

February 19, 2010
File No. 1003.07

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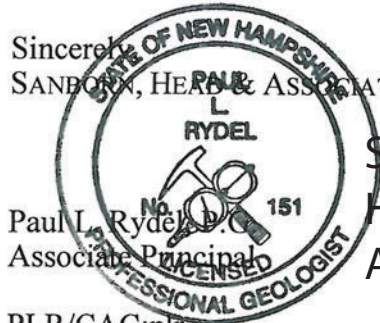
Re: Corrective Action Plan
North Country Environmental Services, Inc. Landfill
Bethlehem, New Hampshire

Dear Karlee:

On behalf of North Country Environmental Services, Inc. (NCES), Sanborn, Head & Associates, Inc. (SHA) has prepared this Corrective Action Plan for the NCES Landfill site in Bethlehem, New Hampshire. The CAP has been revised (from the initial CAP previously submitted to NHDES in November 2009), to address the technical comments provided by NHDES in your letter dated February 8, 2010.

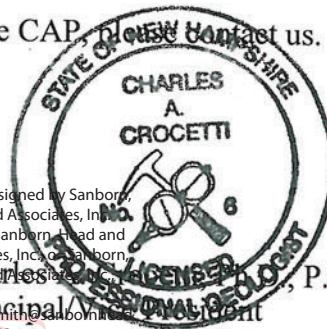
Should you have any questions with regard to the CAP, please contact us.

Sincerely,
SANBORN, HEAD & ASSOCIATES, INC.



Sanborn,
Head and
Associates
, Inc.

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Attachments: NCES Corrective Action Plan

cc: Joe Gay, NCES
Kevin Roy, NCES
John Schwalbe, NCES
David Schmitt, NCES
Bryan Gould, Brown, Olson & Gould

CORRECTIVE ACTION PLAN
North Country Environmental Services Landfill
Bethlehem, New Hampshire

Prepared for
Casella Waste Management, Inc.

Prepared by
Sanborn, Head & Associates, Inc.

File 1003.07
February 2010

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**NORTH COUNTRY ENVIRONMENTAL SERVICES (NCES) LANDFILL
BETHLEHEM, NEW HAMPSHIRE
NEW CORRECTIVE ACTION PLAN
NHDES Site No. 198704033**

1.0 INTRODUCTION

In light of recent remedial actions and related discussions with representatives from the New Hampshire Department of Environmental Services (NHDES), Sanborn, Head & Associates, Inc. (SHA) has prepared this Corrective Action Plan (CAP) for the NCES Landfill Site in Bethlehem. As requested by NHDES, this CAP provides a synthesis and integration of the recent groundwater quality monitoring results with the results of the recent additional remedial actions completed at the site. The CAP has been developed to provide NHDES with a comprehensive assessment of current site groundwater quality conditions through January 2010, and associated temporal trends, as a basis for the observations, conclusions, and recommendations herein. A summary of our current conceptual model of site hydrogeologic conditions is also included, to provide a context for the updated analyses and corrective actions presented herein.

The CAP is intended to accomplish the following objectives:

- Provide a brief history of the landfill's development, the notable impacts to groundwater from the landfill's operations, and NHDES's regulatory response to those impacts (Section 2.0);
- Describe the site's hydrogeology, the qualitative sources of observed impacts to groundwater, and the current groundwater conditions at the site (Section 3.0);
- Describe the progression of remedial activities undertaken by NCES and the *in situ* observations made during those activities (Section 4.0);
- Explain SHA's refined conceptual model describing the sources of VOCs and bromide in downgradient wells, opine on the effectiveness of NCES's remedial actions in addressing those sources, and demonstrate the trending in those wells through statistical methodology (Mann-Kendall and linear regression analyses) (Section 5.0);
- Describe the corrective actions taken since submission of the November 24, 2009, draft of this CAP to NHDES to support the results of the completed remedial actions (Section 6.0);
- Propose that, because the CAP identifies the sources of the contamination in the downgradient wells, documents that the remedial actions taken by NCES are effectively addressing those sources, and describes adjuvant corrective actions, NCES return to triannual monitoring of all wells upon two consecutive sampling rounds that are consistent with decreasing concentration trends for bromide and VOCs in MW-402U and B-913M, as discussed in Sections 5.4 and 6.2 of this CAP, provided that NHDES may, based on new information, request more frequent sampling of other wells at the site if water quality conditions warrant it; and,

- Propose that NCES continue assessment monitoring until VOCs are non-detect in wells MW-402U and B-913M, and bromide concentrations are at 0.1 mg/L or less in these wells, for two consecutive sampling rounds (Section 6.2).

2.0 BACKGROUND

Beginning in the mid-1970s, a prior owner operated an unlined landfill on what is now the NCES site. Operation of the former unlined landfill continued until 1987, when the Stage I lined landfill (the first lined landfill cell at the site) was permitted by NHDES. In accordance with NHDES requirements, a comprehensive hydrogeologic study of the site was performed as part of the solid waste permitting activities associated with development of the Stage I lined landfill. Permitting and development of additional lined landfill units at the site has occurred in three subsequent stages (Stages II through IV), with each lined landfill stage developed in one or more “phases.” The locations of the various landfill areas, indicating the respective stages and phases, are shown on the Exploration Location Plan provided as Figure 1.

A Permit for the Stage II lined landfill was issued by NHDES in 1989, and included development of the lined landfill within the general footprint area of the former unlined landfill. Relocation of waste from the unlined landfill into the lined Stage I landfill was proposed by NCES as a remedy to address the presence of landfill-related constituents (principally VOCs) in groundwater downgradient from the unlined landfill. The unlined landfill waste re-location project was approved by NHDES as a pre-construction requirement of the Stage II Permit, and was completed in October 1993. Excavation of the waste extended to the natural soil subgrade underlying the refuse.

Following completion of waste relocation and development of the lined Stage II landfill (which began Phase I operations in 1996), downgradient groundwater quality was observed to improve significantly, as evidenced by an overall trend of decreasing VOC concentrations in the groundwater samples collected from monitoring wells located in areas downgradient from Phase II of Stage II. A groundwater elevation contour plan, depicting general groundwater flow directions at the site based on recently-measured (July 2009) water levels is provided as Figure 2. Also indicated on Figure 2 are those monitoring wells with recent histories of detection of VOCs and/or bromide at concentrations greater than background.

As required under NHDES’ groundwater permitting process, a Groundwater Management Zone (GMZ), associated with the “plume” from the former unlined landfill, was established. The site GMZ (Figure 1), located in the northeastern portion of the site, was delineated to encompass the area of residual impacts to groundwater quality associated with the former unlined landfill. The site holds a combined Groundwater Management and Release Detection Permit, reflecting the presence of the lined landfill areas (outside of the GMZ) at the site, and their associated network of groundwater release detection wells.

Although an improvement in groundwater quality was observed following relocation of the waste from the unlined landfill, the presence of residual water quality impacts in the area downgradient of the former unlined landfill posed a challenge with respect to the ability to monitor the performance of the Stage II liner system. During the permitting process associated with the Stage II Landfill, NHDES recognized that it could be difficult to differentiate a hypothetical new release from Stage II from the existing, residual groundwater quality impacts associated with the former unlined landfill,

and requested that a means to differentiate a release of leachate from Stage II be developed. NCES proposed the use of bromide, applied to the waste in Stage II in the form of granular sodium bromide, to function as a “tracer” and aid in identification of a potential new release from Stage II. NHDES accepted the proposal, and a requirement to add bromide to the wastes was included as a condition of operational approval of Stage II / Phase I.

The solid waste permit for the development of the Stage III Landfill, located to the southeast of Stage II, was issued by NHDES in July of 2000. Sodium bromide was applied to the waste placed in Stage III beginning in January 2001, and generally continued until such time as the landfill was filled to the point where the pre-established criteria to cease the addition of bromide (e.g., no addition of bromide within 25 feet of an outside side slope of the landfill, etc.) were met.

The Stage IV Landfill, located to the north of Stages I and II, was permitted by NHDES in March of 2003. To date, construction of Stage IV has occurred in Phase I, which is located directly north of Stage II and Stage I / Phase I. In November of 2006, NHDES concluded that in light of the general non-detection of VOCs at key groundwater monitoring wells located in the site GMZ adjacent to the location of the former unlined landfill there was no longer a need for a tracer. Accordingly, bromide has not been added to the waste placed in the Stage IV Landfill.

Beginning in about 2000, VOCs and/or bromide were detected in groundwater samples collected from release detection wells MW-402U and MW-403L, located to the north of the Stage I Landfill. Based on the persistence of detection of these constituents at these monitoring locations (in particular MW-402U), NHDES required NCES to develop a remedial plan to address the presence of VOCs and bromide in groundwater in this area.

In April of 2007, NHDES issued a revised Groundwater Management and Release Detection Permit to NCES. Special Condition #16 to that permit required a scope of work for remedial activities in the area between the landfill and wells MW-402U and MW-403L. NCES provided the scope of work in May of 2007. In July 2007, NHDES required that NCES submit an alternative remedial action plan that would proceed “independent of the status of approval (or non-approval) of construction of Stage IV, Phase II.” NCES submitted the alternative remedial action plan in September 2007, and NHDES approved the plan on November 8, 2007. On the following day, NHDES issued a revised groundwater management and release detection permit to NCES. One of the revisions to the permit was the deletion of Special Condition #16 and the insertion of another condition requiring periodic reports on the progress of the remedial activities. These remedial activities, which came to be known as the “Leachate Management Improvements Project” (LMIP), got underway upon NHDES’s issuance of a “Type II” Solid Waste Permit modification in May 2008. Implementation of the LMIP continued through the construction season of 2008, with work in the area north of Stage I Landfill completed in May 2009, and the overall project completed by November 2009.

As detailed below in Section 4.0, NCES has also recently completed additional, focused remedial actions in response to observed groundwater quality conditions at specific release detection monitoring wells.

3.0 SUMMARY OF HYDROGEOLOGIC AND GROUNDWATER QUALITY CONDITIONS

This Section 3.0 provides a description of site hydrogeology (Section 3.1), site groundwater flow conditions (Section 3.2), the constituents of leachate and landfill gas (Section 3.3), and the current groundwater quality impacts at the site (Section 3.4).

