's Total Estimated Plume Containment Cost - March 2015

Prepared for:

Northrop Grumman Systems Corporation
Bethpage Facility

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Prepared by:

EMAGIN
Environmental Management & Global Innovations, Inc.
15711 Mapledale Blvd, Suite B
Tampa, Florida 33624
(813) 968-7722

This report was prepared for Northrop Grumman Systems Corporation ("Northrop Grumman") in support of its ongoing dialogue with the New York State Department of Environmental Conservation ("Department") regarding environmental conditions in Bethpage (the Bethpage Facility). Specifically, this report provides an assessment of the Massapequa Water District's ("MWD") document entitled "Total Estimated Plume Containment Cost – March 2015" ("MWD proposal"). The goal of the MWD proposal is complete containment of the comingled Operable Unit 2 ("OU-2") and Operable Unit 3 ("OU-3") plumes (i.e., full plume containment), which consist primarily of volatile organic compounds ("VOCs"). Complete containment would purportedly be accomplished by installing paired shallow and deep wells along two transects in the path of the plumes, extracting groundwater at a rate of 20 million gallons per day (MGD), treating the water at two treatment plants, and discharging the treated water in 40 injection wells in Bethpage State Park.

The MWD proposal is a variant of the full plume containment alternatives (Figure 1) that have been intensively evaluated over the past 15 years by the Department, the U.S. Geological Survey ("USGS"), the U.S. Navy, Northrop Grumman, and nationally recognized technical experts. Full plume containment was found to be not feasible in those evaluations within the meaning of "feasible" in 6 NYCRR Part 375-1.2 as "…suitable to site conditions, capable of being successfully carried out with available technology, implementable, and cost effective." Not only is the MWD proposal for full plume containment not feasible, but some of its features would create significant adverse impacts on water districts, the aquifer, and the public.

Full plume containment was first evaluated in the Department's 2001 Record of Decision for OU-2 ("OU-2 ROD") for consistency with the National Contingency Plan ("NCP"), 40 CFR Part 300, and 6 NYCRR Part 375, each of which mandates that a remedy protect human health and the environment as the primary objective, and balance tradeoffs among viable alternatives. The Department did not select full plume containment because of the "…technical infeasibility of implementing such a program in the extensive and diffuse offsite plume." The Department explained that "[t]his is based on the sheer width, depth, and overall area of the plume and on comparison of this plume information with ONCT extraction system data and data from other sites on Long Island where groundwater extraction and treatment is being implemented." The Department concluded "[i]n addition, the area is densely developed and finding the necessary locations to implement total plume containment would be difficult at best and more likely, infeasible to implement." (OU-2 ROD page 58).

In the OU-2 ROD Responsiveness Summary, the Department answered a July 27, 2001, request by the MWD Commissioner that the Bethpage plume be contained by stating "… full plume containment is not a feasible option… it is clear that full plume containment would be too extensive in nature, and is just not feasible." (ROD response 60, page 55).

Twelve years after the OU-2 ROD, the Department expressed again, this time in the 2013 ROD for OU-3, that full plume containment was not feasible and, moreover, was even less realistic than in 2001, when

the plume was characterized as less extensive and diffuse (OU-3 ROD Responsiveness Summary, introduction, page A-2):

> "Full containment of the OU2 groundwater contamination plume was evaluated as part of the OU2 remedy and was not selected. This decision, set forth in the OU2 ROD, has recently been reviewed independently by a number of organizations including the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), the United States Army Corps of Engineers (USACOE) and the Battelle Institute. The Naval Facilities Engineering Command (NAVFAC) finalized this review into the Remedy Optimization Team Report (06/2011). While these four reviewing groups have offered suggestions regarding the need for further evaluation, none have suggested that the selected remedy for OU2 was not appropriate."

The Department also concluded that the expanded pump and treatment system evaluated in the OU-3 ROD would be even more difficult to implement than the full containment system evaluated in the OU-2 ROD (OU-3 ROD Exhibit D, page 15):

> "There is a greater degree of difficulty of implementation for the off-site groundwater remedial program the larger the given pump and treatment system is. This includes the number of groundwater extraction wells, pipelines, treatment system(s) and points of discharge. The off-site full plume containment groundwater system would be constructed in a densely populated area with significant implementability due to the greater difficulty of siting and constructing the off-site groundwater remedial elements for this huge pump and treatment system. All this construction would be occurring within highly developed residential areas or highway rights of way both of which will present significant implementability issues associated with the access and siting of the large pump stations, treatment systems and required pipe lines connecting all the facilities."

While the Department's rejections of full plume containment in 2001 and again in 2013 were conclusive, the following examination revisits the feasibility of full plume containment in light of MWD's proposal.

1. The full plume containment alternative does not satisfy key Department regulations for selecting an appropriate remedy.

Proposed remedies under state and federal regulations must be evaluated for consistency with 6 NYCRR Part 375 and the NCP, which mandate that a remedy protect human health and the environment as the primary objective, balance tradeoffs between other viable alternatives, and also consider remedy implementation, cost effectiveness, and community concerns. This process for evaluating remedy feasibility must be followed because circumventing that process by a particular stakeholder would be inconsistent with federal and state law and could be at the expense of other stakeholders and the environment.

