ATTACHMENT 3

SANBORN HEAD

Building Trust. Engineering Success.

Stage V
Hydrogeologic Report

North Country Environmental Services, Inc.
Bethlehem, New Hampshire

Prepared for North Country Environmental Services, Inc.
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1.0 INTRODUCTION

At the request of North Country Environmental Services, Inc. (NCES), Sanborn, Head & Associates, Inc. (Sanborn Head) has prepared this hydrogeologic report in support of an application for development of Stage V at the NCES facility on Trudeau Road in Bethlehem, New Hampshire.

This report has been prepared to update the information provided in Sanborn Head's January 2002 Hydrogeologic Study – Proposed Stage IV Expansion, the scope of which was developed in conjunction with NHDES as part of permitting Stage IV. The January 2002 Stage IV Report provided a summary of existing hydrogeologic data, and incorporated the data into a report discussing how soil and groundwater conditions in the Stage IV area related to overall site conditions. The proposed Stage V area encompasses generally the same area as originally permitted as Stage IV. As such, the bulk of the Stage IV hydrogeologic information is also pertinent to the proposed Stage V landfill expansion. The objective of our services was to summarize data from historical hydrogeologic investigations, and supplement this information with recent water quality data.[1]

2.0 SITE AND PROJECT DESCRIPTION

This section provides a summary of site features and description of the proposed Stage V landfill. A detailed description of site background and previous investigations is included in Sanborn Head's January 2002 Stage IV Hydrogeologic Report[2] and February 2010 Corrective Action Plan (CAP)[3]. A site locus plan is provided as Figure 1. Locations of site features and site topography based on an October 2013 digital aerial photographic survey are shown on Figure 2. Elevations shown are referenced to the North American Vertical Datum of 1988 (NAVD 88)[4].

2.1 Site Description

The NCES landfill is located on a parcel identified as Lot 1 on Town of Bethlehem Tax Map 419. The site is located to the east of Trudeau Road as shown on Figure 1. Two roads, Muchmore Road and Laurel Lane, are located directly north of the site. Laurel Lane, a dead end road, extends off Muchmore Road to the south (Figure 2). Two residences located on Laurel Lane are owned by NCES. A parcel of land which had been subject to sand and gravel mining in the past abuts the site to the northeast. Undeveloped land abuts the site to the east, south and west.

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1 This report has been prepared for the exclusive use of North Country Environmental Services (NCES) in support of the proposed Stage V landfill expansion at the NCES site in Bethlehem, New Hampshire in accordance with generally accepted hydrogeologic practices.

2 "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 Sanborn Head on behalf of NCES.

3 "Corrective Action Plan - North Country Environmental Services, Inc., Bethlehem, New Hampshire" (dated February 2010), prepared by Sanborn Head on behalf of NCES.

4 Note that elevations presented in hydrogeologic reports prepared prior to 1999 were based on an assumed site datum which was 6.83 feet lower than NAVD 88.

Public water is available on Muchmore Road to the north of the site and a fire hydrant is located about 600 feet north of the landfill near the end of Laurel Lane. The NCES facility has a drilled well located near the maintenance garage for sanitary facilities.

Access to the site is from Trudeau Road. A transfer station operated by NCES for the residents of Bethlehem is located in the southwestern portion of the site near Trudeau Road. The access road to the landfill is located south of the transfer station. The scale, scale house, and maintenance building are located along the facility access road. The landfill is located to the northeast of the scale and maintenance building in the southern portion of the site.

The lined landfill received permits from the NHDES in four general stages. The locations of the stages are shown on Figure 2.

- Stage I, the westernmost stage, was developed in four phases, each with separate leachate collection systems.
- Stage II of the facility is located adjacent to and northeast of Stage I and was developed in two phases, each with separate leachate collection systems.
- Stage III of the facility is located adjacent to and southeast of both Stages I and II, in the location of the former facility Detention Pond No. 1 and facility soil borrow area. Stage III has an independent leachate collection system.
- Stage IV is located north of Stages I and II, generally between Detention Pond No. 3 and No. 4. Stage IV was constructed with an independent leachate collection system. In 2013 as part of sump reconstruction (discussed below), Stage I sumps were reconstructed and connected to the new Stage IV system.

The landfill is surrounded by a perimeter access road. A drainage swale is located between the landfill and access road. Drainage in the perimeter swale flows to one of two detention ponds designated Pond Nos. 3 and 4. Pond No. 3 is located to the northwest of Stage IV and Pond No. 4 is located to the northeast of Stage IV. Water from Pond No. 3 is transferred to Pond No. 4, which discharges to a common swale connected to a natural drainage course to the north. In addition, Pond No. 5 located northwest of Stage I, was constructed as part of Stage IV Phase I in 2005-2006 to receive stormwater from the northwestern portion of the site. Historically, soils in the area to the north of Stage I have been excavated for landfill construction materials and daily cover. In 1997, an excavation was created in this area to obtain granular soil for use in the cap construction. This excavation was backfilled with boulders and on-site soil and the area was graded to drain to a swale to Pond No. 3.

A stockpile of soil/fill material excavated during construction of Stage III is located to the north of Detention Pond No. 3. The area to the north of the soil pile is heavily wooded and generally slopes downward to the northwest to a wetland area. The locations of the wetlands as delineated as part of previous site investigations are indicated on Figure 2.

2.2 Summary of Previous Site Activities

A brief summary of various restoration/remedial activities performed at the site is provided below.

2.2.1 Seep Restoration

Historical hydrogeologic investigations of the NCES site (compiled by Sanborn Head) indicated groundwater migrating from an area of the former unlined landfill at the NCES facility discharges at the Main Seep, located north-northeast of the NCES Landfill (features indicated on Figure 2). As a result of this groundwater discharge, aesthetic impacts associated with an accumulation of iron and manganese precipitate were identified in the Main Seep and its drainage channel. In an August 2006 letter, NHDES requested that NCES obtain permission from the adjacent landowner for access to the Main Seep to develop and implement a restoration plan. Following coordination with NHDES, NCES developed a draft Restoration Plan based on the wetlands delineation, which presented a proposed construction sequence, wetlands protection methods, and erosion and sedimentation controls. Following subsequent permitting with various agencies, aesthetic remediation work commenced on July 21, 2010 and restoration work was complete by September 10, 2010.

On behalf of NCES, Sanborn Head prepared the November 2010 Seep Restoration Report[5] which summarized restoration activities that addressed the aesthetic impacts associated with the Main Seep and its drainage channel. Consistent with NHDES' January 27, 2011 letter regarding review of the Seep Restoration Report, NCES' final post-construction wetland monitoring report was submitted to NHDES in November 2012, and the most recent seep water quality sampling was completed in July 2013 in accordance with the current GMP and results reported to NHDES.