3.1 General Site Hydrogeology

Detailed hydrogeologic studies have been performed as part of the permitting associated with the development of each landfill stage at the site. The most recent of these studies is the 2002 hydro study¹ prepared by SHA for the Stage IV landfill area. That report included a synthesis of the major findings of the prior studies, and thus serves as a comprehensive reference for the documentation of site hydrogeologic conditions. As further described therein, the site overburden stratigraphy consists of three primary units. In descending order from the ground surface downward, these include:

- An Upper Till unit, consisting of a poorly-sorted mixture of fine to medium sand and silt with moderate amounts of coarse-grained material and lesser amounts of clay;
- A Stratified-Drift unit, underlying the Upper Till, and comprised of a relatively thick and heterogeneous sequence of stratified silt and fine sand (generally well sorted), commonly interfingering with “till-like” submembers; and,
- A Lower Till unit, which underlies the Stratified Drift, and is comprised chiefly of sand and gravel with lesser amounts of silt.

Explorations drilled to bedrock at the site encountered the bedrock surface at depths of greater than 100 feet. The site monitoring well network has been developed to include wells screened within selected intervals of the overburden stratigraphic units described above. Principally, these include the Upper Till and Stratified Drift units, as these are generally the uppermost groundwater-bearing units at the site.

A general representation of site subsurface conditions, depicting the distribution of the main stratigraphic units described above, is shown on the hydrogeologic cross-sections provided as Figures 3 through 5, which were originally developed for the 2002 hydro study, and thus have been previously provided to NHDES with that document. Locations of the cross-section lines are indicated on Figure 1.

3.2 Site Groundwater Flow Conditions

Based on groundwater levels measured in the site monitoring wells, groundwater within the Upper Till and the Stratified Drift generally flows in an overall northerly direction across most of the site. A northeasterly component of flow in each of these units is suggested by the groundwater elevations

¹ “Hydrogeologic Report – Appendix V.A, Application for Standard Permit for a Solid Waste Landfill, North Country Environmental Services, Inc., Bethlehem, New Hampshire” (dated January 2002), prepared by SHA on behalf of NCES.

observed in monitoring wells located to the northeast of the Stage II and Stage IV / Phase I landfills. This condition is consistent with the flow of overburden groundwater toward the Ammonoosuc River.

As presented in the 2002 hydro study report, groundwater elevations observed in the site monitoring wells indicate that downward vertical gradients from the Upper Till to the underlying Stratified Drift predominate at the site. Recent groundwater elevation data collected as part of on-going monitoring and reporting² indicate that current conditions with respect to hydraulic gradients and flow directions remain comparable to the findings presented in the 2002 report (Figure 2). Note that groundwater equipotential contours are included on the hydrogeologic cross-sections provided as Figures 3 through 5, to depict generalized vertical groundwater flow patterns.

3.3 Potential Sources of Groundwater Contamination

Based on our understanding of landfill construction, the history of site operations, and the observed concentrations of VOCs and bromide in groundwater, we think that the sources of these constituents in groundwater are both (1) incidental releases and spills of leachate, as previously reported to NHDES (e.g., in the vicinity of the former leachate load-out building north of the Stage I Landfill and associated USTs, and (2) landfill gas (LFG). Sections 3.3.1 and 3.3.2 describe the constituents of leachate and LFG, respectively. We also acknowledge that NHDES considers the breach in the Stage I stormwater downchute (as documented in Section 4.3) to have been a potential source of the contamination in MW 913-M.

3.3.1 Leachate

SHA reviewed recent readily-available analytical data, as indicated on Table 1, for 17 leachate samples collected in 2009 from all of the various site landfill stages and phases. Laboratory analytical data reports for the 2009 leachate results summarized in Table 1 are provided in Appendix A. Based on a review of these data, the following observations with regard to the concentrations of selected constituents (principally VOCs and bromide) detected in the leachate samples were noted.

The VOCs detected at the highest concentrations in leachate are tetrahydrofuran (THF), tertiary-butyl-alcohol (TBA), and the ketones methyl-ethyl-ketone (MEK) and acetone; with the concentrations of the ketones varying considerably more between leachate samples than THF and TBA, and often the ketones are not detected. The VOC 1,4-dioxane was also consistently detected (at approximately a half an order to an order of magnitude lower concentrations than those of the above VOCs) in the most-recent (July and November 2009) leachate sampling rounds that included analysis for this VOC. Similarly, lower concentrations of petroleum-derived aromatic VOCs (AVOCs) were also consistently detected in leachate. Diethyl ether was typically not detected in the leachate samples, and in the six samples in which it was detected, its concentration was approximately one to two orders of magnitude lower than the concentrations of THF and TBA. Leachate VOC concentrations are summarized graphically on Figure 6.

² “2009 Summary of Water Quality Monitoring, North Country Environmental Services (NCES) Landfill, Bethlehem, New Hampshire” (dated September 30, 2009), prepared by SHA on behalf of NCES.

Bromide concentrations detected in the leachate samples, as summarized in Appendix B, are in the range of approximately 20 to 70 milligrams per liter (mg/l) in primary leachate, and approximately 4 to 15 mg/l in secondary leachate³. Chloride concentrations in primary leachate, as summarized in Table 1, typically range from about 2,000 to 5,000 mg/l, and average approximately 3,000 mg/l.

3.3.2 Landfill Gas

Broadly speaking, the composition of LFG is well understood. The discussion we present herein regarding the presence of VOCs in LFG, and the concentrations of VOCs in groundwater attributed to impacts from LFG, is based on our review of the publicly-available published technical literature for LFG from municipal solid waste landfill facilities comparable to the NCES site. Based on our understanding of the NCES landfill, we believe that these published LFG data are generally representative of the LFG at NCES. We have no reason to believe that the composition of LFG at the NCES facility differs significantly from the general composition of LFG as documented at the facilities cited on Table 2, but because the LFG from the NCES landfill has yet to be analyzed for VOCs, we do not yet have site-specific data to confirm this.

VOCs detected in LFG based on our research are summarized on Table 2. The most commonly detected and most abundant VOCs are: chlorinated VOCs (CVOCs) such as – chloroethane (CE), chloromethane (CM), 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), dichloromethane (methylene chloride – MeCl), tetrachloroethene (perchloroethene – PCE), 1,1,1-trichloroethane (TCA), trichloroethene (TCE), and vinyl chloride (VC); AVOCs such as – benzene, ethylbenzene, toluene and xylene; chlorofluorocarbons (CFCs) such as – dichlorodifluoromethane (DCDFM) and trichlorofluoromethane (TCFM); and ketones such as acetone and methyl ethyl ketone (MEK).

VOCs detected in groundwater and attributable to LFG impacts are also summarized on Table 2. The identification of these VOCs as being sourced by LFG is subject to interpretation, but in general, the VOCs we have identified on Table 2 are the same as those identified in the cited papers (i.e., we have not tried to reinterpret the conclusions of these authors). The VOCs in groundwater most commonly attributable to impacts from LFG are: 1,1-DCA and PCE; followed by MeCl, TCE, benzene and vinyl chloride; and cis-1,2-DCE, 1,1-DCE, TCA, DCDFM and TCFM.

Based on our experience, diethyl ether has not been consistently included in the VOC analytes list for LFG or groundwater, particularly prior to about 2000. Accordingly, many of the LFG and groundwater VOC analyses summarized on Table 2 likely do not include diethyl ether.

To collect site-specific data to evaluate VOC presence in LFG at the landfill, we propose sampling and analysis of LFG from selected existing LFG extraction wells located within the footprint of the Stage I Landfill. As a complementary data set, we propose to also collect and analyze samples of LFG condensate from selected Stage I LFG collection system locations, and the (combined) LFG condensate collection tank located in the northeastern part of the site. A Sampling and Analysis Plan (SAP) detailing our proposed technical approach for collection and analysis of these samples

³ Bromide results are from NCES. The analysis of bromide in leachate was completed on a monthly basis for both primary and secondary leachate; and hence, because of this different sampling schedule, the results are listed separately from the other leachate analyses.

was submitted to NHDES on January 11, 2010⁴, and revised based upon comments provided via NHDES letter dated February 1, 2010⁵. The revised SAP was submitted to NHDES on February 9, 2010⁶, and is currently under review by NHDES.

3.4 Current Groundwater Quality Impacts

The site groundwater quality monitoring program includes both the tri-annual monitoring completed in accordance with the Groundwater Management and Release Detection Permit (hereinafter, the “Groundwater Permit”), and the monthly sampling program of selected monitoring wells. The monthly program was undertaken in response to a request from NHDES (letter dated March 19, 2008), for monthly sampling/analysis of wells B-913M and B-921U (for bromide only). Subsequently, the monthly sampling was expanded at NCES’s initiation to address essentially all of the site groundwater monitoring wells with recent histories of detection of VOCs and/or bromide.

Through January 2010, the monthly sampling program included the following monitoring wells: MW-402U, MW-403L, B-913M, B-919U, B-921U, B-921M, and B-304UR. As requested by NHDES, copies of the laboratory analytical data reports associated with the monthly monitoring rounds through January 2010 are provided with this CAP, as Appendix A. As requested by NHDES via letter dated February 10, 2010⁷, for the February and subsequent monthly monitoring rounds, wells B-103S, B-103D, and B-902U will be included in the monthly monitoring program, with the groundwater samples collected from these wells analyzed for bromide (only). Based on the results of the groundwater monitoring program, impacts to site groundwater quality (defined as consistent detection of VOCs and/or bromide at concentrations greater than background conditions) are noted at the following wells, proceeding in a general northeasterly direction from the northwest corner of the Stage I Landfill:

- Monitoring well MW-402U, which is screened in the Upper Till Unit, and located in an area directly north (and generally downgradient from) the Stage I lined landfill. This well has yielded groundwater samples in which VOCs and bromide generally have been detected since about 2000. Neither VOCs nor bromide have been detected in the groundwater samples collected from a “companion” well, MW-402LR, which is screened in the Stratified Drift Unit, underlying the Upper Till.
- Well B-913M, which is screened in the Stratified Drift Unit, and located adjacent to and north of Detention Pond No. 3, to the north of the Stage I Landfill, and to the north and downgradient of the Stage I / Phase I downchute. VOCs and bromide generally have been detected at this location since about 2006. Groundwater samples collected from the adjacent companion monitoring wells

⁴ “Sampling and Analysis Plan for Landfill Gas and Condensate” (dated January 11, 2010), prepared by SHA on behalf of NCES.