Department regulations at 6 NYCRR 375-1.8(f) set forth criteria for selecting an appropriate remedy; these mirror the remedy selection criteria listed in the NCP. The MWD proposal does not satisfy the following criteria for selecting an appropriate remedy:

- Long-term Effectiveness and Permanence (f)(3). The full plume containment remedy would not prevent the groundwater plume from reaching downgradient public supply wells with sufficient certainty to eliminate the need for wellhead treatment; therefore, full plume containment would not be effective over the long term. Factors for evaluating long-term effectiveness include the extent of remaining contamination and the reliability of controls to accomplish the cleanup objective, which militate against selecting hydraulic containment alone for the plume. See DER-10, page 132; 40 CFR § 300.430(e)(9)(iii)(C).

- Short-term Impacts and Effectiveness (f)(5). The MWD proposal for full plume containment does not mitigate short-term adverse impacts. The proposed remedy would take many years to implement and would have significant adverse impacts on the community and the environment associated with constructing the expansive off-site groundwater remedial systems (e.g., noise, dust, disruption of traffic and commerce). Following construction, operating the remedial system proposed by MWD would result in a net loss of groundwater in the local aquifer near public water supply wellfields, thereby worsening an already recognized saltwater intrusion problem. See DER-10 at 133; 40 CFR § 300.430(e)(9)(iii)(E); U.S. EPA, A Guide to Selecting Superfund Remedial Actions (1990).

- Implementability (f)(6). Substantial technical and administrative difficulties, including land acquisition for treatment systems, access agreements for drilling wells and installing piping, and construction in dense, highly-developed neighborhoods, would occur when implementing a full plume containment remedy. See, e.g., NYSDEC, Record of Decision for the Unisys Corporation Site: Operable Unit Number 02: Offsite Groundwater (December 2014) (finding that certain alternatives considered faced difficulty in implementability due to challenges in gaining access to multiple off-site properties that would be required for construction of remediation systems). See DER-10 at 133; 40 CFR § 300.430(e)(9)(iii)(F).

- Cost Effectiveness (f)(7). The Department is required to select the most cost effective remedy from amongst equally effective remedial actions. Even if full plume containment would protect water users to the same extent as current OU-2 ROD remedy, it would fail the cost-effectiveness test because other less costly remedies would be at least as effective. See DER-10 at 133; 40 CFR § 300.430(e)(9(iii)(G)).

2. Four separate peer- and agency-reviewed studies examined the full-plume containment alternative and concluded it was not an appropriate action.

The MWD proposal is a variation of a full plume containment alternative that was evaluated by the Department, the USGS, the Navy, Northrop Grumman, and other technical experts, and then eliminated

as a feasible option for addressing the plume. Specifically, the feasibility of implementing full plume containment has been evaluated on four occasions since 2000.

2000 OU2 Groundwater Feasibility Study

Full plume containment alternatives were first discounted in the Department's 2001 OU-2 ROD following the conclusion of a public process, and based on the findings of the October 2000 "Groundwater Feasibility Study Grumman Aerospace-Bethpage, NY Site #130003A and Naval Weapons Industrial Reserve Plant, Bethpage, NY Site #130003B ("OU-2 Feasibility Study"). At that time, the plume was reportedly 9,600 feet wide, 12,100 feet long and extended to a depth of 580 feet. Several full plume containment alternatives were evaluated in the OU-2 Feasibility Study, each of which included six off-site extraction wells withdrawing a total of 5.2 MGD (Figure 1) followed by treatment of extracted groundwater and discharge to existing storm sewers. Full plume containment was not recommended in the OU-2 Feasibility Study because of implementation difficulties, high costs, and negligible improvements in contaminant mass removal and groundwater cleanup time compared to the recommended alternative.

2001 OU-2 Record of Decision

The findings of the OU-2 Feasibility Study were reflected in the Department's alternatives evaluation in the OU-2 ROD. The selected remedy consisted of focused groundwater remediation to address VOC source areas, on-going wellhead treatment to protect public water supplies, and contingency planning for potential future wellhead treatment. The OU-2 ROD stated "[t]he selected remedy is protective of human health and the environment, complies with State and Federal requirements that are legally applicable or relevant and appropriate to the remedial action to the extent practicable, and is cost effective. This remedy utilizes permanent solutions and alternative treatment or resource recovery technologies, to the maximum extent practicable, and satisfies the preference for remedies that reduce toxicity, mobility, or volume as a principal element." (OU-2 ROD, Declaration). The Department further stated that the remedy (Alternative 3) was selected "…based on the fact that it is not economically or technically feasible to contain and treat all the contaminated groundwater that has migrated from the Northrop Grumman and NWIRP sites to groundwater quality standards." (OU-2 ROD page 28).

