North Carolina Department of Environment and Natural Resources

APPLICATION FOR PERMIT TO CONSTRUCT AND/OR USE A WELL(S) FOR INJECTION
In Situ Groundwater Remediation (15A NCAC 02C .0225) | Tracer Injection (15A NCAC 02C .0229)

Do **not** use this form for the following:

- in situ remediation, tracer, or aquifer test injection wells permitted by rule (ref. 15A NCAC 02C .0217)
- remediation systems that reinject treated contaminated groundwater (ref. 15A NCAC 02T .1600)

RECEIVED/DENR/DWR

Application Number (*to be completed by DWR*): ______________

JUN 05 2015

Water Quality Regional Operations Section

I. APPLICATION INFORMATION

1. Project is: [ ] New [ ] Modification [X] Renewal *without* modification [ ] Renewal *with* modification
2. If this application is being submitted for renewal or modification to an existing permit, provide: existing permit number WI0500447 and the issuance date December 27, 2011
   For renewal without modifications, fill out sections I & II only, sign the certification on the last page of this form, and obtain the property owner's signature to indicate consent (if the applicant is not the owner).
   For all renewals, submit a status report including monitoring results of all injection activities to date.

II. WELL OWNER (generally the responsible party)

1. Name: City of Raleigh Solid Waste Services Department
2. Signing Official's Name*: Frederick D. Battle Title: Director, SWS
   * Signing Official must be in accordance with instructions in Part IX on page 5.
3. Mailing address of applicant: 630 Beacon Lake Dr
   City: Raleigh State: NC Zip: 27610
4. Telephone number: (919) 996-6890 Email: Frederick.Battle@raleighnc.gov
5. Status (choose one): ___Individual ___Business/Org. ___Federal ___State ___County _X_ Municipality

III. PROPERTY OWNER (if different than well owner)

1. Name: ______________
2. Physical address: ______________
   City: ______________ State: ______ Zip: ______
3. Mailing address: ______________
   City: ______________ State: ______ Zip: ______
4. Telephone number: ______________ Email: ______________

IIII. PROJECT CONTACT – Person who can answer technical questions about the proposed injection project.

1. Name: Mike Ranck Title: Hydrogeologist/Project Manager
2. Company: AECOM
3. Address: 1600 Perimeter Park Dr. Suite 400
4. City: Morrisville State: NC Zip: 27560
5. Telephone number: 919-461-1258 Email: mike.ranck@aecom.com

VIII. ATTACHMENTS – provide the following information in separate attachments. The attachments should be clearly identified and presented in the order below to expedite review of the permit application package.

1. INJECTION ZONE – Per 15A NCAC 02C .0225(e)(2) specify the horizontal and vertical portion of the subsurface within which the proposed injection activity will take place and beyond which no violations of groundwater quality standards shall result from the injection as determined by an approved monitoring plan. The determination shall be based on the hydraulic properties of the specified zone. Provide any supporting documentation in a separate attachment.

2. HYDROGEOLOGIC EVALUATION – Per 15A NCAC 02C .0225(e)(3) provide a hydrogeologic evaluation of the injection zone that includes all of the following:

(A) Regional and local geology and hydrology;
(B) Changes in lithology underlying the facility;
(C) Depth to bedrock;
(D) Depth to the mean seasonal high water table;
(E) Hydraulic conductivity, transmissivity, and storativity, of the injection zone based on tests of site-specific material, including a description of the test(s) used to determine these parameters;
(F) Rate and direction of groundwater flow as determined by predictive calculations or computer modeling; and
(G) Lithostratigraphic and hydrostratigraphic logs of any existing test and injection wells.

3. INJECTANT INFORMATION – Per 15A NCAC 02C .0225(e)(5) list each injectant in the space below and provide the following information for each injectant. *NOTE: Approved injectants can be found online at http://portal.ncdenr.org/web/wq/aps/gwpro. All other substances must be reviewed by the Division of Public Health, Department of Health and Human Services. Contact the UIC Program for more information (Ph# 919-807-6496).*

(A) MSDS, concentration at the point of injection, and percentage if present in a mixture with other injectants;
(B) The source of fluids used to dilute, carry, or otherwise distribute the injectant throughout the injection zone. If any well within the area of review of the injection facility is to be used as the fluid source, then the following information shall be submitted: location/ID number, depth of source, formation, rock/sediment type, and a chemical analysis of the water from the source well, including analyses for all contaminants suspected or historically recognized in soil or groundwater on the site;
(C) A description of the rationale for selecting the injectants and concentrations proposed for injection, including an explanation or calculations of how the proposed injectant volumes and concentrations were determined;
(D) A description of the reactions between the injectants and the contaminants present including specific breakdown products or intermediate compounds that may be formed by the injection;
(E) A summary of results if modeling or testing was performed to investigate the injectant's potential or susceptibility for biological, chemical, or physical change in the subsurface; and
(F) An evaluation concerning the development of byproducts of the injection process, including increases in the concentrations of naturally occurring substances. Such an evaluation shall include the identification of the specific byproducts of the injection process, projected concentrations of byproducts, and areas of migration as determined through modeling or other predictive calculations.

4. INJECTION PROCEDURE – Per 15A NCAC 02C .0225(e)(6) submit a table with a detailed description of the proposed injection procedure that includes the following:
(A) The proposed average and maximum daily rate and quantity of injectant;
(B) The average maximum injection pressure expressed in units of pounds per square inch (psi); and
(C) The total or estimated total volume to be injected.

5. FRACTURING PLAN (if applicable) – Per 15A NCAC 02C .0225(e)(7) submit a detailed description of the fracturing plan that includes the following:
(A) Material Safety Data Sheets of fracturing media including information on any proppants used;
(B) a map of fracturing well locations relative to the known extent of groundwater contamination plus all buildings, wells, septic systems, underground storage tanks, and underground utilities located within the Area of Review;
(C) a demonstration that buildings, wells, septic systems, underground storage tanks, and underground utilities will not be adversely affected by the fracturing process;
(D) injection rate and volume;
(E) orientation of bedding planes, joints, and fracture sets of the fracture zone;
(F) performance monitoring plan for determining the fracture well radius of influence; and
(G) if conducted, the results of geophysical testing or pilot test of fracture behavior conducted in an uncontaminated area of the site.

6. WELL CONSTRUCTION DETAILS – Per 15A NCAC 02C .0225(e)(8) submit the following information in tabular or schematic form as appropriate for each item:
(A) number and depth of injection wells;
(B) number and depth of borings if using multi-level or "nested" well systems;
(C) indication whether the injection wells are existing or proposed;
(D) depth and type of casing;
(E) depth and type of screen material;
(F) depth and type of grout;
(G) indication whether the injection wells are permanent or temporary "direct push" points; and
(H) plans and specifications of the surface and subsurface construction details.

7. MONITORING PLAN – Per 15A NCAC 02C .0225(e)(9) submit a monitoring plan that includes the following:
(A) target contaminants plus secondary or intermediate contaminants that may result from the injection;
(B) other parameters that may serve to indicate the progress of the intended reactions;
(C) a list of existing and proposed monitoring wells to be used; and
(D) a sampling schedule to monitor the proposed injection.
Monitoring wells shall be of sufficient quantity and location to detect any movement of injection fluids, injection process byproducts, or formation fluids outside the injection zone. The monitoring schedule shall be consistent with the proposed injection schedule, pace of the anticipated reactions, and rate of transport of the injectants and contaminants.

8. WELL DATA TABULATION – Per 15A NCAC 02C .0225(e)(10) provide a tabulation of data on all existing or abandoned wells within the area of review of the injection well(s) that penetrate the proposed injection zone, including monitoring wells and wells proposed for use as injection wells. Such data shall include a description of each well's type, depth, and record of construction or abandonment.

9. MAPS AND CROSS-SECTIONS – Per 15A NCAC 02C .0225(e)(11) provide scaled, site-specific site plans or maps depicting the location, orientation, and relationship of facility components including the following:
(A) area map based on the most recent USGS 7.5' topographic map of the area, at a scale of 1:24,000 and showing the location of the proposed injection site;
(B) topographic contour intervals showing all facility related structures, property boundaries, streams, springs, lakes, ponds, and other surface drainage features;
(C) all existing or abandoned wells within the area of review of the wells listed in the well data tabulation that penetrate the proposed injection zone;
(D) potentiometric surface map(s) that show the direction of groundwater movement, existing and proposed wells;
(E) contaminant plume map(s) with isoconcentration lines that show the horizontal extent of the contaminant plume in soil and groundwater, and existing and proposed wells;
(F) cross-section(s) to the known or projected depth of contamination that show the horizontal and vertical extent of the contaminant plume in soil and groundwater, major changes in lithology, and existing and proposed wells; and
(G) any existing sources of potential or known groundwater contamination, including waste storage, treatment, or disposal systems within the area of review of the injection well or well system.