⁵ February 1, 2010 letter from NHDES (Karlee Kenison) to John Schwalbe of NCES which provides technical comments based on NHDES’ review of the January 11, 2010 SAP prepared by SHA.

⁶ “Response to Comments - Sampling and Analysis Plan for Landfill Gas and Condensate” (dated February 9, 2010), prepared by SHA on behalf of NCES.

⁷ Letter from NHDES to Casella Waste Management, Inc., dated February 10, 2010, “Bethlehem - North Country Environmental Services Landfill, 581 Trudeau Road, DES #198704033, Project #1737, regarding “November 2009 Water Quality Monitoring Results”, prepared by Sanborn, Head & Associates, Inc, dated December 18, 2009.

B-913U (screened in the uppermost portion of the Stratified Drift Unit, just below the contact with the Upper Till), and B-913D (screened in the Lower Till), have generally not yielded detectable concentrations of VOCs or bromide.

- Well B-920M, which is screened in the Stratified Drift Unit in an area directly to the northwest of the Stage IV / Phase I Landfill (northeast of Detention Pond No. 3), downgradient from the westernmost part of the Stage IV / Phase I Landfill, and obliquely downgradient from the area of the former unlined landfill. Detections at this location have been principally limited to VOCs (since the well was installed and first sampled in April 2006); bromide has generally not been detected. Similar to well B-913M, adjacent wells B-920U and B-920D, screened in shallower and deeper (i.e., as compared to B-920M) intervals of the Stratified Drift Unit, have generally not yielded groundwater samples in which VOCs or bromide have been detected.
- Wells B-921U (bromide only since July 2006) and B-921M (VOCs only since April 2007), both screened in the Stratified Drift Unit. Adjacent well B-921D (Stratified Drift) has not yielded groundwater samples in which either VOCs or bromide have been detected. This well triplet is located further to the northeast of the B-920 cluster, and downgradient of the northeastern part of the Stage IV / Phase I Landfill, as well as the area of the former unlined landfill.
- Well B-919U, also screened in the Stratified Drift Unit, has yielded samples in which VOCs have been intermittently detected since 2006. Bromide has not been detected in the samples from B-919U, and with sporadic exceptions neither bromide nor VOCs have been detected in the samples from adjacent wells B-919M and B-919D. Both of these companion wells are screened in deeper intervals of the Stratified Drift. The B-919 well cluster is adjacent to Detention Pond No. 4, in an area that is downgradient from the northernmost part of the Stage IV / Phase I Landfill, and the area of the former unlined landfill.
- Further to the northeast of the above-listed wells, the well couplet B-304UR (VOCs and bromide) and B-304DR (typically VOCs only), have yielded groundwater samples in which the indicated constituents generally have been present since these wells were first installed/sampled in 2006. Both of these wells are screened in the Stratified Drift, and were installed as replacements (R-designation) for previously-existing monitoring wells B-304U&D located to the south of the replacement wells. These wells are located in an area that is further downgradient from B-919, and thus also further downgradient from the northernmost portion of the Stage IV / Phase I Landfill, Detention Pond No. 4, and the area of the former unlined landfill.

Time-series plots of total VOC and bromide concentrations at the key monitoring wells described above are provided in Appendix B. Tabulated groundwater quality data for these wells are also provided in Appendix B. Further description of the VOC and bromide detections at these wells, and explanation as to the source of these constituents, is presented in Section 5.0 (below).

4.0 RECENT REMEDIAL ACTIONS UNDERTAKEN BY NCES AND THE RESULTANT FINDINGS

The area directly north of Stage I has been the locus of a number of leachate spills and release incidents, wherein leachate was released to the ground surface in the area upgradient from and/or

adjacent to, well MW-402U. We also note that the former leachate consolidation building was constructed as part of a leachate handling improvements project completed in 2001, which upgraded an earlier (original) system, developed by a prior site operator, whereby leachate load-outs were completed by direct pumping from individual leachate underground storage tanks (USTs) to tanker trucks.

This section provides a summary overview of the recent remedial actions undertaken by NCES, to address impacts to site groundwater quality as evidenced by the detection of VOCs and/or bromide at elevated concentrations in specific monitoring wells (principally wells MW-402U and B-913M located to the north of the Stage I Landfill). In particular, this section describes a soil sampling and analysis program (Section 4.1), the Leachate Management Improvements Project (Section 4.2), and the Stage I landfill capping system repair project (Section 4.3). As further described below, these recent actions focus on the area of the former leachate infrastructure to the north of the Stage I Landfill, the northern anchor trench of the Stage I Landfill, and Stage I downchute/drainage improvements. Historical remedial actions principally include the unlined landfill re-location project (completed in 1993), as noted in Section 1.0 (above), and are not included in the discussion below. The LFG extraction improvements project is described in Section 6.1.

4.1 Initial Test Borings and Soil/Sediment Sampling/Analytical Program

As an initial step in the evaluation of the general area of the former leachate consolidation building and associated subsurface leachate handling infrastructure as a potential source area for the VOCs detected in the groundwater samples from monitoring well MW-402U, SHA completed a subsurface exploration program in that area in June 2006. This assessment was performed in response to a directive from NHDES (letter dated September 15, 2005) to complete an assessment of soil quality conditions in the area upgradient of well MW-402U and to assess the potential for a VOC source to exist in the vadose zone soils in that area.

The 2006 exploration program⁸ included drilling of 18 direct-push soil borings in the general area of the former leachate consolidation building, from which subsurface soil samples were collected on a continuous basis. Soil boring locations were constrained by the existing subsurface infrastructure in the area (e.g., leachate USTs, piping, and electrical conduit), but were generally completed in areas proximate to these features, as feasible, as well as within the areas previously indicated as having been loci for spills and discharges of leachate to the ground surface. The soil samples collected (continuously) from the borings were field-screened by SHA for the presence of VOCs using a photo-ionization detector (PID).

Of the soil samples collected from the soil borings, a subset was submitted for laboratory chemical analysis to quantify potential VOC concentrations in soil. Selection of the soil samples for laboratory analysis considered visual/olfactory and PID field-screening results, but these field-based observations did not indicate significant VOC presence in the samples. Accordingly, soil samples collected from the shallowest sampling intervals of the soil borings (generally 0 to 4 feet below the ground surface [bgs]) were generally submitted for laboratory analysis. In addition, SHA collected two samples of sediment from Detention Pond No. 2, which were also analyzed for VOCs.

⁸ "Soil Assessment and Additional Stage IV / Phase I Monitoring Wells" (dated November 10, 2006), prepared by SHA on behalf of NCES.

Results of the laboratory analytical testing detected trace concentrations of the VOCs 1,4-dichlorobenzene in one of the soil samples, and toluene in one of the sediment samples. The VOC concentrations detected in both samples were well below the RCMP Soil Standards⁹ developed by NHDES. Further, neither of these VOCs have been detected in the groundwater samples collected from well MW-402U. These findings indicate that a residual source for the VOCs detected in groundwater at well MW-402U was not observed in the areas assessed as part of the soil investigation.

4.2 Leachate Management Improvements Project

Under the recently-completed LMIP (noted above), the former primary and secondary leachate USTs in this area, and their associated subsurface piping were removed, along with demolition of the former leachate consolidation building and associated concrete pad/load out area. Leachate storage USTs formerly located in this area had included primary and secondary leachate collection system tanks for each Stage I Landfill phase (total of eight USTs), primary and secondary USTs for the Stage II Landfill, and the leachate consolidation UST at the former leachate consolidation building. These features are summarized on Figure 7. Note that the former leachate USTs had a cumulative leachate storage capacity of approximately 160,000 gallons.

Removal of the leachate USTs and their associated subsurface piping in the area north of the Stage I landfill was completed in the fall of 2008. As summarized in Figure 7, stained soils indicative of leachate and/or LFG-related impacts were observed at a number of locations during excavation to remove the leachate infrastructure in this area.

The final phases of the LMIP included plumbing and electrical connection to the leachate USTs and above-ground storage tank (AST) in the northeastern part of the site, to the north of the Stage II Landfill, which were completed in mid-November 2009.

Additional soil excavation in the area of the former leachate USTs to the north of the Stage I Landfill was undertaken by NCES in April and May 2009, to remove the majority of vadose-zone soils in this area, to ensure that potential VOC-bearing, residually-impacted soils in this area were removed. The findings of the additional soil excavation program, which included the removal of approximately 9,200 cubic yards (CY) of soil (which were disposed into the Stage IV lined landfill) are documented in a July 2009 report prepared by CMA Engineers¹⁰, which was previously submitted to NHDES. As documented in that report, stained soils (suggestive of prior contact with LFG and/or liquid leachate) were observed at a number of locations within the area of the additional soil excavation. These observations, and the locations of the main components of the former leachate management infrastructure (e.g., USTs, subsurface piping, leachate consolidation building, etc.) are summarized on Figure 7; site photographs referenced on Figure 7 are provided in Appendix C.1, and were reproduced from the above-referenced CMA report⁶.

⁹ The Method 1 Soil Standards, as developed by NHDES in the “Contaminated Sites Risk Characterization and Management Policy” (RCMP), dated January 1998, with 2000-2007 revisions/addenda.

¹⁰ “North Country Environmental Services Leachate Management Improvements GWP-198704033-B-005, Report on Additional Soil Excavation and Removal” (dated July 10, 2009), prepared by CMA Engineers (CMA) of Portsmouth, NH, on behalf of NCES.

Analysis of confirmatory soil samples collected from these areas generally did not detect VOCs. Specifically, VOC detections in the confirmatory samples were limited to trace concentrations of one or more of the petroleum-derived AVOCs toluene, xylenes, and/or 1,2,4-trimethylbenzene, which were detected in shallow soil/sediment samples collected during excavation of sediment from the drainage swale adjacent to well MW-402. CMA reports that an apparent petroleum odor was noted from stained soils removed from the swale. Concentrations of the above-listed VOCs detected in the soil samples were well below the RCMP Soil Standards, and further, these VOCs have not been detected in the groundwater samples collected from well MW-402U.

The general absence of detected VOCs in these soils is consistent with spills/release(s) of leachate to these soils being the primary source of the VOCs detected in groundwater from MW-402. The concentrations of these VOCs in leachate is relatively low, with total VOC concentrations of approximately 2,000 to 15,000 ug/l, as compared to VOC concentrations in typical NAPLs (e.g., gasoline, solvents). In addition, the principal VOCs in leachate (e.g., THF, TBA, 1,4-dioxane, ketones) are highly water soluble, and would be expected to have dissolved readily in infiltrating precipitation and migrated with groundwater (e.g., similar to chloride), leaving behind the less soluble/less mobile leachate constituents (such as iron and manganese) near the initial spill location.