Completion of the seep restoration work and submission of the above-referenced documents completed the requirements of Special Condition #14 of the previous Groundwater Management and Release Detection Permit (GWP-198704033-B-005). Water quality monitoring at the seep will continue as required by Monitoring Requirement #11 of the current Groundwater Management and Release Detection Permit (GWP-198704033-B-006).

2.2.2 Summary of Corrective Action Plan Activities

As discussed in the February 2010 CAP, limited impacts to groundwater quality associated with past leachate management infrastructure and handling and landfill gas effects have historically been recorded at the site. To address these impacts to groundwater, several remedial activities were performed by NCES including:

- **Leachate Management Improvement Project [LMIP]**: This project entailed removal of several leachate USTs and their associated subsurface piping in the area north of Stage I Landfill in Fall 2008. As summarized in the CAP, stained soils indicative of leachate and/or landfill gas (LFG)-related impacts were observed at a number of locations during

[5] "Seep Restoration Summary Report, North Country Environmental Services, Inc., Bethlehem, New Hampshire" (dated November 18, 2010), prepared by Sanborn Head on behalf of NCES.

excavation to remove the leachate infrastructure in this area. Additional soil excavation in the area of the former leachate USTs to the north of Stage I Landfill was undertaken in Spring 2009 to remove the majority of vadose zone soils in this area, which would remove potential VOC-bearing, residually impacted soils in this area. Analysis of soil samples collected from this area generally did not detect VOCs[6], consistent with the absence of a significant ongoing source for the VOCs detected in groundwater at MW-402U. At the time of excavation, a conservative approach was used and soil immediately surrounding monitoring wells MW-402U and MW-402LR was not excavated to reduce potential disturbance to the wells (refer to discussion of subsequent excavation of soil surrounding the wells in Section 2.2.3 below).

- **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 in late-Summer 2009, 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. This construction-related leachate release had previously been identified as a likely source for the VOCs detected in the groundwater samples from monitoring well B-913M. Secondarily, 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. 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. Further 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. The accessible portion of the cap and anchor trench in the area north of Stage I were reconfigured to remedy these conditions.

- **Stage I enhanced landfill gas extraction**: To reduce the potential for LFG to migrate from beneath the western portion of the Stage I Landfill anchor trench, additional enhancements to the existing LFG extraction system were implemented in 2009-2010 to provide additional direct extraction of LFG from the capped Stage I Landfill. System improvements included: 1) installation of additional gas extraction wells within the footprint of the Stage I Landfill; 2) sealing of leachate sump riser manholes from the atmosphere and enhanced extraction of LFG from the primary leachate collection system; and 3) installation and monitoring[7] of two soil vapor probes [GP-16 and GP-17] in the area directly north of the western end of the Stage I Landfill anchor trench [and south of the MW-402U area].

The remedial activities summarized above are discussed in additional detail in the CAP and subsequent CAP update reports previously submitted to NHDES.

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[6] VOC detections in the confirmatory samples were limited to trace concentrations of petroleum-derived aromatic VOCs (AVOCs) including toluene, xylenes, and 1,2,4-trimethylbenzene in shallow soil/sediment samples collected during excavation of the drainage swale adjacent to the MW-402 well couplet. These AVOCs have not been detected in groundwater samples collected from MW-402U, and are interpreted to be the result of localized surface runoff in the drainage swale prior to excavation/removal.

[7] Refer to Section 2.2.4 for a discussion of soil vapor probes GP-16 and GP-17.

2.2.3 Results of Additional Soil Excavation

As described in the February 2010 CAP, the presence of diethyl ether and 1,1-dichloroethane (1,1-DCA) in groundwater in this area is attributed to historical LFG presence in vadose zone soils to the north of the Stage I landfill. As such, a limited area of remaining vadose zone soils in the vicinity of MW-402U (which had not been removed as part of prior soil excavation work in this area) were suspected to represent a potential source of residual LFG-related impacts. Accordingly, these remaining soils were removed in April 2011 as part of the overall corrective action process to restore groundwater quality at MW-402U to the background conditions defined in the site CAP.

The Stage IV/Phase II construction project (completed separately, but at approximately the same time as the excavation of vadose zone soil near MW-402U) provided an opportunity to assess soil quality beneath a portion of the Stage I landfill, in an area generally upgradient from MW-402U.

The findings from these soil excavation and testing activities were provided in Sanborn Head's June 21, 2011 letter to NHDES, and are summarized below.

2.2.3.1 Soil Excavation – MW-402U Area

Vadose zone soils in the area of MW-402U (and nearby couplet well, MW-402LR) were excavated by NCES in April 2011. The excavation activities completed by NCES were observed and documented by a Sanborn Head representative, who collected samples of in-place and excavated soils for characterization, field screening and laboratory analysis. Excavation proceeded to a depth of approximately 8 to 10 feet below pre-excavation ground surface grades in the area. The excavated soils exhibited apparent iron staining in some of the uppermost depth intervals, but did not display evidence of (non-iron) staining or odors suggestive of potential LFG- or other VOC-related impacts. PID field-screening readings for in-place and excavated soils were all non-detect[8]; VOCs were not detected in either of the two soil samples submitted for laboratory analysis.

2.2.3.2 Stage I Subliner Soil Sampling and Analysis

The Stage IV/Phase II construction project provided an opportunity to assess soil quality beneath a portion of the Stage I landfill, in an area generally upgradient from MW-402U. Based on information provided by NCES, re-construction of the Stage I/Phase IV leachate sump was completed in early 2011, as an approved element of the Stage IV/Phase II construction project. As part of this work, the Stage I liner system and underlying soils in the area of the sump were temporarily exposed, allowing the in-place soils underlying the liner system to be observed. Soil samples were collected by CMA Engineers (CMA) of Portsmouth, New Hampshire, on behalf of NCES, and analyzed VOCs, bromide, and chloride to assess for the potential presence of a VOC source in the subliner soils in this area.

[8] Representative soil samples for field screening were collected from intervals within both the shallow soils and the deeper, glacial till soils; from locations proximate to well MW-402U. In consideration of the absence of visual/olfactory observations or PID responses suggestive of the presence of contaminated soils, only two soil samples were submitted for laboratory analysis.

CMA's observations of the soils underlying the Stage I secondary liner in the area of the (re-built) Stage I/Phase IV secondary leachate sump revealed some limited areas with possible iron and manganese staining, which did not appear to persist below a depth of approximately 1 to 2 inches. Also, odors suggestive of the possible presence of VOCs or LFG were not apparent from the exposed soils in this area. Two soil samples were collected by CMA and submitted for analysis of VOCs, bromide, and chloride. Neither VOCs nor bromide were detected in the soil samples. Chloride concentrations in the samples were suggestive of background concentrations, and not suggestive of impacts related to the presence of leachate or LFG in these soils.