APPLICATION FOR PERMIT TO CONSTRUCT AND/OR USE A WELL(S) FOR INJECTION
***In Situ* Groundwater Remediation | Tracer Injection**

IX. CERTIFICATION* (to be signed as required below or by that person's authorized agent*)

NCAC 15A 02C .0211(e) requires that all permit applications shall be signed as follows:

1. for a corporation: by a responsible corporate officer
2. for a partnership or sole proprietorship: by a general partner or the proprietor, respectively
3. for a municipality or a state, federal, or other public agency: by either a principal executive officer or ranking publicly elected official
4. for all others: by the well owner.

***If an authorized agent is signing on behalf of the applicant, then supply a letter signed by the applicant that names and authorizes their agent.**

"I hereby certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments therein, and that, based on my inquiry of those individuals immediately responsible for obtaining said information, I believe that the information is true, accurate, and complete. I am aware that there are penalties, including the possibility of fines and imprisonment, for submitting false information. I agree to construct, operate, maintain, repair, and if applicable, abandon the injection well(s) and all related appurtenances in accordance with the approved specifications and conditions of the Permit."

Printed Name and Title: Frederick D. Battle, Director City of Raleigh Department of Solid Waste Services

Signature: Frederick D. Battle   Date: June 1, 2015

X. CONSENT OF PROPERTY OWNER (if the property is not owned by the permit applicant)

"Owner" means any person who holds the fee or other property rights in the well being constructed. A well is real property and its construction on land shall be deemed to vest ownership in the land owner, in the absence of contrary agreement in writing.

"*As owner of the property on which the injection well(s) are to be constructed and operated, I hereby consent to allow the applicant to construct each injection well as outlined in this application and agree that it shall be the responsibility of the applicant to ensure that the injection well(s) conform to the Well Construction Standards (15A NCAC 02C .0200).*"

Printed Name and Title:____________________

Signature:____________________   Date:__________

Submit **TWO** copies of the completed application package, including all attachments, to:

DWR – UIC Program
1636 Mail Service Center
Raleigh, NC 27699-1636
Telephone (919) 807-6464

State of North Carolina
Department of Environment and Natural Resources
Division of Water Quality

RECEIVED / DENR / DWQ
AQUIFER PROTECTION SECTION
OCT 31 2011

APPLICATION FOR PERMIT TO CONSTRUCT AND/OR USE A WELL(S) FOR INJECTION
Type 5I Wells – *In Situ* Groundwater Remediation / Type 5T Wells – Tracer Injection

- Do **not** use this form for remediation systems that extract contaminated groundwater, treat it, and reinject the treated groundwater.
- Submit **TWO** copies of the completed application and all attachments to the address on the last page of this form.
- Any changes made to this form will result in the application package being returned.

Application Number (*to be completed by DWQ*): ______________________

I. GENERAL INFORMATION:

1. Applicant's Name (generally the responsible party): City of Raleigh Solid Waste Services Department
2. Signing Official's Name*: Frederick D. Battle Title: Director, SWS
   * Signing Official must be in accordance with instructions in part VI on page 7.
3. Mailing address of applicant: 400 West Peace Street

   City: Raleigh State: NC Zip: 27602
   Telephone number: (919) 996-6867 Fax number: (919) 996-6632

4. Property Owner's Name (if different from Applicant): ______________________
5. Property Owner's mailing address: ______________________

   City: ______________________ State: ________ Zip: ________

6. Name and address of contact person who can answer questions about the proposed injection project:
   Name: John Bove, P.E. Title: Associate
   Company: Hazen & Sawyer
   Address: 4011 Westchase Blvd, #500
   City: Raleigh State: NC Zip: 27607
   Telephone number: (919) 833-7152 Fax number: (919) 833-1828
   Email Address: jbove@hazenandsawyer.com

II. PERMIT INFORMATION:

1. Project is: (X **New** (Modification of existing permit (Renewal of existing permit **without** modification
   (Renewal of existing permit **with** modification
2. If this application is being submitted for renewal or modification to an existing permit, provide:
   existing permit number ______________________ and the issuance date ______________________
   For renewal without modifications, fill out sections I & II only, sign the certification on the last page of this form, and obtain the property owner's signature to indicate consent (if the applicant is not the owner).
   For all renewals, submit a status report including monitoring results of all injection activities to date.

C. PERMITS

List all permits or construction approvals that have been issued for the **facility or incident**, including those not directly related to the proposed injection operation:

1. Hazardous Waste Management program permits under RCRA:____________________
2. DWQ Non-Discharge or NPDES permits: _____NCG120000____________________
3. County or DEH subsurface wastewater disposal permits:____________________
4. Other environmental permits required by state or federal law:____Landfill permit #92-01; Air Quality Permit 08835T00_____

B. PROPOSED OPERATING PARAMETERS

1. Duration of Injection: 3 years
   a. Maximum number of separate injection events: 12
   b. Expected duration of each injection event: 1-2 days
   c. Expected duration between events (if more than one event): ≤ 6 months
2. Injection rate per well: 5-10 gallons per minute (gpm) 4 wells
3. Total Injection volume: ______ gallons per day (gpd); ≤ 1025 gallons per event (if separate events)
4. Injection pressure: 14.7 pounds/square inch (psi)
5. Temperature at point of injection: ambient °F
6. Briefly describe how the above parameters will be measured and controlled: first injection event - potassium permanganate will be mixed in controlled quantities, and then introduced into the wells at 5-10 gpm. Subsequent injections may involved the use of small, temporary tanks to inject predetermined volumes.
7. Estimated hydraulic capacity of the wells: 0.18 (average) gpm

C. INJECTION WELL CONSTRUCTION DATA

1. Injection will be via:

   (Existing well(s) proposed for use as an injection well. Provide the data in (2) through (6) below to the best of your knowledge.

   (X Proposed well(s) to be constructed for use as an injection well. Provide the data in (2) through (6) below as proposed construction specifications.

2. Well Drilling Contractor's Name: Davidson Drilling, Inc.

   NC Well Contractor Certification number: NCWC 2108-A

3. Date to be constructed: December, 2011 – December, 2014 Number of borings: initially 4, then up to a total of 10 as necessary

   Approximate depth of each boring (feet): 70

4. Screened interval/Injection interval of injection wells: (initial 4 wells are italicized)

   Depth: 10 to 70 feet below ground surface (IW-3, *IW-4, IW-5*, IW-6).

   Depth: 15 to 70 feet below ground surface (IW-13, IW-14, *IW-15*).

   Depth: 20 to 70 feet below ground surface (IW-8, IW-11, *IW-12*).

5. Well casing (N/A if injection is through direct push rods):

   Type: (X PVC (Stainless steel (Other:______

   Casing depth: -2 to 10 ft.

   Casing depth: -2 to 15 ft.

   Casing depth: -2 to 20 ft.

(4) summary results of modeling or testing performed to investigate the injectant's potential or susceptibility to change (biological, chemical or physical) in the subsurface.

E. INJECTION PROCEDURE AND EQUIPMENT

Provide a detailed description of all planned activities related to the proposed injection including but not limited to:

(1) construction plans and materials;
(2) operation procedures;
(3) a detailed diagram of the surface and subsurface portions of the system; and
(4) a planned injection schedule.

F. MONITORING PLAN

Provide a plan for monitoring the results of the injection, including:
(1) a list of existing and proposed monitoring wells to be used;
(2) a list of monitoring parameters and analytical methods to be used; and
(3) a schedule for sampling to monitor the proposed injection.

NOTE: The selected monitoring wells must be located so as to detect any movement of injection fluids, process by-products, or formation fluids outside the injection area or zone. The monitoring parameters should include the target contaminants as well as secondary or intermediate contaminants which may result from the injection and other parameters which may serve to indicate the progress of the intended reactions, such as pH, ORP, dissolved oxygen, and other electron acceptors and donors. The monitoring schedule should be consistent with the pace of the anticipated reactions and rate of transport of the injectants and contaminants.