As noted by CMA, stained soils were observed along a former drainage pipe that was previously installed to convey stormwater from the area of the Stage I cap/anchor trench. The drainage pipe, which was removed as part of the additional soil excavation, was observed to have discharged to the swale in the area of well MW-402U. The observations of stained soils are consistent with LFG migration out of the cap/anchor trench on the northern edge of Stage I and along this drainage pipe/backfill. Observations regarding the cap and anchor trench in the area of Stage I / Phase I are described in the following section.

4.3 Stage I Landfill Capping System Repair Project

This project involved the excavation of soils and stone adjacent to a stormwater downchute located above the capped Stage I area, and was initially intended to assess and remove suspected impacted soil associated with the reported leachate release (force main break) that occurred in August 2006. That construction-related leachate release had previously been identified as a likely source for the VOCs and bromide detected in the groundwater samples from well B-913M. Secondly, the project was undertaken to assess (and remedy) a potential hydraulic connection between the Stage I downchute and anchor trench along the north side of Stage I. As further documented in a November 2009 report prepared by CMA¹¹, NCES began work on this project on August 13, 2009, and completed it on September 28, 2009. Photographs taken by SHA during execution of this project on September 14, 2009¹² are provided in the photolog in Appendix C.2. The major findings of this project are briefly summarized below.

During the work, stained soils were observed in areas adjacent to and above the Stage I anchor trench, and were excavated and disposed into the Stage IV lined landfill at the site. Further

¹¹ "North Country Environmental Services Leachate Management Improvements, GWP-198704033-B-005, DES-SW-SP-03-002, Report on Final Soil Excavation and Removal & Construction Certification for Repair to Cap Drainage (dated November 5, 2009), prepared by CMA on behalf of NCES.

¹² NCES letter report to NHDES entitled "Final Soil Excavation, Removal and Construction Certification Report" dated January 19, 2010.

excavation and removal of apparently impacted soil from areas adjacent to the anchor trench revealed that the Stage I capping system was constructed in a manner that, while in compliance with regulatory standards at the time of construction, provided a potential pathway for LFG to migrate laterally into soil beyond the limit of the Stage I Landfill. Specifically, a sheet of synthetic cap material was observed to have been welded to the Stage I cap in this area, apparently to manage stormwater drainage off of the Stage I cap, and maintain the stormwater above the anchor trench. Although this sheet or “flap” of synthetic cap material was welded to the Stage I synthetic cap, an opening below the flap was observed, which allowed a potential connection from the screened till material between the Stage I cap and underlying waste, and the adjacent soils outside of the landfill footprint. The open area underlying the flap, and several apparently construction/installation-related holes observed in the cap, appeared to be pathways for lateral LFG migration. Olfactory observations during the excavation work indicated the presence of LFG in the soils outside of the Stage I anchor trench.

Additionally, during re-configuration of the Stage I downchute as part of this project, a breach (rectangular hole) in the capping system geomembrane and rub sheet of the gabion-lined downchute was found. This breach allowed leachate seeping from beneath the Stage I synthetic cap to enter the stormwater swale and discharge in the area upgradient from the impacted well, B-913M. Samples of the leachate discharging from this seepage area (designated “Below Gabion Swale S-1” and “Below Gabion Swale S-2”) were collected by SHA on September 14, 2009; analytical data for these samples are summarized in Table 1.

As further described in Section 5.2, the VOCs detected in the Gabion Swale samples were dominated by THF and TBA¹³; bromide was also detected at elevated concentrations (i.e., compared to groundwater). The presence of elevated concentrations of these constituents in the leachate seepage samples correlates well with the composition of leachate samples listed on Table 1 and the observed impacts to groundwater quality as evidenced by the recent (i.e., 2006 to 2009) samples from monitoring well B-913M. As discussed in Section 5.2, although the now repaired defect in the downchute may have contributed to the impacts to groundwater quality at well B-913M, we do not believe that it was the principal source of VOCs and bromide detected at this well.

Capping system repairs completed under this project included removal of damaged linear low-density polyethylene (LLDPE) 40 mil cap geomembrane and drainage geocomposite, cleaning and other preparation, installation of new 60 and 40 mil high-density polyethylene (HDPE) geomembrane, installation of replacement and additional 60 mil HDPE barrier in the downchute (extending to Detention Pond No. 3), and backfill of the cap and areas outside the capping system with on-site screened soil. In addition to the cap repairs, the primary and secondary liners were joined/welded near the top of the anchor trench. The replacement cap panels were also welded to the primary liner at the top of the anchor trench. A confirmatory sample of stormwater in the reconstructed downchute was collected by SHA on December 8, 2009, and analyzed for VOCs (including 1,4-dioxane), bromide, and (total) iron and manganese. As reported to NHDES via NCES letter dated January 19, 2010¹⁴, the results of the confirmatory sampling demonstrated that stormwater flow in the reconstructed Stage I downchute was not impacted by leachate.

¹³ These samples were not analyzed for 1,4-dioxane.

¹⁴ NCES letter report to NHDES entitled “Final Soil Excavation, Removal and Construction Certification Report” dated January 19, 2010.

The cap and anchor trench were reconfigured in this manner from the Stage I / Phase I downchute to a distance approximately 216 feet west of the downchute. Work was not continued beyond this point due the presence of subsurface utilities in the area further to the west, and the added complexity this would entail to continue the project into that area.

5.0 EXPLANATION OF OBSERVED VOC AND BROMIDE DISTRIBUTION IN GROUNDWATER

This section summarizes the distribution and source(s) of the VOCs and bromide detected in site groundwater. This summary separately describes monitoring well MW-402U (Section 5.1), monitoring well B-913M (Section 5.2), and the monitoring wells located to the northeast of B-913M (Section 5.3), and concludes with an analysis of groundwater quality trends (Section 5.4).

5.1 Monitoring Well MW-402U

As previously reported to NHDES, the findings of the prior hydrogeologic studies at the site have established that a strong downward vertical component to groundwater flow exists in the area of well MW-402U. Based on the groundwater elevations measured in the couplet wells MW-402U (Upper Till) and MW-402L (Stratified Drift), the observed vertical (downward) gradient in this area is approximately four times the horizontal hydraulic gradient within the Upper Till Unit. This finding indicates that lateral groundwater flow in the Upper Till in this area is limited, with groundwater within the Upper Till principally draining to (or recharging) the underlying Stratified Drift Unit.

Based on this strong downward vertical gradient, groundwater intercepted by MW-402U, which is screened within the uppermost zone of saturated overburden near the base of the Upper Till Unit, is primarily sourced from precipitation recharge to the Upper Till in the area between the landfill and the well. Consistent with this groundwater flow regime, we have concluded that the VOCs and bromide historically detected at MW-402U through late 2008 have been principally sourced from the area of the former leachate management infrastructure (USTs and associated piping, and leachate consolidation building) and related leachate handling operations formerly located between Stage I and well MW-402U. In addition, as described below, a portion of the VOCs historically detected in the groundwater samples from well MW-402U were also likely sourced from LFG. In our opinion, the present concentrations of these LFG-sourced VOCs in MW-402U represent the residual water quality effects related to past migration of LFG. For the reasons discussed below, under current site conditions (i.e., subsequent to the soil excavation north of the Stage I Landfill, and reconfiguration/repair of the Stage I anchor trench), the opportunity for impacts to groundwater quality in the area of well MW-402U associated with active LFG migration have been substantially reduced if not eliminated.

Figure 6 presents a time-series plot of VOC and bromide concentrations in groundwater samples from monitoring well MW-402U. Also indicated on this Figure (as vertical “bars”) are the approximate dates/durations of documented leachate spills/incidents and construction activities in the area, as previously reported to NHDES, and the VOC composition of leachate analyzed in 2009. For the period from approximately 2001 to 2007, a general correlation between the indicated events and the observed concentrations of VOCs and bromide at well MW-402U is apparent.

As indicated on Figure 6, prior to April 2008 the VOCs detected in groundwater samples from well MW-402U typically consisted of approximately equal concentrations (typically about 10 to 20 ug/l) of THF, chlorinated aliphatic (as opposed to aromatic) VOCs (principally, 1,1-dichloroethane [1,1-DCA]), and diethyl ether. THF was most commonly the individual VOC with the highest concentration. Lower concentrations (typically 1 to 3 ug/l) of benzene and methyl tertiary butyl ether (MTBE) were also typically detected during this time period. TBA was not analyzed for in site groundwater until November 2007, and has not been detected in the samples from MW-402U since that time (typical reporting limit 30 ug/l). Analysis for 1,4-dioxane was started in November 2008, when it was detected at 3.7 ug/l; 1,4-dioxane has not been detected since that time (typical reporting limit 1 ug/l). Bromide concentrations were typically in the range of 0.1 to 0.2 mg/l, and occasionally as high as 1.2 mg/l, during this timeframe.

Since December 2008, the VOCs detected in groundwater from well MW-402U have been quite consistent, with diethyl ether at 8 to 11 ug/l, 1,1-DCA at 4 to 6 ug/l, and occasionally cis-1,2-DCE at 1 to 2 ug/l. From November 2008 to June 2009, bromide concentrations were from 0.1 to 0.2 mg/l; bromide has been at background concentrations of less than or equal to 0.1 mg/l for the seven most recent sampling rounds from July 2009 to January 2010, and bromide was not detected during four of these rounds.

Thus, we believe that the VOCs and bromide present in groundwater at MW-402U from 2000 until approximately November 2008 are due largely to the incidental leachate releases that occurred in this area during this timeframe. The observations made during the LMIP and the excavation of considerable volumes of stained soils are consistent with the documented leachate releases in this area. THF and 1,4-dioxane, as well as benzene and MTBE, detected in groundwater during this timeframe, are also present in leachate. The generally short-lived nature of these “spikes” in groundwater VOC and bromide concentrations correlate well in time with known construction activities and leachate spills in this area.