2011 Optimization Study

The Department's conclusion that wellhead treatment is a necessary component of an effective remedy was validated in 2011 when the Navy assembled a technical team to revisit full plume containment. The technical team included experts in chlorinated solvent impacts from the Navy, USGS, and academia, and also included MWD's consultant, Richard Humann of the H2M Group. The technical team concluded in the June 2011 "Remedy Optimization Team Report for the Bethpage Groundwater Plume Remedy" ("Optimization Report") that:

- "The sheer size of the TCE plume footprint … renders complete aquifer cleanup unachievable within a reasonable timeframe, even with the benefit of unlimited economic resources." (page 10); and

- "Experience at other sites shows that geologic heterogeneities, plume migration, and matrix diffusion are significant technical constraints that will likely make large-scale, rapid restoration of groundwater in the downgradient plume to pre-plume conditions impossible. Therefore, impacts to public water supply wells are unavoidable." (page 10)

2012 Alternatives Report

The full plume containment alternative was again dismissed in the Navy's January 2012 "Study of Alternatives for Management of Impacted Groundwater at Bethpage" ("Alternatives Report"). By then, the plume that the MWD proposal purports to address was better defined, revealing an even more extensive and diffuse plume than what was believed to exist in 2001, making full plume containment even more difficult and less reliable. The Navy characterized the plume as having shallow and deep components, with the shallow plume (generally 100-300 feet deep) reported to be approximately 9,700 feet wide and at least 17,000 feet long. The deep western plume occurred between 300 and 750 feet below land surface (bls) and extended downgradient over 12,000 ft. The deep eastern plume was reported to be 300 to 650 feet bls and vertically discontinuous. Full plume containment was not recommended in the Alternatives Report because it would present negative short-term and long-term impacts, would be difficult to implement, would not be cost effective, and would require wellhead treatment. The Alternatives Report was widely circulated, and did not receive any publicly recorded criticism from the MWD nor the Department.

3. The MWD proposal would not reliably contain the plume to eliminate the need for wellhead treatment.

The OU-2 Feasibility Study, OU-2 ROD, Optimization Report, and Alternatives Report all concluded that even an aggressive attempt at full plume containment would not reliably protect the downgradient public supply wells because VOCs would likely migrate past the remedial system. This point was underscored in the Alternatives Report's conclusion that downgradient wellhead protection must be retained as part of any groundwater remediation alternative to achieve the threshold criterion of protecting human health and the environment (Alternatives Report page 3-1):

> "Each of the first four alternatives (Alternatives 1, 2A, 2B, and 2C) progressively reduces the probability of impacts to downgradient supply wells … However, each progressive reduction in this probability comes with a cost increment that can be sizeable in some cases. On the other hand, none of the alternatives reduces the probability of impacts to downgradient wells to zero. Residual risk of impacts to downgradient wells remains with every one of these alternatives [including hydraulic plume containment] and future investments in wellhead treatment cannot

be ruled out under any alternative. Therefore, wellhead treatment in downgradient supply wells is a sizeable component of the cost of every alternative and cannot be eliminated."

A similar conclusion was reached by Dr. Paul Misut, a USGS scientist who reviewed the Alternatives Report and commented "[m]odeled outcomes that evince plume capture do not mean that the plume will be completely captured; therefore, wellhead protection is retained in all alternatives evaluated. Given the complexity and heterogeneity of the Magothy aquifer and top of the Raritan confining unit, it is probable that breakthrough (contaminants moving beyond recovery wells) will occur and contamination will eventually reach downgradient supply wells."

The conclusion that full plume containment would not be effective in protecting downgradient supply wells is supported by a review in the Alternatives Report of remedial programs at eight Superfund sites with a history of managing deep VOC plumes. Based on the information drawn from those sites, the Alternatives Report found that monitoring and remediation was slow, difficult, expensive, and ineffective beyond a depth of 100 feet. Significantly, none of the sites reviewed had VOC impacts as widespread or deep as the plume in Bethpage. Reviews of remedial performance at deep plume sites showed hydraulic containment needs grew over time as breakthrough occurred. In some cases (e.g., Otis Air Force Base from 1999 to 2007 and Aerojet Site from 1983 to 2009), additional extraction wells had to be repeatedly added to the initial remedy to address breakthrough. A similar lack of containment would be expected if the MWD proposal is implemented in the deeper and more extensive and complex Bethpage plume: "As aquifer depth and plume length increase, the plume encounters increasingly complex geology and undergoes more complex dispersion patterns (reflecting the increasingly complex source distribution upgradient and the geologic heterogeneities encountered along the flow path)." (Alternatives Report page 2-15).

The plume is characterized in the Alternatives Report as diluting while migrating vertically and horizontally into numerous fingers that flow through alternating layers of clay, sand, and gravel. Further, "the plume is not uniform: it consists of one or more bands of high concentration groundwater within a broader aquifer cross-section that has little or no impacts." (page 1-4). Full plume containment would be greatly hindered by the presence of the clay lenses and other heterogeneities that were observed to increase with depth in this complex aquifer. This difficulty would arise from trying to extract impacted groundwater from between narrowly spaced clay layers and from multiple plume fingers produced by complex dispersion patterns.

Groundwater containment systems rely on extraction wells to induce groundwater flow towards the wells by lowering the water table (or potentiometric surface) and producing cones of depression (i.e., depression of the water level) around the wells. The conceptual basis for the MWD proposal is Alternative 2C in the Alternatives Report. Alternative 2C consists of 10 paired extraction wells pumping at a combined 20 MGD, treating extracted groundwater at three treatment plants, and reinjecting the treated water downgradient of the extraction wells (Figure 1). Consistent with that conceptual design, the MWD proposal specifies 10 pairs of extraction wells that are spaced roughly 900-1,200 feet apart

and located beyond the southern boundary of the plume. Even in well-designed systems, where the cones of depression for the extraction wells overlap, bands of high permeability in a complex aquifer, like the downgradient perimeter of the Bethpage plume, can allow contaminated groundwater to bypass the containment system. The problems associated with plume containment because of plume depth and complex geology are magnified by the large size of the Bethpage plume. As described in the Alternatives Report, the shallow plume is about 9,700 feet wide and 17,000 feet long, with the deep western plume extending downgradient (southeasterly) over 12,000 feet.

