


COMMONWEALTH OF VIRGINIA
Department of Environmental Quality

Subject: Division of Land Protection and Revitalization Guidance Memo
LPR-SW-SI-15
SUBMISSION INSTRUCTIONS FOR GROUNDWATER NATURE AND EXTENT STUDIES
AT SOLID WASTE LANDFILLS

To: Regional Land Protection and Revitalization Program Managers

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Director, Division of Land Protection and Revitalization

Date: January 31, 2012

Copies: Regional Directors

Summary

This guidance provides owner/operators of regulated solid waste management facilities with an overview of the information applicable to groundwater plume delineation actions required as part of 'Nature and Extent' studies to assess a groundwater release above groundwater protection standards in accordance with 9 VAC 20-81-260.C.1 of the Virginia Solid Waste Management Regulations (VSWMR).

Electronic Copy

An electronic copy of this guidance applicable to regulated solid waste sites is available on DEQ's website at <http://www.deq.virginia.gov/waste/guidance.html>.

Contact Information

Please contact the groundwater program coordinator, Mr. Geoff Christe at (804) 698-4283 or via email geoff.christe@deq.virginia.gov with any questions regarding the development or application of this guidance.

Disclaimer

This document is provided as guidance and, as such, sets forth standard operating procedures for the agency. However, it does not mandate any particular method nor does it prohibit any alternative method. If alternative proposals are made, such proposals should be reviewed and accepted or denied based on their technical adequacy and compliance with appropriate laws and regulations.



Submission Instruction

Plume Delineation Nature and Extent Studies for Groundwater at Solid Waste Landfills

Virginia DEQ - Division of Land
Protection & Revitalization
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Richmond, VA 23219

APPLICABILITY

These Submission Instructions (SI) are applicable to all solid waste management facilities conducting groundwater monitoring under the requirements of the Virginia Solid Waste Management Regulations (VSWMR), originally promulgated by the Virginia Waste Management Board December 21st, 1988; as amended. These SI have been designed in a manner consistent with the regulatory language in Amendment 7 of the VSWMR, effective March 16th 2011 and they supersede those previously issued by the Department as SI #15 in July of 2003.

DEVELOPMENT

The requirement to perform a Nature and Extent Study (NES) is triggered upon the recognition of a statistical exceedance of a groundwater protection standard (GPS). This type of formal groundwater response action was originally defined by EPA in its 1991 solid waste Subtitle D rule [40 CFR 258] and adopted by Virginia within the VSWMR. The Department has released this SI in an effort to assist an owner/operator in the preparation of a complete NES. The SI reference technical information presented within EPA's 1993 *Solid Waste Disposal Facility Criteria Technical Manual* [EPA 530-R-93-017], and the *Federal Register preamble* to the Subtitle D rule. They also reference common hydrologic principles governing groundwater flow in different aquifer systems.

These SI provide an outline of the suggested minimum technical content that should be included within an NES. However, it is ultimately the responsibility of the Permittee to include all the data or information necessary to support each of the conclusions presented in the NES.

These SI have not been developed as Department rule or policy. They have not gone through public comment. They do not supersede any regulatory requirement found in the VSWMR. Their use is not mandated under the VSWMR. If used, the Department recognizes that they may need to be altered to fit facility-specific conditions that cannot be adequately accounted for in boilerplate SI. The final content of any NES submitted to the Department will likely include site-specific considerations.

All SI are considered 'living' documents which will be updated or revised as needed. Comments or suggestions for future SI revisions can be submitted at any time to the attention of the Solid Waste *Groundwater Program Coordinator* at the address listed on the cover of this SI.