In our opinion, the VOCs detected in groundwater at MW-402U since December 2008 (diethyl ether, 1,1-DCA, and occasionally cis-1,2-DCE) have been sourced by LFG, likely emanating from the anchor trench on the north side of Stage I, and following the former drainage pipe that discharged to the swale near well MW-402U (discussed in Section 4.2). *In situ* observations of stained soils along this pathway (consistent with LFG impacts) substantiate this explanation. These VOCs (1,1-DCA, cis-1,2-DCE) are consistent with the VOCs attributed to LFG impacts to groundwater at other landfills, as discussed in Section 3.3.2 above. Further, these VOCs are either **not** detected in leachate as indicated on Table 1 (i.e., 1,1-DCA and cis-1,2-DCE), or are relatively minor and intermittently detected components of leachate (i.e., diethyl ether). Accordingly, the presence of these VOCs at MW-402U prior to December 2008 is also likely due to the effects of LFG.

Diethyl ether is not among the VOCs listed on Table 2 as being in groundwater due to LFG impacts (or detected in LFG). However, we believe this may at least in part be due to diethyl ether not being included on the VOC analyte list for these sites, particularly those analyses performed prior to about 2000.

Based on the leachate data presented on Table 1, if the diethyl ether detected in the groundwater samples from MW-402U was sourced by leachate, then significantly higher concentrations would be expected of the more abundant and typical VOCs detected in leachate, including: THF, TBA and 1,4-

dioxane, none of which have been detected in groundwater at this location since December 2008. In addition, elevated concentrations of the inorganic components of leachate would also be expected (e.g., bromide, chloride). As indicated above, the concentration of bromide has decreased to background concentrations (less than or equal to 0.1 mg/l) for the seven most recent sampling rounds. Further, based on the relative concentrations of chloride and diethyl ether detected in leachate as indicated on Table 1, if the diethyl ether concentrations detected in groundwater from MW-402U since December 2008 were sourced by leachate, groundwater chloride concentrations in the range of approximately 200 to 1,000 mg/l or higher would be expected; actual concentrations are 33 to 38 mg/l.

The LMIP and the associated additional soil excavation effort have in large part addressed the likely source of VOCs (and bromide) evident from the water quality history at MW-402U. Specifically, these entail the removal/re-location of the leachate handling infrastructure historically implicated in a number of leachate releases, and excavation/ removal of the bulk of the vadose-zone soils in this area, which provided a potential pathway for LFG migration to the area of well MW-402U, and displayed visual evidence of LFG and/or leachate impacts.

In addition, as indicated in Section 4.3, the anchor trench and landfill cap on the north side of Stage I / Phase I was reconfigured/repared such that potential pathway(s) for lateral LFG migration from the landfill to adjacent soils outside of the landfill footprint were eliminated. However, the presence of a leachate force main and other subsurface infrastructure precluded the observation and any potentially necessary repair of the western portion of the anchor trench; hence, it is possible that LFG migration out of the landfill may still be occurring in this area.

It is important to note, however, that soils have been excavated to below the elevation of the anchor trench and the preferential pathway for LFG created by the stormwater drainage pipe has been eliminated. These measures have eliminated the conditions under which LFG formerly entered and traveled through the vadose zone between the landfill and MW-402U and contributed to groundwater contamination. Even if LFG continues to escape in some quantity from the western end of the northern anchor trench, then, there is no longer an opportunity for LFG to contaminate groundwater to the degree it previously had. Decreasing concentration trends for the LFG-related VOCs detected in groundwater at MW-402U are expected to be observed in the future; however, the rate of decrease is constrained by the limited rates of groundwater flow through the Upper Till Unit and natural attenuation processes in this area, and the attendant time needed for existing LFG-related impacts to groundwater quality upgradient from the well to migrate through the area.

Notwithstanding our belief that the VOC concentrations now present in this well are attributable to the residual effects of historical LFG migration, we have proposed and implemented, as described in Section 6.0, additional active measures to counteract the potential for LFG migration from the western end of the northern anchor trench. These measures, which are described in Section 6.0, are not only calculated to eliminate LFG migration as a possible ongoing source of groundwater contamination, they will also provide verification and monitorability of their effectiveness.

Lastly, based on the return of bromide concentrations to background values of less than or equal to 0.1 mg/l for the previous seven months (July 2009 through January 2010), and the lack of detection of leachate-related VOCs since 2008, MW-402U is fully functional to serve as intended for the

purposes of release detection (i.e., the re-occurrence of bromide or these VOCs would be apparent in the water quality data).

5.2 Monitoring Well B-913M

As indicated on the hydrogeologic cross-section provided as Figure 4, groundwater flow in the area of the monitoring well B-913 triplet is characterized by a strong downward vertical gradient, thought to be principally due to the proximity of the (unlined) Detention Pond No. 3. As described in the prior hydro studies, this local recharge effect is due to infiltration of stormwater to shallow overburden groundwater in the area, and creates relatively higher hydraulic head in the shallow/uppermost overburden proximate to the detention pond, contributing to the observed downward vertical gradient in that area.

As a consequence of the steep vertical gradient, groundwater flow lines from the area of the screened interval of monitoring well B-913M (screened in a lowermost interval of the Stratified Drift Unit, just above the contact with the Lower Till Unit) trace back to the area of the northern edge of the Stage I (Phase I) Landfill, in the general area of the western limit of Stage IV / Phase I. Accordingly, this general area has been the locus of investigations for a potential source(s) for the VOCs and bromide detected in the groundwater samples from B-913M.

A time-series plot of VOC and bromide concentrations detected at B-913M is provided as Figure 8. Also indicated on this Figure (as vertical “bars”) are the approximate dates of the August 2006 force main break/leachate release, the April/May 2007 Stage I CAP and Detention Pond #3 Inlet Culvert – Drainage Improvement Project, and the August/September 2009 Stage I downchute/drainage repair, described in Section 4.3. In addition, the VOC composition is shown for the leachate samples collected on September 14, 2009 from the hole (now repaired) in the Stage I downchute. The VOCs detected in groundwater from B-913M (THF, TBA and 1,4-dioxane) are consistent with both the predominant VOCs detected in leachate samples listed on Table 1 and the samples from the Stage I downchute.

In general, the VOC and bromide concentrations increase from approximately April 2006 to November 2007, and then generally decrease after that until January 2010, with considerable fluctuation in concentrations noted. THF and TBA are the only VOCs detected at this location until November 2008, when analysis and detection of 1,4-dioxane started. THF and TBA concentrations range up to approximately 40 ug/l (individually), and 1,4-dioxane concentrations are typically 2 to 6 ug/l. Bromide concentrations are typically in the range of 0.1 to 0.7 mg/l, and as high as 1.5 mg/l.

Notably, the analytical results for the sample collected on October 14, 2009, approximately two weeks after the completion of the repairs to the Stage I downchute area located upgradient of B-913M, indicate no detected bromide and the only VOC detected was 2 ug/l of 1,4-dioxane. We think these results are attributable less to the downchute repair, however, than to the continuing trend of decreasing concentrations noted since November 2007 in this well.

While stormwater from Detention Pond No. 3 was initially considered as a potential source, based on the groundwater flow/hydraulic gradient discussion above, the data indicate that the pond does not appear to be hydraulically well connected to deeper groundwater in the Stratified Drift in the interval of B-913M. As a corollary, were stormwater in the pond a significant source of VOCs and/or

bromide, the shallow well of the B-913 triplet (i.e., B-913U) would be expected to yield groundwater samples in which these constituents would be detected. As noted above, samples from B-913U have generally not contained VOCs or bromide.

As previously reported to NHDES, a review of site operational records revealed that a spill of leachate occurred in the area noted above (on August 7, 2006, and indicated on Figure 8) during construction activities related to the Stage IV / Phase I landfill. This release occurred when heavy equipment ruptured a leachate force main, resulting in a release of leachate to the ground surface. While relatively lower concentrations of VOCs and bromide (one detect each) were noted at well B-913M prior to the August 2006 leachate spill, in consideration of the date of this release relative to the approximate time frame in which VOCs and bromide were detected at their greatest concentrations in the samples from B-913M (generally, November 2007 to June 2008), the August 2006 leachate spill was considered to be a main contributing cause for the detection of these constituents at well B-913M.

More recently during re-configuration and repair of the Stage I downchute in August/September 2009, as described above in Section 4.3, a hole in the downchute was observed that allowed leachate seeping from beneath the Stage I synthetic cap to enter the stormwater swale and discharge in the area upgradient from B-913M. As indicated on Table 1 and Figure 8, the predominant VOCs detected in the leachate samples collected from the downchute hole are THF and TBA (these samples were not analyzed for 1,4-dioxane); bromide was also detected at elevated concentrations.

In our opinion, the VOCs and bromide detected in groundwater at B-913M from 2006 to January 2010 and discussed above, are principally due to the above-described August 2006 leachate release that occurred in this area during this timeframe. While we think that releases from the hole in the downchute may have contributed to the contamination in B-913M to some degree, the trend analysis for this well (see Section 5.4) shows that the 2006 “slug” release is by far the predominant cause of that contamination. The decreasing trends at high confidence levels are inconsistent with an ongoing release as the source of the contaminants in this well.

Based on available groundwater data, and observations made during the Stage I Landfill Capping System Repair Project including the repair of the Stage I downchute, and the LMIP and related additional soil excavation, we believe the leachate-related sources of groundwater contamination at B-913M have been remediated.

5.3 Monitoring Wells to the Northeast

As noted above in Section 3.4, several monitoring wells located in areas of the site to the northeast of B-913M have yielded groundwater samples in which VOCs and/or bromide have been consistently detected at concentrations greater than background levels. Proceeding to the northeast from the area of B-913M, these wells include: B-920M (VOCs), B-921U (bromide), B-921M (VOCs), B-919U (VOCs), and the replacement well couplet B-304UR (VOCs and bromide) and B-304DR (principally VOCs). The VOCs detected at these locations are generally similar to each other, and generally distinct from the VOCs detected at MW-402U and B-913M, and thus the recent water quality histories at these wells are discussed together in this section.

Of the above-listed monitoring wells, the recent VOC detections at the highest relative concentrations are found at well B-921M, where recent total VOC concentrations in groundwater have ranged up to 35 ug/l. As noted in SHA's 2009 Annual Report, the chlorofluorocarbon (CFC) compound dichlorodifluoromethane (DCDFM) has been the only VOC detected at this location. A similar condition exists for nearby monitoring well B-919U wherein DCDFM has been the only VOC recently (since 2006) reported, at much lower concentrations, from "not detected" up to approximately 10 ug/l.