The failed attempts at deep plume containment described in the Alternatives Report illustrate that the MWD proposal is not built on a solid foundation of practical experience or on successful project demonstrations. Moreover, there are no technical precedents for containing such a widespread and deep plume in a hydrogeological setting as complex as that in Bethpage. The MWD proposal does not recognize the Alternative Report's conclusions that attempted full plume containment would not be reliable because breakthrough would likely occur.

4. Substantial technical and administrative difficulties would impede construction of MWD's full plume containment design.

Full plume containment under the MWD proposal would not meet the NCP criterion of implementability, i.e., the ability to accomplish or execute a remedial plan. Implementability is a key remedy selection criterion under the NCP and 6NYCRR Part 375-1.8(f)(6) and must address both the technical and administrative feasibility of carrying out a remedy. Technical feasibility refers to the ability to construct the remedy, reliability of the approach, and ease of undertaking any necessary additional remedial action, such as adding additional extraction wells or wellhead treatment to supply wells. Administrative feasibility covers issues related to coordinating with government agencies, such as required permitting, public noticing, and/or local approvals.

Technical Feasibility

The technical feasibility of full plume containment was first evaluated in the October 2000 OU-2 Feasibility Study. The full plume containment alternative was not recommended in the OU-2 Feasibility Study because of implementation problems and high costs even though the remedial system evaluated was considerably smaller and less complex than that proposed by MWD; i.e., 14 fewer extraction wells, shorter piping runs, and use of existing storm sewers and recharge basins. The OU-2 Feasibility Study, concluded that "Alternatives 5 through 8 [those including full plume containment] would be the most difficult to implement, because they would require the greatest number of treatment plants, which will be spread throughout the off-site residential community. The off-site groundwater extraction wells and treatment units under Alternatives 5 through 8 would require property acquisition, building demolition and construction, zoning changes, and tie-ins to existing utilities." (OU-2 Feasibility Study page 5-9)
Consistent with the findings of the OU-2 Feasibility Study, the subsequent 2001 OU-2 ROD described the technical feasibility constraints of this alternative: "full plume containment would be difficult or infeasible to implement because of the multiple difficulties associated with purchasing private property

for system construction; zoning and permitting requirements; and finding the necessary locations to implement total plume containment in a densely populated area." (OU-2 ROD page 58).

The implementability of full plume containment was reviewed again in the 2012 Alternatives Report, which included an additional 14 extraction wells and associated conveyance piping compared to the OU-2 Feasibility Study design. This change in design (from 6 to 20 extraction wells) is consistent with the containment approach described in the OU-2 ROD because the Navy applied the same scientific and engineering principals for remedy design. The additional wells in the Navy's design address deeper portions of plume not characterized prior to the OU-2 ROD.

Construction of the MWD design would be more difficult and intrusive than in previous conceptual designs due to the added complexity presented by many more extraction wells, longer piping runs, and relocating the treated water discharge miles away from the extraction wells. The MWD proposal includes installing nearly 6 miles of 20-inch diameter underground transmission piping and electrical conduits. That installation would require construction of a trench up to 6 feet wide on narrow streets in front of businesses and residential properties. Installing the transmission piping would require slow, surgical efforts to protect business patrons, residents, and existing utilities. Construction activities would disturb roughly 150 residential properties by blocking driveways and street-side parking, producing traffic detours, generating noise, disrupting commerce, placing heavy trucks and construction equipment in neighborhoods, and likely damaging trees, fences, and other features on public and private property.

In addition to these constructability problems, long delays would occur in acquiring access to, or procuring, sufficient land to construct the remedial system. As described in the Alternatives Report: "Real estate for housing treatment plants could be difficult to acquire in densely developed neighborhoods." The Navy recently estimated that it would take over 7 years to construct a small system consisting of only two wells, one treatment plant, and an existing recharge basin (Navy, October 29, 2015, Bethpage RAB meeting). The remedial system in the MWD proposal is far more complex than the Navy's plan, so it would be reasonable to assume a project duration of over 10 years before system startup.

Administrative Feasibility

The MWD proposal does not address administrative difficulties related to legal and engineering efforts or potential delays for securing property access agreements and applicable approvals from local, state, and federal agencies for installing the transmission piping, wells, and treatment systems. Design and construction under the MWD proposal would entail two sequential phases of access agreements:

Phase 1, Pre-Design Investigation. The first phase of access agreements could require several years of effort. The 2011 Optimization Report concluded that the current groundwater model is inadequate in simulating the variations in aquifer properties and capture zones of existing public supply wells. The team recommended that the "…off-site monitoring well network needs to be augmented with vertical

profile borings and multi-level monitoring wells … in order to … [B]etter quantify hydrogeologic parameters critical for improved groundwater flow modeling…" (Optimization Report page iv).