LIMITATIONS/DISCLAIMER

The NES provision contained within the VSWMR originates from Federal language in EPA's Subtitle D solid waste regulations [40 CFR 258.55.(g).(1).(i-iii)]. Because EPA is the source of the NES provision, these SI contain references to EPA's NES commentary in its preamble to the Subtitle D regulations and the technical content of its 1993 Subtitle D regulations. EPA's preamble contains its expanded interpretation of the technical content in the final 40 CFR 258 statute and addresses the response to public comment received during the draft regulation development process. Although EPA's preamble language is referenced within the SI, preamble language is not a binding part of a

law/statute and it can neither enlarge the scope of a statute's applicability nor confer powers to the regulatory authority not already expressly contained within the language of the statute. At the same time, when there is a question of the intent or meaning behind statute text, the content of the preamble cannot be ignored if it addresses the ambiguity raised. The 1993 Subtitle D regulatory guidance developed by EPA expands further upon the content of the preamble, but has the same limitations in that guidance cannot be used to infer requirements that are not expressly part of the Subtitle D statute.

TECHNICAL CONSIDERATIONS OF PLUME DELINEATION

Within the VSWMR, the requirement to complete an NES upon recognition of a statistical exceedance of a GPS is found within *9 VAC 20-81-260.C.1.a*. The primary purpose of a NES is to demonstrate the three dimensional extent of the aquifer impacted above GPS. The submission also must contain a summary of the physical and health characteristics of the groundwater constituents of concern. The conclusions presented within the submittal must be supported by site-specific data derived from the newly installed NES wells as well as published peer-reviewed chemical and health data for the constituents of concern. The submission must be based on factual evidence and is not meant to be based on conjecture or a professional opinion of where the plume could be, or what exposure risks to the plume might be.

While use of these SI may assist in development of a complete NES, use of the SI does not imply any guarantee of final Department approval of the content or conclusions contained within.

General purpose of the NES wells

EPA recognized that in order to define how much of the aquifer was impacted at concentrations exceeding groundwater protection standards (thus subject to remediation requirements) additional monitoring wells would need to be installed on site. With respect to the purpose behind the installation of these wells, EPA commented in the Subtitle D preamble [56 FR 51084] that:

"The purpose of these additional wells is to delineate the contaminant plume boundary and to eventually demonstrate the effectiveness of corrective action in meeting the groundwater protection standard."

Page 288 of EPA's 1993 Subtitle D guidance further noted the performance requirement that:

"The investigation should identify plume geometry, both laterally and vertically."

The lateral and vertical delineation requirements will in most cases require installation of nested well pairs in one or more areas of the plume. The Department recognizes that in a limited number of cases, site specific conditions including the presence of a shallow confining unit may allow a deviation from this requirement and the geologic constraints of such sites will be considered on a case by case basis.

Location criteria

The process for determining the appropriate location and target depths for NES wells is complicated and largely controlled by site-specific factors which govern how groundwater flows in the vertical and horizontal directions on the site. For example, groundwater flow through unconsolidated Coastal Plain sediment will likely be relatively simple, conforming in large part to the surface expression of site topography and location of groundwater discharge points. In areas of the Commonwealth underlain by highly fractured, thinly-bedded shale or sandstone bedrock, the density of the fractures may mean the shale bedrock behaves similar to an unconsolidated aquifer where groundwater flow will typically mimic surface topography.

In areas of the Commonwealth underlain by steeply-dipping folded bedrock, accelerated down-dip plume migration must be evaluated. In regions underlain by metamorphic bedrock, flow through the overlying saprolite must be evaluated taking into consideration that relict bedrock structure will be preserved in the saprolite. Aquifers within which flow occurs through secondary porosity features (fractures, faults, bedding planes, solutional conduits) will likely require a greater number of NES wells in order to define the plume margins as these features typically enhance vertical migration and can promote horizontal migration in a direction other than that suggested by site topography. Owner/operators are reminded that landfills located in recharge zones (or areas of significant topography) will likely be subject to significant vertical flow characteristics. The NES wells must be installed to a depth which will intercept all plume migration pathways on site.