As previously reported to NHDES, we believe that the DCDFM detections at these two locations result from the historical presence of DCDFM in groundwater in areas upgradient from wells B-919U and B-921M. For example, DCDFM was historically detected at higher concentrations in samples from monitoring wells B-101, MW-804, and MW-805, which were located in areas generally upgradient from B-919U and B-921M (and within or proximate to the GMZ for the former unlined landfill). The more recent detections of DCDFM in the samples from wells B-919U and B-921M are thus consistent with the generally northerly migration of DCDFM with groundwater flow from the area of the former unlined landfill and wells B-101, MW-804, and MW-805. Appendix B includes a combined time-series plot showing DCDFM concentrations for these wells. The historical groundwater quality data for wells B-101, MW-804, and MW-805 may be found in the 2006 Annual Report¹⁵, which was submitted to NHDES following the decommissioning of these three wells in November 2005.

It is a further indication that the CFCs DCDFM and trichlorofluoromethane (TCFM) (discussed below in connection with B-920M) detected in groundwater at these wells to the northeast of B-913M are a remnant of the former unlined landfill, that these CFCs are not detected in leachate as presented on Table 1, and that CFCs have been removed from the landfilled waste stream since at least 1994, when CFCs were required by Federal law to be removed from CFC-containing equipment prior to disposal.

Considering the overall pattern of groundwater flow in this portion of the site and the above-described historical VOC detections, the VOCs detected (at lower concentrations) at most of the other monitoring wells in the area are consistent with the scenario put forth above. For reference, the general history of VOC detections at these remaining wells is summarized as follows:

- At monitoring well B-920M, the VOC most recently detected is 1,1-DCA, at concentrations of approximately 2 to 4 ug/l. DCDFM and TCFM were also intermittently detected at this location prior to 2007.
- At well B-304UR, DCDFM has been the only VOC detected, at concentrations of 6 to 19 ug/l.
- At well B-304DR, DCDFM has been the principal VOC detected, at concentrations of approximately 10 to 19 ug/l, with 1,1-DCA also consistently present at lower concentrations of approximately 2 to 3 ug/l.

¹⁵ "2006 Summary of Water Quality Monitoring, North Country Environmental Services, Inc. Landfill – Bethlehem, New Hampshire" (dated September 25, 2006); prepared by SHA on behalf of NCES.

Given the location of B-920M a short distance to the west of the main area of DCDFM presence in groundwater described above, the detection of lower concentrations (i.e., as compared to B-921M and B-919U) of DCDFM at well B-920M is generally consistent with the scenario outlined above for wells B-921M and B-919U. We note that 1,1-DCA was detected historically at concentrations of up to 5 ug/l in the samples from well MW-405U⁹, formerly located to the south of MW-805 in an area generally upgradient from well B-920M. Thus, the presence of 1,1-DCA in groundwater in the area of well B-920M is likely due to its migration with groundwater flow to the north from the area of former well MW-405U.

Similarly, the presence of the above-listed VOCs in groundwater in the area of B-304UR and B-304DR is consistent with the historical presence of these compounds in groundwater directly downgradient from the former unlined landfill, as evidenced by the historical groundwater quality data for monitoring wells MW-802 and MW-803.²

Also, with the exception of B-304UR, bromide has not been consistently detected in the groundwater samples from the above-described wells. Fundamentally, this condition supports the interpretation that VOC detections at these wells are related to a historical (i.e., pre-bromide tracer addition) source/release from the former unlined landfill.

For well B-304UR, while the history of VOC detections (i.e., entirely DCDFM at concentrations consistent with those observed at B-919U and B-921M) is consistent with the “continued northerly migration” scenario outlined above, the detection of low levels of bromide (typically 0.1 to 0.4 mg/l) at this location suggests a limited contribution related to a more recent source/release. Given the relatively shallow screen placement for this well, and its location directly north (and downgradient of) Detention Pond No. 4, which received stormwater/leachate discharge as part of the August 2006 Stage IV / Phase I construction-related leachate incident, the presence of bromide at this location likely resulted from that (August 2006) event. We note that bromide was detected at its highest concentration at this location from April 2007 to April 2008, and since that time has generally decreased in concentration.

For well B-921U, the recent history of bromide concentrations detected in the groundwater samples from that well support a “slug” type release of bromide. We note that VOCs have been essentially not detected at this location. As previously reported to NHDES, we have concluded that the bromide detections at B-921U result from the 2006 leachate/stormwater releases associated with construction of the Stage IV / Phase I Landfill. The continued downward temporal trend in bromide concentrations observed in the samples from B-921U following the transient 2006 release support this prior release scenario as the likely source for the bromide at this location.

5.4 Analysis of Groundwater Quality Trends

In addition to the above-described analysis of individual VOC detections in groundwater, SHA analyzed temporal trends in VOC and bromide concentrations at each location with a recent monitoring history of consistent detection of VOCs and/or bromide. In part, this analysis was completed to objectively assess trends, and the apparent degree of correlation between VOC and bromide concentrations and the documented leachate spills/releases, and related incidents.

This analysis uses the Mann-Kendall test (as suggested by NHDES) to evaluate the data provided in the total VOC and bromide time-series plots in Appendix B. The Mann-Kendall test evaluates whether an apparent (visual) trend (i.e., upward or downward) for a given data range is statistically significant. The Mann-Kendall test was applied to selected data ranges in each time-series plot using a software package developed by the U.S. Geological Survey¹⁶ (USGS). The test results were further assessed using a “Decision Matrix” and data qualifiers developed by the U.S. Air Force¹⁷. The results are summarized in the following table; additional description of the test methods applied to the site data is provided in Appendix D.1.

In addition, considering the particular importance of water quality data for monitoring wells MW-402U and B-913M, potential temporal trends in bromide and VOC concentrations at these wells were also evaluated using linear regression methods¹⁸. Additional description of the linear regression methods employed is provided in Appendix D.2. The combined use of Mann-Kendall and linear regression methods has been applied in a manner consistent with USEPA 2009¹⁸. These methods each have their limitations with regard to statistical evaluation of the data, and hence we believe the results of both tests should be reviewed and considered collectively¹⁹.

Linear regression methods are parametric statistics, and as such assume that the data are distributed in a certain manner, typically normally or log normally for environmental data. The Mann-Kendall test makes no assumptions about the distribution of the data, hence when data sets are not considered sufficiently normal for application of linear regression methods, a non-parametric test (that is a test or method that does not make assumptions about the distribution of the data) such as the Mann-Kendall is recommended by USEPA 2009¹⁸.

One limitation of the Mann-Kendall test is that it does not account for differences in the frequency of data points, and each data point is considered equally regardless of the temporal spacing. Hence, a time period over which data are obtained more frequently (e.g., monthly) is weighted more heavily than an equivalent time period over which data are obtained less frequently (e.g., semi-annually)²⁰.

¹⁶ “Computer Program for the Kendall Family of Trend Tests; Helsel, D.R., Mueller, D.K., and Slack, J.R. (2006), USGS Scientific Investigations Report No. 2005-5275.

¹⁷ “Monitoring and Remediation Optimization System (MAROS) Software – Version 2.2 – User’s Guide” (March 2006); Air Force Center for Environmental Excellence (AFCEE).

¹⁸ “Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance” USEPA, March 2009, EPA 530-R-09-007.

¹⁹ Parametric statistics assume data come from a type of probability distribution and makes inferences about the parameters of the distribution. Generally speaking parametric methods make more assumptions than non-parametric methods. If those extra assumptions are correct, parametric methods can produce more accurate and precise estimates. They are said to have more statistical power. Non-parametric methods make fewer assumptions about the data and their distribution, and hence may be applied in more situations and where less is known about the application in question. However, the wider applicability and fewer assumptions of non-parametric tests comes at a cost: in cases where a parametric test would be appropriate, non-parametric tests have less power, and often require a larger sample size to draw conclusions with the same degree of confidence (from www.statsoft.com).

²⁰ One means that we investigated to account or “normalize” for this difference in temporal frequency of data was to interpolate linearly between the available semi-annual data, and select data points at monthly intervals that lie along the interpolated lines. As an example, the results of the Mann-Kendall analysis that include these interpolated data for MW-402U for the timeframe from April 2007 until present (January 2010) are presented in Attachment D.1, and demonstrate that when the temporal frequency of data collection is “normalized” in this manner (essentially “removing” the more heavily weighted effect associated with the more recent monthly sampling data), a decreasing trend is indicated for both total VOCs and landfill gas (LFG) related VOCs.

Selection of Timeframes for Statistical Analysis:

The timeframes (i.e., start dates) for the statistical analyses were selected based on the observed distribution of VOC and bromide concentrations over time, and the occurrence of multiple potential incidents that may have resulted in VOC- and/or bromide-related impacts to groundwater quality. In particular for well MW-402U, start dates selected for the analysis are April 2004 and April 2007, both of which are times of “peaks” in total VOC concentrations. Highs in LFG VOC concentrations in groundwater also occur at MW-402U in April 2004 and April 2007. For well B-913M, November 2007 (the date of maximum total VOC concentration), was selected as the start date for the analysis.

Incident(s) potentially responsible for the observed VOC and bromide concentrations in groundwater are indicated as occurring approximately 12 to 18 months prior to the observed highs in VOC concentrations in groundwater at wells MW-402U and B-913M. We note however, that the history of leachate spills/incidents and construction activities in the area of these wells is complex, in particular the area north of Stage I and generally upgradient of MW-402U was a locus of heavy operational and remedial activities up until the completion of the Leachate Management Improvements Project (LMIP) and related soil removals in May 2009. Further, these activities/incidents occurred at different locations, likely resulting in multiple overlapping influences to groundwater quality, such that there is likely not a simple cause-and-effect relationship (e.g., with a consistent or predictable “time lag”) between specific events and the observed increase or decrease in the VOC or bromide concentrations detected in the groundwater samples from these wells. Hence, we believe that the timeframe for the statistical analyses should be based on the actual observed water quality at these two wells (i.e., starting from observed highs in total VOC concentrations), similar to the other site wells, and the various remedial activities considered collectively with regard to the observed improvement in water quality. Selection of more recent “start dates” would disregard this complexity and the iterative nature of the remedial work performed at this site, and in effect, penalize NCES for its earlier successful remedial efforts.