G. WELL DATA

Provide a tabulation of data on **all** existing or abandoned wells within ¼ mile of the injection well(s) which penetrate the proposed injection zone, including, but not limited to, monitoring wells and wells proposed for use as injection wells. Such data shall include a description of each well's use (water supply, monitoring, etc), total depth, screened or open borehole depth interval, and well construction or abandonment record, if available.

H. MAPS

Attach the following scaled, site-specific maps:

(1) Area map based on the most recent USGS 7.5' topographic map of the area, at a scale of 1:24,000 and showing the location of the proposed injection site.
(2) Site map including:
  a. all property boundaries;
  b. all buildings within the property boundary;
  c. existing and proposed injection wells or well field(s)
  d. any existing sources of potential or known groundwater contamination, including waste storage, treatment or disposal systems within ¼ mile of the injection well or well system;
  e. all surface water bodies within ¼ mile of the injection well or well system; and
  f. **all** existing or abandoned wells within ¼ mile of the injection well(s) which penetrate the proposed injection zone, including, but not limited to, monitoring wells and wells proposed for use as injection wells.
(3) Potentiometric surface map(s) including:
  a. direction of groundwater movement
  b. existing and proposed monitoring wells
  c. existing and proposed injection wells

ATTACHMENT A

SITE HISTORY

1.0 SITE USAGE

The Wilders Grove Landfill, permitted and opened in 1972 (NCDENR Permit No. 92-01), is owned and operated by the City of Raleigh. The facility was closed for disposal operations on December 31, 1997. The 259-acre facility is bounded to the north by US64 Business (New Bern Avenue), to the east by New Hope Road and commercial properties, to the south by Crabtree Creek and the City of Raleigh Solid Waste Transfer Facility, and to the west by the City of Raleigh Wilders Grove Service Center (under construction), Corporation Parkway, commercial properties and the City of Raleigh Fleet Services facility. A Site Location aerial photograph is provided as FIGURE 1 (ATTACHMENT H), and a Site Plan is provided as FIGURE 2 (ATTACHMENT H). The facility was permitted to receive Municipal Solid Waste (MSW) and served Wake and portions of Johnston County in its history.

The facility consists of approximately 120 acres of disposal area in three separate disposal units, which are identified on FIGURE 2 (ATTACHMENT H):

- The largest of the units (the "***principal waste management unit***") is approximately 102 acres in area and contains roughly 2,000,000 cubic yards of MSW. The most recent expansion of the facility occurred in accordance with specifications for Vertical Expansion, as approved during 1992. This unit was active until December 31, 1997, when disposal operations ceased in order to comply with state regulations. The facility is currently in the Post Closure maintenance phase.
- The "***southeastern waste management unit,***" approximately 15 acres in area, is separated from the principal waste management unit by a perennial stream.
- The "***southwestern waste management unit***" is approximately 3 acres in area and was only operated for a short period of time during the late 1970s.

All disposal units are unlined, with no leachate collection system (as is typical for landfills developed during that era).

The principal waste management unit is associated with a network of groundwater monitoring wells, portions of which were constructed as early as 1992. The facility is currently monitored under the Assessment Monitoring program approved by the NCDENR Solid Waste Section. Additional wells were constructed in accordance with the approved Water Quality Management Plan that was included in the 1994 Transition Plan and again in 2000 as part of the Assessment Monitoring program.

The Wilders Grove Landfill facility is an unlined landfill; consequently, organic compounds have migrated into groundwater at the facility. The organic constituents observed at the Wilders Grove Landfill facility are typical of those observed at older unlined sanitary landfills throughout North Carolina.

3.0 PREVIOUS REMEDIAL ACTIONS

As part of the landfill closure, the City of Raleigh implemented the following remedial measures at the facility:

- Institutional controls
- Engineering controls

3.1 Institutional Controls

Institutional controls encompass the collective operational and regulatory systems that function to limit exposure of the public to refuse or refuse by-products, including leachate, fugitive vectors (litter, odor, etc.) and landfill gas (LFG). Each waste management facility is required to implement and maintain institutional controls established during siting and design, operation, closure and post-closure care.

For purposes of this Application, institutional controls are classified as follows:

- site location restrictions
- site access controls
- deed restrictions
- public water supply

3.1.1 Site Location Restrictions

Owners and Operators of unlined landfills were required to demonstrate compliance with siting restriction criteria as part of the 1994 Transition Plan in order to gain regulatory approval to maintain disposal operations until the 1997 closure deadline. Hazen and Sawyer, P.C. prepared the Transition Plan for Wilders Grove Landfill that demonstrated conformance with North Carolina (15A NCAC 13B Section .1622) siting criteria; the first layer of institutional controls. These siting criteria include:

- *Airports - Greater than 5,000-ft. from a public airfield runway handling piston aircraft and more than 10,000-ft. from a public airfield runway handling turbo or jet powered aircraft (NCAC .1622(l)).* **The Wilders Grove Landfill is greater than 10,000-ft. from any public airport.**

- *Floodplains - Avoid impact to 100-year floodplain (NCAC .1622(2)).* **No landfill unit will impact storage or flow from the a 100-year flood and no washout of MSW is anticipated under these conditions.**

- *Fault Areas - Greater than 200-ft. from a Holocene Epoch fault (NCAC .1622(4)).* **No landfill unit is located within 200 ft. of a known Holocene Epoch fault.**

- *Unstable Area - The facility is not located in an unstable area* (NCAC .1622(6)). **Foundation soils are not poor, there are no areas subject to mass movement and the site is not in Karst terrain.**

- *Water Supply Watersheds (NCAC .1622(9))* - **The facility is not located in a designated critical area of a water supply or in the watershed for a stream classified as WS-I.**

3.1.2 Site Access Controls

Access controls have been established to prevent casual public access to the facility. During disposal operations, the facility controlled access using gates, signs, a manned scale house at the entrance, and restricted areas to which vehicles could gain access. Such measures are believed to have minimized illegal dumping at the facility and contact with waste by the public. Daily and intermediate soil cover placed during operations minimized fugitive vectors such as vermin, odors, and blowing litter.

Now that the landfill is closed and the final cover in place, the risk of contact with refuse or refuse byproduct is greatly reduced. The final cover, if properly maintained, prevents direct contact with the refuse.

For a large facility such as Wilders Grove, it is difficult to prevent all unauthorized access, but its location and the nature of its surroundings reduce this potential. Signs provide notification, and fences limit the opportunity for vehicle or pedestrian access.

A fence and a series of locked gates exists along the edge of the New Hope Road right-of-way from the northern limit of the facility to the Norfolk Southern Railroad easement south of the disposal areas. Locked gates at the City's Fleet Services complex prevent access from New Bern Avenue to the north. A locked gate at the end of the public portion of Corporation Parkway prevents access from this location. Fenced I440/US64 highway right-of-ways serve to limit access from the west, and the railroad and heavily wooded areas prevent vehicle access from the south.

The gates and fences are periodically inspected and maintained by City staff as part of the post-closure monitoring.

3.2 Engineering Controls

Engineering controls encompass the systems designed to help limit exposure of the public to refuse or refuse by-products, including leachate and landfill gas (LFG).

For purposes of this report, engineering controls are classified as follows:

- leachate collection
- infiltration controls (final cover)
- landfill gas controls
- groundwater monitoring

3.2.1 Leachate Collection

Wilders Grove Landfill is an unlined landfill and no leachate collection system is in place. The final cover system appears to have minimized leachate breakouts, and with proper maintenance will continue to do so. The final cover represents the only practical mode of preventing direct public contact with leachate.

3.2.2 Infiltration Controls (Final Cover)

Final cover was placed on the three disposal units, thereby closing them in accordance with applicable North Carolina regulations. The final cover is expected to:

- minimize infiltration of precipitation into the waste
- function with a minimum of maintenance over the life of the facility

For the principal waste management unit (102 acres), the final cover consists of areas that have either the standard "Pre-1991" Subtitle D final cover or a geosynthetic-lined final cover. The "Pre-1991" final cover consists of a minimum of 2-feet of "suitable compacted earth" over the refuse. This cover was constructed over approximately 34 acres of the main disposal unit and approved as properly closed prior to October 9, 1991, the implementation date for Subtitle D closure requirements. Much of the area that received this type of final cover is located on relatively steep (4-horizontal to 1-vertical) slopes, where up to 80% of precipitation runs off or is removed by evapo-transpiration.