2.2.4 MW-402 Area Monitoring

As discussed in the February 2010 CAP, the presence of diethyl ether and 1,1-DCA has been concluded to be a consequence of historical LFG presence in the area sourced from the Stage I Landfill. Although corrective actions undertaken by NCES, as described in the CAP and subsequent communications with NHDES, have been effective at addressing historical LFG sources, as evidenced by non-detects in soil vapor in the area between the Stage I Landfill and MW-402U; diethyl ether and 1,1-DCA continue to be detected in groundwater at MW-402U. As a result, NHDES required that NCES undertake additional investigations to further assess whether there are other potential source(s) for these VOCs.

On November 22, 2011, NCES submitted a Work Plan for installation of a new monitoring well couplet (B-922U/L) at a location closer to the Stage I Landfill, to evaluate the potential presence of VOCs in this area. Monitoring wells B-922U/L were installed in January 2013. As indicated in monitoring reports submitted to NHDES, and discussed in Section 4.1, diethyl ether and 1,1-DCA are detected in monitoring well B-922U at similar, but slightly higher concentrations than detected at MW-402U.

In addition to groundwater monitoring, as described in the February 2010 CAP, Sanborn Head installed soil vapor probes GP-16 and GP-17 in an area to the north of the Stage I Landfill to collect and analyze soil vapor samples for VOCs. The purpose of these soil vapor probes located in an area generally upgradient of monitoring well MW-402U, was to assess whether the VOCs observed in the groundwater samples collected from MW-402U may be the result of an active LFG source (i.e., LFG migration through the landfill liner system) in this part of the site.

As indicated in Sanborn Head's March 14, 2013 letter to NHDES, soil vapor monitoring results from the MW-402U area have consistently indicated low or non-detectable concentrations of VOCs, and none of the VOCs detected in groundwater at MW-402U have been detected in the soil vapor samples from probe GP-17 (and the four rounds that included the former location GP-16). These findings demonstrated that no active LFG source for the low-level VOCs detected in groundwater at well MW-402U is present in the vadose zone in the area of the soil vapor sampling. This is consistent with our site conceptual model, in that the low concentrations of diethyl ether and 1,1-DCA detected in the groundwater samples from monitoring well MW-402U are indicative of residual, low-level contamination associated with an older release of LFG along a pathway in the area upgradient of MW-402U, where both the source and the pathway have since been removed. NHDES concurred with

these findings, and in an April 16, 2013 letter to NCES, eliminated soil vapor monitoring as part of CAP requirements.

The analytical results for groundwater samples from B-922U indicate the same VOCs in the same relative proportions as in groundwater from MW-402U, albeit at modestly higher concentrations (but still a factor of 10 to 100 below AGQS). The B-922U/L cluster has served its intended purpose of providing additional data regarding groundwater quality conditions upgradient of MW-402U nearer to the Stage I landfill, and the findings are consistent with the water quality data from MW-402U, and further support that the VOCs in groundwater are the result of low-level residual impacts related to LFG, rather than a release (i.e., ongoing) related to liner leakage. Because of the similarity in analytical results between these two wells, the long period of record for MW-402U, and the intent of well cluster B-922U/L to serve as a temporary monitoring point, we believe that water quality data from B-922U/L are redundant with data from MW-402U/LR, and as part of Stage V construction, we recommend the B-922 couplet be decommissioned (refer to Section 6).

2.2.5 Summary of 2013 Construction Activities

The information summarized below was provided by CMA, and has previously been reported as part of CMA's 2013 construction activities at the site.

In 2013, as part of the Stage IV, Phase II landfill expansion, the Stage I sumps were excavated and reconstructed to combine leachate from Stage I and Stage IV, Phase II at a single sump, which is managed by the Stage IV, Phase II pump station. The original design of Stage I, Phases I through IV included separate leachate sumps for each Phase. Stage I Phase I leachate flowed by gravity via a sealed liner penetration, while Phases II through IV each had separate leachate pump stations. Stage I leachate was formerly stored in multiple underground storage tanks located north of Stage I.

As summarized in the November 1, 2013 Construction Certification Report, CMA collected soil samples of the subgrade beneath the secondary liner systems of Stage I Phases I, II and III, and Stage IV Phase IIA. The samples were collected at the liner penetration in Phase I, beneath the lowest portions of the sumps in Phases II and III, and the lowest area that could be accessed beneath Stage IV Phase IIA during construction.

The above-referenced soil samples were analyzed for VOCs (including 1,4-dioxane), sulfate, chloride, pH, specific conductance, cadmium, chloride, iron, lead and manganese. These analytes were selected to monitor leachate management systems pursuant to Section Env-Sw 806.08 (d)(5) of the New Hampshire Code of Administrative Rules. Results from the soil analyses indicate VOCs were not detected and all analyte concentrations were below respective NHDES Soil Remediation Standards. As indicated in CMA's Construction Certification Report, the analytical soil data, and observations of the condition of the Stage I lining systems and the subgrade soil provided no evidence of leakage from either the Stage I or Stage IV secondary liners at these critical locations.

The landfill liner system in the modified Stage I sump has been reconstructed to conform to current design standards and conventional practices, including a geosynthetic clay liner beneath the primary liner. In addition, a new double-walled force main was constructed to

convey Stage IV, Phase II leachate (combined with leachate from Stage I Phases I through IV) to a dual-containment above ground storage tank located in the northeast area of the site.

Stage I sump reconstruction included installation of new primary and secondary 60-mil high-density polyethylene (HDPE) geomembrane liners, new drainage geocomposite, and new stone. In addition to typical liner testing, an electrical leak location survey was performed on the Stage I sump as part of the construction quality control program to certify the liner system was constructed in accordance with the technical specifications. No liner defects were identified as part of this survey.

2.3 Project Description

Stage V is a proposed 8.06-acre lateral expansion of the NCES landfill located to the north of Stages I, II, III, and IV, as shown on Figure 2. Similar to the development of Stages I, II, III, and IV, a perimeter road and swale is proposed to be constructed around Stage V. As proposed, and described in additional detail in the Stage V application, the Stage V liner system includes primary and secondary 60-mil textured HDPE geomembrane liners with primary and secondary leachate collection. The secondary leachate collection system will include drainage geocomposite. In base areas of the secondary leachate collection system, a minimum of 12 inches of Select Sand will be provided over the drainage geocomposite. The primary leachate collection system will consist of drainage geocomposite overlain by 18 inches of Select Sand. Drainage geocomposite consists of an HDPE drainage net to which nonwoven geotextile is attached and provides a transmissive material for efficient leachate collection.

