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March 27, 2008

Ms. Jaclynne Drummond
Hydgrogeologist – Environmental Compliance
NCDENR – Solid Waste Section
1646 Mail Service Center
Raleigh, North Carolina 27699

Subject: **Assessment of Corrective Measures Report Amendment for the White Street Landfill Phase II**
Permit No. 41-03

Dear Ms. Drummond:

S&ME, Inc. (S&ME) prepared an Assessment of Corrective Measures Report (ACM) dated August 31, 2007 for Phase II of the White Street Landfill. In accordance with Title 15A NCAC 13B .1635(d), the City of Greensboro held a public meeting with interested and affected parties on December 20, 2007 to discuss the results of the corrective measures assessment.

The potential corrective measures that were identified in the ACM include in-situ air sparging / soil vapor extraction, subterranean physical barriers, in-situ enhanced bioremediation, groundwater pump and treatment, monitored natural attenuation, and maintaining a consistent contour with the pre-1988 waste area.

In preparation to complete the required Corrective Action Plan (CAP) in accordance with Title 15A NCAC 13B .1636, City of Greensboro staff and S&ME staff meet to discuss and finalize the selection of remedy for the pending CAP. Prior to and during the preparation of the ACM, groundwater extraction and discharge to the local POTW was considered the probable primary "active" remedy coupled with monitored natural attenuation (MNA) to address the volatile organic constituents of concern from the Facility's NES Report. The Alternate Source Demonstration prepared by S&ME for the Facility and approved by the NCDENR, essentially eliminated most of the metals listed as constituents of concern at the facility. However, thallium has been periodically detected above the 15A NCAC 2L groundwater quality standard at several downgradient compliance monitoring wells which monitor a relatively widespread area in the downgradient region of the Facility. Although thallium has not been detected in compliance wells at concentrations exceeding the corresponding 15A NCAC 2L groundwater quality standards during the last three compliance monitoring events, the City of Greensboro wishes to include a remedy for this constituent in the pending CAP. Giving due consideration to the area monitored by compliance wells that have contained concentrations of thallium exceeding the

15A NCAC 2L groundwater quality standard, groundwater extraction and discharge to the onsite POTW is not considered a practical or economically feasible remedial option for thallium at the Facility. Therefore, after re-evaluation of the possible remedies to address the constituents of concern including thallium at the Facility, it is the City of Greensboro's desire to include Phytoremediation as one of the possible remedies or combination of remedies to restore groundwater quality at the Facility.

This ACM Amendment document has been prepared for the purpose of adding Phytoremediation to the list of possible remedies for the upcoming CAP outlined in the ACM. The City of Greensboro will make this document available for public review for a period of 30 days after which an additional public hearing will be held to hear public comments regarding Phytoremediation as a remedy to restore groundwater quality at the White Street Landfill.

The following discussion topics regarding Phytoremediation mirror the topics discussed for each of the remedies presented in the original ACM Report. These topics include the method description, performance and reliability, remediation timeframe, implementation requirements, remedy costs, and institutional controls and requirements:

Phytoremediation

Method Description

Phytoremediation uses plants to cleanup contaminated soil and groundwater, taking advantage of plants' natural abilities to take up, accumulate, and for select constituents, even degrade soil and groundwater contaminants. Research indicates that phytoremediation is applicable to a broad range of contaminants including numerous metals, radionuclides, volatile organic compounds (such as chlorinated solvents), BTEX, PCBs, PAHs, pesticides/insecticides, explosives, nutrients, and surfactants. According to the information reviewed, general site conditions best suited for potential use of phytoremediation include large areas with moderate levels of contaminants in shallow soil or large volumes of water with low level contamination subject to low treatment standards. Depth to groundwater for in-situ treatment is limited to about 20 feet, but ex-situ treatment in constructed troughs or wetlands has also been investigated.

There are five basic types of phytoremediation techniques: 1) rhizofiltration, a water remediation technique involving the uptake of contaminants by plant roots; 2) phytoextraction, a soil technique involving uptake from soil, 3) phytotransformation, applicable to both soil and groundwater, involving the degradation of contaminants through plant metabolism, 4) phyto-stimulation or plant-assisted bioremediation, also used for both soil and water, which involves the stimulation of microbial biodegradation through the activities of plants in the root zone, and 5) phytostabilization, using plants to reduce the mobility and migration potential of contaminants in soil.