With respect to nested wells, site specific geology will control the depth and vertical separation of the nested screened intervals. Listed below are several examples of common considerations when installing nested wells in different areas of the Commonwealth:

- In sites located atop Coastal Plain sediments, the presence of a true confining unit may mean both the shallow and deep screened intervals are located in the same geologic horizon (i.e., above the confining unit) with minimal separation (i.e., 25 feet or less).
- In the Piedmont, the shallow NES sampling horizons will typically be located in chemically weathered bedrock (saprolite) while the corresponding deep screened NES interval will be located in the underlying competent bedrock to detect whether the landfill plume has entered the bedrock aquifer.
- In carbonate settings, the saprolitic horizon, if it exists, typically does not yield sufficient groundwater for monitoring purposes. Therefore, the shallow and deep

screened NES intervals will likely be set within successive water-bearing zones within the limestone (or dolomite) bedrock.

While it is outside the scope of these SI to fully review the theory of groundwater flow, owner/operators should be aware that based on the review of NES reports submitted to the Department since 1995, the depth of landfill plumes is commonly under estimated during initial NES work. Landfill contaminants do not stay partitioned within the uppermost portions of the aquifer systems unless the landfill is located near a point (zone) of significant aquifer discharge. Several landfill sites in the Commonwealth have identified groundwater plumes extending 200 feet or more below the base of the waste. In addition, any use of groundwater (private) wells on adjacent properties (including well yield and depth) must be considered a potential long-term local influence on plume vertical and horizontal migration directions. Failure to recognize these plume migration constraints will likely lead to multiple (and potentially expensive) NES well installation efforts.

NES well design

NES wells, as all other wells utilized for groundwater sampling onsite, should be installed consistent with available EPA RCRA guidance (i.e., 1986 RCRA Technical Enforcement Guidance Document; 1989 Groundwater Handbook; 1992 RCRA Ground-water Monitoring Draft Technical Guidance). Although installed to delineate the groundwater release, these sampling points often have a second use as permanent corrective action monitoring points. As a result, NES wells should not be installed as temporary (pre-built) sampling points unless Department pre-approval of the action is obtained.

Consistent with the 1986 EPA RCRA guidance (page 54) and the 1993 Subtitle D guidance (page 248), well screens should not exceed 10 feet unless Department pre-approval is granted. EPA has noted that ...:

“Longer well screens that span more than a single flow zone can result in excessive dilution of a contaminant present in one zone by uncontaminated ground water in another zone. This dilution can make contamination detection difficult or impossible, since contaminant concentrations may be reduced to levels below the detection limits for the prescribed analytical methods because the requirements for additional monitoring are site-specific, the Agency is not able to set requirements for cases where additional monitoring is required nor the number of additional wells that must be installed.”

“Well screen lengths should generally not exceed 10 feet”.

With respect to groundwater sampling, the NES wells should be sampled in a manner

consistent with the existing compliance wells on site to avoid potential problems comparing sampling results obtained from differing methods. This is another reason why temporary NES well installations are not favored.

Determining the number of NES wells required

While EPA defined the purpose of NES wells, it noted it was not possible to define how many new wells would actually be needed to achieve the goal of plume delineation on site. Commenting in the Subtitle D preamble [56 FR 51084] EPA noted:

“... because the requirements for additional monitoring are site-specific, the Agency is not able to set requirements for cases where additional monitoring is required nor the number of additional wells that must be installed.”

In essence, determining the final number of NES wells needed to provide the vertical and horizontal delineation of the plume will depend on a number of site-specific factors including, but not limited to:

- the number of individual site compliance wells which exceed groundwater protection standards,
- the distance from these exceeding wells to the downgradient property boundary,
- the number of exceeding constituents and the magnitude of the exceedance(s) over the respective groundwater protection standard(s),
- the chemical behavior of the exceeding constituent(s),
- the geology (or geologic complexity) of the aquifer, and
- the proximity to any aquifer discharge zone(s).

It is important to recognize that the *plume*, as defined within the Subtitle D program, is that area of the aquifer that contains groundwater impacted at concentrations which exceed constituent-specific GPS. The plume boundary for each exceeding constituent will be marked at its respective groundwater protection standard concentration. The more GPS exceeding constituents within the plume, the more likely that several constituent “boundaries” will exist within the plume as a whole. The intent of the NES is to find these individual boundaries and then delineate that portion of the aquifer which incorporates all of them and is thus subject to remediation efforts (as noted by EPA [56 FR 51084] below):

“... the distribution of contaminants must be delineated to properly define the extent of the area to be addressed by the corrective action program.”