The base grades will slope to leachate collection piping which drains to the Stage IV, Phase I collection sump. The primary leachate collection system is designed to limit head on the liner to less than 12 inches during routine operations. The secondary system is designed so that the travel time for liquid in the secondary system to reach the sump is less than 24 hours.

3.0 SUMMARY OF HYDROGEOLOGIC CONDITIONS

This section provides a summary description of site hydrogeology (Section 3.1) and site groundwater flow conditions (Section 3.2).

3.1 General Site Hydrogeology

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 Sanborn Head's January 2002 Hydrogeologic Report for the Stage IV landfill area. That report included a synthesis of the major findings of the prior studies, and thus serves as a summary reference for the documentation of site hydrogeologic conditions. As indicated previously, because the proposed Stage V area encompasses generally the same area as originally permitted as Stage IV, the bulk of the Stage IV hydrogeologic information is also pertinent to the proposed Stage V landfill expansion. As such, hydrogeologic information from the Stage IV investigation is summarized herein, and supplemented with information from more recent investigations at the site.

3.1.1 Overburden

The NCES facility is located in an area underlain by dense glacial sediments reflecting a complex depositional history. The presence of multiple till units, together with significant textural variability in the stratified drift deposits and in the lower glacial till, suggest multiple advances and retreats of glacial ice. The site overburden stratigraphy consists of three primary units overlying bedrock, in descending order from the ground surface downward, the units are:

- An upper till unit, consisting of a very dense, heterogeneous, 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 interfingered 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.

Based on well logs compiled as part of previous investigations, and as indicated below, the thickness of the upper till unit varies at boring locations across and downgradient of the proposed Stage V area:

Approximate Thickness of Upper Till noted in Monitoring Wells – Proposed Stage V Area

- B-916: 33 feet
- B-917: 43 feet
- B-918: 12 feet
- B-919: 19 feet
- B-920: 8 feet
- B-922: 15 feet
- MW-403: 51 feet

The upper glacial till has been observed to be variably saturated; and as part of the Stage IV investigation, the mean hydraulic conductivity of this unit was estimated to be about 0.08 ft/day.

The stratified drift is a relatively thick deposit consisting of dense to very dense soils ranging from silt and fine sand, to sand or sand and gravel with varying amounts of silt. Hydraulic conductivity data indicate the finer-grained stratified deposits (silt and fine sand) are characterized by an estimated mean hydraulic conductivity of about 0.07 ft/day (as evaluated as part of the Stage IV investigation). Hydraulic conductivity in the coarser-grained stratified deposits is higher, with an estimated mean value of about 6 ft/day. The range in textural variability within the stratified drift soils is significant with respect to the resultant influence on groundwater movement across the site.

The lower till consists of dense sand and gravel with lesser amounts of silt and frequent cobbles and/or boulders. Lower till soils in the vicinity of the proposed Stage V area were observed, in aggregate, to be coarser-grained than those observed in test borings to the south, possibly indicating deposition in a higher energy environment or subsequent

reworking by glacial meltwater. The estimated mean hydraulic conductivity of the lower till soils encountered during this study is about 14 ft/day, reflecting the relatively coarse-grained nature of the till deposits in this area of the site. The coarser grain size/higher permeability of the lower till as compared to the stratified drift and upper till may reflect the depositional environment at the time of lower till placement, or it could be the result of later "re-working" of lower till sediments by subsequent meltwater.

3.1.2 Bedrock

Lyons, J.B. et. al. (1997)[9] indicates that bedrock below the site is late Ordivician, pink, moderately to weakly foliated, biotitic granite of the Oliverian Plutonic Series. Regionally, this northeast-southwest oriented series is closely fault-contacted to the south by the Jurassic-aged, White Mountain Plutonic-Volcanic series.

Although bedrock outcrops have not been observed on or in the vicinity the site, some subsurface explorations performed during prior studies have focused on assessing depth to the top of rock. Explorations drilled to bedrock during prior hydrogeologic studies at the site encountered the bedrock surface at depths of greater than 100 feet, and east of the proposed Stage V footprint. These depths, combined with bedrock depth information collected indicate that the bedrock surface dips steeply from west to east below the site, decreasing in elevation on the order of 150 feet or more between points of known bedrock encounter.

As shown on the cross-section on Figure 4B, bedrock was encountered in two of the borings installed as part of the Stage IV study – B-915D and B-916D – located to the west/north of the proposed Stage V footprint. The top of bedrock at the B-915D location was observed at a depth of 111 feet (1,224.4 feet NAVD 88) and at B-916D at a depth of 102 feet (1,219.4 feet NAVD 88). Well B-916D was completed as a bedrock piezometer. As evidenced by rock chips recovered during drilling, the bedrock at both locations was a pink to gray and white, biotite-rich granite, which is consistent with regional mapping. The drilling technique used to advance the borehole in the bedrock ("drive-and-wash"), however, did not allow for estimation of the degree of fracturing and/or weathering.

3.1.3 Surface Water

The site lies within a portion of a northerly draining approximately 350-acre watershed which comprises a small portion of the Ammonoosuc River watershed. In the vicinity of the site, the Ammonoosuc River flows northwesterly approximately 400 feet northeast of Muchmore Road, and is inferred to represent a local hydrologic boundary and control on shallow groundwater elevations. USGS stream gauging records for the years 1940 to 2011 indicate average flows for the Ammonoosuc River (measured at the Bethlehem Junction gauging station [No. 01137500] located 0.5 miles north of the site) of approximately 200 cubic feet per second (cfs). The riverbanks are relatively steep in the area to the northeast of the site and localized seeps are present along the steeper slopes.

A low lying area is present at an elevation between approximately 1260 and 1280 feet MSL at the toe of the steep slope located in the northern portion of the site (Figure 2). It

[9] Lyons, J.B., Bothner, W.A., Moench, R.H., and Thompson, J.B., Jr. 1997. Geologic Map of New Hampshire. U.S. Geological Survey. Scale 1:250,000.

comprises a wetland area (delineated during prior investigations) which lies generally to the south and west of Laurel Lane (near boring B-910). In addition to this wetland area, other wetland/drainage features include the surface seeps S-1 (or Main Seep), S-108, and S-109 located on the southerly bank of the Ammonoosuc River. Recharge to these drainage features likely arises from surface runoff, as well as discharge of shallow groundwater traveling northward through more transmissive zones which outcrop at or near the ground surface.

3.2 Site Groundwater Flow Conditions

Groundwater elevation data collected as part of on-going monitoring and reporting indicate that current conditions with respect to hydraulic gradients and flow directions remain comparable to the findings presented in the 2002 Stage IV Hydrogeologic Report. A summary of the water level measurement data, is compiled on Table 1. Figure 3A depicts in plan view the equipotential water table surface based on July 2013 measurements. Water table level measurements from April 2012 which included monitoring wells downgradient of the proposed Stage V area are indicated with contours on Figure 3B. Observations regarding water level measurements and inferred groundwater flow directions at the site are summarized below. Groundwater equipotential contours are included on the hydrogeologic cross-sections provided as Figures 4B though 4D to depict generalized vertical groundwater flow patterns (cross-section locations are indicated on Figure 4A).