The City of Raleigh constructed an enhanced geosynthetic final cover over the entire 68-acre post-1991 area that was in operation after October 9, 1991. The capping system was selected in order to provide more effective infiltration resistance and to enhance the operation of the landfill gas (LFG) extraction system. Nearly all of the relatively flat final cover areas (where increased infiltration of precipitation would be expected) have the geomembrane-lined barrier in place. The enhanced final cover, which exceeds Subtitle D requirements for unlined landfills, consists of the following components (listed from the top of refuse upward):

- Intermediate Cover. Twelve-inch thick soil cover placed and compacted over the top of the refuse layer (or the daily cover) once disposal operations ended in each section of the landfill. This layer functions to provide vector control, provide separation from the refuse for landfill workers and forms the substrate for the overlying barrier system.

- Base Layer. This 24-inch minimum thickness soil layer is the lower component of the composite barrier system. This layer was constructed using cohesive soil excavated from the City's borrow site located to the west of the disposal area. The soils were compacted to provide a suitable foundation for the geomembrane and the thickness was verified by direct measurement.

- Geomembrane. The geosynthetic barrier is a 30-mil PVC geomembrane fabricated and installed by experienced specialty contractors. The geomembrane forms the primary infiltration barrier and also serves to prevent vertical migration of LFG through the final cover. The geomembrane panels and seams were carefully inspected and tested to assure conformance with the project requirements.

- Infiltration Collection System. This layer, consisting of a geonet/geotextile geocomposite, was installed directly over the geomembrane. The component functions to drain away precipitation that infiltrates through the overlying soil cover. This layer enhances function of the final cover by reducing the hydraulic head over the geomembrane; decreasing potential for infiltration through the barrier and enhancing sliding stability of the final cover system constructed on landfill slopes. The infiltration collection system drains to the perimeter of the landfill where the liquid is managed as stormwater.

- Vegetative Support Soil. This is a 24-inch thick layer of soil placed over the barrier layer that prevents erosive damage to the barrier and provides support for establishment of vegetative cover over the landfill surface. The surface of the landfill was graded to allow collection and proper management of surface water runoff. A series of armored surface water control ditches, flumes and divider berms conveyed the surface water from the landfill surface in a manner than minimizes erosion damage to the final cover. The surface of the Vegetative Support Soil was then seeded.

The final cover system constructed has been used on hundreds of landfills across the nation and has proven to be an effective institutional control by minimizing infiltration, continuing to function even after significant settlement of the underlying refuse.

3.2.3 Landfill Gas Controls

Uncontrolled migration of landfill gas (LFG) is well established as a potential risk to public health and safety, primarily because of its explosive potential and deleterious impacts to both groundwater and air quality. All MSW landfills will generate LFG, and proper controls and monitoring is a key operational control.

For a large facility such as Wilders Grove, management of LFG is a challenge. An extensive active LFG extraction system has been constructed to help manage LFG and its associated risks. At Wilders Grove, an active extraction system was determined to represent the most effective and extensive means of collecting and controlling LFG. At Wilders Grove, the LFG is collected and sold to an off-site user for alternative energy. This commercial arrangement has resulted in removal of an average of nearly 950 million cubic feet of LFG from the landfill each year since 2000. Excess LFG that is not sold is oxidized using a flare, which is located south of the southeastern disposal unit.

The City of Raleigh operates the LFG extraction system under a Title V Air Quality permit administered by NCDENR Division of Air Quality. Under the Title V permit, the number and location of wells and discharge elements is designed to meet strict operational criteria. Design and operational criteria are implemented so that positive LFG pressure (which drives the uncontrolled migration of the LFG) is essentially eliminated. A vacuum is established in the waste mass, which greatly reduces potential for lateral or uncontrolled vertical migration.

A total of 80 LFG extraction wells (including seven wells constructed in the southeastern unit) have been operating under the Title V permit since 2000, although some of the wells were constructed in the late 1980s. The system must be operated in accordance with state and federal criteria until at least 2015. In addition to the extraction system, the City conducts routine LFG monitoring around the landfill perimeter and at regular intervals on the final cover surface.

The LFG system is believed to represent a highly effective engineering control that reduces the risk from explosions (by removing methane) and minimizes impacts on air and groundwater quality (by removing VOC mass from the system).

3.2.4 Groundwater Monitoring

The groundwater monitoring system (which is described in detail in subsequent sections of this report) is not a control measure *per se*, but provides a tool for assessing the efficacy of both engineering controls and naturally occurring degradation. For large unlined MSW landfills such as Wilders Grove, base controls do not exist and groundwater in the vicinity of the landfill will likely be impacted. Wilders Grove has been monitoring groundwater in accordance with the requirement of Assessment Monitoring and Corrective Action Plan because of the impacts described above. An effective groundwater monitoring system will serve both to document the effects of engineering controls and naturally occurring degradation and to help determine if additional controls will be warranted in the future.

ATTACHMENT B

HYDROGEOLOGIC DESCRIPTION

1.0 AQUIFER CHARACTERISTICS

The Wilders Grove Landfill is located in the Piedmont Physiographic Province of North Carolina. The subject facility is located within the "Raleigh Belt", which consists of metamorphic rocks of Precambrian to Paleozoic age (gneisses, schists, amphibolite), and granitic intrusions of late Paleozoic-age. Granitic bedrock has been observed at various locations within and immediately adjacent to the subject facility.

The uppermost aquifer is unconfined, and consists of unconsolidated, residual soils (unstructured soil and saprolite) derived from the underlying bedrock. In general, the landfill is underlain by sandy silts and clays.

Groundwater generally flows from the north side of the landfill toward the south. Locally, groundwater likely discharges into Crabtree Creek, located at the southern property boundary. Crabtree Creek generally flows east where it eventually discharges into the Neuse River. TABLE 1 (attached) includes historical groundwater elevation data.

1.1 Flow Direction

A review of static water elevation data indicates no significant change in groundwater flow patterns have occurred over time, such that monitoring well MW-4 remains upgradient from all disposal areas and all other monitoring wells. As illustrated on FIGURE 3 (ATTACHMENT H), groundwater generally toward the south.

1.2 Subsurface Profiles

In order to help visualize subsurface conditions in the study area, we have prepared three geologic cross-sections, included in ATTACHMENT H:

- FIGURE 6: Cross-section A-A'
- FIGURE 7: Cross-section B-B'
- FIGURE 8: Cross-section C-C'

The locations of the cross-sections are shown on FIGURE 4 and FIGURE 5 (both in ATTACHMENT H), which show groundwater plumes of total volatile organic compounds (VOCs). As depicted on the cross-sections, the water table generally occurs within the sandy and silty residual soils, and saprolite. Where evidence of bedrock has been observed at the ground surface, the water table obviously occurs within fractured bedrock.

1.3 Hydraulic Conductivity

Hydraulic conductivity values were calculated by Draper Aden Associates based upon field slug tests conducted in six wells (MW-202S, MW-202D, MW-203S, MW-204S, MW-205S, MW-205D). Monitoring wells MW-202S, MW-203S, MW-204S, and MW-205S were screened within overburden. Monitoring wells MW-202D and MW-205D were screened within bedrock.

The hydraulic conductivity values calculated from the slug test data are within the same order of magnitude for the overburden wells, ranging from 1.72×10^{-4} cm/sec to 3.58×10^{-4} cm/sec. The average hydraulic conductivity is 6.36×10^{-4} cm/sec.

The hydraulic conductivity values calculated from the slug test data for the bedrock wells range from 3.82×10^{-4} cm/sec to 1.44×10^{-3} cm/sec. The average hydraulic conductivity is 9.11×10^{-4} cm/sec.

TABLE 2 summarizes the hydraulic parameters and groundwater flow data for all slug tested wells at the facility.

1.4 Horizontal Hydraulic Gradient

Hydraulic gradients estimated by Hazen and Sawyer are summarized on TABLE 2. Hydraulic gradients in the vicinity of the proposed injection area generally range from 0.0143 ft/ft to 0.0188 ft/ft (as calculated for four wells constructed in overburden). The average hydraulic gradient is 0.0165 ft/ft.

1.5 Groundwater Flow Velocity

Groundwater flow velocity, or seepage velocity (V_s), is a function of hydraulic conductivity (K), hydraulic gradient (i) and effective porosity (n_e):

$$V_s = (K*i) / n_e$$

Groundwater flow velocities were previously calculated for wells in the vicinity of the proposed injection area by Draper Aden Associates, and are summarized in TABLE 2. In general, groundwater flow velocities in the vicinity of the proposed injection area average 0.15 ft/day for the overburden wells, and average 0.28 ft/day for the bedrock wells.