An owner/operator is cautioned against locating NES wells in such a way that the resulting samples yield non-detects for the groundwater contaminants of concern. These ‘clean’ wells would not meet the intent of the NES as non-detect wells only tell one where landfill impacts are *not* present; they do not provide data relevant to defining plume boundaries. To demonstrate (using PCE as an example), if the landfill exceeding well (waste boundary) displays sampling results of 60 ppb, and the NES well installed 500 feet downgradient shows non-detect PCE sampling results, the facility has not identified where the PCE plume boundary (i.e., the 5 ppb isoconcentration line) exists. The NES well has only shown where the plume has not yet migrated. The PCE boundary could exist anywhere within the 500 foot linear distance separating the compliance well and the exceeding well and as a result, at least one new well would need to be installed somewhere in between the exceeding compliance well and the non-detect NES well in an attempt to delineate the actual boundary. In general, the further away from the exceeding well one goes, the more uncertainty there is in the ‘likely’ presence of the constituents of concern. Because of the expense involved in well installation, locations chosen must be ones most likely to intercept the migrating contaminants and provide concentration data useful in delineating the plume extent.

While EPA allows the use of computer simulations/modeling in its RCRA programs for assistance in understanding plume behavior, the Commonwealth does not allow such program use to substitute for actual data collection from NES wells. In the small number of cases where modeling programs were used, the plume dimensions modeled ended up being far smaller than eventually determined via the installation and sampling of NES wells.

With respect to the question of how close is “close” when determining plume boundaries; the Department uses the following rationale. If the groundwater protection standard for a constituent is 5 ppb, and the NES well installed yields sample results of 4.7 ppb, one can be reasonably certain that the plume boundary lies in front of (i.e., landfill side) of the NES well location. Any result within 10% of the GPS value (in this case, any result between 4.5 ppb and 5.0 ppb) will be considered close enough to use the NES well location as the plume boundary. In this example, if the NES result obtained was 4.4 or lower, than another NES well would need to be installed closer to the waste mass to find the 5.0 ppb plume boundary. The initial NES well installed on site, even though it may have failed to “find” the plume boundary will still have a purpose in the Corrective Action program, most likely as a ‘performance’ well.

In an alternate scenario, if the NES well yields results which are above 5.0 ppb GPS, then the plume boundary has not yet been delineated (existing somewhere beyond the location of the sampled NES well) and additional NES wells would be required. The Department does not utilize a “10% rule” for wells which still exceed a GPS as this contradicts EPA’s Subtitle D purpose of defining the extent of a landfill groundwater release and under estimating plume length could have serious consequences for

potential ecologic or human receptors. In all cases, plume extent must be accurately delineated before an assessment of remediation efforts can begin.

Property boundary NES well requirement

While EPA noted it was not possible to mandate (via the Subtitle D regulatory text) a pre-determined number of NES wells needed on each site to delineate the plume; EPA did require that no matter how many wells were installed on site, one must be installed at the downgradient property boundary in the direction of plume migration. EPA noted in its Subtitle D preamble [56 FR 51085]:

"The Agency added the specific requirement of a well at the facility boundary so that the owner or operator will be able to determine when contaminants have migrated past the facility boundary so that affected persons who own or reside on land overlying the plume may be notified."

It is important to recognize that in cases where a site has more than one exceeding compliance well, and the groundwater flow away from these impacted compliance wells follows different paths toward downgradient property boundaries, multiple property boundary wells may be needed to meet the purpose behind EPA's Subtitle D requirement. It should also be noted that while the Department has adopted EPA's NES requirements, some flexibility is given to owner/operators that have defined the plume as not having migrated anywhere near a downgradient property boundary. In such cases, the justification to spend additional money installing a property boundary well downgradient from NES wells which already define the plume as remaining on site is not practical. The requirement to install a property boundary well may thus be delayed until additional sampling data indicates the plume continues to migrate past the installed NES well(s) toward the property boundary.