Based on water level measurements in water table wells, groundwater in 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 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.

Water table elevations measured across the site range from typically 1325 to 1330 feet at monitoring well B-902U, to about 1280 feet at MW-604 (Table 1). Mounding of groundwater is evident below Detention Pond No. 3, locally perturbing the northerly groundwater flow direction (Figure 3A).

Groundwater elevations recorded in deeper wells screened below the water table (e.g., in the lower till and stratified drift) indicate an overall flow pattern consistent with that observed at the water table, that is, from south to north, towards the Ammonoosuc River. Unlike other units, however, no mounding was observed in the lower till below Detention Pond No. 3.

As presented in the 2002 Stage IV Hydrogeologic Report, groundwater elevations observed in the site monitoring wells indicate that downward vertical gradients from the upper till to the underlying stratified drift into the lower till predominate at the site. Locally, at well cluster B-917 and B-909, piezometric levels indicate a tendency for groundwater to move upward from the lower till into the stratified drift, and downward from the upper till into the stratified drift, reflecting the presence of more permeable soils in the stratified drift at this location. Similarly, historical water level measurements at boring location B-301 indicated upward flow from the lower till to the stratified drift, and downward flow from the upper till to the stratified drift, reflecting the presence of more permeable soils in the stratified drift at this location. Given the complex depositional environment, considerable local variability in

vertical and horizontal flow directions and gradients is expected. The more areally extensive, coarser grained deposits of the stratified drift unit likely account for zones of convergent groundwater flow observed on the groundwater elevation contour plan.

Based on information compiled as part of the Stage IV Hydrogeologic Report, in the vicinity of the proposed Stage V, horizontal hydraulic gradients through the upper till unit (where saturated) have typically been about 0.15 ft/ft. The gradient through the stratified drift unit was observed to be approximately 0.04 ft/ft, and through the lower till unit, about 0.02 ft/ft. Horizontal gradients through each unit below the site tend to be flatter to the south and to the east near the site property boundary.

4.0 SITE WATER QUALITY MONITORING PROGRAM

Site water quality monitoring is consistent with the Groundwater Management and Release Detection Permit (GWP-198704033-B-006; renewed in April 2013) that includes triannual (April, July, and November) monitoring and reporting, and annual reports for the site, including the most recent Annual Report (for 2013), submitted to NHDES on August 13, 2013. Groundwater monitoring is also being conducted in accordance with the site CAP. In an April 16, 2013 letter to NCES, NHDES modified the requirements of the CAP monitoring, with specific conditions established based on the results of site water quality monitoring that would trigger a resumption of CAP monitoring. Current environmental monitoring includes 41 groundwater monitoring wells (including laboratory sample collection locations and water level monitoring only locations), five sampling locations to the north of the site consisting of surface seeps/springs on the slope down to the Ammonoosuc River, and three surface water (River) sampling locations along the southern shoreline of the River. Permit monitoring locations are summarized in Exhibit 1 below:

Exhibit 1

Groundwater Management Wells/Other					
100-Series	B-102S	B-102D	B-103S	B-103D	
Other	MW-604				
Release Detection Wells					
400-Series	MW-401	MW-402U	MW-402LR	MW-403U	MW-403L
800-Series	MW-801	MW-802	MW-803		
900-Series	B-901UR	B-902U	B-903U	B-904U	
	B-901L	B-902L	B-903L	B-904L	
	B-913U	B-913M	B-914U	B-919U	
	B-913L	B-914L	B-919D	B-919M	
	B-920U	B-920M	B-921U	B-921M	
	B-920D	B-921D	B-922U	B-922L	
Other	B-304UR	B-304DR	MW-603	MW-701	

Notes:

1. Couplet monitoring well installations include a shallow or upper well (designated S or U) and a deeper or lower well (designated D or L). At triplet well cluster locations, monitoring wells were installed as upper, lower and mid-level (designated M).
2. 100-Series monitoring wells are principally downgradient of the former unlined landfill. The contents of the unlined landfill were excavated and placed into the double-lined Stage I landfill between December 1991 and October 1993, as a preconstruction requirement of the Stage II Solid Waste Permit.
3. 400-Series monitoring wells installed to monitor the double-lined Stage I landfill.
4. 800-Series monitoring wells installed to monitor the Stage II landfill.
5. Not all wells are sampled/analyzed in every sampling event. Refer to Table 6 for a summary of the current Permit monitoring requirements.

Surface Water Sampling Locations	
Springs/Seeps	**Ammonoosuc River**
S-101	AR-1
S-108	AR-2
S-109	AR-3
S-1 (Main Seep)	
SF-1 (surface flow down slope from S-1)	

Notes:
River sampling locations (designated AR-1 through AR-3) are located down slope from the seeps, and were established in conjunction with the Site GMZ. The GMZ delineation is shown on a September 9, 1996 plan titled "Groundwater Management Zone Plan for North Country Environmental Services, Inc., Bethlehem, New Hampshire," and previously submitted to NHDES.

Groundwater depth and elevation data are summarized in Table 1 and presented on Figure 3A (July 2013). Concentrations of inorganic parameters detected in groundwater and surface water samples are summarized in Tables 2A and 2B, respectively. Total VOC concentrations detected in groundwater and surface water samples are summarized in Table 3. Acid/Base Neutral Extractable Compound (ABN) concentrations detected in groundwater are summarized in Table 4[10].

[10] Table 4 is provided for reference. Consistent with the Permit, ABNs were not analyzed in July 2013, but will be analyzed next in July 2015.

4.1 Summary of 2013 NCES Water Quality Monitoring

As presented in prior Annual Reports for the site, the record of water quality monitoring data developed over time at the site indicates that the landfill liner systems continue to function as designed. Residual impacts from the former unlined landfill continue to diminish, and are currently evidenced largely by the inorganic parameters and low-level concentrations of VOCs. As discussed in the February 2010 CAP, limited impacts to groundwater quality associated with past leachate handling practices and landfill gas effects have historically been recorded at the site. The remedial activities (e.g., LMIP, Stage I landfill capping system repair project, and Stage I enhanced landfill gas extraction) discussed in the CAP and subsequent CAP update reports, and the 2013 Stage I leachate sump reconstruction project (summarized in Section 2.2.3 of this report) have yielded and are anticipated to yield, continued improvements in related groundwater quality conditions. Water quality monitoring at the site is on-going under the current Groundwater Monitoring Permit.