**SUMMARY STATISTICAL TREND ANALYSIS
TVOC AND BROMIDE CONCENTRATIONS AT SELECTED MONITORING WELLS**

MONITORING WELL	ANALYTE	⁶ DATA RANGE TESTED	¹ KENDALL TEST STATISTIC	² CONFIDENCE FACTOR (%)	³ MANN-KENDALL TREND	⁹ LINEAR REGRESSION
MW402U	Bromide	From TVOC peak to end of data (04/05/04 to 1/06/10)	-116	97.14	Decreasing	Not calculated ⁷
		From 04/10/07 to 1/06/10	-68	97.50	Decreasing	Not calculated ⁷
	TVOC	From TVOC peak to end of data (04/05/04 to 1/06/10)	-84	96.19	Decreasing	Decreasing ⁸
		From 04/10/07 to 1/06/10	-7	18.29	Stable	Decreasing
	LFG-Related VOCs (diethyl ether, aliphatic CVOCs)	From TVOC peak to end of data (04/05/04 to 1/06/10)	-78	94.57	Probably Decreasing	Decreasing
		From 04/10/07 to 1/06/10	1	0.00	No Trend	No Trend
B913M	Bromide	Test from TVOC peak (11/05/07 to 1/06/10)	-127	99.92	Decreasing	Decreasing
		All data (4/10/2006 to 1/06/10)	-93	93.27	Probably Decreasing	Not calculated
	TVOC	Test from TVOC peak (11/05/07 to 1/06/10)	-73	99.71	Decreasing	Decreasing
		All data (4/10/2006 to 1/06/10)	-17	34.86	Stable	Not calculated
B920M	TVOC	All data (04/10/06 to 11/09/09)	-30	99.92	Decreasing	Not calculated
B921M	TVOC	All data (04/10/06 to 1/06/10)	85	99.86	Increasing	Not calculated
		Test from peak to end of data (07/30/09 to 1/06/10)	-10	81.30	Stable	Not calculated
B921U	Bromide	Test from peak to end of data (07/23/07 to 1/06/10)	-235	100.00	Decreasing	Not calculated
		All data (04/10/06 to 1/06/10)	-203	99.99	Decreasing	Not calculated
B919U	TVOC	All data (09/11/01 to 1/06/10)	6	16.78	No Trend	Not calculated
B304DR	TVOCs	All data (4/10/2006 to 11/09/09)	6	45.20	No Trend	Not calculated
B304UR	Bromide	All data except first two rounds (11/06/2006 to 1/07/10)	-57	92.33	Probably Decreasing	Not calculated
		All data (4/10/2006 to 1/07/10)	-47	79.16	Stable	Not calculated
	TVOC	All data (4/10/2006 to 1/07/10)	-6	15.11	Stable	Not calculated

Notes

1. The Kendall statistic, S, indicates whether the data shows an increasing or decreasing trend.
2. The Confidence Factor is a measure of the level of confidence in rejecting the null hypothesis of the Mann-Kendall test. The null hypothesis states that there is no trend in the data.
3. The trend conclusion has been determined from the Kendall S value, the coefficient of variation or standard normal deviate, Z (not listed above) - determined from S and the variance of S, and the confidence factor. Further description regarding the Mann-Kendall methodology applied is provided in Appendix D.1.
4. "Stable" represents data with no definite increasing or decreasing trend and close spread of data about the mean. "No trend" indicates no definite increasing or decreasing trend and more scattered data about the mean.
5. Where a data range includes non-detect (ND) results, a value of zero has been used; if the data range includes duplicate results then the highest result has been used and the other eliminated for purposes of the statistical test.
6. Dates for data range tested extend until the most recent available data (typically January 2010, except for B920M and B304DR, for which November 2009 are the most recent data).
7. At MW-402U, bromide concentrations have been at background (≤ 0.1 mg/l) for the last 7 rounds, July 2009 to January 2010.
8. The residuals of the data (or log transformed data) do not appear to be normally distributed, and the guidance document (USEPA, 2009 – see note 9) indicates the trend should be evaluated using a non-parametric test such as the Mann-Kendall.
9. Linear regression analysis was completed pursuant to the guidance document "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance" US EPA, March 2009, EPA 530-R-09-007. Refer to Appendix D.2 for further discussion and explanation of statistical methods.

With reference to the time-series plots for the individual monitoring wells as presented in Appendix B, the Mann-Kendall and linear regression test results summarized in the above table are further described as follows:

Well MW-402U:

Considering the total VOC results from the high concentration “peak” in April 2004 (87 ug/l) to present, Mann-Kendall indicates a “decreasing” trend (Confidence Factor of about 96 percent). Linear regression also indicates a decreasing trend. When this data range is “shortened” to include the total VOC data from April 2007 to present, Mann-Kendall indicates a stable trend; however, linear regression indicates a decreasing trend. We also note that a “probably decreasing” trend (Confidence Factor of just under 95 percent) is indicated by Mann-Kendall for the LFG-sourced VOCs from the VOC concentration “peak” in April 2004 to present; linear regression indicates a decreasing trend for this data set. In the case of LFG-sourced VOCs from April 2007 to present, both Mann-Kendall and linear regression indicate no trend.

We understand based on its February 8, 2010 letter²¹, that NHDES has stated that:

“In order to demonstrate that LFG is the source of diethyl ether, 1,1-dichloroethane and cis-1,2 dichloroethene, and that the decreasing concentrations of these VOCs are in fact due to the enhanced LFG extraction efforts, the statistical analysis of trends must be based on water quality data collected after the enhanced LFG extraction effort was initiated.”

However, because these enhanced LFG extraction efforts were initiated in November 2009/ January 2010, there are only one or two rounds of water quality data available since then, and no trend analysis can be completed at this time consistent with the criteria for application of Mann-Kendall or linear regression analyses. Going forward, as data are generated on a monthly basis, we will track the data and assess the trends as they develop. As noted above, however, we do not believe that a start date of December 2009 or January 2010 is appropriate from a scientific or regulatory standpoint. LFG-sourced VOCs have demonstrably trended downward from the TVOC peak in April 2004 to the present, and selection of a December 2009 or January 2010 start date would ignore this remedial history and treat the current VOC concentrations in MW-402U as if they are necessarily attributable to a new or ongoing LFG release, or that their decrease in concentration is attributable to a singular event. The trend analyses and our discussion above are contrary to such a hypothesis, and we are aware of no evidence to suggest a new or ongoing LFG release.

For bromide, a decreasing trend is indicated by the Mann-Kendall test for April 2004 to present (Confidence Factor of about 97 percent). A decreasing trend is also indicated by the Mann-Kendall test for April 2007 to present (Confidence Factor of 97.5 percent). As indicated above, bromide concentrations have been at background concentrations of less than or equal to 0.1 mg/l for the seven most recent sampling rounds.

²¹ Letter from NHDES to Casella Waste Management, Inc., dated February 8, 2010, “Bethlehem - North Country Environmental Services Landfill, 581 Trudeau Road, DES #198704033, Project #1737, regarding “Corrective Action Plan North Country Environmental Services Landfill”, prepared by Sanborn, Head & Associates, Inc, dated November 24, 2009.

Well B-913M:

A stable trend is indicated by the Mann-Kendall test for total VOCs at this location when the full range of data is considered. Mann-Kendall indicates a probably decreasing trend for bromide over this same timeframe. When the pertinent data range, extending from the highest observed total VOC concentration (November 2007) through the most-recent available data (January 2010), is considered, Mann-Kendall indicates decreasing trends for both total VOCs and bromide (Confidence Factors of 99+ percent for both). Linear regression also indicates decreasing trends for both total VOCs and bromide over this same timeframe. This finding supports the 2006 leachate release scenario presented herein as the most likely cause for the detections observed at this monitoring location.

In response to NHDES's February 8, 2010 letter²¹, comment No. 4, the overall trend and fluctuations in 1,4-dioxane concentrations detected at B-913M appear to generally follow those of total VOCs and bromide; however, given the shorter period of record for 1,4-dioxane data (since November 2008), the visually apparent downward trend is not "statistically significant" (e.g., by Mann-Kendall: 84.4 percent, 90 percent is required to be classified as "probably decreasing"). Given the observed pattern of low level concentrations of 1,4-dioxane over time at this location, and the abbreviated sampling history, we believe the most defensible explanation for the 1,4-dioxane concentrations observed since November 2008, is that they represent the "tail" of a declining trend, with "scatter" in the concentrations consistent with the level of scatter observed in the bromide and total VOC concentrations at B-913M. We think that total VOC trends are the best indicator of the overall behavior of VOC concentrations at this location, irrespective of fluctuations in individual VOC concentrations within those trends. Further, based on the strong downward trends indicated for both total VOCs and bromide, and consistent with our understanding from NHDES that once downward trends for these parameters are established, monitoring can return to a triannual schedule, we do not believe that continued monthly monitoring is warranted at this location. There is no reason to believe that the 1,4-dioxane present in groundwater at B-913M is derived from another source other than the same leachate release source as the other VOCs and bromide detected at this location, and hence the presence of 1,4-dioxane is not justification for more frequent monitoring.

Wells B-919U, B-920M, B-921M, and B-921U:

As indicated in the summary table above, for the wells of this group with persistent VOC detections (B-919U, B-920M, and B-921M), the Mann-Kendall trend for total VOC concentrations at well B-921M, at which the highest concentration of VOCs is detected, for all data (April 2006 to January 2010) is increasing. This finding is consistent with the "continued northerly migration" scenario described in Section 5.3, given the historical presence of higher concentrations of VOCs in groundwater associated with the former unlined landfill and detected in now-decommissioned wells upgradient from well B-921M. As indicated above in Section 5.3, DCDFM is the only VOC detected at B-921M, and based on the trends in DCDFM concentrations detected in wells nearby and or somewhat upgradient of B-921M (as shown on the time series chart in Appendix B), we would expect DCDFM concentrations at B-921M to show a decreasing trend starting over the next few years that is similar to the trend we observed in the upgradient decommissioned wells. It is interesting to note that Mann-Kendall indicates a stable trend for total VOC (DCDFM) concentration data at B-921M for the more recent period from July 2009 to January 2010, with a confidence factor of 88 percent - only slightly below the 90 percent required to be classified as "probably decreasing" (its Kendall Statistic [S] is -10). VOC concentrations at the other wells within this "VOC group" (i.e.,

B-919U and B-920M) are much lower, and yield Mann-Kendall test results indicating either “no trend” (B-919U) or a “decreasing” trend (B-920M).