Although the Navy continues to advance borings and install monitoring wells, sufficient plume delineation and aquifer characterization associated with groundwater flow and fate and transport simulations are not complete. The flow model would be integral to the design effort and is necessary to design the extraction system and treatment equipment. The flow model would also help estimate the magnitude of the impacts on the local aquifer generated by the additional pumping, including reducing the water supply to drinking water wells and accelerating the rate of salt-water intrusion. A work plan would be needed to address these inadequacies and identify appropriate locations where soil borings and/or monitoring wells could be installed to help fill some of the data gaps, and access agreements would be needed for those properties selected for drilling. At another location within the Bethpage Plume, an access agreement for a single boring and well location took many months to negotiate before drilling could begin.

Phase 2, Construction. Access agreements or acquisition of property for construction would require years of additional legal and engineering effort. Assuming the remedial design is completed, a second round of access agreements or property acquisitions would be needed to install 20 remedial wells over a 9,000-foot expanse, nearly 6 miles of conveyance piping, and 40 injection wells. The conveyance piping would need to be installed on contiguous properties, so the inability to obtain access or acquire even a single property may necessitate rerouting of the piping and restarting the process with other property owner(s).

Substantial legal and engineering effort would be needed to negotiate terms and prepare long-term response/contingency plans to protect the public and utility workers from leakage by conveyance piping. Road Opening Permits and Sidewalk Permits would be required from Nassau County for pipeline construction in public ROWs. Those permits would require extensive, time-consuming surveying and engineering plans for the affected parcels, and require performance and maintenance bonds that would likely carry onerous liability provisions and contingencies to account for leakage or releases of contaminated groundwater. The MWD proposal estimates that pipeline leaks requiring repairs would occur twice per year. Because each transmission pipeline would convey roughly 10 million gallons of groundwater per day (the equivalent of 33 Olympic swimming pools), a pipeline rupture or breach could release a large volume of potentially contaminated groundwater in residential or commercial areas.

The Alternatives Report estimates that two 3-acre plots would be needed to house treatment equipment but the report raised concerns about finding such property in this densely populated area. The MWD proposal does not address the feasibility of procuring properties in a highly-developed residential-commercial area for locating the necessary treatment facilities.

The MWD proposal would trigger the need for a Long Island Well Permit from the Department under Environmental Conservation Law ("ECL") §15-1527. Certain statutory criteria for obtaining a Water Withdrawal Permit under the recently enacted provisions of ECL §15-1527 are specifically incorporated

into the Long island Well Permit statute, and thus the Department must consider those criteria. As such, issuance of a permit would be unlikely because Section 601.16(a)(2), consistent with the statutory purpose, provides that the Department " …may deny an application for a water withdrawal permit if the department determines that… the water withdrawal will exceed or cause to be exceeded the safe yield or sustainable supply of the water source". Moreover, an applicant must demonstrate (Section 601.10(k)) that:

- "the project is just and equitable to all affected municipalities and their inhabitants with regard to their present and future needs for sources of potable water supply" (ECL §15-1527.4 and ECL §15-1503.2.c); and

- "…the department shall determine whether… the proposed water withdrawal will be implemented in a manner to ensure it will result in no significant individual or cumulative adverse impacts on the quantity or quality of the water source and water dependent natural resources." (ECL §15-1503.2.f).

The outcome of such a demonstration would likely show that withdrawal of 20 MGD would have substantial negative impacts on local water supplies, which are detailed in the next section.

5. The MWD proposal would produce harm to other water districts and the public, including depleting water supplies and exacerbating salt water intrusion.

Attempting full-plume containment under the MWD proposal would have major collateral impacts and could do more harm than good. A significant difference between the MWD proposal and Alternative 2C in the Alternatives Report on which it is based is that the MWD proposed approach includes injecting the treated water up- and cross-gradient of the extraction wells instead of downgradient of the extraction wells. This feature of the MWD proposal has a potential for significant damage to other water districts. Extracting an additional 20 MGD of groundwater beyond what is currently withdrawn by nearby supply wells and discharging it more than 2 miles up- and cross-gradient (i.e., outside of the capture zone of the extraction wells and Bethpage, South Farmingdale, and Massapequa Water Districts Supply wells) would cause additional aquifer depletion (Konikow 2013), exacerbate an already serious salt water intrusion problem, accelerate the movement of known and unknown contaminated groundwater to the Bethpage and South Farmingdale Water District supply wells, and reduce the availability of water to these Districts and MWD's supply wells.

Excessive groundwater pumping ("over-pumping") has been debated in Nassau County for over a decade because it leads to depletion of the aquifer. The "safe yield" for Nassau County, traditionally defined as the amount of water that can be withdrawn without producing an undesired effect, is reported to be 185 MGD, a benchmark that was exceeded nine times between 1990 and 2003 (Nassau County Groundwater Monitoring Program 2000 – 2003). The average annual groundwater demand now consistently exceeds the safe yield (Nassau County Master Plan for 2010-2030, Draft 2010). Compounding this problem is the current understanding that "sustainable yield" rather than "safe yield"

should be the objective of prudent water supply planning (Alley et. al. 1999, Alley and Leak 2004, and Bartolino and Cunningham 2003), which necessitates less withdrawal than the "safe yield", as traditionally defined (http://ponce.sdsu.edu/groundwater_sustainable_yield.html):

> "The traditional concept of safe yield, which equates safe yield with natural recharge, is flawed and has been widely discredited. It has now been replaced with sustainable yield. Sustainable yield depends on the amount of capture, and whether this amount can be accepted as a reasonable compromise between a policy of little or no use, on one extreme, and the sequestration of all natural discharge, on the other extreme. …Sustainable yield may also be expressed as a percentage of recharge. Limited experience suggests that average percentages may be around 40%, with the least conservative around 70%, and reasonably conservative around 10%."