The following summary of 2013 water quality monitoring results through July 2013 was excerpted from the 2013 Annual Report (submitted to NHDES on August 13, 2013), with discussion of results from November 2013 monitoring added where relevant. Results from November 2013 water quality monitoring were submitted to NHDES on December 16, 2013.

4.1.1 CAP Monitoring Update

In March 2013, on behalf of NCES, Sanborn Head submitted a work plan to NHDES requesting reductions in the two main elements of the CAP monitoring at the site: soil vapor sampling at soil vapor probe GP-17[11]; and monthly groundwater sampling for bromide at MW-802, and VOCs at MW-402U and B-913M. As presented in our work plan, based on the indication that statistical criteria presented in Section 6 of the approved CAP had been met, NHDES agreed to elimination of monthly VOC monitoring at MW-402U and B-913M, as well as the monthly bromide monitoring at MW-802. NHDES' approval to changes in CAP monitoring permitted these locations to return to tri-annual monitoring, with conditions to "trigger" resumption of monthly monitoring. A discussion of water quality results from these locations is provided below.

- The total VOC concentrations detected during the current monitoring year (since August 2012) at MW-402U were similar to or below recent previous results, and below the "trigger" concentration of 18 micrograms per liter (µg/l) agreed to by NHDES to initiate monthly VOC monitoring at this location. Further, the only VOCs detected at MW-402U were 1,1-DCA and diethyl ether (detection of VOCs other than these two would also trigger the need for monthly sampling). Since 2005, results from MW-402U have indicated the concentration of 1,1-DCA has been more than an order of magnitude lower than its AGQS (81 µg/l), and the concentration of diethyl ether has been more than two orders of magnitude lower than its AGQS (1,400 µg/l).

[11] Because several years of soil vapor sampling results demonstrated no significant presence of LFG in vadose-zone soils in the area of the gas probes to the north of the Stage I Landfill, NHDES agreed to the elimination of vapor sampling (refer to NHDES' April 16, 2013 letter to NCES).

- 1,4-Dioxane concentrations measured at B-913M during the current monitoring year were lower than the concentrations measured earlier in 2012, and below the AGQS. No other VOCs were detected at B-913M during the past year.

- With the exception of a single result in February 2013 that was not replicated in follow-up sampling[12], the bromide concentrations recorded at MW-802 during the current monitoring year ranged from 0.1 to 0.4 mg/l, and did not exceed the "trigger" concentration (>0.5 mg/l) specified by NHDES to initiate monthly sampling (if triggered, monthly sampling would continue until bromide is ≤0.5 mg/l and VOCs are non-detect for two consecutive months). For reference, VOCs were not detected at MW-802 during the last year, with the exception of a one-time low-level (1 µg/l) detection of 1,4-dichlorobenzene.

4.1.2 Summary of 2013 Water Quality

As described herein, the overall results for the past year's monitoring, including the November 2013 data, are generally consistent with the recent prior findings and the conceptual model of hydrogeologic conditions at the site. In addition to the results discussed above for MW-402U, B-913M and MW-802, the following sections summarize specific observations (VOCs in groundwater are discussed first, then inorganic parameters for groundwater, and finally surface water):

4.1.2.1 VOCs

During the November 2012, and April, July, and November 2013 monitoring events, VOCs were below AGQS at all groundwater monitoring locations. A general summary of VOCs is as follows:

- In the upper till north of Stage I Phase IV, consistent with previous results, and similar to nearby monitoring well MW-402U summarized above, VOCs detected at B-922U (sampled in November 2012, and April and November 2013) were limited to 1,1-DCA and diethyl ether.

- In the area north of Stage IV, 1,4-dioxane was detected in November 2012 at B-920M (screened in the stratified drift), but was not detected in the samples collected in April and November 2013. Similar to nearby stratified drift monitoring well B-913M (summarized above), no other VOCs were detected in B-920M during this monitoring period.

- For the northeast monitoring wells, north of Stage IV/Phase I, B-304UR, B-304DR and B-921M screened in the stratified drift unit have historically indicated detections of the CFC (chlorofluorocarbon) dichlorodifluoromethane (DCDFM), which is related to the plume from the former unlined landfill. 1,4-Dioxane was also detected at B-304DR. No VOCs were detected at B-304UR during the current year. In general, concentrations of DCDFM and 1,4-dioxane are stable or decreasing compared to historical results, and there is no indication of other parameters that would suggest a potential more recent release.

[12] The February 2013 bromide result (0.7 mg/l) occurred prior to NHDES' April 16, 2013 letter instituting the 0.5 mg/l "trigger".

- 1,4-Dioxane was detected at 0.36 µg/l in MW-803 in November 2012, similar to concentrations recorded at this location in November 2011 and April 2012, and below the AGQS of 3 µg/l. 1,4-Dioxane was not detected at MW-803 in April and November 2013.

4.1.2.2 Inorganic Parameters

As indicated in previous Annual Reports, the well locations where elevated concentrations of metals (arsenic, manganese, iron) have typically been observed are consistent with residual water quality effects related to the former unlined landfill, principally chemically-reducing conditions, which result in mobilization of these metals which occur naturally in site soils and cause elevated concentrations of these metals in groundwater. AGQS exceedances in groundwater were limited to arsenic and manganese, and were generally recorded at wells nearby or downgradient from the former unlined landfill. With limited exceptions, arsenic and manganese concentrations were within the range of the prior monitoring results.

The chloride concentrations at MW-402LR in April, July, and November 2013 were less than those recorded in July and November 2012, suggesting that chloride concentrations appear to have passed a transient "peak" at this location.

4.1.2.3 Surface Water

Consistent with typical surface water quality results since 2005, VOCs were not detected in surface water samples during the current year.

General surface water quality indicators and inorganic parameters were generally consistent with historical data. Iron concentrations exceeding the SMCL were recorded in several groundwater seep sampling locations; however, the iron concentrations at these locations were significantly lower than historical maximum values. Manganese concentrations were below AGQS in all but two seep samples; and similar to iron, the manganese concentrations at these locations were significantly lower than historical maximum values. Iron and manganese concentrations measured in the Ammonoosuc River samples in July 2013 were below the respective Secondary MCLs and AGQS in the case of manganese, and did not indicate significant impact to the River's surface water quality.

5.0 PROPOSED STAGE V AREA GROUNDWATER MONITORING RESULTS

This section provides a summary of groundwater monitoring results in the proposed Stage V area.

5.1 2012 Stage V Groundwater Quality Monitoring Program

On behalf of NCES, Sanborn Head conducted two groundwater sampling events (June and September 2012) at select monitoring wells in the vicinity of the proposed Stage V landfill expansion, located north of the existing Stage I and Stage IV areas. The locations of the Stage V wells are indicated on the attached Site Plan (Figure 2). The monitoring wells discussed herein were previously sampled by Sanborn Head in 2001 as part of the Stage IV investigation, and the resultant water quality data were summarized in Sanborn Head's 2002 Stage IV Hydrogeologic Report.