The same line of reasoning applies to the provision to sample the property boundary NES well continually along with the compliance wells. EPA had noted in its Subtitle D preamble [56 FR 51085] that:

"... the Director of an approved state must always include this one additional well in the sampling and analysis program."

However, in those cases where the NES well(s) at the property boundary do not display the constituent(s) of concern, and the other NES wells on site identify that the plume has not come close to the property boundary, the justification to spend additional money continually sampling the property boundary well(s) may not be warranted. The requirement to sample property boundary NES well(s) at the same frequency as the compliance wells is therefore reserved for those sites which have contamination at the property boundary or until such time as additional sampling data indicates the plume continues to migrate toward the property boundary.

The issue of offsite plume characterization

EPA understood that there may be instances where a landfill plume has migrated to offsite properties. However, this does not remove the requirement to delineate the plume on those offsite properties. EPA noted in its Subtitle preamble [56 FR 51085] that:

“... it may be difficult in certain circumstances to characterize the nature and extent of the plumes that have moved off-site ... the owner or operator may have difficulty obtaining permission from adjacent land owners to install additional wells ...”

“Nevertheless, the Agency expects owners and operators to make every effort to fully characterize the nature and extent of the contamination”

If the extent of the offsite plume cannot be delineated, the owner/operator must provide the reasons that prevented the action from being completed. If access was denied, a copy of the formal denial should be provided to the Department. Because the Department has no control over the progress (speed) of any negotiations related to possible offsite well access agreements, the timing for plume delineation required in the VSWMR may be replaced by a timeframe agreed to under a separate enforcement mechanism entered into with Department. Contact with the respective Regional Office will be required in this type of situation.

Notifications

Neither EPA in its Subtitle D regulation, nor the Department in the VSWMR require the owner/operator to formally report the NES sampling results prior to completion of the NES delineation actions. However, if the results of the NES indicate the presence of landfill contaminants on offsite properties at concentrations exceeding groundwater protection standards, EPA required the owner/operator notify the offsite landowner or resident (in the case of renters) [40 CFR 258.55.(g).(1).(iii)]. While EPA did not define a timeframe for the notification, the Department clarified that the notification should take place within 15 days of completion of NES sampling and analysis efforts [9 VAC 20-81-260.C.1.b], ... not completion of the entire NES process. In other words, if the analytical results indicate an exceedance of one or more constituents within the property boundary or off site NES well(s), then the notification should be made within 15-days of date of the analytical results release. If the sampling result is suspect and verification sampling will be attempted, the notification can be delayed until the verification results are available. In no case should the off-site plume notification be delayed until the finished NES report is submitted to the Department.

With respect to the form the notification takes, EPA defined the specific content it was looking for in its 1993 Subtitle D guidance [pg 288]:

“... it is expected that the notice could include the following items:

- *date of detected release*
- *chemical composition of release*
- *reference to the constituent(s), reported concentration(s), and the GWPS*
- *representatives of the MSWLF facility with whom to discuss the finding, including their telephone numbers*
- *plans and schedules for future activities*
- *interim recommendations or remedies to protect human health and the environment”*

TECHNICAL CONSIDERATIONS OF PLUME MIGRATION

The second part of the NES process includes a discussion of the calculated rate at which the plume is migrating away from the impacted compliance wells. EPA’s Subtitle D guidance document noted [pg 288]:

“Characterizing the nature of the release should include a description of the rate and direction of contaminant migration”

EPA additionally commented in the Subtitle preamble [56 FR 51085] that:

“... a thorough understanding of the ... hydrology of the site is essential to creating a corrective action program.”