The combined groundwater withdrawal of the three water districts in the area of the extraction system proposed in the MWD approach (Bethpage, South Farmingdale, and Massapequa Water Districts) is 14.5 MGD. The proposed additional groundwater withdrawal of 20 MGD under the MWD proposal would bring the total groundwater withdrawal to around 34.5 MGD; more than double the annual extraction from the aquifer by those three districts and more than 10 percent of the total withdrawal by all water districts in Nassau County.

The additional 20 MGD of extracted groundwater would be discharged more than 2 miles up- and cross-gradient of the extraction wells and not back into the Magothy aquifer from where it was extracted (Plume Containment System Map, MWD). The Alternatives Report estimates that recharge due to rainfall in the Bethpage area is around 16.2 MGD (23 inches of rain per year over an area 5.5 miles long by 2.7 miles wide), and since the total withdrawal in the Bethpage area would be around 34.5 MGD, there would be a local annual groundwater deficit that would grow by approximately 18.3 MGD (34.5 minus 16.2 MGD) or 6.7 billion gallons per year, year after year. It is widely understood by groundwater experts that persistently exceeding the sustainable yield is a problem and would lead to a number of negative impacts:

- Saltwater intrusion in Nassau County is well documented (Barlow, 2003) and has been caused by many years of over-pumping of the primary drinking water aquifers (Bartolino and Cunningham 2003). More recently, the effects of over-pumping were conveyed by the USGS at the Long Island Water Conference's 2014 Groundwater Symposium. It was reported that the extent of salt-water intrusion near coastal communities is worse than previously estimated, which means that saltwater could impact supply wells sooner than expected and at greater salinities. Saltwater impacts often lead to abandoning public supply wells. Pumping an additional 20 MGD under the MWD proposal would further accelerate the rate of saltwater intrusion, particularly in the Magothy aquifer under the southern coastal areas.

- Substantial reductions in the water available to public supply wells, particularly those nearest the proposed containment wells; e.g., South Farmingdale Water District wells.

- The South Farmingdale supply wells are located between the proposed groundwater recovery wells and high VOC concentrations in the plume. Pumping an additional 20 MGD would accelerate the southerly movement of contaminant mass in the plume toward the South Farmingdale wells, which may necessitate modifications to the water district's wellhead treatment system to handle greater concentrations.

- Pumping 20 MGD of mostly clean groundwater would expand the cones of depression created by nearby South Farmingdale supply wells and induce migration of contamination toward public supply wells from other VOC sources (e.g., Liberty Finishing Site, Old Bethpage Landfill, drycleaners) that would otherwise have been outside the capture zone of those wells.

6. The current remedy is protective of public health.

The current remedy, selected under the OU-2 and OU-3 RODs, consists of groundwater remedial measures to treat VOCs in on-site and off-site areas of elevated VOCs and to protect public health through wellhead treatment. These remedial measures are comprised of the following components:

- Containment and treatment of the on-site portion of the VOC plume by operation of the ONCT system and Bethpage Park Groundwater Containment System ("BPGWCS"). The ONCT system, which began operating in September 1998, and the BPGWCS, which began operating in July 2009, consist of extraction wells, water treatment systems, and discharge of treated water to surface impoundments. These systems contain the portion of the plume(s) that are on-site, thereby preventing off-site movement of VOCs in groundwater from the former Navy/Grumman facility and Bethpage Community Park and reducing future contaminant loads to the downgradient public water supplies.

- Additional containment and treatment of the off-site plume is being provided by the off-site GM-38 area treatment system and, in the future, the OU-3 hotspot remedial system. These systems are designed to capture and remove substantial VOC mass from the aquifer and further reduce future contaminant loading to downgradient public well fields.

- Implementation of a Public Water Supply Protection Program consisting of operation and maintenance of treatment systems at impacted well fields and a contingency plan for wellhead treatment at public supply wells that may become affected in the future. The State's maximum contaminant levels, or MCLs, are being met for treated water at each of the affected public supply well fields in the area. This is being accomplished using VOC-removal treatment systems that are operating at the wellheads.

- Groundwater monitoring to give potential downgradient water supplies advanced warning of changes in contaminant concentrations to allow time to implement contingency plans or modify existing treatment systems.

The MWD proposal implies that only full plume containment would protect the health of its customers. The current remedy under the OU-2 and OU-3 RODs was determined, pursuant to a public review process, to be protective of public health. Furthermore, the RODs found that these remedial measures comply with the chemical- and action-specific ARARs, achieve substantial VOC mass removal, use reliable technologies, are implementable in a shorter timeframe than other alternatives, and are cost effective. These determinations were made by developing and evaluating a full and appropriate range of remedial alternatives in the OU-2 and OU-3 feasibility studies in accordance with the NCP and 6 NYCRR Part 375.