On June 11-12, and September 13, 2012, Sanborn Head collected groundwater samples from 12 monitoring wells in the vicinity of the proposed Stage V expansion:

- B-909/B-917U/D
- B-915U/M/D
- B-916U/M/D
- B-918U/M/D

5.2 Stage V Groundwater Monitoring Results Summary

A summary of 2012 Stage V groundwater monitoring results is provided below, with a comparison to September 2001 results (previously submitted in the January 2002 Stage IV Hydrogeologic Report). Tabulated laboratory results from the 2001 and 2012 sampling events are provided on Table 5. A summary of the 2012 sampling procedures is provided in Appendix A.1. The laboratory analytical data reports for the 2012 sampling events prepared by Eastern Analytical, Inc. (EAI) of Concord, New Hampshire (EAI) are included as Appendix A.2. Field-screening parameters were recorded on the Groundwater Quality Field Sampling Summary forms (Appendix A.3). No analytes exceeded their respective NHDES AGQS/GW-1 Groundwater Standards in 2012 sampling.

In addition to the 12 monitoring wells listed above, two additional monitoring wells B-910 and B-911, located further to the north (and presumably downgradient) of the proposed Stage V, were sampled in 2001 (refer to Table 5).[13]

5.2.1 VOCs

- VOCs, including 1,4-dioxane, ethylene dibromide (EDB), and 1,2-dibromo-3-chloropropane, (dibromochloropropane - DBCP), were not detected in the samples collected in 2012.

- In 2001, chloroform (trichloromethane) was detected in samples from three monitoring wells (B-916U at 1.4 µg/L; B-915U at 2.9 µg/L; and B-917U at 15.7 µg/L), at concentrations below its NHDES AGQS/GW-1 Groundwater Standard of 70 µg/L. Chloroform was not detected in 2012 sampling. The presence of chloroform in samples collected from these wells shortly after their installation is thought to be due to the use of water from a chlorinated water supply for the drilling/installation of these wells.

- 1,1-dichloroethane (1,1-DCA) was detected in 2001 at monitoring well B-917D at 1.1 µg/L, below its NHDES AGQS/GW-1 Groundwater Standard of 81 µg/L. 1,1-DCA was not detected in 2012 sampling in the Stage V wells.

5.2.2 Dissolved Metals

The following dissolved metals were detected in the samples collected in 2012: arsenic, barium, chromium, iron, lead, manganese, and nickel; none at concentrations above NHDES AGQS/GW-1 Groundwater Standards. As indicated on Table 5, dissolved metals analysis for the 2001 samples included only iron and manganese. A summary of metals concentrations from Stage V monitoring well sampling is as follows:

[13] Monitoring wells B-919U/B-919M/B-919D were sampled in 2001 as part of the permitting of Stage IV, but are now included in Permit monitoring; water quality results for these wells are indicated on Tables 2A and 3.

Analyte	NHDES AGQS/GW-1 Groundwater Standard (mg/l)	2001	2012
Arsenic	0.01	Not analyzed.	Detected at two locations: B-916U - 0.001 mg/l B-909 - 0.0016 mg/l
Barium	2	Not analyzed.	Detected at each of the 12 proposed Stage V sampling locations. Concentrations ranged from 0.004 (B-917U), to 0.82 mg/l (B-916D).
Chromium	0.1	Not analyzed.	Detected at three sampling locations: B-916D - 0.002 mg/l B-916U – 0.001 and 0.002 mg/l B-909 - 0.003 mg/l
Iron	None	Detected at seven locations (B-910, B-911, B-915M, B-916M, B-917U, B-917D, and B-918U) at concentrations ranging from 0.021 mg/l (B-917U) to 0.197 mg/l (B-917D).	Detected at four sampling locations (B-909, B-915U, B-916U, and B-917U) at concentrations ranging from 0.050 mg/l (B-915U) to 1.7 mg/l (B-916U).
Lead	0.015	Not analyzed.	Detected at two locations B-909 - 0.001 and 0.003 mg/l B-916U - 0.004 mg/l
Manganese	0.84	Detected at nine locations (B-910, B-911, B-915U, B-915M, B-915D, B-916U, B-917U, B-917D, and B-918U) at concentrations ranging from 0.005 mg/l (B-917D) to 1.16 mg/l (B-916U). The concentration at B-916U (1.16 mg/l) exceeded the NHDES AGQS/GW-1.[14]	Detected at six locations (B-909, B-915U, B-916U, B-917U, B-918U, B-918M) at concentrations ranging from 0.006 mg/l (B-915U) to 0.20 mg/l (B-916U).
Nickel	0.1	Not analyzed.	Detected at nine locations (B-909, B-915M, B-915D, B-916U, B-916M, B-916D, B-917U, B-918U, B-918M) at concentrations ranging from 0.001 mg/l (B-915M) to 0.009 mg/l (B-917U).

5.2.3 Indicator Parameters

The following summarizes the indicator parameters detected in Stage V monitoring well sampling; none at concentrations above NHDES AGQS/GW-1 Groundwater Standards:

[14] In 2001 sampling, a manganese concentration of 1.16 mg/l was recorded in the sample from monitoring well B-916U. This concentration is higher than the highest concentration measured at B-916U in 2012 (0.2 mg/l), and because this elevated concentration was not confirmed in 2012 sampling, the 2001 result is considered an artifact of sampling (e.g., turbidity).

Analyte	NHDES AGQS/GW-1 Groundwater Standard (mg/l)	2001	2012
Bromide	None	Detected at two locations (B-916M and B-911) at concentrations of 0.447 mg/l and 2.97 mg/l, respectively.	Detected at four locations (B-909, B-915U, B-918U, B-918M). Concentrations ranged from 0.1 mg/l (B-915U) to 0.4 mg/l (B-918U).
Chloride	None	Detected at eight locations (B-911, B-915M, B-915D, B-916U, B-916M, B-917U, B-917D, and B-918M) at concentrations ranging from 3.02 mg/l (B-917U) to 8.49 mg/l (B-917D).	Detected in all monitoring wells sampled. Concentrations ranging from 1 mg/l (B-909) to 56 mg/l (B-916M).
COD	None	Not detected in 2001 sampling.	Detected at eight locations (B-915U, B-915M, B-915D, B-916U, B-917D, B-918U, B-918M, B-918D). Concentrations ranged from 10 mg/l (B-915M) to 19 mg/l (B-918M).
Nitrate	10	Not analyzed.	Detected at one location (B-918U) at 0.7 mg/l.
TKN	None	Detected at six locations (B-915M, B-915D, B-917D, B-918U, B-918M, and B-918D) at concentrations ranging from 0.072 mg/l (B-918U) to 3.03 mg/l (B-915M).	Detected at one location (B-918D) at 0.8 mg/l.