The rate of contaminant transport may be conservatively estimated by the velocity of groundwater flow; however, several processes (dispersion, diffusion, retardation, biodegradation) will serve to reduce the rate and total mass of contaminants transported via groundwater.

1.6 Vertical Hydraulic Gradient

Two well clusters are located within the proposed injection area at the facility: MW-202S / MW-202D, and MW-205S / MW-205D. Groundwater measurements obtained at cluster MW-202S / MW-202D on September 21, 2010 revealed virtually no vertical gradient. However, groundwater measurements obtained at cluster MW-205S / MW-205D on the subject date revealed an upward vertical gradient, with an elevation difference of 6.46 feet.

TABLE 1
GROUNDWATER ELEVATIONS
WILDERS GROVE LANDFILL
RALEIGH, NORTH CAROLINA

Monitoring Well Designation	TOC Elevation (AMSL)	12/7/1994 Groundwater Elevation (AMSL)	2/24/1995 Groundwater Elevation (AMSL)	3/16/1995 Groundwater Elevation (AMSL)	7/31/1995 Groundwater Elevation (AMSL)	3/29/1996 Groundwater Elevation (AMSL)	9/30/1996 Groundwater Elevation (AMSL)	3/24/1997 Groundwater Elevation (AMSL)	9/15/1997 Groundwater Elevation (AMSL)	3/30/1998 Groundwater Elevation (AMSL)	9/21/1998 Groundwater Elevation (AMSL)	3/22/1999 Groundwater Elevation (AMSL)
MW-1	255.54	238.54		239.54	239.04	239.54	242.54	242.54	242.04	243.54	247.04	242.04
MW-2	201.75	189.75		190.75	189.75	190.75	191.25	190.75	190.75	191.25	195.75	190.25
MW-3	210.69	202.69		200.69	202.69	202.69	202.69	203.19	203.69	200.69	200.69	202.69
MW-4*	264.15	236.15		237.15	237.15	237.15	240.15	241.15	239.15	242.15	240.15	238.15
MW-6	223.09			201.09	202.09	203.09	204.09	204.59	201.09	207.09	203.09	204.09
MW-7	235.58	224.58		228.58	226.58	229.58	228.58	229.08	227.58	230.58	228.08	227.58
MW-8	241.96	224.96		226.96	226.46	227.96	226.96	226.96	225.96	228.96	226.96	225.96
MW-9	259.37	235.37		235.37	235.37	236.37	235.87	236.37	235.37	237.37	236.37	235.87
MW-10	217.55	196.55		197.05	197.55	196.05	207.05	200.55	198.05	197.05	207.55	196.05
MW-11	248.11	236.11		236.51	236.11	236.61	238.11	238.11	223.11	238.61	238.11	237.61
MW-12	248.25	235.25		236.25	235.75	236.25			234.25	236.25	224.25	234.75
MW-100S	199.80											
MW-100D	199.41											
MW-101D	219.70											
MW-102S	231.83											
MW-103S	251.60											
MW-104S	215.48											
MW-104D	215.97											
MW-105S	228.30											
MW-106S	185.52											
MW-201S	193.27											
MW-202S	186.53											
MW-202D	186.70											
MW-203S	191.77											
MW-204S	188.64											
MW-205S	175.79											
MW-205D	175.88											
MW-206D	176.00											

TOC Top of Casing
AMSL Above mean sea level, elevation in feet
* - MW-4 is Upgradient Well
Shaded cells indicate data not available

TOC Top of Casing
AMSL Above Mean Sea Level
* MW-7 was abandoned at end of 2000
Shaded cells indicate data not available

TABLE 1
GROUNDWATER ELEVATIONS
WILDERS GROVE LANDFILL
RALEIGH, NORTH CAROLINA

Monitoring Well Designation	TOC Elevation (AMSL)	9/20/1999 Groundwater Elevation (AMSL)	3/31/2000 Groundwater Elevation (AMSL)	9/28/2000 Groundwater Elevation (AMSL)	3/19/2001 Groundwater Elevation (AMSL)	9/25/2001 Groundwater Elevation (AMSL)	3/22/2002 Groundwater Elevation (AMSL)	9/17/2002 Groundwater Elevation (AMSL)	3/13/2003 Groundwater Elevation (AMSL)	9/24/2004 Groundwater Elevation (AMSL)	10/30/2004 Groundwater Elevation (AMSL)	3/15/2005 Groundwater Elevation (AMSL)
MW-1	255.54			243.04	242.54	241.54	241.14	240.24	242.44	242.54		241.89
MW-2	201.75	190.75		190.75	190.75	189.75	190.05	190.55	191.05	190.00	190.37	190.37
MW-3	210.69	202.69		202.69	201.69	201.99	201.99	201.89	203.19	202.69		202.66
MW-4*	264.15			238.65	243.15	241.65	241.15	240.05	246.15	239.65	243.40	243.40
MW-6	223.09	199.59		202.09	202.09	199.79	201.39	198.39	205.29	203.09	203.14	203.14
MW-7	235.58			226.58	Abandoned	Abandoned	Abandoned	Abandoned	Abandoned	Abandoned	Abandoned	Abandoned
MW-8	241.96	225.96		226.96	241.96	223.36	225.26	222.56	228.46	226.96	226.03	226.03
MW-9	259.37	235.37		235.37	234.37	234.57	234.57	233.77	235.87	235.37		235.75
MW-10	217.55	195.55		194.55	194.05	193.35	193.75	194.05	194.75	194.55	194.45	194.45
MW-11	248.11	237.11		248.11	236.11	236.11	235.91	235.41	236.71	236.86	236.50	236.50
MW-12	248.25			235.25	234.75	233.85	233.85	233.25	234.85	234.75	234.36	234.36
MW-100S	199.80			181.30	179.80	180.10	179.70	170.60	184.20	180.80	181.98	181.98
MW-100D	199.41			181.41	181.41	179.81	181.01	180.41	183.11	181.41	180.81	180.81
MW-101D	219.70			201.20	199.70	199.30	200.50	197.50	203.30	202.20	202.13	202.13
MW-102S	231.83			218.83	217.83	217.93	216.43	216.33	219.83	219.83	219.45	219.45
MW-103S	251.60			232.60	233.60	231.90	232.20	231.30	233.70	233.10	233.30	233.30
MW-104S	215.48			191.48	189.98	189.88	189.68	189.28	191.18	190.73	190.48	190.48
MW-104D	215.97			190.97	189.97	189.67	189.37	189.07	190.97	190.72	190.37	190.37
MW-105S	228.30			206.30	205.30	205.00	228.30	204.00	207.00	206.30		206.37
MW-106S	185.52						180.42	179.02	182.22	180.52		181.20
MW-201S	193.27											
MW-202S	186.53											
MW-202D	186.70											
MW-203S	191.77											
MW-204S	188.64											
MW-205S	175.79											
MW-205D	175.88											
MW-206D	176.00											

TOC Top of Casing
AMSL Above mean sea level, ele
* - MW-4 is Upgradient Well
Shaded cells indicate data not av

TOC Top of Casing
AMSL Above Mean Sea Level
* MW-7 was abandoned at end of 2000
Shaded cells indicate data not available

ATTACHMENT C

INJECTION FLUID COMPOSITION

This ATTACHMENT describes the chemical, physical, biological, and radiological (where available) characteristics of the proposed injectant (potassium permanganate). A Material Safety Data Sheet (MSDS) for the injectant is included.

1.0 SODIUM PERMANGANATE AND POTASSIUM PERMANGANATE

Two common forms of permanganate are commercially available and have been widely tested under field conditions: potassium permanganate ($KMnO_4$), and sodium permanganate ($NaMnO_4$). Both forms have similar chemical reactivity. Sodium permanganate is typically sold as a dark purple liquid, at concentrations up to 40%. Potassium permanganate is typically sold in a purple, crystalline or granular form. Potassium permanganate has a sweetish taste, and is odorless. Potassium permanganate can be mixed to form solutions up to 6%.

Both forms of permanganate are strong oxidizing agents with a unique affinity for oxidizing organic compounds containing carbon-carbon double bonds (such as aldehyde groups or hydroxyl groups). As an electrophile, the permanganate ion is strongly attracted to the electrons in the double bonds found in many regulated organic constituents. It borrows electron density from these bonds to form a bridged, unstable oxygen compound known as a "hypomanganate diester." The diester further reacts by a number of mechanisms (including hydroxylation, hydrolysis, or cleavage).