Completing this requirement will require that groundwater flow direction be determined along flow lines connecting the exceeding compliance wells with their corresponding downgradient NES wells. Care should be taken to avoid calculating flow rate information from wells which are not installed within the same groundwater bearing zone of the aquifer. Most commonly in the Commonwealth, problems arise when calculating flow rate between two wells, one screened in saprolite and one screened in bedrock since the ‘communication’ between the two separate water bearing horizons will be poorly defined or unknown. Because in many cases both the date of initial waste receipt and the lateral distance between the sampling points is known, the presence of contaminants within each impacted sampling point can be used as an independent ‘check’ on whether the calculated groundwater flow rates are sufficient to have driven the contaminants to their current positions on site understanding that several physical and chemical factors work to make actual contaminant transport

rates far less than the rate calculated for groundwater flow.

TECHNICAL CONSIDERATIONS OF CONSTITUENT CHARACTERIZATION

The third part of the NES process includes a discussion of the chemical characteristics of the groundwater constituents of concern. EPA's Subtitle D guidance document noted [pg 288]:

"Characterizing the nature of the release should include a description of ... the chemical and physical characterization of the contaminants."

Completion of this requirement has become easier with the evolution of internet search engines and the online posting of EPA and other government sources of health effect data and fate and transport studies. The NES should include the sources used for any information presented in the final submission.

REVISIONS TO THE NES SUBMISSION

EPA's requirement that the plume of contamination be defined downgradient of each exceeding well means that if, after the initial NES work has been completed, new exceedances are recognized at new compliance wells, or plume expansion leads to GPS exceedances in existing NES wells, additional NES work will need to be completed to define the new or expanding plume. In cases such as these, it is expected that the new groundwater data can be submitted as an addendum to the existing NES within timeframes consistent with the VSWMR. If an extension to the normal submission deadline is justified for cost reasons associated with other corrective action related site activities, the Department will consider approval for the extension request.

FORMAT CONSIDERATIONS

Neither *40 CFR 258.55.g.(1).(i)* nor *9 VAC 20-81-260.C.1.a* of the VSWMR require results of the NES be submitted as a stand-alone document. The results can be submitted as part of the Assessment of Corrective Measures (ACM) report defined under *9 VAC 20-81-260.C.1.f*. However, there are several benefits to submitting the NES results under separate cover. These include:

- Department comment or concurrence on the results of the plume delineation prior to assessing possible remedies
- In those cases where the plume has not been defined during the NES, Department consideration of an extension to the ACM submittal due date to allow additional plume delineation work

If the NES is to be submitted under separate cover, for the sake of consistency and to ensure an expeditious review, the information (technical content) of the submission should be arranged in the order presented below. The sections discussed herein shall be considered standard technical content.

NES submissions that do not provide the standard technical content outlined herein are more likely to be found to be incomplete and requiring revision during the Department's technical review process. The Department also notes that there may be some site-specific instances where a facility's technical data may require additional or different information beyond that listed in these SI as a means of more fully characterizing the technical data available and conclusions derived thereof. These instructions set no limit on the number or content of additional report sections as long as the information included directly pertains to that required of an NES.

The administrative and technical content required for each section of the annual report is briefly described below.

Cover Page - Provide the following information:

- Landfill Name and location.
- DEQ Permit number.
- Date report submitted.
- Preparer's name and contact information.

Signature Page

- Signature (and stamp if applicable) of the report preparer.

Table of Contents

- Specify the order and organization of the report sections. A recommended format is provided in Table 1 of these SI.

Report Summary

Provide a brief summary of the following technical findings:

- Discussion of the number of NES wells installed.
- Results of the NES sampling and analysis.
- Plume delineation results.

Site Description

Provide the following information presented as text, in a table-format, or as bulleted items:

1. Site Background Information

- Identify the current owner/operator.
- Date the facility began waste acceptance and if applicable, date of last receipt of waste and date of final regulatory closure.
- Identify landfill type (i.e. Sanitary, CD&D, etc.), landfill design (i.e., trench, area fill, etc.), and describe the surrounding property land use noting any use of the aquifer as a water source.