Major advantages reported for phytoremediation as compared to traditional remediation technologies include the possibility of generating less secondary wastes, minimal associated environmental disturbance, and the ability to leave soils in place and in a usable condition following treatment. Cited disadvantages include the long lengths of time required (usually several growing seasons), depth limitations, and seasonal effectiveness.

Performance and Reliability

Phytoremediation is an emerging technology that has the potential to treat a wide range of contaminants for a lower cost than traditional technologies. Phytoremediation techniques are almost by definition innovative. Several have been proven to be effective if appropriate site conditions exist . However, many have not been applied very often. In spite of the large amount of information concerning applications of phytoremediation to contaminated soils, groundwater, and surface waters, there is still a need to determine the specific plant(s) and treatment procedures for cleanup at a specific site that will work to remediate the contaminant(s) in the soil or water at the specific site. Many factors will influence the success of phytoremediation at a given site, including contaminant concentration, availability of nutrients, daily maximum and minimum temperature, rainfall or possibility of irrigation, grade on site, aesthetic considerations, daily illumination level, relative humidity, wind patterns, and/or the presence of growth-suppressing contaminants. The desired level of cleanup and the desired rate of decontamination also need to be considered. All of these factors need to be evaluated prior to a substantial expenditure of time and money on a large-scale phytoremediation effort.

Treatability studies could also provide information relating to disposal of contaminated biomass. Such disposal is a major consideration in the cleanup of metal-containing soils. Depending on regulations and plant concentrations of metals, plants may need to be landfilled, or the metals reclaimed through smelting, pyrolysis of biomass, or extraction.

In a discussion of the reclamation of metal-contaminated plant tissue by smelters, Dibakar (1997) stated that plant tissue with a dry-weight concentration of over one percent metal was amenable to reclamation. Ongoing progress of phytoremediation can be measured post implementation of this remedy. Tree sap flow rates can be monitored in order to determine the pumping rates of the trees. A noninvasive technique can be used to measure sap flow on certain trees during the various sampling seasons. Groundwater monitoring data from some successful projects indicate that the trees are capable of pumping large amounts of groundwater to the point that the water table has been lowered by tenths of feet in the planting area at the end of the growing season, indicating possible groundwater withdrawal by the trees for containment of the contaminated groundwater in future growing seasons. Some studies show that trees are utilizing the groundwater at rates of 2 to 10 gpd/tree.

Phytoremediation using trees to clean up groundwater contaminated with volatile organic compounds and metals may be an ideal choice for this site and others due to the low cost, low maintenance, and low impact associated with the technology, especially if this technology is applied in conjunction with other technologies.

Remediation Timeframe

Remediation time frames for phytoremediation can vary widely as with other technologies due to site specific conditions and varying end point remedial goals. Many case studies utilizing phytoremediation technology are on-going. Many of these cases are predicting multiple years until targeted remediation end points will be achieved. However, over time phytoremediation, under proper site conditions, can be effective at remediating volatile organic compounds and metals from groundwater.

Implementation Requirements

Specific methodologies for the application of phytoremediation to contaminated sites have been standardized, and general principals have been established. The general steps followed in the design and implementation of a phytoremediation project, for any of the specific techniques under this technology discussed in the *Method Description* above include:

- Site characterization, including determination of soil and water chemistry/conditions, climate, and contaminate distribution;
- Treatability studies to determine rates of remediation and appropriate plant species, density of planting, location, etc.;
- Preliminary field testing at the site to monitor results and refine design parameters;
- Full-scale remediation;
- Disposition of resulting affected plant material