An important aspect of the current remedy relates to protection of water quality of downgradient water supply wells. A key element of this protection has been wellhead treatment, which has consistently produced safe potable water. Wellhead treatment is not only a key component of the Bethpage groundwater remediation, but is a key component of numerous other groundwater remediation projects throughout Nassau County and Long Island. The Alternatives Report describes the ongoing effectiveness of the current remedy as follows:

- "[The current remedy] …already incorporates a substantial degree of protection [to water supply wells] because of the considerable plume capture already ongoing..." (page 3-2)

- "Between the upgradient source areas and the leading edge of the plume, the plume is subject to mitigating influences including on-site containment wells, hot spot containment, and (fortuitously) impacted supply wells with wellhead treatment. The plume that emerges past all these influences is a much weakened plume … consisting of isolated, dispersed fingers of low concentration, especially in the deeper aquifer, where most of the downgradient supply wells are screened." (page 3-8)

The MWD proposal does not consider the necessity of wellhead treatment to protect public health. The Magothy aquifer from which MWD draws its water supply is not a pristine aquifer, either in the Bethpage area or elsewhere in Nassau County. Nevertheless, residents throughout the County have enjoyed safe drinking water for decades as a result of wellhead treatment methods despite the presence of VOCs and other contaminants in groundwater. Wellhead treatment systems are relatively simple to design and install, and routine monitoring by the water districts and the New York State Department of Health ensures the continued safety of the treated drinking water. Those facts were made clear during a March 9, 2012, presentation to the U.S. EPA on the Fulton Avenue Superfund Site in Garden City, in which H2M (MWD's consultant) introduced a map showing 185 municipal supply wells throughout Nassau County that are currently being treated at the wellhead for VOCs. H2M's presentation offered:

- The "evolving realities" of delivering potable water on Long Island include use of public water supply wells to restore aquifers contaminated with VOCs and at the same time delivering safe drinking water to customers.

- "Water suppliers cannot and will not rely on remedies [e.g., plume remediation technologies] to provide wellhead protection" and that "wellhead protection [is] required regardless".

- Community disturbance during construction of a groundwater remedy is a major concern. Removal of mass using public supply wells and providing safe drinking water was characterized as outweighing the community impacts of constructing and operating a groundwater remediation system.

In a January 21, 2015, Massapequa Observer article, Assemblyman Joseph Saladino, the sponsor of the Chapter 543 bill relating to the regional plume, stressed to local residents that "by the DEC treating the water at the well head, it is made safe at the tap". Further, Stan Carey, MWD Superintendent, stated during an interview by the Long Island affiliate of News 12 on December 2, 2015, that "Bethpage [Water District] wells have been impacted and have treatment in place, making the water safe to drink…"

Given that wellhead treatment would be required under all remedial scenarios to protect public health, attempting to implement both full plume containment and wellhead treatment would substantially exceed the cost of the current source control approach plus wellhead treatment yet, as acknowledged by MWD's consultant and Assemblyman Saladino, wellhead treatment currently being employed is protecting public health.

7. Full plume containment is not cost effective.

Full plume containment is not cost effective because the same or better protection of the drinking water supplies can be provided by additional wellhead treatment. Both of those remedial alternatives would include: 1) groundwater extraction and treatment of VOC source areas (ONCT, BPGWCS, GM-38, OU-3 hotspot); and 2) wellhead treatment for water supply wells upgradient of the MWD-proposed recovery wells; therefore, the costs of those activities are not included in the following cost comparison:

- The estimated total cost of providing wellhead treatment for 15 water supply wells (those identified as downgradient of the full plume containment system in the MWD proposal) under the supplemented current remedy is $187 million.

- The estimated total cost of full plume containment without wellhead treatment on any of the 15 downgradient supply wells, is $343 million.

- If full plume containment is implemented, and wellhead treatment is still required at the downgradient supply wells (as assumed in the Alternatives Report), the estimated total cost of full plume containment plus wellhead treatment for 15 supply wells is $484 million. This assumes that full plume containment would reduce the number of years that wellhead treatment would be required and therefore would reduce the total estimated wellhead treatment costs by $46 million.

Cost effectiveness is a statutory requirement for all Superfund remedies and is determined by comparing the cost of the remedy to its "overall effectiveness." The overall effectiveness of a remedial alternative is determined by evaluating the following criteria: 1) long-term effectiveness and permanence; 2) reduction in toxicity, mobility and volume (TMV) through treatment; and, 3) short-term effectiveness. Accordingly, a cost-effective remedy is one whose "costs are proportional to its overall effectiveness" (NCP §300.430(f)(1)(ii)(D)).

Long-term Effectiveness. The current ROD remedy (source remediation and wellhead protection) would achieve long-term effectiveness by treating all impacted drinking water to meet health-based standards, thereby eliminating long-term risk. Long-term risk would occur with attempted full plume containment because the possibility of impacts to downgradient supply wells above health-based standards would not be eliminated.