5.3 Recommendations from Stage IV Hydrogeologic Report

Sanborn Head's 2002 Hydrogeologic Report included recommendations for well locations for the proposed Stage IV expansion. Because the footprints of permitted Stage IV and the proposed Stage V are effectively the same, we have provided updates to the 2002 recommendations (recommendation in italics, followed by updates in bold).

- *Include newly-installed wells B-915U & M; B-916U, M & D; B-917U & D; B-918U, M & D; and B-919U, M & D; together with well B-909 located at the B-917 cluster (wells B-915M and B-915D are screened in lower glacial till and there is a slight upward gradient from B-915D to B-915M; consequently well B-915D is not recommended for the monitoring program).*

  The vertical gradient is typically upward from B-915D to B-915M; however, in 2012, downward gradients were periodically recorded from B-915M to B-915D (refer to Table 1). Therefore, we recommend that monitoring well B-915D be included in Permit monitoring should Stage V be constructed.

- *Add an additional well cluster at a location approximately half way between B-918 and B-919, north of the proposed Stage IV expansion; this cluster should include water table, stratified drift, and lower till or deep stratified drift screened intervals.*

Well cluster B-921U/M/D was installed in 2006 at the location recommended above, and these wells are included in the current Permit monitoring.

- *Add an additional well cluster at a location to the north of B-301, west of the proposed Stage IV expansion; this cluster should include water table, stratified drift, and lower till screened intervals.*

  Well cluster B-915U/M/D is located north of B-301 and west of the proposed Stage V area, and is adequate for providing an indication of water quality in this area.

- *Retain the existing site monitoring well network, less those monitoring wells which will require decommissioning associated with development of the Stage IV landfill. We recommend that those monitoring wells located within the limit of the proposed Stage IV development be decommissioned prior to commencement of construction. A list of the wells which would require decommissioning is presented in the "Stage IV Construction Design Report" provided in a separate section of this permit application.*

  Refer to Section 6.0 for proposed modifications to Groundwater Management and Release Detection Permit monitoring.

- *Complete a second round of groundwater sampling and analysis in the network of proposed monitoring wells for the Stage IV expansion, prior to commencement of operations in Stage IV. These data will provide additional baseline water quality information, as well as clarification regarding the bromide concentrations observed in wells B-911 and B-916M.*

  Additional groundwater data for monitoring wells downgradient of the proposed Stage V area were collected in 2012 (refer to Sections 5.1 and 5.2 for a discussion of this information).

6.0 PROPOSED MODIFICATIONS TO GROUNDWATER MANAGEMENT AND RELEASE DETECTION PERMIT MONITORING

This section discusses proposed modifications to Permit monitoring should Stage V be constructed.

Based on the summary of current water quality conditions at the site presented above and in previous Annual Reports, we recommend the following modifications to the sampling program defined under the current Permit:

- If Stage V is constructed, site preparation activities would require the decommissioning of the following program monitoring wells:
  - MW-403U/L
  - B-913U/M/L
  - B-920U/M/D
  - B-922U/L

Upon decommissioning the above wells, we propose to include the following monitoring wells (located downgradient of the proposed Stage V area) in the Permit monitoring program:

- B-909/ B-917U/D
- B-915U/M/D
- B-916U/M/D
- B-918U/M/D

Table 6 summarizes groundwater monitoring under the current Permit for comparison to the proposed monitoring following construction of Stage V, which is summarized on Table 7. Figure 2 indicates the location of wells proposed to be decommissioned, as well as those proposed to be included in the revised Permit monitoring program.

If still present, other monitoring wells not included in the current Permit monitoring program (e.g., B-205, B-301, B-302, B-907, and B-908) within the footprint of the proposed Stage V area would also be decommissioned as part of Stage V construction.

7.0 POTENTIAL GEOLOGIC SITING LIMITATIONS

The March 2002 NCES Stage IV Landfill Site Report concluded that there were no known Holocene faults within 200 feet of the landfill, and that the site is not located in an area susceptible to mass movements or subsidence, or underlain by karstfied dolomite or limestone. Because geologic data has been published since the approval of Stage IV, Sanborn Head performed a review of relevant geologic information pursuant to New Hampshire Code of Administrative Rules Env-Sw 804.05 (Geologic Siting Limitations) to re-evaluate potential Geologic Siting Limitations for the proposed Stage V NCES landfill. As part of our review of available geologic information, we conclude the following, which is consistent with our 2002 findings:

There are no known faults which have displaced in Holocene time within 200 feet of the NCES landfill. Subsurface data indicate the site is underlain by up to 100 feet or more of glacially consolidated sediments which provide a stable foundation for landfill development. The site is not located in an area known to be susceptible to mass movements of earth or material subsidence, or underlain by karstified dolomite or limestone.

Sanborn Head's January 23, 2014 Technical Memorandum to NCES summarizing our evaluation of geologic siting limitations is provided in Appendix B.

8.0 CLOSING

The proposed Stage V area encompasses generally the same area as originally permitted as Stage IV. Therefore, the bulk of the Stage IV hydrogeologic information is also pertinent to the proposed Stage V landfill expansion. Stage V pre-construction groundwater conditions have been identified. Specifically: VOCs were not detected in the Stage V wells in 2012 sampling; and no analytes exceeded their respective NHDES AGQS/GW-1 Groundwater Standards in 2012 sampling. Elsewhere at the site, as reported in previous Annual Reports, results of groundwater monitoring related to the Permit indicate the liners are functioning as intended.

As reported previously for the site, including the February 2010 CAP and subsequent water quality monitoring reports, limited impacts to groundwater quality associated with past leachate handling practices and landfill gas effects have historically been recorded at the site. To date, several significant remedial activities have been performed to improve leachate management practices and landfill gas capture at the site. Most recently, in 2013 Stage I leachate sumps were reconstructed. Because these remedial activities have included removal/elimination of potential ongoing sources of contamination to groundwater, they have yielded and are anticipated to yield, continued improvements in related groundwater conditions.

Should Stage V be approved and constructed, groundwater monitoring under the existing Permit (GWP-198704033-B-006) will continue at the site. As proposed, following Stage V construction, the groundwater monitoring network will include additional wells downgradient of the Stage V area which will serve as replacements for the wells to be decommissioned as part of Stage V construction.

Our review of available geologic information pursuant to Env-Sw 804.05 indicates that there are no identified geologic features (e.g., faults, areas susceptible to mass movement, karstified terrain) that would preclude siting the Stage V landfill as proposed.

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