Under normal subsurface pH and temperature conditions, the carbon-carbon double bond of alkenes is broken spontaneously and the unstable intermediates are converted to carbon dioxide through either hydrolysis or further oxidation by the permanganate ion.

The primary by-product of the permanganate compounds is manganese oxide.

ATTACHMENT D

INJECTION RATIONALE

This ATTACHMENT describes the rationale for selecting the injectants, and describes the concentrations proposed for injection.

1.0 GOAL OF THE INJECTION PROJECT

The goal of the injection project is to reduce the concentrations of volatile organic constituents in groundwater to levels below their respective Groundwater Quality Standards.

2.0 VOLUME OF INJECTANT

The volume of injectant for each well is primarily based upon two factors: the volume of the well pipe, and the pore volume of the gravel pack around the well screen. Once the gravel pack pore space and well pipe are full of injectant, the rate of dispersion into the subsurface materials will be a function of the overall hydraulic conductivity of the subsurface materials.

Within the injection well area, the average hydraulic conductivity of the overburden is 6.36×10^{-4} cm/sec, and for the bedrock is 9.11×10^{-4} cm/sec. These values are based upon slug tests performed on six monitoring wells (MW-202S through MW-205D) located within the injection well area.

The effective porosity of the overburden is assumed to be 0.2[1], and for the bedrock is assumed to be 0.15. The average hydraulic gradient (based on four wells constructed in overburden) is 0.0165 ft/ft.

Based on the average hydraulic gradient, and the hydraulic conductivity and effective porosity values above, the average seepage velocity of the overburden is 0.15 ft/day (51 ft/year). Similarly, the average seepage velocity of the bedrock is 0.28 ft/day (102 ft/year). The estimated hydraulic capacities of the injection wells are governed by the seepage velocity of the natural subsurface materials at and beyond the borehole walls, assuming a saturated gravel pack.

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[1] Fetter, C.W., 1988. *Applied Hydrogeology*, 2nd Edition.

It is anticipated that the boreholes will be completed using 10" diameter drilling equipment, and that the wells will be constructed with 4" inner diameter PVC well screen and riser pipe. These dimensions result in a gravel pack pore volume of 7.9 ft^3 for wells constructed with 50 feet of screen, 8.75 ft^3 for wells constructed with 55 feet of screen, and 9.6 ft^3 for wells constructed with 60 feet of screen, assuming a gravel pack porosity of 0.35.

Based on the anticipated borehole diameters, the hydraulic capacities of the wells would be approximately 0.156 – 0.163 gpm for wells with 50 feet of screen, approximately 0.161 - 0.184 gpm for wells with 55 feet of screen, and approximately 0.201 – 0.213 gpm for wells with 60 feet of screen.

The total anticipated dissipation volumes were calculated based on the water/injectant column being equal to the well screen length. Based on the estimated hydraulic capacities of the wells, the estimated times to dissipate the respective volumes are approximately 9.3 – 9.7 hours for wells with 50 feet of screen, 9.1 – 10.4 hours for wells with 55 feet of screen, and 8.6 – 9.1 hours for wells with 60 feet of screen.

These dissipation times are conservative, and do not reflect rapid dissipation rates that will initially occur when the injection wells are filled completely, thus having a high hydraulic head within the well casing.

Example detailed calculations are included with this ATTACHMENT. The table below summarizes the hydraulic capacities and dissipation times for all 15 proposed injection wells. The anticipated schedule for constructing the 15 wells is presented in ATTACHMENT F.

Injection Well	Screen Length (ft)	Fraction Of Screen in Soil/Saprolite	Fraction of Screen in Bedrock	Average Seepage Velocity (ft/min)	Hydraulic Capacity (gal/min)	Injection Quantity (gallons)	Dissipation Time (hrs)
IW-1	60	0.25	0.75	1.72E-04	0.201	110	9.13
IW-2	60	0.2	0.8	1.76E-04	0.206	110	8.90
IW-3	60	0.2	0.8	1.76E-04	0.206	110	8.90
IW-4	60	0.17	0.83	1.79E-04	0.210	110	8.75
IW-5	60	0.13	0.87	1.82E-04	0.213	110	8.60
IW-6	60	0.18	0.82	1.78E-04	0.208	110	8.82
IW-7	55	0.25	0.75	1.71E-04	0.184	100	9.08
IW-8	50	0.30	0.70	1.67E-04	0.163	95	9.71
IW-9	50	0.34	0.66	1.64E-04	0.160	95	9.93
IW-10	50	0.34	0.66	1.64E-04	0.160	95	9.93
IW-11	50	0.38	0.62	1.60E-04	0.156	95	10.15
IW-12	50	0.4	0.6	1.60E-04	0.154	95	10.26
IW-13	55	0.47	0.53	1.52E-04	0.163	100	10.24
IW-14	55	0.49	0.51	1.50E-04	0.161	100	10.35
IW-15	55	0.49	0.51	1.50E-04	0.161	100	10.35

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Subject Wilders Grove Sanitary Landfill UIC Permit Application

Job No. R07373-05
By JCD Date 10/7/11

Seepage velocity calculation:

Well depth = 70 feet
Borehole dia. = 0.83 feet (10 inches)
Well casing dia. = 0.33 feet (4 inches)

Estimated effective porosity of overburden = 0.2
Estimated effective porosity of bedrock = 0.15
Estimated effective porosity of gravelpack = 0.35

Average hydraulic gradient = 0.0165 ft/ft
Average hydraulic conductivity of overburden = 1.80 ft/day
Average hydraulic conductivity of bedrock = 2.58 ft/day

Average seepage velocity of soil/saprolite:

$$\frac{Ki}{n_e} = \frac{(1.8\ ft/d)(0.0165\ ft/ft)}{0.2} = 0.15\ ft/day \simeq 55\ ft/year$$

Average seepage velocity of granite:

$$\frac{Ki}{n_e} = \frac{(2.58\ ft/d)(0.0165\ ft/ft)}{0.15} = 0.28\ ft/day \simeq 102\ ft/year$$

The hydraulic capacity of an injection well, under the natural groundwater gradient, will depend on the seepage velocities of the aquifer materials and the amount of well screen within each aquifer material. The average seepage velocity for a particular injection well can be estimated as:

$$V_{Avg.} = (55\ ft/yr)(\text{screen fraction in overburden}) + (102\ ft/yr)(\text{screen fraction in bedrock})$$

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Subject Wilders Grove Sanitary Landfill UIC Permit Application

Sheet No. 3 of 4

Job No. R07373-05

By JCD Date 10/7/11

Typical injection well with 55 feet of screen

It is assumed that injection wells IW-7, IW-13, IW-14, and IW-15 would have 55 feet of well screen.

Using IW-7 as an example:

Screen length in soil/saprolite = 14 ft nominal
Screen length in bedrock = 41 ft nominal

Screen fraction for soil/saprolite = 14/55 = 0.254
Screen fraction for bedrock = 41/55 = 0.745

Average seepage velocity for well $= (55\ ft/yr)(0.254) + (102\ ft/yr)(0.745)$
$= 90\ ft/yr = 1.71 \times 10^{-4}\ ft/min.$

To get hydraulic capacity:

Borehole surface area with screened interval $= 2\pi r h$
$= 2\pi\left(\frac{0.83\ ft}{2}\right)(55\ ft)$
$= 143.3\ ft^2$

Gravel pack pore volume $= \left(\pi\left(\frac{0.83}{2}ft\right)^2(55\ ft) - \pi\left(\frac{0.33}{2}ft\right)(55\ ft)\right) \times 0.35$

$= (29.7\ ft^3 - 4.7\ ft^3) \times 0.35$
$= 8.75\ ft^3$

Well casing volume within screen $= 4.7\ ft^3$

Total volume of water + permanganate to dissipate through borehole wall $= 8.75\ ft^3 + 4.7\ ft^3 = 13.45\ ft^3 = 100.6$ gal (rounded to 100 gal.)

The hydraulic capacity is: $\left(1.71 \times 10^{-4}\ \frac{ft}{min}\right)(143.3\ ft^2)\left(7.48\ \frac{gal}{ft^3}\right) = 0.18\ \frac{gal}{min}$

The estimated time to dissipate 100 gallons is:

$$(100\ gal)\left(\frac{1}{0.18\ \frac{gal}{min}}\right) = 555.5\ min \cong 9.3\ hrs.$$

ATTACHMENT E

INJECTION PROCEDURE AND EQUIPMENT

This ATTACHMENT describes the equipment and procedures necessary for performing the injections of potassium permanganate.