Reduction in TMV. Substantial reductions of TMV in the plume would continue to occur under the current ROD remedy through groundwater extraction and treatment in VOC source areas (ONCT, BPGWCS, GM-38, OU3 hotspot) and incidental extraction by supply wells with wellhead treatment. Only small additional reductions of TMV would be realized under the MWD proposal through extracting large quantities of mostly clean groundwater from the most diffuse part of the plume in an attempt to contain the leading edge. The Alternatives Report characterized this situation as follows:

- "Much of the effort and funds would likely be directed towards extracting shallow groundwater (because more flow occurs in the highly permeable Upper Glacial formation), whereas all, but one, of the downgradient supply wells are screened in the deep aquifer. There is inefficient utilization of resources." (Table 3-1, page 3-7)

- "Large volumes of relatively clean groundwater would be extracted, treated, and returned to the aquifer, especially in the deeper zones, where the plume is spatially isolated in a few small discrete fingers. This is an inefficient utilization of resources." (Table 3-1, page 3-7)

Short-term Effectiveness. The current ROD remedy would achieve short-term effectiveness by implementing any necessary wellhead treatment systems in about one year and, because construction would occur on the existing water plant properties, short-term risks to the community and environment are not anticipated. Construction of a full plume containment system under the MWD proposal would take many years to implement because of difficulties associated with acquiring necessary access and property, and construction in a densely populated area and would present short-term risks to the community during construction including increased dust, noise, and traffic.

The overall effectiveness of the current remedy, supplemented with wellhead treatment, is superior to full plume containment. Even assuming that full plume containment under the MWD proposal would protect water users to the same extent as wellhead treatment, it would fail the cost-effectiveness test by a large margin (about $300 million).

8. Full plume containment would not be a sustainable remedy.

The MWD proposal is not a sustainable remedy that would be consistent with the Department's or the U.S. EPA's green policies, which require consideration of green remediation principles when selecting remedial alternatives. In particular, the Department's policy, DER-31/Green Remediation, calls for "considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions" including:

- Considering the environmental impacts of remedy stewardship over the long term;
- Reducing direct and indirect greenhouse gas and other emissions;
- Increasing energy efficiency and minimizing use of non-renewable energy; and
- Conserving and efficiently managing resources and materials.

Full plume containment would not meet the green remediation objectives of either regulatory agency. The proposed removal of 20 MGD of water from the aquifer would exacerbate impacts on natural resources including reduced water availability to public supply wells, changes in localized groundwater flow, and increased likelihood for further salt water intrusion. Significant energy would be consumed as a result of pumping billions of gallons of mostly clean groundwater and to treat, transport, and reinject it into the aquifer. Large-scale construction of a full plume containment system would consume more fuel and natural resources and would result in substantially greater impacts to air quality and disruption to communities than wellhead treatment. Also, long-term maintenance and monitoring of the full plume containment system would result in additional fuel and resource consumption and disruptions to the local community.

Conclusions

Full plume containment has been evaluated over the last 15 years by technical and regulatory experts and dismissed as a feasible option for addressing the plume. Those evaluations concluded that full plume containment would not be feasible due to the depth, extent, and complexity of the plume, nor would it reliably protect downgradient public supply wells. Containment systems at other sites with less extensive and complex plumes have been shown to be only marginally effective, with plume containment needs growing over time as system breakthrough occurred. Similar results would be expected if the MWD proposal is implemented, and downgradient wellhead protection would be required to ensure the protection of public health. By ignoring the proven feasible remedies being employed under the current Department-approved approach to plume remediation, the MWD proposal does not address other regulatory and community concerns, high costs, and the likelihood of causing greater damage.

The ROD-selected remedy would provide a higher degree of protection for public water supplies than the MWD plan and would do so more reliably, faster, more cost effectively, and without the negative

collateral impacts associated with additional over-pumping of the Magothy aquifer. The impacts of the full plume containment alternatives are worsened by the remedy modifications in the MWD proposal.

The extensive investigation and remediation work already completed for the Bethpage site and the additional information provided in this document do not support the MWD proposal's assertion that full plume containment be treated as the presumed groundwater remedy. The MWD proposed remedy would not meet applicable remedy selection criteria under state and federal law and has been eliminated on three separate occasions following in-depth studies.

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2015 MASSAPEQUA WATER DISTRICT PROPOSAL INJECTION WELLS (40)

2000 OU2 FEASIBILITY STUDY EXTRACTION WELLS (6) (DISCHARGE TO RECHARGE BASINS AND STORM SEWERS)

2012 NAVY ALTERNATIVES REPORT EXTRACTION WELLS (12) SHALLOW AND (2) DEEP (DISCHARGE TO INJECTION WELLS)

2012 NAVY ALTERNATIVES REPORT INJECTION WELLS (20)

2015 MASSAPEQUA WATER DISTRICT PROPOSAL EXTRACTION WELLS (10) SHALLOW, (10) DEEP

BETHPAGE PARK

BWD WELLFIELD

VOF WELLFIELD

TOH WELLFIELD

SFWD WELLFIELD

NYAW WELLFIELD

0 750 1500

SCALE IN FEET

● PUBLIC SUPPLY WELL

NORTHROP GRUMMAN

BETHPAGE, NEW YORK

FIGURE 1

PLUME CONTAINMENT OPTIONS

EMAGIN Creative Environmental Solutions