Remedy Costs

The associated costs to employ phytoremediation technology at the site would include: design, permitting, capital costs for materials such as plants, irrigation systems, etc., procurement, construction, and construction oversight costs, and operation and maintenance costs. Phytoremediation is not expected to be an energy intensive operation. However, this type of system would require regular inspection and maintenance. Current estimates of costs for phytoremediation vary widely, and little information was found as to the conditions on which the estimates were based. A cost estimate for phytoextraction included $10,000 per acre for planting, with total remediation costs, including maintenance, monitoring, verification testing, etc. estimated at $60,000 to $100,000 per acre. Another estimate estimated costs from $2 to $6 per thousand gallons of water treated, including waste disposal and capital costs. The following estimated costs to apply phytoremediation technology at the site are based on the information available to S&ME at the time this report was prepared. Additionally, because of the occurance of shallow groundwater in the zone between the waste management units and the compliance boundary at the Facility, it is assumed that an engineered drainage basin to assist in plant uptake of the constituents of concern may not be necessary and that trees can be effectively planted directly into the natural ground in the remediation zone. Consequently, it has also been assumed that pumping of groundwater to an engineered basin will not be necessary. Therefore, the costs listed below do not include an engineered phytoremediation basin or the costs associated with pumping and piping extracted groundwater to such an engineered basin. Actual costs may vary based on pilot studies and/or site specific data and information that become available or known in the future. If future studies including pilot studies indicate that pumping affected groundwater to an engineered basin is in fact necessary to effectively implement phytoremediation as a viable remedial option at the Facility, these costs will significantly increase:

Design Costs:	
Engineering Costs .... $	100,000 - $150,000
Permitting Costs... $	5,000 - $10,000
Equipment Costs:	
Tree Plantings .... $	100,000 - $200,000
Contingencies: .... $	100,000– $200,000
Total Estimated Implementation Costs: .... $	**305,000– $560,000**

For budgetary purposes we estimate annual maintenance and upkeep costs for a phytoremediation system to be $20,000 to $30,000. Actual costs may vary.

Institutional Controls and Requirements

Implementation of a phytoremediation system may require several permits for operation. The operating permit for the landfill would require modification by the NCDENR DWM.

Upon receiving NCDENR approval of this Assessment of Corrective Measures Addendum Letter, a second public hearing will be required. Prior to the public hearing, an announcement of the public hearing will be posted in a local newspaper for two (2) consecutive weeks and no fewer than thirty (30) days prior to conducting the public hearing. The public hearing will be conducted in an accessible public meeting place of the City's choice and open to the general public. Any comments received from the public regarding this Addendum Letter will be incorporated into an Attachment that will be added to this letter following the public hearing. If no comments are received from the public, no additions to this letter will be required.

S&ME will then prepare a Corrective Action Plan (CAP) for implementing the City's selected remedy.

We appreciate your assistance in this matter. If you should have any questions, please do not hesitate to contact the undersigned at (336) 288-7180.

Sincerely,

Connel D. Ware
Senior Project Manager

Edmund Q. B. Henriques, P.G.
Environmental Department Manager

CDW/EQBH/mjf

Senior Review By:
Wayne Watterson, P.E.

cc: Jeryl W. Covington, P.E. Director, Environmental Services Department, City of Greensboro

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References

Ehrenfield, J. and J. Bass. 1984. Evaluation of Remedial Action Unit Operations of Hazardous Waste Disposal Sites. Pollution Technology Review No. 110, Noyes Publications, Park Ridge, NJ.

EPA Seminar Publication, 'Site Characterization for Subsurface Remediation', United States Environmental Protection Agency Technology Transfer, Nov. 1991, Office of Research and Development, Washington, DC 20460

Jones-Lee, A. and Lee, G. F., 'Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance,' Proc. Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, pp. 1093-1103, October (1993). [47k]"

Tchobanoglous, G., H. Theisen, S. Vigil, 1993. INTEGRAWTED SOLID WASTE MANAGEMENT, Engineering Principles and Management Issues, McGraw-Hill pp 452 - 455.

Thomas, J.M. and C.H. Ward. 1989. In Situ Biorestoration of Organic Contaminants in the Subsurface. Environ. Sci. Technol. 23:760-766.

Thomas, J.M., M.D. Lee, P.B. Bedient, R.C. Borden, L.W. Canter, and C.H. Ward. 1987. Leaking Underground Canter, and C.H. Ward. 1987. Leaking Underground Storage Tank Remediation with Emphasis on In Situ Biorestoration. EPA/600/2-87/108 (NTIS PB87-168084/REB).

U.S. Environmental Protection Agency (EPA). 1985. Remedial Action at Waste Disposal Sites. EPA/625/6-85/O06 (NTIS PB87-201O34).

U.S. Environmental Protection Agency (EPA). 1990. Basics of Pump-and-Treat Ground-Water Remediation Technology. EPA/600113-90/003.

U.S Environmental Protection Agency (EPA), February 2000, Introduction to Phytoremediation. EPA/600/R-99/107.