As noted in Section 5.3, the general non-detection of bromide in the groundwater samples from the above VOC group wells supports the conclusion that VOC presence at these locations is related to a historical (i.e., pre-bromide tracer addition) source/release from the former unlined landfill.

The Mann-Kendall trend results for the observed bromide concentrations at well B-921U yielded a conclusion of a decreasing trend (Confidence Factor of 99+ percent), for data ranges encompassing both the entire data set and from the relative greatest observed bromide concentration (July 2007 sampling event) through the most-recent (January 2010) available results. This finding supports the previously-described scenario of the August 2006 construction-related release, as the main source for the bromide detected at this well location.

Well B-304UR/DR Couplet:

No trend or a stable trend is indicated when all of the VOC data are considered for these locations. This finding is consistent with the interpretation of the continued northerly migration of a residual VOC plume associated with the former unlined landfill, as described in Section 5.3.

In considering the scenario of a likely contribution of bromide to groundwater in the area of B-304UR related to the August 2006 Stage IV / Phase I construction-related, leachate/ stormwater release, an additional Mann-Kendall test was run on the bromide data from well B-304UR from the November 2006 sampling round (the first data available subsequent to August 2006) to the most-recent (January 2010) data. The test performed on this abbreviated data range indicated a probably decreasing trend (Confidence Factor of 92 percent) to the data. This finding further supports the hypothesis of a short-duration, construction-related (2006) release of bromide affecting groundwater quality in the area of well B-304UR, not related to the longer-term trends associated with VOC presence in groundwater in this area of the site.

Summary of Groundwater Quality Trends:

Overall, the results of the Mann-Kendall testing support the proposition that, for the key release detection monitoring wells MW-402U and B-913M, decreasing temporal trends have been established as a consequence of the recent remedial actions completed at the site and natural attenuation. In the case of bromide at MW-402U, background concentrations have been achieved for the last seven sampling rounds.

The results of the Mann-Kendall analyses as applied to the VOC (principally) and bromide concentrations observed at the “northeast wells” (B-304UR, B-304DR, B-919U, B-920M, B-921M, B-921U) are consistent with the mechanisms that account for the presence of these constituents in groundwater in these areas of the site, as presented in Section 5.3, and thus, no additional corrective actions, except continued monitoring, are proposed to address VOC and/or bromide presence in groundwater in the area of these monitoring wells.

6.0 ADDITIONAL CORRECTIVE ACTIONS AND PERFORMANCE STANDARDS

As described herein, the remedial actions completed by NCES to date have yielded, or are anticipated to yield, continuing improvements in related groundwater quality conditions. These groundwater quality conditions will continue to be monitored, and statistical tests applied to assess trends in the groundwater quality data from key site monitoring wells (described under Section 6.2 below). Based on the findings presented herein, the following additional remedial actions have recently been implemented to address specific observed field conditions and reinforce the observed trends of improving site groundwater quality.

6.1 Enhanced LFG Extraction – Stage I Landfill

As described in Section 5.1, the remedial actions completed to date as part of the LMIP, in the area generally upgradient from well MW-402U, have eliminated the leachate spill-related sources of groundwater contamination and resulted in improved groundwater quality conditions at that monitoring location. The remaining VOCs still detected in groundwater at MW-402U are, in our opinion, sourced by LFG. In addition, the eastern portion of the anchor trench on the north side of Stage I was reconfigured/repared, eliminating potential pathway(s) for LFG migration from the landfill to outside of the landfill footprint. However, the presence of subsurface infrastructure and the end of the 2009 construction season precluded the observation and any potentially necessary repair of the western portion of this anchor trench; hence, there was still the potential that LFG was migrating from this portion of the anchor trench.

To guard against this possibility, NCES recently implemented additional enhancements to the existing LFG extraction system, which now provide additional direct extraction of LFG from the capped Stage I Landfill. These system improvements were accomplished via a three-fold approach, which included the following specific elements:

- Eight new/additional gas extraction wells were installed within the footprint of the Stage I Landfill between November 19 and December 2, 2009, and tied into the existing LFG collection header system currently operating at the site. A limited vacuum was applied to each well as it was tied into the LFG collection system to prevent LFG migration into the atmosphere from the wells themselves; however, the new LFG extraction wells were not fully on-line until each well was integrated/balanced into the greater site LFG collection system infrastructure (work completed on January 7, 2010).
- The existing Stage I / Phases II through IV primary leachate sump riser manholes were sealed from the atmosphere, and enhanced LFG extraction from the primary leachate collection system was implemented via connection to the sideslope primary leachate collection system cleanouts for these Phases. This work was completed by approximately December 1, 2009. As this system extends essentially to the edge of waste at the northern edge of the Stage I Landfill, these LFG extraction system enhancements are anticipated to be effective at limiting further fugitive LFG migration in the area upgradient of MW-402U. To assess the performance of LFG collection from the primary collection system, monitoring ports were installed in the Stage I / Phases II, III, and IV primary sump risers to monitor pressure/vacuum near the northern limit of waste in Stage I. With vacuum applied to the LFG collection system and primary leachate collection system in Stage I / Phases II through IV, we anticipate that the LFG collection system will induce a vacuum

not only in the vicinity of the LFG extraction wells, but also within a zone of influence extending to the limit of waste. These enhancements to Stage I LFG extraction have resulted in an additional approximate 300 cubic feet per minute (CFM) of LFG removal from the NCES landfill (based on 50% methane concentration for LFG), and typical vacuums of approximately 10 inches of water at the Stage I primary leachate sump risers.

- Two soil-vapor probes (GP-16, GP-17) were installed on December 17, 2009 in the area directly north of the western end of the Stage I Landfill anchor trench (and south of the MW-402U area). The screens of the probes were installed just above the water table as observed during drilling. Soil-vapor samples were collected from each probe on December 22, 2009 and submitted for laboratory analysis for VOCs using USEPA Method TO-15. During purging prior to sample collection, soil vapor from each of the probes was screened for the presence of methane and CO₂ (as general indicators of the presence of LFG). The results of this initial round of soil-vapor sampling were submitted to NHDES via a February 5, 2010 report²² prepared by SHA. As further described therein, LFG-sourced VOCs detected in the recent groundwater samples collected from monitoring well MW-402U (e.g., diethyl ether and 1,1-dichloroethane [1,1-DCA]) were not detected in either of the soil-vapor samples analyzed by the laboratory, and methane was not detected at concentrations greater than background in the field-screening samples. These findings are indicative of a general absence of significant LFG presence in the vadose zone in the area of the new soil-vapor probes. .

Documentation of the above-described LFG extraction system improvements, including as-built drawings and logs for new LFG extraction wells, was provided to NHDES via a February 5, 2010 report²³ prepared by SHA.

6.2 Evaluation of Groundwater Analytical Data

As discussed at length in Section 5.0, we have now been able to identify, to a reasonable level of certainty, the sources of VOCs and bromide detected in MW-402U and B-913M as well as the wells in the northeast. The remedial measures undertaken by NCES to date and natural attenuation have resulted in marked reduction in the concentrations of VOCs and bromide in MW-402U and B-913M. While we cannot be certain that the repair work performed this past summer along the anchor trench on the north side of Stage I will prevent *any* further LFG impact to groundwater, the excavation of soils below the elevation of the anchor trench and the elimination of the stormwater drainage pipe as a preferential pathway for LFG has eliminated the principal demonstrated pathway by which LFG contributed to groundwater contamination detected in MW-402U. Decreasing concentration trends for the LFG-related VOCs detected in groundwater at MW-402U are expected to be observed in the future; however, as discussed above, the rate of decrease from this point forward is constrained by the limited rate of groundwater flow.

NCES has recently implemented the measures in Section 6.1 to capture LFG from Stage I (including the area of the western portion of the anchor trench), and verify the efficacy of the gas extraction system. These measures provide assurance that LFG in the northern portion of Stage I will be drawn

²² "Soil-Vapor Probe Installations and Initial Sampling/Analytical Results" (dated February 5, 2010), prepared by SHA on behalf of NCES.

²³ "Fall 2009 Landfill Gas System Improvements" (dated February 5, 2010), prepared by SHA on behalf of NCES.

away from the landfill perimeter, captured by the LFG collection system, and combusted at the facility's flares. As noted above, NCES has recently submitted a revised LFG SAP, and once the SAP is approved by NHDES, we expect to collect and analyze LFG and LFG condensate samples within the next several weeks so we have site-specific data to better understand the composition of LFG in Stage I.

Now that NCES has completed the implementation of the measures in Section 6.1, we propose that once there are two consecutive sampling rounds that are consistent with decreasing concentration trends (as assessed using the statistical methodology presented herein) for bromide and VOC concentrations at MW-402U and B-913M, NCES be permitted to return to triannual monitoring. We think that this modification of the sampling schedule will be warranted at that point because NHDES can then be confident that NCES has identified the sources of the contamination in those wells, the remedial and corrective actions taken have been effective and are likely to continue to be effective, and hence there is no ongoing source of contamination.

The final goal of the remedial actions described in this CAP is restoration of site groundwater quality at the key release detection monitoring wells MW-402U and B-913M to background conditions, defined as non-detectable concentrations of VOCs and bromide concentrations of less than or equal to 0.1 mg/l in the groundwater samples collected from these locations. Attainment of background conditions will be confirmed by two consecutive groundwater sampling round results attaining these performance standards.

7.0 PROPOSED SCHEDULE

The LMIP, the Stage I capping/downchute repair project (Section 4.0), and the implementation of the additional LFG extraction system enhancements are complete. We anticipate collection and analysis of the LFG and LFG condensate samples within approximately two weeks following NHDES approval of SHA's February 9, 2010 revised SAP, which is currently under review by NHDES.

8.0 REPORTING

We propose to submit CAP status reports to NHDES on a monthly and then tri-annual basis, consistent with the schedule for further statistical analysis of the groundwater analytical results proposed under Section 6.2 (above). Our status reports will include updated summary groundwater analytical data tables, time-series plots, summary results of the statistical testing, and a narrative discussion of the results to present the key findings and our associated recommendations. Copies of the relevant laboratory analytical data reports will be included as appendices to our reports. Reporting will continue until VOC and bromide concentrations in the key site release detection monitoring wells described above (MW-402U and B-913M) are at background concentrations for two consecutive sampling rounds.

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