2. Aquifer Recognition

- Identify the geologic setting (regional and local) of the landfill.
- Note the nature of the uppermost aquifer (i.e. overburden, saprolite, bedrock).

- Identify the nature of the groundwater table (i.e. confined, semi-confined, unconfined) and whether or not surface water is present on site or forms a site boundary.

3. Groundwater Protection Standards Exceedance Description

- Identify all downgradient compliance wells within the network described in Permit Module X and XI which exceed GPS.
- Identify the sampling event during which the exceedance was noted and when the Department was formally notified of the exceedance. Also note any past GPS exceedances that may be relevant to the NES.
- Identify whether the NES actions were completed under a Department approved extension or other compliance agreement.

4. Well Installation / Sampling Actions

- Identify each of the NES wells installed on site in an effort to delineate the plume.
- Give the date(s) of installation, method of installation, completion specifics, aquifer zones screened within, and development and sampling techniques used.
- List the sampling dates, including all verification events, conducted during the NES investigation. Discuss the results and how they are used to define the plume boundaries.

Hydrologic Evaluation

A calculation of the groundwater flow rate must be provided, derived from site specific data collected during the NES. Complete calculations used to determine the groundwater flow rate shall be provided in the Appendix of the NES. Units of flow rate must correspond to the units of map scale used on the site plan drawing (i.e. english – english, or metric - metric). Flow rate data should be presented in a “distance/per year” measurement.

This section must discuss the NES groundwater sampling results with respect to whether or not there has been any statistically significant increases (SSI's) over GPS in any of the new wells installed on site and whether the results verify that the boundaries of the plume have been defined. Constituents identified at GPS exceeding concentrations must be listed in table format with the corresponding NES and Compliance monitoring well identified.

Health Effects Evaluation

For each constituent of concern, published environmental health effect data should be summarized, along with the chemical (chemical composition of VOCs), and fate and transport characteristics (density compared to water, abiotic half-life if known, whether it likes to migrate with groundwater, or has an affinity to bind with the aquifer media, whether it likes to partition to a vapor form, and how it breaks down biologically). Sources of the data must be completely referenced in the NES.

Conclusions

Provide a summary of findings corresponding to the content included in the Executive Summary section. If the plume has not yet been fully defined, the section should include a summary of recommended actions needed to delineate the plume. No NES should be submitted with a claim of successful plume delineation in the absence of actual sampling data supporting the claim.

Figures

This section must contain, at a minimum:

- A USGS topographic map used to locate the site, a site plan drawing showing potentiometric surface contours and including topographic land surface contours, permanent structures, surface water features, a bar scale, north arrow, facility boundary, waste management unit boundary, all monitoring wells – labeled with ID #, and groundwater flow direction arrows for those sites located above all aquifer types other than fractured bedrock.
- Aerial or satellite imagery of the landfill and surrounding area.
- Horizontal plume delineation map overprinted on the most recent potentiometric map.
- Vertical plume delineation map shown as cross sections through the exceeding compliance well and the associated downgradient NES well(s) showing vertical plume concentrations overprinted on the subsurface site geology.

Attachments

This section should contain, at a minimum, a table of all GPS exceeding constituent detections at each well, (if applicable) statistical calculations, groundwater flow rate calculations, well completion / boring logs for all NES wells, field data sheets and laboratory analytical results from the NES sampling events (which can be presented on a CDROM).

REFERENCES CITED

USEPA, 1986, RCRA Ground-water Monitoring Technical Enforcement Guidance Document, Office of Solid and Emergency Response, OSWER 9950.1,208p.

USEPA, 1989, Ground Water Handbook, Office of Research and Development, 212p.

USEPA, 1991, Solid Waste Disposal Facility Criteria; Final Rule, Federal Register, vol.56, no.196, p.50978-51119.

USEPA, 1992, RCRA Ground-water Monitoring: Draft Technical Guidance, Office of Solid and Emergency Response.

USEPA, 1993, Solid Waste Disposal Facility Criteria – Technical Manual, Office of Solid Waste and Emergency Response, EPA/530/R93/017, 349p.

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