As discussed previously in ATTACHMENT D, the injection wells will be constructed of Schedule 80 PVC screen and riser pipe. FIGURE 9 (ATTACHMENT H) shows a schematic of a typical injection well.

Once the injection wells are constructed, the potassium permanganate solution can be prepared onsite and then introduced directly into the well pipe. For the first injection, to be performed within 90 days of approval of the Underground Injection Permit application, the solution will be prepared in controlled quantities, in order to verify the anticipated injectant volumes and well hydraulic capacities.

Subsequent events may consist of injecting predetermined volumes of injectant, using small tanks that would be connected via manifold to the tops of the injection wells. This would allow for more prolonged injection periods, until the tanks were emptied. The City of Raleigh would be required to ensure that the manifold connections are secure while in use, as required by NCDENR regulations for groundwater wells. When injections are not occurring, the injection wells must be locked and secured, per NCDENR regulations.

The anticipated schedule for injections is every 3-6 months.

ATTACHMENT F

INJECTION MONITORING PLAN

This ATTACHMENT presents the list of existing and proposed monitoring wells to be used; presents a list of monitoring parameters and analytical methods to be used; and includes a schedule for sampling to monitor the proposed injections.

1.0 INJECTION AND MONITORING WELLS

As presented in the approved Corrective Action Plan, the proposed injection wells will be constructed along a "front" defined by existing monitoring wells MW-202S/MW202D, MW-203S, MW-204S, MW-205S/MW-205D, and MW-206D. The first phase of injection wells will consist of constructing IW-4, IW-5, IW-12, and IW-15. Details regarding monitoring wells to be associated with each injection well are presented below.

- IW-4: well MW-206D

  Injection well IW-4 will be constructed upgradient of, and within 50 feet of, monitoring well MW206D. The monitoring of well MW206D will allow for evaluating the effectiveness of the injectant at decreasing VOC concentrations at this location.

- IW-5: well cluster MW205S/MW-205D

  Injection well IW-5 will be constructed upgradient of, and within 50 feet of, monitoring well cluster MW205S/MW205D. The well cluster is located immediately west of the drainage to Crabtree Creek. The monitoring of wells MW205S and MW205D will allow for evaluating the effectiveness of the injectant at decreasing VOC concentrations at this location.

- IW-12: well MW203S

  Injection well IW-12 will be constructed upgradient of, and within 50 feet of, monitoring well MW203S. The monitoring of well MW203S will allow for evaluating the effectiveness of the injectant at decreasing VOC concentrations at this location.

- IW-15: well cluster MW202S/MW202D

  Injection well IW-15 will be constructed upgradient of, and within 50 feet of, monitoring well cluster MW202S/MW202D. The monitoring of wells MW202S and MW202D will allow for evaluating the effectiveness of the injectant at decreasing VOC concentrations at this location.

The additional proposed injection wells will be constructed "as needed", in accordance with the timeframe and conditions listed below (as included in the approved Corrective Action Plan):

- If the concentration of any constituent of concern exceeds its Groundwater Quality Standard (GQS) ***and*** its Solid Waste Section Limit (SWSL) in well MW-204S during ***two*** consecutive regularly scheduled groundwater sampling events, then:
  - *Construct injection well IW-8 upgradient of monitoring well MW-204S.*

- If the concentration of any constituent of concern exceeds its SWSL at well cluster MW-208S/MW-208D (either well) during ***four*** consecutive regularly scheduled groundwater sampling events, then:
  - *Construct injection well IW-3 and injection well IW-6.*

- If the concentration of any constituent of concern exceeds its GQS, or continues to exceed its SWSL where the SWSL is greater than the GQS, at well cluster MW-208S/MW-208D during ***four*** consecutive regularly scheduled groundwater sampling events subsequent to the initial injection of well IW-3 and/or well IW-6, then:
  - *Construct injection well IW-1, injection well IW-2, and injection well IW-7.*

- If the concentration of any constituent of concern exceeds its SWSL at well cluster MW-207S/MW-207D (either well) during ***four*** consecutive regularly scheduled groundwater sampling events, then:
  - *Construct injection well IW-11, injection well IW-13, and injection well IW-14.*

- If the concentration of any constituent of concern exceeds its GQS, or continues to exceed its SWSL where the SWSL is greater than the GQS, at well cluster MW-207S/MW-207D during ***four*** consecutive regularly scheduled groundwater sampling events subsequent to the initial injection of well IW-11, well IW-13, and/or well IW-14 then:
  - *Construct injection well IW-9 and injection well IW-10 in the central injection zone (EIZ).*

In summary, it is anticipated that up to ten (10) injection wells (IW-3, IW-4, IW-5, IW-6, IW-8, IW-11, IW-12, IW-13, IW-14, IW-15) could be constructed within the three-year period of the initial injection permit.

All proposed injection wells are located in an area identified by the National Flood Insurance Program as a "special flood hazard area subject to inundation by the 1% annual chance flood" (i.e. a 100-year flood). A portion of the Flood Insurance Rate Map and legend are included in this ATTACHMENT. NCDENR regulation 15A NCAC 02C .0213 (a)(1) indicates that injection wells shall not be located in areas subject to flooding, such as those with concave slope, alluvial or colluvial soils, gullies, depressions, and drainage ways.

As none of the proposed locations appear to be affected by these criteria, no special well surface completion features appear to be required. However, all proposed injection wells will include protective steel surface casings that extend a minimum of three (3) feet above the ground surface, and all proposed injection well PVC casings will be fitted with locking expandable caps.

2.0 MONITORING PARAMETERS

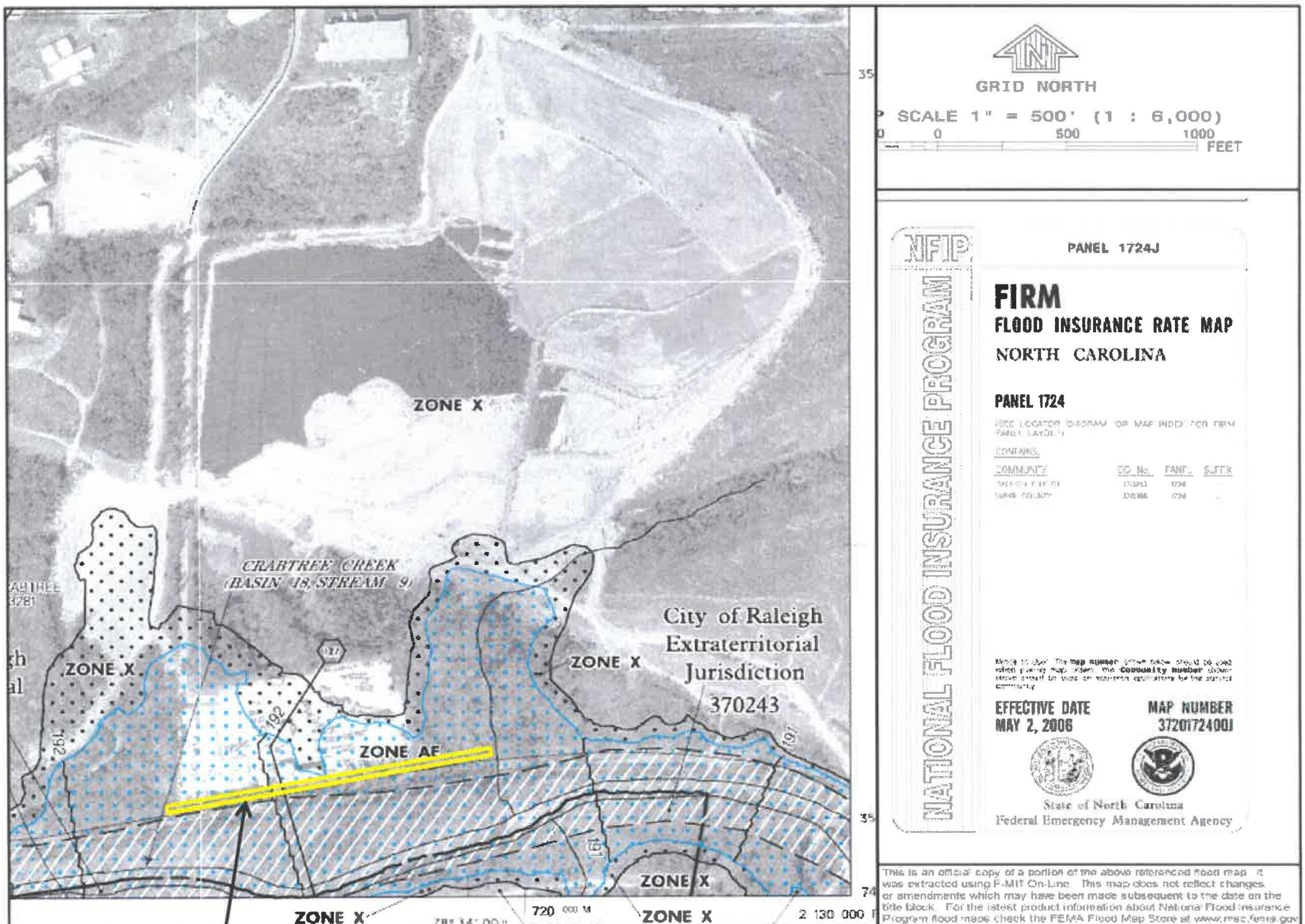
During the remediation period, the facility will continue to monitor all compliance wells semi-annually, in accordance with NCDENR Assessment Monitoring requirements. In addition, the facility will obtain additional groundwater samples from wells MW-202S, MW-202D, MW-203S, MW-205S, MW-205D, MW-206D, well cluster MW-207S/MW-207D and well cluster MW-208S/MW-208D, for analysis of the following parameters:

- carbon dioxide (RSK-175)
- potassium (SW-846 6010C)
- chloride (EPA 300)
- manganese (SW-846 6010C)
- ORP (field measurement)
- VOCs (SW-846 8260B)

3.0 MONITORING SCHEDULE

The primary indicator of the oxidation process is an increase in oxidation-reduction potential (ORP). The facility will measure ORP in the above-listed wells prior to the initial injection event, in addition to continued measurements during the injection period.

In addition to measuring ORP, the facility will obtain groundwater samples for analysis of the constituents listed above (except for VOCs) immediately prior to the first injection of potassium permanganate. The facility will then obtain groundwater samples for analysis of all constituents listed above on a quarterly basis during the injection period, or until NCDENR – DWQ determines that a less-frequent monitoring schedule is appropriate.



Proposed Injection Zone

ATTACHMENT G
CONSTRUCTION DATA FOR WELLS WITHIN 1/4 MILE OF INJECTION ZONE
WILDERS GROVE LANDFILL
RALEIGH, NORTH CAROLINA

				GROUND SURFACE				BELOW GROUND SURFACE			
WELL #	TYPE OF WELL	DATE COMPLETED	DRILLING METHOD	NORTHING	EASTING	ELEVATION (FT)	TOP OF CASING ELEVATION (FT)	TOTAL WELL DEPTH (FT)	DEPTH TO TOP OF SAND (FT)	DEPTH TO TOP OF BENTONITE SEAL (FT)	SCREEN LENGTH (FT)
MW-1	monitoring	3/19/1992	$4^{1/4}$ in HAS	7743587.166	2129946.616	254.44	255.54	21.5	8	6	10
MW-2	monitoring	8/29/1994	$4^{1/4}$ in HAS	741200.5472	2128978.915	199.95	201.75	15.4	3.5	2.5	10
MW-3	monitoring	3/20/1992	$4^{1/4}$ in HAS	741613.2032	2129450.108	209.11	210.69	14.8	3	2	10
MW-4*	monitoring	1/23/2001	$4^{1/4}$ in HAS	742263.3758	2131921.131	262.25	264.15	32.5	17	15	10
MW-6	monitoring	8/30/1994	$4^{1/4}$ in HAS	741529.3	2127561.406	221.14	223.09	33.3	17.4	15	15
MW-7**	monitoring	9/8/1994	$4^{1/4}$ in HAS	742508.3343	2128148.187	233.56	235.58	15.2	3.2	2	10
MW-8	monitoring	9/6/1994	$4^{1/4}$ in HAS	742043.6292	2130248.033	240.3	241.96	20.5	4.5	3	15
MW-9	monitoring	9/8/1994	$4^{1/4}$ in HAS	743800.6367	2128570.644	257.8	259.37	29.5	12.5	10	15
MW-10	monitoring	8/30/1994	$4^{1/4}$ in HAS	741437.5388	2128222.59	215.68	217.55	27.8	11.5	10	15
MW-11*	monitoring	1/23/2001	$4^{1/4}$ in HAS	743038.6105	2130154.625	245.51	248.11	20.7	4.5	3	15
MW-12	monitoring	9/7/1994	$4^{1/4}$ in HAS	742670.5276	2130259.492	246.16	248.25	20.3	4.4	3	15
MW100D	monitoring	3/17/2000	Air Rotary	741056.22	2128873.48	197.06	199.41	42	28	25	10
MW100S	monitoring	3/8/2000	$4^{1/4}$ in HSA	741052.58	2128882.47	197.04	199.80	22	11	9	10
MW101D	monitoring	3/20/2000	Air Rotary	741506.09	2127535.72	217.72	219.70	42	30	28	10
MW102S	monitoring	3/6/2000	$4^{1/4}$ in HSA	742752.81	2128258.67	230.00	231.83	19.5	7	4.75	10
MW103S	monitoring	3/7/2000	$4^{1/4}$ in HSA	743768.66	2128408.20	249.72	251.60	23.5	11	8	10
MW104D	monitoring	3/17/2000	Air Rotary	741305.31	2128216.06	213.56	215.97	71.5	54	51.5	10
MW104S	monitoring	3/7/2000	$4^{1/4}$ in HSA	741296.81	2128219.97	213.48	215.48	28.5	16.5	14	10
MW105S	monitoring	3/7/2000	$4^{1/4}$ in HSA	741871.33	2127305.31	226.37	228.30	24	12	10	10
MW-106S	monitoring	3/19/1992	$4^{1/4}$ in HSA	741113.82	2128758.60	183.52	185.52	15	3	2	10
MW-201S	monitoring	7/1/2009	6 in Air Rotary	740880.89	2127599.3	190.73	193.27	30	18	12	10
MW-202S	monitoring	6/30/2009	6 in Air Rotary	740407.27	2127459.91	184.32	186.53	26	13	10	10
MW-202D	monitoring	6/30/2009	6 in Air Rotary	740407.15	2127469.00	184.33	186.7	55	43	29	10
MW-203S	monitoring	6/30/2009	6 in Air Rotary	740453.64	2127756.32	189.12	191.77	30	18	15	10
MW-204S	monitoring	7/1/2009	6 in Air Rotary	740520.51	2128322.73	186.24	188.64	30	18	15.5	10
MW-205S	monitoring	8/12/2009	$4^{1/4}$ in HSA	740613.47	2128613.81	173.64	175.79	17	5	3	10
MW-205D	monitoring	8/12/2009	HSA / Air Rotary	740615.92	2128613.93	173.62	175.88	60	42	10	10
MW-206D	monitoring	8/12/2009	HSA / Air Rotary	740624.2	2128663.45	173.62	176.00	60	43	10	10
MW-207S	proposed monitoring	TBD	HSA	TBD	TBD	TBD	TBD	25	13	11	10
MW-207D	proposed monitoring	TBD	HSA / Air Rotary	TBD	TBD	TBD	TBD	60	48	≤46	10
MW-208S	proposed monitoring	TBD	HSA	TBD	TBD	TBD	TBD	25	13	11	10
MW-208D	proposed monitoring	TBD	HSA / Air Rotary	TBD	TBD	TBD	TBD	60	48	≤46	10
IW-1	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-2	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-3	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-4	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-5	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-6	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	8	6	60
IW-7	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	13	11	55
IW-8	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	18	16	50
IW-9	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	18	16	50
IW-10	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	18	16	50
IW-11	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	18	16	50
IW-12	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	18	16	50
IW-13	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	13	11	55
IW-14	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	13	11	55
IW-15	proposed injection	TBD	10" Air Rotary	TBD	TBD	TBD	TBD	70	13	11	55
A1-60	geothermal***	2010	6" Air Rotary	TBD	TBD	TBD	210-215	335	none	5	none

HSA = Hollow Stem Auger TBD - To Be Determined

* - Replacement Well

** - Abandoned in 2001

***-60 closed-loop geothermal wells constructed on property adjacent to transfer station; information is for typical well